VIETNAM ELECTRICITY

BAN QLDA NHIỆT ĐIỆN VĨNH TÂN
CÔNG VĂN ĐẾN
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ENVIRONMENTAL IMPACT ASSESSMENT REPORT

of the Project

VINH TAN 4 POWER PLANT

LOCATION: TUY PHONG DISTRICT - BINH THUAN PROVINCE

BINH THUAN, 12/2013

VIETNAM ELECTRICITY

ENVIRONMENTAL IMPACT ASSESSMENT

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VINH TAN 4 POWER PLANT

LOCATION: TUY PHONG DISTRICT-BINH THUAN PROVINCE

THE PROJECT OWNER

VINH TAN THERMAL POWER PLANT PROJECT MANAGEMENT BOARD

GIÁM ĐỐC

BAN QUẢN LÝ DỰ ÁN NHIỆT ĐIỆN VĨNH TÂN
CHI NHÁNH CÔNG TY TNHH MỘT THÀNH VIÊN TỔNG CÔNG TY PHÁT ĐIỆN 3
M.S.C.N: 3502208399-002 - C.T.T.N.H.H - BÌNH THUẬN

Quách Đình Thành

THE CONSULTING AGENCY

POWER ENGINEERING CONSULTING JOINT STOCK COMPANY 2

CHIEF EXECUTIVE OFFICER

CÔNG TY CỔ PHẦN TƯ VẤN XÂY DỰNG ĐIỆN 2
M.S.D.N: 0300420157 - C.T.C.P - QUẬN 3 - TP. HỒ CHÍ MINH

Nguyễn Chơn Hùng

BINH THUAN, 12/2013

ABBREVIATION

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DONRE	Department of Natural Resources and Environment
EIA	Environmental Impact Assessment
EMP	Environmental management plan
EVN	Electricity of Vietnam
ESP	Electrostatic Precipitator
FGD	Flue gas desulphurization
GDP	Gross Domestic Production
HC	Hydrocarbons
MONRE	Ministry of Natural Resources and Environment
PC	People's Committee
PECC2	Power Engineering Consulting Company 2
PM10	Suspended particles with diameter less than 10μm
PPA	Power Purchase Agreement
QCS	Air quality control system
QCVN	National technical regulation
SCR	Selective catalytic reduction
SS	Suspended solid
TCVN	Vietnamese standard
TSP	Total suspended solid
USD	US dollar
VND	Vietnam dong
VOC	Volatile organic compounds
WHO	World Bank

TABLE OF CONTENTS

INTRODUCTION

CHAPTER 1: BRIEF DECRIPTION OF THE PROJECT

CHAPTER 2: NATURAL, ENVIRONMENTAL AND SOCIO-ECONOMIC CONDITIONS

CHAPTER 3: ENVIRONMENTAL IMPACT ASSESSMENT

CHAPTER 4: MITIGATION MEASURES FOR NEGATIVE IMPACTS, PREVENTION AND RESPONSE TO ENVIRONMENTAL RISKS

CHAPTER 5: ENVIRONMENTAL MANAGEMENT AND MONITORING PROGRAM

CHAPTER 6: PUBLIC CONSULTATION

CHAPTER 7: CONCLUSION AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

SUMMARY OF ENVIRONMENTAL IMPACT ASSESSMENT REPORT - VINH TAN 4 THERMAL POWER PLANT PROJECT

1. INTRODUCTION

Vinh Tan 4 Thermal Power Plant belonging to Vinh Tan Power Complex will be located in Vinh Tan Commune, Tuy Phong District, Binh Thuan Province.

The Plant's capacity of 2x600MW will play an important role in stabilizing the power supply network in the province as well as in the South of Vietnam. The conventional thermal power technology of steam-condensing will be applied.

The Environmental Impact Assessment (EIA) Report of Vinh Tan 4 Thermal Power Plant Project has been developed by Vinh Tan Thermal Power Project Management Board (VTTPMB - the Project Owner) and Power Engineering Consulting Joint Stock Company 2 (PECC2 – the Consultant). The Report shall be reviewed and approved by Ministry of Natural Resources and Environment (MONRE).

2. PROJECT OWNER

The Project Owner: Vinh Tan Thermal Power Project Management Board (VTTPMB).

Head office: Hung Vuong ,Boulevard, Quarter 4, Phú Thủy Ward, Phan Thiet City, Binh Thuan Province

Legal Representative: Mr. Quach Dinh Thanh

Position: Director of VTTPMB.

Tel: 062.2461222 Fax: 062.3739684

3. SITE LOCATION

Vinh Tan 4 Thermal Power Plant (Vinh Tan 4 TPP) is one of the four Plants in Vinh Tan Power Complex and will be located in Vinh Tan Commune, Tuy Phong District, Binh Thuan Province, about 25-30km from Phan Ri Town towards the North-East. The South borders on the East Sea, the South-West on Vinh Hao Commune, Tuy Phong District and the North-East on Phuoc Diem Commune, Ninh Phuoc District, Ninh Thuan Province. Its coordinates are as follow:

- Longitude: 108° 48' 00"
- Latitude: 11° 20' 00"

The total used area of the Plant's main area is expected to be 70.2 ha, including:

- The Plant's main area of 50.18ha, of which onshore area is 19.16ha and encroachment area is 31.02ha.
- Greenery corridor: 3.54ha

- Corridor of cooling water discharge pipe lines: 16.48ha

Coordinates of benchmarks of Vinh Tan 4 TPP and Port are shown in the below Table

Table 1.1 Coordinates of benchmarks of Vinh Tan 4 TPP and Port

Coordinates of benchmarks of Vinh Tan 4 PPP		
Point	Coordinates (VN2000)	
	Coordinate System VN2000, $L_0 = 108^0 30'$, projection 3^0	
	X	Y
VT4-1	1251782,963	531616,471
VT4-2	1251687,186	531776,409
VT4-3	1250482,426	532032,478
VT3-4	1250570,254	532447,570
VT3-3	1251176,125	532318,643
VT3-2	1251152,738	532208,612
VT3-1	1251876,078	532054,861
Coordinates of benchmarks sewage pipeline corridor		
VT4-3	1250482,426	532032,478
VT4-4	1249386,451	532265,449
BT-5	1249417,076	532409,334
BT-27	1250512,602	532176,473
Coordinates bounding Vinh Tan 4 Port		
	X	Y
A	1250214,112	532754,774
B	1249911,072	532819,194
C	1250207,725	532724,731
D	1249904,685	532789,146

Source:PECC2,9/2012

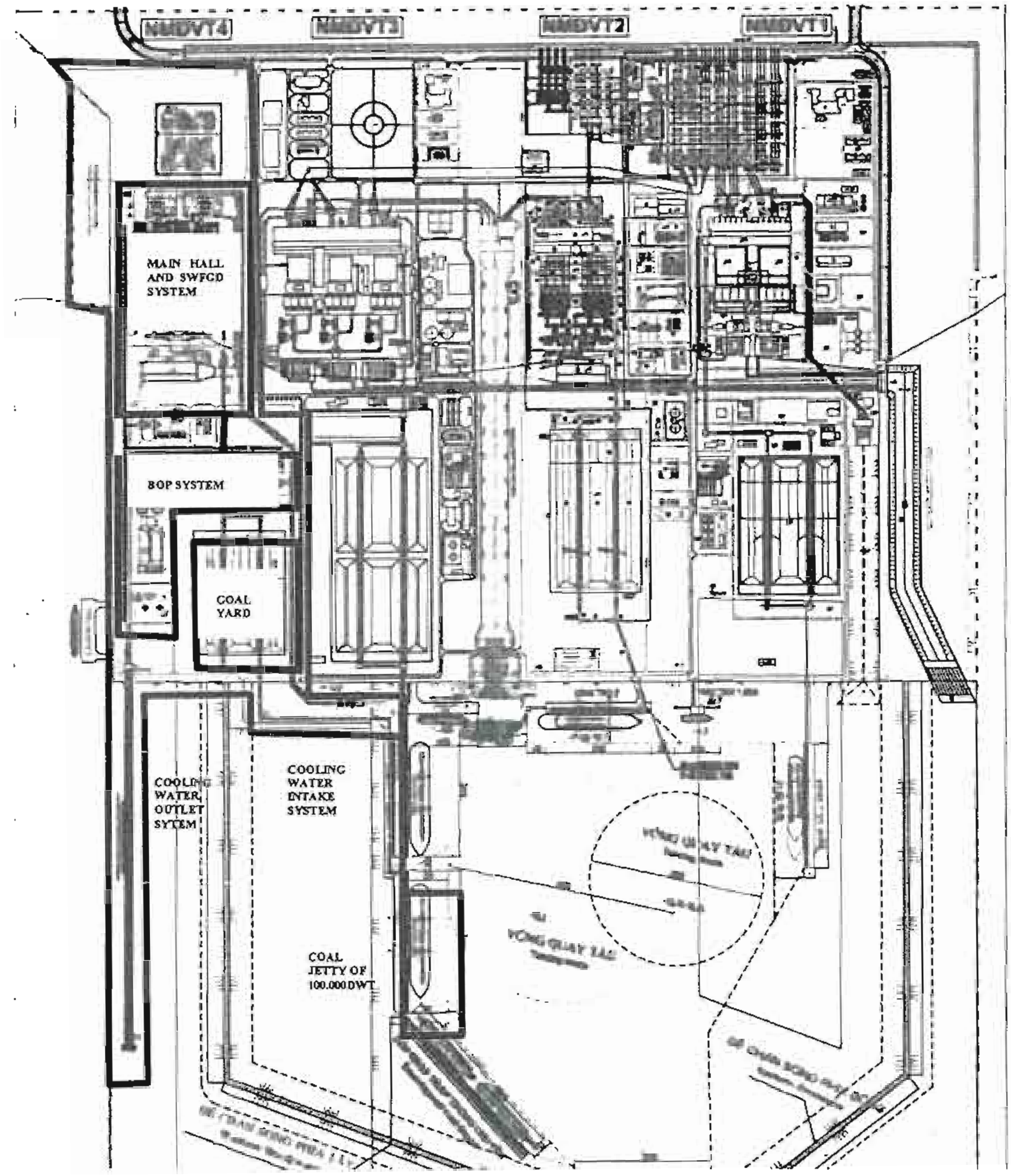


Figure 1. General layout of Vinh Tan 4 TPP

4. CAPACITY AND TECHNOLOGY

4.1. Capacity

The conventional thermal power technology of steam-condensing will be applied, with supercritical team parameters. The Plant's two 600MW Units of will be designed to use imported coal.

4.2. Main Mechanical Equipment

1. Boiler

Type of Boiler: super-critical, single reheat, pulverised fuel fired, balanced draft boiler. The furnace is likely to be of the two pass opposed firing type (although the tower type would also be an acceptable option).

Main parameters (expected) in MCR conditions of boilers:

No	Parameters	Unit	Super-critical (SC)
1	Steam output at MCR	t/h	1755
2	Superheat pressure	MPa	25.75
3	Superheat temperature	°C	568.9
4	Flow of reheat steam	t/h	1.424
5	Pressure of input/output reheat steam	MPa	5.356/5.15
6	Temperature of input/output reheat steam	°C	335/567
7	Water supply temperature	°C	286.4

Source: PECC2,9/2012

Steam flow in BMCR condition is about 5% higher than the above steam flow.

Boiler efficiency (in expected operation conditions): 92.9% (LHV).

2. Steam Turbine

Type: Super-critical parameter, intermediate one-time reheat, single shaft, 3 or 4-cylinder, 2 or 4-exhaust condensing steam turbine

Main parameters (expected) in MCR conditions of steam turbines:

No	Parameters	Unit	Super-critical (SC)
1	Power output	MW	600
2	Pressure of upstream main STOP valve	MPa	25
3	Temperature of upstream main STOP valve	°C	565
4	Pressure of re-heat steam	MPa	5

5	Temperature of re-heat steam	°C	565
6	Rated speed	RPM	3000
7	Cooling water temperature	°C	27,6
8	Back pressure	kPa	7
9	Main steam flow	t/h	1755
10	Reheated steam flow	t/h	1424.0
11	Turbine heat rate	kJ/kWh	7548
12	Number of extractions	set	8
13	Driven feedwater pump	3x50%	3x50% electric pump or 2x50% turbine pump + 1x30% electric pump

Source: PECC2,9/2012

3. *Steam turbine generator*

Expected main parameters of the steam turbine generator:

- Rotating field, two poles, cylinder rotor, fully enclosed, synchronous generator.
- Type: Steam turbine generator, cooling by hydrogen, static excitation.
- Rated power capacity: 600MW
- Power factor (cosφ): 0.85
- Frequency: 50Hz

4.2.2. Stack

According to calculations, the height of the stack is 210m and the inner diameter of each small stack of each Unit is 6 m.

4.2.3. Coal demand

Coal demand of Vinh Tan 4 TPP is shown below:

No	Parameters	Particular
1	Capacity, MW	1200
2	Technology	Conventional thermal power technology of steam-condensing
3	Higher Heating Value (HHV), kJ/kg	24284
4	Coal consumption, t/h	425.73
5	Coal consumption, t/day	10.217
6	Coal consumption, t/5.000h	2,128,633
7	Coal consumption, t/5.500h	2,341,497

No	Parameters	Particular
8	Coal consumption, t/6.000h	2,554,360
9	Coal consumption, t/6.500h	2,767,223

4.2.4. Self-consumption power output

Self-consumption power output of Vinh Tan 4 TPP is about 111.4 MW (equivalent to 9.28% of the Plant's total capacity 1200MW).

4.3. **Auxiliary systems**

- *Cooling water system*: Cooling water is taken directly from sea, pumped to the condenser through the circulatory system and water intake channel. Warm water after cooling the condenser is discharged to the siphon pit before being discharged into the cooling water discharge pipe. The requested cooling water flow is about $50m^3/s$.
- *Coal handling system*: Coal will be imported by 100,000DWT ships to 100,000DWT coal jetty of Vinh tan 4 TPP, then will be unloaded by ship unloaders and conveyed to the Plant coal yard by belt conveyer; and then will be supplied to the bunker bay in the main station building through bucket wheel stacker/reclaimer. The total coal consumption of the Plant is about 2.8 million tons/per year.
- *Oil supply system:* Oil supply system is designed to support ignition during start-up of boiler or for operation with low load by diesel oil (DO). Total oil consumption of Vinh Tan 4 TPP is about 6000 tons/per year.
- *De-NOx system*: In order to meet environmental standard of NOx discharge, measures for reduction of NOx by burning low NOx will be applied.
- *FGD system:* The seawater FGD system will be installed for the Plant.
- *Ash handling system:* The plant is expected to produce about 137,248 tones of conditioned ash per year. Fly ash will be removed by compressed air to fly ash silo. Bottom ash will removed by submerged drag conveyor to silo. Outside the plant, bottom ash and fly ash will be transported to the ash pond by trucks.
- *Wastewater treatment system:* in order to meet environmental standard of wastewater discharge from the Plant, chemical, oil and coal contaminated wastewater treatment systems and domestic wastewater treatment system will be constructed.
- *Coal port:* The coal port will provide coal for the Plant during operation phase. It can accommodate ships with loads of up to 100,000 DWT.

- *Ash pond:* Vinh Tan 4 TPP will share the Ash Pond with Vinh Tan 2 TPP with the area of 64.7ha. As the two Plants are under EVN's management, the Ash Pond will be shared and will not be divided into areas for each Plant.
- Besides, there are other auxiliary systems such as transportation, water supply, rain water drainage, fire prevention and fighting and lighting systems, etc.

4.4. Labour structure in pre-construction, construction and operation phases

4.4.1. Pre-construction

The number of unskilled labours doing levelling and encroachment works (preparation phase) is about 500 people.

4.4.2. Construction

The number of unskilled labours in construction phase is about 1500 people.

4.4.3. Operation

Total number of the Plant's staff is about 500 people, divided into two main functions:

- Direct production function: work in workshops.
- Indirect production function: work in departments.

4.5. Project Implementation Schedule

The expected time for construction of the Plant is 48 months for 2 Units. It is expected to be put into commercial operation in 2017-2018.

4.6. Total Investment Cost

The expected Total Investment Cost (TIC) of about 35,949 billion VND will be financed by the Project Owner and international and national commercial banks.

5. ENVIRONMENTAL IMPACTS

The construction of Vinh Tan 4 Thermal Power Plant will contribute positively to the development of local socio-economic. However, it also has concerning impacts on the environment, natural and social conditions of the region.

Negative environmental impacts from Vinh Tan 4 TPP are unavoidable because of great amount of coal which is the main fuel. Those impacts can be affected various environmental factors (natural and social), changing regional scenery and eventually disturbing human health and surrounding natural resources.

The impacts are from 3 main phases of the project:

- Pre-construction phase: impacts from project location, designs and site clearance, sea encroachment.

- Construction phase: land reclamation, plant and port construction, worker gathering.
- Projected impacts from the operation of Vinh Tan 4 TPP: impacts from cooling wastewater, exhausted gases, solid wastes, noise, vibration, transportation and other impacts to the socio-economic.

5.1. Pre-construction and construction phases

5.1.1. Waste related impacts:

1. Dust and gas emission:

In the stages of land leveling and construction, air pollution can be caused by:

- Gas emission from transportation vehicles, construction equipments and machinery on-site such as: trucks, bulldozers, excavators, drilling machines, generators. Most of these machines use gasoline or oil as their fuel so that toxic gases will be emitted into the air including SOx, NOx, CO…
- Dust, soil, rock, sand will be released from various processes such as land reclamation, backfilling, constructing of embankment and plant, the transportation of building materials.
- Dust, exhausted gases from transportation vehicles, construction equipments as well as the transportation and loading/unloading of materials.

2. Wastewater:

In the stages of land leveling and construction, water sources can be polluted by:

- Domestic wastewater from workers: approximately 68 m^3/day and 203 m^3/day of domestic wastewater flow in land leveling phase and construction phase respectively will be discharged. Main pollutants include suspended solid (SS), organic substances, grease, Nitrogen (N), Phosphorous (P) and bacteria (T. Coliform).
- Wastewater from transportation vehicle and equipment cleaning process: is about 20-25 m^3/day (land leveling phase), 5-10 m^3/day (construction phase)
- Run-off rainwater: is about 0.26 m^3/s.
- Wastewater from ships, barges during the construction of embankment and seaport.

3. Solid waste:

- Domestic waste: volume of solid waste is estimated as 250 kg per day (in land leveling phase) and 750 kg per day (in construction phase).
- Industrial solid waste: mainly concrete, stones, bricks and other materials disposed from the construction. Estimately, the volumes are about 200 – 300 kg per day (leveling phase) and 300 – 400 kg per day (construction phase).

- Hazardous waste: mainly waste oil and oily cloth disposed during the constructing process. During the leveling phase, the volumes are estimated as 92 L per month of waste lubricant and 1.1 kg per month of cloth. On the other hand, during the construction phase, estimately 47 L/month waste lubricant and 0.6 kg/month cloth are disposed.

4. *Impacts from the encroachment of sea*

- The leveling activities may raise the turbidity level at the nearby seacoast. According to the modeling calculation, the generated TSS concentration caused by encroachment activities will be 0.008 – 0.02 kg/m^3, lower than the standard TSS regulated in QCVN 10:2008/BTNMT on coastal water quality, application for aquaculture, aquatic protection (0.05 kg/m^3).
- Since the backfilling is only started when the embankment construction is done, thus, range of influence of increasing TSS concentration by the sea-encroaching activities is local and will not spread to others area in Vinh Tan coastal.
- The Breda sandbar zone and Hon Cau island zone are not affected by the leveling process. Hence, the leveling activities will not affect significant on is seawater quality and regional ecosystem.
- The leveling has little impact on the erosion and accretion at regions because spreading of suspended sediment blocked by the construction. In further place, influences of leveling activities are small because the spreading of suspended sediment strong decrease in spatial.

5. *Impacts from dredging in front of berth area*

- The dredging activities in front of the berth area may raise the turbidity level at the nearby seacoast. According to the modeling calculation, during the dredging, the level of TSS will be 0.005 – 0.015 kg/m^3 (which lower than the standard TSS regulated in QCVN 10:2008/BTNMT)
- The TSS level at Breda sandbar zone and the remaining zones in Hon Cau marine protected area are pretty low. Therefore, it is concluded that the dredging activities barely have little and local impact in dredging area; both Hon Cau Island and Breda areas are not affected.
- Remote areas are not affected because the dredging occurs only inside of the breakwaters.

5.1.2. Impacts from non-waste relating sources

1. *Impacts on socio-economic from displacement and site clearance*

The construction and operation of Vinh Tan 4 TPP may adverse the socio-economic of the nearby areas owing to:

- The recovery of 9.73 ha land will have direct impact on 13 local households in which 7 households will lose living land and all 13 households will lose productive land.
- Affecting the land planning of the region.
- Changing occupational structure of the region.

Besides, the project brings variety of positive effects to the local socio-economics such as:

- Occupation opportunity for local people in and outside of the project site.
- Vinh Tan 4 TPP project helps to improve the infrastructure (road, electricity, water supply systems...) and economics of the area.
- Enhancing the income of local families from retailing, doing services...

2. *Noise*

Noise is caused mainly by the construction machinery, transport on-site. Total impacts from caused noise still meets the permissive value stipulated in QCVN 26:2010/BTNMT (application for common area) over 700m. Hence, the households nearby the construction area may be influenced by the construction activities while other resident areas and Vinh Tan commune administrative area are not affected by noise.

3. *Vibration*

During the construction phase, vibration is mainly caused by hammer machines (for staking) whose activities may affect nearby households. Other areas are free from impacts of vibration.

4. *Socio-economic impacts*

- Increase immigration
- Health and safety related impacts: higher chances for infectious diseases to spread, increase vices in the surrounding areas.

5. *Others*

- Affect the road and waterway traffic: increase the density of transportation through Highway 1A.
- Affect biological resources: affect the aquatic biota at project site.

5.2. OPERATION PHASE

5.2.1. Waste related impacts

1. *Dust and air emission:*

- Air pollution from dust, NOx, SOx emitted from the stacks: Vinh Tan 4 TPP with capacity 2x600 MW using imported coal, installing ESP equipment, LowNOx Burner and SWFGD equipment and stack height of 210m, all air pollutants will meet the standards regulated in QCVN 22:2009/BTNMT about industrial gas emission with Kp=0.85, Kv=1 and QCVN 05:2009/BTNMT about ambient air quality.

- Dust diffused from ash yard: every year the plant produces 137,248 tons of ash which will be transported to the 64.7 ha ash yard at Ho Dua mountain. This ash can affect the air quality particularly in dry season.
- Pollution from the unloading and storage of coal: may produce a huge volume of dust due to the windy pattern of seacoast-near location. However, the transportation of coal will be done by closed conveyor system combinated with water spray system for dust reduction. Thus, impact on air quality caused by unloading and storage of coal is assessed insignificant.

2. *Wastewater*

- *Impact from wastewater of the circulating cooling system:* Vinh Tan 4 TPP requires a cooling water flow of 50m3/s. After cooling, the maximum temperature of wastewater is about 38^{0}C, 8^{0}C higher than input seawater. This value still meet the permission regulated in QCVN 40:2011/BTNMT type B, Kf=0,9, Kq=1 (40^{0}C)
- *Impact from chemical, oil contaminated wastewater*: wastewater from the treatment process, chemical feed system and cleaning boilers, oil tanks, etc. Total volume of these chemical polluted waters is 50m^3/h with main elements including strong sodium hydroxide or acids, metal based compounds, suspended solid and grease…
- Domestic wastewater: the flow of domestic wastewater from Vinh Tan 4 TPP is approximately 5m^3/h. Main pollutants include suspended solid, BOD, COD, Nitrogen and Phosphorous.
- Coal contaminated wastewater: includes water from washing coal conveyor, unloading bridge, coal yard, coal-dust spraying water and runoff stormwater. The flow of coal contaminated wastewater is approximately 50m^3/h, main pollutants are coal dust and high level of suspended solid.
- Wastewater from the sanitation of seaport: includes wastewater from cleaning transportation machinery (conveyor, loading/unloading equipments), washing wharf, runoff stormwater through coal contaminated surfaces. These waters usually have high level of suspended solid.

3. *Solid waste*

During operation phase, Vinh Tan 4 TPP will produce various types of manufactural and domestic waste such as:

- Ash: with the average volume estimately 137,248 ton/year, this ash is stored at the ash yard which is use common with Vinh Tan 2 TPP and considered to be reused as construction materials.
- Domestic waste: total volume is about 400 kg/day, this waste will be collected and treated by legal and expertised organizations.
- Hazardous waste: including oily waste from oil tanks, oily clothes, batteries, chemical contaminated tanks, insulators, ect. These wastes will be collected separately and treated by legal and expertised organization.

5.2.2. Non-waste related impacts

1. *Noise - vibration*

   - Generated from the transportation by trucks, activities of machinery, generators and turbines, activities of pumps, fans and other engines.
   - Loading and unloading activities at the port.

2. *Impact on aquatic biota of the area*

- Impacts on biological environment from cooling water intake: affecting living area of aquatic creatures.
- Impacts on biological environment by discharging cooling water: increase the temperature of seawater affecting aquatic living organisms.

3. *Impact on socio-economic*

- Impact on regional tourist activities: impact on tourist is assessed insignificant since local tourist is not developed yet.
- Impact on aquaticulture farming: currently, Binh Thuan province has stopped land grant for shrimp farming projects in the area to be allocated to power projects. Breeding shrimp production facilities will be moved to Ganh Hao – Chi Cong area. Thus, the operation of Vinh Tan 4 TPP will negligible impact on farming.
- Impact on population and population structure
- Impacts due to risks and incidents

5.2.3. Risks and incidents from the construction processes

- Landslide
- Environmental incidents from transportation (road and waterway)
- Leakage of storing fuels
- Labor accidents

5.2.4. *Risks and incidents from the operation processes*

- Incidents from air treatment system
- Incidents from industrial wastewater treatment system
- Leakage of chemicals
- Explosion
- Oil-pill
- Labor accidents

6. MITIGATION MEASURES

6.1. Construction phase

6.1.1. *Mitigation measures for waste related impacts*

1. *Mitigation measures for air pollution.*

- Increase transporting materials and equipments by waterway in combination with road traffic.
- Water the construction area and transportation routes in sunny days to control dust.
- Material yard will be covered during the construction phase.
- All construction equipment and vehicles should be checked for air emission and should have certificates from National Accrediting Agency about exhaust quality prior to their operation.
- Speed limit will be set for all construction and transportation vehicles.

2. *Mitigation measures for pollution from wastewater*

- *Run-off stormwater treatment*: stormwater drainage system will be built which all stormwater from the construction area will be collected and passed to sedimentation tank to remove suspended sediments before being discharged to the sea.
- *Domestic wastewater treatment*: toilets with septic tank will be built at workers' camps and mobile toilets will be built at the construction site.
- *Vehicle and equipment washing water treatment*: passed through sedimentation tanks before being discharged to the sea.

3. *Solid waste management*

- *Mitigation measures for pollution from domestic solid waste*: the wastes will be collected and transported to dumping area by the service of Urban Environment Company.

- *Mitigation measures for pollution from industrial waste*: classify and reuse for other purposes or sell as scraps. The remaining will be collected and transported to prescribed places.
- *Management of hazardous waste*: sign contract with expertised organizations to collect and treat hazardous waste.

4. *Mitigation measures during sea encroaching leveling*

- Follow all the regulations and guidelines.
- Leveling activities should be started only when the encroaching embankment construction is done to prevent turbid flow affecting surrounding sea area.
- Fixed recovery vessels are installed on sea level to recovery oil and solid waste produced from barges and construction process on the sea
- Barges and ships should meet prescribed regulations about sea pollution prevention.
- During the construction, the un-finishing segments should be intermediately covered by Tetrapod in stormy weather.

5. *Mitigation measures during dredging process*

- Follow all the regulations and guidelines.
- Dredging activities should be done only inside of the breakwaters.
- Dredging area and the area for dredging sludge disposal should be positioned by buoys light and signals following regulations of maritime safety.
- Expertised staff will be arranged to supervise the activities at dredging area, transportation routes and dredging sludge disposal area.

6.1.2. Mitigation measures for non-waste related impacts

1. *Mitigation measures for impacts from displacement and site clearance*

- Investor co-operates with local authorities in conducting compensation and resettlement complying with current regulations.
- Priorize local workers in recruitment employees for construction and operation phases of the projects if they meet job requirements.

2. *Mitigation measures for noise and vibration pollution*

- Noise control: arranging reasonably the high noise source, minimizing the impact on sensitive subjects by noise.
- Control for impact on vibration: arranging reasonably the high vibration source.

3. *Mitigation measures for impact on traffic*

- Install light and signal system on the part of Highway 1A passed through the project site and construction area.

4. *Mitigation measures for impact on local ecology*

- Strictly forbidden the deforestation outside of the required area.
- Establish rules, penalties and arrange staff to frequently supervise the enforcement

5. *Mitigation measures for impact of worker gathering*

- Install proper sanitary equipments at workers' camp.
- Regularly collect and transport waste from workers' camp to dumping area.
- Priorly use local workforce for simple construction work.
- Report temporary residency for worker to Vinh Tan authorities.

6.2. OPERATION PHASE

6.2.1. Mitigation measure for impacts relating to waste

1. *Control on air emission*

- In order to ensure that the levels of pollutants released from the power plant meet the permission of QCVN 22:2009/BTNMT, Kp=0.85, Kv=1 and QCVN 05:2009/BTNMT at ambient environment, Vinh Tan 4 TPP will install an air emission controlling system as follow:
    + Install electrostatic precipitator (ESP) for dust controlling: the efficiency is over 97,8% ;
    + Treatment of NOx inside of the boiler (Low Nox Burner)
    + Install seawater Flue Desulphurization (SW-FGD) to treat SO_2: the efficiency is over 86.7%
    + Stack: with the height of 210 m.
- *Control the emission of dust at coal unloading, transportation and storage areas.* Use closed conveyor to transport coal and spraying water coal yard to avoid the dispersion of coal dust.
- *Control the emission of dust at ash yard*: plant trees at surrounding areas to prevent wind and water the surfaces to avoid dispersion of ash.

2. *Mitigation measures for pollution from solid waste*

- Controlling of industrial and domestic waste: classify wastes from sources, sign contract with expertised organizations to collect and treat.
- Controlling of hazardous waste: sign contract with expertised organizations to collect

and treat.

- Controlling of ash: ash from the production processes will be collected and transported to ash yard and find consumers to reuse in order to reduce the storage capacity of ash yard and reduce environmental pollution.

3. *Mitigation measures for impacts from wastewater*

- Chemical contaminated wastewater: treated by coagulation, fluctuation, sedimentation and filtration to meet QCVN 40:2011/BTNMT, column B, Kf=0.9, Kq=1 before discharging to the environment.
- Domestic wastewater: the waste is treated partly by septic tank and then fully treated by biological filtration and disinfection processes to meet QCVN 14:2008/BTNMT ,before reusing or discharging to the environment.
- Oily wastewater: primarily treated by oil separators and continuously treated in central wastewater treatment system.
- Coal contaminated wastewater: : treated by coagulation, fluctuation, sedimentation and filtration to meet QCVN 40:2011/BTNMT column B, Kf=0.9, Kq=1 before discharging to the environment.
- Wastewater from 100000DWT unloading coal jetty: will be collected in wastewater tanks located in jetty and pumped to wastewater treatment system in Vinh Tan 4 TPP for further treatment to meet QCVN 40:2011/BTNMT before discharging to the environment.

4. *Mitigation measures for cooling water intake and discharge*

- *Mitigation measures for cooling water intake*: the cooling water system will be equipped with screens to avoid wastes and fish species entering the system.
- *Mitigation measures for cooling water discharge:* control the velocity of cooling water in pipes and control level of residual Chlorine in cooling water before discharge to receiver.

6.2.2. Mitigation measures of impacts not related to waste

1. *Mitigation measures of impacts due to noise and vibration*

    - Machine and equipment generated loud noise will be arranged in soundproof rooms or will be arranged muffler systems around these machine equipment.
    - Equip labor protection facilities such as ear plugs for workers who work near high level of noise areas to protect their health.
    - Ensure the degree of greenery blanket in a range of about 10% in the total surface area.

- Arranging a girdle of green trees at coal yard and slag yard.

2. *Mitigation measures of impacts due to Socioeconomic*

- Priorize local workers in recruitment employees for operation phases of the project.
- Associated with local authorities in labor administrative management at residential area surrounding the project site.
- Propagandizing, educating for workers in order to build a good relationship with local communities.
- Notification of lodgment for workers to local public security.

6.3. Prevention of accidents and risks

6.3.1. Construction phase

1. *Solution for preventing landslide*

- In order to prevent landslide, an embankment will be built. Embankment is about 1051 m of length. A roofing-declined rook-covered dike structure has a protective layer made of Tetrapod wave-breaking block in the sea direction.

2. *Mitigation of accidents due to water traffic activities*

- Control of equipment volume carrying on not to be over an allowed weight of boats, ferries.
- The ship, ferries are anchored in a port need to be equipped lighting and blinker equipment at night.
- Fully equipped with rescue equipment in response promptly to emergency situations.
- Accommodating the degree of traffic properly in order to reduce a large amount of transports at construction site.

3. *Mitigation of explosion and fire*

- Building a fire prevention and firefighting system according to the regulations
- Building an isolated guard at dangerous area such as oil basin and electric generator.
- Limiting fuel leak accidents during the pumping process and having collected system, greasy split.
- Building fuel stores which are far from offices, canteens, residential house.

4. *Mitigation of labor accidents*

- Providing protective equipment for construction workers.
- Educating about labor safety and guiding workers to ways of using personal protective equipment.
- At a construction site, there will be arranged a medical aid station to take care of health of workers, first-aid in a case of accident.

6.3.2. Operation phase

1. *Mitigation measures of accidents related to waste treatment equipment*

- Installing an automatic monitoring system at stack in order to monitor following parameters of pollution: dust, SO2, NOx, CO.
- When pollutant concentration in the exhaust exceed the discharge standard, the plant will be stopped to check and repair the equipment.
- Designing two chains of a wastewater treatment system 2x100% to provide in a case of accidents.

2. *Prevention of accidents of collision and wreck*

- Not allowed to transport merchandises over the allowed weight.
- Regularly checking and maintaining headlight system, flasher on boats.
- Regularly tracking meteorological forecasts to arrange a suitable schedule for boats, barges.
- Planning to cope with oil spill accidents.

3. *Mitigation measures of chemicals leakage during operation*

- Chemicals have to be conserved in their own area and regulation, ensure in airy condition, well ventilated, avoid directly sunshine and heat source.
- Chemical stores have to fully equipped means, suitable protective equipment according to a danger of the chemical and in compliance with regulations in decree no. 68/2005/ND-CP of May 20, 2005 on chemical safety.
- No smoking as well as using a heat source which is easy to burn in a workplace.

4. *Prevention of of explosion and fire*

- Oil basins are designed according to the safety regulations and be checked by the authorities before being put in use.

- In the process, there will have a proper maintenance regime, discharging sediment, and periodic hygiene to remove long-settled sediment at the bottom.
- Building bunds to prevent oil surrounding the oil basin area, the volume of a surrounding wall is 1.1 times more than the volume of the oil basin.
- Fire prevention and firefighting system including fire sensors, early warning devices, fire alarms, fire signals and fire prevention system will be installed at the plant.

7. ENVIRONMENTAL MONITORING AND MANAGEMENT PROGRAM

To ensure implementing those mitigation measures of negative impacts of Vinh Tan 4 TPP effectively, an environmental supervision and management program has been applied for Vinh Tan 4 TPP in three periods of time: pre-construction phase, construction phase, and operation phase.

Vinh Tan Thermal Power Project Management Board will be responsible for managing and supervising the environment in preconstruction and construction phase of Vinh Tan 4 TPP. In the operation phase, the office, which is directly in charge of operating the Vinh Tan 4 TPP, will be responsible for managing and supervising the environment for the plant.

7.1. Waste Monitoring

7.1.1. Pre-construction phase

In pre-construction phase, the following waste source need to be monitored:

- Dust: is mainly arisen from the leveling phase and a transportation of construction materials.
- Noise and vibration: is generated from means of transport and vehicles,
- Domestic wastewater: is approximately 68m3/day.
- Domestic waste: is approximately 200-250 kg/day with the main components such as vegetable, plastic, paper, metal, glass…
- Industrial waste: is approximately 100-200 kg/day with the components such as concrete, rock, brick….
- Hazardous waste: is approximately 92 L/month of oily wastes and 0.82-1.1 kg/month of oily clothes.
- Frequency of monitoring: is about every 3 months

7.1.2. Construction phase

In the construction phase, the following emission sources need to be monitored:

- Dust: is mainly arisen from construction plant and port and transportation of construction materials.
- Dredging materials: 352720 m3
- Noise and vibration: is arisen from is generated from means of transport and vehicles as grader, power-shovel, power hammer, etc.
- Domestic wastewater: is approximately 203 m3/day.
- Domestic waste: volume approximately 600-750 kg/day with the main components such as vegetation, plastic, paper, metal, glass…
- Hazardous waste: is approximately 47L/month of oily wastes and 0.6 kg/month of oily clothes.
- Frequency of supervision is every 3 months.

7.1.3. Operation phase

The Vinh Tan 4 Thermal Power Plant (TPP) with the capacity of 2x600 MW, in consequences it, the waste generating from production activities is relatively huge (wastewater, exhaust gas, solid waste). In order to get a job of monitoring of the plant done correctly and have an effective control plan, the frequency of monitoring will be implemented every 3 months. Waste components need to be monitored including:

- Flow, wastewater quality generating from the plant:

+ Domestic wastewater: Flow rate 120 m^3/day
+ Greasy wastewater: Flow rate 240 m^3/day
+ Wastewater from production: Flow rate 720 m^3/day
+ Cooling water: Flow rate 50 m^3/s

Monitoring wastewater quality at a connection points of wastewater system with environment as well as parameters as: pH, temperature, DO, EC, turbidity, TDS, COD, BOD, NH4+, NO3-, Cl-, total N, total P, total Coliform, grease, Cd, As, Pb, Hg, Fe, Cr, Zn, in which those parameters will be monitored continuously as: flow rate, temperature, and chlorine residual.

- Exhaust gas releasing from the plant:

+ Exhaust flow rate: Q=1541.29 m^3/s
+ Nox Concentration: 455mg/Nm^3
+ Dust Concentration: 150 mg/Nm^3

+ SOx Concentration: 350 mg/Nm^3

Moreover, the plant will be installed a continuous emission monitoring system (CEMS) at stack in order to supervise parameters such as flow rate, temperature, total dust, and dust PM10, SO2, NOx, CO.

- Frequency of supervision is every 3 months.

Table 1. Environmental monitoring program for Vĩnh Tân 4 TPP's project

Item	Frequency of Monitoring	Parameters of Monitoring	Methods of monitoring	Standard of Comparison	Implementing Agency
1	2	3	4	5	6
Preparation phase					
Air quality	Every 6 months during leveling phase	Temperature, humidity, wind direction, wind speed, total suspended dust, dust PM10, SO_2, NO_2, CO.	Vietnam National Standard Methods	QCVN 05: 2009/BTNMT	Owner
Noise level	Every 6 months during leveling phase	- L_{Aeq} Equivalent Sound Level - L_{Amax} Maximum equivalent sound level - $L_{AN,T}$ percent level	According to TCVN 5964: 1995 và TCVN 5965: 1995.	QCVN 26:2010/BTNMT	Owner
Vibration level	Every 6 months during leveling phase	- Vibration velocity - Vibration acceleration - Vibration amplifier	According to the guidance of using vibration machine.	QCVN 27:2010/BTNMT	Owner
Water quality	Every 6 months during leveling phase	pH, temperature, DO, EC, turbidity, TDS, COD, BOD, NH_4^+, NO_3^-, Cl^-, total Coliform, greasy, heavy metal	The sampling process, preservation, transport and analysis. TCVN.	QCVN 08:2008/BTNMT QCVN 10:2008/BTNMT	Owner
Biology	Every 6 months during leveling phase	- Phytoplankton (qualitative, quantitative) - Zooplankton (qualitative, quantitative) - Bottom animals (qualitative, quantitative)	Vietnam National Standard Methods		Owner
Construction phase					
Air quality	Every 6 months during construction phase	Temperature, humidity, wind direction, wind speed, total suspended dust, dust PM10, SO_2,	Vietnam National Standard Methods	QCVN 05: 2009/BTNMT	Owner

Item	Frequency of Monitoring	Parameters of Monitoring	Methods of monitoring	Standard of Comparison	Implementing Agency
1	2	3	4	5	6
		NO_2, CO.			
Noise level	Every 6 months during construction phase	- L_{Aeq} Equivalent Sound Level - L_{Amax} Maximum equivalent sound level - $L_{AN,T}$ percent level	According to TCVN 5964: 1995 và TCVN 5965: 1995.	QCVN 26:2010/BTNMT	Owner
Vibration level	Every 6 months during construction phase	- Vibration velocity - Vibration acceleration - Vibration amplifier	According to the guidance of using vibration machine.	QCVN 27:2010/BTNMT	Owner
Water quality	Every 6 months during construction phase	pH, temperature, DO, EC, turbidity, TDS, COD, BOD, Cl^-, total N, total P, total Coliform, greasy, heavy metal	The sampling process, preservation, transport and analysis TCVN.	QCVN 08:2008/BTNMT QCVN 10:2008/BTNMT	Owner
Biology	Every 6 months during construction phase	- Phytoplankton (qualitative, quantitative) - Zooplankton (qualitative, quantitative) - Bottom animals (qualitative, quantitative).	Vietnam National Standard Methods		Owner
Operation phase					
Air quality	Every 6 months during operation phase	Temperature, humidity, wind direction, wind speed, total suspended dust, dust PM10, SO_2, NO_2, CO.	Vietnam National Standard Methods	QCVN 05: 2009/BTNMT	Owner
Noise level	Every 6 months during operation phase	- L_{Aeq} Equivalent Sound Level - L_{Amax} Maximum equivalent sound level	Vietnam National Standard Methods	TCVN 3985-1999 QCVN 26:2010/BTNMT	Owner

Item	Frequency of Monitoring	Parameters of Monitoring	Methods of monitoring	Standard of Comparison	Implementing Agency
1	2	3	4	5	6
		- $L_{AN,T}$ percent level			
Vibration level	Every 6 months during operation phase	- Vibration velocity - Vibration acceleration - Vibration amplifier	According to the guidance of using vibration machine.	QCVN 27:2010/BTNMT	Owner
Water quality	Every 6 months during operation phase	pH, temperature, DO, EC, turbidity, TDS, COD, BOD, Cl^-, total Coliform, greasy, heavy metal	The sampling process, preservation, transport and analysis TCVN.	QCVN 08:2008/BTNMT	Owner
Biology	Every 6 months during operation phase	- Phytoplankton (qualitative, quantitative) - Zooplankton (qualitative, quantitative) - Bottom animals (qualitative, quantitative).	Vietnam National Standard Methods		Owner

8. CONCLUSION

Vinh Tan 4 Thermal Power Plant will play an important role in providing electricity serving socio-economic development of the Southern and Central provinces in Vietnam as well as significantly contributing to Vietnam's power supply sources.

Upon MONRE's approval of the Environmental Impact Assessment Report of Vinh Tan 4 Thermal Power Plant Project, environmental protection measures will be implemented according to MONRE's instructions.

Investment Project for Vinh Tan 4 Power Plant has been in line with the national guideline on socio-economic development. By engineering and management measures mentioned in the Investment Project and EIA Report, the Project will be able to limit and control adverse impacts on the environment to the extent as prescribed in the issued environmental regulations. The Owner of Vinh Tan 4 Power Plant Project would be very much appreciated if the EIA Report can receive much attention and support from competent authorities and be approved as soon as possible so that the next steps can be carried out to ensure the Project implementation schedule.

Chapter

INTRODUCTION

0.1. ORIGINATION OF THE PROJECT

In recent years, the high-speed growth of the Vietnam's economy has resulted in shifting gradually to integrate with regional and the world economies. The supply of energy, in which power is the decisive factor, plays an important role in the sustainable social and economic development tasks and the target of industrialization and modernization of the country. Therefore, the planning and development of power sources in this period is essential to develop the social economy of Vietnam in the current period as well as future.

From the late 1980's, Vietnam is one of the economy has developed rapidly and It is forecasted at least the next 10 years, growth will be maintained at a high level. In order to maintain economic growth, the power output, especially the power plant, must be strengthened to continue rapid growth compared to GDP growth.

Due to high demand for economic growth, Vietnam is coping with the matter of power supply, particularly in the dry season. In an attempt to solve it and at the same time, to improve the quality and stability of power supply for industrial, agricultural, commercial and individual consumers, Electricity of Vietnam (EVN) has planned for developing new sources totaling at 13,400MW in the period of 2010 – 2015.

Out of the total capacity mentioned above, 10,600 MW will be produced by coal fired thermal power plants, of which Vinh Tan Thermal Power Complex with the capacity of 5,600 MW, phase 4 with capacity of 1,200MW will be a key development in the master plan for electricity development of Vietnam.

According to Decision No.1208/QD-TTg of the Prime Minister dated 21/7/2011 on approving the Master Plan VII _ Plan for national power development for the 2011 – 2010 period with vision to 2030, the Government agreed to develop Vinh Tan 4 TPP with a capacity of 1,200 MW which is expected to operate for the 2017-2018 period (provided in list of power sources in Master Plan VII).

Master Plan of Vinh Tan Power Center in Binh Thuan province was approved by the Ministry of Industry and Trade in Decision No.1532/QĐ-BCT dated 4/5/2007. The 2nd revised version of Master Plan of Vinh Tan Power Center (supplement Vinh Tan 4 TPP) was approved by the Ministry of Industry and Trade in Decision No. 1020/QĐ-BCT dated 06/3/2012.

According to Report on Land use planning up to 2020 of Binh Thuan province, an additional area of about 370ha was allocated for Vinh Tan Power Center and this supplemented area will be 7960ha in 2020 which accounts for 7.35% of non agricultural land. The expanded area of Vinh Tan 4 TPP was agreed by Binh Thuan People's Committee in Document No. 2050/UBND-ĐTQH dated 06/5/2011 on suggestions for the revised Master Plan of Vinh Tan Power Center. Hence, the expanded area of Vinh Tan 4 is consistent with the Land use planning of Binh Thuan province up to 2020.

Hon Cau MPA was founded according to Decision 2606/QĐ-UBND of Binh Thuan People's Committee dated 15/11/2010. Vinh Tan 4 TPP will be located partially in ecological restoration area and entirely in development area of Hon Cau MPA.

Vinh Tan Power Center with total capacity of 5,624MW will be considered as a major power source in the National Master Plan for power development.

The construction of Vinh Tan 4 TPP, one of 4 units of Vinh Tan Thermal Power Center is urgent with reasons as follows:

- The plant will supply electricity for the national economy from 2017 onwards so as to reduce the dependency on imported power and therefore to secure the national electricity supply.
- It will energize provinces in the South of Central Vietnam and the other areas. The demand for transmitting electrical power from other Power Centers and loss due to such transmission will be thereby reduced.

The Environmental impact assessment (EIA) report and Investment project report of Vinh Tan 4 TPP project will be approved by MONRE and MOIT, respectively.

0.2. LEGAL AND TECHNICAL BACKGROUNDS FOR ENVIRONMENTAL IMPACT ASSESSMENT

0.2.1. Legal Background for EIA

At present, Vietnam environmental policies that should be complied with in the EIA study include:

- **The Law on Environmental Protection (LEP):** Law on Environmental Protection was passed by the National Assembly of the Socialist Republic of Vietnam, Session XI, Plenum 8 on 29.11.2005, promulgated on 12.12.2005 under the President's Ordinance 29/2005/L/CTN. The Law on Environmental Protection is valid as of 01.7.2006.
- **Decree No. 29/2011/ND-CP** dated 18/04/2011 by the Government on "providing strategic environmental assessment, environmental impact assessment and environmental protection commitment".
- **Circular No. 26/2011/TT-BTNMT** dated 18/07/2011 by the MONRE on guiding in detail numbers of articles of Decree No. 29/2011/ND-CP dated 18/04/2011 on strategic environmental assessment (SEA), environmental impact assessment (EIA) and environment protection commitment.

The EIA report on Vinh Tan 4 TPP project with the capacity of 1200 MW has been prepared as regulated by the LEP, Decree 29/2011/ND-CP by the Government, Circular 26/2011/TT-BTNMT by the MONRE. In addition, the following legal instruments are strictly observed in this EIA study.

- **The Construction Law**, promulgated by the National Assembly of Vietnam on 26/11/2003.
- **The Land Law 2003**, promulgated by the National Assembly of the Socialist Republic of Vietnam, Session XI, Plenum 4 on 26/11/2003.
- **The Land Law 2009**, promulgated by the National Assembly of the Socialist Republic of Vietnam, Session XII, Plenum 5 on 18/06/2009, amending and supplementing Article 121 of the Land Law 2003.
- **The Law on Water Resource**, passed by the 13th National Assembly of the Socialist Republic of Vietnam, Session 3, on 21/06/2012.
- **The Law on Minerals**, promulgated by the National Assembly of the Socialist Republic of Vietnam on 17/11/2010.

- **The Biodiversity Law** passed by the National Assembly on 16/09/ 2008.
- **Decree 08/2005/ND-CP** dated 24/01/2005 by the Government on construction planning
- **Decree 209/2004/ND-CP** dated 16/12/2004 by the Government on quality control of construction works
- **Decree 52/1999/ND-CP** by the Government on environmental requirements in construction administration.
- **Decree 68/2005/ND-CP** dated 20/5/2005 by the Government on Chemical Safety
- **Decree 149/2004/ND-CP dated 27/07/2004** by the Government on the licensing of exploration and exploitation of water resources, discharge of wastewater into water sources.
- **Decree No. 69/2009/ND-CP** dated 13/08/2009 by the Government on additional providing for land use planning, land prices, land acquisition, compensation, support and resettlement.
- **Circular No. 08/2009/BTNMT** dated 15/07/2009 by MONRE on providing regulations on environmental management and protection of economic zones, hi-tech parks, industrial zones and complexes.
- **Circular No. 48/2011/BTNMT** dated 28/12/2011 by MONRE on amending and supplementing a number of articles of Circular No. 08/2009/BTNMT dated 15/07/2009 on providing for the environmental management and protection of economic zones, hi-tech parks, industrial parks and industrial complexes.
- **Circular No. 14/2009/TT-BTNMT** dated 01/10/2009 by the MONRE on detailing the compensation, support and resettlement and order of and procedures for land acquisition, allocation and lease.
- **Circular 02/2005/BTNMT** dated 24/06/2005 by MONRE on guiding the implementation of Decree 149/2004/ND-CP.
- **Decree 59/2007/ND-CP** dated 09/04/2007 by the Government on solid waste management
- **Circular 13/2007/TT-BXD** dated 31/12/2007 by the Ministry of Construction guiding for implementation of some clauses of Decree 59/2007/ND-CP dated 09/4/2007 by the Government on solid waste management
- **Circular 12/2011/TT-BTNMT** dated 14/04/2011 by the MONRE with the hazardous waste management.
- **Decree 65/2010/ND-CP** dated 11/6/2010 by The Prime Minister about detailed regulations and guidelines for implementation of some articles of Law on Biodiversity.
- **Decision 04/2008/QD-BTNMT** dated 18/7/2008 by MONRE promulgating and applying national technical regulation on the environment.
- **Decision 16/2008 /QD-BTNMT** dated 31/12/2008 by MONRE promulgating and applying national technical regulation on the environment.
    + National technical regulation on the allowable limits of heavy metals in the soils (QCVN 03:2008/BTNMT).
    + National technical regulation on surface water quality (QCVN

08:2008/BTNMT).

+ National technical regulation on coastal water quality (QCVN 10:2008/BTNMT).
+ National technical regulation on underground water quality (QCVN 9:2008/BTNMT).
+ National technical regulation on domestic wastewater (QCVN 14:2008/BTNMT).

– **Circular 16/2009/TT-BTNMT** dated 07/10/2009 by MONRE stipulating National Technical Regulation on the environment

  + National technical regulation on ambient air (QCVN 05:2009/BTNMT).
  + National technical regulation on hazardous substances in ambient air (QCVN 06:2009/BTNMT).

– **Circular 25/2009/TT-BTNMT** dated 16/11/2009 by MONRE stipulating National Technical Regulation on the environment

  + National technical regulation on hazardous waste Thresholds (QCVN 07:2009/BTNMT).
  + National technical regulation on Industrial Emission of Inorganic Substances and Dust (QCVN 19:2009/BTNMT).
  + National technical regulation on Industrial Emission of Organic Substances (QCVN 20:2009/BTNMT).
  + National technical regulation on Emission of Thermal Power industry (QCVN 22:2009/BTNMT).

– **Circular 39/2010/TT-BTNMT** dated 16/12/2010 by the MONRE on issuance and application of national environmental norms.

  + National technical regulation on Industrial emission of Noise (QCVN 26:2010/BTNMT).
  + National technical regulation on Industrial emission of Vibration (QCVN 27:2010/BTNMT).

– **Circular 47/2011/TT-BTNMT** dated 28/12/2011 by the MONRE on stipulating National Technical Regulation on the environment.

  + National technical regulation on Industrial wastewater (QCVN 40:2011/BTNMT).

– **Other standards:**

  + TCVN 6707-2000: Hazardous wastes – Warning signs.
  + TCVN 6696-2009: Solid wastes – Sanitary landfills – General requirements to the environmental protection.
  + TCXDVN 261-2001: Solid waste landfills – Design standard.
  + TCXDVN 320-2004: Hazardous waste landfills – Design standard.

The legal documents of the Vinh Tan 4 TPP project:

- Document No. 12921/BCT-NL dated 23/02/2010 of the Ministry of Industry and Trade of expansion Vinh Tan Power Complex, Binh Thuan province.
- Document No.5384/EVN-DT dated 28/02/2010 of Vietnam Electricity regarding additional planning of the Vinh Tan 4 power project into master plant of Vinh Tan power complex.
- Document No 2050/UBND-DTQH dated 06/05/2011 of the People's Committee of Binh Thuan province on feedback revision planning of Vinh Tan Power Complex.
- Decision 1020/QD-BCT dated 06.03.2011 approving adjustments and supplements of Vinh Tan 4 power plant on the master plan of Vinh Tan power complex, Binh Thuan province.

0.2.2. Technical literature

This EIA report has used the technical documents as follows:

- Technical guidelines for environmental impact assessment of thermal power plant project issued by EIA department under MONRE in 10/2009.

0.2.3. Technical document prepared by the project owner

- Report on the Project for Master Planning of Vinh Tan Power Center, prepared and revised by PECC2, December 2009.
- Report on the investment project for Vinh Tan 3 thermal power plant, SKM/PECC 12, 2009.
- EIA report for Vinh Tan 1 Thermal Power project, prepared by PECC2/VESDI in February/2007.
- EIA report for Vinh Tan 2 Thermal Power project, prepared by PECC2/VESDI in April/2008.
- EIA report for Vinh Tan deep sea port, phase 1 prepared by PECC2 in March/2011.
- EIA report for land leveling of Vinh Tan Power Center prepared by PECC2.
- Special report on diffusion of cooling wastewater, prepared by PECC2 in March/2012.
- Special report on prediction of air emissions dispersion, prepared by PECC2, March, 2012.
- Special report on prediction of suspended solid dispersion due to land leveling and dredging activities, prepared by PECC2/IMER, March, 2012.

0.2.4. Reference Literature

- Statistical Yearbook in 2010 & 2011 of Tuy Phong district, Binh Thuan Province.
- The meteorological and hydrological document of Phan Rang station in1998-2011 period.
- The meteorological and hydrological document of Phu Quy station in 1979-2006 period.

- Report on socio – economic development planning of Tuy Phong district up to 2020.
- Report on annual socio – economic situation of Vinh Tan commune in 2011.
- Report on environmental quality in Vinh Tan TPP area, prepared by EDC-HĐ, February 2012.
- Report on construction of Hon Cau MPA project
- Report on dredging and construction of sea port around coral reef, prepared by PIANC, 2010.

0.3. METHODS OF INVESTIGATION AND ANALYZE OF ENVIRONMENTAL COMPONENTS

The main methods which have been applied in this EIA study are described below. With high ability of quantification, those advanced methods are widely used in the world as well as specialized laboratories in Vietnam.

0.3.1. Methods of environmental impact assessment

- Matrix of impacts: Relationships between the impacts of every activity in the project on every environmental aspect are shown in the matrix of impacts and based on which, studies into detailed impacts are directed.
- Web: This helps to consolidate environmental impacts and consequences (including secondary and tertiary results) in a certain interaction between activities of the project and affected environmental components. This method shows the impacts in depth (time) and simple interactions.
- Rapid assessment: Based on the pollution coefficients issued by the World Health Organization (WHO) (1993), compositions, and flow rates, pollution loads of emissions, effluent and solid waste from construction machines as well as living activities are determined and quantitatively predicted.
- Check list: Relationships between the impacts of every activity in the project on every environmental aspect are shown in the check list and based on which, studies into detailed impacts are directed.
- Estimation: Based on theoretical basis and experience to estimate the possible impact, on that basis assessment impact of project on environmental quality and ecosystem in the region.
- Modeling: Mathematical equations integrated in modellings are applied to quantify the scales and levels of impacts due to dispersion of air emissions, wastewater and suspended solids on environment quality and regional ecosystem.
- Impact Quantification System (IQS): The IQS is built up based on combination of the EIA guidelines by E&P Forum, the UN Environmental Program (UNEP), and the World Bank (WB). This is an advanced method that many international organizations recommend and some research institutes of Vietnam have employed in the EIA for various kinds of projects, which is based on quantification of impacts by means of rating (weighing) and the overall assessment is made based on those results.

- Sociological investigation: This was employed in interviews with local leaders in the project site.
- Expert: In collaboration with experts with full skills and experiences in EIA.
- Information collection: To collect information from local authorities and on the internet.

0.3.2. Methods of investigation and analysis of environmental components

- **Global position equipment**

  Garmin- GPS 12 (America).

- **Air quality measurement**
  - Air temperature, humidity and wind speed was measured with Lutron LM-8000, Taiwan.
  - Integrated noise was directly measured with a Testo 815, Germany.
  - Vibration was measured with a Rion VM-83, Japan.
  - Total suspended particle (TSP) and PM10 samples were collected with a Sibata HV-500F, Japan (flow rate: 100-800l/min), analyzed in compliance with TCVN 5067 – 1995.
  - Air samples were taken with Sibata MB - ∑300, Japan (flow rate: 0.2-3 l/min).
  - Air pump EDC – HĐ, flow rate: 0.5 – 3l/min.
  - The analysis method of air parameters are listed below:
    + CO: TC 52 TCN 352- 89;
    + SOx: TCVN 5971: 1995;
    + NOx: TCVN 6137:1996;
    + H_2S: TQKT – BYT 2002.

- **Water quality measurement**
  - Sampling methods

Water from the sea, rivers and underground was sampled and stored as guided by the Environment Department (MOSTE) (1999), reference to methods of the Global Environmental Monitoring System (GEMS), 1995.

  - Analyzing methods

Tests at site

Those complied with standard methods stipulated by the Environment Department – MOSTE in combination with methods guided by the instrument manufacturers (site analyses).

- pH, temperature: measured at site with a ProfiLine pH3210
- Electrical conductivity (EC): measured at site with a ProfiLine Cond3210, unit: µS/cm.

- Dissolved oxygen (DO): Measured at site with a ProfiLine Oxi3210, unit: mg/l and % saturation.
- Turbidity (NTU): Measured at site with a ProfiLine, unit: NTU.

Laboratory tests

- Chemical oxygen demand (COD): digestion and colorimetry on a spectrophotometer at 420 nm with COD digestion reagent vial.
- Biological oxygen demand (BOD_5): piezometry: 20^0C for 5 days and measurement of pressure changes
- Heavy metals (Pb, As, Zn): atomic adsorption photometry (Varian, US).
- Total of Nitrogen: manual spectrometry method.
- Total of P: Disintegrate by Stannous chloride, colorimetry with a photometer and standard color scale.
- NH_4^+: Photometry on a spectrophotometer at 655 nm with ammonia cyanurate and ammonia salicylate test kit.
- NO_3^-: Colorimetry on spectrophotometer Drel 2400 (Hach – US) at 500 nm with NitraVer 5 test kit.
- Coliform: as specified in ISO 93081: 2000.

- **Soil quality measurement**
  - Sampling methods

Removing the superficial layer.

Sampling at the layer at the depth of 10 to 20 cm.

Labeling and coding at stipulated.

  - Analysis methods

Heavy metals

After digestion of samples in standard procedures, the obtained solutions were analyzed to determined heavy metals on an atomic adsorption spectrophotometer (AAS).

Analysis methods:

+ TCVN 6649:2000 (ISO 11466:1995)_ Soil quality. Extraction of trace elements soluble in aqua regia.
+ TCVN 6496:1999 (ISO 11047:1995)_ Soil quality. Determination of cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc in aqua regia extracts of soil. Flame and electrothermal atomic absorption spectrometric methods.

Oil and fat

Soil samples were extracted with n-hexane after removing impurities and garbage, etc., then the solutions were evaporated and contents of oil and fat were determined by weighing.

- **Sampling and analysis of aquatic biota**

The study into compositions and density of aquatic species provide additional information for assessing water quality, bio-resources and environmental impacts of water pollution.

- At site

Phytoplankton was caught with specialized nets, mesh: 25µm, made in Switzerland, volume of water through the net: 60 L.

Zooplankton was caught with Juday-type nets, mesh: 40µm, volume of water through the net: 60 L.

Zoo benthos was sampled with Petersen hoe of 0.025 m2, made in China, each sample was taken with 4 hoes, i.e. 0.025 x 4 = 0.1 m2.

- In laboratory

Counting the number of each Phytoplankton species in 1 out of 30 samples.

Counting the number of each Zooplankton in samples.

Counting the number of each Zoo benthos in samples.

Based on analyzing results, typical and dominant species were determined together with similarity and diversity coefficients in order to assess the properties of the water environment at the sampling points or the waters.

- **Terrestrial ecosystem**

This was performed by direct observation, photography and cross-check against the "Nomenclature of botanical species".

Wild animals were determined by site observation and recordings of local people's opinions.

0.4. EIA IMPLEMENTATION

EIA study for Vinh Tan 4 thermal power plant project was accomplished by the investor (Vinh Tan TPMB).

The consultant for the project is PECC2.

Basic information of PECC 2 is given below.

- **PECC2**
  - Deputy CEO: Nguyen Chon Hung
  - Address: 32, Ngo Thoi Nhiem, District 3, Ho Chi Minh City
  - Tel.: (08) 22211057
  - Fax: (08) 22210408
- **List of people directly involving in this EIA**

Vinh Tan PMB:

1. Do Hoai Nam – Deputy of Vinh Tan TPMB

2. Nguyen Van Manh -Head of technical department- Vinh Tan TPMB.

PECC 2:

1. Nguyen Chon Hung – Chief operating officer of PECC2.
2. Vo Van Binh - Electrical engineer –Project manager- PECC2.
3. Nguyen Thuy Ha – Environmental engineer- Deputy manager of Project.
4. Dau Thi Thuy An - Environmental team leader- PECC2.
5. Nguyen Quynh Nhu - Environmental engineer- PECC2.
6. Nguyen The Vinh - Environmental engineer- PECC2.
7. Doan Trung Tin – Mechanical engineer -PECC2.
8. Vu Duy Vinh – Modelling expert.

Sac ky Hai Dang science technology services JSC. (environmental investigation agency):

9. Tran Thuy Thanh Thao - Environmental engineer.

EIA and Investment project studies for Vinh Tan 4 Thermal power plant project are implemented at the same time. Input data as well as calculation results of each expert group are notified to other groups in order to obtain consolidated information in those reports. EIA study team has taken part in implementation of initial report, pre-FS report. Site investigation and environmental component sampling process was conducted at the beginning stage of EIA study; meanwhile public consultation was carried out after finishing the preliminary EIA report.

Chapter

1

PROJECT BRIEF DESCRIPTION

1.1. PROJECT TITLE

VINH TAN 4 THERMAL POWER PLANT PROJECT

1.2. PROJECT OWNER

– Project Owner: Vinh Tan Thermal Power Plant Project Management Board.

– Head office: Hung Vuong boulevard, quarter 5, Phu Thuy ward, Phan Thiet City, Binh Thuan Province.

– Representative: Mr Quach Dinh Thanh.

– Position: Director of Vinh Tan Power plant Project Management Board.

– Tel: 062.2461222 Fax: 062.3739684

1.3. LOCATION OF THE PROJECT

Vinh Tan 4 Thermal Power Plant (abbreviated: Vinh Tan 4 TPP), located in Vinh Tan Commune, Tuy Phong District, Binh Thuan Province, is one of the four plants belonging to the Vinh Tan Thermal Power Complex. Its location is about 25-30km away from Phan Ri Town towards the northeast; The South borders on the East Sea, the Southwest borders on Vinh Hao Commune, Tuy Phong District; and the Northeast borders on Phuoc Diem Commune, Ninh Phuoc District, Ninh Thuan Province. The coordinates are as follows:

– Longitude: 108° 48' 00"

– Latitude: 11° 20' 00"

The terrain of the project area is out sketching toward the coast in the Northeast; the West- Southwest borders on the East Sea; the Northeast borders on the National Road No.1A; the Southwest borders on the Vinh Hao commune, Tuy Phong District, Binh Thuan Province; and the Northeast borders on the Vinh Tan 3 TPP.

The project area is located near the residential area of hamlet 7, which is belonging to Vinh Tan commune towards the Southwest and borders on the National Road No.1A towards the Northwest. Linh Son Tu Pagoda is located about 4km from the project area towards the Northeast. Ho Dua Mountain is about 4km from the project area towards the North and 5km from the Ong Do Mountain towards the Northeast.

The project area is about 100m from the nearest residential area in hamlet 7 and about 1.5km from the east residential area. The project area is about 1.5km from the aquaculture area (shrimp mainly) towards the East; and about 3.7km from the salt-made area towards the West.

Hon Cau Marine Protection Area (MPA) with total area of 12500ha was established by

People's Committee of Binh Thuan Province according to Decision No.2606/QD-UBND dated October 15, 2010, including 4 functional zones:

- Strictly conservation zone – core area (1250ha): Hon Cau Island zone and Breda sandbar zone
- Buffer zone (1210ha): surrounding the core area (Buffer zone #1) at Hon Cau and Buffer zone #2 – Breda sandbar area;
- Ecological restoration area (808ha).
- Development zone (9232ha).

It is obviously that Hon Cau MPA was founded after Master plan of Vinh Tan Thermal Power Complex which had been approved by Ministry of Industry – the former of Ministry of Industry and Trade according to Decision No.1532/QĐ-BCN dated May 4th 2007.

According to the above information, Vinh Tan 4 TPP is entirely located in the development zone and a part of the ecological restoration area of Hon Cau MPA. Vinh Tan 4 TPP project is about 8 km from boundary of buffer zone #1 of Hon Cau MPA and 5-6km away from buffer zone #2 of Breda sandbar area.

- Relationships between Vinh Tan 4 TPP and surrounding structures and works are shown in Figure 1.1.
- Location of Vinh Tan 4 TPP in the Vinh Tan power complex is shown in Figure 1.2.
- The benchmark coordinates of Vinh Tan 4 TPP are shown in Figure 1.3.
- The coordinates of Vinh Tan 4 TPP and its port area are shown in Table 1.1.

Table 1.1. Benchmark coordinates of Vinh Tan 4 TPP and its port area

The benchmark coordinates of Vinh Tan 4 TPP		
Code	Coordinates (VN2000)	
	Coordinate system VN2000, central meridian $L_0 = 108^0 30'$, projection 3^0	
	X	Y
VT4-1	1251782.963	531616.471
VT4-2	1251687.186	531776.409
VT4-3	1250482.426	532032.478
VT3-4	1250570.254	532447.570
VT3-3	1251176.125	532318.643
VT3-2	1251152.738	532208.612
VT3-1	1251876.078	532054.861

The benchmark coordinates of cooling wastewater pipeline corridor of Vinh Tan 4 TPP		
VT4-3	1250482.426	532032.478
VT4-4	1249386.451	532265.449
BT-5	1249417.076	532409.334
BT-27	1250512.602	532176.473
The coordinates of Vinh Tan 4's port area		
A	1250214.112	532754.774
B	1249911.072	532819.194
C	1250207.725	532724.731
D	1249904.685	532789.146

Source: PECC2, 9/2012

Figure 1.1. The location of Vinh Tan 4 TPP and surrounding construction

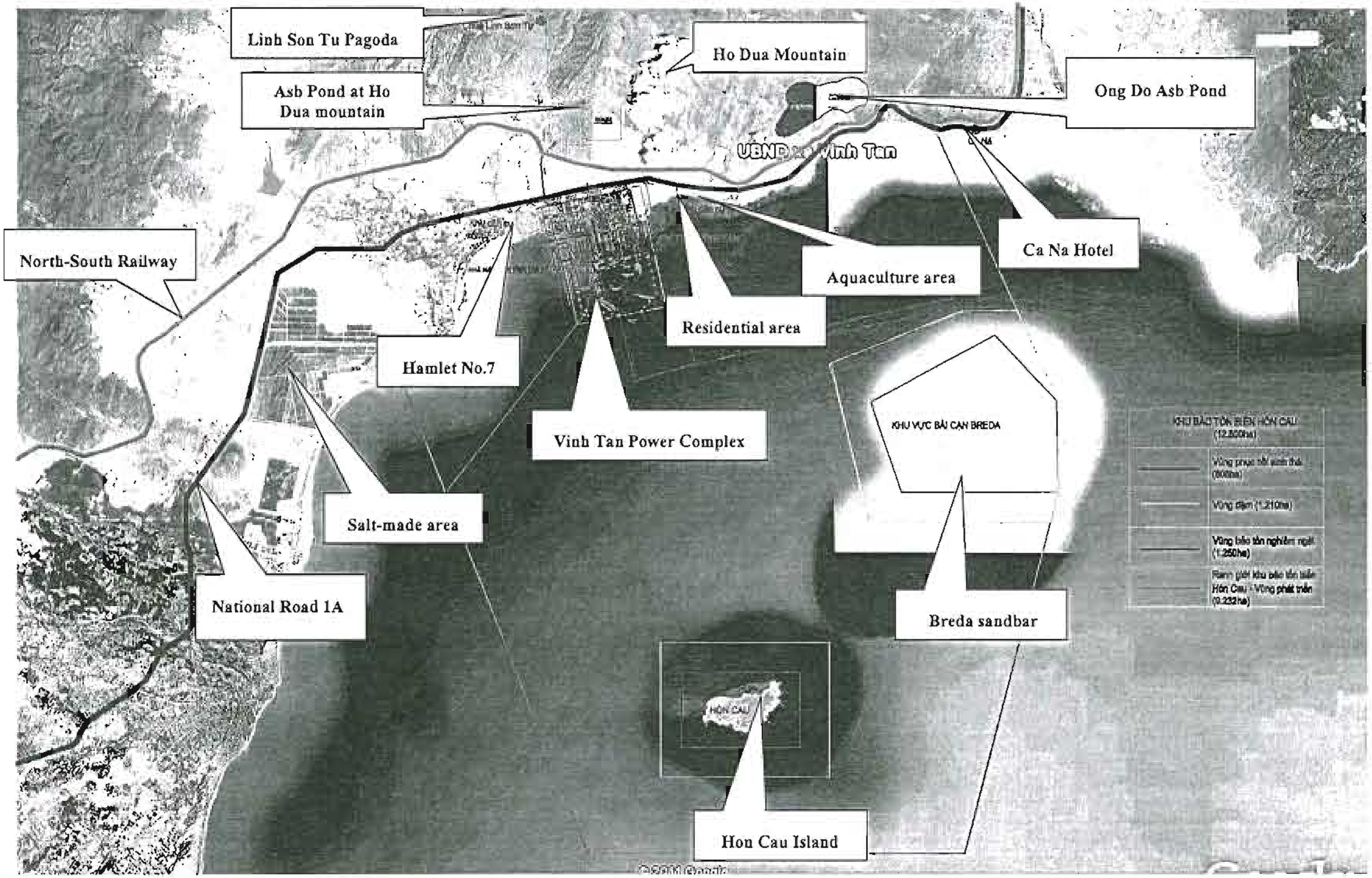


FIGURE 1.2. LAYOUT LOCATION OF VINH TAN 4 TPP IN VINH TAN POWER COMPLEX

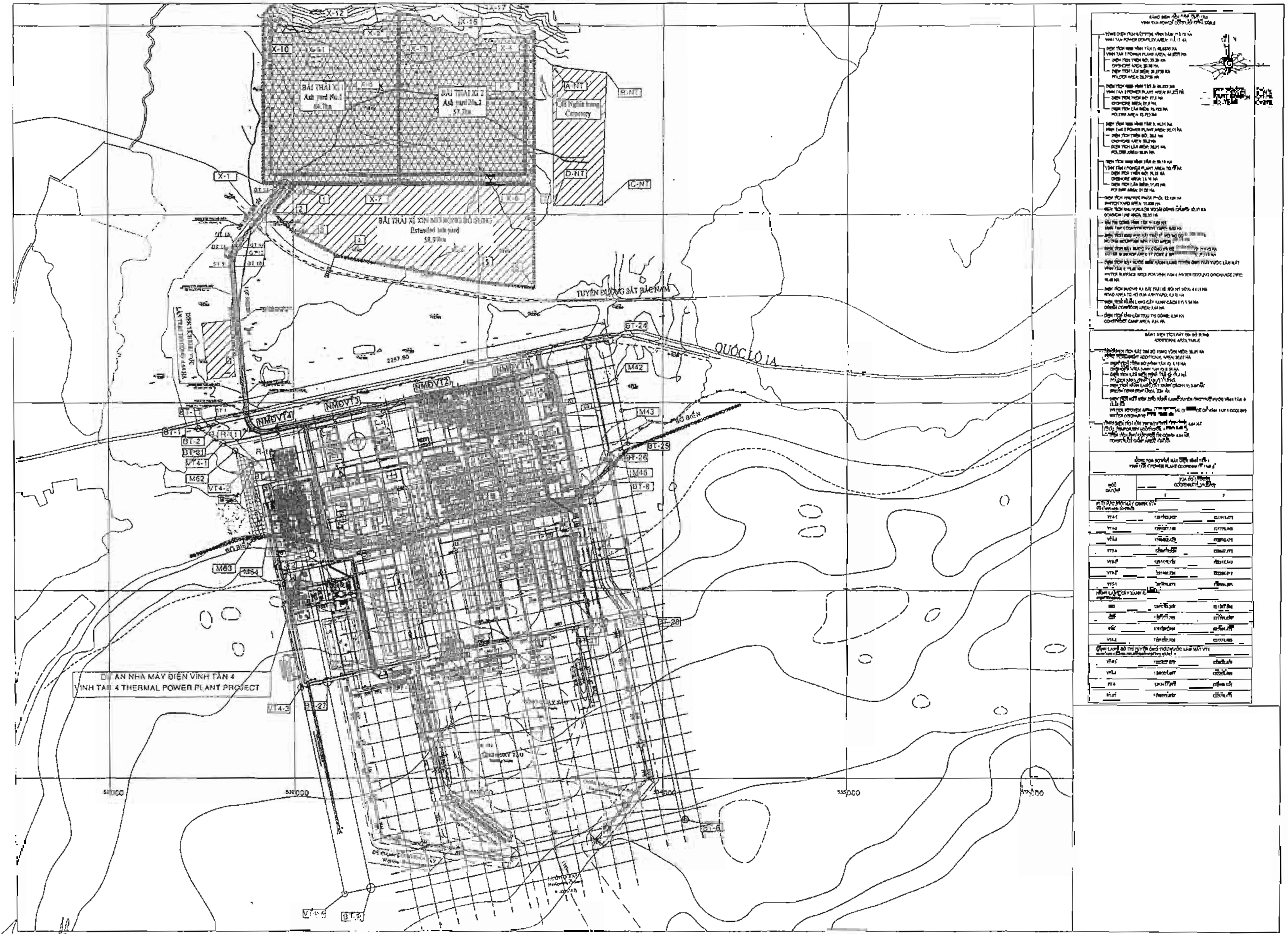


FIGURE 1.3. BENCHMARK COORDINATES OF VINH TAN 4 THERMAL POWER PLANT

BẢNG DIỆN TÍCH TTĐL VĨNH TÂN
VINH TAN POWER COMPLEX AREA TABLE

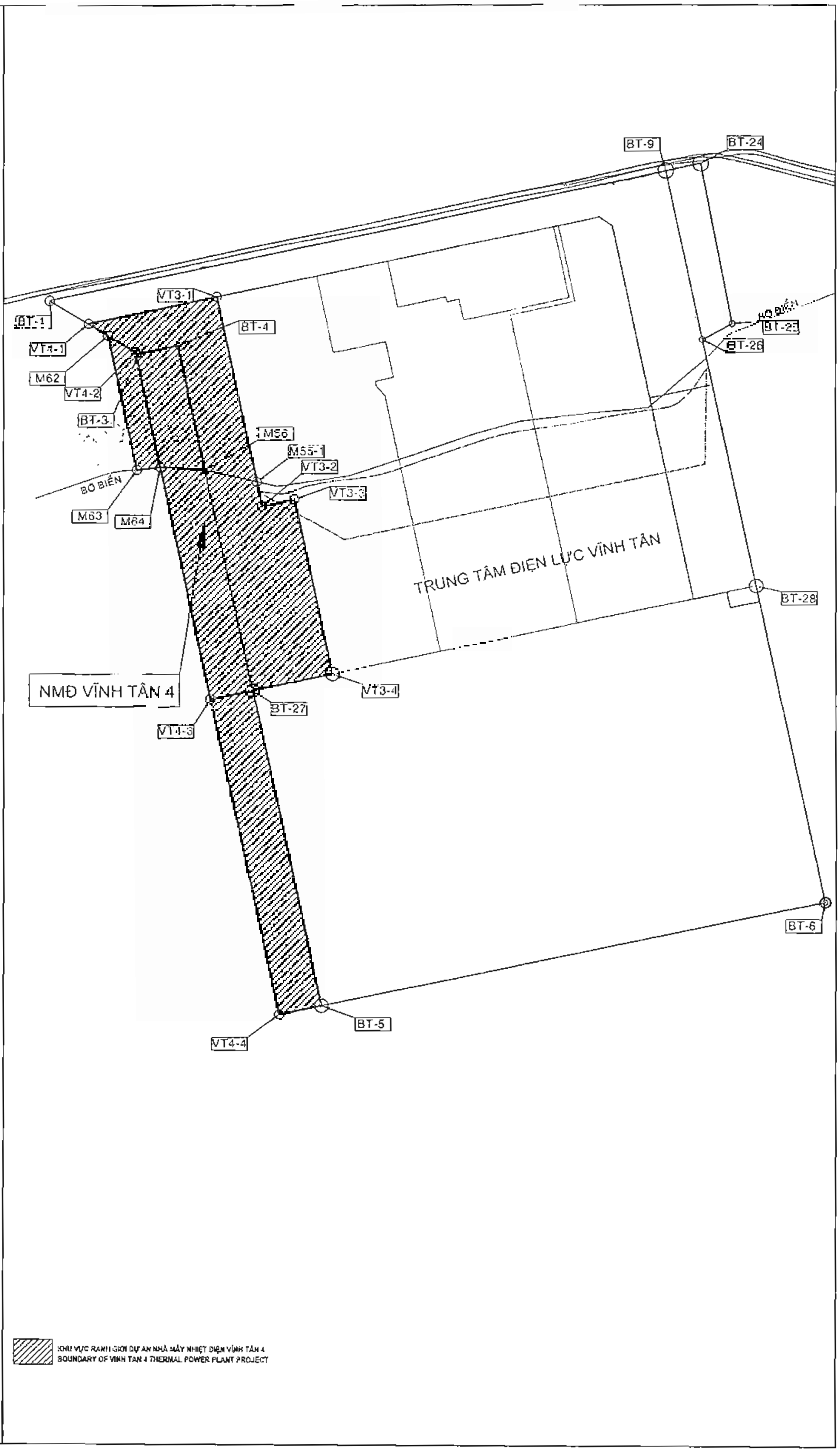
- TỔNG DIỆN TÍCH ĐẤT TTĐL VĨNH TÂN: 712.12 HA
  VINH TAN POWER COMPLEX AREA: 712.12 HA
  - DIỆN TÍCH NMĐ VĨNH TÂN 1: 48.6535 HA
    VINH TAN 1 POWER PLANT AREA: 48.6535 HA
    - DIỆN TÍCH TRÊN BỜ: 20.38 HA
      ONSHORE AREA: 20.38 HA
    - DIỆN TÍCH LẤN BIỂN: 28.2735 HA
      POLDER AREA: 28.2735 HA
  - DIỆN TÍCH NMĐ VĨNH TÂN 2: 61.323 HA
    VINH TAN 2 POWER PLANT AREA: 61.323 HA
    - DIỆN TÍCH TRÊN BỜ: 27.6 HA
      ONSHORE AREA: 27.6 HA
    - DIỆN TÍCH LẤN BIỂN: 33.723 HA
      POLDER AREA: 33.723 HA
  - DIỆN TÍCH NMĐ VĨNH TÂN 3: 56.11 HA
    VINH TAN 3 POWER PLANT AREA: 56.11 HA
    - DIỆN TÍCH TRÊN BỜ: 30.2 HA
      ONSHORE AREA: 30.2 HA
    - DIỆN TÍCH LẤN BIỂN: 25.91 HA
      POLDER AREA: 25.91 HA
  - DIỆN TÍCH NMĐ VĨNH TÂN 4: 50.18 HA
    VINH TAN 4 POWER PLANT AREA: 50.18 HA
    - DIỆN TÍCH TRÊN BỜ: 19.16 HA
      ONSHORE AREA: 19.16 HA
    - DIỆN TÍCH LẤN BIỂN: 31.02 HA
      POLDER AREA: 31.02 HA
  - DIỆN TÍCH KHU VỰC PHÂN PHỐI: [illegible] HA
    SWITCH YARD AREA: [illegible] HA
  - DIỆN TÍCH KHU VỰC [illegible] DÙNG CHUNG: 32.33 HA
    COMMON USE AREA: 32.33 HA
  - BÃI THI CÔNG VĨNH TÂN 1: 8.68 HA
    VINH TAN 1 CONSTRUCTION YARD: 8.68 HA
  - DIỆN TÍCH KHU VỰC BÃI THẢI XỈ NÚI HỒ DÙA: 181.15 HA
    HO DUA MOUNTAIN ASH YARD AREA: 181.15 HA
  - DIỆN TÍCH MẶT NƯỚC KỲ CẢNG VÀ ĐÊ CHẮN SÓNG: 213.48 HA
    WATER SURFACE AREA AT PORT & BREAKWATERS: 213.48 HA
  - DIỆN TÍCH MẶT NƯỚC BIỂN HÀNH LANG TUYẾN ỐNG THẢI NƯỚC LÀM MÁT VĨNH TÂN 4: 16.48 HA
    WATER SURFACE AREA FOR VINH TAN 4 WATER COOLING DISCHARGE PIPE: 16.48 HA
  - DIỆN TÍCH ĐƯỜNG RA BÃI THẢI XỈ NÚI HỒ DÙA: 4.815 HA
    ROAD AREA TO HO DUA ASH YARD: 4.815 HA
  - DIỆN TÍCH HÀNH LANG CÂY XANH CÁCH LY: 3.54 HA
    GREEN CORRIDOR AREA: 3.54 HA
  - DIỆN TÍCH KHU LÁN TRẠI THI CÔNG: 4.54 HA
    CONSTRUCT CAMP AREA: 4.54 HA

BẢNG DIỆN TÍCH ĐẤT XIN BỔ SUNG
ADDITIONAL AREA TABLE

- TỔNG DIỆN TÍCH ĐẤT XIN BỔ SUNG VĨNH VIỄN: 36.81 HA
  TOTAL PERMANENT ADDITIONAL AREA: 36.81 HA
  - DIỆN TÍCH TRÊN BỜ (VĨNH TÂN 4): 6.10 HA
    ONSHORE AREA (VINH TAN 4): 6.10 HA
  - DIỆN TÍCH LẤN BIỂN (VĨNH TÂN 4): 11.8 HA
    POLDER AREA (VINH TAN 4): 11.8 HA
  - DIỆN TÍCH HÀNH LANG CÂY XANH CÁCH LY: 3.54 HA
    GREEN CORRIDOR AREA: 3.54 HA
  - DIỆN TÍCH MẶT BIỂN CHO HÀNH LANG TUYẾN ỐNG THẢI NƯỚC VĨNH TÂN 4: 16.48 HA
    WATER SURFACE AREA FOR TECHNICAL CORRIDOR OF VINH TAN 4 COOLING WATER DISCHARGE PIPE: 16.48 HA
- TỔNG DIỆN TÍCH ĐẤT XIN BỔ SUNG TẠM THỜI: 4.54 HA
  TOTAL TEMPORARY ADDITIONAL AREA: 4.54 HA
  - DIỆN TÍCH KHU LÁN TRẠI THI CÔNG: 4.54 HA
    CONSTRUCT CAMP AREA: 4.54 HA

BẢNG TỌA ĐỘ NHÀ MÁY [illegible] VĨNH TÂN 4
VINH TAN 4 POWER PLANT COORDINATE TABLE

MỐC DATUM	TỌA ĐỘ (VN2000) COORDINATE (VN2000) X	Y
KHU VỰC NHÀ MÁY CHÍNH VT4		
VT4-1	[illegible]	531616.471
VT4-2	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
BT-4	[illegible]	[illegible]
VT3-4	[illegible]	[illegible]
PHẦN DIỆN TÍCH [illegible] CỦA NMĐ VT4		
VT4-1	[illegible]	[illegible]
VT4-2	1251667.386	531776.408
M64	[illegible]	[illegible]
M56	[illegible]	[illegible]
M55-1	[illegible]	[illegible]
VT3-1	[illegible]	[illegible]
DIỆN TÍCH [illegible] CỦA NMĐ VT4 OFFSHORE [illegible] VT4		
M64	[illegible]	[illegible]
M56	[illegible]	[illegible]
M55-1	[illegible]	[illegible]
VT3-2	[illegible]	[illegible]
VT3-3	[illegible]	[illegible]
VT3-4	1250570.254	532447.570
[illegible]	[illegible]	[illegible]
DIỆN TÍCH PHẦN ĐẤT XIN THÊM TRÊN BỜ CỦA VT4 [illegible] VT4		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
DIỆN TÍCH NMĐ VT4 [illegible] DƯỚI BIỂN [illegible] AREA OF VT4		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
BT27	[illegible]	[illegible]
VT4-3	[illegible]	[illegible]
HÀNH LANG CÂY XANH CÁCH LY GREEN CORRIDOR		
M62	[illegible]	[illegible]
M63	[illegible]	[illegible]
M64	[illegible]	[illegible]
VT4-1	[illegible]	[illegible]
HÀNH LANG [illegible] ỐNG THẢI NƯỚC LÀM MÁT VT4 [illegible]		
VT4-3	[illegible]	[illegible]
VT4-4	[illegible]	[illegible]
BT-5	[illegible]	[illegible]
BT-6	[illegible]	[illegible]



1.4. THE MAIN CONTENT OF THE PROJECT

1.4.1. Objectives of the project

Vinh Tan 4 TPP with the capacity of 1,200MW shall supply more than 7.2 billion kWh per year to National power system. It is extremely necessary and strongly important to satisfy the need of power demand not only for the South of Vietnam but also for whole country.

For the national power system, Vinh Tan 4 TPP will contribute to reduce the power transmission from the North to the South. Therefore, it will also help to mitigate the loss of power, improve the stability for the whole electrical system, and ensure the energy security.

Furthermore, ensuring adequate electricity supply for socioeconomic development is urgently necessary to increase competitiveness and attract external resources to implement national industrialization and modernization.

Vinh Tan 4 TPP will attract more investment for industrial zones in the region and contribute to the rapid development of the economics, creating jobs for the local people.

1.4.2. Capacity and investment scale of the project

1.4.2.1. Capacity of the project

Vinh Tan 4 TPP with the capacity of 2x600MW will be applied the conventional steam turbine technology with the supercritical (SC). The total area of Vinh Tan 4 TPP is about 70.2 ha, consisting of main power plant, auxiliary areas, cooling water, coal storage area, and corridor of green belt.

1.4.2.2. The investment scale of the project

The scopes of the project are as follows:

1. The investment items of Vinh Tan 4 TPP (belong to scope of EIA report for Vinh Tan 4 TPP Project)

Investment items of Vinh Tan 4 TPP include two main parts:

- Vinh Tan 4 TPP with the following structures:
  + Main plant (Boiler area + steam turbine + main transformers);
  + Cooling water supply system;
  + Cooling water discharge system;
  + Pump station and water intake gate;
  + Fresh water supply system;
  + Demineralization water system;

+ Fuel coal receiving and supply system;
+ Fire prevention and fighting system;
+ Wastewater treatment system;
+ Flue gas treatment system (stack, FGD, ESP, etc.);
+ Ventilation and air- condition system;
+ Internal road system;
+ Electrical system, communication system;
+ Landscape;
+ Auxiliary works;
+ Other structures.

– The 100,000DWT port area of Vinh Tan 4 TPP with the following structures:

+ Construction of 100,000DWT coal port;
+ Dredging the port with scale of 100,000DWT;
+ Auxiliary equipment.

2. *Investment items out of scope of Vinh Tan 4 TPP (excluded in scope of the EIA report for Vinh Tan 4 TPP)*

+ Land clearance and compensation (belongs to scope of infrastructure Project of Vinh Tan Power Complex);
+ Common ash yard (S=64.7ha) of Vinh Tan 4 and Vinh Tan 2 TPP (belongs to scope of Vinh Tan 2 TPP and was assessed in EIA report of Vinh Tan 2 TPP);
+ Land levelling of Vinh Tan 4 TPP (belongs to scope of revised infrastructure Project of Vinh Tan Power Complex);
+ Exploitation of sand and rock for construction of Vinh Tan 4 TPP; construction of supply water system for construction phase (belongs to scope of infrastructure Project of Vinh Tan Power Complex and was assessed in Environmental protection commitment report);
+ Construction of supply power system for construction phase (belongs to scope of infrastructure Project of Vinh Tan Power Complex and was assessed in Environmental protection commitment report);
+ Dredging approach channel for 100,000DWT vessel (belongs to scope of Vinh Tan 3 sea port).

3. *Land use area of the Vinh Tan 4 Thermal Power Plant*

The total area of Vinh Tan 4 TPP's main plant is expected to be approximately 70.2ha in which including:

– The main plant of Vinh Tan 4 TPP: 50.18ha, in which onshore area covers about 19.16ha and sea-encroached area covers about 31.02ha.

- Green corridor area: 3.54ha.
- Corridor of cooling water discharge pipelines: 16.48ha.

A part of the onshore area of about 13ha and the sea-encroached area of about 19.2ha are conducted for compensation and land clearance in the previous Vinh Tan Power Complex according to Decision No.426/QD-UBND dated February 15, 2008 of the People's Committee of Binh Thuan province.

The total land area for expansion of Vinh Tan 4 TPP is approximately 38.01ha in which the onshore expansion area is 9.73ha and sea encroachment area is 28.28 ha (including 11.8ha of sea-encroached area and 16.48ha of corridor of cooling water discharge pipelines). Land clearance, compensation and resettlement of the expansion area are belonging to the scope of this project.

Land use status of the expansion area is mainly surface seawater (make up 74.4% of the total acquisition area); residential area (1.33%); annual crop area (2.75%), aquaculture area (3.46%); specializing surface water (0.79%); unused land (12.75%), river and stream (4.05%) and traffic land (0.45%).

4. *Structure of functional subsections*

Vinh Tan 4 TPP comprises main plant, auxiliary areas, cooling water intake channel, coal storage area and coal port. Location of the rests are arranged based on the operational functions, technical line, and lay out arrangement, environmental management in a way of convenience for management and maintenance.

Table 1.2. The area and land use ratio for the functional subsections of the project (excluded green belt and cooling water discharge corridor)

No.	Subsection	Area (ha)	Percentage (%)
1	Main plant	11.3	22.5
2	Coal port	5.27	10.5
3	Landscape	11.8	23.5
4	Internal road	2.68	5.34
5	Wastewater treatment system	2.4	4.78
6	Auxiliary area	16.73	33.3
7	Total	50.18	100

5. *The common items*

Common systems of Vinh Tan 4 TPP in the Vinh Tam Power Complex are presented as follows:

Table 1.3. The common items of Vinh Tan 4 TPP with Vinh Tan 2 TPP and Vinh Tan PC

TT	Items	Common items
1	*Coal port system*	
1.1	Multipurpose Port 3000DWT	Invested in the coal port's project of Vinh Tan Power Complex – Stage 1: Vinh Tan 2 Port. EIA Report for Vinh Tan 2 TPP's Port was approved by MONRE according to the document No. 1448/QD-BTNMT dated 25/7/2011.
1.2	Breakwater	Invested in the coal port's project of Vinh Tan Power Complex – Stage 1: Vinh Tan 2 Port. EIA Report for Vinh Tan 2 TPP's Port approved by MONRE according to the document No. 1448/QD-BTNMT dated 25/7/2011.
1.3	Navigation signal	Invested in the coal port's project of Vinh Tan Power Complex – Stage 1: Vinh Tan 2 Port. EIA Report for Vinh Tan 2 TPP's Port was approved by MONRE according to the document No. 1448/QD-BTNMT dated 25/7/2011.
1.4	Port's administrative offices	Invested in the coal port's project of Vinh Tan Power Complex – Stage 1: Vinh Tan 2 Port. EIA Report for Vinh Tan 2 TPP's Port was approved by MONRE according to the document No. 1448/QD-BTNMT dated 25/7/2011.
1.5	Dredging approach channel and turning basin	Sharing approach channel with Vinh Tan 3 TPP's port. EIA Report of Vinh Tan 3 TPP's port has been implemented in this stage.
2	*Ash yard*	
2.1	Ash yard- Stage 1	Leveling and clearance of ash yard belongs to the infrastructure project of Vinh Tan Power Complex and invested by EVN. Vinh Tan 4 TPP's project will share Ho Dua ash yard of Vinh Tan 2 TPP with the area of 64.7ha. Construction of the ash yard including embankment, lightning, soil improvement, and water supply and drainage will belongs to the scope of Vinh Tan 2 TPP. The ash yard in the stage 1 was assessed in the EIA report of Vinh Tan 2 TPP. It's approved by MONRE according to the document No.1386/QD-BTNMT dated 22/7/2009.
2.2	Access road to the ash yard - stage 1	Invested by EVN in the infrastructure project of Vinh Tan Power Complex. This item was approved by the People's committee of Tuy Phong District according to the document No.1537/UBND-KT dated 12/12/2008 on the confirmation of environmental protection commitment of Vinh Tan Power Complex at Vinh Tan commune, Tuy Phong District.
3	***Fresh water supply system***	
3.1	Fresh water supply piping lines and	Invested by EVN in the infrastructure project of Vinh Tan Power Complex

TT	Items	Common items
	pumps station from Da Bac River for construction of Vinh Tan 4 TPP	This item was approved by the People's committee of Tuy Phong District according to the document No.1537/UBND-KT dated 12/12/2008 on the confirmation of environmental protection commitment of Vinh Tan Power Complex at Vinh Tan commune, Tuy Phong District.
4	*Traffic system*	
4.1	Internal roads	Construction separately for each plant and be connected to the common road of the Power Complex.
4.2	External roads	Two roads connected National Road No. 1A and Vinh Tan power complex will be built. This belongs to the infrastructure of Vinh Tan Power Complex invested by EVN. This item was approved by the People's committee of Tuy Phong District according to the document No.1537/UBND-KT dated 12/12/2008 on the confirmation of environmental protection commitment of Vinh Tan Power Complex at Vinh Tan commune, Tuy Phong District.

1.4.2.3. Technology infrastructure system planning

1. *Sea port system*

The coal port for Vinh Tan 4 TPP invested by the Project owner of Vinh Tan 4 TPP includes a coal port with the capacity of 100,000DWT located at the export area of the coal substation.

2. *External road system of Vinh Tan 4 TPP*

- Route No.1: from the intersection of road No.4 and road No.1 in front of the plant towards the Northeast of the Vinh Tan Power Complex to the National Road 1A with total length of 244.57m, and is a minor urban road type 3. Designed weight: single axis 12 ton and 10 ton.
- Route No.2: a conjoined road from the plant to the ash yard, started from the intersection between Road No.4 and Road, intersecting with the National Road No.1A, passing the North-South Railway No.2 to the ash yard with the length of 1,455.9m. The route No.2 is a delta road type 3. Designed weight: single axis 12 ton and 10 ton.
- Route No.4: alongside the barriers of the Center towards the East (the side of Vinh Tan 1 TPP) and The North of the center (the North of the distribution yard with the total length is about 2,297.8m. The minor urban road type 3. Designed weight: single axis 12 ton and 10 ton.
- Scaffold tunnel passing the Nation Road No.1A: at the intersectional point between the National Road No.1A and Route No.2, being designed in a way of

crossing the National Road throughout the scaffold tunnel.

- Scaffold bridge passing the North – South Railway: at the intersectional point between the No.2 road and the North-South Railway, being designed in a way of passing the North south Railway throughout the scaffold bridge.
- Other systems: surface water drainage system, the alongside green system, lighting system, cable system, and water supply.
- Auxiliary works: signs, signals, piles, traffic light, etc.
- The traffic transportation system is shown in the Figure 1.13.

3. *Plan of land leveling and rainwater drainage*

a) Leveling plan (for Vinh Tan 4 TPP)

The leveling design elevation of the Vinh Tan Power Complex is calculated based on the leveling elevation of EL+3.5m; in ensure the suitableness with the general layout of the entire plant and master plan as well as response to the requirement of flood prevention. The leveling elevation is +3.5m for the area of Vinh Tan TPP counting to the sea-encroached breakwater and +4.5m for the distribution area, and administrative building (according to the Hon Dau Elevation System).

b) Rainwater drainage

Including the surface water drainage system in the plant and the port area.

4. *Power supply system (for Vinh Tan 4 TPP)*

In order to supply the power for the works of construction for Vinh Tan 4 TPP, the expected plant is to reform and improve the 22kV power route from Lien Huong to Ca Na with the length of 25km.

5. *Water supply system (for Vinh Tan 4 TPP)*

a) *The cooling water supply and discharge system*

The cooling water supply and discharge system for Vinh Tan 4 TPP are exclusively arranged and implemented by the project owner. Taking the water from the inside of the breakwater (the north of coal substation) and discharge the cooling water to the outside of the breakwater towards the West of Vinh Tan Power Complex. The cooling water flow rate for Vinh Tan 4 is approximately $50m^3/s$. The dimension of cooling water intake (for a section inside the plant) is around 9.2 m x 4.9 m; the dimension of waste pipe section (a segment from a waste hole to the sea with the diameter of 4m)

b) *Fresh water supply system*

The total amount of fresh water needed for operation of Vinh Tan 4 TPP is $220m^3 / h$ including the need of using water such as additional water for boilers, cooling water for closed electric circuit, water for living demand, Sea-FGD system, fire protection systems, coal transportation, spraying dust, conveyor systems, port's operations and water for other purposes.

To optimize a cost of the operation, the raw water source is expected to provide for the operation of Vinh Tan 4 TPP will be taken from the current raw water supply system of the Vinh Tan Power Complex. The raw fresh water treatment system will be designed % 2x100 with the capacity of $256m^3$/ h to ensure adequate supply of fresh water needed for the plant.

However, in case of water shortage in the dry season (approximately 3 months), Vinh Tan 4 TPP will install additional raw water source such as sea water to serve for the continuous operation of the plant. The 4 Vinh Tan TPP will invest a standby seawater treatment system with the design capacity of $680m^3$/ h (2*50%) to ensure the sufficient supply of fresh water needed for the plant.

c) The surface water discharge system

The natural surface water discharge system will collect the wastewater and bring to the common drains before pouring to the sea. The total area of the designed plant will be correspondenced with the rainwater discharge slope of 3-5%.

6. *Communication system (for Vinh Tan 4 TPP)*

a) To connect to the power network

Vinh Tan 4 TPP will be connected at the level of 500Kv.

b) SCADA System

The connection from the plant to the Control Centre, the Regional Load Dispatch Centre, and the National Load Dispatch Centre.

7. *Landscape system (for Vinh Tan 4 TPP)*

Landscape system of the plant comprises flower garden, green trees, greensward, etc. All will be harmoniously designed with the surrounding natural landscape and general infrastructure of the Vinh Tan Power Complex. Moreover, in order to ensure the safety for the neighbourhood area, the isolated greenery corridor will be installed with the area of 3.54ha. The general layout of the landscape is shown in the Figure 1.12.

The EIA Report of Vinh Tan 4 TPP's project will be evaluated especially for two main items. Those are the main building and the coal port of 100,000DWT.

The general layout of Vinh Tan 4 TPP is shown in the figure 1.5 and the general layout of the Vinh Tan Power Complex is shown in the Figure 1.6.

1.4.2.4. The general layout of Vinh Tan 4 TPP

The general layout of Vinh Tan 4 TPP is shown in the Figure 1.5.

1. The functional parts of the plant

The whole plant will be divided into separate functional areas such as main building areas, coal storage areas, distribution yards, administrative buildings, auxiliary areas. Accordingly, the function of the areas will be divided and clearly identified between the static and the dynamic, the productive and non –productive area...

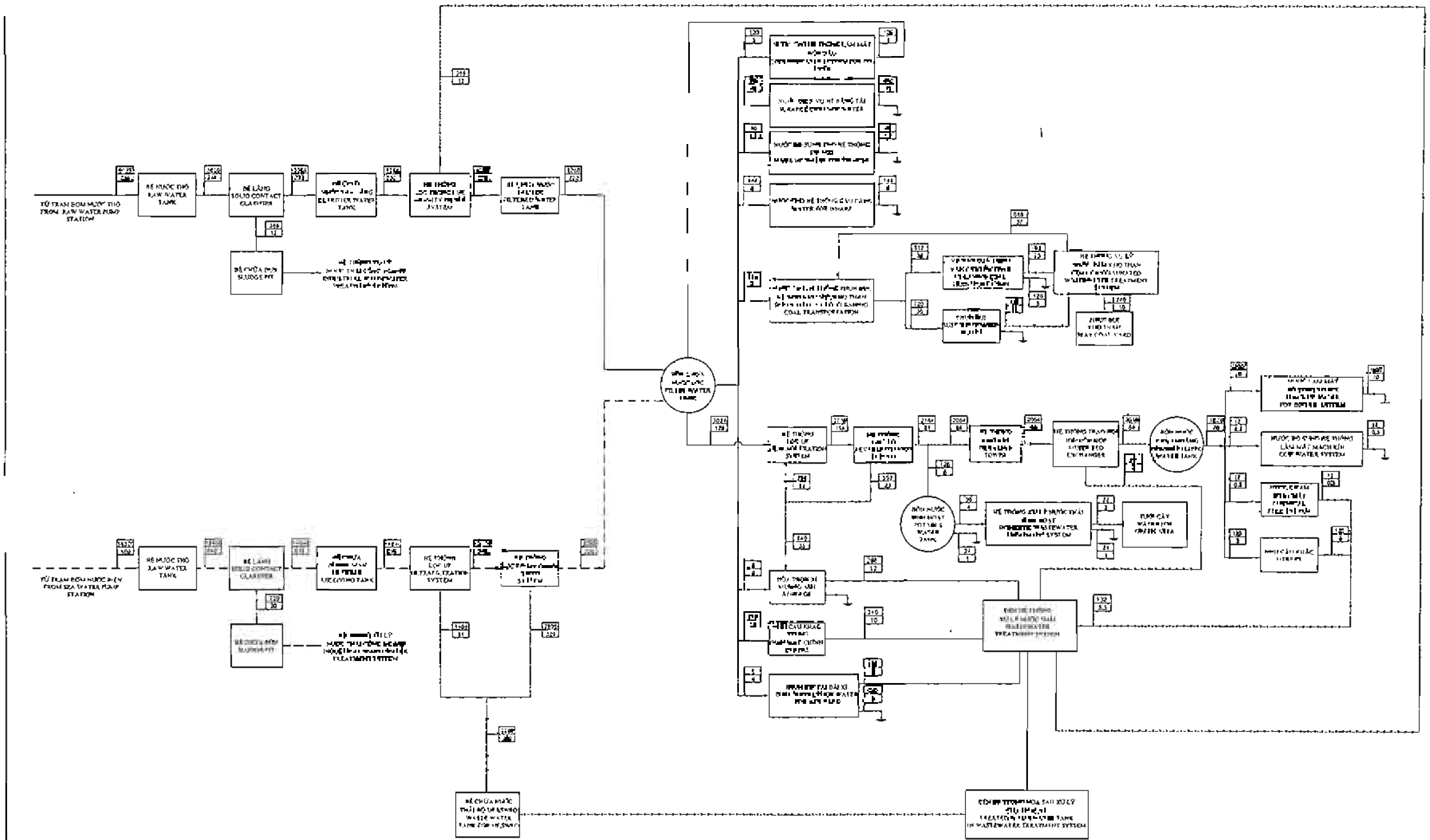
- The main building area of about 50.18 ha, including the onshore area and the water area which is used to arrange all items of the plant except steel pipeline for cooling water discharge. This area also includes the construction yard for the plant.
- The cooling water discharge area of about 16.48ha. This area is a prolonged water surface from the plant's fence along the Western breakwater of the port.
- Vinh Tan 4 TPP's port system is located in the port system of Vinh Tan power complex, arranged perpendicular to the substation of the coal storehouse. The port has a length of 310 m and width of 29 m, satisfied the landfall of ships with the shipload of 100,000 DWT.
- Green corridor area is approximately 3.54 ha from the Northern fence of the plant towards the south to the water edge with a corridor width of about 80m. In the construction phase, it is expected to use this area as a camp for construction and will return the area after completion of the project.
- Other items: road system, lighting system, external fence system, and ash yard system.

(The general layout of Vinh Tan 4 TPP is shown in Figure 1.5)

1.4.2.5. Spatial organization and architecture landscape

In the general layout of the plant, the harmonization of construction works, green covers are essential. As a component of Vinh Tan Power Center, Vinh Tan 4 thermal power plant must follow the principle applicable to the architectural spaces and scenes of Vinh Tan Power Center. For each of the construction, the plant will be arranged flower gardens, greenswards... in order to generate harmoniously landscape and to ensure the green tree density in a range of 10% of the total area of the plant. The general layout of the greenery landscape is shown in the Figure 1.14.

FIGURE 1.4. DIAGRAM WATER BANLANCE OF VINH TAN 4 TPP



Ghi chú/ Notes:

LƯU LƯỢNG NƯỚC SÔNG CẦN CẤP VỀ CHO NHÀ MÁY LÀ 256 m3/h.
Total raw river water demand for Vinh Tan 4 Power Plant is 256 m3/h.

LƯU LƯỢNG NƯỚC BIỂN CẦN CẤP VỀ CHO NHÀ MÁY LÀ 680 m3/h.
Total raw sea water demand for Vinh Tan 4 Power Plant is 680 m3/h

m3/ngày (m3/day)
m3/h

Tổn thất

ĐƯỜNG NƯỚC NGỌT/ Freshwater pipeline

ĐƯỜNG NƯỚC BIỂN/ Seawater pipeline

ĐƯỜNG NƯỚC THẢI/ Wastewater pipeline

Bể lắng và bể chứa bùn sẽ được sử dụng chung cho hai phương án xử lý nước

Clarifier and sludge pit will be common used for two water treatment plans

FIGURE 1.5 GENERAL LAYOUT OF VINH TAN 4 THERMAL POWER PLANT

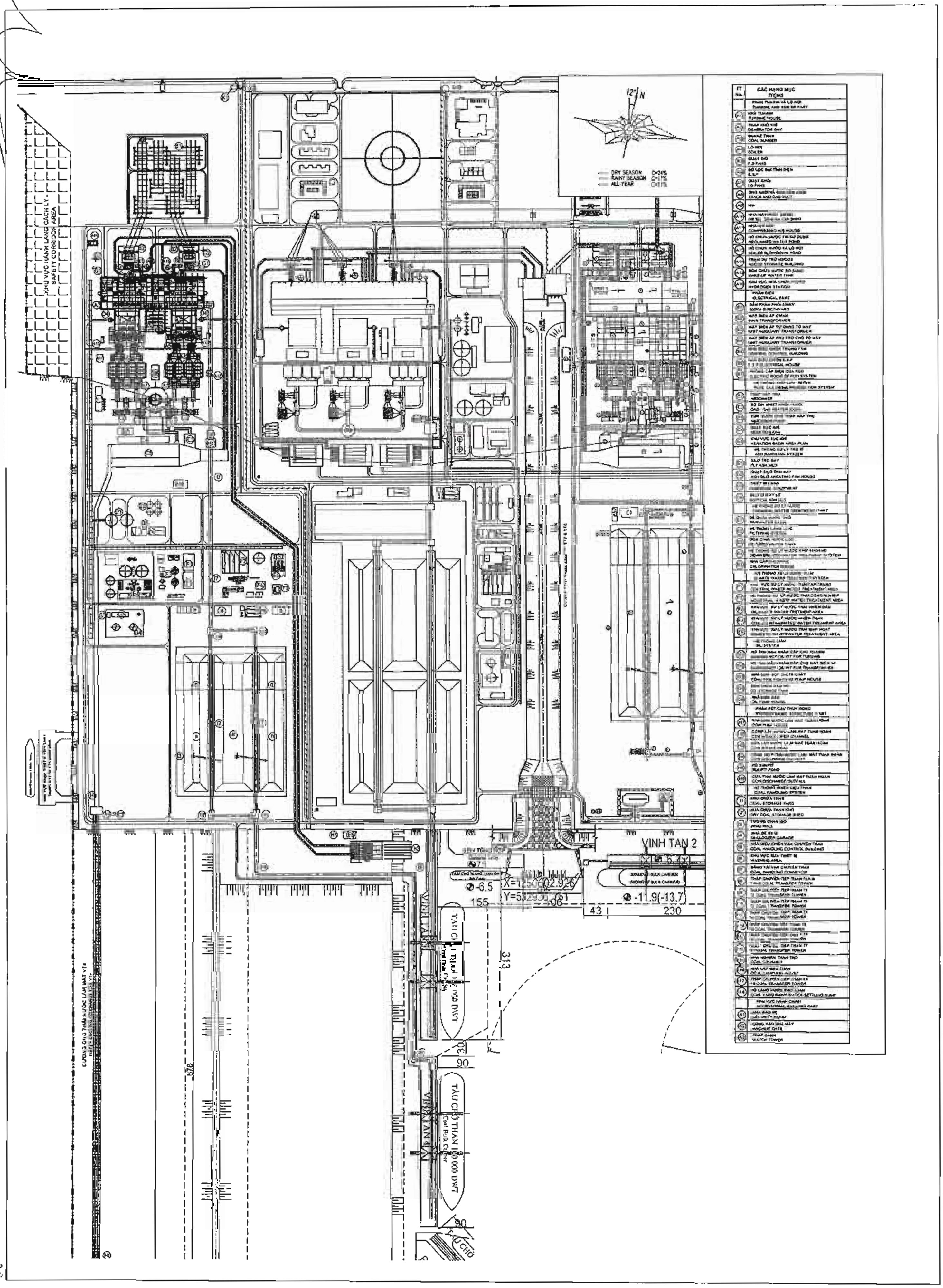
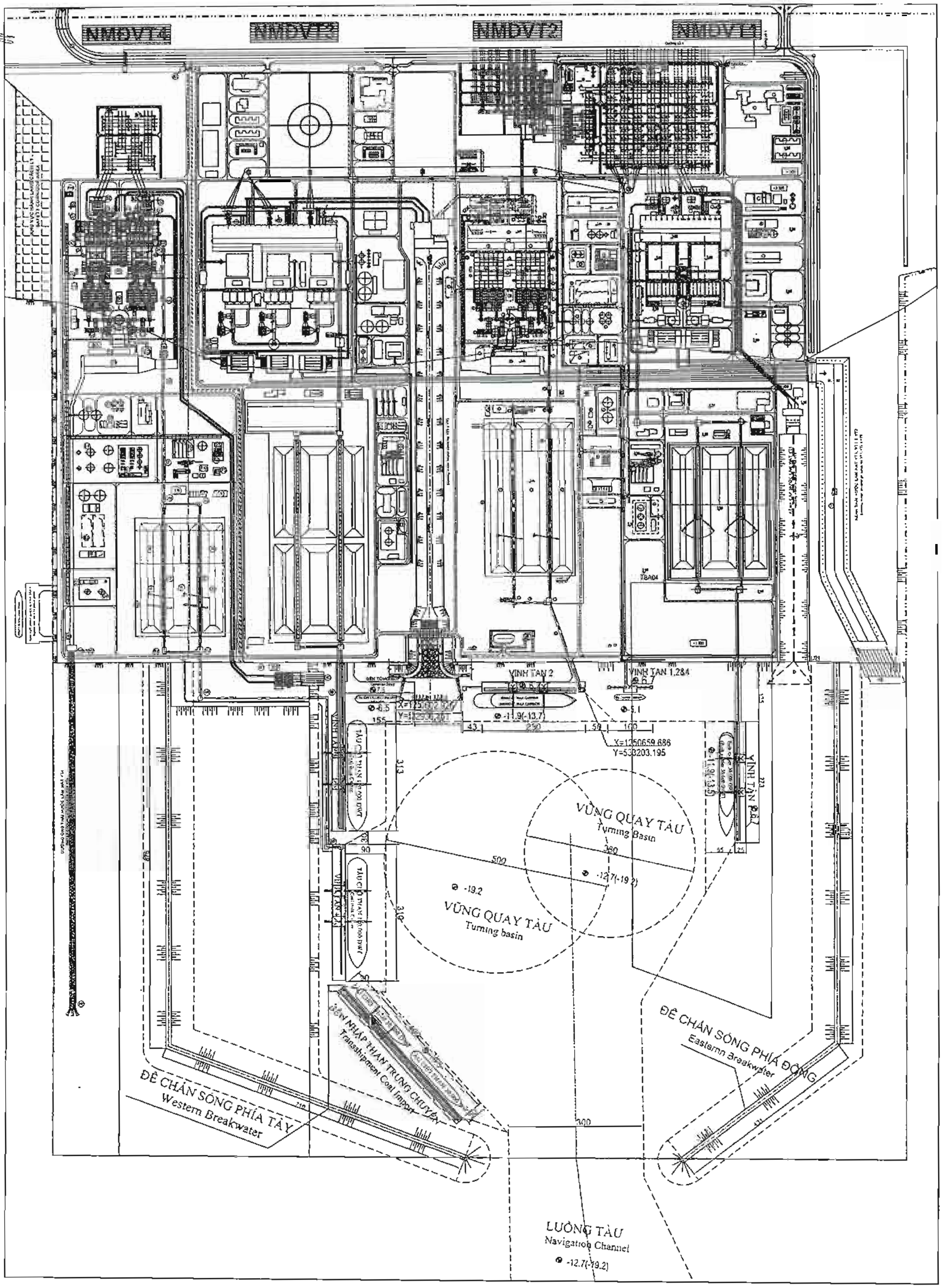


FIGURE 1.6 GNERAL LAYOUT OF VINH TAN POWER COMPLEX



1.4.2.6. Infrastructure and auxiliary systems

1. *Land leveling*

The leveling topography of Vinh Tan 4 TPP is relatively complicated, it is not only as a part of a foothill with the elevation sketching from +5.5 (m) to +17.5(m), but also as a part of sea-encroached land with the lowest elevation of about -6.5 (m). The elevation of plant ground is +3.5m for the main building area to the breakwater and +4.5m for the distribution yard. The main building area (the Hon Dau elevation system) is applicable to the common elevation of the Vinh Tan Power Complex with the area of about 14.89ha. The benchmark coordinates of the leveling area of Vinh Tan 4 TPP are shown in the following table:

Table 1.4. The benchmark coordinates of the leveling area of Vinh Tan 4 TPP

Benchmark	Coordinates (VN2000)	
	X	Y
BT - 3	1251680.702	531787.244
BT - 4	1251709.365	531922.093
M56	1251278.410	532013.690
M64	1251286.968	531861,479
VT 4 – 3	1250482.426	532032.478
BT – 27	1250512.602	532176.473

The leveling calculation for Vinh Tan 4 TPP is conducted by the "Sumac – Modeling for land leveling and simulation of terrain surface. The results of calculation are shown as follows:

Table 1.5. Volume of land leveling for Vinh Tan 4 TPP

Total	Excavation volume (m^3)	Backfill volume (m^3)	Total (m^3)
On land (+4.5m)	-117718.64	652.40	
On land (+3.5m)	-96037.09	46941.02	
Sea encroachment (+3.5m)		981151.94	
Total	-213755.73	1028745.36	814989.63

The total sand volume for land leveling for Vinh Tan 4 TPP must be added about 846,362 m^3.

In addition, during the implementation of leveling, thickness for subsidence offset is calculated about 0.229m. Therefore, the total volume of sand cover subsidence would be about 31,373m^3.

In conclusion, the total volume of sand for land leveling work in Vinh Tan 4 TPP would be: 814,989 m^3 + 31,373m^3 = 846,362 m^3.

The sea-encroached leveling is shown in Figure 1.7.

Solutions dealing with the lack of sand volume for Vinh Tan 4 TPP are as follows:

The volume of leveling sand is expected to be taken from dredging approach channel for vessels with the shipload of 100,000 tons and then being transferred directly to the leveling area of Vinh Tan 4 TPP. The dredged material volume from Vinh Tan 4 TPP's port is estimated about 0.353 million cube, and will be provided for leveling Vinh Tan 4 TPP. The lack of sand volume will be purchased from other areas or taken from the dredged material source of the Vinh Tan 3 which has the dredged volume of about 4.2 million cubic meter, ensuring to supply enough material for leveling Vinh Tan 4 TPP.

2. *Sea encroached embankment*

The surrounding embankment to protect the plant will be build, and it consists of three segments:

- M63 ÷ M64 segment (the length of 81m).
- M64 ÷ VT 4-3 segment (the length of 823m).
- VT 4-3 ÷ BT – 27 segment (the length of 147m).

The benchmark coordinates of the embankment of the Vinh Tan 4 TPP are presented in Table 1.6 and Figure 1.8:

Table 1.6. The benchmark coordinates of the sea-encroached embankment

Benchmark	Coordinate (VN2000)	
	X	Y
M63	1251277.758	531781.650
M64	1251286.968	531861.479
VT 4 – 3	1250482.426	532032.478
BT – 27	1250512.602	532176.473

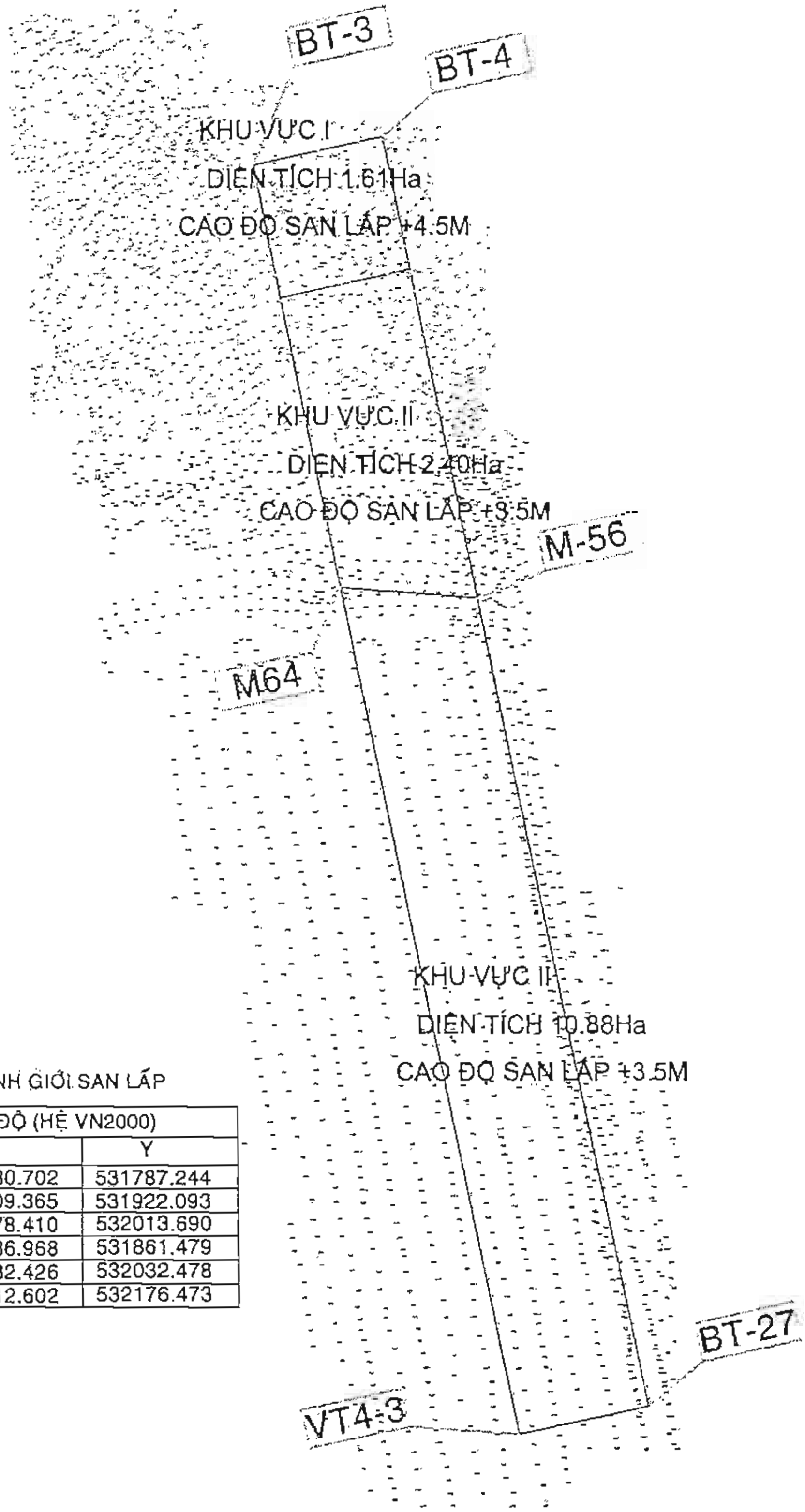
Source: PECC2, 9/2012

The rubble mound structure covering the externally protective blanket by Tetrapod rock:

- The top elevation of the embankment is the top elevation of the breakwater approximately +5m (Hon Dau Elevation System)
- Ground elevation inside the plant is about +3.50 m (Hon Dau Elevation System).
- The crest width is arranged by reinforced concrete with the width of 6m and the thickness of 0,5m
- Reinforced concrete breakwater built with the stone of 1x2 M300, and 2.5m of height.
- The seaside armor slope is covered with two layers of Tetrapod rock. The tray of the breakwater are using the stone block with the weight of G = 50-150kg. The core of the breakwater is made of the stone block with the weight of G = 50-100kg. For the upper layer, there will be a stone block
- Seaward slope m = 2, the inner slope of m = 1.25

- At the seaside, embankment is covered by Tetrapod (2 layers). Embankment body using freestone with the weight of G = 50-150kg, and inside is freestone G = 10-100kg. Top layer is bedding course by freestone with D = 50cm and thickness is 100cm.
- At the landside, embankment is covered by break stone (2x4, 4x6 in dimension), and geotextile fabric layer.
- Embankment is covered by Tetrapod 9.7Tons (2 layers).
- Cross section of sea encroachment embankment of Vinh Tan 4 showed in Figure 1.9.

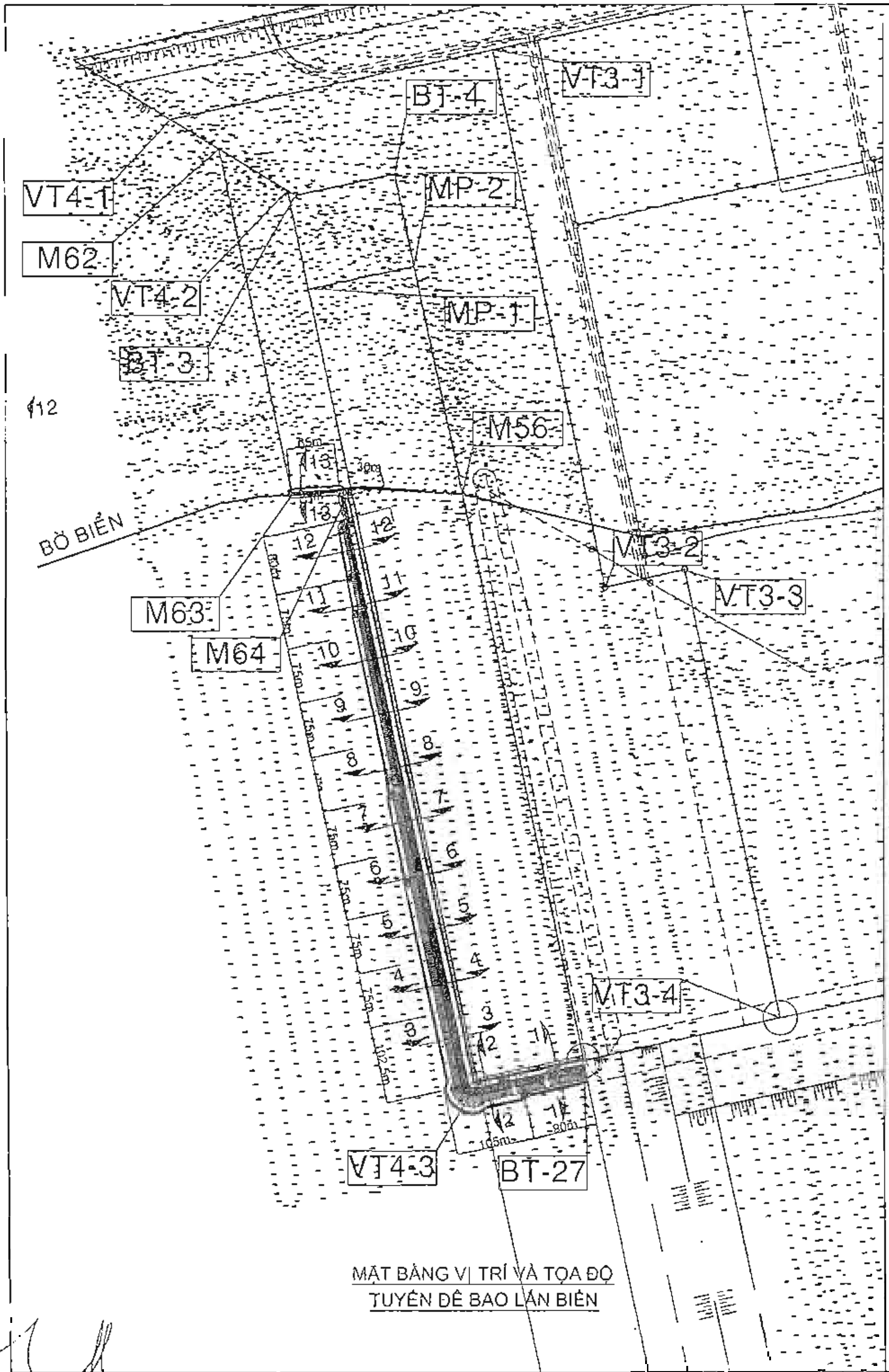
Figure 1.7. Layout of sea encroaching levelling area of Vinh Tan 4 TPP



TỌA ĐỘ RANH GIỚI SAN LẤP

TÊN MỐC	TỌA ĐỘ (HỆ VN2000)	
	X	Y
BT-3	1251680.702	531787.244
BT-4	1251709.365	531922.093
M-56	1251278.410	532013.690
M-64	1251286.968	531861.479
VT4-3	1250482.426	532032.478
BT-27	1250512.602	532176.473

FIGURE 1.8. LAYOUT LOCATION AND COORDINATES SEA ENCROACHING EMBANKMENT



Tên mốc	Tọa độ (VN2000)	
	X	Y
M63	1251277.758	531781.650
M64	1251286.968	531861.479
VT 4 – 3	1250482.426	532032.478
BT – 27	1250512.602	532176.473

Công trình xây dựng đê bao bảo vệ nhà máy sẽ xây dựng hệ thống đê bao bảo vệ đất lấn biển bao gồm 3 đoạn:

- Đoạn M63 ÷ M64 (chiều dài đê khoảng 81m)
- Đoạn M64 ÷ VT 4-3 (chiều dài đê khoảng 823m).
- Đoạn VT 4-3 ÷ BT – 27 (chiều dài đê khoảng 147m)

3. *The 100,000 DWT sea port*

The Vinh Tan 4 coal port is considered as an item of Vinh Tan 4 TPP. The 100,000 DWT coal port of Vinh Tan 4 is arranged perpendicular to the coast, close to the cofferdam of coal substation area.

Table 1.7. Main parameters for each item of the project

No	Items		Unit	Parameter
1	The 100,000DWT coal port for Vinh Tan 4	Port length	m	310
		Surface elevation of port	m	6.7
		Bottom elevation of port	m	-15.7
		Port width	m	29
2	Turning basin	Diameter	m	500
		Bottom designed elevation	m	-15.7
3	Fairways	Width	m	190
4	Auxiliary items	Conveyer	m	2460
		Turning house	House	3
		Loading equipment 1500T/h	set	2

The location of the Vinh Tan 4 port (100,000DWT) will be showed in the Figure 1.10

a) *Investment Scope of The Vinh Tan 4 port*

- The 100,000DWT coal port;
- The auxiliary system on the port;
- Dredging in front of the Vinh Tan 4 port.

Vinh Tan 4 TPP's coal jetty with capacity of 100,000DWT will share the approach channel with Vinh Tan 3 TPP and will not have to execute the work of dredging approach channel. Vinh Tan 4 TPP's coal jetty will be responsible for the work of dredging in front of the port. Environmental impact assessment due to the work of dredging channel will be reported in the EIA report of Vinh Tan 3 TPP's port.

b) *Dredged volume*

Dredged volume of Vinh Tan 4 TPP's coal jetty is presented in the following table

Table 1.8. Dredged volume in the scale of 100,000 DWT

Scope of work	Unit	Volume		Total	Process
		Front of the Port	Approach channel and turning basin		
Vinh Tan 4 TPP's Port 100,000DWT	m^3	352,720	-	352,720	2015

The dredged volume of 352,720 m^3 will be used to reuse to leveling the sea-encroached area of Vinh Tan 4 TPP.

c) *Annual dredging volumes*

According to the survey data in April, 2007 conducted by FHDI, the suspended sediment density is low, and the seawater is clear in the sea area surrounding the plant. During the tides, the average density value of the suspended sediments is about 0.0022 kg/m^3. For the time when the tide raising and falling, the values are 0.0019 kg/m^3 and 0.0028 kg/m^3, respectively.

The sediments distributed in the survey area include: sand, gravel sand, fine sand and gravel in which sand is the main component, the gravel mixed sand and fine sand are the next. The average diameter of the particle is in a range of 0.036 to 1.682 mm and the average diameter is 0.334 mm.

Due to the limited alluvial sediment sources, there is just a small amount of alluvial sediments redistributed each year. The ability of re-sedimentation of dredged area is high, especially in the outside area, which is not being protected by the breakwater.

As calculated by mathematic and physical models, the annual dredged volume for the Vinh Tan 4 Power Complex's coal port is about 23,076.8 m^3.

The sludge generated during the dredging process will be transported to the coal store substation of the Vinh Tan Power Complex.

d) *Dumping site for the dredged material*

As mentioned above, the dredged volume generated during the construction period of the 100,000DWT coal port will be reused to leveling for the sea-encroached area of Vinh Tan 4 TPP.

The annual dredged volume of Vinh Tan 4 TPP's port will be used to leveling for the coal substation (shown in the Figure 1.11). The location of dumping site and Table 1.9.

The annual dredged material volume will be dumped at the middle of the breakwater in the West and the embankment with an area of about 28,6ha (according to the decision No.1172/QD-EVN dated November 22, 2010 of the Vietnam Electricity on approving, amending and supplementing the basis design-the total investment for construction of the coal jetty).

The embankment with the length of 984m in associate with the breakwater in the West to form a coal substation. The coal substation is located in the West of the port with the total area of 28.6ha, can hold approximately 1,659,395.56 ton per year. The elevation of the coal substation is 5m. Its surface is covered by sheets. The surface of the road is made by the reinforced concrete.

The ability of receiving dredged material of the coal substation is estimated as follows:

- The total area of coal storage: 28.6ha (286,000m^2)
- Leveling elevation: +5m
- Average depth of the sea bottom surrounding the coal storage: -7.45m

The volume of the coal storage

$$V = SxH\ (m^3)$$

In which: S – total area of the coal storage (m^2)

H – height of the leveling material (m)

$\rightarrow V = 286{,}000m^2x(5+7.45)m = 3{,}500{,}000m^3$

According to the EIA Report of the Vinh Tan Power Complex's coal imported port – Stage 1: the Vinh Tan 2's port has already approved by MONRE on the

Decision No. 1448/QD-BTNMT date July 25, 2011. The dredged material volume of Vinh Tan 2' port for the scale of 50,000DWT in the construction stage and annual dredged volume are used to level the site of coal substation as follows:

- In the construction stage: about 2.6 million m^3 of the dredged material volume used to level the coal substation.
- In the preparation stage: about 0.097 m^3 of the dredged material volume used to level the coal substation.

Thus, the construction stage is just satisfied approximately 74% of the total material volume needed to levelling for the coal substation. Therefore, this site can hold the dredged material volume in the period of over 11 years.

However, the dredged material volume of the Vinh Tan 2 in the construction state currently remains about 1.9 million m^3. Therefore, the dredged material volume need to level the coal substation is about 1.6 million m^3

In the operation, the dredged material volume of both Vinh Tan 2 and Vinh Tan 4's port is about 0.1 million m^3. Therefore, this site can hold the annual dredged material volume in the period of over 15 years.

In conclusion, the coal substation area can be received the annual dredged material volume of Vinh Tan 4's port.

The planned coordinates and location of the dredged material dump site of the Vinh Tan TPP's port are shown in the Figure 1.11 and Table 1.9.

Table 1.9. The landmark of the dredged material dump site

Point name	Coordinate system VN-2000	
A	1250534.676	532280.321
B	1249681.413	532461.688
C	1249637.764	532792.830
D	1250600.132	532588.272

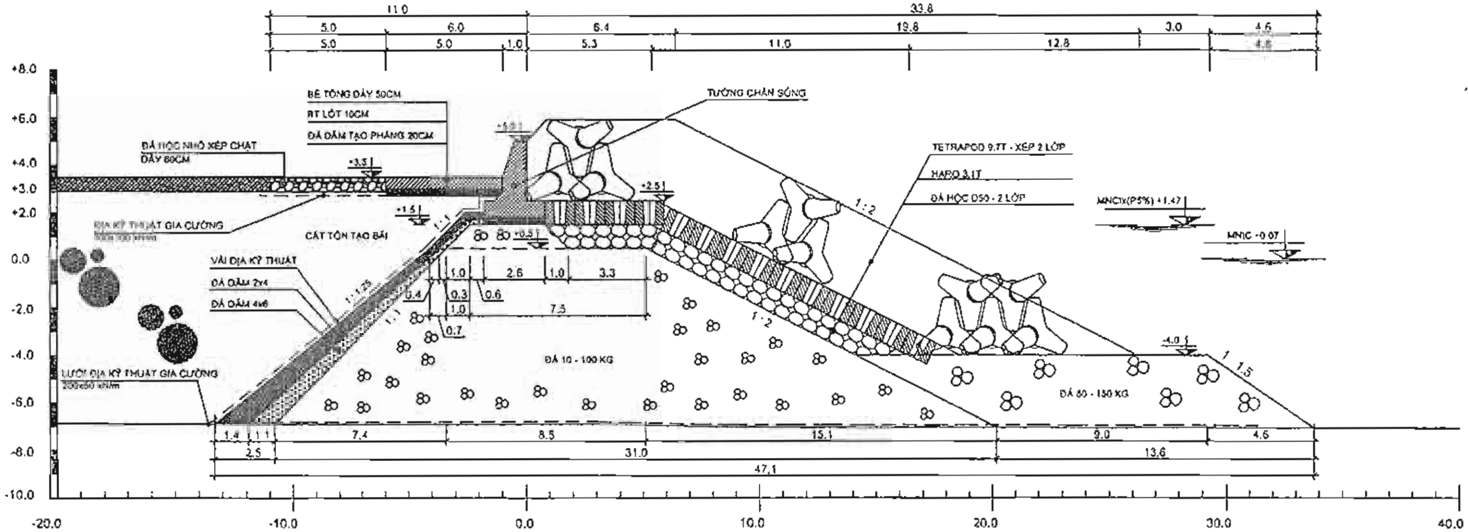
Source: EIA Report of Vinh Tan 2 TPP, 7/2011

e) *Structure of 100,000 DWT port*

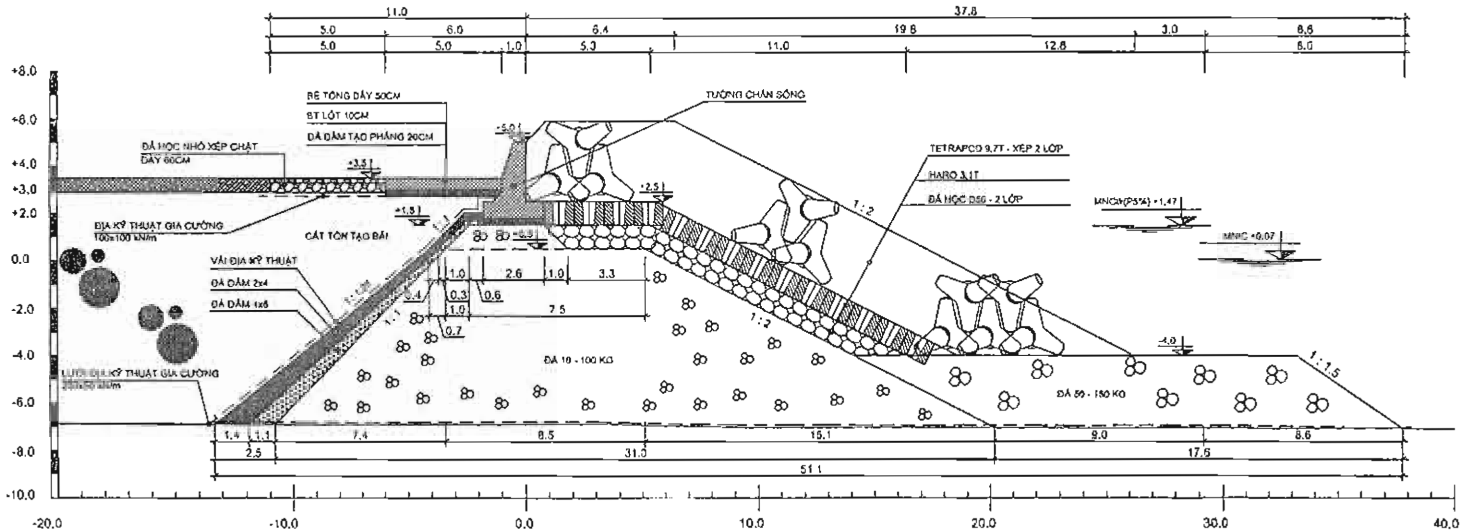
Port length is 310 m and the width is 25 m, with pile structure and floor beam. Beam aperture is 8.0 m, each curved structure consist of 8 beams type D1000 mm tubular steel piles, which consists of a pair of straight poles (under the rails beam), two pairs of inclined piles with inclination of 4:1 and a pair of straight poles. Steel piles are made of Q345B steel with a thickness of 20 mm placed on rock. Each superstructure frame consists of three prestress reinforced concrete beams and two stressed concrete iron beams. The height of the vertical beam and iron beam is 2.1 m.

Bridge with the length of 439m is divided into 2 parts. The first part of the bridge is used for transportation and the other for the conveyer belt. The distance from the head of the bridge to the head of port, approximately 413m of length and 14m of width. The second part is located next to the port with the length of 29m and the width of 23m. The whole structure is laid on the steel foundation Φ100cm with the pipe thickness of 16mm.

FIGURE 1.9 CROSS SECTION OF SEA ENCHROACHING EMBANKMENT OF VINH TAN 4 TPP



MẶT CẮT 1-1



MẶT CẮT 2-2

FIGURE 1.10 GENERAL LAYOUT OF COAL UNLOADING JETTY 100000DWT OF VINH TAN 4 TPP

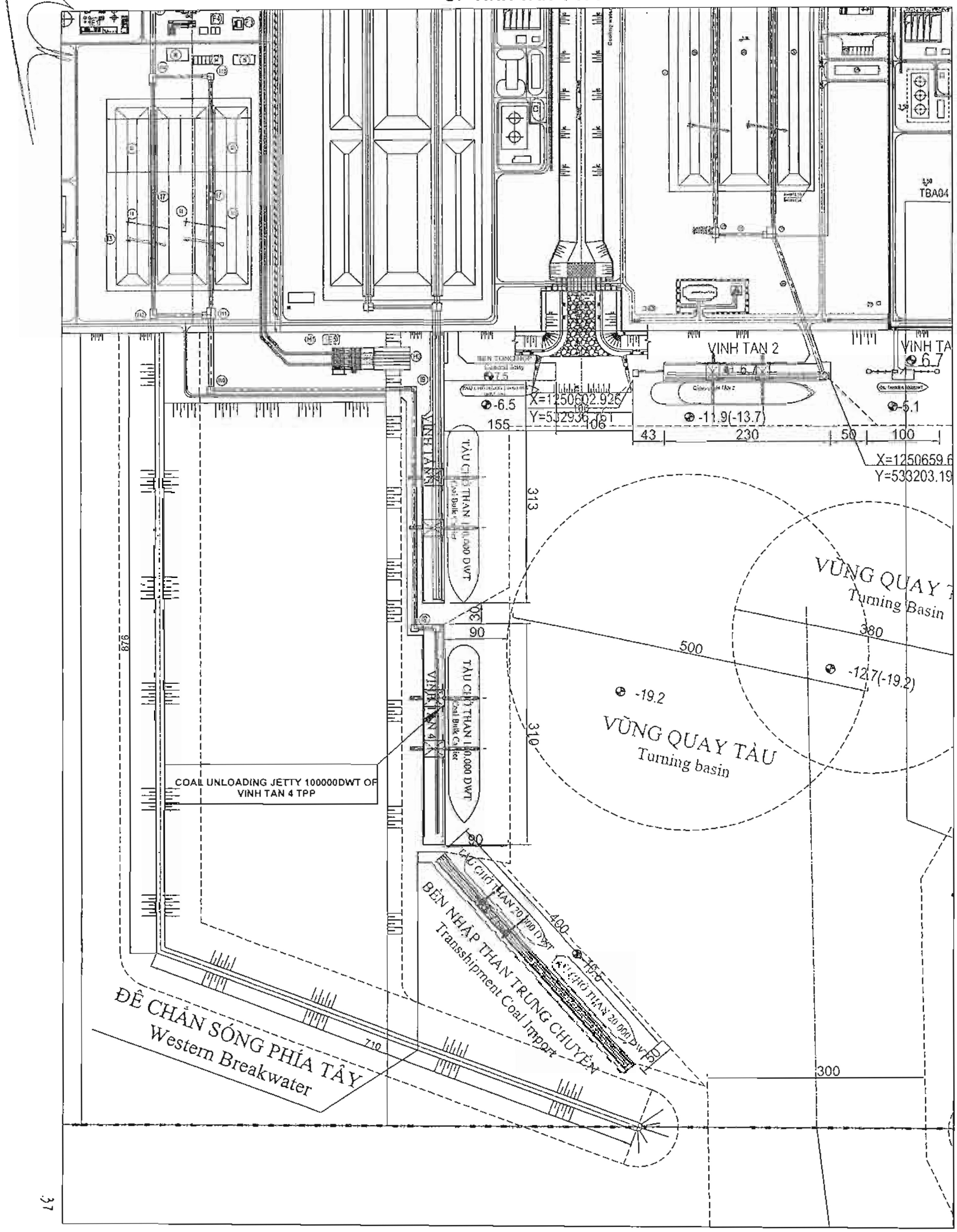
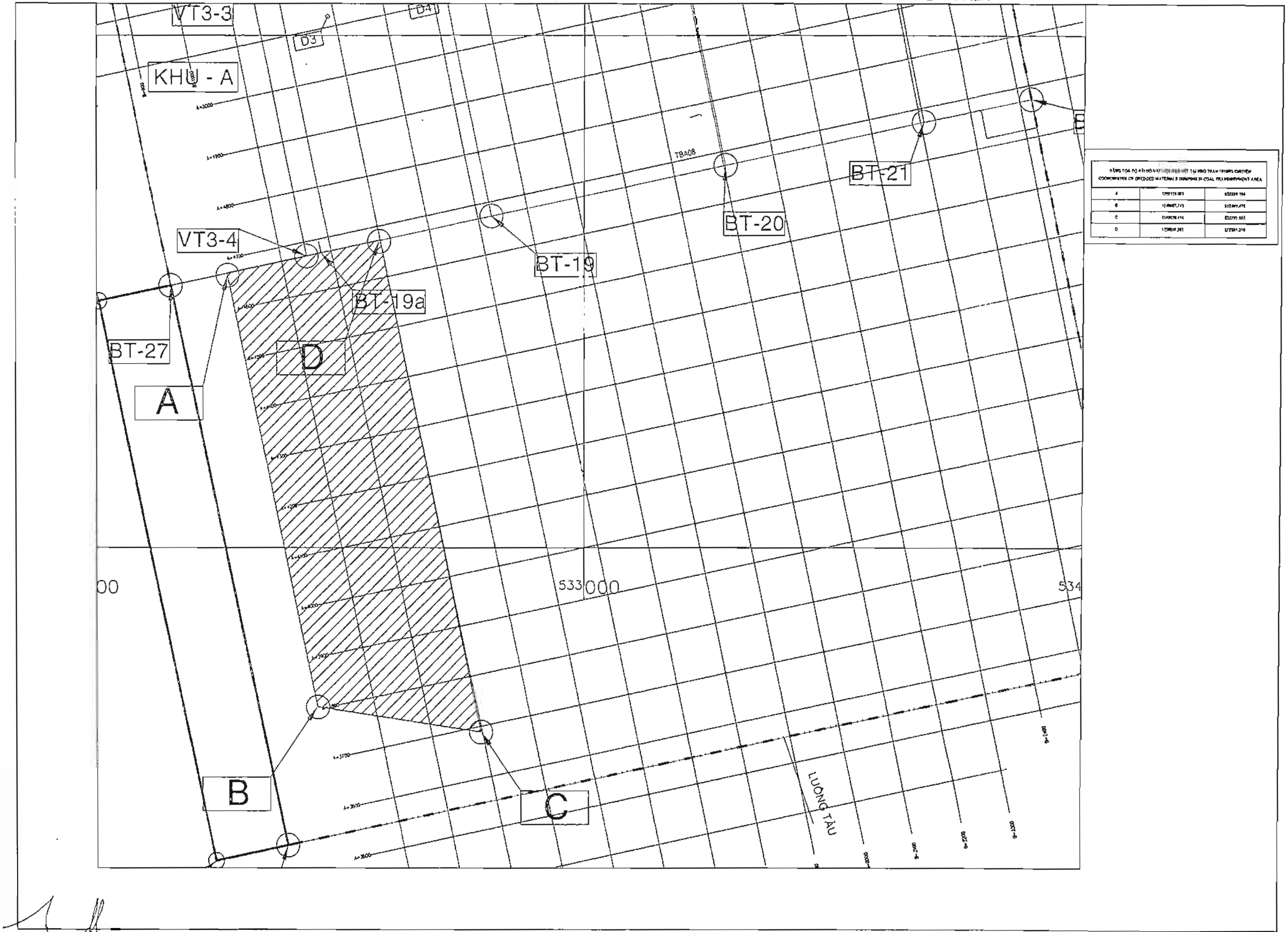


FIGURE 1.11. LOCATION OF DREDGED MATERIALS DUMPING IN COAL TRANSSHIPMENT AREA



1.4.3. Civil solutions and construction volumes of the project

1.4.3.1. Architectural concept

The plant is suitably designed with the technical line of the thermal power plant, in correspondent with the surrounding environment and convenient for the operation and production of the plant.

Principles for the design of the architecture are as follows:

- Strategical, stable, economical and aesthetic.
- Suitable for the surrounding landscape and environment.
- Suitable for the characteristics of the climate at the site
- The contractor will determine the main structural forms which are used at the power station. The selection will be based on considerations of schedule, economy, maintenance costs, and operational requirements

The construction architecture is mainly shown through the above structure including the steel structure and reinforced concrete structure. Each structure will be equipped with the internal and external finishing material correspondingly.

1.4.3.2. General layout arrangement solution

General layout arrangement solution, technical systems and corridors in Power Complex must be suitable for the current planning as well as for the future. Each arrangement solution will be chosen based on the principle of economy, and in accordance with the landscape and general planning of the area.

General layout arrangement solution is a very important factor, it must be complied with the technical systems, construction conditions, environmental requirements, and management conveniences of the plant in order to create a safe and comfortable working environment for all operators. General layout of Vinh Tan 4 is shown in Figure 1.12.

1.4.3.3. Foundation solution

According to the Geological Investigation Report for Vinh Tan 4 Power Plant, it can be evaluated that the geologic of the area has a good status. The surface of the ground, which has the low capacity of load pressure, will be removed when conducting the foundation construction. The second layer, which has the SPT index higher than 50 with the geologic as above, will be proposed to use drilled pile foundation for important items. For the minor items which has low load, it will be applied by shallow and normal foundation.

1.4.3.4. Structural solution over foundation

Structural solution for the Plant will includes two main types of structure: steel structure and reinforced concrete structure. Depending on the purpose of using, compatibility with other equipment and technology to choose a suitable structure with design standards.

Figure 1.12. General layout of Vinh Tan 4 TPP

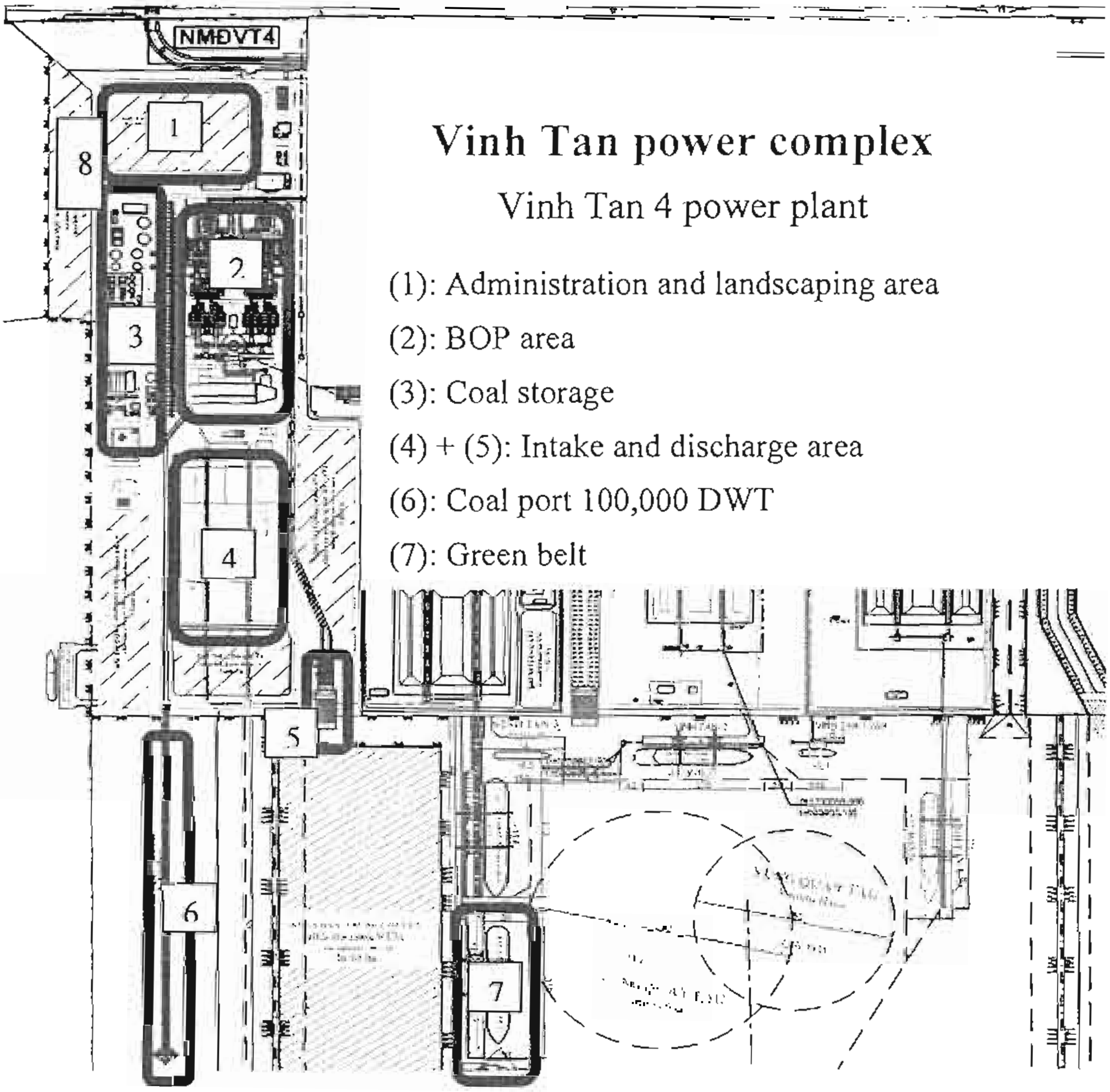
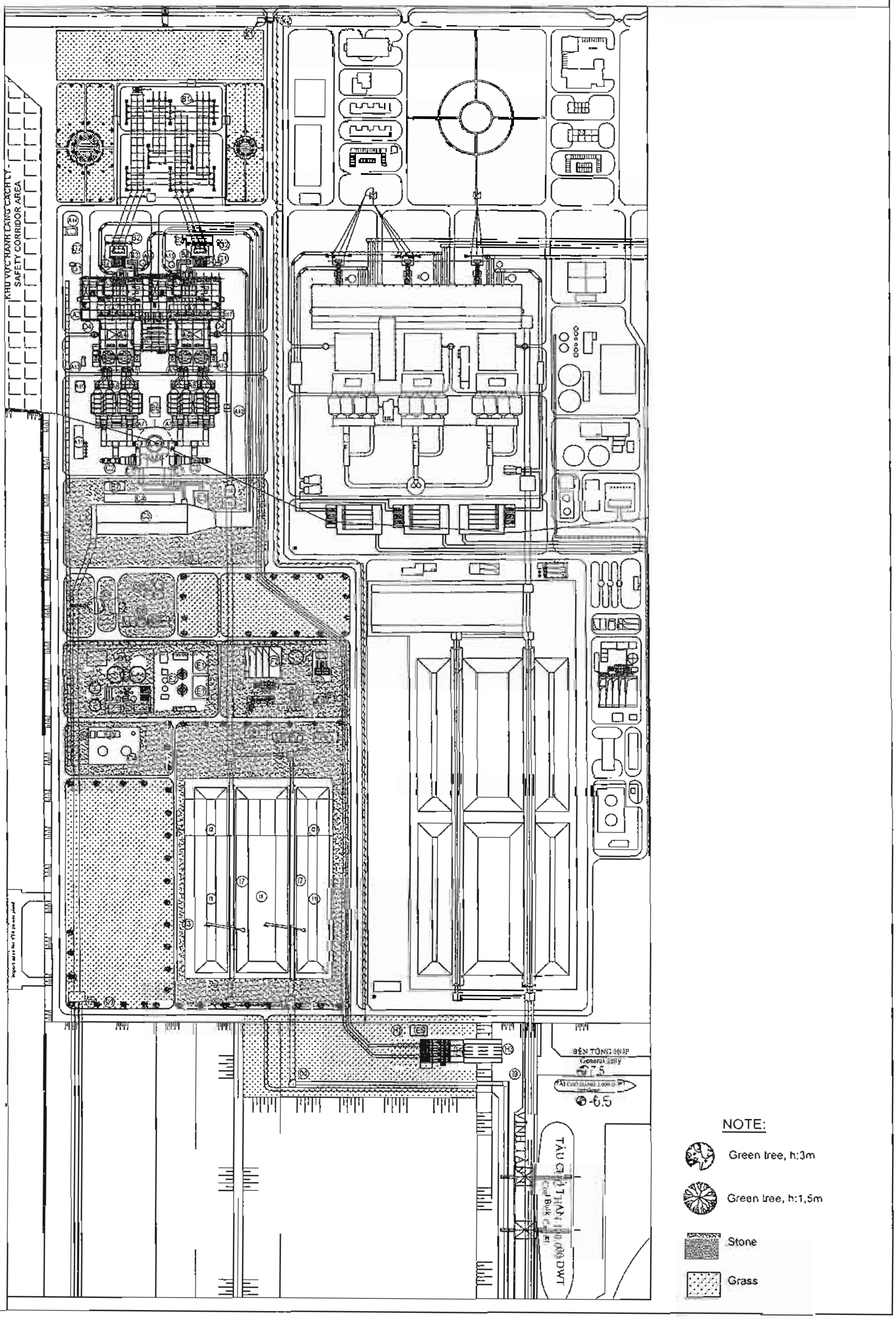


FIGURE 1.13. TRANSPORTATION SYSTEM OUTSIDE VINH TAN 4 TPP

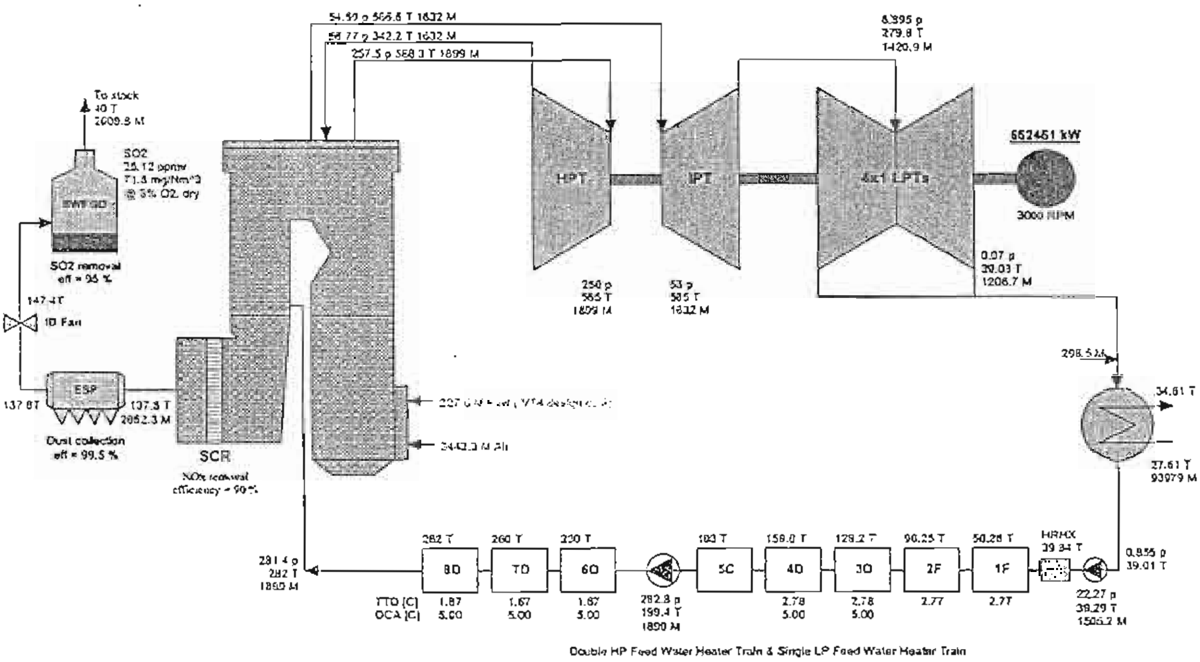
FIGURE 1.14 LAYOUT OF LANDSCAPE



1.4.4. Technological solutions

Conventional steam turbine technology is a conventional power generation technology. It has been developed in a long time with high efficiency, high reliability, long life-time, and capacity of one unit can be reached up to 1000MW. In addition, this technology can be flexible in fuel selection such as oil, coal, etc. Therefore, conventional thermal power technology will be selected for Vinh Tan 4 Power Plant.

Figure 1.15. Technical diagram of Vinh Tan 4 TPP



1.4.4.1. Main mechanical equipment

1. Boiler

Type: super-critical, single reheat, pulverized fuel fired, balanced draft boiler. The furnace is likely to be of the two pass opposed firing type (although the tower type would also be an acceptable option). The boiler will be top suspended from a steel structure. It will incorporate rotary air preheaters, preheating both the primary and secondary combustion air.

Table 1.10. Main parameters (expected) in MCR conditions of boilers

No.	Parameters	Unit	Supercritical (SC)
1	Steam output at MCR	t/h	1755
2	Superheat pressure	MPa	25.75
3	Superheat temperature	°C	568.9
4	Flow of reheat steam	t/h	1.424
5	Pressure of input/output reheat steam	MPa	5.356/5.15
6	Temperature of input/output reheat steam	°C	335/567
7	Water supply temperature	°C	286.4

Source: PECC2,5/2013

Steam flow in BMCR condition is higher about 5% than above steam flow.

2. Steam turbines

Type: super critical parameter (SC), intermediate one-time reheat, single shaft, 3 or 4-cylinders, 2 or 4-exhaust condensing steam turbine.

Table 1.11. Main parameters of the steam turbines (expected)

STT	Turbine parameters	Unit	Super critical (SC)
1	Power output	MW	600
2	Pressure upstream main STOP valve	MPa	25
3	Temperature upstream main STOP valve	°C	565
4	Pressure of re-heat steam	MPa	5
5	Temperature of re-heat steam	°C	565
6	Rated speed	RPM	3000
7	Cooling water temperature	°C	27,6
8	Back pressure	kPa	7
9	Main steam flow	t/h	1755
10	Reheated steam flow	t/h	1,424.0
11	Turbine heat rate	kJ/kWh	7,548
12	Number of extractions		3 HP heaters +4 LP heaters + 1 deaerator

3. Steam turbine generator

Expected type and main parameters of the turbine generator:

- Type: Rotating field, two poles, cylinder rotor, fully enclosed, synchronous
- Steam turbine generator, water to hydrogen, static excitation.
- Out-going net power: 660MW
- Rated power factor (cosφ): 0.85
- Rated frequency: 50Hz
- Excitation system: static excitation.
- Insulation class: F
- Temperature rise class: B
- Rated rotation speed: 3000 rpm
- Rated voltage: 22-30kV (depending on manufacturer)

4. Stack

The calculated height of the stack is 210m and the inner diameter of each stack is 6m.

5. Production technology

Production and operation processes of Vinh Tan 4 TPP are described in Figure 1.16 and Figure 1.17 as follows:

The mixture including coal fuel and air is put into the boiler with a suitable rate in order to get the highest combustion efficiency. The steam generated from the boilers is taken to the steam drum. The steam is then overheated (increase the steam temperature) before passing the noise reduction and decompression equipment. Finally, it runs into the high pressure turbine. From here, the steam current with high pressure and temperature will be dilated to generate forces which are used to rotate the turbine. The temperature releasing from the high pressure turbine, which is lost their temperature due to generating forces, is taking back to the boiler to overheat before going the medium-pressure turbine. The steam releasing from the medium pressure turbine after dilating is taken to the low pressure turbine. The steam dilated and generating forces turns the turbine wings, which also turns the electric generator and taken the power to the power grid. The whole steam volume releasing is taken to the condenser that is an equipment to condense steam. In order to condense the whole volume releasing at the condenser, it is necessary to use the cooling tower or the direct cooling water directly pumped from the sea. The steam after condensing at the condenser is pumped through the low pressure overheated champers to increase the steam temperature. To overheat the condensed water, the steam at the turbines will be extracted for the overheated champers. The condensed water after pumped through the low pressure overheated champers will be the gas remover to eliminate uncondensed gases such as CO_2, O_2 ... exiting in the condensed water. Because those kinds of gases will corrode the pipes and turbine wings if they are exiting in the water at high temperature and pressure. The condensed water after degassing will be pumped the high pressure overheated champers. The water is then transferred to the boiler. Finally, the water continues generating steam and completing a periodic cycle.

Smoke produced in the combustion includes harmful gases to the environment such as NO_x, SO_2... will be evaluated and taken through the ESP, the de-SO_x system (SWFGD) to treat the flue gas to meet the discharge standards at source. Part of unburnt coal (fly ash) will be taken to the fly ash silo and transported to the ash pond.

Industrial wastewater generated during operation process of the plant includes wastewater from water treatment systems, wastewater from the condensated water treatment system, coal contaminated wastewater from the coal storage area, oil contaminated wastewater from oil tanks, wastewater during the cleaning process of treatment equipment of dust and flue gas, boiler and sanitary wastewater from workers.

Figure 1.16. Thermal cycle diagram of Vinh Tan 4 TPP

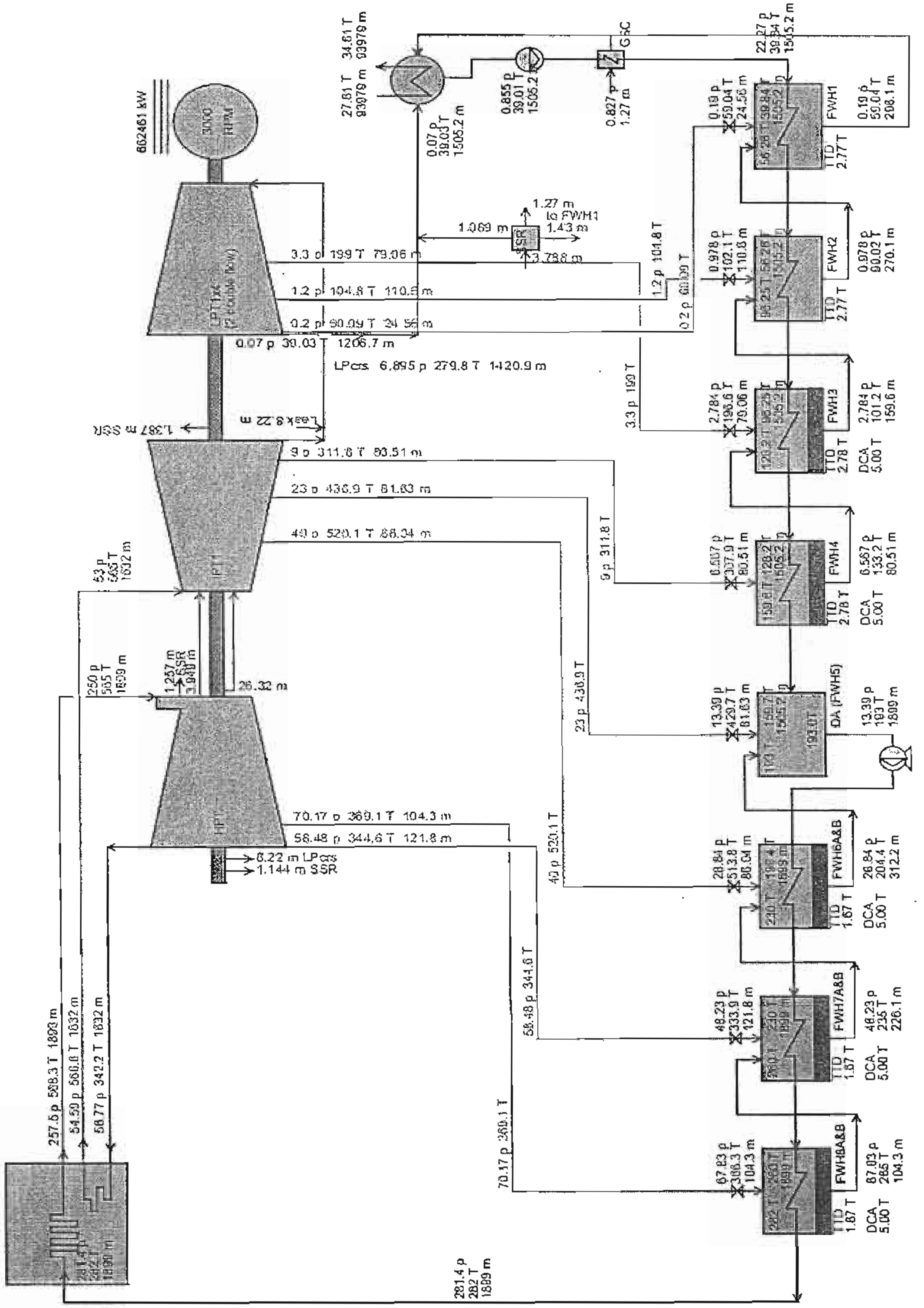
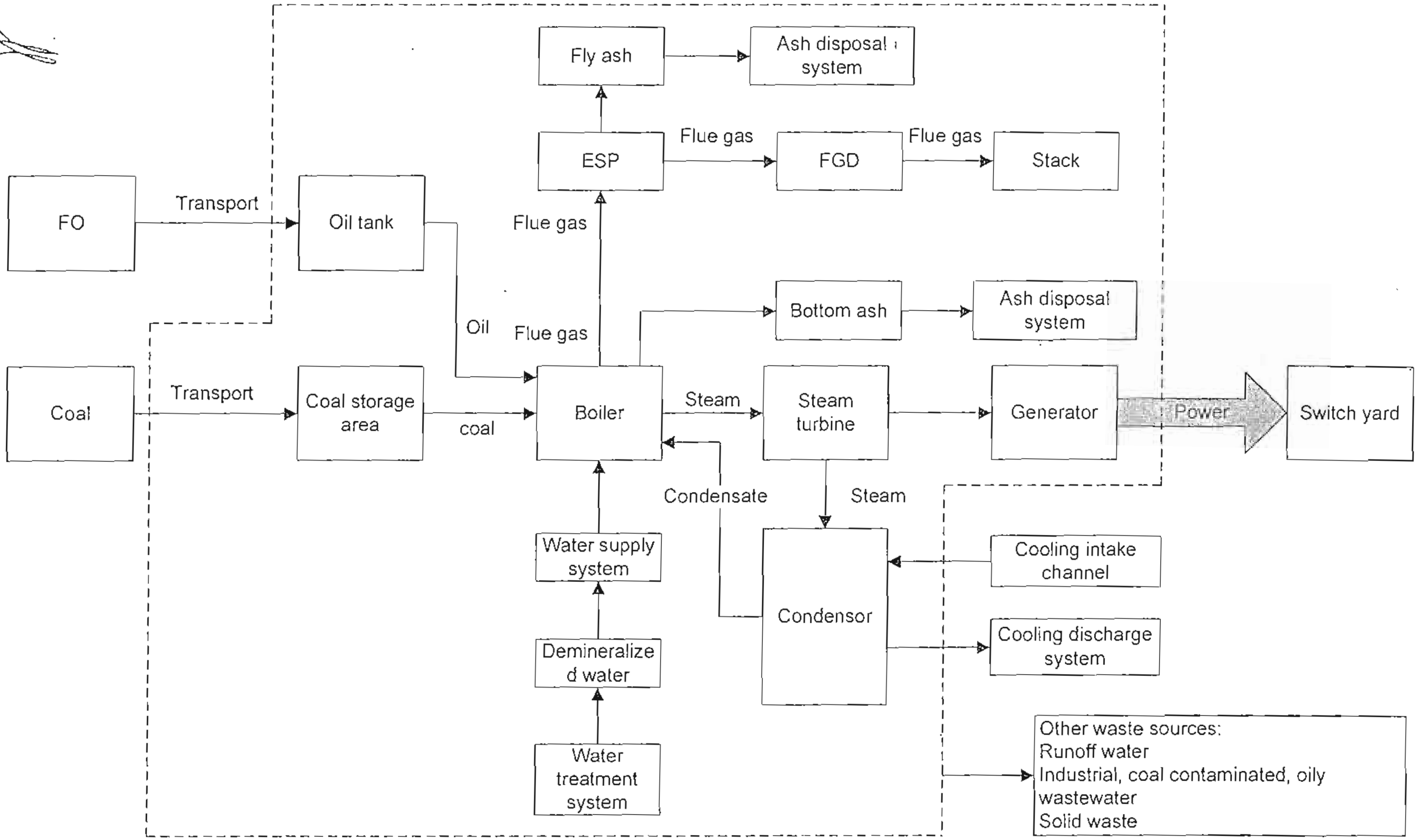


Figure 1.17. Technical diagram of Vinh Tan 4 TPP



1.4.4.2. Auxiliary systems

1. The cooling water supply and discharge system

The cooling water supply and discharge system for Vinh Tan 4 TPP are separately arranged and implemented by the project owner. The cooling water source is taken from the inside of breakwater (the North of coal substation) and discharged to the outside of the breakwater toward the West of Vinh Tan Power Complex. The cooling water flow rate for the Vinh Tan 4 is about $50m^3$.

Chlorine is put in the cooling water (seawater) and pumped from the pump station to the condenser to condense the steam after releasing out of turbine. A part of the cooling water is taken from the main cooling water pipe to supply for the. auxiliary cooling water system. The water then will be taken to the desulfurization system before discharging into the sea.

Each cooling water pump is equipped with: 1 set of valves, drains, screen, pumps to washing screen, in which 4 screens will share a mobile trash rake and equipped with a lift suitable for use in case of maintenance.

To control the growth of aquatic plants in the cooling recirculating water system, chlorine system is used to put chlorine into the water cooling system.

Chlorine is produced by electrolysis of sea water to provide for the cooling water system. Chlorine manufacturing process was carried out as follows: Sea water is pumped from the circulating water pump station → the sand deposition → the preliminary filters → the force pump→ the automatic spraying filters → the NaOCl production → the NaOCl basin → Chlorine for the cooling water system. NaOCl solution is pumped from the tank to the inlet of the station

2. *Coal supply system*

The main fuel used for Vinh Tan 4 TPP 2x600MW will be a coal imported from Indonesia and Australia by 100,000DWT vessels. The coal will be unloaded by the unloaders and transported to the coal storage by belt conveyer, and then supplied to the coal bunker in the main building through bucket wheel stacker/reclaimer. The coal transportation system of this project is designed based on the designed capacity of 1,200MW. Facilities include:

- Coal unloaders.
- Belt conveyors.
- Transfer towers.
- Coal weighing.
- Coal sampling.
- Fire detection/fighting.
- Dust suppression.

The coal yard will be designed to provide a storage capacity of 30 days operation of the power station based on 100% BMCR with the designedly blent coal. There are two coal yards, 1 yard have 3 piles and 2 stacker/reclamers. Equipment for coal storage is includes:

- Measurement
- Magnetic Separators
- Coal Samplers
- Belt and Pulley Cleaners
- Take-up and Tensioning Gear
- Chutes
- Driving Gear

3. FO supply system

The function of the FO receiving, storage and transporting system is ensure safe receiving, storing, heating and forwarding of distillate oil at required pressure and temperature to the boiler for ignition and firing support purposes.

FO oil shall be transported to power plant by 1,000DWT vessels, and then transferred to oil tanks through unloading system at port and pipelines. Oil remained in pipelines during unloading process shall be drained off to oil recovery tank. Oil recovery pump will be used for forwarding the drained oil to oil tanks.

The $2\times1000m^3$ oil tanks shall be provided to store oil fuel. When having the demand, oil will be pumped from oil tanks to burners inside the furnace of boiler. Auxiliary equipment shall be installed on oil pipelines to ensure the safety of system during operation. Unfired oil from boiler will be turned back to oil tanks through return pipelines. On this pipeline, an oil cooler shall be installed.

4. ESP system

The project will install electrostatic precipitators (ESP) for treatment of dust in flue gas before discharge to the environment. This device is commonly applied and effective in the thermal power plants with dust removal efficiency up to 99.9% and concentration of dust in the smoke at the ESP outlet is smaller than $170mg/Nm^3$.

Major equipment of ESP includes the shell and cover structure, electrodes, vibrating hammer system, rectifier transformers, structural support and ash hoppers delivering to the ash transport system,...

An electric field is created between the discharge electrode and collector electrode plates. When the flue gas passes through this electric field, the dust grains will be negatively charged and attracted towards the surface of the positively charged plates. To control the thickness of the dust layer on the positively charged plates, a hammer/rapper type system will regularly impact on the positively charged plates to make the dust grains fall off into the the ash receiving hoppers below. From there the ash is transported to the fly ash silo.

During the normal operation, the output temperature of the hopper of the ESP is about 130°C. Under the abnormal operation, the highest temperature of the ash is 250°C (in half an hour).

5. SWFGD system

The seawater FGD system is arranged before the stack and after ESP, and it can be divided into two areas: absorber tower area and aeration tank area.

The absorber tower area includes absorber, gas duct (including damper), booster fan, and seawater booster water pump house arranged on the two sides of the area. The aeration tank area is arranged near the absorber tower area and a road passes through the middle to facilitate maintenance of water pump, aeration fan and booster fan. Two units are provided with one aeration tank and six aeration fans.

6. De- NOx system

Vinh Tan 4 TPP will use the low NO_X burner to mitigate the NO_X in the flue gas. In this method, wind is provided for all burners, but only part of the wind is mixed with coal in the evaporation phase, the rest is taken to the end stage of the flame to complete fire process. To design low NO_x burners can reduce NO_x emissions from 30% to 60% compared to conventional burners.

Vinh Tan 4 TPP will use the method of burning NO_x in boilers, the NO_x concentration at an output of the stack is less than 552.5mg/m^3.

7. Ash handling system

The total ash amount generated from power plant is about 137,248 tons per year. The bottom and fly ash handling system of Vinh Tan 4 power plant is designed to meet demand of two units 2×600MW with characteristics of design coal. Depending on the current status of Vinh Tan 4 TPP, the fly ash will be removed by compressed air, bottom ash will be removed by submerged scraper chain conveyor.

The fly ash after collected at fly ash silo will be mixed with water in the ratio of 1:3 in order to reach the moisture content of 20-30%. At this moisture content, the mixture will be shortened and can prevent the fly ash from releasing to the environment. Next, the mixture will be transported to the dump site by dedicated vehicles. The dry slag will be taken to the dump site and arranged to become globs in line, the slag are put in layers and spraying adequate water to keep the moisture of the globs. When reaching the final height, the dump site will be covered by unpermeatable membrane to prevent the water from pouring into the slag. On the surface of the membrane will be put soil and grass to reduce the rainwater that can permeate to the slag in order to mitigate pollution.

8. Hydrogen generator system description

The hydrogen generator system includes hydrogen generator equipment and hydrogen storage tank to supply hydrogen for normal make-up to the electric generator, hydrogen cooling systems. Electrolysis method is applied to produce hydrogen. Demineralised water is received in an atmospheric storage tank and provides make-up to electrolytic cells. Potassium hydroxide is added to the cells to form the electrolyte. An impressed direct current from power transformer/rectifiers create an electromotive force at the electrodes of the cells where the water disassociates to hydrogen and oxygen gases. The by-product oxygen is released to the atmosphere.

9. Fire prevention and fighting system

Fire prevention and fighting system of Vinh Tan 4 Power Plant will be designed to ensure a safe operation environment for human and equipment. This can be achieved by laying equipment out with sufficient separation and segregation to minimize the risks from fire and explosion, by the selection of suitable equipment and materials and by providing a suitable fire prevention and fighting system to all areas of the plant. The fire prevention and fighting system will be designed in accordance with the National Fire Protection Association (NFPA) codes, the Vietnamese Standards (TCVN). The design of the fire prevention and fighting system will be based on one fire in the plant area at a time with two (2) adjacent fire hydrants in operation. The system will be sized to meet the requirements of the largest single source of fire. The fire prevention and fighting system for this plant includes the indoor and outdoor hydrants, the fire detection, and alarm systems will be provided to monitor the various zones in the plant. In addition to water fire extinguishing system, CO_2 system, foam fire extinguishing facilities will be provided according to the fire characteristics of each protection zone of the power plant.

10. Raw water treatment system

Freshwater is usually supplied for systems in Vinh Tan 4 TPP such as: boiler makeup system, closed circulating cooling system, domestic water system, Sea-FGD water system, firefighting system, coal handling system, dust depression system, hydrogen generation system, water system at port and other demands.

The raw water planned to supply for the Vinh Tan 4 Power Plant will be taken from seawater in Vinh Tan area. Vinh Tan 4 Power Plant is in charge of building pipeline system from cooling water pump station to the Plant and water treatment system as well as storage tanks. Technical schemes capable of large scale sea water desalination and wide application mainly include distillation method and reverse osmosis method (SWRO). See water will be settled and treated through ultrafiltration system (UF-Ultrafiltration) then desalination by reverse osmosis system two phases (RO). Concentrated flow is returned environment. Clean water is stored for use in the production and operation needs.

11. Demineralized water treatment system

The demineralized water treatment system will treat water from seawater desalination system to supply demineralized water for boilers. Demineralized water quality needs to be in accordance to very strict requirements in order to ensure the safe and effective operation for the entire Plant. Total amount of raw supplied for demineralized water treatment system is approximately $86m^3/h$.

To ensure a stable and reliable operation of the entire plant, demineralized water treatment system has to be designed with enough capacity for backup in case of regerating resins, the demineralized water treatment system will be designed with configuration of 2x100%.

According to the water source quality and the water quality requirement of supercritical coal-fired unit, the process of boiler make-up water treatment system is as follows: permeate water from BWRO system→ degasser→ mixed bed exchanger → demineralized water basin → demineralized water pump→ demineralized water tank→ demineralized water pump→ main station building.

Two-Mixed bed are provided where in on mixed bed exchanger will be regenerated once every 24 hours and the standby skid will come in to service when one of the exchanger goes in for regeneration.

12. Chemical supply system

Chemical dosing system for boiler feed water is designed including three types of chemical such as: Ammonia, Hydrazine and Phosphate.

Chemical dosing system for feed water treatment system and discharge water includes three types of chemical as: NaOH, HCl, coagulation and flocculation aids, etc..

Chemical dosing system will be equipped for two units.

13. Wastewater treatment system

Wastewater generated from Vinh Tan 4 TPP will be divided into two types, namely industrial wastewater and domestic wastewater.

Chemical wastewater treatment system of Vinh Tan 4 Power Plant will be designed with capacity of 50 m^3/h. Configuration of some equipment in this system such as coagulation, flocculation, sedimentation, gravity filter and pumps is 2x100% for backup in case of incidents.

Oily wastewater treatment system of Vinh Tan 4 Power Plant will be designed with capacity of 10 m^3/h. Configuration of oil separator is 2x100% for backup in case of incidents.

Coal contaminated wastewater treatment system of Vinh Tan 4 Power Plant will be designed with capacity of 50 m^3/h. Configuration of some equipment in this system such as coagulation, flocculation, sedimentation and pumps is 2x100% for backup in case of incidents.

Domestic wastewater treatment system of Vinh Tan 4 Power Plant will be designed with capacity of 6m^3/h. Configuration of some equipment in this system such as preliminary sedimentation, biofilter and pumps is 2x100% for backup in case of incidents.

14. Power supply

The power supply source for the power plant in operation phase includes 11kV and 0.4kV. The power level can be adjusted depending on the manufacturer standard in the next stage.

The power supply for additional load is designed based on the principle of ensuring the standby regime 2x100%.

For each unit, auxiliary power supply is taken from the IPB branch between GCB and GSUT through two (02) UAT type 3-phase, 3 coils 100/35-65MVA and equipped with the under load transformer system. Those transformer also supplies power for automatical loads.

The DC auxiliary electric system includes the DC system for each set of machinery and common machinery of the plant.

The DC system includes the three 220V DC battery system designed with the capacity of 3x50%, supply power for the set of machinery unit 1, unit 2 and common sub-loading of the plant. Each battery system comprises 1 set of battery and 2 chargers.

The net control system for each unit and plant are equipped with two continuously power supply equipment 230V AC-UPS (2x100%), these systems are received the power from the 220V DC system and supply for the sub-loading.

1.4.5. List of machines and equipment

The main construction equipment includes as follows:

Table 1.12. List of machines and equipment used in the construction stage

No.	Names	Specifications	Capacity	Unit	Quantity
1	Hydraulic crane	FZQ2000	80t	Set	2
2	Tower crane	QZ80EA	80t.m	Set	1
3	Tower crane	QZ80EA	80t.m	Set	1
4	Crawler Cranes	M250S2	250t	Set	1
5	Crawler Cranes	IHICCH1500-3	150t	Set	1
6	Crawler Cranes	P&H7150	150t	Set	2
7	Crawler Cranes	QUY50	50t	Set	2
8	Portal crane	HC248	150t	Set	1
9	Portal crane	RT980	80t	Set	1
10	Portal crane	QLD-16G	16t	Set	1
11	Mobile crane	NK-500E3	50t	Set	1
12	Mobile crane	NK-400	40t	Set	1
13	Mobile crane	QY25	25t	Set	1
14	Mobile crane	QY16	16t	Set	2
15	Mobile crane	QY12	12t	Set	1
16	Crane	Model 300TM-D	30t/6t	Set	2
17	Single crane	5t/10.5m	5t	Set	1
18	Gantry crane	40t/10t/42m	40t/10t	Set	3
19	Gantry crane	20t/5t/42m	20t/5t	Set	2
20	Capstan	STJ-A 1000kg	1000kg	Set	2

21	Hydraulic hoisting device	GYT-200(II)type	200t	Group	4
22	Electric winch	DZS-III		Set	1
23	Excavator	PC300	$1.5m^3$	Set	1
24	Drilling machine			Set	4
25	Bulldozer			Set	1
26	Roller	ZL50	$3m^3$	Set	1
27	Roller	ZL30	$2m^3$	Set	2
28	Concrete batch plant	HZS90	$90m^3/h$	Set	1
29	Standby concrete batch plant	HZS50	$50m^3/h$	Set	1
30	Concrete mixer	MR45-T	$6m^3$	Set	5
31	Concrete pump	HBT-60	$60m^3/h$	Set	3
32	Specializing devices	JTGS1.6Q		Set	4
33	Compactor	HW120		Set	10
34	Hydraulic lift truck	QGZH480	400t	Set	1
35	Specializing truck	SZG9200D	40t	Set	1
36	Trolley	SH273KA	30t	Set	2
37	Specializing truck	DJ250	25t	Set	2
38	Truck	EQ-144	8t	Set	2
39	Truck	CQ1260	15t	Set	10
40	Truck	EQ1141G1	5t	Set	5
41	Skip truck	ND2628	15t	Set	3
42	Diesel truck	F10D	1t	Set	10
43	Caterpillar crane	5250	250t	Set	1
44	Mobile crane	TG-1500E	150t	Set	1
45	Mast crane	WT-4000B	400t	Set	1

List of machines and equipments of Vinh Tan 4 TPP and its port in the operation stage are shown in the following table:

Table 1.13. List of machines and equipment for Vinh Tan 4 TPP and its port in the operation stage

VINH TAN 4 THERMAL POWER PLANT		
No	**Equipment Name**	**Quantity**
1	Boiler	2
2	Steam turbine	2
3	Generator	2
4	Coal supply system	
	Coal unloading equipment	1
	Coal flow measurement	1
	Coal crusher	1
	Conveyor belt	6
	Coal Samplers	1
	Fire control system	1 system
	Coal Bunker	2
	Coal supplier unit	2
	Coal crusher machine	1
5	Oil supply system	
	Fuel oil unloading	2
	Fuel oil filter	2
	Oil separator	1
	Oil heater	2
	Pure Oil separator	2
	Pump, valve system	1
6	Water treatment and waste water system	
	Tank and pond system	1
	Water and chemical pump system	1
	Air fan system	1
7	Air-condition system	
	Cooler	1 system
	Cooler (FCU)	1 system
	Fan system and wind pipe	1 system
8	De- SO_2 system(SeaFGD)	
	Absorber	2
	Water pump system	1
9	ESP	2

VINH TAN 4 THERMAL POWER PLANT		
No	Equipment Name	Quantity
10	Crane and lifting equipment	1 system
11	Fire fighting system	1 system
	CO_2 fire extinguisher	
	Foam fire extinguishing system	
	Fire alarm system	
12	The hydrogen production system	
	Machines for the production of hydrogen	2
	Intermediate-pressure compressor	2
	High-pressure compressor	2
	Dry cooling equipment	2
	Dry-type adsorption	2
	Purity analyzer	1
	Piping systems, valves	1
13	Ash disposal system	1
14	Air compressor system	1
15	CO_2 supply system	1
16	Cooling water system	1
VINH TAN 4 PORT		
1	Unloading equipment	2
2	Coal conveyor	2
3	Tanker clean machinery	2
4	Should represent	1.6 m
5	Electric winch	1
6	Grabbing bucket	2
7	Tractor	1
8	Trailers	1
9	Back up	1
10	Magnetic Separators	1

Source:PECC2,4/2013

Remarks: the above machines and equipment are planned to import from Germany, USA, China... The detailed source of equipment will be listed in the next stage.

1.4.6. Material, fuel (input) and types of product (output) of the project

1.4.6.1. Coal fuel

The Bituminous coal source imported from Indonesia or Australia for Vinh Tan 4 TPP has obtained the following characteristics.

Table 1.14. Technical parameters of the coal fuel

Parameters			Unit	Value
Industrial analysis	Gross Calorific Value	CV gar	kcal/kg	5,800
	Moisture Total (As received)	Mt	%	30
	Ash (Air Dry Basis)	A	%	6
	Volatile Matter (Air Dry Basis)	V	%	38
	Fixed carbon (air Dry Basis)	FC	%	42
	Inherent moisture (Air Dry Basis)	M	%	15
	Sulfur (Air Dry Basis)	St	%	0.8
Chemical analysis	Carbon (Dry Ash Free)	C	%	64
	Hydrogen (Dry Ash Free)	H	%	4.1
	Oxygen (Dry Ash Free)	O	%	15
	Nitrogen (Dry Ash Free)	N	%	0.8
	Sulfur (Dry Ash Free)	S	%	0.8
Coal ash melting temperature	Hargrove Grind ability Index	HGI	/	60
	T1 Initial Deformation, ID	DT (T1)	^0C	1,350
	Hemispherical, HT (H-1/2W)	HT	^0C	1,440

Source:PECC2, 4/2013

Coal consumption of Vinh Tan 4 TPP is presented in the following table:

Table 1.15. The total coal consumption of Vinh Tan 4 TPP

Coal Demand	Unit	Value	Note
Capacity	MW	1200	Net capacity
Heating values (HHV)	kJ/kg	24284	
Consumption level	t/h	425.7	
	t/day	10,217	
Operation in 6,500 hour	ton	2,767,223	full load
Consumption level	g/kWh	323.9	Net efficiency

Source:PECC2, 4/2013

1.4.6.2. FO fuel

The oil fuel used for Vinh Tan 4 TPP is FO with total coal demand of about 6000 m^3/year; characteristics of the fuel oil are presented in the following table:

Table 1.16. FO fuel characteristics

Parameters	Value	Testing methods
Density at 15°C, mt/m^3	=< 0,991	TCVN 6594:200 (ASTM D1298)
Kinematic viscosity at 50°C, cSt	=< 180	ASTM D445
Sulfur content by mass	=< 3,0%	TCVN6701:2000 (ASTM D2622/ ASTM D129/ ASTM D4294
Freezing point, °C	=< +24	TCVN3753:1995 ASTM D97
Ash content, %	=< 0,15	TCVN2690:1995/ASTM D482
Water content by volume	=< 1%	TCVN2692:1995/ASTM D95
Contaminant content by mass	=< 0,15%	ASTM D 473
Conradson carbon content by mass	=< 16%	TCVN6324:2000/ASTM D189/ASTM D4530
Flash point, °C	66	TCVN6608:2000/ASTM D3828/ASTM D93
HHV, kcal/kg	>=10.000	ASTM D240/ASTM D4809

Source: PECC2, 4/2013

Oil is transported to the plant by waterway. At ports, oil will be discharged and transferred to the oil tank of the plant.

1.4.6.3. Ash

1. Ash volume

The total ash volume generated during the production process of Vinh Tan 4 TPP is about 30ton/hour and presented in the following table:

Table 1.17. The total ash volume of the plant

	Unit	Value	Remark
Fuel ash content	%	4.94	
Total fly ash volume	ton/h	18.93	Dry

	Unit	Value	Remark
	ton/year	123,031	6500 hour
Total bottom ash volume	ton/h	2.19	Dry
	ton/year	14,217	Operation in 6,500 hour
Total ash volume	ton/year	137,248	Operation in 6,500 hour
	m^3/year	114,373	Ash density is 1.2 ton/m^3

Source: PECC2, 4/2013

2. Ash characteristics

The ash characteristics are presented as follows:

Table 1.18. The ash characteristics of Vinh Tan 4 TPP

Ash content analysis (dry)	SiO_2	%	28.57
	$Al2O_3$	%	18.90
	Fe_2O_3	%	12.54
	CaO	%	11.01
	MgO	%	4.15
	TiO_2	%	0.66
	Na_2O	%	4.50
	K_2O	%	0.88
	Mn_3O_4	%	0.17
	P_2O_5	%	0.54
	SO_3	%	19.08

Source: PECC2, 4/2013

1.4.7. Schedule of the project

Vinh Tan 4 TPP with the capacity of 2x600MW plans to operate in the period of 2017 -1018, allowed by the government (located in the list of power source of Master Plan VII for National power development).

However, under the difficult circumstances of the global economy as well as the economy in the area, raising funds for the construction of power projects are facing many difficulties. Therefore, based on the construction time of thermal power projects with the same scale from 48 to 50 month, the process of Vinh Tan 4 TPP will be in a period from 2018 to 2020 depending on the ability of raising funds (the ECA commercial fund and ODA fund). The detailed schedule and process of the plant are presented in the Figure 1.21.

1.4.8. Total investment cost

Total Investment Cost (TIC) has been prepared on the second and third quarter of 2012. Vinh Tan 4 TPP will include the main following scopes:

- Construction of Vinh Tan 4 power plant;
- Dredging for channel and in front of port;
- 100,000DWT port for Vinh Tan 4;
- Facilities belonging to scope of Infrastructure project: Construction power system; access road to ash yard, Ong Do mountain ash yard; leveling for Vinh Tan 4; Operation Staff Quarter of Vinh Tan 4.

TIC has been prepared in compliance with Decree No.112/2009/ND-CP dated February 10th, 2009 issued by the Government; the forms prepared in accordance with Circular No.04/2010/BXD dated May 26th, 2010 issued by Ministry of Construction. TIC in Investment Project Report stage will include as follows:

- Construction cost;
- Equipment cost;
- Compensation, site clearance and resettlement;
- Project management cost;
- Consultancy cost;
- Other costs;

TIC of Vinh Tan 4 using SC technology will be about 1,726,028,072 USD (equivalent to 35,949 billion dong.

Table 1.19. TIC for SC technology

No.	Description	Value before VAT (USD)	VAT (USD)	Value after VAT (USD)	Equivalent to billion VND
I	Construction cost	210,284,415	21,028,441	231,312,856	4,817.8
II	Equipment cost	870,427,459	87,042,746	957,470,205	19,942.2
III	Compensation, site clearance and resettlement cost	2,113,513	211,351	2,324,864	48.4
IV	Project management cost	3,562,971	-	3,562,971	74.2
V	Consultancy cost	12,213,063	1,219,866	13,432,929	279.8
VI	Other costs	313,404,794	2,893,790	316,298,584	6,587.9

No.	Description	Value before VAT (USD)	VAT (USD)	Value after VAT (USD)	Equivalent to billion VND
VII	Contingencies	201,625,662	-	201,625,662	4,199.5
1	Physical contingency	70,600,311		70,600,311	1,470.5
2	Price contingency	131,025,352		131,025,352	2,729.0
TOTAL		1,613,631,878	112,396,195	1,726,028,072	35,949.7

Source: PECC2, 9/2012

The investment costs for environmental items for Vinh Tan 4 power plant are presented in the following table:

Table 1.20. The investment costs for environmental items

No	Items	Cost (VND)
1	Stack	152,020,000,000
2	ESP	383,442,000,000
3	FGD	980,111,300,000
4	Automatic monitoring system	11,990,000,000
5	Sea water treatment system	268,210,000,000
6	Ventilation and air condition system	6,770,000,000
7	Discharge water treatment system (consists of domestic wastewater treatment system, coal and oil contaminated waste water treatment system, and industrial waste water treatment system)	89,652,000,000
8	Solid waste and hazardous waste control system	4,360,000,000
9	Landscape	3,500,000,000
Total		**1,900,055,300,000**

Note: the above costs were calculated based on fix prices in 2012.The actual cost depends on the time of purchase / installation of equipment.

1.4.9. Project management and implementation

1.4.9.1. Investment preparation phase

Including five stages: evaluation of investment projects, technical design and total estimates cost, selection and technical consultation, preparation EPC bidding documents and capital arrangement.

1. Evaluation of investment plan

The investor must submit the document to the authority to apply for the necessary licenses and certificates. Investment project assessment stage must be carried out within 45 days after receiving a complete dossier.

2. Technical design and general estimation

In case of the project must prepare technical design as required by state agencies, investors will submit the technical design and total estimate cost (if any) to competent authorities for approval. Ministry of Trade and Industry will preside along with the related Ministries appraisal of technical design and total estimate cost and approval as a basis for the implementation in the next steps.

3. Technical selection and consultant

Include the following:

- Review basic design;
- Prepare bidding documents, technical design and the total estimated cost (bidding documents shall be made two-stages, in parallel with the bid evaluation stage 1, the Consultant will prepare technical designs and cost estimate);
- Bid evaluation;
- Contract negotiation;
- Construction supervision;
- Acceptance, testing and handing over the plant.

4. The EPC bidding documents

Scope of work of each bid package will be shown in the design bidding documents and bidding documents for Procurement and Construction:

- Design: scope of bidding package relating to the detailed design for construction of the tems, the interface and connection system.
- Procurement and Construction: scope of bidding package includes the entire parts that are out of Design Bidding Package.

1.4.9.2. The construction investment stage

During the construction phase, the investor will manage directly in the implementation of procedures for land application, clearance compensation, design and construction organization, and other administrative procedures until the end of the construction stage. The scope of work in the project investment phase will include as follows:

- Land lease agreement.
- Certificate allows the exploitation of natural resources.
- Compensation and clearance.
- Purchase of equipment and technology.

- Conduct surveys and construction design.
- Construction.
- Quality control as contract.
- Equipment and construction management.
- Testing, acceptance, determination the total of final investment cost, EPC contractors hands over and warranty.

1. Construction organization

Main construction works will include:

- Site preparation.
- Organization for construction.
- Technical survey and investigation.
- Soil improvement (if any).
- Sea-encroached area (if any).
- Excavation
- Leveling.
- Pile construction
- Pile experiments
- Production and construction of concrete.
- Steel structure.
- Brick and stone works.
- Mixing and use of construction mortar.
- Finishing.
- Road works.
- Basement works.
- Main construction works: the plant, flues, and canals
- Ventilation and air conditioning.
- Drainage systems, fire prevention and fighting systems.
- Water supply systems for construction.
- Power grid and communications.
- The process of installation of equipment and pipes
- Transportation and installation of overweight and overlong equipment
- Work safety and prevention of environmental pollution
- Other auxiliary works.

2. Main construction material

Main construction materials to be used for the plant consist of below:

- Cement; sand…
- Free stone, break stone, macadam ....
- Building bricks, tiles, roofing tiles;
- Sheet metal, insulating sheet metal;
- Water paint, coloured paint, mastic, painted steel structure and other finishing materials ...
- Ready-mix concrete;
- The type of concrete admixtures, Sika ....
- Admixtures, waterproofing materials, corrosion protection, chemical resistance (for tanks);
  Asphalt concrete ...
- Iron, steel, bolts ...
- Structural steel, floor plate grating, handrails stairs...
- Other materials for the construction and building ...

Materials for the construction of power plants must have clear origin and must be approved by the investor for construction. Volume of main materials is presented in the following table:

Table 1.21. The material volume for Vinh Tan 4 TPP

No	Items	Unit	Quantity
1	Stone	m^3	7,600
2	Reinforce concrete pile d400	100m	20
3	Reinforce concrete pile d1000	100m	20
4	Bore pile	100m	50
5	Brick	m^3	17,550
6	Lean concrete	m^3	19,000
7	Concrete M200	m^3	1000
8	Concrete M300	m^3	265,100
9	Reinforcement bar	tones	25,500
10	Formwork	$100m^2$	16,600
11	Steel Structure	Tones	17,400
12	Roll door	m^2	200

No	Items	Unit	Quantity
13	Steel door	m^2	6,100
14	Window	m^2	3,000
15	Clading for roof and wall	$100m^2$	605
16	Plastering (d=1.5)	m^2	92,000
17	Ceramic tile	m^2	55,400
18	Flooring tile	m^2	34,650
19	Paint for steel structure	m^2	296,700
20	Paint for wall, ceiling	m^2	310,000
21	Geotextile fabric	$100m^2$	10,000
22	Sanitary equipment	unit	130
23	Cement PC40	Tones	90
24	Sand	m^3	150
25	Break stone 4x6 cm	m^3	90
26	Break stone 1x2 cm	m^3	185
27	Reinforcement bar	tones	31
28	Door, Window	m^2	470
29	Paint	m^2	4800
30	Plastering	m^2	4800
31	Formwork	m^2	2275
32	Brick	m^3	152

Source: Investment project – PECC2,9/2012 (The data in the above table is for reference use and the accurate data will be updated in the next construction stage)

Table 1.22. The total material volume for 100,000DWT Port of Vinh Tan 4 TPP

No	Items	Unit	Quantity
I	**Port**		
1	Steel pipe φ1000 (δ=18mm)	t	6,824.36
2	Steel pipe on the sea Φ1000mm (no.200)	no.	400.00
3	Concrete pile cap, C40	m^3	5,144.83
4	Prestressed concrete,C50	m^3	2,510.10

No	Items	Unit	Quantity
5	Installation of concrete slab	no.	432.00
6	concrete slab,C40	m^3	2,004.66
7	Prestressed concrete beam, C50	m^3	3,507.09
8	Installation of Prestressed concrete beam	no.	192.00
9	Concrete beam, C40	m^3	1,235.57
10	Prestressed concrete cross beam,C50	m^3	1,395.24
11	Installation of Prestressed concrete cross beam.	no.	112.00
12	Concrete cross beam,C40	m^3	1,838.76
13	Precast wharf structure	m^3	686.22
14	Installation of wharf structure	nos.	56.00
15	Stop bead concrete, C40	m^3	60.32
16	Anchorage pole 1000KN	no.	22.00
17	Installation of Anchorage pole 1000KN	no.	22.00
18	Anchor block,C40	m^3	13.61
19	Rubber fender (SUC1250,RO,2 poles/ plate)	no.	30.00
20	Installation of Rubber fender (SUC1250,RO,2 poles/ plate)	no.	30.00
21	Rubber fender (DA-A600Hx2000L)	no.	44.00
22	Installation of Rubber fender (DA-A600Hx2000L)	no.	44.00
23	Rubber fender (DA300Hx4800L)	no.	4.00
24	Installation of Rubber fender (DA300Hx4800L)	no.	4.00
25	Installation of Steel crane rail QU100	m	966.00
26	Protected Anode	no.	800.00
27	Installation Protected Anode	no.	800.00
28	Corrosion protection for steel tube pipe	m^2	34,557.52
29	Pile head Concrete,C40	m^3	1,605.71
30	Steel Baluster	m	540.54
31	XYPEX	m^2	30,505.02
32	Blanket	m^3	822.25
II	**Approach bridge**		
1	Structure of Approach bridge		
1.1	Bored pile (Φ1000mm, depth of 24m)	m	316.80

No	Items	Unit	Quantity
1.2	Test pile by ultrasonic	no.	12.00
1.3	Steel box for pile protection	t	49.12
1.4	Pile concrete,C30 (Φ1000mm)	no.	12.00
1.5	Pile concrete,C30 (Φ1000mm)	m^3	362.85
1.6	Steel pile Φ800 (δ=16mm) under water	no.	38.00
1.7	Steel pile Φ800 (δ=16mm)	t	452.58
1.8	Pile head Concrete,C40	m^3	96.82
2	**Super structure of Approach bridge**		-
2.1	Pour concrete horizontal beams, C40	m^3	329.47
2.2	The precast prestressed concrete core,C50	m^3	360.36
2.3	Installation of The precast prestressed concrete core	no.	60.00
2.4	Pour concrete cover, C30	m^3	156.29
2.5	Edge, C40	m^3	15.18
2.6	Steel rail	m	202.40
2.7	Cover layer	m^3	92.68
2.8	Concrete,C40	m^3	422.88
3	**Corrosion protection measures**		-
3.1	Anti-corrosive paint for concrete (XPYEX)	m^2	2,669.28
3.2	Anti-corrosive paint for steel	m^2	1,575.82
3.3	Protected Anode	unit	76.00
3.4	Installation of Protected Anode	unit	76.00

Source: Investment project – PECC2,9/2012 (The data in the above table is for reference use and the accurate data will be updated in the next construction stage)

Table 1.23. The construction material volume for the sea-encroached embankment

Item	Unit	Quantity
Consolidated Geotechnical grid	$100m^2$	547,02
Stone 10-100kg	m^3	167755,76
Stone 50-150kg	m^3	8767,08
Macadam 4x6	m^3	6525,44
Macadam 2x4	m^3	6614,69
Stone D50	m^3	15539,26

Item	Unit	Quantity
Geotextile	$100m^2$	162,74
Close-packed small rubble 60cm	m^3	3149,85
Macadam thick 20cm	m^3	1049,45
Lined Concrete stone 4x6M100	m^3	524,98
Concrete stone 2x4 M250	m^3	2624,88
Breakwater Wall concrete stone 2x4 M300	m^3	4231,30
Concrete layer Haro 3.1T	m^3	18846,60
Tetrapod 9.7T	m^3	73422,48

Source: Investment plan – PECC2,9/2012 (The data in the above table is for reference use and the accurate data will be updated in the next construction stage)

3. Construction layout

Construction layout of Vinh Tan 4 TPP will be included five (5) area with total area is about 33.86ha (excluded worker camps) used to store materials, equipments, and for construction of the power plant and port area. The arrangement of storages in construction laydown area will be designed by EPC Contractor.

Location of each area in Vinh Tan 4 Power Plant will be shown in Figure 1.20 as follows:

- Construction organization area No.1: total area is about 6.2ha, located in the North of the Plant, to construct items in the Power Plant.
- Construction organization area No.2: total area is about 1.97ha, located below the main building area, to construct items in the Power Plant, and treat wastewater in the plant .
- Construction organization area No.3: total area is about 5.49ha, located in the South of the Plant, close to the cool store, to construct items in the Power Plant, Coal Yard and Port.
- Construction organization area No.4: total area is about 20.2ha, located near the coal substation of the plant. The coal substation will be leveled to the elevation of +5,0m (Hai Do Elevation System), to construct the plant.

In addition, the planned isolated area with area of about 3.54ha will be used for worker camp and this land will be returned for the isolated area after completing construction work.

4. Sources of equipment and materials

All the construction materials of Vinh Tan 4 power plants such as cement, sand, rock and timber are anticipated to be taken from the neighbouring areas of plant. Reserves and supply capacity of these materials were investigated and assessed carefully.

- Bricks and tiles can be supplied from the brick factories at Long Thanh, Bien Hoa.

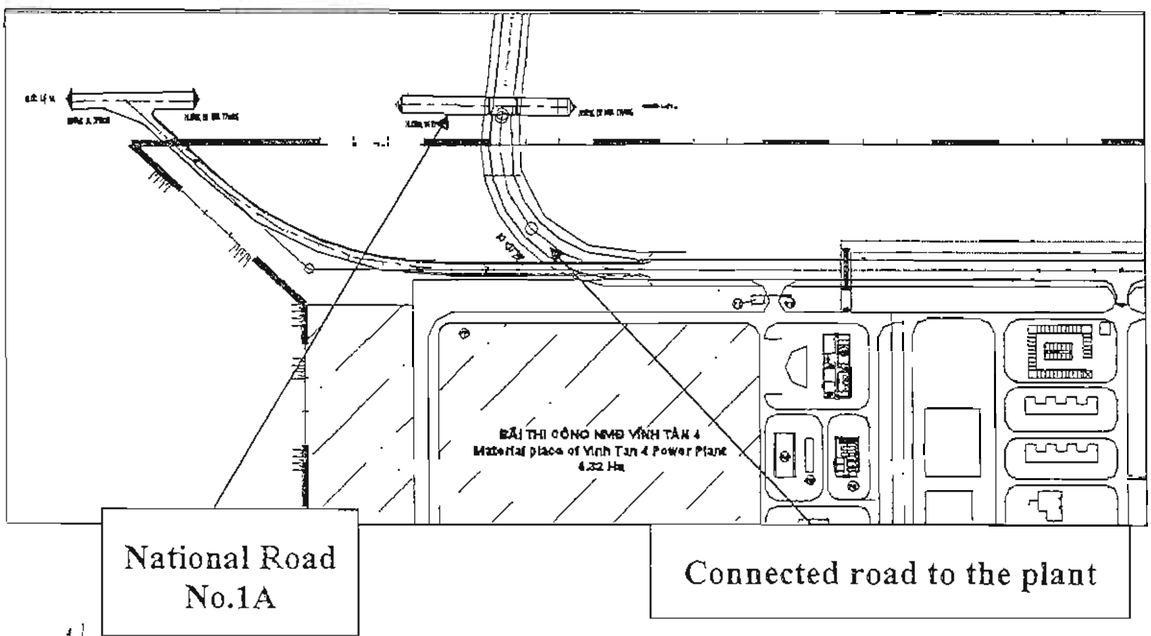
- Binh Thuan is located in the area endowed with plentiful and high-quality materials such as cement from Sao Mai, Ha Tien, Holcim Cement factories.
- Sand can be supplied from the pits with good quality and rich reserves is Song Luy sand mining near Song Luy bridge on Highway 1A, about 45km from power plant on the Southwest. Last time, this field was surveyed to provide the Dai Ninh and Bac Binh hydropower plant, sand exploited by means of suction from the river to be clean and well grade. The survey results showed that the grain composition and criteria as module, size, clay dust content and aggregate durability in sulfate environment to meet all requirements for structural concrete aggregate as standard 14TCN 68-2002.
- Rock is mined from Phong Phu quarry 25km from to the plant on the South, next to National Highway 1A, stone is being exploited and crushed to provide for the construction works in the Tuy Phong town and its vicinity.
- Conventional structural steel items can be imported from the most prestigious manufacturers in the Vietnam market.
- For special materials, special technical requirements, or other materials not in domestic supply source, imported materials will be used.

All materials shipped to the site must have their clear origin, quality certificate, specification must comply with the technical requirements have been approved by the investors.

5. The transportation of equipment and material

Light devices and construction materials for the construction the Vinh Tan 4 will be transported to the site by road via National Highway No.1A passed to the site at the North. These roads have a width of 7 ~ 10m, asphalt road with very good quality. From the Highway No.1A going on road No 4 to go to the construction and material area of the plant

Figure 1.18. Material and equipment transportation route



6. Construction organization chart

Construction organization chart shows the relationship between the parties involved in the project to ensure that the responsibility and roles of the parties involved in the project. Construction organizational chart will be arranged in accordance with the characteristics of the work to ensure the construction schedule, quality.

Figure 1.19. The construction organization chart of the project

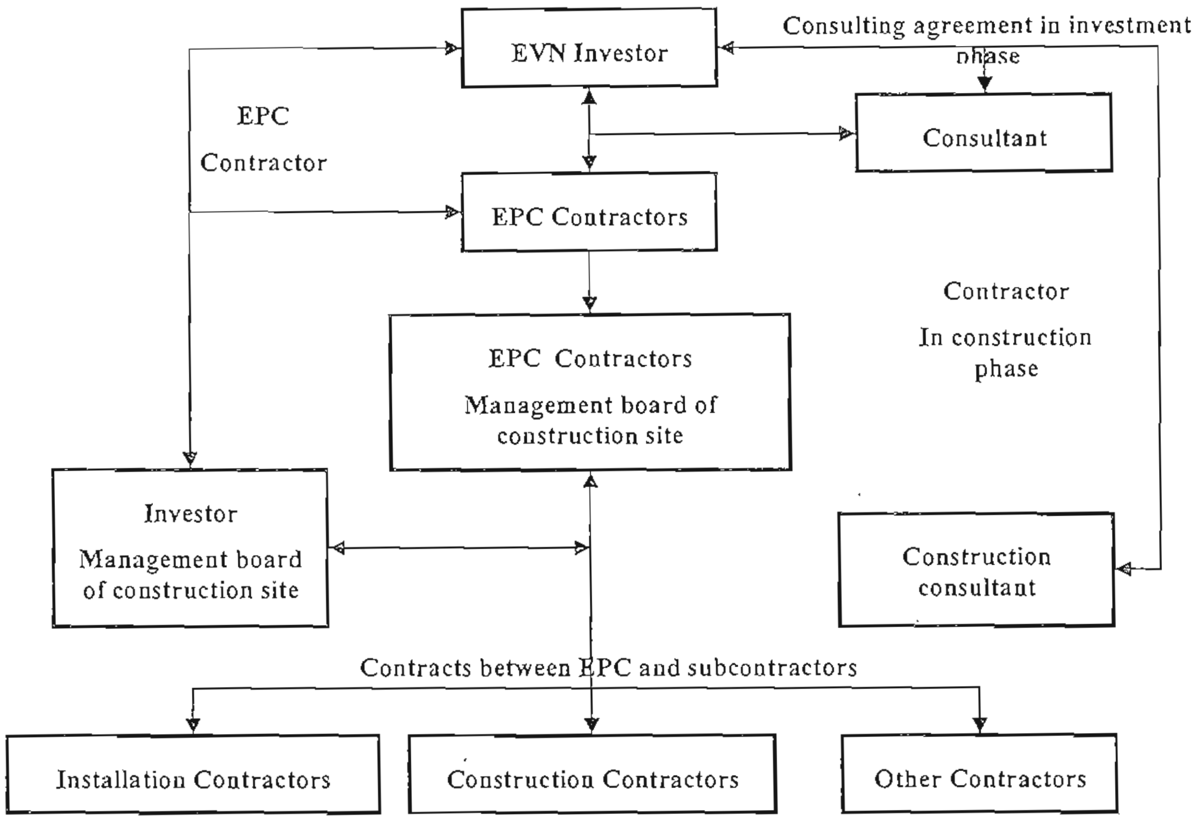
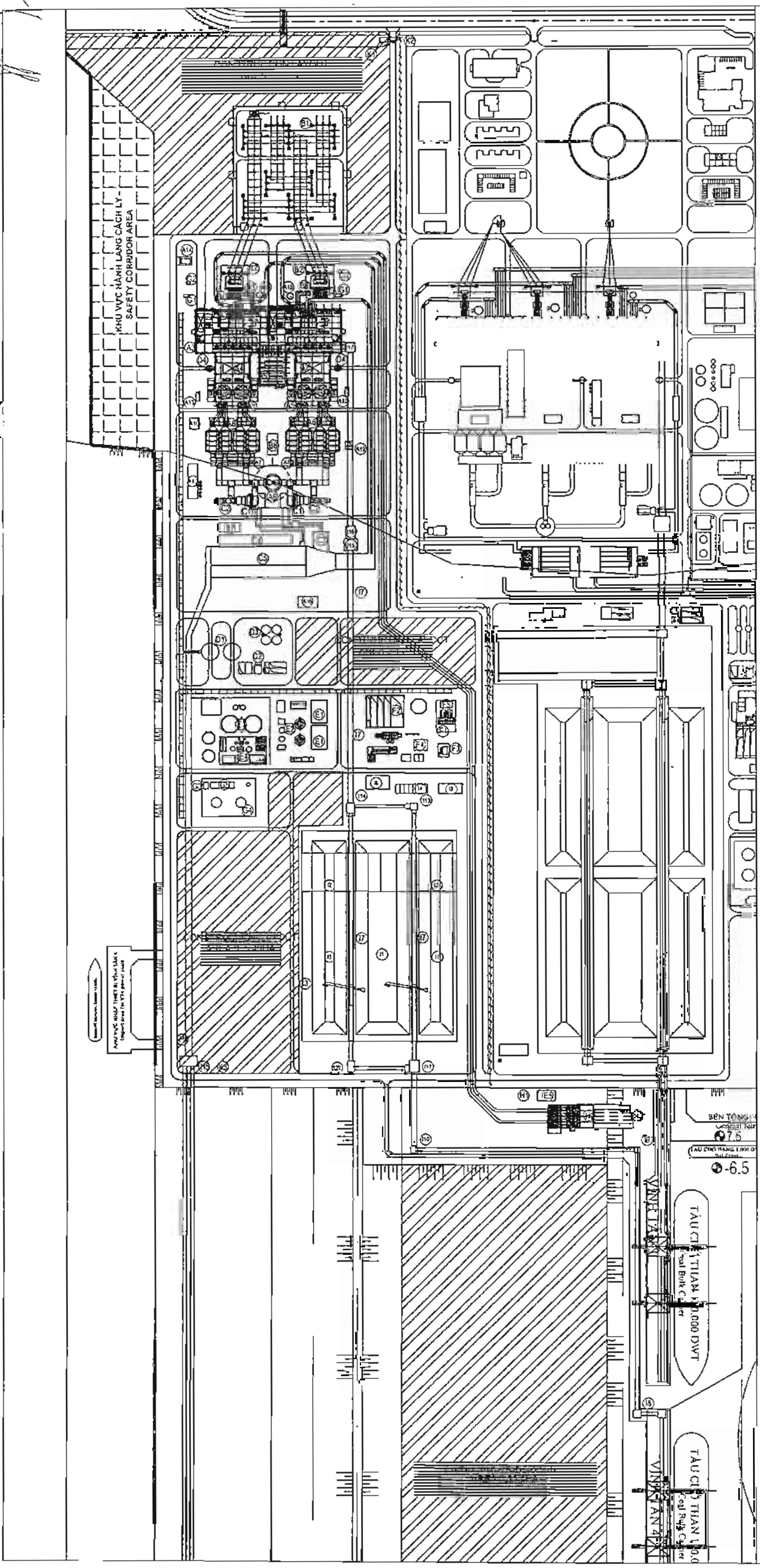


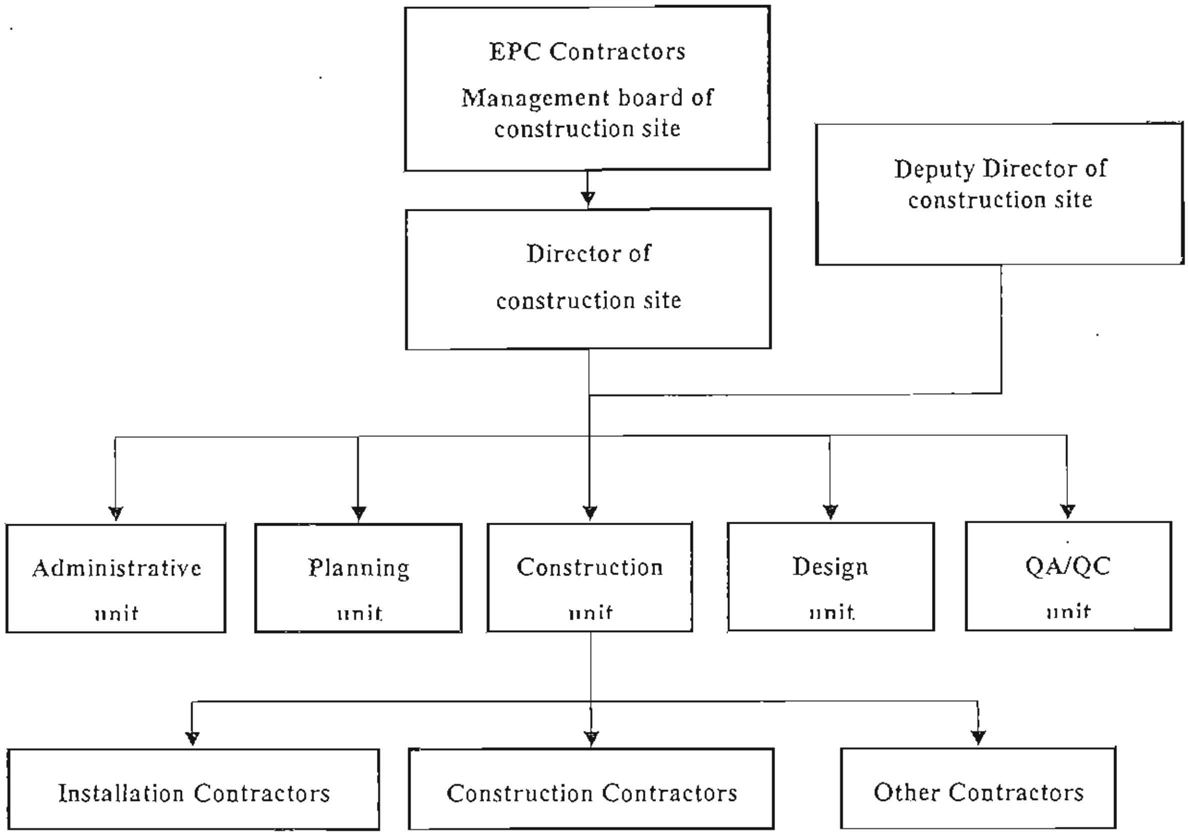
FIGURE 1.20. CONSTRUCTION LAYOUT OF VINH TAN 4 TPP



GHI CHÚ - NOTES:

MẶT BẰNG TỔ CHỨC THI CÔNG
CONSTRUCTION LAYDOWN AREA

Figure 1.21. The construction organization chart of the contractor



7. Construction solution

a/ Construction solution for the port

Construction solution for bridge

The procedures and methods of construction should be implemented as follows:

- Step 1: Site clearance and technical preparation.
- Step 2: Steel piles are manufactured in factories and transported to the site by sea way. The steel piles are set higher than the sea-level by hammer D125 or equivalent. The upper structure will be constructed after completing the pile foundation. The prefabricated structures are ready-made and being transported to the site by vessels. The concrete are mixed on land and transported by the vessel and poured by the floating cranes. Testing piles will be executed to measure the suitable length of the pile before driving massively. The pile drives is set on the barges. When conducting the driving piles, it is necessary to use the two theodolites for monitoring. The piles must be check for acceptance before driving. The piles have to be in the right coordinates, elevation and obliquity according to the designed requirements.

- Step 3: After driving, it is necessary to manacle linking the head of the piles together by clamping system made by I-shaped steel and bolt ∅30.
- Step 4: In case of the crest of the piles after driving is higher than the design elevation, cutting pile head will be conducted as design elevation by specialized cutters.
- Step 5: Installation of formwork, steel structure and to build horizontal and vertical reinforced concrete beams of the main port and bridge. Concrete will be poured by using cranes and batching plant on barges through the hopper or concrete pumping on land.
- Step 8: Installation of formwork, reinforced concrete for the bridge beam, linking items, to concrete the bridge surface. Construction of the covering layer of the surface bridge.
- Step 9: Installation the linked details of the rail system for cranes. Installation of anchor flange, stairs ...
- Step 10: Completing, handing over and putting into operation.

Construction for approach bridge

- Site preparation and approach bridge beams.
- To skate a test pile for approach bridge. Piles ware made at the factory and transported to the construction site.
- To skate massively piles for approach bridge, including all piles sustaining for the approach bridge.
- Installation formwork, construction of concrete pillars for approach bridge, the pipe support.
- Installation approach path beam.
- Installation approach bridge handrail, lighting system.
- Installation conveyor system.
- Finishing and painting the approach bridge handrail.

The work of dredging

Based on the designed size of ship, the dredging requirements for approach channel and turning basins, the natural conditions such as topography, geology and hydro- meteorology of the dredging area as well as the ability and capacity of contractor to be able to propose appropriate construction methods to ensure quality of work and quickly put into operation.

The main criteria for proposing the dredging plan are listed as follows:

- Length, width and height of the bottom for dredging the approach channel and turning basin;
- The geology of dredging area.
- Material transport distance to the dump site.
- The effect of tides in the construction area.
- Dredging volume.
- The topography and the influence of the weather at the construction site.
- Machine, the means and the capacity of the construction units

According to the above information, when constructing, it can be used the hopper dredger or floating dredger to carry the dredged materials. The vessels carrying the dredged material and soil have to be equipped with the channel-led pipe system in order to take the sand and sludge to the bottom of the vessels which in turn will help to reduce the pollution due to turbidity and to limit the dispersion of sand influencing the environment. In case of the dumping site is near the vessels, it can be used the floating pipe system to transfer the material to the dump site.

b/ Leveling work

After preparation of the construction site, the surface vegetation and grass will be removed to serve to the leveling work. The principle of leveling work is to level the land in high elevation to low elevation. For Vinh Tan 4 TPP, the land in the North of the plant will be removed to level for the land in the south of the plant. The earth volume used for leveling is estimated approximately 211,952 m^3, the sand lacked for leveling is about 846,362m^3.

The leveling construction organization area can be describes as follows:

c/ Construction solution for the sea-encroached embankment

Landmark position work

- To reposition landmarks of the embankment to build and pour reinforced concrete, protecting these landmarks permanently, painting in order to easily recognize.
- To use the synodic position method of three theodolite machines for the embankment, use steel piles or reinforced concrete to immobilize at least two

points: the head and the middle of the embankment, stick red flag on the top of the pile.

Arrangement of the construction organization site

Due to the construction almost located offshore, the average distance is approximately 800m sketching on 1050m of length. Therefore, the construction organization site will be arranged as follows:

- The construction materials such as stone block, cement and steel are transported to the site by the road and seaway.
- For the prefabricated materials such as Tetrapod are mold on the molding site on land and transfer to the barge to the construction site.
- Sea-encroached construction in two directions and combine with seaward embankment construction in four direction from the middle to the outside and from the two outsides to the inside in order to construct the seaward embankment prior to the two segment from the coast.

Material transportation and congregation solution for construction work

- Barges will be used to transport the construction material from the material storage to the construction site. The Tetrapod block are mold ready-made onshore and transported by barges to the construction and installation site.
- The construction direction will be from the inside to the outside. The material are concentrated at the coast, then transported to the embankment construction location by barges.
- The main transportation used for construction is a crane on the barge installed at construction position. The material transported to will be moved and unload by the crane.

Construction order

- Executing the construction from the outside to the inside or in the oppositing order from coast to the offshore, or from the two head to the middle. However, it is necessary to have a suitable and appropriate method to implementing in order to ensure the construction safety and meet the project schedule.
- The construction order from the bottom to the top, finishing each layer: core, pad layer and outside protective layer.
- Each segment with the length from 15m to 20m and technical acceptances.

To riprap, arrange, and install the upper layer

- During the execution of riprapping, it is necessary to notice the elevation, slope as designed.

- When arranging the stone in layers, it is essential to conduct the work correctly and ensure the consistence of each layer.
- The stone will be put in appropriate order and direction in order to strengthen the consistence for the whole structure.
- For the small stone layer (D=10-40m), the core of embankment will be executed each segment from 15 to 20m right after finishing the protective stone block footing D=50-60 and D=60-80. The dimension of the stone for the embankment core is D=10-40m and calculated in accordance with the bank velocity of 2 m/s
- In a case of facing a huge waves during construction, it is necessary to use the stone block or Tetrapod block to cover the embankment that are not pretected. When the wave stops, crane will be used to pick the stone block out of the embankment for construction.
- Therefore, there is always having barge storing stone block or Tetrapod block in standby case.

Installation of Tetrapod block, woven sheet, and breakwater

Installation of Tetrapod block

- The Tetrapod block should be installed by the floating cranes on both sides
- When installing the Tetrapod block, it is necessary to used cables through the block to avoid damages and incidents. To ensure the regulated density, all feets close together, in ricketiness condition
- Requirement of hooking the Tetrapod block only used when solving formwork. Using the cables to install when arranging the block, the hook of the block will be covered by bitumen to prevent corrosion and break the Tetrapod block.
- The minimum time for solving formwork of the concrete block to reach at least 50 percent of strength.

Installation of woven sheet and breakwater

The woven sheet can be used the floating cranes on the both sides to install or rag-wheel cranes to install from the inside to the outside.

The woven sheet are ready-made designed having a hook to install when covers bitumen.

Before installing the woven sheet, it is necessary to create an embankment surface by tamping the stone block D10-20 with the thickness of 50 cm. The next layer will be a cover-stone chips with dimension of 4x6 and the thickness of 20cm. The stone concrete 4x6 M150 is lastly arranged.

8. Labor supply

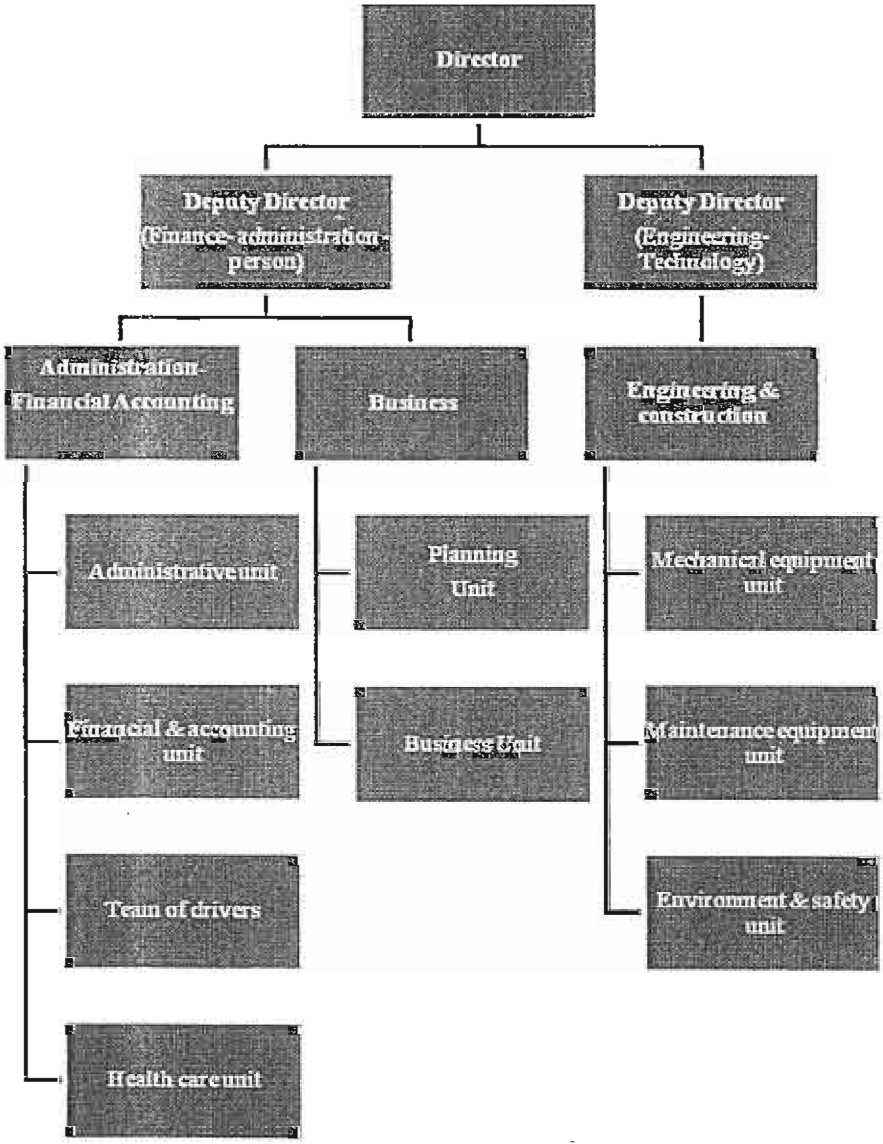
The majority of workers will be recruited from the local area. However, depending on terms of EPC contract, workers might come from other areas. In the short term, the number of plant operators and maintenance staffs will be recruited from other areas. Before being put into operation, the number of operators and maintenance staffs at all levels will be trained on the operation and maintenance process by experts and technicians of the manufacturers and equipment suppliers. Therefore, these technical labors can be used for the plant operation in the future.

1.4.9.3. Commercial operation stage

After handing over, the project owner is responsible for operating the plant as design capacity, organizing the production and operation force, completing the management and organization in order to implement the project effectively and economically.

After the completion of construction, the project owner will propose the establishment of a management unit (abbreviated as the Management Board) with management and operation model as follows:

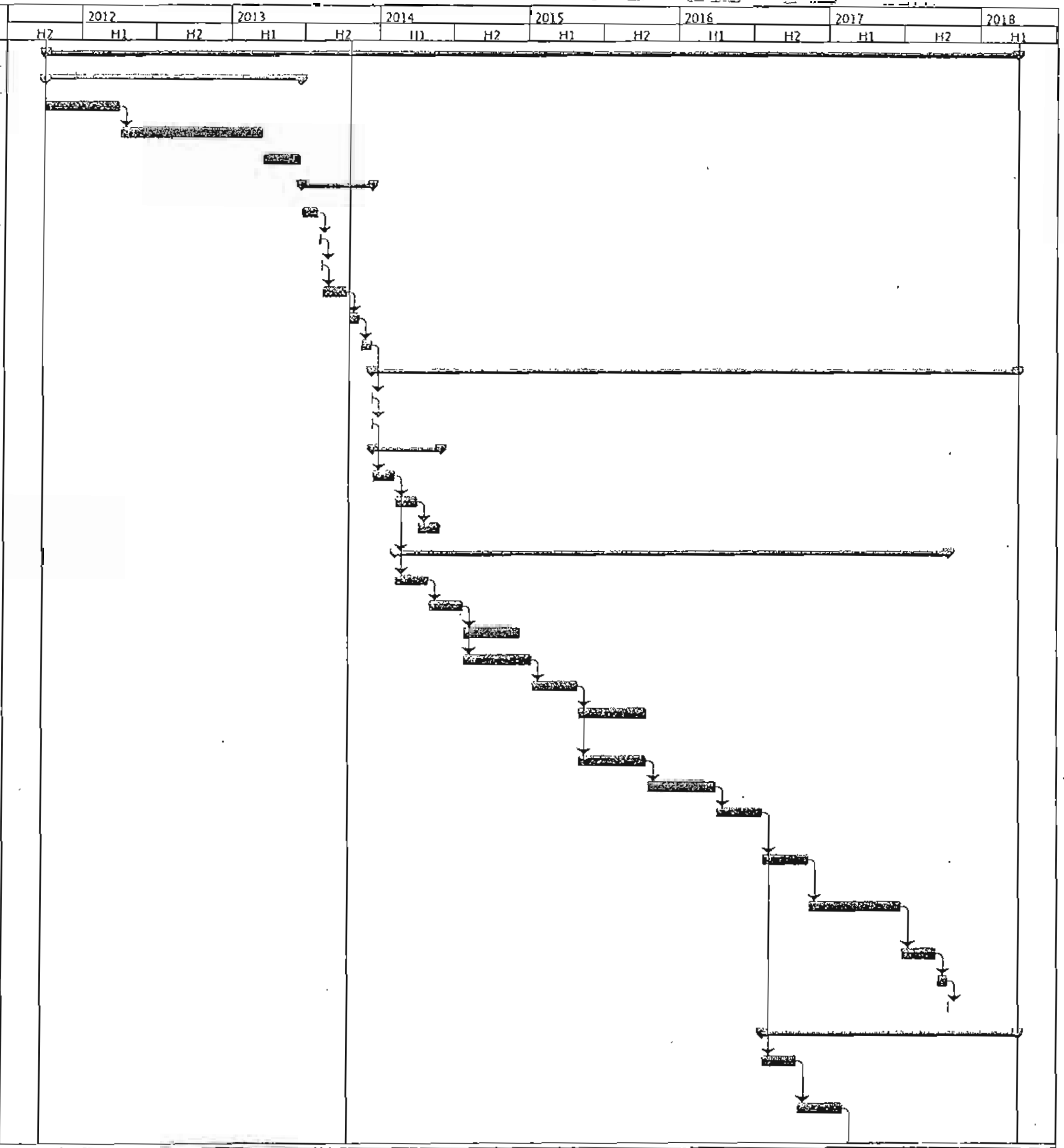
Figure 1.22. Management and operation model of the project



In the operation stage, the PMU will be responsible for implementing the general tasks of the plant including the environmental management of the port. The environmental management of the project will be assigned to labor safety and sanitation unit for management and implementation.

Table 1.24: schedule of Vinh Tan 4 T

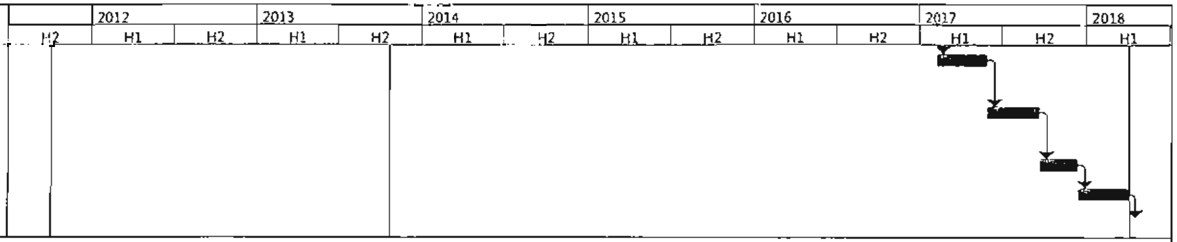
ID		Task Name	Start	Predecessors	Finish
1		VINH TAN 4 THERMAL POWER PLANT	Tue 10/4/11		Mon 4/2/18
2		Investment project report	Tue 10/4/11		Fri 6/21/13
3		Draft 1 preparation	Tue 10/4/11		Wed 4/4/12
4		Complete and report submission	Thu 4/5/12	3	Wed 3/20/13
5		Approval	Thu 3/21/13		Fri 6/21/13
6		Bidding process	Tue 6/25/13		Mon 12/16/13
7		Bidding document preparation	Tue 6/25/13		Mon 8/5/13
8		Bidding document approval	Tue 8/6/13	7	Wed 8/14/13
9		Bidding document issuance	Thu 8/15/13	8	Thu 8/15/13
10		Preparation of contractor	Fri 8/16/13	9	Thu 10/17/13
11		Bidding document evaluation	Fri 10/18/13	10	Fri 11/15/13
12		Contract negotiation	Mon 11/18/13	11	Mon 12/16/13
13		EPC contract implementation	Tue 12/17/13		Mon 4/2/18
14		EPC contract decision	Tue 12/17/13	12	Tue 12/17/13
15		Commencement	Wed 12/18/13	14	Wed 12/18/13
16		Technical design	Thu 12/19/13		Wed 6/4/14
17		Technical design draft	Thu 12/19/13	15	Wed 2/12/14
18		Technical design document issuance	Thu 2/13/14	17	Wed 4/9/14
19		Approval	Thu 4/10/14	18	Wed 6/4/14
20		Unit 1 accomplishment	Thu 2/13/14	17	Wed 10/18/17
21		Workforce gathering	Thu 2/13/14	17	Tue 5/6/14
22		Accomplish project area excavation	Wed 5/7/14	21	Tue 7/29/14
23		Accomplish project area leveling	Wed 7/30/14	22	Tue 12/16/14
24		Accomplish first concrete casting	Wed 7/30/14	22	Tue 1/13/15
25		Preparation done for the construction	Wed 1/14/15	24	Tue 5/5/15
26		Construct steel structure for the plant area	Wed 5/6/15	25	Tue 10/20/15
27		Construct steel structure for boiler area	Wed 5/6/15	25	Tue 10/20/15
28		Accomplish steel tubes	Wed 10/21/15	27	Tue 4/5/16
29		Get the boiler house ready for the construction	Wed 4/6/16	28	Tue 7/26/16
30		Commence generator stator arrangement	Wed 7/27/16	29	Tue 11/15/16
31		Accomplish construction of turbine - generator	Wed 11/16/16	30	Tue 6/27/17
32		Accomplish Hydro-testing for the boiler	Wed 6/28/17	31	Tue 9/19/17
33		Unit 1 commencement	Wed 9/20/17	32	Tue 10/17/17
34		Unit 1 commercial operation	Wed 10/18/17	33	Wed 10/18/17
35		Unit 2 accomplishment	Wed 7/27/16		Mon 4/2/18
36		Construct steel structure for the plant area	Wed 7/27/16	29	Tue 10/18/16
37		Get the boiler house ready for the construction	Wed 10/19/16	36	Tue 2/7/17



Project: Vinh Tan 4 Schedule
Date: Tue 10/22/13

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

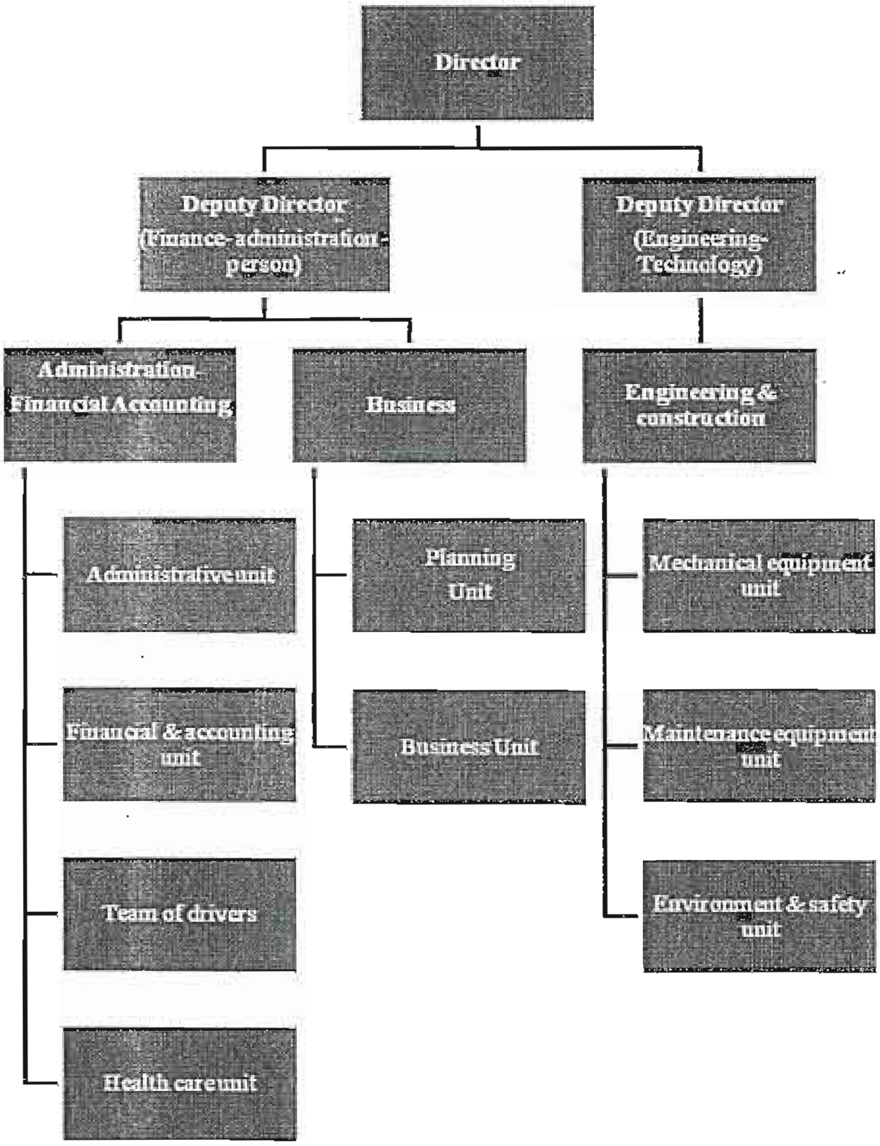
ID	Task Name	Start	Predecessors	Finish
38	Commence generator stator arrangement	Wed 2/8/17	37	Tue 5/30/17
39	Accomplish construction of turbine - generator	Wed 5/31/17	38	Tue 9/19/17
40	Accomplish Hydro-testing for the boiler	Wed 9/20/17	39	Tue 12/12/17
41	Unit 2 commencement	Wed 12/13/17	40	Fri 3/30/18
42	Unit 2 commercial operation	Mon 4/2/18	41	Mon 4/2/18



Project: Vinh Tan 4 Schedule
Date: Tue 10/22/13

Task	Project Summary	Manual Task	Start-only
Split	Inactive Task	Duration-only	Finish-only
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks
Summary	Inactive Summary	Manual Summary	External Milestone
Deadline	Progress	Manual Progress	

Figure 1.22. Management and operation model of the project



In the operation stage, the PMU will be responsible for implementing the general tasks of the plant including the environmental management of the port. The environmental management of the project will be assigned to labor safety and sanitation unit for management and implementation.

Chapter

2

STATUS OF NATURAL ENVIRONMENT AND SOCIO-ECONOMIC CONDITIONS

2.1. NATURAL ENVIRONMENTAL CONDITION

In the process of conducting environmental impact assessments for the Vinh Tan 4 power plant project (Vinh Tan 4 TPP), the consultant agency (PECC2) carried out field investigations to collect the documents on economic and social (socio-economic), took samples, analyzed the samples as a basis to have an overview assessment of the natural environment and socio-economic status in the project's area.

2.1.1. Topographical and geological conditions

During the period from 1/11 to 18/12/2011, PECC2 surveyed the terrain, geological conditions in the project area. Topographical and geological characteristics of the project area are following presented.

2.1.1.1. Topographical condition

Vinh Tan 4 TPP is located in Vinh Tan commune, Tuy Phong District, Binh Thuan Province. The topography of project's area is relative complicated, high hills and mountains are located in the north and strongly segmented. The regional topography is described as follows: (1) Lowland in the north includes low mountains and plains of Luy River basin. The elevation is up to 500m. (2) Coastal delta along Phan Ri includes marine or alluvial sediment.

2.1.1.2. Geological conditions

The geological survey and rock sample testing were implemented by South Survey Enterprise (SGIE) - PECC2 from 1st November to 18th December, 2011. Geological layout and section were shown in Figure 2.1.

Physical and chemistry water samples are taken at six boreholes as VT4-01, VT4-02, VT4-03, VT4-04, VT4-05, VT4-06.

Measuring soil resistivity was implemented in 4 boreholes as VT4-01, VT4-02, VT4-04, VT4-05.

1. Stratigraphic subdivisions

According to data of 11 boreholes and collected results in the LAB, standards 6BXD/VKT was applied, the geological conditions of the rocks determined from the top are shown as follows:

Table 2.1. The geological structures in the project's area

Layer	Name/Note	Thickness (m)	SPT index	Geological characteristics
Layer 1	Marine deposits (mQIV)	1 - 4	40	Sand is medium to coarse grained with silt, along stream banks and coastal sand is fine to medium grained interbedding gray, yellowish gray, medium to dense clayey sand containing quartz gravel and dhelly with few laterites. The low bearing soil layer could be used for earth filling to expand coastal area
Layer 2	Marine deposits-	10-32	>50	whitish gray, light yellowish gray, dense

	eluvion (mdQIII)			to very dense clayey sand, sandwiched with aggregation layers containing multi-mineral gravel (quartz, granite, dacite…), the weathered boulders with hard laterite This soil has high load capacity to very high
Layer 3	Moderately weathered rock (IA1)	0-15	>50	As a weathering product of granodiorit stone of Deo Ca complex. whitish gray, brownish gray with blackish spots, very dense, hard clayey sand – sandy clay containing weak fragments of granite, , containing 20-40% less solid granite Homogeneous layer, this soil has high load capacity to very high
Layer 4	completely weathered rock(IA2)	0-8	-	Weathering product of granodiorit stone has grey, light gray color, low to medium-hard contained less clayed sand Has high load capacity
Layer 5	slightly weathered rock (IB)	0-3	-	Granodiorit: gray, light gray, dark spots color. Rocks is very firm, cracking is medium to strong. The thickness is quite thin, rock zone IB has high load capacity.
Layer 6	Highly fracture and hard rock zone(IIA)		-	Granodiorite rock is light gray with blackish spots, very hard, massive structure, low fractured. This is a zone having high compressive strength, sustain huge load and is rated as very high load capacity. Foundation in place against super heavy load to put on this rock (the rock without IB).

Source: Survey report -*PECC2 01/2012*

2. Physical-mechanical properties of soils

Physical mechanical properties of soils of layer 1, 2, 3 were presented in Table 2.2

Table 2.2. Physical mechanical properties of soils

Layer	Value	Particle component							Harticle component			Moisture Content %	Natural Density g/cm3	Dry Density g/cm3	Specific Gravity g/cm3	Void Ratio			UC strength qu, kG/cm2	Triaxial Compression Test						Compression Index Cc
																				CU				UU		
		75	19	4,75	2,0	0,425	0,075	0,005	Liquid limit	Plastic Limit	Plasticity Index						Internal Friction (degree)	Cohesion, kG/cm2		Internal Friction (degree)	Cohesion , kG/cm2	Effective Internal Friction (degree)	Internal Friction kG/cm2	Internal Friction (degree)	Cohesion kG/cm2	
Layer 1 mQIV	Min	100	100	85,8	64,3	13,8	4,9	1,4	-	-	-	1,3	1,81	1,70	2,65	0,32	2904 7	0,030	-	-	-	-	-	-	-	0,041
	Max	100	100	94,2	84,5	42,3	19,8	3,6	-	-	-	9,6	2,20	2,04	2,69	0,57	3203 1	0,058	-	-	-	-	-	-	-	0,130
	TB	100	100	90,1	73,7	30,6	10,9	2,2	-	-	-	5,1	1,95	1,85	2,67	0,44	3005 2	0,044	-	-	-	-	-	-	-	0,070
Layer 1 mQIV	Min	100	100	84,5	51,8	28,0	10,6	4,6	23	17	5	11,9	1,81	1,45	2,62	0,46	1802 5	0,080	0,486	2304 4	0,240	3102 2	0,065	1405 4	0,314	0,040
	Max	100	100	100	100	96,2	81,4	25,0	39	23	16	24,6	2,07	1,81	2,73	0,86	2705 5	0,271	1,017	2404 4	0,243	3202 2	0,069	1405 4	0,326	0,106
	Aver	100	100	96,5	80,7	58,1	34,9	12,0	30	20	11	16,7	2,01	1,73	2,66	0,54	2401 8	0,170	0,698	2305 3	0,242	3105 3	0,067	1405 4	0,320	0,069
Layer 1 mQIV	Min	100	99,5	91,1	59,0	29,1	18,0	6,2	24	18	6	13,7	1,92	1,97	2,64	0,53	1805 9	0,090	0,624	2201 7	0,262	2902 7	0,066	1203 5	0,300	0,060
	Max	100	100	99,9	99,0	91,3	55,2	20,9	39	24	16	24,1	2,03	2,13	2,73	0,72	2700 4	0,257	0,936	2501 7	0,334	3302 7	0,165	1500 6	0,377	0,126
	TB	100	100	96,8	86,8	63,6	37,9	14,2	35	21	14	19,4	1,98	2,05	2,70	0,63	2104 2	0,218	0,799	2302 6	0,303	3101 2	0,127	1303 3	0,332	0,099

Source: Investigation report, PECC2 01/2012.

Physical mechanical properties of rock of layer 5, 6 were presented in Table below

Table 2.3. **Physical-mechanical properties of rocks**

Zone, layer	Level	Density g/cm3			Spec. Gravity, g/cm3	Porosity	Hardness coefficient		Compression resistance strength (kG/cm2)	
		Air-dry	Saturation	Dry			Air-dry	Saturation	Air-dry	Saturation
Granite IB zone (layer 5)	Min	2.64	2.66	2.60	2.84	8.5	3.6	2.0	556	428
	Max	2.64	2.66	2.60	2.84	8.5	3.6	2.0	556	428
	Mean	2.64	2.66	2.60	2.84	8.5	3.6	2.0	556	428
Granite IIA zone (layer 6)	Min	2.66	2.66	2.65	2.69	1.5	11.1	10.0	824	769
	Max	2.75	2.76	2.74	2.82	2.8	16.7	14.3	1022	984
	Mean	2.69	2.69	2.68	2.73	1.8	13.7	12.2	911	863

Notes: the properties of IB rock zone (layer 5) is based on the rock lab test results of Vinh Tan 3 project.

In summary, the physical-mechanical properties of layer 2, 3 and 4 are high and able to be the heavy load bearing capacity. The friction pile set into these layers is also suitable but need to calculate in order to satisfy load conditions. Because the layer 2 is thick and quite solid, while excavating often have to use borer, crowbar and blasting, so the structural load is not too large can lay foundation on layer 2 and this layer is recommended for friction pile and bearing pile for moderate loading.

In the case of using super heavy loading structure or vibration structure, need to have the bearing pile into layer 5 (IB) or layer 6 (IIA).

For factory chimney site located at borehole VT4-06, due to the heavy load work using pile foundation on the stable and high load bearing capacity bedrock. Based on the results of drilling, the conditions of rock foundation at factory chimney site are very convenient. Marine-deluvial deposits are covered directly on hard rocks. Using the bored cast-in-place pile for IIA surface hard rock is suitable.

2.1.1.3. Hydrogeological conditions

Water level in the boreholes in boiler and turbine area is usually between 7 and 9 m in layer 2. Water levels in the areas near onshore and stream is below 2m. Groundwater in coastal area is usually salinity and organic pollution due to domestic sewage of local people, therefore the source cannot use for domestic demand. Groundwater conditions are shown in the two layers.

❖ Pore Aquifer

Belongs to Marine deposits (mQIV) and sandy clay mdQIII and onshore part is seabed level 1.

Aquifer's thickness ranges from 2-10m, average of 5m in rainy season and an average of 3-4m in the dry season. Groundwater is mainly located in pore of coarse/medium graining sand and a fraction of clay sandy layer. Distribution depth of this aquifer is 1-2m to 12-13m in rainy season and 3-4m to 12-13m in the dry season from the natural surface ground.

This aquifer is located in the aeration zone and is heavily influenced by surface water. Evaporation from the aquifer into the atmosphere is created by impact of air temperature. Aquifer is not abundant, heterogeneous and contamination by the external environment. This aquifer is contaminated salinity in coastal areas. The analysis results of the chemical composition of ground water are presented in Table 2.4.

❖ Fissure aquifer

Including water in fissured granodiorit rock (mainly in terrene IB, IIA) ib onshore and offshore. Aquifer's thickness change and distribute fairly complex. Distribution depth of aquifers is about 20-21m (from the surface ground) to range of fissured young terrene - zone IIA (estimated about 35-40m). Water in this layer is not abundant and it is not ability to exploit for industry with high flow but can be exploited to provide for small and medium residential areas (It is necessary to setup exploitation drilling holes networks to assess the volume and quality of water, the water in this aquifer is capable slightly saline). In scope of Vinh Tan 4 TPP in particular and Vinh Tan PP in general, this aquifer has not been thoroughly researched, water samples in the drill hole were taken in the aquifer pore.

Table 2.4. **Chemical content of groundwater**

Aquifer	Borehole name / Outcrop	Sample no.	Depth (m)	Total mineralization mg/l	Total ion mgdl/l	PH	Negative ion								Positive ion												Total hardness mgdl/l	Free CO_2 mg/l	Corrosion CO_2
							HCO_3^-		Cl^-		SO_4^{--}		CO_3^{--}		NH_4^+		Ca^{++}		Fe^{++}		Fe^{+++}		Mg^{++}		$Na^+ + K^+$				
							mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l			
mQIV	VT4-1	BM251	3.7	100.48	1.55	5.97	30.51	0.50	35.45	1.00	2.40	0.05	0.00	0.00	0.00	0.000	4.01	0.20	0.16	0.006	1.46	0.079	2.92	0.24	23.57	1.03	0.44	22.00	21.20
mQIII	VT4-2	BM252	8.5	103.89	1.55	6.20	36.61	0.60	31.91	0.90	2.40	0.05	0.00	0.00	0.00	0.000	3.41	0.17	0.18	0.006	1.02	0.055	2.19	0.18	26.17	1.14	0.35	6.60	6.40
mQIII	VT4-4	BM257	7.5	94.44	1.35	7.74	42.71	0.70	21.27	0.60	2.40	0.05	0.00	0.00	0.00	0.000	4.21	0.21	0.08	0.003	1.32	0.071	2.31	0.19	20.14	0.88	0.40	26.40	24.74
mQIII	VT4-5	BM253	9.5	90.98	1.40	6.26	27.46	0.45	31.91	0.90	2.40	0.05	0.00	0.00	0.00	0.000	3.81	0.19	0.16	0.006	1.13	0.061	2.43	0.20	21.68	0.94	0.39	22.00	21.21
	T. Binh			**97.45**	**1.46**	**6.54**	**34.32**	**0.56**	**30.14**	**0.85**	**2.40**	**0.05**	**0.00**	**0.00**	**0.00**	**0.000**	**3.86**	**0.19**	**0.15**	**0.005**	**1.23**	**0.067**	**2.46**	**0.20**	**22.89**	**1.00**	**0.40**	**19.25**	**18.39**
								38.49		**58.10**		**3.41**		**0.00**		**0.00**		**13.17**		**0.36**		**4.55**		**13.84**		**68.08**			

Corrosion assessment: For artesian project, for normal concrete, at mean value of sample: did not corrode

$$M\,0.35 \quad \frac{Cl\ 58 \quad HCO_3\ 38}{(Na+K)\ 68 \quad Mg\ 12 \quad Ca\ 13} \quad pH\ 6.5$$

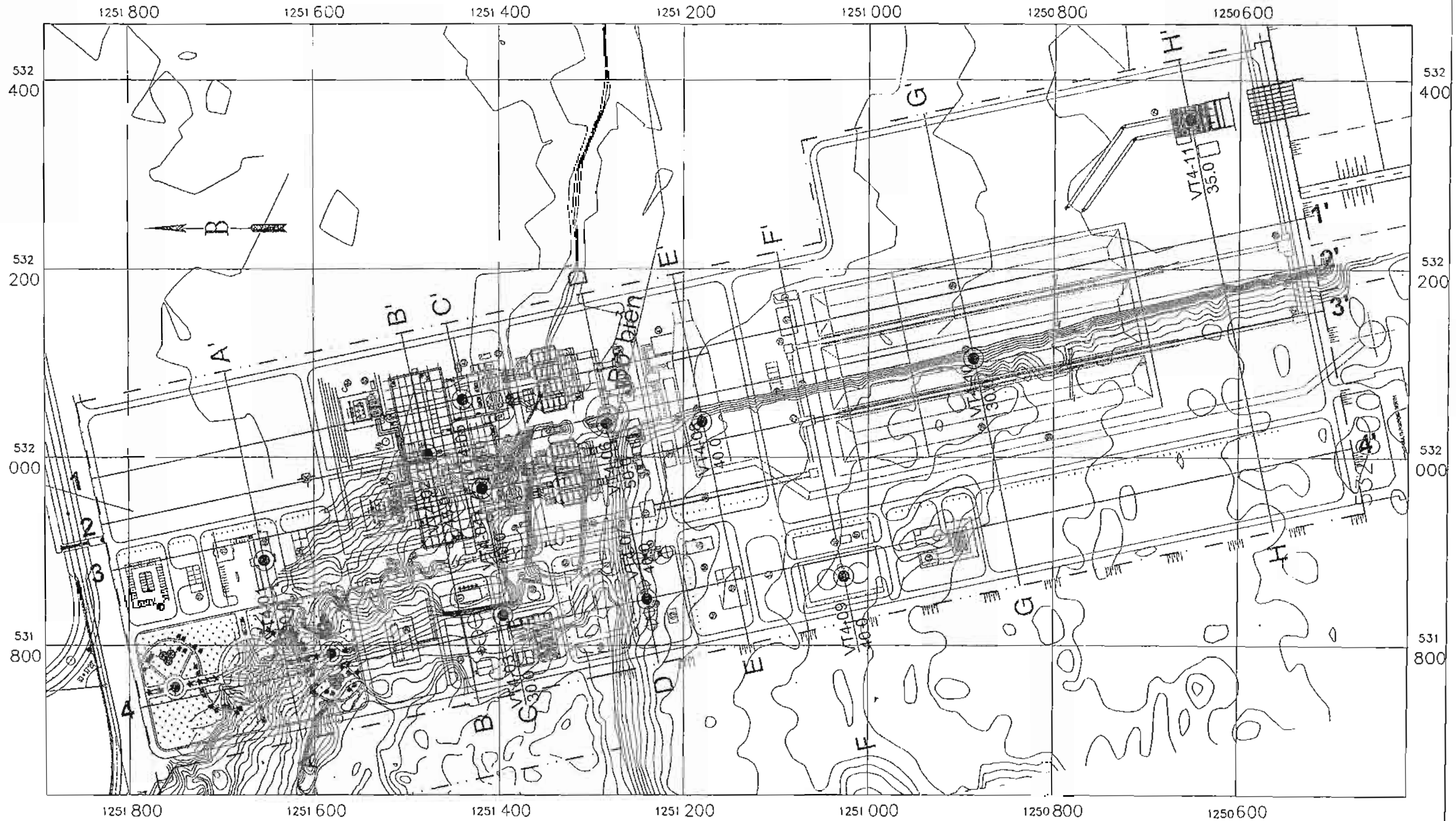
Clorur Bicarbonate kalium calcium water.

Aquifer	Borehole name / Outcrop	Sample no.	Depth (m)	Total mineralization mg/l	Total ion mgdl/l	PH	Negative ion								Positive ion												Total hardness mgdl/l	Free CO_2 mg/l	Corrosion CO_2
							HCO_3^-		Cl^-		SO_4^{--}		CO_3^{--}		NH_4^+		Ca^{++}		Fe^{++}		Fe^{+++}		Mg^{++}		$Na^+ + K^+$				
							mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l	mg/l	mgdl/l			
Salinization water	VT4-3	BM256	0.5	27181.37	471.93	7.59	274.59	4.50	15349.85	#####	1661.64	34.56	0.00	0.00	0.00	0.000	388.78	19.40	0.02	0.001	0.05	0.003	1012	83.16	8494.73	369.37	102.56	17.60	0.00
	VT4-6	BM254	1.5	4050.52	69.31	6.82	146.45	2.40	2183.72	61.58	256.00	5.32	0.00	0.00	0.00	0.000	72.95	3.64	0.02	0.001	0.05	0.003	133.4	10.97	1257.93	54.70	14.61	15.40	9.36
	T. Binh			**15615.95**	**270.62**	**7.21**	**210.52**	**3.45**	**8766.79**	**#####**	**958.82**	**19.94**	**0.00**	**0.00**	**0.00**	**0.000**	**230.87**	**11.52**	**0.02**	**0.001**	**0.05**	**0.003**	**572.56**	**47.06**	**4876.33**	**212.03**	**58.58**	**16.50**	**4.68**
								1.28		**91.35**		**7.37**		**0.00**		**0.00**		**4.26**		**0.00**		**0.00**		**17.39**		**78.35**			

Corrosion assessment: For artesian project, for normal concrete, at mean value of sample: did not corrode

$$M\,0.35 \quad \frac{Cl\ 91}{(Na+K)\ 78 \quad Mg\ 17} \quad pH\ 7.6$$

Clorur kalium calcium water.



CHÚ THÍCH - NOTES:

VT4-06 / 50 — Hố khoan, xuyên tiêu chuẩn (SPT) giai đoạn DAĐT tại Nhà máy điện Vĩnh Tân 4
Số hiệu/độ sâu, m
Borehole, SPT in the Feasibility Study Stage/ depth, m

Bản đồ được thành lập trên cơ sở bản đồ địa hình tỷ lệ 1/1 000, hệ tọa độ VN-2000, kinh tuyến trục 108 30', múi 3 .
Cao độ Hòn Dấu-Hải Phòng

This map was made base on the topography map 1/1,000; coordinates VN-2000, meridian 108 30', zone width 3 . Elevation Hon Dau-Hai Phong.

STT No.	Hố Khoan DrillHoles	Tọa độ - Coordinates X	Tọa độ - Coordinates Y	Cao độ Elevation (m)	Độ sâu Depth (m)	Vị trí Location	Ghi chú Notes
1	VT4-01	1251653.69	531890.23	13.80	30	Nhà Hành Chính	Trên cạn
2	VT4-02	1251477.83	532002.73	12.73	45	Nhà Tua Bin	Trên cạn
3	VT4-03	1251395.98	531831.48	0.47	30	Khu xử lý nước biển	Trên cạn
4	VT4-04	1251418.23	531966.31	8.51	40	Lò hơi	Trên cạn
5	VT4-05	1251439.36	532060.88	12.19	40	Lò hơi	Trên cạn
6	VT4-06	1251283.79	532035.62	1.06	50	Ống Khói	Trên cạn
7	VT4-07	1251241.65	531852.7	-1.39	40	Khu xử lý tro xỉ	Dưới nước
8	VT4-08	1251179.95	532037.45	-2.43	40	Bể sục khí	Dưới nước
9	VT4-09	1251028.53	531873.16	-4.73	40	Khu vực bồn dầu	Dưới nước
10	VT4-10	1250888.41	532103.19	-2.65	30	Kho than	Dưới nước
11	VT4-11	1250653.88	532357.93	2.13	35	Trạm bơm	Dưới nước
Tổng cộng - Total					420		

HÌNH 2.1. MẶT BẰNG VÀ MẶT CẮT ĐỊA CHẤT CỦA NMĐ VĨNH TÂN 4

FIGURE 2.1. LAYOUT AND GEOLOGICAL SECTION OF VINH TAN 4 TPP

2.1.1.4. Phenomenon, dynamical geology process

1. Tectonic structures, faulting

Study on tectonic structures was detail presented in report on Earthquakes which were implemented by Institute of Geophysics in 4/2010.

Tectonic faults characteristics were studied within 100 km radius from the plant location. Results showed that there are mainly three fault systems in study area including as NE-SW, sub-longitudinal and NW-SE.

❖ NE-SW faults

In Da Lat zone and also offshore on the continental shelf the NE-SW faults arc dominant, controlling the generation and development of structures such as Da Lat, Cuu Long basin and Con Son swell. They are usually of large scale (2nd or 3rd order) and have rather intensive present activities, among them are Tuy_Hoa - Cu Chi fault (II-1), Thuan Hai - Minh Hai fault (III-2), Nha Trang - Tanh Linh fault (III-2), Van Linh - Tanh Linh fault (III-1), Con Son swell NW margin fault (II-4) Con Son swell SE margin fault (II-5) with left strike-slip and normal movement mechanism. They are likely to generate earthquakes with different magnitude and seismic risk to the project. Of the most seismic danger for the Vinh Tan Power Complex is the Thuan Hai. Minh Hai active fault zone passes at a distance of > 40 km SE of the plant.

❖ The faults of sub-longitudinal system

The faults of sub-longitudinal system probably are the youngest faults closely related with the N2 - Q basaltic extrusions and thermal-mineral water springs. The results of survey in the Long Song, Da Bac lake, Dinh cape show that these faults are brittle deformation zones characterized by highly fractured zones, tectonic crushing and cataclasis zones reflecting rather clearly the extensional mechanism being dominant in the present period (N2-Q). However, the faults near the project site are of small scale (usually of 5th or higher order, thus they are not much likely to cause seismic dander for the project).

A giant sub-longitudinal fault zone associating with a series of high order faults of the same trend (the $109^0 30'$ sub-longitudinal suture zone) was formed and was active with normal and right strike-slip mechanism, playing the role as a boundary between different parts of the continental crust. This zone is likely to generate strong earthquakes (MS >= 5). However, as it is relatively far from the project site (>= 115km to the East), when having bean spread to the project site the earthquakes will be weakened considerably. Present activities of this zone are expressed rather clearly on the topography of the sea floor (nearly coinciding with the continental shelf where the depth of the sea floor increases abruptly from 300 - 400 m to >1000m), causing deformation of Cenozoic sediments and where N2-Q volcanic activities are increased.

Table 2.5. Basic characteristics of the main fault zones with evidences of being active in the study area

No	Name of fault	Order and No	Trend	Extent (km)	Depth	Attitude of sliding surface	Movement mechanism in N2 -Q	Nearest distance to the project (km)
1	109030' Sub-longitudinal fault	I-1	SL.	>1000	Lithosphere	E/Steep	N-RSS	115
2	Thuan Hal - Minh Hai fault	II-2	NE-SW	~700	CP	SE/60 -700	LSS-N	40
3	Tuy Hoa shear zone	III-9 and III-10	NW-SE	~200	CP	NE, SW/Steep	RSS-N	~100
4	Con Son swell NW margin fault	II-4	NE-SW	>(130)*	CP	NW/Steep	LSS-N	95
5	Con Son swell SE margin fault	II-5	NE-SW	>(40)*	CP	SE/Steep	LSS-N	150
6	Sub-longitudinal fault III-7	III-7	SL	>(300)*	CP	E/Steep	N-RSS	65
7	Sub-longitudinal fault III-8	III-8	SL	>(300)*	CP	E/Steep	N-RSS	85
8	Nha Trang - Tanh Linh	III-1	NE-SW	285	Intracrustal	SE/70-800	LSS-N	57
9	Van Ninh - Tanh Linh	III-2	NE-SW	300	Intracrustal	NW/60-700	LSS-N	75
10	Tuy Hoa - Cu Chi	II-1	NE-SW	370	CP	NW/70-800	LSS-N	122
11	Phan Thiet - Bao Loc mountain	III-4	NW-SE	~200	Intracrustal	SW/800	RSS-N	80

Notes: - LSS: Left strike-slip — - CP: Crust penetrating
- RSS: Right strike-slip — - (130)*: Extent within the study area

❖ NW-SE faults

Developing primarily at onshore (Srepokc and Dalat faults). In Da Lat zone, we usually have small scale (grade IV or higher). The only fault zones of Phan Thiet - Bao Loc Pass (grade III) is noteworthy. However, it is quite far from project area (80km) and is relatively stable fracture in the modern period , so that it is less likely to cause dangerous earthquakes on buildings.

❖ NW-SE faults zones

The NW-SE faults zones are mainly developed on land (in both the Da Lat and Srepok zones). In the Da Lat zone they are usually of small scale (of 4th or higher order). Only the Phan Thiet - Bao Loc 3rd order fault is significant. However it is located rather far from the project site (> 80km) and is a relatively stable in the present period, so it is not likely to cause seismic danger for the project.

The project area and the surroundings have evidences of relatively strong young tectonic activities. The faults developed here are only high order faults (4th or higher order), with limited scale. In the present period, they are characterized by brittle deformation caused by the intra-plate movements of blocks with various sizes, but they are not likely to generate strong earthquakes causing danger to the project.

The project area is not crossed by any large scale faults, there is only a small 5th order fault (V-24) passing closely the SE side of the project foundation and some other high order faults V-43 (sub-longitudinal), V-28 (NW - SE), V-29 (NE - SW) located at a distance of 1.5 to 1.8km from the project site.

2. Earthquakes

There have been 46 observed events in the studied area and surroundings from 1877 up to now. The epicenter of the 1877, 1882 historical earthquake with magnitude Mg > 5.1, intensity at epicenter I = 7 was located at 116 kilometers far from construction site towards the South-East South. The earthquake occurred in 1960 with a magnitude of 4.1 has its epicenter at distance of 40 kilometers away from construction site towards the East-East South. There was also an earthquake in 1965, with the magnitude of 4.8, of which its epicenter was 122 kilometers away from construction site, relatively far towards the North-East.

The strong earthquakes occurred and recorded in studied area and surroundings were in the following faults: Thuan Hai - Minh Hai Fault, 109°30' Sub-longitude fault, Nha Trang - Tanh Linh Fault, etc.

Level of seismic at project area is calculated based on the fracture and geodynamic conditions. I_{max} = VII (MSK-64), a_{max} = 89cm/s^2, these motions were caused by maximum earthquake M_{Smax} = 5.5, h = 15 km in Thuan Hai - Minh Hai fault zone with epicenter distances 13 km.

3. Tsunamis

There are two reasons that can cause a tsunami which be able to affect this seawaters is earthquake in Philippine waters and the risk of volcanic eruption in offshore water of Binh Thuan and Ba Ria - Vung Tau, however, according to evaluation of the experts, the waves height is 1-1.5 m when earthquakes occurred. Impacts due to earthquakes are assessed insignificantly.

When works will be constructed in both onshore and offshore, it is necessary to design seismic resistance at level VII earthquake to ensure safety.

2.1.2. Meteorology conditions

The meteorological data of The Phan Rang meteorological station of Ninh Thuan province ware used for designing of Vinh Tan 4 TPP. Sequence data were measured from1993 to 2011.

2.1.2.1. Air temperature

This is an area of high air temperature, the annual average temperature in period 1994-2011 is about 27.1°C, the highest temperature is 39.4°C. The lowest temperature is 16.1°C.The temperatures between the months are not different much. The average, maximum and minimum air temperatures at Phan Rang station are shown in table below.

Table 2.6. Air temperature at Phan Rang station period 1993-2010

Unit: °C

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean	24.8	25.5	26.6	28.1	28.7	28.9	28.6	28.5	27.8	26.9	26.2	25.2	27.1
Max	33.1	33.8	35.7	37.4	39.4	38.8	37.6	38.6	37.0	34.7	33.9	32.7	39.4
Min	17.0	17.8	18.1	21.0	22.1	22.6	23.2	17.5	22.0	21.0	17.8	16.1	16.1

Source: Monitoring data at Phan Rang station

2.1.2.2. Air humidity

The project' area is low rainfall, so humidity is quite low with annual average relative humidity of 76% from XII to VIII next year. The months during the rainy season increase humidity.

Table 2.7. Relative humidity at Phan Rang station period 1993-2010

Unit: %

Month	1	2	3	4	5	6	7	8	9	10	11	12	Year
Aver.	71.6	72.3	74.7	75.8	76.9	74.8	74.0	75.6	79.1	80.2	77.5	74.5	75.6
Max	90.0	85.0	93.0	89.0	93.0	91.0	91.0	92.0	94.0	96.0	99.0	95.0	99.0
Min	36.0	38.0	35.0	29.0	34.0	40.0	37.0	35.0	35.0	39.0	44.0	44.0	29.0

Source: Monitoring data at Phan Rang station

2.1.2.3. Air pressure

The annual average value of the air pressure reached 1008mb. The average value as well as the maximum and minimum values between the months does not differ much. Calculation results are shown in table below.

Table 2.8. Air pressure at Phan Rang station in period 1994-2011

Unit: mb

Month	1	2	3	4	5	6	7	8	9	10	11	12	Year
Aver.	1012	1011	1010	1009	1007	1006	1005	1006	1007	1009	1009	1008	1008
Max	1018	1017	1020	1014	1011	1011	1011	1010	1012	1013	1019	1018	1020
Min	1007	1000	1003	1002	1002	1000	1000	998	994	1000	1000	1005	994

Source: Monitoring data at Phan Rang station

2.1.2.4. Wind regime

Wind in Binh Thuan province has two distinct seasons; East and North East wind prevailed from October to April next year and West-south-west wind prevailed from May to

September. The characteristic of wind regime at Phan Rang station in the periods presented in below tables.

Table 2.9. Frequency of wind in eight directions at Phan Rang station, period 1994-2011.

Direction	Calm	N	NE	E	SE	S	SW	W	NW
Frequency (%)	31.6	4.8	19.6	2.3	6.4	2.0	9.4	2.1	3.4

Table 2.10. Frequency of wind in eight directions in rainy season (IX-XII) at Phan Rang station, period 1994-2011.

Direction	Calm	N	NE	E	SE	S	SW	W	NW
Frequency (%)	30.9	12.6	33.4	2.4	5.0	2.0	6.1	2.3	5.4

Table 2.11. Frequency of wind in eight directions in dry season (I-VIII) at Phan Rang station, period 1994-2011

Direction	Calm	N	NE	E	SE	S	SW	W	NW
Frequency (%)	32.0	7.5	19.9	4.2	9.4	3.9	14.9	3.5	4.8

Note: E: East W: West S: South N: North

Source: Monitoring data at Phan Rang station

- Maximum wind velocity

Maximum wind speed: This area is less affected by the storms, there are only 2 storms and some batches of tropical depression from 1978 to 2010 affected this area.

Calculated results of maximum wind speed in Phan Rang station are in table below.

Table 2.12. Maximum wind speed scalar, Phan Rang station (m/s)

Direction	N	NE	E	SE	S	SW	W	NW	Calm
P = 1%	19.5	22.7	15.9	14.3	16.4	15.8	12.1	16.7	22.7
P = 2%	18.2	21.1	14.8	13.6	15.6	15.3	11.6	14.8	21.1
P = 3%	17.5	20.2	14.2	13.2	15.1	14.9	11.2	13.7	20.2
P = 4%	17.0	19.5	13.8	12.9	14.7	14.6	10.9	13.0	19.5
P = 5%	16.5	18.9	13.4	12.6	14.4	14.4	10.7	12.4	18.9
P = 10%	14.9	17.2	12.2	11.8	13.4	13.6	9.9	10.5	17.2
P = 20%	13.2	15.4	10.8	10.9	12.1	12.8	9.0	8.9	15.4
P = 25%	12.5	14.8	10.3	10.5	11.6	12.4	8.7	8.3	14.8

Direction	N	NE	E	SE	S	SW	W	NW	Calm
P = 50%	10.0	12.7	8.4	9.2	9.6	11.1	7.4	6.9	12.7

Source: Monitoring data at stations.

2.1.2.5. Rainfall

In Binh Thuan, the rainy season begins middle of May and ends in last October, rainy season is less of 10 - 15 days than Dong Nai and Ba Ria - Vung Tau provinces. At the beginning and middle of the rainy season, rainfall is very little at most places in Binh Thuan Province, therefore it is cause drought in widespread, rainfall is unevenly distributed in space and time, which tends to decrease from south to north and from east to west. There are not rainy or little of rainfall from 12/2008 to 03/2009 in a large part of the province. Total rainfall measured in Phan Thiet station and Mao River in 2009 is 1071mm and 902.2mm, respectively. Data on total monthly rainfall in Binh Thuan province in the station are shown in the table below.

Table 2.13. Total monthly rainfall, period 2005-2009 (mm)

Station		Rainfall, mm												
		1	2	3	4	5	6	7	8	9	10	11	12	Total
Phan Thiet	2005	0,0	0,0	0,0	0,5	180,7	102,8	204,6	205,9	184,3	225,9	5,1	39,7	1149,5
Song Mao		0,0	0,0	0,2	97,9	90,4	95,3	40,5	146,2	421,9	220,7	3,4	33,4	1149,9
Phan Thiet	2006	0,3	0,0	3,0	30,4	174,6	200,3	249,6	221,2	248,7	89,4	0,0	0,0	1217,5
Song Mao		0,0	0,0	4,9	0,0	85,4	76,3	173,8	142,8	369,3	64,9	4,6	0,0	922,0
Phan Thiet	2007	0,0	0,0	0,3	4,3	265,7	163,6	169,8	230,6	201,2	113,6	173,6	2,3	1325,0
Song Mao		0,0	0,0	14,7	4,8	269,7	199,5	145,5	202,5	316,7	176,2	119,8	4,7	1454,1
Phan Thiet	2008	5,0	1,6	0,0	16,5	218,0	207,9	310,0	121,7	186,4	104,2	44,3	6,5	1222,1
Song Mao		5,0	2,1	0,0	8,3	153,2	53,8	107,4	104,2	157,2	118,7	0,0	0,0	709,9
Phan Thiet	2009	0,0	0,2	0,0	134,4	149,5	78,9	195,4	161,9	168,1	173,6	9,0	0,0	1071
Song Mao		0,0	0,0	0,0	190,9	91,1	28,1	105,1	82,2	96,5	292,7	15,6	0,0	902,2

Source: Monitoring data from stations

Maximum rainfall for design calculations periods is shown in table below.

Table 2.14. Design rainfall at the Vinh Tan 4 (mm)

Period	Frequency P (%)						
	1	2	3	5	10	20	50
10 minutes	30.9	28.5	25.9	23.9	21.4	18.2	13.7

Period	Frequency P (%)						
	1	2	3	5	10	20	50
20 minutes	46.7	43.6	40.3	37.6	34.5	30.2	23.6
30 minutes	60.8	56.3	51.6	47.9	43.6	37.9	29.6
1 hour	103.1	91.9	80.6	72.5	62.7	51.3	37.4
3 hour	164.0	141.5	119.0	103.8	85.8	68.6	47.5
6 hour	188.0	163.5	139.0	121.2	101.7	81.6	56.7
12 hour	265.8	230.4	194.9	166.5	136.0	103.9	65.9
1 day	352.9	303.1	253.3	214.6	173.1	129.6	79.3

Source: PECC2 01/2012

2.1.2.6. Evaporation

This area has clear rainy season and dry season, the variant process of evaporation amount is opposite to one of rainfall, evaporation is high in dry season and vice versa in rainy season. The distribution of monthly evaporation in Phan Rang station is presented in Table below.

Table 2.15. Evaporation (Piche) of Phan Rang stations from 1993-2010.

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Evaporation	193	178	173	154	141	156	157	160	122	110	130	169	154

Source: Monitoring data at Phan Rang station

2.1.2.7. Abnormal weather phenomena

Meteorological condition in Binh Thuan province is relatively complex, long dry season, annual average rainfall is small of 800 mm. So there were drastic, water shortages for production and living in various regions, in addition there were some abnormal weather phenomena in Binh Thuan Province. This caused heavy damages to people in the centre and northern districts.

1. Storms and tropical low pressures (TLP)

Storms and tropical low pressures occur in Binh Thuan- Ca Mau territorial water in 1962 – 2010 are given in the following table.

Table 2.16. Storms and tropical low pressures in Binh Thuan-Ca Mau in 1962–2010

No	Date	Name	Level
1	18/01/2010	TLP	Level 6 (39 - 49 km/h)
2	23/11/2009	TLP	Level 6 (39 - 49 km/h)
3	22/01/2008	TLP	Level 6 (39 - 49 km/h)
4	13/01/2008	TLP	Level 6 (39 - 49 km/h)

No	Date	Name	Level
5	04/11/2007	Peipah	Level 6 (39 - 49 km/h)
6	02/11/2007	TLP	Level 6 (39 - 49 km/h)
7	24/11/2006	Durian	Level 13 (> 133 km/h)
8	22/10/1999	TLP	Level 6 (39 - 49 km/h)
9	11/11/1998	CHIP (No 4)	Level 6 (39 - 49 km/h)
10	31/10/1997	LINDA (No 5)	Level 8 (62 - 74 km/h)
11	07/11/1996	ERNIE (No 8)	Level 6 (39 - 49 km/h)
12	26/06/1994	TLP	Level 6 (39 - 49 km/h)
13	03/11/1988	TESS (No 10)	Level 11 (103 - 117 km/h)
14	10/10/1985	TLP	Level 6 (39 - 49 km/h)
15	14/11/1973	THELMA (No 14)	Level 10 (89-102 km/h)
16	18/10/1968	HESTER (No 8)	Level 8 (62 - 74 km/h)
17	28/11/1962	LUCY (No 9)	Level 9 (75 - 88 km/h)

Source: National meteo-hydrological center

2. Thunderstorms and tornados

Rainy season in Binh Thuan Province started in mid May and ended in early November During the rainy season, there were hazardous weather phenomena such as thunderstorms and tornados at communes of Huy Khiem and La Ngau (Tanh Linh District); tornados and hailstorms at Bac Binh; and flash floods at Tien Thanh – Phan Thiet. These resulted in heavy damages to some places in districts of Duc Linh, Tanh Linh, Phan Thiet and Bac Binh, negatively impacting people's living conditions, the economy and the environment.

Table 2.17. Frequency of tornados in Binh Thuan province in 1971 – 2010

No.	District	Number of year	1	2	3	4	5	6	7	8	9	10	11	12
1	Bac Binh	3	0	0	0	1	3	0	0	0	0	0	0	0
2	Duc Linh	1	0	0	0	0	0	0	1	0	0	0	0	0
3	Ham Tan	3	0	0	0	0	2	0	1	0	0	0	0	0
4	Ham Thuan Nam	2	0	0	0	0	1	0	0	1	0	0	0	0
5	Tanh Linh	1	0	0	0	0	1	0	0	0	0	0	0	0

3. Flash floods

The main characteristics of all the rivers in the province are short, narrow and steeply sloped. As the result, in wet season, water flows very fast, causing sweeping floods. In recent years, the numbers of floods during wet seasons for all rivers were higher than the annual averages and they mostly occurred in September and October. In dry season, especially from February to late April, most rivers and springs run out of water, water level at major rivers significantly decreases. Statistics of flash floor in Binh Thuan province is presented in below Table.

Table 2.18. Statistics of flood in Binh Thuan province in 1992 – 2010

No.	District	River	Date	Damage (billion VND)
1	Bac Binh	-	29/06/1998	
2	Bac Binh	-	29/06/1998	
3	Bac Binh	La Nga	14/06/1999	9700/3districts
4	Bac Binh	-	15/09/1996	3704/the whole province
5	Bac Binh	-	19/05/1996	7528.5/2districts
6	Duc Linh	-	25/07/1994	
7	Duc Linh	-	15/09/1996	3704/the whole province
8	Duc Linh	La Nga	14/06/1999	9700/3districts
9	Duc Linh	Dinh	21/08/2000	
10	Ham Tan	Dinh	29/08/1999	
11	Ham Tan	-	15/09/1996	3704/the whole province
12	Ham Tan	Dinh	09/09/1995	625 billion VND
13	Ham Thuan Bac	-	19/05/1996	7528.5/2districts
14	Ham Thuan Bac	-	15/09/1996	3704/the whole province
15	Ham Thuan Nam	-	15/09/1996	3704/the whole province
16	Tanh Linh	-	15/09/1996	3704/the whole province
17	Tanh Linh	La Nga	14/06/1999	9700/3districts
18	Tanh Linh	-	26/07/1997	
19	Tanh Linh	La Nga	01/07/1994	
20	Tanh Linh	Dinh	18/08/2000	
21	Tanh Linh	-	30/08/2002	
22	Tuy Phong	-	24/10/1992	
23	Tuy Phong	-	15/09/1996	3704/the whole province
24	Tuy Phong	-	15/09/1996	3704/the whole province

No.	District	River	Date	Damage (billion VND)
25	Phan Thiet	-	15/09/1996	3704/the whole province
26	Phan Thiet	-	17/05/2004	

Source: National meteo-hydrological center

4. Coastline landslide

Binh Thuan coastal erosion is a dangerous disaster, according to coastal landslide statistics in the central region to 2005, there are 24 landside segments from the Tuy Phong to Ham Tan with a total length of 28 km, accounted for 14.6% of the length of the coastal line of Binh Thuan. The most serious points of erosion are Phuoc The, Lien Huong, Phan Ri Cua (Tuy Phong district), Ham Tien, Doi Duong beach, Mui Ne (Phan Thiet city).

Phuoc The commune (Tuy Phong district) has a coastline of about 7km; the process of coastal landslide occurred continuously in many years due to sea waves and was approached closer to residential areas. On average, coastline erosion at Phuoc the from 1994 to 2001 occurred 5 - 10m/year, maximum 15-20 m/year on coastline of 500-1500 m long.

At the estuary of Phan Ri, the average erosion speed from 1990 to 1993 was 6 - 7 m/year over the length of 1,000 m on both sides of Phan Ri estuary.

In addition, this is a region of events such as droughts, moving dunes and desertification.

5. Erosion

The coastline in this area is directional with northeast - southwest. Sediment transport and erosion condition are influenced of hydrodynamics that changed with the season (northeast and southwest monsoon).

In the coastal zone of Vinh Tan, the coastline is fairly stability, except Phuoc The and Lien Huong segment. The main material is medium sand, bank and edge 3-5m and without vegetation cover. Phuoc The – Lien Huong coastal zone is eroded now with rate about 5-13m/year (Bui Hong Long et al., 2001). Recently results show that the erosion of Phuoc The and Lien Huong caused by some reason:

Endogenous:

The continental shell in the part of western and northern was lift while the part of eastern was sinking. On the other hand, there is a sink zone in offshore (about 100m depth). May be that is a trap zone of sediments which increase eroded process in the coastal zone.

Exogenous cause:

This is the coastal zone with big slope. Therefore, sediment transported to the offshore more than otherwise.

Wave is quite big and its impact on the coastline in this area in both season northeast and southwest monsoon.

Material in the coastline and bottom are material with light, crumbly, and easy to be transported to the seaward but almost no come back onshore.

Others activities include dam, aquaculture, agriculture and so on are not impact on the balance of sediments transport in this area.

On the above causes, sediments transported to the offshore more than otherwise is main factor impact on the erosion of Phuoc The, Lien Huong coastal area ((Bui Hong Long et al., 2001).

2.1.3. Hydrological and oceanographical conditions

2.1.3.1. Tidal regime in the studied area

Along Binh Thuan province's coastline, there is not any tidal level station, there is only Phu Quy Hydo- oceanographically station on Phu Quy Island, this island is far from Phan Thiet city about 98 km to the South- east. There is Vung Tau oceanographically station in Vung Tau city (1978-2010).

Monitoring data of water level were measured at tidal stations established by PECC2 from 14/10/2007 to14/12/2007 at the project location.

Some characteristics of the tidal regime of the project area are shown in table below

Table 2.19. Characteristic water levels at Vinh Tan stations (Vinh Tan 4 project area)

Unit: cm

	Htb	Hmax	Hmin
H (cm)	21	151	-100
Time appears		21h on 26/11/2007	7h on 27/11/2007

Source: Vinh Tan 1 investment project, 11/2007

Table 2.20. Characteristic water levels at Vung Tau station -period 1978-2010

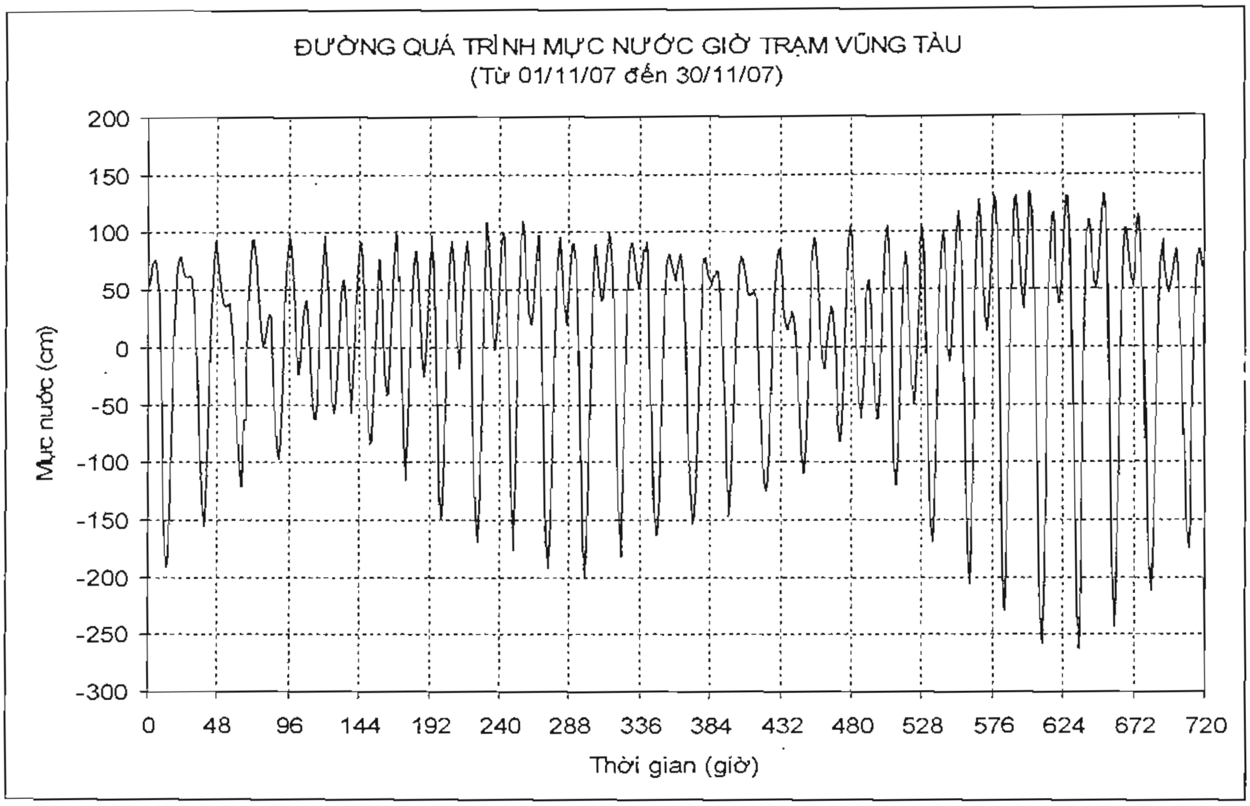
Month	I	II	III	IV	V	VI	VII	VIII	I X	X	XI	XII	Year
Average	-13	-19	-24	-29	-36	-46	-47	-44	-33	-13	-4	-5	-26
Max	143	145	140	121	111	94	101	110	126	142	144	147	147
Min	-297	-281	-256	-282	-314	-333	-324	-311	-274	-256	-291	-289	-333

Source: Monitoring data at Vung Tau station

Note: Water level of Vung Tau station is in national elevation system

According to measured data at Vung Tau station (1979-2010) showed that tide regime at this area is irregular semi-diurnal tide. There are two crests and two bottoms observed in a day, water level of two nearly crests and also of two nearly bottoms is not equal

Figure 2.2. Process of tides 11/2007 in Vung Tau station



2.1.3.2. Calculate the design water level

Based on measured tide water level at Vinh Tan 2 and Vung Tau station from 14/10 to 14/12/2007 shows that the water level correlation of Vung Tau and Vinh Tan station is rather good (correlation coefficient R> 0.9), so that the design water level at the Vinh Tan can be calculated according to the designed water level in Vung Tau, the results is shown in table below.

Table 2.21. The annual mean design tidal level in Vinh Tan

Unit: cm

P (%)	5	10	20	25	50	75	90	95
Htb.p (cm)	4	2	-1	-2	-5	-8	-11	-12

Source: PECC2 11/2011

Table 2.22. Maximum design tidal level in Vinh Tan

Unit: cm

P (%)	0.5	1	2	3	4	5	10	20	50
Hmax.p (cm)	167	164	160	158	156	154	150	144	134

Source: PECC2

Table 2.23. Minimum design tidal level in Vinh Tan

Unit: cm

P (%)	50	70	75	80	90	95	97	98	99
Hmin.p (cm)	-120	-124	-125	-126	-129	-132	-133	-135	-137

Source: PECC2.

Note: water level is in national elevation system

2.1.3.3. Wave and coastal current

Wave direction significantly affected by monsoon, waves in southwest direction prevailed mid-May and September each year, influenced by the southwest monsoon. Waves in East direction prevailed in mid November and the following months, influenced by northeast monsoon.

As Northeast monsoon gradually transformed into southwest monsoon in April, mainly wave direction is East - southeast and East. When the southwest monsoon gradually transformed into the North East monsoon in October, mainly oriented eastward waves, the wave direction is south-west side. In year, east direction is main direction with a frequency of 34.2% and the secondary is the southwest with a frequency of 24.5%.

Maximum wave height in Phu Quy station is shown in table below.

Table 2.24. The maximum design wave height at Phu Quy station

Year	1999	2000	2001	2002	2003	2004	2005
Hmax, m	5,0	3,5	4,0	4,0	3,5	3,0	3,5

Source: Monitoring data in Phu Quy station

Because the observed data at Phu Quy station is incomplete, data on wave height and direction were taken from Vung Tau oceanographic and meteorological stations located in Ba Ria - Vung Tau.

Table 2.25. Wave height and direction on Vung Tau station

Year	Month	1	2	3	4	5	6	7	8	9	10	11	12	Year
2005	Hmax, mm	0,75	0,75	1,00	0,75	1,25	1,00	1,50	1,25	1,25	0,75	1,00	1,00	1,50
	Direction	NE	NE	NE	NE	SW	W	W	W	W	NE	W	NE	W
	Day	2	22	14	3	10	29	29	13	13	21	1	8	29/07
2006	Hmax, mm	1,00	1,00	0,75	0,75	1,00	1,00	1,25	1,50	1,25	1,25	1,00	1,25	1,50
	Direction	NE	NE	NE	NE	SW	SW,W	SW	SW,S	SW	SW	NE	SE	SW,S
2007	Hmax, mm	1,00	1,00	1,00	0,75	1,00	1,00	1,25	1,50	1,25	2,00	1,25	1,00	2,00
	Direction	NE	NE	NE	NE	SW	SW	SW	W	SW	SW	NW	NE	SW

Year \ Month		1	2	3	4	5	6	7	8	9	10	11	12	Year
	Day	18	13	21	5	13	25	12	5	18	2	22	1	02/10
2008	Hmax, mm	1,00	1,00	1,00	1,00	1,25	1,25	1,25	1,50	1,25	0,75	1,00	0,75	1,50
	Direction	NE	NE	E	NE	W	SW	W	W	SW	E	NE	NE	W
	Day	16	6	10	17	12	25	20	8	24	8	19	16	08/08
2009	Hmax, mm	0,75	1,00	1,00	1,00	1,00	1,25	1,50	1,25	1,50	1,00	1,00	1,00	1,50
	Direction	NE	NE	NE	NH	SW	SW	SW	SW	W,SW	W	N,NE	NE	SW
	Day	1,22,27	28	1,2,3	NH	25,27	2	16	2	7,29	8	3,7	17,19	16/07

Source: Monitoring data in Vung Tau station

From the measured data of current on the layers: 0m, 5m, 10m, 20m of depth showed that the more deep layer the more stable current. The project area is near the northern of La Gan Headland; the current is southwest and is stable from surface to bottom. Average speed of the flow in this region is stronger than southern region.

2.1.3.4. Seawater temperature

To assess water temperature in the studied area, we use the observational data at Phu Quy station from1979 to 2005 and data of Vung Tau station (onshore) from1979 to 2009. Monitoring data at the two stations is shown in below Tables.

Table 2.26. Seawater temperature at Phu Quy station (°C), period (1979-2005)

Month	1	2	3	4	5	6	7	8	9	10	11	12	Year
Average	25.5	25.6	26.9	28.7	29.3	28.8	28.4	28.3	28.8	28.5	27.0	25.5	27.6
Max	30.9	35.2	35.4	34.9	34.0	34.0	34.0	33.3	33.9	34.2	33.1	31.9	35.4
Min	20.3	20.0	20.6	24.4	21.8	24.8	25.0	25.1	25.0	24.6	23.2	21.2	20.0

Source: Phu Quy observation station

Table 2.27. Seawater temperature at Vung Tau station (°C), period (1979-2009)

Month	1	2	3	4	5	6	7	8	9	10	11	12	year
Average	26.5	26.6	27.8	29.5	30.1	29.5	28.7	28.5	28.6	29.0	28.4	27.3	28.4
Max	29.5	30.0	31.5	32.1	32.5	32.2	31.8	31.4	31.9	31.6	31.0	30.3	32.5
Min	23.8	24.0	24.1	26.9	26.7	26.7	25.8	25.0	24.0	26.5	24.0	24.8	23.8

Source: Vung Tau observation station

It shows that the monthly average temperature at both stations is not much different. The temperature is lowest in December or January. The temperature is highest in April or May. Monthly minimum temperature observed at stations Phu Quy is about 20°C (II/ 2001) and at Vung Tau station is 23.8° C (I/1993). Maximum temperatures are 35.4^{0}C (3/2005) at stations Phu Quy and 32.5^{0}C (5/1992) at Vung Tau station.

2.1.3.5. Salinity

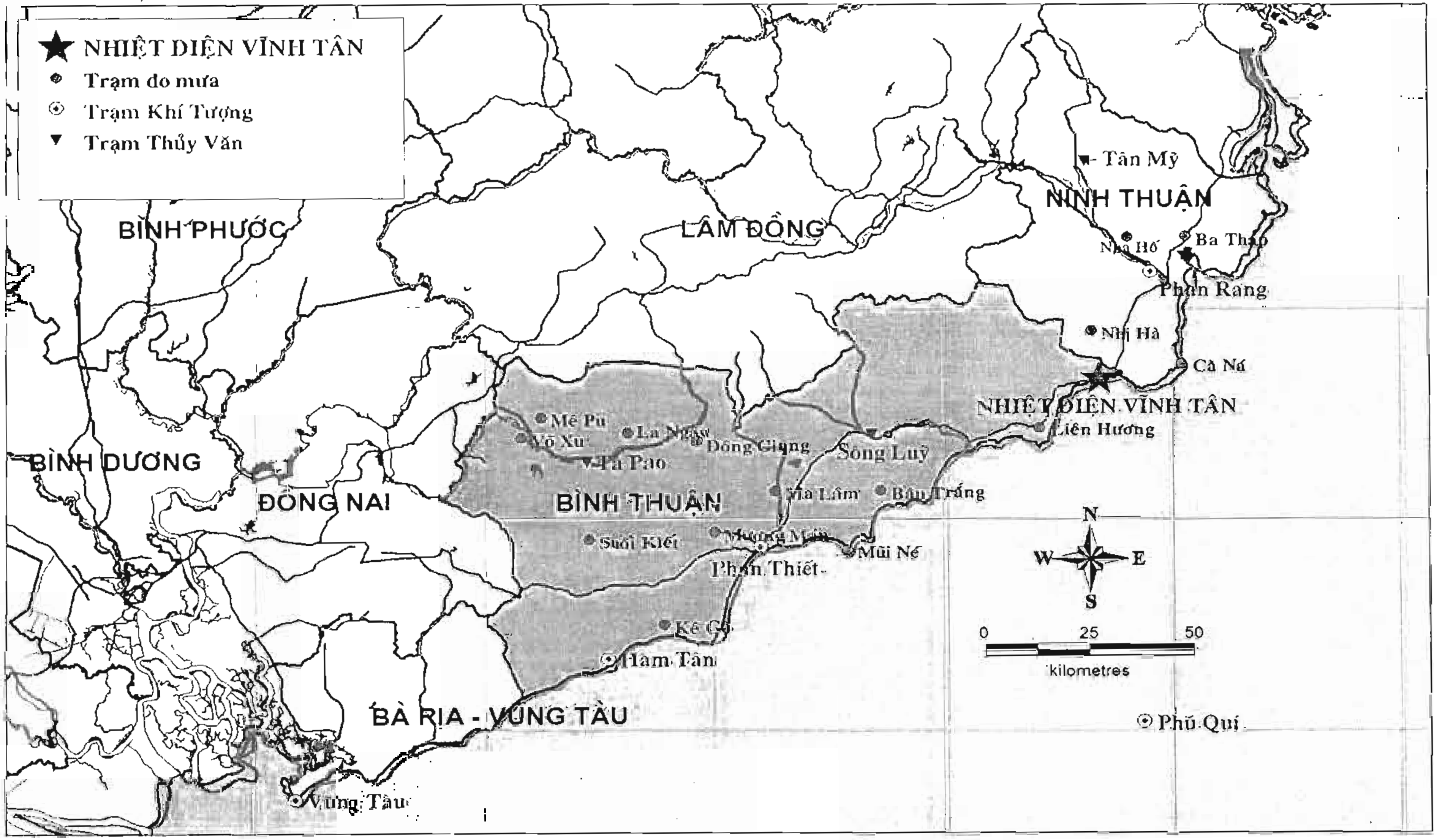
Salinity of sea water was only measured at Phu Quy station in period from 1979 to 2005. Salinity measuring regime at this station is 4 times a day (1,7,13 and19h). Salinity characteristics are shown in Table below.

Table 2.28. Salinity at Phu Quy station in period 1979-2005 (%)

Month	1	2	3	4	5	6	7	8	9	10	11	12	Year
Average	32.1	32.4	32.5	32.6	32.4	32.2	31.7	31.1	31.2	31.0	31.4	31.5	31.9
Max	35.3	35.2	37.6	35.9	35.2	35.3	35.5	35.7	35.1	34.7	35.3	35.1	37.6
Min	20.6	21.7	21.9	21.7	20.1	20.7	21.0	20.7	21.1	21.3	21.5	21.4	20.1

Source: Phu Quy observation station

Figure 2.3. Project Location and Hydrometeorological station in and around studied area



2.1.4. Natural resources

2.1.4.1. Land Resources

According to the investigation of land use planning of Tuy Phong district in 2009, the district has 9 mainly soil groups, distributed on the specific terrain is mountainous and coastal plains. Most of the soil is not high fertility.

1. Red soil group (Ferralsols): This group land has the largest proportion compared with other group of land in the Binh Thuan province. In Tuy Phong district, land area is 44493.59ha, which is equivalent to 56% of the natural area.

+ Endolithi acri - Rhodic Ferralsols.
+ Epilithi acri - Rhodic Ferralsols.
+ Epilithi areni - Xanthic Ferralsols.
+ Areni - Xanthic Ferralsols.
+ Epilithi - Humic Ferralsols.

2. Sandy soil: In Tuy Phong district, this area is about 9.023,38ha, accounting for 11.35% of the natural area. The sandy soil group includes white sand dunes(Ct), yellowish white sand dunes (CtV), reddish sand dunes (Cđ)and sea sand soil

+ Yellow and white sand soil (Dystri - Luvic Arenosols): These types of soil are acidic, humus poor, poor nutrient on the topsoil, holding capacity of humus and water is not good. In some places where irrigation is possible, they plant the food crops and short-term industrial crops, coastal protected forest ware planted in some area. The remaining majority of land has not been put to use.
+ Reddish sand dunes (Dystri - Rhodic Arenosols): Mechanical composition of the land is distributed evenly from top to bottom layer, reaction acid, humus-poor, strong resolution of organic, poor nutrient. On this land is currently used to grow many crops, fruit trees and industrial crops.
+ Sea sand soil (Dystri - Haplic Arenosols): this type of land characterized byalkalinity, humus-poor, poor nutritional content. Landis distributed in most districts in the province, mostly in Tuy Phong (5583 ha). Currently the majority of seas and was not used. In some places where irrigation is possible, they planted rice and legumes.

3. Alluvial soil (Fluvisols): The area is about 4.729,15 ha, which is equivalent to 1.07% of the natural area of Tuy Phong district. This land has a high rate clay composition, holding capacity of water and humus is good. This land suitable for rice, vegetables, short-term industrial crop sand fruit.

4. Gray soil: The area is about 3,693.64ha, which is equivalent to 4.64% of the natural area of Tuy Phong district. Soil has light and medium mechanical composition, acidic soil, humus-poor. In some place they plant rice, crops, and industrial crops with low productivity. Some areas are used for afforestation against erosion

5. Salty soil: The area is about 424,36ha, which is equivalent to 0,53% of the natural area of Tuy Phong district.. The salty soil group includes the salty soil of aegiceras species, low

and medium salty soil (Salic -UmbricFluvisols), soil with high salinity (Eutri - SalicFluvisols).

Salty soil is found mostly in Tuy Phong district. Soil has light and medium mechanical composition and is acidic, and with high humus content, poor nutrient, medium total phosphorus. This soil is suitable for agricultural production if is invested. At present the most of land are being used to grow rice and vegetables.

6. Saline alkali soil: The area is about 160,25ha, which is equivalent to 0.20% of the natural area of Tuy Phong district. Characteristics of the soil is high salt content Na2CO3 (> 9%) and NaHCO3, now it has been used to exploit NaOH in the technology soap production. But this soil is also suitable for planting crops and other upland crops.

7. Red-brown soil and gray in semi-arid regions (Livisols): an area isd9430.67 ha, accounting for 11.68% of the natural area of the district. Land is divided into gray-brown semi-arid regions (Rhodium - Haplic Lixisols), red-brown soil semi-arid areas (Ferri - Haplic Lixisols). These soils mainly concentrated in Tuy Phong district

Land with mechanical composition of mild to moderate, less acidic, humus content from medium to good, protein and total phosphorus is poor. The ability of agricultural production on land is limited, in some small area, this soil is used to plant crops and short-term crops

8. Newly modified soil: an area is 204.3 ha, accounting for 11.68% of the natural area of the district

9. Eroded soil with bare rocks: an area is 1,226.73ha, accounting for 1.54% of the natural area of the district

Therefore, in the Tuy Phong District, there are 9 soil groups with 16 different soil types. However, due to arid conditions, most of these soils are nutrient-poor, some are eroded and there are signs of desertification in coastal areas

2.1.4.2. Water resource

In Binh Thuan province, there are seven main river basins: Song river, Luy river, Cai river, Ca Ty River, Phan river, Dinh and La Nga Rivers. The total catchment area is 9880 km2 with 663 km length of rivers and streams. However, water distribution imbalances in space and time. The area in La Nga River Basin is often flooded but in Tuy Phong, Bac Binh, coastal of Phan and Dinh River basins with water shortages, this is the warning signs of desertification.

The main characteristics of rivers in this area are steeply sloped, flowing through areas with scattered vegetation and thin soil layers. Downstream flow is small due to existing irrigation dam.

1. Surface water

In Tuy Phong district there are two main rivers: the Long Song river (the endpoint is estuary Phuoc The) with 43km long and Luy river (endpoint is Phan Ri estuary) with 25km long. These rivers are both short and have steep slopes, beside that there are irrigation reservoirs on both these rivers to provide water for agriculture in the region.(There are irrigation dams such as Da Bac, Long Song reservoirs on the Long Song river, Ca Giay and Ca Tot reservoirs on the Luy River. In studied area the rainfall is small, the evaporation is high, therefore surface water is not enough to provide for agriculture and daily life of people in dry season

Data on the rivers and streams flow in Tuy Phong district are presented in Table below

Table 2.29. Water discharge of rivers in Tuy Phong District area

No.	River basin	Area km2	Water volume106m3	Discharge(106m3/day)
1	Luy River	1910	591	246.8
2	Mui Ne river			146.6
3	Long Song river	511	108	123.7

Source: ***http://www.vawr.org.vn.*** Irrigation Science Institute South of Vietnam

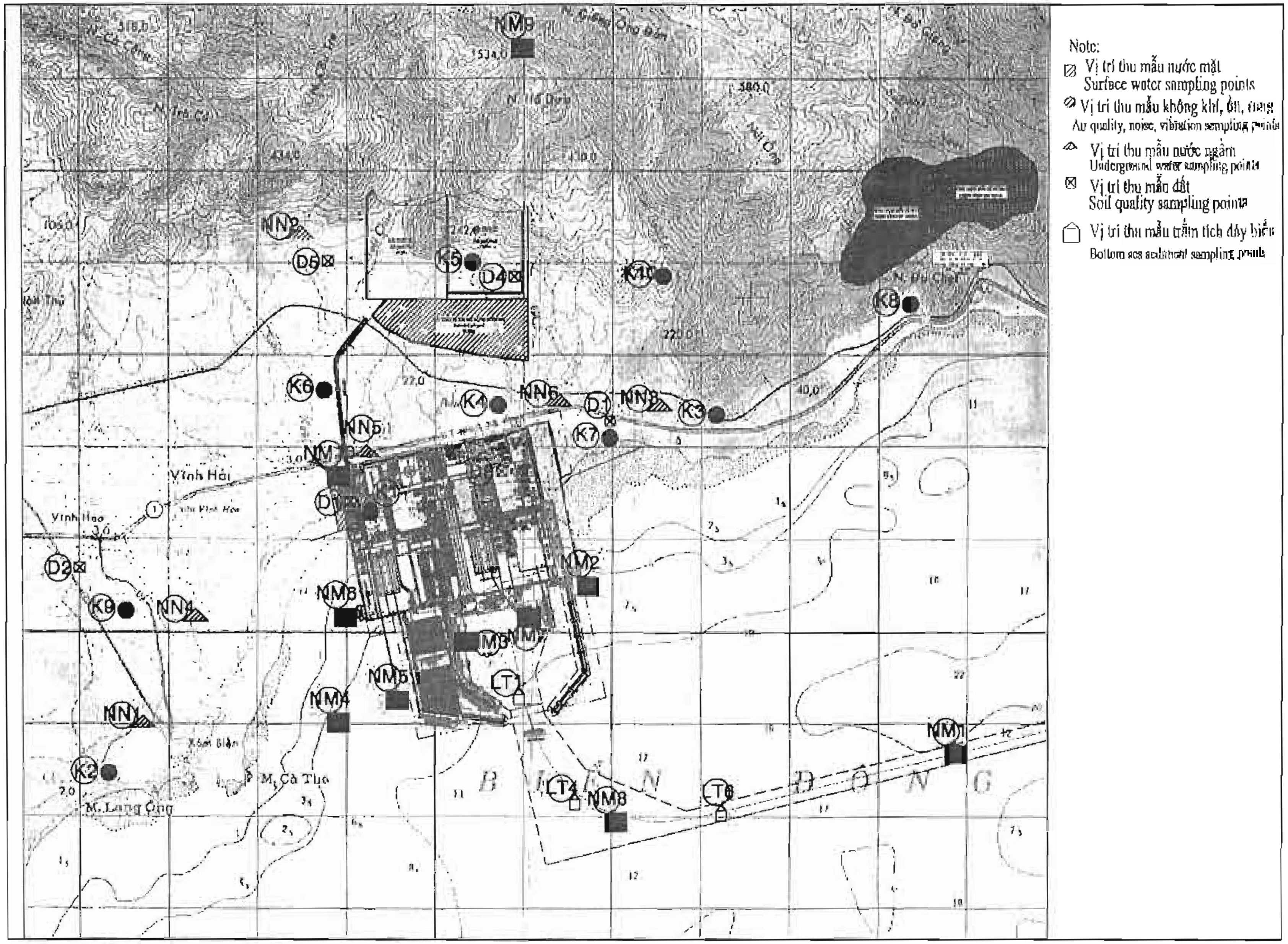
2.1.5. Current Situations of Environmental Quality in the Project's Area

Locations of measurement and sampling points of air, surface water, seawater, groundwater and soil of the project area are selected to be located in sensitive areas, potentially affected by the operation of the plant; and these locations are also the basis for selection of environmental monitoring point in the construction and operation of plant.

- For air, noise and vibration, location of sampling is near the residential area, or along the transportation routes of materials which may be affected by exhaust gas, dust, noise, vibration, or flue gas emitted during the operation (K2, K3, K4, K6, K7, K8, K9, K10), or a construction site (K1,K5).
- For water environment, water samples are taken at intake and discharge of cooling water, domestic and industrial wastewater of Vinh Tan 4 TPP, surface water, coastal water around the project area to consider the increase in water pollution due to construction activities, wastewater discharging in the operation, the possibility of leakage and seepage of wastewater into the groundwater.
- For groundwater environment: groundwater is taken from wells in households around project's site to assess groundwater source provided for domestic purpose of resident in project site.
- Similarly, soil samples are taken from locations near the construction site and around the plant area to consider the possibility of dissolving of metals fixed in the soil due to industrial wastewater leakage from the plant or the direct absorption of heavy metals in solid waste and wastewater of the plant into the soil.

The sampling sites to evaluate the water quality, atmospheric, and soil environments, as well as aquatic ecosystems inside and outside the project's area are shown in figure 2.4.

Figure 2.4. Map of sampling soil, water, air and noise vibration measurements



2.1.5.1. The surface and coastal water quality

Surface water sampling was taken in 2/2012 by PECC2 and Sac Khi Hai Dang scientist technology services joint Stock Company.

There are two locations of surface water sampling in the river including: one location of upstream Chua streams (NM9) was measured in the dry season in 25/03/2010 and one location of downstream Chua streams (NM10) was measured in the rainy season in 09.28.2010 (due to dry season have no water) and there are 6 locations of sea water measured in 2/2012. Two location of sea water samples (NM7, NM8) were measured in 4/2010 by the Institute of Science and Technology of Vietnam, Institute oceanographic.

Location of surface water and sea water sampling is presented in Table 2.30 and figure 2.4. Results of surface water and sea water quality are presented in table 2.31.

Table 2.30. Sampling sites of surface and inshore water quality

No.	Code	Geographical coordinates	Sampling site
			Sea water samples
1	NM1	110 17'44.4 N 1080 50'01.56 E	At the approach channel (at low tide), taken at a depth of 2.0 m
2	NM2	110 18'45.00 N 1080 48'49.95"E	Near the discharge point in eastern of center power (at low tide) taken at a depth of 2.0 m
3	NM3	110 18'21.2" N 1080 48'00.0" E	At the Vinh Tan 3, Vinh Tan 4 ports (at low tide) taken at a depth of 2.0 m
4	NM4	110 18'02.5 " N 1080 47'18.9"E	On the East Sea, distance from the discharge point to the location is 700m southwest (at ebb-tide) taken at a depth of 2.0 m
5	NM5	110 18'33.5 N 1080 47'29.48" E	In the position of expected cooling discharge water of Vinh Tan 4 (tidal flood) taken at a depth of 2.0 m
6	NM6	110 18'33.5 " N 1080 47'29.48" E	At local port 3000 DWT distance 700 m (tidal flood), taken at a depth of 2.0 m
7	NM7	110 18'31.32 " N 1080 48'36.72" E	At Vinh Tan 1 port, taken at a depth of 2.0 m
8	NM8	110 17'27.64 " N 1080 48'50.36" E	At the approach channel, taken at a depth of 2.0 m
			Surface water samples
7	NM9	110 21'02.7 " N 1080 47'29.4" E	Upstream Chua river
8	NM10nn	110 21'02.7 " N 1080 47'29.4" E	Downstream Chua river

Table 2.31. Results of analysis of surface water quality in project's area

Parameter	Unit	Sea water sample								Surface water sample		QCVN 10:2008/ BTNMT	QCVN 08:2008/ BTNMT
		NM1	NM2	NM3	NM4	NM5	NM6	NM7	NM8	NM9	NM10		
pH		7.99	7.98	7.99	7.99	7.99	7.97	8.06	8.13	6.9	7.2	6.5-8.5	5.5-9
EC	µS/cm, 25oC	60500	59200	58950	59800	58800	59000	51000	51000	183	1228	-	-
T0	0 C	28.9	29.0	29.1	28.9	28.6	28.6	29	29	27.4	32.2	30	-
DO	mg/l	6.5	6.3	6.6	5.8	6.4	6.4			6.6	4.3	≥5	≥ 2
COD	mg/l	2	2	2	3	3	5	11	10	9	34	3	50
BOD5	mg/l	KPH	KPH	KPH	KPH	KPH	KPH	1.19	0.73	5	17	-	25
TSS	mg/l	5	5	5	6	6	8	24	22	3	53	50	100
NO3-	mg/l	0.31	0.29	0.31	0.32	0.33	0.32	0.0294	0.0285	2.57	0.63	-	15
*NO2-	mg/l	KPH	KPH	KPH	KPH	KPH	KPH	0	0	<0.01	0.006	-	0.05
N-NH4+	mg/l	KPH	KPH	KPH	KPH	KPH	KPH	0.013	0.020	1.4	1.2	0.1	1
*PO43-	mg/l	KPH	KPH	KPH	KPH	KPH	KPH	0.032	0.0349	0.013	0.402	--	0.5
* Cl-	(g/l)	18.82	18.89	18.82	19.03	19.03	18.96			30	230	-	-
Residual	mg/l	KPH	KPH	KPH	KPH	KPH	KPH	<0.0005	<0.0005	<0.01	<0.01	-	-

Parameter	Unit	Sea water sample								Surface water sample		QCVN 10:2008/ BTNMT	QCVN 08:2008/ BTNMT
		NM1	NM2	NM3	NM4	NM5	NM6	NM7	NM8	NM9	NM10		
Cl													
* Hg	mg/l	KPH	KPH	KPH	KPH	KPH	KPH	0.00027	0.00031	<0.0005	<0.0005	0.001	0.002
*Pb	mg/l	KPH	0.00048	0.00042	0.00044	0.0011	0.001	0.001	0	<0.001	0.035	0.05	0.05
*Cu	mg/l	KPH	KPH	KPH	KPH	KPH	KPH	0.0007	0.0006	0.001	<0.001	0.03	1
*Ni	mg/l	KPH	KPH	KPH	KPH	KPH	KPH	0.0003	0.0003	<0.001	<0.001	-	0.1
Fe	mg/l	0.29	0.28	0.31	0.3	0.28	0.27	0.149	0.167	0.458	0.213	0.1	2
Grease	mg/l	KPH	KPH	KPH	KPH	KPH	KPH	0.616	0.467	<0.01	0.01	Undetectable	0.3
Coliform	MPN/100ml	9.1x100	4.3x101	4.3x101	1.5x101	9.3x101	2.3x101	9.2x101	0	7.0x102	4.3x102	1000	10000

- *Source: Sac Khi Hai Dang science technology services joint Stock Company, Institute of Science and Technology of Vietnam* ***Oceanographic Institution 4/2010***
- Note: KPH: Not Detectable, (-) is not specified in the standard
- *NM7, NM8 sea water sampling location carried out in 4/2010*
- *NM9, NM10 surface water sampling at upstream and downstream of Chua creek in 3/2010.*

Note:

The project area is located in Hon Cau MPA via Decision No.2606/QD-UBND dated 15/11/2010. So sea water quality has to ensure QCVN 10:2008/BTNMT on coastal water for the aquaculture and aquatic conservation purpose.

For surface water quality of rivers and streams meet water quality standards for the purpose of navigation and other purposes with low water quality requirements via QCVN 08:2008/ BTNMT on surface water quality.

Remarks

- pH

pH at all sampling points from NM1 to NM8 varies from 7.99 to 8.13, within the allowable limits of QCVN 10:2008/BTNMT (6.5 – 8.5, applicable to coastal sea water used for aquaculture).

Points NM9 and NM10 are located in a region of fresh water and pH is from 6.9 to 7.2, within the allowable limits of QCVN 08:2008/BTNMT applicable to surface water class B2 (5.5 – 9.0).

- Electrical conductivity (EC)

Electrical conductivity in sea water at the project site varies in the range of 51000-60500 µS/cm with the highest one at NM1 (60500 µS/cm) and the lowest at NM7,8 (51000 µS/cm).

Particularly, NM9 and NM10 are located in a region of fresh water, so electrical conductivity is low, from 183 to 1228 µS/cm.

- Dissolved oxygen (DO)

DO in sea water at the project site is high, from 5.8 to 6.6 mg/l. This may be due to strong winds and waves at the sampling time that causes oxygen in the air to dissolve well in surface water.

DO in river water is from 4.3-6.6 mg/l. Thus, DO concentrations in sea water and river water are within the permitted limits for aquaculture and transportation.

- COD and BOD_5

COD in surface water at the project site : at 6/8 sampling locations are within the limits of QCVN 10:2008/BTNMT. At NM7, NM8 COD exceeds roughly 3 times the allowable limit of QCVN 10:2008 BTNMT. It shows that sea surface water contaminated organic.

COD's concentration in two river water sampling sites is from 9-34mg/l, and within the allowance limits of QCVN 08:2008/BTNMT.

BOD5 in sea water at the project area are mostly not detectable, only in two samples NM7, NM8 were found, and however BOD is not specified in QCVN10:2008/BTNMT.

At the river water sampling location, BOD5 varies between 5-17mg/l which meets QCVN 08:2008/BTNMT.

- ***Nutrient pollution***

The pollution due to nutrients is expressed by concentrations of N-NH_4^+ and NO_3^-, total N and total P.

N- NH_4^+: at 6 locations/ total of 8 locations (NM1-NM6), concentrations of nutrients are not detectable. At NM7, NM8, NH_4^+ varies from 0.013-0.02 mg/l which meets QCVN 10:2008/BTNMT. For river water, NH_4^+ is from 1.2-1.4 mg/l which higher than in the limit set forth in QCVN 08:2008/BTNMT.

NO_3^-: NO_3^- in sea water and river water is from 0.028-0.32 mg/l, 0.63-2.57 mg/l, respectively, which is less than the allowable limit.

PO_4^{3-}: PO_4^{3-} in sea water is not detectable in 6/8 sea water sampling locations, or have found but very small. For river water, PO_4^{3-} is within allowable limit.

- ***Metal pollution.***

Concentration of heavy metals such as Pb, Cu, Fe, Ni, Hg at the river and sea water sampling locations are not detectable or are within the allowable limit of QCVN 10:2008/BTNMT and QCVN 08: 2008/BTNMT.

- Oil and Grease

The oil and grease content of surface water in the project site in the East Sea at 6/8 sampling locations are not detectable, only found at NM7, NM8 locations with ranging from 0.467-0.616mg/l. That oil and grease may be discharged by fishing boats anchoring in the region as well as by domestic activities.

At two rivers water samples (NM9 and NM10), oil content in surface water, respectively, 0.458 and 0.213 m /l. So at NM9, oil content is higher than the allowed value in QCVN 08:2008/BTNMT (prescribed 0.3 mg/l for surface water type B2).

- Bacteria (Coliform)

In all water samples collected, Coliform is very low, from 9.1 to 700MPN/100ml, which is much lower than the allowable limits on coastal sea water used for aquaculture (QCVN 10:2008/BTNMT, 1000 MPN/100ml) and on surface water source class B2 (QCVN 08:2008/BTNMT, 10,000 MPN/100ml) .

Remarks:

Through statistical indicators of chemical, microbiological and other indicators at the sample's locations of sea water and surface water in the project area showed that surface sea water is slightly contaminated expressed by chemical oxygen demand (COD) which is higher than the allowable limit of about 3.4 times (in 2/8 position observation NM9, NM10).

Oil pollution is low levels; this pollution can be caused by waste water from daily life, from fishing boats and from food for shrimp, which is discharged directly into the marine environment in this area without treatment.

2.1.5.2. Underground water quality

To assess the quality of groundwater in the project area, groundwater samples were taken in and around the project area by Sac Khi Hai Dang scientist technology services joint Stock Company and PECC2 on 02/2012. Sampling locations are shown in Table 2.32 and Figure 2.4. The analysis results of the groundwater samples are presented in Table 2.33.

Table 2.32. Sampling sites of underground water quality

No.	Symbol	Geographical coordinates	Sampling site
1	NN1	110 18'46.9 " N 1080 46'55.7" E	In existing residential areas near the project area (Hamlet7) 194 Vinh Tien village, Vinh Tan commune, Tuy Phong district, Binh Thuan province. Opposite the Company Hai Thu. Measured 02/2012
2	NN2	110 20'09.6 " N 1080 47'29.2" E	Ash disposal area, Tran Van Hoi's house 453 Vinh Phuc hamlet, Vinh Tan commune, Tuy Phong district, Binh Thuan province, Measured 02/2012
3	NN3	110 19'27.3 " N 1080 48'53.9" E	In existing residential areas near the project area, Dinh Thi Ngat's house , 453 Vine Tien hamlet, Vinh Tan commune, Tuy Phong district, Binh Thuan province, Opposite the seed private company Tran Hau Dien. Measure 02/2012
4	NN4	110 19'13.5 " N 1080 47'27.1" E	Wells at the Thanh Tuyen hotel , measure 3/2010
5	NN5	110 19'00.2 " N 1080 47'20.4" E	Wells at the Truc Thien coffee , measured 3/2010
6	NN6	110 19'27.3 " N 1080 48'24.2" E	Wells opposite the management office. Measure 3/2010

- **Remark**

Based on the results of the groundwater samples in table 2.33, characteristics of ground water in the project areas are as follow:

- *Salinity*

All of the wells in project area are found to have high salinity. This is shown by high concentration of chloride (Cl^-). Cl^-concentration in underground water is 250 mg/l regulated in the QCVN 09:2009/ BTNMT-National technical regulation on groundwater quality. While in the wells NN1, NN4, NN5, NN6, the concentrations of Cl^- are in the range of 815-5680 mg/l which higher of 3.26-22.7 times than the allowance limits in

QCVN 09:2008/BTNMT.

- Nutrients

The level of nutrient pollution in water is expressed by parameters of ammonium ($N-NH_4^+$), nitrate (NO_3^-), nitrite (NO_2^-), total Nitrogen (N), and total phosphate (P).

NO_2^- indicators: In the 5/6 monitoring wells, at NN1, NN2, NN4, NN5, NN6, concentration of NO_2^- ranges from 0.024-0.15 mg/l, which within the allowable limits by QCVN 09:2008/BTNMT (1.0 mg/l). However, at NN3 location in Vinh Tien hamlet, Vinh Tan commune, NO_2^- concentration reached 15.59mg/l is higher of 15.6 times than acceptable limits.

NO_3^- indicators: At 4/6 monitoring wells (NN1, NN3, NN4, NN5), the concentration of NO_3^- ranged from 20.9 mg/l (NN4) - 51.26mg/l (NN5) exceeded 1.39 to 3.42 times than the permitted standard (15mg/l).

NH_4^+: at the 3 positions in Vinh Tien, Vinh Phuc hamlets, Vinh Tan commune (NN1, NN2, NN3), the *NH_4^+* concentration are not detected, only in 3 positions of NN4, NN5, NN6, this concentration is higher of 22.7-32.4 times than the allowable limit.

Concentrations of NO_3^-, NO_2^-, NH_4^+ are significantly high at monitoring positions may be due to the impact of waste of shrimp feed, excrement and metabolism of nutrients in shrimp farms of Tran Hau company located opposite with observation wells (NN3) and a number of points in residential areas may be affected by daily waste, livestock, cultivation of the people..

- The organic compounds

To assess the presence of organic compounds in the water, we based on following indicators as dissolved oxygen in water (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD).

COD's concentrations in groundwater monitoring wells (NN1, 2,3,4,5) are within allowance limits of QCVN 09:2008/BTNMT ≤ 4 mg/l. The only NN6 location exceed 4.25 times than the permitted standard (COD in NN6 = 17mg/l), it shows that groundwater has been polluted by organic in some places in the project area.

BOD5 concentrations in groundwater in the project area ranged from 1-2 mg/l, and only were monitored in positions NN4, NN5, NN6. BOD_5 concentration is not stipulated in QCVN 09:2008 / BTNMT.

- PH.

In groundwater, pH ranged from 6.6 (NN4) – 8.15 (NN1) are less than acceptable standards. Thus, groundwater is neutral response to weak alkaline in the project are.

- Hardness.

At 5 monitoring wells positions, hardness ranges from 896-1960 $mgCaCO_3/L$, exceeding from 1.79 - 3.92 times than the permitted limit of QCVN 09:2008/BTNMT.

- Heavy metal pollution.

Iron content in monitoring wells positions ranged from 0.00075 (NN2) – 0.01(NN4) and it was much lower than the permitted limit of QCVN 09:2008/BTNMT (0.05 mg/l). Thus in the project area groundwater is not contaminated by heavy metals.

- Microorganism contamination

Most of the wells are contaminated by microorganism and the levels are much higher than QCVN 09:2008/BTNMT. It is caused by domestic wastewater of local residents which is not collected, treated and discharged into the proper receiving source. Most of this wastewater is discharged into soil by the self-permeable mechanism. Domestic wastewater containing large amount of coli form has soaked into the soil and penetrated aquifers.

Table 2.33. Results of analysis of underground water quality in project's area

No	Parameter	Unit	NN1	NN2	NN3	NN4	NN5	NN6	QCVN 09:2008/BTNMT
1	To	oC				30.3	29.8	29.3	
2	pH		8.15	7.20	7.66	6.6	7.0	7.3	5.5-8.5
3	COD	mg/l	3	3	3	4	4	17	4
4	TS	mg/l	11650	154	552				
5	BOD5	mg/l				2	1	<1	
6	NH4+	mg/l	KPH	KPH	KPH	3.24	2.61	2.27	0.1
7	NO3-	mg/l	36.78	13.08	32.05	20.9	51.2	4.3	15
8	NO2-	mg/l	0.15	0.056	15.59	0.02	0.02	0.05	1.0
9	hardness	mgCaCO3	1960	26	152.5	896	975	153	500
10	F-	mg/l	1.23	1.09	1.32	0.93	0.29	0.29	1
11	SO42-	mg/l	553.33	11.29	31.21	45	105	135	400
12	CN-	mg/l	KPH	KPH	KPH	0.00	0.00	0.00	0.01
13	Cl-	mg/l	5680	30.53	95.14	815	102	222	250
14	As	mg/l	0.0044	0.0007	0.002	0.01	0.00	0.00	0.05
15	Fe	mg/l	0.22	0.21	0.29	0.00	0.00	0.62	5
16	Coliform	MPN/100ml	9.3x101	4.6x103	9.3x102	43	4600	230	3

Source: Sac Ky Hai Dang Science Technology Services JSC. 02/2012

2.1.5.3. Seabed sediments

To determine particle composition, concentration of heavy metals in seabed sediments, this report refer to the sediment analysis data in EIA report of Vinh Tan Power Complex deep sea port - Stage 1. The sediment samples was collected and analyzed on May 2010. Location of seabed sediments sampling is presented in Table 2.34 and figure 2.4. Results of seabed sediments quality is presented in table 2.35.

Table 2.34. The sampling sites of seabed sediments

No	Symbols	Coordinates (VN2000)	
1	LT1	1249502,40	533393,65
2	LT4	1248694,29	533918,51
3	LT6	1248575,85	534912,08

Table 2.35. The analyzed result of heavy metal concentration in seabed sediment

Standard / Parameters		Position 1	Position 4	Position 6	QCVN 43:2012/BTNMT (mg/kg)
pH		7,58	7,47	7,61	-
TOC (%)		0,26	0,28	0,28	-
Total heavy metal					
As (µg/g)		2,2	2,8	2,9	41,6
Ba (µg/g)		0,05	0,06	0,07	-
Bo (µg/g)		1,32	1,77	1,61	-
Cd (µg/g)		0,03	0,03	0,05	4,2
Cr (µg/g)	Cr6+	2,4	2,4	2,1	-
	Total	3,1	3,1	2,8	160
Co (µg/g)		1,4	2,7	3,3	-
Cu (µg/g)		1,3	2,6	3,6	108
Fe (µg/g)		5589,0	6545,9	7069,2	-
Pb (µg/g)		8,2	8,8	10,7	112
Hg (µg/g)		0,19	0,19	0,17	0,7
Mn (µg/g)		78,3	83,4	65,9	-
Ni (µg/g)		1,0	3,4	2,9	-
Se (µg/g)		0,02	0,03	0,03	-
Ag (µg/g)		ND<0,001	ND<0,001	ND<0,001	-
Zn (µg/g)		8,6	16,3	20,4	271
Cyanide (µg/kg)	Free	ND<5	ND<5	ND<5	-

Standard					QCVN 43:2012/BTNMT (mg/kg)
Parameters		Position 1	Position 4	Position 6	
	Total	ND<5	ND<5	ND<5	-
Ammonia (µg/g)	- ..	0	0,55	0	-
Nitrate (µg/g)		0,68	0,61	1,62	-
Nitrite (µg/g)		0,19	8,31	0,51	-
Phenols (µg/kg)		ND<0,1	4,15	0,40	-
Phosphorus (µg/g)		132,9	155,5	91,5	-
Phosphate (µg/g)		0,78	1,8	2,22	-
Sulphide (µg/kg)		57,45	71,25	57,78	-
Sulphates (mg/g)		6,1	4,1	3,9	-
Sn (µg/g)		0,01	0,02	0,02	-
VOC (µg/kg)		5,47	5,75	7,15	-
PAHs (µg/kg)(*)		8,04	10,35		
Dioxin (pgTEQ/g samples)(*)		0,0364	0,0469		0,085
Particle size (%)					-
Sand (0.063 - 2 mm)		92,78	78,12	79,38	-
Clay (<0.063)		6,61	16,92	19,2	-
Gravel (> 2 mm)		0,61	4,96	1,42	-

Source: *PECC2, May/2010*

*: *PAHs and Dioxin content are analyzed in LT1,LT2 samples*

In general, the dominant particle size in bed sediment in the oceanic area – project's area – is coarse sand with the diameter from 0.063 mm to 2 mm. The longer the distance from the coast, the percentage of fine sand is higher (from LT1 to LT6, the percentage of fine sand increases from 6.61-19.2%).

Based on the analysis results showed that the concentrations of heavy metals in seabed sediment are much lower than allowance limits regulated in QCVN 43:2012/BTNMT on seabed sediment quality.

Seabed sediment at turning basin and approach channel are not contaminated by heavy metal and PAH, dioxin.

2.1.5.4. Soil contamination

At 10 sampling sites inside and surrounding the project's area, samples from the soil layer with the depth of 15-20 cm from the surface were taken and analyzed to assess the pollution due to hazardous substances. The analyzing results are in *Table 2.36*. The location of each sampling site is shown in *Figure 2.4*.

Table 2.36. Results of analysis of soil quality in the Project area

Symbol	Coordination (VN2000)		Location	Parameters (mg/kg)					
				Oil	*Zn	As	*Pb	*Cu	* Cd
D1	1251403,63	531904,66	In the Vinh Tan project, house No 484 Vinh Tien hamlet, Vinh Tan commune, Tuy Phong province	14,99	8,25	0,50	13,79	1,81	KPH
D2	1251405,64	530816,10	In the Residential hamlet 7	19,92	27,79	2,02	12,83	3,59	KPH
D3	1252064,47	528968,88	In residential areas northeast Duc Linh Town	54,95	28,82	0,55	38,30	3,39	KPH
D4	1253819,12	532454,07	Ash disposal area No1	34,91	29,40	0,53	58,23	4,54	KPH
D5	1254164,48	531862,48	Ash disposal area No2	24,88	7,73	0,22	6,57	2,06	KPH
D6	1251786,04	533000,11	Vinh Tan power center	34,94	31,30	4,01	17,29	2,07	KPH
			QCVN 03-2008/BTNMT (used for agricultural purposes)	-	200	12	70	50	2

Source: PECC2, 03/2012

Note: KPH: Not Detectable; (*): This criterion is accredited VILAS. (ISO 17025: 2005).

Remark

Most of the heavy metals in the analyzed soil samples such as Zn, Pb, Cu, As, Oil have much lower concentration than the standards in QCVN 03-2008/BTNMT for soil using for agricultural. Particularly, the content of Cd is not detectable in all soil samples.

2.1.5.5. Atmospheric environment quality, noise and vibration.

EIA study team conducted to take air samples at 8 positions in February 2012. Monitoring activity was implemented in dry season which is when background levels for dust are expected to at their highest. Microclimate condition at taking samples moment is described as follows

- Air temperature: 28.3^0C-33.9^0C
- Weather: heat, light wind
- Wind speed: 0.1 -1 m/s.

Location of air quality, noise, vibration sampling is presented in Table 2.37 and Figure 2.4. Analysis results of air quality, noise, vibration is presented in Table 2.38.

Table 2.37. sampling sites of atmospheric quality, noise and vibration

No	Symbol	Coordinate	Sample sites
1	K1	$11^0$19'10.0" N $108^0$47'31.3" E	In the project are, measured February 2012
2	K2	$11^0$18'59.0" N $108^0$47'11.2"E	Residential hamlet 7, measured on February 2012
3	K3	$11^0$19'27.1"N $108^0$49'09.06"E	People's Committee of Vinh Tan area , measured on February 2012
4	K4	$11^0$19'29.0" N $108^0$48'15.3"E	At the Highway1A , Km 1597, measured on February2012
5	K5	$11^0$20'06.5"N $108^0$47'44.6"E	Ash disposal area, measured on February 2012
6	K6	11019'38.4"N 108047'26.0"E	In the area lead to ash disposal area, measured on February2012
7	K7	$11^0$19'21.9"N $108^0$48'45.1" E	In residential areas northeast of the Duc Linh town, measured on February2012
8	K8	$11^0$20'02.9" N $108^0$50'41.8" E	In the area of Ca Na, measured on February2012
9	K9	11°19'02.4 N 108°47'14.6'' E	Residential hamlet 7, measured on March 2010
10	K10	11°19'46.6" N 108°48'53.0'' E	Near the Ba Bon 2 (Hilly area, there are no inhabitants) , measured on March 2010

Note: K9, K10 was analyzed in March 2010 (refer to Vinh Tan 3 project)

Remark

From analysis results of ambient air environmental quality in the surrounding area of the project's area, it can be seen that the primary quality of atmospheric environment in this area is good. All of the parameters on total particles, SO_2, NO_2, CO have lower values than QCVN 05:2009/BTNMT (ambient air quality)

At the moment, the ambient air environment is only slightly influenced by transportation on 1A Highway and construction activities of Vinh Tan 2 project. At the sites near the highway, the air quality decreases due to the emissions from transportation. However, in general, the air environmental quality surrounding the project's area is good.

+ Concentrations of toxic gases such as CO, NO_2, SO_2 at all measurement points are much smaller than QCVN 05:2009/BTNMT. H_2S concentrations were undetectable at all measurement points.

+ Concentration of total suspended particle ranges from 0.012 to 0.21 mg/m3, which is lower than permitted value (QCVN 05:2009/BTNMT - TSP concentration is 0.3 mg/m3).

+ **Noise**: In 6 points of 8 point measurement, the noise is in the range of 54.9-70.5dBA which lower than the allowable standard of QCVN 26:2010/BTNMT (the integral noise level: 75.0dBA). Only at K4, K8 point at 1A national road and Ca Na area, the measured noise level is 74.3-76.9 dBA, which higher than permitted value. It is reason due to the influence of the vehicle on Highway.

+ **Vibration**: The vibration acceleration value measured at all sampling sites were lower than the maximum allowed limit applies to common areas for production, trade and services are specified in QCVN 27:2010/BTNMT (0.03 m/s2).

Table 2.38. Analyzing results of air quality, noise and vibration in the project area

		Air quality							Noise (dBA)		Vibration						
No.	Location	*NO2 (mg/m3)	*SO2 (mg/m3)	CO (mg/m3)	VOC Mg/l	*TSP (mg/m3)	*PM10 (mg/m3)	H2S (mg/m3)	Leq	Lmax	Velocity (cm/s)		Acceleration (m/s2)		Amplitude (µm)		Wind speed (m/s)
											Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	
1	K1	0.063	0.075	1.36		0.15	0.08	KPH	54.9	67.7	<0.0001	<0.0001	<0.0098	<0.0098	0.02	0,01	0,1–0,3
2	K2	0.078	0.082	1.46		0.17	0.09	KPH	70.5	88.7	0.0020	0.0014	<0.0098	<0.0098	0.08	0,08	0,0–0,1
3	K3	0.056	0.10	2.05		0.18	0.07	KPH	67.4	84.8	0.0033	0.0012	<0.0098	<0.0098	0.08	0,05	0,2–0,5
4	K4	0.11	0.13	2.80		0.16	0.10	KPH	74.3	92.2	0.0040	0.0037	<0.0098	<0.0098	0.07	0,03	0,5–0,9
5	K5	0.060	0.10	1.50		0.17	0.11	KPH	63.5	76.2	<0.0001	<0.0001	<0.0098	<0.0098	0.02	0,02	0,1–0,4
6	K6	0.081	0.064	2.10		0.19	0.14	KPH	64.8	86.5	<0.0001	<0.0001	<0.0098	<0.0098	0.02	0,01	0,1–0,3
7	K7	0.087	0.096	1.46		0.14	0.09	KPH	62.1	69.2	<0.0001	<0.0001	<0.0098	<0.0098	0.02	0,03	0,2–0,7
8	K8	0.054	0.077	1.47		0.21	0.15	KPH	76.9	90.3	<0.0028	<0.0020	<0.0098	<0.0098	0.04	0,04	0,3–1,0
9	K9	0.035	0.034		1.939	0.02	0.016										0,5-1,5
10	K10	0.016	0.016		1.460	0.012	0.01										0,7-1,3
QCVN 05:2009/BTNMT		0.20	0.35	30.0		0.30	-	42 (QCVN 06:2009)	-	-	-	-	-	-	-	-	-

No.	Location	Air quality							Noise (dBA)		Vibration						
		*NO2 (mg/m3)	*SO2 (mg/m3)	CO (mg/m3)	VOC Mg/l	*TSP (mg/m3)	*PM10 (mg/m3)	H2S (mg/m3)	Leq	Lmax	Velocity (cm/s)		Acceleration (m/s2)		Amplitude (µm)		Wind speed (m/s)
											Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	
QCVN 26:2010/BTNMT		-	-	-	-	-	-	-	70.0	-	-	-	-	-	-	-	-
QCVN 27:2010/BTNMT		-	-	-	-	-	-	-	-	-	-	-	0.03			-	-

Source: Sac Ky Hai Dang science technology service Joint stock Company

2.1.6. Bio-diversity Characteristics and Terrestrial Biological Values in Project's area and Surrounding Area

2.1.6.1. Flora

The vegetation system of the study area has close relationship with flora-fauna system of South Truong Son, and North Mekong, the air environmental quality surrounding the project's area is as follows:

1. The migratory line from the Malaysian-Indonesian vegetation system, with the dominance of Dipterocarpaceae family.
2. The migratory line from Indian-Myanmar vegetation system, with some dominant families: Lythraceae, Combretaceae, Bombaceae, and Verbenaceae.
3. The migratory line from North Vietnam – South China vegetation system, with dominant families: Fabaceae, Euphorbiacea, Ebenaceae, Sapindaceae, Meliaceae, Rubiaceae, and Anacardiaceae.

From the survey done by PECC2, the project's area is on the coast of Cana, Tuy Phong District The fauna system here is both natural and planted.

The planted vegetation: is mainly *Anacardium occidentale* garden, which is distributed along the 1A Highway, with the density below 300 trees/ha, DBH = 10-12 cm and the height of 7-8 m. However, the seed productivity is low because they are planted and managed by some households. Previously, most of the area was covered by planted *Acacia auriculaeformis*, but they have been cut down and only the stumps remain.

Natural plantation The community has an average height lower than 10m, but the species composition mostly comprise of woody tree with high economic value, such as *Dipterocarpus alatus,Shorea siamensis, Sindora siamensi, Markhamia stipulate, Azadiracta indica.* Their density is high, about 100 trees/ha. However, most of those species are regenerated from buds, below 5m in height, below 10 cm of stem diameter. Besides those species, there are some dominant small woody species, such as: *Dimocarpus longan, Buchanania reticulate, Niebuhria siamensis, Capparis annamensis*

The shrub layer is dominant by *Grewia spp*, with the coverage percentage of 80% and there are also *Selaginella tamariscina* and *Cycas micholitzii* present. Towards the beach, there are *Calotropis gigantean, Opuntia dillenii, Euphorbia antiquorum,* and *Canavalia maritime*

From surveying and sampling of all the lines and transects in the project's area, the consultant agency found 56 terrestrial flowering plants, which belong to 26 families and 3 different floral phyla (Appendix 2.1 chapter 2)

2.1.6.2. Fauna

The habitat of the project's area is characterized by the coastal sand plain and scrub-land. Therefore, the animals living here often have large range, high temperature and aridity resistance, or the ability to find food on grassland. Their common characteristic is that their breeding and growing season is often during the time of the year when there is little rainfall. In addition, there are some species living near the people, such as: rat, house toads and gecko, sandy salamander, and field sparrow species. There are also many sea species migrating along the coast

From surveying, terrestrial ecosystems at Vinh Tan Commune the consultant agency found 53 wild fauna species in study area of the project, in which 5 species belong to Mammalia (4 families), 35 species belong to Aves (28 families), 10 species belong to Reptilia (6 families) and 3 species belong to Amphibia (2 families).

The distribution of these fauna species in this area is as follows

- Mammalia

In the habitats of grassland, arid forestland and coastal sandy plain, there are many small mammalian species and some species feeding near the residential areas, such as *Lepus nigricollis, Tamiops rodophei, Rattus exulans.*

- Avifauna

The habitat in project's area is heavily impacted by the ocean and coastal sand plains. Additionally, fishing activities, and fisheries also have some impacts on the composition of these species in this region. Areas where there are lots of fishery activities are the feeding places for some species such as *Egretta garzetta, Passer montanus, Himantopus himantopus, Artamus fuscus, Calidris ruficollis, Charadrius dubius.*

Birds in the project area are mainly Passer montanus, Turnix suscitator, Centropus sinensis, Saxicola torquata.

- Reptiles and amphibians

The habitat in project's area is dominanted by some lizard species living on scrub trees or grassland, such as *Calotes vesicolor, Leiolepis reeversi, Psammophis condanarus, Trimeresurus stejnegeri, Mabuya multifasciata.* In the wet areas near residential areas, next to the project's area, the dominant species are *Xenochrophis piscator, Bufo melanostictus, Rana guentheri.*

Detailed list of wild animal species at Vinh Tan commune is given in *Appendix 2.2, chapter 2.*

2.1.7. Characteristics of Aquatic Ecosystem in the Vinh Tan commune

2.1.7.1. Freshwater ecosystem in project's area

- *Phytoplankton*

The survey results at 10 points around the project has identified 35 species of planktonic belongs to 5 algae sectors, in which Eulenophyta is dominated with 11 species, next to Chrysophyta with 9 species, Cyanophyta) with 8 species and Chlorophyta with 6 species, and Dinophyta is lowest as 1 species.

In terms of phytoplankton composition can be seen that most of them are the indicators for organic contamination. They are *Cyclotella meneghiniana, Nitzschia palea, Synedra ulna.*

The characteristics of 2 types of freshwater areas in project's area are also clearly illustrated by the appearance of Chrysophyta species (*Desmogonium sp., Eunotia pectinalis, Navicula* – 3 species, *Gomphonema gracile),* Chlorophyta species (*Closteriopsis longissima, Closterium ehrenbergii, Closterium moniliferum, Pleurotaenium ehrenbergii),* and Dinophyta species (*Peridinium cinctum)*

In Dachet spring, the number is 6,360,000 individuals/m^3, in which *Navicula sp.* is dominant. Both dominant species above are indicators for weakly acidic water

- Zooplankton

The plankton communities in freshwater are poor in the number of species and individuals. There were 7 species and the larva of *Nauplius copepoda* found. Among those *Philodina roseola* and *Thermocyclops hyalinus* are indicators of medium organic contaminated water; and *Lecane luna, Alona davidi* are indicators of weakly acidic water

The density of Zooplankton in Dachet streams 2.900 individuals/m^3, in which Nauplius larva dominates.

- *Zoobenthos*

In freshwater areas, there are 1 species *of Limnodrilus hoffmeisteri,* and 5 species of insects and insect larva. The *Limnodrilus hoffmeisteri* species and larva of dipterans *Chironomus sp., Sialis sp.* are indicators of medium to highly polluted environment, while larva of two red mosquitoes *Cryptochironomus sp., Polypedilum sp.* are indicators of acidic water

Density of Zoobenthos in freshwater is very high (490-960 individuals/m^3). *Chironomidae* is dominant

In the dry season, the freshwater environment in project's area is polluted by organic matters. The level is from mesosaprobic to polysaprobic.

Detailed ecosystem in fresh water is presented in Appendix 2.3-2.6 of chapter 2.

2.1.7.2. Characteristics on Coastal ecosystem in the Project Area.

The project is located entirely in the development and part of the ecological restoration of Hon Cau MPA, so to assess the status of coral reefs and seagrass in the project area, PECC2 in collaboration with the Institute NhaTrang Oceanography to survey, evaluate characteristics of coral, sea grass in the Vine Tan central power area on April 2010. Research and survey results are summarized below

1. Seagrass and Seaweed

 – Sea grass: Major seagrass and Seaweed communities determined from the video through the selected transect. The coordinates and position of study sites of seagrass beds and seaweed beds are given in Table 2.39.

Table 2.39. Coordinates of survey stations sea grass and seaweed in the area Vinh Tan

Site	Coordinate VN2000	
Sea grass beds	X	Y
1	1251247.617	533169.867
2	1250342.080	535648.822
3	1250408.282	535503.197
4	1250648.734	534837.037
5	1250309.451	534189.703
6	1250358.569	534437.088
7	1250021.229	533584.148
8	1249692.392	533207.873
Seaweed beds		
1	1251779.254	532976.467
2	1251247.617	533169.867
3	1250969.002	534381.848
4	1250823.253	533697.924

According to survey results, there were three major patches of sea grass beds mainly found at the depth of 6 - 9m with an area of about 3-4ha/ clusters and some some small clusters distributed in deeper waters. However, current sea grass degraded by coral mining activities of the people and the construction activities in the region.

A total of 4 species of sea grass were found in the waters surrounding the Vinh Tan Complex Site, including Halophila ovalis, *Halophila decipiens*, *Halodule pinifolia* and *Thalassia hemprichii*. Halophila ovalis was common at almost study site whereas Halodule pinifolia and Halophila decipiens were only found at one study site (Plate 1). *Thalassia hemprichii* was only found at site 1 on coral reefs.

The distribution of seagrass in this area are mostly formed mono-specific species dominating by Halophila ovalis. Average coverage is relatively high of 39.7% (range from:1-55%). Seagrass density at each survey station ranges from 84-987 plants, averaging 712.7 plant/m2 excepting station 5 (Table 2.40). Halophila ovalis species also dominate on density at most of survey stations, except for station 1, it is dominated by Thalassia hemprichii species.

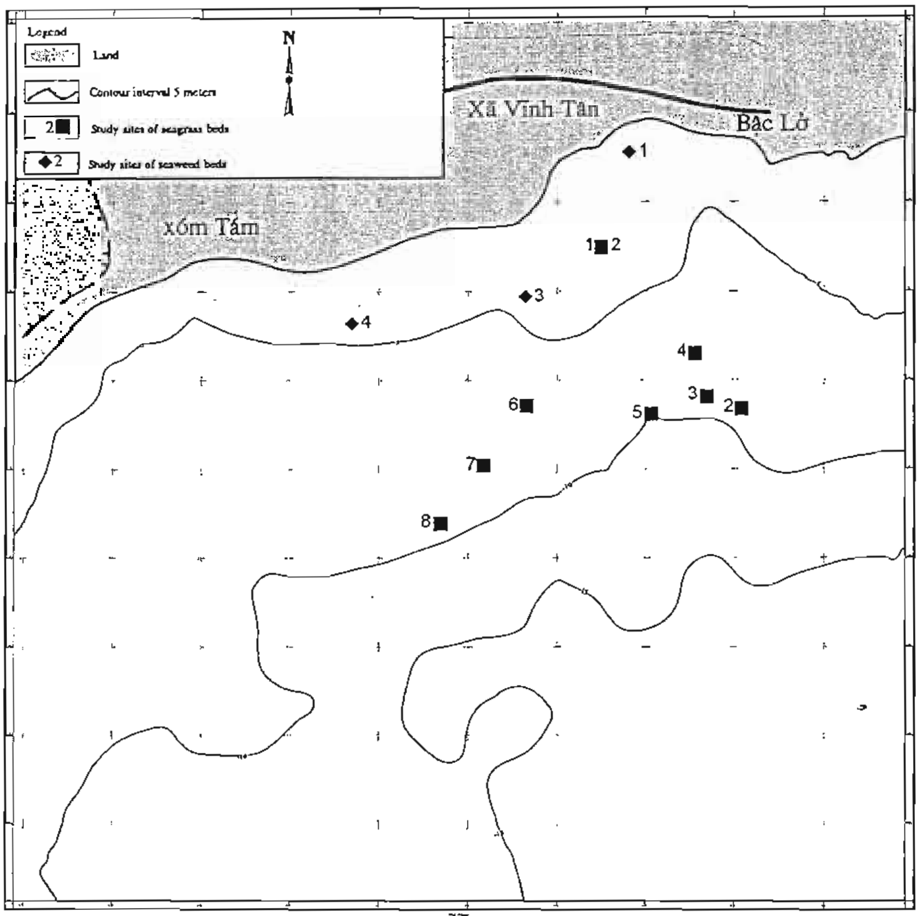


Figure 2.5. Map of sea grass and seaweed stations survey the area, Vinh Tan power plant

Table 2.40. Coverage (%) and density (plant/m2) of some dominated seagrass species in survey station

Items	1	2	3	4	5	6	7	8
Coversge								
- Total	15	47	45	55	1	55	45	55
- Halophila ovalis		47.0	38.3	50.0	1.0	53.3	33.3	51.7
- Thalassia hemprichii	15							
Density								
Total	84	987	670	786		942	593	927
- Halophila ovalis		987	667	786		924	520	927
- Thalassia hemprichii	84							

Source: Nha Trang Oceanographic Institute, 5/2010

– Seaweed

There were some small patches of seaweeds found on coral reefs, dominating by Sargassum, Padina, Ulva, Laurencia, Chnoospora and Amphiroa. Seaweed beds of Sargassum, Laurencia, Chnoospora and Amphiroa were mainly distributed in shallow waters of coral reefs close to the shore at 2 – 4m depth. Padina and Ulva beds were found in deeper waters (> 4m depth)

Analysis seaweed sample on coral reefs (Table 2.41) has identified 50 species belonging to 34 genera and 4 phyla of macro-algae. Two phyla (Rhodophyta and Phaeophyta) had the highest species (16 and 17 species respectively) compared to that of Chlorophyta (14 species) and Cyanophyta (3 species). Some common species of macro-algae found in this area included Gelidiella acerosa, Acrochaetium sp., Turbinaria ornata, Padina boryana, Dictyosphaeria cavernosa, Halimeda discoidea, Halimeda opuntia, Amphiroa foliacea and Amphiroa fragilissima. Numbers of species in each study site was low, ranging from 7 to 23 species.

Previous study indicates that seaweed beds of Sargassum are commonly found in the shallow waters close to the shore at depth ranging from 2 – 4m. The Sargassum beds were reached to the highest abundance in April when sea water temperature being highest and faded in July when sea water temperature reduced by influence of upwelling waters (Vo Si Tuan, 1996).

However, there were no major Sargassum beds recorded in the area during this investigation. Information from local fishers are shown that collection of Sargassum for producing food and fertilizers by local communities have been increasing in recent years in this area, mainly occurred in March and April. *These activities may cause over-harvestation/absence of Sargassum before this investigation conducted.*

Table 2.41. Number of species of each phylum of seaweeds at study sites.

Division	1	2	3	4	5	6	7	8	9	10	11	12	Total
Cyanophyta	1	1	1	0	1	0	0	1	0	1	1	0	3
Rhodophyta	4	2	7	4	2	3	5	7	6	6	7	2	16
Phaeophyta	4	12	8	9	5	6	4	6	3	2	3	1	17
Chlorophyta	7	5	7	4	4	6	4	4	3	4	3	4	14
Total	16	20	23	17	12	15	13	18	12	13	14	7	50

Source: IO Nha Trang,5/2010

Table 2.42. Coverage (%) and density (plant/m2) of some dominated seaweed species in survey station

No.	Species	1	2	3	4
Coverage					
1	Sargassum polycystum	18			
2	Laurencia snackeyi	45			

No.	Species	1	2	3	4
3	Ulva reticulata	8.3			
4	Amphiroa fragilissima	2	1.7		
5	Triclocarpa cylindrica	1.7			
6	Chnoospora minima		15		
7	Padina boryana		3.3		
8	Halimeda discoidea		1.7		
9	Amphiroa foliacea			75	75
Density					
1	Sargassum polycystum	55			
2	Laurencia snackeyi	67			
3	Ulva reticulata	UNC			
4	Amphiroa fragilissima	UNC	UNC		
5	Triclocarpa cylindrica	0.3			
6	Chnoospora minima		UNC		
7	Padina boryana		8		
8	Halimeda discoidea		6.7		
9	Amphiroa foliacea			UNC	UNC

Note: UNC: Not counted.

Source: IO Nha Trang,5/2010

2. Coral reefs

For coral reefs, there are 12 stations along the six sections were selected to conduct the survey and detailed assessment. The locations and coordinates of the stations for detailed survey of coral reefs are shown in Table 2.43 and Figure 2.6.

Table 2.43. Position and coordinates of study sites of coral reefs at the Vinh Tan Complex Site May 2010

Survey station	Coordinates VN2000		Survey station	Coordinates VN2000	
	X	Y		X	Y
1	1251718.208	534799.482	7	1250884.564	532978.605
2	1252774.628	534905.361	8	1250643.453	533050.720
3	1251177.711	534179.979	9	1252806.936	532331.388
4	1251326.105	534175.574	10	1250826.435	532319.147
5	1251077.563	533614.571	11	1250498.316	531723.632

- Coral reefs are mainly distributed in the shallow waters along the coast of the port area of Vinh Tan Complex Site, from the depth of 1m down to 5 - 6m, they are found in the north and a small patch mainly formed by coral assemblages on sandy bottom in the south of the port area of Vinh Tan

Complex Site. These reefs were dominated by dead corals in inner reef and by filiose and braching corals.

– Data from 12 detailed surveys show that there were some 73 species in 31 genera and 13 families of corals were recorded in the waters of the Vinh Tan Complex Site. Among them, 68 species of 12 families of reef-building corals, 3 species of fire corals (Milleporidae) and 2 species of soft corals were recorded. The most common families of reef-building corals were Faviidae (28 species), Acroporidae (16 species), Poritidae (8 species) and Fungiidae (6 species).

– Some common species found at most of the study sites included Acropora nobilis, Montipora digitata, Porites and Pocillopora damicornis. However, coral reefs are no longer maintained in good condition. Cover of hard corals at each study site showed a low value, ranging between 0.6 – 9.2%. Dead corals were dominated at all study sites with cover ranging between 5.8 – 85.5% (table 2.44). *The low cover of hard corals found at all study sites may be explained by degradation of coral reefs caused by dynamite and poisoning fishing, harmful algal bloom occurred in 2002, collection of living corals for sourvenir (Vo Si Tuan et al., 2005)*

Table 2.44. Number of species of each family of reef-bulding corals at study sites in Vinh Tan power plan

STT	Family	1	2	3	4	5	6	7	8	9	10	11	12	T2mi
1	Faviidae	9	12	4	10	3	6	0	1	10	2	3	3	28
2	Acroporidae	2	9	6	2	4	7	7	8	5	6	1	4	16
3	Poritidae	1	3	2	1	2	2	3	0	2	0	4	1	8
4	Fungiidae	0	2	1	0	0	0	0	1	3	1	2	3	6
5	Milleporidae	0	0	0	0	0	1	2	0	0	0	1	0	3
6	Agariciidae	0	0	0	0	0	0	1	0	1	0	0	0	2
7	Mussidae	0	0	0	0	1	1	0	0	0	0	2	0	2
8	Pocilloporidae	0	1	1	1	1	1	1	1	1	0	0	1	1
9	Pectiniidae	0	0	0	0	1	1	0	0	0	0	1	0	1
10	Oculinidae	0	0	0	0	0	0	0	0	1	0	1	1	1
11	Merulinidae	0	0	0	0	0	0	0	0	0	0	1	1	1
12	Trachyphylliidae	0	0	0	0	0	0	0	0	0	0	0	0	1
13	Caryophylliidae	0	0	0	0	0	0	0	0	0	0	0	0	1
Total		13	29	17	18	17	25	21	19	32	19	27	26	71

Source: IO Nha Trang,5/2010

Table 2.45. Cover (%) of major benthic substrata at study sites at the Vinh Tan Complex Site, May 2010.

Site	HC	SC	DC	CA	TA	SW	SP	RB
1	1.7	0.0	5.8	0.8	0.0	6.7	1.5	48.3
2	9.2	0.0	42.5	31.7	0.0	3.3	0.0	13.3
3	5.8	0.0	48.3	4.2	1.7	15	2.5	16.7
4	5.8	0.0	11.8	0.0	0.0	7.5	0.0	36.7
5	0.6	0.0	38.3	0.0	0.0	20.5	0.5	15.7
6	0.8	0.0	28.3	39.2	0.0	13.3	0.0	11.7
7	1.7	0.0	85.8	2.5	0.0	9.2	0.0	0.8
8	5.8	0.0	39.2	8.3	14.2	7.5	0.0	25.0
9	4.2	0.0	31.7	0.0	0.0	4.2	0.0	35.8
10	5.8	0.0	67.5	14.2	0.0	9.2	0.0	2.5
11	9.2	0.0	74.2	0.8	0.0	1.7	0.0	10.0
12	4.4	0.0	58.8	1.9	0.0	2.5	0.0	29.4

Note: HC: Hard corals, SC: Soft corals, DC: Dead corals, CA: Coralline Algae, TA: Turf Algae, SW: Seaweeds, SP: Sponges, RB: Rubble corals.

Source: IO Nha Trang,5/2010

- Species richness of reef-building corals at each study site ranged between 13 – 32 species (average: 25.8 species, s.e.: 4.4), in which sites on the reef slope supported a higher species than that on the reef flat. The diversity of reef-building corals documented in this survey is low, and represents less than 40 % of species recorded before 1996 (Vo Si Tuan and Phan Kim Hoang, 1996) and some 30% of totals recorded in 2008 (ca. 234 species; Nguyen Van Long et al., 2008) in the waters of Ca Na Bay.
- **Coral reef fishes**: A total of 76 species of reef-associated fishes belonging to 45 genera and 21 families were recorded in the waters of the Vinh Tan Complex Site (table 2.42). Among 21 families, the familiy Labridae and Pomacentridae with the highest number of species, each of them has 16 species. The next were butterflyfishes (Chaetodontidae) and snappers (Lutjanidae) - 7 species each. The number of species of target fishes belonging to parrotfishes (Scaridae), groupers (Serranidae), sweetlips (Haemulidae), emperors (Lethrinidae), fusiliers (Caesionidae) and rabbitfishes (Siganidae) at each study site were very low (1 – 3 species).
- Density of fishes was large variation between the study sites, ranging from 42 – 858 individuals/250m2 (average: 188.2 individuals/250m2, s.e.: 20.3) (table 2.43). Fishes at size class of 1 – 10cm were dominant at all of the study sites (average: 184.7 individuals/250m2, occupied with 98.1% of total density). The total density of fishes of size classes 11 - 20cm was very low,

averaging 3.5 individuals/250m2 (s.e.: 0.3). Larger fishes at size classes of > 20cm were absent at all study sites. This indicates that resources of coral reef fishes in this area have been overexploited.

– The numbers of species recorded in the Vinh Tan Complex Site from this investigation were 23.4% of the totals found in the waters surrounding Ca Na Bay (324 species, Nguyen Van Long et al., 2008).

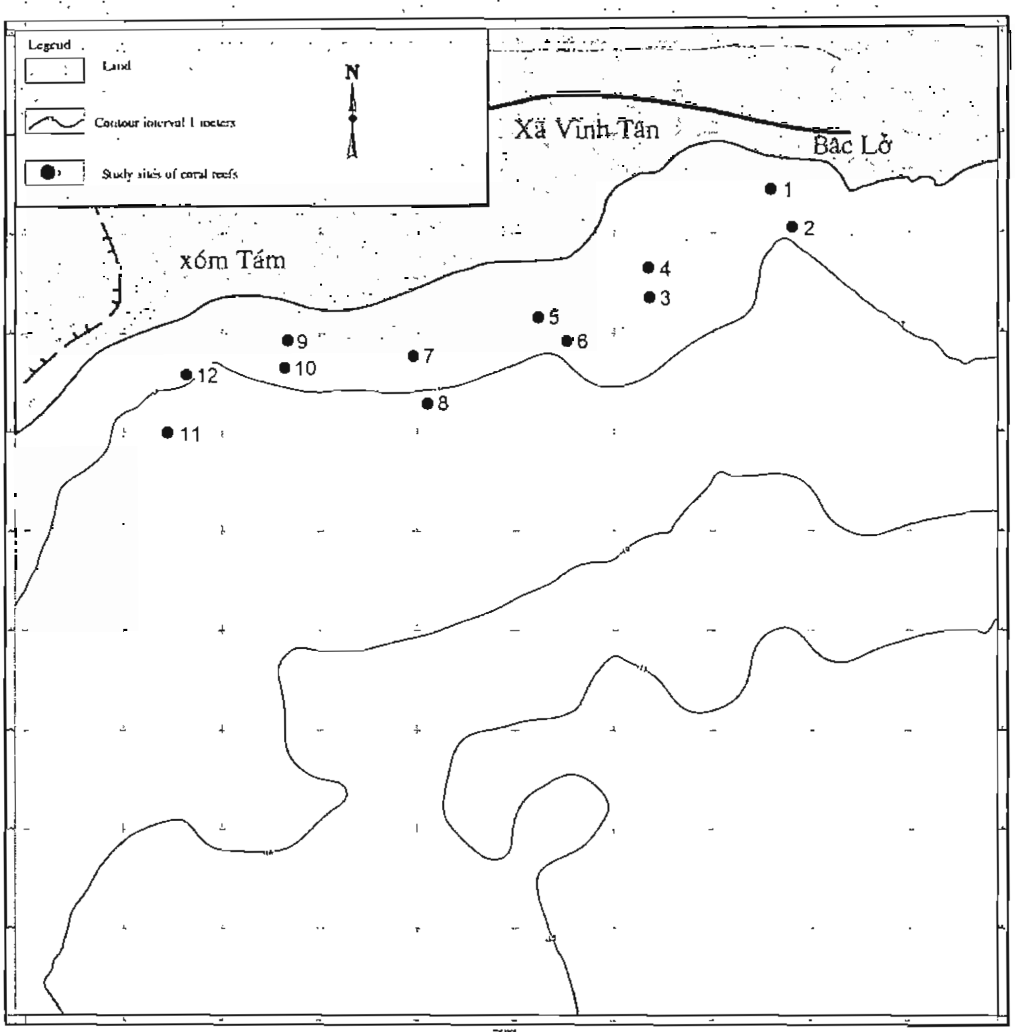


Figure 2.6. The map of the surveyed points of the reef at Vinh Tan

Table 2.46. Number of species of each family of coral reef fishes at study sites

No	Family	Total
1	Labridae	16
2	Pomacentridae	16
3	Chaetodontidae	7
4	Lutjanidae	7
5	Apogonidae	3

No	Family	Total
6	Gobiidae	3
7	Siganidae	3
8	Acanthuridae	2
9	Blenniidae	2
10	Haemulidae	2
11	Mullidae	2
12	Nemipteridae	2
13	Scaridae	2
14	Serranidae	2
15	Other	7
	Total	76

Source: IO, Nha Trang,5/2010

Table 2.47. Density (individuals/250m2) of fishes at each size class at study sites

Site	1-10cm	11-20cm	21-30cm	>30cm	Total
1	195	9	0	0	204
2	254	9	0	0	263
3	91	5	0	0	96
4	143	1	0	0	144
5	89	3	0	0	92
6	120	6	0	0	126
7	857	1	0	0	858
8	71	4	0	0	75
9	225	3	0	0	228
10	53	0	0	0	53
11	76	1	0	0	77
12	42	0	0	0	42
Mean	184.7	3.5	0.0	0.0	188.2
s.e.	20.3	0.3	0.0	0.0	20.3

Source: IO, Nha Trang, 5/2010

– In marine ecosystems in the project area the sea grass and coral on the list of plants and animals should be preserved. But coral reefs in this region are no longer maintained in good condition and were dominated by dead corals in inner reef and by filiose and braching corals in outer reefs. The coral in all areas are covered with sediment, which seriously affected area is the near-shore reef. Overall average cover of major substrata show that the cover hard corals was very low (4.6%) whereas the covers of dead corals, seaweeds, coralline algae, and rubble corals were relative high, giving overall average of 44.4%, 21.3%, 8.6% and 20.5% respectively.

– In addition, In Hon Cau marine protected areas, coral reefs mainly distributed in coastal areas Hon Cau (located away from the project area about 10km to the south), and seaweed gathered in Breda shallow beach area (located away from the project area about 5km to the southeast), only a small reef (most had died lying coastal areas Vinh Hao, Phuoc Vinh and Tan).

3. **Sessile invertebrate communities - Molluscs, crustaceans and echinoderms**

– Molluscs: sessile invertebrate communities occurred at all sites in the waters of the Vinh Tan Complex Site are Modiolus philippinarum with low individual density from 1 - 17 individuals/site, Strombus vittatus with low frequency, but the individual density to 41-80 individuals/site, Paphia cf. Undulata, Pinna bicolor, Cucullaea labiata, Conus sp with low individual density to 1-10 individuals/site.

– *Echinodermata*: Have a low number of species with 372 individuals (accounted for 3.8%). Some common species of Echinodermata recorded at this area were sea urchins (Diadema setosum and Toxopneustes pileolus) . These species formed small patches with abudance ranging between 2 – 40 individuals/site. There are also some other popular groups of species have been recorded in this area such as Amphiura sp. (Amphiuridae), Lovenia elogata (Loveniidae) và Fibularia sp. (Fibulariidae).

In addition, there is distribution of sea cucumbers, sea pens and worms on several small beaches are recognized in the regional waters of Vinh Tan power plant.

– Crustaceans: occurred with high frequency and had higher density were Amphipoda, Isopoda and Tanaidacea (Kalliapseudidae and Leptocheliidae), Portunus sp. (Portunidae) and Sphaeroma sp. (Sphaeromatidae)

– *The class Polychaeta:* also occupied with relative high density, Among them, Spionidae had the highest species (13 species), Syllidae (11 species), Syllidae, Eunicidae, Onuphidae and Phyllodoce (7 species each). The family Maldanidae had highest density and recorded at almost of sampling sites with dominance of Asychis gangeticus. The next families were Eunicidae, Capitellidae, Amphinomidae and Onuphidae with dominant species including Eunice rubrivittata, Scyphoproctus sp., Pseudeurythoe sp., Onuphis eremite

2.1.8. Resources and resource use

Fish resources: Information from interviews with local fishermen and visits to local fish landing sites indicate that most of species of fishes caught in coral reefs were groupers

(Cephalopholis spp. and Epinephelus spp.), snappers (Lutjanus spp.), emperors (Lethrinus spp.) and sweetlips (Plectorhinchus spp.)

Molluscs resources : Resources harvested from coral reefs were abalones (Haliotis spp.), top shells (Trochus spp.), turbo shells (Turbo spp.), elongate cockle (Trachycardium cf. elongatum), antique ark (Anadara antiquata), undulating venus (Paphia cf. undulata), hooded ark (Cucullaea labiata), cone shells (Conus sp.), vittate conch (Strombus vittatus) and noble volute (Symbiola nobilis). The production caught per day by diving boat averaged 20 – 30 kg of turbo shells and top shells and 2 - 3 kg of cuttlefishes (Loligo spp. and Sepia spp.)

Resources of crustaceans harvested were swimming crabs (Portunus pelagicus) and lobster seeds (Panulirus spp.). The swimming crabs are mainly caught by bamboo fishing boats with the production ranging between 6 – 8 kg/day/boat.

Echinoderms resources: Echinoderms harvested are sea cucumbers (Holothuria spp.) and collector urchins (Tripneustes gratilla) by hookah diving. Information from local consultation show that these resources are extreme rare due to over-harvestation, especially edible sea cucumbers

Information from interviews with local fishermen through local consultation indicate that there is a temporal decline in fisheries production, giving an estimate of decline of 60 – 70% compared with 5 recent years depending on species. The decline of fisheries production may be caused by overfishing, dynamite fishing, particularly on coastal land of Ca Na bay and the area east and southeast of the island of Cu Lao Cau. Collection of living corals for souvenirs and Sargassum beds. . On the other hand, the event of hamful algal bloom occurred in 2002 has been caused serious degradation of most of the reefs in the shallow waters along the coast of the mainland from Cat Trang to Vinh Hao

2.2. SOCIO-ECONOMIC CONDITION

2.2.1. Social condition

2.2.1.1. Population

Vinh Tan Commune has a population of 6096 people in 2011, the rate of natural increase of population was 11.35 ‰. The population growth is due to natural birth rate and emigrant. Status of population in Vinh Tan commune is described in table 4.48.

Table 2.48. Population statistics of Tuy Phong district and Vinh Tan commune over the years

	Item	Unit	2009	2010	2011
Vinh Tan commune	Area	Ha	59,08	59,08	59,08
	Population	People	5.392	5.438	6.096
	Male	People	2.805	2.816	2.949
	Female	People	2.587	2.622	3.147

	Item	Unit	2009	2010	2011
	Density	people/km2	91	92	103

Sources: Statistical Yearbook of Tuy Phong district- Binh Thuan province 2011

2.2.1.2. Gender, Ethnicity

Population diversity covering one or more characteristics such as: age, gender, ethnicity ... which are the key factors in assessing the social impact that may occur if newcomers have the characteristics that are different from those of the local population

Gender: male ratio in Vinh Tan commune is from 48.5 to 52%, women ratio is accounted from 47.5 to 51.5% of the total population of the commune. And the percentage of men/women have changed over the years from 0.94 to 1.08. The health care programs, especially reproductive health care for women has increased higher income employment for women ... in the project area are equivalent to the common ground of Tuy Phong district.

Kinh is dominated ethnicity occupied with 99.3% in Vinh Tan commune, the rest are minorities such as Khmer, Tay, Cham.

Table 2.49. Status of population in Vinh Tan commune as age- gender – ethnicity

	Househbold			**A number of peoplr**		
Ethnicity group	Total	Male	Female	Total	Male	Female
Total	1,247	967	280	5,356	2,759	2,597
Kinh	1,239	960	279	5,317	2,743	2,574
Khơ-me	1	1	-	11	1	10
Tày	-	-	-	1	-	1
Chàm	7	6	1	27	15	12

Source: Data for the population census of Binh Thuan Province in 2009

2.2.1.3. Religion

Predominant religions in the project area are Catholic , followed by Buddhism, Christianity and Protestantism;

Table 2.50. Status of religion in Vinh Tan commune

Religion	**Unit**	**Total**	**Buddhism**	**Catholic**	**Christianity**	**Protestantism**	**Other**
Total	People	147	3	110	12	13	0
Female	People	76	1	58	8	6	3

Source: Data for the population census of Binh Thuan Province in 2009

2.2.1.4. Education

Currently, there are elementary schools, middle school and high school in Vinh Tan commune.

However, overall education levels in Vinh Tan commune are quite low, expressed through the survey data of education level in 2009 shows that children from 5 years of age and older are in school only a tiny percentage reached 23.01%; most students just finish secondary school level. The number of students in 3rd grade is at only 2.02%; the status of dropouts is accounted for 65.8% of the population in commune. The data above corresponds to the economic conditions of Vinh Tan, which is a mountainous area with many poor households.

Table 2.51. Education level in Vinh Tan Commune

Education situation in population from over 5 year old	Total	Studying	Stop studying	Not studying	Percent of population not studying in total population (%)
Total (people)	4742	1095	3123	524	11.05
5-14	1190	950	170	70	5.88
15-24	1087	140	863	84	7.73
25 - 54	2151	5	1834	312	14.50
> 54	314		256	58	18.47

Education	Total	Kinder garten	Primary	Secondary school	High school	Vocational School College University
Number of students	4198	114	2122	1485	392	85
%	100.0	2.72	50.55	35.37	9.34	2.02

The number of illiterate people over 5 years old	Total	Not studying	Kindergarten	Primary
People	733	523	108	102

Source: 2009 population census of Vinh Tan commune

2.2.1.5. Health care, health

Currently, Vinh Tan commune has 02 clinics where implemented health care and preventive health programs. These activities on health care are well maintained. Regularly performing better on sanitation – hygiene, food safety and propagandizing for people on food safety. There is not food poisoning from early 2009 until now.

Also, in 2011, clinics has implemented health care for 2718 turns and the ratio of under 1-year-old children fully immunized is 135 children, and implementing a plan of action to prevention A H1N1 in humans.

Statistics of healthcare in Vinh Tan commune shown in Table 2.52

Table 2.52. Statistics of health facilities, beds and medical staff in Vinh Tan commune in 2010

No	Item	Unit	Vinh Tan commune
I	Health facilities	facility	2
	hospital		-
	Clinic		-
	Commune health stations.		2
II	Number of beds	Bed	10
	hospital		-
	Clinic		-
	Commune health stations.		10
III	Medical staff	People	11
	Doctors and higher level		2
	Medical Graduate		6
	Nurses and Midwives.		1
IV.	Pharmaceutical staff	People	2
	Senior pharmacist		
	Intermediate Pharmacist.		
	Druggist.		

Sources: Statistical Yearbook of Tuy Phong district- Binh Thuan province -2011

2.2.1.6. Infrastructure in Vinh Tan commune

1. Traffic Condition

• ***Road***

There are a number of important transport routes running through in the area that has created favorable conditions for the region to connect to other growing urban centers. For example, National Highway 1A to the northeast – southwest or provincial roads 716 runs along the coast. But generally, the development status of the region's traffic is limited, low density of roads, mostly soil roads and gravel roads.

Table 2.53. The status of the road network in the project area

No	Type of road	Length (km)	The length of the pavement structure			
			Asphalt	asphalted surface	gravel roads	earth

No	Type of road	Length (km)	The length of the pavement structure			
			Asphalt	asphalted surface	gravel roads	earth
I	Highway	21,4	21,4			
1	1A Highway	21,4	21,4			
II	Provincial Road	7,3		7,3		
1	Provincial Road 716	7,3		7,3		
III	district roads					
1	1A Highway, hamlet 7, Vinh Tan commune	3,3		3,3		
2	1A Highway, hamlet 8, Vinh Hao commune	2,3	2,3			
3	1A Highway, Da Bac reservoir- Vinh Son Hamlet	4,0		4,0		
4	1A Highway-Long Song river	1,5	1,5			
IV	Rural Roads	27,0			5,4	21,6
1	Vinh Hao commune	22,0			4,4	17,6
2	Vinh Tan commune	5,0			1,0	4,0

Source: Department of Trade and Industry Tuy Phong district

- *Railway*

In addition, Vinh Tan commune has the north - south railway route going through Vinh Hao Station. This station primarily used for the local operational ships, avoiding vessels and a small part in the transport of goods in the region.

- Water navigation : navigation in Tuy Phong district has not been developed; At some river estuaries such as Phan Ri (Luy river), Lien Hương (Long Song river), water transportation can only serve vessels entering and exiting fishing ports, and these estuaries are the shelters for vessels to avoid storms.

Presently, As transport planning of Binh Thuan province, deep-sea port serving vessels with the load from 30,000-50,000 tons and providing coal to Vinh Tan thermal power plant will be located in Tuy Phong and has now in the preparation process. This will be a driving factor for the development of industry, the formation of a large trade and service centre, contributing to the socio-economic development of Tùy Phong.

2. Communication

Communications networks have developed widespread with quality of service improved....Rate of phone and internet use increase; it will contribute to the improvement of the use of telecommunications services and information technology. By 2010, the density of telephone subscribers reaches 49 telephones per 100 people (of which 22,9 fixed telephones per 100 people), rate of internet users account for about 6%

of the population.

3. Power supply system.

Currently, in the Tuy Phong district, 100% of communes have the national grid. Until now, the region has about 32 km of medium voltage lines, 20 km of low voltage lines and 16 substations. Percentage of households is using electricity reached to 100%.

In addition, electricity is also used for lighting in the administrative center, public parks and along Highway 1A.

Currently, in the Vinh Tan commune, the Vinh Tan power plants with total capacity of 5600MW are building to contribute to the power supply for the district in particular and for Binh Thuan province in general and contribute to promoting socio-economic development in the region.

4. Water supply system

Water supply and production activities in the area of Vinh Hao - Tan Vinh district in particular and Tuy Phong in general are mainly from the use of surface and ground water part. Until now, the whole region (permanent Tan Vinh Hao) have two pumping stations with an average capacity of each station up to 200 m3/day/night; with a total length of pipes and water distribution around 12 km. Combined with more than 50 wells and other precipitate process measures. Percentage of households using clean water is over 95%, the percentage of households using tap water is at 35%.

5. The drainage system

Drainage in Vinh Tan commune is natural and does not treat before being released to the natural environment. Rain-water drainage is primarily via the ditches along roads. Domestic wastewater is processed through a septic tank before escaping. Thus, in the future there is a need to build wastewater treatment system to ensure environmental safety, health and urban civilization.

6. Solid waste treatment establishments.

In the Vinh Tan-Vinh Hao commune area have planned two landfills and waste treatment (one in Vinh Hao is an area of 2ha and the other one is of 5ha in Vinh Tan). Garbage will collected and treated simply to reduce doors.

7. Irrigation.

In recent years, these systems of irrigation are invested. The irrigation works including as Da Bac Lake has 394 ha of design capacity; the dam of Vinh Hao designed to has a capacity of 100 ha and the irrigation canal system has been gradually solidified. However, the water supply only for agricultural production, water treatment activities and industrial production only meets a certain level.

2.2.2. Economic Condition

2.2.2.1. Agriculture

- Husbandry

In general, the husbandry sector in the period 2008 - 2010 has been gained some certain development; the number of cattle and poultry has increased over the years. Facilities of the sector are still small and do not reach a large scale of farming. Grass area has not been expanded for feeding and water for breeding is still problematic.

The husbandry sector in recent years has repeatedly affected by many types of dangerous diseases. Therefore, there is a restructuring of cattle and poultry towards increasing the number of domestic animals that are less affected by epidemics such as goats and cows. The number of cattle and poultry are shown in Table 2.54.

Table 2.54. Statistics of cattle and poultry in Tuy Phong district

Unit: heads

No	Term	Vine Tan commune		
		2008	2009	2010
1	Buffaloes	-	-	-
2	Cows	596	513	520
3	Pigs	1103	944	779
4	Poultry	1000	1000	1000
5	*cattle (goats, sheeps, horse)*	-	-	-

2.2.2.2. Fisheries

Thanks to its location and favorable natural conditions, aquaculture and marine fishing in general and shrimp farming in the province particularly reaches high growth. Binh Thuan Province is considered the center on feed and seed supply in the country especially the Center shrimp of Tuy Phong district. In year, shrimp produce and consumption is relatively stable dueto favorable weather conditions, the price of shrimp increased and strong market demand that helped fishermen to have more jobs and significantly increase incomes for fishermen.

Production of shrimp seeds increased on average 66.3%/year, accounting for 84.8% of Tuy Phong district. Seafood products increase 8.0%/year, accounting for 5.0% seafood exploitation of the District. Aquaculture has formed the shrimp farming areas as planned. Besides, the protection of aquatic resources are often interested, guidelines and policies of the state is timely disseminated to fishermen.

In 2010, the district had 9,399 aquaculture households, in which Vinh Tan commune has 550 aquaculture households. Indicating that the aquaculture industry of Tuy Phong district played an important part in the local economy, and income of households, in which obtained from aquaculture accounting for 42% of the main industry of the household.

Aquaculture output increased over the years is presented in Table 2.55.

Table 2.55. Statistics of surface water area and aquaculture production in Tuy Phong, Vinh Tan over the years

No	Item	Unit	Tuy Phong district			Vinh Tan- Vinh Hao		
			2008	2009	2010	2008	2009	2010
I	The area of salt water, brackish	ha	452	483	580	195	170	148
	Area for fish	ha	12	12	14	8	7	6
	Area for *shrimp*	ha	382	413	508	138	114	93
	Area for breeding	ha	58	58	58	49	49	49
II	*The area for freshwater*	ha	-	-	-			
III	Production of fishery	ton	44.861	44.598	47.457	2198	2607	2570
IV	Fishing device	ship	1639	-	-	69	73	70
	The total capacity	CV	83329	-	-	2005	2511	2437

Sources: Statistical Yearbook of Tuy Phong district- Binh Thuan province -2011 and Planning report Vinh Tan-Vinh Hao 2020

According to survey result of fisherman group in Vinh Tien and Vinh Phuc Hamlet (known as Hamlet No.7 residential area), fishing activities mainly concentrated inside coral reef area in Vung Mu Bay, belonging Vinh Tan Commune. Upon to local weather condition (calm or rough sea), fishing will be happened inside or outside coral reef area. Normally, favorable time is from April to August, fishing activities can take place continuously, every day. And from December to next March, the working days are assumed 20days/month. In the bad weather condition (from September to November), fishing activities can be happened outside coral reef area or be interrupted.

Main maritime products are shell-fish, cuttlefish, squids, shrimps, Cucumber Sea, grouper, carp etc.

Fishermen using the coracle operate from sunrise to around midday, whereas the fishermen in small boat start the fishing operation at around 06:00pm and return to shore early in the morning after sunrise. The majority of the landings take place in the morning so that the catch can be taken to the markets and sold on the same day.

In general, fish which is not sold is processed (i.e. frozen or sun dried). They sold directly for human consumption. The fish can be processed by the fishermen themselves or by the company. The annual catch of fish was difficult to estimate. It is estimated that fishermen who were interviewed can earn 200,000 – 300,000 VND per day in average.

The rapid exhaustion of the marine products resource in Vung Mu bay in recent five years is the result of excessive exploitation of local people. Due to lacking large boats and equipment to exploit the offshore fishing ground, most of their marine activities have taken place inshore area, especially inside coral reef. Moreover, a large of local people illegally exploited coral to increase their income while fishing resource is reducing. Therefore, marine product resource in this area is more and more exhausted.

In terms of fisheries management, the government has established a series of rules and regulations as a means of contributing towards the sustainability of the fisheries resources. It was observed, however, that the enforcement of some of these rules was considerably weak, mainly resulting from the lack of physical means to carrying it out.

In summary, from the data collected during the survey, it is possible to conclude that local economy is greatly dependent on aquaculture and fishery.

2.2.2.3. Salt making

Currently, the area of salt production in Tuy Phong district is about 848.4 hectares, concentrated in Vinh Hao commune (784.5 ha) and Chi Gong commune (62ha) (as report on land use in Binh Thuan 2020). At Vinh Tan area, there is not any salt production activity. The salt field located nearest with Vinh Tan PC is salt field in Vinh Hao commune, far away about 3.7 km to the west. Salt production ranges from 5-8 tons/ha with the price of crude salt of 700000 VND/ ton.

Vinh Tan 4 power plant project located quite far from salt area, so operation of the plant does not affect on the salt making in the area.

2.2.2.4. Trade and services

2. Trade:

In the commune of Vinh Tan-Vinh Hao, trading network and services has been extended and fast developed along main roads and residential areas. By 2010, there are approximately 455 commercial businesses - services with 1385 employees; there are on average three employees/establishments and mainly individual business households.

Vinh Tan commune has Vinh Tan market where is invested in upgrading and refurbishment, basically favorable for trading activities - services. In addition, restaurant facilities, hotels, motels initially meet the needs of the market; room service progresses are constantly.

The commercial facilities and services start to meet the initial requirements to provide materials, goods and consumer products for people. However, most of establishments are small, low quality, and has not provided product market stability for farmers and fishermen.

3. The service sector:

As tourism services, transport, telecommunications, ect, has not been developed because they has been properly invested but their potential will develop strong when Vinh Tan Power Complex comes into operation.

Chapter

3

ENVIRONMENTAL IMPACT ASSESSMENT

3.1. OVERVIEW

Vinh Tan 4 thermal power plant project (hereafter as the Project) with capacity of 2 x 600 MW is one of four power plants belonging to Vinh Tan power complex (Vinh Tan PC) with capacity of 5,600MW. The construction of Vinh Tan 4 TPP includes various items including land reclamation, construction of port, plant and so on.

The construction of Vinh Tan 4 TPP will contribute actively to the growth of power capacity of the Central South. In one hand, the establishment of Vinh Tan 4 TPP plays the role of essential factor to promote the development of the Central South economic while in the other hand, its construction and operation may affect the local environment adversely. This Chapter will assess potential environmental impacts during the preconstruction, construction and operation phases of the project following the guidance given in Annex 2.5, Circular 26/2011/TT-BTNMT dated on 18/07/2011 by the MONRE.

3.2. IMPACT ASSESSMENT

3.2.1. Impacts in the pre-construction phase

3.2.1.1. Impact on land use planning

Among the total area of 9.73ha at the extended site of Vinh Tan 4 TPP, it is estimated to have about 1.14 ha of annual tree planting area, 1.3 ha aquaculture land, 0.42 ha agricultural land, 0.3 ha specialized water surface land, 6.55 ha for other purpose use (including unused land, streams and traffic roads). The alteration in land use purpose due to the establishment of the project will certainly affect the livelihood of local residents. Compensation and resettlement processes will be applied during the clearance to support the rehabilitation of affected people.

The employment of 28.28 ha aquatic area will also affect the land use planning of Vinh Tan commune. According to the land use planning of Vinh Tan commune in 2005, the area being employed by the project was planned to be an aquaculture area (raising breeding and industrial shrimps). However, the Binh Thuan province People's Committee has recently stopped giving land to shrimp farming projects to give to power project instead. Furthermore, the People's Committee has planned to employ the area of Ganh Hao – Chi Cong (153.6 ha) to build the provincial breeding shrimp farming; those shrimp farms affected by the project will be priorly moved to this area.

At present, most of people in Vinh Tan commune have been living on fishing onshore; some raise breeding lobster on the sea while others nurture cobia and grooper. However, the number of shrimp farming household has decreased to 10 – 15 owing to the bankruptcy occurred due to the lack of experience, knowledge, spontaneity and common epidemics.

The impacts on land use planning by the establishment of the project are estimated significant. Nonetheless, the Ganh Hao – Chi Cong area planned to be breeding shrimp farming area and priorly accept resettled households from the project site. The local authorities have favored the Project with all advantages for the sake of quick establishment and promotion of regional socio-economics.

3.2.1.2. *Impacts due to displacement and site clearance*

The area of land withdrawn for the Project is around 38.01 ha in which terrestrial area accounts for 9.73 ha while aquatic area accounts for 28.28 ha. There are about 13 households having land to be withdrawn in which 9 of them will lose houses and all 13 households will lose their production land.

According to the observed results at site, there are 9 households needs to be displaced and most of them are bricked, 4 – graded or temporary houses with small area. These land withdrawn households will be arranged to resettle at a residential site in the center of Vinh Tan commune (2.5 km eastward from the project). Therefore, the compensation and site clearance are evaluated as favorable.

For aquaculture area (approx. 1.3 ha): average income of aquaculture households is about 200 mil. VND/year in convenient conditions. The land withdrawing will definitely affect the living and earning of those household. Hence, they will be compensated appropriately and supported by cash at the rate of 2.5 time the agricultural land price; they are also supported to move to the planned shrimp planning area of the Binh Thuan province.

For annual tree planting area: mostly short-term crops such as onion, beans, melon and other foodstuffs. The crop productivity is just enough for local demand and the economic efficiency is not high.

The compensation, support and resettlement will be carried out simultaneously in order to lessen the impact of the Project construction to local socio-economic as well as domestic activities of residents.

According to the overall schemes for compensation, support and resettlement process of Vinh Tan TPP project, requisite expenses are estimated as follows:

Table 3.1. Summary of compensation, support expenses

No.	Items	Unit	Amount	Total (1,000 VND)	Note
A	Compensation – support cost			12,147,669	*Estimated*
I	Plants – crops			695,575	*Estimated*
II	Land			1,703,562	*Estimated*
III	Construction structure			5,778,575	*Estimated*
IV	Support cost			3,969,957	*Estimated*
B	Resettlement cost			4,504,640	*Estimated*
C	Other costs			499,569	*Estimated*
D	Contingency	%	15	2,572,782	*Estimated*
	Total (A+B+C+D)			19,724,660	*Estimated*

Source: PECC2, 2013

Note: The data will be revised during the compensation, support and resettlement implementation process.

Although it may disturb the production, livelihood at the region, the establishment of

Vinh Tan 4 TPP will improve the appearance of the region, the infrastructure, service activities which will directly enhance the local income and living condition. The economic structure of the region will also change; more people will work in the trade, service and industrial sectors by working in the power plant.

Major part of local population expect their family members to be trained and work in the power plant in order to enhance and ensure their income. However, the education level of the region is not sufficient to do so. Hence training program is ultimately required by the residents.

Basically, the impacts caused by site clearance is not severe and compensation and resettlement plan will be implemented simultaneously to lighten them. During the operation phase, the project owner will employ local labor force to work in the plant so that the living condition of affected household will be improved.

3.2.1.3. Impacts on technical infrastructure planning of Vinh Tan Power Complex

The technical infrastructure, power supply and water supply systems will be constructed synchronously to support the construction of Vinh Tan 4 thermal power plant. These items belongs to the project of Vinh Tan infrastructure.

Traffic system outside the plant: belongs to the project of Vinh Tan Power Complex infrastructure construction. These traffic roads are designed as type 3 urban road (Road No. 1 and No. 4) and third-grade lowland road. These roads are constructed to support the movement on site as well as the transportation of ash during the operation phase of Vinh Tan Power Complex. As designed, the new traffic system will be available for the movement of 2690 vehicles/day (including motorcycles, automobiles and trucks). Hence, despite the establishment of Vinh Tan 4 TPP, the transportation in the area is still guaranteed. Therefore, these impacts are estimated as insignificant.

Power supply system: belongs to the project of Vinh Tan Power Complex infrastructure construction. In order to ensure the power supply for Vinh Tan 4 TPP construction, the current 22kV Lien Huong in the area is still guarant.5) will be renovated and upgraded about 19 MWA. The renovation and upgrade will be carried out by local power companies so that the power supply for Vinh Tan 4 TPP construction will be guaranteed.

Water supply system: belongs to Vinh Tan Power Complex infrastructure project. At present, the raw water source is serving the construction of Vinh Tan 2 TPP which will be finished in 2014 At present, the raw water source is serving the construction of Vinh Tan 2 TPP which will be finished in 2014 4 TPP construction will be guaranteed.pact^3/h to provide water for the construction of power plants in Vinh Tan Power Complex. According to the proposed progress, Vinh Tan 1 TPP construction will be wrapped up in 2015 – 2016 whereas Vinh Tan 3 and Vinh Tan 4 will be built simultaneously. Hence, it is expected that the water Da Bac lake is able to ensure the water for two plant construction and the water supply for the whole complex will not be affected.

Planning for land levelling, drainage system and landscape: Vinh Tan 4 TPP is will be designed and constructed in associated with the infrastructure planning of the power complex so that the structural landscape of the whole area will be maintained. Therefore, the impacts on infrastructure system of Vinh Tan power complex is not considerable.

3.2.1.4. Impacts from sea leveling

3.2.1.4.1. Impact source relating to waste

The environmental impacts relating and not relating to waste during the pre-construction phase of the Project are mainly from the sea levelling activities as well as embankment establishment.

Table 3.2. Impact sources relating to waste in the sea levelling process

Impact source	Affected objective	Impact assessment	Impact level
Activities of vehicles, machinery on site Transportation of materials and equipment	Air environment	Negative impacts on air environment due to air emission and dust generation of vehicles	Small Local Temporary
	Water environment	Spilled oil and waste from the machineries and vehicles potentially pollutes surface water, especially during rainy season.	Small Temporary
Land reclamation, construction of sea encroaching embankment	Air environment	Dust generation from land leveling and clearance will affect the local air quality.	Small Temporary
	Water environment	Run-off rainwater at construction areas (leveling, backfilling sites) will bring construction waste including soil, concrete, cement to adjacent water sources, increasing the turbidity, and polluting the water sources. Spilled oil and waste from equipment working on sea will increase the possibility of sea pollution.	Small Temporary
Gathering a great number of workers.	Water environment	Increase pollution of surface and underground water due to increasing volume of solid and liquid waste on site.	Small Temporary

1. <u>Impacts from air emission</u>

   a. *Dust generation from site and vegetation clearance*

   According to experimental data from the United State Environmental Protection Agency (US.EPA), the coefficient of dust generated from vegetation clearance by excavators is 0.029 kg dust per ton vegetation cleared.

   At the project area, approximately 2700 tons vegetation need to be cleared. If the work is performed in 1 month, dust will be released at the rate of about 0.16 kg/h. The 1 hour average concentration is estimated as 0.148 mg/m^3 in the levelled area of 21.53 ha and wind height about 5m.

   b. *Dust from leveling and reclamation process*

Construction activities such as earth working, compacting to stable the ground by earthmovers, bulldozers, and road rollers is the main reason causing air pollution of local area. Dust concentration will locally increase at construction site, adjacent areas, particularly in the days without rain (residential areas in hamlet 7, households along the highway 1A).

The total volume of sand for leveling activities of Vinh Tan 4 TPP is approximately 929,280 m^3 equivalent to 1,208,064 tons (1m^3 sand is equal to 1.3 ton) and the execution time is within 12 months. This amount of sand will be taken from dredging of Vinh Tan 3 and 4 sea port.

According to experimental results of US.EPA, emission factor from land clearing or compacting can be estimated as follows:

$$E = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad (1)$$

Where: E : emission coefficient (kg/h)
s : material silt content (7.9 %)
M : material humidity content (6.9 %)

The concentration of dust generated can be quickly estimated as follows:

$$\chi = \frac{Q x 10^6}{S x H} \; (2)$$

where: χ : Concentration of pollutant (mg/m^3)
Q : Pollution load (kg/h)
S : Area (m^2)
H : Height of meteorological factors (m)

According to calculations, the amount of particulate matter arising from the earth working and leveling of the power plant area is about 0.35 kg/h. The average 1 hour concentration is expected at 0.32 mg/m^3, in the area of 21.53 ha and the wind height about 5 m; higher than the permissive level regulated in QCVN 05:2009/BTNMT (0.3 mg/m^3). Thus, the dust concentration arising from earthwork activities, leveling will affect air environment. However, the concentrated dust generation is expected to occur only short-term during the construction phase and within the construction site; main affected objective are workers working and living directly on-site.

Furthermore, air pollution cause by dust can be significantly reduced by appropriate mitigation measures such as watering transporting roads and others (refer to Chapter 4). Therefore, the impact of dust generation is estimated as trivial.

c. *Dust generation from embankment construction for land reclamation*

The construction of embankment will be implemented on the sea with most of its activities happens underwater. Construction time is about 12 months. The length of reclamation serving embankment is about 1051 m calling for 320,000 m^3 of rock and 150,000 m^3 of on-site prepared concrete.

i) Dust generation due to the transportation, gathering of materials and equipment:

The total volume of material needed for on-site activities of the construction of embankment is about 851,787 tons which will be transported to the project area by 30-ton trucks and stored at the construction site. Rock and sand materials serving the embankment construction will be taken from Phong Phu area and Luy river, which are respectively 25 km and 45 km away from the project site..

Based on the equation of US.EPA, the total volume of dust released from the material transport and loading during the construction of embankment can be roughly estimated.

The total volume of dust during material transport on asphalted roads within the radius of 1,000 m from the project site:

$$E = k \times \left(\frac{sL}{2}\right)^{0.65} \times \left(\frac{W}{3}\right)^{1.5} \qquad (3)$$

Where:
- E : particulate emission factor (kg/VKT)
- k : particle size coefficient (kTSP = 24 g/VKT)
- sL : road surface silt loading (0.6m/s)
- W : average weight (tons) of the vehicles (full and empty trucks; estimated weight of empty truck is 12.5 tons)
- VKT : kilometers travelled (km/day)

Emission from unloading materials and equipment activities.

$$E = k \times 0.0016 \times \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \qquad (4)$$

Where:
- E : emission factor (kg/ton material)
- k : particle size coefficient ($k_{TSP < 30\mu m} = 0.74$)
- U : average wind speed (5m/s)
- M : average humidity of materials (rock, sand, and cement) (7.4%)

In order to assess the impact of dust generation in material transport, Sutton model was employed to determine concentration of a pollutant at a certain position. Such concentration is calculated as follows:

$$C = \frac{0.8E\left\{\exp\left[\frac{-(z+h)^2}{2\delta_z^{\,2}}\right] + \exp\left[\frac{-(z-h)^2}{2\delta_z^{\,2}}\right]\right\}}{\delta_z u} \qquad (5)$$

Where:
- C : concentration of dust in the atmosphere (mg/m^3).
- E : flow rate of pollutant at source (mg/m.s).

z : height of the considered position (1m).

h : difference between heights of the road and surrounding land (0.5m)

u : wind speed (3.5 m/s)

x : required distance (m).

δ_z : amplifying coefficient in z direction, determined as: $\delta_z = 0.53x^{0.73}$

Table 3.3. Dust generated from the transportation and unloading of materials for reclamation embankment construction

Item	Quantity
- Total volume of construction materials	851,787 tons
- Weight	30 tons/truck
- Transporting frequency during the embankment construction	79 round trip/day
- Average weight of the vehicles traveling the road	27.5 tons
a. Emission from transportation of materials on roads	
- Emission coefficient, E	304.42 g/VKT
- Vehicle kilometers travelled per day	79 km/day
- Average dust emission during the construction of reclamation embankment	24.04 kg/ day
b. Emission from loading materials	
- Emission coefficient, E	0.00028 kg/ton
- Average dust during the construction of reclamation embankment	0.67 kg/ day
- Total volume of dust during the construction of embankment.	24.71 kg/ day

Source: PECC2, 09.2012

Based on the equation for calculating dust concentration on road (5), the 1 hour average concentration of dust generated in 1km transporting at site can be estimated as follows:

Table 3.4. Diffusion coefficient in the atmosphere in z direction and dust concentration:

x	3	5	10	15
δ_z	1.18	1.72	2.8	3.83
C (mg/m^3)	0.075	0.05	0.032	0.024

As shown in Table 3.4, the volume of dust generated from material transportation on roads is about 24.71 kg/day. The concentration at 2 sides of the roads at the distance of 1 km is ranging from 0.024 – 0.075 mg/m^3 which is still lower than allowable value regulated in QCVN 05:2009/BTNMT (0.3 mg/m^3).

Besides, the concentration of dust generated during the gathering of material at project land is estimated at 0.04 mg/m^3, within the leveled area of 21.53 ha and wind speed about 5 m (according to equation (2) which is still lower than the limit regulated in QCVN 05:2009/BTNMT.

Consequently, it is evaluated that impact of dust generated from the transportation, loading/unloading of materials is considerable. However, air pollution due to dust generation can be significantly controlled by appropriate mitigation measures such as watering roads, improving the condition of road system, covering trucks' trunk during the transportation. Moreover, such impact is short-term lasting only during the construction phase.

ii. Air emission due to the transportation of construction materials and equipment.

Impacts from emission due to road transport: trucks used for transportation can generate exhausted air causing pollution due to their usage of burning fuel such as gasoline, DO, etc., affecting worker and the surround environment directly. With the aforementioned weight of material and equipment at 851,787 tons, there will be maximum 79 trips of 30-ton truck per day. According to pollution coefficient instructed by WHO and Sutton equation, concentration and volume of air pollutants along the transporting road can be estimated as shown in Table 3.5.

Impact from air emission due to activities of ships, barges on sea: in construction process of port, vehicles transporting construction materials on sea are barges with the load of 800 to 1000 tons/barge, so the total number of barges transported materials and constructed on sea is estimated about 2 barges/day. Based on pollution coefficients by rapid assessment procedure of WHO and the equation (2) above, the volume of air pollutant by barges at Vinh Tan Power Center in the area of 331.43 ha, height 5 m is given in Table 3.6.

Table 3.5. Volume of air pollutant released from the transportation of materials and equipment on roads

No.	Pollutant	Pollution coefficient (g/km)	Total length (km)	Total volume (kg/day)	Max concentration (mg/m^3)	QCVN 05:2009
1	Dust	0.9	158	142.2	0.0027	0.3
2	SO_2	4.15S	158	19.67	0.0004	0.35
3	NO_X	14.4	158	2275.2	0.044	0.2
4	CO	2.9	158	458.2	0.009	30
5	HC	0.8	158	126.4	0.0024	-

Source: PECC2, 09.2012

Table 3.6. Volume of air pollutants due to high-weigh ships (ships, barges working on sea) during the construction of reclamation embankment

	Number of ship	Anchoring time of ships (unit-U)	Coefficient (kg/U)	Load (g/h)	Concentration (mg/m³)	QCVN 05:2009
TSP	2	45	6.8	302.2	0.018	0.3
SO_2			136S	181.3	0,01	0.35
NOx			90.7	4031.1	0.24	0.2
CO			0.036	1.6	0.000009	30
VOC			4.1	188.2	0.011	-

Note: Pollution coefficient referred from Rapid Assessment of Sources, WHO 1993.
Content of Sulfur in FO is 3%.
Anchoring time at port are 45 hours for all kinds of ship.

From the calculation results above, it is obvious that load of pollutants released from vehicles, machinery, ships, barges is not high, except for NOx concentration which is 1.2 time higher than the standard. In addition, the construction site is located in a wide well-ventilated area, so that the pollution caused is only local and lasting during the construction phase. *In conclusion, air pollution due to emissions from construction machinery is considered medium and controllable.*

2. Wastewater source

During the land reclamation process (including embankment establishment), wastewater is mainly produced from workers' living activities, washing of transporting vehicles, constructing equipment, machinery. To each source, a detailed assessment will be performed as follows:

a. Domestic activities of workers

There will be approximately 500 workers working on construction site so that the wastewater released from camps, cafeteria, bathrooms, restrooms will be main source of pollution. At an average supplying standard of 150 L/person.day, the flow of wastewater is about 68 m3/day and main pollutants include suspended solid (SS), organic matters, grease, Nitrogen (N), Phosphorous (P) and bacteria (T. Coliform)

Load of main pollutants in domestic wastewater is estimated as shown in Table 3.7.

Table 3.7. Estimated volume, concentration of pollutants in wastewater

Parameter	Average pollutant volume by 1 person in 1 day (g/person/day)	Total volume of pollutant (kg/day)	Pollutant concentration (mg/m³)	QCVN 14:2008/BTNMT
BOD_5^{20}	45-54	22.5-27	330-397	50

SS	70-145	35-72.5	514-1066	100
Grease	0-30	0-15	0-221	20
Total Nitrogen	6-12	3-6	44-88	-
Organic Nitrogen	2.4-4.8	1.2-2.4	17.6- 35.2	-
NH_4^+	3.6-7.2	1.8-3.6	26.5-52.9	10
Total Phosphorous	0.8-4	0.4-2	2.9- 29.4	
Total Coliform	10^6-10^{10} (10^8) (MPN/100 mL)	-	-	5000

Source: PECC2, 9.2012

With above characteristics, domestic wastewater of workers will impact on surrounding water source if no treatment proper is performed due to exceeding concentration of pollutants compare to the permissive value stipulated in QCVN 14:2008/BTNMT (K=1, category B).

However, the volume of wastewater produced is not high. Most of workers live in the rental houses near the construction site or residential areas in Vinh Tan commune and they will use the common sanitary system. Therefore, the amount of wastewater generated on site is less than the calculated values.

Additionally, wastewater from ships and barges in the construction of embankment will also affect coastal water quality at Vinh Tan area and regional marine ecosystems if there is no mitigating measures. Under the provisions of Decree No. 21/2012/ND-CP dated 03/21/2012 on Management of port and maritime channels, the sanitary sewage from boats, barges must not be discharged to the port area when lading in order to reduce pollution of water environment. The ship owners will be responsible for implementing garbage collection/ pumping dirty wastewater according to regulations and instructions of the port authority. The owners will contract the vessels sanitation service company to collect, classify and handle solid waste and hazardous waste from the ship when the ship docked and paid in accordance with the regulations. Thus, ship owners and barges will have to comply regulations specified in the Decree, therefore, impact on water environment by wastewater from ships and barges is assessed is insignificant.

b. *Wastewater from washing constructing machinery, trucks, equipment*

The transporting ships and trucks after unloading the materials will be washed prior to move out of site. With about 79 trips each day, the flow of washing water is estimated about 20-25 m^3/day. This water contains high content of suspended solid and may also contain a certain level of heavy metal. Hence, without proper treatment, this water can affect the quality of coastal water and aquatic ecosystem at the area of Vinh Tan commune. Yet, the amount of such washing wastewater is not high so that the effect is not significant.

In addition, the ship's operation during embankment construction can discharge oily waste into the sea. There are 2 barges per day working at the construction site during 12 execution months (average 10 hours per day operation). Daily oil consumption for the operation of barges is estimated at 500 liters. Thus, the amount of oil lost to the marine environment due to construction/repair activities is about 0.1 liter (the amount of oil lost by 0.01% daily oil consumption). This effect is negative but minor and manageable.

c. *Runoff water*

As planned, the Project will recover an area of 9.73ha to extend Vinh Tan 4 TPP. The leveling works will be swept away soil, sand, waste, oil to sea waters in the region by runoff when it rains. If this water is not managed well, it can cause adverse effects to local aquatic life. According to statistical data of WHO, substances concentration in runoff are approximately 0.5 – 1.5 mgN/l; 0.004 – 0.03 mgP/l; 10 – 20 mgCOD/l and 10-20 mgTSS/l. The volume of runoff water at construction site can be calculated as follows:

$$Q = q \times F \times \varphi \qquad (6)$$

Where	Q	:	Flow rate, m^3/s	=	0.26
	q	:	Calculated rainwater intensity, l/s.ha *(Phan Rang area)*	=	174.2
	F	:	Rainwater drainage area, ha	=	9.73
	φ	:	Flow coefficient for grass cover	=	0.15

Pollutant load: There are high concentration of pollutant accumulated on the ground in the first rainfalls such as grease, dust etc. These substances can be estimated as follows:

$$G = M_{max}\left[1 - \exp(-k_z \times T)\right] \times F \quad (kg) \qquad (7)$$

Where	G	:	Accumulated substance load , kg	=	192
	M_{max}	:	Maximum accumulated dust load in area, (in area with low transport density), kg/ha	=	20
	K_z	:	Kinetic coefficient on accumulated substances in project area , day^{-1}	=	0.3
	T	:	Accumulated time, day	=	15

Therefore, accumulated contaminants in 15 days in the project area would be about 0.19 ton. These substances will be swept away by runoff water and negatively impact freshwater resources or marine ecology of local region.

According to the design, the drainage system is to collect rainwater and settle sediments before being discharged to the sea. Moreover, there are not too many rainy days at site and they gather mostly in the rainy season (May - October). Therefore, the impact of storm water runoff is negligible.

3. <u>Solid waste</u>

Sources of solid waste produced from the pre-construction phase of Vinh Tan 4 TPP are summarized in Table 3.8 below:

Table 3.8. Sources of solid waste in the pre-construction phase

Waste	Source	Component	Volume
Waste from workersaste in	From activities of 500 workers	Paper, food waste, plastic, glass c	Maximum volume of domestic waste is about 200-250 kg/day (0.4 e of Vinh Tan 4 TPP a
Construction waste	Construction waste from the construction of embankment.	Inorganic substances such as cement, concrete, brickn	Depending on construction method and workerse, bricknApprox. 100-200kg/day.
Hazardous waste	From the maintenance of vehicles and equipment	Grease, oil-contaminated cloths an	About 92 L/month of grease and 0.82 - 1.1kg/month oil-contaminated cloth.

Source: PECC2, 9.2012

a. *Domestic waste*

Major source of waste is from activities of 500 employees gathering at site who release about 200-250 kg/day (0.4-0.5 kg/person.day), in which organic matter (waste food) accounts for 60-70% of the total solids wastes. The rest are inorganic substances such as glass, paper, plastic bag...

Despite the low volume, domestic waste has a complicated composition with degradable organic matters which produce inconvenient smell and undegradable substances. Hence, without proper management, these wastes will adversely affect environmental quality.

These effects is medium and lasts shortly during the construction phase. Also, due to the large construction area, these impacts hardly affects local residents but workers on-site.

b. *Industrial and hazardous waste*

Solid waste produced during the construction of embankment includes mainly concrete, brick, glass and other construction materials with an estimated volume of about 100-200 kg/day. This waste is harmless and capable of reusing for other construction works. Also, this waste can be collected and treated by local specializing organizations.

Besides, the operation of machinery will release hazardous waste such as oils, grease and oily cloths at an amount depending on the number of vehicles and machinery operated. The maximum intensity of vehicle used is 79 trips/day; averagely 7 liters oil are released at an oil replacing time and each truck is changed oil once in 3 – 6 months (Research to recycle oil waste into liquid fuel - in Military Science and Engineering Center Technology - Department of Defense 2002). Hence, the maximum volume of oil released is 92 L/month. Moreover, most of the vehicles will be changed oil at a specialized area outside the project area which means the volume of wasted oil will be much lower than estimated. The volume of oily cloths is about 0.82-1.1 kg/month.

This type of waste is classified as hazardous and will be managed following a proper procedure. In the current project, this waste will be collected to specialized containers and treated by specialized organizations.

3.2.1.4.2. Sources of non-waste impacts

Table 3.9 reveals impact sources not relating to waste, affected objectives and assessment of major impacts occur during the land reclamation.

Table 3.9. Waste non-related impact sources in land reclamation process

Impact source	Affected object	Impact assessment	Impact level
Land reclamation and embankment construction	Local residents Aquaculture environment	Increase the total suspended solid due to the leveling work affecting aquaculture activities and living conditions of local people	Small, temporary
	Ecosystem	Disturb the habitat of local organisms	Medium, local, unrecoverable
	Local oceanography regime	Disturb the flow, causing erosion, sedimentation at project area.	Small, temporary

1. Impacts due to land reclamation

Total volume of soil for the project construction is about 879,809 m3 which means the oceanography regime of local coastal area will be affected to some extent; sedimentation, erosion will also occur. To assess the impacts of dredging work to the hydrodynamic condition, erosion of the project area as well as Hon Cau Marine Protected Area, Delft3D modeling was employed. Delft3D developed by Delft Hydraulic Institute (Netherland) is able to stimulate the hydrodynamic condition area will be affected to some extent; sedimentation, (WL|Delft Hydraulics, 1999).

a. Mathematical base of Delft 3D

i. Basic equations of hydrodynamics model

Mathematical base of the hydrodynamics model is Navier Stokes equation for incompressible fluid in shallow water and Boussinesq approximation.

The depth-averaged continuity equation is as given: (written in an orthogonal coordinate system for estuaries and coastal areas):

$$\frac{\partial \zeta}{\partial t}+\frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)U\sqrt{G_{\eta\eta}}\right]}{\partial \xi}+\frac{1}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)V\sqrt{G_{\xi\xi}}\right]}{\partial \eta}=Q$$

with Q representing the contributions per unit area due to the discharge or withdrawal of water, precipitation and evaporation:

$$Q=H\int_{-1}^{0}(q_{in}-q_{out})d\sigma+P-E$$

Where:

ζ,η : Horizontal, curvilinear co-ordinates

$\sqrt{G_{\zeta\zeta}}, \sqrt{G_{\eta\eta}}$: Coefficients used to transform curvilinear to rectangular coordinates

d: depth below some horizontal plane of reference (datum)

ζ : water level above some horizontal plane of reference (datum)

U, V: velocity component in direction ζ, η

q_{in} and q_{out} : local source and local sink per unit volume

H: total water depth ($H = d + \zeta$)

P, E: precipitation and evaporation

ii. Basic equations for wave modelling

Wave modeling for simulate wave characteristics in this study is Delft3D-WAVE was developed based on SWAN model (Simulating Waves Nearshore) by TU Delft (Delft University of Technology, Netherlands). SWAN model is a typical model for calculation wave characteristics in the coastal zone, estuaries area, lake from wind, bathymetry and current conditions.

The equation written in Cartesian coordinates is as follows (Hasselmann et al. (1973)):

$$\frac{\partial}{\partial t}N + \frac{\partial}{\partial x}c_x N + \frac{\partial}{\partial y}c_y N + \frac{\partial}{\partial \sigma}c_\sigma N + \frac{\partial}{\partial \theta}c_\theta N = \frac{S}{\sigma}$$

In Delft3D-Wave model, the following processes are considered:

- Wave generation by wind
- Dissipation by white capping, bottom friction and depth-induced breaking
- Non-linear wave-wave interaction (quadruplets and triads).

Sediment transport model

Sediment transport model based on equation of dispersion and diffusion of material in the environmental water:

$$\frac{\partial C}{\partial t} = \frac{\partial}{\partial x}\left(D_x \frac{\partial C}{\partial x} - u_x C\right) - \frac{\partial}{\partial y}\left(D_y \frac{\partial C}{\partial y} - u_y C\right) - \frac{\partial}{\partial z}\left(D_z \frac{\partial C}{\partial z} - u_z C\right) + F(C,t)$$

where:

D_x, D_y, D_z Ddiffusions coefficient in x, y, z direction

F(C, t)usions coefficient i

C: concentration

iii. Initial and boundary condition

– For firstly running, initial conditions of the model are set at zero (0) for sea level, salinity, suspended sediment concentration. Initial conditions for next running are taken from previous results (restart file).

– Open boundaries condition: Harmonic constant of four main tidal components O1, K1, M2, S2 are used to for forcing of hydrodynamics model. Harmonic tidal constants in near coastal line are based on observational data of sea level at Phan Rang and Phan Thiet port. The others harmonic tidal constants in offshore are based on data base of tidal Fes2004.

- Refer to Appendix 3.1 for more details on mathematical base of the model.

iv. Model calibration and validation

- Hydrodynamics model

The bottom roughness coefficients in this study employs spatial Chezy (C) coefficients in the rang 0-1000m-1/2s. At the studied area, C=60 was chosen for further calculation.

The parameters relating to turbulence condition can be defined and used by users as constants, spatial variables, or calculated following Horizontal Large Eddy Simulation (HLES). The HLES model has been included in the Delf3D according to the theoretical Uittenbogaard (1998) and discussed in the study of Van Vossen (2000). In this study, the horizontal eddy viscosity and horizontal diffusion were selected with the value of 10 m^2/s. These coefficients in the vertical are 10 - 5 m^2/s. The 2D turbulence model is HLES in the Delft3D and k-ϵ turbulence model for 3D.

- Suspended sediment model

The settling velocity of suspended sediment was used as of 0.1mm/s, in freshwater. In calculation, the impact of salinity will be concerned.

The critical erosion shear stress of sediment ($\tau_{c,e}$) is changing in 0.1-1.0 N/m^2 (Van Rijn, 1993). In this study, after calibration, the value of erosion standard is chosen as 0.25 N/m^2.

The critical deposition shear stress of sediment ($\tau_{c,d}$) is changing in 0.005-0.25 N/m^2 (Van Rijn, 1993). In this study, after calibration, the value of erosion standard is chosen as 0.2 N/m^2.

Rate of natural erosion is ranging from 10^{-5}-10^{-3} kg/m^2s. With the density of bottom sediment is 2650 kg/m^3, density of suspended sediment near bed about 500 kg/m^3, the initial rate of natural erosion is assumed at 10-3kg/m^2.s.

- Wave model

The wave model in this study was setup online coupling with the hydrodynamics and sediment transport model. At each time step, wave model will use results of hydrodynamics (depth, current, water elevation).

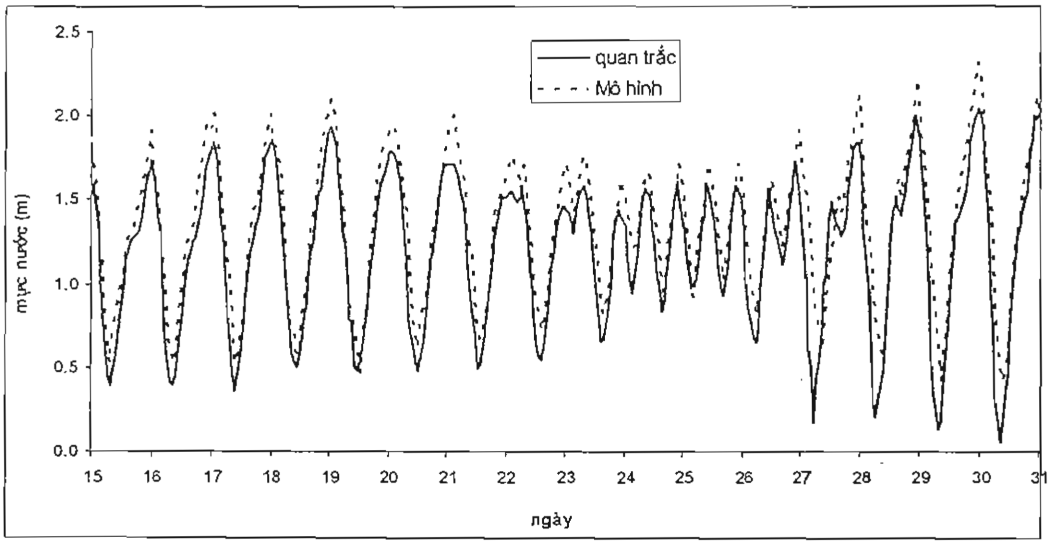
The open boundaries condition of the wave model for the study area was use wave prediction of the wave climate (WaveClimate.com service) in 2009.

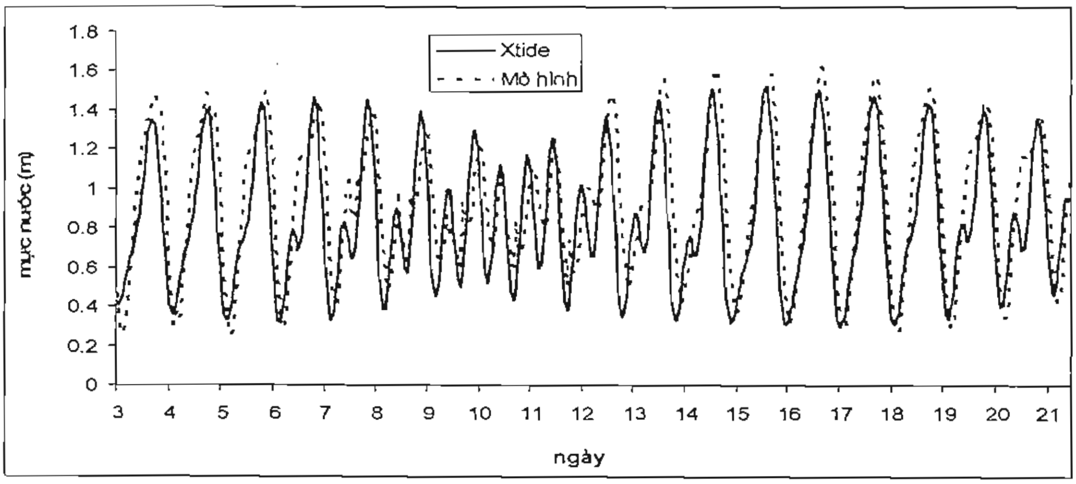
The Alfa coefficients in the wave model changing in 0.1-10, in this study it is used with the values of 1.0. The Gamma coefficients in the wave model changing in 0.55-1.2, in this study it is used with the values of 0.73. The Bottom friction of wave model in this study is JONSWAP with value of

0.067. The B&J model (Battjes, J. and J. Janssen, 1978) was used in order to model the energy dissipation in random waves due to depth induced breaking (Delft Hydraulics, 2003).

To clarify the validity of hydrodynamics model in coastal zone of Binh Thuan and Cu Lao Cau, we used sea level from modeling results to compare with measured water level at Vinh Tan (14/10-12/12/2007) and calculated data of WinXtide32 at Mui Dinh (Ca Na Headland, Ninh Thuan Province) in rainy and dry season of 2012. After last calibration processing, comparisons between modeling results and these data have a relative agree both amplitude and phase (Figure 3.1). Therefore, results of hydrodynamics model could be used to setup sediment transport model.

Figure 3.1. **Comparison between modeling, monitoring results and data from WinXtide (b)**





b. *Main parameters of the models*

Main parameters for modeling hydrodynamics, wave and sediment transport are setup based on processing data and summarized in the table below:

Table 3.10. Summary main parameters of the models

Module	Parameter	Value
Flow	Number of calculated points	M=668, N=366
	Δx, Δy	68.7-670.0m
	Time step	60 seconds
	Threshold between dry and wet	0.1 m
	Number of layer	4(25%/ layer)
	Horizontal eddy viscosity	1,0m^2/s
	Vertical eddy viscosity	1.0 x 10^{-6} m^2/s
	Horizontal eddy diffusivity	1.0m^2/s
	Vertical eddy diffusivity	1.0 x 10^{-6} m^2/s
	Chezy coefficient	60
	Turbulence closure model	*k*-e turbulence closure
	Advection scheme	Cyclic method
	Sigma-coordinate correction	On
	Forrester filer vertical	On
	Forrester filter horizontal	Off
Wave	Maximum number of iteration	8
	Spectrum	JONSWAP
	Setup	False
	Hydrodynamics (water level, bathymetry, current, wind)	Use and doncs (water
	Forcing	Wave energy dissipation
	Friction	Madsen et al, (1978)
	Breaking	Bettjes & Janssen (1978)
	Alfa	1.0
	Gamma2	0.73
	Wind	Komen et al, (1984)
	Quad	Hansselman et al, (1985)
Sediment transport	N	10
	f_{MOR}	10
	EQMBC	True
	Densin	False
	ALFABS	1
	ALFABN	1.5
	f_{SUS}	1

Module	Parameter	Value
	f_{BEB}	1
	f_{SUSW}	1
	SEDTHR	0.5
	THETSD	0
	RHOSOL	2650
	D_{50} *sand*	150
Dredging	DepthDef (m)	1
	MinimumDumDepth (m)	-999
	MaxVolDump (m^3)	897809
	DumpDistr	1
	Percentage	100

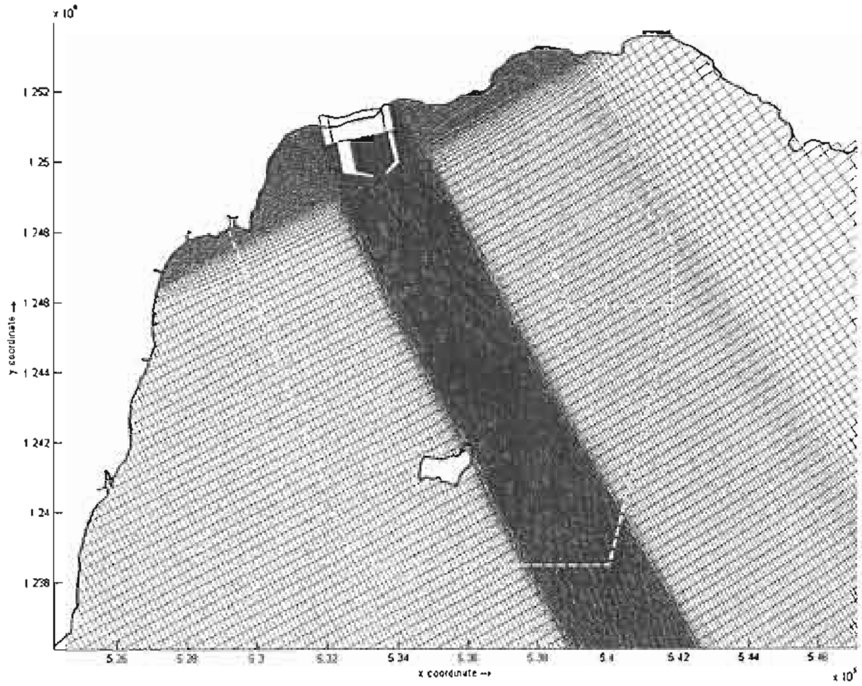
c. Modeling time frame and simulation scenarios

To assess the impacts of dredging work on the hydrodynamic conditions, sediment transport at Vinh Tan coastal area and Cu Lao Cau area, the following scenarios were created.

- Scenario 1: before the commencement of dredging work (no impact) during northeast monsoon season (dry season) and southwest monsoon season (rainy season).
- Scenario 2: reclamation after the establishment of the embankment during northeast monsoon season (dry season) and southwest monsoon season (rainy season).

These scenarios were used to calculated typical trends during 2 seasons: northeast and southwest monsoon season. In this area, the northeast monsoon season (dry season) lasts from November to next year March while southwest monsoon season (rainy season lasts from May to September annually. In other time, the wind direction is diffusive with some windless period (Nguyen The Tuong, 1996; National Center for Hydro-meteorological Service, 2000).

Figure 3.2. Grid of dredging area in modeling frame



To assess the impacts of dredging work on hydrodynamic conditions and sediment transport at certain points in the studied area, some points were included into the modeling for testing. The positions of these points are described in the following figure:

Figure 3.3. **Map of testing points at Vinh Tan coastal area**

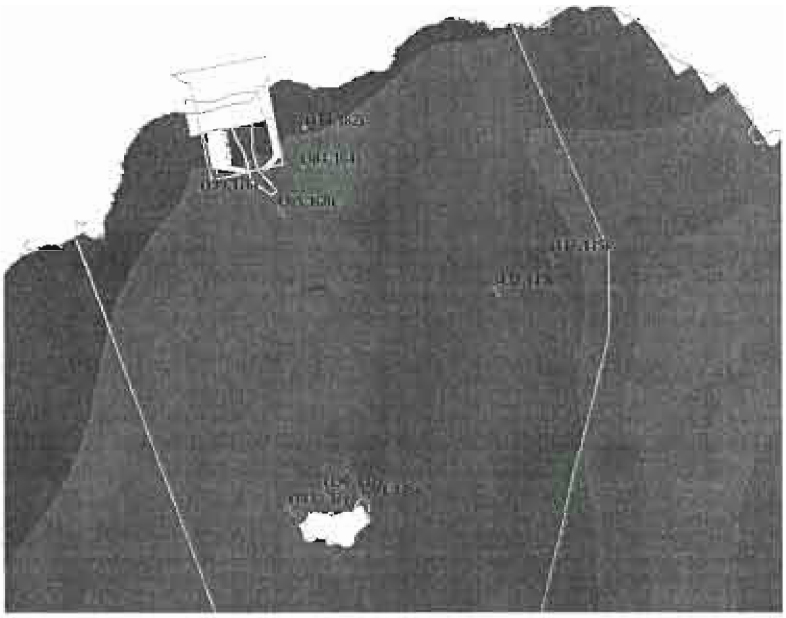
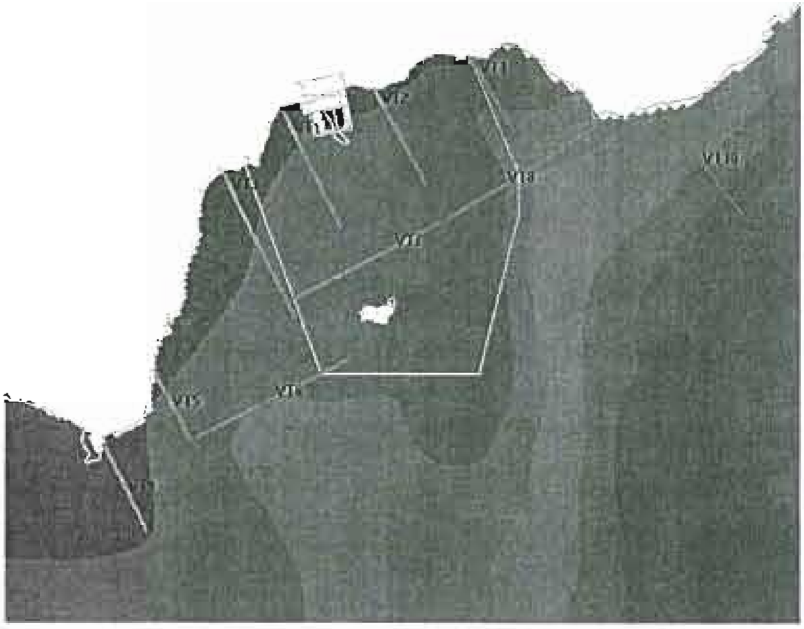


Table 3.11. Position of testing points

No.	Position		Note
	M	N	
V1	447	145	Breda shoal

V2	432	145	Breda shoal
V3	183	137	West site of Cu Lao Cau area
V4	190	137	Northwest site of Cu Lao Cau area
V5	201	135	Northeast site of Cu Lao Cau area
V6	410	182	East site of the dredging area
V7	384	164	East site of the dredging area
V8	305	196	Southeast site of the dredging area
V9	199	176	Southwest site of the dredging area

Figure 3.4. Position of cross-sections for calculating sediment transport



To assess the influences of dredging activities on sediments transport in the study area, some cross-sections were taken into account in the model which are perpendicular and parallel with the coastline. These cross-sections include:

- Cross-sections control sediment flux alongshore of Vinh Tan coastal zone: VT1, VT2, VT3, VT4
- Cross-sections control sediment flux alongshore of Vinh Tan southern coastal zone: VT5, VT9
- Cross-sections control sediment flux alongshore of Vinh Tan northern coastal zone: VT10
- Cross-sections control sediment flux to seaward Vinh Tan coastal zone: VT6, VT7, VT8

d. *Modeling result:*

i. Influence on hydrodynamic conditions

Hydrodynamic conditions before dredging:

Hydrodynamics of Binh Thuan coastal area in general and Vinh Tan coastal area in particular are impacted by a range of factors such as wind, sea level oscillation and wave action. Results of the model show that integrated current in this study have not high velocity. Prevalent magnitude of current which is between 0.1 - 0.3 m/s alters with water level oscillation. Current directions in this area are directional along the seacoast: directional east-northeast (flood tide stage, Figure 3.5) or directional south-southwest (ebb tide stage).

Wave induced currents in the area have low velocity most of which is lower than 0.4 m/s. These currents are almost directional alongshore (similar to integrated current) and alter following tidal oscillation and wind season. During southwest monsoon season, the velocity of these wave induced currents increases in flood tide stage and dramatically drops in ebb tide stage. Meanwhile, during northeast monsoon season, such velocity falls in flood tide stage and rise in ebb tide stage.

The wave field of Binh Thuan coastal area change largely following the wind velocity and tidal oscillation. Wave height usually reaches maximum value at high tide. During the southwest monsoon season, the wave direction is mostly north and northwest and wave height is in the range of 0.4 ollowing tidal oscillation and wind season. During southwest monsoon seasonirection is west - southwest and wave height is about 0.3 – 1 m (Figure 3.6)

Figure 3.5. **Integrated current field at surface at Vinh Tan coastal area (m/s) (Southwest monsoon season, flood tide stage, before dredging)**

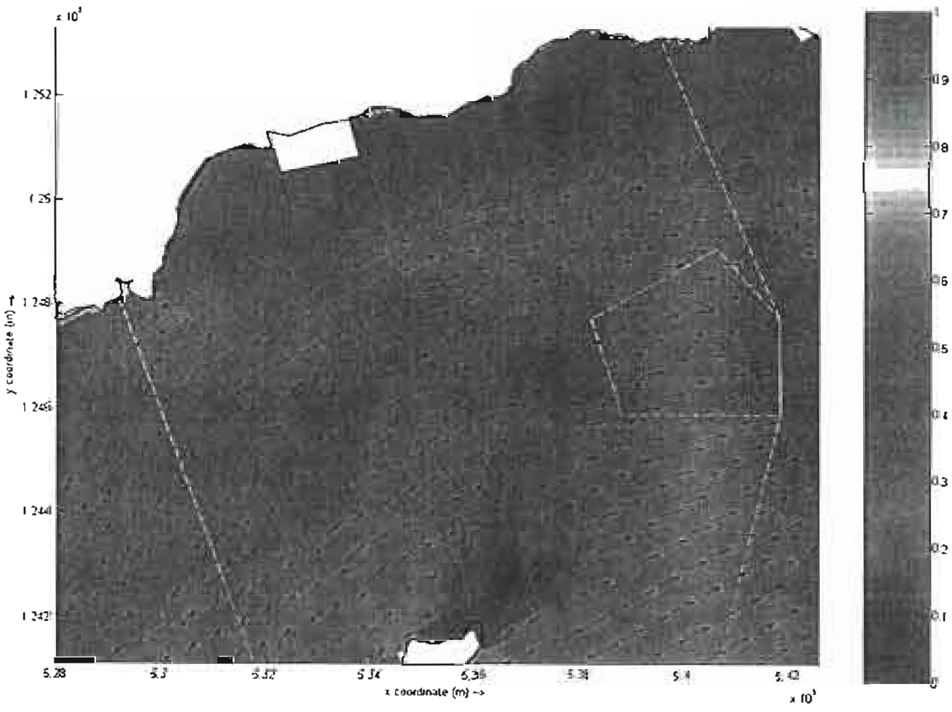
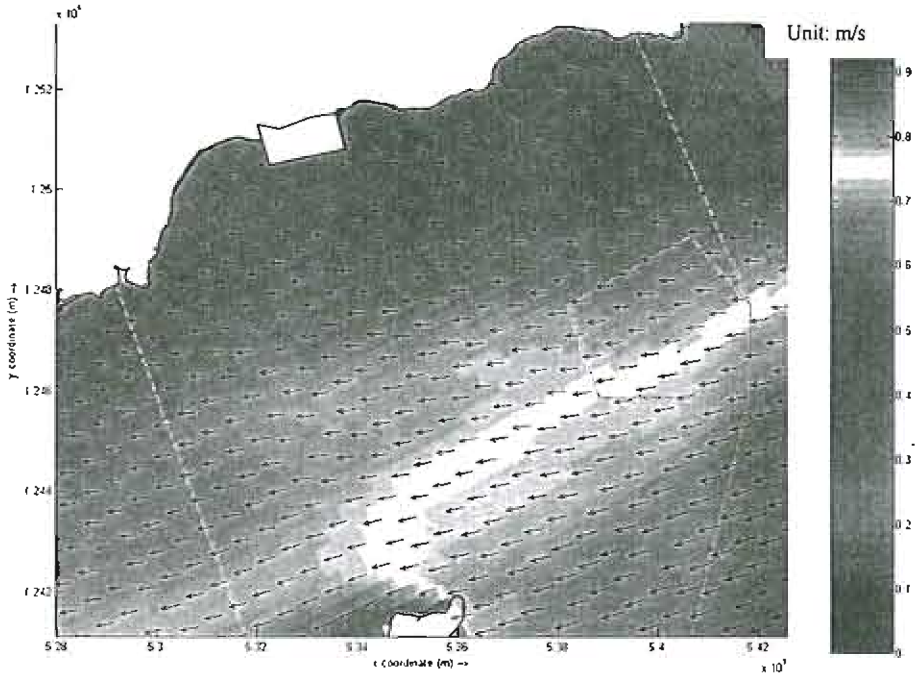


Figure 3.6. Current height (m) at Vinh Tan coastal area (Northeast monsoon season, flood tide stage, before dredging)



Hydrodynamic condition after dredging: calculated results reveal that the dredging work hardly affect the spatial distribution of integrated currents and the common wave field at Vinh Tan coastal area (Figure 3.7 - Figure 3.8).

Figure 3.7. **Integrated current field at surface at Vinh Tan coastal area (m/s) (Southwest monsoon season, flood tide stage, after dredging)**

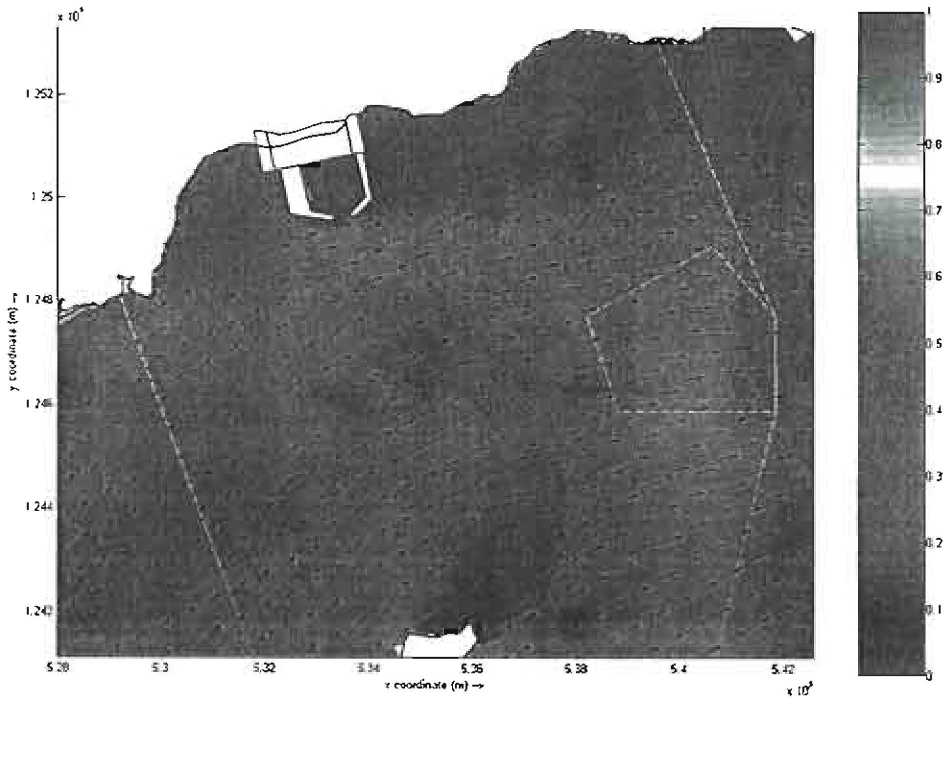
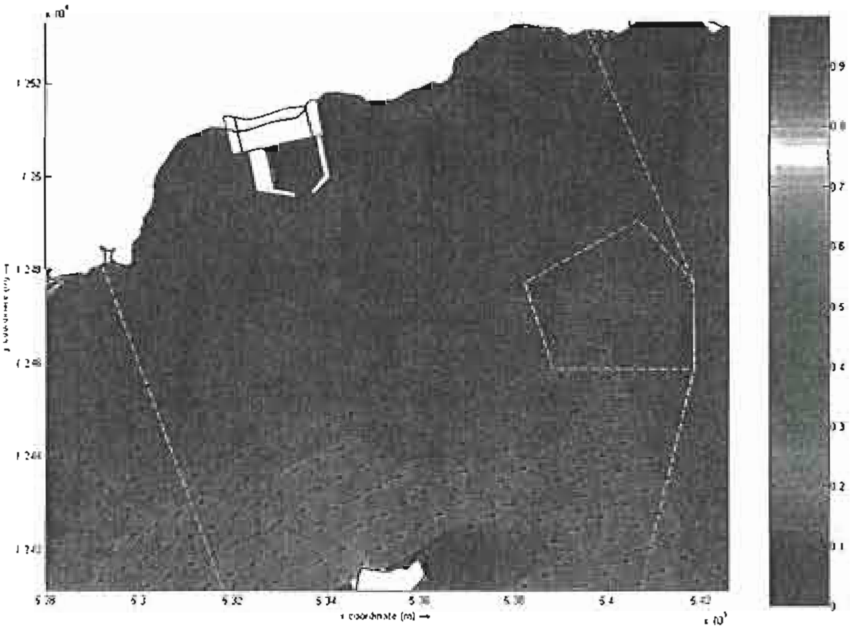


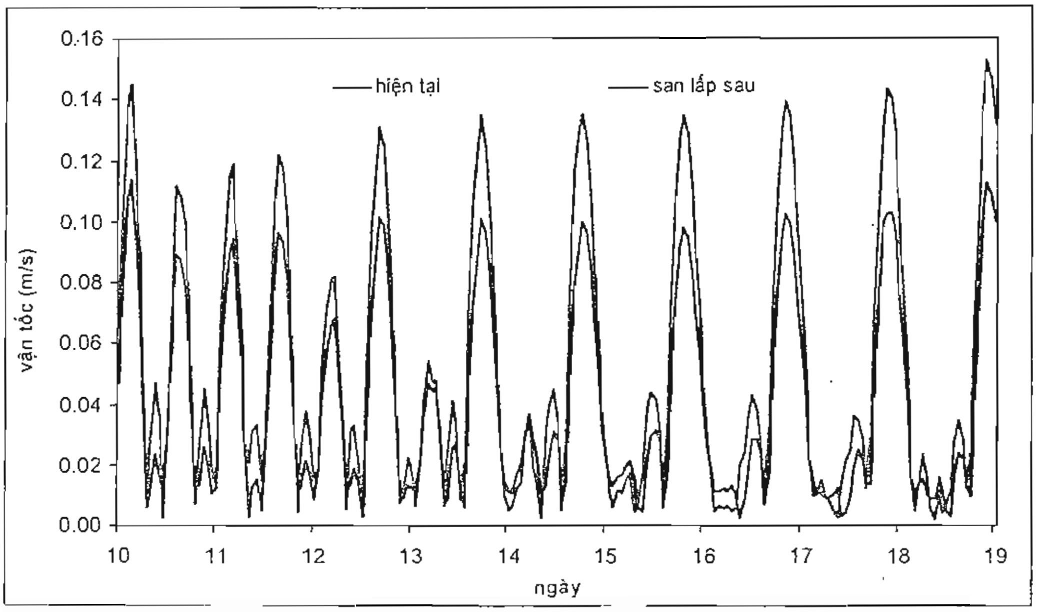
Figure 3.8. Integrated current (m/s) at surface at Vinh Tan coastal area (northwest wind, flood tide stage oastal areae at)



Assessment of current and wave fluctuation at testing points:

- At the eastern site of the dredging area (V6), no big alteration is observed compare to current stage; the current velocity decreases about 2-6 cm/s (Figure 3.9). The velocity at V7 also tends to decrease about 2-3 cm/s compare to present stage. The decrease found in current velocity at V6 and V7 when the dredging work is performed is mainly because of the construction of the embankment (but not the dredging itself) which plays the part of a dam preventing the movement of water from northeastern site to the southwestern site.
- At the southeastern site (V8) and southwestern site (V9) of the dredging area, the current velocity changes insignificantly.
- The fluctuation of current at Breda shoal and west-northwestern site of Cu Lao Cau reveals that the current velocity at V1 and V2 does not change much before, during and after performing dredging work. This happens in both dry and rainy seasons. A probable reason is that Cu Lao Cau area is quite far from the dredging area.
- At Vinh Tan coastal area nearby the construction site, wave height at surrounding areas (northern, southwestern, northeastern and eastern sites) decreases slightly in the range of 0.05-0.15m (Figure 3.10).
- Similarly, wave height at areas surrounding Bai Can and Cu Lao Cau area is not different before, during and after the dredging work.
- In conclusion, the dredging work hardly affect the hydrodynamic condition and current at external areas (Cu Lao Cau, Bai Can, northeastern and southwestern parts of Vinh Tan coastal area. At areas nearby the project, the current velocity and wave height decrease to some extent after the establishment of the reclamation embankment.

Figure 3.9. Current fluctuation at the Eastern site of the dredging area (V6; a tirainy season; b- dry season)



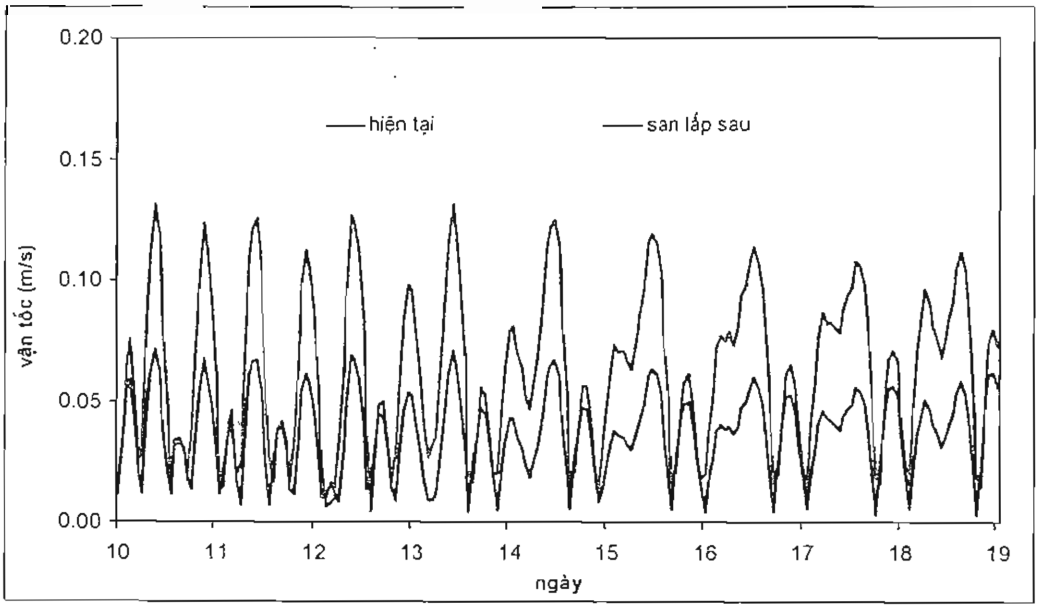
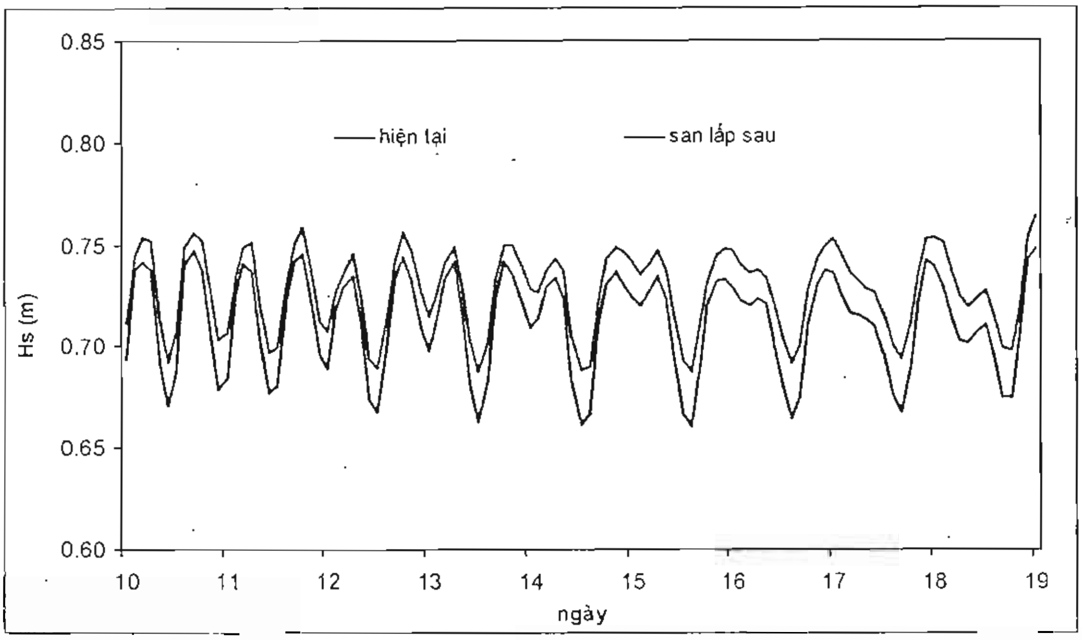
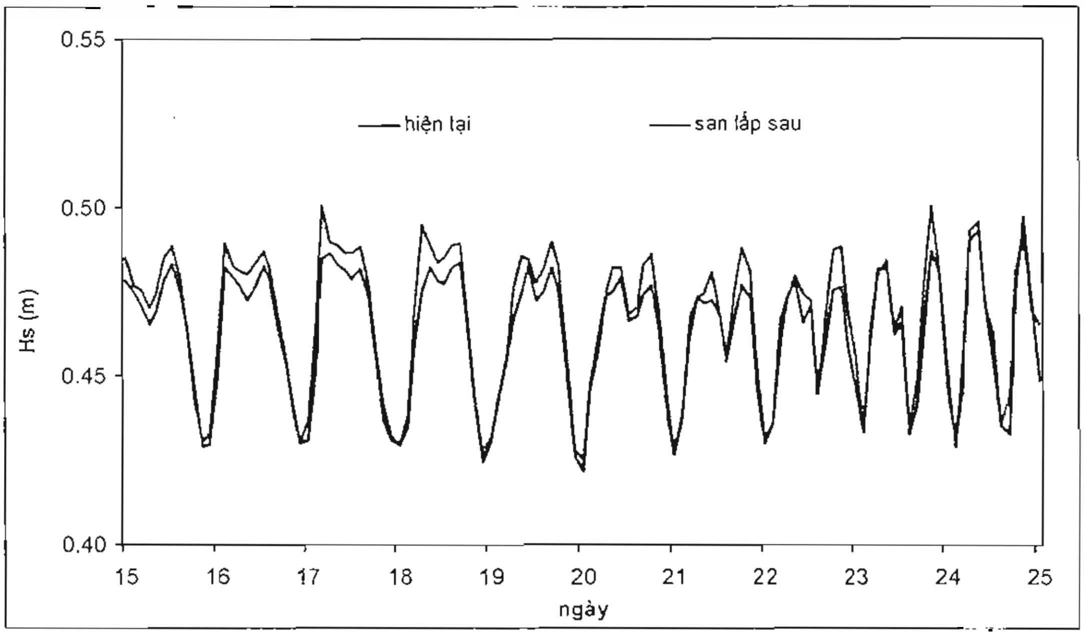


Figure 3.10. Fluctuation of the wave height at the Eastern site of the dredging area (V6; a – rainy season; b- dry season)





e. *Impacts on sediment transport*

The characteristics of sediment transport at Binh Thuan coastal area and Vinh Tan area depend on the integrated hydrodynamics northeastern and southwestern parts of Vinh Tan coastal area. At areas nearby the project, the current velocity and wave height def these factors.

Sediments source from the river to the coastal zone in this area is very small. Therefore, sediment transport in this area almost by re-suspension due to wave activities and carried by integrated current. Suspended sediment concentration is relative small with prevalent value less than 0.008 kg/m^3 and decreasing gradually from near-shore to offshore. The difference in sediment concentration between rainy and dry seasons is not considerable. (Figure 3.11)

To assess the impacts of the dredging work, calculation on the distribution and transport of total suspended sediment (TSS) was performed before and after the dredging process. The results are as follows:

+ *Before dredging work during southwestern wind*, the activities generate turbid area with TSS value about 0.01-0.015kg/m^3 spreading on the area of 1.1km^2 around the dredging site and inside of the port. This turbid water spreads to the east – northeastern parts during flood tide stage and west – southwestern parts during the ebb tide (Figure 3.12). The concentration of sediment decreases outside of the dredging area and hardly spatially dependent. The impact of such turbid water to Cu Lao Cau, Breda shoal is negligible.

During the dredging work in northeastern wind, the dredging activities generate turbid area with TSS value about 0.008-0.02kg/m^3 spreading on the area of 1.1km^2 around the dredging site and inside of the port. . This turbid water spreads to the east ly dependent. The impact of such turbid water to Cu Lao Cau, Breda shoal is negligible. tide (in Figure 3.13). The concentration of sediment decreases outside of the dredging area and spatially homogenous. The impact of dredging work on the turbidity of Cu Lao Cau area, Breda shoal is generally negligible.

+ Hence, except increasing the turbidity at surrounding areas, the leveling works do not significantly affect the core of Hon Cau MPA.

Figure 3.11. TSS distribution at medium layer at Vinh Tan coastal area (northeastern wind, flood tide ortheastern wind)

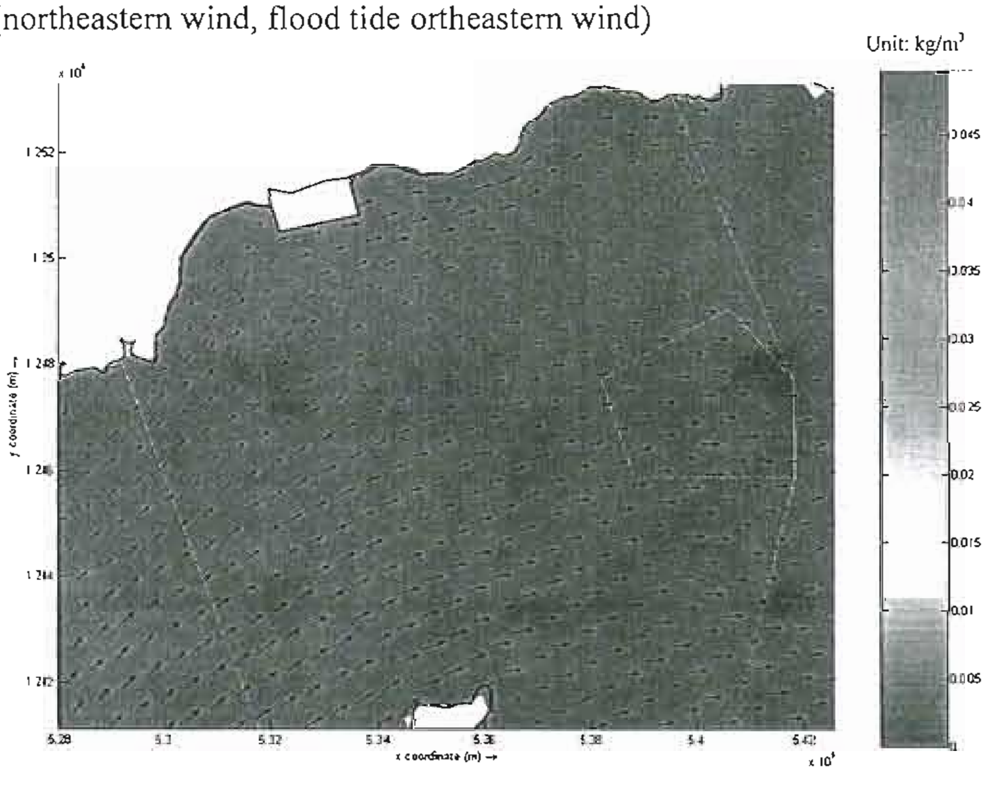


Figure 3.12. TSS distribution at medium layer at Vinh Tan coastal area (southwest monsoon season, ebb tide onsoon seasonum)

Unit: kg/m³

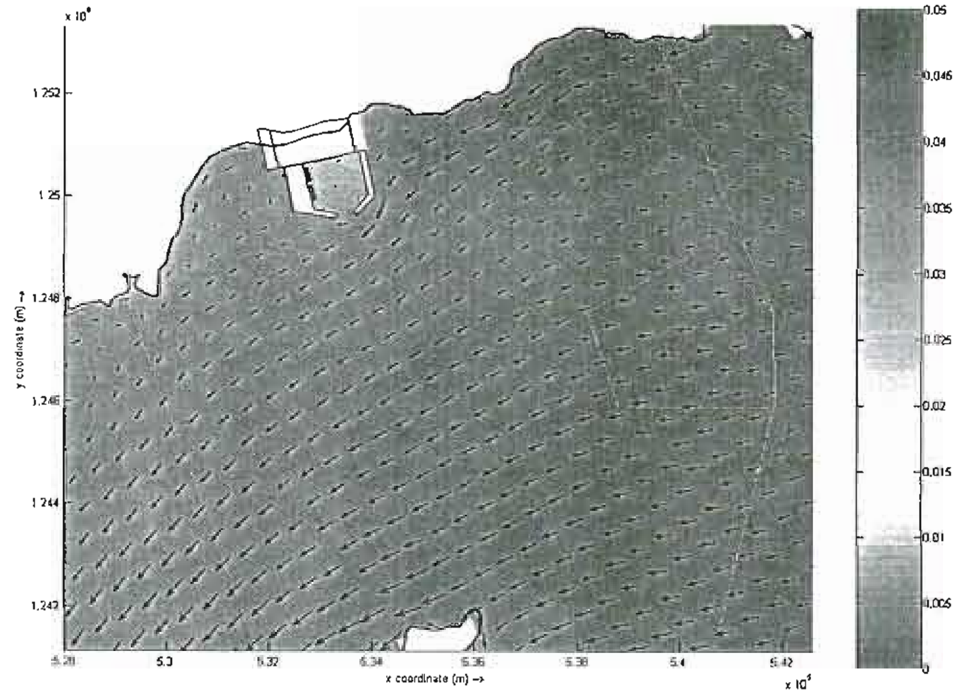
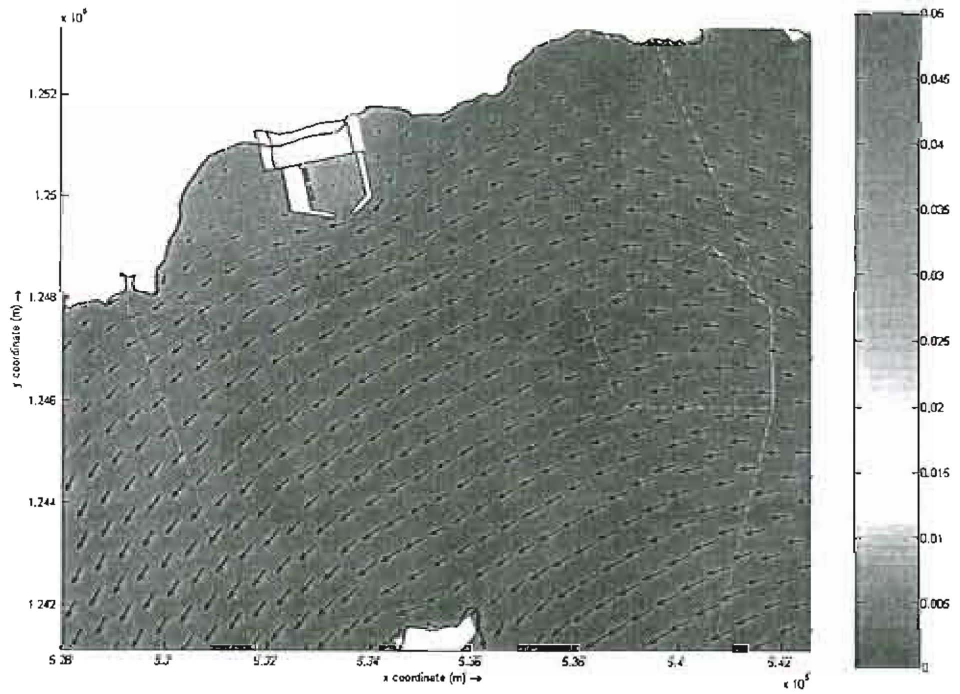


Figure 3.13. TSS distribution at medium layer at Vinh Tan coastal area (northeast monsoon season, ebb tide onsoon seasonum)

Unit: kg/m³



To assess the fluctuation of sediment flux at various cross-sections due to the dredging work, the calculation results of these cross-sections were analyzed. The results have revealed:

+ At far site of the dredging area, the dredging activities have negligible effect on regional turbidity. At Breda shoal, the values of sediment concentration at V1 and V2 are not different from before and after dredging work. This happens in both rainy and dry seasons. Similarly, at west – northwestern site of Cu Lao Cau (V3, V4 and V5), impact of dredging on sediment content is trivial.

\+ At eastern site of the dredging area (V6), the sediment content increases about 0.02 kg/m^3 during the dredging work in narrow scope (Figure 3.14).

\+ At southeastern site of the dredging area (V8), the suspended sediment content is not high with common value lower than 0.02 kg/m^3 and the scope is not big.

Figure 3.14. TSS content fluctuation (kg/m^3) at the eastern site of the dredging area (V6; a asrainy season; b- dry season)

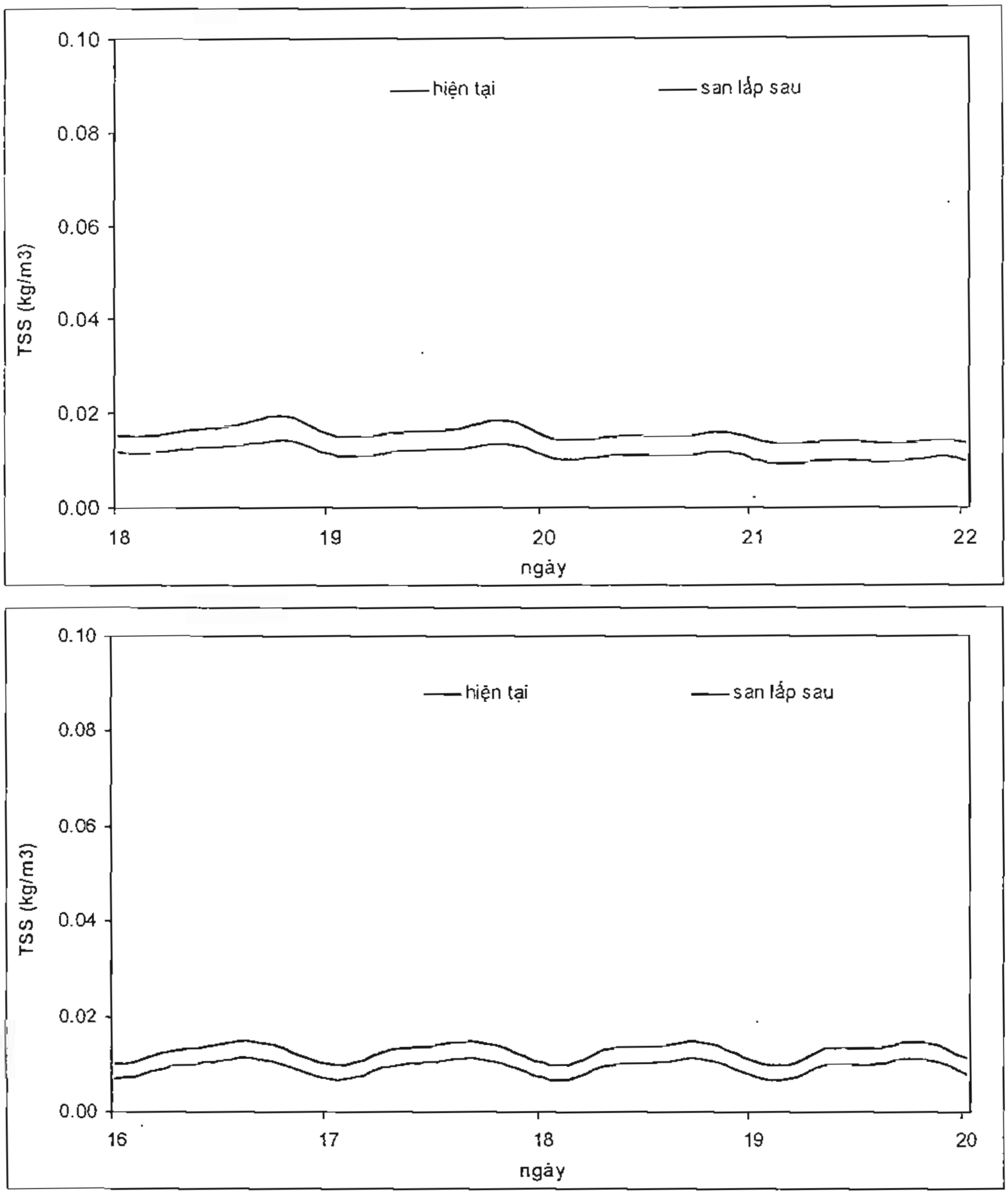
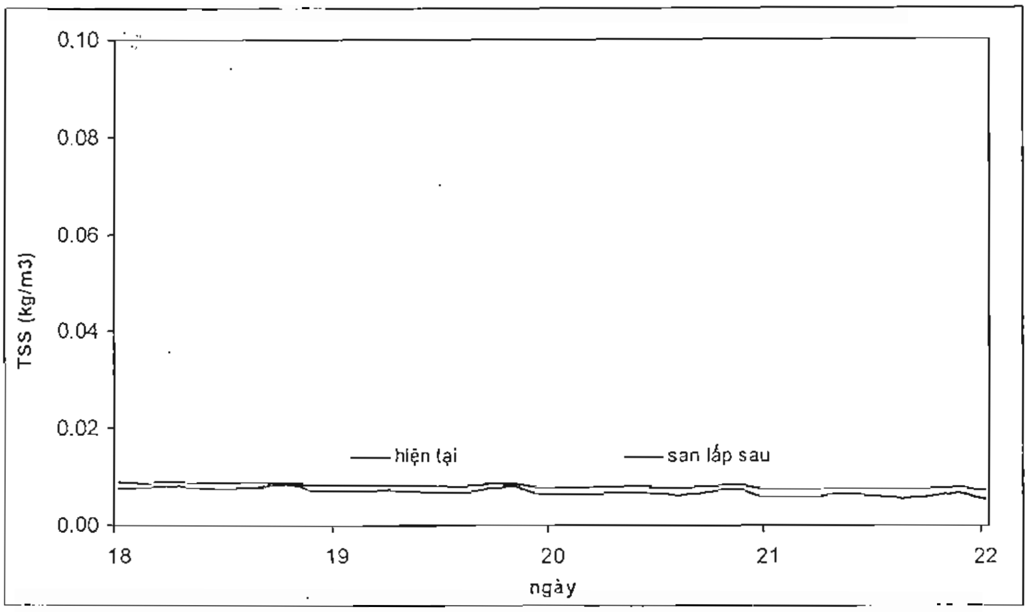
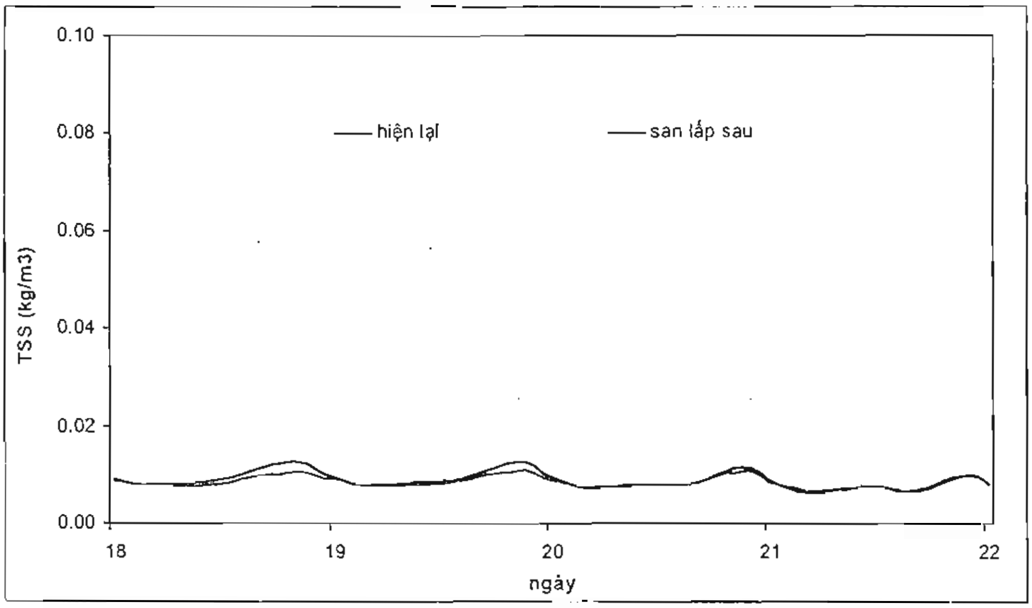


Figure 3.15. TSS content fluctuation (kg/m^3) at Hon Cau island (V3; a – rainy season; b- dry season)



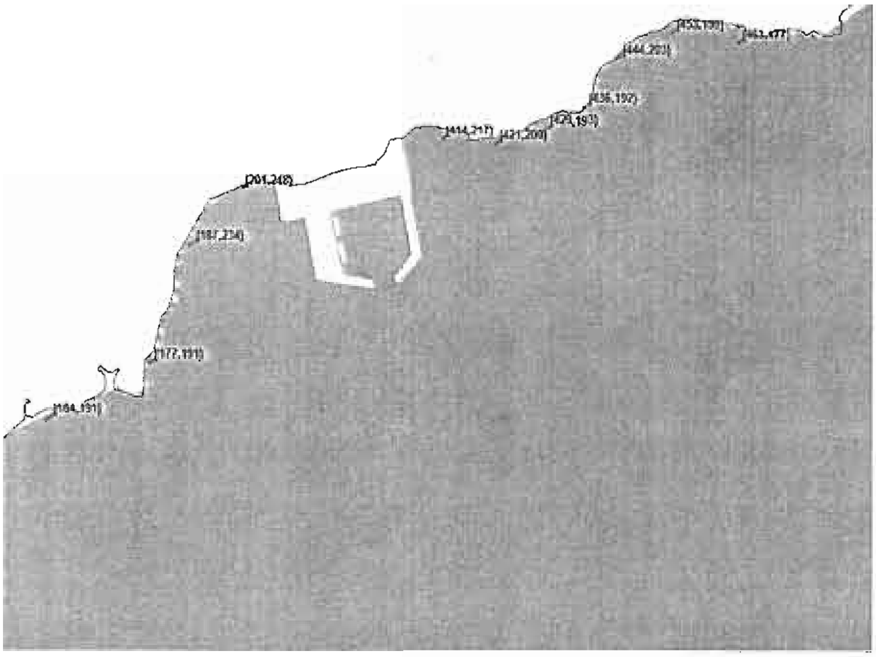


In conclusion, the suspended sediment content will increase during the dredging work at about 0.02 kg/m^3 compare to the current value; that is still lower than the permissive value of 0.05 kg/m^3 in QCVN 10: 2008/BTNMT (applied for aquaculture and aquatic biota protection). Hence, the impact of dredging work on water quality is negligible.

f. Impacts on erosion of dredging work on water quality

The impacts on erosion and sedimentation at the coastal area were evaluated using calculation results from raw data at testing points on the northeastern and southwestern coasts of Vinh Tan port (Table 3.16).

Figure 3.16. Map of positions for investigating impact on erosion – sedimentation due to dredging work.



The calculation results reveal that monthly fluctuation of erosion – sedimentation at the area is relatively small and seasonal due to the seasonal alteration of wind and wave field. The average rate of erosion currently at around the construction varies 0.0115-0.04982 m/month while the average rate of deposition varies 0.00517-0.03103 m/month. At coastal points from B1 to B9, erosion tends to occur in rainy season due to direct impact from wave direction induced by southwestern wind. However, due to northeast monsoon season, as southwest wind gets weaker and northeast wind gets stronger, slight erosion tendency occurs at B1-B7 (Table 3.12). At B10 and B11, sedimentation occurs in rainy season and erosion in dry season with the rate of 0.02-0.03m/month and 0.012-0.013m/month respectively. At B8 and B9, slight erosion occurs in both rainy and dry season.

Table 3.12. Average erosion – sedimentation velocity (m/month) at positions nearby the project area

Position		Scenarios			
		Scenario 1		Scenario 2	
Name	**Coordinates (m,n)**	**Rainy season**	**Dry season**	**Rainy season**	**Dry season**
B1	463, 177	-0.01965	0.01230	-0.02056	0.01234
B2	453,199	-0.02167	0.01353	-0.02357	0.01358
B3	444,203	-0.03271	0.00405	-0.03242	0.00427
B4	436,192	-0.03711	0.00480	-0.03655	0.00476

Position		Scenarios			
		Scenario 1		Scenario 2	
Name	Coordinates (m,n)	Rainy season	Dry season	Rainy season	Dry season
B5	429,193	-0.04343	0.01019	-0.04365	0.01019
B6	421,200	-0.04034	0.00517	-0.00330	0.00529
B7	414,217	-0.04982	0.01032	-0.03359	0.01243
B8	201,248	-0.01150	-0.00329	0.00459	0.00234
B9	187,234	-0.04586	-0.02017	-0.01009	0.02455
B10	177,191	0.03103	-0.01302	0.02893	-0.01130
B11	164,191	0.02474	-0.01215	0.02606	0.01209

Note: minus (-) expresses erosion trend

Dredging work after the establishment of reclamation embankment affect the erosion – sedimentation trend to some extent. These impacts express clearer at project area adjacent positions such as B6, B7, B8 and B9 with slight increase in sedimentation rate and decrease in erosion rate. Due to the impacts of dredging work, at the southwestern part of working area, the erosion trend in dry season has turned to sedimentation in current time with the rate of 0.00234 – 0.02455 m/month. At further area, the impacts are minor due to spatial reduction of sediment dispersion.

From analyzed results, the dredging process affect erosion and sedimentation schemes at the project area and surrounding area to some extent. However, These impacts are minor, only notable at nearby area to the project site and somehow positive to the erosion – sedimentation scenario of the region.

Refer to Appendix 3.1 Chapter 3 for more details on method, result and calculation of erosion – sedimentation modeling.

3.2.1.4.3. Impacts of noise

Currently, the noise level at the project site is still lower than national standard (Refer to Chapter 2). During the land reclamation and ash yard leveling processes, noise from working equipment and machinery will contribute to the noise background of the region. Noise level of each equipment is revealed in Table 3.13.

During the construction of the project, noise is mainly generated from construction equipment, transporting vehicles, from ships and barges on sea as well as collision between equipments and metallic materials. The diffusion of noise at surrounding area can be estimated as follows:

$$L_p(X) = L_p(X_o) - =_d - =_c \quad \text{(dBA)}$$

Where: $L_p(X)$: Noise level at investigation position at distance X to the source, dBA

$L_p(X_o)$: Noise level at noise source at distance X_o to the noise source, dBA

ΔL_d	: Reduction of noise level at X distance, frequency i $\Delta L_d = 20 \lg [(X/X_o)^{1+a}]$, dBA
X_o	: Distance to noise source with $L_p(X_o)$, m
X	: Distance from the receiver to noise source $L_p(X)$, m
a	: coefficient that accounts for topography and ground effect (a = 0)
ΔL_c	: Reduction of noise level by obstacle. Suppose $\Delta Lc = 0$ in project area.

Therefore, noise dispersion can be calculated as follow:

$$L_p(X) = L_p(X_o) + 20 \lg [(X_o/X)] \quad (dBA)$$

Table 3.13. Noise level by construction equipment as a function of distance

No.	Equipment	$L_p(X_o)$	$L_p(X)$ *(dBA)*				
			5m	200m	500m	700m	1000m
	QCVN 26:2010/BTNMT		70 dBA (06 am TNMTdistancedBA (21 pm – 06 am)				
		$X_0 = 5m$ (a)					
1	Pump	83.9	84	52	44	41	38
2	Mortar mixing machine	81.4	81	49	41	38	35
3	Derrick	89.1	89	57	49	46	43
4	Generators	86.4	86	54	46	43	40
5	Concrete pump	102.6	103	71	*63*	*60*	*57*
6	Concrete mixer	91.3	91	*59*	51	48	45
7	Truck	87	87	55	47	44	41
8	Crane	97.8	98	*66*	*58*	*55*	52
9	Road roller	103.6	104	72	*64*	*61*	*58*
10	Water atomizer	100.6	101	*69*	*61*	*58*	55
11	Vibrating compactor	111	111	79	71	*68*	*65*
		$X_0 = 15m$					
1	Hammering machine 1.5tons	75	85	53	45	42	39
2	Concrete 1.5tons	90	100	*68*	*60*	*57*	54

No.	Equipment	$L_p(X_o)$	$L_p(X)$ *(dBA)*				
			5m	200m	500m	700m	1000m
	QCVN 26:2010/BTNMT		70 dBA (06 am TNMTdistancedBA (21 pm – 06 am)				
3	Bulldozer	93	103	71	*63*	*60*	*57*
4	Hammer drill	87	97	*65*	57	54	51
5	Motorized concrete breaker	85	95	*63*	55	52	49
6	Saw	82	92	*60*	52	49	46
7	Compressors	80	90	*58*	50	47	44
8	Boats/barge (200 tonnage)	87	97	*65*	57	54	51
9	Barge (100- 150 tonnage)	85	95	*63*	55	52	49
10	Truck	75	85	53	45	42	39
11	Roller tractor	86	96	*64*	*56*	53	50

Note: (a): Survey of Noise level in construction – US.EPA – 1989

According to the results in Table 3.13, these conclusions can be drawn out: construction equipment induced noise decreases as a function of distance in which noise at the distance higher than 500 m by most of the equipments passes the regulated standards in QCVN 26:2010/BTNMT (< 70dBA from 6 am to 21 pm, applied for normal area), except vibrating compactor.

Moreover, when all the construction equipment operate at the same time, the total noise level is determined by:

$$L_{\sum} = 10 \times \lg \sum_{1}^{n} 10^{0.1L_i}$$

Where :

L_{Σ} - Noise level at investigating point, dBA

Li – Noise level at investigating point of source number i, dBA

According to the above equation, total noise level of some machineries to destination at the distance of 500 m, 700 m and 1000 m is revealed in the following table (Table 3.14).

Table 3.14. Total noise by construction equipments

No	Item	$L_p(X_o)$	L_{Σ}		
			500m	700m	1000m
	QCVN 26:2010:BTNMT		70 dBA (06 am TNMTstruction equipmentsAT ise		
		X_0 = 5m	72	69	66

No	Item	$L_p(X_0)$	L_Σ		
			500m	700m	1000m
	QCVN 26:2010:BTNMT		70 dBA (06 am TNMTstruction equipmentsAT ise		
1	Derrick	89.1			
2	Generators	86.4			
3	Concrete mixer	91.3			
4	Truck	87			
5	Vibrating compactor	111			
		$X_0 = 15m$			
1	Hammering machine (1.5 tons)	75			
2	Pile driver	90			
3	Bulldozer	93			
4	Motorized concrete breaker	85			
5	Boats/barge (200 tonnage)	87			
6	Truck	75			

Source: PECC2, 10.2010

From the table above, noise generated from transporting vehicles and constructing equipment on site will meet the regulation in QCVN 26:2010/BTNMT at the distance of 700 m. The residential area at Hamlet 7 will be affected due to the distance of 100 m. Other areas including administrative area Vinh Tan People's Committee which is over 700 m away from the project site will not be affected.

3.2.1.4.4. Impacts on biological resources

1. Terrestrial ecosystem

   The leveling of the project area will replace all living species on-site. As presented in Chapter Two, the vegetation cover at the project area is about 30% including mostly patches of shrubs without natural forest or any species listed in the Red Data Book of Vietnam. Hence, the leveling process will not severely affect the terrestrial ecosystem.

   However, the loss of vegetation cover may significantly affect the microclimatic condition of the area. The loss of shrubs will augment surface water evaporation, lower underwater level and air humidity. Therefore, living condition of people in this area will be affected. This impact is estimated as *small but irreversible.*

2. Aquatic ecosystem at Hon Cau Marine Protected area

   The impacts on the aquatic ecosystem at Hon Cau Marine Protected area are described in Section 3.2.2.4.

3.2.1.4.5. Impact on aquaculture

Presently, the aquaculture performance at Vinh Tan area (2011) is described as follows:

- Total area of aquaculture is 110 ha. People need to use seawater for shrimp farming. However, as preliminary investigation, seawater at this area has already been polluted because of shrimp farming activities. Hence, local people recently have to catch seawater offshore to serve the shrimp farming.

- Additionally, people at Vinh Tien hamlet have also developed cage farming on sea (cobia, grouper). The survey reveals that there are still 12 farming rafts at the distance of 1500-2000 m away from the leveling area.
- Besides, local people also developed inshore fishing using gillnets, trawls, squid catching u
- The biological resource of the area have decreased about 60 – 70% compare to 5 years ago. The main reasons are exhausted exploitation, exploiting by explosives (rarely found onshore these days), catching coral reefs for decoration, catching sargassum. Besides, in 2002 and 2011, there were red tides destroying most of the coral reefs as well as other resources along coast from Cat Trang to Vinh Hao area.

According to the stimulation on substance dispersion due to leveling work at Vinh Tan 4 TPP project area as described in Section 3.2.1.4.4:

- During the leveling process, at the working area, the current velocity decrease 2-6 cm/s due to the establishment of the embankment which prevent the movement of water from Northeast site to Southwest site. Other adjacent areas at Vinh Tan coast are not affected by leveling work. Hence, current activities do not affect aquaculture activities at the region..
- According to calculation, the value of TSS is about 0.008 – 0.02 kg/m3, lower than the permissive standard in QCVN 10: 2008/BTNMT, applied for aquaculture and aquatic biota protection (0.05 kg/m3), focusing at the leveling area. Additionally, the reclamation embankment will be cover with geotextile on the inside in order to capture leveling materials. Hence, TSS concentration will be rather lower than calculated value. Although at present, there is no study on the threshold of suspended solid in aquatic organisms, it is forecasted that the turbidity enhancement during leveling process can affect the growth of these organisms.
- Barges used for embankment construction can release wasted oil causing pollution to the local sea and affecting aquaculture activities.
- Besides, the construction of the embankment will be implemented from the inside out and from the downside up. These rock layer will be stacked as technically required. The Tetrapod will be used to cover the open embankment part during rainy and stormy conditions to prevent dyke break. In addition, the construction area is 1500 m away from farming rafts so that construction activities will not affect the aquatic environmental as well as aquaculture activities.

In summary, the leveling process and embankment construction will affect the growth of local aquatic organism adversely. Yet, since the leveling work will only commence once the embankment construction has finished and the construction time is within 12 month, the impact of it on local aquaculture is not serious. It is estimated as medium and short-term lasting only until the leveling work has finished.

3.2.1.4.6. Impact on local traffic

Leveling activities, especially embankment construction of Vinh Tan 4 TPP will need a large volume of raw materials which will be transported from other places. Thus the traffic density in the region will increase significantly. These construction materials will be transported by road via Highway 1A.

The number of trucks using for material transported in this phase is about 79 vehicles/day. This is a significant increase for roads in the project area (not to mention the generation of dust or increasing noise level in the project area). So, it is necessary to arrange measures to enhance traffic safety on the road effectively. Without an appropriate traffic management plan, the risk of road traffic accidents is quite high. Although the traffic density is relatively high in this period, this effect only occurs shortly during execution period.

National highway 1A runs through the north of the project area is in good quality with relatively low traffic flow, mostly trucks and passenger cars. The regular operation of transporting vehicles on road are likely to degrade the quality of roads and increase the risk of traffic accidents. However, the impact level cannot be predicted due to the dependence on several factors (transport management, driver level, awareness of traffic laws, etc.).

Generally, the impact on local traffic is considered moderate reducible and controllable using appropriate management measures.

For barges, vessel operation, there are a total number of 2 turns of vessels/barges per day during the embankment construction. On the Vinh Tan coast, vessel flow is not high (mainly fishing boats of people) so the impact on waterways activities in the project area is negligible and completely acceptable.

3.2.2. Impacts in construction phase

With a huge amount of work including construction of plant, port, transportation of materials, equipment, etc. about 1,500 workers are needed at peak time. The operation of construction equipment along with worker's domestic activities is main factor causing environment pollution in this phase; these impacts will be assessed for more details at next section. Construction activities and major impact sources are summarized in Table 3.15.

Table 3.15. Activities and sources of impact in construction phase

Sources of impact	Affected objects	Assessment	Impact level
Activities of vehicles, equipment at construction area (cranes, tank trucks, road rollers, diesel hammers, welding machines). Transport of materials and equipment	Air environment	Dust and polluted gases from transporting vehicles will affect the atmosphere adversely.	Medium Local Temporary
	Water environment	Wasted oil from vehicles, machinery will increase the risk of water pollution, especially during rainy season.	Small Temporary
Constructing and	Air	Dust from construction phase	Small

Sources of impact	Affected objects	Assessment	Impact level
installing buildings and equipments	environment	will affect local air quality.	Local Temporary
	Water and soil environment	Waste and wasted oil from the machineries and construction activities will enhance the possibility of water and soil pollution.	Small Local Temporary
Dredging, port construction	Air environment	Dust from construction will be affect local air quality.	Small Local Temporary
	Water environment	Waste and wasted oil from the machineries and construction activities increase the possibility of water pollution.	Medium Local Temporary
Gathering a large number of worker (reach to 1500 people/day during peak time)	Water, soil environment, visual landscape and public health	Domestic waste will affect water and soil environment if no proper treatment is performed. The volume of domestic wastewater without being collected and treated properly will pollute the water sources.	Medium impact during certain period

3.2.2.1. Sources of impact relating to waste

3.2.2.1.1. Air emission and dust generation

1. Air pollution due to activities of construction equipment

   Air pollution are generated from construction equipment (including excavators, bulldozers, material transporting vehicles) and other construction activities of the plant and the 100,000DWT coal port. The specific impact of each activity on the environmental is evaluated as follows:

   a. *Air pollution due to the transportation of materials, equipment and machinery by roads*

      Main air pollution sources are from the transport of construction materials (sand, gravel, rock, cement) and activities of construction equipment during the construction phase. The content of dust in the atmosphere increases locally at the transporting routes (National Highway 1A), especially during dry days.

      The volume of material needs transport, processing on-site is about 0.97 million tons (in which the materials for plant construction weighs about 908,550 tons, for ash yard construction about 63,978 ton); these materials will be transported to the project site by 30-ton trucks during the course of 48 months. Based on equation (3) at section 3.2.1.4.1, the total volume of dust generated during the transportation and unloading of material is estimated and introduced in Table 3.16 below.

Table 3.16. Volume of dust generated during the transportation

Assessment content	Volume
Total volume of material	972,528 ton
Truck load	30 ton/vehicle
Transport frequency	23 vehicles/day
Average weight of vehicles	27.5 tons
Transport of construction materials by road	
Pollution coefficient E	304,417 g/VKT
Total length of transporting at project area	23 km/day
Average volume of pollutant	7 kg/day
Total	7 kg/day

Source: PECC2, 2012

Based on the equation (5) about the calculation of dust concentration in Section 3.2.1.4.1, the average 1 hr concentration with the distance of 1 km in the project site is estimated as follows:

Table 3.17. Diffusion coefficient of dust in the atmosphere in dimensional z and dust concentration in air

X(m)	3	5	10	15
δ_z	1.18	1.72	2.8	3.83
C (mg/m^3)	0.021	0.015	0.009	0.0069

According to the results in the Table 3.17 above, total volume of dust generated from road transport of material is about 7 kg/day and the concentration at two sites of the transporting route at the distance of 1 km is ranging from 0.0069 – 0.021 mg/m3 which is lower than the standard regulated in QCVN 05:2009/BTNMT (0.3 mg/m3).

The volume of dust from transportation is not large owing to long construction period and discontinuous schedule. Therefore, the transport induced dust pollution is estimated as negligible where proper management is implemented.

b. *Air pollution due to vehicles for transporting materials and equipment by waterway*

Beside transporting by road, a part of equipment will be transported by waterway to the construction area. During the construction of the plant and 100,000 DWT port, total volume of material to be transported by waterway is about 200,000 tons. And the installation phase requires about 10 ships to transport super heavy equipments. Since 500-ton ships are used for the transportation of material, equipment, the number of ships and barges needed is not much; about 10 trips/day of ship movement is estimated for material and equipment transport.

The average time for unloading 1000-ton ships/boats is 01day and for large ships is 03 days. So that, as large ships are unloading, the port has to receive largest volume of waste. So far, only the statistical data on pollution emissions from large ships is available in which the pollution coefficients of large ships to estimate pollution caused by emission from ships. According to the emission coefficient from quick assessment of WHO and equation (2) in Section 3.2.1.4.1, the level of pollution by emission from construction barges is given in Table 3.1, measured in Vinh Tan Power Complex with the area of 331.43 ha, at the height of 5 m.

Table 3.18. Load of polluted air from transporting ships in construction phase

	Number of ship in port	Anchoring time of ship in berth (unit-U)	Coefficient (kg/U)	Load (g/h)	Concentration (mg/mnt	QCVN 05:2009
TSP	1	36	6.8	188.9	0.011	0.3
SO_2			136S	113.33	0.0068	0.35
NOx			90.7	2519.4	0.15	0.2
CO			0.036	1	0.000006	30
VOC			4.1	113.89	0.069	-

Note: Pollution coefficient referred from Rapid Assessment of Sources, WHO 1993.
Content of Sulfur in FO is 3%.
Bulk cargo ships, 40,000 GRT tonnage, ship time in port for 36h.

Base on the results in Table 3.18, the substance concentrations meet the permissive values stipulated in QCVN 05:2009/BTNMT. In addition, the project area locates in an well-ventilated coastal site so that the air emission from ships and barges is considered as negligible and acceptable.

c. *Air pollution due to emission from construction equipment, vehicles and machinery*

As expected, there are about 23 truck and other equipments (drilling machines, compactor, bulldozertion, the project area locates in an well-ventilated coastal site so that the air emission from ships and barges is considered as negligible and acceptable. icient from quick assessment of WHO and equation (2) in Section 3.2.1.4.1, the level of pollution by emission from construction barges is given in Table 3.19, measured in Vinh Tan Power Complex with the area of 331.43 ha, at the height of 5 m.

Table 3.19. Exhaust emission from fuel combustion for transportation and equipment

	Emission factor (kg/ton fuel)	Consumption (ton oil/day)		Emission (kg/day)		Concentration (mg/ml/		QCVN 05:2009
		From	to	From	to	From	to	
TSP	4.3	0.5	1	2.15	4.3	0.0054	0.011	0.3
SO_2	0.1	0.5	1	0.05	0.1	0.00013	0.00025	0.35
NOx	55	0.5	1	27.5	55	0.07	0.14	0.2
CO	28	0.5	1	14	28	0.035	0.07	30
VOC	12	0.5	1	6	12	0.015	0.03	-

Source: PECC2, 9.2012

According to the above results, the concentration of all substances meets the permissive value stipulated in QCVN 05:2009/BTNMT. Besides, the pollution caused by emission from barges will only affect the project area within the construction period. *Hence, this effect is estimated as negligible.*

2. Emission from unloading material activities

The material unloading process (grave, sand, steel, cement, etc.) from the trucks to the storage area will also release a large amount of dust if no control measures are undertaken, particularly in windy days. Based on the equation (3) presented in Section 3.2.1.4.1, the emission of dust from unloading process can be estimated as in Table 3.20 below.

Table 3.20. Total dust emission from unloading materials activities in construction of power plant and 100,000 DWT port

Item	Quantity
Total material and equipment weight	972,528 tons
Weight	30 tons/truck
Frequency	23 round trip/day
Average weight of the vehicles traveling the road	27.5 tons
Total dust emission from unloading activities	
Emission factor, **E**	0.00028 kg/tons
Average dust emissions	0.19 kg/day
Total	**0.19 kg/day**

Source: PECC2, 9. 2012

3.2.2.1.2. Wastewater

As in the pre-construction phase, the construction phase of power plant (including 100,000DWT port), wastewater arises primarily from the daily activities of workers and from washing of vehicles, construction equipment. Corresponding to each source, the detailed evaluation is presented as follows:

1. Workerssponding to each sour

It is planned that there will be approximately 1500 workers on construction site. Therefore, the flow of domestic wastewater is about 203m3 per day (averagely 150L clean water will be supplied to a worker per day). The loads of the main pollutants in the workers' sanitary wastewater are predicted as follows:

Table 3.21. Estimated loads of main pollutants in domestic wastewater

Parameters	Pollution load per capita per day (g/person)	Total pollution load (kg/day)	Pollution Concentration (mg/m3)	QCVN 14:2008/BTNMT
BOD_5^{20}	45 - 54	67.5 - 81	332 - 399	50

Parameters	Pollution load per capita per day (g/person)	Total pollution load (kg/day)	Pollution Concentration (mg/m3)	QCVN 14:2008/BTNMT
SS	70 -145	105 - 217.5	628 - 1071	100
Grease	0 - 30	0 - 45	0 - 222	20
Total nitrogen	6 - 12	9 - 18	44 - 87	-
Organic nitrogen	2.4 - 4.8	3.6 - 7.2	17.7- 35	-
NH_4^+	3.6 - 7.2	5.4 - 10.8	26.6 - 53	10
Total phosphor	0.8 - 4	1.2-6	2.9 - 29.6	-
Total coliform	$10^6 - 10^{10}$ (10^8) (MPN/100 ml)	-	-	5000

Source: PECC2, 2012

The highest concentration of pollutant such as BOD, SS, oil and grease of such wastewater is about 399 mg/l, 1071 mg/l, 222 mg/l respectively, which are all 6-10 time higher than Vietnamese standard (QCVN 14:2008/BTNMT- K=1, column B). Therefore, this wastewater will pollute the water environment in the region if being left untreated.

Most of workers mainly live in the rental houses near the construction site or residential areas in Vinh Tan commune and will use the local sanitary system. Therefore, the amount of wastewater generated on site is less than the calculated values. These houses will be equipped with devices for sanitary wastewater treatment to reduce the environmental impact on the region.

In addition, regarding the wastewater generated from ships and barges in the construction of 100,000DWT port, since there will be only about 10 trips of vessels/ barges per day, the wastewater volumes are predicted insignificant. Yet, it will affect the quality of coastal water in Vinh Tan areas and regional marine ecosystem if there are no measures for collection and process. As described above, the ship/barge owner must not discharge waste to sea; these wastes will be collected and processed by functional unit as contracts are signed (according to Decree No.21/2012/ND-CP). Therefore, the impact is considered insignificant.

2. <u>Wastewater from washing/cleaning the construction of machineries, equipments, vehicles</u>

Trucks used for transporting materials and equipment will be washed before leaving the project area. As an estimated number of 33 trucks and barges working per day, the amount of water used for washing these vehicles is estimated at 5-10 m3/day. This wastewater has high value of suspended solid and potentially contains heavy metals. Therefore, it will impact the surface water quality and the aquatic ecosystem at Vinh Tan coastal area. Yet, this impact is insignificant because of low wastewater volume.

In addition, the operation of ships during the construction of 100,000 DWT port and transport materials for main plant building may discharge oily waste into the sea. Every day, there are 10 barges operating regularly at the construction site during the 48 execution months (averagely 10 operating hours per day). The daily oil consumption for the operation of barge is estimated about 500 liters. Thus, the volume of oil from construction/ maintenance activities being discharged to the sea is about 0.25 L (assume that oil loss is equal to 0.01% of the daily oil consumption). *This effect is negative but small and manageable.*

3. Runoff rainwater

Runoff water once passing by the construction area will bring construction materials and wastes to the sea. The total area of the Vinh Tan 4 construction site is about 11.72 ha in which an area of about 5.9 ha is used for material storage. Based on equations (6) and (7) in Section 3.2.1.4.1, the volume of waste discharged in 15 day is about 0.12 ton; these waste can be taken by rainwater to the sea affecting aquatic habitat as well as polluting the surface water quality. However, since the number of rainy days in Binh Thuan is not high and the material storage area will be covered, the impact of rainwater is considered minor.

3.2.2.1.3. Source of solid waste

Sources of solid waste generation in the construction phase of Vinh Tan 4 TPP project are summarized as follows:

Table 3.22. List of solid waste sources in the construction phase

Waste	Sources	Composition	Quantity
Domestic waste from workers in the	Generated from activities of 1500 workers	Including organic and inorganic matters, such as food, plastic, glass, paper, cans, etc.	Quantity of domestic waste is about 600-750 kg/day (each worker discharges 0.4-0.5 kg/ day).
Construction waste	Generated from construction of embankment reclamation	Including inorganic matter such as cement, rock, plastic, glass, etc.	Depends on execution methods and professionalck, plastic, glass, etc.arges 0.4-0.5 kg/ day).mmarized as followsaffectin
Dredging wastes	Generated from dredging of port	Including sand, sludge	Estimated about 649,000 m^3
Hazardous solid waste	Generated from maintenance vehicle, machinery and equipment	Including grease and oily cloth.	The amount of used oils, oily cloth is about 47 L/month, 0.4-0.6 kg/month, respectively .

Source: PECC2, 9.2012

1. Domestic waste

The total volume of domestic waste is about 600-750 kg/day containing degradable organic waste which releases inconvenient smell and undegradable inorganic waste. Consequently, without proper control measure, these wastes will affect the environment adversely.

This impact is assessed medium but only happens in a short time (construction period) and affects directly the daily activities of workers due to large construction area.

2. Industrial and hazardous waste

   In construction phase, the volume of industrial waste released is about 300-400 kg/day containing mostly concrete, stone, brick and other construction waste. These wastes are not harmful and reusable for other construction purposes.

   The dredging of 100,000DWT port wastes about 352,720 m3 dredging waste which will be reused for the reclamation of Vinh Tan 4 TPP.

   Besides, the operation of about 40 vehicles each day (vehicles and equipment) will release a large amount of hazardous waste including grease, oil, oily cloths. Thus, every month, there will be about 47 L grease and 0.4 - 0.6 kg oily cloths being released. These wastes are classified as hazardous waste and will be treated according to the corresponding regulation.

3.2.2.2. Sources of impacts not relating to waste

Sources of impacts not relating to waste, affected objects and detailed assessment in construction phase are summarized in the following table:

Table 3.23. Sources of impact not relating to waste in construction phase

Sources of impact	Affected objects	Impact assessment	Impact level
Port dredging process	Marine environment	Affect the marine environment due to the increasing turbidity	Small Temporary
	Aquatic ecosystem	Affect the ecosystem due to environmental disturbance	Medium Long-term
	Aquaculture	Affect the seawater quality due to the increasing turbidity	Medium Temporary
Activities of vehicles, equipments on-site	Air environment Local traffic	Induce noise pollution, vibration at project nearby area and along transport routes Increase the traffic intensity	Small Temporary
Activities of material and equipment transport	Aquaculture	Affect seawater quality due to the possibility of oil spill, and waste discharge at the project area	Medium Temporary
Gathering a large number of workers	Local culture and socio-economics	The immigration of workers from other areas will interrupt the traditional lifestyle, raising the risk of cultural conflictions Contribute to the local economic development	Small Temporary
Explosion, combustion, occupational accidents	Construction workers, residents at project site	Occupational and traffic accidents are potentially happens.	Medium

3.2.2.2.1. Assessment of impacts due to dredging work for 100,000DWT Vinh Tan 4 port

Currently, the dredging of the port for Vinh Tan 2 TPP, which is designed for 30,000 DWT ships with the average depth of -11.7 m, is performed and expected to finish before 2014 (Vinh Tan 2 TPP starts its operation in 2014). The ports for Vinh Tan 3 and Vinh Tan 4 TPPs which are designed for 30,000 DWT – 100,000 DWT will commenced its dredging work in the period of 2014 – 2016. The dredging of passageway and turning basin will be started in 2014 due to the commencement of Vinh Tan 3 TPP and Vinh Tan 4 berth in 2015. As a result, there are only the dredging work of Vinh Tan 3 and 4 TPPs being implemented in 2014.

The total volume of material from the dredging of passageway, turning basin and berth for 100,000 DWT port is about 4.2 million tons in which 352,720 m^3 are from berth of Vinh Tan 4 TPP. The implementing time is about 1.5 months with an average volume of 8350 m^3/day of dredged materials. Hopper dredger and ladder dredger will be used for dredging in the sea port area.

With the above dredging volume, these impacts are expected:

- Disturb local waterway traffic and fishery activities at Vinh Tan coastal area;
- Pollute the water sources by increasing turbidity and grease;
- Affect the aquatic ecosystem due to habitat disturbance, water pollution and sediment disruption.

Although the above impacts cannot be enumerated, they are considered as obvious but local owing to available studies on similar project. These impacts are expected not affect Hon Cau island area (a conservation area 10 km away southeastward from the project site) and coastal tourist area at Phan Thiet city and Bac Binh district (about 30 km southwestward from the project site).

The impacts are assessed as follows:

1. Impacts on erosion - sedimentation and hydrological regime

   The huge volume of dredging materials (about 0.35 million tons) is expected to affect the hydrological regime, erosion and sedimentation patterns of the region. Delft3D model was employed to stimulate such impacts. The maximum volume of dredging material which is 4.2 million m^3 was used to stimulate the impacts of dredging work on the hydrological regime, erosion and sedimentation patterns of the region and Hon Cau marine protected area.

   a. *Mathematic base and input data of Delft3D model*

   Refer to Section 3.2.1.4.2 and Appendix 3.2 for more details on mathematical base and the validity of wave diffusion, pollutant diffusion and hydrodynamics models of Delft3D model.

Table 3.24. Summary of the input parameters of the model

Module	Parameter	Value
Hydrodynamics	Number of calculated points	M=668, N=366
	Δx, Δy	68.7-670.0m
	Time step	60 seconds
	Threshold between wet and dry	0.1 m

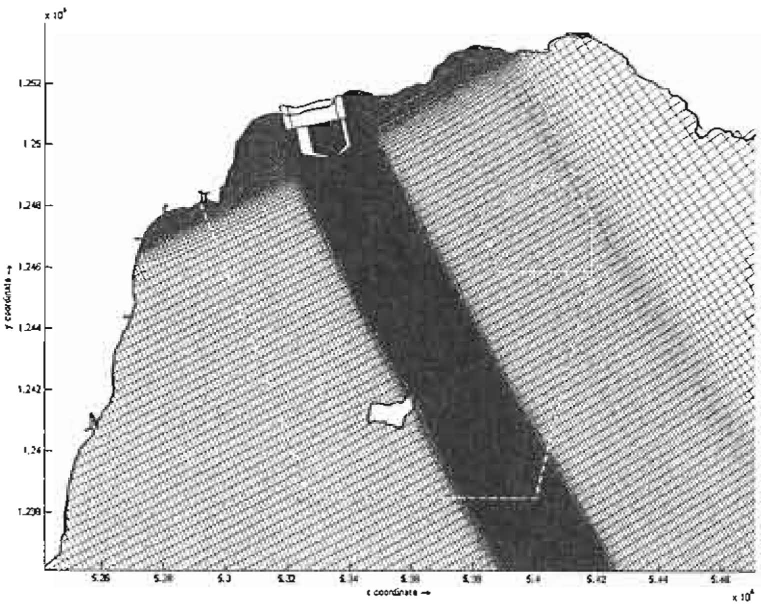
Module	Parameter	Value
	Number of floor	4(25%/ layer)
	Horizontal eddy viscosity	$1.0 m^2/s$
	Vertical eddy viscosity	$1.0 \times 10^{-6} m^2/s$
	Horizontal eddy diffusivity	$1.0 m^2/s$
	Vertical eddy diffusivity	$1.0 \times 10^{-6} m^2/s$
	Chezy coefficient	60
	Turbulence closure model	*k*-e turbulence closure
	Advection scheme	Cyclic method
	Sigma-coordinate correction	On
	Forrester filer vertical	On
	Forrester filter horizontal	Off
Wave	Maximum number of repetition	8
	Spectrum	JONSWAP
	Setup	False
	Hydrodynamics (water level, bathymetry, current, wind)	Use and doncs (water
	Forcing	Wave energy dissipation
	Friction	Madsen et al, (1978)
	Breaking	Bettjes & Janssen (1978)
	Alfa	1.0
	Gamma2	0.73
	Wind	Komen et al, (1984)
	Quad	Hansselman et al, (1985)
Sediment transport	N	10
	f_{MOR}	10
	EQMBC	True
	Densin	False
	ALFABS	1
	ALFABN	1.5
	f_{SUS}	1
	f_{BEB}	1
	f_{SUSW}	1
	SEDTHR	0.5
	THETSD	0
	RHOSOL	2650
	D_{50} *sand*	150

Module	Parameter	Value
Dredging	DepthDef (m)	1
	DredgeDepth (m)	7
	MaxVolRate (m^3)	4.200,000
	MaxVolRate (m^3/day)	42960
	DredgeDistr	1
	Dredging time	16
	Major materials	Sludge-9%, sand-84%, rock-7%
	Ratio of returning sand after dredging (%)	15%

Calculation time and scenarios: to assess the impact of dredging work on hydrodynamic conditions, sediment transport of Vinh Tan coastal area and Cu Lao Cau area, below scenarios were established:

- Scenario 1: Before the dredging work in Northeast monsoon season (dry season) and Southwest monsoon season (rainy season)
- Scenario 2: During the dredging work in Northeast monsoon season (dry season) and Southwest monsoon season (rainy season)
- Scenario 3: After the dredging work in Northeast monsoon season (dry season) and Southwest monsoon season (rainy season)

Figure 3.17. Grid of dredging area in modeling frame



To assess the impacts of dredging work on hydrodynamic conditions and sediment transport at certain points in the studied area, some points were included into the modeling for testing. The positions of these points are described in the following figure:

Figure 3.18. Map of testing points at Vinh Tan coastal area

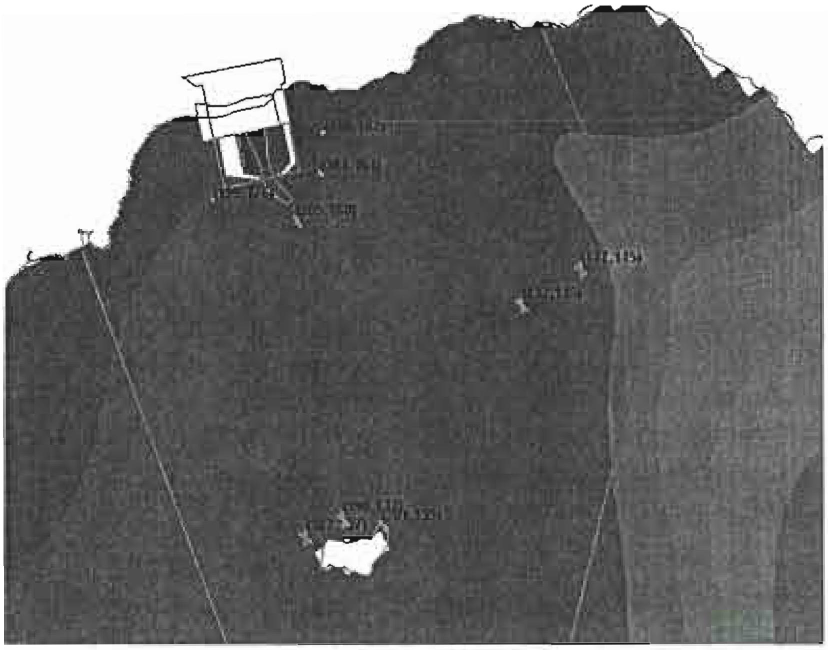


Table 3.25. Position of testing points

STT	Position		Note
	M	N	
V1	447	145	Breda shoal
V2	432	145	Breda shoal
V3	183	137	West site of Cu Lao Cau area
V4	190	137	Northwest site of Cu Lao Cau area
V5	201	135	Northeast site of Cu Lao Cau area
V6	410	182	East site of the dredging area
V7	384	164	East site of the dredging area
V8	305	196	Southeast site of the dredging area
V9	199	176	Southwest site of the dredging area

b. Modeling result:

i. Impacts on hydrodynamic conditions:

+ Hydrodynamic conditions before dredging:

As presented above, the hydrodynamics of Binh Thuan coastal area in general and Vinh Tan coastal area in particular are impacted by a range of factors such as wind, sea level oscillation and wave action. Prevalent magnitude of current which is between 0.1 - 0.3 m/s alters with water level oscillation. Wave induced currents have velocity lower than 0.4m/s, wave height varies in the range of 0.1-1.2 m/s (southwest monsoon season) and 0.3-1.0 m (northeast monsoon season).

Refer to Section 3.2.1.4.2 and Appendix 3.2 for stimulating results of hydrodynamic conditions of Vinh Tan coastal area before dredging.

+ Impacts of dredging work on hydrodynamic conditions: stimulating results reveal that the dredging work has no effect on the spatial distribution of integrated currents and common wave field of the region (refer to Figure 3.19 and Figure 3.20).

Figure 3.19. Wave current field at Vinh Tan coastal area (m/s) (Southwest monsoon season, ebb tide stage, during dredging)

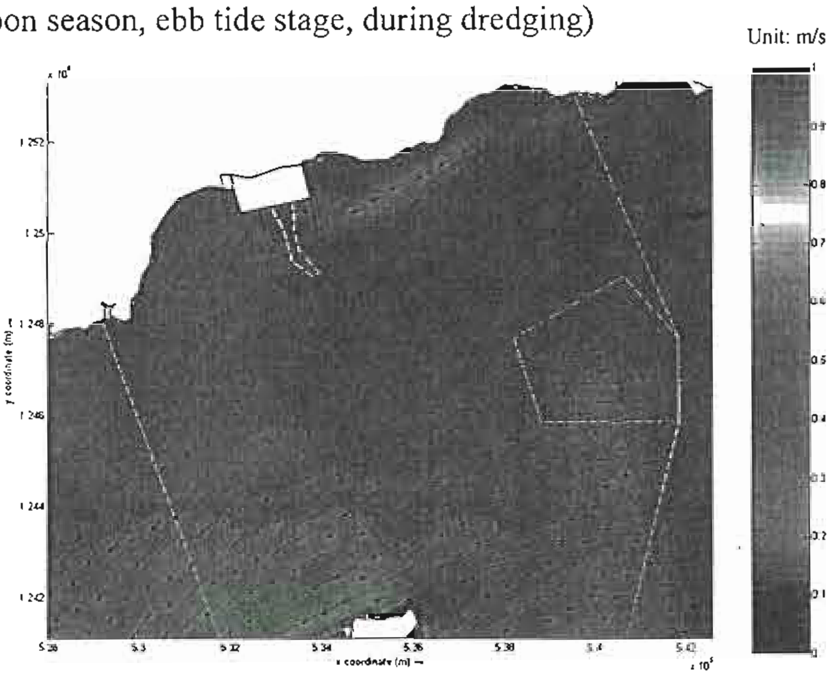
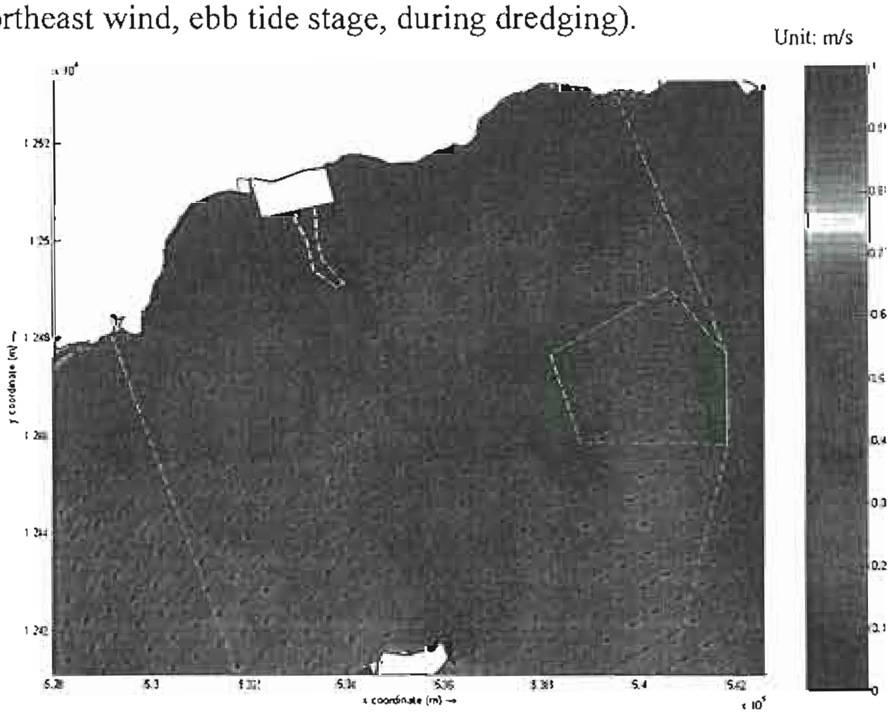


Figure 3.20. Integrated current field at surface at Vinh Tan coastal area (m/s) (Northeast wind, ebb tide stage, during dredging).

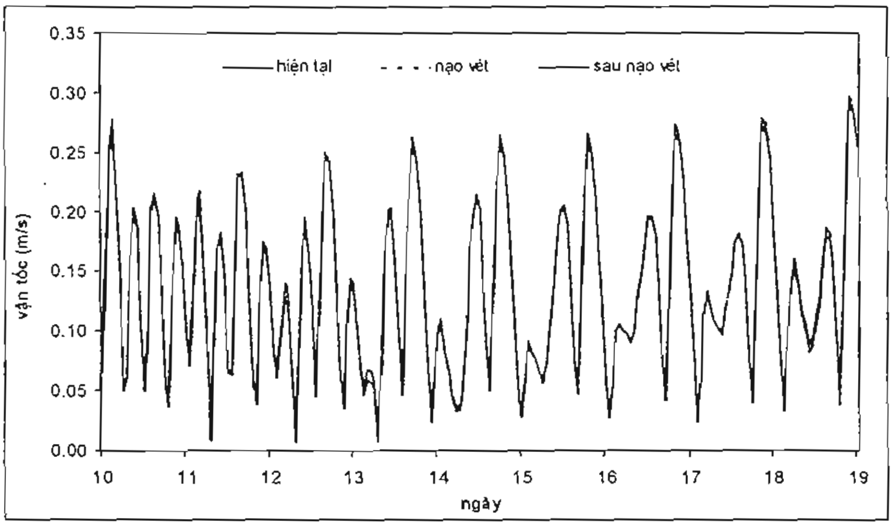


+ Assessment of current and wave fluctuation at testing points:

✓ At the eastern site of the dredging area (V6 and V7), no clear alteration was observed in the current velocity during the dredging process.

- ✓ The velocity of currents at Breda shoal (V1 and V2), west and northwestern site of Cu Lao Cau (V3, V4 and V5), southeastern site of the dredging area (V8), southwestern site of the dredging area (V9) do not change much before, during and after the dredging process. This results are observed in both rainy and dry seasons (Figure 3.21,Figure 3.22 and Figure 3.23).
- ✓ Similarly, wave height at areas surrounding Bai Can and Cu Lao Cau area is not different before, during and after the dredging work.
- ✓ In conclusion, the dredging work hardly affect the hydrodynamic conditions and currents at external areas (Cu Lao Cau, Bai Can, northeastern and southwestern parts of Vinh Tan coastal area).

Figure 3.21. Current fluctuation at Breda shoal (V2; a a rainy season; b- dry season)



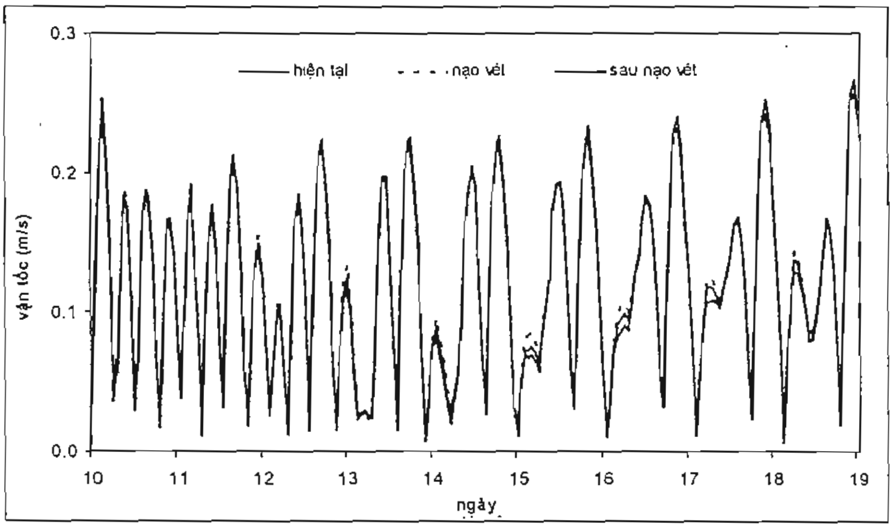
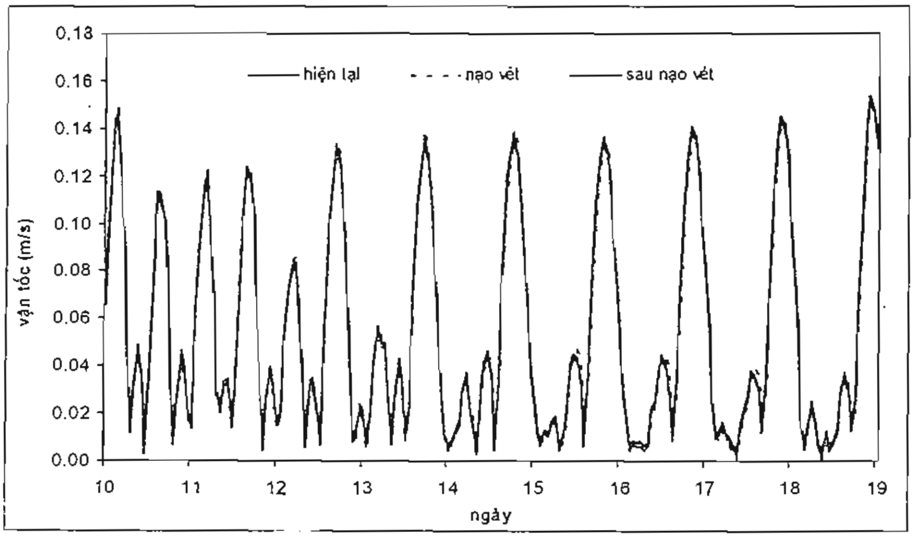


Figure 3.22. Current fluctuation at the Eastern site of the dredging area (V6; a ic conditions and currents at



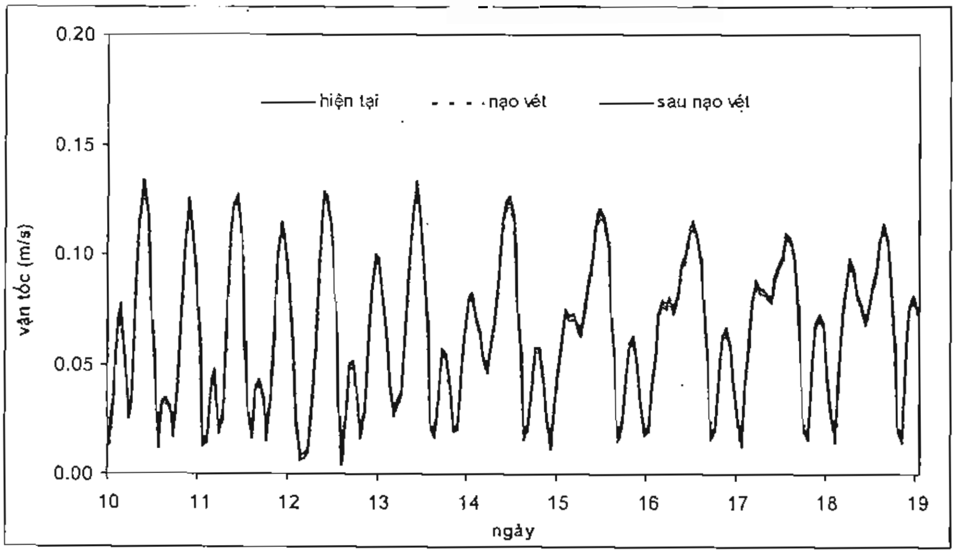
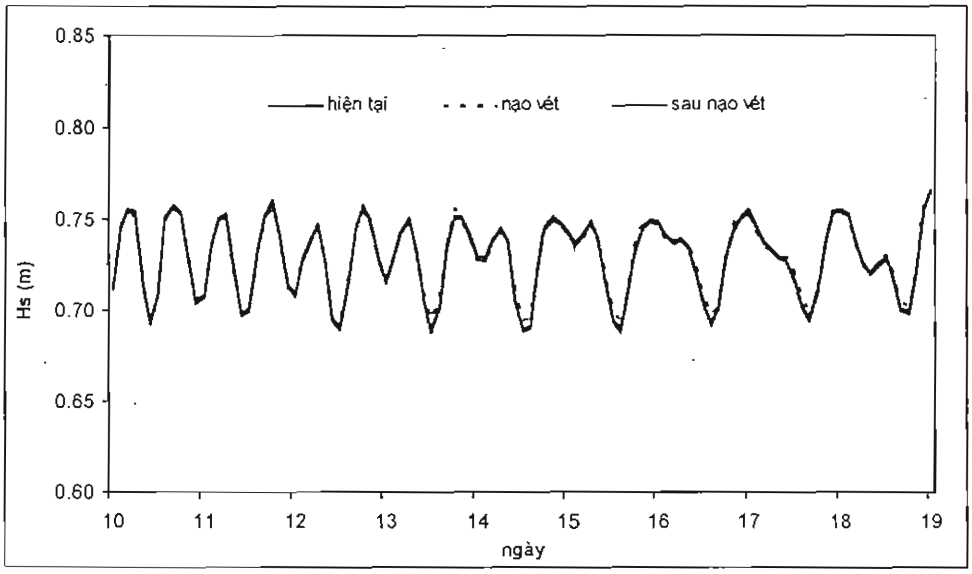
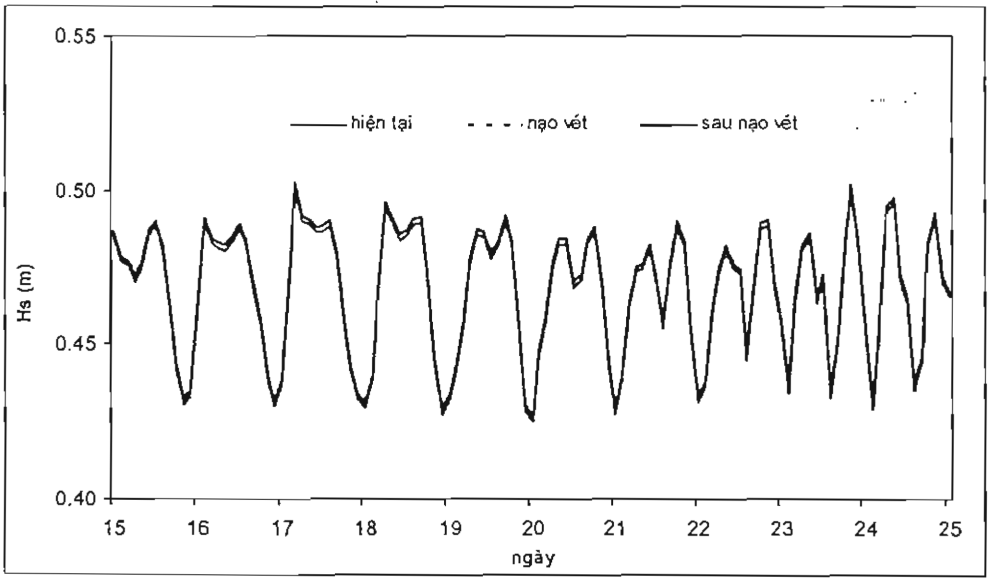


Figure 3.23. Fluctuation of wave height at the Eastern site of the dredging area (V6; a tirainy season; b- dry season)





ii. Impacts on sediment transport

+ Sediment source from the river to the coastal zone in this area is very small. Therefore, sediment transport in this area almost by re-suspension due to wave activities and carried by integrated current. Suspended sediment concentration is relative small with prevalent value less than 0.008 kg/m^3 and decreasing gradually from onshore to offshore. The difference in sediment concentration between rainy and dry seasons is not considerable.
+ To assess the impacts of the dredging work, calculation on the distribution and transport of total suspended sediment (TSS) was performed before, during and after the dredging process. The results reveal that there are certain impacts affecting regional distribution of TSS during dredging process (refer to Figure 3.24 and Figure 3.26). Once the dredging is finished, the regional distribution of TSS is trivially different from current stage. In conclusion, the impacts on the water turbidity by increasing TSS

value happen only during the dredging process (Figure 3.24 and Figure 3.27).

+ *During the dredging work in southwest monsoon season:* the dredging activities generate a turbid area with TSS value about 0.005-0.012 kg/m^3 spreading on the area of 0.9 km^2 around the dredging area. *The highest turbidity value of this area is about* 0.015 kg/m^3 at the inside of the seawall. This turbid water spreads to the east area is about TSS value abouts trivially different from current stage. In conclusion, the impacFigure 3.24). The concentration of sediment decreases outside of the dredging area and hardly spatially dependent. During the dredging work, the impact of such turbid water on Cu Lao Cau area is negligible. At Breda shoal, despite the smaller distance to the dredging area, the impact is not small. Other areas are also affected negligibly by dredging work.
+ *During the dredging work in northeast monsoon season*: the dredging activities generate a turbid area with TSS value about 0.005-0.013 kg/m^3 spreading on the area of 1km^2 around the dredging area. *The highest turbidity value of this area is about* 0.015 kg/m^3 at the inside of the breakwater. This turbid water spreads to the east area is about h TSS value aboutand hardly spatially dependent. During the dredging work, the impFigure 3.24). The concentration of sediment decreases outside of the dredging area and relatively uniform in space. In this case, the west , the impact of such turbid water on Cu Lao Cau area is negligible. At Breda shoal, despitng activities.
+ To assess the fluctuation of sediment flux at various cross-sections in studied area (Table 3.1), modeling results at these cross-sections are analyzed and evaluated. The results are as follows::

✓ At the eastern site of the dredging area (V6, V7), sediment volume increases during the dredging process ranging from 0.005-0.012 kg/m^3. However, this volume returns similar as current stage as the dredging has finished (Figure 3.29).

✓ At the southeastern site of the dredging area (V8), the volume of suspended sediment insignificantly increases during the dredging process altering in the range of 0.005-0.013 kg/m^3. This volume returns similar as current stage as the dredging has finished (Figure 3.28). Similar trend was observed at the southwestern site of the area.

✓ In conclusion, the volume of suspended sediment insignificantly increases during the dredging process altering in the range of 0.013-0.015 kg/m^3 (lower than Vietnamese standard regulated in QCVN 10: 2008/BTNMT, applied for aquaculture and aquatic biota protection area, which is 0.05 kg/m^3) and has small effect on the surrounding environment. The impact at other area is negligible; once the dredging has finished, the suspended sediment content returns stable as present.

The 100,000DWT port of Vinh Tan 4 TPP has a total dredging volume of 352,720 m3 (account for 8.4% total dredging volume of passageway, turning basin of the port). Hence, the TSS content from the dredging of berth is expected lower than calculation. As a result, the impact of Vinh Tan 4 dredging work is estimated insignificant and only occurs within the breakwater.

Figure 3.24. TSS distribution (kg/m3) at the middle layer at Vinh Tan 4 coastal area (sou'hwest monsoon season, ebb tide, during dredging)

Unit: kg/m3

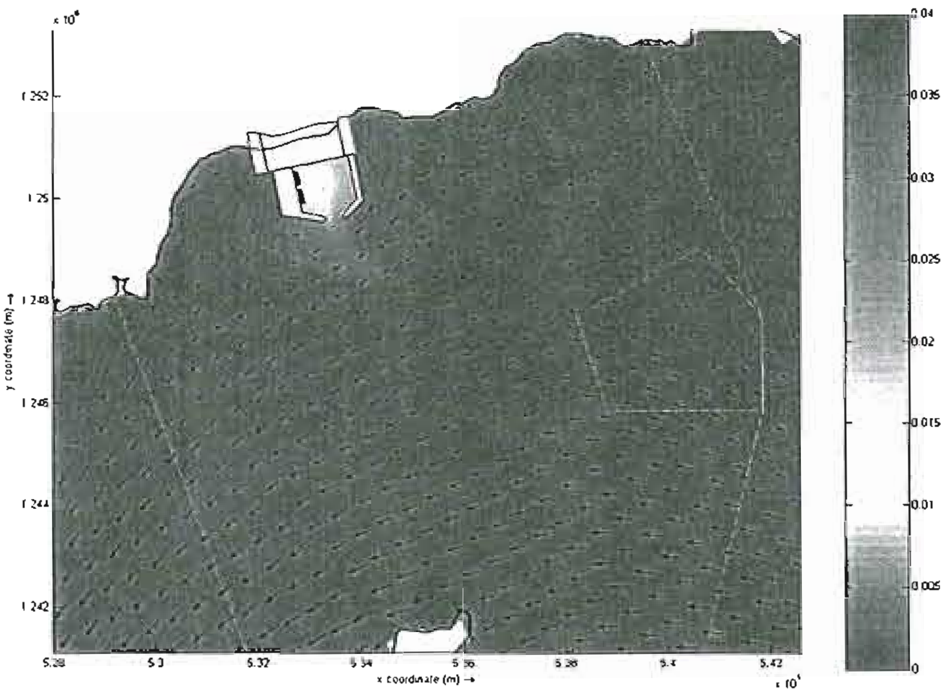


Figure 3.25. TSS distribution (kg/m^3) at the middle layer at Vinh Tan 4 coastal area (southwest monsoon season, flood tide, after dredging)

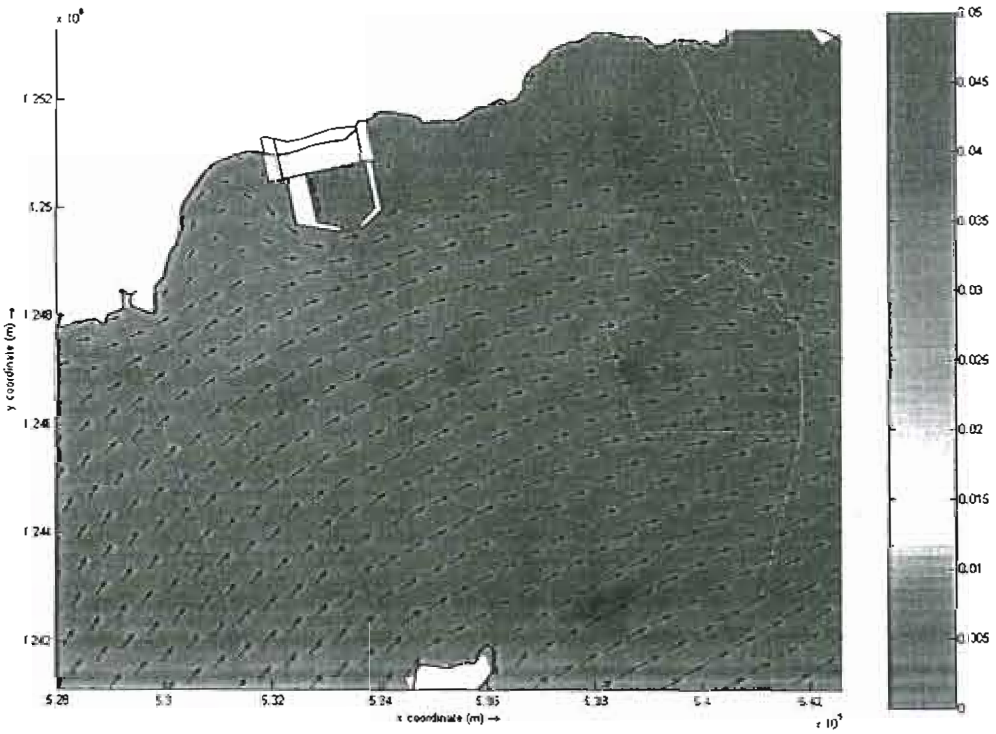


Figure 3.26. TSS distribution (kg/m^3) at the middle layer at Cu Lao Cau coastal area (northeast monsoon season, flood tide, during dredging)

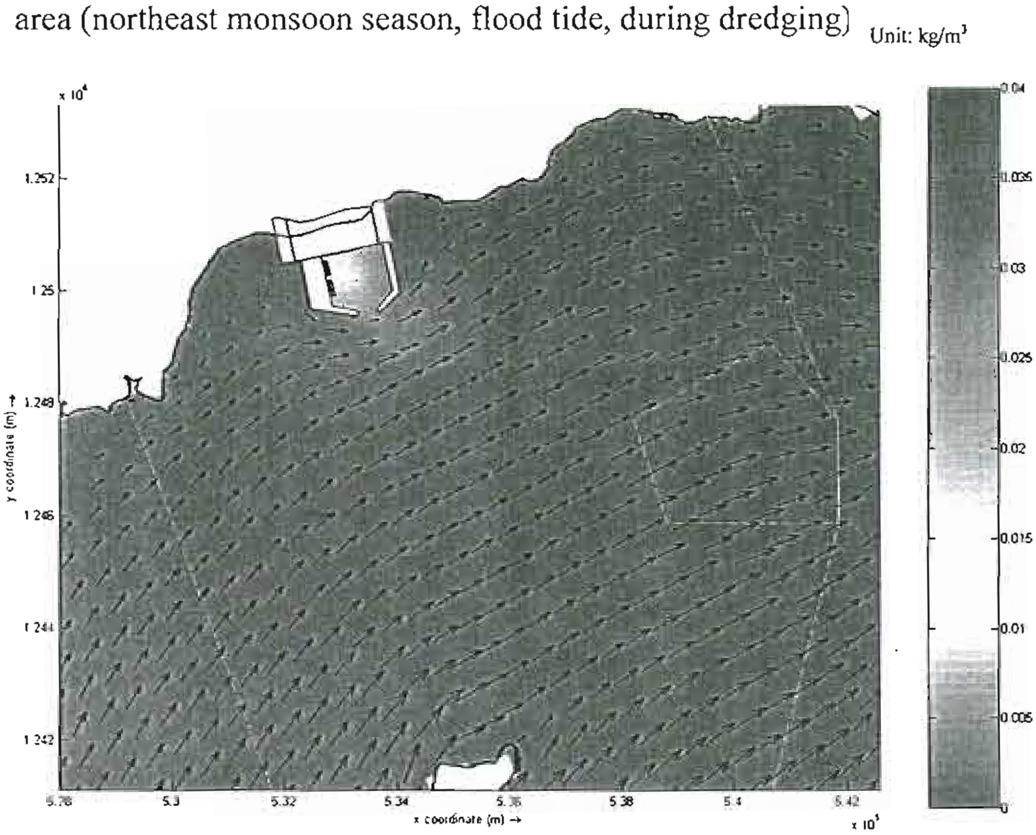


Figure 3.27. TSS distribution (kg/m^3) at the middle layer at Vinh Tan 4 coastal area (northeast monsoon season, ebb tide, after dredging)

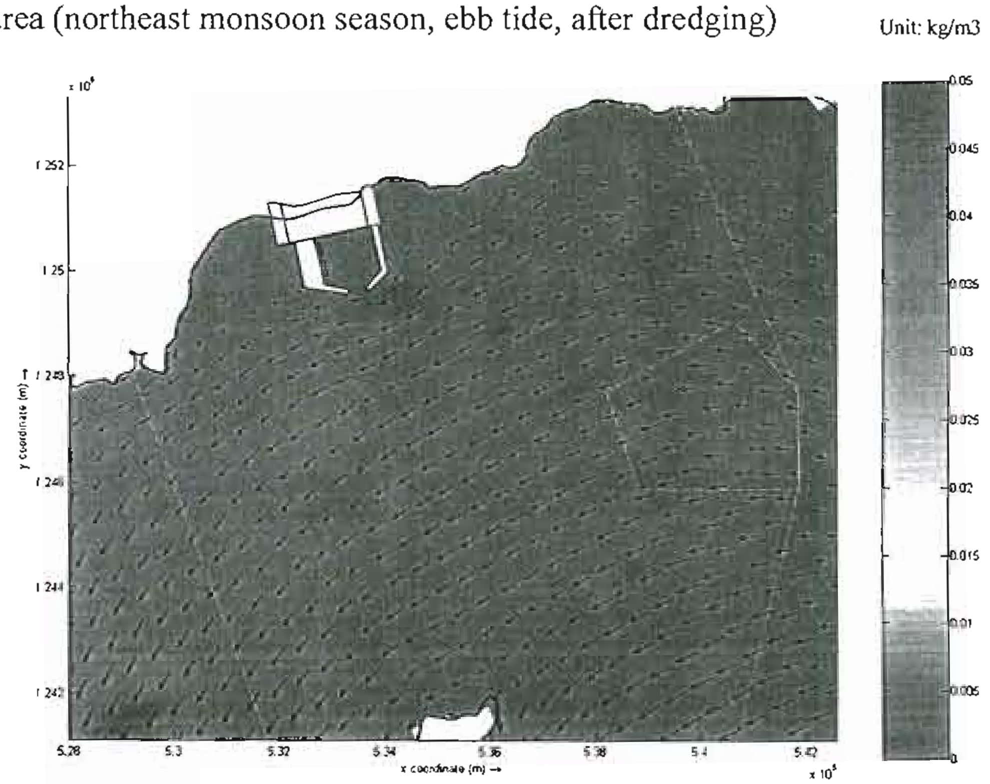
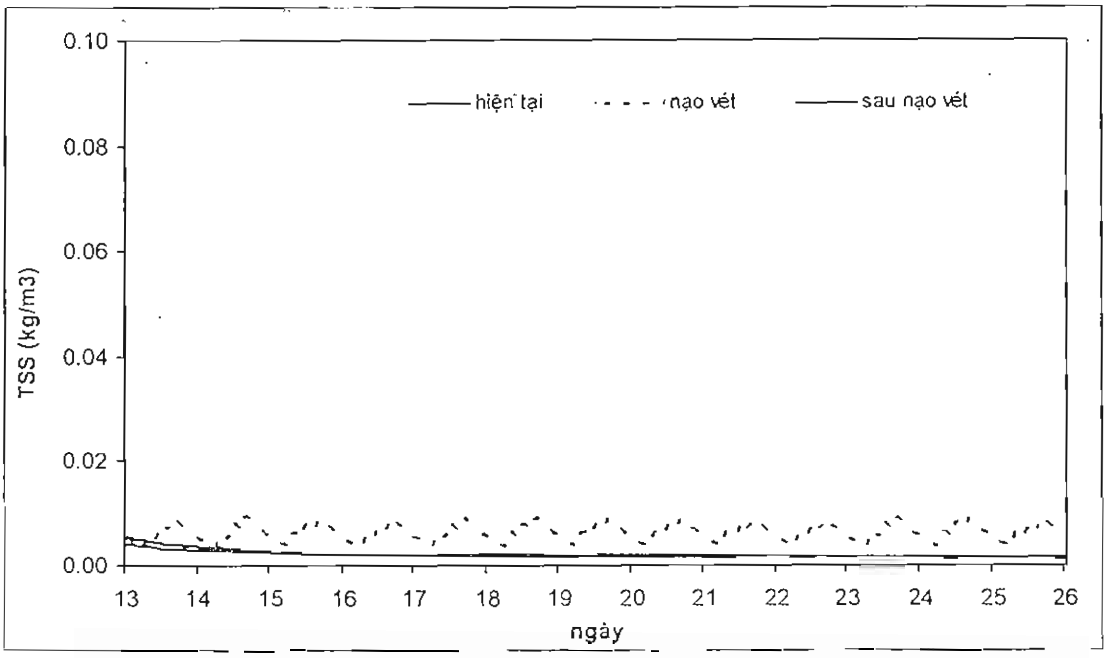
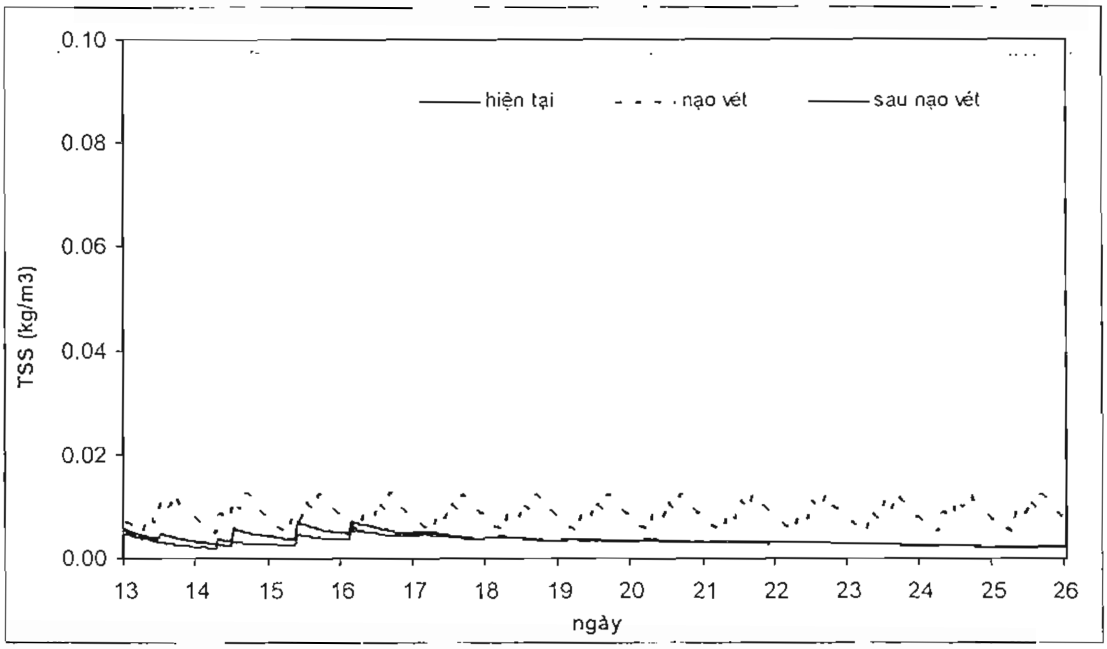
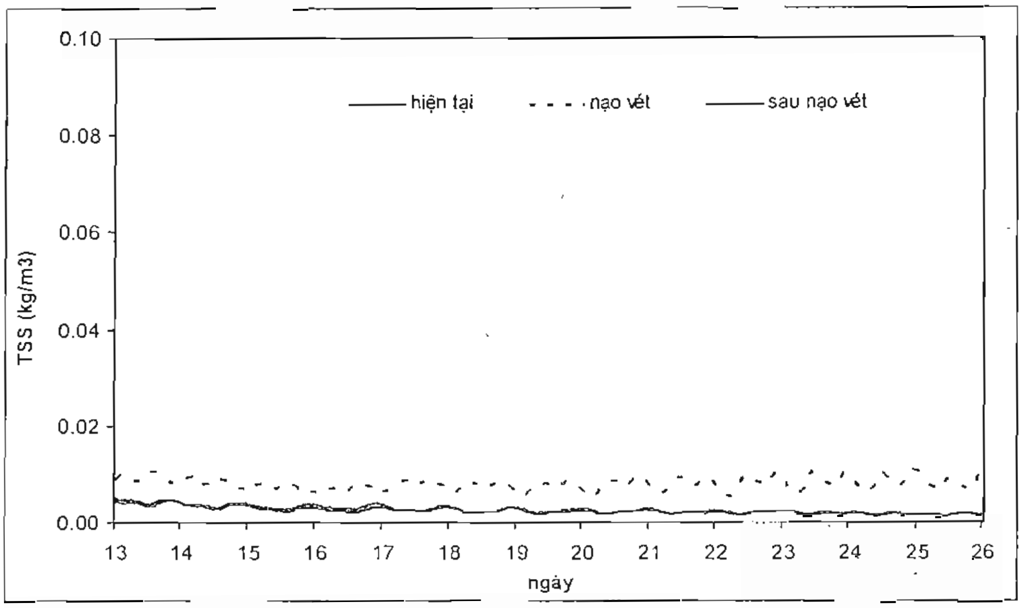


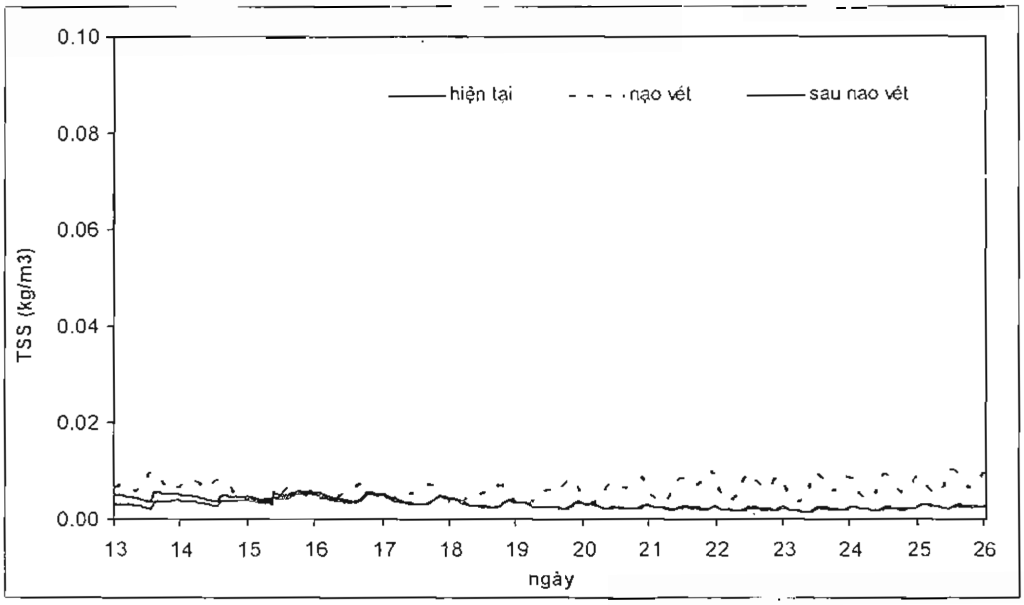
Figure 3.28. Fluctuation in TSS content (kg/m3) at southeastern site of the dredging area (V8; a earainy season; b- dry season)





Figurè 3.29. Fluctuation in TSS content (kg/m³) at eastern site of the dredging area (V6; a – rainy season; b- dry season)

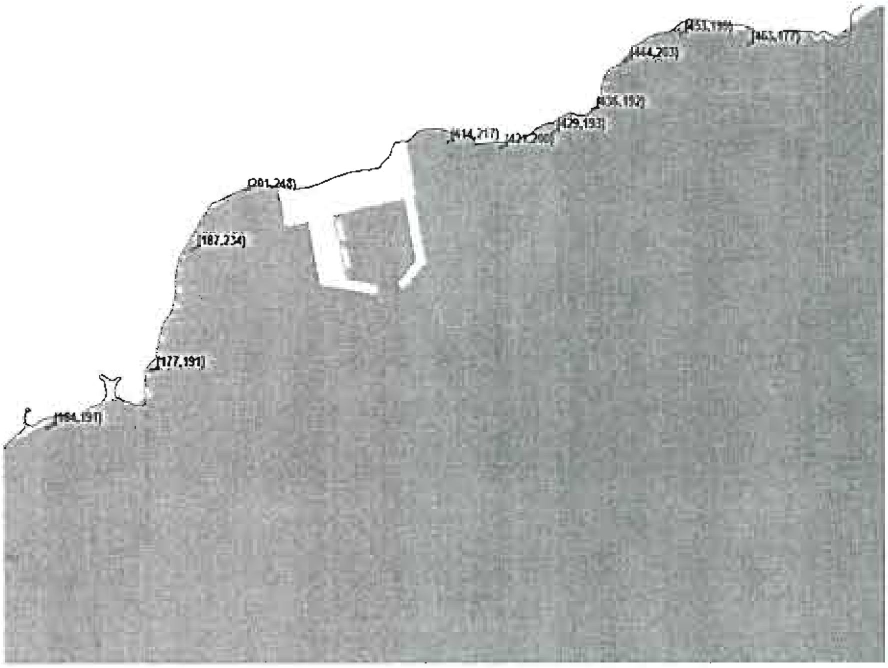




a. *Impacts on the erosion e sedimentation at surrounding area*

Impacts on the erosion e sedimentation at surrounding areaon; b- dry season)ason)ide, after dredging)ng)tide, during dredging)f berth is expected lower than calculation. As a result, the impact o0).

Figure 3.30. Map of testing points for investigating impacts of dredging work on local erosion - sedimentation



The calculation results reveal that monthly fluctuation of erosion local erosion - sedimentationing)ng)tide, during dredging)f bThe average rate of erosion currently at around the construction varies 0.0115-0.04982 m/month while the average rate of deposition varies 0.00517-0.03103 m/month. At coastal points from B1 to B9, erosion tends to occur in rainy season due to direct impact from wave direction induced by southwestern wind. However, in northeast monsoon season, as southwest wind gets weaker, slight sedimentation occurs at B1-B7 (Table 3.26). At B10 and B11, sedimentation occurs in rainy season and erosion in dry season. At B8 and B9, slight erosion occurs in both rainy and dry season.

Table 3.26. Average erosion – sedimentation rate (m/month) at nearby positions

Position		Scenario					
		Current		During dredging		After dredging	
Name	Coordinates (m,n)	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season
B1	463, 177	-0.01965	0.01230	-0.01965	0.01230	-0.01965	0.01230
B2	453,199	-0.02167	0.01353	-0.02161	0.01353	-0.02166	0.01354
B3	444,203	-0.03271	0.00405	-0.03270	0.00403	-0.03271	0.00406
B4	436,192	-0.03711	0.00480	-0.03712	0.00484	-0.03710	0.00484
B5	429,193	-0.04343	0.01019	-0.04346	0.01021	-0.04345	0.01018
B6	421,200	-0.04034	0.00517	-0.04030	0.00518	-0.04034	0.00517

B7	414,217	-0.04982	0.01032	-0.04980	0.01033	-0.04984	0.01030
B8	201,248	-0.01150	-0.00329	-0.01143	-0.00330	-0.00115	-0.00325
B9	187,234	-0.04586	-0.02017	-0.04471	-0.02013	-0.04588	-0.02019
B10	177,191	0.03103	-0.01302	0.03105	-0.01302	0.03102	-0.01302
B11	164,191	0:02474	-0.01215	0.02474	-0.01211	0.02476	-0.01215

Note: Minus (-) expresses erosion trend

Impact of dredging work on local sedimentation and erosion is minor due to short implementing time. Calculated results reveal that the erosion ason..03103 m/month. At coastal points from B1 to B9, erosion tends to occur in rainy scompare to current value (B6, B7, B8 and B9). The main reason is due to the dispersion of dredged materials to the surrounding environment. At other positions, no clear trend was observed due to trivial impact.

After finishing, some minor impacts were observed on the sedimentation – erosion of Vinh Tan coast but no obvious trend was found.

In conclusion, the impacts of dredging work on erosion e sedimentation – erosion of Vinh Tan coast but no

Refer to *Appendix 3.2 Chapter 3* for more details on method, result and calculation of erosion – sedimentation modeling.

b. *Conclusion*

Analysis has revealed that the impact of dredging work on hydrodynamic conditions and wave pattern of the area is small, almost negligible. After finishing, no change in such characteristics was detected. At positions nearby the dredging area, current velocity and wave height decrease to some extent compare to current stage. These changes are positive impacts on sediment transport and erosion – sedimentation pattern of the area.

Dredging activities increase the turbidity of surrounding area; yet the area is narrow along the Vinh Tan coast while Breda shoal and Cu Lao Cau area are not affected. At the end of the process, the difference found in water turbidity is negligible.

Therefore, it is estimated that the impacts occur locally around the dredging site; the impact level is low and no clear trend was created.

2. Seawater pollution

The dredging may increase the turbidity, TSS content, heavy metal and release oily waste polluting seawater. In which, the pollution due to heavy metal is insignificant because of good sediment quality.

According to modeling results, as the dredging is performed, the highest concentration of TSS is about 0.005-0.015 kg/m^3 (lower than the permissive value in QCVN 10: 2008/BTNMT, applied for aquaculture and aquatic biota protection area) spreading in the area of 1 km^2 around the dredging area. The level of TSS at Breda shoal and Cu Lao Cau marine protected area is small. Hence, it is evaluated that seawater pollution due to dredging work is small and local; no impact was found at the Cu Lao Cau area and Breda shoal.

In fact, the total volume of dredging work for Vinh Tan 4 TPP berth accounts only for 8.4% total calculated volume so that the TSS content is expected lower than calculated value and occurs only within the breakwater. Therefore, seawater pollution due to the dredging of Vinh Tan 4 berth is negligible.

Besides, the activities of suction and grab dredgers may release oil to the sea. About 5 suction and grab dredgers will be working on-site everyday during the course of 1.5 months (averagely 10 – 12 hours per day). Every day the dredgers need about 500 L oil for operation. As a result, the oil leaked to the sea due to dredging work and machine repairing is about 0.25 L (assume that oil loss is equal to 0.01% of the daily oil consumption). This impact is negative but small and reducible.

3. Impact on aquaculture

As presented in Section 3.2.1.4.5, the performance of aquaculture at Vinh Tan commune in 2011 is as follows:

- Total farming area (aquaculture) is 110 ha and offshore seawater is used for shrimp farming.
- There are about 15 fish rafts on sea and onshore fishery dominates at the area.
- The biological profit of the region has decreased about 60 – 70% compare to that of 5 years ago for each item correspondingly.

According to the stimulation for substance dispersion from the dredging of Vinh Tan 4 TPP in Section 0:

- During the dredging, the current pattern at project area remain similar to present stage so that the aquaculture activities will not be affected.
- According to the result of substance dispersion modeling, TSS content is about 0.005-0.015 kg/m3, lower than the permissive standard regulated in QCVN 10: 2008/BTNMT, applied for aquaculture and aquatic biota protection area (0.05 kg/m3), gathers mostly inside of the breakwater. So far, no studies are found about the threshold of TSS that aquatic organisms can tolerate. Yet, it is predicted that the increasing TSS during dredging process will affect adversely to the organisms.
- Barges used in the dredging activities may release oil and grease to the sea polluting local seawater, affecting aquaculture activities.

In summary, the dredging may affect negatively to the growth of aquatic organisms and indirectly affect local aquaculture. However, due to short implementing period as well as a boundary inside of the seawall, these impacts will not influence the water quality and outside aquaculture significantly. This impact is medium, controllable and expected to stop as dredging process finishes.

3.2.2.2.2. Impacts from dredging material disposal on landfill of Vinh Tan 4 TPP

The total volume of dredging material is 0.35 million m^3 will be reused for the reclamation of Vinh Tan 4 TPP (no materials are disposed to the sea).

According to analysis data from Chapter 2, the dredging material has good quality with no heavy metal, no PAHs, Dioxin. Hence, this material is suitable for land reclamation and not harmful to the water quality.

- Positive impacts:
  + Reuse a large amount of dredging material for land reclamation for Vinh Tan 4 TPP.
  + Reduce the impacts from moving 0.35 million m^3 leveling material from other places such as air pollution, dust emission, traffic nuisance and also reduce the investment expense.
- Negative impacts
  + As calculated, the extra amount of sand needed for Vinh Tan 4 TPP leveling process is 0.7 million m^3, hence, all dredging material can be reused. The remain volume of about 0.35 million m^3 can be taken from Vinh Tan 3 port dredging process.
  + Local aquatic ecosystem will be affected. This impact is significant and irreversible. Detailed assessment is presented in Section 3.2.2.4.
  + The filling of leveling material is only carried out after the construction of the reclamation embankment which includes several layers of Tetrapod, core rock, stone chips 2x4, 4x6, along with a layer of geotextile and cover rock. Consequently, these layers will keep dredging material inside and leave only seawater to permeate through. Besides, the height difference between the embankment and sea level at about 5m helps prevent the runoff through the embankment which may affect surface water quality.
  + The dredging material is transported by barges to the area at about 1 km away from the leveling site. On barges, this materials will be stored and closely covered to prevent the dispersion to surrounding environment. Hence, such impact is limited on transport routes.
  + The dredging volume at 8350 m^3/day will be transported by 2500 m^3 barges so that there will be averagely 5 turns of barges to the leveling site. Due to low transport frequency and short implementing time (about 1.5 months), the dredging work is expected not affect air environment as well as waterway traffic at the region.

In conclusion, the impact of dredging material disposal is considered small and reducible by suitable technical measures as described in Chapter 4.

3.2.2.3. Sources of impact not relating to waste

Sources of impacts not relating to waste, affected objects and major assessment are summarized in the table below:

Table 3.27. Sources impacts not relating to waste in construction phase

Impact source	Affected objects	Impact assessment	Impact level
Activities of vehicles, equipment on site. Transportation of materials and equipment	Air environmental Local traffic	Cause noise pollution, vibration at construction site and transport route Increase the traffic intensity at routes to the project	Small
Dredging and port construction	Aquaculture	Affect to local seawater quality	Small, local
Gathering of construction workers	Culture, socio nstruction workers routes	Disturb traditional lifestyle and culture of local life, increase the possibility of confliction between construction workers and local residents. Contribute to the development of local economics	Small
Explosion, occupational and traffic accidents	Construction workers and local residents	Occupational and traffic accidents are highly potential to happen.	Medium

3.2.2.3.1. Noise - vibration

1. Impact of noise

The main sources of noise produced during construction activities include: piling, foundation and erection of buildings and structures, transport of materials, activities of ships and barges on sea. The ability of spreading noise to the surrounding area as a function of in the construction of the main plant and port is shown in **Table 3.14** and Section **3.2.1.4.3**.

According to the table above, total noise level by construction equipment machinery, means of transport on site will ensure the provisions of QCVN 26:2010/BTMNT applied to normal area with distance of above 700 m. Therefore, residential area of hamlet no.7 will be affected by noise (Hamlet no.7 is about 100m from project site). Other residential areas and administrative of Vinh Tan commune of People's Committee will not be affected by noise. Impact of noise from vehicles, construction equipment in construction phase of Vinh Tan 4 TPP is considered medium and will be reduced by technical measures.

Concrete mixer station: Noise level generating concrete mixer area (concrete mixer, concrete pump) at a distance of 15 m is up to 90dBA and will gradually decrease by distance. At the distance of 200 m, noise level is about 71 dBA while at the distance of 500 m, noise level is about 63 dBA. According to Vietnamese regulation on industry emission of noise, noise level in daytime (from 6.00 - 21.00) and at night (from 21.00 – 6.00) are 70dBA and 55dBA respectively. Therefore, if concrete mixer area continuously operates all day, the area affected by noise will be within a radius less than 500 m. So, concrete mixer station must locate over 500 m from residential areas.

2. Impact of vibration

During the construction, the main source of vibration will be hammer machines (for staking) with the impacts described below:

- Binding sheet stakes of 5 to 7.5 m long with U-shape cross-section will be staked to the necessary depth forming a binding panel. The staking machine, i.e. 8 ton hammer machines with the input power of 48 KJ can cause shaking of 7 mm/s at the distance of 10m.
- Staking in mud basement with the input power of 30 KJ can cause shaking of 4.30 mm/s at the distance of 10m.
- A diesel hammer machine working on clay basement can cause shaking of 7 mm/s at the distance of 10 m..

Potential source of vibration during construction phase is from constructing machinery, transportation, piling and foundation works. Vibration levels of some equipment are shown in Table 3.28

Table 3.28. Vibration level for construction equipment (VdB)

No.	Equipment		Vibration level (at 25ft) L_v^0	Vibration level L_v (VdB)				
	QCVN 27:2010/BTNMT		75					
	Distance D (m)		7.6	50	100	200	300	500
1	Pile Driver	Upper range	112	95.66	89.64	83.62	80.10	75.66
		typical	104	87.66	81.64	75.62	72.10	67.66
2	Clam shovel drop (slurry wall)		94	77.66	71.64	65.62	62.10	57.66
3	Large bulldozer		87	70.66	64.64	58.62	55.10	50.66
4	Caisson drilling		87	70.66	64.64	58.62	55.10	50.66
5	Loaded trucks		86	69.66	63.64	57.62	54.10	49.66
6	Jackhammer		79	62.66	56.64	50.62	47.10	42.66
7	Small bulldozer		58	41.66	35.64	29.62	26.10	21.66

Source: PECC2, 09.2012.

Calculation results show that the vibration level of almost of construction equipment ensure the permitted value for construction and residential area at a distance of over 100 m. Particularly, the vibration of pile driver at typical threshold in distance of over 300 m and over 500 m for upper range meets the value permitted under the provisions of QCVN 27:2010/BTNMT applied for normal area.

Residential area of hamlet no.7 near the project area may be affected the piling operation. There are not any sensitive places or positions within 1 km radius of project area such as hospitals, pagodas, churches, heritage structures. Hence, the vibration level of the project will not impact these sensitive positions.

3.2.2.3.2. Impacts on local socio-economics

1. Increase immigration

Construction activities for the project requires a large number of workers from nearby regions with 1500 people per average day at peak periods. Although the project has policy to provide employment priority to local laborers, local inhabitants' skills are far below requirements and the project has to recruit labour from other locations.

Confliction between workers and local residents occurs due to the gathering of a large number of people from foreign sites, differences in lifestyle, viewpoint and culture.

2. Impacts on health and safety

Spreading of infectious diseases: due to the concentration of large number of workers at one time, infectious diseases may spread easily through waterway (cholera, dysentery, typhoid, diarrhea) or through intermediate vectors (malaria, dengue ...). Without control measures, these impacts expected to happen.

Thc ability of increasing the evils in the region: up to now in the Vinh Tan commune, Tuy Phong district, the rate of social evils is relatively low. The concentration of hundreds of workers from different areas to a limited project area may exacerbate the social evils such as alcohol, drugs and others. The impact is likely controllable by appropriate measures.

The concentration of workers is predicted to cause adverse impacts. Yet, this also promotes the local economics, increases employment rate; currently, the income of local people is quite low which some have not a certain career.

3. Impact on aquaculture

The construction works on the sea (port construction) and operation of maritime transport in this period will adversely affect to aquatic ecosystems and aquaculture industry.

The drive pile activities of cooling water pipe will cause disturbance and change of sea bottom and lead to a decline of pH in coastal water. The increase of suspended solid concentration in the seawater in the basin near the construction site will negatively affect the bottom fauna in the area.

Besides, many fish species will be affected by the loss of food supply and spawning due to increased turbidity. Thus, the biological diversity in the region will be significantly affected. However, the planning of the Binh Than province People's Committee, the shrimp farmers in the project area will be relocated to another place (Ganh Hao - Chi Cong area) to hand over the Vinh Tan Power Complex. Therefore, the impacts on aquaculture activities around the project area are only temporary and will not occur in the future. Thus, this impact is assessed minor.

4. Impact on local traffic

The construction of Vinh Tan 4 TPP including power plant and 100,000DWT port construction will need a large volume of raw materials, these construction materials will be transported from other places. So, traffic density on Highway 1A will increase significantly.

A number of trucks transported materials for the project in this period is estimated about 23 vehicles/day, average 1 trip/hour. The number of vehicles is not high, however, traffic accidents may be happened if there is not appropriately traffic safety of management plan. Currently, the traffic circulation on highway 1A is relatively low, mostly trucks and passenger cars. Therefore, the impact is assessed minor and can be mitigated by enhancing measures for ensuring safety traffic.

For barges, vessel operations, there are a number of 2 trips of vessels/barges per day during the construction and installation power plant phase. The impact on waterways activities in the project area is negligible and completely acceptable.

In summary, the impact on traffic in the area is considered minor and can be reduced, prevented by the application of appropriate management measures.

3.2.2.4. Impacts on Hon Cau Marine Protected Area during the dredging and leveling of Vinh Tan 4 port

3.2.2.4.1. Impacts on Hon Cau Marine Protected Area during the dredging and leveling of the port

The Hon Cau Marine Protection Area with total area of 12500ha was established by People's Committee of Binh Thuan Province on Decision No.2606/QD-UBND dated 15/11/2010, including 4 functional zones:

- Strictly conservation zone – core area (1250 ha): Hon Cau Island zone (350 ha) and Breda zone (900 ha).
- Buffer zone (1210 ha): is area around two core area; Buffer zone #1 – Hon Cau Island (350 ha); Buffer zone #2 – Breda (900 ha);
- Ecological restoration area (808ha): is limited by Vinh Hao coastline.
- Development zone (9232 ha): many areas located outside strictly protected areas, buffer zones and ecological restoration.

In the ecological restoration area, there have been still habitats at good conditions and area where the biological profit is severely damaged due to exploitation activities. These areas require proper recovery measures.

The Vinh Tan Power Complex is about 7.5 km away from boundary of buffer zone #1 of Hon Cau protection area and 4km away from buffer zone #2 of Breda sandbar area. And the Vinh Tan 4 TPP is located in development zone and a part of ecological restoration (28.28 ha) of Hon Cau MPA (Figure 3.31). Thus, the aquatic ecosystem at project area will be affected by the construction activities to some extent.

According to survey results, characteristics of marine ecosystem at Vinh Tan Power Complex implemented in October 2010 (referred from the EIA report of Vinh Tan sea port – phase 1 approved by MONRE in document no.1448/QD-BTNMT dated 25/7/2011) were as follows:

- Seaweed and sargassum:

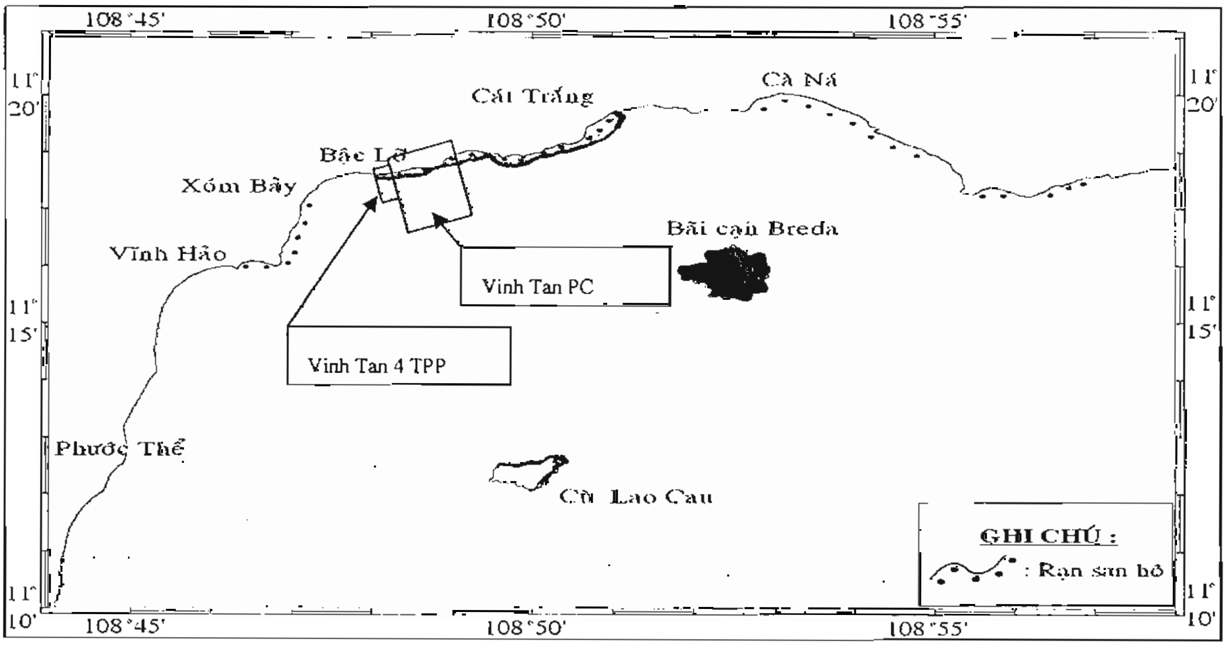
  According to survey results, there were no patches of sea grass at leveling area of Vinh Tan 4 TPP. All over the area, there were 3 beds of sea grass scattering at the depth of 6 – 9 m with the area of 3 - 4 ha/bed; smaller beds distributed at deeper layer.

On the other hand, no *sargassum* was detected in the studied area (sargassum are commonly found in the shallow water close to the shore at depth ranging from 2 – 4m [Vo Si Tuan, 1996]). This was probably due to the increasing exploitation of local people to produce animal feeds and fertilizers in recent years, especially in March and April annually. This exploitation might be carried out in former time so that no sargassum is found in the survey period.

- Coral reef

According to the report on the establishment and management of Hon Cau MPA implemented by the People's Committee of Binh Thuan province, the coral reef distributed mostly around Hon Cau island, along the coastline from Cat Trang to Vinh Hao and some at Breda shoal. Soft coral was dominant at around Hon Cau island while dead coral was found along the coastline from Cat Trang to Hamlet 7 (Figure 3.31). The report assessed that these coral reefs along the coastline were completely dead (over 50%) or being degraded due to the threats from algal blooms in 2002.

Figure.3.31. Locations of Vinh Tan 4 TPP, Vinh Tan Power Complex and Hon Cau MPA



Source: Report on the establishment and management of Hon Cau MPA

According to the survey on the marine characteristics of Vinh Tan Power Complex Coral implemented in October 2010, the coral reefs mainly distributed in shallow water along the coast of the Vinh Tan TPP, from the depth of 1m down to 5 – 6 m. These reefs were dominated by dead corals in inner reef and by foliose and branching corals (Acropora, Montipora) in outer reefs. Most communities were exposed to levels of sedimentation, with near-shore sites severely affected. The largest patch of coral reefs of typical fringing reefs are found in the north and a small patch mainly formed by coral assemblages on sandy bottom are found in the south of the Complex Site.

Data from detailed surveys also indicate that condition of the reefs were generally not in good condition. Coverage rate of hard corals at every station is low ranging between 0.6 – 9.2%. The cover of hard corals at sites located on the reef flat was generally lower than that in the reef slope. Dead corals were dominant at all study sites with cover ranging between 5.8 – 74.2% and sites on the reef flat had a higher cover of dead corals compared to that on the reef slope. In general, the reefs in the waters of the Vinh Tan Complex Site supported high cover of coralline algae, turf algae, seaweeds and rubble corals, ranging between 0.0 – 39.2%, 0.0 – 14.2%, 1.7 – 20.5% and 0.8 – 48.3% respectively. The cover of sponges was low, ranging between 0.0 – 2.5%.

Average cover of major substrata showed that the cover of hard corals was very low (4.6%) whereas the covers of dead corals, seaweeds, coralline algae, and rubble corals were relative high, giving overall average of 44.4%, 21.3%, 8.6% and 20.5% respectively

The above data have shown that coral reefs at Vinh Tan 4 TPP in particular and at Vinh Tan Power Complex in general were severely damaged remaining mostly dead coral.

At present, the reclamation process for the Vinh Tan Power Complex has been carried out. Hence, a part of the coral reefs at Bac Lo was buried under the reclamation area.

The fisheries production at Vinh Tan coastal declined by 60 – 70% compare to that of 5 years ago depending on species. Such decline may be caused by overfishing, dynamite fishing, collection of living corals for souvenirs and seaweed over-harvestation. On the other hand, the event of harmful algal bloom occurred in 2002 has caused serious degradation of most of the reefs in the shallow waters along the coast of the mainland from Cat Trang to Vinh Hao.

The activities of land reclamation and embankment construction will directly interrupt or destroy the habitat of benthic species, a small portion of dead coral at the western site as well as various species of fish living in coral at Bac Lo area. This effect are inevitable and hardly recoverable. However, due to the existence of mostly dead coral as well as low fishery production, the impact of leveling activities is considered as medium and irrecoverable.

The dredging of Vinh Tan 4 berth will be implemented within the boundary of the seawall of Vinh Tan power complex. The impacts on marine ecosystem inside of the seawall are evaluated in the EIA report for Coal port of Vinh Tan Power Complex – phase 1 approved by the Ministry of Natural Resource and Environmental via Decision No. 1448/QĐ-BTNMT dated 25/7/2011. Those impact the area are all unavoidable.

The berth for 100,000 DWT port is about -8.5m deep, with no existence of coral so that the dredging activities barely affect the regional coral reefs. Benthic and sea grass are expected to be negatively affected and these impacts are inevitable and hardly retrievable. However, the impact will only occur within the seawall and not disturb surrounding area. Therefore, the impacts of berth dredging for Vinh Tan 4 port are estimated medium and irrecoverable.

In summary, the land reclamation and port dredging will affect local marine ecosystem of the Hon Cau MPA at the project site (the development zone and ecological restoration zone) but not other areas including the buffer zones and core zone of Hon Cau MPA.

3.2.2.4.2. Impacts on the ecosystem due to increase in TSS content from land reclamation and dredging for Vinh Tan 4 port

According to the Report Dredging and port construction around coral reefs, PIANC Tolerance limits of coral to TSS concentrations reported in the literature range from less than 10 mg/l in reef areas not subject to stresses from human activities to 40mg/l or even 165mg/l in marginal reefs in turbid near shore environment (Table 3.29). This wide range demonstrates that different coral species and corals in different geographic regions may respond differently to increased suspended matter concentrations.

Table 3.29. Critical thresholds of corals for Total Suspended matter (mg/l)

Description	Location	Value (mg/l)	Reference
Coral reefs	Caribbean	10	Rogers , 1990
Coral reefs	Florida, USA	20	Bogers and Hardner, 2004
Corals	Dominican Republic	20	Ban der Klis and Bogers 2004
Marginal reef environments	Banten Bay, Indonesia	40	Hoitink,2003
Marginal reef environments	Paluma Shoals, Queenland, Australia	40	Larcombe ef.al.2001
7 resistant coral species	Florida, USA	165	Rice and Hunter,1992

Source: PIANC, 2010

Based on the above table, the critical thresholds of coral for SS in Indonesia is about 40 mg/l. That value can be applied to assess the critical thresholds of coral for SS in Vietnam owing to the meteorological condition Vietnam compare to Indonesia.

The maximum TSS concentration arisen in dumping phase is about 0.005-0.02 kg/m3 (5-20 mg/l). Meanwhile, TSS concentration at Breda shoal, Cu Lao Cau island and the rest of Hon Cau MPA remains same as current. According to the modeling results, during dredging process, the highest TSS value is ranging from 0.005-0.015 kg/m3 (5-15 mg/l). Meanwhile, TSS concentration at Breda shoal, Cu Lao Cau island and the rest of Hon Cau MPA remains still.

The maximum TSS concentration in this phase is lower than the permissive value (40 mg/l), so that the coral reefs at Hon Cau MPA will not be affected by suspended sediments. The coral species will be adapted new condition. Some tolerant species can temporarily switch between autotrophy (growth through photosynthesis) and heterotrophy (growth through filter feeding) or adjust their respiratory demands to maintain a positive energy balance in response to turbidity.

The increasing TSS will affect the living of sea grass and benthic species owing to the reduction in light permeation which subsequently reduces respiration of organisms and indirectly affects nutrient resources, growth and breeding rate of benthic and sea grass. However, these effects are expected to occur only within the project area. Therefore, the impact of TSS increase induced by land reclamation and dredging activities are estimated as small and short-term (within the implementing period); the organisms may adapt to the environmental change.

Consequently, the impact of TSS increase induced by land reclamation and dredging activities on coral reefs and sea grass at Hon Cau MPA are estimated as small and short-term (within the implementing period). These activities have no impact on the buffer zones and Core zone of the MPA.

3.2.2.4.3. Impact on the ecosystem due to the construction of the main plant and port

During the construction of the main plant and port, Hon Cau MPA can be impacted by following sources:

- Dust, wasted soil from construction activities, material taken by runoff rainwater to the water sources enhancing the turbidity and affecting the ecosystems of Hon Cau MPA.
- Activities of ships, boats and equipment as well as the transport of material in the construction phase (including land reclamation, dredging and port construction) may waste oil. These oils may harmfully affect the aquatic ecosystem at Hon Cau MPA.
- Besides, wastewater from construction barges and ships is also a significant threat.

Such impacts are estimated as significant yet reducible and controllable by appropriate management measures.

3.2.3. Impacts in operation phase

3.2.3.1. Sources of impacts relating to waste

Waste related impact sources, affected objects and impact assessment in the operation phase of the power plant are summarized in the table below:

Table 3.30. Sources of impacts relating to waste in operation phase

Impact sources	Affected objects	Impact assessment	Impact level
Cooling water discharge	Water quality at the discharging point Aquatic ecosystem	Impact of heat to the ecosystem and water quality at the region	Significant Long-term
Industrial wastewater discharge	Water quality at the discharging point	Affect the water quality at the region	Small
Air emission	Air environment	Emit polluted air containing NO_x, SO_2, dust and CO from fuel combustion affecting the air quality. Emit organic volatile compounds into the air	Medium
Transport and storage of coal	Air environment	Generate large volume dust affecting the ambient air quality	Small
	Water	Wastewater from washing the coal	Medium

	environment	transporting conveyor affects surface water quality if not being treated properly	
Activities of construction workers	Water environment	Wastewater from activities of operation staff affects surface water quality if not being treated properly (filtration, sedimentation, disinfection…)	Small
Industrial waste disposal	Air, water, soil environment	Solid waste from industrial activities will affect the surrounding environment if not being collected and treated properly.	Medium
Activities at the coal port	Air environment	Generate noise and vibration from unloading activities of ships and barges Emit dust from coal loading/unloading activities affecting air environment.	Medium
	Water quality	Wasted oil from equipment will pollute the water sources if not being treated properly	Medium
Oil spill, explosion of the pipeline	Air, water, soil environment	Potentially happen during the operation phase.	Medium

3.2.3.1.1. Air emission and dust

1. Air pollution due to flue gas from the plant

An air dispersion model has been used for predicting the diffusion of air pollutants from the flue gas of Vinh Tan 4 TPP. It incorporates all parameters of sources, climate, and atmospheric stability.

a. *Calculation of dust, NOx, Sox concentration in flue gas:*

Emission and dispersion of dust, NO_x, SO_x from flue gas of the power plant to the environment depends on coal fuel content, boiler technology, capacity and efficiency of the plant. Dispersion of dust and toxic gas is also dependant on the climate conditions and stack height. Hence, the power plant will use technology as well as the operation regime to ensure that toxic substances from stack emissions are lower than the permissive values as regulated in environment regulation of Vietnam.

The boiler used in Vinh Tan 4 TPP is Super Critical, spraying coal, wind – smoke balance. Main fuel is coal imported from Indonesia/Australia. Refer to Chapter 1 for more detail on characteristics of coal. Concentration and tonnage of NOx, SOx, dust, CO from Vinh Tan 4 TPP will be presented in following sections.

b. *Regulation to be applied for the power plant*

These regulation issued by MONRE regarding permissive values of pollutants need to be complied:

- QCVN 22:2009/BTNMT – National technical regulation on Emission of Thermal Power Industry.
- QCVN 05:2009/BTNMT – National technical regulation on ambient air quality

Based on the technology used and scale of emitting sources, the allowable concentrations of NO_x, SO_x, PM10 and CO for Vinh Tan 4 TPP are presented in

Table below.

Table 3.31. Permissive standard for toxic substances on ground and at source (Unit: mg/Nm^3)

Parameters	*At source - Stack*		
Capacity	1200MW		
Coal	Indonesia/ Australia		
Coefficient	QCVN 22:2009/BTNMT Kp = 0,85, Kv = 1		
NOx(calculating as NO2)	552,5 (650)		
SOx	425 (500)		
Dust	170 (200)		
CO(*)	800 (1.000)		
	On the ground: QCVN 05:2009/BTNMT		
	1h average	24h average	Annual average
NOx	0,2	0,1	0,04
SOx	0,35	0,125	0,05
PM 10	-	0,15	0,05
CO	30	5	-

Note: Values stipulated in parentheses () are the ones regulated in QCVN 22 without adjustment with correlative factors of the project: Kp:capacity factor, Kv: zone factor

Kp=0.85, applied for the plant with capacity of 300<P ≤1200MW

Kv=1, Vinh Tan 4 TPP is one of four power plants in the Vinh Tan Power Complex with total capacity of 5600MW.

*: *Permissive concentration of CO is stipulated in QCVN 19:2009/BTNMT (Kp=0,8, Kv=1).*

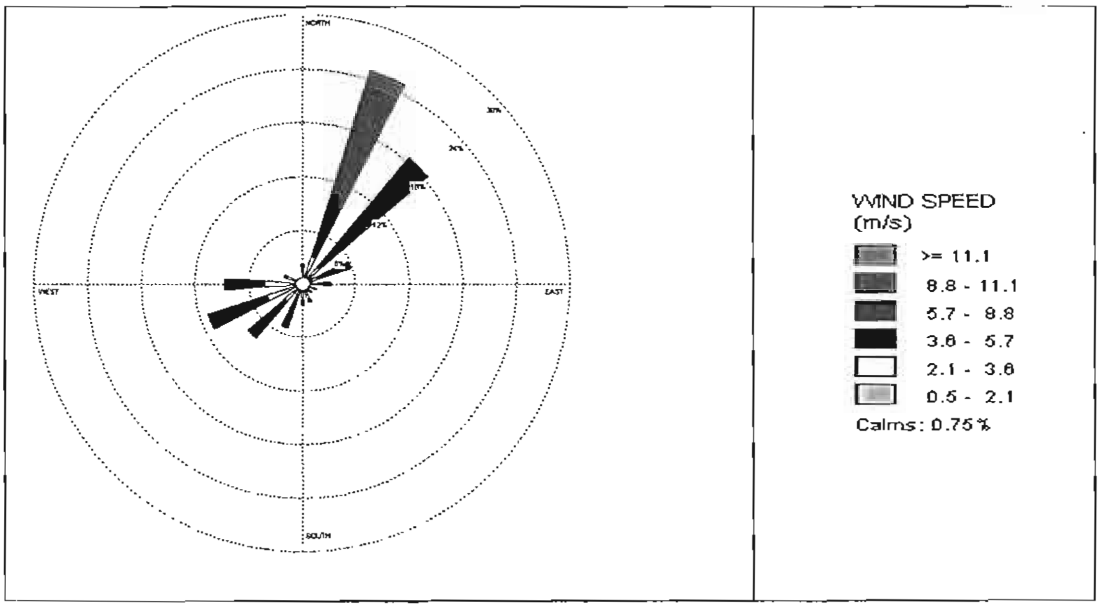
c. *Modeling and calculation methodology*

The modelling used to calculate air dispersion of thermal power plant is AERMOD View. The AERMOD atmospheric dispersion modeling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 kilometers) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data preprocessor (AERMET) that imports surface meteorological data, upper air soundings to calculate atmospheric necessary parameters such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.
- Aermod includes module Prime, for calculating build downwash due to impacts of neighboring buildings and structures.
- *Input data*
  + The most important flue gas discharged sources in plants are stacks of each unit. Each stack of power plant is a separate source; specifications of stack in the power plant are in Table 3.30.

+ Meteorology data: data of wind, temperature, rainfall, solar radiation, cloud cover… will be reported by the MM5 model – the Fifth-Generation meso-scale model of the National Center of Atmospheric Research and Penn State University – USA. Time span for the modeling is set as 1 year (2010). Wind rose diagram is presented in following figure.

Figure 3.32. 1-year wind rose diagram of the project area - data from MM5 model



d. Input parameters

The data of the flue gas (each unit) of the power plants in Vinh Tan power complex is presented in the table below. According to the calculation, the loads of NOx, SOx, dust from Vinh Tan 4 TPP as well as other plants are extracted from Steam Pro thermal cycle (USA), which is a commonly used cycles around the world with high reliability.

The program computes heat balance, system performance as well as calculates the concentration of pollutants in flue gas based on the combustion of fuel. However, the Steam Pro is not able to calculate the concentration of CO. The tonnage and concentration of CO is estimated by quick evaluation method of WHO (0.3 kg CO/ton of coal). The input data of the flue gas is described in the following table.

Table 3.32. Input data of the flue gas (each unit) of the power plants in Vinh Tan power complex

Parameter	Vinh Tan 4	Vinh Tan 3	Vinh Tan 2	Vinh Tan 1
Boiler	Supercritical (SC)	Supercritical (SC)	Sub-critical (SSC)	Sub-critical (SSC)
Coal	Imported coal	Imported coal	Domestic coal	Domestic coal
Stack height (m)	210	210	210	210
Number of stack (*)	1	1	1	1
Stack diameter (m)	8.5	9.5	8.5	8.2
Flue gas flow (m^3/s)	1541.29	1952.9	1566.4	1548.25

Parameter	Vinh Tan 4	Vinh Tan 3	Vinh Tan 2	Vinh Tan 1
Concentration of dust in flue gas (post-treated) (mg/Nm^3)	150	50	148	98
Load of dust in flue gas (post-treated) (g/s)	197.98	77.7	179.66	120.76
Concentration of SO_2 in flue gas (post-treated) (mg/Nm^3)	350	200	153	144
Load of SO_2 in flue gas (post-treated) (g/s)	461.94	310.87	185.73	177.45
Concentration of NO_2 concentration in flue gas (mg/Nm^3)	228	228	139	150
Load of NO_2 in flue gas (post-treated) (g/s)	300.26	353.61	168.74	184.84
Concentration of CO in flue gas (mg/Nm^3)	27	42.47	34.27	32.21
Load of CO in flue gas (g/s)	35.63	72	45.42	43.3
Temperature of flue gas post-treated (^oC)	75	70	80	70

Sources: Investment report of Vinh Tan 4 TPP (PECC2), 9/2012

*Note: *: consider the usable area of 2 small stacks as 1 big stack and calculate as one emission source (point source).*

Table 3.33. Concentration of the pollutants at the stack of each working unit before and after treatment system.

No.	Without ESP, FGD, control NOx measures				With ESP, FGD, control NOx measures				QCVN 22:2009/ BTNMT (mg/Nm^3)
	Concentration (mg/Nm3)				Concentration (mg/Nm3)				
	Vinh Tan 4	Vinh Tan 3	Vinh Tan 2	Vinh Tan 1	Vinh Tan 4	Vinh Tan 3	Vinh Tan 2	Vinh Tan 1	
NO_2 (3)	-	-	1200	1200	228(2)	228(2)	139(1)	150(1)	552.5
NOx treatment efficiency of SCR (%)							88.4	87.5	
SO_x (4)	2660	1600	1530	1530	350	200	153	144	425
SOx treatment efficiency of SeaFGD (%)					86.8	88.5	90	90.5	
PM10(5)	6891	7600	36920	36920	150	50	148	98	170
Dust treatment efficiency of ESP (%)					97.8	99	99.5	99.7	

No.	Without ESP, FGD, control NOx measures				With ESP, FGD, control NOx measures				QCVN 22:2009/ BTNMT (mg/Nm^3)
	Concentration (mg/Nm3)				Concentration (mg/Nm3)				
	Vinh Tan 4	Vinh Tan 3	Vinh Tan 2	Vinh Tan 1	Vinh Tan 4	Vinh Tan 3	Vinh Tan 2	Vinh Tan 1	
CO	-	-	-	-	27	42.47	34.27	32.21	800

Note:

(1) Using NOx external treatment by SCR

(2) Using Use NOx internal treatment

(3) Conversion factor between NO_2 and NOx: $\frac{NO_2}{NO_x} = 0,5$

(4) Treating SOx by SW-FGD system

(5)Treating particulate by ESP system

e. Calculation scenarios

There are two scenarios:

Scenario 1: Vinh Tan 4 TPP operates using SC boiler with ESP, FGD, control NOx measures installed.

Scenario 2: Vinh Tan 1, 2, 3, and 4 simultaneously operate (with ESP, FGD, control NOx measures installed for Vinh Tan 3, 4 TPP while Vinh Tan 1, 2 use SCR system for NOx treatment)

f. Calculation of stack height

According to the instruction of IFC regarding safety, health and safety, the calculation of stack height where adjacent building exist is presented as follows:

$$H_G = H + 1.5L$$

Where:

HG: the height of stack compare to the elevation at the bottom of the stack

H= the height of construction items nearby the stack

L: distance (diameter, height or width of the construction item nearby the stack).

"The construction item nearby the stack" is defined as the construction with in the distance of 5L but not higher than 800 m.

The following calculation was based on the dimension of construction items in Vinh Tan 4 TPP:

Boiler building: height 83.6m, length 221 m and width 84m

Turbine building: height 34.2m, length 221 m and width 32m

In such case, the construction of boiler building will affect the flue gas emission of the TPP the most and the height of stack was calculated as follows:

$$HG = 83.6+1.5x\ 84 = 209.6\ (m) \sim 210\ (m)$$

According to that, 210 m is the minimum height for internal building not to affect the dispersion of flue gas.

g. *Calculation results*

The results of PM10, NO_x and SO_2 dispersion are revealed in Table 3.1 and Figure 3.40.

- Scenario 1: considering only operation of Vinh Tan 4 TPP: in case that Vinh Tan 4 TPP uses Indonesian coal with the treatment efficiency of ESP is 97.8%; the SO2 treatment efficiency of FGD is 86.8%; low NOx burner is employed and the stack height is H=210 m, the concentrations of pollutants (dust, NOx, CO and SO_2) at 1 h average and 24h average are all lower than the standards regulated in QCVN 05-2009/BTNMT.

+ The maximum concentration of PM10 – 24h average on the ground is about 0.008 mg/m^3, lower than allowable value regulated in QCVN 05:2009/BTNMT (0.15 mg/m^3).
+ The maximum concentration of SO_2 – 1h and 24h average on the ground is about 0.148 mg/m^3 and 0.019 mg/m^3 respectively, lower than allowable value regulated in QCVN 05:2009/BTNMT (0.35 mg/m^3 and 0.125 mg/m^3).
+ The maximum concentration of NOx – 1h and 24h average on the ground is about 0.096 mg/m^3 and 0.012 mg/m^3 respectively, lower than allowable value regulated in QCVN 05:2009/BTNMT (0.2 mg/m^3 and 0.1 mg/m^3).
+ The maximum concentration of CO – 1h and 24h average on the ground is about 0.014 mg/m^3 and 0.0019 mg/m^3 respectively, lower than allowable value regulated in QCVN 05:2009/BTNMT (30 mg/m^3 and 5 mg/m^3).
+ The annually average concentration of NOx, SOx, CO and PM10 are all lower than allowable value regulated in QCVN 05:2009/BTNMT.

- Scenario 2: all the plants in Vinh Tan PC simultaneously operate: in such case where the height of all stacks of Vinh Tan 1, 2, 3 and 4 TPP is 210m, load of pollutants (dust, NOx, SO2, CO) 1h and 24h average is described as follows:

+ The maximum concentration of PM10 – 24h average on the ground is about 0.019 mg/m^3, lower than allowable value regulated in QCVN 05:2009/BTNMT (0.15mg/m^3).
+ The maximum concentration of SO2 – 1h average on the ground around the project area is about 0.303 mg/m^3, much lower than allowable value regulated in QCVN 05:2009/BTNMT (0.35 mg/m^3) while the maximum concentration of 24h average is 0.034 mg/m^3 , still lower than allowable value in QCVN 05:2009/BTNMT (0.125 mg/m^3).
+ The maximum concentration of CO – 1h average on the ground around the project area is about 0.055 mg/m^3, much lower than allowable value regulated in QCVN 05:2009/BTNMT (30 mg/m^3) while the maximum concentration of 24h average is 0.0067 mg/m^3 , still lower than allowable value in QCVN 05:2009/BTNMT (5 mg/m^3).
+ The maximum concentration of NOx – 1h average is 0.268 mg/m^3, about 1.3 time higher than allowable value in QCVN 05:2009/BTNMT (0.2 mg/m^3). However, the sites where maximum concentration of NOx

observed focus mainly at East sea area, around 3.3 km from the project site to the southeast. The sites with NOx concentration about 0.21-0.25 mg/m^3 focus mostly at the mountain area in the Northeast (about 2 km away from the VT4 TPP) and the eastern site (about 3.2 km from VT4 TPP) has the NOx concentration ranging from 0.20-0.21 mg/m^3.

+ The maximum concentration of NOx at Hamlet 7(Vinh Phuc and Vinh Tien villages) ranges from 0.12-0.15 mg/m^3, about 1.2 – 1.6 time lower than the permissive value and that of the residential area at the eastern site is about 0.19-0.2 mg/m^3, close to the standard.
+ The concentration of NOx at Hon Cau island is about 0.1 mg/m^3 not exceeding the value regulated in QCVN 05:2009/BTNMT.
+ Additionally, the air emission modeling, i.e. AERMOD has predicted the 1h average concentration of NOx at 99.98 percentile is about 0.2 mg/m^3, meets the regulated standard in QCVN 05:2009/BTNMT (0.2 mg/m^3). This means at the northeastern mountain, eastern site and East Sea where the concentration is above 0.2 mg/m3, there are only twice per year, the NOx value exceeds the allowable value.
+ According to the Directive 2008/50/EC of the European Parliament and of the Council of May 21 2008 on Ambient air quality and cleaner air for Europe, the permissive value of 1h average is 200 $\mu g/m^3$ (0,2 mg/m^3), and this value must not be exceeded more than 18 time (hour) per year (8760 h) equivalent to percentile 99.79^{th}.
+ According to the calculation for pollutant diffusion of Vinh Tan 4 TPP, at places where the NOx value is over 0.2 mg/m^3, the actual concentration only exceeds the permissive standard about 2 hours per year, less than the allowable 18 hours. Hence, this impact is evaluated as acceptable.

Details on method, result and calculation of air emission at Vinh Tan 4 TPP are described in Appendix 3.3.

h. Conclusions

As Vinh Tan 4 TPP operates, imported coal is used as fuel; ESP for dust removal, SWFGD for SOx removal, Low NOx Burner for NOx restriction are employed; stack height is 210 m, the emission of PM10, SOx and NOx is expected not pollute the ambient environment.

In case that the whole Vinh Tan PC is taken into calculation, with the height of all stacks of Vinh Tan 1, 2, 3, 4 TPP is 210 m, the 1h average of NOx at ground will be higher than the allowable standard. Yet, the total duration of this excess is only 2 h per year, focusing mostly offshore and on the mountain. Therefore, the impact of NOx is estimated as acceptable.

– Increasing air pollution due to using oil as fuel: Vinh Tan 4 TPP will have to use oil in the startup process or additional combustion at low load. Oil used as diesel oil FO. In the case of using as fuel oil, dust emissions will be treated with ESP equipments. The SO_2 removal is also treated by SW-FGD equipment.

Figure 3.33. NOx diffusion – Maximum 1h average – Scenario 1

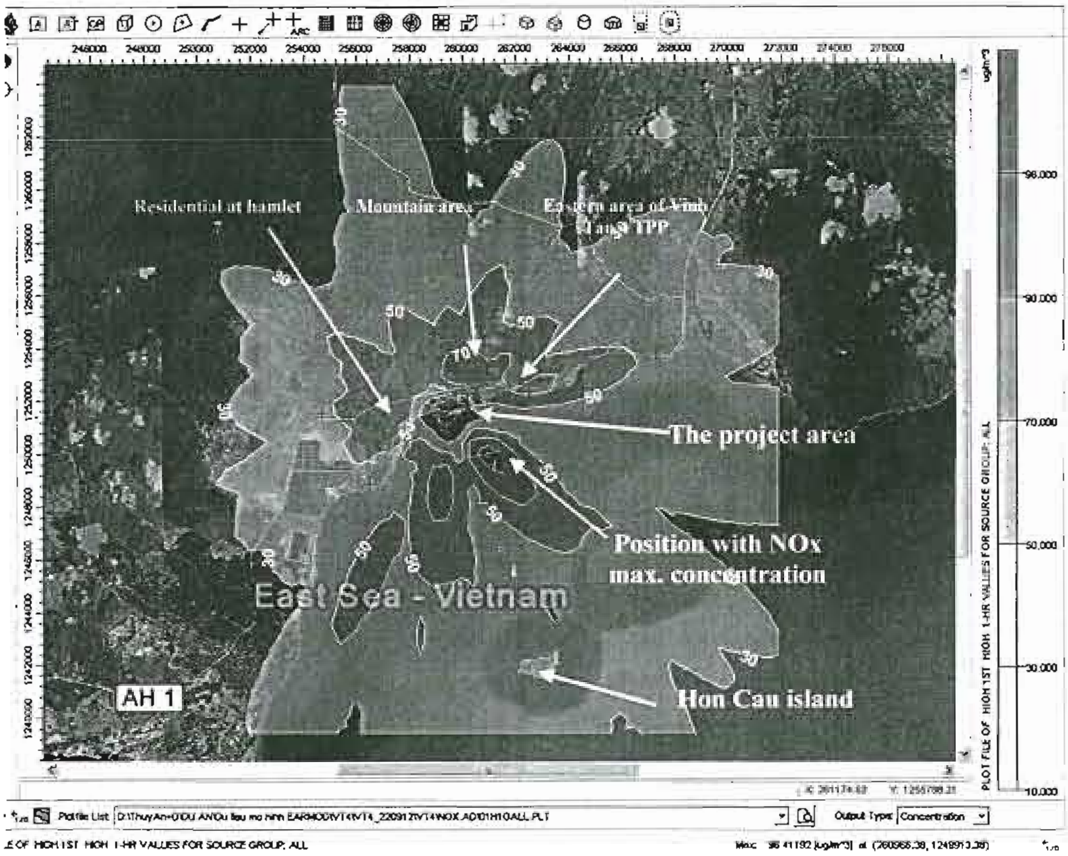


Figure 3.34. NOx diffusion –Maximum 1h average – Scenario 2

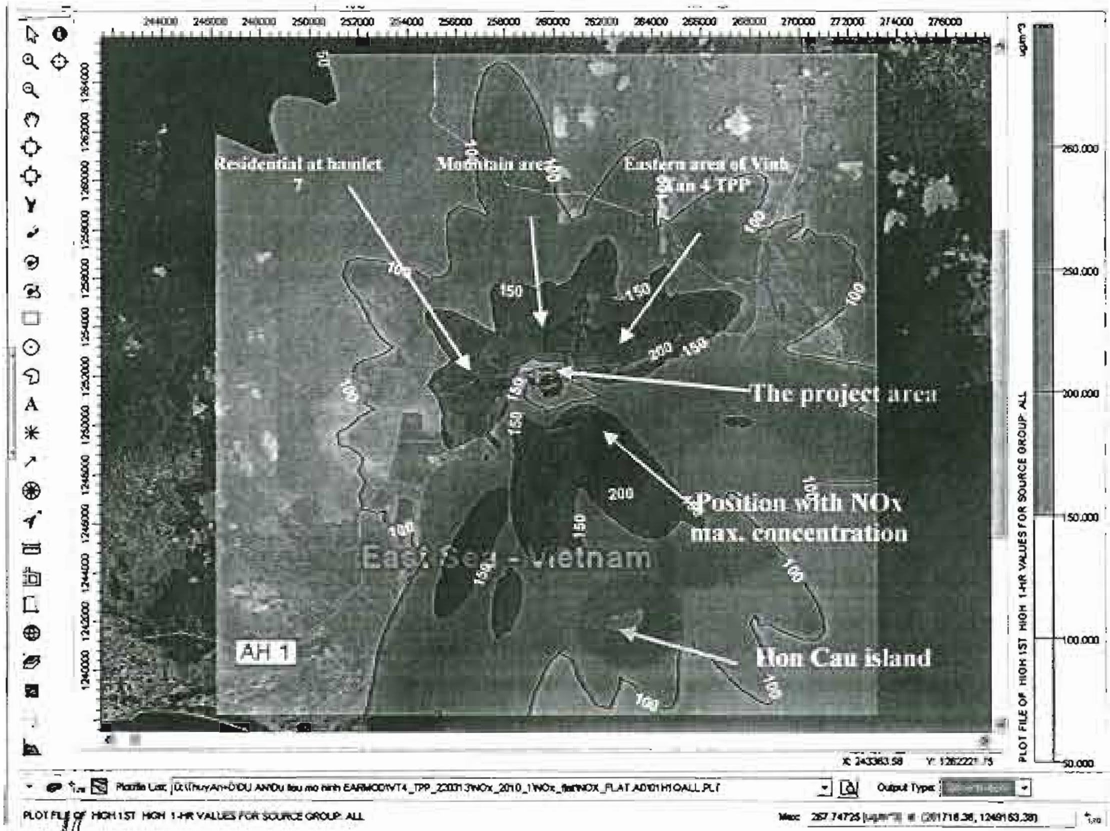


Figure 3.35. NOx diffusion – Maxium 1h average - 99.98% percentile – Scenario 2

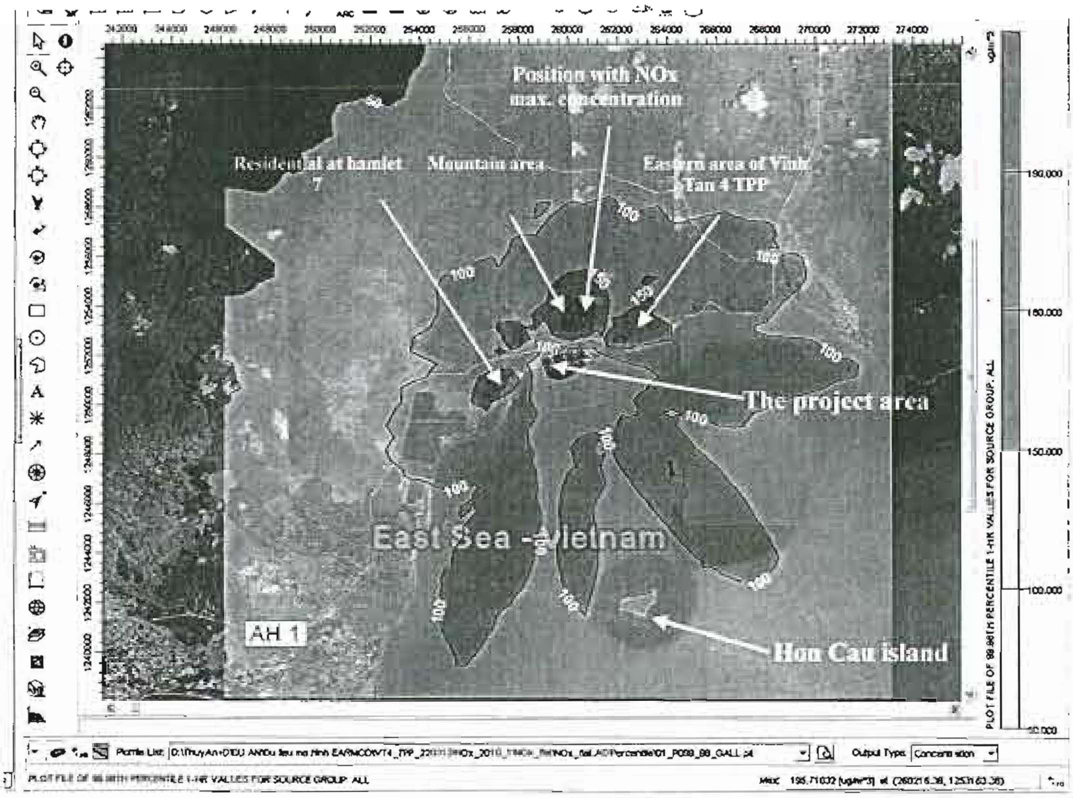


Figure 3.36. SOx diffusion –Maximum 1h average – Scenario 1

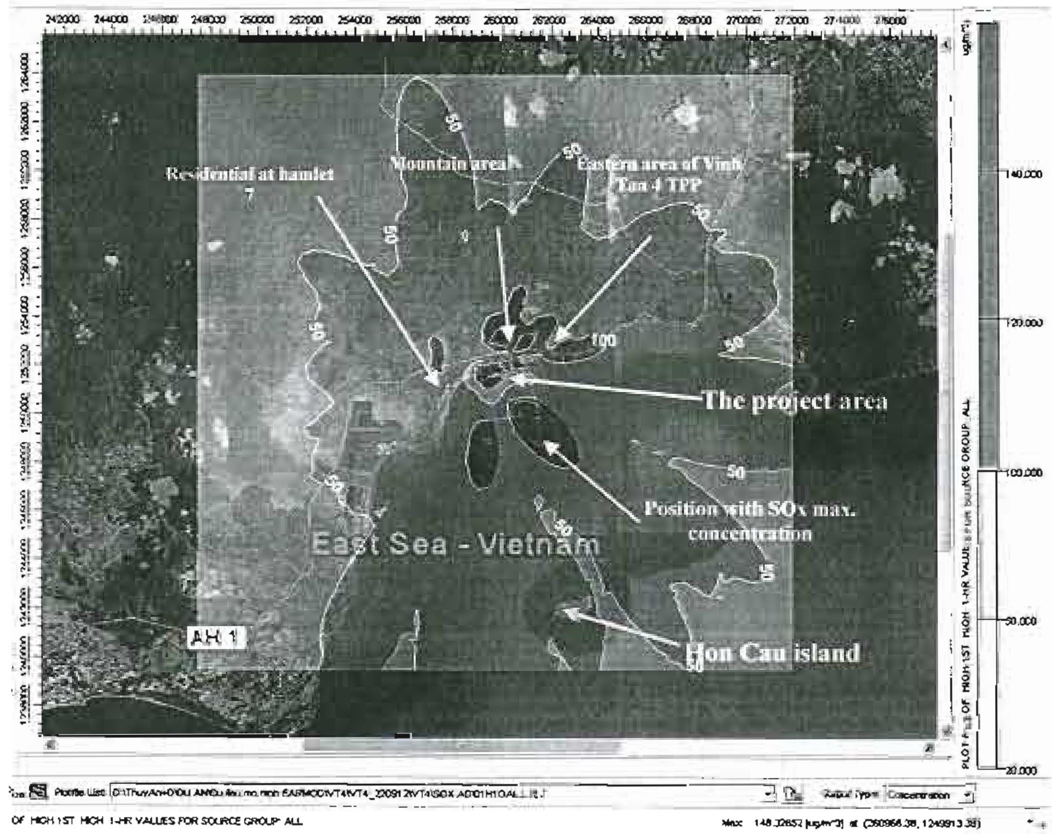


Figure 3.37. SOx diffusion - maximum 1h average – Scenario 2

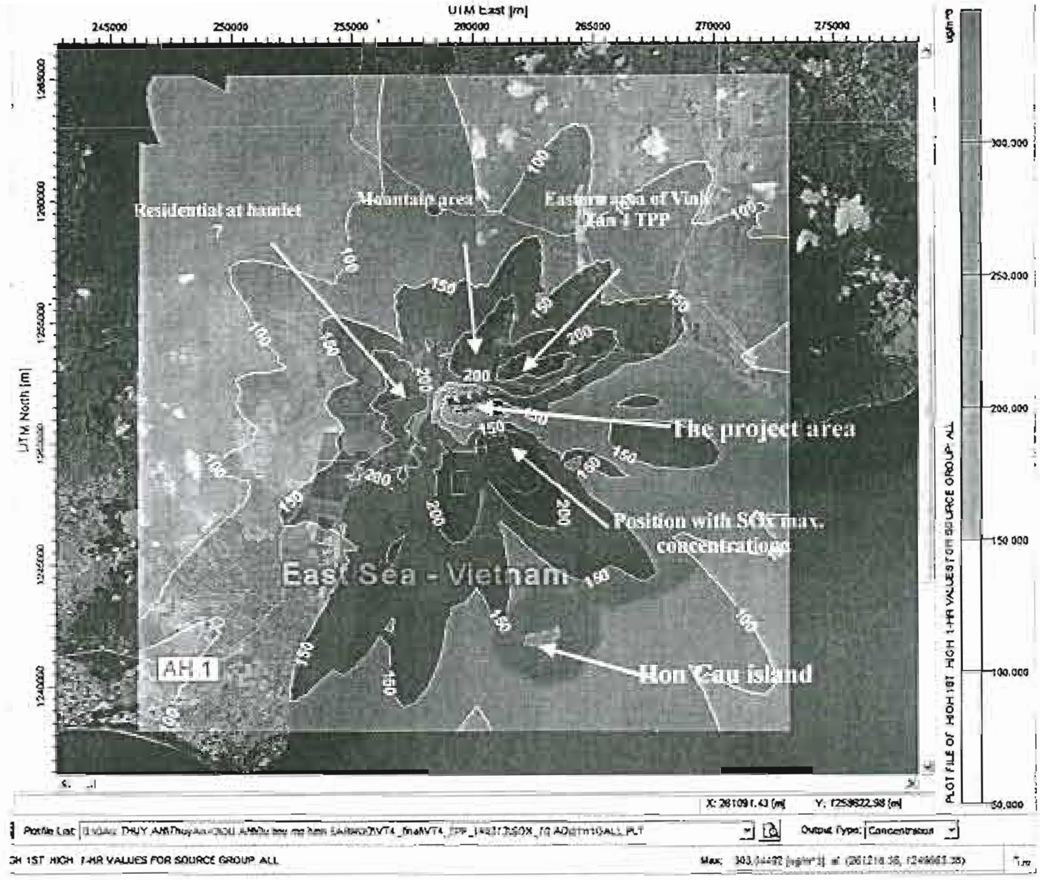


Figure 3.38. PM10 diffusion – Maximum 24h average – Scenario 1

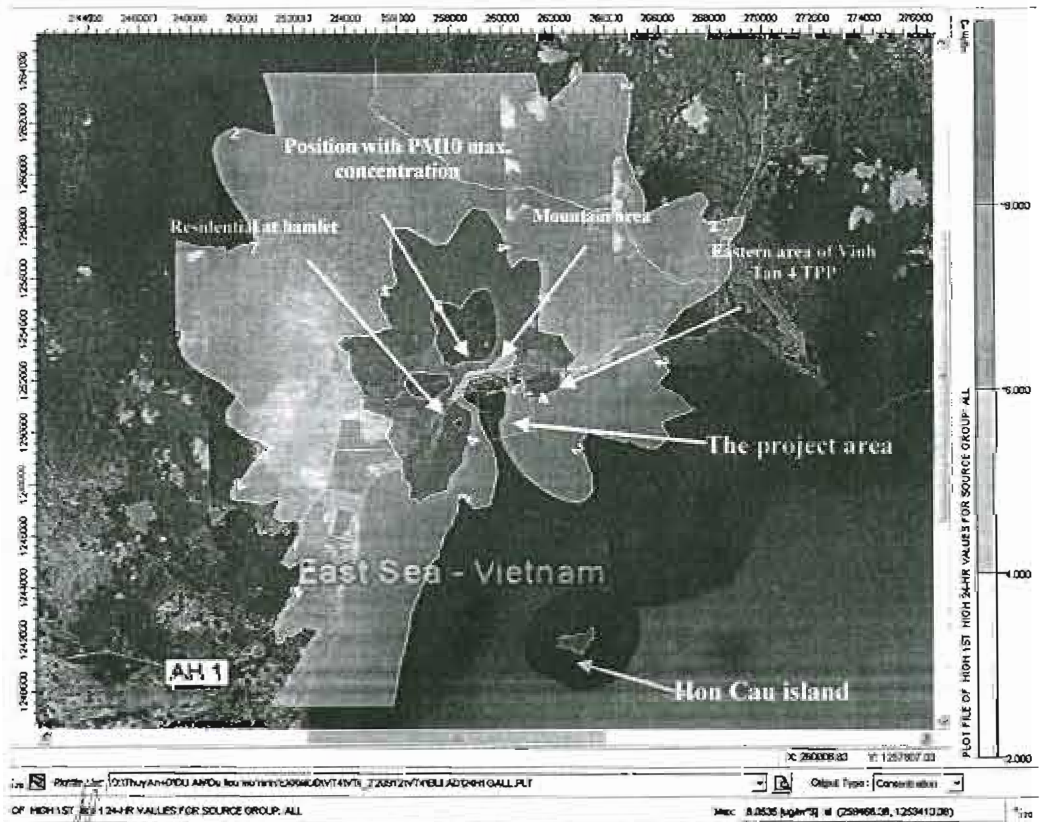


Figure 3.39. PM10 diffusion - Maximum 24h average – Scenario 2

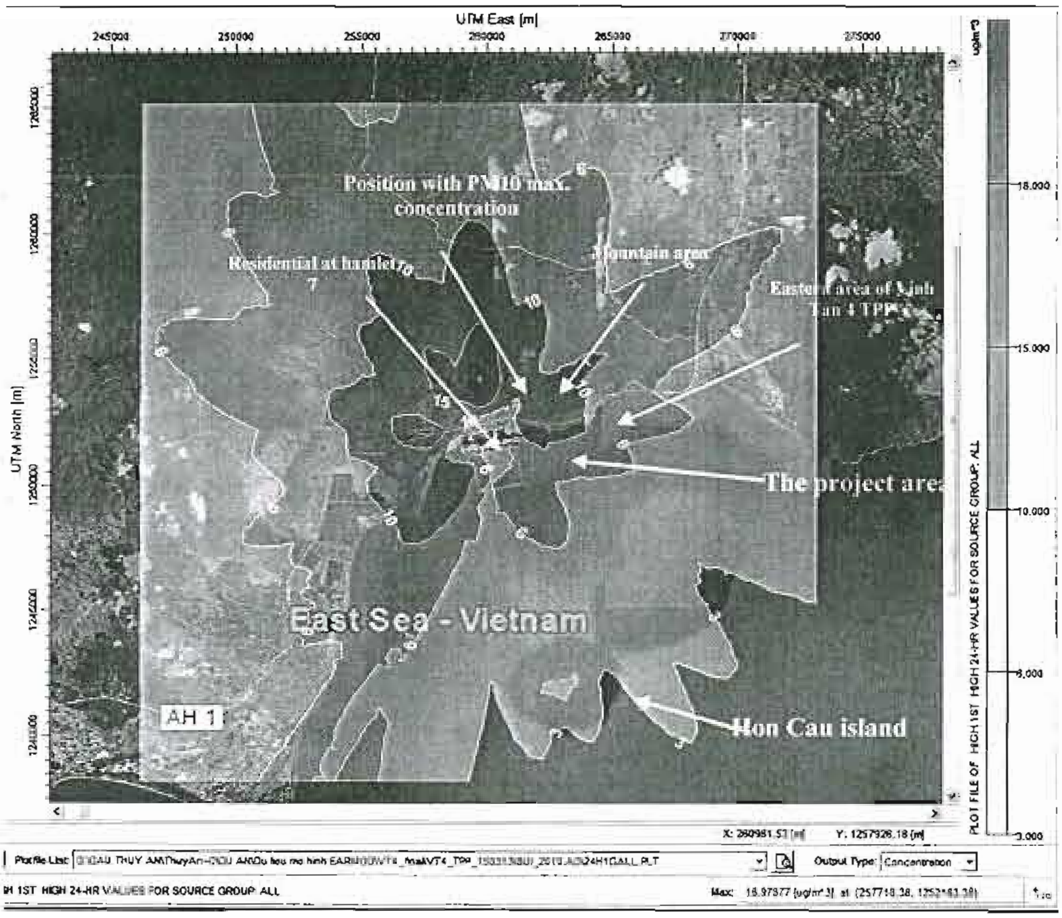


Figure 3.40. CO diffusion – Maximum 1h average – Scenario 2

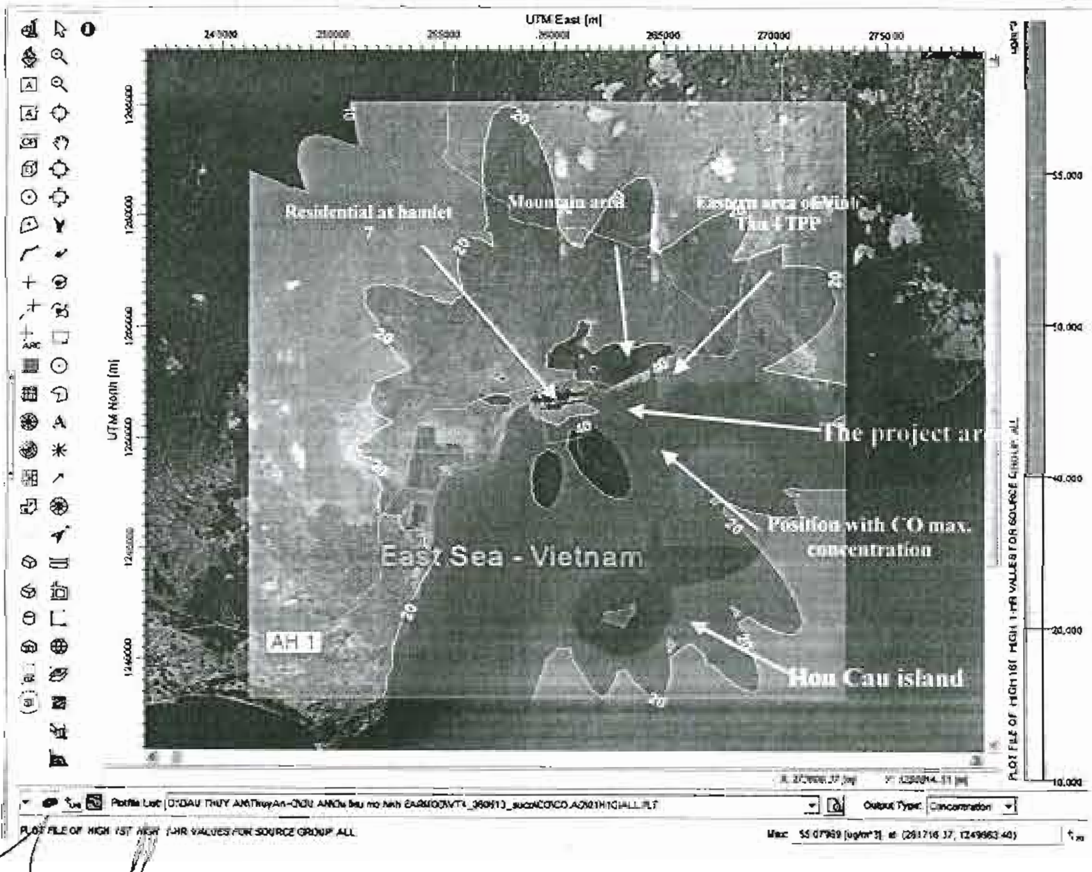


Table 3.34. Calculation results of PM10, SOx, NOx concentration on the ground

Scenario	Calculation results												
	Para meter	QCVN 22:2009	Concentration at stack				Average time	Maximum concentration of air pollutants on the ground		Distance from the stack	QCVN 05:2009 (max. concentration on ground))	Direction	Note
		mg/Nm3	mg/Nm3					(mg/m3)	(mg/m3)	(km)	(mg/m^3)		
			VT 1	VT2	VT3	VT 4			99.98th Percentile				
Scenario 1: only operation of Vinh Tan 4 TPP	SOx	425				350	1h	0.148		2.5	0.35	Southeast	
							24h	0.019		1.9	0.125	North	
							Annual	0.003		3.0	0.05	Southwest	
	NO_2	552.5				228	1h	0.096		2.5	0.2	Southeast	
							24h	0.012		1.9	0.1	North	
							Annual	0.0019		3.0	0.04	Southwest	
	PM10	170				150	1h	0.063		2.5	-	Southeast	
							24h	0.008		1.9	0.150	North	
							Annual	0.0012		3.0	0.005	Southwest	
	CO	800				27	1h	0.014		2.5	-	Southeast	
							24h	0.0019		1.9	0.150	North	
							Annual	0.0003		3.0	0.005	Southwest	
Scenario2: operation	SOx	425	144	153	200	350	1h	0.303		3.3	0.35	Southeast	
							24h	0.038		1.5	0.125	North	

Scenario	Calculation results												
	Parameter	QCVN 22:2009	Concentration at stack				Average time	Maximum concentration of air pollutants on the ground		Distance from the stack	QCVN 05:2009 (max. concentration on ground))	Direction	Note
		mg/Nm3	mg/Nm3					(mg/m3)	(mg/m3)	(km)	(mg/m^3)		
			VT 1	VT2	VT3	VT 4			99.98th Percentile				
of all power plant in Vinh Tan PC							Annual	0.0056		2.5	0.05	Southwest	
	NO_2	552.5	150	139	228	228	1h	0.268	0.2	3.3	0.2	Southeast	
							24h	0.034		1.5	0.1	North	
							Annual	0.006		2.5	0.04	Southwest	
	PM10	170	98	148	50	150	1h	0.154		3.3	-	Southeast	
							24h	0.019		1.5	0.150	North	
							Annual	0.0032		2.5	0.05	Southwest	
	CO	800	32.2	34.2	42.4	27	1h	0.055		3.3	30		
							24h	0.0067		1.5	5		
							Annual	0.001		2.5			

Source: PECC2-6/2013

*Note: *: 99.98th percentile: 99.98 % of the observed values is less than 0.2 mg/m^3*

2. Air pollution by emissions from the transport serving for plant, ports (ships, barges, trucks, tanks, trailers, etc.):

During operation phase, emissions arising from transport are mainly two routes: roads and waterways.

Operation of barges, ships transporting coal for Vinh Tan 4 TPP will arise, emissions as dust, SOx, NOx, CO, THC, which will affect to the environment. Load and concentration of emissions depend on the density, quantity and type of fuel used by vessels operating daily transportation. However, it can be predicted that the level of air pollution caused by ships is not great due to the maximum receiving limit of Vinh Tan 4 TPP 's port which will only receive a maximum of 40 vessels per year. Hence, the amount of dust, SO2, NOx, CO releasing from ship is not great. Furthermore, each year, Vinh Tan Power Complex receives about 394 boats which means there is only about 1 ship/day operating at Vinh Tan PC despite the operation of all the power plants.

The amount of pollutants due to emissions from transport ships of 100,000 DWT is estimated in Table 3.35. The average number of vessels in port is about 1 ship/3 days. Based on the pollution coefficient established by WHO and experimental equation (2), it is assessed the level of pollution caused by emissions from the ship is very small compared to the standard evaluated in the area of 331.43 ha, 5 m high and revealed in the following table:

Table 3.35. Emission tonnage by big vessels in operation of Vinh Tan 4 TPPs port

	Number of vessels on port	Ships in berth (ship-days in berth) (unit-U)	Coefficient (kg/U)	Tonnage (g/h)	Concentration (oncent	QCVN 05:2009
TSP	1	45	6.8	151.1	0.02	0.3
SO_2			136S	90.67	0.01	0.35
NOx			90.7	2015.56	0.12	0.2
CO			0.036	0.8	0.0001	30
VOC			4.1	91.1	0.012	-

Note: Pollution coefficient referred from Rapid Assessment of Sources, WHO 1993.
Sulfur content in FO oil is 3%.
Time of ship in port: 45h.

The air emission from high tonnage ships is evaluated as small in both cases when only Vinh Tan 4 TPP operates or the whole power complex works.

Coal from ships/boats will be unloaded by grab dischargers and transported to coal storage of power plant by closed conveyor system along the port. Therefore, dust is not generated during transportation. Other goods will be unloaded from ships by floating cranes, wheels or caterpillar crane and transported to power plants by large trucks/trailers.

Operation of the port facilities (trucks, trailer relay etc.), the transport vehicles using mainly gasoline and diesel as fuel will discharge exhausted gas (NO_2, CxHy, CO) into the environment. However, this impact is significantly limited due to low density of vehicle traffic (coal is transported by conveyor) and spreading duration of transport as well as working schedule in daytime.

3. Air pollution from emissions arisen from unloading coal from boats/ships to coal storing place

The loading and unloading of coal from ships to coal storing places will arise a large amount of dust if there is no mitigation measures applied. Coal dust will affect to ambient air quality in ports and coastal areas as well as the health of the operator.

As designed, coal will be transported by big ships to ports before being unloaded by belt conveyors to coal storage place. Conveyor system is designed horizontally for transporting coal in which a two-conveyor system is arranged with rail system for loading and unloading equipment.

Ship → coal unloading grabber → belt conveyor system in front of the port → {transfer station → belt conveyor system at back of the port → the power plant}

Dust concentration in the air in the port area at coal unloading time can be up to ten mg/m^3 where there is no control measures.

On the other hand, the dust generated in the port terminal area may disperse via winds in air and then sediment to surface land. Dust will accumulate in land, water source and cause pollution land/water.

According to calculation of US.EPA, dust emission sources of coal pile mainly include 2 sources: emission from coal unloading/transporting and emission from wind erosion at open coal storages and can be calculated as following:

Dust emission from coal unloading:

$$E = k \times 0.0032 \times \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where: E : Emission factor (lb dust/tons of coal)

K : particle size multiplier ($k_{TSP} = 1$)

U : average wind speed (5m/s ≈ 11.18 mile/h)

M : average humidity of particle (6.9%)

Emission from wind erosion

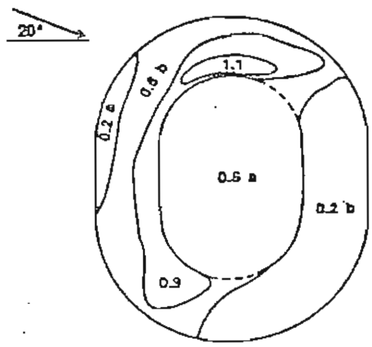
$$E = k\sum_{i=1}^{N} P_i \quad where \quad P_i = 58\times(u^* - u^*_t)^2 + 25(u^* - u^*_t) \quad for \quad u^* > u^*_t$$

$$and \quad P_i = 0 \quad for \quad u^* \le u^*_t$$

Where: E : emission factor (g/m²/year)

k : particle size multiplier ($k_{TSP} = 1$)
P_i : emission potential factor (g/m²)
u^* : equivalent friction velocity ($= 0.1 \times u_s^+$)
u_s^+ : surface wind speed distribution ($= u_s/u_r \times u_{10}^+$)
u_{10}^+ : fastest wind speed at 10m high (m/s)
u_s/u_r : ratio of surface wind speed to approach wind speed
u^*_t : threshold friction velocity (= 1.12m/s for dry coal pile

The coal pile form of Vinh Tan 4 TPP is truncated oval shapes. Coal storage yard Vinh Tan 4 TPP consists of three coal piles with one big and 2 small coal piles (*see drawing on general layout of Vinh Tan 4 TPP*). Assuming the shape of the coal pile and approached wind direction and dividing the coal pile to sectors form with us/ur ratio is shown in figure below. These sectors will be used to calculate the equivalent friction velocity (u *)



Pile B2

From above equations, the volume of dust generated at coal storage area of Vinh Tan 4 coal port can be calculated as in Table below.

Table 3.36. Dust generated from coal storing place of Vinh Tan 4 TPP

	Dust tonnage (g/s)	Note
Maximum coal volume (thousand tons)	392.4	
Number of coal pile	1 big and 2 small coal piles	
Total generated dust tonnage		
None mitigation measures		
Coal unloading	0.01	
Emission from wind erosion	0.72	
Total	0.73	
Mitigation measures applied		
Efficiency 90%	0.07	Semi- roof + wind against wall + water spraying system.

Source: PECC2, 9.2012

To simulate the dust dispersion arising from coal storage area, the project used Aermod model by the U.S. Environmental Protection Agency

(US.EPA) to predict dust dispersed to the air environment as well as the highest concentration of dust on the ground. Aermod Model can be used to calculate the pollutant concentrations and deposition range from complex industrial waste sources.

Meteorological data are from continuous measurement every hour during one year at the project area (data are taken from MM5 model – meteorological data predicting model).

Source of dust emissions from the Vinh Tan 4 TPP's port and the coal handling at the port is considered as the area source.

The results of the model are presented in Table 3.37, Figure 3.41 and Figure 3.42.

Table 3.37. Results of TSP dispersion on ground

	Maximum concentration on ground (mg/m^3)		
	1h	24h	Annual
QCVN 05:2009/BTNMT	0.3	0.2	0.05
No mitigation measures applied	0.35	0.056	0.018
Control measures applied – efficiency 90%	0.035	0.006	0.0018

Source: PECC2, 9.2012

Comments:

- In the case of no dust mitigation measures being applied in the coal storage area, the maximum dust concentration on ground is 1.2- time higher than permitted value in QCVN 05:2009/BNTMT – National technical regulation on air ambient quality. The polluted area range is near project area (Figure 3.41), the highest dust concentration was found offshore at about 700 m southward from the coal strorage area. Therefore, without appropriate management measures, air pollution due to dust from coal yard is significant.

  Actually, to limit the spreading of dust from transporting and unloading coal at the coal yard of Vinh Tan 4 TPP, the coal port and coal storage area will adopt some mitigating measures such as:
- To build windbreaks walls for each coal bunker, install a semi- roof system with 3 texture windscreen, and the water spraying system and fire fighting system are installed along coal transport conveyor system with a flow of 20-30 l/s. Estimatedly, the amount of dust will be reduced about 90% (by Fugitive Dust Handbook, Wrapair, 2006)
- According to the calculated results in Table 3.37, with the efficiency of 90%, the maximum dust concentration meets the allowed values specified in QCVN 05:2009/ BTNMT(dust concentration is more 9 times than allowed values), and concentrated around the coal storage area within the scope of the project, not affecting to the surrounding residential areas. The dispersion of dust is presented in Figure 3.41. Concentration of dust in the Vinh Tien and Vinh Phuc village, Vinh Tan commune is less than 20 µg/m^3, which is 15-time lower than the permitted value.

Figure 3.41. Dust diffusion – Maximum 1h average – Without mitigation measures

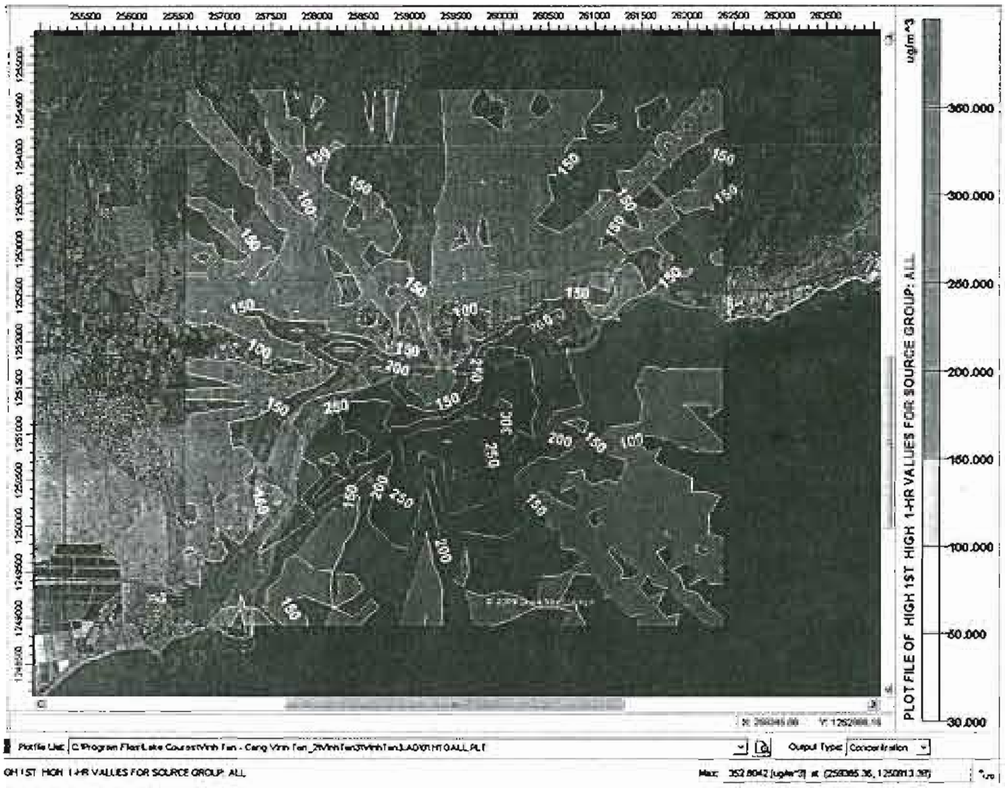
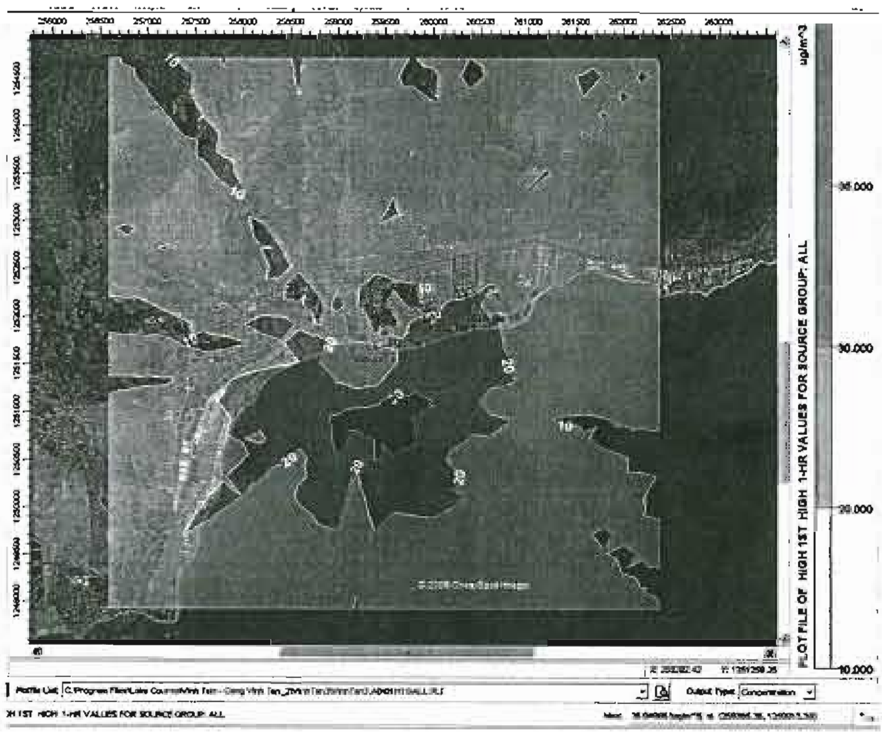


Figure 3.42. Dust diffusion – Maximum 1h average – Applied mitigation measures – Effiency 90%



4. Greenhouse gases emissions

The activities of the power plant will release a large amount of greenhouse gases into the atmosphere. Content of Carbon in fuel coal is about 64%; with about 2.8 million tons of coal being used per year, a volume of 5.3 million tons CO_2 will be released. This accounts for 5.3% the total volume of CO_2 released from all sources of Vietnam (98.76 million tons/year, 2009). The total volume of CO_2 emission of Vietnam and some Asian countries in 2009 is listed as follows:

Table 3.38. The CO_2 emission of Vietnam and some Asian countries in 2009

Country	Total CO_2 emission (million ton)
Vietnam	98.76
Philippines	72.39
Thailand	253.38
Indonesia	413.29
China	30398.42

Source: UNFCCC, 2011

3.2.3.1.2. Wastewater sources

1. Wastewater pollution from the operation of the power plant

Sources and characteristics of wastewater generated from the operation of the Project include:

Runoff water in the area of the power plant.

Wastewater from the operation of the power plant includes: (i) Domestic wastewater of employees in the factory; (ii) production wastewater (sewage washing air heaters, waste water from demineralized water system, waste water from washing the floor, etc.) and (iii) circulated cooling water system.

Characteristics of each type of wastewater generated from the power plant area are summarized in Table 3.1.

The total number of worker working at Vinh Tan 4 TPP is about 500 people, operating in 3 consecutive shifts. The amount of wastewater generated is about 120 m³/day.

Vinh Tan 4 TPP will build the wastewater treatment plants include production wastewater treatment systems, domestic wastewater treatment system to handle all types of wastewater arising from power plant. Wastewater after treating will meet environmental standards in QCVN 40:2011/BTNMT, type B, Kq = 1, Kf = 0,9.

Table 3.39. Composition and impacts of wastewater from Vinh Tan 4 TPP

Type of wastewater	Environmental impacts
A. Cooling water	
1. Cooling water	Cooling water is taken from the sea, running through the condenser and being discharged to the sea through a discharge point at the eastern site of the Plant. The flow of cooling water discharged is estimated at a maximum value of 50m³/s as if the Vinh Tan 4 TPP uses

Type of wastewater	Environmental impacts
	super-critical technology. After cooling, the temperature of water is about 8°C higher than the seawater temperature, which is approximately 37°C. This value still satisfied the regulation of QCVN 40:2011/BTNMT type B where the temperature must be lower than 40°C. However, the increase in water temperature can cause negative impacts on regional ecosystems, especially on the areas near the discharge points of cooling water. This is one of the significant potential impacts of the project which will be presented next sections
B. Industrial wastewater	
I. Chemical contaminated wastewater: wastewater from supply water treatment system, demineralized water treatment system, boiler cleaning wastewater (irregular, wastewater from the condenser and hydrogen production process)	This wastewater has a flow of about 30 m³/h and a diverse chemical composition. The main chemicals include: strong caustic or acid, metal compounds, SiO_2, PO_3, $CaSO_3$ $CaSO_4$ and high suspended solids matter... They will affect significantly to environment, unless treatment measures are applied.
2. Oily wastewater	Oily wastewater generated from production activities has a flow of about 10 m^3/h. Due to the flexibility of oil in water, it spreads quickly and forms a thin layer covering the surface and therefore hinder the interaction between oxygen and water. This means the concentration of dissolved oxygen in water is reduced, causing decrease of self-cleaning capability of the water source as well as significant influences on regional aquatic life
3. Coal contaminated wastewater	With flow of 50 m^3/h, coal contaminated wastewater flow even can be increased on rainy days. It contains high content of suspended sediment. However, this wastewater type is assessed as having negligible impacts on environment because it can be handled in coal contaminated wastewater treatment system before being reused in the plant (moisturize ash, cleaning the coal yard).
Wastewater from SeaFGD system	Seawater distributed in absorber and contacted, mixed with the flue gas. SO_2 in the flue gas will chemically react with alkalinity components in sea water, creating ion sulphite SO_3^{2-} and H^+, while the pH of the water will reduce, the sea water will be acid seawater (pH ~ 3) if there is no treatment measures, they will affect water resources and aquatic systems
4. Wastewater from the ash yard	Wastewater generated from ash yard will be collected, treated and re-circulated to the ash and slag storage tank in the ash yard. This wastewater group often has high contents of suspended solids and contains some chemicals such as HCO_3^-, Cl^-, etc. Without appropriate treatment performed, this

Type of wastewater	Environmental impacts
	wastewater will affect water resources and aquatic systems.
5. Wastewater from the RO system	It is contaminated with salt and therefore has a high salinity concentration. This wastewater type will not change the chemical properties of water and therefore will be discharged directly into sea.
C. Domestic wastewater	Domestic wastewater of workers has quite large volume (≈ 120m^3/day) and contains pollutants such as COD, BOD, SS, and Coliforms.
D. Runoff water	Runoff water in areas as transformers, oil tanks will be collected and transferred to oily wastewater treatment system. Runoff water in other areas (roofs, roads, etc.) establishes as the water and will be collected via manholes and discharge to receiver via drainage system.

Source: PECC2, 9/2012

Table 3.40. Predicted wastewater flow of Vinh Tan 4 TPP

No.	Using purposes	Wastewater flow		Note
		Total flow	Treatment needed flow	
REGULAR WASTEWATER				
1	*Domestic wastewater* (m^3/h)	5	5	Approx 120 m³/day. Because of the water scarcity of the area, this water will be reused for watering plants inside of the project area.
2	-Cooling wastewater (m^3/s)	50	-	Discharged directly to cooling water discharge canal of the Plant.
3	*Chemical contaminated wastewater*			
	Demineralization system. (m^3/h)	3	3	Wastewater from the resin regeneration process accounts for 2.5% of the total water volume supplied for the closed demineralization system.
	Chemical feed system (m^3/h)	7	7	Collected into the industrial wastewater treatment system
	Production system in plant (m^3/h)	10	10	Collected into the industrial wastewater treatment system
	Other	5	5	Collected into the industrial wastewater treatment system
4	*Oily wastewater* (m^3/day)	10	10	Collected into the industrial wastewater treatment system

No.	Using purposes	Wastewater flow		Note
		Total flow	Treatment needed flow	
5	Seawater – FGD			
	Wastewater from the SW-FGD system (m^3/h) ((Water used for desulfurization system is taken from wastewater of the cooling system.)	14.6	-	Water from the cooling system will be transported to the absorber. After going through the absorber, it is contaminated with acid. Hence, the water will be transported to aeration tank in SW-FGD area to mix with cooling seawater before being discharged directly to sea (not running through the industrial wastewater treatment system).
		53.3	-	Generated from aerotank of SW-FGD system. Water from aerotank of SW-FGD system will be mixed with cooling wastewater before being discharged to the sea. Hence, it is not considered in the total volume of wastewater.
6	- Ash system	-	-	Ash discharging method uses dry ash. There is almost no water because wastewater was evaporated.
7	*Coal contaminated wastewater* (m^3/h)	33	33	This water is mainly generated from washing of coal storage area and rainwater overflows on this area and will be reused to spray water in coal storage.
IRREGULAR WASTEWATER				
1	- Washing boiler and air heater system (m^3/year)	7500	7500	Washing frequency: once per year. This wastewater will be stored in the storage before being treated in chemical contaminated wastewater treatment system.

Source: PECC2, 2012

2. Impact on water environment due to cooling wastewater

The flow rate of cooling water of Vinh Tan 4 TPP is 50 m^3/s and Vinh Tan 1, 2, 3 TPPs is 186.6 m^3/s and the maximum of designed seawater temperature for the project is 30^0C; the designed heating rate between input and output point of condenser and through FGD is $\Delta t = 7^oC$. Therefore maximum temperature of cooling water is about 38^oC, and it will be discharged directly into the coastal area of Vinh Tan Commune – Tuy Phong District. Cooling water of Vinh Tan 4 TPP will be separate discharged via cooling water discharge system in the western site of Vinh Tan power complex and Vinh Tan 1, 2, 3 TPPs will be discharged by the cooling water discharge system in the eastern site of Vinh Tan power complex. In order to forecast impacts of the discharged cooling water on the quality of seawater and aquatic biota, PECC2 will apply the model

MIKE 21 to stimulate and evaluate the water quality in the area.

a. Calculation model

The models used are the MIKE 21 and MIKE 3 software. They are flow modeling systems established by the Danish Hydraulic Institute (DHI) - an independent research and consulting international organization.

MIKE 21 and MIKE 3 are based on the flexibility grid approach and are developed for applications in oceanography, coastal and estuarine environments. These modeling systems are also applied to study the effects of socio-economic activities on water quality in estuaries, where under the influence of the tidal regime.

This system is based on the experience of the Navier-Stokes equations, Reynolds two- and three- dimensional space with the Boussinesq assumption and hydrostatic pressure. So this model consists of the equations of density, salinity, temperature, momentum, continuity and it play with puppets diagram. For 3-D model, the free surface uses sigma coordinate system transformation.

The discretization as space of the basic equations by using finite volume method in the center. Space is digitized by sub-region as the none overlapping cells/continuum elements. The horizontal surface uses unstructured grid while the vertical surface has a structural 3D grid 3 dimensionally. In 2D model, the element is triangular or quadrilateral element. In 3D model, the element is prismatic or rectangular with the cross-section is triangular or quadrangular, respectively.

Model based on the Navier-Stokes equations, uncompressed Reynolds 3-D with the Boussinesq assumption and hydrostatic pressure.

The continuity equation:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=S \qquad (2.1)$$

And corresponding momentum equations in x and y directions are:

$$\frac{\partial u}{\partial t}+\frac{\partial u^2}{\partial x}+\frac{\partial vu}{\partial y}+\frac{\partial wu}{\partial z}=fv-g\frac{\partial \eta}{\partial x}-\frac{1}{\rho_0}\frac{\partial p_a}{\partial x}-$$
$$\frac{g}{\rho_0}\int_z^{\eta}\frac{\partial \rho}{\partial x}dz-\frac{1}{\rho_0 h}\left(\frac{\partial s_{xx}}{\partial x}+\frac{\partial s_{xy}}{\partial y}\right)+F_u+\frac{\partial}{\partial z}\left(v_t\frac{\partial u}{\partial z}\right)+u_s S \qquad (2.2)$$

$$\frac{\partial v}{\partial t}+\frac{\partial v^2}{\partial y}+\frac{\partial uv}{\partial x}+\frac{\partial wv}{\partial z}=-fu-g\frac{\partial \eta}{\partial y}-\frac{1}{\rho_0}\frac{\partial p_a}{\partial y}-$$
$$\frac{g}{\rho_0}\int_z^{\eta}\frac{\partial \rho}{\partial y}dz-\frac{1}{\rho_0 h}\left(\frac{\partial s_{yx}}{\partial x}+\frac{\partial s_{yy}}{\partial y}\right)+F_v+\frac{\partial}{\partial z}\left(v_t\frac{\partial v}{\partial z}\right)+v_s S \qquad (2.3)$$

In which, t is time; x, y, z: Cartesian coordinates; η: surface height; d: water depth; h = η + d: total depth of water; u, v and w: factors of velocity following x, y and z direction; f = 2Ω sin φ Coriolis coefficient; g: gravitational acceleration ; ρ: water density; s_{xx} , s_{xy}, s_{yx} and s_{yy} : components of radiation strain; v_t vertical disorder; p_a atmospheric pressure; ρ_0: reference density of water. S discharged volume from point source and (u_s, v_s) is the velocity of wastewater.

The horizontal strain factors are described by relational strain gradient, simplified as:

$$F_u = \frac{\partial}{\partial x}\left(2A\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial y}\left(A\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)\right) \qquad (2.4)$$

$$F_v = \frac{\partial}{\partial x}\left(A\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)\right)+\frac{\partial}{\partial y}\left(2A\frac{\partial v}{\partial y}\right) \qquad (2.5)$$

Where: A: horizontal viscous disorder. Top and bottom marginal condition for u, v and w is:

At z = η:

$$\frac{\partial \eta}{\partial t}+u\frac{\partial \eta}{\partial x}+v\frac{\partial \eta}{\partial y}-w=0, \quad \left(\frac{\partial u}{\partial z},\frac{\partial v}{\partial z}\right)=\frac{1}{\rho_0 v_t}\left(\tau_{sx},\tau_{sy}\right) \qquad (2.6)$$

At z = -d:

$$u\frac{\partial d}{\partial x}+v\frac{\partial d}{\partial y}+w=0, \quad \left(\frac{\partial u}{\partial z},\frac{\partial v}{\partial z}\right)=\frac{1}{\rho_0 v_t}\left(\tau_{bx};\tau_{by}\right) \qquad (2.7)$$

In which, (τ_{sx} ,τ_{sy}) and (τ_{bx} ,τ_{by}) are x and y components of surface and bed of wind strain.

Water depth h can be calculated from surface marginal condition, velocity field is calculated from continuous momentum equations. Vertically integrating the continuity equation, we have:

$$\frac{\partial h}{\partial t}+\frac{\partial h\bar{u}}{\partial x}+\frac{\partial h\bar{v}}{\partial y}=hS+\bar{P}-\bar{E} \qquad (2.8)$$

In which, P and E are the velocity of rainfall and evaporation, u and v are average velocity as function of depth

$$h\bar{u}=\int_{-d}^{\eta}u\,dz, \quad h\bar{v}=\int_{-d}^{\eta}v\,dz \qquad (2.9)$$

The liquid is assumed uncompressed. Hence, density ρ is not dependent on pressure but temperature T, and salinity s via status equation:

$$\rho = \rho(T,s) \qquad (2.10)$$

Equations for temperature T and salinity s diffusion are as below:

$$\frac{\partial T}{\partial t} + \frac{\partial uT}{\partial x} + \frac{\partial vT}{\partial y} + \frac{\partial wT}{\partial z} = F_T + \frac{\partial}{\partial z}\left(D_v \frac{\partial T}{\partial z}\right) + \hat{H} + T_s S \qquad (2.11)$$

$$\frac{\partial s}{\partial t} + \frac{\partial us}{\partial x} + \frac{\partial vs}{\partial y} + \frac{\partial ws}{\partial z} = F_s + \frac{\partial}{\partial z}\left(D_v \frac{\partial s}{\partial z}\right) + s_s S \qquad (2.12)$$

In which, D_v is vertical disorder diffusion coefficient. $\hat{H}$ is source formed due to heat exchange to the atmosphere, T_s is temperature of source. F is horizontal diffusion factor, described as follows:

$$F_T = \left[\frac{\partial}{\partial x}\left(D_h \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(D_h \frac{\partial T}{\partial y}\right)\right]$$

$$F_s = \left[\frac{\partial}{\partial x}\left(D_h \frac{\partial s}{\partial x}\right) + \frac{\partial}{\partial y}\left(D_h \frac{\partial s}{\partial y}\right)\right]$$

In which D_h is horizontal disorder diffusion coefficient. The diffusion factors can be replaced by viscous disorders as follows:

$$D_h = \frac{A}{\sigma_T} \qquad D_v = \frac{\nu_t}{\sigma_T} \qquad (2.14)$$

In which σ_T is Prandtl number. In some cases, Prandtl constant can be used.

The surface and bottom marginal conditions for temperature are:

At $z = \eta$:

$$D_h \frac{\partial T}{\partial z} = \frac{Q_n}{\rho_0 c_p} + T_p \hat{P} - T_e \hat{E} \qquad (2.15)$$

At $z = -d$:

$$\frac{\partial T}{\partial z} = 0$$

Where Q_n is surface heat and cp = 4217 J /(kg.°K) is specific heat of water.

Surface and bottom marginal conditions for salinity are:

At $z = \eta$:

$$\frac{\partial s}{\partial z} = 0 \qquad (2.17)$$

At z = −d :

$$\frac{\partial s}{\partial z} = 0 \qquad (2.18)$$

During the heat exchange from the atmosphere, including the evaporation:

$$\bar{E} = \begin{cases} \dfrac{q_v}{\rho_0 l_v} & q_v > 0 \\ 0 & q_v \le 0 \end{cases} \qquad (2.19)$$

In which q_V is hidden heat flow and $l_V = 2.5.10^6$ is hidden heat of water evaporation.

b. Input data

Input data for the models are described as in the following Table.

Table 3.41. Input parameters for thermal diffusion model

Parameter	Value
Discharging ways of Vinh Tan 1, 2, 3 TPP	Discharging channel is straight cubic shaped, perpendicular with the coastline, at depth of -4 m and width of 12 m
Discharging ways of Vinh Tan 4 TPP	Discharging by 3 steel pipes at a depth of – above 7.5 m with diameter of each pipe is 4m.
Number of layer and depth of each layer	The simulation area is divided into 10 layers; depth of each layer depends on the topographical depth. At the point of discharging sewer above -7.5m deep, each layer is at 1.9 m deep.
Wastewater flow rate	237 m^3/s
Average temperature of seawater	30°C
Salinity	30g/l
Tide	Predicted tide
Wind	Average wind velocity: 2 m/s
Simulation time	Rainy season: 0h 18/10/2007 – 23h30 17/11/2007 Dry season: 0h 3/2/2007 – 23h30 2/3/2007

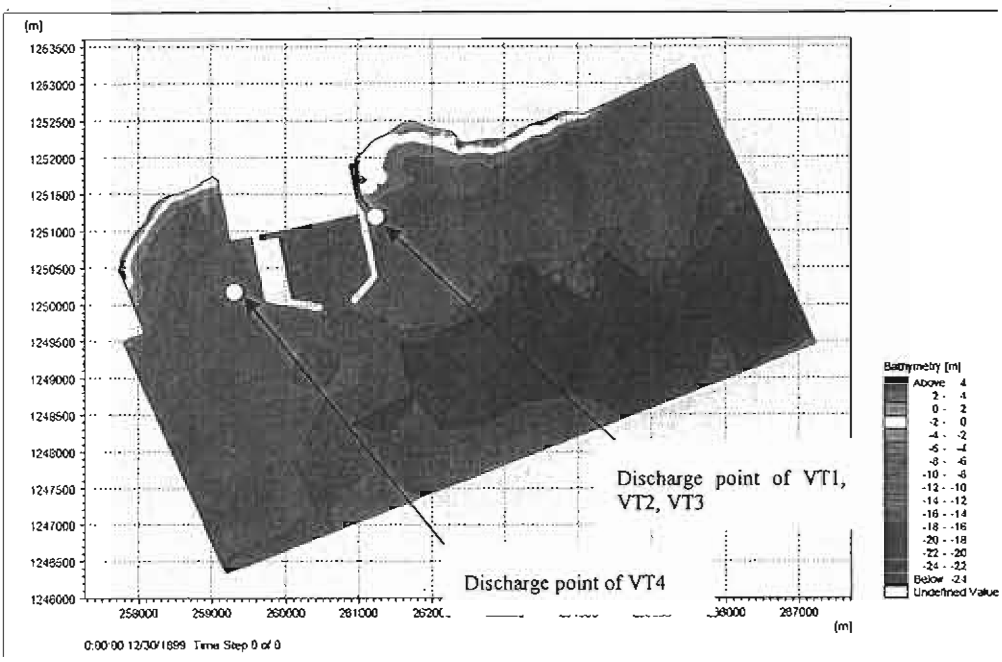
c. Modeling scenarios

A scenario for cooling water discharging is consider as follows:

The whole Vinh Tan power complex works; cooling water from the Vinh Tan 4 TPP is discharged through cooling water discharge system to western side of the breakwater. Meanwhile, cooling water of Vinh Tan 1, 2 and 3 Thermal Power Plants is discharged to eastern side of the breakwater in rainy and dry seasons.

The topography of the project site and discharging area is presented in Figure 3.3 below

Figure 3.43. Topography of the project site and cooling water discharge point of Vinh Tan Power Complex

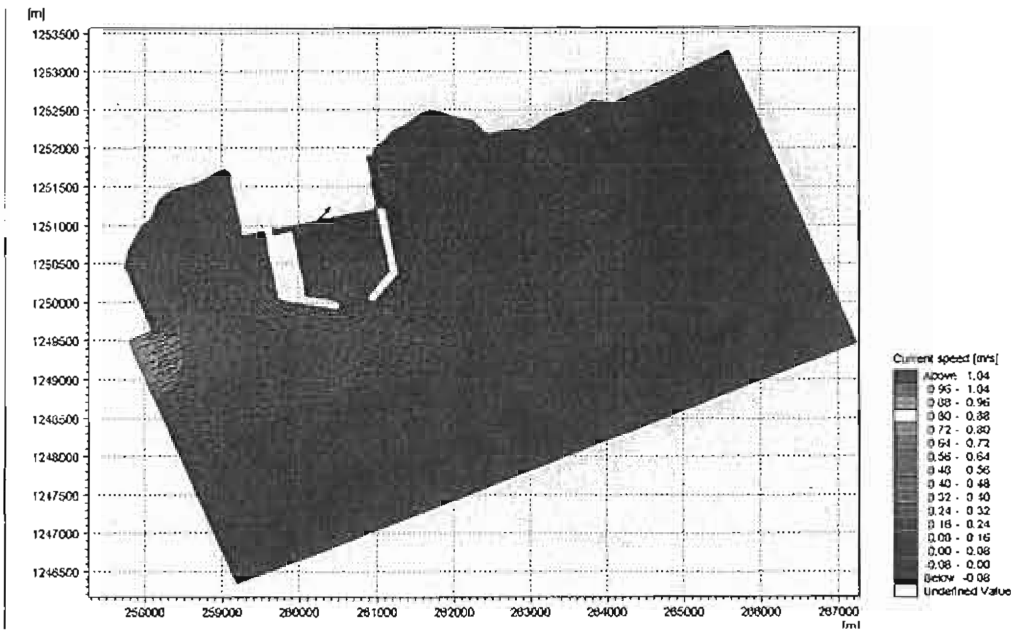


d. Results

i. Current

- The hydrodynamic condition of Binh Thuan coastal area in general and Vinh Tan area in particular is under influence of various factors such as wind, sea level alteration and wave. Results from the models reveal that the integrated current of the area is not high. Popular range of the current is about 0.1 – 0.3 m/s and mostly following the phase of sea level. The main current direction is mostly alongside with the coast: East – Northeast (flood tide) or South – Southwest (ebb tide).
- The current offshore is mostly from North to South so that the appearance of the embankment may alter the direction of the current leading it to the sea. On the other hand, due to circulated impact of the cooling water intake and discharge points, the current between these two points will be affected to some extent.

Figure 3.44. Current velocity at surface y from Nort



ii. Impact of thermal diffusion

According to the National regulation on industrial wastewater (QCVN 40:2011/BTNMT, Kf=0.9, Kv=1), temperature of wastewater must be lower than 40°C (from the report, the maximum temperature of cooling wastewater at discharging point is about 38°C). Therefore, the input water temperature is taken as actual temperature transformation with the maximum value of 38°C (worst case for local water sources) and the impacted area can be determined through it.

The results are presented as a function of depth from the water surface for each layer, in flood tide and ebb tide conditions. The impacted area of heat diffusion on water surface (surface layer) were revealed in Figure 3.1.

Refer to the Appendix 3.4 of Chapter 3 for details of the impacted area of heat diffusion at the middle and bottom layers.

In rainy season

- Flood tide conditions
  - ✓ *Vinh Tan 4 TPP*

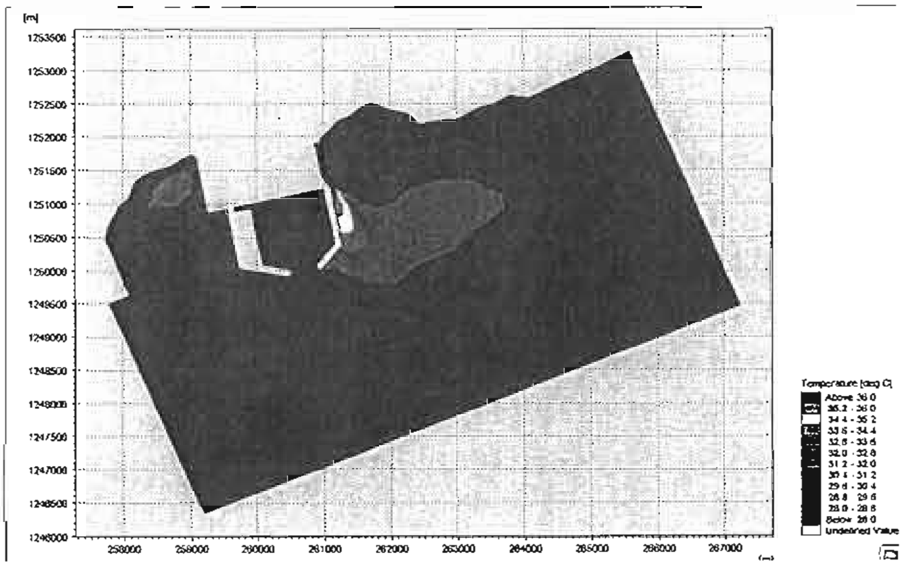
30 – 31°C area tends to move to the Northwestern site of the intake and discharge point; the impacted area is about 1.3 km^2. Since the discharge point of Vin Tan 4 TPP is about above -7.5m deep, the diffusion of heat into the environment is relatively high. Places which have temperature about 31-32°C with an area of 0.23 km^2 distribute mostly at the Northwestern site of the discharge point, about 1000 m away from the discharge point.

  - ✓ *Vinh Tan Power Complex*

30 – 31°C area tends to move to the Southeastern site of the discharge point; the impacted area is about 2.9 km^2 and is 3 km Eastward from the

Vinh Tan Power Complex. Meanwhile, the 31 – 32°C area has an area about 1.6 km^2 distributing mainly at the Eastern site, 2.5 km away from the discharge point. The places which have temperature about 32-33 °C with the area of 0.69 km^2 distribute mainly at the Southeastern site, 1 km away from the wastewater source; and 0.25 km^2 area which has temperature about 34°C gather mostly nearby the discharge channel alongside the embankment, 500 m away from the source. 35°C area focuses around the discharge point.

Figure 3.45. Temperature distribution at the water surface due to impacts of cooling water from Vinh Tan 4 TPP and Vinh Tan Power Complex – flood tide



Water temperature at the port is about 30-31°C. Since the power plants of Vinh Tan PC mostly take water at the surface layer, it's only needed to consider the temperature of surface water at the cooling water intake point in all tidal conditions.

In flood tide condition, at the water intake of Vinh Tan 4 TPP, the temperature is approximately 30.5-31°C (about 0.5-1°C higher than the average temperature). At the intake points of Vinh Tan 3, 2, 1, the temperature is about 30°C.

- ❖ Ebb tide

- ✓ *Vinh Tan 4 TPP*

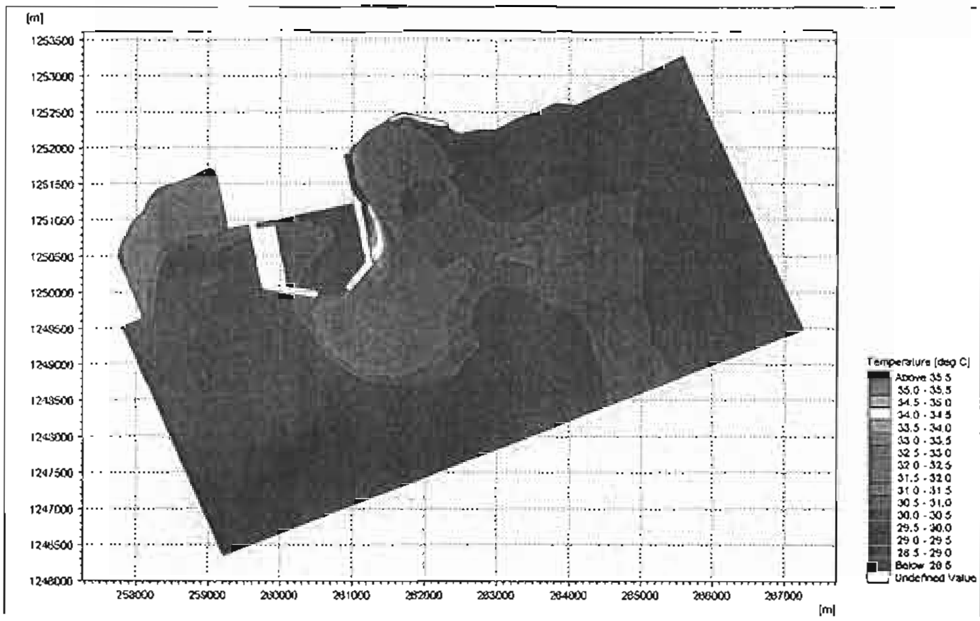
In ebb tide condition, the area with temperature of 30 – 30.5°C tends to move to the Southeastern and Northwestern sites of the discharge point; spreading to the Vinh Tan coastal area. At the discharge point, the area of 30.5-31 °C is about 0.43 km^2 and tends to move to the Northwestern coastline. Area of 31-32°C is about 1.23 km^2 (in which, the area of the highest temperature which is 32°C accounts for about 0.2 km^2), spreading mainly at the Northwestern site, approximately 700 m away from the discharge point.

- ✓ *Vinh Tan Power Complex*

In ebb tide condition, the area of 31 – 32°C accounts for about 1.8 km2 moving to the Southern site of the discharge point, 2 km away from the discharge point. Meanwhile, the 32 – 33°C area has an area about 0.75

km^2 distributing mainly at the Southern site, 1.8 km away from the discharge point. The places which have temperature about 33-34 °C with the area of 0.14 km^2 distribute mainly alongside the embankment and adjacent areas, about 800 m away from the wastewater source. 0.12 km^2 of area which has temperature above 34°C gather mostly nearby the discharge channel alongside the embankment, 700 m away from the source.

Figure 3.46. Temperature distribution at the water surface due to impacts of cooling water from Vinh Tan 4 TPP and Vinh Tan Power Complex 4, the 32



Water temperature at the port is about 30-31°C. At the water intake for Vinh Tan 4 TPP, the temperature is about 30.5-31°C (0.5-1 °C higher than the average value). At the intake points for Vinh Tan 3, 2, 1 TPPs, the water temperature is about 30°C.

In dry season

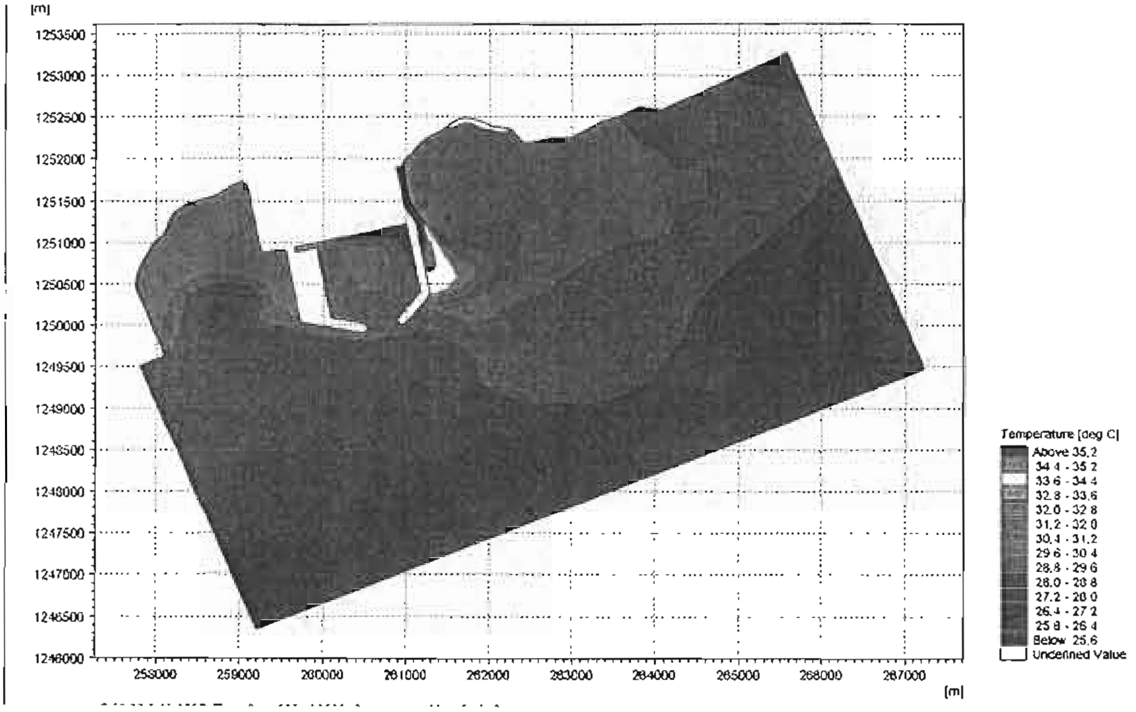
- Flood tide
- ✓ *Vinh Tan 4 TPP*

Area at 29 – 30°C is at the discharge point and tends to move to the Northwestern site of the discharge point; the impacted area is about 0.9 km^2. Places which have temperature about 30-31°C (1 °C higher than the average temperature) with an area of 0.55 km^2 distribute mostly at the Northwestern site of the discharge point, about 1000 m away from the discharge point.

- ✓ *Vinh Tan Power Complex*

Area which has 30 – 31°C temperature tends to move to the Southeastern site of the discharge point toward the port; the impacted area is about 0.9 km^2 and is 2.2 km eastward from the Vinh Tan Power Complex. Meanwhile, the 32 – 33°C area has an area about 0.68 km^2 distributing mainly at the Southeastern site, 1.2 km away from the discharge point. The places which have temperature about 33-34 °C with the area of 0,13 km^2 distribute mainly nearby the discharge point alongside the breakwater, 700 m away from the wastewater source. Area which has temperature about 34 - 35°C gather mostly nearby the discharge channel 500 m Southward from the source.

Figure 3.47. Temperature distribution at the water surface due to impacts of cooling water from Vinh Tan 4 TPP and Vinh Tan Power Complex – flood tide



In flood tide condition, at the water intake points of Vinh Tan 4, 3, 2, 1, the temperature is about 29-30°C.

❖ Ebb tide condition

✓ *Vinh Tan 4 TPP*

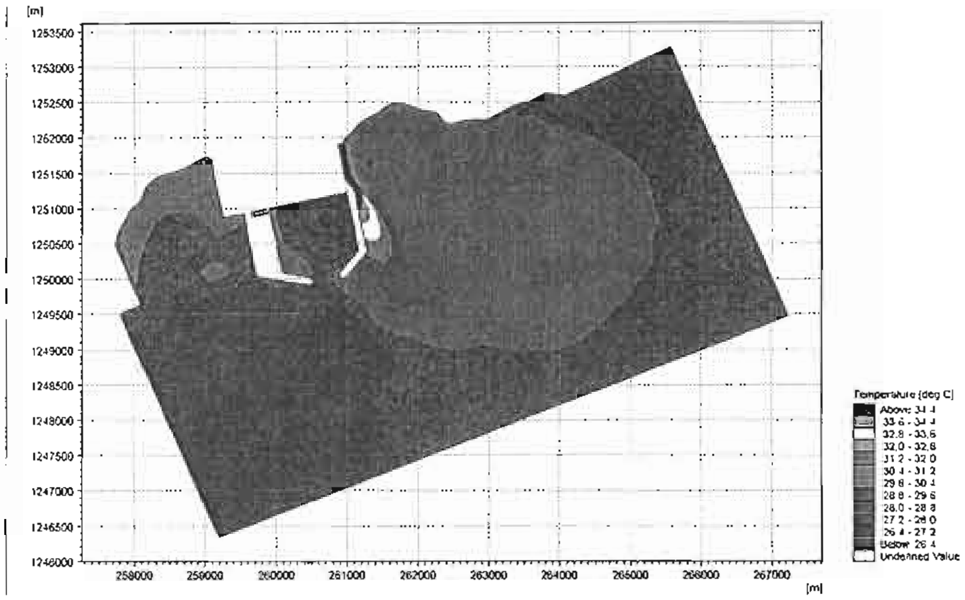
In ebb tide condition, the area with temperature of 29 – 30°C tends to move to the Northwestern site of the discharge point; the impacted area is about 1 km^2. The area of 30-31 °C (1°C higher than the average temperature) is about 0.55 km^2 and tends to move to the Northwestern site of the wastewater source, approximately 1000 m away from the discharge point.

✓ *Vinh Tan Power Complex*

In ebb tide condition, the area at 30 – 31°C locates at the southeastern site of the wastewater source, accounts for about 3.5 km^2, 3 km away from the discharge point of Vinh Tan power complex. Meanwhile, the 31 – 32°C area has an area about 0.53 km^2 distributing mainly at the Southern site, 1.8 km away from the discharge point. The places which have temperature about 32-33 °C with the area of 0,15 km^2 distribute mainly at the Southeastern part, 0.9 km away from the discharge point. 0.09 km^2 of area which has temperature 33-34°C gathers mostly nearby the discharge channel alongside the breakwater, 500 m southward from the source.

In the ebb tide condition, the temperature of seawater at the intake point of Vinh Tan 4, 3, 2, 1 TPPs is about 29- 30°C.

Figure 3.48. Temperature distribution at the water surface due to impacts of cooling water from Vinh Tan 4 TPP and Vinh Tan Power Complex – ebb tide.



Conclusion:

According to the National technical regulation on industrial wastewater (QCVN 40:2011/BTNMT, Kf=0.9, Kv=1), temperature of wastewater must be lower than 40°C (according to investment project report, the maximum temperature of cooling wastewater at discharging point is about 38°C). Therefore, the input water temperature is taken as actual temperature transformation with the maximum value of 38°C (worst case for local water sources). As a result, the temperature of cooling water in both scenarios is lower than 40°C and meets the regulation.

At the water discharge point of Vinh Tan 4 TPP, the temperature is about 31°C (increase 1°C compare to the temperature of ambient environment). The area which has temperature of 32 °C (increase 2°C compare to the average ambient temperature) gathers mainly at the Northwestern bank.

At the water discharge point of Vinh Tan Power Complex, the water temperature is about 34-35°C (increase 4-5°C compare to the ambient temperature) and gradually decrease toward the sea. Area which has the temperature increases about 2-3°C compare to the ambient temperature gathers around the breakwater, 500 – 1000 m away from the wastewater discharge point.

3. <u>Impact of wastewater due to port's operation</u>

In the operation phase of 100,000DWT port, effluents are mostly produced by the sources as follows:

- Domestic wastewater from operation staffs.
- Domestic wastewater from worker of ships during anchoring period which will be treated by professional companies before releasing to the receiver.
- Wash water from jetties with high contents of suspended solid, oil and fat.
- Runoff water from the jetties and coal storing area with high contents of

suspended solid, turbidity resulted from coal dust which is settled in ports and storages.

Water demand for operating activities is approximate 219.5m^3/day (excluding fire fighting water and water for cleaning conveyor and unloading equipment). Water consumption for Vinh Tan 4 TPP's port is estimated in Table 3.42.

Characteristics and amounts of wastewater from the operation of Vinh Tan 4 TPP's port are presented in Table 3.43.

Table 3.42. Water demand for operation of port

Water demand	Daily consumption (m^3/day)
Water consumption by ship (m^3/ship) – frequency of 6 days/vessel - water supply for the purpose of balance.	450
Domestic consumption by operation staffs of the port.	7,5
Industrial water	
Cleaning conveyor, unloading equipment (irregular, frequency: once a week, m^3/time).	632
Water for environmental protection (cleaning the jetties)	42
Fire fighting water (m^3/time)	423
Other (excluding fire fighting water)	170
Total regular water demand (excluding water for fire fighting and irregular water)	219,5
Total (excluding fire fighting water)	1301,5

Source: PECC2,2012

Table 3.43. Characteristics of each group of wastewater and estimated flow rate of wastewater

Group	Characteristic	Flow rate (m^3/day)	Note
Wastewater from ships	Water supply for ships (450 m^3/ship) with the purpose to balance the ship (ballast) before leaving the sea port and supply water for the crew, so wastewater is not generated from this source.	0	Wastewater is not generated in the port, and will be treated in the port which imports coal/oil for the project (out of scope of the project). Each ship will be treated in accordance with the Decree NĐ 21/2012/NĐ-CP and the

Group	Characteristic	Flow rate (m^3/day)	Note
			International Convention MARPOL 73/78).
	Generating from sanitary wastewater of deck and crew members on board. -Sanitary wastewater contains high levels of mixture of suspended matter and oil/grease. -Domestic wastewater contaminated with components (SS, BOD, N, P, oil) high.	20 m^3/time	- This wastewater will be collected in each ship and treated by local authorized specific company through a contract. - It is not collected in wastewater treatment system of Vinh Tan 4 port.
Domestic wastewater of staff	This wastewater comes from domestic activities such as bath, toilet, kitchen, cafeteria of the port' staffs.	6.75	90% of water supply demand. Collecting and treating with septic tanks BASTAF then directed to domestic wastewater treatment system of Vinh Tan 4 TPP.
Irregularly wastewater (cleaning conveyor and unloading equipment)	This group of wastewater is generated from washing fuel transport equipment from ships to the coal storage yard (according to experience from similar projects, cleaning frequency is once a week or more). Therefore, this wastewater contains suspended solid content, a little of grease and classified as irregular wastewater.	632 (m^3/time)	100% of water supply demand. Collected in the pit to deposit sediment and oil before taken to coal contaminated wastewater treatment system of Vinh Tan 4 TPP for further treatment.
Wastewater for environmental protection (cleaning wharf surface)	This group of wastewater contains high content of suspended solid and a small amount of grease from repairing and lubricating engines and equipment.	42	100% of water supply demand. Collected in the pit to deposit sediment and oil before taken to coal contaminated wastewater treatment system of Vinh Tan 4 TPP for further treatment.
Fire fighting water	Released into the environment	-	
Runoff water		25 (m^3/h)	Runoff water at the harbor, jetties (during

Group	Characteristic	Flow rate (m^3/day)	Note
			the first 15 minutes of the rain) will be collected to sedimentation tanks before being pumped back to coal contaminated wastewater treatment system of Vinh Tan 4 TPP for further treatment.
Backup water (excluding water for firefighting)	This water is usually distributed at convenient places for employees washing hand and floor cleaning. So this wastewater contains high suspended solid. It is collected to the rainwater drainage system at port and then discharged into the receiving source	170	100% of water supply demand
Total volume of wastewater		238.75	Regularly wastewater (excluding ballast , irregularly wastewater , runoff water, fire fighting water).
		870.75	Maximum water flow is found in conveyor cleaning day (excluding runoff water, firefighting water).

Source:PECC2, 9.2012

Table 3.44. Component and impact of wastewater of Vinh Tan 4 TPP's port

Type of wastewater	Impacts on the environment
From activities of operational staffs	Domestic wastewater in port area is about 6.75m^3/day from the port operation staffs with high content of organic compounds, suspended solids, nutrients and germs. If not being collected and treated, the concentration of organic matter, nutrients will excess the permitted value stipulated in QCVN 14:2008/BTNMT, K=1 (column B). However, the amount of this wastewater is low and it will be collected and treated at the Vinh Tan 4 TPP to meet standards before being discharged into the receiving sources, therefore the impact is *insignificant*.
From activities of ships/boats	It is estimated that the water demand for ships is 450 m^3/ship for with the purpose to balance the ship (ballast) before leaving the dock and supply water for the crew. So that the wastewater from this source is

Type of wastewater	Impacts on the environment
	not generated in the project area. According to Decree 21/2012/ND-CP dated 21/3/2012 on management of seaports and marine navigable channels and International Convention for the Prevention of Pollution from ships (Marine Pollution Prevention - MARPOL 73/78), vessels must not discharge ballast water at the ports, ship owners are required to change the water and discharge ballast waters in the sea region which is out of scope of Vietnam. The discharge of ballast water will follow the specific instructions of the port authority. Besides, according to MARPOL 73/78: every ships of 400 gross tonnage and above must be equipped sewage treatment system, sewage comminuting and disinfecting system or a storing tank. – The ship which has a sewage treatment system, is allowed to release the effluent at the port. – The ship which has a decomposition system, is allowed to release the effluent at a distance of more than 3 nautical miles from the nearest land. – Size of the storing tanks must comply with regular working routes and the tanks must have enough connectors to release the water to receivers. Wastewater from the storing tanks can be released at a distance of more than 12 nautical miles from the land and only when the steady speed is about 4 nautical miles/hour. The ship-owner is responsible for pumping wastewater according to the regulation and direction of the Maritime Administration (Article 77-78, Decree 21/2012/ND-CP). The ship-owner will sign a contract with vessel cleaning service-providing organizations in a port to arrange facilities for reception of rubbish and dirty water discharged from vessels and be entitled to collect service charges as prescribed.
Port cleaning activities	Wastewater from the sanitation of transportation equipment (conveyors, fuel handling equipment), water for wharf sanitation, runoff water flows through overflow port areas contain high contents of suspended sediment due to sandy soil, dust and coal, oil and grease etc. Irregularly wastewater includes water for cleaning floor, coal transporting system with frequency of once a week). All wastewater will be collected in the pit on port and be directed to wastewater treatment system of Vinh Tan 4 TPP for further processing. The affected areas at Vinh Tan coastal area will not be affected significantly.
Runoff rainwater	Storm water in the areas as wharf, jetties is about 25 m^3/h collected in the pits (3 sedimentation pits in coal port before pumping back to the wastewater treatment system Vinh Tan 4 TPP for further processing. Detail is presented in Chapter 4.

Source:PECC2, 9.2012

3.2.3.1.3. *Domestic waste and industrial waste*

Source of solid waste in the operation phase of port includes:

- Daily activities of workers/staffs in the power plant and port area.
- Solid waste from ships travelling to and from the port
- Industrial solid waste from coal transportation and production activities in the power plant.

1. Domestic solid wastes from power plant and port

Domestic solid waste in the power plant and port: the volume of solid waste by 500 staffs is about 400 kg/day (assuming each worker emit 0.8 kg of garbage a day –referred from the report "Environmental Monitoring in Vietnam in 2004 - Solid waste (World Bank, 2004). Its main composition includes 60 – 70% of decomposable organic substances (vegetable, food ends and odds, etc.) and inorganic materials, nylon, sand and soil etc. Without proper collection and treatment, this solid waste will pollute the local environment.

Solid waste from ships in port activities is estimated at about 50 kg/ship and ship-owners will contract to sanitation services organizations for collection, transportation and processing for each ship when the ship docked and pay fee as current regulations.

2. Ash

The average volume of ash generated every year is about 137.248 ton/year which will be transported to the 64.7ha ash yard at Ho Dua mountain by trucks. Ash which has no hazardous components can be used as additive for concrete, cement production or used for road construction. The Vinh Tan 4 TPP will try to find consumer for this ash to reduce the volume of ash being moved to the ash yard, inhibiting environmental pollution.

However, ash storage may pollute the environment and enhance illegal exploitation of residents. This impact is significant; yet the plant will apply several technical and managing measures to mitigate this impact.

3. Industrial solid waste from power plant and port

The data in **Error! Reference source not found.** provides the list of solid waste sources in the operation phase of Vinh Tan 4 TPP.

Table 3.45. List of solid waste sources in the operation phase of Vinh Tan 4 TPP.

Solid waste	Source	Physical, chemical composition	Volume
Dredging sludge	Generated from annual maintenance dredging of 100000DWT berth under Vinh Tan 4 TPP.	Containing coal sludge and mud etc. Because their contents are still lower than the allowable limits, they are not considered as hazardous waste.	Annual volume of sludge from dredging berth is about 23,076.8m3.
Chemicals	Collection of	Containers of chemicals,	Not determined. Predicted

Solid waste	Source	Physical, chemical composition	Volume
and hazardous materials	chemicals, hazardous materials, and chlorine used in the operation	excess chemicals, chemical spills e.g. oil. Depending on the nature of chemicals, this may become hazardous or non-hazardous waste.	to be minor
Garbage from the cooling water intake canal.	Garbage from the screening of the cooling water intake canal	Organic matters (dead vegetation, animals, etc.) and inorganic waste (nylon bags, plastic, paper, etc.)	Not determined yet. Predicted to be minor
Oily waste	Washing of machines and equipment	Oily mud, waste oil, oily waste.	Not determined yet. Predicted to be minor
Sediments	From boiler chemical cleaning	Include: metal, salt, low pH, etc.	Estimatedly 0.5 ton/time (avery 4 years)
	From the wastewater treatment system		Estimatedly 0.07 ton/day
Coal	From coal import at the 100,000 DWT harbor (transportation frequency: every week)	Main component is coal	Not determined yet. Possibly minor because the coal will be transported from the port to coal storage yard by closed conveyor system .

Source: PECC2, 9.2012

Generally, the volume of waste generated in operation phase of Vinh Tan 4 TPP is insignificant and reducible by proper collection and treatment measures so that the impact is not significant. The collection and handling of solid waste are given in Chapter 4.

4. Hazardous waste

Oil may arise from the oil tank area of the plant. Oil demand is estimated about 6000 tons/year in operation phase. This oil is stored in two 1000-ton tanks. A very little of oil scum is able to spill drainage ditch of oil tank area. Oil sediment from tank washing appears once every 3 years at the volume of 5-7 tons. In which, oil sludge accounts for 6.5% with mainly metallic oxide. As a result, the volume of oil sludge at each time of tank washing is about 7 x 6.5% = 0.45 tons.

Hazardous waste during operation and maintenance equipment in power plant is essentially oily clothes, grease, packing equipment, etc. The amount of hazardous solid wastes is 48 kg/day (estimated ≈ 10% of total volume of domestic solid wastes). This volume is not much but the waste is highly toxic. If there is no thorough treatment measures, this waste will pollute surface water in the region.

3.2.3.1.4. Environmental impacts of the ash yard

1. Water pollution

A major part of solid waste in the operation phase of the plant include bottom slag, flying ash and mud from the wastewater treatment system, will be disposed into the 64.7 ha ash yard.

The power plant will construct a dam to inhibit runoff rainwater from running through the ash yard. Runoff water falling outside of the dam is clean and will be collected by the drainage system at the bottom of the dam and directed to the receiver.

The highest volume of rainwater at the ash yard is about 121 m^3/h with a rainfall intensity of 0.0002 m/h and the area of 64.7 ha. Runoff rainwater running through the ash yard may pollute the surrounding water sources owing to high level of SS, heavy metals, HCO_3^-, Cl^- chemical... Besides, the pollutant may penetrate into the soil and pollute the groundwater. The impact of the ash yard to surface water and groundwater quality is estimated as considerable if no mitigation measure is applied.

2. Air pollution

a. Dust and air emission from ash transport by trucks

The total volume of flying ash and bottom mud from Vinh Tan 4 TPP is about 702.24 ton/day which will be transported by 50-ton trucks to the ash yard. The transport frequency is about 14 trips/day. These trucks may pollute the ambient air due to fuel combustion (gasoline, DO...), directly affecting to the atmosphere. Based on the pollution coefficient from rapid assessment of WHO and Sutton equation, the volume and concentration of air emission on the transport routes can be computed as follows.

Table 3.46. Tonnage of air pollutants generated from ash transport activities

No.	Pollutant	Pollution coefficient (g/km)	Total length (km)	Total tonnage (kg/day)	Maximum concentration (mg/m³)	QCVN 05:2009
1	Dust	0.9	42	0.038	0.00018	0.3
2	SO_2	4.15S	42	0.0009	0.00004	0.35
3	NO_X	14.4	42	0.6	0.0028	0.2
4	CO	2.9	42	0.12	0.0006	30
5	HC	0.8	42	0.03	0.0001	-

Source: PECC2, 2013

According to the above calculation, the tonnage and concentration of these air pollutants are small and will not affect to the ambient atmosphere.

b. Dust emission from the ash yard

Total volume of ash released every year is about 137,248 tons.

Flying ash and bottom mud will be transported to ash yard No. 1 at Ho Dua mountain which has an area of 64.7 ha. Here, the ash will be piled, moisturized, processed to a required dry density. After processing, the ash block will have a hard cover, reducing the diffusion into the atmosphere.

The ash is piled, compressed into layers by bulldozers, corner compaction will be performed manually by rollers. During the compaction, water will be spray on the surface of ash to prevent flying ash. A washing station will be built inside of the ash yard to wash all trucks used for transport of ash and equipment into the ash yard. Ash surface will be backfilled or planted right after reaching the designed height.

The Vinh Tan 4 TPP will try to find consumer for this ash to reduce the volume of ash being moved to the ash yard, inhibiting environmental pollution.

In the case when no consumer is found, as soon as the ash yard at Ho Dua mountain is filled, the ash will be transported to a new ash yard between Ong Do and Da Chet mountains which is 7 km away from Vinh Tan Power Complex.

The amount of dust generated is predominantly from grading, rolling, compacting slag, the operation of bulldozers, truck and by wind in slag disposal

i. Dust emission from ash compaction and discharging

Emission from ash compaction and discharging is calculated using the US.EPA emission rate calculation for overburden bulldozing:

Emission factor:

$$E_{PM} = k \times 0.0032 \times \frac{(U/5)^{1.3}}{(M/2)^{1.4}} \quad (lb/ton)$$

Where:

k	:	Particulate size multiplier	=	0.74	For suspended dust
U	:	Mean wind speed (mile/hr)	=	11.2	
M	:	Material average moisture (%)	=	15	
		Control efficiency	=	80%	Water spraying applied...
E	:	Emission factor (lb emission/ton ash)	=	0.00004	
		Ash mass (ton/yr)	=	190601	
PM	:	PM emission, lb/hr	=	0.00087	
		PM emission, ton/yr	=	0.0038	

ii. Emission from vehicle activities on the ash yard (bulldozers, trucks etc.)

Transport in the ash yard is considered as transport on unpaved road and is a significant source of dust emission. The speed of vehicles in the ash yard is controlled to inhibit the generation of dust.

Emission from vehicle activities on the ash yard is calculated using US.EPA emission factor for travelling an unpaved road. As follows:

Emission factor:

$$E=\left(k\times\left(\frac{s}{12}\right)^{a}\times\left(\frac{W}{3}\right)^{b}\right)\left(\frac{365-P}{365}\right)$$

Where:					
	k	:	particulate size multiplier for PM	= 4.9	
	s	:	material silt content (%)	= 2.2	
	a	:	empirical constant for PM	= 0.7	
	b	:	empirical constant for PM	= 0.45	
	W	:	Mean vehicle weight (tons)	= 34.3	See calculation below
	P	:	Number of days with 0.01inch precipitation	= 73	Reference from daily rainfall data from 2005-2009 (Nha Ho rainfall station)
			Control efficiency	= 80%	Water spraying and speed controlling applied
	E	:	Long term emission factor (lb/VMT)	= 0.71	
	PM		Long-term emission, ton/yr	= 4.92	

Table 3.47. Summary of vehicle travelling at the ash yard

Vehicle Type	Vehicle weight (ton)	Vehicle Miles Traveled (VMT)	Vehicles (trips) per day trips	VMT per day
Ash Trucks (Full)	50	0.5	15	7.5
Ash Trucks (Empty)	20	0.5	15	7.5
Bulldozer	15	9.5	2	19.5
Tank Trucks	10	4	1	4.0
Mean Vehicle Weight (tons)	34.3		Total VMT (VMT/day)	38

Source: PECC2, 9.2012

From the equation of wind speed, the load of dust emitted to the environment can be calculated. The practical formula for estimating concentrations of pollutants from ash yards with total area of 64.7 ha is:

$$\chi=\frac{Q\,x\,10^{6}}{S\,x\,H}$$

Where

χ: Pollutant concentration (mg/m^3)

Q: Pollution load (kg/h)

S: Surface area (m^2)

H: altitude where meteo-factors are measured (H = 5m)

Combined particular matter emission from slag yard (ash compactor and vehicle travel activities) is 4.6 tons/yr and the average concentration of PM from the slag yard ≈ 0.17mg/m³.h, reaching the permissive value in the regulation of the quality of ambient air QCVN 05:2009/BTNMT (0.3mg/m³.hr). Dust content will increases year by year but not worth considering and this impact is considered major but controllable by technical measures (to spray water, clean wheels…). Detail on mitigation measures for impact of dust from the ash yard is presented in Chapter 4.

Besides, there are no residential areas or cultural heritages surrounding ash yard area. There are only few households locating on the foot of mountain of Linh Son pagoda, doing small business for pilgrims. These households can be impacted because of activity of ash transportation. However, the affected level is low because the number of households is not much, ash will be transported by covered-trucks. Appropriate technical measures will be applied to reduce the impact to environment.

3.2.3.1.5. Impacts on the sea environment due to annual dredging activities and discharging of dredging material offshore dumpsite

Annual maintenance of dredging activities in jetties area will be performed during the operation of the port. This activity will affect water quality, aquatic ecosystems. The mixing of bottom sediment layer will cause water pollution and affect to the species (fish eggs, fish, plankton, etc.) due to increasing turbidity.

The whole volume of dredging materials is approximate 23,076.8 m³/year. The dredging process will be done by the method described in Chapter 1. The maintenance dredging will only be conducted in the inner region of the breakwater so that the impact only appears on aquatic species living inside of the breakwater. D

The material from annual maintenance dredging will be used to level 28.6 ha of intermediate coal yard. Due to close distance between dredging area and the intermediate coal yard, the material will be spray directly to the yard. As a result, the impact of transporting dredging material is evaluated as inconsiderable.

The intermediate coal yard is constructed by connect the dike of the coal yard and the western breakwater with the area of 28.6 ha. The disposal of dredging material will only be implemented after the completion of the breakwater and dike; the layers of the breakwater and dike are core rocks, 400 mm gravel, 600 mm reverse filter layer, two layers of geotextile and cover rocks orderly. Therefore, these layers will keep sand and dredging materials inside of the breakwater and leave only water moving outside. Beside, the difference between the height of dike, breakwater and sea level is about 5m, no water will run over the dike inhibiting the impact on adjacent water sources.

Vinh Tan coastal area is far from big estuaries so that sedimentation and subsequently dredging needed sediment is not much. Consequently, the impact of dredging activities is minor and local at the dredging area.

This impact is evaluated as small and reducible by proper technical measures.

3.2.3.2. Impact source not relating to waste

Waste non-related sources of impact, affected objects and assessment of main impacts during the operation phase of the plant are summarized in the table below:

Table 3.48. Source of impacts not relating to waste during operation phase

Impact sources	**Affected objective**	**Impact assessment**	**Impact level**
Cooling water discharge	Aquatic organisms at discharging points	Difference between the temperature of cooling water and seawater is about 8°C. The temperature of cooling water is higher than the natural temperature causing decrease in DO level, affecting living condition, type and quantity of aquatic organisms.	Small, long-term
	Aquaculture	Affecting aquaculture activities due to the change of water quality	Small, long-term
	Riverbed terrain	Possibly disorder the flow, causing erosion at the discharging point	Insignifica nt
Operational activities	Worker	Operational activities generate noise affecting workers' health.	Small, long-term
Residual heat	Air environment	Residual heat from operational activities affects ambient temperature	Small
Explosion and occupational accidents	Operation. staffs, residents at and around the project area	Explosion can occur at oil-storing area, severely affecting to people and ambient environment Accident between ships for coal transport During the operation, repair and maintenance, occupational accidents may happen unless the workers rigorously comply safety regulations.	Medium

3.2.3.2.1. Impact of noise

Noise and vibration sources in the operation phase of the project include:

- Activity of Boilers and Associated Pumps in the Boiler House;
- Activity of turbine and generators;
- Activity of pump, fans, transformers and other engines;
- Transport activity of trucks;
- Activities at the 100,000 DWT port.

1. Operation of the power plant

Level of noise generated by activities of main equipments in the plant are presented in Table 3.49. Where noise source is isolated such as turbine house, boiler house, the noise level will be estimated at the entrance of such areas.

The dispersion of noise from port area to the ambient atmosphere can be calculated as follows:

$$L_p(X) = L_p(X_o) - \Delta L_d - \Delta L_c - \Delta L_{cx} \text{ (dBA)}$$

Where:

ΔLc	: Reduction of noise level by obstacle. Suppose $\Delta L_c = 0$ in project area.
ΔL_{cx}	: Reduction of noise by tree belts. Assume at a distance of 300 m, 150 m wide tree belt will be planted to isolate noise dispersion to residential area $DL_{cx} = 1.5Z + \beta\,\Sigma B_i$ (dBA)
1.5Z	: Reduction of noise by reflection of tree belt.
Z	: Number of tree belts
ΣB_i	: Width of tree belts. (m)
$\beta\,\Sigma B_i$	: Reduction of noise by absorption and dispersion of tree belt
b	: Average reduction number by frequence (β = 0.1 – 0.2 dBA/m)

Therefore, noise dispersion can be calculated as follows:

$$L_p(X) = L_p(X_o) + 20 \lg [(Xo/X)] - 1{,}5Z - \beta\,\Sigma Bi \text{ (dBA)}$$

Besides, as all machinery operates at once, the total noise level can be calculated as in the pre-construction phase:

$$L_{\sum} = 10 \times \lg \sum_{1}^{n} 10^{0,1L_i}$$

According to above equations, total noise level from the operation of equipment in plant to ambient environment are revealed in Table 3.49.

Table 3.49. Total noise level of key machinery and equipment of Vinh Tan 4 TPP

Items	Noise level (L_0)	Lp(X)					LΣ		
	X_0 = 1.5m	10	50	200	300	500	200	300	500
QCVN 26:2010/BTNMT		70 dBA (from 6.00 of key machinery and equipment of V							
Boiler house Building	112	96	82	70	49	45	76.8	56.8	52.4
Turbine hall Building	110	94	80	68	47	43			
ID fan Building	115	99	85	73	52	48			
Exhaust stack Area	114	98	84	72	51	47			
Circulating water pump Point	105	89	75	63	42	38			

Source: PECC2, 9.2012

According to above calculation, the level of noise generated from machinery and equipment in operation phase will meet permissive value stipulated in QCVN 26:2009/BTNMT for residential area at a distance of more 300 m, applied for normal area. Additionally, the resulted noise level were calculated in open space without consideration about noise reduction caused by obstacles as walls, construction... Hence, the practical noise level will be lower than calculated results.

-Also, at other locations in the plant, noise reduction measures such as low-noise machinery, sound insulation, etc. will be applied to ensure the noise level at each working position meets standards of TVCN 3985:1999 not affecting workers' health.

Table 3.50. Allowed noise level at working position in TCVN 3985:1999

No.	Working position	Noise level [dBA]
1	At the directly work place	85
2	Monitoring and remote control room (non phone, laboratories having noise source.	80
3	Monitoring and remote control room (having phone, control room, machine room).	70
4	The function administrative, planning and statistics rooms	65
5	Offices, research, design room, statistic, laboratories, etc.	55

At places where loud noise affects to operational staffs, the staffs will be equipped with appropriate safety gears and earmuffs.

In summary, impacts of noise due to plant operation is not significant when applying the appropriate mitigation measures. Details of mitigation measures are presented in Chapter 4.

2. Port's operation

Total noise level during the operation of Vinh Tan 4 port was calculated and presented in following table:

Table 3.51. Noise level from port's operation

Items	Noise level (L_0)	Lp(X)					LΣ		
	X_0 = 1.5m	10	50	200	300	500	200	300	500
QCVN 26:2010/BTNMT		70 dBA (from 6.00 – 21.00) 55 dBA (from 21.00 – 6.00)							
Ships/Boats	94	78	64	42	38	34	51.6	48.1	43.7
Cranes	96	80	66	44	40	36			
Loaders	84	68	54	32	28	24			
Air compressor	100	84	70	48	44	40			
Generator	98	82	68	46	42	38			

Source: PECC2, 9.2012

Calculation results show that the noise arising from the operation of machinery and equipment on the port ensure allowed limits on the construction site and within the allowed limits for residential areas at a distance of at least 200 m in accordance with the QCVN 26:2010/BTNMT, applied for normal area. Existing residential area is about 500 m from port, so that the operation of port do not affect residential areas and administrative offices.

At places where loud noise affects to operational staffs, the staffs will be equipped with appropriate safety gears and earmuffs.

3.2.3.2.2. Impacts from heat pollution

Heat generated mainly from the combustion of fuel (coal); at places such as boilers, stacks, the temperature may reach 40°C. Central affected objects from heat are operational workers. Working closely in high temperature environment, the body temperature of worker may increase significantly due to residual heat causing high level of biological heat in the bodies. As the bodies fail in neutralized residual heat, they will get tired increasing the possibility of accident and clinical symptoms of high-heat disease may occur. And if workers keep working in such conditions for long time, physiological activities will be disordered affecting directly to the central neural systems. This process as keeping happening will lead to chronic headache.

However, most of the staffs, workers will be working in control rooms; direct inspection will only be performed at certain period. Also, the mechanization at most of operation activities reduces greatly the damage of residual heat on operation staffs.

Therefore, impact of residual heat barely occur locally at some areas of the plant, not affecting nearby residents.

3.2.3.2.3. Impact on biological environment of Hon Cau MPA

The discharge of cooling water of Vinh Tan 4 TPP as well as Vinh Tan power complex will increase the temperature of seawater at Hon Cau MPA, affecting the ecology at Hon Cau MPA due to changes in environmental conditions. Directly affected objects will be fish, coral reefs, sea grass and benthic; details are presented as follows:

1. Impact of Temperature Increase on Fish Species

The increase of seawater temperature will decrease the level of oxygen dissolved in water and water density. This strongly affects physical characteristics of aquatic ecosystem, subsequently affects living conditions of local aquatic species. As the temperature exceeds the maximum natural temperature some degrees, lowly resistant organisms will be killed while strongly temperature resistant species will increase greatly, leading to alteration in structure of the community, affecting to ecological balance.

For example, if the temperature gets higher than 32°C for a while, cyanobacteria will become dominant species while some exotic species such as tubifieid Baranchiura sowerbyi will get more crowded.

At high temperature, rate of respiration and development of aquatic species changes altering rate of nutrient absorption, breeding and developing cycle.

For aquatic animal species, body temperature is usually only 0.5 - 1°C different from the external water temperature. Therefore, water temperature strongly and directly influences metabolism. Fish easily adapt to the seasonal change of temperature when the temperature difference between winter and summer is 0-30°C. However, fish will be affected by temperature when put into a medium with sudden change, warmer or colder 8-12°C depending on the species. In such cases, they may die from respiratory symptoms or heart muscle paralysis. For young fish, it can occur when the water temperature suddenly varies in a range of 1.5 – 3°C.

Study on direct or indirect effects of water temperature on aquatic bio-resources as well as particularly concentrated on aquatic animal species have been carried out by Kennedy, and J.Mihursky (1967), and E.Raney, and B.Menzel, (1967). However, almost all studies were taken place on fresh water fish such as *Cyprinus carpio, Carssius, Tinca tinca, Rutilus rutilus, Ctepharyngodon idella, Hypothalmichthys molitrix, Perca fluviatilis, Exoslucius...*

For the Vinh Tan area, most aquatic animal species are brackish or saline water species and have not been mentioned in any study. According to the above modeling results, most of the area affected by cooling water has the temperature difference only less than 1°C compare to the intake water (only a small part has the difference higher than 2°C) so that the impact on aquatic species is not considerable.

When the temperature of river water increases, respiration and pulse rate of fish increase and the demand of oxygen for metabolism increases accordingly. A study indicated that Ciprinus caprio at 1°C can survive the concentration of oxygen of 0.5mg/l but at 35°C, it can only survive if the concentration of oxygen is over 1.5 mg/l. Some fish species living in cold water can adapt to oscillation of water temperature in the range of 12 - 15°C, but are quickly affected at a higher temperature oscillation rate.

2. Effect of water temperature increase on coral reefs and sea grass

Data on coral reefs and sea grass are presented in *Chapter Two* shown:

- Seagrass mainly distributes in coastal area of Vinh Hao Commune, about 5-7 km far away from the project.

- At the coastline from Cat Trang to Hamlet 7, dead coral reefs dominate the inner site (approximately 50%) while plates and coral branches (Acropora, Montipora) govern the outer space. Most of the reefs are covered by sediment.
- The coral reefs mainly distribute at the Hon Cau coastal areas (approximately 10km to the south from project area), and seaweed concentrates in Breda sandbar (approximately 5km to the south east from project area), only few small reef (most of reefs are dead at Vinh Hao, Phuoc The and Vinh Tan coastal areas).
- The discharge of cooling water from Vinh Tan 4 TPP as well as Vinh Tan PC will warm up the ambient temperature of Vinh Tan coastal area. The most sensitive species to this change is coral. The temperature tolerant characteristic of coral are difference depending on environmental conditions (Coles và Jokiel, 1976; Hoegh-Guldberg, 1999). Many species of coral family has been living in the area of its temperature bearing ability (Hoegh-Guldberg, 1999; Fitt et al., 2001). Usually, coral can not tolerate a temperature which exceeds its highest annually average temperature more than 3°C. A limit of not-greater-than 2°C compare to ambient temperature is widely accepted regarding effect of temperature on coral. This well agrees with instruction of water quality of ASEAN on temperature increase not greater than 2°C compare to environmental temperature for coral.
- According to the above heat dispersion model, cooling water from Vinh Tan 4 TPP is discharge through a system of steel pipes at a depth of above-7,5m. As a result, local temperature increases up to 2°C compare to the surrounding temperature in an area of 0.23 km^2, about 1km northward from the discharging point. There are only a small reef of dead coral inside and hard plates Montipora at the outside. The increase of temperature at site is still in the tolerant range of tropical coral so that the coral is expected to quickly adapt to the new condition. Other places area from Hamlet 7 to Vinh Hao as well as Hon Cau island and Breda sandbar are not affected by the increase of temperature due to cooling wastewater from Vinh Tan 4 TPP.
- Regarding the temperature increases due to cooling wastewater from Vinh Tan 1, 2, 3 TPPs, the area which ha temperature increases about 2°C spreads in an area of 0.9 km^2 and 1.5 km southward from the wastewater source, alongside of the breakwater pointing to the sea from North to South and mainly focus at the Southern and Southeastern areas. The coral reefs at Bac No to Ca Na distribute mainly along shore where the temperature raises 1°C. Hence, the cooling water from Vinh Tan 1, 2, 3 merely affect the coral at shore. Cau island and Breda sandbar are not affected by the increase of temperature due to cooling wastewater.

  Therefore, impact of cooling wastewater on coral is estimated as minor; and regular monitor will be implemented.
- For tropical seaweed, demand temperature is about 25-35°C and in fact, they can leave at shores where water temperature does not exceed 40^0C. Hence, seaweed is expected to quickly adapt to the new condition of the environment.
- Impact on coral, seaweed due to heat is small and these species can adapt to the alteration of environmental condition. Hence, impact on biological diversity is

not considerable.

Therefore, the impact of cooling water on coral reefs and sea grass is consider as minor and will be regularly monitored.

3. Effect of water temperature increase on benthic

As mentioned above, the average water temperature of Vinh Tan coastal sea is 30^0C. If the discharge of cooling water of the thermal power plant raises the temperature 1-2^0C, the highest temperature will be 32^0C which should not considerably impact benthic animals in the whole area. According to the experiments done at the Institute of Tropical Biology in Ho Chi Minh City on some aquatic species such as Artermis salina, Metapecnacus eusis, Macrobrachium rosenbergii, Mytilus smargadimus, the temperature death threshold for tropical animals is in the range of 40 - 42^0C. In fact, the amplitude of temperature for reproduction of tropical aquatic animals in nature is 20 - 34^0C, the optimum temperature for their reproduction aquatic is 25 - 28^0C. It is necessary to consider the development of species, which live stuck to hydraulic works include Balamu amphitrite, Ostresa sp, Limnoperna siamense. The temperature their metabolism decreases is 35^0C. From 37^0C up, the intensity of metabolism decreases considerably. They could be seriously affected at 40 - 42^0C

4. Effect of water temperature increase on planktons

The increase in temperature impacts the development of planktons. At 16 – 19°C the bio-diversity of micro-organism is the highest. The bio-diversity is reduced according to the increase of the temperature but only in area which has a considerable number of individual.

So far, no studies has been found on the impact of heat pollution from cooling water of power plant in Vietnam. However, the operation of Vinh Tan 4 TPP may cause great disturbance for local ecosystem so that such impact will be monitor regularly.

Although the temperature increase is unavoidable and predicted to cause negative impact on aquatic ecosystem, the level is expected not significant. The area where temperature increases 2°C due to Vinh Tan 4 cooling wastewater accounts for only 0.2 km^2. As a result, impact of cooling water on benthic at Vinh Tan coastal area is not insignificant. The minor change of temperature in long-term period enhance the adaptation of aquatic organisms to the new environment.

Besides, incidents of oil spill, leakage of coal during transportation may severely affect the aquatic ecosystem at Hon Cau MPA. The assessment on oil spill, leakage incidents will be presented for more details in sections 3.2.4.2.5 and 3.2.4.2.6 below.

3.2.3.2.4. Erosion due to cooling wastewater discharge

Cooling water from Vinh Tan 4 TPP which the flow rate of 50 m^3/s after moving out of the condensers will be led to the siphons through a system of steel pipes and then led to the discharging point through box sewers. From the discharging point, cooling wastewater will be led to the sea, to the point about 400m away from the shore by a system of underground pipes with velocity lower than 1.3 m/s to the West of Vinh Tan power complex. Hence, erosion caused by discharging of cooling water will not occur.

3.2.3.2.5. Impact on local tourism

As presented in Chapter 1, the proposed project area is about 7km toward East from Ca Na Tourism, thus, Vinh Tan 4 TPP of operation will not affect tourism activities in the area.

Currently, the Vinh Tan coastal area has some households who making food service business to serve the people in the village. Due to coastal areas with deep water so tourism activities on local sea is not developed. Tourists mainly come from the village. In this region, the tourism has not developed and there are no infrastructures for tourism activities. Therefore, implementing Vinh Tan 4 TPP project in particular and Vinh Tan Power Complex in general will not significantly impact to the local tourism activities.

Coal transportation and storage: the plant will transport coal by closed conveyor system and the bunker will be designed with a roof, windbreak walls around and planting trees to prevent dust dispersion into the surrounding environment. Thus, dust emission from the transport and storage of coal is minimized and does not affect the area around the project.

3.2.3.2.6. Impact on aquaculture

Temperature is an essential factor affecting shrimp's life; as the temperature get too different from the physiological demand of shrimp, the metabolism will be affected (expressed as hindering in hunting, activity and ultimately dying as such condition lasts for a while). If the temperature exceeds tolerant limited of shrimp, they will be physiologically disordered and die. Some biological and ecological characteristics of shrimp are described in following table.

Table 3.52. Biological and ecological characteristics of prawns

Species	*P.monodon*	*P.vannamei*	*P.merguiensis*
Vietnamese name	Tôm sú	Tôm chân trắng	Tôm thẻ, bạc
Maximum size (mm)	360	230	
Growth	21-33g in 80-225 days	7-23g in 2.5 days	7-13g in 70-112 days
Temperature (°C)	24-34	26-33	25-30
Salt concentration (ppt)	5-25	5-35	5-33

Source: www.tepbac.com

Shrimps have the ability to resist the temperature up to 33-34°C. At above 32°C, food consuming of shrimps increases and they grow stronger. However, this growth of nutrient may stimulate the development of algae owing to high rate of nutrient release from food and organic matter at the bottom of pond. Consequently, dead bodies of algae will gather at the surface of ponds. This turns worse if the nutrient grows so fast exceeding the limit leading to the appearance of various toxic compounds such as nitrite, vibrio as well as other pathogens which can cause mass death of shrimp. Hence, it would be better not to feed shrimp at high temperature (higher than 32°C).

The discharge of cooling water may disturb shrimp farming at Breeding center of Vinh

Tan commune. The discharging will only increase the temperature to about 31-32 °C with a small area at the seashore. At this temperature, the breeding shrimp still can adapt to the change.

The discharge of cooling water from Vinh Tan power complex may affect to the shrimp at high range of temperature (above 33°C). Yet, this temperature usually gather around the breakwater, about 700m southward from the wastewater source. The place of breeding shrimp is about 1.5 km away from the high temperature area of Vinh Tan PC. Therefore, this impact is considered as acceptable.

Binh Thuan Province now has stopped implementing land grant for shrimp farming activities in the project area in order to supply land for the power project. According to the provincial planning, Ganh Hao - Chi Cong area (153.6ha in area) will be built into shrimp/lobster production areas of the province, shrimp hatching households affected by the construction of Vinh Tan power complex will be priority moved to this area.

Farming activities at Vinh Tan and adjacent communes (Vinh Hao, Phuoc The, etc.) are relatively well developed, mostly included shrimp and fish farming. Farming area is about 1 km away from the Vinh Tan 4 TPPs with about 15 medium shrimp and fish cages. This type of fish cage can be moved to other places so that the project will support the movement of such cages. Consequently, the discharge of cooling water does not severely affect the cage farming at Vinh Tan coastal area.

Thus, the construction and operation phase of Vinh Tan 4 TPP in particular and Vinh Tan power complex in general will negligible impact on farming and fishing of local people.

3.2.3.2.7. Impact due to coal and oil transport at port

In order to provide enough fuel for Vinh Tan power complex to reach its capacity of 5600MW, about 17.7 million tons of coal and 0.28 million tons of oil will be transported to Vinh Tan PC annually. Hence, every year, there about 394 trips of boats will reach the port of Vinh Tan PC and about 30 trips per year will reach Vinh Tan 4 port individually. That also means only one boat trip will reach the port everyday so that the transportation at site is estimated as stable.

However, material and fuel transport for Vinh Tan PC in general and Vinh Tan 4 TPP in particular will increase the density of local waterway transport. Accordingly, the frequency of boats, ships collision is increased affecting to local people and environment. Details of boat collision assessment are given in section 3.2.4.2.5.

3.2.3.2.8. Impact on the socio-economics

1. Impact on population and population structure

   The impact on population and population structure Vinh Tan 4 TPP's operation is due to the presence of a large amount of workers. Labor force for the plant is approximately 500 people. Although the policy of the project will focus on recruiting local labor for the project, a large number of workers will be recruited from other places for the project due to limited skills of local people which hardly meet the requirements of the project. Such impact in the operation phase is expected to occur at lower level than the construction phase.

2. Health and safety issue

   The disposal of waste to the ash yard will cause negative impacts on public health, especially for workers in this area. Accidents related to the high water level in the ash yard may cause death for workers and local people. However, this impact is considered small and preventable.

3.2.3.2.9. Impact on cultural relics and scenic

Linh Son Pagoda at Vinh Phuc village will not be directly affected by the activities of Vinh Tan 4 TPP. However, due to the appearance of the plant, especially activities of the ash yard, the transportation to and from the pagoda will be disturbed. Other cultural and religious sites in the project area will not be affected.

3.2.4. Risks and incidents

3.2.4.1. Environmental incidents in construction phase

Construction of a power plant is a complicated task requiring the activities of various specialized equipments. During the construction phase, these incidents may occur:

3.2.4.1.1. Landslide

Landslide mostly occurs due to the excavation of foundations which are relatively shallow and focus at plant site. So that, landslide is not a clear threat to the surrounding area but a local and controllable impact.

Besides, landslide possibility only occurs during the leveling of Vinh Tan 4 TPP. Landslide will block the flow to Chua stream (through the project area) affecting the ability of flood discharge and increase the turbidity in rivers during rainy season. *This impact is evaluated as medium as happening yet controllable.*

3.2.4.1.2. Collision of waterway transport vehicles, sinking, oil spilla

During construction phase, the activities of vessels, barges for transporting equipment may cause incident of collision between vessels in the project site. In case of accident, oil spill can adversely affect the ecosystem of Hon Cau MPA. As the oil concentration exceeds 0.2 mg/l, the water will turn smelly. Oil pollution hinders the self cleaning ability of the water source by destroying the planktons, benthic which are main factor for water self-cleaning as well as coral and sea grass. Oil contaminated water also causes depletion of oxygen owing to oxygen consumption for hydrocarbon oxidation as well as prevents oxygen dissolved from air. Consequently, the respiration of aquatic species at Hon Cau MPA will be affected. This impact is estimated as negative and significant if happening but proper controllable by technical measures.

3.2.4.1.3. Leakage of stored fuel

In construction phase, leakage of liquid and gaseous fuel from temporary storing places (paint, gasoline, oilntrollable by technical measures. project site. In case of accident, oil spill can adversely affect the ecosystem of Hon Cau MPA. As the, short circuit usually happens causing fire and explosion at the project area. This type of accident may cause huge socio-economic damage as well as harm to the local and surrounding ecosystem. However, since the volume of fuel stored is not high so that impact only occur within a limited region. Therefore, safety measures will be carefully implemented and supervised.

3.2.4.1.4. Occupational accidents

Occupational accidents may occur at the construction area which diverse reason including workersident may cause huge so at prohibited area, spark from engines, short circuit, lightning, or working in severe natural condition such as strong wind, sunlight, temperature and high elevationarea which diverse reason including workersident may cause huge so at prohibited area, spe death. This impact is estimated as negative, significant yet preventable by proper technical and managing measures.

3.2.4.2. Environmental risks and incidents in operation phase

Environmental incidents in operation phase of Vinh Tan 4 TPP include:

– Breakdown of ESP system

– Breakdown of SeaFGD system

– Leakage of chemicals

– Breakdown of wastewater treatment system

3.2.4.2.1. Leakage of chemicals

During operation, the thermal power plant will use some types of chemical for inhibiting the growth of weed and bacteria in the cooling system. These include ammonia hydroxide, hydrazine and sodium hypochloride, etc.

Ammonia hydroxide (NH4OH) as being leaked will affect the health of workers and the local community. By direct inhalation, NH4OH toxicity will be expressed as symptoms as follows:

Through eyes: cause allergy, possibly burns and blindness.

Through inhalation: cause allergy depending on the inhaled level. High concentration may cause pneumochysis and dead. The lethal dose is 5000ppm.

Through skin: cause allergy or burns

Through digestion: probably cause burns of esophagus, stomach and peritonitis. Symptoms include chest pain, nausea; lethal dose is about 3-4 ml.

As a result, the leakage of chemical may pollute the whole storing area and adversely affect to workers' health. However, the Project will apply chemical management measure according to the regulated in Decree No. 68/2005/ND-CP dated 20/5/2005 of the Government on Chemical safety.

3.2.4.2.2. Breakdown of the flue gas treatment systems

In the case of ESP and SeaFGD breakdown, the temperature of air heater is about 137°C, levels of pollutant dispersed are predicted as follows:

Table 3.53. Calculated results during breakdown of gas treatment systems

Parameter (*)	Concentration of pollutant before the treatment system (mg/Nm^3)	QCVN 22:2009/BTNMT (mg/Nm^3) (K_p=0,85, K_v=1)	Maximum concentration of pollutants at ground (mg/Nm^3)			Distance to stack (km)	QCVN 05:2009/BTNMT (mg/Nm^3)		
			1h	24h	Annual		1h	24h	Annual
Dust	6891	170	1.86	0.25	0.034	2.7	0.3	0.2	0.14

Parameter (*)	Concentration of pollutant before the treatment system (mg/Nm^3)	QCVN 22:2009/BTNMT (mg/Nm^3) (Kp=0,85, Kv=1)	Maximum concentration of pollutants at ground (mg/Nm^3)			Distance to stack (km)	QCVN 05:2009/BTNMT (mg/Nm^3)		
			1h	24h	Annual		1h	24h	Annual
SO_2	2660	425	0.72	0.098	0.013	2.7	0.35	0:125	0.05

As ESP is broken down, the temperature of dust at source will be about 40.5 times higher than the allowable value in QCVN 22:2009/BTNMT (170 mg/m^3). Similarly, as SeaFGD is broken down, the concentration of SO_2 at source will be about 6.3 time higher than the allowable value in QCVN 22:2009/BTNMT (425 mg/m^3).

Based on the results from air pollutant diffusion model, the level of dust, SOx at ground during the breakdown will be many fold higher than the allowable level regulated in QCVN 05:2009/BTNMT, refer to Table 3.1 for more results.

The maximum concentration of 1h average of SOx at ground is 0.72 mg/m^3, 2-time higher than the regulated value in QCVN 05:2009/BTNMT (0.35 mg/m^3). The point which has highest level of SOx at ground locates about 2.7 km away from stack of Vinh Tan 4 TPP to the Northeast. The entire Vinh Tan commune and a part of Ca Na area will be affected by SOx during the breakdown. The average concentration of SO_2 at 24 h and annual value at ground meets the environmental standard.

The maximum concentration of 1h average and 24h average of dust at ground are 1.86 mg/m^3 and 0.25 mg/m^3 respectively; about 1.3 – 6.2 time higher than the regulated value in QCVN 05:2009/BTNMT (0.3 mg/m^3). The point which has highest level of dust at ground locates about 2.7 km away from stack of Vinh Tan 4 TPP to the Northeast. The entire Vinh Tan commune and Ca Na area within the radius of 30 km will be greatly affected.

From the results of Table 3.1, Figure 3.4 and Figure 3.4, as the flue gas treatment systems break down, the entire Vinh Tan commune will be polluted by air emission of the power plant with the concentration of pollutant exceed many folds compare to the regulated value in QCVN 22:2009/BTNMT (Kp=0,85, Kv=1) and QCVN 05:2009/BTNMT. Therefore, during the breakdown, the plant will stop operating until the systems get fixed.

Figure 3.49. Dust diffusion - 1h average in case of incidents

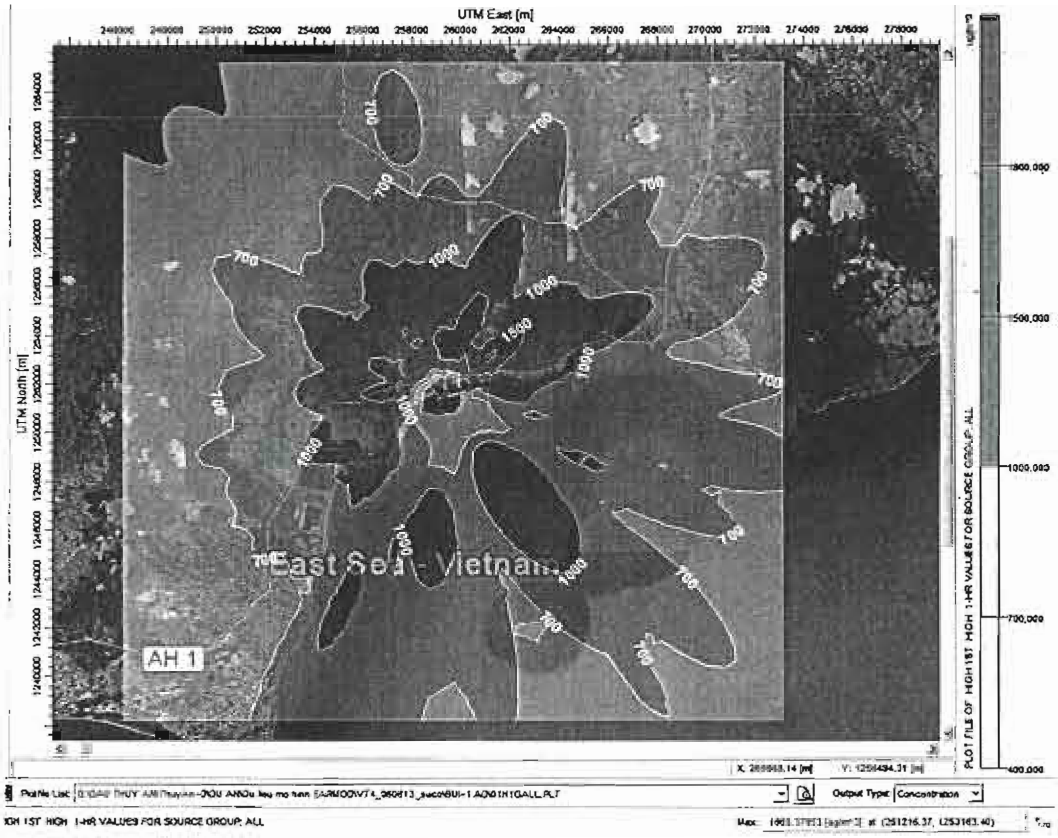
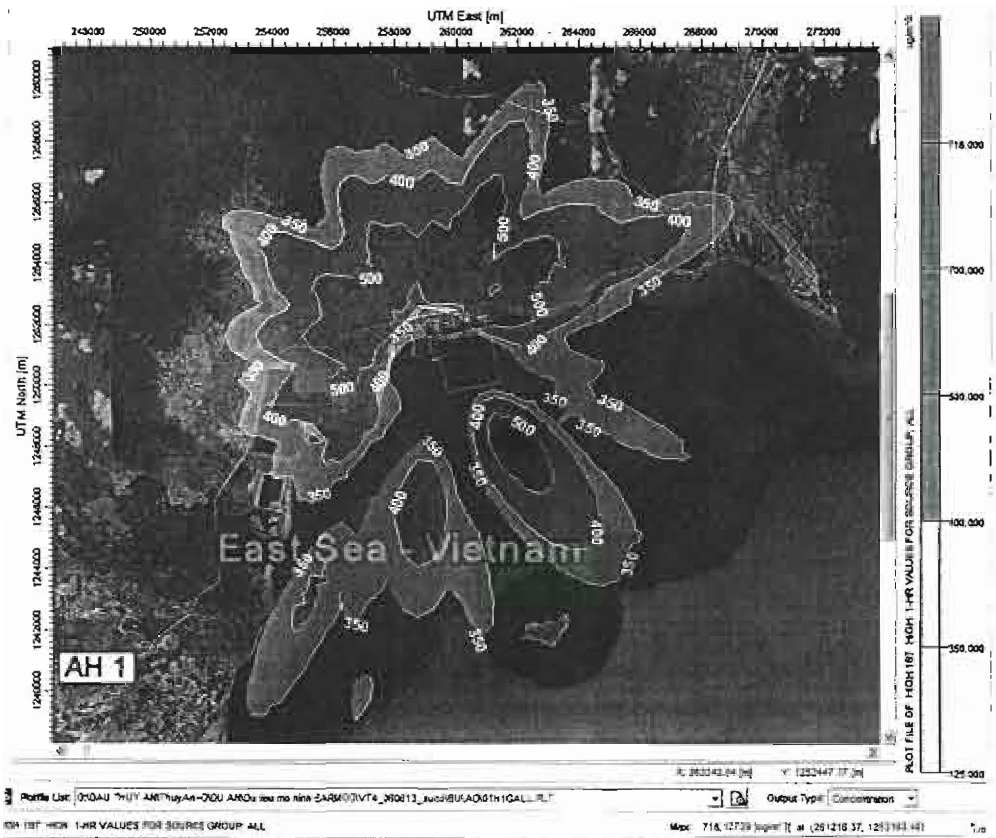


Figure 3.50. SOx diffusion in case of of incidents



3.2.4.2.3. Breakdown of the wastewater treatment system

As the wastewater treatment system breaks down, direct affected object will be seawater environment. A total volume of 105 m^3/h including oil-, coal-, chemical-contaminated wastewater and domestic wastewater will significantly change the characteristics of the receivers such as pH, increase BOD, COD, turbidity affecting people health and the aquatic ecosystem of Hon Cau MPA. Oil contamination reduce self-cleaning ability of the water source by destroying the planktons and benthic. The oil layer also prevent the permeate of oxygen into water.

However, backup system for wastewater treatment will be constructed (2x100%) which share the same capacity to perform the treatment continuously during the breakdown.

3.2.4.2.4. Occupational accidents

a. Objective causes

- Unsightly weather conditions affect to the productivity and safety. On rainy days, slipping hazard increases, motorcycle riding gets more difficult.
- The working environment pollution is the reason to affect the health of workers and indirect causes of labor accidents. Working in the sun for a long time, exposed to high temperature area, exceeds 90 dBA noise, etc. causing fatigue to employees.

b. Subjective causes

- Managing and operational causes such as failure in foreseeing incidents, noticing those risks to employees. For example, no danger signs under the rotation of the crane, machinery; using workers with low professional skills or non-conformity function.
- Subjective reasons usually occurs to workers who have experience in labor, as they disregard safety rules such as not carrying safety helmets, safety belts when working on high, going into restricted areas...

3.2.4.2.5. Incidents due to sinking and colliding of fuel transporting ships

To meet fuel demand for Vinh Tan Power Complex operating at full capacity of 5600 MW, annually, there will be 394 ships (an average of 2 times/day) into the port. Thus, possibility of collision between vessels is very small. In addition, even though the coastal area of Ninh Thuan-Binh Thuan is rarely affected by storms, the capability of sinking still exists in this region.

When incidents of collision occur, sinking ships will cause the following effects: Coal will be poured into the sea with very large volume (several tens of thousands of tons) that they will increase the turbidity of the sea and will settle to the bottom forming layer covering the surface of the seabed after a period of time. Negative impact on seawater quality due to this type of incident is increasing turbidity, damaging living condition of various aquatic species such as coral, seaweed at Hon Cau MPA.

As settling to the seabed, coal will form a thick layer hindering respiration of benthic, coral, seaweed and probably causing death to such species. However, coal will be travelled in closed compartments on vessels so that the volume of dropped coal will be very less in the case of incidents. Additionally, the salvage will be performed faster, limiting impact to the environment.

Besides, vessel collision at port may cause oil spill affecting the aquatic ecosystem and local water environment. More details are given in section 3.2.4.2.6.

The consequence of this effect is increasing marine pollution and economic loss for the coal port management unit. Sinking incidents and coal dispersion into the sea will be great threat to the benthic, coral and aquatic living at Hon Cau MPA as happening. This impact is hardly recoverable yet preventable.

3.2.4.2.6. Oil spill

Vinh Tan 4 TPP takes FO oil from Vinh Tan 2 TPP through the transportation by ships via Vinh Tan 2 port. Impact of oil spill is assessed in more detail in EIA report for Vinh Tan Power Complex coal port – Phase 1 approved by MORNE. In the scope of Vinh Tan 4 TPP, only oil spill caused by vessel collision, oil pipes break will be considered.

Refer to the modeling results of oil dispersion due to ship sinking from EIA report of Vinh Tan PC Coal port – Phase 1, the oil spill when occurs will affect the Ninh Thuan – Binh Thuan coastal area from Ca Mau to Phan Thiet, including Hon Cau MPA and tourist sites, onshore aquaculture areas.

As being released into the environment, oil and other volatile organics quickly evaporate into the air with specific smell. Factors directly affect the air quality in this case is hydrocarbon derivatives which are harmful to human health at a certain dose.

When oil spill happens, the surface water source will be polluted reducing the density of plankton significantly; possibly changing the structure of aquatic ecosystem and organism community; affecting to the water quality and the food chain.

As the oil concentration exceeds 0.2 mg/l, the water will turn smelly. Oil pollution hinders the self cleaning ability of the water source by destroying the planktons, benthic which are main factor for water self-cleaning as well as coral and sea grass. Oil contaminated water also causes depletion of oxygen owing to oxygen consumption for hydrocarbon oxidation as well as prevents oxygen dissolved from air. Consequently, the respiration of aquatic species at Hon Cau MPA will be affected.

As exceeding 0.1-0.5 mg/l, the productivity and quality of fish will be decreased. The limit of oil in water for aquaculture must not exceed 0.05 mg/l, where as DO value must be not less than 6 mgO_2 /l.

In water, oil will be transformed to toxic compounds such as phenol and chlorine derivatives of phenol. Limit of phenol in water for domestic water supplying is 0.001 mg/l.

Oil and its decomposed products penetrates into the soil and directly damages trees as well as reduces decomposition activities of microorganisms. Consequently, porosity and fertility of soil are decreased and the productivity of plant is indirectly affected.

This impact is *severe* on aquatic ecosystem at Hon Cau MPA and some *economic sections* such as aquaculture and tourism. Hence, prevention of oil spill is an important task that requires great care from the project and fuel transport companies.

3.2.4.2.7. Explosion incidents

Since the plant operation always require a volume of fuel stored such as: FO, gasoline for engines, machinery… These fuels are all combustible and explosive. The nature of combustion process can be divided into 4 main groups:

- Group 1: combustion of combustible materials such as: coal, covers, paper, wood, garbage…;
- Group 2: combustion of liquid fuel such as: gasoline, oil, gas…; explosion of gasoline tanks, oil tanks at port;
- Group 3: combustion of electrical equipments;
- Group 4: combustion by lightning.

Main reasons of combustion include:

- Transport of combustible fuel and materials such as gasoline, oil through places where heat and sparks are generated;
- Store fuel and material at unprescribed places;
- Throw cigarette or other ignition sources at petroleum, oil storage areas, coal storage areas, packaging paper, wood, etc;
- The problem of overloaded electrical equipment during operation, or short circuit in case of encountering storm;
- Explosion and combustion caused by lightning...

The incidents will cause serious damage to the environment, human, destruction to ships and other technical equipment. Consequences of fire will be very serious, especially in the dry season, when it not just directly affects the infrastructure at the port, but also spreads to neighboring areas. Hence, during the operation, Fire must be paid extra attention to ensure human safety and minimize loss

- Explosion of oil tanks
  + Fires can occur in the tank area as well as gas leading pipes. Burning of diesel oil and natural gas will cause serious environmental impact to the plant and surrounding areas. In the project area, during dry season with high air temperature, low humidity, fire at fuel storage has high chance to occur, especially when there is high concentration of hydrocarbon in air or there is igniter.
  + Impact of a fire is usually very dangerous; a simulation for one fire is calculated as follows:
  + Calculation method: flow of oil releasing: 1000 tons/s

The calculated results of thermal radiation as well as prediction of affected area for the fire incident cases with the flow of releasing oil is presented in 0 and 0.

Table 3.54. Results of radiation calculation

No.	Amount of released (ton/s)	Fireball radius (m)	Firing time (second)	Affected area (m)
1	300	164.7	2006.3	77
2	600	207.5	1263.9	87
3	1000	246	899.1	95

Note: The affected area is where the radiation is greater than or equal 30 kW/m^2

Remarks

- The above calculation results show that the affected range in case of incident is very wide (≈ 95m depending on the amount of oil leakage)

- Such radiation level can cause fire to the surroundings (the radiation from 30 kW/m² can cause fire). Also, owing to high pressure of the tanks, the explosion of fuel tanks will cause much higher impact level. The radiation and affected areas of 1 fire are presented in 0.

Figure 3.51. Radiation attenuation as a function of distance in case of oil spillage of 1000 tons/s

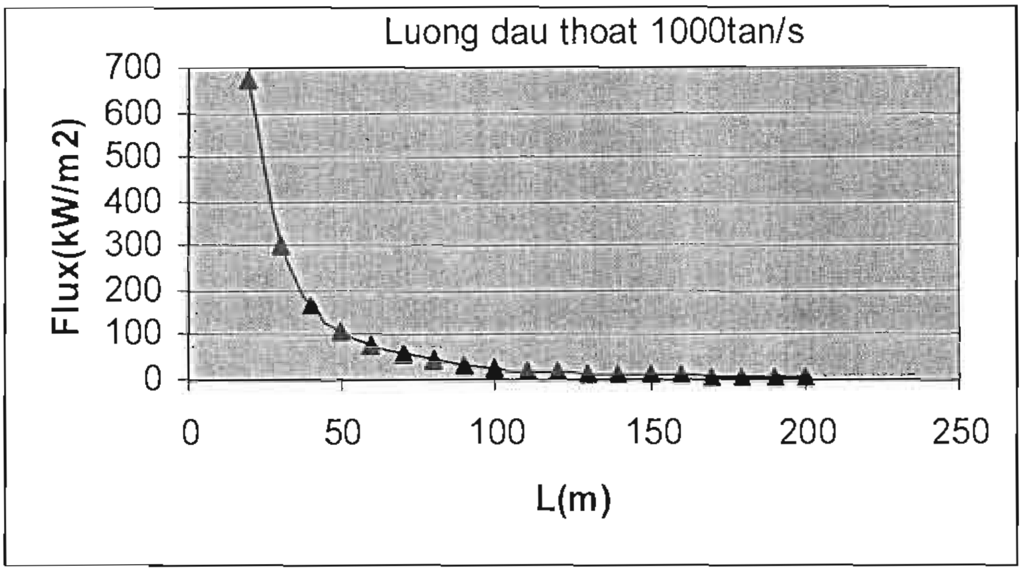


Figure 3.52. Simulation of fire (viewed from above) with oil spillage of 1000 tons/s

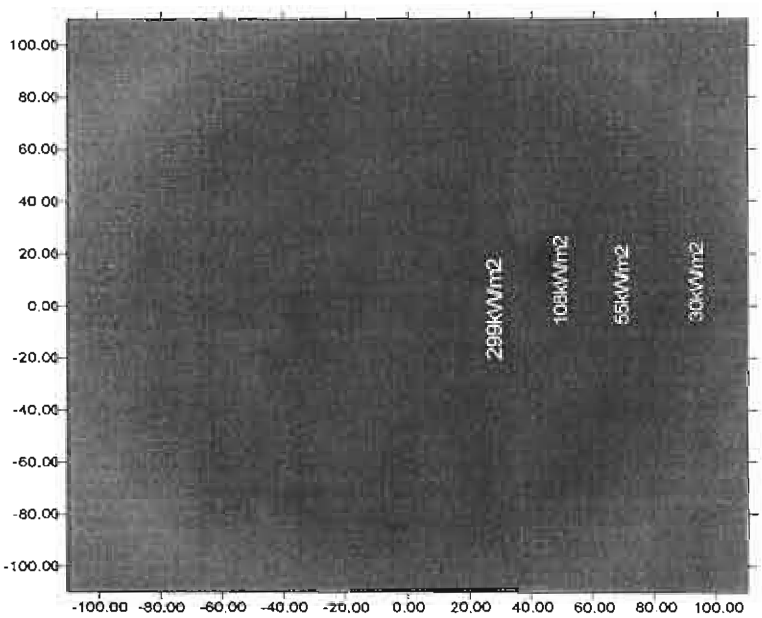
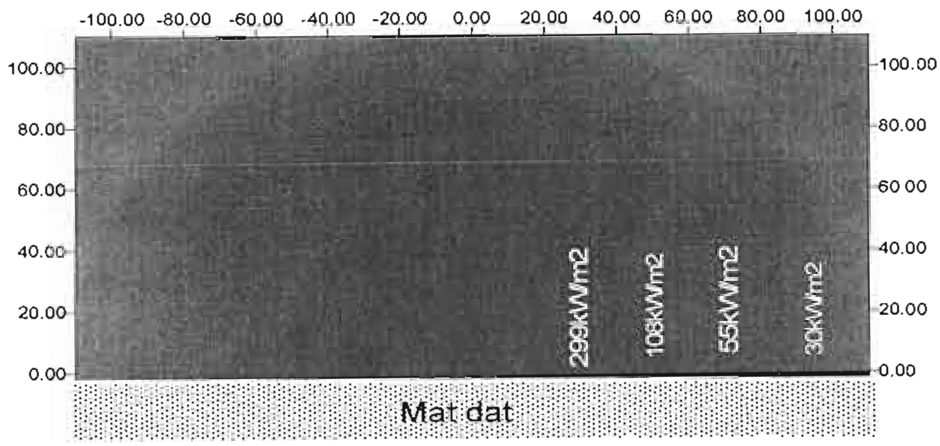


Figure 3.53. Simulation of fireball (cross section) with oil spillage of 1000 tons/s



3.3. COMPREHENSIVE ASSESSMENT ON IMPACTS OF THE PROJECT ON THE ENVIRONMENT AND SOCIO-ECONOMIC CONDITIONS

In order to evaluate the intensity of environmental impacts that may occur due to the project, the Impact Quantitative System (IQS) has been used in this EIA. It is an advanced method of high comprehensibility. To calculate environmental impacts due to diffusion of emissions and cooling water from the plant, as well as fire and explosion, mathematical models (simulation method) are used for quantitative prediction.

IQS is developed based on combination of EIA guidelines by E&P Forum, United Nations Environmental Program (UNEP), and the World Bank (WB). In IQS, each identified impact is rated based on the factors as follows:

Factor	Typical parameters
- Physical, chemical and biological interactions	- Intensity, frequency
- Probability of occurrence	- Scope of impact
	- Time for restoration
- Management	- Laws, costs, and community attention

The impacts will be analyzed, evaluated, and scored based on the characteristics of the impact. The total score will be calculated based on the following formula:

Total score (TS) = (M + S + R) x F x (L + E + P) = the overall level of impact (TS)

Based on IQS and analyses and assessments above, negative environmental impacts of the project are summarized in 0.

More detail on the Impact Quantitative System (IQS) is given in Appendix 3.5 - Chapter 3.

3.4. EVALUATION ON DETAIL AND RELIABILITY OF THE ASSESSMENTS

3.4.1. Remarks on the reliability of methods used in this EIA

The methods used for prediction of environmental impacts in this EIA study include:

- Field investigation

This method was implemented in February 2012. The investigation content includes:

Survey, collect data on socio-economic conditions, infrastructure of the project site.

Take sample for analyses of air, surface water, groundwater, sediment, microorganism;

Collect data on meteorological conditions at and around the project site;

This method basically bases on analysis and data processing in the laboratory according to standardized procedures, regulation in the laboratories as well as method for socio-economic investigation on the background of locally practical conditions. Hence, the collected data are reliable and real.

- Statistics and comparison

  Based on socio-economic reports of Tuy Phong district, Vinh Tan commune in 2011, 2012 and results from environmental quality analysis at project site, the sources and level of impact are assessed in compliance with current regulations. This method are able to provide quantitative and qualitative assessment results with high reliability. Hence, it is proper to use for the assessment of environmental impact in plant.

- Checklist, matrix:

  Used to identify the initial environmental impacts. The checklist shows the relationship between the activities of the project with the environmental parameters which are able to be affected by the project, preliminarily assessing level of impacts.

- Rapid assessment:

  Applied according to the World Health Organization (WHO) and the United States Environmental Protection Agency (US.EPA). This method is used to determine the amount of pollutants based on pollution coefficients of each parameter. This method is also used to quantify amount of pollutants arising from construction and operation activities based on information about volume of construction materials, equipment and number of workers… as well as data on local environmental status. According to the calculated results, environmental impacts are classified by level of impacts on environment. Therefore, this method is proper to assess the environmental impact in plant.

- Expert judgment

  Based on experiences of experts, the result of this method depends on subjectivity and objectivity of experts.

- Environmental modelling

  Modeling is a mathematic approach simulating the changes in environmental quality under the influence of one or more factors.

  Model simulating the diffusion of flue gas in the atmosphere: based on data of load, the input flow of the plant is calculated by SteamPro (a software for calculation of heat cycle of plant with high reliability) and meteorological data in hourly average during the year (such data was obtained from MM5 model of

American atmosphere research center) to predict the diffusion of flue gas from the project site. AERMOD model (USA) is used to simulate flue gas diffusion. This model is widely accepted to used by environmental agency in USA, Australia and Europe. Hence, this method is proper to assess the impact caused by flue gas from the plant.

Model simulating the dispersion of substance due to dredging and leveling: Delft3D model (Netherland) is used to simulate the substance dispersion of such activities. This model is widely used all over the world with high reliability. Based on the data of leveling/dredging volume, time as well as topographical condition at the project area, wave, tidal data at nearest stations, hydrodynamic condition and substance dispersion are simulated.

Model for heat dispersion simulation: MIKE 2D, 3D (Denmark) model were used. This model is widely used all over the world with high reliability. Based on the data of flow, temperature of cooling water, heat cycle of the plant as well as topographical condition at the project area, wave, tidal data at nearest stations, hydrodynamic condition and substance dispersion are simulated. This method is proper for simulating heat dispersion from the plant.

- Overall assessment:

This method assesses all the impacts of the project generally and subsequently suggest appropriate measures for mitigating the impacts, preventing incident and rescuing during incidents. Although the efficiency of this method depends on the person, it still ensures the reliability since the assessment will be implemented by environmental experts.

- Impacts quantitative system (IQS)

Built on the combination of EIA guidelines of United Nations Environment Program (UNEP), World Bank (WB), etc so that the reliability is ensured. This method assesses the environmental impacts based on the results of above methods in order to classify and rate the impacts.

All the methods above are used widely in EIA for development projects in Vietnam and in the world. In this EIA study, they were applied by experienced and skillful experts in EIA as well as specific domains (modeling, assessment of terrestrial biosystem, study of aquatic biota, etc.). Therefore, the results of the assessment have high reliability

EIA for the project complies with the following procedure:

- Identify and quantify sources of impact for the power plants activities (or components of the activities) of the project.
- Determine the spatial scope and time of affected objects.
- Evaluate impacts based on scale of sources, spatial scope and sensitivity affected objects.

The assessment of the impacts of the project is quite detailed and specific. Therefore, according to this evaluation, the project has set out feasible mitigation, prevention and response measures.

3.4.2. Reliability of environmental impact assessments

Environmental impact assessment methodologies are presented and evaluated above. Assessment results are reliable. Therefore, assessment of impacts and level of impacts on the environment during each phase of the project is practical. The project owner's commitments are described in detail in this report to reduce and prevent pollution in order to ensure development of the project and protection of local environment.

Remarks on the level of detail and reliability of environmental assessments are presented in Table 3.1.

Table 3.55. Summary of impact and remarks on environmental impact assessment

Source of impacts	Affected objects / Remarks	Remarks on level of details and reliability
PRE CONSTRUCTION/CONSTRUCTION STAGE		
Dust and Air Emission	Transport of materials and equipment.	US.EPA formulas are empiric with high reliability and widely applied in many countries such as USA, Canada, New Zealand, Australia etc. Defect: the load of substances depends on operation condition of machinery, equipment or vehicles such as departing, standing by or stopping, etc. In real condition, mass of transported materials candition of machinerys expected. The calculation of substance dispersion depends on meteorological condition at the calculated time. In the EIA report, calculation is for average annual data. Therefore, the derivation at actually time is irresistible.
Noise	Operation of equipment and machinery	The US.EPA formulas are empiric with high reliability and widely applied in many countries such as USA, Canada, New Zealand, Australia etc. Calculation of noise based on research on noise during construction phase of USEPA (USA). Defect: the common noise level of each vehicle depends on flow, type, road condition and surrounding topography, etc. Noise of vehicle is usually not stable (rapidly change by time). Hence, equivalent coefficient of average noise integrated from a period of time is used to express the noise and integrated average noise meter was used to measure noise level of vehicles line.
Wastewater	Workerwater le is usual	Flow rate and substances concentration in domestic wastewater: based on supply water demand of each worker to estimate flow rate of wastewater. Hence, there was the error because of the difference of each workere, there w - Volume of industrial wastewater was estimate based on supply water demand or experiences. So the error will occur. - Scope of impact: the definition is quite qualitative because of the lack information about the parameters of receiving sources.

Source of impacts	Affected objects / Remarks	Remarks on level of details and reliability
Impact on sedimentation-erosion	Flow regime Causing sedimentation in the region.	Analysis and assessment are quite detailed based on survey of detailed topography as well as hydro-meteorological data from stations at the region. DELF3D model was used to simulate the flow and dispersion of substance in seawater to assess the impact on flow and seawater quality at the project area once the breakwater was built. The assessment is reliable.
Erosion and sedimentation due to dredging work.	Impact on flow regime Cause sedimentation in the coastal area	Analysis and assessment are quite detailed based on survey of detailed topography as well as hydro-meteorological data from stations at the region. DELF3D model was used to simulate the flow and dispersion of substance in seawater to assess the impact on flow and seawater quality at the project area during dredging work. The assessment is reliable.
Suspended solid dispersion to the disposal area	Increase turbidity of the coastal area. Impact on ecosystem at receiving area	Analysis and assessment are quite detailed based on survey of detailed topography as well as hydro-meteorological data from stations at the region. DELF3D model was used to simulate the flow and dispersion of substance in seawater to assess the impact on flow and seawater quality at the project area during dredging material disposal. The assessment is reliable.
Solid waste		Calculation based on number of proposed workers for construction of the plant. Mass of solid wastes was estimated base on average emission norm so that difference from actual situation is not preventable.
	Local traffic Biological resources - Socio-economic - Regional securities	Analysis and assessments are quite detailed based on baseline data collected at site. Public and local consultation opinions help adjust assessment to be more accurate. This analysis is also based on experiences in similar projects in other areas and statistical data of trusted sources.(such as WHO, US.EPA). The assessment results are trustable.
OPERATION PHASE		
Air emissions from plant	Air pollution Significant impacts, long-term but controlable.	Analysis and assessments are quite detailed based on baseline data collected at site. Meteorological data are exported from the MM5 model – moderate scale meteorological models of National atmospheric research center and University of Pennsylvania in America with time series of 1 year. AERMOD model is used to simulate dust dispersion to assess the impacts of the project's activities on the surrounding environment.

Source of impacts	Affected objects / Remarks	Remarks on level of details and reliability
		The assessment result is trustable. *Defect:* Modeling is limited by rigorous marginal conditions, baseline substances concentration is presumed as "Zero", effect of terrain condition was not considered in modeling.
Domestic and industrial wastewater	Pollute the receivers (seawater onshore)	Analysis and assessments are quite detailed based on modeling results from SteamPro and referred from similar power plant project. The results are reliable.
Cooling wastwater	- Increase in seawater temperature - Impact on local infauna and flora - Significant impacts, long time but can be controlled.	Analysis and assessments are quite detailed based on baseline data collected at site and results of mathematical modeling. Met data were taken from local stations (meteorological and hydrographic) Mike 3 was used to simulate thermal dispersion of cooling wastewater to assess increase in seawater temperature and its impact on surrounding environment. The assessment result is trustable. *Defect:* data were not enough, some of data for modeling were taken from Phu Quy, Vung Tau stations after interpolated. Therefore, the modeling results were affected. Modeling is limited by strictly marginal conditions.
Domestic and industrial solid waste	Worker's daily activities and operation of the plant.	Calculation based on number of workers and proposed actual data supplied by the owner for operation of the plant. Amount of solid waste was estimated based on average emission norm. So it will be different from the real condition.
Impact on fishery	Increase in traffic density	Analysis and assessments are quite detailed based on baseline data collected on site. Public and local consultations help adjust assessment to be more accurate. Assessment results are reliable.
Impact on social – economic conditions	Local securities	

Table 3.56. Summary of negative impacts of Vinh Tan 4 TPP on the natural and socio-economic environments

Phase of the project	Environmental impact	IQS								
		M	S	R	F	L	E	P	TS	Rating
Pre-construction phase										
	Impact on socio-economic condition due to land withdrawing	2	2	3	2	2	2	3	98	Medium
	Increase in air pollution	2	2	1	1	1	2	2	25	Minor
	Increase in noise pollution	2	2	1	1	1	1	2	48	Minor
	Impacts of vibration	0	0	1	0	0	1	1	0	None impact
	Surface water pollution due to wastewater	2	2	2	2	2	2	2	72	Medium
	Soil and underground pollution	1	0	1	1	1	2	1	8	None impact
	Impacts on bio-resources due to land reclamation	2	2	3	2	2	3	3	112	Medium
	Impacts on local traffic	2	2	1	2	0	1	2	30	Minor
	Impacts in cultural and religious works	0	0	1	1	1	2	2	5	None impact
	Matters of safety and health	1	1	1	1	0	1	2	9	Minor
	Impacts of workers' aggregation	2	1	2	1	0	1	1	10	Minor
Construction phase										
	Increase in air pollution	2	2	1	1	1	2	2	25	Minor
	Increase in noise pollution	2	2	2	2	1	1	2	48	Minor
	Impacts of vibration	0	0	1	0	0	1	1	0	None impact
	Surface water pollution due to wastewater	3	2	2	2	2	2	2	72	Medium
	Soil and underground pollution	1	0	1	1	1	2	1	8	None impact
	Impacts on bio-resources by discharging dredged material	2	2	4	2	2	3	3	128	Medium
	Impacts on local traffic	2	2	1	1	0	1	2	15	Minor
	Impacts in cultural and religious works	0	0	1	1	1	2	2	5	Minor
	Matters of safety and health	1	1	1	1	0	1	2	9	Minor

Phase of the project	Environmental impact	IQS								
		M	S	R	F	L	E	P	TS	Rating
	Impacts of workers' aggregation	2	1	2	1	0	1	1	10	Minor
Operation phase										
	Increase in air pollution due to flue gas	3	2	2	2	2	3	3	112	Medium
	Increase in air pollution due to standby electric generator	1	1	1	0	0	1	1	0	None impact
	Increase in noise pollution	2	2	3	2	2	3	2	98	Medium (inside the plant)
	Increase in vibration	1	1	1	2	0	1	1	12	Minor
	Pollution of surface water, underground water due to effluent	2	2	2	3	2	2	2	108	Medium
	Impacts of solid waste, ash	2	2	3	3	2	1	2	105	Medium
	Impacts of hazardous waste	2	1	3	1	2	3	3	48	Minor
	Impacts on bio-resources	2	2	3	2	2	3	3	112	Minor
	Thermal pollution	3	3	3	2	1	2	1	72	Minor (inside the plant)
	Impacts of transport of materials and products	2	2	2	2	0	2	2	48	Minor
	Fire and explosion at fuel zone	4	3	1	1	2	3	1	48	Minor
	Work accidents	2	1	1	1	2	2	1	20	Minor
	Negative impacts on local socio-economy	1	1	1	1	2	1	3	27	Minor

Source: PECC2, 2012

Note:

M: Intensity
F:Frequency
P: community concern

S: Scope of impact
L: Law

R: Recovery time
E: Cost

Chapter

4

MEASURES FOR MITIGATION OF NEGATIVE IMPACTS, PREVENTION AND RESPONSES TO ENVIRONMENTAL RISKS

4.1. GENERAL

In addition to the positive socio-economic activities, the Vinh Tan 4 thermal power plant project has been also brought some negative impacts and influences to the environment during the construction and operation phase. Therefore, the following mitigation measures will be implemented in order to prevent and mitigate the negative impacts which might occur in the pre-construction, construction and operation phase to ensure the good environmental status for the protection area, safety and health of workers. The detailed measures are shown as follows.

4.2. MITIGATION MEASURES IN PRE-CONSTRUCTION PHASE

4.2.1. Mitigation measures for impacts in design stage

In order to prepare for the construction phase of the project, a proper planning of roads for material transportation, power supply for construction, sites for workers camps and other auxiliary systems, etc. is necessary to mitigate potential impacts due to construction activities such as noise, vibration, air and water pollution on local residential areas and surrounding environment.

Some main requirements on the planning of these items in order to minimize environmental impacts are given below:

- Appropriate planning and utilization of water-way transportation to minimize dust generation along the transport routes and around the project areas.
- Proper planning of sites for workers' camps with adequate sanitary systems to prevent impacts of sanitary wastes and local security.
- Suitable planning of constructional power supply system to avoid impacts on local power consumption as well as to prevent accidents and incidents related to power transmission.
- Appropriate planning of roads for material and fuel transportation to limit maximally the generation of dust, noise and vibration which may cause impacts on surrounding residential areas.

In addition to those mitigation measures, all items of the project are designed to satisfy with the requirements of environmental protection, especially for the Hon Cau marine protection area (MBA) with the following criterias:

- Air quality in the entire areas of the plant and auxiliary facilities meet Vietnamese National Technical Regulations (QCVN).
- Using international standards and Vietnamese standards (TCVN) for designing the project.
- To design a proper wastewater treatment facility, so that the entire volume of domestic and industrial wastewater, which are containing high content of organic matter, solids, nutrients, grease and oil, can be treated in order to meet wastewater standards before being discharged.
- To design a proper rainwater drainage system separated from domestic and industrial wastewater drainage system to transfer runoff water to sea.

- To design proper cooling water intake and discharge channel to avoid negative impacts on the natural ecosystems in project area. Cooling water will be taken from the sea, through cycle pump system to the condenser. Hot water is discharged ensuring that the cooling wastewater temperature is not over 40^0C.
- Proper design of safety system for the sensitive sites to fire and explosion, e.g. fuel storages, smoking areas, etc. All design for fire prevention and fighting should be approved by the Binh Thuan Police.
- Design of ash yard with proper capacity for storage of ash for the whole life time of the plant. Bottom layer, cover layer, dikes, etc of the ash yard are designed to a high safety standard to avoid potential impacts on groundwater and the surrounding environment.
- Design of proper coal storage area to avoid air pollution caused by coal dust dispersion.
- Design and operation of highly effective dust, SO_2, NO_2, etc. control facilities to minimize air pollution from flue gas and to meet the National technical regulation on emission of thermal power industry (QCVN 22:2009/BTNMT), Kp = 0.85, Kv = 1.
- Design of a centralized wastewater treatment system meeting National technical regulation on industrial wastewater (QCVN 40:2011/BTNMT), B category with Kg = 1.0 and Kf = 0.9.

The mitigation measures in terms of planning and design that mentioned above will ensure quick and proper construction activities as well as close and appropriate analyses and prevention of risks and incidents which may happen during the operation of the project. Additionally, proper planning and design will help avoid unexpected changes and amendments in later stages so as to minimize cost and save time for the project.

Advantages: high efficiency in supporting the planning of environmental protection and management programs. Besides, these measures will help optimize the control of cost and schedule in implementing the Project.

Disadvantages: high cost for consulting services and detailed planning and design. However, due to the necessity of the Project and the importance of these measures, the project owner will have considerations and proper financial solutions to guarantee the quality of the planning and design works. Therefore, these measures are considered as feasible.

4.2.2. Mitigation measures for impacts on land use planning

Formation of the project will change the land use planning of Vinh Tan commune, Tuy Phong district and affect the orientation of local socio-economic development as well.

The project area is planned for aquaculture (shrimp farming industry). Therefore, the formation of the project will affect the local aquaculture industry. Currently, People's Committee of Binh Thuan province has stopped implementing land acquisition for shrimp farming in the project area. According to provincial plan, Ganh Hao- Chi Cong area (153.6ha) will be proposed to be a breeding shrimp production area. Aquaculture households affected by construction of the Vinh Tan power complex in general and

Vinh Tan 4 thermal power plant in particular will be given priority in settlement in this area. Therefore, impacts on the local aquaculture industry in the project area will be substantially mitigated.

4.2.3. Mitigation measures for impacts due to land withdrawal and site clearance

During the land withdrawal and site clearance stage of the Project, there should be good cooperations between the project owner, the consultants, the local authorities and affected households in the project area to ensure the following tasks will be done efficiently and obviously as per required by related regulations and laws: land lost enumeration, compensation preparation, compensation, resettlement, etc. Main solutions of the project owner are as belows:

1. *Compensation solution, support and land clearance*

   To meet the project schedule, the compensation and site clearance will be conducted in accordance with Vietnam laws.

   - To co-operate with local authorities in conducting compensation and resettlement complying with current regulations. Announcement of land withdrawal reasons, resettlement time and plan, enumeration time, resettlement areas (if any) for affected households.
   - To measure, inventory the lands, crops, trees, and infrastructure.
   - To form a detailed compensation plan.
   - After the detailed compensation plan is approved, it is necessary to conduct and compensate for the affected households and announce emigration to leave the land for the contractor to implementing the project.
   - To collect and response to grievances (if any) of affected organizations, individuals, and households.
   - During the implementation, to co-operate with local authorities to organize propagandas to enhance people's awareness and agreements toward the compensation plan.

2. *Resettlement*

The resettlement for households, whose lands are withdrawn, will be carried out by two methods that are namely concentrated resettlement and dispersedly resettlement.

- Option 1: The affected households will be expectedly arranged at a resettlement area in Vinh Tan Commune, Tuy Phong District, and Binh Thuan Province.
  + The Vinh Tan 4 TPP's project has seven households being affected entirely and 13 households lost their entirely production land. Therefore, it is necessary to resettle for the seven households.
  + The planned resettlement area is in the Vinh Tan commune, Tuy Phong district.

+ However, the project are currently being depended on the demand of the affected households either concentrated resettlement or dispersedly resettlement. This will be conducted in the next stage of the project.

– Option 2: The affected households will be interspersedly resettled to other households depending on their needs.

The resettlement for households depends on the wish of people in an affected area, so the project has been proposed two options of resentment that are often executed and similarity to other project in the province. The detailed option will be determined in the compensation and support option for resentment implementation when the investment project of the Vinh Tan 4 TPP is approved.

3. Other solutions

In this pre-construction stage, apart from undertaking compensation and resettlement for affected households, the project owner will also give priorities in recruitment of local labor forces for construction and operation activities of the Project.

The above mitigation measures are necessary in terms of management, control and communication to ensure that the compensation and support plans for affected households will be finished quickly and clearly. These measures will not only minimize impacts caused by land withdrawal on the local residents but also contribute to guarantee the construction schedule of the Project. Consequently, unexpected grievances and dispute will be avoided to minimize cost and save time for the Project.

4.2.4. Mitigation measures for impacts due to land leveling

4.2.4.1. Mitigation measures for air pollution

The following measures will be applied in order to mitigate the air pollution at the project site and along the transportation routes during the construction stage. The polluted concentration such as SO_2, NO_x, CO dust generated during the construction stage can be controlled effectively and meet Vietnamese National Technical Regulation QCVN 05:2009/BTNMT on ambient air quality.

– Vehicles, trucks, construction equipments used in this project should be checked for their air emission to meet the Vietnamese Standards for Carbon monoxide (CO), Hydrocarbons (HC) and smoke (TCVN 6438 - 2001). All construction equipment should have certificates on exhaust quality given by the Vietnamese Registration Authority. This is a condition of the Bidding document for selection of the construction contractor by the project owner. This method has high feasible, effective in mitigate environmental pollution to the surrounding area during the land leveling stage.

– The wheels and the lower parts off the vehicles will be washed before existing the construction site in order to mitigate the dust dispersion on the road. This method has high feasible, effective in control dust dispersion to the surrounding environment during the land leveling stage.

– Construction contractors will water construction site and transportation routes in sunny days to control dust. Number of watering times per day is adequate to control dust pollution during transportation and construction process as follows:

+ Regarding transport routes (including National road 1A an internal roads), contractors will arrange workers or trucks to water, especially the stretch of road passing residential areas, schools, markets and medical stations with the frequency of once per day. According to the Vietnamese Construction Standard TCXDVN 33:2006 on water supply- construction and pipe networks- design standard in which the standard for watering on the finishing road is about $0.4L/m^2$. The dust flow rate is $4.8\ m^3$/time (for the length of the road is 1km and the width is 12m)

+ Regarding construction site onshore approximately 9.37 ha, on sunny days, at areas with high content of dust, watering frequency can be 2 times/day, depending on the level and period of dust generation in transportation and earth working process. The flow rate needed to spray for once is about $38.92m^3$/time and taken from the construction water source (taken from the Da Bac Lake with the flow rate of 550-600 m^3/h)

The above mitigation measures once being applied strictly and seriously will minimize the generation of air pollutants from construction and materials transportation activities during the construction stage of the project.

- Advantages: highly feasible, simple, suitable with contractor's capability and in term of prevention and mitigation of impacts. Therefore these measures have high efficiency in air quality control.

- Disadvantages: merely can mitigate the impacts of dust and other air pollutants not eliminate the sources of pollution. However, because the total production of dust is not too large and the quantity of vehicles and machines is quite small, surrounding air environment quality will be controlled in good conditions after the complete implementation of the mentioned mitigation measures.

4.2.4.2. Mitigation measures for noise and vibration pollution

During the sea-encroached leveling stage, noise pollution caused by construction activities is a major problem to residential areas in hamlet No.7, Vinh Tan commune. Therefore, the following mitigation measures should be applied to prevent noise impacts and to meet Vietnamese National Technical Regulation QCVN 26:2010/BTNMT on noise quality:

- Operation of heavy vehicles and machines entering/exiting the site is recommended to be properly managed to reduce noise generation, particularly in places near the sensitive receptors such as residential areas and schools.

- To minimize the noise impacts to the sensitive receptors by supplying the noise-proof equipment for workers. In addition, the working or moving into the area of load noise will be strictly controlled.

- Normal construction working hours will be from 6 am to 10 pm. There is no activity that generates high noise level is permitted from 10 pm to 6 am of the following day.

The above mitigation measures once being applied strictly and seriously will effectively mitigate the impacts of noise and vibration from the construction activities on sensitive receptors.

- Advantages: highly feasible, simple, suitable with contractor's capability and effective in the protection of sensitive areas from vibration and noise from the Project construction.
- Disadvantages: merely can mitigate the impacts of noise and vibration, not eliminate the sources of pollution. However, as mentioned above, because minimum distance between the Project boundary and the residential areas is 250m, the impacts will be insignificant if the recommended measures are adopted adequately.

4.2.4.3. Mitigation measures for water pollution

During the stage of sea encroached leveling and embankment construction, water pollution caused by following sources needs to be considered: runoff water, domestic (sanitary) wastewater, and wastewater from vehicles washing activities.

1. Runoff water

Runoff water flowing over construction areas may contain high contents of sediment and other pollutants which could increase the suspended solid concentration in the receiving water sources near the project area. Besides, excavation activities may cause erosion and turbidity in these water sources, especially in rainy season.

However, contamination contents in this type of wastewater are relatively small, which mainly contains suspended solids, sand and mud. A temporary drainage system which will be constructed early when the land leveling period begins will have screenings and settling units for separating solid wastes. This will ensure that all runoff water collected at the site will be treated well before being discharged.

2. Domestic wastewater

The main measure recommended for treatment of domestic wastewater is to require the contractor to rent mobile water-closet (toilets). Another option could be considered by the contractor is to build toilets with septic tanks installed. The following method will be applied with high efficiency and meet Vietnamese Standard QCVN 14:2008/BTNMT, type B, K = 1 for domestic wastewater before discharging into the environment:

- *On the construction site*: during the construction process of the plant, mobile-water closets (toilets) are installed on the construction sites. Domestic wastewater containing in a tank will be arranged at a bottom of the toilets. The capacity of each mobile toilet is about 1600L per vehicle. The total number of the mobile toilet is from 10 to 15 vehicles (The real numbers will be adjusted exactly in the real construction stage). The effluent generating from mobile toilets will be transported and treated according to QCVN 14:2008/BTNMT, type B, K = 1 for domestic wastewater. This method has high feasible in treating the domestic wastewater collected at the sire and mitigate maximally pollution to the environment.
- *On the construction offices*: the volume of wastewater generating from office areas is not much and will be collected and treated at the BASTAF advanced septic tanks with the BOD, COD, SS treatment efficiency about 65%, respectively. The treated wastewater will be meet QCVN 14:2008/BTNMT, type

B, K = 1 for domestic wastewater, then discharged into the sea. This method has high feasible in treating the domestic wastewater collected at the sire and mitigate maximally pollution to the environment.

- *On the workers' residential area:* the construction workers are arranged at the workers' residential area (the site for workers' camps). The sanitary house and septic tank will be synchronously constructed to meet Vietnamese Technical Regulation QCVN 14:2008 on domestic wastewater with type B, K = 1 before being discharging to the environment. Consulting the calculated formula on the septic tank form the "Guide to design, construction, installation, operation management, and maintenance of the Ministry of Construction dated 12/2007, the capacity of the septic tank on the preliminary calculation is about 140m^3 with nearly 500 people and the domestic wastewater standard is about 150L/person/day. This method is high feasible in collecting and treating the domestic wastewater at the worker's residential area and camp site, mitigate maximally the wastewater pollution to the surrounding environment

Additionally, in this stage, other mitigation measures are recommended to minimize impacts on water environment due to the sea-encroaching leveling such as:

- Must not dispose of solid wastes (sand, stone, etc.) and oil (sediments) into water sources. All types of constructional wastes need to be collected and transported to landfill as per regulated by the local authority.
- No discharge of domestic wastewater and solid wastes from workers' camps on surface water is allowed. Domestic solid wastes will be collected, transported and handled in a sanitary manner as per regulated, through a contract with local environmental service company.

3. *Washing wastewater*

To mitigate the negative impacts to the environment due to the washing wastewater, the following mitigation measures should be applied:

- The construction site will be equipped with the vehicle washing bridge to wash all vehicles before exiting the site.
- To build the temporary drainage system surrounding the vehicle washing area to avoid the water deposition on the surface influencing the construction site.
- The cleaning wastewater contents almost are sand, soil and some oil discharged into temporary drainage channel at construction site to settlement basin which is equipped oil traps. Here, suspension will settle down and be kept in settlement basin and oil is kept by oil traps. Water after settlement basin will be discharged into environment (sea). Sediment will be collected every 2 weeks and signing appropriated unit for collection and handle according to current regulation.
- These requirements will be stipulated in Bids document between investor and contractor, if the contractor violates, there will be sanctions in accordance with law.

The above mitigation measures have been widely applied in many projects and have proved their effectiveness in control of wastewater and water pollution. Once being applied strictly and seriously, these measures will minimize the generation of wastewater and optimize the control of water pollution in the construction areas during this stage of the Project.

– Advantages: highly feasible, simple, suitable with contractors' capability and effective in prevention of impacts caused by wastewater from the construction areas on surrounding environment.

– Disadvantages: merely can mitigate the impacts of wastewater, not eliminate the sources of pollution. Besides, these measures depend much on the environmental protection awareness of the workers, therefore, education programs and punishment/awarding regulations need to be incorporated. The project owner will check these activities regularly and closely.

4.2.4.4. *Control of wastewater from vessels and vehicles*

The following measures will be applied to mitigate the wastewater pollution due to the washing activities of ship, trucks, barges and machines serving for the construction of sea encroached embankment.

- In the construction period, fixed recovery vessels are installed on the surface of the sea to collect oil and solid waste produced from barges and construction process on the sea. Wastes are collected and treated by signing contracts with authorities which have proper capability and regulatory licenses for waste transport and disposal.

- The ships must comply with procedures on sea pollution of prevention system by ships (TCVN 6276:2003 Normative on sea pollution of prevention system and Decree No. 21/2012/ND-CP of the Government on management of seaports and marine navigable channels.)

- The ship owners must comply regulations in Decision No. 59/2005/QĐ – BGTVT of the Ministry of Transport about the Regulation on equipment for maritime safety and prevention of marine pollution on Vietnam ships operating domestic routes as follows:

  + Cargo ships, passenger ships from 1000 GT to under 10000 GT, oil ships from 400 GT to under 10000 GT must be equipped oil filtration system to ensure any water and oil mixture after the system must contain less than 15ppm.

  + Ships over 10000 GT must be equipped oil filtration system which has to have light and sound signals and be closed automatically when oil content in wastewater is over 15ppm.

- Requiring the owners of ships and barges must manage, collect and treat waste water satisfied discharge standards (such as to require the owners must equip oil separator system to treat waste water before discharged into environment or collect waste water then hiring appropriate unit to treat it when landing ships, barges).

- Not to allow cleaning ships, barges in port area in order to avoid discharging waste water causing pollution increase of port area's water.

- These requirements will be stipulated in Bids document between investor and contractor, if the contractor violates, there will be sanctions in accordance with law.

The above mitigation measures have been widely applied in many projects and have proved their effectiveness in control of wastewater and water pollution. Once being applied strictly and seriously, these measures will minimize the generation of wastewater and optimize the control of wastewater from barges and ships.

- Advantages: highly feasible, simple, suitable with contractor's capability and effective in prevention of impacts caused by wastewater from the construction areas on surrounding environment.
- Disadvantages: these measures depend much on the environmental protection awareness of the ship owners; therefore, education programs and punishment/awarding regulations need to be incorporated. The project owner will check these activities regularly and closely.

4.2.4.5. Mitigation measures for impacts due to solid waste

1. Excavated soil

Balance between quantity of excavated and filled soil will be calculated to minimize soil discharged into environment. The residual soil on mainland will be utilized to level sea encroaching area of Vinh Tan 4 TPP.

Large tree in removed top soil will be reused; the remains will be gathered at regulated dump site by hiring functional agencies.

2. Domestic solid waste

The domestic solid waste is divided into 2 main groups as follows:

– *Reusable wastes:* include wastes from production that can be collected, reused, or recycled. This group mainly contains paper, metals, glass, plastics, etc.
– *Wastes need to be treated or disposed:* organic wastes, domestic wastes that contain chemicals, or other solid wastes that cannot be reused.
– Dustbins will be arranged to collect domestic wastewater at site (especially at smoking areas). Number of dustbins is estimated at 20 (the actual number will be adjusted in the construction phase).
– The construction contractor will sign a contract with local environmental service company to periodically collect and transport solid wastes from workers' camps areas and construction site to local sanitary landfill. The collecting frequency is proposed at 2 – 3 times per week. Where practical, solid wastes will be recovered by the contractor for recycle and reuse purposes.
– Solid waste (domestic and construction waste) storage area should be located in site where is convenient to collect and transport to landfills.

3. Hazardous waste

The project owner should undertake following measures to control hazardous wastes such as oil, batteries, bitumen, paint, etc.:

- To repair machinery and vehicles only at garages where the means for collecting and storing oily wastes are available.
- To register owner of hazardous waste with Department of Natural Resources and Environment of Binh Thuan province.
- To collect all hazardous wastes having on the list of hazardous waste such as grease and rags… into the specialized garbage-bins at the regulated area.
- To arrange hazardous waste bins at site (4 for oily waste and 2 for other types of hazardous waste)
- To arrange the temporary storage area for hazardous waste. The location of the temporary area must be satisfied with the regulations on packaging, preservation of hazardous waste according to the circular No.12/2011/TT-BTNMT of MONRE on hazardous waste management.
- To sign contracts with entities which have proper capability and regulatory licenses for hazardous waste management, transport and disposal.
- Facilities and vehicles to be used in transporting hazardous wastes must satisfy technical requirements for safe operation. In addition, they need to be registered and awarded license as required by the traffic law.
- To establish an environment team at site to collect solid waste from bins to temporary storage area for functional agency to transport and treat in accordance with regulations.
- Managerial and operational human resources for the collection and transportation of hazardous wastes must be trained and meet the requirements on safety and sanitation.
- Undertake the responsibilities to handle any leakage and scatter of hazardous wastes out to the environment.
- The collection, storage, transportation, and treatment of hazardous wastes will comply with regulations on hazardous waste management stipulated in the Circular No.12/2011/TT-BTNMT of Ministry of Resources and Environment.

These mitigation measures have been widely applied in many projects and have proved their effectiveness in management of normal and hazardous solid wastes during land leveling and construction of sea encroaching dike stage of the Project.

- Advantages: highly feasible, simple, suitable with capabilities of the contractors and local environmental management agency.
- Disadvantages: merely can mitigate the impacts of solid wastes, not eliminate the sources of pollution. Besides, these measures depend much on the environmental protection awareness of the workers, therefore, education programs and punishment/awarding regulations need to be incorporated. The Project's Owner will check these activities regularly and closely.

4.2.4.6. Mitigation measures for coastal erosion

During construction of sea encroaching embankment, the coastal line of Vinh Tan commune may be erosive and accumulated mainly at the bank area. The mitigation measures in term of the effect of erosion and accumulation is lowest are as follows:

- The project will be build by the reinforced concrete with the total length of 1051m. The embankment structure covered on the seaward by the Tetrapod block is described as followed: The top elevation of the embankment is the top elevation of the breakwater approximately +5m (Hon Dau Elevation System). Seaward slope m = 2, the inner slope of m = 1.25. The seaside armor slope is covered with two layers of Tetrpod rock. The tray of the breakwater are using the stone block with the weight of G = 50-150kg. The core of the breakwater is made of the stone block with the weight of G = 50-100kg. For the upper layer, there will be a stone block with dimension of (2x4, 4x6 in dimension), and geotextile fabric layer. Embankment is covered by Tetrapod 9.7Tons (2 layers). The section of the sea encroached embankment is shown in the Figure 4.2.
- Not to allow soil and backfilling material leaking into sea, using geotextiles lining the inside face of the embankment to prevent filling material leakage.
- Reinforce land abutment to avoid erosion by coating stones from the bottom to the top.
- Material yard needs to be rolled to ensure the required density, applying measures for washing by rain such as enclosing this area to avoid materials swept away by rain.
- Construction contractors must assign staffs to supervise the surrounding project area and install safety corridor.
- Embankment will be constructed from land to sea; covering segment will be constructed first to protect the landside.

The above mitigation measures have high feasible and effective. The accumulation and erosion impacts on the region in the process of construction and operation will be minimized.

4.2.4.7. Mitigation measures during construction phase of embankment

During construction, it is necessary to use freestone or tetrapod to cover the un-finishing segment in stormy weather. Therefore, tetrapod or freestone will be always prepared on barge carrier holding of nearly 30-50 Tetrapod blocks near the construction area.

The Investor and Contractors will ensure labor safety for workers and divers; do not allow people with no responsibility to go around construction area and place warning signals to instruct workers.

The damaged parts must be promptly handled and replaced.

By applying the above mitigation measures, impacts on environment and workers during construction of embankment may minimize.

4.2.4.8. *Mitigation measures for impacts on seawater quality and ecosystem of Hon Cau marine protection area (MBA)*

The sea-encroached leveling activities will be covered a part of the inshore coral reefs at the Hon Cau Martine Protection Area. This impact is not easy to recover the natural environment of the area. Therefore, there are no measures to moderate this impact.

For the other area of the Hon Cau Martine Protection Area, the following mitigation will be executed in order to reduce impacts to the ecosystem of Hon Cau Martine Protection Area and sea water quality surrounding the project area. The following measures will be applied as follows:

1. Construction solution of sea encroaching embankment

Due to the project is located in the Hon Cau Martine Protection Area, construction technique of sea encroaching embankment shall be strictly implemented in accordance with following sequences:

- Determine the right position in order to ensure construction correctly:
  + To repositioning the landmark of embankment to pour concrete, construct and to protect these landmark permanently.
  + To use the position methods of converging the three theodolite in determine the embankment, to use the steel pile or reinforced concrete to fix at least two points: the top, middle, and stick the red flag on the top of the steel pile.
- Collection method, transportation of material and equipment serving construction.
  + Using barge carrier to transport materials to site. Tetrapod will be pre-casted on site and transported by crane, arranged in blocks by floating bridge and checking by plunger.
  + Embankment will be constructed from land to sea; the material are gathered on land and then transported to the construction site by barges.
  + Main construction equipment is crane placing on barges. Materials will be unloaded by cranes.
- Rock filling and installing top layer
  + Rock fill and top layer must be done follow the design level and slope.
  + Rock fill work must be done with high accuracy, density, spacing, and safety.
  + Freestone at the bottom embankment must have square shape to ensure about the stabilization for above layer.
  + Breakstone layer D=10-40cm will be constructed with small segment about 15-20m after finish the bottom embankment (with

freestone D=50-60 and D = 60-80). The body embankment using freestone D=10-40cm to avoid moving by flow (V_{max} = 2m/s).

+ During construction, it is necessary to use freestone or tetrapod to cover the un-finishing segment in stormy weather.
+ Tetrapod or freestone will be always prepared on barge carrier near the construction area

In addition, the following measures will be carried out in sea encroaching levelling to minimize impacts on marine ecosystem of Hon Cau MBA.

- Sea encroaching leveling must be conducted after finishing construction of sea encroaching embankment to prevent suspended solid diffusion.
- To perform seawater quality monitoring during leveling period to evaluate marine pollution due to leveling activities.
- Fixed recovery vessels are installed on sea level to recovery oil and solid waste produced from barges and construction process on the sea.
- The ships must comply with procedures on sea pollution of prevention system by ships (TCVN 6276:2003 Normative on sea pollution of prevention system and Decree No. 21/2012/ND-CP of the Government on management of seaports and marine navigable channels.)
- Not to allow cleaning ships, barges in port area in order to avoid discharging waste water causing pollution increase of port area's water.
- Drainage system and collection pits should be built to collect rainwater.
- Soil compaction work in rainy season: digging drainage ditches to prevent runoff water flowing into works; middle areas will be higher; leveling work will be done carefully to ensure surface water drainage slope of 1% ~ 2%, land filling and leveling work is carried out in turns; accumulated sludge on the surface will be dredged at the appropriate time after the rain.
- The reinforcement of the slope around the project area will prevent erosion of soil materials during leveling process as well as reduce surface water pollution.
- In addition, the project will compensate all the damage according to the law when having the negative impacts to the onshore coral reef due to accidents in the construction (Article No.75 of the Biodiversity Law of the National Assembly on term XII, session 4 No.20/2008 dated 13/11/2008)

The above mitigation measures are wisely applied and effective in many projects, well control the negative impacts to the water quality and the ecosystem of the Hon Cau Martine Protection Area.

4.2.4.9. Mitigation measures for impacts on local traffic system

National road No.1A will be the main route to project site. In order to limit impacts of transportation of material and equipment for the project on traffic activities on these routes, Vinh Tan Power Complex will associate with the Transport Division and Police Department of Binh Thuan province in implementing the following measures:

- To install transport signs and lighting systems on the street passing project site. Transport signs should be installed at the places where accidents may be easily happened.
- Police should strictly control traffic safety along the routes used for material transportation for the project.
- To establish and execute traffic management plan to regulate operation of means of transport.
- National road No.1A may be damaged by heavy truck movement. The contractor should repair the damaged road sections for compensation after completion of the plant construction.
- To educate safety awareness for drivers.

These aforementioned measures will limit traffic accidents and traffic jams on the transport routes. However, these measures should be combined with enhancing awareness of drivers on traffic safety.

4.3. MITIGATION MEASURES IN CONSTRUCTION STAGE

During the construction of Vinh Tan 4 PP, impacts due to construction activities of the project are inevitable, so the project owner will apply some effective methods to ensure environment protection, labor safety and workers's health.

4.3.1. Mitigation measures for impacts relating to waste from construction of power plant and port

4.3.1.1. Mitigation measures for impacts due to wastewater

The mitigation measures due to domestic wastewater during the construction stage are applied as the mitigation measure on the pre-construction stage, the domestic wastewater before being discharged to the environment meets QCVN 14:2008/BTNMT. The mitigation measures are summarized as follows:

- The project owner will be strictly managed the contractors not to allow discharging the wastewater to the environment, causing pollution for the surrounding area.
- *On the construction site*: during the construction process of the plant, mobile-water closets (toilets) are installed on the construction sites. Domestic wastewater containing in a tank will be arranged at a bottom of the toilets. The capacity of each mobile toilet is about 1600L per vehicle. The total number of the mobile toilet is from 10 to 15 vehicles (The real numbers will be adjusted exactly in the real construction stage). The effluent generating from mobile toilets will be transported and treated according to QCVN 14:2008/BTNMT, type B, K = 1 for domestic wastewater. This method has high feasible in treating the domestic wastewater collected at the sire and mitigate maximally pollution to the environment.
- *On the workers' residential area:* the construction workers are arranged at the

workers' residential area (the site for workers' camps). This area will be built by the EPC contractor of Vinh Tan 4 PP and carried out the exclusive environment impact assessment. Therefore, the mitigation measures due to domestic wastewater generating from workers will be presented in this report, not in scope of Vinh Tan 4 environment impact assessment. The toilets and septic tanks are synchronously built to meet the requirement of QCVN 14:2008/BTNMT, type B, K = 1before charging into the environment. The capacity of the septic tank is preliminary calculated about 410m^3 (the real data will be adjusted in the real construction stage. This method is high feasible in collecting and treating the domestic wastewater at the worker's residential area and camp site, mitigate maximally the wastewater pollution to the surrounding environment.

– In addition, the majority of engineers, technicians will rent house, hotel near the surrounding commune and will be used the sanitary system there.
– The above mitigation measures will be maximally restricted the negative impacts to the environment if being applied correctly and properly in associated with the environmental protective awareness of the workers and the staffs on the construction site.

4.3.1.2. Mitigation measures for impacts due to washing construction equipment and ships

The mitigation measures due to wastewater from washing vehicles, equipment during the construction stage are applied as those in the pre-construction stage. The treated water will be met QCVN 40:2011/BTNMT before being discharged into the environment. The mitigation measures are summarized as follows:

- At the construction site, all vehicles will be washed before leaving the site.
- Building the temporary drainage ditches surrounding the washing area to avoid the stagnating water on the surface of the construction site.
- The wastewater after being washed will be taken to drainage channel at the construction site then to the sedimentation basin equipped with oil and grease trap. The water after sedimentation will be discharged to the received environment (sea). The sludge will be periodically collected and treated by the functional agency according to the current law.
- Regularly canalizing the channel based on the natural terrain in order to avoid stagnation, muddiness.
- Fixed recovery vessels are installed on sea level to recovery oil and solid waste produced from barges and construction process on the sea.
- Owners of ships and barges must manage, collect and treat wastewater satisfied discharge standards. Not to allow cleaning ships, barges in port area in order to avoid discharging wastewater causing pollution increase of port area's water.

The above mitigation measures have been widely applied in many projects and have proved their effectiveness in control of wastewater and water pollution. Once being applied strictly and seriously, these measures will minimize the generation of wastewater and optimize the control of water pollution in the construction areas during the construction stage of the Project.

4.3.1.3. Mitigation measures for air pollution

The mitigation measures due to air pollution in the construction stage will be applied as in the section 4.1.4.1, the air quality in the construction stage will be monitored and controlled to meet the National Technical Regulation QCVN 05:2009/BTNMT. Mitigation measures are summarized as follows:

- To make a plan to ensure the environmental sanitation, labor safety and human health during the design stage which are implemented by the contractors.
- To arrange traffic into and out from the construction site as regulation, with considerations for transportation of materials and machines.
- All construction equipment and vehicles should be checked for their air emission and should have certificates on exhaust quality prior to their operation. This method has high feasible in mitigating the surrounding environmental pollution during the construction stage.
- Vehicles are not allowed to overweighed transport.
- All vehicles used for transporting construction materials (sand, clay, cement, stones, etc.) should be covered to prevent dust dispersion. Wheels and lower body parts of trucks will be washed before they exit the construction site. This method has high feasible and effective during the construction stage.
- The wheels and the lower parts off the vehicles will be washed before existing the construction site in order to mitigate the dust dispersion on the road. This method has high feasible, effective in control dust dispersion to the surrounding environment during the land leveling stage.
- The material yard to prevent dispersion of dust, cover all materials inside buildings by the dust-againsted net during the construction stage. This method has high feasible and effective during the construction stage.
- Construction contractors will water construction site and transportation routes in sunny days to control dust. Number of watering times per day is adequate to control dust pollution during transportation and construction process. This method has high feasible and effective during the construction stage.

The above mitigation measures have been widely applied in many projects and have proved their effectiveness in control of wastewater and water pollution. Once being applied strictly and seriously, these measures will minimize the generation of dust and optimize the control of air pollution in the construction areas during this stage of the Project. Those methods have high feasible, simple, effective and suitable for the capacity of the contractor.

4.3.1.4. Mitigation measures for noise and vibration

During the construction phase, concentration of construction equipment with high intensity will cause noise pollution at high level. Thus, in addition to the normal mitigation measures, the following methods will be applied to control impacts of noise and vibration to meet QCVN 26:2010/BTNMT on noise and QCVN 27:2010/BTNMT on vibration at construction site as follows:

- To install anti-noise instruments for strong noise generating sources (such as generators, air compressors, etc.). Some other noisy machines will be placed in sound-proof rooms.
- To conduct maintenance regularly for construction equipment. This method has high feasible, effective in moderating noise to the surrounding environment during the construction stage.
- No piling work will be permitted from 21pm to 6 am of the following day and no construction works will be permitted at rest time: from 11h30 to 13h30 and after 22h00. This method has high feasible, effective in moderating noise affecting people surrounding the project during the construction stage.
- Drivers are not allowed to use honk in residential areas, limiting transportation at rest time (after 20pm). This method has high feasible, effective in moderating noise affecting people surrounding the project during the construction stage.
- Construction equipment and machines are periodically checked and will operate in the best condition to meet regulations on noise and vibration for construction equipment. This method has high feasible, effective in moderating noise to the surrounding environment during the construction stage.
- Equip labor protection facilities such as ear plugs for workers who work near high level of noise areas to protect their health. This method has high feasible, effective in moderating noise affecting workers during the construction stage.
- Not to arrange construction activities occurring at the same time and in the same area. This method has high feasible, effective in reducing the total noise of the area.
- Good management of construction workers should be performed to avoid disturbing local people.
- In case of the safety distance is not guarantee for the noise, the wall construction method of noise reduction will be applied. Walls with a height of 3 to 4 meters and is made of fiberglass or wood with good noise reduction capabilities. Depending on the selected material to reduce noise walls that noise can be reduced from 10 to 40 dBA on the front and behind of walls. This method is feasible and effective in reducing noise affecting the health of people in the area during construction.
- The above mitigation measures have been wisely applied in many countries and proved their effectiveness in a lot of different projects, especially, in control the noise in the power plant. This method has high feasible and effective in mitigating and reducing noise, ensure the noise generated from the plant meet QCVN 26:2010/BTNMT and QCVN 27:2010/BTNMT in construction site.

4.3.1.5. Mitigation measures for solid waste and hazardous waste

The mitigation measures due to solid waste and hazardous waste will be applied as in the section 4.1.4.5. Mitigation measures are summarized as follows:

1. Domestic solid waste

- All domestic waste from workers' camps will be collected daily and gathered at the regulated dump site.
- To arrange domestic dust bins at the construction site (especially in smoking area). Number of dust bins is estimated at 30 (the actual data will be adjusted in the construction phase).
- The project owner will be signed a contract with the local environmental sanitation agencies to periodically collect the domestic wastewater to the local landfill. The frequency of collection is about 2 or 3 times per week.
- The sanitation team at site is responsible for gathering solid waste in dust bins to a prescribed place in order to have local environmental service company transport and treat in accordance with regulations.
- Garbage collection places have been selected in pre-construction phase.

2. Construction solid waste

The construction solid waste such as organic sludge, rock, sand, material waste generated during the construction stage will be categorized into the two main groups:

- The dredged material in the port construction and cooling water intake channel dredging process will be reused to leveling at the Vinh Tan 4 PP area.
- All construction wastes include brick, rock, cement will be categorized and recycled for different purposes, or for selling scrap. The rest waste will be collected and treated by the local environmental service agencies according to the law.

3. Hazardous waste

The following methods will be undertaken to manage hazardous waste (including oil, battery, grease, paint, bituminous tar and other types which are considered as hazardous waste according to Vietnamese regulation):

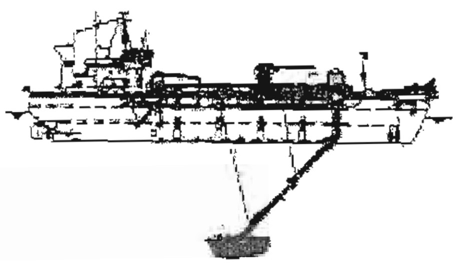
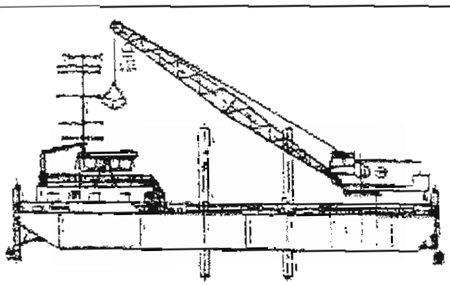
- Repair machinery and vehicles only at garages where the means for collecting and storing oily waste are available.
- Perform declaration and registration of hazardous waste owner with Binh Thuan DONRE.
- Arrange hazardous waste containers at site (including 4 for oily waste and 2 for other types of hazardous waste).
- Temporary storage area for hazardous waste must comply with regulations of Circular 12/2011/TT-BTNMT on providing management of hazardous wastes and other current regulations.

- Collect all types of oil, grease, oily cloth, battery, paint, bituminous tar into separate containers which are placed at regulated areas.
- Sign contracts with entities which have proper capability and regulatory licenses for hazardous waste management, transport and disposal.
- Facilities and vehicles to be used in transporting hazardous wastes must satisfy technical requirements for safe operation. In addition, they need to be registered and awarded license as required by the traffic law.
- The sanitation team at site is responsible for gathering hazardous waste at site to a temporary place in order to have functional agency transport and treat in accordance with regulations.
- Undertake the responsibilities to handle any leakage and scatter of hazardous wastes out to the environment.
- The collection, storage, transportation, and treatment of hazardous wastes will comply with regulations on hazardous waste management stipulated in the Circular No.12/2011/TT-BTNMT of Ministry of Resources and Environment.

4.3.1.6. Mitigation measures for impacts on marine environment and Hon Cau Martine Protection area due to dredging

The dredging area in 100,000 DWT port will be carried out within Vinh Tan breakwaters. Hopper dredger and floating dredger or grab dredger will be used for dredging process. For upper sand layers with porous and soft characteristic, hopper dredges will be used; for below sand layers with relatively hard, floating dredger or grab dredger will be used. Characteristics of dredging equipment are described in Table 4.1.

Table 4.1. Type of dredger

Type	Description
1. Hopper dredger Trailing suction hopper dredger (TSHD) pulls its sucker when working and load dredged materials to the ship's tanks. When the tank is full, the dredger will move to the dumping area and poured mud through doors of the hull or pumps materials out of the tank.	
Floating dredger Dredgers with a grabbing bucket of material at the seabed and a grabbing bucket hung on a crane mounted on the deck, or carried by hydraulic arms, or assembled similar to a mounted grab. Most of dredgers of this type are	

barges with cranes and grab.	

According to the results of material propagation model on dredging process calculated in the Chapter 3, when the dredging process is executed, the highest TSS concentration is about 0.15kg/m^3 concentrating on the surrounding dredging area. The other surrounding areas just have the value in the range of 0.005 to o.013kg/m^3. The dispersion scale is about 1 km2 counting from the dredging area in the breakwater. The construction executed correctly will control the dredging process and avoid the break ability of pipes.

1. Mitigation measures during dredging execution

Because the Project is located in Hon Cau Marine Protection Area (in the development area), methods of execution must be carried out strictly in accordance with processes and procedures to minimize the impacts on protected areas and their surroundings.

a) Execution principles

Construction of rolling for each stage of the Project aims to ensure the progress and quality of works as well as to avoid sedimentation of the dredged construction area. After dredging is completed, measurement of map of seabed surface status by the method of echo sounding method.

- Execution on dredged strips, dredged layers reached the designed elevation (execution on the first layers, then second layer up to the designed elevation), and the executing direction of ships is along the coast.
- Using myriapod construction method for half side of the approach channel (from the center to the side).
- When the ships get close to the side of approach channel, operators will control the arm up or down depend on the thickness of layer, reduce the cutter's speed and holding until the injection pressure was reduced and then continue to dredge.
- The slope is constructed by stepped method on each designed section to ensure technical normal standards.
- Surveying, checking and setting up buoys along the passages.
- Checking dredged depth regularly.

b) Inspection methods of execution

- The dredgers are monitored by a technical officer; measurement equipment should be checked regularly on execution time.
- Checking the dredging work every day by scoring measure, plumb and wire tension.
- To ensure technical normal standards in dredging work, each dredged section is measured by echo sounder and positioned by geodetic measuring device.

c) Control of dredging work

At dredged area, using buoys and installing temporary signal posts on execution time.

- Signals on the water:
  + The limiting buoys is installed in the site: 02 buoys, diameter 1.2m
  + The limiting buoys is installed in temporary way: 02 buoys, diameter 1.2m
- Signals on the onshore:
  + Attention signal: 01 post + 01 signboard
  + No turning, no over-taking signal: 01 post + 02 signboards

d) Positioning dredged line

- The dredged line is positioned by Global Positioning System GPS, concurrently checked by leading lines (at shoal water) or buoy lines (at deep water)
- The benchmarks are made from round steel tubes and straight bamboo, associated with together by iron wires to ensure tightly.
- The height of benchmarks must be not submersed when rising tide, the back benchmark should be higher than the fore one to ensure the sight of dredging operators.
- The benchmarks are painted with red and white, attached signboards and hung signal lights.

e) Positioning starting section

- Starting section is positioned by buoys. After the ship has been positioned and anchored, dredging machine begins to work. The buoys will be removed to ensure safety for working equipment.
- During working process, must check the positioning benchmarks and adjust in case of variations.
- The starting section of hopper dredger is available on execution graph. When the dredger moves to starting section, the operator controls suction arm down, start up the suction pump…After a turn of dredging, controlling the arm up, hanging up the pump and the dredger will return to continue dredging.

Execution methods in dredging process will implement instructions, regulations, use modern dredging equipment and only working on the project scope. In addition, following mitigation measures should be applied to mitigate environmental impact due to dredging works:

- Not to discharge oil contaminated waste of the construction equipment into the water. All oily waste must be collected and treated according to current regulations. This method is feasible and limits water pollution and protect for the ecosystem of Hon Cau MPA during dredging.

- Not to discharge wastewater, solid waste from hopper dredger into sea. This method is feasible and effective in controling the pollution on the sea environment.
- In order to prevent suspended solid spreading during dredging period, complying with execution method, dredging will carry out when the completion of breakwater; limiting the possibility of breaking the sludge suction pipes. This method is feasible and limits water pollution and protect for the ecosystem of Hon Cau MPA during dredging.
- Dredged area and dredged material dumping area must be positioned by buoys, signal lights as follow regulations of marine safety. These methods are feasible and avoid constructing outside of the project area, reduce water pollution and protect for the ecosystem of Hon Cau MPA during dredging.
- Registration of transportation route, transportation equipment, project execution period with appropriate authorities to used as basis for checking and monitoring the dredging activities, transportation and waste discharge of the execution unit. This method has high feasible in controlling the dredged work in order to mitigate the pollution to the surrounding environment.
- Appointing technical officers to monitor at dredged area, on transportation routes, and at the area used to contain dredged material. The discharge of dredged material is monitored by radar and logged. Quarterly, the project has observation report and environment control by the investor, sub-contractors, supervision consultant and appropriate authorities of Binh Thuan province.
- The equipment transporting dredged sludge to waste area has to ensure no drips and drops of dredged sludge on the route to minimize water turbidity.

With applying such mentioned methods, the impact on dredged area environment will be reduced significantly.

4.3.1.7. Mitigation measures for impacts due to dredging material disposal

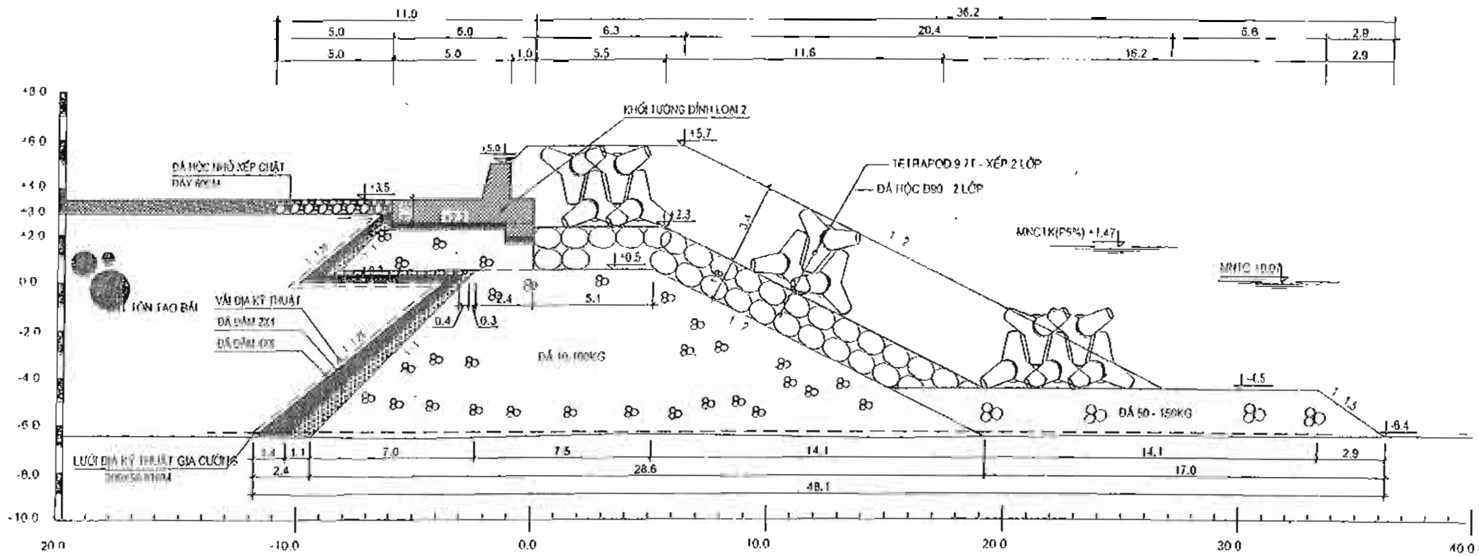
The sea-encroached embankment area (the dredged material dump of Vinh Tan 4 power plant during the construction phase) will be enclosed by the sea-encroached dike. Coordinates of the sea-encroached area of Vinh Tan 4 power plant is presented in Table 1.5 and figure 1.7 of Chapter 1.

The dredged material will be sucked from the trailing suction hopper dredger and hold in the storage accommodation of the barge and transported to the sea-encroached area. The sand used to levelling below the sea level will be self-compressed, the upper part above the sea level will be levelled and tamped to form a layer until reach the designed elevation.

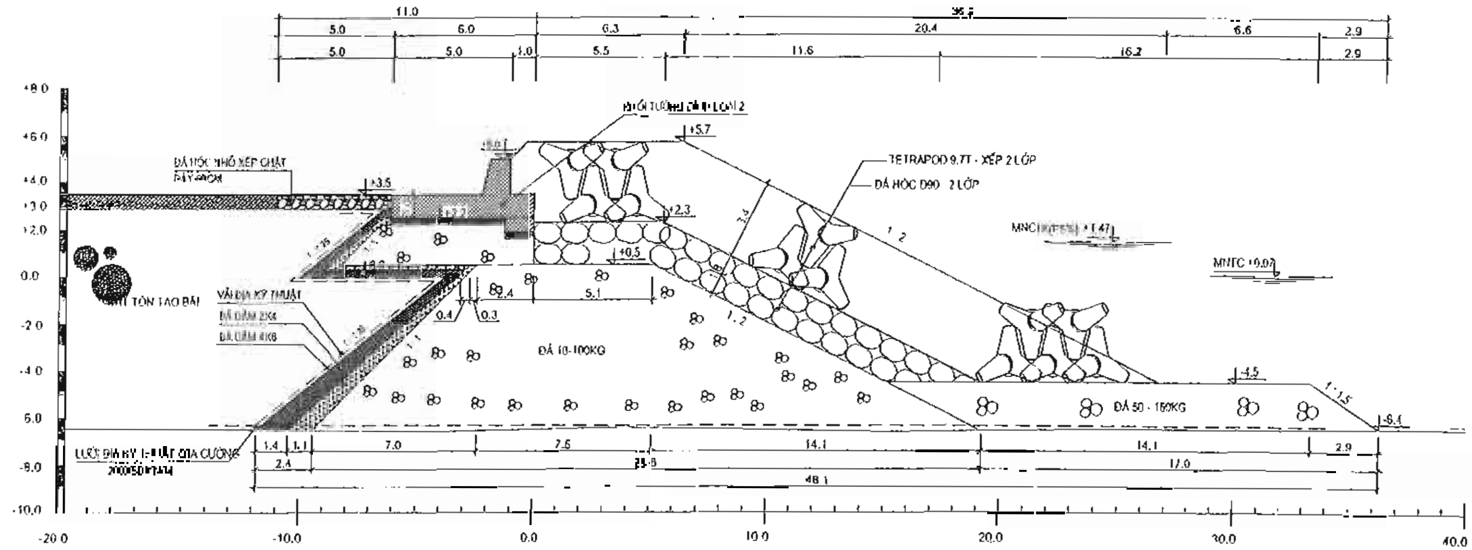
The structure of the sea-encroached embankment includes stone block, geotextile layer, back-filter layer. The water will be released to the outside via the back-filter layer, geotextile layer, and stone layers in order to prevent the dredged material leaking to the sea. In addition, all these layers will help to filter water and hold the suspended solid so the water releasing from this area will not influence to the environment. Owing to the difference of the embankment elevation and the water level approximately 5.5m, there is no water which can be overflowed to the top of the elevation and breakwater during the dredged material disposal process. The section of sea-encroached embankment are shown in the Figure 4.2.

Transportation method for dredged material: transporting the dredged material to the sea-encroached area by the barge. The distance between the dredged positions to the levelling position is about 1km, and belonging in the Vinh Tan complex power. The dredged material (include water and solid) have high moisture content will be held in the storage accommodation of the barge. Therefore, there will be no dust generated to the environment due to dredged material. The dredged material will be perfectly held in accordance with the designed volume in order to moderate leakage into the surrounding environment.

Figure 4.1. Example figure of barge transported dredged material.



SECTION 3-3



SECTION 4-4

Transportation method by barge presented above are often used for projects with high dredging volume and transportation distance of about 1km. Structure of sea-encroached area will be constructed in accordance with design so that dredged material will not leak out. Therefore, this method of construction has high feasible and the environmental impact to the project will be minimized.

To ensure the dredged material being dumped properly and in the right position, in addition to supervision under regulations. Investors will require dredging contractors equipped GPS navigation system on the barge/vessel transporting dredge material so that investors will closely monitor the location of each trip dumping the via navigation systems. This method is highly feasible, limiting spillage of materials during disposal.

The containers are arranged on the barge system to collect the solid waste generated in the transportation, then hiring professional units to collect and treat properly. This method is highly feasible and effective in moderating the generation of waste to the sea environment.

Do not put the wastewater, oil spills into the surrounding environment and to comply with the principles of maritime safety, signal lights when get in and out the dump area. This method is highly feasible and reducing the generation of waste causing sea pollution.

When performing maintenance, periodically maintenance, part replacement, and repair of emergency vehicles need to comply with the rules to ensure no leakage of oil, waste oil and oily rags in water. This method is highly feasible and reducing the generation of waste causing sea pollution.

The guidelines listed methods of operation and safety principles of the environment on the construction equipment and work areas to support awareness and prompt compliance of the direct operation. This method is highly feasible and reducing the generation of waste causing sea pollution.

With the application of the above measures, the impact on the environment caused by the dumped dredged material will not cause much impact on the surrounding environment. During dredging, the investors will monitor the construction units to strictly implement the construction method described above.

4.3.1.8. Mitigation measures for impacts due to pile driving of approach bridge

The piling work of the Vinh Tan 4 PP's port will be conducted in the scope of the embankment. To mitigate the impacts due to construction, the whole construction work is implemented based on the procedures and standards as follows:

- The unloading and loading process of piling reinforced concrete will always put on at least two points and careful loading in order to avoid damaging to the reinforced concrete piles.
- Piling rig is positioned in the chain and can more accurately locate than the previously marked piling position. The reinforced concrete piles will be positioned to ensure the initial soil disturbance is minimal and does not affect the pile. Pile driver will be moved to the piling position with the angle adjustment related to wheel drive to adjust the row straight of the reinforced concrete pile during pile driving.

- Start piling at the bottom of the pile by keeping the height of the pile hammer in the early stages of the test pile driving direction of reinforced concrete pipe.
- When the pile is executed, this process will continue until completion and not stop halfway.

In addition, to ensure safety while piling in the port area, the following measures will be implemented:

- The employees working on or near water will be provided with protective equipment such as safety shoes, gloves, ear plugs, life jackets and harnesses attached to the anchor where appropriate to avoid falling into the water.
- To inspect all equipment before using in order to avoid leaking and damaging the equipment.
- The work will be suitably divided depending on the type of work and location
- When having heavy rain, the piling work will be stopped
- Light equipment will be adequately arranged when working at night
- The fire extinguisher will be supplied to extinguish fire. All the fire extinguishers are arranged at an easily approach location and not having any obstacles and being marked properly.

The above mitigation measures once being applied properly and strictly will reduce effectively negative impacts to the environment due to the piling work.

The advantages of the measures are highly feasible, simple, and suitable with capabilities of the contractor and in terms of management. However, the mitigation measures depend much on the environmental protection awareness of the workers. Therefore, education programs and punishment/awarding regulations need to be incorporated. The Project owner will check these activities regularly and closely. Besides, these measures require close cooperation between the Project's Owner, the contractors, and local authorities.

4.3.1.9. Mitigation measures for impacts due to the washing activities of vessels and construction equipment.

The wastewater from the washing activities of barges, vessels, material transportation vehicles and other machines serving for the construction process of the plant, especially for construction of port will be causing pollution for the received environment if they are not managed correctly and strictly. The mitigation measures will be applied as those in the sea-encroached leveling stage (Article 4.2.4.4).

The fixed recovery vessels are installed on the surface of the sea to collect oil and solid waste produced from barges and construction process on the sea. Wastes are collected and treated by signing contracts with authorities which have proper capability and regulatory licenses for waste transport and disposal.

The ships must comply with procedures on sea pollution of prevention system by ships (TCVN 6276:2003 Normative on sea pollution of prevention system and Decree No.

21/2012/NĐ-CP of the Government on management of seaports and marine navigable channels.). Here is the mandatory condition for the vessels to be operated in the sea area of the Socialist Republic of Vietnam. This method has high feasible, and effective in mitigate the water pollution due to the activities of vessels and barges.

The ship owners must comply regulations in Decision No. 59/2005/QĐ – BGTVT of the Ministry of Transport about the Regulation on equipment for maritime safety and prevention of marine pollution on Vietnam ships operating domestic routes as follows:

- To require the ship owners to manage, collect, and treat the wastewater in accordance with the discharge standard.
- Not allowed to wash vessels in the port area in order to avoid causing pollution to the surrounding environment

The wastewater from the washing activities of vehicles, equipment on land will be taken to the drainage channel then to the sedimentation basin, the oil will be kept at oil trap. The water after sedimentation will be released to the received environment. The sludge will be periodically collect twice per week and hiring the proper agencies for treatment according to the current law.

The above mitigation measures will help to mitigate the influence due to the washing activities of equipment, vessels, to the environment. During the construction time, the contractor will supervise the units for strictly and properly implementation.

4.3.2. Mitigation measures for impacts due to non-waste sources during construction of the power plant and port

4.3.2.1. Mitigation measures to the aquaculture activities

In the construction stage, the mitigation measures will be applied to limit the negative impacts to the fishery activities

- To not allow the oil contaminated waste of the construction equipment into the water source. All types of oil contaminated waste have to collect and treat according to the current Vietnamese Laws. These methods have high feasibility, and reduce the water pollution due to fishery activities.
- The dredging and construction works are only allowed to execute in scope of breakwater in order to prevent the pollution from spreading to the surrounding seawater.
- The fixed recovery vessels are arranged on the surface of the seawater to collect the oil and solid waste generated from construction cargos and construction offshore. Garbage is centralizedly collected and treated as regulated by hiring the functional agencies. These methods have high feasibility, and reduce the water pollution due to aquaculture activities.
- All marine vessels must be satisfied with the regulation on the marine pollution prevention (TCVN 6276:2003- Standard on the marine pollution prevention of vessel and Degree No.21/NĐ-CP on navigation channel and port management. This is a mandatory condition for the vessels to be operated in Vietnam. These methods have high feasibility, and reduce the water pollution due to fishery activities.

The above mitigation measures will help to reduce the water pollution and moderate impacts to the aquaculture activities. During the construction time, the contractor will supervise all construction units to ensure implementing the work correctly and effectively.

4.3.2.2. Mitigation measures for impacts related to access road to the project

Mitigation measures for impacts on local traffic in construction phase are similar to those provided in section 4.2.4.9 and summarized as follows:

- Install transport signs and lighting systems at the places where accidents may be easily happen.
- Police should strictly control traffic safety along the routes used for material transportation for the project.
- National road No.1A may be damaged by heavy truck movement.

The above mitigation measures will help to reduce the traffic accidents and traffic jams in all road. However, these methods will need to increase driver's awareness of traffic issues.

4.3.2.3. Health issues of workers

The following measures have to be applied to ensure cleaning environment during construction phase:

- Build temporary worker's camps with good sanitation conditions including houses, toilets and canteen.
- Worker's camps must be large enough and airy for living, hygiene and recreation for workers.
- Water supply for workers must meet portable water standard to prevent digestive diseases for workers.
- Domestic solid waste from worker's camps are mainly organic matter will be collected by sanitary team.
- Educate awareness of environmental protection for workers.
- Equip enough protection clothes for workers.

4.3.2.4. Safety issue and fire and explosion prevention

Labor safety problems are the most important in construction phase of project, especially with big project, concentrate many workers. During construction phase, the unsafely construction is possible, therefore some measures to mitigate as follow:

- Establishing the construction plan, labor arrangement and defining construction period suitably for all vehicles go in/out project area are not impeded to avoid impact due to driver's careless.
- Following the regulations on labor safety in establishment of the plan of construction organization such as site hut construction or hiring house to ensure the material facilities for workers (rest, bath, WC,...)...or in contract implementation.

- Workers who building or operators shall be trained and work properly in emergency cases and always in their position, operate, check in accordance with technical, period maintenance.
- Equipping all clothes as well as necessary labor protection equipments and reduce the damage for workers. Labor protection equipment consists of life-jacket, rebreather (working in water environment); protection clothes, shoes, gloves (working at site); other equipments are belt, safety belt (working on high level)...
- When working in dangerous places, it is necessary to arrange barriers, protection screen in construction area and install all signals.
- If working at night, it is necessary to install lighting devices especially in dangerous places.
- Contractor must follow the regulations on sanitation and labor safety (according to TCVN 5308-91), electrical protection (TCVN 4086-95) and construction code – 1996, fire protection and fire fighting (TCVN 3254 – 89), explosion protection (TCVN 3255-86) in construction process.
- In construction site, it will build a medical station for looking after worker's healthy, first aid when accident happened.

To minimize the risk of fire and explosion, following measures will be applied:

- Installing the fire prohibition notice at dangerous places such as: petrol storage area, transformer station... Workers do not allowed smoke; bring lighter, equipments which produced fire in flammable areas.
- Installing fire fighting equipments as foam bottles, CO2, sand...
- Educating and training, checking and monitoring the fire fighting and fire protection work at warehouse, site hut of construction company.
- Cooperating with local government and management agency to solving the problems which happened at construction site or neighboring area.
- All necessary emergency contacts shall be written clearly in case accident happens such as: addresses, phone numbers of hospital, fire department.

The above mitigation measure has high feasible, simple and necessary to ensure the safety, fire prevention, and limit maximally the unexpected accidents during the construction time. The implementation of these measures is obligatory and once being applied strictly, it will bring a good and effective result.

4.3.2.5. Mitigation measures for impacts on socio-economic conditions

Project management board and construction contractors have to perform good management and educate healthy lifestyle for workers.

Promote role of public in dealing with conflicts between local people and workers (if any) and building cultural and spiritual life such as organization of exchanges to create good relationships between workers and local people.

Individuals committing crimes such as stealing and fighting will be stopped the employment contract by project management board or punished before the law. Besides, to avoid conflicts between construction workers and local people, the following measures will be applied:

- Employment of local young people of Tuy Phong District or other districts of Binh Thuan Province for simple construction activities (earthworks, transport, cooking, etc.).
- Registration of construction workers with the police of Vinh Tan Commune.
- Regular (every 2 months) meetings between representatives of the Contractor and People's Committee of Vinh Tan Commune and Tuy Phong District to discuss problems of relationships between workers and local people and any other matters of concern.
- Regular education for workers about relations with local people.
- Education moral and manners for workers to minimize drinking alcohol, gambling, stealing, fighting between workers and local people.
- To prevent transmission of infectious diseases, water-born and vector-borne diseases such as HIV, etc. from local population to workers and vice versa, the following measures are suggested:
- The Contractor, as a requirement of the Project Owner, should operate a medical centre for the construction site with 2 to 3 medical staffs, who will be responsible for providing health care, medicines for disease prevention, administering first aids, and emergency treatment in case of any accidents.
- Education for construction workers on preventive measures of infectious diseases by distributing booklets, leaflets.
- Organizing regular training on safety in the work place
- Cooperation with medical centre of Vinh Tan Commune in disease prevention and health care, provide annual periodical health examination for construction workers.

These mitigation measures are necessary to minimize conflicts between the construction workers and local people as well as other social impacts such as social evils, security, etc.

The advantages of the measures: highly feasible, simple, suitable with capabilities of the contractor and in terms of management.

The disadvantages of the measures: depend much on the environmental protection awareness of the workers. Therefore, education programs and punishment/awarding regulations need to be incorporated. The Project owner will check these activities regularly and closely. Besides, these measures require close cooperation between the Project's Owner, the contractors, and local authorities.

4.4. MITIGATION MEASURES IN OPERATION PHASE

When Vinh Tan 4 TPP and its port are put into operation, generation of waste from operation and activities of workers including emissions, cooling wastewater, industrial wastewater, oily wastewater, solid waste and other types of waste are inevitable. Therefore, measures for controlling the pollution of each waste will be introduced in the following sections

4.4.1. Mitigation measures for impacts related to waste in the operation phase

4.4.1.1. Mitigation measures for impacts due to cooling water

1. Impact due to cooling water intake

- The cooling water system will be equipped with screens to avoid wastes and fish species entering the system.
- The cooling water intake needed for the Vinh Tan 4 PP is $50m^3/s$ and will be transported to the plant by two cooling water pipes. The cooling water intake gate will be reinforced and designed with intake velocity from 0.7 to 0.9 m/s in order to prevent erosion in surrounding area. In addition, the cooling water intake gate will be enforced to mitigate and limit erosion in the project area.

2. Impact due to velocity of discharge flow

In the Project Investment report, the cooling water channel is designed with sufficient length to reduce velocity of cooling water flow to meet discharge requirements and the cooling water will be taken to the siphon hole in order to turn the flow to lapse status before discharging to the sea and prevent erosion in the area.

3. Thermal impact at discharge area

Average temperature of cooling water at the intake area (to the condenser) is about 30^oC. The highest temperature disparity between the cooling water intake and discharge area of the condenser and SWFGD system is about 8^0C (as designed).

The cooling water intake with the length of 1.5km comprises:

- A system combining the two underground drains with the diameter of each drain is about 3.9m taking the wastewater from the condenser to the siphon hole.
- Form the siphon, the cooling water will be taken to the cooling water discharge gate and releasing to the sea by a system including the 3 steel pipes with the diameter of each one is 4m.

After releasing from the condenser and the SWFGD system, the cooling wastewater having the temperature of 38^0C will be taken to the long steel pipe routes, and the wastewater will be exchanged temperature at siphon hole. Therefore, the temperature of the cooling wastewater at the discharging point will be lower than the regulated limit, which is 40^0C (QCVN 40:2011/BTNMT, Kf = 0.9; Kq = 1).

4. Impact due to residual chlorine in cooling water

The hypochlorite dosage added into the cooling water system needs to be accurately calculated. Also, chlorine concentration in cooling water needs to be checked and controlled well (<2mg/l). Therefore, the cooling wastewater will not considerably influenced the ecosystem of surrounding area.

4.4.1.2. Mitigation measures for wastewater pollution

Wastewater from the power plant and port is divided into the following types:

- Chemical contaminated wastewater
- Domestic wastewater
- Coal contaminated wastewater
- Oily contaminated wastewater
- Washing wastewater

These types of wastewater will be treated in separate systems. In order to improve efficiency and reduce construction cost for these systems, at appropriate stages, some treatment process will be integrated in a common system.

1. Chemical contaminated wastewater

All types of regular and irregular wastewater contaminated by chemicals will be collected and transferred to separate storage tanks. These tanks are designed with sufficient capacity to store the amount of wastewater generated during the repair and overhaul of the power plant.

Regular wastewater will be transferred into neutralization tank and implemented subsequent treatment processes.

At irregular wastewater tank, wastewater will be mixed with air to uniform its concentration and to avoid sedimentation; NaOH or HCl will be added in order to regulate its pH to form an optimum condition for the reaction $Fe^{2+} \rightarrow Fe^{3+}$. The dissolved amount of bivalent ferrum (Fe^{2+}) in the wastewater will be transformed into ferrum precipitate (Fe^{3+}), then settled down to the bottom. These tanks will be designed with small slope (about 2%) to help collecting sediments into a pit at the end of each tank. Then irregular wastewater will attend further treatment processes together with regular wastewater.

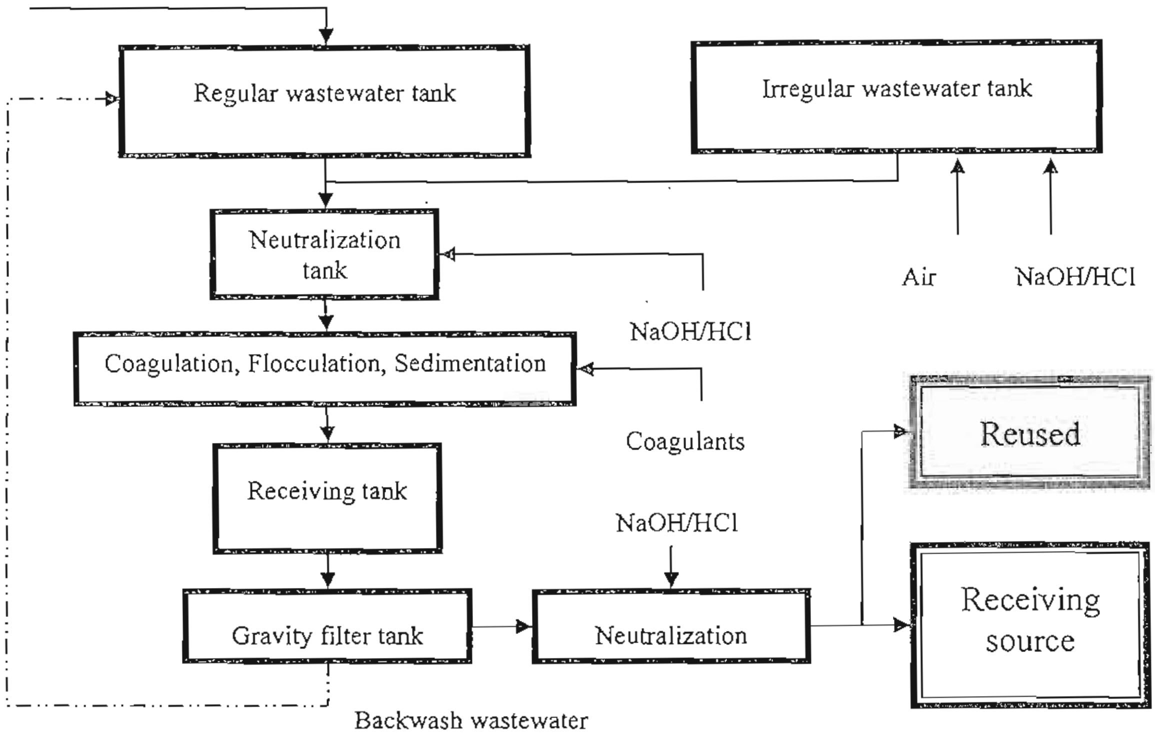
Then, the wastewater will flow to neutralization tank 1 for adjusting its pH with NaOH or HCl respectively depending on its acid or base characteristic. This is to form an optimum condition for the coagulation – flocculation treatment process. At this tank, the wastewater will also be mixed with air to uniform its concentration and to avoid sedimentation.

After pH adjustment, the wastewater is sent to the coagulation tank. Coagulant (alum, or iron sulphate) will be injected into the wastewater with sufficient dosage. The tank will be equipped with agitator for well mixing the coagulant with the wastewater.

Then, the wastewater will flow into flocculation tank. Polymer will be injected into the wastewater with sufficient dosage. In this tank, the flocculants will help suspended solids and dispersed heavy metal in water to stick and form larger sediment. This tank will also be equipped with agitator but its rotating speed is much smaller than the one operates in the coagulation tank.

Consequently, the wastewater will be directed to a clarifier for settling of floc particles. After sedimentation process, the water will flow into pressured filtration tank to filter remained sediment. Then the outlet water will be pumped into a final neutralization tank for pH adjusting (with NaOH or HCl) to acceptable level (pH = 6 – 9) stipulated in the Vietnamese regulation QCVN 40:2011/BTNMT (type B, Kq = 1; Kf = 0.9. Post-treated water will be discharged to the sea or will be recycled for appropriate purpose.

Figure 4.3. Diagram of chemical contaminated wastewater treatment system



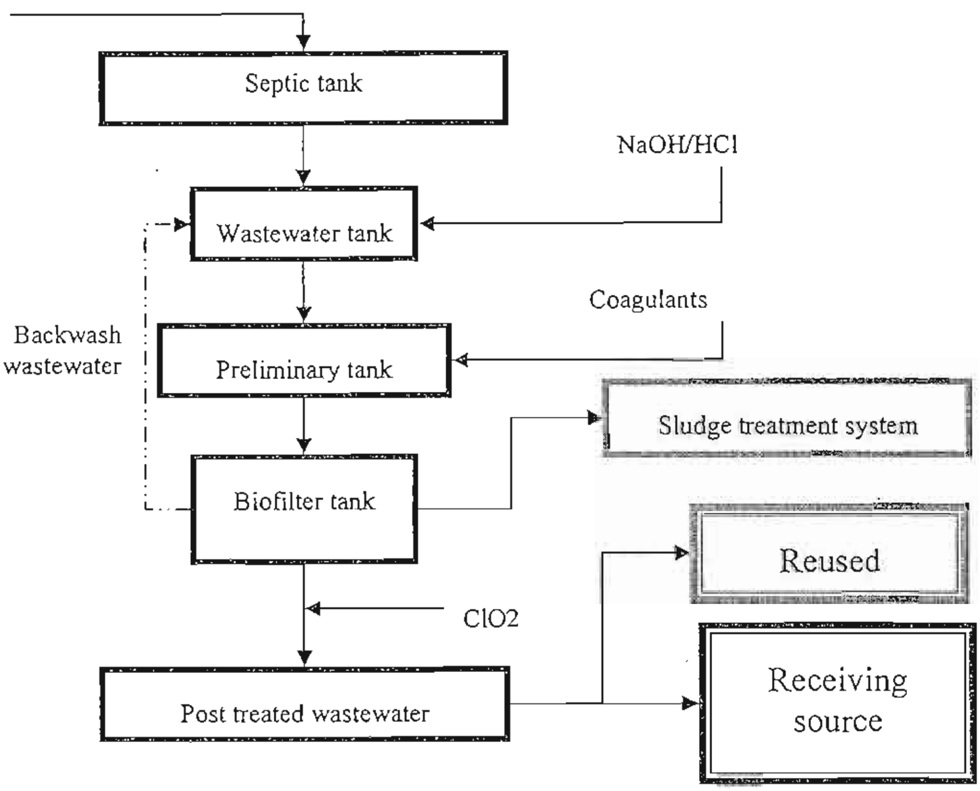
Sludge at the bottom of sedimentation tank will be collected and treated at sludge thickener in order to decrease water content in the sludge from 99% to 97%. Sludge after compression will be transported to dehydrator to further decrease the water ratio to 70%. At this stage, sludge will be compressed to solid form which will then be discharged outside the Plant.

Wastewater types generated from backwash and sludge compression processes will be sent back to the regular wastewater storage tank by gravity. From here, the wastewater will be treated in subsequent treatment processes.

2. *Domestic wastewater*

Domestic wastewater from the Plant will be partially treated in septic tanks. The effects of septic tanks are to settle down solids, to anaerobically decompose organic matter and to store sediment. Average treatment efficiency calculated by the removal of suspended solids (SS), chemical oxygen demand (COD), and biochemical oxygen demand (BOD5) is from 50-70%. The wastewater after treatment in septic tanks will be collected to a storage tank by gravity flow principle. This tank will be equipped with air blown pipes to uniform the wastewater concentration and to avoid sedimentation. From here, the wastewater will be pumped to clarifier to remove residual SS in wastewater. Then, wastewater will be directed to bio-filter tanks to further break down the organic material remaining in the wastewater. In the bio-filter tanks, organic matter is oxidized by aerobic and anaerobic micro-organisms (mainly bacteria) in biological membranes sticked on filter materials. Post-treated water will flow into the disinfection tank to remove bacteria and germs in order to meet the QCVN 14:2008/BTNMT, category B, K=1 before being discharged into the receiving source.

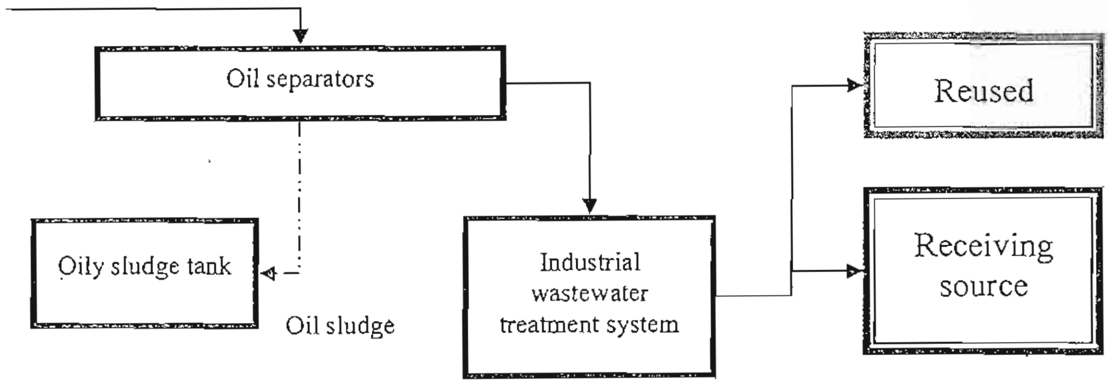
Figure 4.4. Diagram of domestic wastewater treatment system



3. *Oily wastewater*

Oily wastewater will be collected into oily wastewater storage tanks in each region. To meet environmental requirements and to improve the efficiency of the subsequent treatment works, the oily wastewater will flow by gravity to oil separators placed in oil storage and substation areas. After the oil separation process, the oil will be separated and collected periodically to oily waste storage tank. Then the water after treatment will be sent to the pressured filtration tanks. From here, together with chemical contaminated wastewater, oily wastewater will continue to be treated in subsequent treatment stages. Oil sludge collected periodically from the bottom of the pit will be transported and treated along with other industrial wastes.

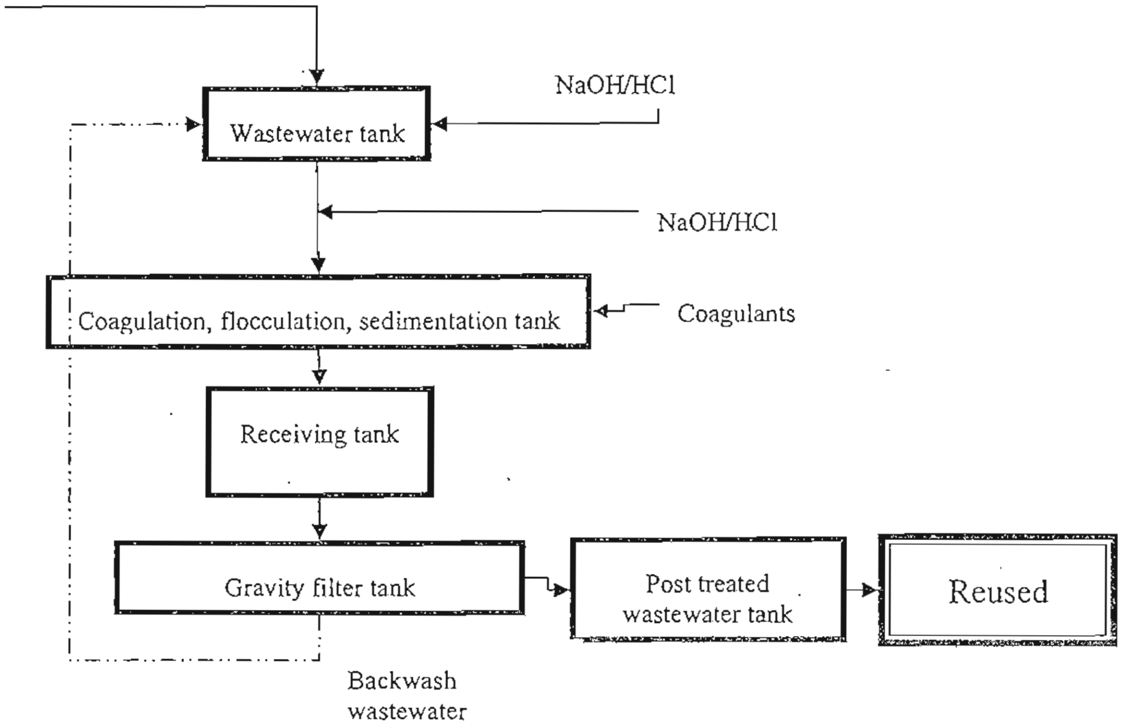
Figure 4.5. Diagram of oily wastewater treatment system



4. Coal contaminated wastewater

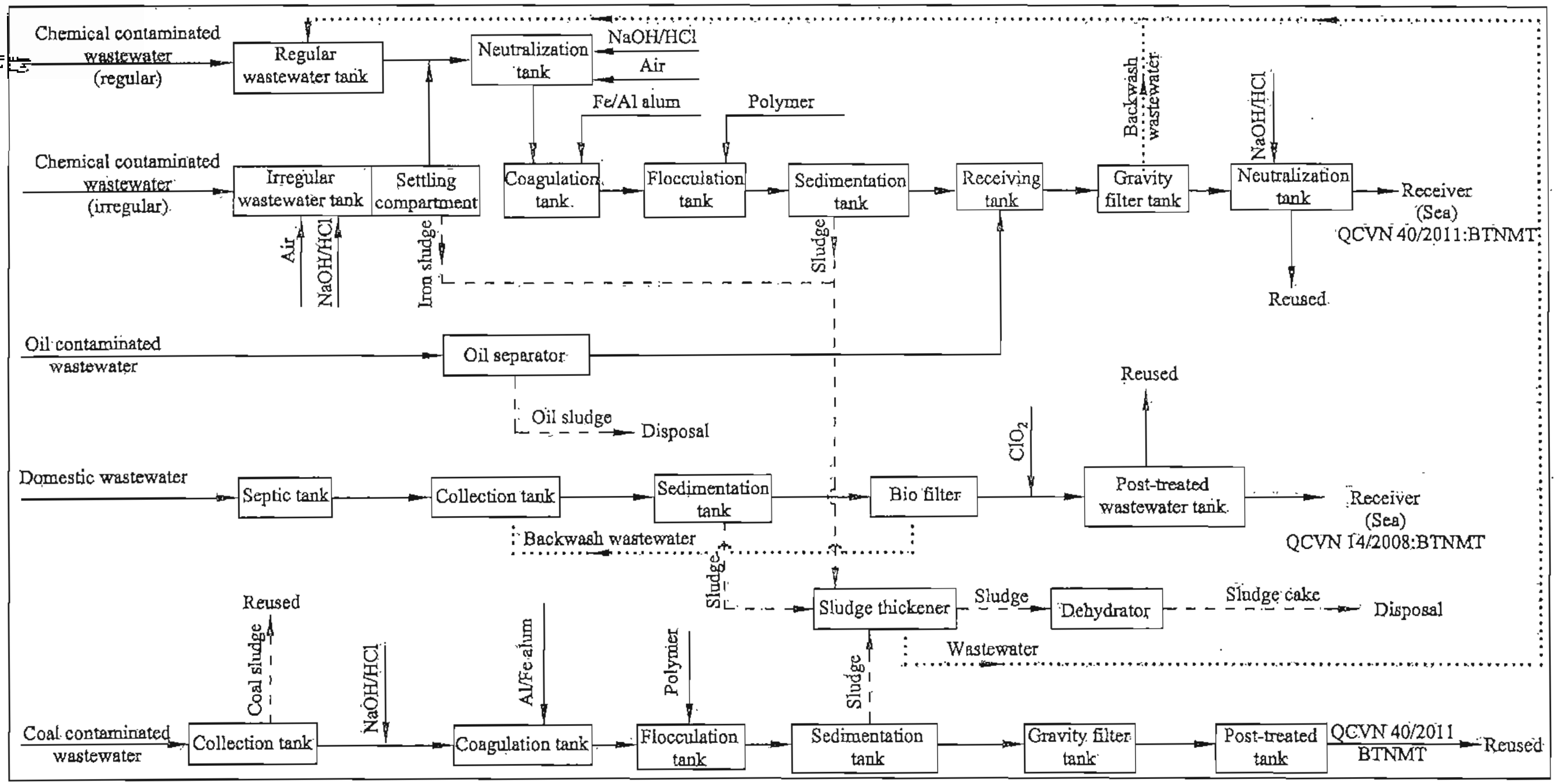
To avoid impacts of pollution caused by wastewater from the coal system, wash water from coal stockpile and storm water runoff on the surface of this area will be collected by a storm water ditch around the coal stockpile area into a rainwater sedimentation tank. After preliminary settling in the horizontal settling tank, suspended impurities in the wastewater will be significantly reduced and the wastewater will then be pumped to the wastewater storage tanks for subsequent treatment. From here, the wastewater will be pumped into the neutralization tank for pH adjusting and then it will flow to the coagulation tank. Here, coagulant (alum, or iron sulphate) are injected into the wastewater with sufficient dosage to optimize the processes of coagulation. After the floc particles are formed in the flocculation tank with the help of flocculants, the wastewater will continue to flow by gravity to the sedimentation tank. Clean water after settling process will flow to the gravity filtration tanks to remove remaining suspended solids. Post-treated water will be directed to the final storage tank and will be reused for washing and watering purposes. The water which is used in backwashing of the pressured filtration tanks will be pumped back to the horizontal sedimentation tank for further treatment. Coal sediment at the bottom of the sedimentation tank will be collected periodically and reused. Sludge will be discharged periodically and collected to the sludge thickener. Coal contaminated wastewater treatment system of Vinh Tan 4 TPP are demonstrated in the following figure.

Figure 4.6. Diagram of coal contaminated wastewater treatment system



The aforementioned wastewater treatment systems have been developed and proved their effectiveness in variety of power plant projects. Therefore, they can be applied for this project.

Figure 4.7. Diagram of wastewater treatment system of Vinh Tan 4 TPP



5. Wastewater at port area

- Domestic wastewater of the Port of Vinh Tan 4 TPP will be preliminary treated by septic tanks and taken to the domestic wastewater treatment system of Vinh Tan 4 TPP for further processing meeting QCVN 14:2008/BTNMT, category B, K=1 before reuse for other purposes in power plant.
- Coal contaminated wastewater arises mainly from sanitary conveyor operation, handling equipment and coal port and runoff rain water (when rain flows through the port area). This wastewater will be collected to waste water tanks (located in coal storage area). Coal contaminated wastewater from the power plant and coal port will be treated to meet QCVN 40:2011/BTNMT, Kf = 0.9; Kq = 1 before being reused for other purposes in power plant.
- For ballast wastewater: Because there is no vessel repairing activity in the port, wastewater from vessels entering and exiting the port shall not be discharged into the port area. Under current regulations of Vietnam (Decree No. 71/2006/ND-CP dated 07/25/2006 on port management and maritime channels - Maritime Code of Vietnam) as well as regulations of protecting international marine environment (MARPOL 73/78), vessels shall not discharge ballast water to the port, vessel owners are required to discharge and replace the water to waters beyond the sovereignty of Vietnam and must not pour ballast water within Vietnam's waters. The discharge of ballast water will follow the specific instructions of the port authorities of Binh Thuan. Vessels operating in the port must carry out the garbage discharge, dirty water and ballast water discharge according to regulations and instructions of the relevant port authority.

Measures to reduce water pollution caused by domestic wastewater and waste arising from vessels are presented in Section 4.3.5.4.

4.4.1.3. Mitigation measures for air pollution

1. Mitigation measures for heat impacts

Air temperature in areas such as boilers, turbines, and heating areas can reach 35 – 40°C. Therefore, countermeasures to be applied are as follows:

- Workshops will be designed with sufficient and good ventilation between production areas and surrounding environment. Based on architectural plan and the use of construction works, air conditioning and ventilation systems will be calculated and designed to ensure the technical specifications (as per required by the construction works) to be consistent with current Vietnamese standards and regulations as well as to have high economic efficiency.
- Pipelines transferring chemical with high temperature such as steam pipelines, supply water pipelines, oil pipelines, oil tanks, stacks and valves are insulated in order to meet labor hygiene standard according to Decision No. 3733/2002/QĐ-BYT promulgated by Ministry of Health.

2. *Pollution control due to organic compounds leakage*

Organic compounds leakage from production process at plant is mainly from raw materials storage areas and transportation process. The following measures will be used to reduce the evaporation of these compounds into the atmosphere:

- To install equipment, pipes, and valves with high tightness, these devices must be strictly tested about tightness before using.
- Tightness of equipment must be usually tested in operation process.

3. *Control of pollution from vehicles*

- Boats are not allowed to transport goods exceeding their regulated loading capacity. When anchoring at harbor, they are not allowed to directly discharge solid waste and washing wastewater into sea. The project owner will associate with local authorities to control public order and social evils when concentrating a large number of boats and people in this region.
- Considering road traffic, vehicles must have periodically verified certificate of appropriate authorities to travel in site.
- Vehicles have to use designed fuel for their engine.
- Fuel loading/unloading and transporting systems will be closed conveyor systems. On the other hand, in order to prevent dust from coal handling, coniferous trees will be planted around coal loading/unloading areas, coal storages and coal piles.
- Specifically, in order to prevent oil spill due to boats striking, project owner will contract with local rescue team to promptly overcome this incident. In addition, plant will train 1 – 2 staffs to be responsible for dealing this problem.
- Ash transportation route and time will be planned reasonably; ash will be stored in the sealed container to prevent dust emissions during transportation route.

4.4.1.4. Mitigation measures for flue gas pollution

1. *Mitigation measures for dust pollution*

In order to ensure dust content in flue gas from stacks meeting QCVN 22:2009/BTNMT, Kq = 0.85, Kv = 1 (permissible level is 170 mg/m^3), ESP selected for the plant should reach the efficiency of at least 97.8%.

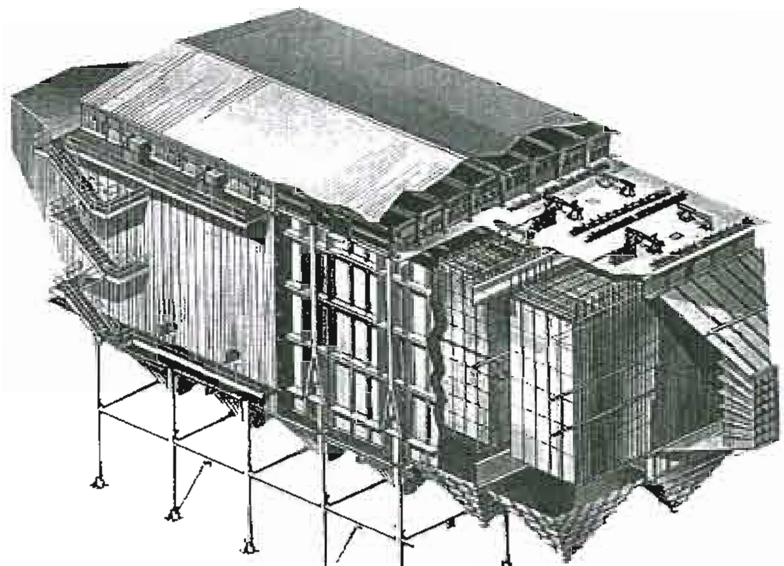
In order to ensure dust content on the ground meeting QCVN 05:2009/BTNMT, Vinh Tan 4 TPP will install stacks with the height of 210 m. This stack can disperse dust which in turn not cause any influence to the surrounding environment.

Flue gas after passing ESP system will be emitted into the air by stacks with height of about 210m. In Vinh Tan 4 TPP, each boiler will be equipped with one ESP system. Operation principle and structure of ESP system is given as follows:

- ESP removes solid particles out of the gaseous phase by electrostatic forces and accumulates them on electrodes. ESP is consisted of parallel steel electrodes with the gases flow amid electrodes. High voltages are kept between electrodes.

- Solid particles are electrically charged when they pass the electrical field where moving gaseous ions have high density. The electrical fields among electrodes will force electrically charged particles to move to dust-collecting electrodes.
- Ash accumulated on electrode surfaces are removed by "striking", i.e. shaking for dust to fall down the funnel.
- The fly ash recuperated from the hopper of the ESP system will be transferred by compressed air to the reserved silo. The silos have a dimension which is enough to contain the fly ash at least 24 hours.
- The fly ash conveyance system by compressed air transported the fly ash to the two fly ash silo. The air from the silo will be deflated via filter bag arranged on the top of the silo.
- The silo is made by reinforced concrete, the silo is equipped with a sheet creating fluidized bed in order to ensure the amount of fly ash deflated.
- Spraying from 15 to 30% water to mix ash becomes wet powder in order to avoid releasing dust. The mixed machines will release ash to the specialized vehicles to transport to the ash yard. The part of environmental impact mitigation for the ash yard is shown in the section 4.4.1.8

Figure 4.8. Typical design of ESP system



The above mitigation measures have been wisely applied in many countries and proved their effectiveness in a lot of different projects, especially, in control the dust in the thermal power plant (the efficiency of about 97.8%), ensure the dust generation at the plant meets standards at source QCVN 22:2009/BTNMT, Kp=0,85, Kv=1.

2. *De- SO_2 system*

According to the designed parameters, Vinh Tan 4 TPP will install SW- FGD system with efficiency of about 87%.

This method has many advantages such as: high SO_2 removal efficiency up to 99%; simple treatment process with seawater and air; saving large amount of freshwater (80 – 90%) comparing with lime – FGD technology; reducing manpower cost for operation and maintenance process; saving natural resources (lime) and non-waste and non-byproduct generation; minimizing environmental impacts; reusing cooling wastewater after condenser (about 20% of total amount of cooling wastewater).

SW-FGD can treat 20~6.500ppm SO_2 in flue gas from furnaces, power plants, aluminum factories and petrochemical plants. The principle of this method is given as follows:

The seawater FGD process is a desulphurization technology that utilizes the natural alkalinity of seawater to absorb SO_2 in the flue gas. This technology does not need a desulphurizer, has no wastewater and solid waste discharge and has the advantages of simple system, reliable operation, low investment, little additional consumption, low operation maintenance cost and high desulphurization efficiency.

However, this technology in general is only applicable to the seaside power plant and can be used only when sufficient seawater resupplies are available.

According to Alstom's requirements on SeaFGD technology, pH value and DO content of input seawater must be more than 6 and 3mg/l, respectively.

Table 4.2. Seawater quality at the project site

STT	Parameters	Unit	Value	TCVN 5502:2003
1	Turbidity	NTU	1.6	5
2	Acidity ($CaCO_3$)	meq/l	KPH	8
3	pH		7.99	6-8.5
4	Total hardness ($CaCO_3$)	mg $CaCO_3$/l	6230	300
5	Temporary hardness ($CaCO_3$)	mg $CaCO_3$/l	115	
6	Permanent hardness ($CaCO_3$)	mg $CaCO_3$/l	6120	
7	DO	mg/l	5.12	6
8	BOD_5	mg/l	KPH	
9	COD	mg/l	2.06	
10	TDS	mg/l	50700	1000
11	TSS	mg/l	2.4	
12	Bicarbonate (HCO_3^-)	mg/l	115.9	
13	Carbonate (CO_3^{2-})	mg/l	12	
14	Hydroxit (OH^-)	mg/l	KPH	
15	Carbon dioxide (CO_2)	mg/l	0.44	
16	Sulphate (SO_4^{2-})	mg/l	3070	

STT	Parameters	Unit	Value	TCVN 5502:2003
17	Amoniac (N)	mg/l	0.25	3
18	Ammonia (NH_4^+)	mg/l	0.33	
19	Chloride (Cl^-)	mg/l	17300	250
20	Nitrate (NO_3^-)	mg/l	KPH	10
21	Nitrite (NO_2^-)	mg/l	KPH	1
22	Total alkalinity ($CaCO_3$)	meq/l	2.3	
23	Phenol alkalinity ($CaCO_3$)	mg/l	10	
24	Silica (SiO_2)	mg/l	0.37	
25	Fe^{3+}	mg/l	KPH	0.5
26	Fe^{2+}	mg/l	KPH	
27	Al	mg/l	KPH	0.5
28	K	mg/l	564	
29	Na	mg/l	10200	
30	Ca	mg/l	393.3	
31	Ba	mg/l	KPH	
32	Mg	mg/l	1260	
33	Sr	mg/l	7.15	
34	Oil	mg/l	KPH	0.1
35	Coliform		<3.0	2.2
36	TS	mg/l	50700	
37	TOC	mg/l	25.30	

Source: Analysis results of seawater sample at Vinh Tan in November 2011

According to analysis results, quality seawater at the project area meets requirements of absorbent solution for FGD system.

The main principle of this technology is as follows:

- Seawater delivered into the absorber contacts and is mixed with the flue gas in the absorber.
- Sulfur dioxide (SO_2) in the flue gas reacts chemically with the alkaline components in seawater and generates sulfite ion SO_3^{2-} and hydrogen ion H^+ and seawater pH drops and it becomes acidic seawater.
- Hydrogen ion in the acidic seawater neutralizes the alkaline components in the seawater to generate water and the desulphurized flue gas has mist drops

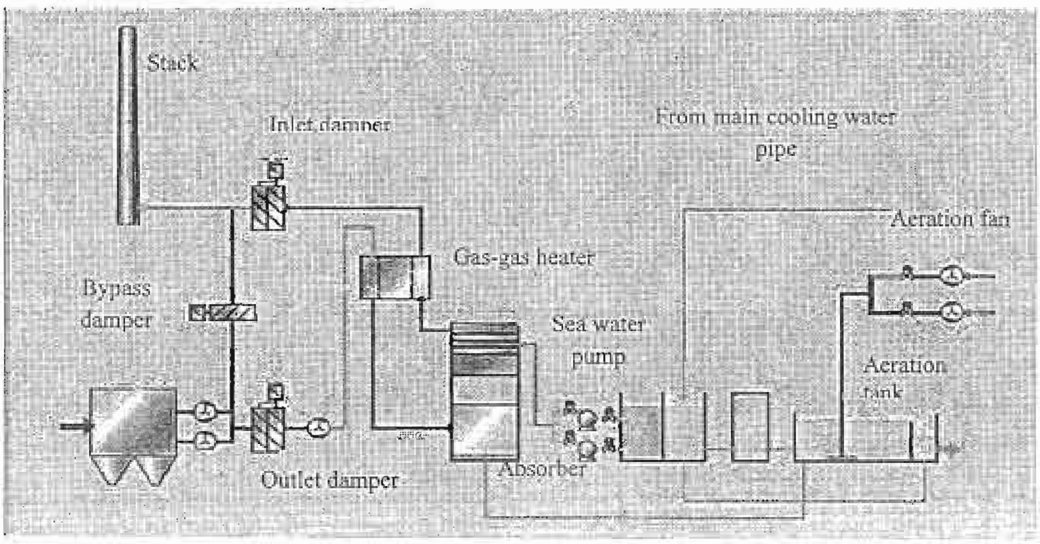
removed in turn through the mist eliminate and is discharged from the stack into the atmosphere.

- The typical flow of this process is shown in the above figure and the chemical reaction principle is as follows:

$$SO_2 + H_2O \rightarrow 2H^+ + SO_3^{2-}$$
$$SO_3^{2-} + 1/2O_2 \rightarrow SO_4^{2-}$$
$$CO_3^{2-} + H^+ \rightarrow HCO_3^-$$
$$HCO_3^- + H^+ \rightarrow CO_2 + H_2O$$

- The acidic seawater from the absorber is discharged into the aeration basin in the seawater treatment plant and is mixed with the great deal of seawater that has not participated in the desulphurization reaction and plenty of air is blown in to make the unstable sulfite ion SO_3^{2-} react with oxygen O_2 in the air to generate stable sulfate ion SO_4^{2-} which is discharged into the sea with seawater to achieve the goal of desulphurization.
- Plenty of air blown in the aeration basin also accelerates the generation and release of carbon dioxide CO_2 and makes pH and dissolved oxygen amounts return to the allowable normal level of discharge.
- After being mixed with air and neutralization, the seawater used to desulfurizate has the pH fluctuated from 6.5 to 8.5 meet QCVN 40:2011/BTNMT and being discharged on the cycling cooling water channel.
- A complete set of the system for this process usually includes seawater supply system, SO_2 absorption system, flue gas system and seawater quality restoration system etc. At present, the SW-FGD system is technically proven, systematically reliable, and maximum installed capacity of a single unit reaches 700MW. It is widely used and can treat the flue gas with 20~6500ppm sulfur concentration. It is widely used in the power plants and aluminum smelters and oil refineries.

Figure 4.9. Diagram of seawater desulfuration flow



The above mitigation measures have been wisely applied in many countries and proved their effectiveness in a lot of different projects, especially, in control the SOx in the power plant. This method has high feasible and effective in mitigating and reducing SOx, ensure the SOx generated from the plant meet QCVN 22:2009/BTNMT, Kp=0,85, Kv=1.

3. *De-NOx system*

Mitigation measures for NOx in furnace are listed as follows:

- Stage burning: burning with insufficient air at the first stage and supplementing air at later stage
- Using low NOx burners: these burners will divide combustion air into some parts, air and fuel is mixed well to create low temperature flame and to reduce NOx generation.
- Low NOx burner method does not generate the wastewater. Hence, the wastewater treatment system is not applied for this technology.

The above mitigation measures have been wisely applied in many countries and proved their effectiveness in a lot of different projects, especially, in control the NOx in the power plant. This method has high feasible and effective in mitigating and reducing NOx, ensure the NOx generated from the plant meet QCVN 22:2009/BTNMT, Kp=0,85, Kv=1.

4. *Air emission monitoring*

Continuous emissions monitoring system (CEMS) will be installed on the air discharged pipe. CEMS system will turn on light alarm when pollutants concentration exceeds allowable value in standard and automatically operate to reduce electrical capacity in order to minimize pollutants concentration.

4.4.1.5. Mitigation measures for air pollution during coal handling, storage and transportation

When Vinh Tan 4 TPP goes into operation, dust may be arisen from the unloading and loading coal, and transportation and storage in coal yard. Based on calculation results, dust content from these activities meets QCVN 05:2009/BTNMT after applying some appropriate mitigation measures.

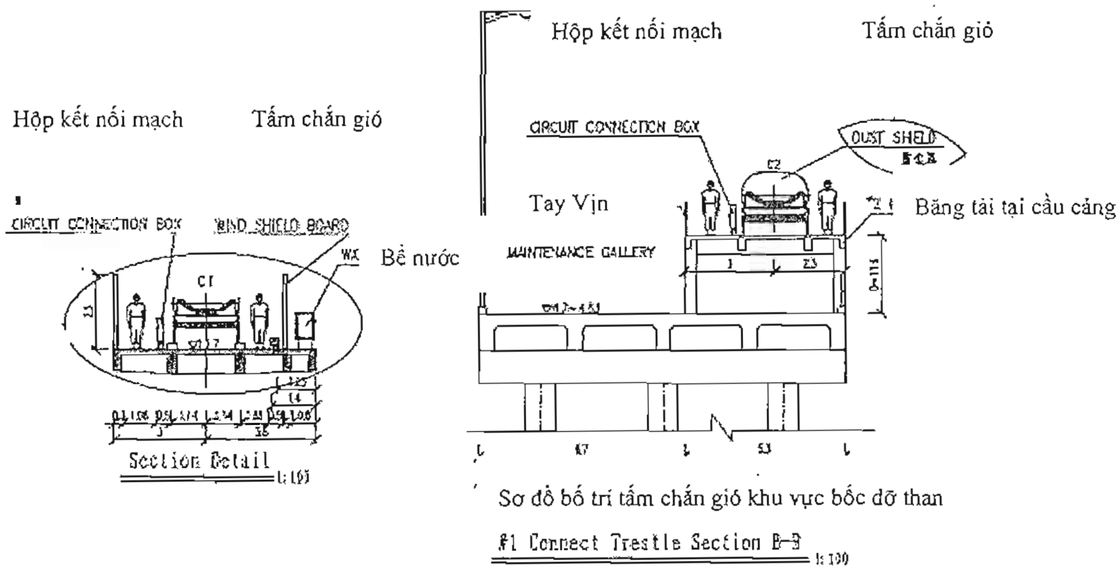
1. *Mitigation methods at the loading and unloading area*

- Unloading and loading coal by part-closed system: In this technology, coal from ship will be moved by grab to quayside belt conveyer into entrepôt; and then coal will be moved by rear belt conveyer from entrepot to power plant. Therefore, the quantity of dust generating from the transportation from the port to coal storage and the Plant is almost negligible.
- The wind shield which is 3.0m high is installed on two sides of the primary Trestle Bridge. Storm back plate's pillar use double T-iron, be apart from for the 5m in the lengthways, a cold bend thin-wall steel wall beam be located on the pillar, the side is 3 each time, total 6. The wall beam passes from offend bolt to press a profiled steel sheet (The thickness is 0.53mm). The steel railing which is

1.0m high is installed on two sides of the others. Typical design windshield for loading and unloading coal area is shown in Figure 4.10.

- Reducing air dispersion of coal – dust by cleaning and washing unloading equipments once every week.
- The aforementioned measures will help to reduce the air pollution in the unloading area because of dust to 80-90% and will not cause significant impacts on the local air environment.

Figure 4.10. Typical design of wind barrier in loading and unloading coal area.



2. *Measures to minimize dust from the coal storage area*

- The coal yard is designed as semi-closed with against wind walls; the surrounding of the coal storage area is planted with trees with the width of about 3m. Besides, water spraying around the coal storage area will be carried out to minimize dust generated. There are three spraying pumps (Q = 120 ÷ 143.6 m3/h, H = 0.8 ÷ 0.66 MPa; N = 55kW) installed. Bubbled water wash system will serve all of the transfer station and frame girder, all transportation vehicles, hydraulic stretch tools on the ground and considered with cleaning and drainage facilities. Sprinkler system at the coal yard can be controlled manually or automatically, combining local control and remote control.
- After applying mitigation measures, air pollution level due to dust at coal storage area can be reduced to 90% of original value which is proved by AERMOD modeling at Chapter 3.

4.4.1.6. Mitigation measures for noise and vibration

Plant will apply these measures to minimize noise and vibration from production areas:

1. Mitigation measures for noise impacts

- Install noise reduction equipment for high noise level sources such as discharged fans, guard valves, discharged fans, etc.
- Build noise baffle wall for turbine and place generator at separate place
- Design and install automatic control system to reduce number of workers working at high noise and vibration level areas.
- Periodically inspect and maintain machines and equipment, feed oil for machines
- Arrange high noise level equipment at separate places that is far from other areas
- Plant green belt, build walls, parterres and grass cover within plant area, around workshops, internal roads to prevent noise and dust. Green area is estimated at about 10% of total space.

The above mitigation measures have been wisely applied in many countries and proved their effectiveness in a lot of different projects, especially, in control the noise in the power plant. This method has high feasible and effective in mitigating and reducing noise, ensure the noise generated from the plant meet QCVN 26:2010/BTNMT.

2. Mitigation measures at the port area

In coal-mill areas where it is likely to cause significant noise, the following measures will be taken to minimize the noise impact:

- Installation of silencers at the input/output of crushing equipment.
- The noise inside the area of coal and limestone crushing will reduce noise by using noise reducing materials to made walls or ceilings workshops (e.g., noise absorbing material by mineral to be a wall).
- The wear test, the details of equipment in accordance with the technical guide. Regular maintenance of the equipment to work properly, technical process improvement that reduces noise. Periodically lubricants for machinery in operation mode.
- Employees working in this area will be equipped with sound reduction headphones.

A mitigation measure mentioned above is commonly used in the world and has proved effective in controlling noise in the port area. Measures are feasible, highly effective in limiting noise, ensuring noise arising from the port meet QCVN 26:2010/BTNMT in normal place.

3. Mitigation measures for vibration impacts

- Cast machine foundation base with enough quality, increase depth of foundation, dig canal and fill with dry sand to prevent vibration transfer.
- Install rubber gasket and antirattle storing for high capacity equipment which has mobile or beating devices such as conveyor, engine, etc.

The above mitigation measures have been wisely applied in many countries and proved their effectiveness in a lot of different projects, especially, in control the vibration in the power plant. This method has high feasible and effective in mitigating and reducing vibration, ensure the vibration generated from the plant meet QCVN 27:2010/BTNMT in normal place.

4.4.1.7. Mitigation measures for solid waste

1. Industrial solid waste

The industrial solid waste is divided into 2 main groups:

- Reusable wastes: include wastes that can be collected, reused, or recycled. This group mainly contains paper, metals, glass, plastics, etc.
- Wastes need to be treated or disposed: organic wastes, domestic wastes that contain chemicals, or other solid wastes that cannot be reused.

Everyday, the solid waste from the plant will be collected and classified as the above regulations. The part of the solid waste which can not reuse or recycle will be disposed and transported to the landfill according to the law. This work will be executed by the appropriate functional agencies.

This mitigation measure has high effectiveness and feasibility, and is consistent with the actual conditions.

2. Ash

Industrial solid waste of Vinh Tan 4 TPP is mainly ash from coal fired process. According to calculation, the annual amount of ash is approximately 137,248 tons per year for the capacity of 1200 MW.

According to the ash research, the fly ash can be use to made the concrete, cement or to produce bricks. Therefore the plant will find specialized customer to consume the ash volume in order to reduce the ash holding area and pollution cause by ash to the environment.

In the beginning of operation phase, ash generated from Vinh Tan 4 TPP will be stored at the common ash yard (ash yard 1) of Vinh Tan 2 power plant within 5 years of operation. After ash yard 1 is full, ash from Vinh Tan 4 TPP will be stored at ash yard 2 with an area of 120ha (common item in Vinh Tan power complex) located at the valley of Ong Do and Da Chet mountain 7km from Vinh Tan power complex.

Proposed ash disposal technology applied for Vinh Tan 4 TPP is dry method. A green belt with suitable width will be planted around the ash yard to prevent dust dispersion. After being full, the ash yard will be covered by soil and vegetation to prevent dust dispersion and ash sweeping away by rain water as well as improve local landscape and environment.

Mitigation measures for environmental impacts at ash yard were presented in section 4.4.1.8.

3. Domestic solid waste

Impacts of solid waste in this project depend on two factors such as solid waste collection ability and at- source classification in order to apply prompt treatment measures.

Solid waste collection rates at plant will reach the level of 100%. In order to collect solid waste easily, trash cans will be arranged. Solid waste is classified immediately after collection. Collected waste will be transported to landfill by specialized trucks. In addition, plant will contract with urban sanitation company for transporting waste to concentrated treatment area.

This mitigation measure has high effectiveness and feasibility, and is consistent with the actual conditions.

4. Hazardous waste

Hazardous wastes including oil sludge, oily cloth, etc. will be collected and stored in hazardous waste containers with lids located at the port and power plant. Storage of hazardous waste must comply with regulations of Circular 12/2011/TT-BTNMT on providing management of hazardous wastes and other current regulations.

Management board of the Plant will prepare documents, registration of hazardous wastes with the Department of Natural Resources and Environment of Binh Thuan province, and sign contract with agencies licensed in hazardous waste business to collect and process in accordance with Decree No. 59/2007/ND-CP on management of solid waste and Circular No. 12/2011/TT-BTNMT on regulations on hazardous waste.

At present, Binh Thuan has no agency specializing in handling hazardous waste. The Project Owner is committed to being in compliance with the management and storage of hazardous waste before the authorized agency transport and handle under the current regulations (Circular No. 12/2011/TT-BTNTM guiding conditions for practice and procedures for records, registration for license and code of Project management; Decision No. 23/2006/QD-BTNMT issuing the list of hazardous wastes and QCVN 07:2009/BTNMT on threshold of hazardous wastes). Specific agencies to receive, transport and handle hazardous waste arising from the Project will be specified in the implementation phase (through bidding among eligible units).

This mitigation measure has high effectiveness and feasibility, and is consistent with the actual conditions.

4.4.1.8. Mitigation measures at ash yard

1. Operation procedures for ash collection system

- *Fly ash conveyance system*: Fly ash collected from ESP hoppers, warming water and air heater will be transported to the fly ash silo by air compressed system. Compressed air used to transport ash is the air compressor service. Fly ash silo are located in the south, away from the main factory area about 210m long. Two reinforced concrete silos will be built for 2 units. Each fly ash silo has diameter of 22, height of 27m, and volume of 10,300 m³ in response to continuous operation for 7 days at BMCR condition. From the silo, fly ash will be brought to the mix ash and transported to the ash yard by vehicles.

- *Bottom ash conveyance system*: bottom ash will be transported to the bottom ash silo by conveyor belt. Each boiler was installed one conveyer belt to receive ash from the ash at hopper. Bottom ash will be taken through a preliminary crusher to reduce the size of the bottom ash, then transported to the bottom silo and bottom ash production stations. Vehicles will transport the ash from the bottom station of the landfill.
- *The conveyance system outside of the ash yard:* form the fly ash silo, and bottom silo, the ash will be transported by the specialized truck to the ash yard of the plant.

2. *Ash yard management and operation responsibility:*

Because of the Vinh Tan 2 and Vinh Tan 4 Power plant is having the same investor that is EVN, ash yard management and operation work will be controlled by EVN investor.

The staff force on management and operation the ash yard includes:

a) Unit directly at ash dumps

Management and operation force directly at the ash yard will be belonging to Vinh Tan 2 power plant. This work includes:

- Specialized vehicle management team in the receiving process and transportation
- Infrastructure management of the ash yard
- Operation management of vehicles, equipment serving for the ash yard, includes excavators, bulldozers and compacted, the water pump by reducing dust caused by blown

b) Transportation and collection unit at the plant

This unit is belonging to the Vinh Tan 2, Vinh Tan 4 and the directly force of each plant. This unit will be assigned depending on the actual condition of power plants under intensive methods to ensure effective exploitation of all the plant and ensure the safety conditions of the environment.

c) Ash yard management responsibility

- The ash yard management responsibility belongs to the Technical Director of the Vinh Tan 2 PP, the first plant using the ash yard.
- The ash yard of the Vinh Tan 4 PP are arranged at ash yard, controlled and managed by the Technical Director of the Vinh Tan 2 PP.
- Responsibility for transporting ash from the plant in Vinh Tan Vinh Tan 2 and 4 is belonging to each plant management.

3. Mitigation measure for impacts at the ash yard

Ash dust easily released into the surrounding air when having high winds because they are a small proportion. Therefore, to prevent the spread of dust from the ash yard to the surrounding air, the project will apply mitigation measures as follows:

- Dry slag will be transported to the landfill dumping in sequence, and slag will be wet and leveled until get the required dry density. The surfaces after compression forming a hard crust in order to moderate the ash fly when having whirlwind. When slag is dumped in the pile, bulldozers will be leveling, before compacted layers. Slag surface will be sprayed to prevent fly ash. Truck washing station will be built at the site, all slag transport vehicles or machinery, equipment will be washed slag out before exiting the ash yard. The surface will be covered by land and crops as soon as the ash yard get to the design elevation.
- In the conditions, when the slag is transported by large capacity truck to ash yard, where it has arranged station, garage, office and reservoirs. Ash yard control station will be operated by senior officers to ensure safe and economic operation of the ash yard.
- Water injection in the ash yard is taken from the rain source at the ash yard and reused from the industrial wastewater treatment system of plants.
- According to the Vietnam Construction Standard TCXDVN 261:2001 of solid waste landfills - Design standards, around landfills have green insulation barrier. Thus, the plant will also create green belt planting around the ash yard. The smallest width of the range of isolated trees is 5m with an area of about 6.5 ha. Types of trees, which can be used to create green belt area at the ash yard, should choose coniferous trees, broad and evergreen canopy. In addition, trees are effective in reducing wind speed, creating quiet zones before and after the wind and reduce dust dispersion. Serious implementation of all above recommended solutions will ensure the quality of ambient air in the area surrounding the project.

This mitigation measure has high effective, feasible, practical and consistent with the limited dispersal of dust in the ash yard into the environment

4. Mitigation measures for impacts due to wastewater from the ash yard

Due to the infiltration through the soil, ash also alters the chemical composition and mechanism change of surface water, groundwater, polluting the surrounding water environment. In order to limit leakage of wastewater from ash yard to groundwater, the structure inside the ash yard is designed as follows:

- Protective soil layer and the slope of drainage channel, compacted with k> 0.90; approximately 50cm of thickness;
- HDPE damp-proof membrane layer with the thickness of 1.5 mm or GCL damp-proof clay layer, permeability coefficient K <10- cm/s.
- Geotextile layer to protect the HDPE membrane or GCL damp-proof clay layer
- Sand bearing layer.

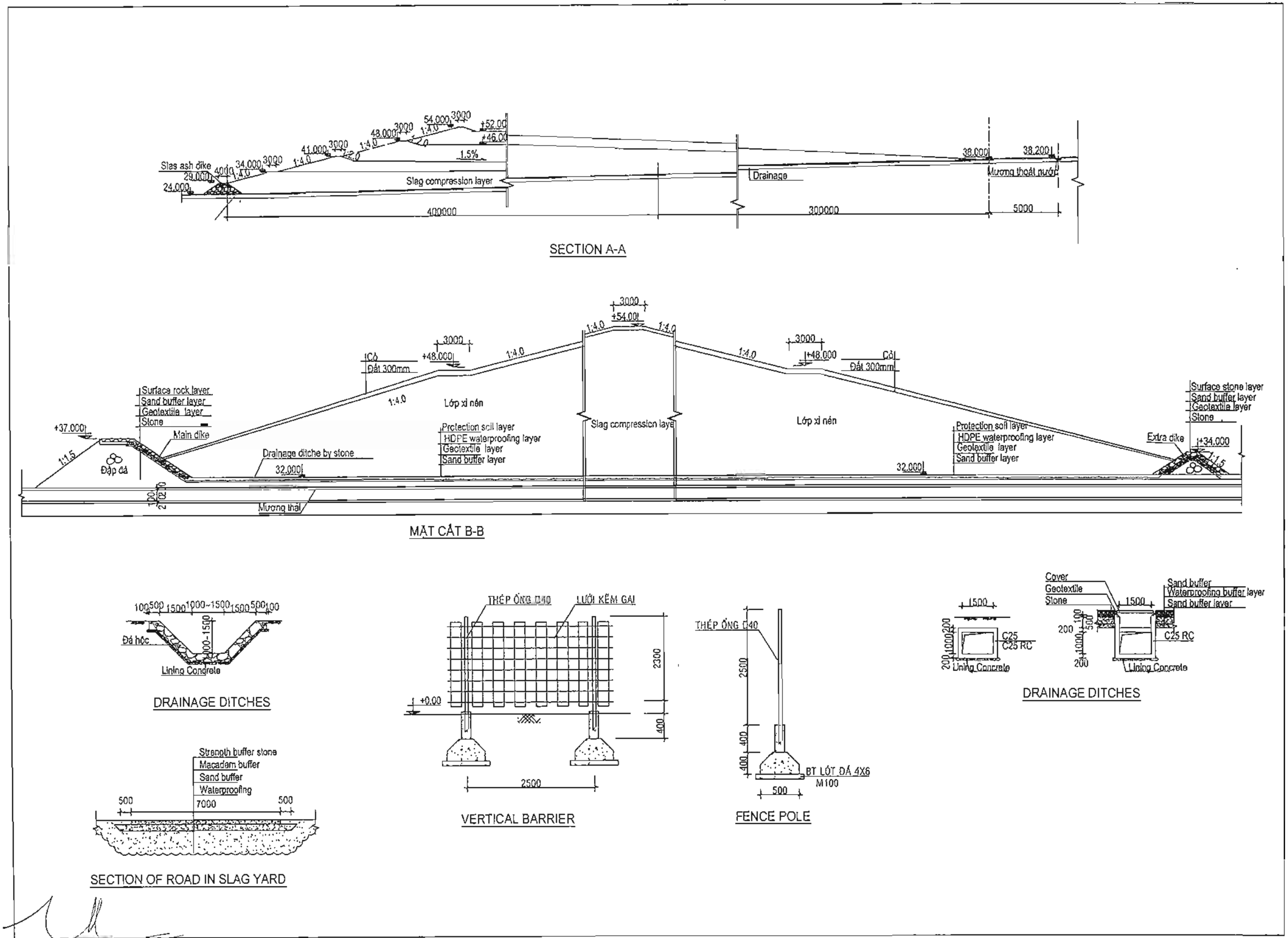
HDPE damp-proof membrane layer and geotextile layer will ensure no leakage of wastewater into surrounding groundwater. The core structure of the ash yard No. 1 at

For the rain water in the ash yard: Based on the bottom topography, drainage channels are arranged according to the slope. Inside the embankment there are tanks containing the water during rainy days. Rain water will be collected to the reservoir. The water after sedimentation will be reused for watering ash in ash yard.

Besides, the ash yard area will be designed to build dikes to prevent water leakage in the ash yard to the surroundings. Dike structure is designed as follows:

The embankment selected for the ash yard is the rock embankment, without considering the traffic problems on the crest. The length of the main embankment is about 1590m, the inside and outside slope is 1:1.5, the height of 5m, the width of 4m; the subsidiary embankment is about 800m of length, the internal and external slope is 1:1.5, height of 2m, the crest width of 1m; stone used to build embankment an be used from the nearby mountains. To prevent ash from releasing out of the embankment, there will be a filtration layer with the thickness of 300mm made of stone and geotextile layer arranged on the surface of the rock dike. To keep geotechnical layer, overlaid sand layer with the thickness of 200mm, using the stone block with the thickness of 400mm to protect the surface, the function is to prevent dust and to filter water. The structure of the ash yard No.1 at Ho Dua mountain is shown in Figure 4.11.

FIGURE 4.11 CROSS SECTION OF ASH YAD (64.7HA) IN HO DUA MOUNTAIN



4.4.1.9. Mitigation measures for impacts due to periodical dredging of turning basin and approach channel

Amount of annual dredged materials for Vinh Tan 4 port is estimated at about 23,076.8 m^3, which will be levelled for transhipment coal storage area. According to initial calculation, transhipment coal storage area will need more than 3.5 million m3 of aggradation materials after leveled up to +5.0 m in elevation as expected.

Transhipment coal storage in sea port area of Vinh Tan power center is expected to invest to transit coal for coal-fired power plants in the southern region. However, base on the announcement No. 346/TB-VPCP of Government dated 09/10/2012 on some of the conclusions of the Deputy Prime Minister Hoang Trung Hai at the meeting about location alternatives for coal transshipment in Mekong delta, the government currently has not advocated the construction of transhipment coal storage in sea port area of Vinh Tan power center.

Therefore, the capacity of this transhipment coal area can store the annually dredged material of ports for Vinh Tan 2 and Vinh Tan 4 TPP in operation phase.

In order to mitigate the impacts due to periodic dredging of roadsteads and passages, the port authority will take some measures as follows:

- Using stopping sheets to enclose the dredging zone in order to limit the emission of muddy water.
- Dredged materials will be taken to offshore dump site which was specified in construction phase or leveled area with applying similar mitigation measures.
- Not discharging of waste oil and fats from dredger's activities to the sea.
- When conducting dredging, port management board should limit vessels carrying fuel barge to be in and out off the harbor during dredging to minimize increases in turbidity and minimize incidents when boats collide in the port area.
- The dredged material will be utilized for leveling of coal substation area and presented as follows:
  + The location of coal substation (the dump area of the dredged material) will be enclosed by embankments and breakwater on the West. Since the dredged area near the disposal area, dredged material will be sprayed directly onto dredgers bunker to the coal substation. Sand used for leveling below sea level elevation will automatically compacted, high above sea level, sand will be compacted in layers until reaching detailed elevation.
  + The west breakwater have design elevation of +8,5m and the width of +7,3m, the embankment have the design elevation of +5,5m and the width of +7,3m. The breakwater and embankment structure are the stone rock, the giotextile and back-filter layer. The water will be released via the back-filter layer, geotextile layer, and the Stone layer in order to prevent the dredged material from releasing to the environment. In addition, these layers will help to keep the suspended solid. Therefore, the drainage work from this area is not affecting the environment. Owing to the difference of the embankment elevation and water surface approximately 5.5, there is no circumstance of overflowing onto the embankment or the breakwater, affecting to the

surrounding marine environmental quality. The section of coal substation is shown in the Figure 4.14. The location of coal substation is presented in the figure 1.11, Chapter 1.

Sand spraying method: The method used to spray large quantities of sand. This method does not need material pipeline and path on the ground. Spraying ships will be equipped with sand spraying tube having vertical angle of about 30°. With a 30° spraying angle, sand is expected in a flat orbit in the region and limited sand to flow back into the boat. Currently, sand dredgers are designed with high exit velocity in order to spray sand more than 150 meters distance. The directly sand spraying ships are shown in Figure 4.13.

Figure 4.12. The shield during the dredging process

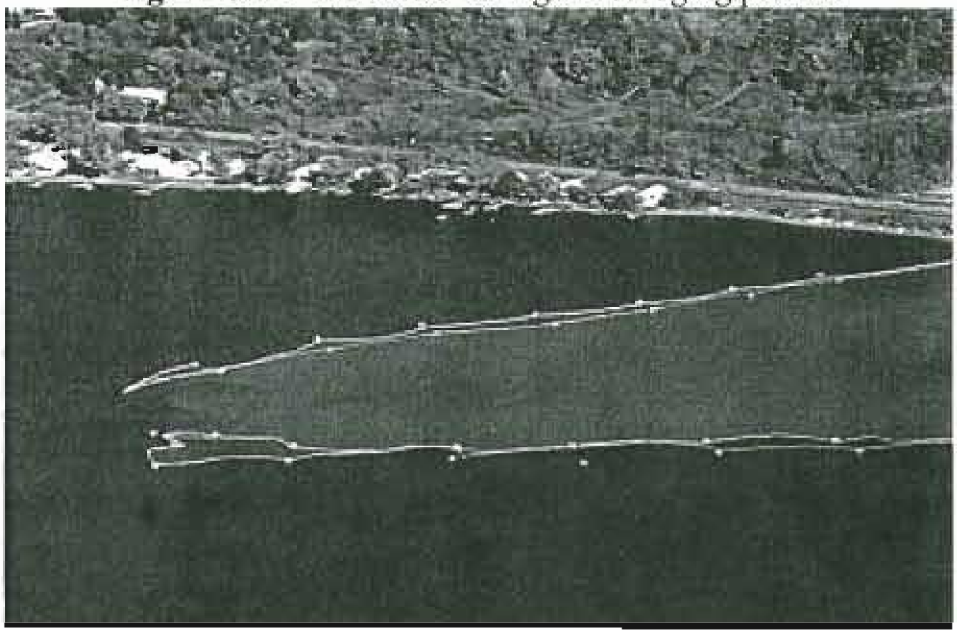
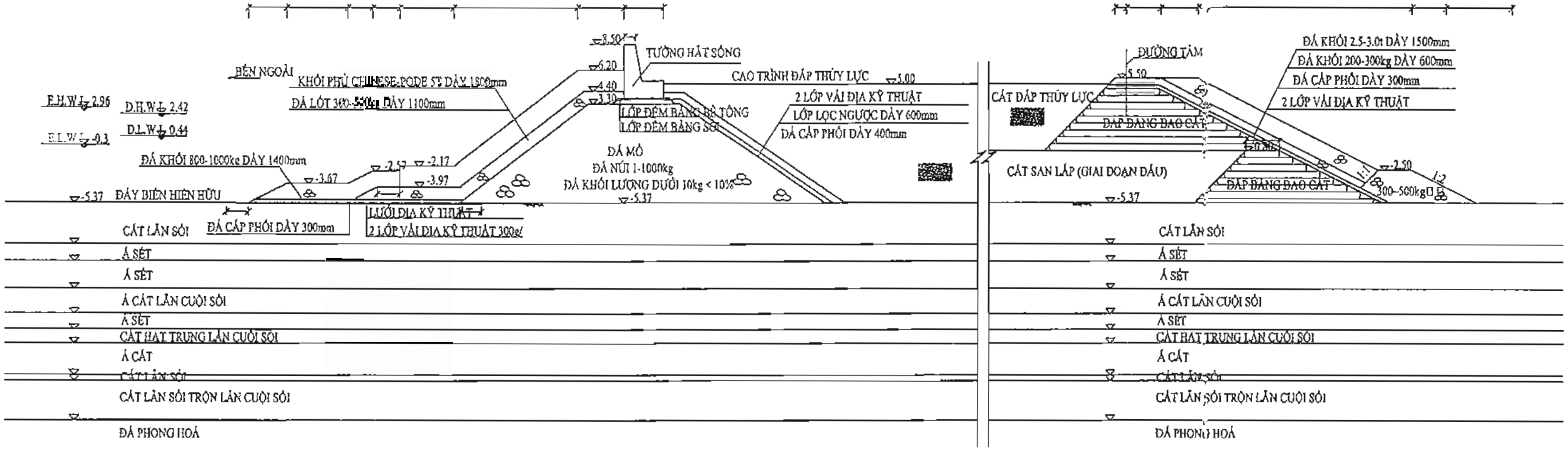
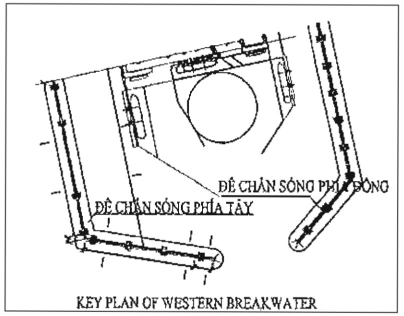


Figure 4.13. Typical sand spraying ships

Spraying method of sand presented above is often used for dredging works. The structure of coal substation will be constructed in accordance with design so that dredged material will not leak out. Therefore, the construction has high feasible and effective in controling environmental impacts to the project.

FIGURE 4.14 CROSS SECTION OF DREDGED MATERIALS DUMPING IN COAL TRANSSHIPMENT AREA





4.4.1.10. *Mitigation measures for impacts due to marine activities*

1. Reduction of risk of collision of fuel-transporting vessels

In order to limit the occurrence of collision and shipwreck, the port authority will take measures as follows:

- Support equipments include floating aids for navigation channel, roadsteads, and marine lanterns installing stably on the breakwaters and jetty berth. Marine support system will meet the IALA regulation in floating aid system, group A and concerning other related IALA regulations.
- Training navigators for navigating ships going in and out of ports.
- Regularly checking the compliance with Vietnamese and international marine safety regulations.
- Regularly checking safety and environmental treatment systems on fuel-transporting vessels.
- Not allowing the use of ships that fail to meet standards on safety and environmental protection in transportation of fuel.
- Establishing a safety and environment committee directly administered by the director of the port authority to perform specific functions of inspection and checkup of safety of ships, and response to incidents of environmental pollution.
- Periodically dredging and maintaining passages and roadsteads to secure the depth and width to facilitate ships.
- Announce schedule and landing time of coal and oil vessels to local fishermen to minimize collision.

The aforementioned measures are feasible and when they are fully and seriously taken, it is hard for any collision and aground run to occur in the region.

2. Control of waste matters from ships

The waste matters from fuel-transporting vessels may be liquids or solids. In order to control waste matters of various kinds, all ships going in the water of Vietnam shall comply with Vietnamese regulations on protection of the sea as set forth in the Marine Law (2000) and MARPOL 73/78 (Annexes I and II) of the International Marine Organization (IMO), to which Vietnam is a member state and Decree 21/2012/ND-CP dated 21/3/2012 Decree 21/2012/ND-CP on managing seaports and shipping flows.

- Vessels entering and leaving the area must ensure that the quality of gas emissions meets relevant provisions in Annex VI of MARPOL when being discharged into the environment. To meet these requirements, vessel owners will have to install filtration equipment on vessels.

- Waste burning on vessels is prohibited when operating on the route.
- Vessel owners are encouraged to use fuels with low sulfur level.
- Currently, there is no radical measure to handle waste from engine but there are only some mitigation measures being applied such as control of the combustion of engines, using good engine (according to standard of fabrication), installing catalytic sheets for de-toxication of exotic gas in front of the gas emission door (to promote the thorough combustion: CO, VOCs into CO2; reducing NOx into N2), using more friendly fuels to the environment (Biofuels, fuels with low sulfur content).
- When vessels and barges come to the port, buoys will be used to prevent oil spilling out and periodically pick up this oil spill.
- Do not discharge oily waste and food ends and odds to the sea.
- Installing collectors for waste matters such as tanks for waste oils, drips and drops of oils, dust bins and containers for solid waste so as to temporarily storing waste matters as when the ship is at sea.
- Wastewater from cleaning process of boats and barges carrying fuels shall not be discharged in the port area to reduce water pollution in the area.
- Vessel owners will be responsible for garbage dumping, dirty water discharge according to regulations and instructions of the Port Authority (Decree No. 21/2012/ND-CP). The owners will hire companies providing vessel sanitation services at the port to collect, classify and handle solid waste and hazardous waste for vessels when vessels arrive at the port and pay fees according to current regulations.
- Arranging services for collection and treatment of waste matters for ships anchoring at the ports
- The port authority regularly checking up the collection and treatment as well as environmental protection equipment in all anchoring ships.

The above mitigation measures once being applied strictly and seriously will minimize the generation of waste from the vessels and boats.

4.4.1.11. Mitigation measures for coastal erosion

When the port facilities come into operation, activities of boats will increase the erosion in the port and surrounding coast. The port authority will take several managerial and technical measures as follows:

Building a system of embankments and breakwaters at the zones which are exposed to erosion.

- With natural conditions such as wave, flow, sand and soil, etc. taken into account, breakwaters in the east and the west are proposed to protect underwater zones and facilities inside the port. The eastern breakwater will start in the east of the entrance of the power plant so as to prevent the waves from the northeast and east as well as the hot water flow issuing from the plant. Its total length is 1290m with a head of 100m long and top elevation of +6.5m; its body length is 1190m and top elevation of 5.5m. The breakwater from the eastern end of the plant is to prevent waves from the west and southwest. Its total length is 1586m with a head of 100m and top elevation of 6.5, its body length is 1486m and top elevation of 5.8m.

Coastal sedimentation and erosion along the coast of Vinh Tan commune will be periodically monitored and in case of abnormal phenomenon, countermeasures will be taken in due time (dredging or embankment).

The above measure has high feasible, and effective in controlling and preventing the coastal sedimentation and erosion

4.5. PREVENTION AND RESPONSE TO ENVIRONMENT INCIDENTS

4.5.1. Construction phase

4.5.1.1. Mitigation measures for landslide

A sea encroaching embankment needs to be built against landslides in the project area before implementing land leveling. Embankment for Vinh Tan 4 TPP will be used border embankment with total length is about 1096m. Structural of embankment will be used shelving type, the outside shelving (sea side) will be protected by Tetrapod. The structure of the embankment is as follows:

- The top elevation of the embankment is the top elevation of the breakwater approximately +5m (Hon Dau Elevation System).
- Ground elevation inside the plant is about +3.50 m (Hon Dau Elevation System).
- The crest width is arranged by reinforced concrete with the width of 6m and the thickness of 0,5m.
- Reinforced concrete breakwater built with the stone of 1x2 M300, and 2.5m of height.
- Seaward slope m = 2, the inner slope of m = 1.25.
- At the seaside, embankment is covered by Tetrapod (2 layers). Embankment body using freestone with the weight of G = 50-150kg, and inside is freestone G = 10-100kg. Top layer is bedding course by freestone with D = 50cm and thickness is 100cm.
- At the landside, embankment is covered by break stone (2x4, 4x6 in dimension), and geotextile fabric layer.
- Embankment is covered by Tetrapod 9.7Tons (2 layers).
- The slode of a roofing depends on the embankment structure, the outside covering layer structure, and the stableness of the roofing: selected the slope m=2 on the seaward and m=1.25 on the leveling direction for calculation.
- Typical section of sea encroaching embankment is provided in Figure 4.2.

This measure is applied to many projects to prevent soil erosion, which is assessed as appropriate with the contractor's ability and highly effective in control and prevention from landslides during construction phase.

4.5.1.2. Mitigation measures for chemical leakage in operation phase

The project will implement mitigating measures for prevention of chemical leakage during the operation phase. These measures are presented below:

- Arranging the fuel's warehouse at the airy places and avoiding directly to contact with sunlight, ...
- Checking regularly safety of the fuel tanks in order to repair, replace and remedy the leakage of fuel promptly.
- In the storage of chemicals must be equipped with safety facilities and equipment in conformity with the dangerous nature of chemicals and comply with regulations on chemical safety by Decree No. 68/2005/ND – CP dated 20/5/2005.
- Using packaging, tank in accordance to design of provider; checking regularly the quality of packaging, tanks in the warehouse.
- Maintaining the integrity of the tanks;
- Designing warehouse reasonably to avoid the harmful effects when leakage of fuels. Creating a trench around the warehouse in order to avoid spilling fuel into surrounding area in case of leaking of fuels.
- The heat, sparks and flames source such as welding, smoking, collision/friction works generated strong sparks and vehicles must be isolated about 10m from the chemical warehouse.
- Equipping facilities for safety including helmet, clothing, shoes, masks, gloves.

4.5.1.3. Mitigation measures for water way traffic

Operation of ships must conform to Decree 21/2012/ND-CP on managing seaports and shipping flows.

The transportation of a large amount of material by waterway will increase the traffic density in coastal area; it can bring to accidents as ship crash, therefore to reduce these accidents, PMU need to implement measures as follows:

- Arranging buoy near passages of port.
- Limiting the weight of material which not exceeds the acceptable capacity of ship or barges.
- Ship, barges operator shall operate their ship, barges run in proper passage, usually monitor and detect barrages to change the passage suitably. When operating at night, it should have lighting system to detect and avoid the barrages and equipped alarm signal for other ships can recognize as well.
- When berthing ship, ferry at berth, it shall be equipped signal to avoid crashing with other ship running in this area at night.

– Equipping all life saving equipments to act immediately in emergency cases.

The measure has been widely applied in many projects to prevent the waterway accidents. It has high feasible, technological and effective in controlling, obviating the waterway accidents during the sea encroached leveling and construction.

4.5.1.4. Prevention of fire and explosion incidents

- In the process of construction plant and auxiliary systems, in areas, where fire hazards are highly possible will be equipped with smoke alarms (signal lights, fire alarms, ...) and the handheld firefighting equipment according to the required norms.
- Installing fire ban signs in areas where having high fire ability, substation ... Workers are not allowed to smoke, do not bring lighters, fire appliances to the flammable region .
- Plan area contains fuel, flammable chemicals, protection, shielding, watering in hot weather conditions;
- Regular checks the reliability of safety equipment include fire, detection and taking measures for timely replacement.
- Perform electrical safety measures, ensure no fire caused by short circuit...
- To propose labor regulations, specific instructions on operation and safety when working with machinery. To check closely and having measures for individual violations.
- There are plans to prepare vehicles, materials, and fire to rescue incident occurred when fire.
- Firefighting equipment such as fire fighting foam bottle, CO2 bottle, sand.
- Organization, training, testing and inspection of fire prevention in warehouses, sheds of the construction unit.
- Coordinate with local governments and regional authorities in the area of construction as needed to solve the problems that occur at the site or surrounding area.

Fire protection plan shall be made in a separate report and approved by the fire prevention and fighting police before implementing the construction phase and operation of the plant. Therefore, these measures are feasible . However, to obtain high efficiency, measures will combine to raise the awareness of workers and fire protection training for workers.

4.5.1.5. Measures for epidemic prevention

Besides construction of worker's camps and sanitation works to control infectious diseases, contractors will conduct a training program on epidemic prevention which provides workers safety guidelines on how to implement disease prevention and sanitation principles in daily life.

Medical center should be arranged in construction site for health care and first aid for construction workers suffering from health problems.

4.5.1.6. Prevention for labor accidents during construction phase

In order to limit incidents occurring in construction phase, besides prevention measures for fire and explosion aforementioned in 4.5.1.4, the following measures will be applied:

- Establish HSE team at site.
- Construction machines and equipment must be attached with history record and checked specifications regularly.
- To conform strictly safety regulations on installation and operation of electrical devices. Installation workers must be trained safety regulations on transportation and installation of electrical devices.
- Transportation and installation of electrical devices will use specialized devices to fasten; not use steel wire and chain cable to fasten insulated components and tangential points.
- Reliability and stability of scaffolding system must be checked regularly in implementation of framework, reinforcing and packing of concrete in form. Stair and railing should be installed for safety issues. Workers must use safety belt when working at high elevation.
- Workers rated stainless steel glasses. When installing steel reinforcement phase, workers have to stand on the floor, not stood on the reinforcement phase operation.
- Workers must use eye glasses when filing up steel. When reinforcing steel into framework, workers have to stand on the platform not on the framework.
- The construction site must be arranged appropriately with paying attention to safety of framework. When the upper floor is being constructed, not allow going on lower floor to avoid materials falling down.
- When constructing oil pipeline and related works, it is necessary to pay attention to fire fighting issues.
- Safety regulations at site including travelling to and from construction site, protection clothes, usage of equipment and traffic safety must be established.
- Direct construction workers must be trained on professional skills.
- Keep close watch on labor accidents; promptly identify causes and measures in time to avoid similar accidents occurring.
- Install warning signs for forbidding entrance at dangerous areas.
- Wire system, electric contacts and switches which can cause sparks must be arranged so safe.

- Portable fire extinguishers will be placed at appropriate locations for convenient usage, which will also be checked regularly to ensure ready.
- Installing equipments at height will conform to safety regulations on safety working clothing and safety belt.
- Establish medical staff and equip medicine cabinet at site to provide first aid for serious accidents.

Above measures are simple but necessary to improve knowledge on labor safety and health care for workers to minimize labor accidents during construction phase.

The most difficulty of applying these measures is the self-awareness and execution of the workers. However, these measures are obligatory and would bring high efficient if they are strictly conformed.

4.5.2. Operation stage

4.5.2.1. Mitigation measures for incidents of environment treatment system

1. Mitigation measure for incidents of flue gas treatment system

- The investors will install an automatic monitoring system at stacks. The following parameters will be monitored automatically at the stacks: dust, NO_x, SO_x, CO. The results of this measure will be transferred to the central control room and displayed on the control screen. When the concentration of one of four pollutants exceeds the limitation in the standards, the plant will stop working to check and repair equipment.
- In addition, to reduce negative impacts causing by broken treatment equipment, the backup design is necessary. The dust filter and desulphurization devices are installed into 2 or 4 modules in order to separately repair damaged components (if any) and avoid the risk of polluted gas leakage.
- This method has been wisely applied for many projects in order to prevent the accidents of the air treatment system. The method has high feasible, advanced technology, suitable with the capacity of the plant, and strongly effective in controlling and preventing the incidents in the plant.

2. Mitigation measures for incidents of wastewater treatment system

Two wastewater treatment chains with configuration of 2x100% will be designed for Vinh Tan 4 TPP. When some main equipment in wastewater treatment systems such as sedimentation tank, filter tank, pumps, etc. are getting troubles, backup equipment will be put into operation to ensure environmental standards.

However, in case of incidents, pollutants concentration in wastewater may exceed allowable value in standards; the project owner will apply the following mitigation measures:

- Regularly inspect machines, valves, pipeline system to detect any problems (if any) in time replace for replacement.
- Machines and equipment for wastewater treatment system, especially pumps should be designed with backup coefficient.

- Gate valves will be arranged at the inlet and outlet of all pipelines.
- Designed capacity of each wastewater treatment system is 10 - 20% larger than the actual capacity.

According to the design of the wastewater treatment system of the Vinh Tan power plant 4, it will be designed to operate 2 x100%. When one system is broken down, the other will be operated to treat wastewater in the plant. In addition, chemical contaminated wastewater treatment systems are equipped with a tank with the volume of 7500m^3 to store irregular wastewater. However, the irregular wastewater does not appear often (approximately 3-5 years/times) so if in case there is a problem, the volume of the tank still contains enough entire wastewater flow system regularly. Therefore, wastewater treatment plant does not need to build more reservoirs wastewater.

3. Safety measures for boilers

During operation, fire incidents may occur in boiler area. Fire alarm and fire fighting systems will be equipped around boiler area such as firefighting water supply system, CO_2 extinguishers, foam system, sprinkler system, and portable CO_2 extinguishers to promptly respond to fire incidents. Detailed fire fighting system for the power plant was provided in section 4.5.2.4. Therefore, safety of boilers will be guaranteed in the operation process.

4.5.2.2. Mitigation measures for chemical leakage in operation phase

To reduce impacts of chemicals leakage on environment and people's health, the following measures will be implemented:

1. Chemicals storage

- Chemicals will be stored in separately specified areas where is designed to ensure dry places, well ventilated and avoid directly sunlight and heat sources.
- To regulate separately areas for dangerous chemicals such as solid acid, alkaline, inflammables, etc.
- Strong oxidants (as H_2SO_4) must not be stored near flammable materials (fuel, $N_2H_4.H_2O$, etc.).
- Stored chemicals must be labeled clearly with information such as chemical name, concentration, date of entry (or preparation day). The toxic chemicals will be specially labeled and marked as danger.
- Chemicals missing labels are not allowed for usage unless they spend analytical checking methods and achieve validation records.
- Tools, chemicals and related equipments must be arranged in neat, tidy, serial. The workplace is always kept clean, dry. When chemicals are spilled, immediately to clean and dry.
- When the acid falls to the ground, not to uses water to flush immediately but covered with lime and then wipes, then flush the water and wipe dry.

- Dangerous chemical containers/equipments are hazardous solid wastes do not washed and used for other purposes.
- In the storage of chemicals must be equipped with protection facilities and equipment in accordance with the dangerous nature of chemicals and comply with regulations on chemical safety by Decree No. 68/2005/ND – CP, dated 20/5/2005.
- The heat, sparks and flames source such as welding, smoking, collision/friction works generated strong sparks and vehicles must be isolated about 10m from the chemical warehouse.
- Checking regularly safety of the fuel tanks in order to promptly repair, replace and overcome the fuel leakage.

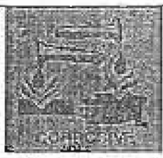
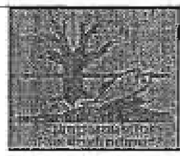
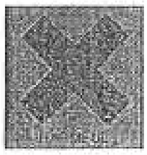
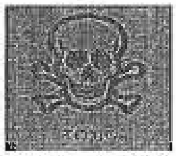
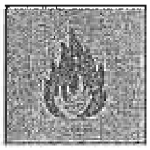
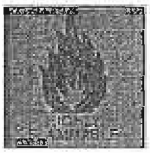
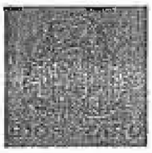
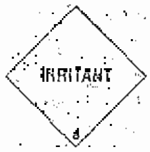
2. *Chemical transportation*

- Not to allow anything obstructing the transportation way.
- Chemical tanks more than 10 kg must be transported by carriers.
- Acid and alkali with amount of more than 5kg must be stored in closed tanks and transported by carriers.

3. *Chemical usage*

- When using and touching with chemicals must use appropriate protective equipment, and workplace should be taken accordingly ventilation measures.
- The toxic and volatile substances, the reactions forming substances affected human health must take into toxic extraction hood.
- When repairing facilities contained alkali, acid must be discharged emptying them to the outside by cleaning by water lime before repairing.
- When washing toxic bottle, facilities must be filled with water to two to three times to escape remaining vapor in facilities. When filled with water, to turn away to avoid inhaling vapors.
- Do not to eat while working with chemicals, especially toxic chemicals; not to leave food in work area. Only eat or drink when washing your hands thoroughly with soap several times and going out of work.
- Strictly forbidden to smoke or use heat sources in the workplace. With the need for work, you must use the kitchen; the kitchen must be is insulated and isolated.
- Regulating warning labels, identifying signs the chemicals used in the factory as shown below figure:

Table 4.3. REGULATIONS ON WASRNING LABELS/IDENTIFYING SIGNS	
Corrosive	Toxic to environment

	
Harmful 	Toxic 
Flammable 	Highly flammable 
Biohazard 	Irritant 

Source: Safety - health - environment Manual, the Petro Electricity Corporation of Vietnam, 2010

These measures are applied to many projects to ensure safety use of chemicals during operation of power plants, these measures are suitable with capabilities of the workers and have highly effective in the controllable and prevention of leakage of fuels

4. *Emergency response action and cleaning after incident*

When the incident happened , all the action was done based on the first principle is to protect human lives and communities , followed by environmental protection , and the asset protection.

Response activities for incident consist of two phases:

- Rescue stage
- Cleaning after incident

a) Emergency response action

Each chemical has its special character , so when problems occur we need to accurately judge the cause to make the appropriate rescue measures . The person responsible for troubleshooting in the field need to quickly make decisions to prevent incidents , scattered incidents , ensuring the safety of people, property and the environment , reducing the risk caused by the incident , and considering whether need to support from the outside or not .

- To prevent the spread and consequences of incidents of damage , put the victim out of the incident , preliminary diagnosis , emergency , eliminating exposure to hazardous substances and take victim to hospital
- To limit the damage caused by the incident, preliminary learn the cause of the incident to fix in place and stops right direction to solve the problem.

- To eliminate all serious risks in order to start cleaning

b) Cleaning after incident

- When a hazardous substance is broken or leaking use protective coverings covered with suitable material indicated. Following is no need to calculate whether a small amount of leakage should not rush to flush water used directly and do not let it hit the water flowing into the sewer drains.
- Spilled liquid with sand and sawdust should suck the dust. Dust or sawdust should be fired or oxidized if they are in type 3 and 5.
- The cracks should be cleaned solid with the industrial vacuum cleaner.
- For toxic gases released by burning or leaks, it should be coped with by use of ventilation and respiratory protection devices for people.
- Managing waste: all waste, including packaging, should be arranged in containers of hazardous waste and that is not affected to the surrounding environment.
- All containers should not be dirty and reused, to cleanse the necessary places and do blow before leaving.

These measures are applied to many projects to ensure the safety of chemicals used in the operation of power plants, these measures are consistent with the ability of workers to perform, and is highly effective in controlling, preventing leakage of materials .

4.5.2.3. Flood prevention measures

To prevent floods in the factory sector, the following measures will be applied:

- To meet flood conditions, selected water level is calculated with the highest water level frequency calculations for the 100 year cycle (P = 1%) and leveled elevation of factory area is +3.5m, distributing yard area is 4.5 m.
- To prevent flooding as well as coastal erosion control, the project will build embankment with the length of around 1051m with a crest elevation (height of wave splashing wall) is +5 m. Details of the embankment are presented in the section 4.5.1.1.
- Regular inspection and maintenance of protective embankment to prevent erosion.

To prevent ash spill out in case of heavy rain days, slag dumps will be designed as follows:

- To build the embankment with the length of 1590m, a crest elevation of 5m, internal and external slope is 1:1.5. To prevent ash flows out of the embankment, there will be a filter layer made by stone rock with the thickness of 300mm and geotextile layer are arranged on the surface of the rock dike. Structure of the ash yard No. 1 in the Ho Dua mountain is presented in section 4.4.1.8.
- Drainage channel system is designed to collect slag dumps and taken water from ash yard to the sedimentation basin. The water after sedimentation will be used to water the ash yard.

These measures are applied to many projects for flood control, has high technology, and effective in controlling, preventing flood protection.

4.5.2.4. *Prevention for collisions and shipwreck*

In order to ensure safety operation of Vinh Tan 4 port and to avoid lamentable incidents, all ships and barges transporting coal in and out of the port must strictly conform to marine transportation law and regulations as follows:

- To limit the weight of material which do not exceed the acceptable capacity of ship or barges.
- The operators of the vessel, barge must always operate properly defined ferry lanes, regularly observe and appropriately move ship channel when detection of barriers.
- Vessels and barges must make a U-turn in turning basin with support of tug boats if necessary.
- Regularly check and maintain lighting system on boats, provide backup equipment in case of incidents.
- Pay attention to announcement of marine management agency to update any changes in routes.
- Keep a close watch on meteorological and hydrological forecast to arrange boat schedule.
- Arrange directional distribution buoys and alarm signals at turning basin and barges to avoid collision with small ships/boats.

The above method can be totally applied and has high feasible, effective in reducing and mitigating the risk as well as accident during the operation stage of the plant. However, this method impartially depends on the awareness of the ship owners.

4.5.2.5. *Prevention of and response to fire and explosion*

1. Oil storage tanks

Oil storage tanks are manufactured according to safety standards by highly specialized agencies and are tested by functional authorities before being put into use.
Appropriate maintenance mode will be applied during using time in association with periodical sludge discharge and cleaning tanks to remove residue at the bottom of tanks.

In addition, oil storage tanks will be periodically checked to detect problems and apply appropriate measures promptly.

A dike should be built around oil storage area with volume of more than 1.1 times the total volume of oil storage tanks.

2. Vinh Tan 4 TPP

A complete and integrated fire protection system will be provided for the plants for effective detection, early warning, alarm, signaling, control and extinguishment of fires. It will consist of fire pumps, underground ring main for fire water distribution, automatic water deluge and sprinkler system, CO_2 suppression system, foam suppression system, yard hydrants and hose cabinets, fire alarm and detection system with function of automatic actuation, and mobile and portable fire extinguishers with dry powder, CO_2 and foam.

A suitable fire alarm panel will be located in the central control room, and the system will be connected to the UPS system to prevent sudden power cut.

The plant will be designed to provide a safe operating environment for equipment and personnel. This will be achieved by arranging equipment with sufficient separation and segregation to minimize the risks from fire and explosion, and by selection of suitable equipment and materials. Particular attention will be paid to boiler, coal transportation and storage, fuel oil and lubricating oil storage, hydrogen making system, gas heater, etc.

A manual and automatic fire detection and alarm system will be provided, with detection devices selected to suit particular risks and with control system designed to provide operating and fire brigade staff with sufficient information to identify and respond correctly to any fire detected.

Automatic and manual extinguishing systems will be provided for major items of plant. A foam system will be provided to protect fuel oil storage and handling area.

Portable fire extinguishers will be provided throughout the station particularly in the administrative buildings, workshops and water treatment plant areas beside fixed fire fighting system.

Hose reels and internal hydrants will be provided within building where appropriate. Foam making equipment and concentrate will be provided where necessary at hydrants near oil risks.

Fire hydrants will be located throughout the power plant area and the outdoor hydrants will be easily accessible by fire fighting vehicles.

The fire fighting systems will be designed and constructed in accordance with international standards and applicable Vietnamese regulations.

The fire fighting system of the plant is described as follows:

a) Water supply system

Water supply for the fire protection system will be provided from the raw water storage tank to satisfy fire protection demands. The fire protection water storage capacity will be to supply simultaneously the largest fixed water extinguishment system at 100% fire pump capacity for duration of 2 hours.

b) Fire fighting pumps

One motor driven and one engine driven fire fighting pump will be provided. The ratings of both the motor driven fire fighting pump and the diesel engine driven fire fighting pump will be fixed at detailed design stage after assessment of fire water demand for the largest fire risks in the plant. The pumps start will be interlocked with the pressure of fire water in ring main. The motor driven fire fighting pump will start automatically upon loss of system pressure. If the system pressure cannot be maintained with the motor driven running, then the diesel engine driven fire fighting pump will start. In the event the motor driven fire pump does not start, diesel engine driven fire fighting pump will start. The fire fighting pumps will be stopped manually at the pumps.

The water pressure in the distribution system will be maintained by a low capacity electric motor driven pressure maintenance pump (jockey pump), started automatically on drop in pressure and stopped on restoration of pressure after a suitable time delay.

Power for the electric motor driven pump will be supplied from the normal plant power supply. Fuel supply for the diesel engine driven fire pump will be located in a tank adjacent to the pump and suitably protected against fire or mechanical damage. The diesel fuel oil tank and piping will be arranged so that the diesel oil does not seriously expose the equipment and adjacent areas to risks.

c) Underground fire fighting pipeline system

The underground fire fighting water distribution system will be provided and installed in accordance with the requirement of Vietnamese Fire Agency or international standards.

d) Fire fighting hydrants and hoses system

A fire fighting hydrants and hoses system will be installed throughout the plant structures. Sufficient number of hydrants and hoses will be provided to insure that all portions of the buildings can be reached by effective hose streams.

e) Fire detection and alarm system

Fire detection, alarm, actuation and signaling system will be designed in accordance with international standard. A main fire control panel located in the control room will be provided to monitor, alarm, detect and actuate all detection circuits, manual alarm circuits, and fire pump readiness and suppression systems.

All detection, alarm, actuation and signaling circuits will be electrically supervised for continuity and all discontinuities will be indicated by a trouble indicator and alarm. Trouble alarm horn sound will be distinctive from the alarm bell.

f) Firefighting equipment

Firefighting equipment will be provided throughout the plant and will be labeled properly for identification, inspection and refilling. Extinguishers will be provided in readily accessible locations in conformance with regulations of Fire Agency (an Agency of Ministry of Public Security).

3. 100,000DWT coal port of Vinh Tan 4 TPP

Firefighting is indispensable for operation of a port, which must comply with Vietnamese regulations.

All loading and unloading facilities must comply with fire and labor safety regulations. Insulating cable will be equipped for ships to avoid creating sparks. The following firefighting system will be provided for Vinh Tan 4 port: Water firefighting system: A separate firefighting water supply system with high pressure will be equipped for the port; a pipeline network will be installed in port area to connect to the main pipeline system of Vinh Tan 4 TPP.

- Fire detection and fire alarm systems;
- Fire fighting water main ring
- Deluge system
- Fixed foam system
- Automatic CO_2 fire fighting system
- Portable fire extinguishers
- Fire truck, protective clothing and helmets and others.

To ensure fire and explosion safety, it is necessary to equip fire fighting facilities and equipment at all important and sensitive areas, including:

- Transfer towers: fire alarm system, sprinkler system and manual fire hydrant.
- Electric system: fire alarm system and sprinkler system.

4.5.2.6. *Mitigate measures of incidents in operation phase which relate to onshore coral reef.*

- The Vinh Tan 4 TPP will perform a good operation of the plant in associated with implementing the treatment solutions of wastewater, exhaust gas, solid waste, hazardous waste, and water way traffic safety in order to mitigate accidents.
- However, in case of occurring accidents, it is predicted that the accidents can be affected the Hon Cau marine protection area. Therefore, the project needs to apply some mitigation measures as follows:

+ Organizations implementing corrective measures, prevention of incidents. Measures to prevent oil spills, chemicals, fire and explosions have been presented in detail in Section 4.5.2.7, 4.5.2.5, 4.5.2.2 above.
+ To inform urgently for local government and relevant agencies.
+ To use suitable and appropriate method to limit the oil spills in order to mitigate the pollution to overspreading surrounding environment.
+ In case of collision of tankers, quickly applying all measures possible to response the oil spill and moving to safety place.
+ To implementing the oil spill treatment procedures by using Enretech microorganism and chemical treatment by sand and sawdust…
+ In addition, the project will have to pay compensation in accordance with the law when impacts on the ecosystems of coastal coral reefs caused by the incident (Article 75 of the Law of Biodiversity, National Assembly XII, the Circular No. 20/2008/QH12 on 13/11/2008).

4.5.2.7. *Prevention and response to oil spills*

In case of collision of fuel-transporting vessels, the most concern is that the fuel oil on big vessels will spill to the sea. Whenever having the severe accidents, it is estimated that hundreds of cubic meter of oil will spill, which can cause severe pollution. Below are some measures for prevention of and timely response to such incidents.

Vinh Tan 4 TPP project (including Vinh Tan 4 port) and stage 1 of Vinh Tan deep sea port project – Vinh Tan 2 port are invested by EVN and directly executed by Vinh Tan thermal power plant project management board. Therefore, response plan to oil spills for Vinh Tan TPP will be organized and undertaken together with stage 1 of Vinh Tan deep sea port project – Vinh Tan 2 port

Response plan to oil spills of stage 1 of Vinh Tan deep sea port project – Vinh Tan 2 port was provided in details in EIA report of this project which was approved by MONRE according to Document no. 1448/QĐ-BTNMT dated 25/07/2011. Some main contents of response plan to oil spills are summarized as follows:

- All ships at rivers and sea of Vietnam must observe Regulations on marine safety equipment and prevention of environmental protection that are provided on Vietnamese seagoing ships working in domestic routes issued by the Ministry of Transport on 21 November 2005 and Regulations on systems for prevention of sea pollution by ships (TCVN 6276:2003), and Regulations on safety equipment of seagoing ships (TCVN 6278:2003).
- Establishing a safety and environment committee under the port authority in order to cooperate with specializing state bodies and local people's committees in response to oil spills.
- Cooperating with Centers for Response to Oil Spills (under the National Salvage Committee) of Central Vietnam (located in Da Nang) and South Vietnam (located in Vung Tau) in preparing the Action Plan for Response to Oil Spills, purchasing equipment, training staff and in deployment of activities for response when an oil spill occurs inside the port and its surroundings.
- The detailed response plan to oil spills will be submitted to functional agency (People's Committee of Binh Thuan province) for approval according to current regulations.
- The main contents of response plan to oil spills for the stage 1 of Vinh Tan deep sea port project – Vinh Tan 2 port are summarized as follows:

1. Response regions

For convenience of assessment, due to the difference of environmental conditions as well as response equipment needed for oil spill locations, response regions are classified as follows:

Ashore region: this needs response equipment for shoal wind-shielded waters with weather and sea conditions better than offshore regions.

Regions of big flows: this needs special equipment for waters of big flows and limited operation range (meaning that oil collection systems cannot drift with the flow to reach the relative speed difference of 0.5 m/s between stopping buoys and water.

Onshore regions: this needs equipment for cleaning the coast and for storing temporarily.

2. *Response equipment*

For effective response, Vinh Tan 2 port will provide equipment for response to oil spills such as stopping buoys, oil collecting system to prevent oil spreading to other regions. Vinh Tan 4 will share this equipment with Vinh Tan 2 port when carrying out response plan.

In addition, Vinh Tan 4 port will coordinate with the Centers for oil spill rescue in the Central and the South to handle oil spills. These centers will equip the following accessories in support to response tasks.

- Specializing response ships
- Protection cloths for rescue staffs.

3. *Organization and procedures of response to oil spills*

Since the fuel to be transported is coal, oil spills mean fuel oil of ships and therefore any oil spill is only of level 1 ($\leq$ 200 ton). Therefore, the port authority of Vinh Tan 2 and/or Vinh Tan 4 port needs not to organize an organ specializing in response to oil spills yet it should cooperate with centers for response to oil spills of Central Vietnam and the South in dealing with incidents of this kind.

The Port authority is responsible for response to oil spills that occur due to operation of the port with the participation of forces such as: centers for response to oil spills of Central Vietnam and the South, the police and army, local authorities, state bodies specializing in environment, the sectors of fishery, agriculture and justice, etc.

4. *Handling and rescuing oil spills*

In a case of oil spills, Port Management Board not only deploys rescuing works rapidly, but also informs to local authority and neighboring residential areas, households, enterprises impacted by oil spill such as: aquaculture, salt, travel agencies, etc. in the area to alert and assist households and enterprises to protect shrimp ponds, salt fields, beach, etc. Otherwise, all enterprises will support the Port Management Board in rescuing works.

However, if serious oil spills occur, the Port Management Board will have to implement the following:

- Treatment of oil pollution on sand and land ground (using Enretech – OTI technology
- Strewing Enretech microbial product to absorb and destroy oil on sand or land surf.
- Ploughing, raking or digging up to mix microbial products with sand, soil in oil contaminated area.

- When these products contact to oil, the biological decomposition process of the oil (being isolated) is disintegrated biologically by micro-organisms, 70-80% of absorbed oil volume is decomposed after 2 months. In suitable condition, 80% of hydrocarbon is decomposed after 30days.
- Hydrocarbon decomposition time is much faster than the time that Enretech is decomposed itself. Therefore, they don't endanger the surrounding environment.
- For the processing of oil contaminated soil layer at 0.5 meter in depth, mixing Enretech-1 to soils by hammers. If oil contaminated soil layer is deeper, it is necessary to excavate the whole contaminated layer and mix with Enretech-1.

Mitigation measures mentioned above are high feasible, effective to mitigate and prevent the oil spill during the operation stage.

Chapter 5

ENVIRONMENTAL MANAGEMENT AND MONITORING PROGRAM

5.1. OVERVIEW

In order to mitigate negative impacts on human health and living environment as well as to evaluate efficiency of mitigation measures for environmental impacts, an environmental monitoring and management program will be established.

5.2. ENVIRONMENTAL MANAGEMENT PROGRAM

To effectively implement mitigation measures for negative impacts of the power plant project, an environmental management program is designed and executed during pre-construction phase, construction phase and operation phase.

5.2.1. Legal background

The legal background for implement of the environmental management and monitoring program is presented in section 0.2.1 (Introduction)

5.2.2. Organization and staffs for environmental management

To implement proposals on pollution management and monitoring program, the project management board will organize and establish a Safety and Environment section for the whole project.

In order to implement proposals on pollution management and control program, the project management board (MB) will establish a Safety and Environment department for the whole project. This department will be in charge of carrying out the following functions as allocated by the MB:

- To ensure operation of the plant and to comply with standards and legal regulations of Vietnam on environmental protection;
- To cooperate and keep close relationship with local residents and related agencies (e.g. fire fighting agency, environmental protection agency, etc) in Vinh Tan commune for environment and safety issues.
- To regularly check and monitor environmental issues, safety and environmental incidents for whole plant area.
- To draw out plans on managing environment, safety and incidents for the plant.
- To conduct internal environmental monitoring and supervision.

5.2.3. Personnel organization for environmental activities

An environmental sanitation team will be set up to be responsible for the following functions:

- To implement sanitary works, collect garbage from offices, workshops and worker accommodations, then transport to the regulated place;
- To cooperate with environmental service units in the safe and clean collection and transport of waste from the plant to treatment facilities.
- To water down access route and internal roads in the plant for dust suppression purposes.
- To plant and to take care of trees, grass, and parks inside the plant.

Table 5.1 Environmental management plan for Vinh Tan 4 TPP

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
Pre-construction phase						
Clearance work	An area of 9.73ha will be withdrawed for the project, that causes impacts on livelihood of households.	Compensation and resettlement program are implemented to support households who are affected by land acquisition for the project.		Before construcstion	The project owner (Vinh Tan thermal power project management board)	People's committee of Binh Thuan province + the project owner
Transportation of construction materials and equipments (vehicles, vessels, etc). *Operation of construction equipment such as crane, lift truck, etc.*	Air pollution (dust dispersion)	Design a route far away residential area and limit traffic velocity to mitigate dust, noise and vibration. Heavy equipments are transported by waterway. Vehicles and transport equipment must meet TCVN 6438: 2001 on emission limits of exhaust gas, certified on emission quality by	Included in investment project	During construction phase	Contractor	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		Vietnam Register. Wash wheels of transport vehicles before entering the construction site. Undertake watering of the construction site and stockpiles during dry and windy conditions. Cover all trucks carrying materials during transportation (sand, clay, cement, stone, etc). Improve safe knowledge for drivers.				
	Water pollution due to washing machines and equipments.	Undertake settling of suspended solids from washing water prior to discharge.	Included in investment project	During construction phase	Contractor	The project owner
	Soil pollution due to oily waste	Oil is collected and stored in container and then treated by	Included in investment project	During construction phase	Contractor	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		functional agencies.				
	Increase in traffic density on National road 1A	Cooperate with Department of traffic and transport and Department of police of Binh Thuan province to set up traffic signals and traffic signs at dangerous points on transportation routes. Repair the damaged road sections for compensation after completion of the plant construction Prepare and implement detailed transport management plan to regulate vehicle movements.	Included in investment project	During construction phase	Contractor/ Traffic consultant	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
Workers aggregation (About 500 workers)	Surface water and groundwater pollution.	Hire mobile toilets and sign contract with local environmental service company to collect and discharge sewage.	270,000,000 VND (5 mobile toilets + 4 temporary toilets)	During the construction phase	Contractor	The project owner
	Soil pollution due to domestic solid waste	Domestic solid waste will be collected daily. The contractor will sign contract with urban environmental service company to collect and treat. Utilize waste which can be recycled or reused.	Domestic solid waste: 10,000,000 VND (500 x 20 buckets 200l) Hazardous waste 15,000,000 VND (4 oil buckets and 2 hazardous buckets)	During the construction phase	Contractor	The project owner
	Conflict between workers and local residents. Impacts on worker's health.	Employ local labour force for construction activities; build good relationship with local people. Declare temporary residence of external workers to police agency of Vinh Tan		During construction phase	Contractor	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		commune. Contact with local agencies to discuss related issues. Provide regular health check for construction workers; cooperate with Vinh Tan medical station to propagandize preventive measures for infectious diseases. Educate workers on labor safety and the need to maintain hygienic conditions at the worker camp. Set up grievance regime.				
	Social issues	Organize a team to manage consultancy and contact to local community. Set up community plan and grievance.	Included in the investment project.	Before construction phase	Contractor	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
Construction of embankment and sea encroachment	Impact on conservation area of Hon Cau MBA. Increase in turbidity. Impact on flow regime.	Build embankment around leveling area with special structure to prevent erosion. Leveling work must commerce after finishing construction of embankment.	Included in the investment project.	Before construction phase	Contractor	The project owner
Construction phase						
Construction of infrastructure (plant, port) and installation of equipment.	Air pollution (Noise, dust, vibration)	Keep strong noise sources at least 200m from resident areas or bordering construction area by soundproof walls. Well manage operation of heavy machines and transportation vehicles. Limit operating time from 6 am to 10 pm. Equip construction workers with labor safety equipment.	Using street washer: 10,000,000 VNĐ/month.	Construction phase	Contractor	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
Construction of embankment and sea encroachment	Impact on conservation area of Hon Cau MBA. Increase in turbidity. Impact on flow regime.	Build embankment around leveling area with special structure to prevent erosion. Leveling work must commerce after finishing construction of embankment.	Included in the investment project.	Before construction phase	Contractor	The project owner
Construction phase						
Construction of infrastructure (plant, port) and installation of equipment.	Air pollution (Noise, dust, vibration)	Keep strong noise sources at least 200m from resident areas or bordering construction area by soundproof walls. Well manage operation of heavy machines and transportation vehicles. Limit operating time from 6 am to 10 pm. Equip construction workers with labor safety equipment.	Using street washer: 10,000,000 VNĐ/month.	Construction phase	Contractor	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		With proper location of strong vibration sources, the residential areas near the project site will not be affected by the vibration. However, workers who work with strong vibrated machines should be equipped with protective clothes for health and safety protection. During dry days, periodic watering of transportation roads and construction site will be necessary for dust control. Cover transportation vehicles and loose material storage piles at site to prevent windblown dust. Concrete mixer station should be				

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		located 300 m from residential areas in Vinh Tan commune.				
	Impacts on soil quality	Store chemicals in roofed and concrete area. Excavated soil is compacted. Drainage system is designed to settle suspended solid before discharged into sea.	Included in the investment project.	During the construction phase	Contractor	The project owner
		Construction solid waste is collected, reused or using as wasted materials. Solid waste is classified into hazardous waste and non-hazardous waste before being reused or transported to landfill. Local urban environmental service company is hired to	20,000,000 VND/month	During the construction phase	Contractor	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		transport the remaining solid waste after utilizing process to landfill.				
		Prepare and implement soil erosion control plan, construct rainwater drainage ditch and settling pit to collect runoff water before discharging.	Included in the investment project.	During the construction phase	Contractor	The project owner
		Settle solids from washing wastewater prior to discharge.		During the construction phase	Contractor	The project owner
		Throwing waste into river, stream or coastal sea is forbidden. Oil contaminated waste and hazardous waste need to be collected and disposed in compliance with regulations. Maintenance of	Included in the investment project.	During the construction phase	Contractor	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		machines and equipment are only performed at workshops equipped with oily waste tanks. Oil contaminated waste is collected separately and stored in regulated area for reuse or treated by functional agencies.				
	Groundwater and surface water pollution	A temporary drainage system will be built to settle solids from runoff water prior to discharge. Oil tanks and chemical tanks are placed in embanked area to prevent leakage. Wastewater is collected and treated before being discharged into environment. Wash deck and barge in the coal port area is	Included in the investment project. Dustbin in vessels: 1,000,000 VND/vessel. Warning signs: 5,000,000VND	During the construction phase	Contractor	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		not allowed. Vessels are equipped with oil separators. Solid waste is collected on board. Arrange speed limit signs around the project area.				
Dredging port	Impacts due to disposal of dredging materials	Select suitable dump site for dredging materials. Apply safe construction and protect marine environment.		During construction phase	Contractor	The project owner
	Impacts on aquatic biota in dredging zone	Advanced technologies are applied to shorten dredging duration. Give priority in selection of dredging equipment which releases less sludge. Ensure not to scatter dredging materials				The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		during transportation route to dump site. Disposal of domestic solid waste, oil sludge and oily cloth to water sources is forbidden.				
High concentration of workers *(About 1500 workers in rush hour)*	Groundwater and surface water pollution	Construction contractor will arrange hired mobile toilets in worker camp area and sign contract with urban environmental service company for collection and disposal.	450,000,000 VND (10 mobile toilets + 5 (5 temporary toilets used in the pre-construction phase)	During the construction phase	Contractor	The project owner
	Soil pollution due to domestic solid waste	Domestic solid waste is collected daily and stored in dustbin. Construction contractor will sign contract with urban environmental agency to transport this waste to landfill. Maximize reuse of solid waste if possible;	Domestic solid waste: 20,000,000 VND Hazardous waste 15,000,000 VND (4 oil containers and 2 hazardous waste containers).	During the construction phase	Contractor	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
	Conflict between workers and local residents. Impacts on worker's health.	Mitigation measures are applied similarly in the pre-construction phase.	Included in investment project.	During the construction phase	Contractor	The project owner
	Social issues	Mitigation measures are applied similarly in the pre-construction phase.	Included in investment project.	Before the construction phase	Contractor	The project owner
Fire and explosion, labor accidents and traffic accidents	Impacts on worker and local residents. Soil and water pollution	Establish relationship with local authorities and community organizations to get their support in response to issues happened during construction phase. Regular organize training on labor safety for workers. Provide enough emergency tanks for	Included in investment project.	Before the construction phase	Contractor	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		containing oil and chemicals in case of leakage.				
Operation phase						
Operation phase of plant	Air emission, noise and vibration	Apply National technical regulation on emissions of thermal power plant (QCVN 22:2009/BTNMT, Kp=0.85, Kv=1) to monitor flue gases from stack. Build stack with height of 210m for flue gas dispersion. Apply low NOx burner to minimize NOx concentration in air emission to meet environmental regulations/standards. Install ESP and seaFGD system to reduce concentration of dust, SOx in air	Continuous Emissions Continuous environmental monitoring system (CEMS): 11,990,000,000 ESP: 383,442,000,000VNĐ SeaFGD system: 980,111,300,000VNĐ Stack: 152,020,000,000VNĐ	Before operation phase of plant	The division which executes Vinh Tan 4 power plant directly.	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		emissions to meet environmental regulations/standards. Install CEMS to monitor concentration, flow rate and temperature of flue gases before releasing into environment. Ensure maintenance and examination of air pollution control system in accordance with technical regulations.				
		All vehicles transporting materials should be covered to prevent dust dispersion. Limit transportation vehicles operating at night time. All means of transportation should	Included in the investment project.	Before operation phase of plant	The division which executes Vinh Tan 4 power plant directly.	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		have certificates on exhaust quality given by the Vietnamese Registration Authority. Toxic substances need to be contained and transported by specializing vehicles in accordance with government's regulation on transportation of hazardous chemicals.				
	Water pollution due to industrial and domestic wastewater	Industrial wastewater will be treated to meet QCVN 40:2011/BTNMT, category B, Kf=0.9, Kq=1 before being discharged.	Industrial wastewater treatment system: 69,880,000,000 VNĐ	Before operation phase of plant	The division which executes Vinh Tan 4 power plant directly.	The project owner
		Oil contaminated water: Runoff water from oil storage tanks is collected into oil	Oil contaminated wastewater treatment system: 3,350,000,000 VNĐ	Before operation phase of plant	The division which executes Vinh Tan 4 power plant directly.	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		separators. Oily sludge will be collected periodically, meanwhile, treated water is reused.				
		Domestic wastewater: Activated sludge technology is used to treat domestic wastewater to meet QCVN 14:2008/BTNMT,K=1, column B then reuse for acceptable purposes.	Domestic wastewater treatment system: 6,570,000,000 VNĐ	Before operation phase of plant	The division which executes Vinh Tan 4 power plant directly.	The project owner
		Coal contaminated wastewater: Coal contaminated wastewater generated at the plant and port area will be collected and treated to meet QCVN 40:2011/BTNMT, Kf=0.9, Kq=1 then	Coal contaminated wastewater treatment system: 9,852,000,000 VNĐ			The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		reuse for acceptable purposes.				
		Hydraulic adapters and connectors are made of stainless steel.				The project owner
	Soil pollution due to solid waste	*For industrial and domestic solid waste:* Solid waste is collected and stored in containers for movement and treatment. *For hazardous waste:* Hazardous waste is stored in closed containers placed away from sunlight, wind, rain and on the waterproof surface with ventilation system. Hazardous waste will be collected and treated	Collection cost: 25,000,000 VND	Before operation phase of plant	The division which executes Vinh Tan 4 power plant directly.	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		according to regulations by functional agencies hired to minimize duration of storage time and avoid leakage into surrounding environment. Hazardous waste is stored carefully to avoid leakage into surrounding atmosphere, soil and water sources. Hazardous containers are labeled carefully, made of uneroded materials.				
	Impacts on landscape	The minimum area of green belt is ensured at least 10% to make comfortable space and landscape as well as wind shield for the plant.	Included in investment project.	Before operation phase of plant	The division which executes Vinh Tan 4 power plant directly.	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
	Impacts on workers in the plant.	Declare temporary residence of external workers to police agency of Vinh Tan commune. Design training plans for educating and improving working skills for local workers. Design and organize training plans on labor safety and maintaining sanitary environment for workers. Build medical station and supply health care service for workers. Provide health insurance and social insurance for workers in the plant. Organize periodical health examination for worker every year.	Included in investment project.	Before operation phase of plant	The division which executes Vinh Tan 4 power plant directly.	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
	Social impacts	Organize a team to manage consultancy and contact to local community. Set up community plan and grievance.	Included in investment project.	Before operation phase	The division which executes Vinh Tan 4 power plant directly.	The project owner
		Establish relationship with local authorities and community organizations to get their support in response to issues happened during phases.	Included in investment project.	Before operation phase	The division which executes Vinh Tan 4 power plant directly.	The project owner
Intake and discharge of cooling water	Water pollution, impacts on aquaculture	Chlorine is added to prevent algae growth, dust deposit inside pipeline. Apply technical measures such as screens or high flow self-cleaning aquatic sieve, and behavioural barriers to prevent fish	Included in investment project.	Before operation phase	The division which executes Vinh Tan 4 power plant directly.	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		death. Cooling water is released by two steel pipe systems 4x4 m, cooling water temperature decreases significantly due to evaporation process; erosion is decreased by reducing hydraulic pressure with particular design.				
Storage, unloading and transportation of coal.	Air pollution, dust, noise and vibration	Apply new technology on loading and unloading works. Install windshield along coal conveyor. Spray water during coal unloading process. Plant trees along roads and green belt in coal port. Periodically monitor ambient air.	Investment cost for planting trees will be added to cost of construction plant			The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
Washing activities of coal port and unloading equipment.	Water pollution due to wastewater of coal port.	All wastewater from coal port will be transported and treated at the coal contaminated wastewater treatment system in Vinh Tan 4 power plant. Collect and classify solid waste (domestic solid waste, hazardous solid waste) at sources.	Drainage system: 1,134,000,000VND	Before operation phase	The division which executes Vinh Tan 4 power plant directly.	The project owner
Ash yard	Groundwater and coastal water pollution.	Using as geotextile for bottom layer to avoid groundwater pollution.	Bottom ash, fly ash system and discharge system outside the plant: 291,303,000,000 VNĐ	During the operation phase	The division which executes Vinh Tan 4 power plant directly.	The project owner
	Impact on security of local community.	Set up security equipment at ash pond and design procedures of safety and rescue.		During the operation phase	The division which executes Vinh Tan 4 power plant directly.	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
	Potential benefit from utilizing ash pond after being closed.	Gradually cover ash pond surface by soil and green trees.		During the operation phase	The division which executes Vinh Tan 4 power plant directly.	The project owner
Incidents in environmental protection system, fire and explosion, labor accidents	Air, water and soil pollution. Impacts on workers and local residents. Impacts due to waterway accidents.	In case that there is incident in environmental protection system, a large amount of pollutants with concentration exceeding allowable value will release, the plant will stop to be maintained. Provide enough emergency tanks for containing oil and chemicals in case of leakage. Provide training on emergency response for workers. Set up procedures of			The division which executes Vinh Tan 4 power plant directly.	The project owner

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
		emergency response and provide training for workers. Supervise complying with Vietnam and international marine rules. Provide training for navigators. Regularly check safety system of fuel vessels. Regularly dredge approach channel and turning basin to ensure breadth and depth for movement of ships. Prevention and response measures for spill and explosion of sea port of Vinh Tan 4 power plant will be carried out together with Vinh Tan 2's.				
Fire protection	Air, soil and	Fire protection system is designed with	Included in investment	Before operation	The division which executes	The project

Project activities	Environmental impacts	Mitigation measures	Cost of implementing mitigation measures (VND) (*)	Implementation time	Responsibility	
					Implementation (**)	Supervision
	water pollution. Impact on local residents and workers.	functions such as fire detection, fire warning, alert, control and extinction.	project.	phase	Vinh Tan 4 power plant directly.	owner

5.3. ENVIRONMENTAL MONITORING PROGRAM

To ensure effective implementation of mitigation measures for negative impacts of the project, an Environmental Monitoring Program will be carried out during three phases, i.e. preconstruction, construction and operation phase.

5.3.1. Types of environmental measuring and monitoring program

Two types of environmental monitoring will be performed as follows:

– Site monitoring of the implementation of mitigation measures: To check up and evaluate implementation and efficiency of mitigation measures during the preconstruction, construction and operation phase.

– Environmental quality monitoring: To sample and to analyze quality of environmental components during the project's life in order to assess level of compliance with environmental standards and regulations of Vietnam (TCVN and QCVN).

Agencies participating in the monitoring program:

– The project owner: internal monitoring.

– Department of Natural Resources and Environment (DONRE) of Binh Thuan province: monitoring with the governmental role for environmental management.

5.3.2. Monitoring implementation of measures for pollution control and environmental protection

The monitoring contents, objectives and locations under monitoring during preconstruction, construction and operation phase of Vinh Tan 4 Power Plant are given in Table 5.1 (Chapter 5). Responsibilities of the Project Owner (internal monitoring) and environmental protection agency under MONRE (assigned to supervise and confirm construction of environmental protection works) are also defined in this table.

– The expenses on internal monitoring should be invested by the Project Owner.

– The expenses for monitoring carried out by the environmental protection agency under MONRE should be covered by the Government.

5.3.3. Environmental monitoring program

5.3.3.1. Waste monitoring

1. Preconstruction phase

In the pre-construction phase, these waste sources need to be monitored:

– Solid waste: from activities of workers (domestic solid waste) and construction activities (construction solid waste).

– Dust: mainly from land leveling and transportation of construction materials.

– Noise and vibration: generated at construction site due to transporting vehicles, bulldozer, excavator, mechanical hammer, etc.

– Domestic wastewater: approximately 68m^3/day.

- Domestic solid waste: about 200-250kg/day with main components of vegetation, residual food, plastic, paper, metal, glass, etc.
- Industrial solid waste: about 100-200kg/day with main components of concrete, stone, brick, etc.
- Hazardous waste: oily waste with amount of 92l/month, oily cloth with amount of 0.82-1.1 kg/month.

Measuring frequency: every 3 months.

2. *Construction phase*

In the construction phase, these waste sources need to be monitored:

- Solid waste: from workers' activities (domestic solid waste) and construction activities (construction waste).
- Dust: dust sources are mainly from unloading and transportation of construction materials.
- Sludge from dredging of sea port: 352.720m^3
- Noise and vibration: generated at construction site due to transporting vehicles, bulldozer, excavator, mechanical hammer, etc.
- Domestic wastewater: approximately 203m^3/day.
- Domestic waste: about 600-750 kg/day with main components of food, residual food, plastic, paper, metal, glass, etc.
- Hazardous waste: oil with amount of 47 L/month, oily cloth with amount of 0.6 kg/month.

Monitoring frequency: every 3 months.

Environmental standards:

- QCVN 14:2008/BTNMT: National technical regulations on domestic wastewater.
- TCVN 3985:1999: Noise level at work place.

3. *Operation phase*

Vinh Tan 4 Power Plant with the capacity of 600MWe for each unit (2 units) will generate a large amount of waste (including wastewater, air emissions, solid waste) which may cause highly potential pollution to environment without control measures. In order to implement effective monitoring of environmental impacts due to operation of the project, monitoring is carried out every 3 months. The following types of waste need to be monitored in the operation phase:

- Quantity and quality of wastewater:
    + Domestic wastewater: about 120m^3/ngày
    + Oil contaminated wastewater: about 240m^3/ngày
    + Industrial wastewater: 720m^3/ngày
    + Cooling wastewater: about 50m^3/s

Parameters of wastewater to be monitored at the connecting points of discharge system and receiving source: pH, temperature, DO, EC, turbidity, TDS, COD, BOD, Cl^-, Coliform, grease, Cd, As, Pb, Hg, Fe, Cr, Zn.

Regarding cooling wastewater, the following parameters will be monitored continuously: temperature and residual Chlorine.

- Air emissions from the plant:
  - + Flow rate: 1541,29m^3/s
  - + Concentration of NOx =455mg/Nm^3;
  - + Concentration of dust: 150 mg/Nm^3
  - + Concentration of SOx: 350 mg/Nm^3

Frequency: every 3 months.

In addition, CEMS is set up at stack to monitor these paraameters such as flow rate, temperature, PM10, SO_2, NOx, CO.

Standards to be applied:

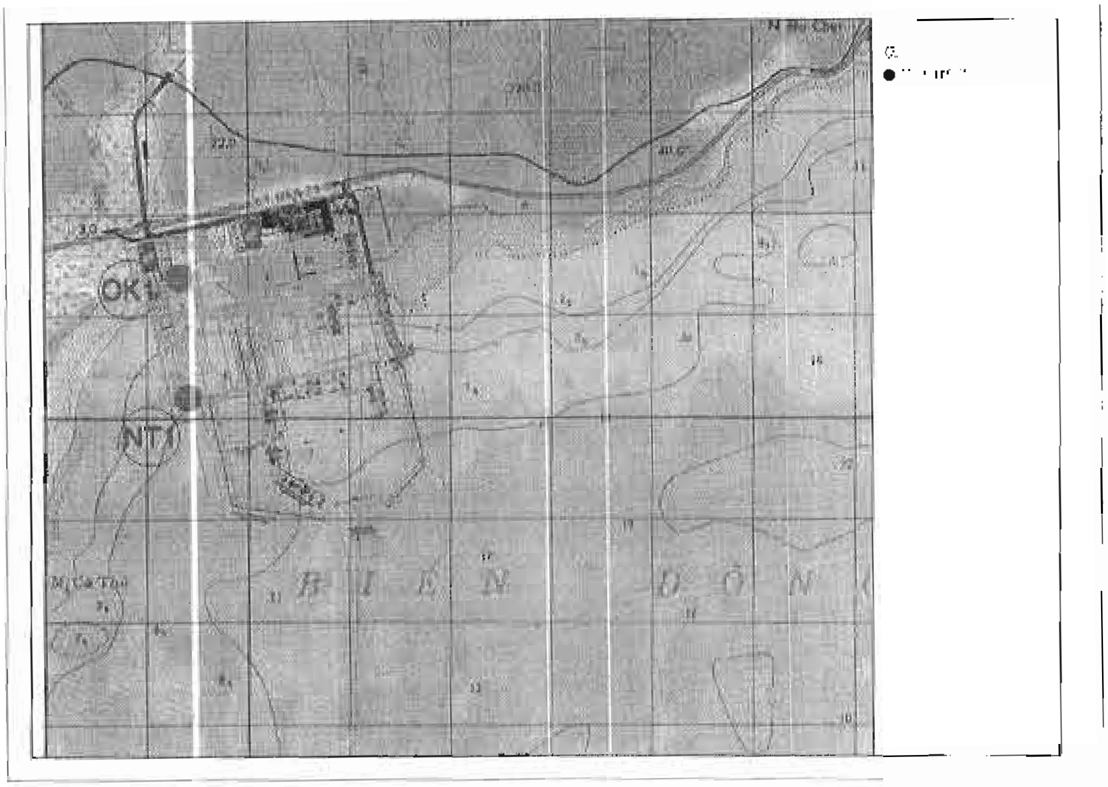
- QCVN 14:2008/BTNMT: National technical regulations on domestic wastewater.
- QCVN 40:2011/BTNMT: National technical regulations on industrial wastewater.
- QCVN 22:2009/BTNMT: National technical regulation on emission of thermal industry.

Monitoring positions of air emission and wastewater of Vinh Tan 4 are presented in Table 5.2 and Figure 5.1.

Table 5.2 Continuous monitoring positions of air emissions and wastewater of Vinh Tan 4

No.	Positions	Coordinate VN2000		Purpose
		X	Y	
OK1	At the stack of Vinh Tan 4 power plant	1251276,64	532016,40	Monitor concentration of air pollutants in emissions to promptly find out incidents and apply effective measures to overcome.
NT1	At siphon pit of cooling wastewater discharge system of Vinh Tan 4 power plant	1250524,58	532067,65	Monitor temperature and residual Chlorine to apply mitigation measures in time in case these parameters exceed allowable values.

Figure 5.1. Map of continuous monitoring positions of air emissions and wastewater in the operation phase of Vinh Tan 4 power plant



5.3.3.2. Ambient environment monitoring

Purposes of ambient environment monitoring:

- To assess environmental quality at project site during pre-construction, construction, and operation phase.
- Support to environmental management and predict changes of environmental quality due to activities of construction and operation.

Selection of positions of ambient environmental monitoring:

Positions of air, seawater, underground water and soil monitoring are selected at sensitive receptors which may be affected by construction and operation activities of the power plant as follows:

- Sampling positions of air, noise and vibration level are at residential areas surrounding the project area which may be affected by air emissions, noise, vibration from construction activities and transportation of construction materials during construction phase or flue gases from stack and transportation of ash during operation phase.
- Sampling positions of water quality are selected at cooling wastewater, domestic wastewater and industrial wastewater discharge points, coastal areas and underground water sources surrounding the project area to evaluate increase in concentration of pollutants due to construction, operation and leakage of wastewater and penetration of wastewater into underground water.

The detailed ambient environment monitoring is presented in Table 5.3.

Table 5.3 Ambient environment monitoring program of Vinh Tan 4 power plant

Items	Purpose	Monitoring positions	Monitoring frequency	Monitoring parameters	Monitoring methods	Applied standards	Implement
1	2	3	4	5	6	7	8
The pre-construction phase							
Air quality	Determining total suspended particle (TSP), PM10, SOx, NOx, CO in the atmosphere in sensitive areas and evaluating whether the pollution exceeds the Vietnamese standards and regulations.	5 points Please refer Table 5.4 and Figure 5.2	Every 6 months during sea encroaching level.	Temperature, moisture, wind direction and speed, TSP, PM10, SO_2, NO_2, CO.	According to Vietnamese standards and regulations.	QCVN 05: 2009/BTNMT	The project owner
Noise	Evaluating noise level in sensitive areas surrounding the construction site and evaluating whether the noise level exceeds the Vietnamese regulations.	The same positions as air monitoring points.	Every 6 months during sea encroaching level.	LAeq: Average level LAmax: Maximum level $L_{AN,T}$: percent level	TCVN 5964: 1995 or TCVN 5965: 1995.	TCVN 3985-1999 QCVN 26:2010/BTNMT	The project owner
Vibration	Evaluating vibration level in sensitive areas surrounding the construction site and evaluating whether the vibration level exceeds the Vietnamese regulations.	The same positions as air monitoring points.	Every 6 months during sea encroaching level.	Vibration velocity Vibration acceleration Vibration range.	Based on guideline of vibration meter.	QCVN 27:2010/BTNMT	The project owner
Water	Determining	5 positions	Every 6	pH, temp, DO, EC,	Monitoring	QCVN	The project

Items	Purpose	Monitoring positions	Monitoring frequency	Monitoring parameters	Monitoring methods	Applied standards	Implement
1	2	3	4	5	6	7	8
quality	concentration of pollutants in water sources in sensitive areas and evaluating whether increase in concentration of pollutants in surface water and groundwater exceeds Vietnamese regulations.	for surface water + 3 positions for groundwater Refer to *Table 5.5.;5.6* and Figure *5.3.;5.4*	months during sea encroaching level.	turbidity, TDS, COD, BOD, NH_4^+, NO_3^-, Cl^-, total Coliform, grease, Cd, As, Pb, Hg, Fe, Cr, Zn.	method is according to Vietnamese standards.	08:2008/BTNMT QCVN 10:2008/BTNMT	owner
Biological monitoring	Evaluating impact level due to construction of the project on aquatic biota.	The same positions as surface water monitoring points	Every 12 months during sea encroaching level. 5.3.3.3. 5.3.3.4.	Phytoplankton (qualitative, quantitative) Zooplankton (qualitative, quantitative) Zoobenthos (qualitative, quantitative) Aquatic ecosystem	Basing on standard methods of Vietnam		The project owner
The construction phase							
Air quality	Determining total suspended particle (TSP), PM10, SOx, NOx, CO in the atmosphere in sensitive areas and evaluating whether the pollution exceeds the	The same positions as air monitoring points in the preconstruction phase.	Every 6 months during construction phase.	Temperature, moisture, wind direction and speed, TSP, PM10, SO_2, NO_2, CO.	According to Vietnamese standards and regulations.	QCVN 05: 2009/BTNMT	The project owner

Items	Purpose	Monitoring positions	Monitoring frequency	Monitoring parameters	Monitoring methods	Applied standards	Implement
1	2	3	4	5	6	7	8
	Vietnamese standards and regulations.						
Noise	Evaluating noise level in sensitive areas surrounding the construction site and evaluating whether the noise level exceeds the Vietnamese regulations.	The same positions as air monitoring points.	Every 6 months during construction phase.	LAeq: Average level LAmax: Maximum level $L_{AN,T}$: percent level	TCVN 5964: 1995 or TCVN 5965: 1995.	TCVN 3985-1999 QCVN 26:2010/BTNMT	The project owner
Vibration	Evaluating vibration level in sensitive areas surrounding the construction site and evaluating whether the vibration level exceeds the Vietnamese regulations.	The same positions as air monitoring points.	Every 6 months during construction phase.	Vibration velocity Vibration acceleration Vibration range.	Based on guideline of vibration meter.	QCVN 27:2010/BTNMT	The project owner
Water quality	Determining concentration of pollutants in water sources in sensitive areas and evaluating whether increase in concentration of pollutants in surface water and groundwater exceeds Vietnamese regulations.	The same positions as water monitoring points in the preconstruction phase.	Every 6 months during construction phase.	pH, temp, DO, EC, turbidity, TDS, COD, BOD, NH_4^+, NO_3^-, Cl^-, total Coliform, grease, Cd, As, Pb, Hg, Fe, Cr, Zn.	Monitoring method is according to Vietnamese standards.	QCVN 08:2008/BTNMT QCVN 10:2008/BTNMT	The project owner
Biologic	Evaluating impact level	The same	Every 12	Phytoplankton	Basing on		The project

Items	Purpose	Monitoring positions	Monitoring frequency	Monitoring parameters	Monitoring methods	Applied standards	Implement
1	2	3	4	5	6	7	8
al monitoring	due to construction of the project on aquatic biota.	positions as surface water monitoring points	months during construction phase.	(qualitative, quantitative) Zooplankton (qualitative, quantitative) Zoobenthos (qualitative, quantitative) Aquatic ecosystem	standard methods of Vietnam		owner
The operation phase							
Air quality	Tracking any changes in air quality at the power plant and surrounding areas	The same positions as air monitoring points in the preconstruction, construction phase.	Every 6 months during operation phase	Temperature, humidity, wind speed and direction, TSP, PM10, SO_2, NO_2, CO.	Basing on standard methods of Vietnam	QCVN 05: 2009/BTNMT	The Project owner (division directly executes Vinh Tan 4 power plant).
Noise	Evaluating impacts due to operation of the power plant on surrounding areas.	The same positions as air monitoring points.	Every 6 months during operation phase	LAeq: Average level LAmax: Maximum level $L_{AN,T}$: percent level	Basing on standard methods of Vietnam	TCVN 3985-1999 QCVN 26:2010/BTNMT	The Project owner (division directly executes Vinh Tan 4 power plant).
Vibration	Evaluating impacts due to operation of the power	The same positions as	Every 6 months	Vibration velocity Vibration acceleration	Based on guideline of	QCVN 27:2010/BTNM	The Project owner

Items	Purpose	Monitoring positions	Monitoring frequency	Monitoring parameters	Monitoring methods	Applied standards	Implement
1	2	3	4	5	6	7	8
	plant on surrounding areas.	air monitoring points.	during operation phase	Vibration range	vibration meter.	T	(division directly executes Vinh Tan 4 power plant).
Water quality	Evaluating impacts due to operation of the power plant on local surface and underground water quality	The same positions as water monitoring points in the construction phase.	Every 6 months during operation phase	pH, temperature, DO, EC, turbidity, TDS, COD, BOD, Cl-, total Coliform, grease, Cd, As, Pb, Hg, Fe, Cr, Zn.	Basing on standard methods of Vietnam	QCVN 08:2008/BTNMT	The Project owner (division directly executes Vinh Tan 4 power plant).
Biological monitoring	Evaluating impact level due to operation of the project on aquatic biota.	The same positions as water monitoring points.	Every 12 months during construction phase	Phytoplankton (qualitative, quantitative) Zooplankton (qualitative, quantitative) Zoobenthos (qualitative, quantitative) Aquatic ecosystem	Basing on standard methods of Vietnam		The Project owner (division directly executes Vinh Tan 4 power plant).

Figure 5.2. Map of monitoring positions of ambient air, noise and vibration in the preconstruction, construction and operation phase

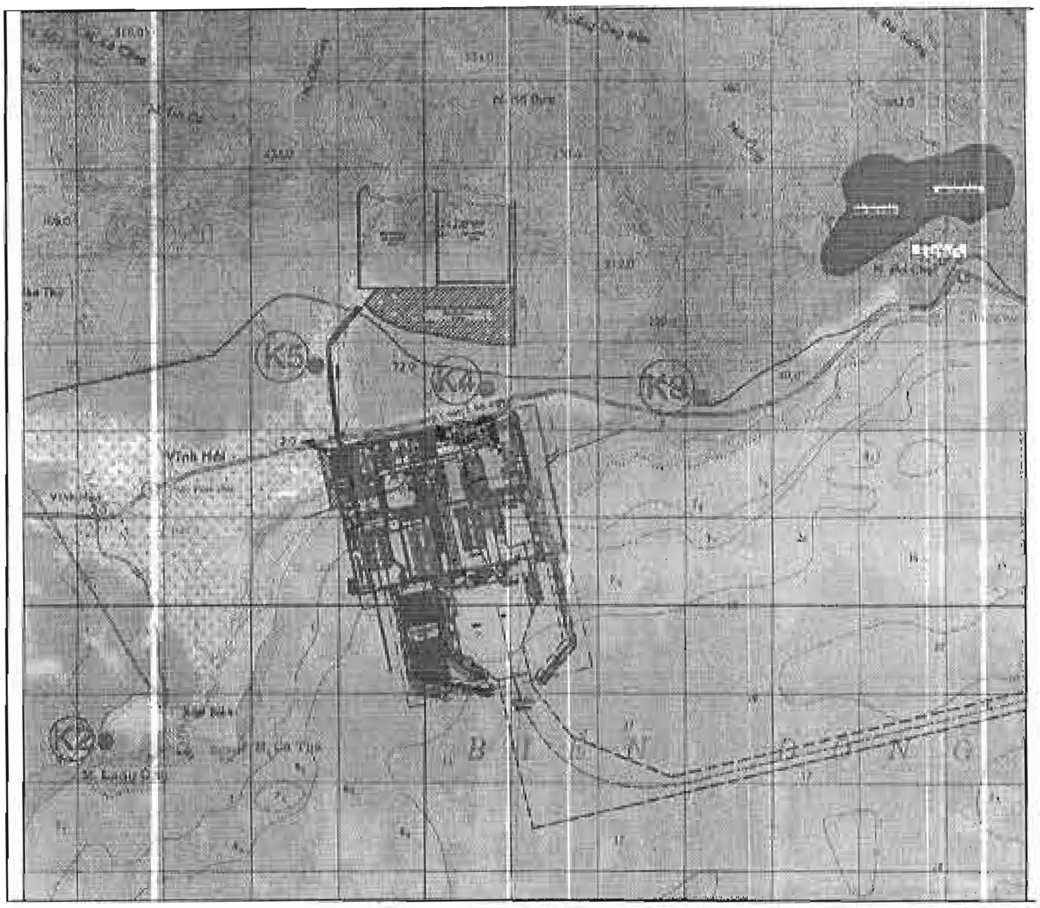


Table 5.4 Sampling positions of air, noise and vibration monitoring in the preconstruction, construction and operation phase

No.	Position	Coordinate VN2000		Purpose
		X	Y	
K1	Center of construction site of Vinh Tan 4 power plant	1251692.41	531877.09	Air pollution, noise and vibration at the project area during the preconstruction, construction and operation phase which may affect workers and local people.
K2	At current residential area at hamlet 7, the west of the project	1251353.84	531267.95	Air quality, noise and vibration at residential area which may be affected by construction and operation activities of the power plant.
K3	People's committee of Vinh Tan commune	1252220.90	534840.78	Air quality, noise and vibration at residential area which may be affected by air emissions from the power plant.

K4	On National road 1A	1252277.54	533210.64	Air quality, noise and vibration at residential area which may be affected by transportation of materials, ash during construction and operation phase.
K5	On access road to Ash pond 1	1252564.82	531715.51	Air quality, noise and vibration at residential area which may be affected by transportation of materials, ash during construction and operation phase.

Table 5.5 Monitoring positions of surface water during the construction phase and operation phase

No.	Position	Coordinate VN2000		Purpose
		X	Y	
NM1	At ports of VT4, VT3 plant	1250193.95	532748.86	Determination of surface water quality and aquatic ecosystem which may be affected by the project during the preconstruction, construction and operation phase.
NM2	At the anticipated cooling wastewater discharge point of VT4 power plant	1249703.81	532238.071	Determination of surface water quality and aquatic ecosystem which may be affected by discharge of cooling wastewater.
NM3	On the sea, 700 m from discharge point of VT4 power plant.	1250926.78	534262.73	Determination of surface water quality which may be affected by the project during the preconstruction, construction and operation phase.
NM4	At 3000DWT local port, from 700 m from the coast	1249789.65	532173.73	Determination of surface water quality and aquatic ecosystem which may be affected by the project during the preconstruction, construction and operation phase.
NM5	On the ship channel	1248549.97	534277.71	Determination of surface water quality and aquatic ecosystem which may be

				affected by the project during the preconstruction, construction and operation phase.

Figure 5.3. Map of monitoring positions of surface water and aquatic biota in the preconstruction, construction and operation phase

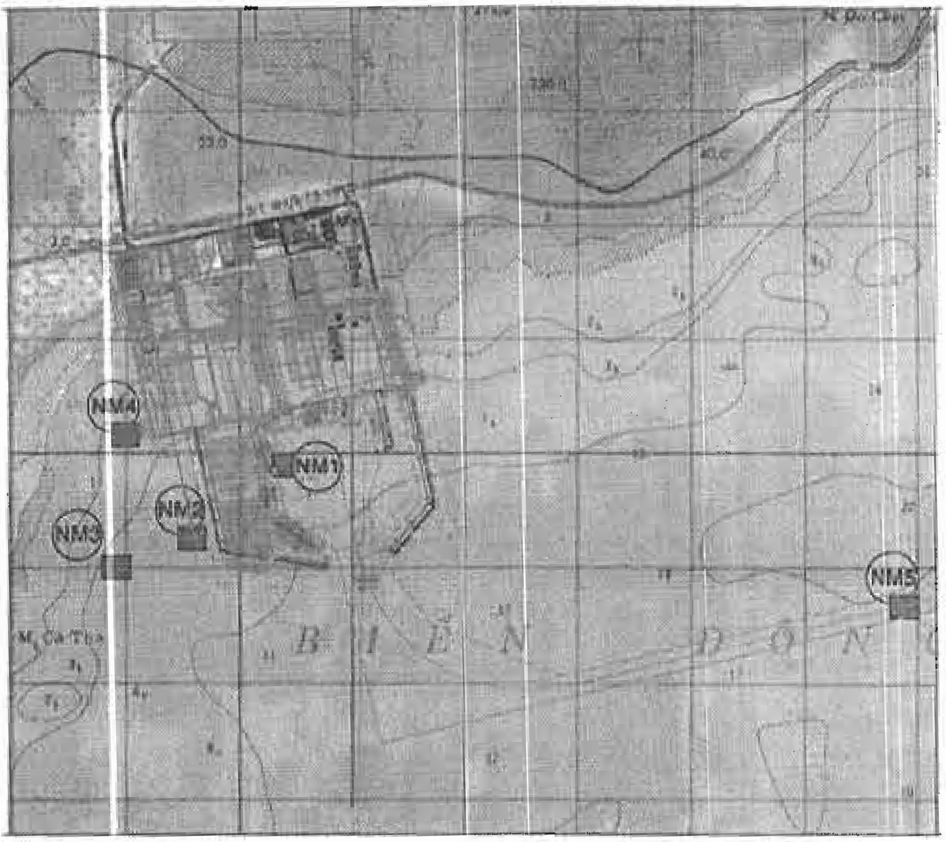
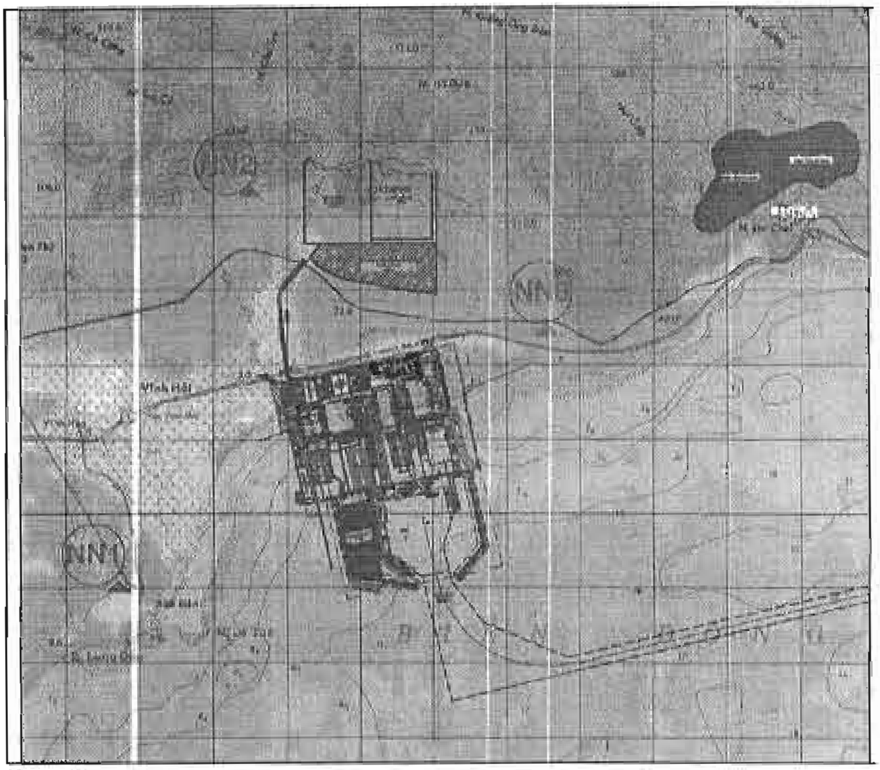


Table 5.6 Monitoring positions of groundwater during the construction phase and operation phase

No.	Position	Coordinate VN2000		Purpose
		X	Y	
NN1	At current residential area at hamlet 7, near the project site	1250981.62	530798.31	Monitoring groundwater quality at the project area that may be affected by operation of the project.
NN2	Residential area near Ash pond 1, at foothills of Ho Dua mountains	1253523.52	531811.58	Monitoring groundwater quality at the project area that may be affected by operation of the Ash pond.
NN3	Residential area at the east of project	1252226.55	534381.10	Monitoring groundwater quality at the project area that may be affected by operation of the project.

Figure 5.4. Map of monitoring positions of underground water in the preconstruction, construction and operation phase



5.3.3.5. Other monitoring

1. In the preconstruction and construction phase

Monitoring of coral and seaweed clearance in sea encroaching level

During sea encroaching level process, clearance of coral in Vinh Tan commune outside the project area will be strictly monitored and supervised.

2. Monitoring of aggradation and erosion

During construction phase, monitoring of aggradation and erosion at sea embankment of Vinh Tan 4 power plant will be conducted to supervise level of aggradation and erosion in order to apply mitigation measures in time.

3. In the operation phase

a) Monitoring of socio-economic conditions

- Evaluate impacts of the project on socio-economic conditions at surrounding residential areas.
- Support to environmental management and predict impacts of the project on local community.

Monitoring frequency: every year.

b) Monitoring of changes in aquatic biota in area affected by thermal of cooling wastewater

During operation of the power plant, discharge of cooling wastewater may affect local aquatic biota; therefore, monitoring of changes in aquatic biota must be done.

Monitoring frequency: every year in the operation phase.

5.3.4. Estimating expense for environmental monitoring program

Expense for this program is presented in Table 5.7, included in the project investment cost.

Table 5.7 Estimated expense for environmental monitoring program

No.	Content	Expense (VND)
Construction phase (the first year)		
1	Expense for environmental monitoring program includes travel, sampling, analysis of samples, prepare report expense: 4 times for waste monitoring; 2 times for ambient environment monitoring and 1 time for aquatic biota monitoring	1.320.000.000
Operation phase (the first year)		
2	Expense for environmental monitoring program includes travel, sampling, analysis of samples, prepare report expense: 4 times for waste monitoring; 2 times for ambient environment monitoring and 1 time for aquatic biota monitoring	1.060.000.000

Source: Estimated by PECC2,2012

Note: Environmental monitoring cost is just estimated and will be adjusted in next phases.

5.4. IMPROVEMENT OF ENVIRONMENTAL MANAGEMENT CAPABILITY

Environmental management is important activity for thermal power plants in Vietnam. Therefore, it is essential to train employees who will be involved in the environmental management plan (EMP) before implementation of the project. They will be provided with knowledge of mitigation measures as well as environmental monitoring plans.

The training will include:

- Training for employees of Vinh Tan 4 Power Plant
  + Environmental issues related to the construction and operation of Vinh Tan 4 Power Plant
  + Methods for environmental monitoring (especially for coal-fired power plants).
  + Environmental management in the operation phase of the plant.
- Training for construction engineers and workers of construction contractors:

Construction engineers will be trained for better knowledge of:

  + Safety: safety in construction.
  + Environmental management: Fundamental knowledge of environmental issues related to the construction of the plant.
  + EMP monitoring and report: Site observation methods and how to fill in

environmental monitoring sheets.

Table 5.8 Training expenses are estimated as shown in Table 5.8

No.	Training content	Item	Estimation	Expense (VND)
1	Training for employees of Vinh Tan 4 power plant	3 topics mentioned above	20 people* 3 days + materials	10,000,000 (Package)
2	Safe training	Consulting expert	1/2 people-month	5,000,000
		About 40 people	40 people x 1 day x 100.000 VNĐ/day	4,000,000
		Other costs	Package	5,000,000
3	Environmental protection training related to Vinh Tan 4 power plant	Consulting expert	1/2 people-month	5,000,000
		About 40 people	40 people x 1 day x 100.000 VNĐ/day	4,000,000
		Other costs	Package	5,000,000
4	Training on environmental monitoring and report	Consulting expert	1/2 people-month	5,000,000
		About 30 people	30 people x 1 day x 100.000 VNĐ/day	3,000,000
		Other costs	Package	5,000,000
	Total			51,000,000

Source: Estimated by PECC2,2012

Table 5.9 Estimated expense for the EMP implementation (VND)

No.	Item	Construction phase	Operation phase
1	Mitigation measures	Included in the expenditure of the project	Included in the production cost of Vinh Tan 4 Power Plant
2	Environmental monitoring	1.320.000.000	1.060.000.000 (for the first year) (*)
3	Capability improvement	51,000,000	
	Total	*1.371.000.000*	*1.060.000.000*

Source: Estimated by PECC2,2012

Note: Environmental monitoring cost is just estimated and will be adjusted in next phases.

5.5. ENVIRONMENTAL MANAGEMENT PLAN (EMP) IMPLEMENTATION

The system recommended for EMP implementation under the project of Vinh Tan 4 Power Plant is shown in Table 5.10.

Table 5.10 Responsibility of agencies in EMP implementation

Agency	Responsibility
Vietnam Electricity	Vietnam Electricity is the investor and has responsibility to generally manage, include environmental management.
The project management board	The project management Board of Vinh Tan TTP (Vinh Tan MB) is in charge of undertaking the following tasks: – To implement the EMP, the Vinh Tan MB (in the construction phase) and operation division for Vinh Tan 4 TPP (in the operation phase) will found an environmental management department. This department takes charge of management, monitoring and implementing the EMP as follows: + Planning, managing and monitoring the environmental management throughout the project life + Guiding the construction contractor to take all measures for pollution mitigation and environmental protection in order to comply with environmental standards. + Cooperating with Binh Thuan DONRE and Tuy Phong District PC in all environmental management activities. + Holding training courses for contractors and staff in measures for environmental protection and work safety (inviting environmentally experienced experts as consultant). + Internal monitoring and independent monitoring. + Funding monitoring activities. + Reporting environmental matters to relevant state bodies.
EPC contractor	The construction contractor will be selected by the Vinh Tan MB with responsibility for building up the works and fulfill duties specified in the environmental protection agreement, include: – Undertaking mitigation measures for impacts on environment (water, air, noise, etc.) in the preconstruction and construction phase. – Ensuring safety for construction workers and local inhabitants in the preconstruction and construction phase. – Complying with national regulations on environmental protection during the preconstruction and construction phase. – Designing sufficient and proper systems for collecting and treating waste of the plant. – Purchasing equipment for treatment of dust, SO_2, NO_X and other treatment equipment for complying with Vietnamese standards and regulations. – Installing sufficient equipment for pollution control and environmental protection.

Chapter

6

PUBLIC CONSULTATION

In compliance with regulations in Circular 26/2011/BTNMT by the MONRE, Vinh Tan Management Board (MB) (the owner) rendered a dispatch dated 16/5/2012 to the People's Committee (PC) and the Fatherland Front's Committee (FFC) of Vinh Tan commune (where the project will be implemented) and Hon Cau MBA Management Board together with the summary of the EIA report in order to ask for their opinions about environmental matters relating to Vinh Tan 4 thermal power plant project. Details of the dispatch are given in the Annex to Chapter Six.

The project owner also rendered a dispatch to Binh Thuan Association of breeding shrimp to collect their point of view about environmental issues caused by the project.

6.1. OPINIONS OF CONSULTED AGENCIES ABOUT THE PROJECT

6.1.1. Opinions of Vinh Tan commune's PC (as raised in Official Letter 39/CV-UBND dated 31/5/2012 to Vinh Tan MB)

6.1.1.1. About negative impacts of the project on natural and socio-economic environment:

- Vinh Tan commune's PC agrees with contents presented in the summary report. However, during construction phase of project, there are some unforeseen environment impacts due to floods, tornadoes, natural disasters which need to be paid attention to by the project owner.
- Vinh Tan is the key area for supply of fish and breeding shrimp. Currently, land leveling for Vinh Tan 1, 2, 3 power plant is conducting, which affects seawater quality and local breeding shrimp production. In the operation of power plants, cooling wastewater discharged into the environment can cause long term impacts on socio-economic development in this region.
- There are about 20ha of river and stream among 65.76ha of onshore area which are serving for flood drainage in Vinh Tan and Vinh Hao commune will be filled for Vinh Tan 4 TPP. That can cause negative impacts on local residents.

6.1.1.2. About mitigation measures for negative impacts of the project on environment:

- Vinh Tan commune's PC agrees with contents presented in the summary report.
- Conduct more extensive study on long term environmental impacts due to sea encroaching leveling and cooling wastewater discharge.

6.1.1.3. Recommendations for the project owner:

- Employ local laborers for suitable works to mitigate the disorder due to disagreements about customs, culture etc... between local people and workers from other places.
- The project should be liable for damages relating to the environment, people's health and production that result from the project causing environmental consequences.

- The policies on compensation and site clearance should be reasonable and accord with popularity;
- During the construction, measures for environmental protection and mitigation of negative environmental impacts caused by the project should be taken; and environmental monitoring should be performed as required in the approved EIA report;
- Investors should coordinate with local authority in terms of administrative management to avoid conflicts between local people and workers of the plant.
- Find out solutions for flood drainage for this region due to filling the estuary.
- Conduct study on long term impacts on marine and air environment due to operation of the power plant and ash yard.
- The functional environmental agencies have to regularly inspect and monitor environmental impacts during construction and operation of the power plant and ash yard.

6.1.2. Opinions of Vinh Tan commune's FFC (as raised in Official Letter 35/CV-UBMTTQ dated 25/5/2012 to Vinh Tan MB)

6.1.2.1. About negative impacts of the project on natural and socio-economic environment:

- To agree with negative impacts due to the project on natural environment, socio-economic conditions that mentioned in the summary document.

6.1.2.2. About mitigation measures for negative impacts of the project on environment:

- To agree with mitigation measures for negative impacts on environment that mentioned in the summary report.

6.1.2.3. Recommendations for the project owner:

- The Project Owner should associate with local authorities in administrative management to prevent out of public order due to workers concentration.
- The project should employ good and advanced engineering and technique in construction and operation in order to lower the pollution due to smoke, dust, noise, vibration, wastewater, solid waste under the allowable limits, to protect people's health and the ecological environments, air, soil, underground water, surface water, and sea water environment in the locality;
- The project should be responsible for active participation and contribution into programs for improving community awareness and protecting the community environment;
- The project should be liable for damages relating to the environment, people's health and production that result from the project causing environmental consequences.

- All parties should discuss to deal with new issues which were not mentioned in the summary report every month or quarter.
- During construction phase, if there is any conflict and dispute with local people, the project owner will be responsible for announcing to local authorities promptly to find out solutions.

6.1.3. Opinions of Hon Cau MBA Management Board (as raised in Official Letter 42/KBTBHC dated 30/5/2012 to Vinh Tan MB)

6.1.3.1. About negative impacts of the project on natural and socio-economic environment:

- Hon Cau MBA Management Board agrees with contents presented in the summary report. However, the project owner is requested to supplement "impacts on coastal ecosystem and coral reefs in Hon Cau MBA" to this report.

6.1.3.2. About mitigation measures for negative impacts of the project on environment:

- The project owner is requested to supplement mitigation measures for impacts on the ecosystem in Hon Cau MBA due to construction and operation of the power plant.

6.1.3.3. Recommendations for the project owner:

- Supplement mitigation measures for impacts on coastal ecosystem and coral reefs in Hon Cau MBA due to construction and operation of the project.
- Supplement environmental impact assessment of the project on Hon Cau MBA.
- The project owner should take responsibility for compensation of all damage on environment, health and production caused by the project.
- Implement environment monitoring in accordance with contents provided in approved EIA report.
- Strictly conform to requirements of approval decision for EIA report.

6.1.4. Opinions of Binh Thuan Association of breeding shrimp

In the appraisal meeting of EIA report for Vinh Tan 4 TPP held by MONRE in 13/05/2013, the appraisal council requested Vinh Tan MB to supplement consultation of Binh Thuan Association of breeding shrimp which is potentially affected by construction and operation of the project. In compliance with this request, the project owner also rendered a dispatch to Binh Thuan Association of breeding shrimp together with the summary of the EIA report to ask for their opinions. As a result of this, the official document no. 18/HHTGBT dated 20/07/2013 was sent by Binh Thuan Association of breeding shrimp to Vinh Tan MB for giving their own views about the project. (Detailed contents of the document are given in the Annex to Chapter Six).

- Agree to construction of Vinh Tan 4 TPP in accordance with the government's policy.

- A concentration area has been planned by Binh Thuan province at Chi Cong commune, Tuy Phong district for relocation of shrimp breeding enterprises which will be affected by the project. However, construction of this area as well as essential infrastructure has not been conducted yet.
- The project owner is kindly requested to strictly conform to construction technique, consolidate the embankment, and prevent suspended solid dispersion which may cause impacts on quality of water supply for shrimp breeding.
- Build separate treatment system to deal with domestic wastewater produced in land leveling and construction phase in order not to cause negative impacts on seawater.
- Coal contaminated wastewater and oily wastewater also must be treated to meet environmental standards before being discharged into sea.
- Temperature of cooling wastewater should be controlled before being discharged.
- Draw out solutions to prevent and overcome oil spills during loading/unloading process.
- Provide storage area and proper transportation and disposal method for ash to avoid impacts on seawater.
- Control quality of domestic and industrial solid waste to prevent seawater pollution.
- The project owner is kindly requested to put into action all methods mentioned in the summary report, timely overcome environmental incidents, strictly conform to current environmental protection regulations during the implementation process to mitigate impacts on regional water sources, water supply for shrimp breeding as well as local community's livings.
- The project owner should coordinate with relevant agencies to well manage solid waste, cooling wastewater, control and overcome incidents caused by air emissions during construction and operation phase.
- Provide assessment of extent and level of impacts on natural and socio-economic due to wastewater, solid waste, environmental incidents, etc. in more details.
- The project owner is kindly requested to associate with Vinh Tan MB and Binh Thuan Association of breeding shrimp in dealing with production area for shrimp breeding enterprises. At first, Vinh Tan MB should organize some meetings for scientists, local authorities and shrimp breeding households to discuss sources of impacts, extent and level of impacts and mitigation measures for impacts caused by construction and operation of the project as well as experiences and practical solutions in similar plants.
- Negative impacts from the project which affect marine environment may drive shrimp breeding enterprises discontinuing production and have a direct effect on their living and occupation.

6.1.5. Opinions of affected community

The EIA study team also carried out public consultation for households who are directly affected by the project. Their opinions were recorded as follows:

Ms. Tran Thi Minh Ha (Vinh Tan commune):

- Shrimp breeding in village 7 may be affected by land leveling activities
- Dust dispersion from ash yard may strengthen during wind season (August, September, and October); it is necessary to apply proper mitigation measures.
- Give opportunity for local people to work in the Power Center.
- Local people can continue aquaculture and coastal fishing activities or have to earn their living by other works? (Which works?)

Mr. Nguyen Van Gia (aquaculture household in Vinh Phuc hamlet, Vinh Tan commune):

- Scattered mud and soil from land leveling of Vinh Tan Power Center has formed a layer of about 10-15cm at the bottom of fish breeding rafts which causes diseases for lobster and destroys habitat of cobia.
- Dust dispersion in strong wind days covers all regional works. In the north wind season, roots of tree are swept into the bottom of rafts, so that aquaculture household cannot continue fishing breeding on these rafts.

Ms. Nguyen Thi Trang (Vinh Hung hamlet, Vinh Tan commune)

- In the south wind season, mud and soil from land leveling increases turbidity in seawater that affects fishing activities of local community.
- The project owner is kindly requested to provide new occupation, reasonable compensation and support for affected households.
- Recruit local labor and offer vocational training for local youth to improve their livings.

In general, opinions of local people in the project area can be summarized as follows:

- Make effort to reduce negative impacts due to construction and operation of the project on local people.
- Direct impacts: Agriculture is not developed in this area; hence, most local people earn their livings by coastal fishing which is extremely affected by land leveling activities.
- When the project is put into operation, whether aquaculture and coastal fishery can be kept alive. The functional agencies should specify types of service and sector that local people can choose to ensure their stable life. Impacts due to the project must be assessed as much exactly as possible to help local people in choosing suitable jobs.
- Impacts on public health: These impacts are considered as long term accumulation. It is necessary to examine local people's health before and after operation of the project to conclude whether these impacts are negative.

- Disclosure of information to local people widely.
- Contribute to improve socio-economic infrastructure (ex. road, service, water and power supply) and intellectual standard for Vinh Tan residents.
- Recruitment demand of Vinh Tan Power Center should be announced as soon as possible so that local authorities can prepare training plan to meet labor needs of the center.

6.2. FEEDBACKS AND COMMITMENTS OF THE PROJECT OWNER

- The project owner (Vinh Tan MB) agrees to the opinions raised by the PC and Vinh Tan commune, MB of Hon Cau MPA and Binh Thuan Association of breeding shrimp and commits to perform the following tasks:
- The project owner has provided impacts of the project on environment and socio-economic conditions in details as well as mitigation measures and responses to environmental incidents in this EIA report.
- The project owner undertakes to good performance of environmental protection, treatment of waste from the project, and at the same time, taking managerial and technical measures for prevention and mitigation of negative impacts on the local natural and socio-economic environments as predicted in this EIA report.
- The project owner will support local inhabitants in some social activities and compensate for any damages caused by the project under current laws.
- The project owner undertakes to closely observe regulations on environmental protection in the LEP which was passed by the 11th National Assembly, Session 8 of the Socialist Republic of Vietnam on 29/11/2005, promulgated on 12/12/2005 under Order 29/2005/L/CTN by the President.
- The project owner undertakes to comply with Vietnamese standards (TCVN) and National Technical Regulations (QCVN) in environmental protection.
- The project owner undertakes to control and treat domestic wastewater produced in the construction phase to meet National Technical Regulations before discharging into environment.
- The project owner undertakes to strictly conform to mentioned techniques applied in construction of sea encroaching embankment.
- The project owner undertakes to complete environmental protection works such as wastewater treatment system, air emissions treatment system and solid waste management system before the project is put into operation.
- The project owner undertakes to provide storage area and proper transportation and disposal method for ash.
- The project owner undertakes to control temperature of cooling wastewater as specified in design before discharging into environment.
- The project owner undertakes to perform all methods mentioned in the report.

- The project owner undertakes to give priority in recruitment to local labors which have good skills.
- The project owner undertakes to monitor all wastewater, air emissions and solid waste sources generated during construction and operation of the project, in which, implementing continuous and automatic monitoring of the flow rate, temperature, concentration of residual chlorine in cooling wastewater and temperature, concentration of NOx, SOx, PM10 in flue gas. The project owner will store these automatic and continuous monitoring data to keep follow operation of environmental protection systems as well as to provide for functional agencies' inspection.
- The project owner undertakes to establish training program for staffs to timely overcome environmental incidents during construction and operation of the project.
- The project owner will draw out plan on organizing some conferences about operation of the TPP as well as environmental protection measures applied in the plant with consideration for extended participants.
- Regarding request to relocate production area for, based on plan of Binh Thuan province, shrimp breeding enterprises at Vinh Tan commune will be moved to a concentration production area at Chi Cong commune, Tuy Phong district. The resettlement tasks need close coordination of Binh Thuan People's Committee and other authorities. Vinh Tan TPMB playing role of the project owner of Vinh Tan 4 TPP will offer our suggestion to the provincial People's Committee to relocate new production area as specified in the Plan for stable shrimp farming production.

7.1. CONCLUSION

Vinh Tân 4 thermal power plant will play an important role in securing the supply of electricity for the socio-economic development of the provinces in the South of Central Vietnam as well as the national energy source.

EIA has identified and fully assessed the environmental impact of the project and assessed the extent and scale of the identified impacts and the feasibility of mitigation measures to adverse impacts and prevention and response incident, environmental risk.

Nevertheless, during its construction and operation, if appropriate measures of environmental protection are not taken, the Project will be causative of negative impacts on the natural and socio-economic environments as follows:

1. *Main impacts in the construction stage*

   - Reduction of the vegetation areas at the plant.
   - Reduction of aquatic ecosystems and fisheries resources at the plant and the port area.
   - Air and water pollutions due to dredging, leveling, construction waste and workers' refuse.
   - Noise and vibration pollution due to construction machines.
   - Impacts on terrestrial and aquatic biosystem in the surroundings of the project site.
   - Social matters due to aggregation of a large number of workers.

   Those impacts are assessed as significant but can be mitigated. The given mitigation measures are feasible. However, effects on degrading of vegetation area and on coral ecosystems in the area caused by coastal reclamation cannot has mitigation measures because destroy of vegetation layer is permanent to replace with a vision for the new plant construction.

2. *Main impacts in the operation phase*

   - Air pollution due to flue gas from the plant when the flue gas treatment system fails to meet its designed capacity. Main pollutants include dust, SO2 and NOx.
   - Noise and vibration pollution inside the plant.
   - Air pollution due to transportation and discharge of slag and ash.
   - Coastal pollution and air pollution due to ash yards.
   - Possible pollution of water sources and aquatic biota due to wastewater and cooling water.

All the aforementioned negative impacts in the operation stage will be minimized as the Project will use highly effective technologies to treatment air emissions, discharges, and solid wastes. The mitigation measures are feasible.

In order to prevent and well control negative impacts, the following measures will be taken:

3. In the construction phase

The contractors, under the supervision of the investor, shall take managerial and technical measures necessary to mitigate pollution of the air, water, noise and vibration as well as social matters due to construction and workers' aggregation.

4. In the operation phase

Modern technical solutions to control pollution and environmental incidents during the operation include selection of equipment for flue gas and dust treatment system at the source. The installation of treatment equipment of dust, SO2 and NOx reduction technologies in the furnace is to ensure flue gas from Vinh Tan 4 thermal power plant meets both the standard of discharge at stack (QCVN 22:2009/BTNMT, Kp=0.85, Kv=1) and ambient air quality standard QCVN 05:2009/BTNMT.

The amount of domestic wastewater of the plant will be handled by septic tank and biological treatment works to meet standard QCVN 14:2008/BTNMT type B with factor K=1.

Coal contaminated wastewater will be locally processed and re-circulated. Oil contaminated wastewater after treatment locally will be transported to the centralized treatment plant. The power plant will be installed a wastewater treatment plant for wastewater treatment to meet the standard QCVN 40:2011/BTNMT, type B with Kq = 1, Kf = 0.9.

The plant will apply the classification measures (at source) for solids wastes and handle the solids waste according to the characteristics of each type, to ensure not cause environmental pollution.

Ash and slag will be collected and transported to the ash yard of the plant. The plant will look for signing contracts with cement manufacturer to sell fly ash, reduce the amount of ash and slag.

Sanitary solid waste and industrial solid waste which have similar components as the sanitary waste will be collected and treated by contacting with specialized units for the collection and hygienic handling.

Hazardous wastes will be registered the hazardous wastes source by investors and stored at the regulated places and contracted with specialized units for hygienic collection and handling.

The power plant will install and equip firefighting devices.

In case the treatment equipment has problems, the plant will be stopped.

7.2. RECOMMENDATION

It is recommended Binh Thuan People's Committee to solve problems beyond the ability of the project related as to land compensation and resettlement and new places of seed shrimp production facilities.

The functional authorities should consider for early approval of Project Investment, Basic Design and the EIA Report of the Vinh Tan 4 thermal power plant, as legal basis for next steps to ensure the progress of the project.

7.3. COMMITMENT

The project's owner is committed to:

7.3.1. Commitment of uundertaking minimize measures to the negative impact

The project owner committed to implement measures for control and mitigate the negative impacts outlined in the report and the requirements stated in the decision approving the EIA report to ensure to meet standards and environmental regulations Vietnam. The project will have professional staff to manage environmental issues during project activities.

7.3.2. Commitment to undertaking all measures, general provisions on environmental protection related projects

On the basis of emission sources of stage of the project stated in the report, the project owner committed to implement all measures to minimize adverse impacts, prevention and environmental incidents presented in Chapter 4 and committed to implement all the measures, general provisions on environmental protection, including:

1. Air Emissions:

Full application of the mitigation measures (described in Chapter 4) ensures to meet Vietnam environmental regulations QCVN 22:2009/BTNMT, Kp=0.85, Kv=1- National Technical Regulation on industrial thermal emission.

Performing ongoing monitoring on emissions parameters as NOx, SOx, PM10 dust, CO. Storing data for testing when functional agencies needed.

2. Ambient air environment:

The pollutants in the emissions of the project dispersed in ambient air ensure to meet Vietnam environmental regulation QCVN 05:2009/BTNMT on national technical standards for ambient air quality, QCVN 06:2009/BTNMT on national technical regulation on hazardous substances in the ambient air.

3. Noise - Vibration

Noise generated during operation of the project must meet the criteria of noise in QCVN 26:2010/BTNMT - National technical regulation on noise, application for common area.

Vibration generated during operation of the project must meet the criteria for vibration QCVN 27:2010/BTNMT - National Technical Regulation on vibrate application for common area.

4. Domestic solid wastes, production solids wastes

Domestic solid wastes, production solids wastes are collected, transported and processed to ensure the requirements of environmental sanitation in accordance with Decree No.59/2007/ND-CP on the management of solid waste.

5. Hazardous waste

The project owner will be responsible for collecting, storing, handling all hazardous waste generated during construction and operation to ensure compliance with Circular 12/2011/TT-BTNMT dated 14/4/2011 of the Ministry of Natural Resources and Environment about regulations on hazardous waste management, the project owner will sign a contract with functional units handling hazardous wastes to handle and simultaneous registration and reporting the Binh Thuan Province Department of Natural Resources .

6. Domestic wastewater, industrial wastewater and cooling wastewater

Domestic wastewater and industrial wastewater will be collected and processed at the wastewater treatment plant to achieve QCVN 40:2011/BTNMT (column B, Kq = 1, Kf = 0.9) - National Technical Regulation of industrial wastewater.

Temperature, residual Chloride of cooling wastewater reaches QCVN 40:2011/BTNMT (column B, Kq = 1, Kf = 0.9) and is consider no impact on other power plant.

Ongoing monitored temperature and residual chlorine in cooling wastewater.

7.3.3. Commitment to undertaking environmental management and monitoring program

The project's owner commits to comply with environmental management and monitoring program during the construction phase and the operational phase with frequency and analyzed parameters in accordance with current regulations as stated in Chapter 5 reports EIA. The project owner will coordinate with agencies to take samples, monitor and storage of data as the basis for the assessment of environmental changes so that timely adjust corrective and prevent and mitigation measures in efficiently way.

7.3.4. Other commitment

- The project's owner is committed to install, operate all waste treatment system (including flue gas treatment system, drainage system, industrial and hazardous solid waste collect and storage system). All pollution control systems will be completely constructed and operated prior to the official operation of the plant.
- The project's owner is committed to implement measures on prevent environmental pollution and the mitigation measures as in Chapter 4 and to train professional staffs to improve environmental management ability, ensuring safety operation of port.
- The project's owner is committed to compliance with the environmental inspection as prescribed by law/standards.
- The project's owner is committed to officially operate only after receiving the approval of competent agencies on the implementation of the contents in the EIA report.
- The project's owner is committed to overcome environmental pollution in case of environmental risks/problems which caused by the project.
- The project's owner is committed to collaborate well with other projects in Vinh Tan PC to resolve arisen conflicts.

- The project's owner is committed to collaborate closely with the government and people to resolve arisen conflicts.
- The project's owner is committed to compensate for damages if the environmental problems affect to the local environment.
- The project's owner is committed to strictly comply with regulations on environmental protection in the Vietnamese Environmental Protection Law of the National Assembly, published by order 29/2005/L/CTN of the President dated 12/12/2005.
- The project's owner is committed to strictly comply the national technical regulation promulgated by Decision No.16/2008/BTNMT on 31/12/2008, Circular 16/2009/TT-BTNMT dated 07/10/2009, Circular 25/2009/TT-BTNMT on 16/11/2009, Circular 39/2010/TT-BTNMT on 16/12/2010 and Circular 47/2011/TT-BTNMT on 28/12/2011.
- The project's owner is committed to be responsible to law of Socialist Republic of Vietnam if there are environmental pollutions which caused by project activities, adversely affect on people's health.

Vinh Tan 4 thermal power plant Investment project is in accordance with the policy of the State. With technical and managerial solutions outlined in the Investment project and this EIA report, the project has capability to limit and control the adverse impacts on the environment as stipulated in the environmental standards. The Project's owner of Vinh Tan 4 thermal Power Plant is looking forward the approval and support by authorities for the project can be constructed soon.

APPENDICES

- APPENDICES OF CHAPTER 2
- APPENDICES OF CHAPTER 3
- APPENDICES OF CHAPTER 6

APPENDIX CHAPTER 2

CÔNG TY CP DV KHCN SẮC KÝ HẢI ĐĂNG
SAC KY HAI DANG SCIENCE - TECHNOLOGY SERVICES JOINT-STOCK COMPANY
VP & PTN : 79 Trương Định, Quận 1, Tp.Hồ Chí Minh, Việt Nam
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Sắc Ký Hải Đăng

VILAS 238

Số: 1202 0815/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020452 / 1202161

Đơn vị yêu cầu: **CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2**
Nơi lấy mẫu: **DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4**
Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận
Ngày lấy mẫu: 09/02/2012 **Ngày trả kết quả:** 17/02/2012
Người lấy mẫu: Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh
Loại mẫu: Đất sét pha cát **Số lượng:** 01 mẫu
Phương pháp lấy mẫu: TCVN 5297 : 1995
Vị trí lấy mẫu: **Tại TTDL Vĩnh Tân**
Tại tọa độ LAT 11^0 19'13.01 " LONG 108^0 48'08.34"

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* Zn	mg/Kg	TCVN 6496 – 2009	31,30
02	As	mg/Kg	TCVN 6496 – 2009	4,01
03	* Pb	mg/Kg	TCVN 6496 – 2009	17,29
04	* Cu	mg/Kg	TCVN 6496 – 2009	2,07
05	* Cd	mg/Kg	TCVN 6496 – 2009	KPH(LOD=0,017)
06	Dầu mỡ tổng	mg/Kg	TCVN 6496 – 2009	34,94

<u>Ghi chú:</u> *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

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S.Đ.K.K.D: 0...60 - C.T.C.P * QUẬN 1 - TP.HỒ CHÍ MINH

TS Phạm Thị Ánh **TS Diệp Ngọc Sương**

Sắc Ký Hải Đăng

CÔNG TY CP DV KHCN SẮC KÝ HẢI ĐĂNG
SAC KY HAI DANG SCIENCE - TECHNOLOGY SERVICES JOINT-STOCK COMPANY
VP & PTN : 79 Trương Định, Quận 1, Tp.Hồ Chí Minh, Việt Nam
Điện Thoại : (84.8) 3823 9643 / 3824 8814 - Fax (84.8) 3823 9872
E-mail : info@sackyhaidang.com.vn

Bộ Nông Nghiệp & PTNT chỉ định kiểm nghiệm chất lượng Nông Lâm Thủy Sản

ILAC-MRA BUREAU OF ACCREDITATION VIETNAM VILAS 238

Số: 1202 0813/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020450 / 1202161

Đơn vị yêu cầu: **CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2**
Nơi lấy mẫu: **DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4**
Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận
Ngày nhận mẫu: 09/02/2012 **Ngày trả kết quả:** 17/02/2012
Người lấy mẫu: **Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh**
Loại mẫu: Đất sét pha cát **Số lượng:** 01 mẫu
Phương pháp lấy mẫu: TCVN 5297 : 1995
Vị trí lấy mẫu: **Tại khu vực Bãi Xi**
Tại tọa độ LAT 11^0 20'19.2 " LONG 108^0 47'50.4"

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* Zn	mg/Kg	TCVN 6496 – 2009	29,40
02	As	mg/Kg	TCVN 6496 – 2009	0,53
03	* Pb	mg/Kg	TCVN 6496 – 2009	58,23
04	* Cu	mg/Kg	TCVN 6496 – 2009	4,54
05	* Cd	mg/Kg	TCVN 6496 – 2009	KPH(LOD=0,017)
06	Dầu mỡ tổng	mg/Kg	TCVN 6496 – 2009	34,91

Ghi chú: Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

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S.Đ.K.K.D: 030591586 - C.T.C.P - QUẬN 1 - TP.HỒ CHÍ MINH

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TS Diệp Ngọc Sương

Sắc Ký Hải Đăng

CÔNG TY CP DV KHCN SẮC KÝ HẢI ĐĂNG
SAC KY HAI DANG SCIENCE - TECHNOLOGY
SERVICES JOINT-STOCK COMPANY
VP & PTN : 79 Trương Định, Quận 1, Tp.Hồ Chí Minh, Việt Nam
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BUREAU OF ACCREDITATION VIETNAM VILAS 238

Bộ Nông Nghiệp & PTNT chỉ định kiểm nghiệm chất lượng Nông Lâm Thủy Sản

Số: 1202 0812/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020449 / 1202161

Đơn vị yêu cầu: **CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2**
Nơi lấy mẫu: **DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4**
Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận
Ngày nhận mẫu: 09/02/2012 **Ngày trả kết quả:** 17/02/2012
Người lấy mẫu: **Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh**
Loại mẫu: Đất sét pha cát **Số lượng:** 01 mẫu
Phương pháp lấy mẫu: TCVN 5297 : 1995
Vị trí lấy mẫu: **Tại khu dân cư phía Đông Bắc, TT Đức Linh**
Tại tọa độ LAT 11^0 19'22.2 " LONG 108^0 45'55.4"

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* Zn	mg/Kg	TCVN 6496 – 2009	28,82
02	As	mg/Kg	TCVN 6496 – 2009	0,55
03	* Pb	mg/Kg	TCVN 6496 – 2009	38,30
04	* Cu	mg/Kg	TCVN 6496 – 2009	3,39
05	* Cd	mg/Kg	TCVN 6496 – 2009	KPH(LOD=0,017)
06	Dầu mỡ tổng	mg/Kg	TCVN 6496 – 2009	54,95

Ghi chú: *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

Phụ trách chất lượng **TỔNG GIÁM ĐỐC**

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Sắc Ký Hải Đăng

CÔNG TY CP DV KHCN SẮC KÝ HẢI ĐĂNG
SAC KY HAI DANG SCIENCE - TECHNOLOGY
SERVICES JOINT-STOCK COMPANY
VP & PTN : 79 Trương Định, Quận 1, Tp.Hồ Chí Minh, Việt Nam
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E-mail : info@sackyhaidang.com.vn
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BUREAU OF ACCREDITATION VIETNAM
VILAS 233

Số: 1202 0811/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020448 / 1202161

Đơn vị yêu cầu: **CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2**

Nơi lấy mẫu: **DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4**

Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận

Ngày nhận mẫu: 09/02/2012 **Ngày trả kết quả:** 17/02/2012

Người lấy mẫu: **Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh**

Loại mẫu: Đất sét pha cát **Số lượng:** 01 mẫu

Phương pháp lấy mẫu: TCVN 5297 : 1995

Vị trí lấy mẫu: **Tại khu dân cư xóm 7**

Tại tọa độ LAT 11^0 19'00.7 " LONG 108^0 46'56.3"

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* Zn	mg/Kg	TCVN 6496 – 2009	27,79
02	As	mg/Kg	TCVN 6496 – 2009	2,02
03	* Pb	mg/Kg	TCVN 6496 – 2009	12,83
04	* Cu	mg/Kg	TCVN 6496 – 2009	3,59
05	* Cd	mg/Kg	TCVN 6496 – 2009	KPH(LOD=0,017)
06	Dầu mỡ tổng	mg/Kg	TCVN 6496 – 2009	19,92

Ghi chú: *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

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S.Đ.K.K.D: 0305503860 - C.T.C.P
CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG
QUẬN 1 - TP. HỒ CHÍ MINH

4

Sắc Ký Hải Đăng
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SẮC KY HAI DANG SCIENCE - TECHNOLOGY
SERVICES JOINT-STOCK COMPANY
VP & PTN : 79 Trương Định, Quận 1, Tp.Hồ Chí Minh, Việt Nam
Điện Thoại : (84.8) 3823 9843 / 3824 8814 - Fax (84.8) 3823 9872
E-mail : info@sackyhaidang.com.vn
Bộ Nông Nghiệp & PTNT chỉ định kiểm nghiệm chất lượng Nông Lâm Thủy Sản
VILAS 238

Số: 1202 0810/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020447 / 1202161

Đơn vị yêu cầu: CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2
Nơi lấy mẫu: DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4
Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận
Ngày nhận mẫu: 09/02/2012 **Ngày trả kết quả:** 17/02/2012
Người lấy mẫu: Hồ Phùng Tâm; Lê Anh Bằng, Nguyễn Văn Sinh
Loại mẫu: Đất sét pha cát **Số lượng:** 01 mẫu
Phương pháp lấy mẫu: TCVN 5297 : 1995
Vị trí lấy mẫu: **Tại khu vực dự án VT4 nhà số 484 Thôn Vĩnh Tiến, Xã Vĩnh Tân, H.Tuy Phong, T. Bình Thuận.**
Tại tọa độ LAT 11^0 19'00.6 " LONG 108^0 47'32.2"

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* Zn	mg/Kg	TCVN 6496 – 2009	8,25
02	As	mg/Kg	TCVN 6496 – 2009	0,50
03	* Pb	mg/Kg	TCVN 6496 – 2009	13,79
04	* Cu	mg/Kg	TCVN 6496 – 2009	1,81
05	* Cd	mg/Kg	TCVN 6496 – 2009	KPH(LOD=0,017)
06	Dầu mỡ tổng	mg/Kg	TCVN 6496 – 2009	14,99

Ghi chú: Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

Phụ trách chất lượng **TỔNG GIÁM ĐỐC**

S.Đ.K.K.D: 0305305868 - C.T.C.P ★ QUẬN 1 - TP. HỒ CHÍ MINH
CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG

Sắc Ký Hải Đăng
CÔNG TY CP DV KHCN SẮC KÝ HẢI ĐĂNG
SAC KY HAI DANG SCIENCE - TECHNOLOGY
SERVICES JOINT-STOCK COMPANY
VP & PTN : 79 Trương Định, Quận 1, Tp.Hồ Chí Minh, Việt Nam
Điện Thoại : (84.8) 3823 9643 / 3824 8814 - Fax (84.8) 3823 9872
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VILAS 238

Số: 1202 0809/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020446 / 1202161

Đơn vị yêu cầu: CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2

Nơi lấy mẫu: DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4

Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận

Ngày nhận mẫu: 09/02/2012 **Ngày trả kết quả:** 17/02/2012

Người lấy mẫu: Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh

Loại mẫu: Nước ngầm **Số lượng:** 01 mẫu

Phương pháp lấy mẫu: TCVN 5992 : 1995

Vị trí lấy mẫu: **Tại khu dân cư hiện hữu gần khu vực dự án nhà hộ dân Đinh Thị Ngát Số 453 Thôn Vĩnh Tiến, Xã Vĩnh Tân, H.Tuy Phong, T. Bình Thuận. Đối diện DNDT Tôm Giống Trần Hậu Điền Tại tọa độ LAT 11^0 19'27.3 " LONG 108^0 48'53.9"**

Ghi chú: *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

Phụ trách chất lượng	**TỔNG GIÁM ĐỐC**
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6

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CÔNG TY
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DỊCH VỤ KHOA HỌC
CÔNG NGHỆ
SẮC KÝ
HẢI ĐĂNG
Q.1 - TP HỒ CHÍ MINH

BẢNG KẾT QUẢ

Mã số: 12020446 / 1202161

Trang 2/2

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* pH	-	TCVN 6492 - 1999	7,66
02	* COD	mg/L	SMEWW 5220 C – 2005	3
03	* TS	mg/L	SMEWW 2540 D – 2005	552
04	NO_3^-	mg/L	SMEWW 4500 – 2005	32,05
05	* NO_2^-	mg/L	TCVN 6178 – 1996	15,59
06	* NH_4^+	mg/L	TCVN 5988 – 1995	KPH(LOD=0,05)
07	* Độ cứng	$mgCaCO_3$/L	SMEWW 2340C - 2005	152,50
08	F^-	mg/L	SMEWW 4500 – 2005	1,32
09	* SO_4^{2-}	mg/L	SMEWW 4500 – 2005	31,21
10	* CN^-	mg/L	TCVN 6181 – 1996	KPH(LOD=0,05)
11	* Cl^-	g/L	SMEWW 4500 – 2005	95,14
12	* As	mg/L	SMEWW 3500 – 2005	0,0020
13	* Fe	mg/L	SMEWW 3500 – 2005	0,29
14	* Coliforms	MPN/100mL	TCVN 6187 – 2 : 1996	$9,3x10^2$

7

Sắc Ký Hải Đăng

CÔNG TY CP DV KHCN SẮC KÝ HẢI ĐĂNG
SAC KY HAI DANG SCIENCE - TECHNOLOGY SERVICES JOINT-STOCK COMPANY
VP & PTN : 79 Trương Định, Quận 1, Tp.Hồ Chí Minh, Việt Nam
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E-mail : info@sackyhaidang.com.vn
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BUREAU OF ACCREDITATION VIETNAM VILAS 238

Số: 1202 0808/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020445 / 1202161

Đơn vị yêu cầu: CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2

Nơi lấy mẫu: DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4

Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận

Ngày nhận mẫu: 09/02/2012 **Ngày trả kết quả:** 17/02/2012

Người lấy mẫu: Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh

Loại mẫu: Nước ngầm **Số lượng:** 01 mẫu

Phương pháp lấy mẫu: TCVN 5992 : 1995

Vị trí lấy mẫu: **Khu vực Bãi Xi nhà hộ dân Trần Văn Hội**

453 Thôn Vĩnh Phúc, Xã Vĩnh Tân, H.Tuy Phong, T. Bình Thuận

Tại tọa độ LAT 11^0 20'09.6 " LONG 108^0 47'29.2"

Ghi chú: *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

Phụ trách chất lượng **TỔNG GIÁM ĐỐC**

S.Đ.K.K.D: 0305905860 - C.T.C.P. CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG QUẬN 1 - TP. HỒ CHÍ MINH

TS Phạm Thị Ánh **TS Diệp Ngọc Sương**

8

BẢNG KẾT QUẢ

Mã số: 12020445 / 1202161

Trang 2/2

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* pH	-	TCVN 6492 - 1999	7,20
02	* COD	mg/L	SMEWW 5220 C – 2005	3
03	* TS	mg/L	SMEWW 2540 D – 2005	154
04	NO_3^-	mg/L	SMEWW 4500 – 2005	13,08
05	* NO_2^-	mg/L	TCVN 6178 – 1996	0,056
06	* NH_4^+	mg/L	TCVN 5988 – 1995	KPH(LOD=0,05)
07	* Độ cứng	$mgCaCO_3/L$	SMEWW 2340C - 2005	26
08	F^-	mg/L	SMEWW 4500 – 2005	1,09
09	* SO_4^{2-}	mg/L	SMEWW 4500 – 2005	11,29
10	* CN^-	mg/L	TCVN 6181 – 1996	KPH(LOD=0,05)
11	* Cl^-	g/L	SMEWW 4500 – 2005	30,53
12	* As	mg/L	SMEWW 3500 – 2005	0,00075
13	* Fe	mg/L	SMEWW 3500 – 2005	0,21
14	* Coliforms	MPN/100mL	TCVN 6187 – 2 : 1996	$4,6x10^3$

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VILAS 238

Số: 1202 0807/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020444 / 1202161

Đơn vị yêu cầu: **CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2**

Nơi lấy mẫu: **DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4**

Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận

Ngày nhận mẫu: 18h35phút, 09/02/2012 **Ngày trả kết quả:** 17/02/2012

Người lấy mẫu: **Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh**

Loại mẫu: Nước ngầm **Số lượng:** 01 mẫu

Phương pháp lấy mẫu: TCVN 5992 : 1995

Vị trí lấy mẫu: **Tại khu dân cư hiện hữu gần khu vực dự án (xóm 7)**

194 Thôn Vĩnh Tiến, Xã Vĩnh Tân, H.Tuy Phong, T. Bình Thuận

Đối diện Công Ty Hải Thu

Tại tọa độ LAT 11^0 18'46.9 " LONG 108^0 46'55.7"

<u>*Ghi chú:*</u> *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

Phụ trách chất lượng **TỔNG GIÁM ĐỐC**

CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG
S.Đ.K.K.D: 0305905860 - C.T.C.P - QUẬN 1 - TP. HỒ CHÍ MINH

TS Phạm Thị Ánh **TS Diệp Ngọc Sương**

S.Đ.K.K.D: 0305905860 - C.T.C.P ★ CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG ★ QUẬN 1 - TP. HỒ CHÍ MINH

BẢNG KẾT QUẢ

Mã số: 12020444 / 1202161

Trang 2/2

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* pH	-	TCVN 6492 - 1999	8,15
02	* COD	mg/L	SMEWW 5220 C – 2005	3
03	* TS	mg/L	SMEWW 2540 D – 2005	11 650
04	NO_3^-	mg/L	SMEWW 4500 – 2005	36,78
05	* NO_2^-	mg/L	TCVN 6178 – 1996	0,15
06	* NH_4^+	mg/L	TCVN 5988 – 1995	KPH(LOD=0,05)
07	* Độ cứng	$mgCaCO_3/L$	SMEWW 2340C - 2005	1 960
08	F^-	mg/L	SMEWW 4500 – 2005	1,23
09	* SO_4^{2-}	mg/L	SMEWW 4500 – 2005	553,33
10	* CN^-	mg/L	TCVN 6181 – 1996	KPH(LOD=0,05)
11	* Cl^-	g/L	SMEWW 4500 – 2005	5 680
12	* As	mg/L	SMEWW 3500 – As – 2005	0, 0044
13	* Fe	mg/L	SMEWW 3500 – 2005	0,22
14	* Coliforms	MPN/100mL	TCVN 6187 – 2 : 1996	$9,3x10^1$

Sắc Ký Hải Đăng

CÔNG TY CP DV KHCN SẮC KÝ HẢI ĐĂNG
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VILAS 238

Số: 1202 0806/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020443 / 1202161

Trang 1/2

Đơn vị yêu cầu: CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2

Nơi lấy mẫu: DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4

Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận

Ngày nhận mẫu: 18h35phút, 09/02/2012 **Ngày trả kết quả:** 17/02/2012

Người lấy mẫu: Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh

Loại mẫu: Nước biển **Số lượng:** 01 mẫu

Phương pháp lấy mẫu: TCVN 5992 : 1995

Vị trí lấy mẫu: Tại cảng 3000DWT của địa phương cách 700m (lúc triều lên) lấy ở độ sâu 2,0m

Tại tọa độ LAT 11^0 18'33.5 " LONG 108^0 47'29.48"

<u>*Ghi chú:*</u> *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

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12

CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG

BẢNG KẾT QUẢ

Mã số: 12020443 / 1202161

Trang 2/2

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* pH	-	TCVN 6492 - 1999	7,97
02	* COD	mg/L	SMEWW 5220 C – 2005	5
03	* BOD_5	mg/L	SMEWW 5210 B – 2005	KPH(LOD=1)
04	* TSS	mg/L	SMEWW 2540 D – 2005	8
05	Nhiệt độ	^0C	EUTECH 510	28,6
06	DO	mgO/L	SMEWW 4500 – O.C - 2005	6,4
07	EC	µS/cm	District 3 HANNA	59 000
08	NO_3^-	mg/L	SMEWW 4500 – 2005	0,32
09	* NO_2^-	mg/L	TCVN 6178 – 1996	KPH(LOD=0,01)
10	* NH_4^+	mg/L	TCVN 5988 – 1995	KPH(LOD=0,05)
11	* PO_4^{3-}	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,1)
12	* Cl^-	g/L	SMEWW 4500 – 2005	18,96
13	Clo dư	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,04)
14	* Hg	mg/L	SMEWW 3112B – 2005	KPH(LOD=0,0001)
15	* Pb	mg/L	SMEWW 3500 – 2005	0,0010
16	* Cu	mg/L	SMEWW 3500 - 2005	KPH(LOD=0,013)
17	* Ni	mg/L	SMEWW 3500 – 2005	KPH(LOD=0,013)
18	* Fe	mg/L	SMEWW 3500 – 2005	0,27

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VILAS 238

Số: 1202 0805/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020442 / 1202161

Trang 1/2

Đơn vị yêu cầu: CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2

Nơi lấy mẫu: DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4

Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận

Ngày nhận mẫu: 18h10phút, 09/02/2012 **Ngày trả kết quả:** 17/02/2012

Người lấy mẫu: **Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh**

Loại mẫu: Nước biển **Số lượng:** 01 mẫu

Phương pháp lấy mẫu: TCVN 5992 : 1995

Vị trí lấy mẫu: **Tại điểm xả nước làm mát dự kiến của VT4 (lúc triều lên)**

lấy ở độ sâu 2,0m

Tại tọa độ LAT 11^0 18'33.5 " LONG 108^0 47'29.48"

Ghi chú: *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

Phụ trách chất lượng **TỔNG GIÁM ĐỐC**

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141

S.Đ.K.K.D: 0305905860 - C.T.C.P
CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG
QUẬN 1 - TP. HỒ CHÍ MINH

BẢNG KẾT QUẢ

Mã số: 12020441 / 1202161

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* pH	-	TCVN 6492 - 1999	7,99
02	* COD	mg/L	SMEWW 5220 C - 2005	3
03	* BOD_5	mg/L	SMEWW 5210 B – 2005	KPH(LOD=1)
04	* TSS	mg/L	SMEWW 2540 D – 2005	6
05	Nhiệt độ	^0C	EUTECH 510	28,9
06	DO	mgO/L	SMEWW 4500 – O.C - 2005	5,8
07	EC	µS/cm	District 3 HANNA	59 800
08	NO_3^-	mg/L	SMEWW 4500 – 2005	0,32
09	* NO_2^-	mg/L	TCVN 6178 – 1996	KPH(LOD=0,01)
10	* NH_4^+	mg/L	TCVN 5988 – 1995	KPH(LOD=0,05)
11	* PO_4^{3-}	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,1)
12	* Cl^-	g/L	SMEWW 4500 – 2005	19,03
13	Clo dư	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,04)
14	* Hg	mg/L	SMEWW 3112 – B – 2005	KPH(LOD=0,0001)
15	* Pb	mg/L	SMEWW 3500 – 2005	0,00044
16	* Cu	mg/L	SMEWW 3500 - 2005	KPH(LOD=0,013)
17	* Ni	mg/L	SMEWW 3500 – Ni – 2005	KPH(LOD=0,013)
18	* Fe	mg/L	SMEWW 3500 – 2005	0,30
			[illegible] – 2005	KPH(LOD=0,01)

Sắc Ký Hải Đăng

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VILAS 238

Số: 1202 0805/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020442 / 1202161

Trang 1/2

Đơn vị yêu cầu: **CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2**

Nơi lấy mẫu: **DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4**

Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận

Ngày nhận mẫu: 18h10phút, 09/02/2012 **Ngày trả kết quả:** 17/02/2012

Người lấy mẫu: **Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh**

Loại mẫu: Nước biển **Số lượng:** 01 mẫu

Phương pháp lấy mẫu: TCVN 5992 : 1995

Vị trí lấy mẫu: **Tại điểm xả nước làm mát dự kiến của VT4 (lúc triều lên)**

lấy ở độ sâu 2,0m

Tại tọa độ LAT 11^0 18'33.5 " LONG 108^0 47'29.48"

<u>*Ghi chú:*</u> *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

Phụ trách chất lượng **TỔNG GIÁM ĐỐC**

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TS Phạm Thị Ánh **TS Diệp Ngọc Sương**

16

CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG

BẢNG KẾT QUẢ

Mã số: 12020442 / 1202161

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* pH	-	TCVN 6492 - 1999	7,99
02	* COD	mg/L	SMEWW 5220 C - 2005	3
03	* BOD_5	mg/L	SMEWW 5210 B – 2005	KPH(LOD=1)
04	* TSS	mg/L	SMEWW 2540 D – 2005	6
05	Nhiệt độ	^0C	EUTECH 510	28,6
06	DO	mgO/L	SMEWW 4500 – O.C - 2005	6,4
07	EC	µS/cm	District 3 HANNA	58 800
08	NO_3^-	mg/L	SMEWW 4500 – 2005	0,33
09	* NO_2^-	mg/L	TCVN 6178 – 1996	KPH(LOD=0,01)
10	* NH_4^+	mg/L	TCVN 5988 – 1995	KPH(LOD=0,05)
11	* PO_4^{3-}	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,1)
12	* Cl^-	g/L	SMEWW 4500 – 2005	19,03
13	Clo dư	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,04)
14	* Hg	mg/L	SMEWW 3112 – B – 2005	KPH(LOD=0,0001)
15	* Pb	mg/L	SMEWW 3500 – 2005	0,0011
16	* Cu	mg/L	SMEWW 3500 - 2005	KPH(LOD=0,013)
17	* Ni	mg/L	SMEWW 3500 – Ni – 2005	KPH(LOD=0,013)
18	* Fe	mg/L	SMEWW 3500 – 2005	0,28

Sắc Ký Hải Đăng
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VILAS 238

Số: 1202 0803/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020440 / 1202161

Trang 1/2

Đơn vị yêu cầu: **CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2**

Nơi lấy mẫu: **DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4**

Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận

Ngày nhận mẫu: 09h45phút, 09/02/2012 **Ngày trả kết quả:** 17/02/2012

Người lấy mẫu: **Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh**

Loại mẫu: Nước biển **Số lượng:** 01 mẫu

Phương pháp lấy mẫu: TCVN 5992 : 1995

Vị trí lấy mẫu: **Tại khu vực cảng VT4, VT3 (lúc triều xuống)**

lấy ở độ sâu 2,0m

Tại tọa độ LAT 11^0 18'21.2 " LONG 108^0 48'00.0"

Ghi chú: *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

Phụ trách chất lượng	TỔNG GIÁM ĐỐC
TS Phạm Thị Ánh	TS Diệp Ngọc Sương

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18

S.D.K.K.D: 0305805860 - C.T.C.P ★ CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG ★ QUẬN 1 - TP. HỒ CHÍ MINH

BẢNG KẾT QUẢ

Mã số: 12020440 / 1202161

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* pH	-	TCVN 6492 - 1999	7,99
02	* COD	mg/L	SMEWW 5220 C - 2005	2
03	* BOD_5	mg/L	SMEWW 5210 B – 2005	KPH(LOD=1)
04	* TSS	mg/L	SMEWW 2540 D – 2005	5
05	Nhiệt độ	^0C	EUTECH 510	29,1
06	DO	mgO/L	SMEWW 4500 – O.C - 2005	6,6
07	EC	µS/cm	District 3 HANNA	58 950
08	NO_3^-	mg/L	SMEWW 4500 – 2005	0,31
09	* NO_2^-	mg/L	TCVN 6178 – 1996	KPH(LOD=0,01)
10	* NH_4^+	mg/L	TCVN 5988 – 1995	KPH(LOD=0,05)
11	* PO_4^{3-}	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,1)
12	* Cl^-	g/L	SMEWW 4500 – 2005	18,82
13	Clo dư	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,04)
14	* Hg	mg/L	SMEWW 3112 – B – 2005	KPH(LOD=0,0001)
15	* Pb	mg/L	SMEWW 3500 – 2005	0,00042
16	* Cu	mg/L	SMEWW 3500 - 2005	KPH(LOD=0,013)
17	* Ni	mg/L	SMEWW 3500 – Ni – 2005	KPH(LOD=0,013)
18	* Fe	mg/L	SMEWW 3500 – 2005	0,31

Sắc Ký Hải Đăng
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VILAS 238

Số: 1202 0802/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020439 / 1202161

Trang 1/2

Đơn vị yêu cầu: **CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2**

Nơi lấy mẫu: **DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4**

Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận

Ngày nhận mẫu: 09h00phút, 09/02/2012 **Ngày trả kết quả:** 17/02/2012

Người lấy mẫu: **Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh**

Loại mẫu: Nước biển **Số lượng:** 01 mẫu

Phương pháp lấy mẫu: TCVN 5992 : 1995

Vị trí lấy mẫu: **Gần khu vực điểm xả phía đông của TTDL (lúc triều xuống) lấy ở độ sâu 2,0m**

Tại tọa độ LAT 11^0 18'45.00 " LONG 108^0 48'49.95"

<u>Ghi chú:</u> *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

Phụ trách chất lượng	**TỔNG GIÁM ĐỐC**
	CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG · S.Đ.K.K.D: 0305905860 · QUẬN 1 - TP HỒ CHÍ MINH
TS Phạm Thị Ánh	**TS Diệp Ngọc Sương**

S.Đ.K.K.D: 0305805160 - C.T.C.P
CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG
QUẬN 1 - TP HỒ CHÍ MINH

BẢNG KẾT QUẢ

Mã số: 12020439 / 1202161

Trang 2/2

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* pH	-	TCVN 6492 - 1999	7,98
02	* COD	mg/L	SMEWW 5220 C - 2005	2
03	* BOD_5	mg/L	SMEWW 5210 B – 2005	KPH(LOD=1)
04	* TSS	mg/L	SMEWW 2540 D – 2005	5
05	Nhiệt độ	^0C	EUTECH 510	29,0
06	DO	mgO/L	SMEWW 4500 – O.C - 2005	6,3
07	EC	µS/cm	District 3 HANNA	59 200
08	NO_3^-	mg/L	SMEWW 4500 – 2005	0,29
09	* NO_2^-	mg/L	TCVN 6178 – 1996	KPH(LOD=0,01)
10	* NH_4^+	mg/L	TCVN 5988 – 1995	KPH(LOD=0,05)
11	* PO_4^{3-}	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,1)
12	* Cl^-	g/L	SMEWW 4500 – 2005	18,89
13	Clo dư	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,04)
14	* Hg	mg/L	SMEWW 3112 – B – 2005	KPH(LOD=0,0001)
15	* Pb	mg/L	SMEWW 3500 – 2005	0,00048
16	* Cu	mg/L	SMEWW 3500 - 2005	KPH(LOD=0,013)
17	* Ni	mg/L	SMEWW 3500 – Ni – 2005	KPH(LOD=0,013)
18	* Fe	mg/L	SMEWW 3500 – 2005	0,28

Sắc Ký Hải Đăng
CÔNG TY CP DV KHCN SẮC KÝ HẢI ĐĂNG
SAC KY HAI DANG SCIENCE - TECHNOLOGY SERVICES JOINT-STOCK COMPANY
VP & PTN : 79 Trương Định, Quận 1, Tp.Hồ Chí Minh, Việt Nam
Điện Thoại : (84.8) 3823 9643 / 3824 8814 - Fax (84.8) 3823 9672
E-mail : info@sackyhaidang.com.vn
Bộ Nông Nghiệp & PTNT chỉ định kiểm nghiệm chất lượng Nông Lâm Thủy Sản

Số: 1202 0801/KQ

KẾT QUẢ PHÂN TÍCH

Mã số: 12020438 / 1202161

Trang 1/2

Đơn vị yêu cầu: **CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2**

Nơi lấy mẫu: **DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4**

Địa chỉ: Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận

Ngày nhận mẫu: 08h15phút, 09/02/2012 **Ngày trả kết quả:** 17/02/2012

Người lấy mẫu: **Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh**

Loại mẫu: Nước biển **Số lượng:** 01 mẫu

Phương pháp lấy mẫu: TCVN 5992 : 1995

Vị trí lấy mẫu: **Tại Luồng Tàu (lúc triều xuống) lấy ở độ sâu 2,0m**

Tại tọa độ LAT 11^0 17'44.4 " LONG 108^0 50'01.56"

Ghi chú: *Thời gian lưu mẫu: 5 ngày kể từ ngày trả kết quả.*
(*): Chỉ tiêu được VILAS công nhận.(ISO 17025 : 2005)

Phụ trách chất lượng **TỔNG GIÁM ĐỐC**

CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG
S.Đ.K.K.D: 0305905860 - C.T.C.P. * QUẬN 1 - TP. HỒ CHÍ MINH *

TS Phạm Thị Ánh **TS Diệp Ngọc Sương**

CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG
S.Đ.K.K.D: 0305905860 - C.T.C.P
QUẬN 1 - TP HỒ CHÍ MINH

BẢNG KẾT QUẢ

Mã số: 12020438 / 1202161

Trang 2/2

TT	CHỈ TIÊU	ĐƠN VỊ	PHƯƠNG PHÁP THỬ	KẾT QUẢ
01	* pH	-	TCVN 6492 - 1999	7,99
02	* COD	mg/L	SMEWW 5220 C - 2005	2
03	* BOD_5	mg/L	SMEWW 5210 B – 2005	KPH(LOD=1)
04	* TSS	mg/L	SMEWW 2540 D – 2005	5
05	Nhiệt độ	^0C	EUTECH 510	28,9
06	DO	mgO/L	SMEWW 4500 – O.C - 2005	6,5
07	EC	µS/cm	District 3 HANNA	60 500
08	NO_3^-	mg/L	SMEWW 4500 – 2005	0,31
09	* NO_2^-	mg/L	TCVN 6178 – 1996	KPH(LOD=0,01)
10	* NH_4^+	mg/L	TCVN 5988 – 1995	KPH(LOD=0,05)
11	* PO_4^{3-}	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,1)
12	* Cl^-	g/L	SMEWW 4500 – 2005	18,82
13	Clo dư	mg/L	SMEWW 4500 – 2005	KPH(LOD=0,04)
14	* Hg	mg/L	SMEWW 3112 B – 2005	KPH(LOD=0,0001)
15	* Pb	mg/L	SMEWW 3500 – 2005	KPH(LOD=0,00025)
16	* Cu	mg/L	SMEWW 3500 - 2005	KPH(LOD=0,013)
17	* Ni	mg/L	SMEWW 3500 – Ni – 2005	KPH(LOD=0,013)
18	* Fe	mg/L	SMEWW 3500 – 2005	0,29

23

CÔNG TY CP DV KHCN SẮC KÝ HẢI ĐĂNG
SAC KY HAI DANG SCIENCE - TECHNOLOGY SERVICES JOINT-STOCK COMPANY
VP & PTN : 79 Trương Định, Quận 1, Tp.Hồ Chí Minh, Việt Nam
Điện Thoại : (84.8) 3823 9643 / 3824 8814 - Fax (84.8) 3823 9872
E-mail : info@sackyhaidang.com.vn
Bộ Nông Nghiệp & PTNT chỉ định kiểm nghiệm chất lượng Nông Lâm Thủy Sản

VILAS 238

Số: 1202 1023A/KQ

KẾT QUẢ ĐO MÔI TRƯỜNG KHÔNG KHÍ

Mã số mẫu: 1202 0430 – 1202 0437/1202 161

(Trang 1/6)

1. **Đơn vị yêu cầu:** **CÔNG TY CỔ PHẦN TƯ VẤN XÂY DỰNG ĐIỆN 2**
2. **Nơi lấy mẫu:** **DỰ ÁN NHÀ MÁY ĐIỆN VĨNH TÂN 4**
3. **Địa chỉ:** **Thôn Vĩnh Phúc, Xã Vĩnh Tân, Huyện Tuy Phong, Tỉnh Bình Thuận**
4. **Ngày lấy mẫu:** 07,08/02/2012 - **Ngày trả kết quả:** 17/02/2012
5. **Người lấy mẫu:** Hồ Phùng Tâm, Lê Anh Bằng, Nguyễn Văn Sinh.
6. **Phương pháp lấy mẫu và phân tích:**

NO_2: TCVN 6137:1996; ISO 6768 – 1985	SO_2: TCVN 5971:1995; ISO 6767-1990
CO: Tiêu chuẩn ngành 52 TCN 352 – 89	**Bụi:** TCVN 5067 – 1995; 7241:2003
H_2S: TQKT BYT - 2002	**Vi khí hậu:** Máy đo nhanh.
Độ ồn tích phân: TCVN 5964:1995 TQKT YHLĐ &VSMT 2002	
Độ rung: TCVN 6963:2001; TCVN 7191:2002	

7. **Kết quả phân tích:** *(xem Trang 2/2)*

Phụ trách chất lượng

TS. Phạm Thị Ánh

TỔNG GIÁM ĐỐC

S.Đ.K.K.D: 0305909... C.T.C.P. CÔNG TY CỔ PHẦN DỊCH VỤ KHOA HỌC CÔNG NGHỆ SẮC KÝ HẢI ĐĂNG QUẬN 1 - TP. HỒ CHÍ MINH

TS. Diệp Ngọc Sương

211

BẢNG KẾT QUẢ PHÂN TÍCH

Mã số mẫu: 1202 0430 – 1202 0437/1202 161

(Trang 2/6)

Vị trí lấy mẫu	Thời gian lấy mẫu lúc	Tọa độ
K1: Tại khu vực dự án VT4	6h00 phút	LAT 11^{0}19'10.0" LONG 108^{0}47'31.3"
K2: Tại khu dân cư xóm 7	7h10 phút	LAT 11018'59.0" LONG 108047'11.2"
K3: Khu vực UBND Xã Vĩnh Tân	10h30 phút	LAT 11^{0}19'27.1" LONG 108^{0}49'09.06"
K4: Tại khu vực Trên Đường Quốc Lộ 1A, Km 1597	11h40 phút	LAT 11^{0}19'29.0" LONG 108^{0}48'15.3"
K5: Tại khu vực Bãi Xi	8h30 phút	LAT 11020'06.5" LONG 108047'44.6"
K6: Tại khu vực trên đường vào Bãi Xi	9h00 phút	LAT 11019'38.4" LONG 108047'26.0"
K7: Tại khu dân cư phía Đông Bắc thị trấn Đức Linh	11h10 phút	LAT 11^{0}19'21.9" LONG 108^{0}48'45.1"
K8: Tại khu vực Cà Ná	9h50 phút	LAT 11020'02.9" LONG 108050'41.8"

$K_{x,y,z}$: Giá trị đo tại vị trí **x** trong giờ đo thứ **y**, lần đo thứ **z**.

Mã số	Vị trí đo	* NO_2 (mg/m^3)	* SO_2 (mg/m^3)	CO (mg/m^3)	* Bụi (mg/m^3)	*Bụi PM10 (mg/m^3)	H_2S (mg/m^3)	Nhiệt độ (^{0}C)	Độ ẩm (%)	T/độ gió (m/s)
1202 0430	K1	0,063	0,075	1,36	0,15	0,08	KPH	28,3	71,6	0,1 – 0,3
1202 0431	K2	0,078	0,082	1,46	0,17	0,09	KPH	29,5	68,5	0,0 – 0,1
1202 0432	K3	0,056	0,10	2,05	0,18	0,07	KPH	33,3	60,7	0,2 – 0,5
1202 0433	K4	0,11	0,13	2,80	0,16	0,10	KPH	34,4	55,5	0,5 – 0,9
1202 0434	K5	0,060	0,10	1,50	0,17	0,11	KPH	31,5	65,4	0,1 – 0,4
1202 0435	K6	0,081	0,064	2,10	0,19	0,14	KPH	29,7	70,1	0,1 – 0,3
1202 0436	K7	0,087	0,096	1,46	0,14	0,09	KPH	33,9	61,7	0,2 – 0,7
1202 0437	K8	0,054	0,077	1,47	0,21	0,15	KPH	32,7	60,9	0,3 – 1,0

Ghi chú: - Vi khí hậu, Tiếng ồn: đo tại hiện trường theo biên bản lấy mẫu số: **MTPT12020708/02EDC-HD.**

- (*): Chỉ tiêu được VILAS công nhận; KPH: không phát hiện; Kết quả có giá trị tại thời điểm lấy mẫu.

BẢNG KẾT QUẢ ĐO ĐỘ ỒN TÍCH PHÂN & ĐỘ RUNG

Mã số mẫu: 1202 0430 – 1202 0437/1202 161

KẾT QUẢ ĐO ĐỘ RUNG

TT	THÔNG SỐ	ĐƠN VỊ	KẾT QUẢ							
			K1		K2		K3		K4	
1	Độ rung		Phương đứng	Phương ngang	Phương đứng	Phương ngang	Phương đứng	Phương ngang	Phương đứng	Phương ngang
	Gia tốc (ACC)	m/s^2	<0,0098	<0,0098	<0,0098	<0,0098	<0,0098	<0,0098	<0,0098	<0,0098
	Vận tốc (VEL)	cm/s	<0,0001	<0,0001	0,0020	0,0014	0,0033	0,0012	0,0040	0,0037
	Biên độ (DISP)	µm	0,02	0,01	0,08	0,08	0,08	0,05	0,07	0,03
			K5		K6		K7		K8	
			Phương đứng	Phương ngang	Phương đứng	Phương ngang	Phương đứng	Phương ngang	Phương đứng	Phương ngang
	Gia tốc (ACC)	m/s^2	<0,0098	<0,0098	<0,0098	<0,0098	<0,0098	<0,0098	<0,0098	<0,0098
	Vận tốc (VEL)	cm/s	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001	<0,0028	<0,0020
	Biên độ (DISP)	µm	0,02	0,02	0,02	0,01	0,02	0,03	0,04	0,04

KẾT QUẢ ĐO ĐỘ ỒN TÍCH PHÂN

TT	THÔNG SỐ		ĐƠN VỊ	KẾT QUẢ				
				K1	K5	K6	K7	K8
2	Độ ồn tích phân	L_{peak}	dBA	82,5	89,4	97,1	84,6	119,8
		L_{50}		50,1	60,2	57,3	59,1	70,4
		L_{90}		48,2	58,4	49,4	54,2	63,2
		L_{max}		67,7	76,2	86,5	69,2	90,3
		L_{min}		46,0	56,1	43,7	54,8	56,7
		L_{EQA}		54,9	63,5	64,8	62,1	76,9

BẢNG KẾT QUẢ ĐO ĐỘ ỒN TÍCH PHÂN

Mã số mẫu: 1202 0430 – 1202 0437/1202 161

TT	THÔNG SỐ		ĐƠN VỊ	KẾT QUẢ											
				$K_{2.1.1}$	$K_{2.2.2}$	$K_{2.3.1}$	$K_{2.4.1}$	$K_{2.5.1}$	$K_{2.6.1}$	$K_{2.7.1}$	$K_{2.8.1}$	$K_{2.9.1}$	$K_{2.10.1}$	$K_{2.11.1}$	$K_{2.12.1}$
	Độ ồn tích phân	L_{peak}	dBA	110,2	108,7	108,9	113,1	106,3	114,2	100,6	110,5	99,7	97,5	113,1	100,8
		L_{50}		70,1	64,8	61,8	59,7	63,1	63,8	62,1	68,7	59,4	60,1	62,8	61,3
		L_{90}		64,6	53,1	52,6	53,4	54,8	59,4	53,4	62,4	55,1	52,6	55,4	52,1
		L_{max}		88,6	86,5	86,4	90,1	88,7	92,7	82,6	90,4	82,8	83,8	91,2	86,3
		L_{min}		58,3	48,6	45,5	46,6	50,1	54,2	50,3	56,3	48,7	46,5	48,8	46,3
		L_{EQA}		75,5	70,2	71,5	68,8	67,8	74,8	68,8	73,1	62,8	68,8	67,2	68,5
				$K_{2.1.2}$	$K_{2.2.2}$	$K_{2.3.2}$	$K_{2.4.2}$	$K_{2.5.2}$	$K_{2.6.2}$	$K_{2.7.2}$	$K_{2.8.2}$	$K_{2.9.2}$	$K_{2.10.2}$	$K_{2.11.2}$	$K_{2.12.2}$
3	Độ ồn tích phân	L_{peak}	dBA	106,5	120,7	113,8	112,6	109,1	114,2	112,8	116,5	109,3	117,9	115,8	109,7
		L_{50}		62,9	62,6	63,1	63,7	64,6	66,1	63,7	63,3	61,0	63,7	60,3	59,8
		L_{90}		57,8	53,5	55,4	54,9	58,7	58,4	59,3	56,4	52,9	54,3	53,8	52,6
		L_{max}		85,3	92,5	91,5	90,6	89,3	90,8	88,9	87,0	86,8	92,7	90,8	88,6
		L_{min}		52,1	48,6	51,8	47,6	52,4	54,2	52,0	51,5	47,2	46,8	48,6	46,2
		L_{EQA}		69,4	72,1	71,3	72,4	69,7	74,7	69,2	68,8	70,6	72,2	69,7	69,6
				$K_{2.1.3}$	$K_{2.2.3}$	$K_{2.3.3}$	$K_{2.4.3}$	$K_{2.5.3}$	$K_{2.6.3}$	$K_{2.7.3}$	$K_{2.8.3}$	$K_{2.9.3}$	$K_{2.10.3}$	$K_{2.11.3}$	$K_{2.12.3}$
	Độ ồn tích phân	L_{peak}	dBA	106,5	113,5	108,7	105,7	116,3	118,4	107,6	103,1	113,5	113,5	116,5	107,6
		L_{50}		67,5	62,1	64,3	60,4	63,8	62,1	64,1	60,3	61,2	62,6	60,7	60,9
		L_{90}		63,7	52,3	58,5	55,4	58,6	57,4	57,3	53,7	52,1	50,0	53,4	56,1
		L_{max}		82,4	92,6	86,2	89,9	90,1	91,8	90,6	84,3	90,3	92,2	89,0	88,8
		L_{min}		59,6	48,8	48,2	49,8	54,4	54,2	56,1	46,7	46,8	47,6	47,2	46,7
		L_{EQA}		72,5	72,4	72,1	69,2	72,0	70,6	72,3	67,6	72,8	72,7	68,6	68,8

Ghi chú: $K_{x,y,z}$: Giá trị đo tại vị trí **x** trong giờ đo thứ **y**, lần đo thứ **z**.

27

BẢNG KẾT QUẢ ĐO ĐỘ ỒN TÍCH PHÂN

Mã số mẫu: 1202 0430 – 1202 0437/1202 161

(Trang 5/6)

TT	THÔNG SỐ		ĐƠN VỊ	KẾT QUẢ											
				$K_{3.1.1}$	$K_{3.2.1}$	$K_{3.3.1}$	$K_{3.4.1}$	$K_{3.5.1}$	$K_{3.6.1}$	$K_{3.7.1}$	$K_{3.8.1}$	$K_{3.9.1}$	$K_{3.10.1}$	$K_{3.11.1}$	$K_{3.12.1}$
3	Độ ồn tích phân	L_{peak}	dBA	116,5	108,7	108,5	115,7	105,4	108,2	107,5	117,5	98,6	108,7	97,1	100,5
		L_{50}		62,1	59,7	60,2	62,7	59,1	63,4	58,9	63,1	55,1	57,6	53,8	62,1
		L_{90}		51,2	52,0	50,4	53,1	56,7	55,6	50,1	55,8	49,6	53,1	47,7	53,7
		L_{max}		93,2	87,6	86,8	93,2	80,5	84,1	85,1	92,8	76,0	82,8	74,1	86,3
		L_{min}		46,3	45,2	46,8	45,2	46,9	49,6	45,7	51,4	46,6	47,5	41,5	43,5
		L_{EQA}		74,6	65,4	70,8	70,8	64,4	68,8	68,2	70,6	63,4	65,6	61,6	71,8
				$K_{3.1.2}$	$K_{3.2.2}$	$K_{3.3.2}$	$K_{3.4.2}$	$K_{3.5.2}$	$K_{3.6.2}$	$K_{3.7.2}$	$K_{3.8.2}$	$K_{3.9.2}$	$K_{3.10.2}$	$K_{3.11.2}$	$K_{3.12.2}$
	Độ ồn tích phân	L_{peak}	dBA	118,7	103,5	100,6	117,2	114,3	111,0	115,4	114,6	97,8	114,3	95,2	107,6
		L_{50}		64,2	57,4	59,7	61,0	62,9	60,2	58,6	64,3	57,6	61,2	56,8	57,8
		L_{90}		59,7	47,3	50,1	49,7	53,4	53,6	52,3	57,6	51,6	55,8	51,0	49,8
		L_{max}		94,0	82,1	81,1	89,5	88,4	84,6	84,9	89,8	78,3	89,2	76,1	81,7
		L_{min}		52,1	43,7	43,8	45,4	45,8	48,5	46,5	52,0	45,2	50,2	44,4	43,6
		L_{EQA}		75,9	66,7	65,9	68,8	70,7	67,3	64,8	68,8	63,1	67,8	62,8	65,2
				$K_{3.1.3}$	$K_{3.2.3}$	$K_{3.3.3}$	$K_{3.4.3}$	$K_{3.5.3}$	$K_{3.6.3}$	$K_{3.7.3}$	$K_{3.8.3}$	$K_{3.9.3}$	$K_{3.10.3}$	$K_{3.11.3}$	$K_{3.12.3}$
	Độ ồn tích phân	L_{peak}	dBA	106,1	98,7	104,3	117,6	113,4	106,9	105,1	99,4	107,3	103,2	105,4	110,2
		L_{50}		62,1	58,7	60,2	64,1	59,6	61,2	60,1	57,4	60,3	56,4	55,9	58,7
		L_{90}		57,1	49,6	50,2	50,6	52,4	54,6	52,3	51,6	53,8	50,0	47,9	48,1
		L_{max}		82,5	80,6	86,0	96,4	88,7	84,7	84,5	77,8	82,3	79,9	79,5	86,1
		L_{min}		52,8	43,7	45,5	45,3	49,3	49,1	48,4	46,6	46,6	43,9	43,0	43,7
		L_{EQA}		66,0	64,4	68,8	71,8	67,9	69,0	67,3	63,8	67,5	63,7	62,7	68,7

Ghi chú: $K_{x,y,z}$: Giá trị đo tại vị trí x trong giờ đo thứ y, lần đo thứ z.

Appendix 2.1. List of flora in the area

TT	Tên khoa học	Tên Việt Nam	Dạng sống	Đa dạng sinh học	Qúy hiếm
	Lycopodiophyta	**Ngành thạch tùng**			
	Selaginellaceae	**Họ quyền bá**			
1.	*Selaginella tamariscina (Beauv.)*	Quyển bá	K	++	
	Cycadophyta	**Ngành tuế**			
	Cycadaceae	**Họ thiên tuế**			
2.	*Cycas micholitzii Dyer.*	Thiên tuế	K	+	
	Magnoliophyta	**Ngành Hạt kín**			
	Magnoliopsida	**Hai lá mầm**			
	Anacardiaceae	**Họ xoài**			
3.	*Buchanania reticulata Hance*	Ma ca	Gn	+++	
4.	*Anacardium occidentale L.*	Điều	Gn	+++	
	Aslepiadaceae	**Họ thiên lý**			
5.	*Calotropis gigantea (L.) Dryand. ex Ait.f.*	Bồng tím	Tm	+++	
6.	*Streptocaulon kleinii W. & Arn.*	Bạc can	Dl	+	
	Fabaceae	**Họ đậu**			
7.	*Caesalpinia godefroyana*		Gn	+	
8.	*Sindora siamensis Teysm. ex Miq*	Gõ mật	Gl	++	
9.	*Cassia alata L.*	Muồng trâu	Tm	+	
10.	*Bauhinia bracteata (Benth.) Baker*	Móng bò	Dl	+	
11.	*Canavalia maritima (Aubl.) Piper.*	Đậu biển	Dl	++	
12.	*Acacia auriculaeformis A. Cunn. ex Benth.*	Keo lá tram	Gl	+++	
13.	*Pithecellobium dulce (Roxb.) Benth.*	Me keo	Gl	+	
14.	*Mimosa pudica L.*	Trinh nữ	C	+	
	Bignoniaceae	**Họ quao**			
15.	*Markhamia stipulata (Dop) Sant.*	Thò đo	Gl	+++	
	Capparraceae	**Họ cáp**			
16.	*Capparis annamensis (Bak.f.) jac.*	Cáp trung bộ	Gn	++	
17.	*Niebuhria siamensis Kurz.*	Chan chan	Gn	++	
	Combretaceae	**Họ bàng**			
18.	*Combretum quadrangulare Kurz.*	Chưn bầu	Tm	++	
	Connaraceae	**Họ lốp bốp**			
19.	*Connarus cochinchinensis Pierre.*	Lốp bốp	Tm	+++	

	Cucurbitaceae	**Họ bầu bí**			
20.	*Gymnopetalum cochinchinensis (Lour.) Kurz.*	Cứt quạ	Dl	+	
	Dipterocarpaceae	**Họ dầu**			
21.	*Dipterocarpus alatus Roxb.*	Dầu con rái	Gl	+++	
22.	*Shorea siamensis Miq.*	Cẩm lien	Gl	+++	
	Euphorbiaceae	**Họ thầu dầu**			
23.	*Breynia fruticosa (L.) Hook.f.*	Dé bui	Tm	+	
24.	*Jatropha gossypifolia*	Thầu dầu lai	Tm	+	
25.	*Euphorbia antiquorum L*	Xương rồng	Tm	+	
26.	*Opuntia dillenii (Ker-Gawl.) Haw.*	Vợt gai	Tm	+	
	Lamiaceae	**Họ hung**			
27.	*Leonotis nepetifolia (L.) R.Br.*	Sư nhĩ	C	+	
	Lythraceae	**Họ tử vi**			
28.	*Lagerstroemia lecomtei Gagn.*	Bằng lăng	Tm	+	
	Meliaceae	**Họ xoan**			
29.	*Melia azedarach L.*	Xoan	Gl	+++	
30.	*Azadiracta indica Juss. f.*	Sầu đâu	Gl	++	
	Moraceae	**Họ dâu tằm**			
31.	Ficus sp.	Sung	Gl	+	
	Myrtaceae	**Họ sim**			
32.	*Syzygium cumini(L) Druce.*	Trâm mốc	Gl	+	
33.	*Eucalyptus*	Bạch đàn	Gl	+++	
	Rhamnaceae	**Họ táo**			
34.	*Zizyphus oenoplia (L.) Mill.*	Táo rừng	Tm	++	
	Rubiaceae	**Họ cà phê**			
35.	*Randia spinosa Bl.*	Găng gai	Tm	++	
	Rutaceae	**Họ cam**			
36.	*Severinia monophylla*		Tm	++	
37.	*Clausena dimidiata Tan.*	Mơ ray	Tm	++	
38.	*Limnocitrus littorale (Miq.) Sw.*	Cam đường	Tm	++	
	Sapindaceae	**Họ bồ hòn**			
39.	*Dodonea viscosa Jacq.*	Chàng rang	Tm	+++	
40.	*Dimocarpus longan Lour.*	Nhãn rừng	Tm	+++	
	Sterculiaceae	**Họ trôm**			
41.	*Helicteres hirsuta Lour.*	Dó long	Tm	++	
42.	*Melochia nodiflora Swartz.*	Trứng cua	Tm	+	
	Tiliaceae	**Họ đay**			
43.	*Triumphetta pseudocana Sprague & Craib.*	Gai đầu long	C	++	

	Liliopsida	**Một lá mầm**			
	Cyperaceae	**Họ cói**			
44.	*Cyperus bulbosus Vahl.*	Cú	C	+	
45.	*Fimbrisylis argentea (Rottb.) Vahl.*	Mao thư	C	+	
46.	*Kyllinga sesquiflora Torr..*	Bạc đầu	C	+	
47.	*Scleria ciliaris Nees..*	Cương rìa	C	+	
	Poaceae	**Họ lúa**			
48.	*Chloris barbata Sw..*	Lục long	C	+	
49.	*Chrysopogon crevostii A. Cam.*	Cỏ may	C	+	
50.	*Cynodon dactylon (L.) Pers.*	Cỏ chỉ	C	+	
51.	Echinochloa crus-galli (L.)P.Beauvorr	Lồng vực	C	+	
52.	Eleusine indica (L.) Gaertn.	Mần trầu	C	+	
53.	Thysanolaena maxima (Roxb.) O. Ktze.	Cỏ chit	C	+	
54.	Spinifex littoreus (Burm.f.) Merr.	Cỏ chông	C	+	
55.	Eragrostis pilosa (L.) P.Beauv.	Tình thảo	C	+	
	Liliaceae	**Họ bạch huệ**			
56.	*Asparagus cochinchinensis racemorus Willd.*	Thiên môn	Dl	+	

Appendix 2.2. List of infauna in the area

TT	Tên khoa học	Tên Việt Nam	Nguồn	Sự phân bố
	MAMMALIA	**LỚP THÚ**		
	Viverridae	**Họ cày**		
1.	*Paradoxurus hermaphroditus Pallas, 1777*	Cầy vòi hương	PV	1,2
2.	*Viverricula indica Desmarest, 1817*	Cầy hương	PV	1,2
	Sciuridae	**Họ sóc cây**		
3.	*Tamiops rodophei Milne-Edwards, 1868*	Sóc chuột lửa	QS	1,2
	Muridae	**Họ chuột**		
4.	*Rattus exulans*	Chuột lắt	QS	1
	Leporidae	**Họ thỏ**		
5.	*Lepus nigricollis Cuvier, 1823*	Thỏ rừng	PV	1,2
	AVES	**LỚP CHIM**		
	Ardeidae	**Họ diệc**		
1.	*Egretta garzetta Linaeus, 1766*	Cò trắng	QS	1
2.	*Egretta sacra Gmelin, 1789*	Cò đen	QS	1
	Accipitridae	**Họ ưng**		
3.	*Elanus caeruleus Latham, 1790*	Diều trắng	QS	1,2
4.	*Haliaeetus leucogaster Gmelin, 1758*	Đại bàng	PV	1
5.	*Accipiter badius Hume, 1874*	Ưng xám	PV	2
	Phasanidae	**Họ trĩ**		
6.	*Gallus gallus Linnaeus, 1758*	Gà rừng	QS	1
	Artamidae	**Họ nhạn rừng**		
7.	*Artamus fuscus Vieillot, 1817*	Nhạn rừng	QS	1
	Turnicidae	**Họ cun cút**		
8.	*Turnix suscitator Swinhoe,1871*	Cun cút lưng nau	QS	1,2
	Recurvirostridae	**Họ cà kheo**		
9.	*Himantopus himantopus Linnaeus, 1758*	Cà kheo	PV	1
	Charadriidae	**Họ choi choi**		
10.	*Charadrius dubius Gmelin, 1789*	Choi choi nhỏ	TL	1
11.	*Charadrius leschenaultii Lesson,1826*	Choi choi lưng hung	TL	1
	Scolopacidae	**Họ rẽ**		
12.	*Calidris ruficollis Pallas, 1776*	Rẽ cổ hung	TL	1
	Columbidae	**Họ bồ câu**		
13.	*Streptopelia chinensis Temminck, 1810*	Cu gáy	QS	1
14.	*Treron vernans Schlegel, 1863*	Cu xanh đầu xám	QS	1,2
	Psittacidae	**Họ vẹt**		

15.	*Psittacula roseata,Biswas, 1915*	Vẹt đầu hồng	QS	1,2
	Cucuclidae	**Họ cu cu**		
16.	*Cuculus micropterus Gould, 1837*	Bắt cô chói cột	QS	1,2
17.	*Centropus sinensis Hume, 1873*	Bìm bịp lớn	QS	1,2
	Apodidae	**Họ yến**		
18.	*Apus affinis,Blyth, 1849*	Yến cằm trắng	PV	1
	Meropidae	**Họ trâu**		
19.	*Merops orientalis Neuman, 1910*	Trẩu đầu hung	PV	1
	Coraciidae	**Họ sả rừng**		
20.	*Coracias benghalensis Mc Clelland, 1839*	Sả rừng	QS	2
	Upupidae	**Họ đầu rìu**		
21.	*Upupa epops Jerdon, 1862*	Đầu rìu	QS	1
	Picidae	**Họ gõ kiến**		
22.	*Picus flavinucha Deignar, 1945*	Gõ kiến xanh	QS	1,2
	Alaudidae	**Họ sơn ca**		
23.	*Mirafra assamica Baker, 1915*	Sơn ca	TL	1
	Motacillidae	**Họ chìa vôi**		
24.	*Motacilla alba Gould, 1837*	Chìa vôi trắng	PV	1
	Pycnonotidae	**Họ chào mào**		
25.	*Pycnonotus jocosus Linneaus, 1758*	Chào mào	QS	1
	Irenidae	**Họ chim xanh**		
26.	*Irena puella Latham, 1970*	Chim lam	QS	2
	Turdininae	**Họ chích chòe**		
27.	*Copsychus saularis Linnaeus, 1758*	Chích chòe	QS	1
28.	*Saxicola torquata Parrot, 1908*	Sẻ bụi đầu đen	QS	2
	Muscicapidae	**Họ đớp ruồi**		
29.	*Muscicapa dauurica Pallas,1811*	Đớp ruồi nâu	QS	2
	Monarchidae	**Họ rẻ quạt**		
30.	*Hypothymis azurea Hartlaub,1900*	Đớp ruồi xanh	QS	2
	Estrildidae	**Họ chim di**		
31.	*Lonchura striata Baker, 1925*	Di cam	QS	1
	Ploceidae	**Họ sẻ**		
32.	*Passer montanus Dubois, 1885*	Sẻ	QS	1
	Sturnidae	**Họ sáo**		
33.	*Gracula religiosa Hay, 1844*	Yểng	QS	1
	Dicruridae	**Họ chèo bẻo**		
34.	*Dicrurus remifer Stuart Baker, 1818*	Chèo bẻo	QS	2
	Corvidae	**Họ quạ**		

35.	*Corvus macrorhynchos*	Quạ đen	QS	1
	REPTILIA	**LỚP BÒ SÁT**		
	Gekkonidae	**Họ tắc kè**		
1.	*Hemidactylus frenatus Dumerin, 1836*	Thạch sùng đuôi sần	PV	1
	Agamidae	**Họ nhông**		
2.	*Calotes versicolorDaubin, 1802*	Nhông xanh	QS	1,2
3.	*Leiolepis reeversi Gray, 1831*	Nhông cát	QS	1
	Scincidae	**Họ thằn lằn bóng**		
4.	*Mabuya multifasciata Kuhl, 1820*	Thằn lằn bóng hoa	QS	1,2
	Colubrridae	**Họ rắn nước**		
5.	*Amphiesma stolata Linnaeus, 1758*	Rắn sãi thường	QS	1,2
6.	*Dendrelaphis pictus Gmelin, 1789*	Rắn leo cây	PV	1,2
7.	*Xenochrophis piscator Scheider, 1799*	Rắn nước	QS	1
8.	*Psammophis condanarus Merrem, 1920*	Rắn cát	QS	1
	Viperidae	**Họ rắn lục**		
9.	*Trimeresurus stejnegeri Schmid, 1952*	Rắn lục xanh	QS	1,2
	Chenoniidae	**Họ vích**		
10.	*Chelonia mydas Linnaeus, 1758*	Vích	PV	1
	AMPHIBIA	**LỚP LƯỠNG CƯ**		
	Bufonidae	**Họ cóc**		
1.	*Bufo melanostictus* Schneider	Cóc nhà	QS	1
	Ranidae	**Họ Ếch nhái**		
2.	*Rana rugulosa* Wiegmann	Ếch	QS	1
3.	*Rana guentheri* Boulenger	Chẫu	QS	1

Ghi chú:

QS = Quan sát

TL = Tài liệu

PV = Phỏng vấn

1 = Khu vực dự án

2 = Khu vực bãi xỉ

Appendix 2.3. List of phytoplankton in the area

TT	Tên khoa học	Vị trí thu mẫu									
		1	2	3	4	5	6	7	8	9	10
	CYANOPHYTA										
	Cyanophyceae										
1	Merismopedia elegans	+									
2	Merismopedia tenuissima	+									
3	Aphanocapsa delicatissima	+									
4	Microcystis sp.										+
5	Oscillatoria limnetica	+									
6	Oscillatoria splendida										+
7	Oscillatoria sp.							+			
8	Trichodesmium erythraeum						+	+		+	
9	Pseudanabaena sp.	+									
10	Lyngbya sp.1		+	+	+	+				+	
11	Lyngbya sp.2										+
	CHRYSOPHYTA										
	Chrysophytceae										
12	Dictyocha fibula		+				+	+		+	
	Bacillariophyceae										
13	Melosira sulcata		+	+		+	+	+	+	+	
14	Cyclotella meneghiniana	+									
15	Cyclotella cf. striata						+				
16	Cyclotella stylorum			+	+	+	+				
17	Coscinodiscus asteromphalus						+				
18	Coscinodiscus bipartitus					+	+	+		+	
19	Coscinodiscus excentricus									+	
20	Coscinodiscus janischii					+		+			
21	Coscinodiscus jonesianus						+	+	+	+	
22	Coscinodiscus lineatus				+		+				
23	Coscinodiscus marginatus		+	+	+	+	+	+		+	
24	Coscinodiscus radiatus									+	
25	Coscinodiscus subtilis		+			+	+	+			
26	Asteromphalus cleveanus						+		+		
27	Actinoptychus undulatus			+			+				
28	Thalassiosira subtilis						+	+	+	+	
29	Thalassiosira sp.1						+	+	+	+	
30	Thalassiosira sp.2								+	+	
31	Lauderia borealis			+		+	+	+	+	+	
32	Guinardia flaccida							+	+		
33	Leptocylindrus minus							+	+	+	
34	Skeletonema costatum				+	+	+				
35	Corethron hystrix		+	+	+	+	+	+	+	+	
36	Bacteriastrum comosum		+								
37	Bacteriastrum delicatululm					+	+				
38	Bacteriastrum elongatum								+	+	

39	Bacteriastrum varians						+	+		+	
40	Rhizosolenia bergonii				+			+	+	+	
41	Rhizosolenia calcar-avis						+				
42	Rhizosolenia crassispina							+			
43	Rhizosolenia delicatula		+			+	+	+	+	+	
44	Rhizosolenia hebetata f. semispina			+	+	+	+	+	+	+	
45	Rhizosolenia hyalina					+					
46	Rhizosolenia imbricata		+			+	+	+	+	+	
47	Rhizosolenia setigera		+	+		+	+	+	+	+	
48	Rhizosolenia stolterfothii				+	+	+	+	+	+	
49	Chaetoceros abnormis			+			+	+	+		
50	Chaetoceros affinis							+		+	
51	Chaetoceros borealis						+			+	
52	Chaetoceros compactum		+	+	+	+	+	+	+	+	
53	Chaetoceros compressus				+			+	+		
54	Chaetoceros decipiens				+	+	+	+	+	+	
55	Chaetoceros didymus					+	+				
56	Chaetoceros distans			+	+	+		+		+	
57	Chaetoceros diversus						+	+	+	+	
58	Chaetoceros leavis									+	
59	Chaetoceros lorenziana						+				
60	Chaetoceros muelleri		+		+	+	+	+			
61	Chaetoceros peruvianus					+	+	+	+	+	
62	Chaetoceros peruvianus f. robusta						+	+			
63	Chaetoceros pseudocurvisetus			+		+	+	+	+	+	
64	Chaetoceros teres							+		+	
65	Biddulphia dubia				+						
66	Biddulphia mobiliensis				+		+	+	+		
67	Biddulphia pulchella							+			
68	Biddulphia regia					+	+	+	+	+	
69	Biddulphia reticulum				+						
70	Biddulphia sinensis		+	+	+	+	+	+	+	+	
71	Triceratium favus							+			
72	Hemiaulus sinensis					+	+	+	+	+	
73	Ditylum sol		+	+	+	+	+	+	+	+	
74	Cerataulina campacta				+	+	+	+	+	+	
75	Bellerochea malleus							+			
76	Streptotheca thamesis		+	+	+	+	+	+	+	+	
77	Hemidiscus hardmanianus						+	+			
78	Asterionella japonica		+				+	+		+	
79	Thalassionema nitzschioides		+	+	+	+	+	+	+	+	
80	Thalassiothrix frauenfeldii		+	+	+	+	+	+	+	+	
81	Thalassiothrix longissima						+	+	+	+	
82	Synedra ulna										+
83	Synedra sp.						+	+		+	

84	Climacosphenia moniligera		+	+	+	+	+		+	+	
85	Desmogonium sp.										+
86	Eunotia cf. pectinalis										+
87	Grammatophora marina		+	+			+				
88	Achnanthes cf. brevipes		+								
89	Cocconeis cf. scutellum		+								
90	Navicula cuspidata	+									
91	Navicula lyra						+	+			
92	Navicula cf. marina							+		+	
93	Navicula cf. membranacea							+			
94	Navicula sp.1			+	+	+	+	+	+	+	
95	Navicula sp.2						+				
96	Navicula sp.3										+
97	Navicula sp.4										+
98	Pinnularia divergens										+
99	Diploneis elliptica				+						
100	Diploneis scabra			+				+	+		
101	Diploneis sp.					+		+			
102	Gyrosigma cf. spenceri						+				
103	Donkinia cf. recta				+			+		+	
104	Pleurosigma cf. affine		+	+		+	+	+	+		
105	Pleurosigma angulatum		+	+	+	+	+	+		+	
106	Pleurosigma elongatum								+		
107	Pleurosigma intermedium						+	+			
108	Pleurosigma pelagicum		+	+		+	+	+	+	+	
109	Amphiprora alata			+							
110	Amphora quadrata		+	+	+	+	+	+	+	+	
111	Amphora sp.			+							
112	Trachyneis aspera		+	+	+		+	+	+		
113	Gomphonema gracile										+
114	Gomphonema gracile f. turris										+
115	Pseudnotzschia spp.			+	+	+	+	+	+	+	
116	Nitzschia longissima v. reversa		+	+	+	+	+	+	+	+	
117	Nitzschia lorenziana		+	+	+	+	+				
118	Nitzschia palea	+									
119	Nitzschia panduriformis		+	+	+						
120	Nitzschia paradoxa		+	+	+	+	+	+	+	+	
121	Nitzschia sigma			+	+		+	+			
122	Nitzschia sigma v. intercedens		+	+	+	+	+	+	+	+	
123	Surirella ovata		+	+	+	+	+	+			
124	Surirella robusta										+
125	Campylodiscus cf. echeneis			+				+			
126	Campylodiscus cf. taeniatus			+							
127	Campylodiscus cf. undulatus		+	+						+	
	CHLOROPHYTA										
	Chlorophyceae										
128	Closteriopsis longissima	+									

129	Closterium ehrenbergii										+
130	Closterium moniliferum										+
131	Pleurotaenium ehrenbergii										+
132	Spirogyra sp.										+
133	Mougeotia sp.										+
	EUGLENOPHYTA										
	Euglenophyceae										
134	Euglena caudata										+
135	Euglena oxyuris										+
136	Euglena texta v. ovata										+
137	Euglena sp.										+
138	Lepocinclis fusiformis										+
139	Lepocinclis ovum										+
140	Lepocinclis ovum v. australis										+
141	Phacus swirenkoi										+
142	Trachelomonas armata										+
143	Trachelomonas volvocina v. derephora										+
144	Trachelomonas sp.										+
	DINOPHYTA										
	Dinophyceae										
145	Prorocentrum micans						+	+			
146	Dinophysis sp.									+	
147	Pyrophacus horologium							+			
148	Ceratium furca						+	+			
149	Ceratium fusus					+					
150	Ceratium macroceros								+	+	
151	Ceratium tripos						+				
152	Protoperidinium oceanicum								+		
153	Protoperidinium sp.1		+	+	+		+	+	+		
154	Protoperidinium sp.2					+			+	+	
155	Peridinium cf. cinctum	+									+
	Tổng	**10**	**35**	**41**	**39**	**47**	**73**	**75**	**50**	**59**	**29**

Appendix 2.4. Desity of phytoplankton in the area

Điểm lấy mẫu	Mật độ (cá thể/L)	Loài ưu thế	Mật độ của các loài ưu thế (cá thể L)
1	984000	Closteriopsis longissima	663000
2	13100	Nitzschia lorenziana	3300
3	6600	Thalassionema nitzschioides	1500
4	11200	Pseudonitzschia spp.	1200
5	13450	Nitzschia paradoxa	2400
6	44900	Thalassionema nitzschioides	8800
7	76000	Thalassionema nitzschioides	17200
8	74200	Pseudonitzschia spp.	22100
9	65600	Thalassionema nitzschioides	14400
10	6360	Navicula sp.3	1280

Appendix 2.5. List of zooplankton in the area

TT	Tên khoa học	Điểm lấy mẫu									
		1	2	3	4	5	6	7	8	9	10
	I. Trùng bánh xe (ROTATORIA)										
	Lecanidae										
1	Lecane (Lecane) luna (Muller)										2
	Philodinidae										
2	Philodina roseola (Ehrenberg)										6
	II. Giáp xác râu ngành (CLADOCERA)										
	Chydoridae										
3	Alona davidi Richard										1
	III. Giáp xác Ostracoda										
	Cypridae										
4	Heterocypris anomala Klie										1
	Cypridinidae	1									
5	Cypridina sp.		1								
	IV. Giáp xác chân chèo (COPEPODA)										
	Eucalanidae										
6	Eucalanus subcrassus Giesbrecht					1		1		1	
	Paracalanidae										
7	Paracalanus parvus (Claus)		6	9	5	11	7	18	27	7	
8	Paracalanus crassiroitris Dahl		9	3	5	6	12	21	34	11	
9	Acrocalanus gracilis Giesbrecht		1	3	1	4	6	5	8	2	
	Scolecithricidae										
10	Scolecithricella longispinosa				1			1	2	1	

	Chenet Zhang										
	Temoridae										
11	Temora turbinata (Dana)						1				
	Centropagidae										
12	Centropages calaninus (Dana)		2	1		1	1	1	2	1	
	Pseudodiaptomidae										
13	Pseudodiaptomus marinus Sato							1			
	Pontellidae										
14	Calanopia thompsoni A. Scott				1				1		
15	Labidocera minuta (Giesbrecht)						1			2	
	Acartiidae										
16	Acatia erythraea Giesbrecht		2	5	9	1	4	3	11	6	
	Othonidae										
17	Oithona rigida Rosendorn		7	11	3	8	2	3	7	1	
18	Oithona plumifera Baird)		14	8	11	5	3	17	38	12	
19	Oithona brevicornis (Giesbrecht)		7	6	4	3	5	12	6	2	
	Corycaeidae										
20	Corycaeus speciosus Dana		1			1					
	Cyclopidae										
21	Microcyclops varicans (Sars)										1
22	Thermocyclops hyalinus Rehberg										1
	Ectinsomidae										
23	Microsetella norvegica (Boeck)		1	2	6	4	7	4	2	3	
	Tachidiidae										
24	Euterpina acutifrons (Dana)		1	4	7	2	6	2	3	2	
	V. Giáp xác chân khác (AMPHIPODA)										
	Corophiidae										
25	Corophium intermedium Dang		2	4	6	2	2	4	1	1	
	Hyalidae										
26	Hyale brevipes Barnard		5	7	2	1		1		3	
	Gammaridae										
27	Melita sp.		3	4	2	3	5	1		1	
	VI. Hàm tơ (CHAETOGNATHA)										
	Sagittidae										
28	Sagitta enflata Grassi							1	2		
	VII. Côn trùng và ấu trùng côn trùng (INSECTA AND INSECTA LARVA)										
	HETEROPTERA										
	Corixidae										
29	Corixa sp.	4									
	Notonectidae										
30	Anisops sp.	3									

	DIPTERA										
	Chironomidae										
31	Rheotanytarsus sp.										2
	VIII. Các dạng ấu trùng (LARVA)										
32	Nauplius copepoda		6	12	7	13	15	31	46	23	16
33	Zoe		1	9	7	4			1		
34	Mysis		1	4	1				1		
35	Trứng cá								1	1	
	Số lượng loài	2	18	16	17	17	15	18	18	18	7
	Mật độ (cá thể/m²)	700	7.000	9.200	7.800	7.000	8.300	12.800	20.100	8.900	2.900

Appendix 2.6. Component of zoo benthos in the area

TT	Tên khoa học	Điểm lấy mẫu									
		1	2	3	4	5	6	7	8	9	10
	I. GIUN NHIỀU TƠ (POLYCHAETA)										
	ERRANTIA										
	Nephthydidae										
1	Nephthys californiensis Hartman						2	4			
	Nereidae										
2	Dendronereis aesturina Southern				3	2					
3	Neanthes caudata (Delle Chiaje)			1	1	1	2		2		
	SEDENTARIA										
	Owenidae										
4	Owenia fusiformis Delle Chiaje			6	2			1			
	Spionidae										
5	Prionospio malmgreni Claparede						1				
	Maldanidae										
6	Maldane sarsi Malmgren			4					5	3	
	Terebellidae										
7	Pista cristata (O.F. Muller)							3			
	II. GIUN ÍT TƠ (OLIGOCHAETA)										
	Tubificidae										
8	Limnodrilus hoffmeisteri Claparede										4
	III. GIÁP XÁC (CRUSTACEA)										
	AMPHIPODA										
	Gammaridae										
9	Melita nitida					4			2		
	DECAPODA										

	Portunidae										
10	Portunus (Portunus) pelagicus (Linnaeus)		1								
	IV. CÔN TRÙNG VÀ ẤU TRÙNG CÔN TRÙNG (INSECTA AND INSECTA LARVA)										
	HETEROPTERA										
	Corixidae										
11	Corixa sp.	9									2
	DIPTERA										
	Chironomidae										
12	Chironomus sp.	23									26
13	Cryptochironomus sp.	18									10
14	Polypedilum sp.	44									7
	Sialidae										
15	Sialis sp.	2									
	V. NHUYỄN THỂ (MOLLUSCA)										
	BIVALVIA										
	Arcidae										
16	Arca sp.		1								
	Perridae										
17	Avicula sp.									5	
	GASTROPODA										
	Potamididae										
18	Cerithidea charbonnieri (Petit)			3							
.	**VI. DA GAI (ECHINODERMATA)**										
	Cidariidae										
19	Prionocidaris sp.									2	
	Number of species	**5**	**2**	**4**	**3**	**3**	**3**	**3**	**3**	**3**	**5**
	Quantity	**96**	**2**	**14**	**6**	**7**	**5**	**8**	**9**	**10**	**49**
	Quantity (individual/m²)	**960**	**20**	**140**	**60**	**70**	**50**	**80**	**90**	**100**	**490**

APPENDICES OF CHAPTER 3

Appendix 3.1: Substance dispersion modeling due to sea encroaching embankment for Vinh Tan 4 Power Plant.

Appendix 3.1: Substance dispersion modeling due to dredging of coal port of 100000DWT for Vinh Tan 4 Power Plant.

Appendix 3.3: Air dispersion modeling for Vinh Tan 4 Power Plant and Vinh Tan Power Complex.

Appendix 3.4: Results of cooling wastewater diffusion model for Vinh Tan Power Complex.

Appendix 3.5. The impact quantitative system – IQS.

Appendix 3.1: Substance dispersion modeling due to sea encroaching embankment for Vinh Tan 4 Power Plant

TABLE OF CONTENTS

1. Introduction

Despite the different scale and level the results have shown, any topographical change has certain impact on hydrodynamics, sediment transport as well as local environment. Therefore, in the context of the mission: ***Study and prediction impact of dumping in Vinh Tan port area on hydrodynamics, sediment transport condition and erosion-deposition in Vinh Tan coastal area,*** we carried out an assessment of the impact of levelling activities on Vinh Tan coastal area and its surroundings. Impacts include hydrodynamics, turbid water area, and characteristics of sediment transport during and after the levelling and construction activities. In order to implement such contents, we collected related hydrometeorological data, setting up a numerical model to simulate hydrodynamics and sediment transport in the study area with various scenarios. This report will present those results with structure as follows:

- Introduction: give a summary of the objectives of the study
- The second part supplies information about methods and materials used to implement the study.
- Since mathematical models were mainly used for the study, Part 3 of report presents mathematical backgrounds of modelling concept including hydrodynamics, wave and sediment transport models.
- Part 4 introduces overall natural conditions of the project site including geography, topography, hydrometeorology and erosion-sedimentation characteristics.
- Part 5 presents content related to modeling setup (hydrodynamics, wave, sediment transport) according to the scenarios and forecasts for the studying site.
- Analyses on the impacts of leveling activities on hydrodynamic conditons, sediment transport are presented in Part 6 of the report.

Finally, conclusions and recommendation are presented in the seventh of the report.

1.1. Object and target of the study

In order to predict the impact of leveling activities on Cu Lao Cau Marine Protected Area (MPA), main objects of the study are:

- Flow condition
- Characteristic of TSS (total suspended solids) distribution
- Characteristics of sediment transport and morphological alteration

1.2. Approaches and methods

To gain the above targets, key approaches and methods include:

- Collect and process related data:
- Model studied objects on the basic application of hydrodynamics, wave transition, and sediment transport models in the study area.
- Setting up the model according to various scenarios: southwest wind monsoon and northeast wind monsoon, before, during and after leveling work.

1.3. Scope of study

The study frame is whole of coastal zone around of Vinh Tan port. The study area also extends to some where around as well as Bai Can (Breda sand bar) and Cu Lao Cau Island (Figure 1). Model frame also is extend to eastward, northeastward and southwest (figure 6).

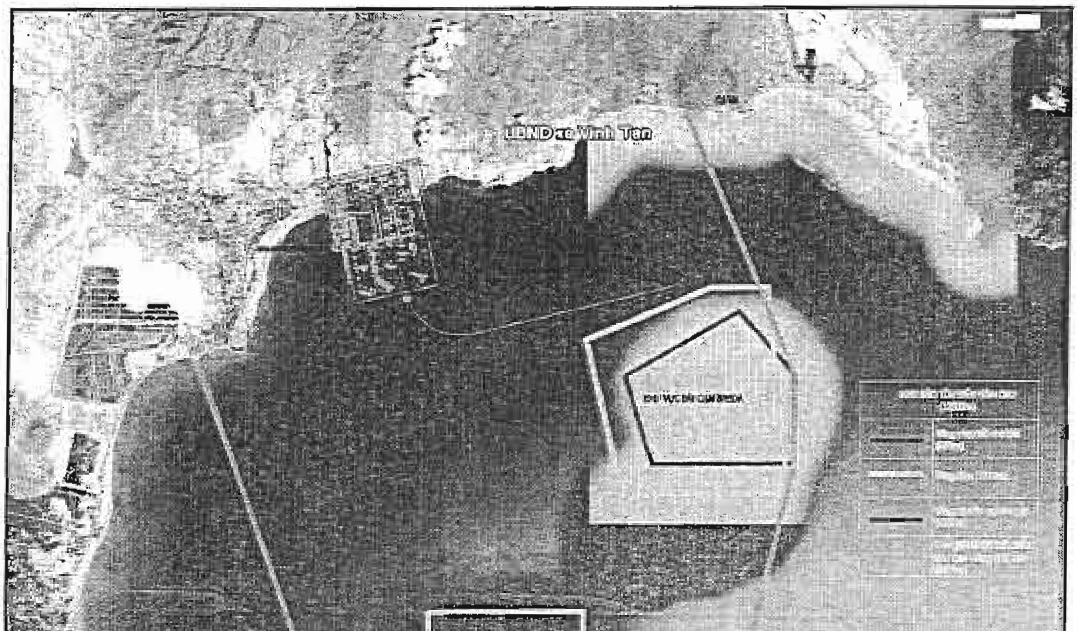


Figure 1. Vinh Tan port area and its neighboring

2. Material and methodology

2.1. Material

In order to implement the target of this study, data below were collected:

- Meteorological data: wind speed and direction, sea level oscillation. These data were measured by National Hydro-Meteorological Central (National Hydro - Meteorology Agency, 1976; National Hydro - Meteorology Agency, 2000; Nguyen The Tuong, 1996).

- Oceanographic data: group of tidal harmonic constant in the coastal zone from database Fes2004 (F. Lyard, F. Lefevre, T. Letellier, and O. Francis, 2006).

- Bathymetry data: bathymetry was digitalized and treated from bathymetry map of Binh Thuan and Ninh Thuan with scale: 1:50000 (published by Department of survey and mapping, Ministry of Environment and resources). Bathymetry in offshore area used bathymetry database of GEBCO -1/8 (General Bathymetric Chart of the Ocean (GEBCO) from British Oceanographic Data Centre (BODC).

- Others data included erosion- deposition, information about leveling activity, Cu Lao Cau MPA…etc.

2.2. Methods

A basic method to implement the above objectives is using mathematic models called Delft3d model which is developed by Delft Hydraulics Institute (Netherlands). Delft3d can closely simulate hydrodynamics condition, wave transition, water quality and sediment transport in the coastal zone (WL|Delft Hydraulics, 1999).

3. Concepts of the model

3.1. Basic equation of Hydrodynamics model

Mathematical basis of the model is to solve the Navier Stokes equations with an incompressible fluid under the shallow water and the Boussinesq assumptions. A change in vertical velocities in the momentum equation is neglected. In 3D models, the vertical velocities are computed from the continuity equation.

With regard to horizontal, depend on specific conditions of each area, one of the following coordinate systems primarily are applied:

- Descarters coordinate system: (x,y) (Cartesian). Applied for the region having simple terrain and coastline.

- Orthogonal curvilinear coordinates: (ζ,η). Applied for the region having complex terrain such as estuarine region, coastal region, gulf..
- Spherical coordinates: (λ,ϕ). Applied for the large region, spreading over different longitudes and latitudes.

The continuity equation (with regard to orthogonal curvilinear coordinates) is given by:

$$\frac{\partial\zeta}{\partial t}+\frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)U\sqrt{G_{\eta\eta}}\right]}{\partial\xi}+\frac{1}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)V\sqrt{G_{\xi\xi}}\right]}{\partial\eta}=Q \qquad (1)$$

with Q representing the contributions per unit area due to the discharge or withdrawal of water, precipitation and evaporation:

$$Q=H\int_{-1}^{0}(q_{in}-q_{out})d\sigma+P-E$$

here:

ζ,η: Horizontal, curvilinear co-ordinates

$\sqrt{G_{\zeta\zeta}},\sqrt{G_{\eta\eta}}$: Coefficients used to transform curvilinear to rectangular coordinates

d: depth below some horizontal plane of reference (datum)

ζ : water level above some horizontal plane of reference (datum)

U, V: velocity component in direction ζ,η

q_{in} và q_{out} local source and local sink per unit volume

H: total water depth (H = d + ζ)

P, E: precipitation and evaporation

The momentum equations in ζ and η direction are given by:

$$\frac{\partial u}{\partial t}+\frac{u}{\sqrt{G_{\xi\xi}}}\frac{\partial u}{\partial\xi}+\frac{v}{\sqrt{G_{\eta\eta}}}\frac{\partial u}{\partial\eta}+\frac{\omega}{d+\zeta}\frac{\partial u}{\partial\sigma}+\frac{uv}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\zeta\zeta}}}{\partial\eta}-\frac{v^2}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\eta\eta}}}{\partial\xi}-fv$$
$$=-\frac{1}{\rho_0\sqrt{G_{\zeta\zeta}}}P_\zeta+F_\zeta+\frac{1}{(d+\zeta)^2}\frac{\partial}{\partial\sigma}\left(v_v\frac{\partial u}{\partial\sigma}\right)+M_\zeta \qquad (2)$$

$$\frac{\partial v}{\partial t}+\frac{u}{\sqrt{G_{\xi\xi}}}\frac{\partial v}{\partial\xi}+\frac{v}{\sqrt{G_{\eta\eta}}}\frac{\partial v}{\partial\eta}+\frac{\omega}{d+\zeta}\frac{\partial v}{\partial\sigma}+\frac{uv}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\zeta\zeta}}}{\partial\eta}-\frac{u^2}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\eta\eta}}}{\partial\eta}-fu$$
$$=-\frac{1}{\rho_0\sqrt{G_{\zeta\zeta}}}P_\eta+F_\eta+\frac{1}{(d+\zeta)^2}\frac{\partial}{\partial\sigma}\left(v_v\frac{\partial v}{\partial\sigma}\right)+M_\eta \qquad (3)$$

The vertical velocity ω in the adapting σ co-ordinate system is computed from the continuity equation:

$$\frac{\partial\zeta}{\partial t}+\frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)u\sqrt{G_{\eta\eta}}\right]}{\partial\xi}+\frac{1}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\mu}}}\frac{\partial\left[(d+\zeta)v\sqrt{G_{\zeta\zeta}}\right]}{\partial\eta}+\frac{\partial\omega}{\partial\sigma}=H(q_{in}-q_{out})\ (4)$$

In equations (2), (3), (4):

ω : velocity in the σ direction in the σ co-ordinate system (m/s)

fv, fu: Coriolis force components

M_ζ, M_η: source or sink of momentum in ζ,η direction

ρ_0 : water density

Main physical process shown in equations above includes:

- Coriolis force
- Turbulence closure model: K-epsilon, k-L, algebraic
- Bottom stress formulas:
  + Chézy: C- Chézy coefficient ($m^{1/2}$/s
  + Manning: $C=\frac{\sqrt[6]{h}}{n}$

In there: h- depth total; Manning coefficient.

+ White Colebrook formula: $C=18\log_{10}\left(\frac{12h}{k_s}\right)$

k_s- Nikuradse coefficient (m)

- Heat transfer from the study area to outsite (advection – diffusion)
- Surface strain caused by wind.

3.2. Grid and bathymetric grid

In the horizontal, grid of the model is alternate (figure 2). In each grid cell has a water level point, depth point, u velocity and v velocity components. Water level point is defined in central of grid cell. The velocity components are perpendicular to the grid cell faces where they are situated.

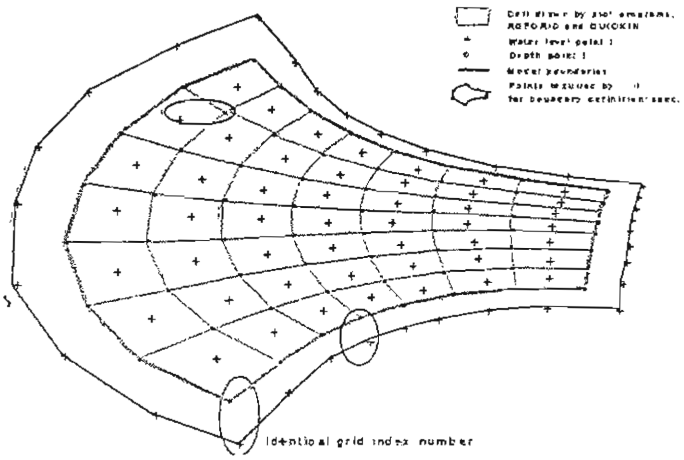


Figure 2. Example of a grid in Delft3D-FLOW

Bathymetric grid is created by model grid and depth point in the model frame. Depth points are measured data and data from digitized map.

3.3. Initial and boundary condition

The boundaries of the hydrodynamics model include closed and open boundaries. Closed boundaries are natural boundaries between seawater and land. On the other hand, open boundaries are artificial water-water boundaries where water flow can move in and out of the model frame. In hydrodynamics model, the parameters at open boundaries should be defined correctly since it may influence directly to simulated results. These data may be determined from measure or calculation or nesting from bigger-scoped model. The further the open boundaries from concerned positions, the lower noise signals appear.

In specific situation, one of these types of boundary condition can be used for various open boundaries:

- Sea level boundary

- Current boundary

- Flow boundary

3.4. Critical stability of hydrodynamics model

Above equations are solved by ADI (Alternating Direction Implicit) method (WL|Delft Hydraulics, 1999) on curvilinear grid. Courant number, a parameter to assess the accuracy and stability of the model, can be used to estimate the critical stability of the model. In the coastal area with a large change of depth and coastline, Courant number should be between 10-30 (Van Ballegooyen and Taljaard, 2001).

According to Stelling (1984), for 2D model, the Courant number may be defined as follows:

$$C = 2\Delta t\sqrt{gh\left(\frac{1}{\Delta x^2}+\frac{1}{\Delta y^2}\right)} \tag{5}$$

Where:

C: Courant number

g: acceleration of gravity (m/s^2)

h: water depth at calculated time (m)

Δt: time step (s)

Δx: grid size in x direction (m)

Δy: grid size in y direction (m)

The Courant number strictly depends on time step (Δt), the water depth and grid size. This is necessary to select suitable time step, which is not too long for each time running yet still ensure the accuracy and stability of the model. The parameters relate to time step include:

- Stability
- Demanded accuracy level
- Minimum grid size
- Depth
- Calculated time

3.5. Wave model

The model used for simulating wave characteristics in this study is Delft3D-WAVE which was developed based on SWAN model (Simulating WAves Nearshore) by TU Delft (Delft University of Technology, Neitherland). SWAN is a typical model for calculation wave characteristics in the coastal zone, estuaries area, lake from wind, bathymetry and current conditions. This model is based on equilibrium equation of wave action (or equilibrium equation of energy in case of no currents) with energy sources and consumption.

Delft3D-WAVE expects input data to be expressed in S.I. unit: m, kg, s, N and W. Consequently, the wave height and water depth are in [m], wave period is in [s] respectively. Wave direction is in degrees [^{0}] but not radians. Delft3D-WAVE can operate in plane or spherical coordinates system.

In the input for Delft3D-WAVE the directions of winds and (incident) waves are defined relative to the maritime or Cartesian coordinate systems. In the Cartesian system, all geographic locations and orientations in SWAN are defined in a common Cartesian coordinate system with a predetermined origin (0,0).

In wave model, the waves are described by a two-dimensional equation of action spectrum density, even when non-linear phenomena dominate. The ratio of using the spectrum in such non-linear conditions is high; wave spectral distribution is in second order moment of the waves. The spectrum that is considered in SWAN is the action density spectrum $N(\sigma,\theta)$ rather than the energy density spectrum $E(\sigma,\theta)$ since in the presence of currents, action density is conserved but not energy density (Whitham, 1974). The independent variables are the relative frequency σ and the wave direction θ. The action density is equal to the energy density divided by the relative frequency (in SWAN, this spectrum is temporally and spatially dependent):

$$N(\sigma,\theta) = E(\sigma,\theta)/\sigma \quad (6)$$

The evolution of the wave spectrum is described by the spectral action balance equation which is written in Cartesian co-ordinates as follows (Hasselmann et al. (1973)):

$$\frac{\partial}{\partial t}N + \frac{\partial}{\partial x}c_x N + \frac{\partial}{\partial y}c_y N + \frac{\partial}{\partial \sigma}c_\sigma N + \frac{\partial}{\partial \theta}c_\theta N = \frac{S}{\sigma} \quad (7)$$

The above equation describes the evolution of wave spectrum, in which the first term in the left-hand side represents the local rate of change of action density as a function of time; the second and third terms represent propagation of action density spectrum in geographical space (with propagation velocities Cx and Cy in x- and y-axes, respectively). The fourth term represents shifting of relative frequency under the influence of depth and current (with propagation velocity C_σ). The fifth term represents depth- and current-induced refraction. The expressions for these propagation speeds were taken from linear wave theory. The term S at the right-hand side of the equation is the value of source equation term in terms of energy density withdrawn from effects of wave generation, dissipation and non-linear wave-wave interactions. Refer to the Delft3d User Manual (WL|Delft Hydraulics, 1999) for more detail on Delft3D – Wave model.

The following processes are also considered in Delft3D – Wave model:

- Wind induced wave,

- Energy dissipation due to falling wave, bottom friction and depth-induced breaking,

- Non-linear wave-wave interaction, wave – current interaction.

3.6. Sediment transport model

Sediment transport model based on equation of dispersion and diffusion of material in the environmental water:

$$\frac{\partial C}{\partial t}=\frac{\partial}{\partial x}\left(D_x\frac{\partial C}{\partial x}-u_xC\right)-\frac{\partial}{\partial y}\left(D_y\frac{\partial C}{\partial y}-u_yC\right)-\frac{\partial}{\partial z}\left(D_z\frac{\partial C}{\partial z}-u_zC\right) \quad (8)$$

If adding a source from outside, (8) can be rewrite:

$$\frac{\partial C}{\partial t}=\frac{\partial}{\partial x}\left(D_x\frac{\partial C}{\partial x}-u_xC\right)-\frac{\partial}{\partial y}\left(D_y\frac{\partial C}{\partial y}-u_yC\right)-\frac{\partial}{\partial z}\left(D_z\frac{\partial C}{\partial z}-u_zC\right)+F(C,t) \quad (9)$$

Here:

D_x, D_y, D_z : disffusions coeficient in x, y, z direction

F(C, t) : source or sink.

C: concentration

For suspended sediment transport model, assume that suspended sediment concentration will be decreased when occurs sediment process. On the other hand, process of re-suspension will be accursed if concentration of suspended sediment in the water column increases.

Sedimentation process depends on ambient shear stress (Tau) and critical shear stress for sedimentation (Tau_{cr}^{sed}). If Tau less than Tau_{cr}^{sed}, occurring sedimentation process.

Sedimentation flux = P_{sed} x V_{sed} x (IM1) (g/m^2/day)

Here: P_{sed} can defined by equation:

$$P_{sed}=\max\left(0{,}1-\frac{Tau}{Tau_{cr}^{sed}}\right) \quad (0{,}1) \quad (10)$$

Otherwise, erosion occurs if ambient shear stress bigger than critical shear stress for re-suspension process (Tau_{cr}^{res}).

$$\text{Resuspension flux}=P_{res} \times Z_{res} \qquad (g.m^2/day) \qquad (11)$$

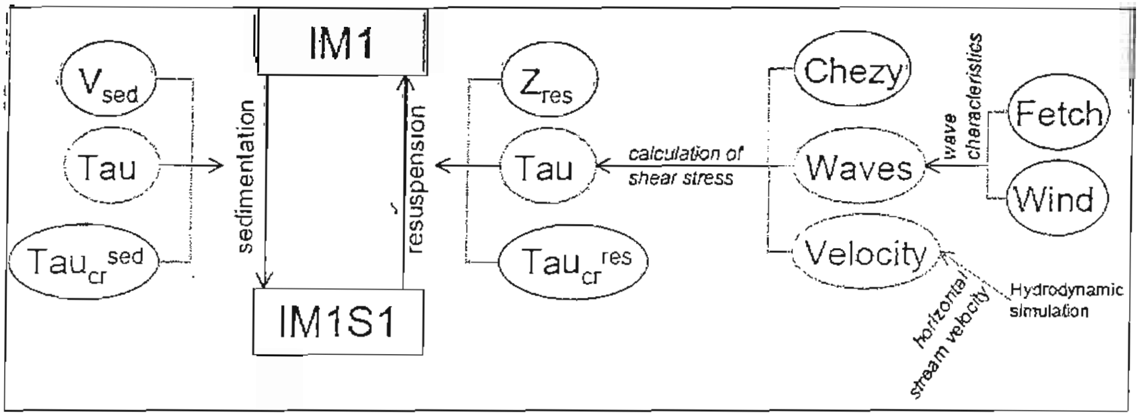


Figure 3. Basic processes in sediment transport model (Delft, 1999)

Where: P_{res} is defined by equation:

$$P_{res}=\max\left(0,\frac{Tau_{cr}^{res}}{Tau}-1\right) \qquad (12)$$

With : IM1 suspended sediment concentration; P_{sed}- probably of sedimentation; V_{sed}- settling velocity of sediments; Tau- ambient shear stress; Tau_{cr}^{sed}- critical shear stress for sedimentation; Tau_{cr}^{res}- critical shear stress for re-suspension; P_{res}-probability of re-suspension process; Z_{res}- rate of resuspension from bottom.

Ambient shear stress depends on dynamics process:

Tau=f (wave, wind, current, sea water level, bottom stress)

Sediment transport calculation

Regarding the calculation of the sediment transport, Delft3D allows the combined use of cohesive and non-cohesive sediment. By default, the formulations of Van Rijn are applied for the suspended and bed load transport of non-cohesive sediment, which is the case of the sandy sediment in the area nearby Puerto Chiapas. If desired, it is possible to use other sediment transport formulae for non-cohesive sediment; however it has been decided to stick to Van Rijn's approach, because it is the most used in other studies involving Delft3D, hence the most experienced and functional.

For simulations including waves, Delft3D first calculates the magnitude of the bed-load "sand" transport using the following equation (Van Rijn et al):

$$|S_b| = 0.006\eta\rho_s w_s d_{50} M^{0.5} M_e^{0.7} \qquad (13)$$

S_b : bed load transport [kg/m/s]

η : relative availability of the sediment fraction in the mixing layer

ρ_s: specific density of sediment [kg/m3]

w_s: sediment falling velocity [m/s]

d_{50} : representative (mean) sediment diameter [m]

M: sediment mobility number due to waves and currents

M_e: excess sediment mobility number

And:

$$M = \frac{v_{eff}^2}{(s-1)gd_{50}} \quad (14)$$

$$M_e = \frac{\left(v_{eff} - v_{cr}\right)^2}{(s-1)gd_{50}} \quad (15)$$

$$v_{eff} = \sqrt{v_R^2 + U_{on}^2} \quad (16)$$

s: relative density of sediment

g: gravity acceleration [m2/s]

v_{cr}: critical depth averaged velocity for initiation of motion (based on a parameterization of the Shields curve) [m/s]

v_R: magnitude of an equivalent depth-averaged velocity computed from the velocity in the bottom computational layer, assuming a logarithmic velocity profile [m/s]

U_{on}: near-bed peak orbital velocity [m/s] in onshore direction (in the direction on wave propagation) based on the significant wave height

The direction of the bed-load transport vector is determined by assuming that it is composed of two parts: part due to current ($S_{b,c}$) which acts in the direction of the nearbed current, and part due to waves ($S_{b,w}$) which acts in the direction of wave propagation. These components are determined as follows:

$$S_{b,c} = \frac{S_b}{\sqrt{1 + r^2 + 2|r|\cos\varphi}} \quad (17)$$

$$|S_{b,w}| = r|S_{b,c}| \quad (18)$$

$$r = \frac{\left(|U_{on}| - v_{cr}\right)^3}{\left(|v_R| - v_{cr}\right)^3} \quad (19)$$

with:

φ: angle between current and wave direction (for which van Rijn suggests a constant value of 90°) [deg]
and:

$$S_{b,c} = 0 \text{ if } r < 0.01 \tag{20}$$

$$S_{b,w} = 0 \text{ if } r > 100 \tag{21}$$

Then, the computed sediment transport vectors are relocated from water level points to velocity points using an "upwind" computational scheme to ensure numerical stability, and the transport components are adjusted for bed-slope effects. The transfer of sediment between the bed and the flow is modelled using sink and source terms acting on the near-bottom layer that is entirely above Van Rijn's reference height (a). This layer is identified as the reference layer (for brevity the *kmx* layer). The sediment concentrations in the layer(s) that lie below the *kmx* layer are assumed to rapidly adjust to the same concentration as the reference layer.

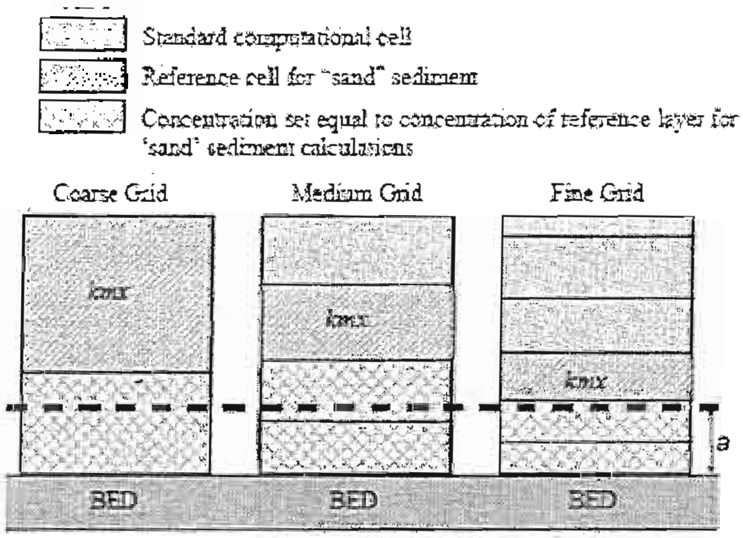


Figure 4. Define kmx layer

Each half time-step the source and sink terms model the quantity of sediment entering the flow due to upward diffusion from the reference level and the quantity of sediment dropping out of the flow due to sediment settling. At last, the suspended sediment transport is calculated by the application of turbulence closure modules that are representations of turbulence distributions, such as the k – L and the k – ε turbulence closure modules, and by the calculation of the vertical sediment mixing coefficient due to currents and waves.

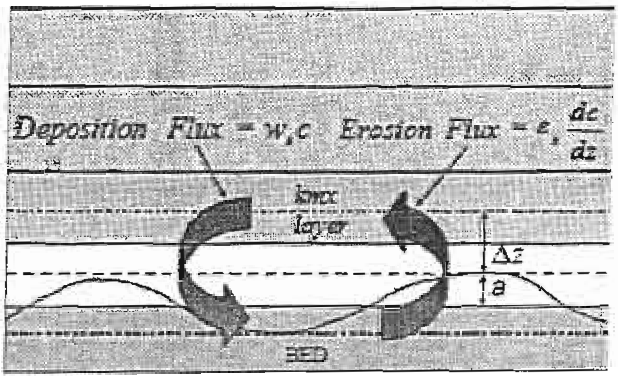


Figure 5. Transformation sediment between bottom layer and above layers

4. Overview of natural conditions of study area

4.1. Site location and terrain

The study area is located in Vinh Hao and Vinh Tan communes, Tuy Phong district – northeastern of Binh Thuan province. This area is limited between $11^0 12'$-$11^0 21'$N latitude and $108^0 44'$-$108^0 56'$E longitude, belonging to central of Vietnam. It is about 92km far from Phan Thiet and 270km far from Ho Chi Minh city.

Terrain of the study area has these typical characteristics of Central coastal region with high bathymetric slope. The bathymetry varies in the range of 2-20m in the near coast and in the range of 30-50m in the further area.

4.2. Meteorology and climate conditions

The climate condition in the study area possesses characteristics of tropical monsoon climate: hot and sunny day, high temperature, and large solar radiation. However, regional humidity is low and its evaporation is high. The rainy season usually comes late and ends soon (rainy season is short).

The average annual air temperature varies from 26.5 to 27.0^0C. The maximum air temperature may reach to 40^0C and the minimum air temperature stays about 15^0C.

Coastal zone of Binh Thuan province has the lowest average rainfall in Vietnam (about 700mm/year).

Binh Thuan coastal area as well as Vinh Tan is governed by two kinds of monsoon system: Northeast monsoon from November to March and Southwest monsoon from May to September. In April, May, October and November, the wind is light, alternating with a long period of calm wind. The result obtained from analysis of observed data in Phan Thiet during 31 year (1978-2009) shows that in May, June, September and October, wind velocity is often small (averagely about 2.4-2.8 m/s) and prevalent wind direction is West/SouthWest. Meanwhile, from November to April, the wind velocity is relatively high (averagely about 2.9-4.0 m/s) with prevalent direction in East – Northeast (Table 1).

Table 1. Frequency of wind according to different directions in Phan Thiet (1978-1994)

month	Average Velocity	N	NE	E	SE	S	SW	W	NW	Clam
1	3.8	10.5	17.0	43.9	7.5	1.3	0.5	0.7	3.9	14.9
2	4.0	8.0	17.3	46.5	8.5	2.0	0.4	0.6	2.8	13.9
3	3.8	8.8	16.5	42.7	10.9	5.5	0.6	0.9	2.2	11.9
4	3.3	10.1	11.5	27.7	13.2	12.9	2.4	2.9	2.7	16.7
5	2.8	9.6	5.0	10.5	8.3	13.2	8.8	19.7	8.5	16.5
6	2.8	4.3	1.5	2.9	3.0	8.0	15.5	46.3	8.3	10.1
7	3.1	2.8	1.1	1.0	2.3	8.7	18.5	47.8	7.5	10.3
8	3.1	3.4	0.6	0.8	3.5	6.5	17.8	52.2	7.7	7.5
9	2.7	6.0	1.9	3.4	5.7	8.1	13.2	35.1	11.0	15.4
10	2.4	14.5	6.5	15.1	9.2	6.3	3.2	12.0	10.9	22.4
11	2.9	15.0	14.0	28.1	8.0	2.8	1.0	4.9	7.5	18.7
12	3.1	12.7	15.8	36.7	6.5	2.0	0.6	1.7	5.8	18.4
averaged	**3.1**	**8.8**	**9.0**	**21.6**	**7.2**	**6.4**	**6.9**	**18.7**	**6.6**	**14.7**

The averaged wind velocity in years in this study area is 3.1m/s. The prevalent wind directions are E, W, NE, SE and SW. Frequency of the calm wind is about 14.7% (table 1).

Following statistical data from 1911 to 2011 (100 years), the study area was attacked by 23 typhoons. Typhoon often occurs in the period of October to December. In the other month few or no typhoon occurs (table 2).

Table 2. Frequency of typhoon occuring in the coastal zone of Binh Thuan

month	1	2	3	4	5	6	7	8	9	10	11	12	Total
number	0	0	1	1	1	0	1	1	3	8	11	4	31
%	0.0	0.0	3.2	3.2	3.2	0.0	3.2	3.2	9.7	25.8	35.5	12.9	100

4.3. Hydrodynamic condition

The average water temperature of Binh Thuan coastal zone varies in the range of 25- 30^{0}C. Months, from June to August,have high basic temperature. On the contrary, months, from December to February, have lower water temperature (table 3).

Table 3. Water temperature on surface layer in the coastal zone Binh Thuan

Temperature	Month												Year
	1	2	3	4	5	6	7	8	9	10	11	12	
Maximum	27.2	27.5	28.8	19.1	28.5	31.7	31.1	29.2	29.7	28.2	28.8	27.3	31.7
Minimum	24.6	26.0	27.5	24.9	26.4	28.2	28.0	27.9	26.3	27.1	28.1	24.3	24.3
Average	26.2	26.6	28.0	27.8	27.5	29.4	29.8	28.4	27.9	27.1	28.4	25.6	27.7

Tidal pattern in the coastal zone of Binh Thuan is quite complicated because of its transitional position between diurnal tide (Central of Vietnam) to semidiurnal tide (Southern of Vienam). Every month, there are 5-10 days of diurnal tide (in flood tide period) and 5-10 days of semidiurnal tide (ebb tide period), the remaining days have mixture tidal. Tidal amplitude gradually increases from 1.5-2.0m in Phan Rang area to 2-2.5m in Phan Thiet coastal area. Tidal amplitude in low flow period stays approximately 0.5- 0.7m. Toward the South, the amplitude of tide gradually increases while the number of diurnal tide day decreases.

Wave in this study area depends on wind field and seasonally changes. In months of winter, prevalent wave direction comes from Northeast with common height of 0.7-1.2m. On the other hand, in months of rainy season, prevalent wave direction comes from southwest with common height of 0.6-1.1 m.

4.4. Erosion and deposition

Owing to the fact that the coastline of this area is oriented northeast – southwest, sediment transport and erosionare influenced of hydrodynamic conditions that change according to seasons (northeast and southwest monsoon).

In the study area, its coastline is fairly stable, except for Phuoc The and Lien Huong segment (to the west of Cu Lao Cau island). The material covered this area is medium sand, the bank and the edge is steeply sloping with a height of 3-5m and no vegetation covers. Phuoc The – Lien Huong now are coastal zones with erosion rate of about 5-13m/year (Bui Hong Long et al., 2001). According to results of recent research, the erosion of Phuoc The and Lien Huong was caused by some following reasons:

Endogenous reasons: the continental part to the western and northern are lifting while the continental part to the eastern are sinking. With regard to offshore, there is a sink zone (about 100m depth). Perhaps that is a trap zone of sediments which increase erosion process in the coastal zone.

Exogenous reasons:

- It is the coastal zone with upper slope. Therefore, sediment transportation to the offshore hardly is compensated.

- Wave height impacts directly the coastline in both northeast and southwest monsoon.

- The material stayed at the coastline and bottom are light, crumbly, and being transported easily to other places.

- Other activities in this area include dam, aquaculture, agriculture and so on which do not impact the balance of sediments transport in this area.

Among above reasons, lack of materials due to sediments transportation to the offshore is main factor causing erosion of Phuoc The, Lien Huong coastal area ((Bui Hong Long et al., 2001).

5. Models setup

5.1. Gird and bathymetry

The grid and bathymetric grid of the model are built base on bathymetry database digitized map in Binh Thuan coastal area. Model frame is extended to the outside of Vinh Tan area in order to reduce influences of open marginal conditions (if any). Model frame is about 174 km long in northeast – southwest direction (parallel with the coastline) and 92 km long in northwest – southeast direction (perpendicular with the coastline). The total area of sea surface is about 11.7 km^2.

Horizontally, the grid was used in orthogonal curvilinear co-ordinates with model frame split to 668 x 366 grid points with grid size varies between 68.7 and 670m (Figure 6). The σ coordinate was used for vertical grid. In hydrodynamics model, the total depth was divided into 4 layers (each layer account for 25% of the total depth of the water column).

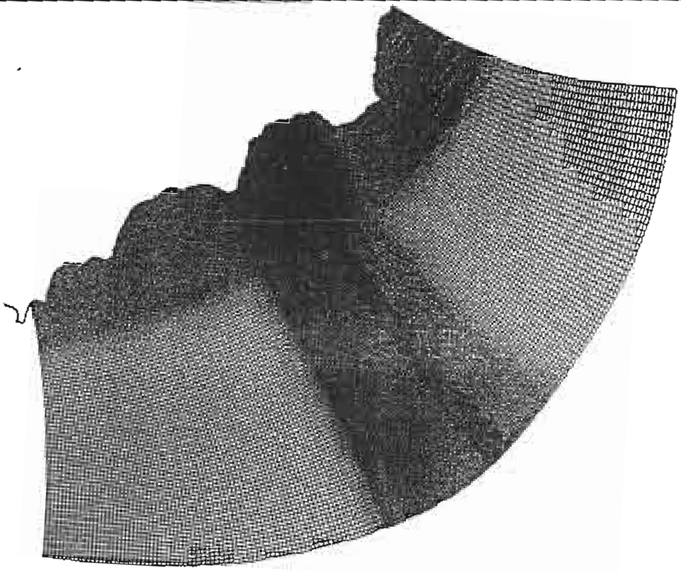


Figure 6. Model frame and model gird of the study area

Bathymetric grid for Binh Thuan coastal area is a bathymetric file, which was processed in the Delft3d- QUICKIN associating with model grid. Bathymetric grid of the model is shown in Figure 7.

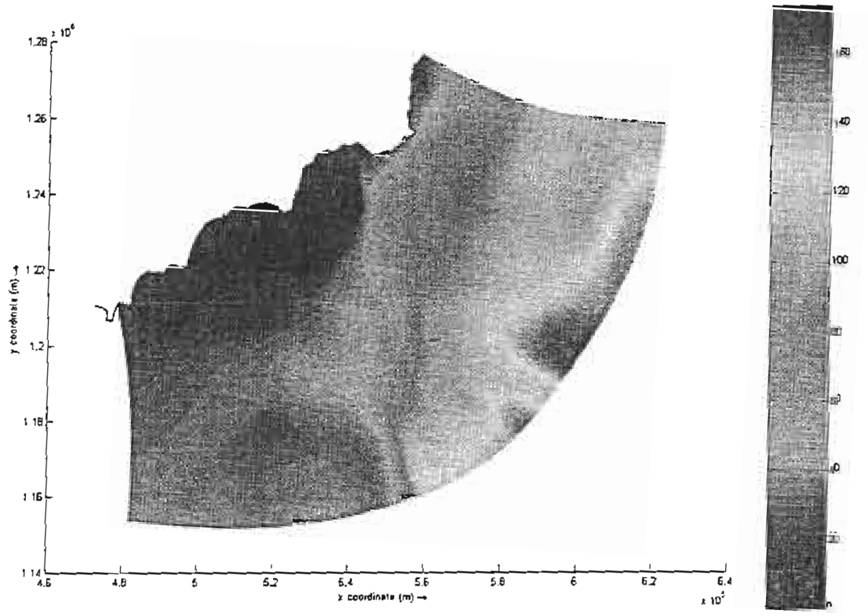


Figure 7. Bathymetric gird of the mode

Bathymetric grid and model grid of the wave model are used same as the grids of hydrodynamics model.

5.2. Main processes of the model

In order to assess and predict influences of dredging activities on hydrodynamic conditions, wave and sediment transport at Vinh Tan coastal area and adjacent areas, main processes supporting the calculation of the model were defined. Influences include flow regime, wave and impacts from turbidity area due to dredging, characteristic of sediment transport after the work. Main processes include:

- Hydrodynamics
- Sediment (suspended and settled sediments)
- Wind
- Wave (online coupling with hydrodynamics and sediment transport)
- Dredging activities

5.3. Boundary and initial conditions

Location and boundary conditions

Hydrodynamics, wave - sediment transport models for the studied area have open boundaries at northeastern, southwestern and southeastern sites. These open boundaries are shown in Figure 7.

Initial and boundary conditions

At first-time running, the initial conditions of the model are set as zero (0) for sea level, salinity, and suspended sediment concentration. Initial conditions for next running are results from previous running (restart file).

For open boundaries to the sea: tidal harmonic constants of 4 main constituents O1, K1, M2, S2 are used. Open boundaries for other models are from the database harmonic tidal constants Fes2004. Harmonic tidal constants in near coastal line are based on observational data of sea level at Phan Rang and Phan Thiet ports.

5.4. Model calibration and validation

Model calibration and validation are essential and important in applying the models at the specific area. Results of the model were compared with observational data in order to assess differences between calculation and observation. Accordingly, the model calibration aims to optimize the calculation process and reduce of the variation to a possible level (Donigian A. S., 1999).

For those software have been tested in practical conditions and being used widely, the difference between the modeling and actual observation may occur due to one (or some) of these causes (Mulla D. J and Addiscott T. M., 2000):

- Lack of parameter correction, especially local parameters such as Coriolis force, bottom roughness coefficient, etc.

- Lack or inaccuracy of input data (initial conditions, boundary conditions, bathymetric data)...
- Inaccuracy in parameter selection

Root Mean Square Errors (RMSE) is important indicators to assess the accuracy of the model.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(P_i - O_i)^2}{N}}$$

Where:

i = 1, n is the number of observation
P_i is the predicted value of simulation at time i
O_i is the observed value of observation at time i

Hydrodynamics model

- The bottom roughness coefficients in this study employ spatial Chezy (C) coefficients in the range of 0-1000$m^{-1/2}$s. At the studied area, C=60 was chosen for further calculation.

- The parameters relating to turbulence can be defined and used by users as constants, spatial variables, or calculated values following Horizontal Large Eddy Simulation (HLES). The HLES model has been included in the Delf3D according to the theoretical Uittenbogaard (1998) and discussed in the study of Van Vossen (2000). In this study, the horizontal eddy viscosity and horizontal diffusion were selected with the value of 10 m^2/s. These coefficients in the vertical are 1.0 x 10^{-6} m^2/s. The 2D turbulence model is HLES in the Delft3D and k-ε turbulence model was used for 3D turbulence model.

Suspended sediment model

- The settling velocity of suspended sediment was used with value of 0.1mm/s. This value is used in case of fresh water ($w_{s,f}$). In calculation, the settling velocity of suspended sediment (w_s) will take into account effect of salinity.

- The critical shear stress of sediment erosion ($\tau_{c,e}$) is changing in 0.1-1.0 N/m^2 (Van Rijn, 1993). In this study, the value of 0.25 N/m^2 was selected as erosion critical shear stress after calibrations.

- The critical shear stress of sediment deposition ($\tau_{c,d}$) is changing in 0.005-0.25 N/m^2 (Van Rijn, 1993). In this study, the value of 0.2 N/m^2 was selected as deposition critical shear stress after calibrations.

- Erosion rate in the nature was determined changing in 10^{-5}-10^{-3} kg/m^2s. With the density of bottom sediment assumed as 2650 kg/m^3, density of suspended sediment in near bed is about 500kg/m^3, the initial rate of natural erosion was assumed as 10^{-3} $kg/m^2.s$.

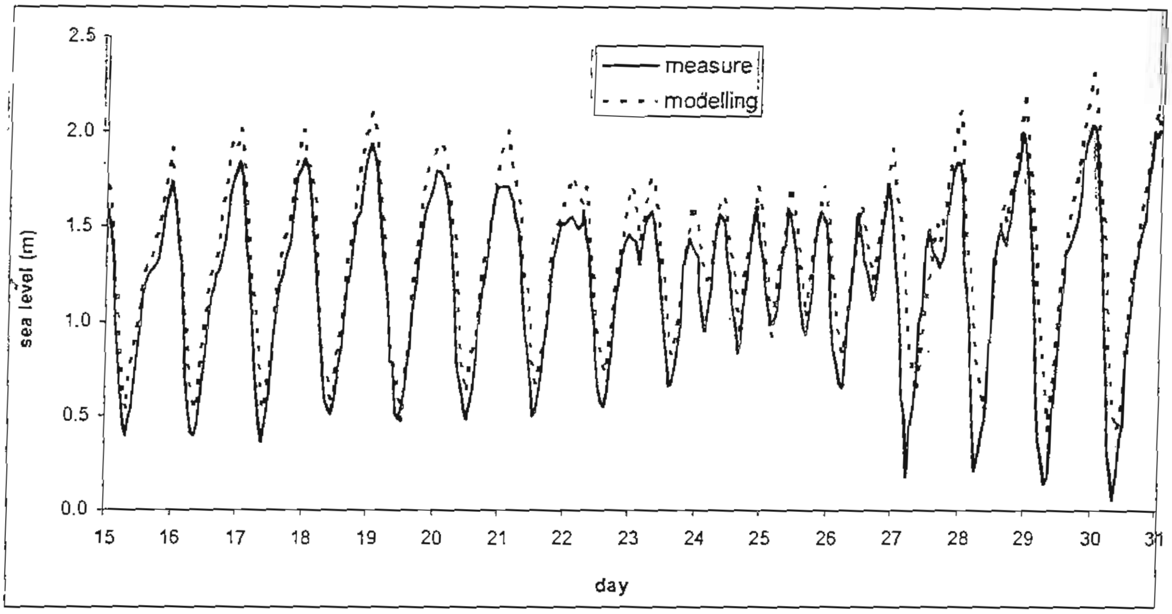
Wave model

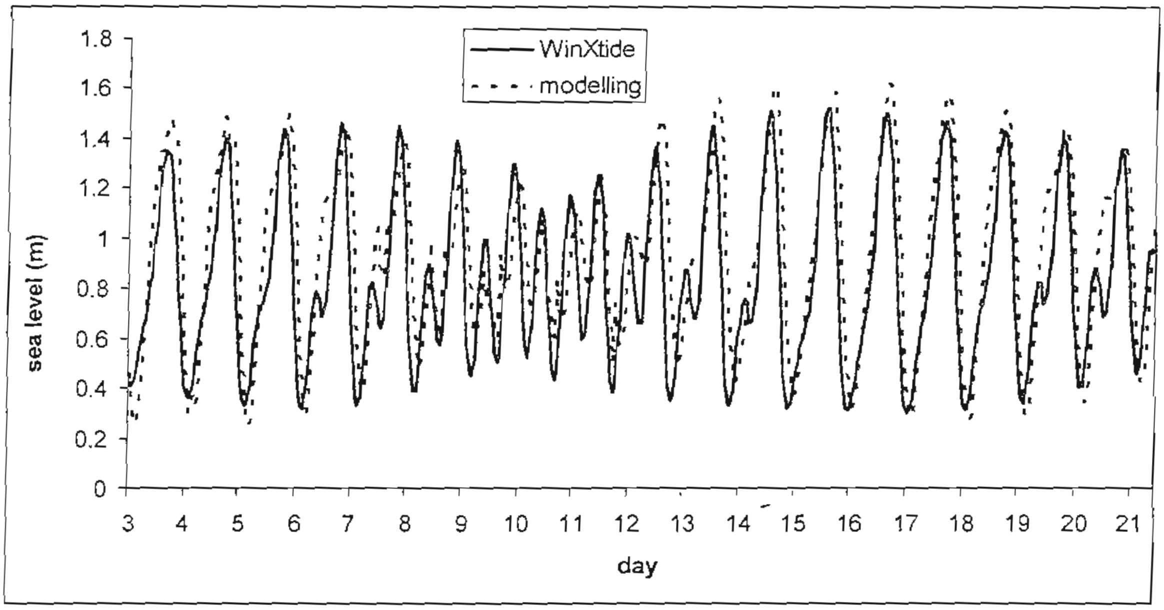
The wave model in this study was setup online coupling with the hydrodynamics and sediment transport models. At each time step, wave model uses the grid, wind filed as well as results of depth, current, water elevation from hydrodynamics model.

- The open boundary condition of the wave model for the study area was from wave prediction of the wave climate (WaveClimate.com service) in 2009.

- The Alfa coefficients in the wave model changing in 0.1-10, in this study it was used with the values of 1.0. The Gamma coefficient in the wave model changes in the range of 0.55-1.2 and in this study, it was used with the values of 0.73. The Bottom friction of wave model in this study is JONSWAP with value of 0.067. The B&J model (Battjes, J. and J. Janssen, 1978) was used to model the energy dissipation in random waves due to depth induced breaking (Delft Hydraulics, 2003). Other parameters are summarized as in Table 4.

In order to validate the hydrodynamics model at the coastal zone of Binh Thuan and Cu Lao Cau, we compared the calculated sea level with measured value at Vĩnh Tân (14/10-12/12/2007) and data at Mui Dinh (Ca Na Headland, Ninh Thuan Province) calculated by WinXtide32 in rainy and dry seasons of 2012. After final calibration processing, the comparison reveals a relative agreement in both amplitude and phase between calculated and measured values (Figure 8). Therefore, the results of hydrodynamics model are proposed suitable to setup sediment transport model.





Hình 8. Comparison of water level calculated by the model and measure at Vinh Tan (a) and calculated by WinXtide32 at Mui Dinh (b)

Main parameters of the models

Main parameters for hydrodynamics, wave and sediment transport modeling are setup based on calibration process and summarized in the following table:

Table 4. Summary main parameters of the models

Module	Parameters	Values
hydrodynamics	Number ofameter gird cell	M=668, N=366
	Δx, Δy	68.7-670.0m
	Step time	60 seconds
	Threshold of dry and wet	0.1 m

	Number layer	4(25%/ layer)
	Horizontal eddy viscosity	$1.0 m^2/s$
	Horizontal eddy diffusity	$1.0 \times 10^{-6} m2/s$
	Horizontal diffusion	$1.0 m^2/s$
	Veritical diffusion	$1.0 \times 10^{-6} m2/s$
	Chezy coefision	60
	Turbulence closure model	*k*-e turbulence closure
	Advection scheme	Cyclic method
	Sigma-coordinate correction	On
	Forrester filer vertical	On
	Forrester filter horizontal	Off
wave	Maximum number of iteration	8
	Spectrum	JONSWAP
	Setup	False
	Hydrodynamics (water level, bathymetry, current, wind)	Use and don't extend
	Forcing	Wave energy dissipation
	Friction	Madsen et al. (1978)
	Breaking	Bettjes & Janssen (1978)
	Alfa	1.0
	Gamma2	0.73
	Wind	Komen et al. (1984)
	Quad	Hansselman et al. (1985)
Sediment transport	N	10
	f_{MOR}	10
	EQMBC	True
	Densin	False
	ALFABS	1
	ALFABN	1.5
	f_{SUS}	1
	f_{BEB}	1
	f_{SUSW}	1
	SEDTHR	0.5
	THETSD	0
	RHOSOL	2650
	D_{50} *sand*	150
leveling	DepthDef (m)	1
	MinimumDumDepth (m)	-999
	MaxVolDump (m^3)	1.609.251
	MaxVolRate (m^3/ngày)	8350
	DumpDistr	1
	Percentage	100
	DepthDef (m)	1

5.5. Modeling time frame and simulation scenarios

In order to assess influences of dredging activities on hydrodynamics, wave condition and sediment transport as well as erosion condition in coastal zone of Vinh Tan and it surrounding, scenarios simulation have been setup. These scenarios focus on three groups: before dredging activities, dredging activities and after dredging activities (finish dredging and construction). Simulation and prediction scenarios are established. These scenarios include before dreḍing (no impact), during dredging and after dredging activities and the construction.

Table 2. Scenarios for hydrodynamics and sediment transport simulation

No	Scenario	Wind direction		Annotate
1-2	Present	South-west	North-east	Before dredging activity
3-4	Dredging	South-west	North-east	During dredging process
5-6	After dredging	South-west	North-east	After dredging activities

Time simulation for each scenario: 60 days (30 first days is to stabilize the modelling conditions and to provide initial conditions of the next 30 days).

Time step: 60 seconds

These scenarios are representative for two main wind monsoons: Southwest and Northeast wind monsoons. In the study area, Southwest wind is prevalent in the periods of May to September while Northeast wind is prevalent in the periods of November to March. Other months in the year, wind has scattered direction along with wind-free period (Nguyen The Tuong, 1996; National Hydro - Meteorology Agency, 2000)

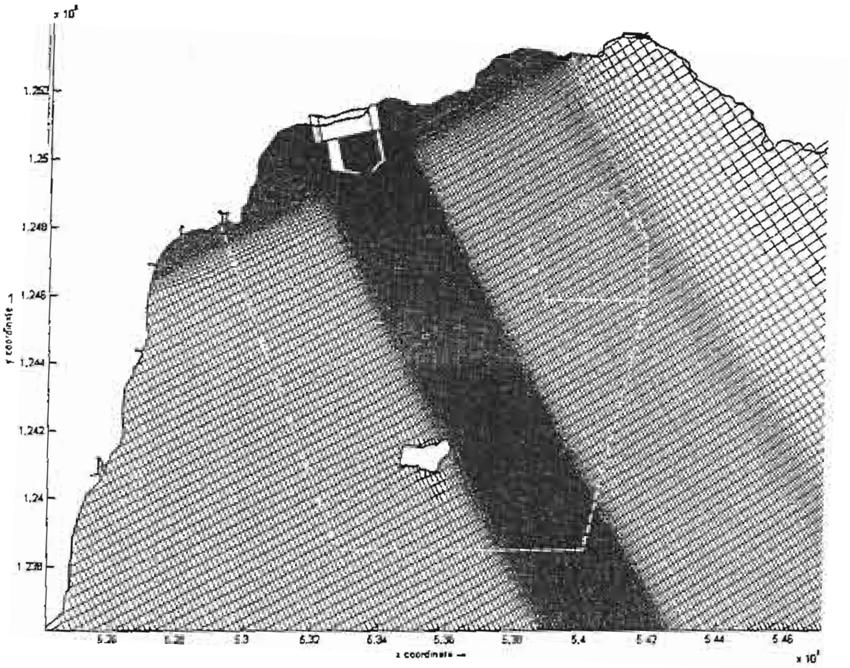


Figure 9. Gird of the model with the dredging area finished in the model frame

In addition, monitoring points were added into the model frame to assess the impact of dredging activities the hydrodynamics conditions and sediment transport. The positions of these monitoring points are shown in figure 10.

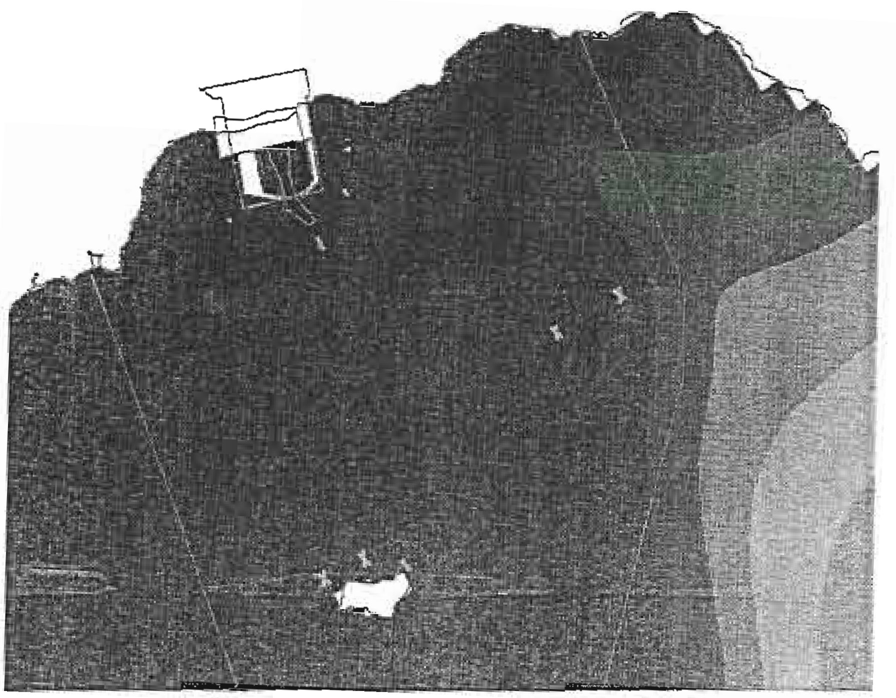


Figure 10. Position of monitoring points in the study area

Table 6. Position of monitoring point

Number	Position (i,j)		Annotate
	M	N	
V1	447	145	Breda sandbar
V2	432	145	Breda sandbar
V3	183	137	West of Cu Lao Cau Island
V4	190	137	Northwest of Cu Lao Cau Island
V5	201	135	Northeast of Cu Lao Cau Island
V6	410	182	East of the dredging area
V7	384	164	East of the dredging area
V8	305	196	Southeast of the dredging area
V9	199	176	Southwest of the dredging area

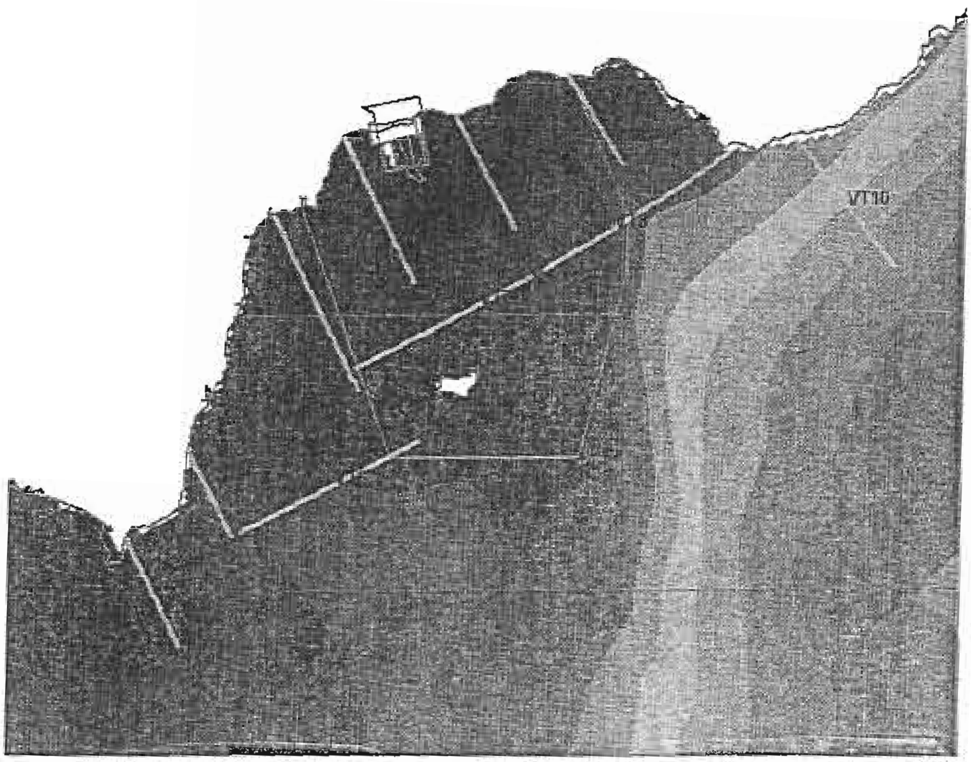


Figure 11 Position of some cross-section in order to calculate sediment flux

To assess the influences of dredging activities on sediment transport in the study area at some cross-sections, during the calculation, cross-sections were added perpendicular and parallel with the coastline. These include:

- Cross-sections control sediment flux alongshore of Vinh Tan coastal zone: VT1, VT2, VT3, VT4

- Cross-sections control sediment flux alongshore at the South of Vinh Tan coastal zone: VT5, VT9

- Cross-section controls sediment flux alongshore at the North of Vinh Tan coastal zone: VT10

- Cross-sections control sediment flux perpendicular to the Vinh Tan coastline: VT6, VT7, VT8.

6. Results and discussions

6.1. Influences on hydrodynamic conditions

The current hydrodynamic conditions

Hydrodynamics of Binh Thuan coastal area in general and Vinh Tan coastal area in particular are impacted by a range of factors such as wind, sea level oscillation and wave action. Results of the model show that integrated currents in this study have not high velocity. Prevalent magnitude of current, which is between 0.1 - 0.3 m /s, alters with water level oscillation (Figure 12-13 and Figure 22-23). Current directions in this area are directional along the seacoast: directional east-northeast (flood tide stage) or directional south-southwest (ebb tide stage).

During the northeast monsoon, integrated field velocity is intensified (increase) in the ebb tide stage and restricted (reduce) in the flood tide stage (North - Northeast) (Figure 22-23). On the other hand, in southwest monsoon, field velocity with directional north - northeast in the flood tide is increased and decreased in the ebb tide stage (Figure 12-13).

Wave induced currents in the area have low velocity most of which is lower than 0.4 m/s. These currents are almost directional alongshore (similar to integrated current) and alter following the tidal oscillation and wind season. During southwest monsoon season, the velocity of the wave induced current increases in flood tide stage and dramatically drops in ebb tide stage (Figure 18 – 19). Meanwhile, during northeast monsoon season, such velocity falls in flood tide stage and raises in ebb tide stage (Figure 26-27).

The wave field of Binh Thuan coastal area change largely following the wind velocity and tidal oscillation. Wave height usually reaches maximum value at high tide. During the southwest monsoon season, the wave direction is mostly south and southwest and wave height is in the range of 0.4 – 1.2 m (Figure 24). During the northeast monsoon season, on the other hand, the wave direction is west - southwest and wave height is about 0.3 – 1.0 m (Figure 30).

Influence of leveling activities on hydrodynamics

Results of modeling reveal that leveling activities mostly have no impact on spatial distribution of integrated currents and wave field in the study area (see Figure 12 to Figure 31).

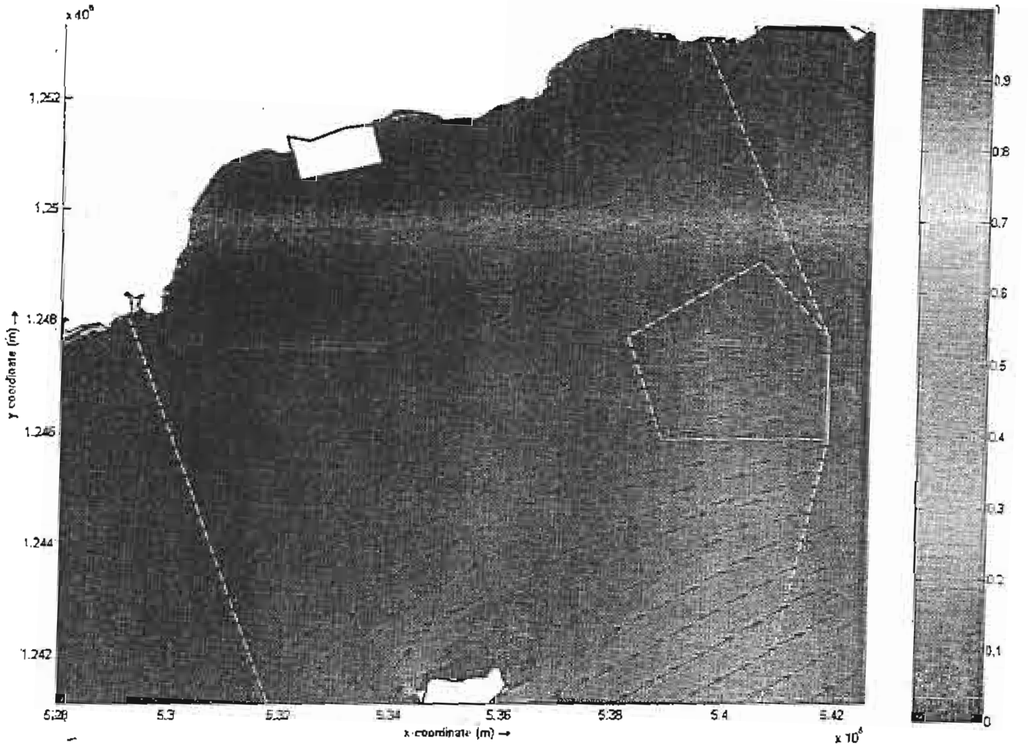


Figure 12. Integrated current field velocity in surface layer in Vinh Tan coastal area (southwest wind, flood tide- before leveling)

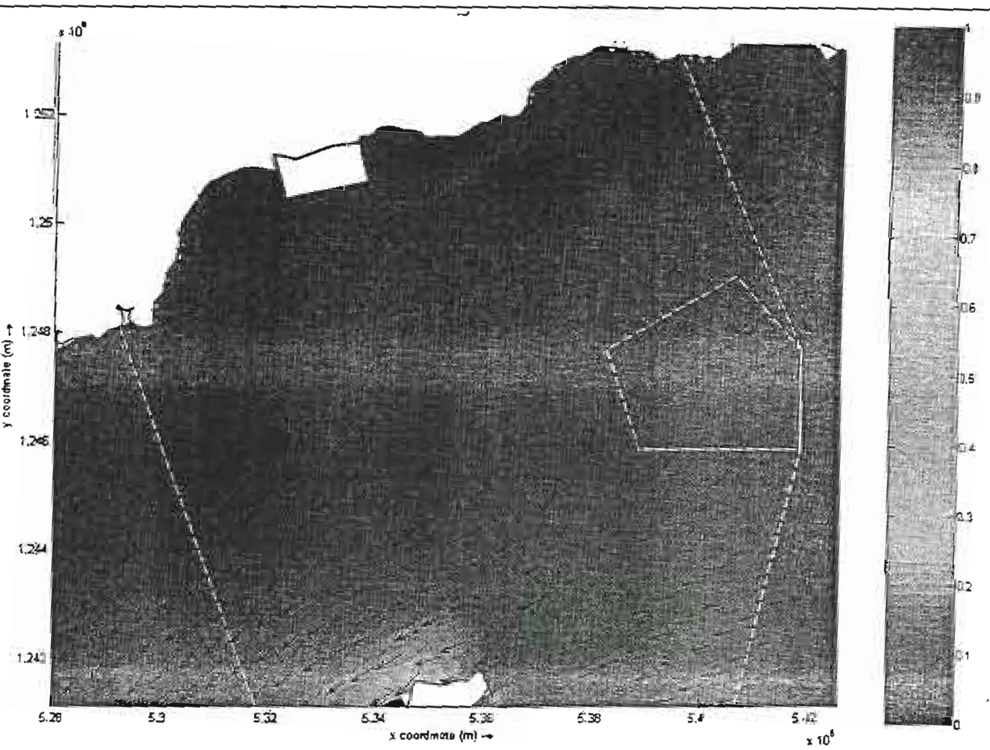


Figure 13. Integrated current field velocity in surface layer in Vinh Tan coastal area (southwest wind, ebb tide- before leveling)

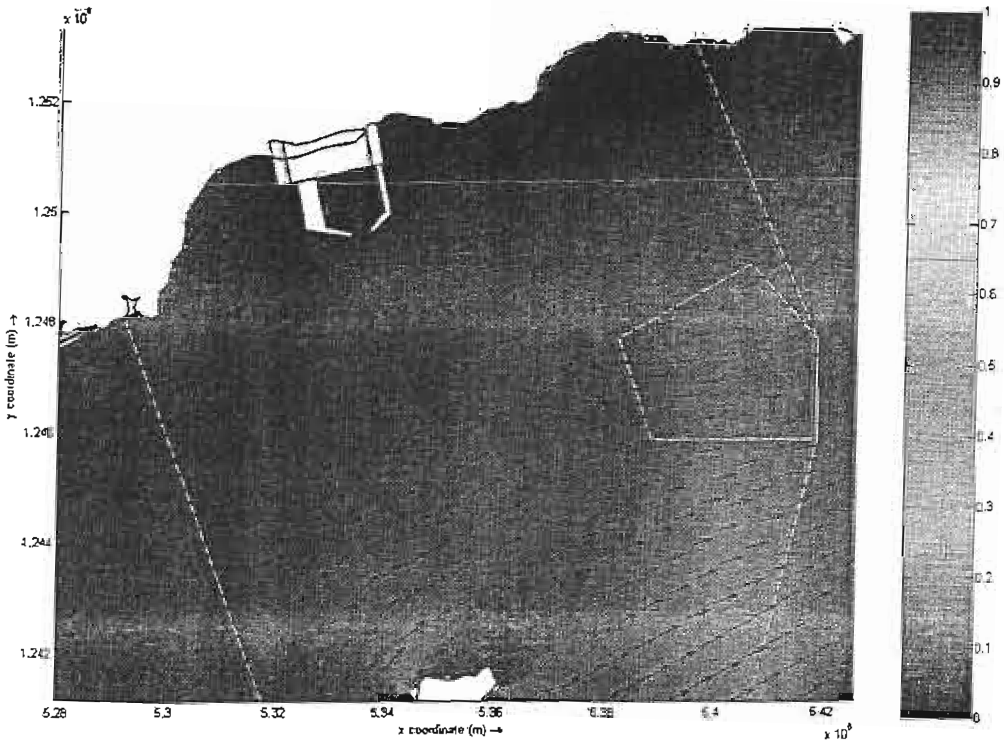


Figure 14. Integrated current field velocity in surface layer in Vinh Tan coastal area (southwest wind, flood tide- leveling after construction)

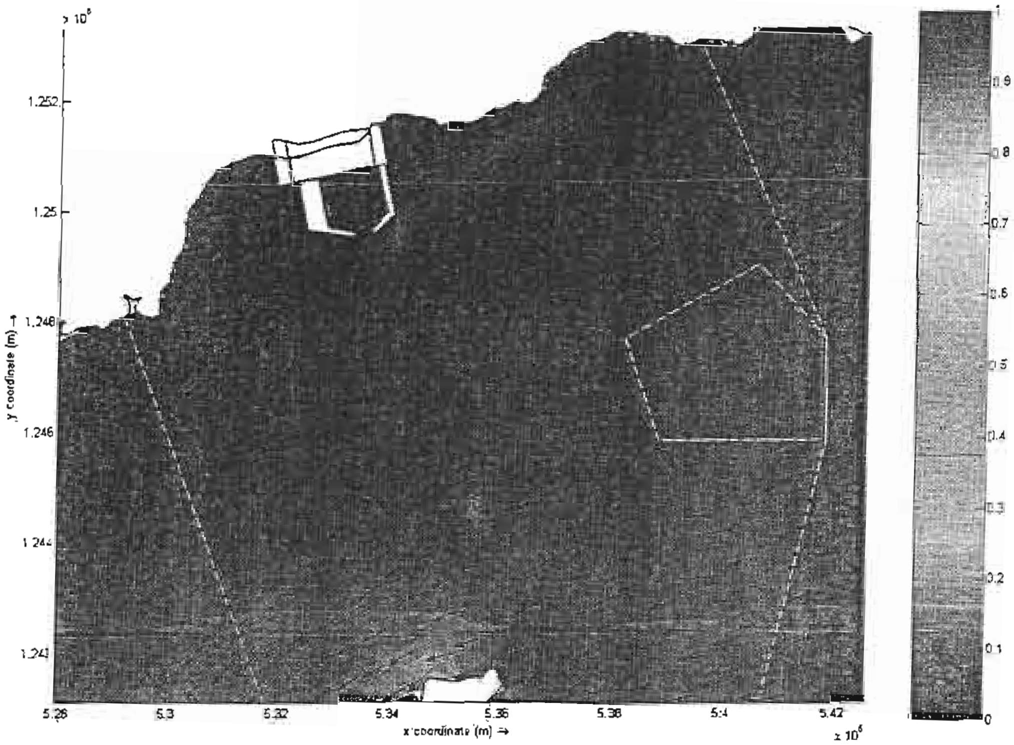


Figure 15. Integrated current field velocity in surface layer in Vinh Tan coastal area (southwest wind, ebb tide- leveling after construction)

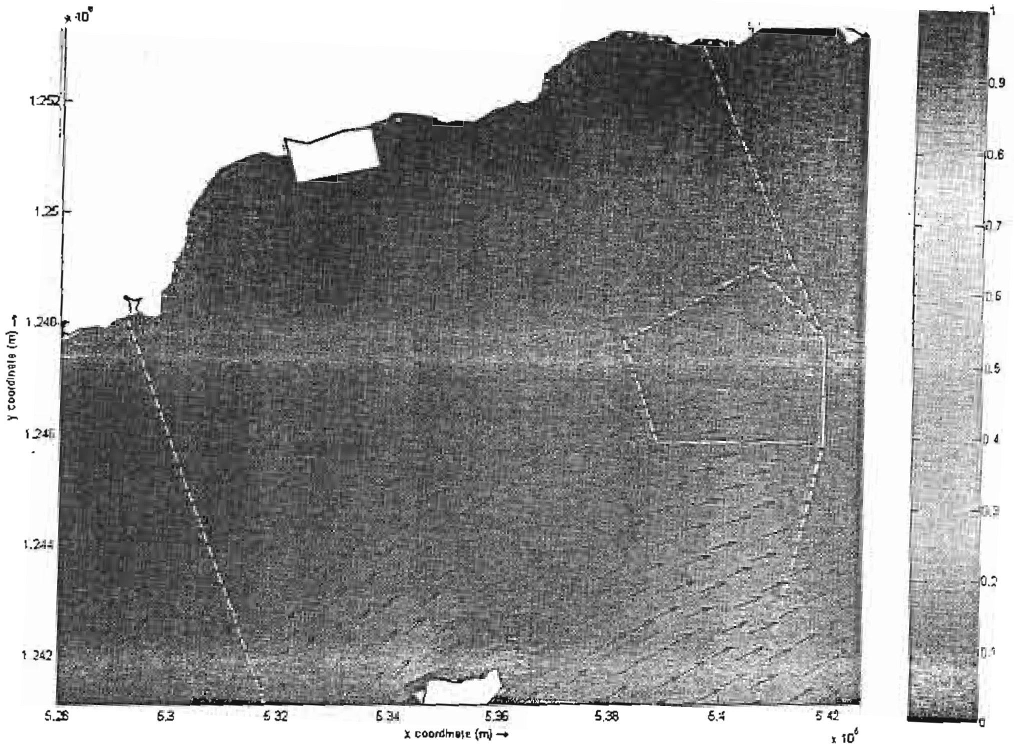


Figure 16. Currents induced by wave in Vinh Tan coastal area
(southwest wind, flood tide- before leveling)

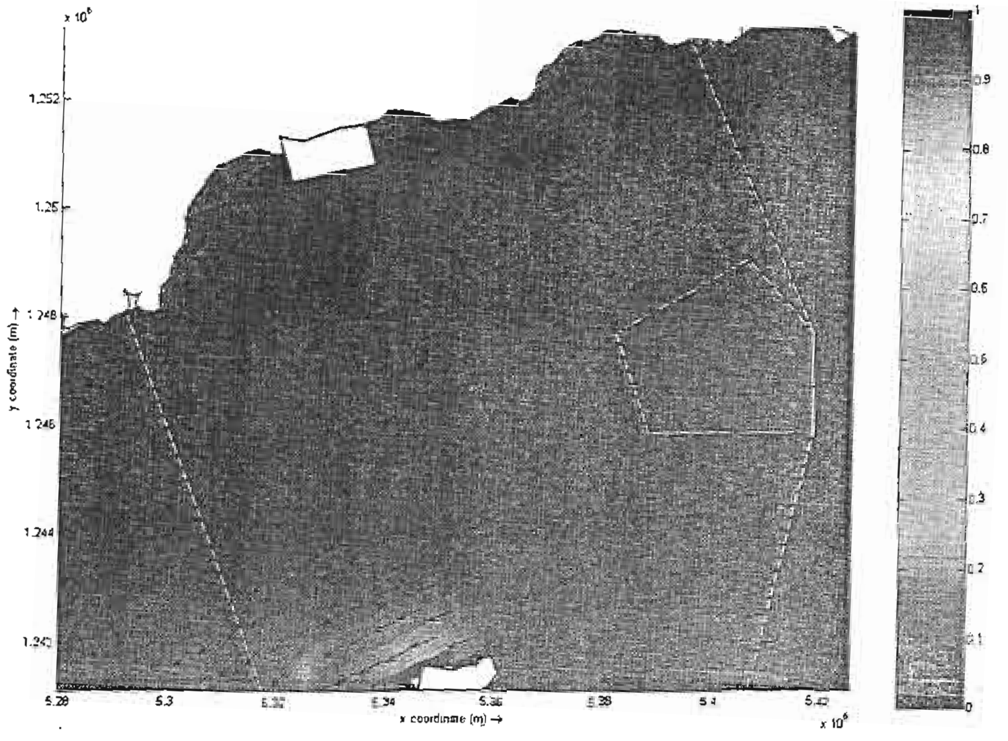


Figure 17. Currents induced by wave in Vinh Tan coastal area
(southwest wind, ebb tide- before leveling)

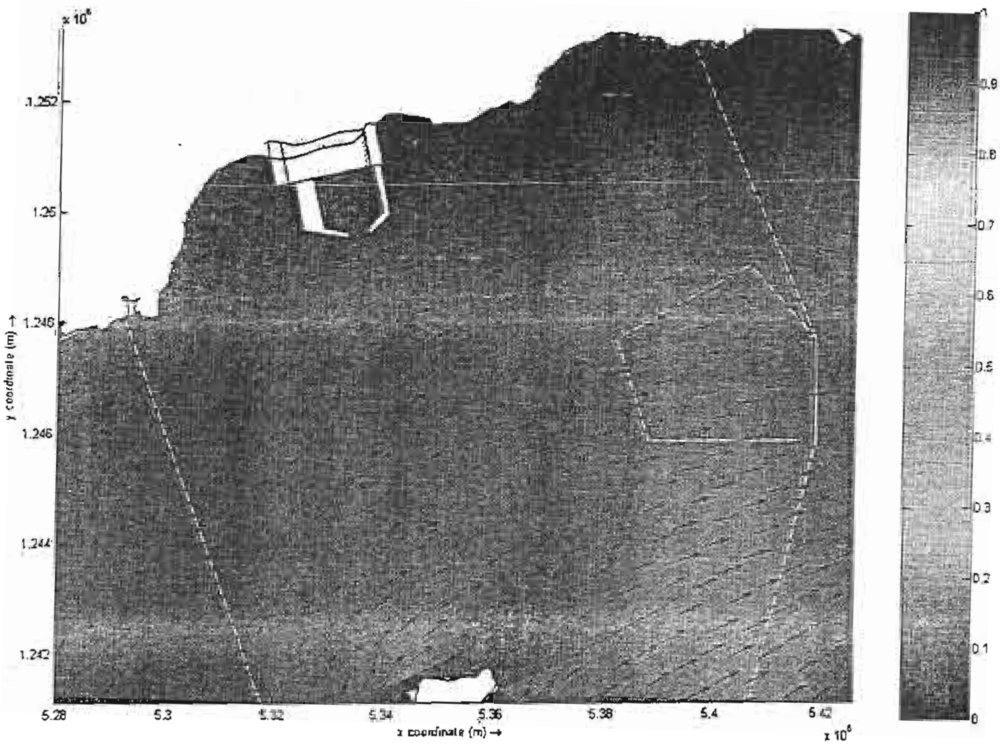


Figure 18. Currents induced by wave in Vinh Tan coastal area (southwest wind, flood tide- leveling after construction)

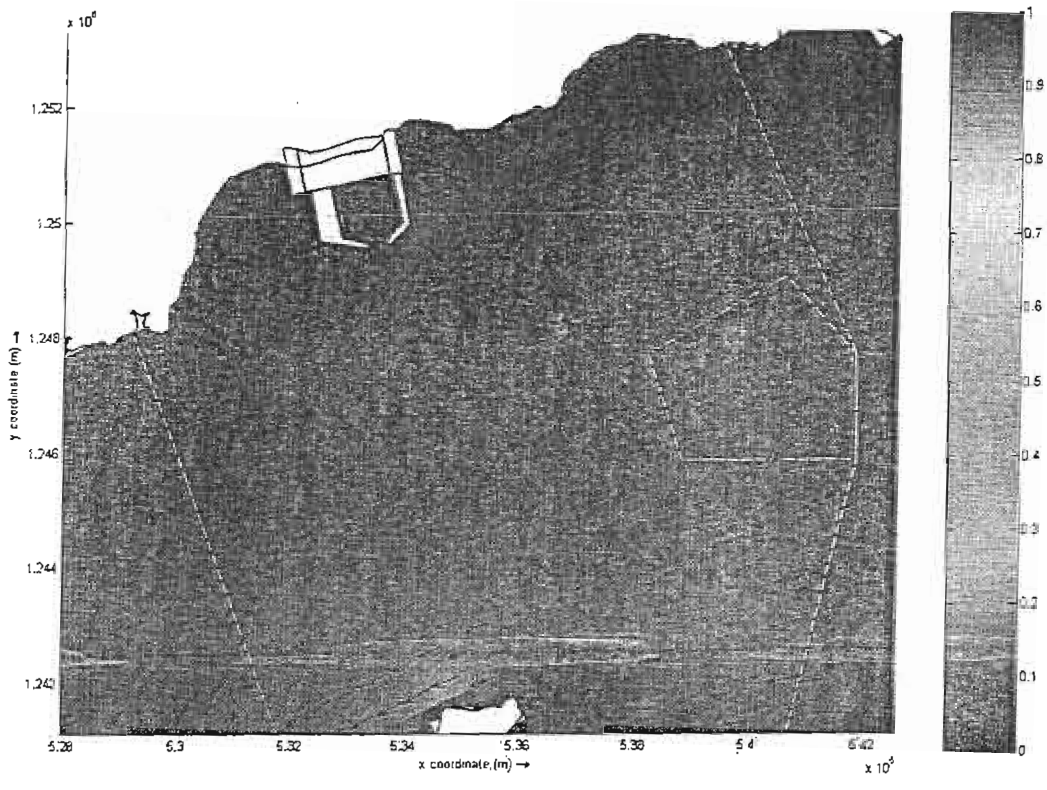


Figure 19. Currents induced by wave in Vinh Tan coastal area (southwest wind, ebb tide- leveling after construction)

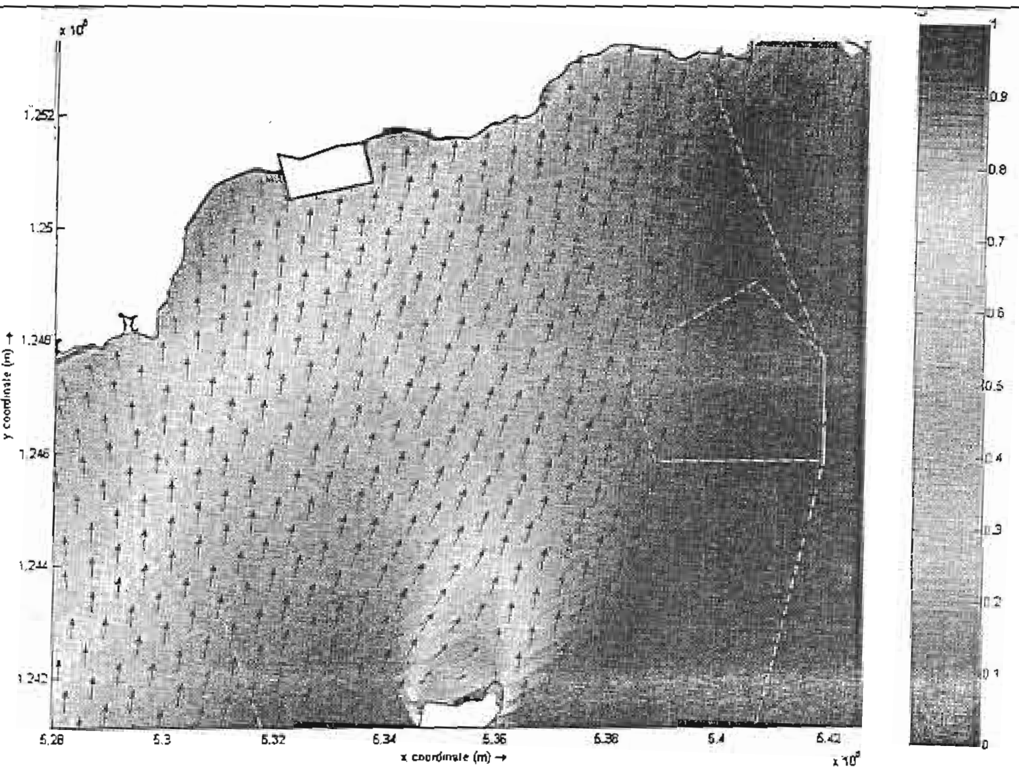


Figure 20. Wave height in Vinh Tan coastal area (southwest wind, high tide- before leveling)

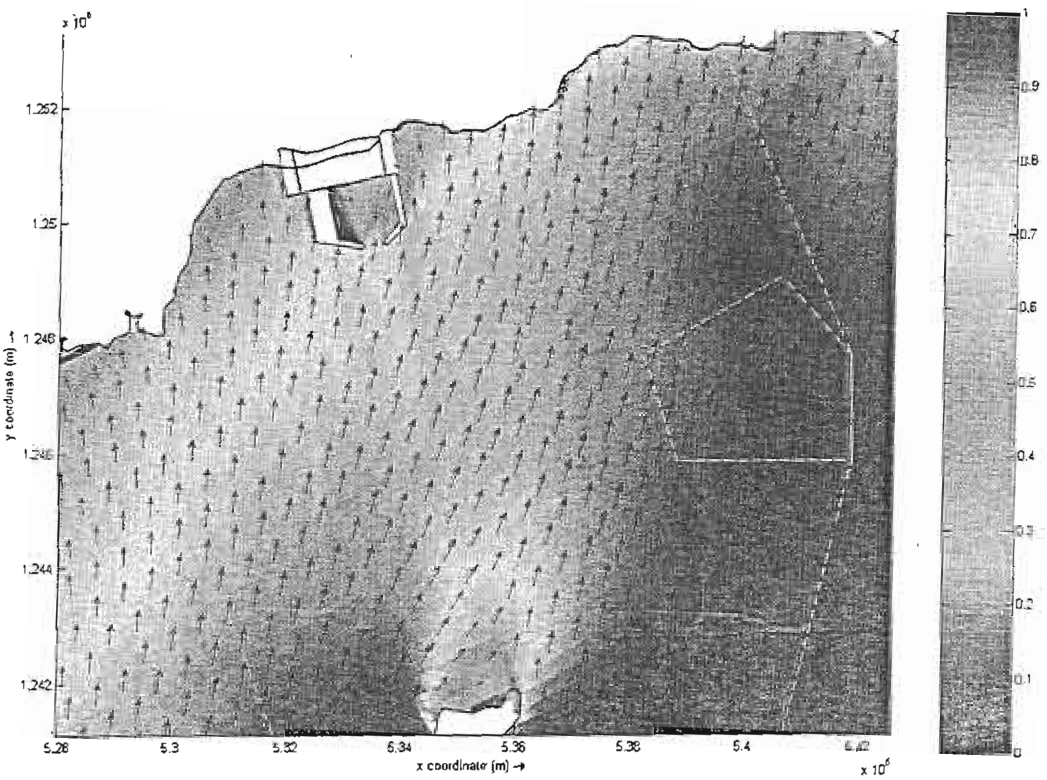


Figure 21. Wave height in Vinh Tan coastal area (southwest wind, high tide- leveling after construction)

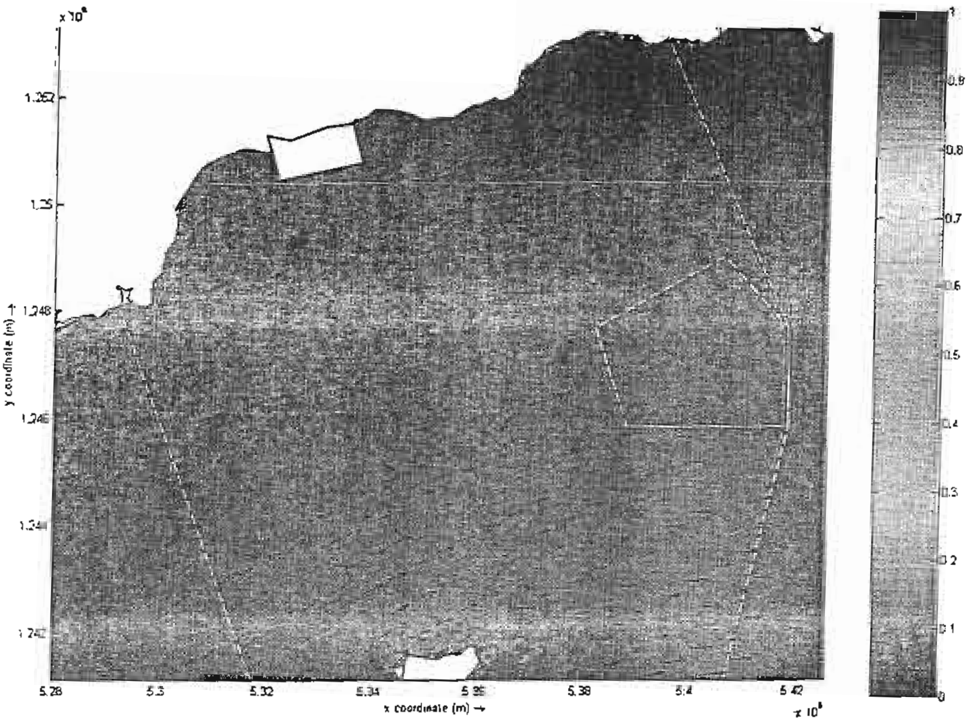


Figure 22. Integrated current field velocity in surface layer in Vinh Tan coastal area (northeast wind, flood tide- before leveling)

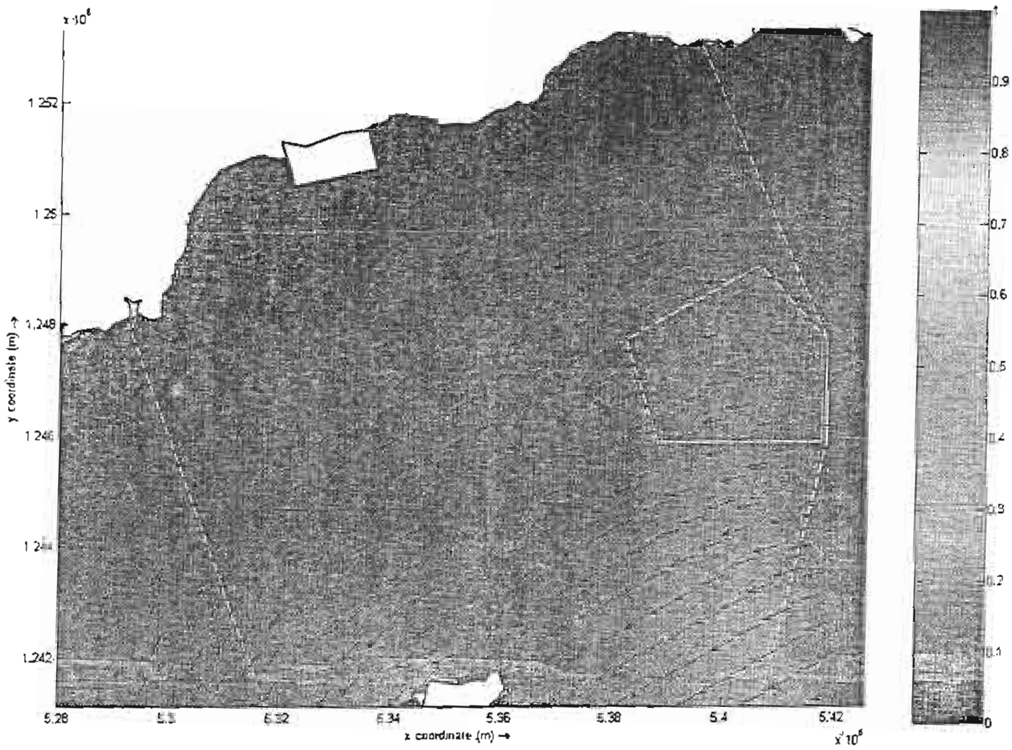


Figure 23. Integrated current field velocity in surface layer in Vinh Tan coastal area (northeast wind, ebb tide- before leveling)

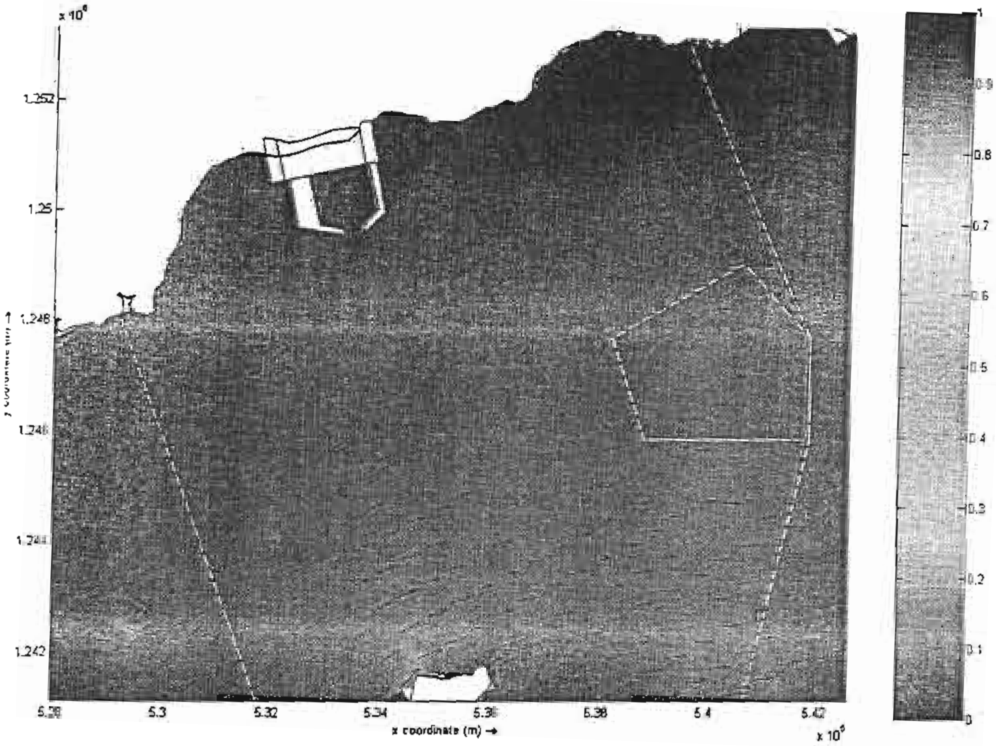


Figure 24. Integrated current field velocity in surface layer in Vinh Tan coastal area (northeast wind, flood tide- leveling after construction)

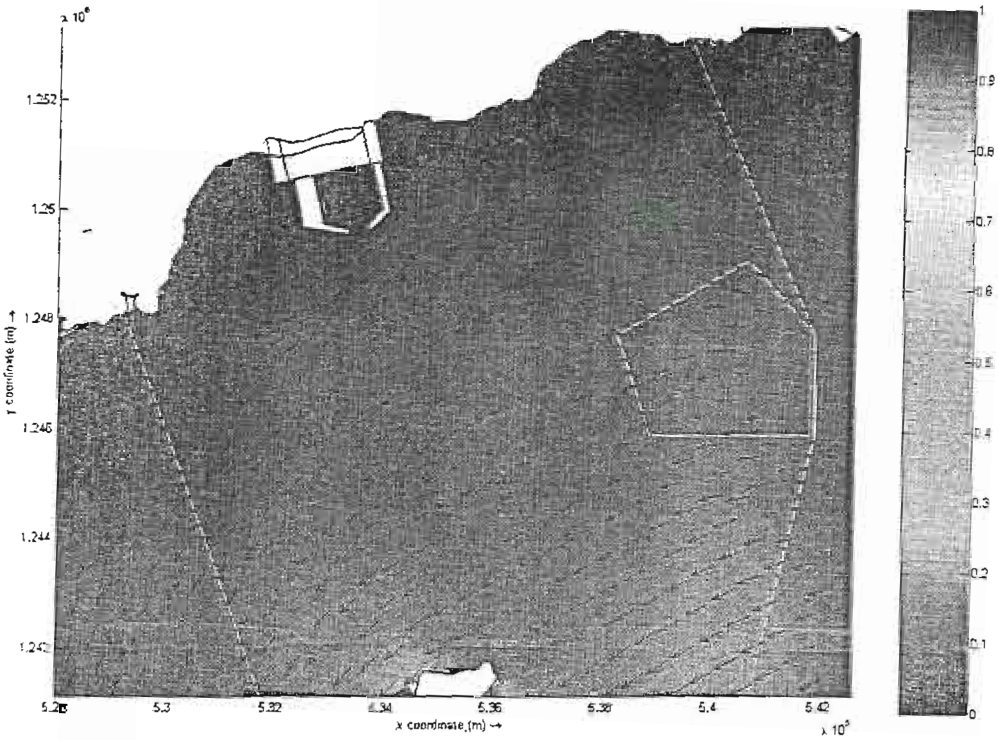


Figure 25. Integrated current field velocity in surface layer in Vinh Tan coastal area (northeast wind, ebb tide- leveling after construction)

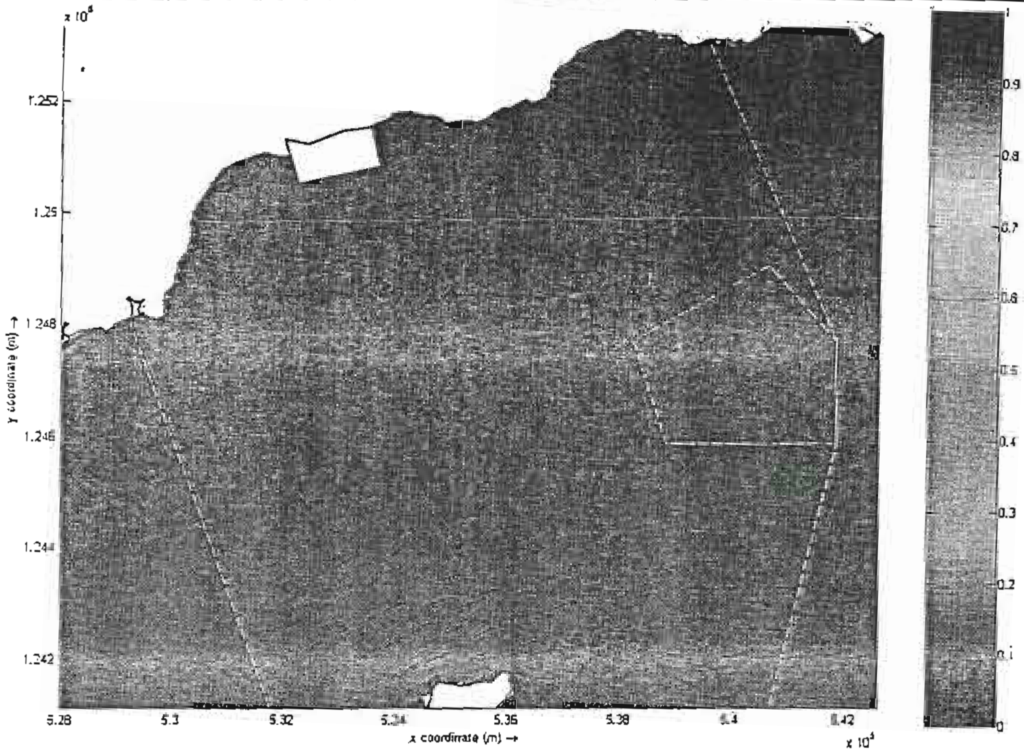


Figure 26. Currents induced by wave in Vinh Tan coastal area (northeast wind, flood tide- before leveling)

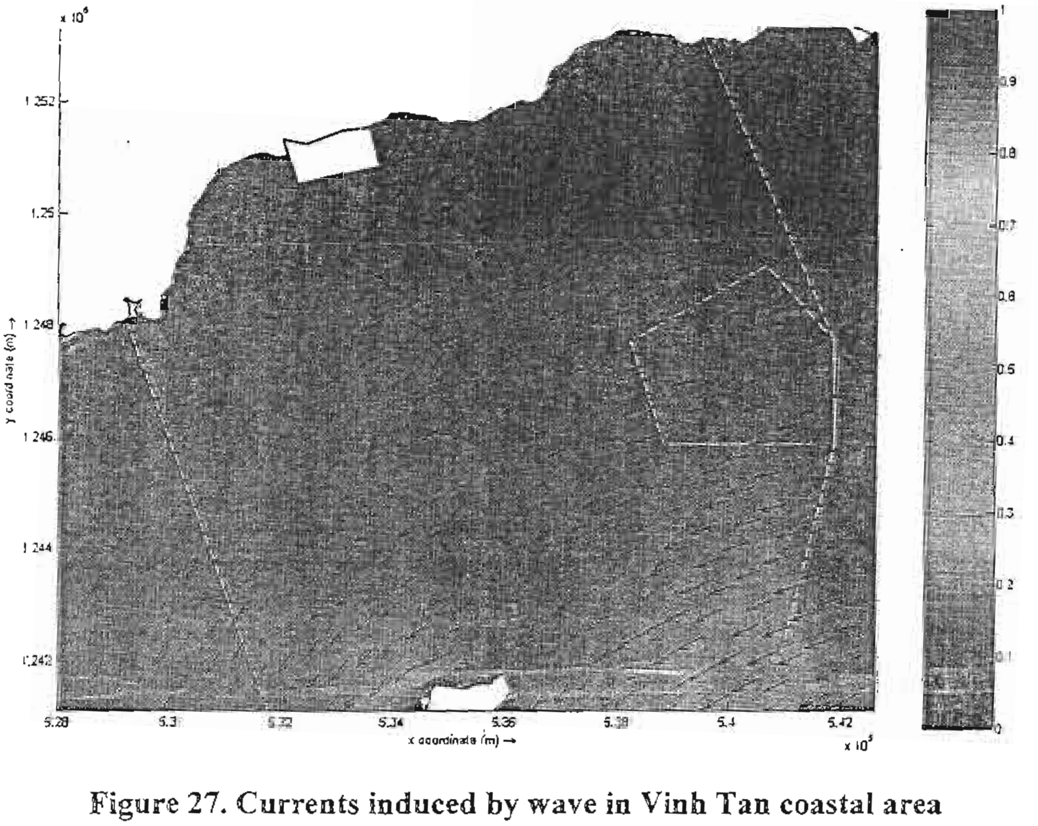


Figure 27. Currents induced by wave in Vinh Tan coastal area (northeast wind, ebb tide- before leveling)

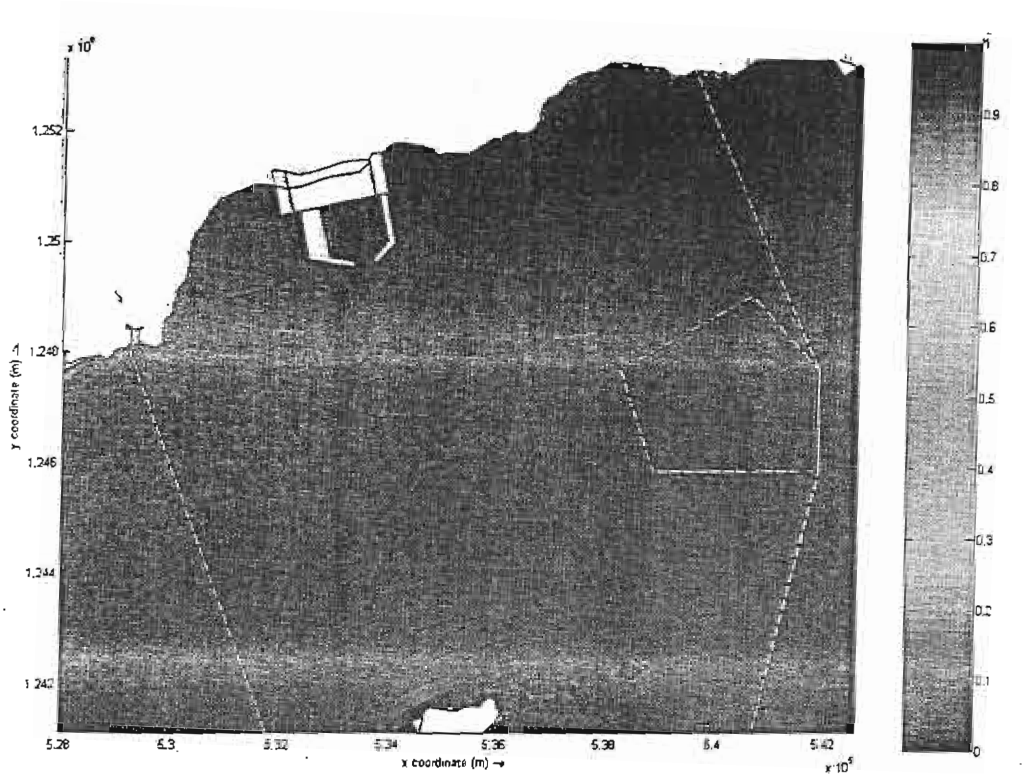


Figure 28. Currents induced by wave in Vinh Tan coastal area (northeast wind, flood tide- leveling after construction)

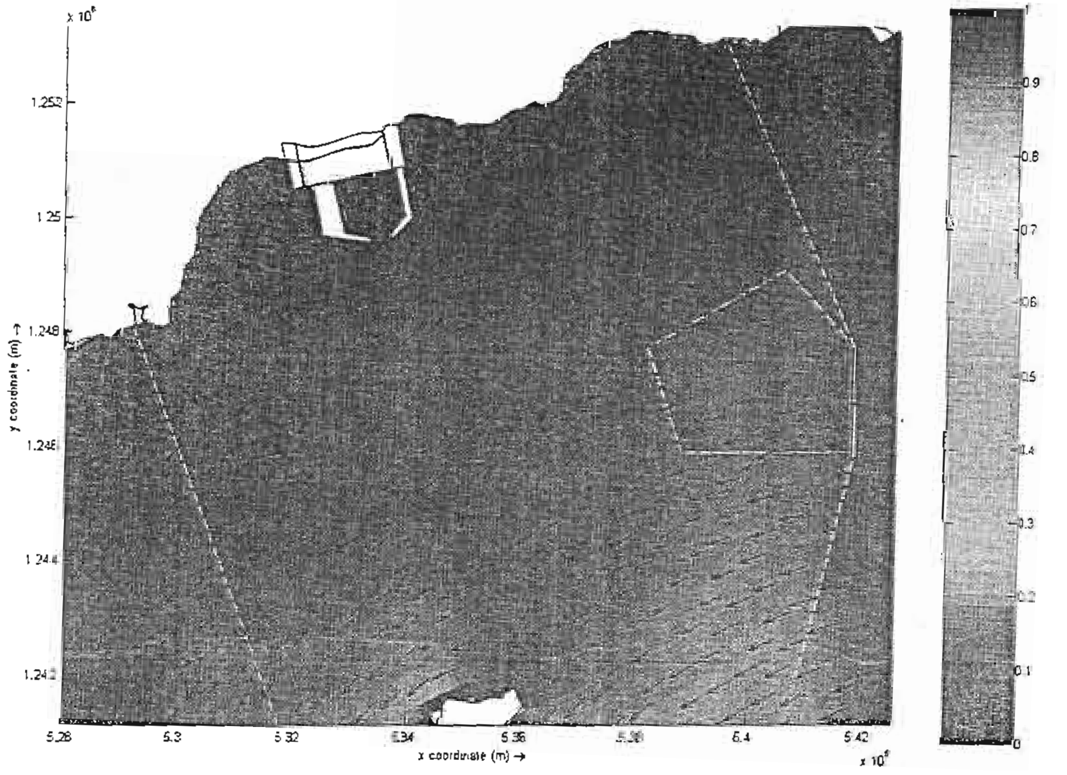


Figure 29. Currents induced by wave in Vinh Tan coastal area (northeast wind, ebb tide- leveling after construction)

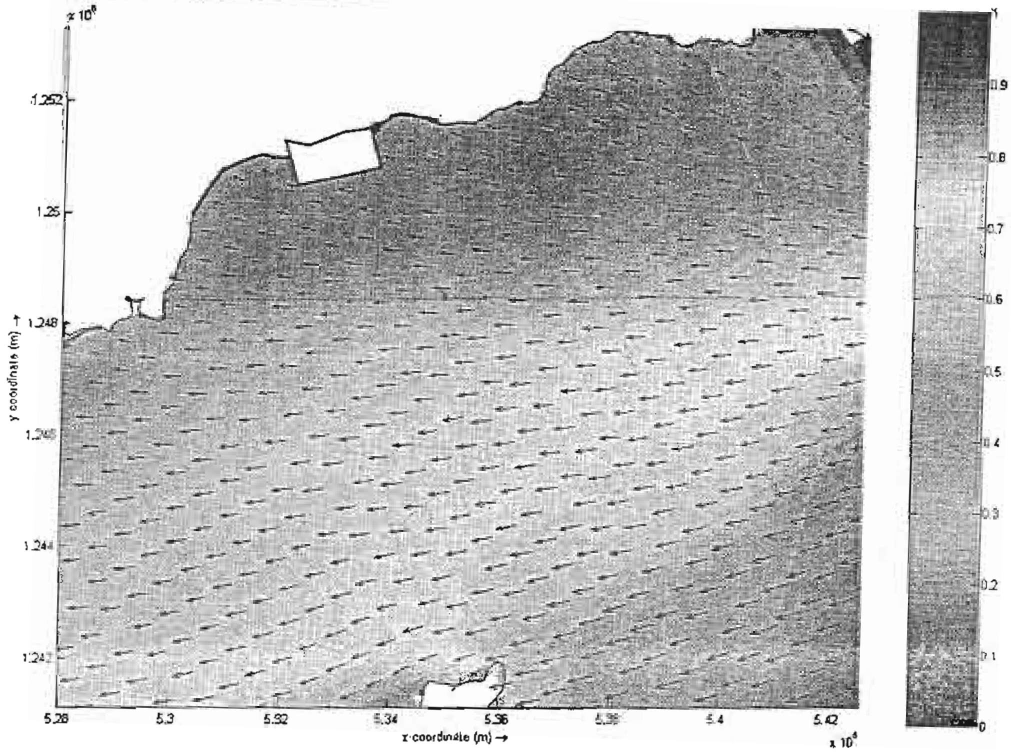


Figure 30. Wave height in Vinh Tan coastal area (northeast wind, high tide- before leveling)

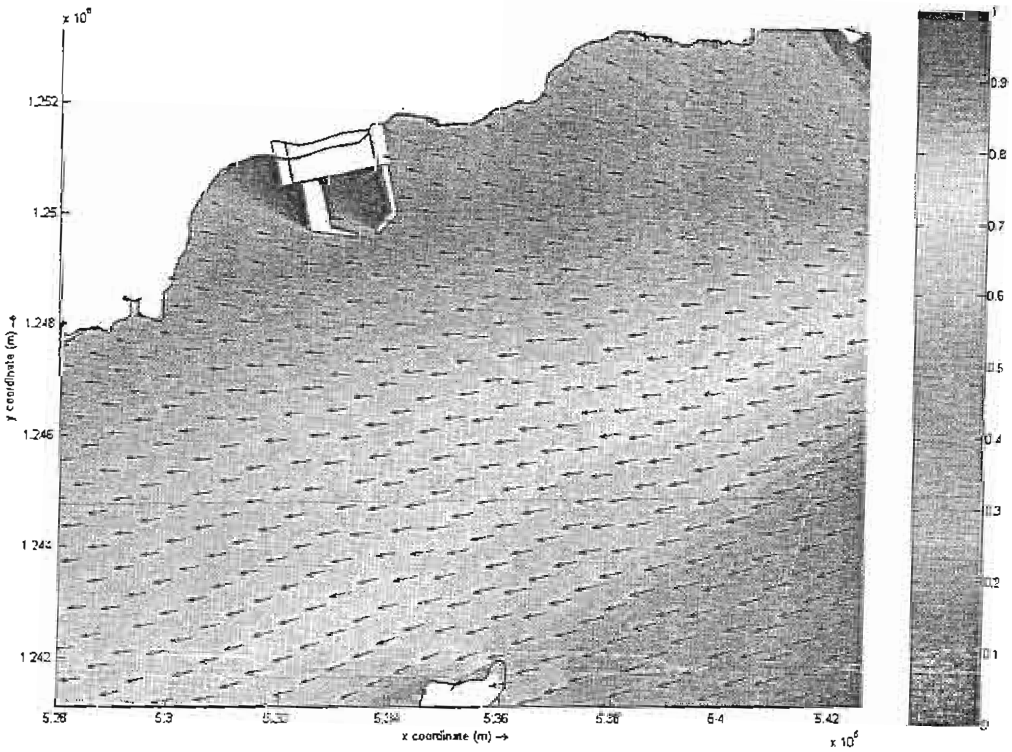


Figure 31. Wave height in Vinh Tan coastal area (northeast wind, high tide- leveling after construction)

Variation of magnitude current and wave in some monitoring points

The fluctuation of currents at Breda shoal (Figure 32-33) reveals that the current velocity at V1 and V2 does not change much before, during and after performing leveling work. This phenomenon happens in both dry and rainy seasons. This is due to the fact that position of Breda sandbar is quite far from the leveling site.

Similarly, at the west – northwestern site of Cu Lao Cau (V3, V4, V5), the impact of leveling activities on the currents is negligible (Figure 34 - 36).

In the eastern leveling position (point V6), there is almost no considerable impact of leveling activities (before and after construction phase) on magnitude velocity, with a decrease of 2-6cm/s (figure 37). On the other hand, magnitude velocity at V7 has no change in implementation phase with a decrease of 2-3cm/s during performing leveling work after construction phase (figure 38). A decrease in magnitude velocity after leveling is mainly because of the impact of construction, but not due to effect of the leveling activities. To be more specific, the port construction and breakwater play a role as seawall which does not allow motivation of water bodies from northeast to the southwest.

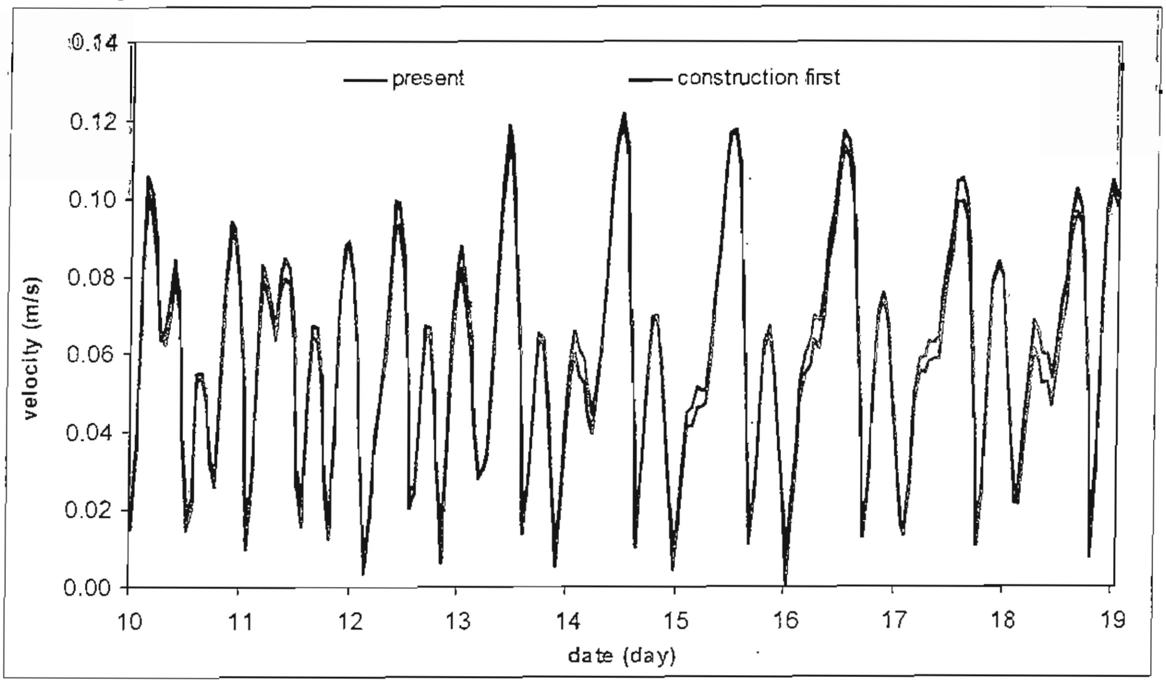
In the southeastern dredging place (V8), there is almost no variation in magnitude velocity between time points of before and during leveling levelinglevelingafter construction phase (figure 39).

In the southwestern leveling site (V9), magnitude velocity changes slightly when leveling after construction in rainy season. However, there is almost no considerable influence on magnitude velocity in the dry season (figure 40).

Similarly, wave heights measured at different monitoring points in Breda sandbar and Cu Lao Cau Island show that there is no difference between sceneries before and during leveling when construction is done leveling(see in figure 41-45).

In Vinh Tan coastal zones near construction, wave height has not significant change during leveling implementation. However, wave height in zones near the construction (northern, southwestern, northeastern and eastern construction) decreases slightly by 0.05-0.15m leveling(figure 46-49).

In summary, it could be said that the leveling activities have no considerable effect on hydrodynamics and wave condition in Vinh Tan coastal area as well as neighboring area (Cu Lao Cau island, Breda sandbar, northeastern and southwestern of Vinh Tan). In some place which is closer to the construction, magnitude velocity and wave height decrease slightly in the case of leveling after construction finalization. However, these effects is mainly because of the constructions, but not leveling activities .



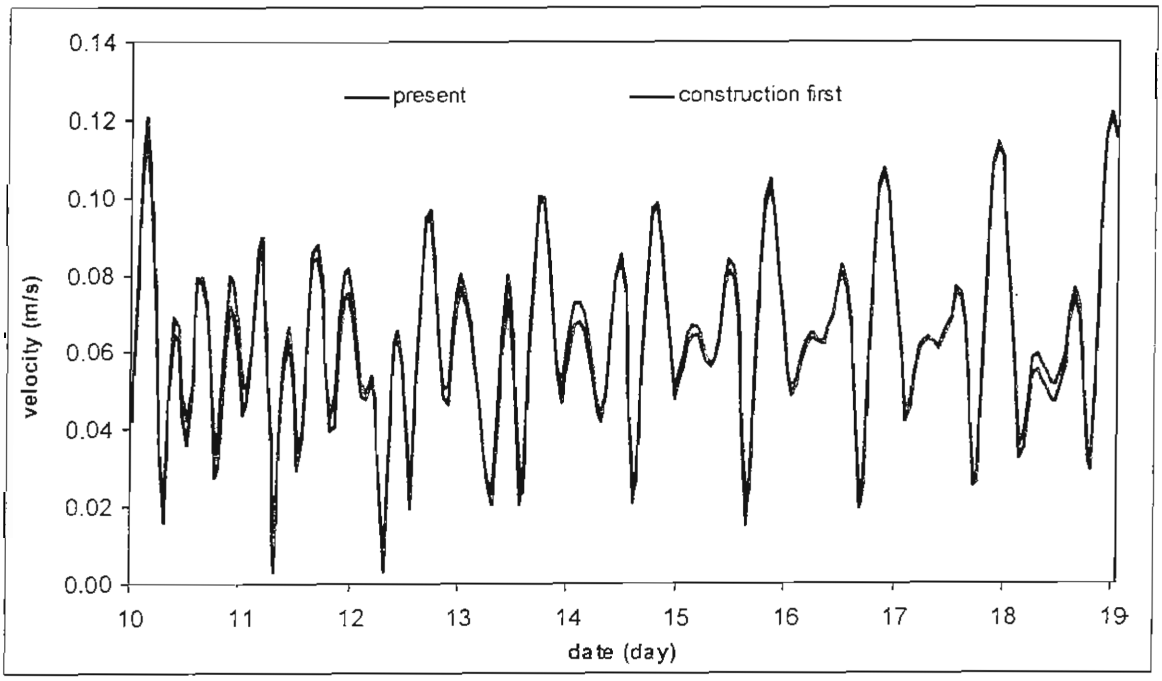


Figure 32. Variation of magnitude current at Breda sand bar
(V1; a – rainy season; b- dry season)

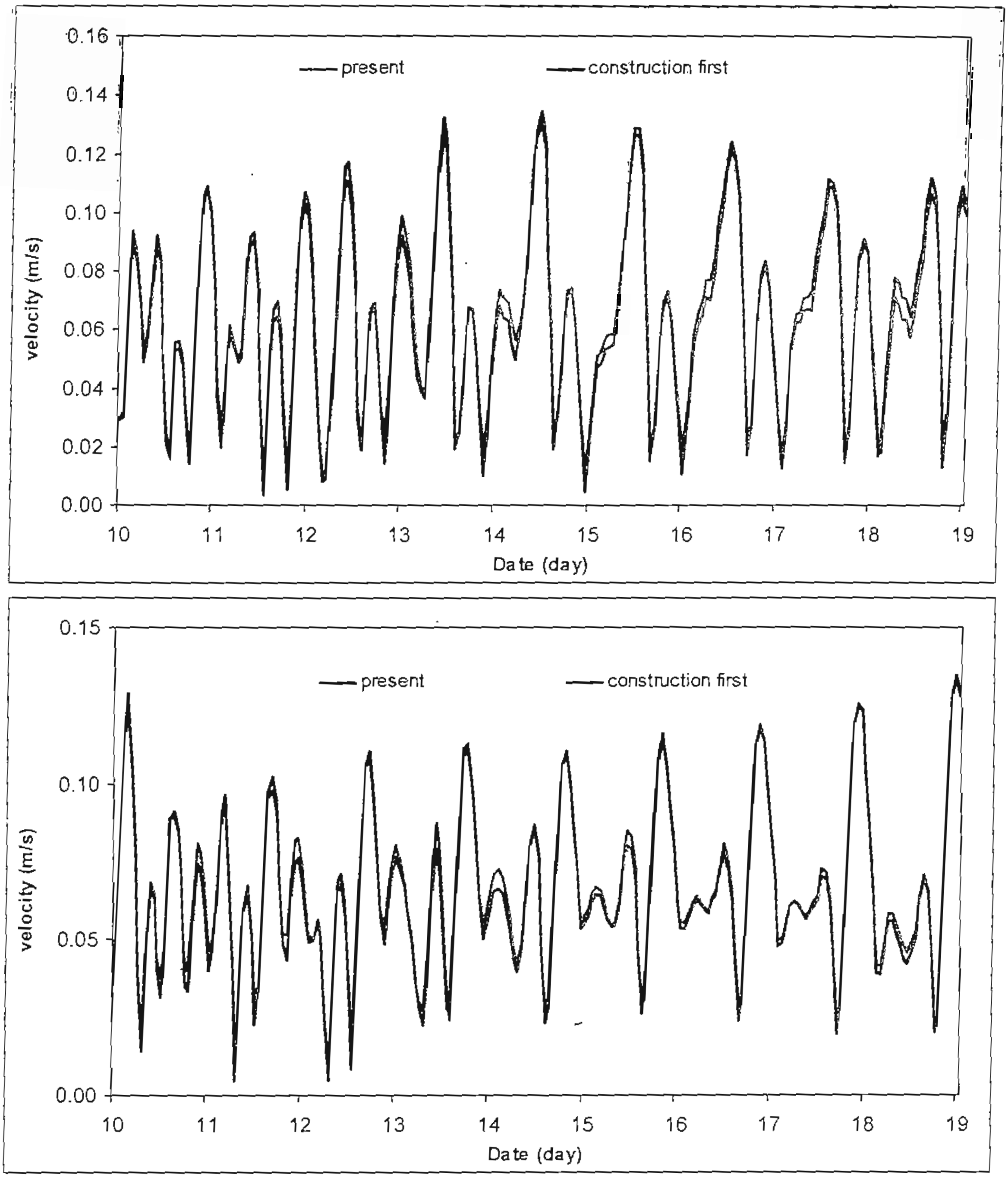


Figure 33. Variation of magnitude current at Breda sand bar
(V2; a – rainy season; b- dry season)

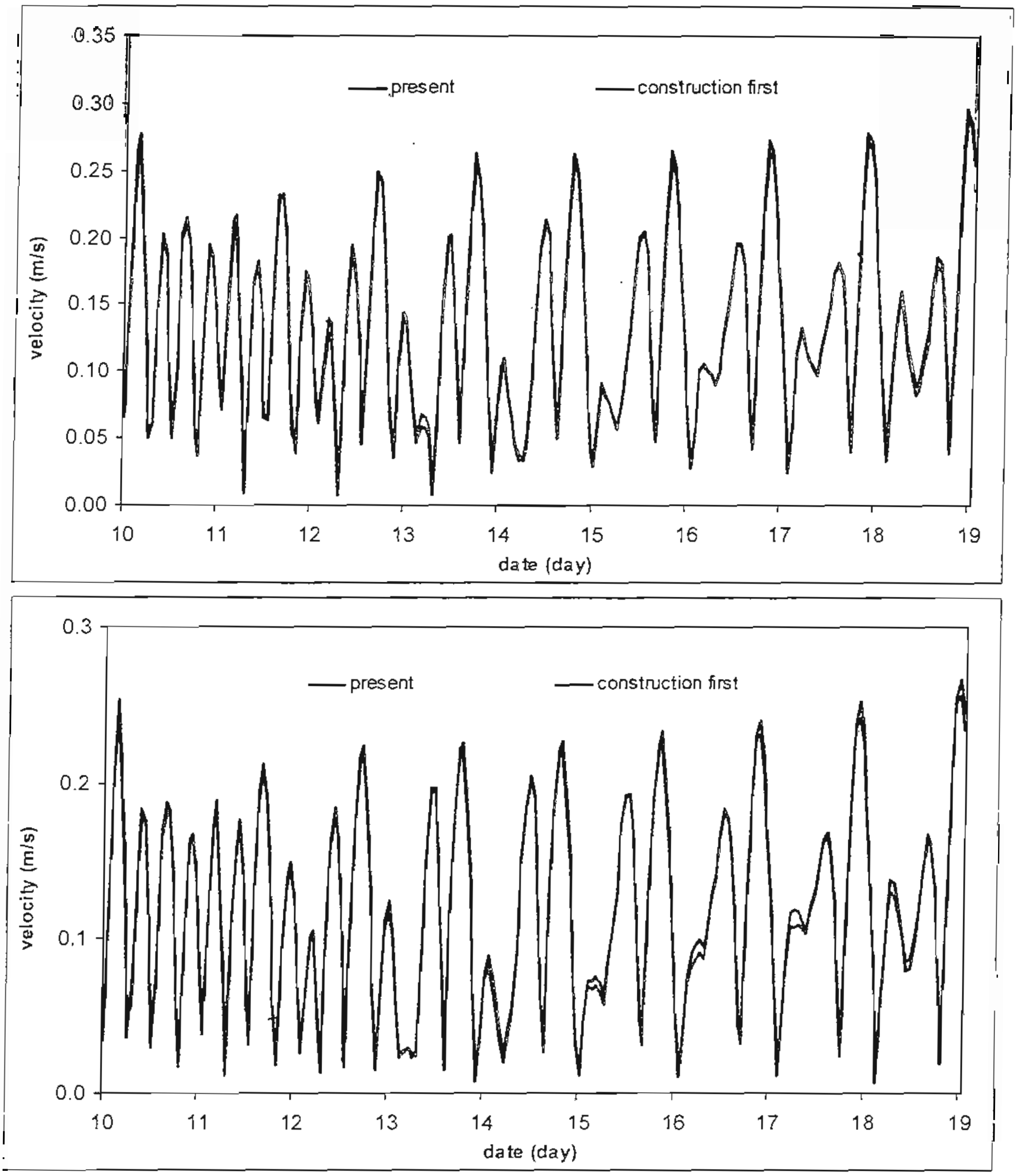


Figure 34. Variation of magnitude current at Cu Lao Cau coastal area (V3; a – rainy season; b- dry season)

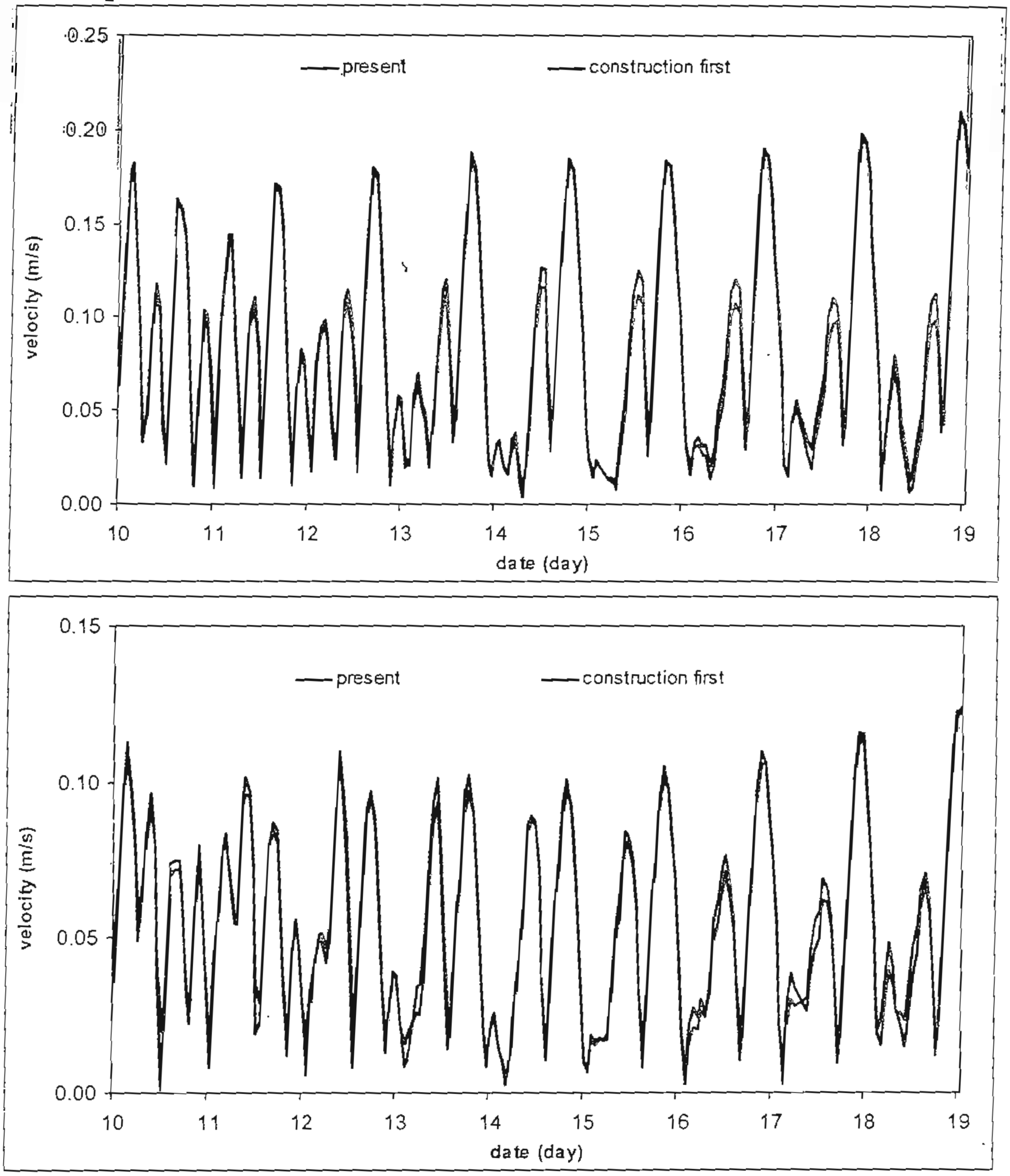
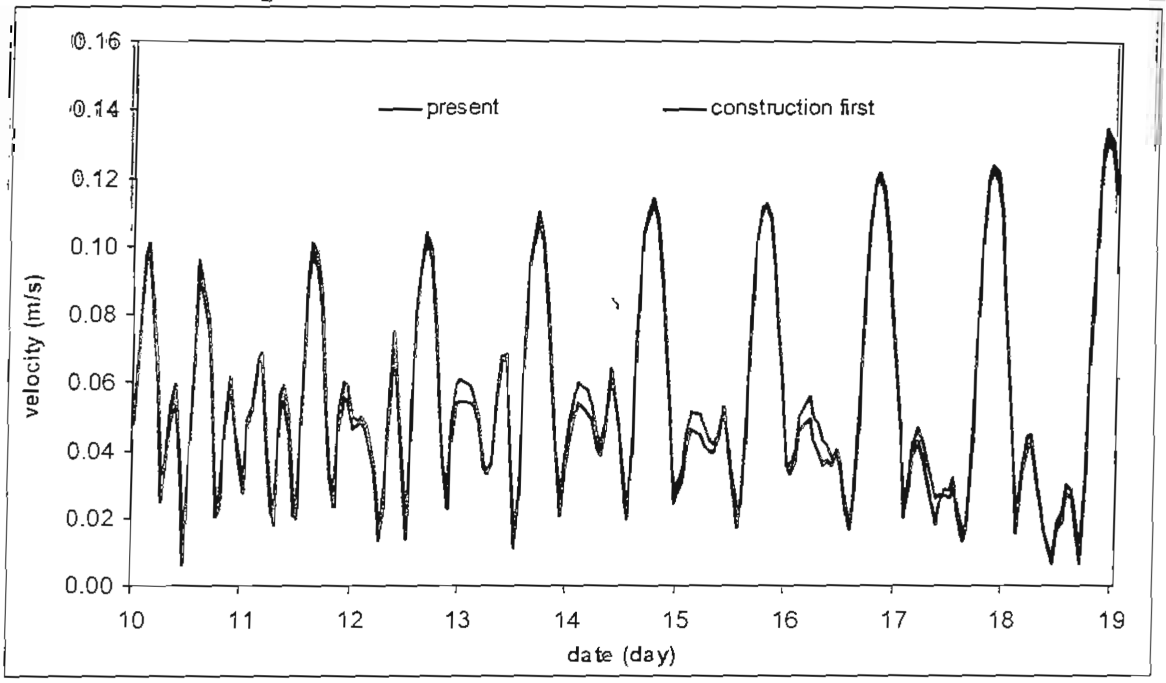


Figure 35. Variation of magnitude current at Cu Lao Cau coastal area
(V4; a – rainy season; b- dry season)



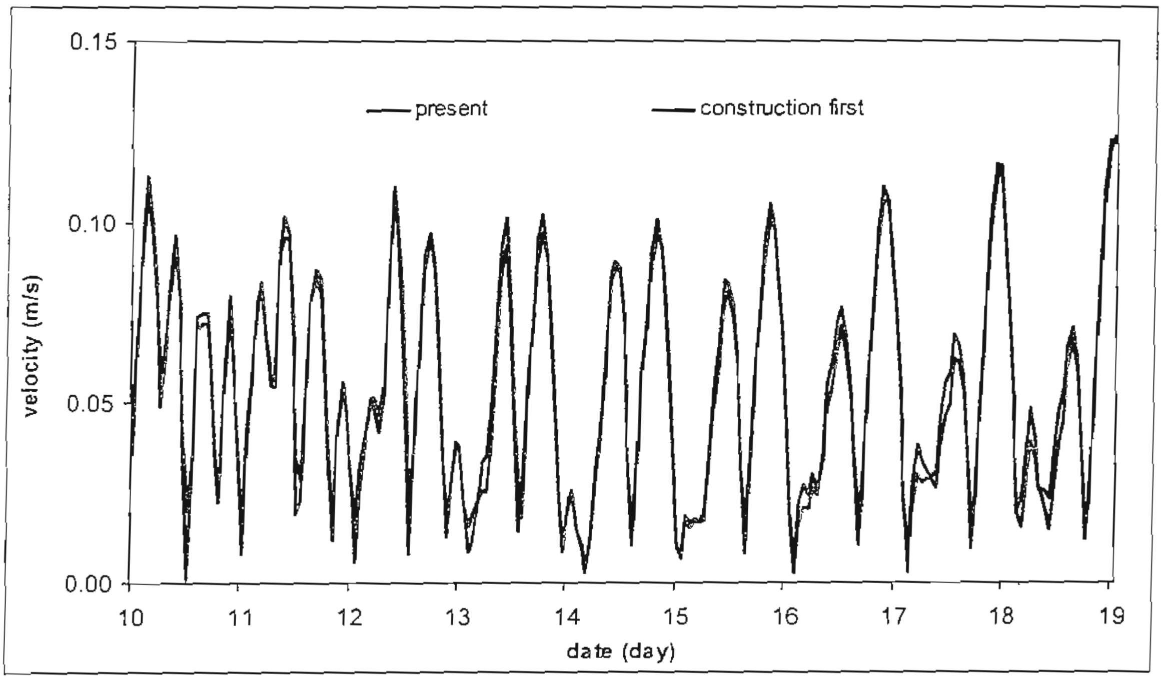
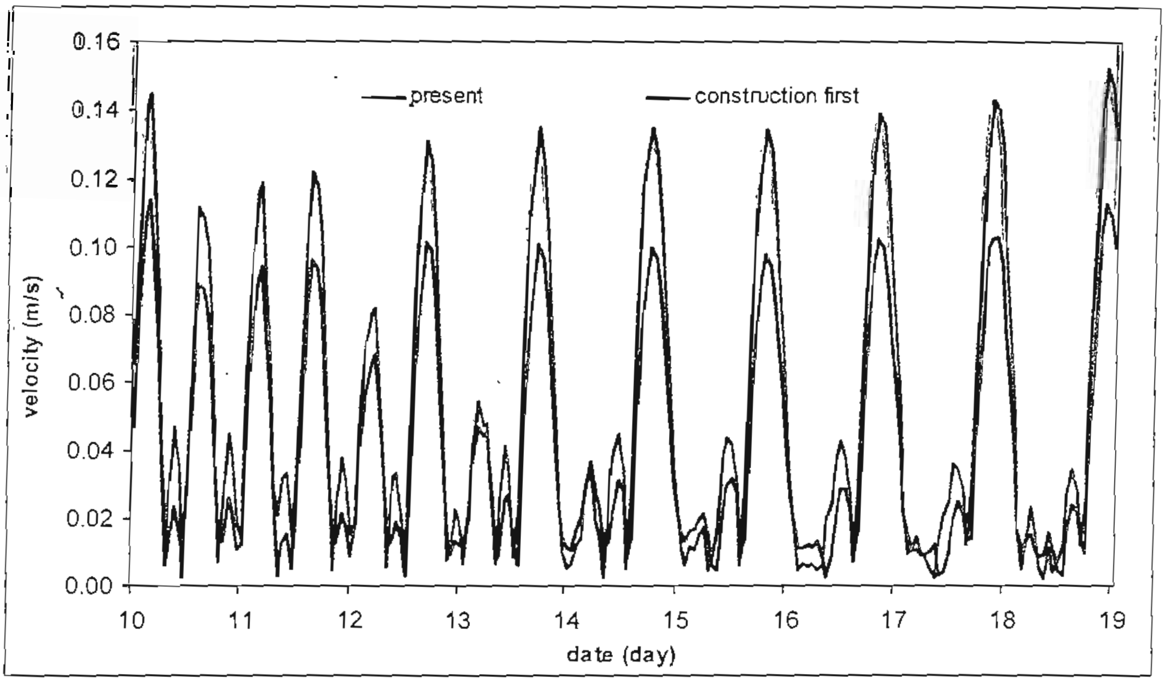


Figure 36. Variation of magnitude current at Cu Lao Cau coastal area (V5; a – rainy season; b- dry season)



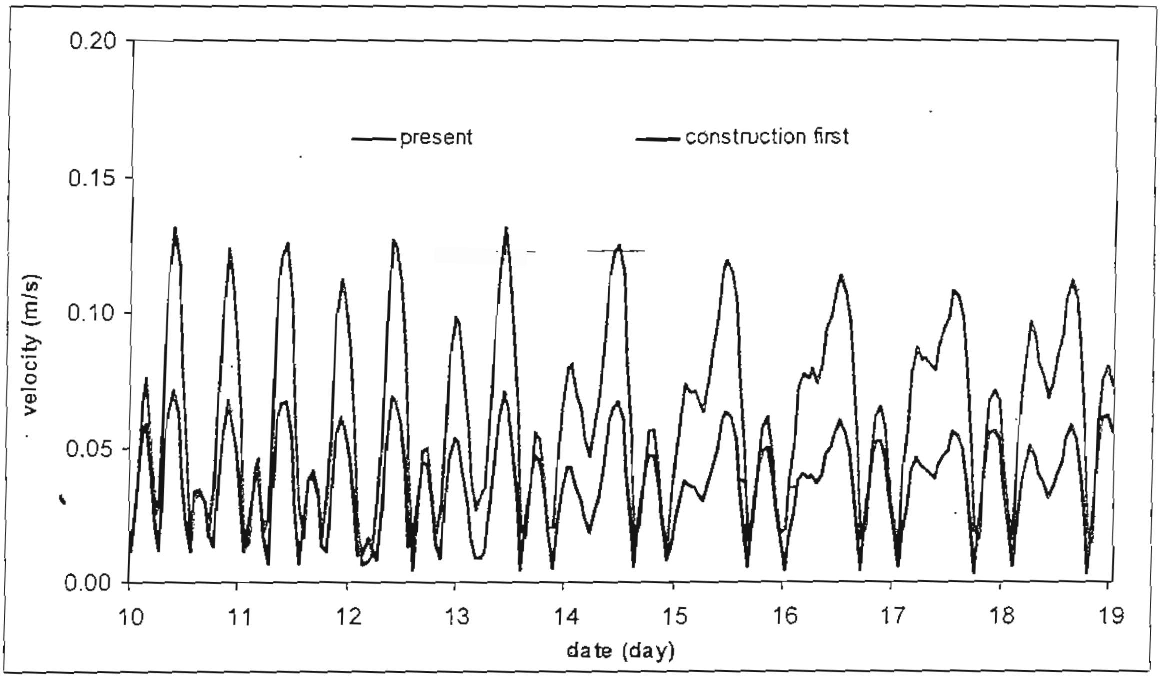
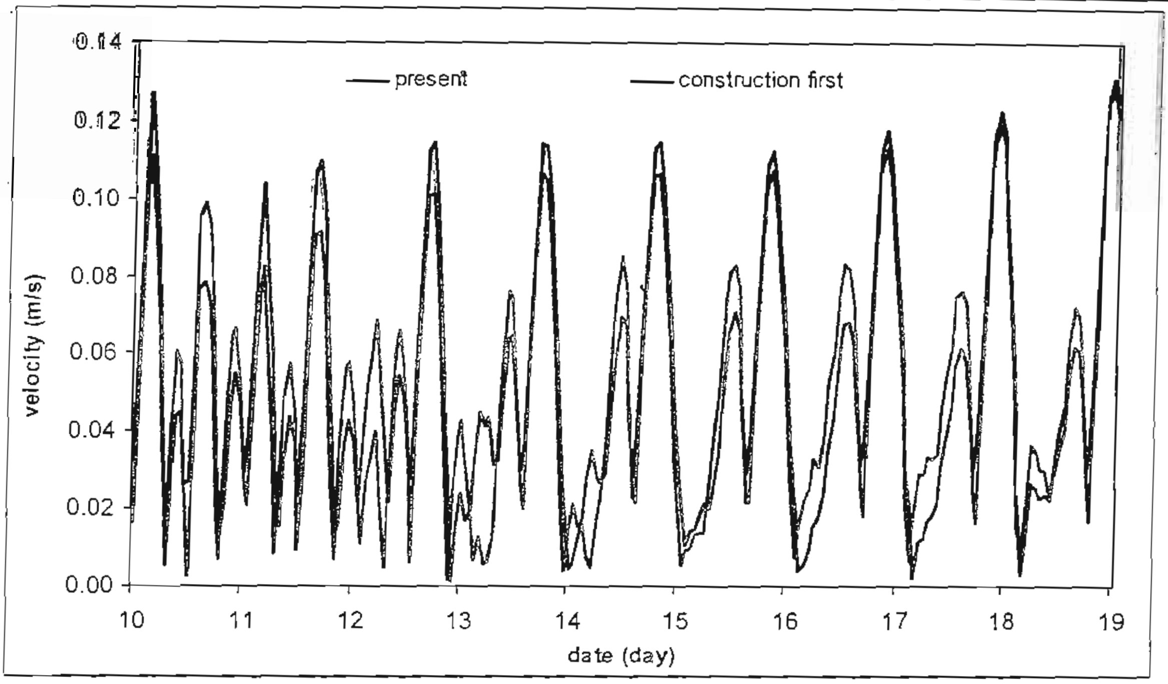


Figure 37. Variation of magnitude current at the eastern of the leveling site
(V6; a – rainy season; b- dry season)



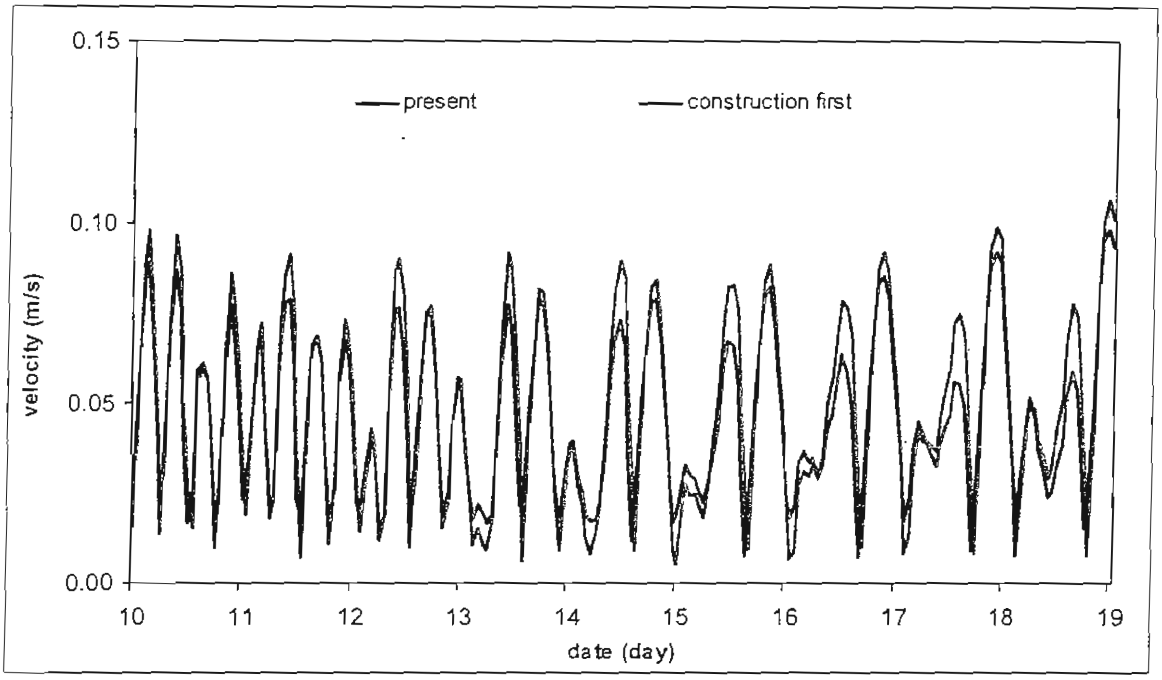


Figure 38. Variation of magnitude current at the eastern of the leveling site (V7; a – rainy season; b- dry season)

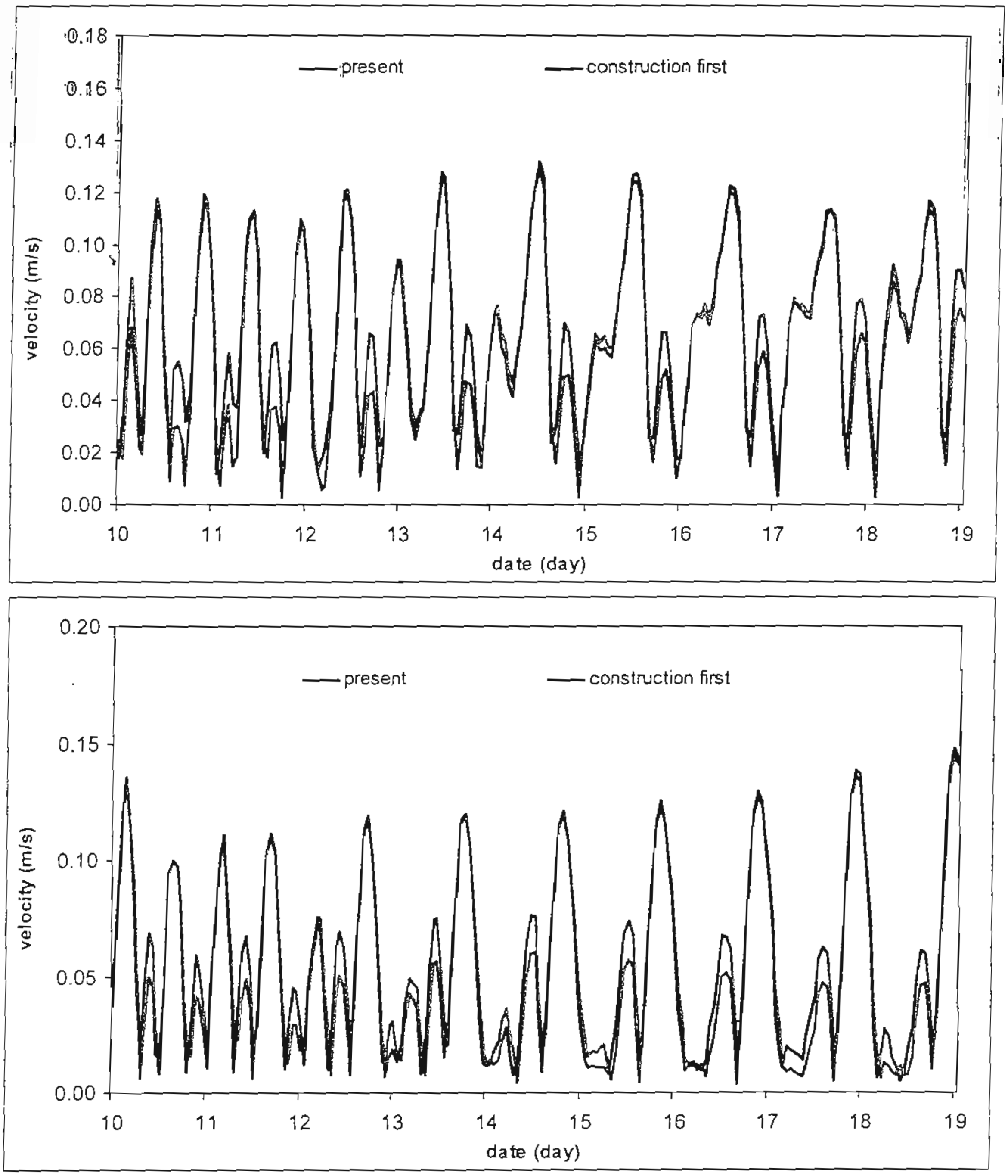


Figure 39. Variation of magnitude current at the southeastern of the leveling site (V8; a – rainy season; b- dry season)

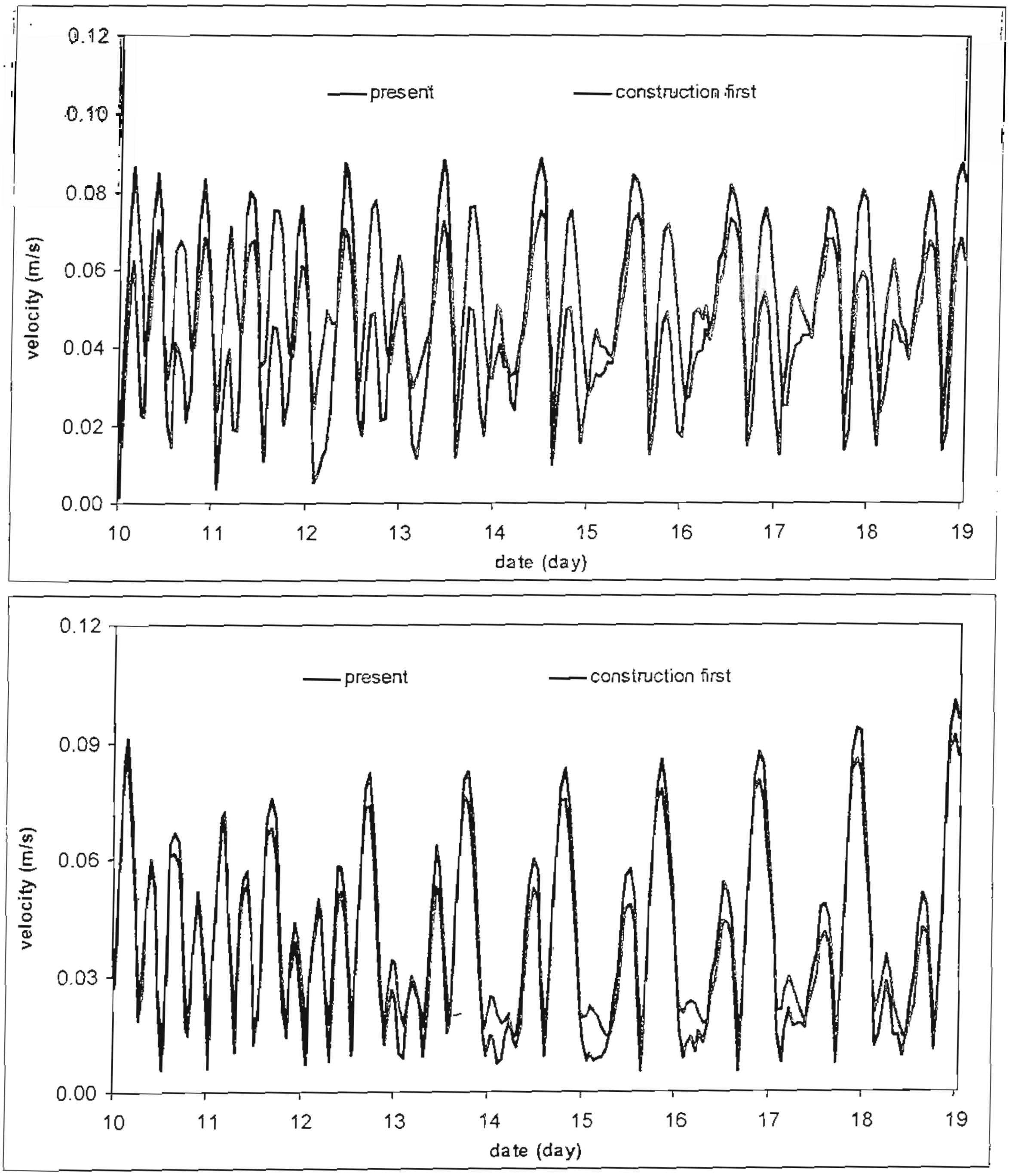
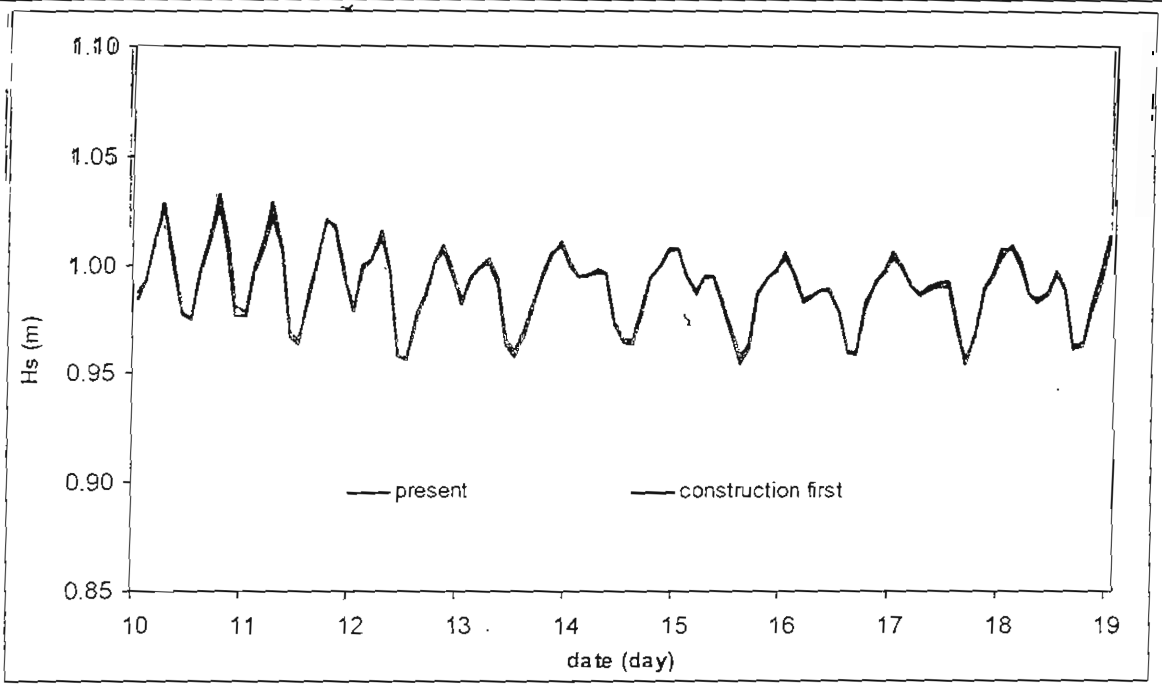


Figure 40. Variation of magnitude current at the southwestern of the leveling site (V9; a – rainy season; b- dry season)



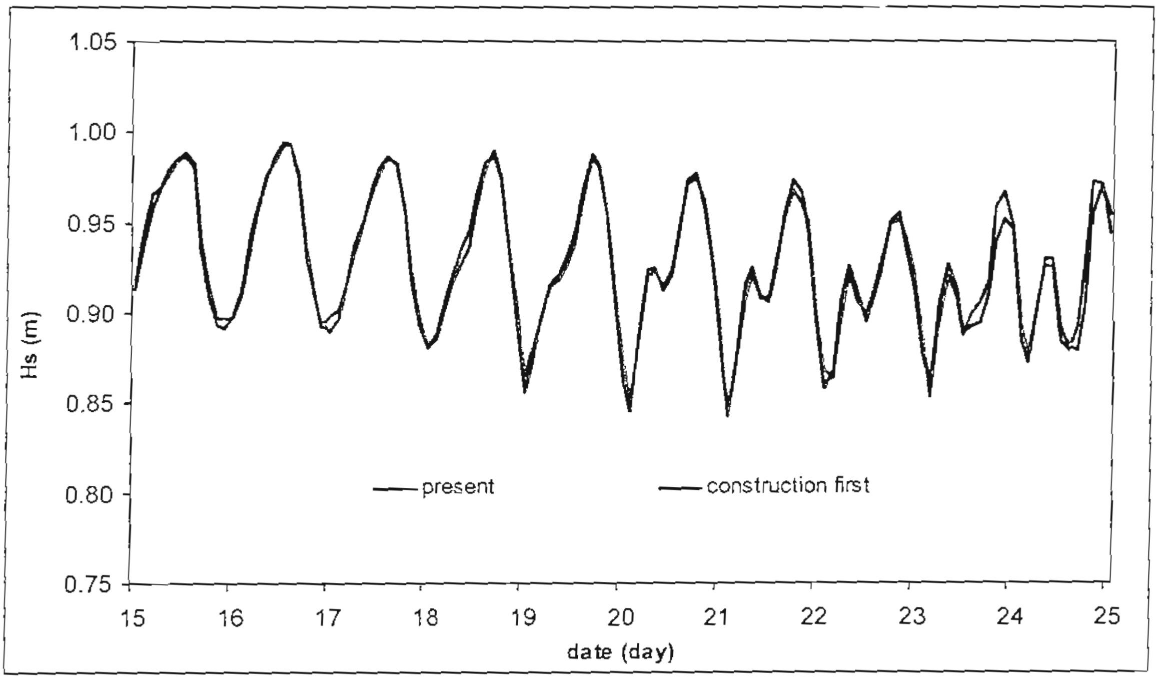


Figure 41. Variation of wave height at the Breda sandbar
(V1; a – rainy season; b- dry season)

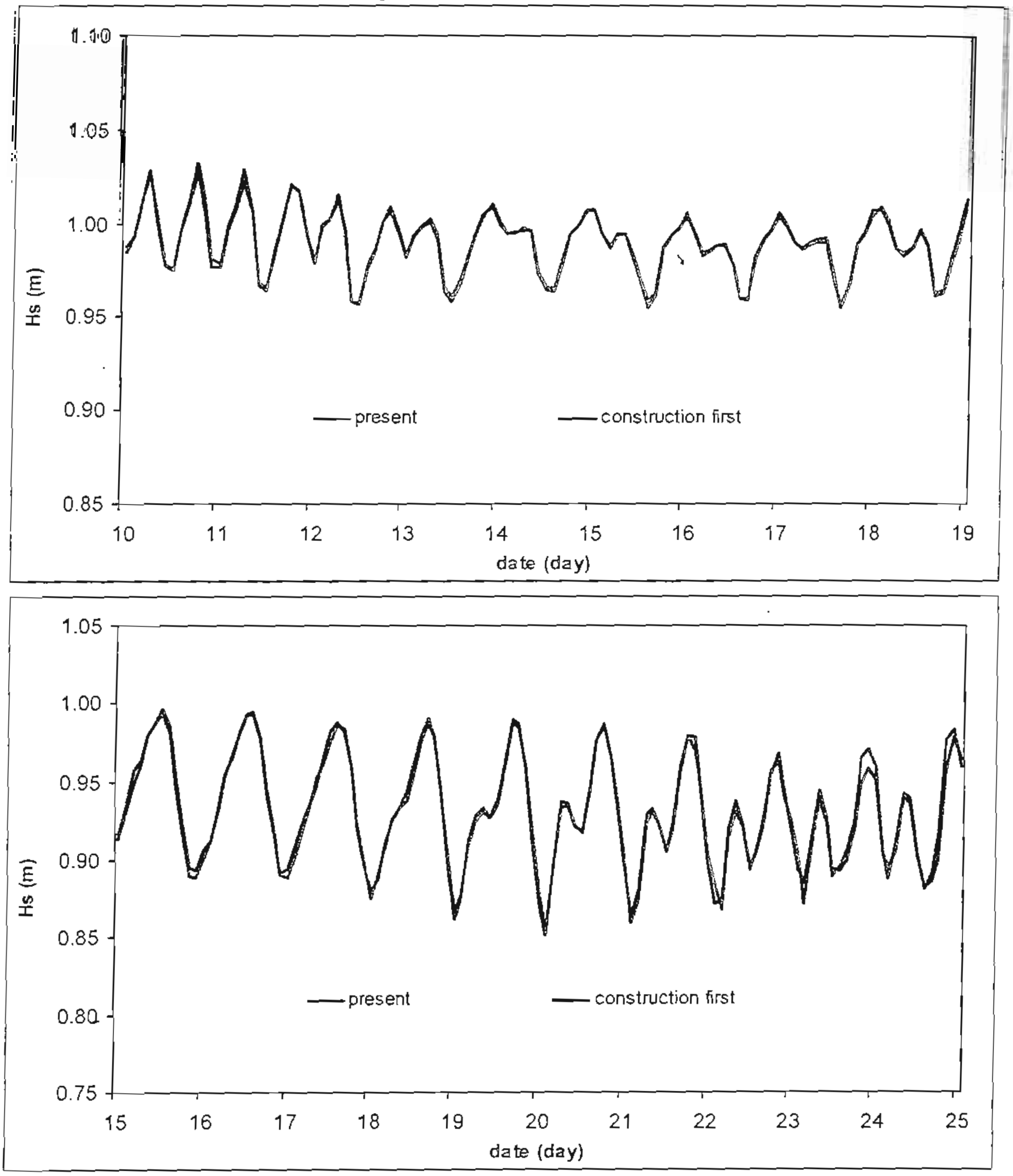
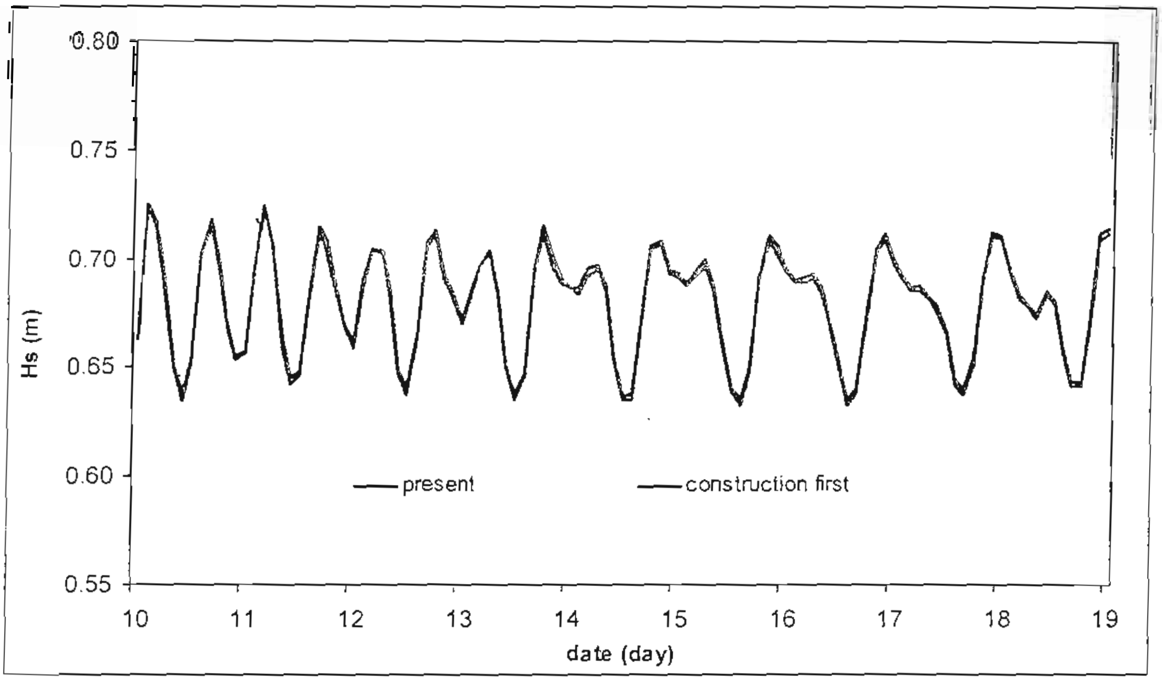


Figure 42. Variation of wave height at the Breda sandbar (V2; a – rainy season; b- dry season)



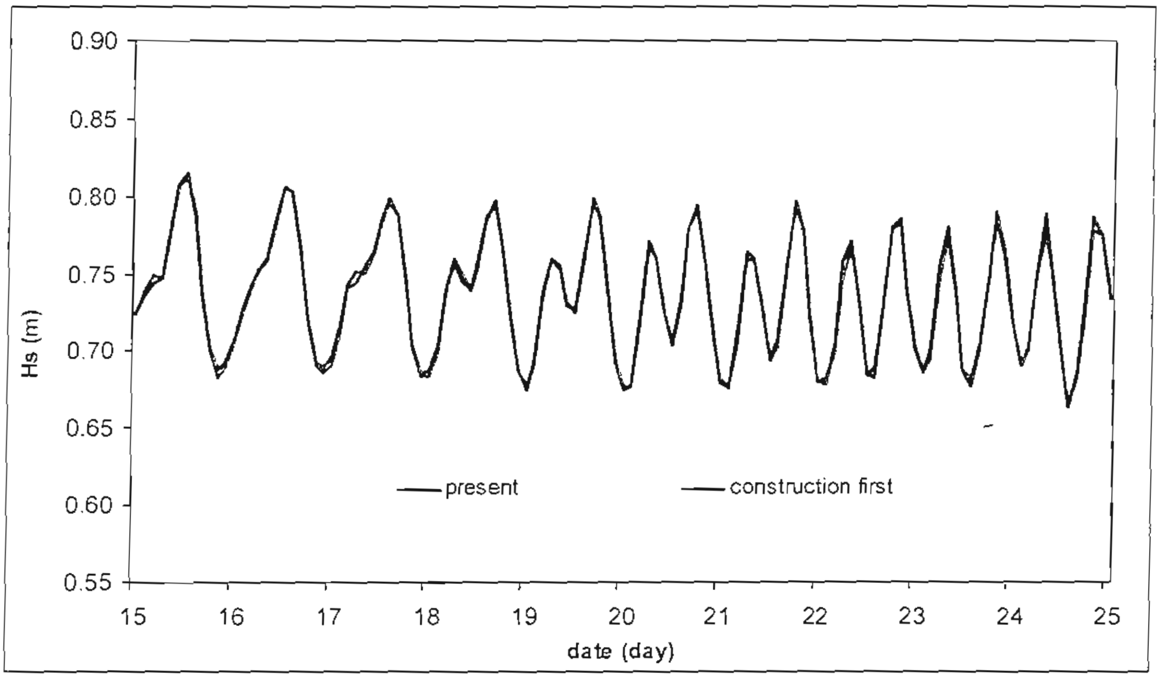


Figure 43. Variation of wave height in Cu Lao Cau coastal area
(V3; a – rainy season; b- dry season)

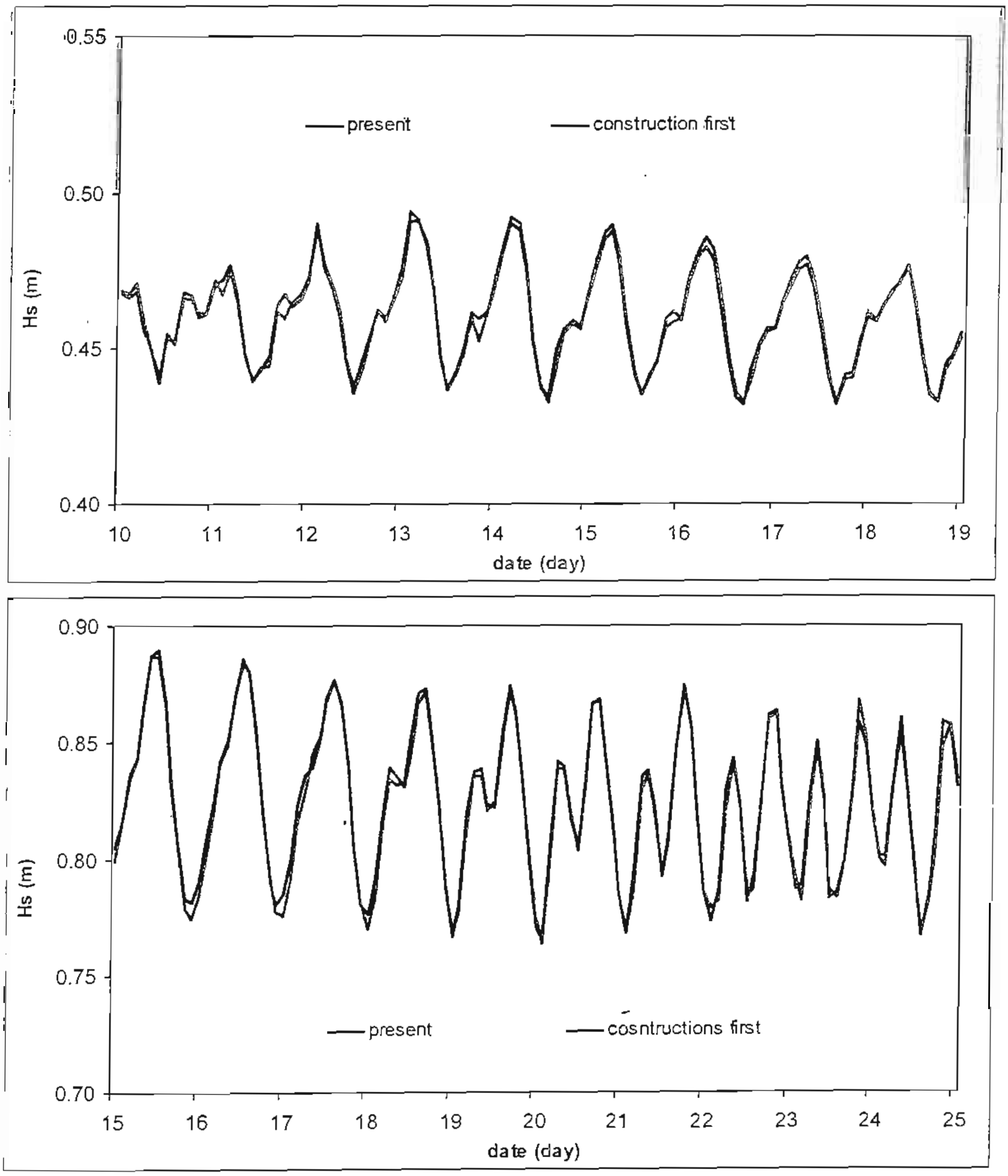
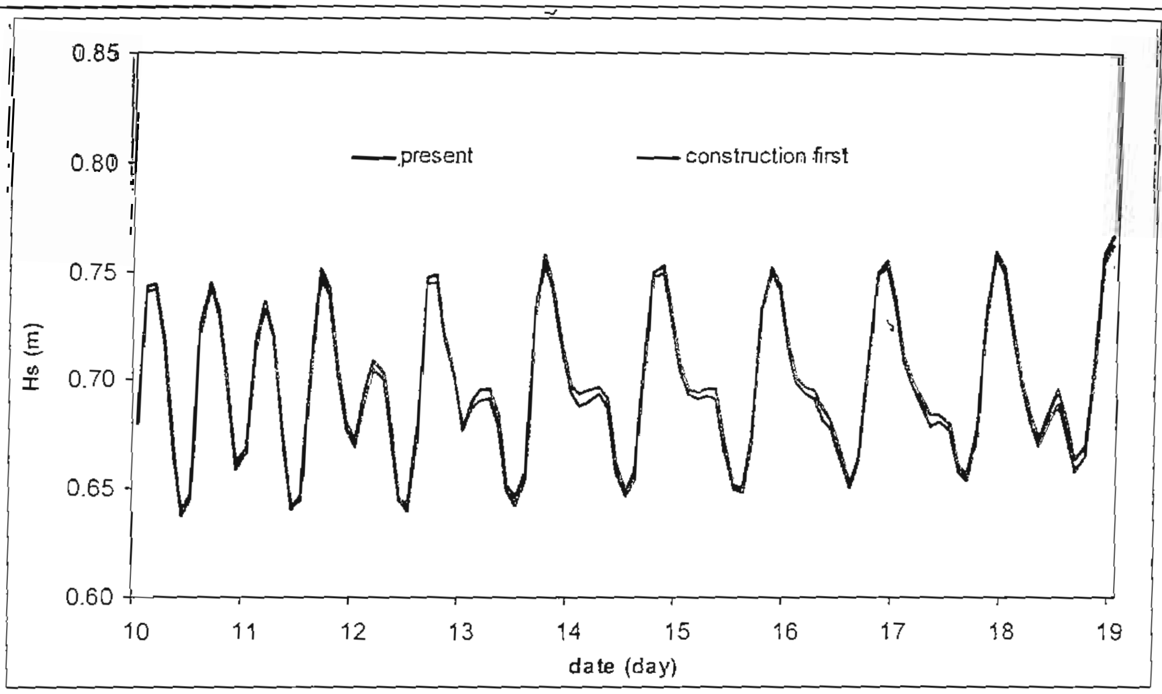


Figure 44. Variation of wave height in Cu Lao Cau coastal area (V4; a – rainy season; b- dry season)



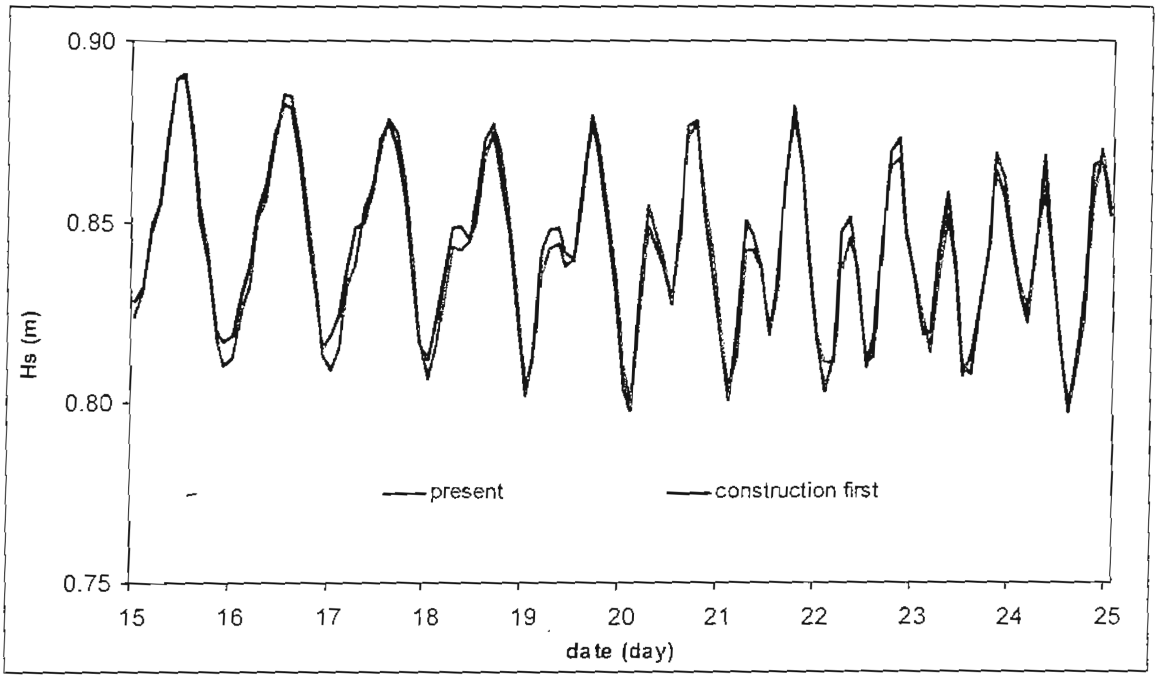


Figure 45. Variation of wave height in Cu Lao Cau coastal area
(V5; a – rainy season; b- dry season)

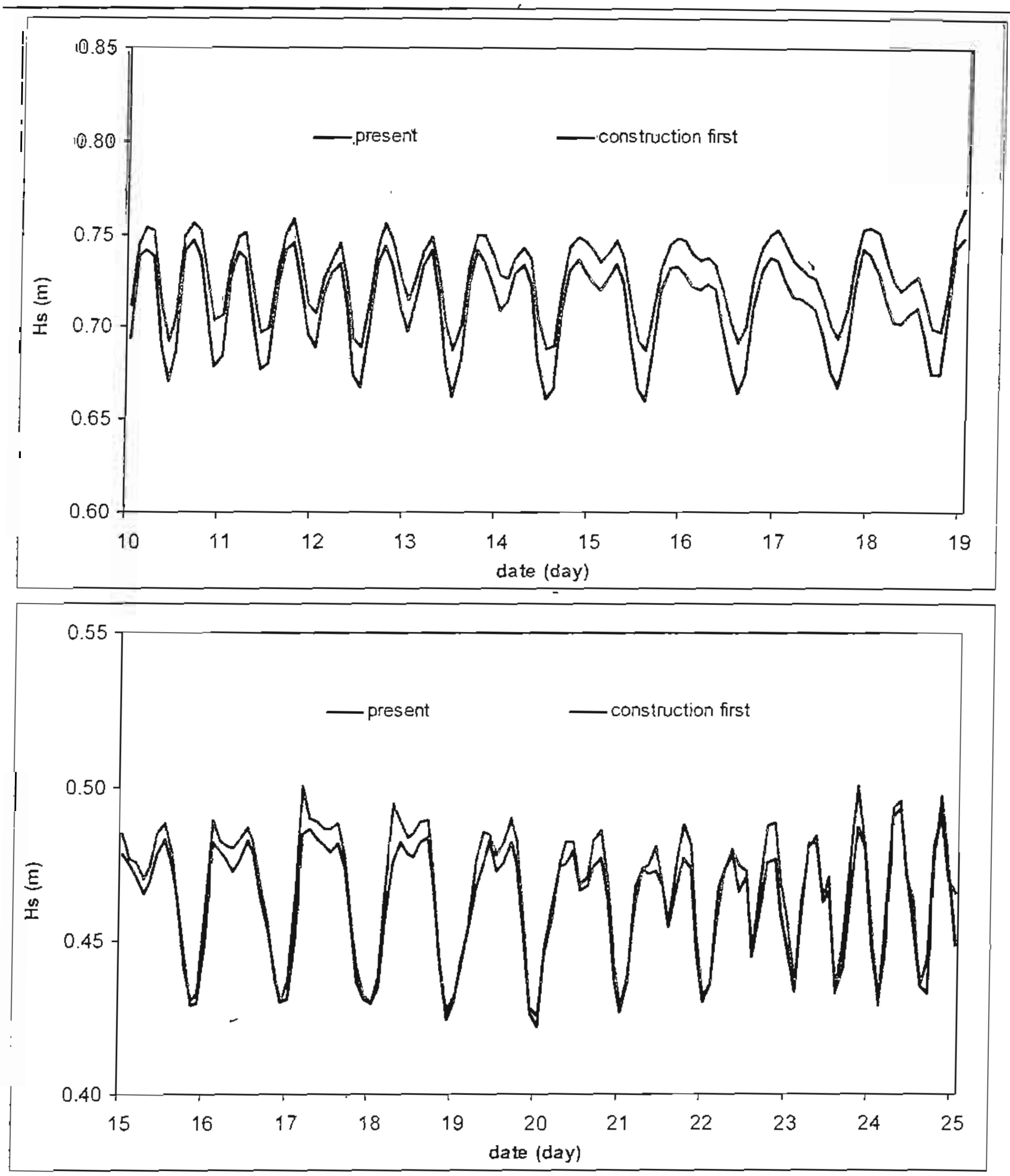
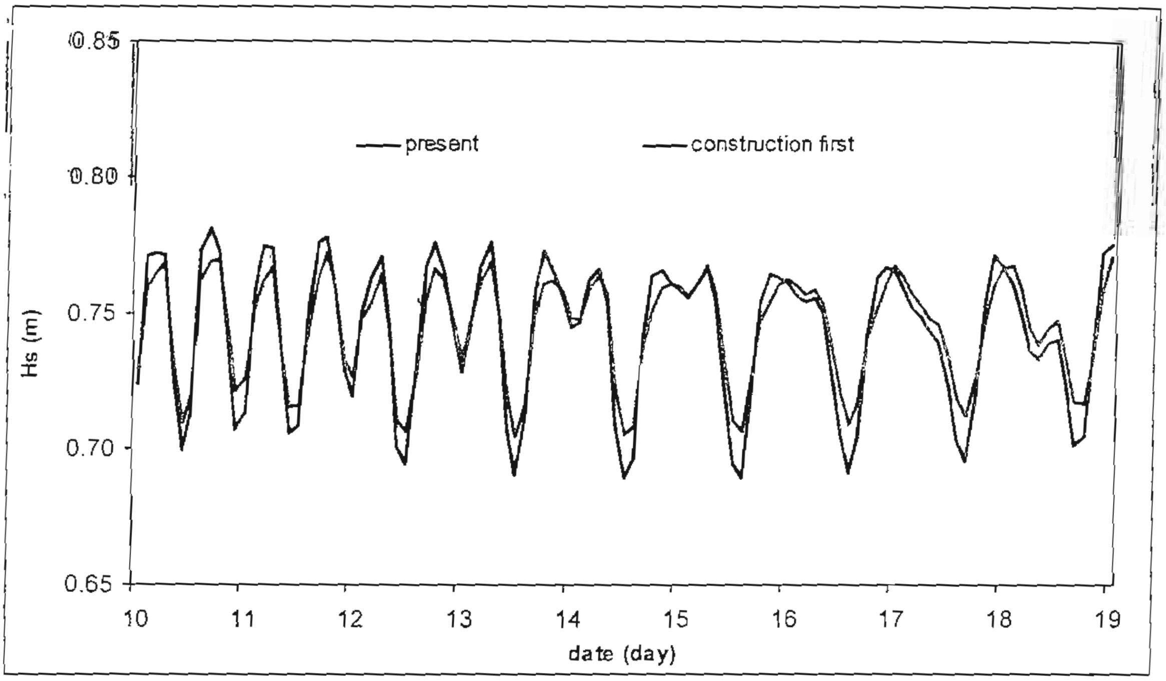


Figure 46. Variation of wave height in the eastern of the leveling site (V6; a – rainy season; b- dry season)



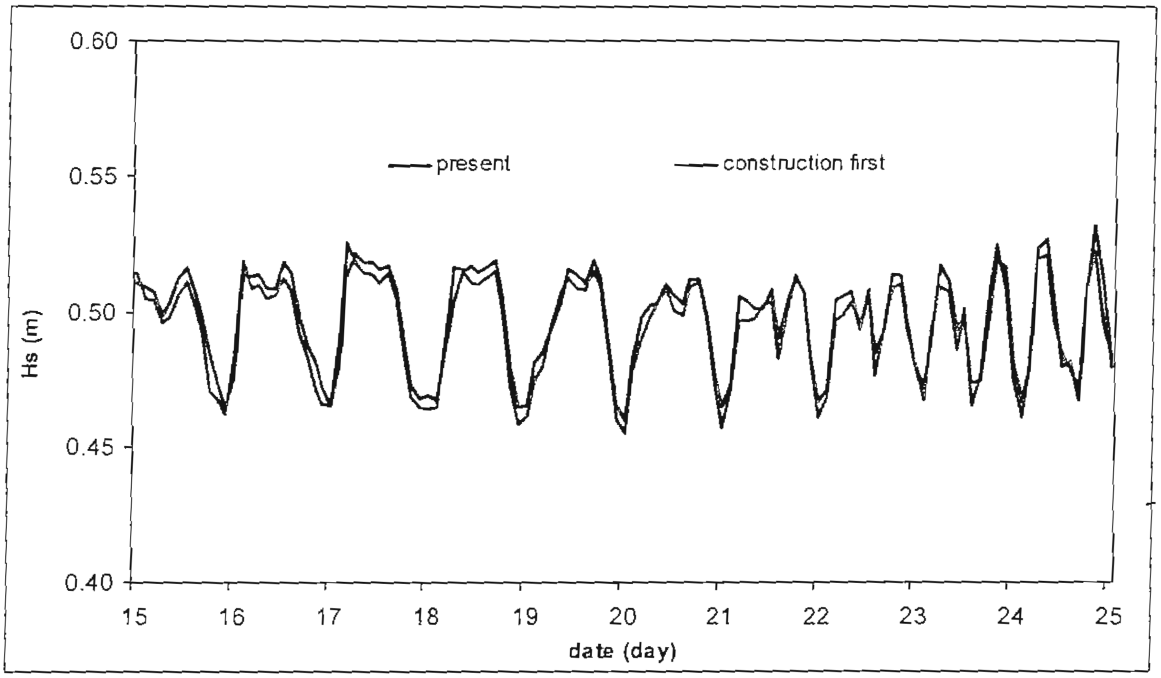


Figure 47. Variation of wave height in the eastern of the leveling site (V7; a – rainy season; b- dry season)

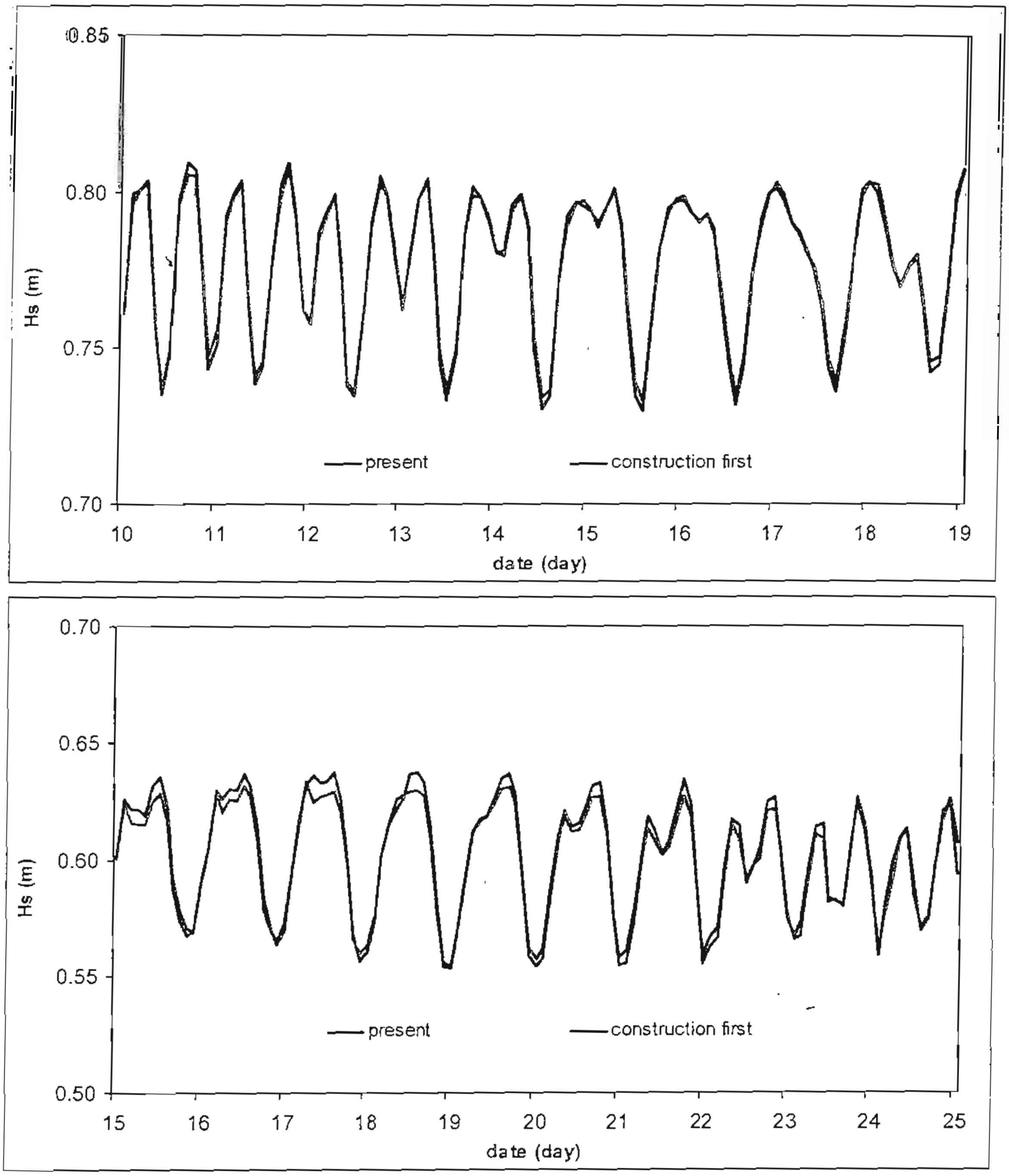
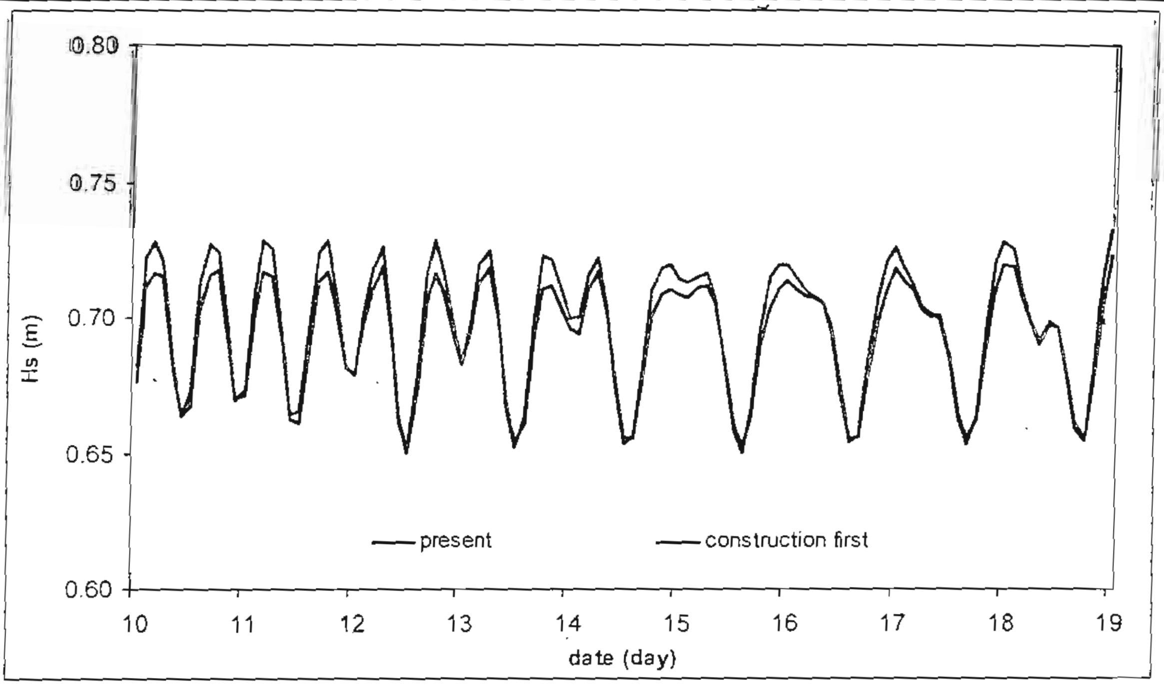


Figure 48. Variation of wave height in the southeastern of the leveling site (V8; a – rainy season; b- dry season)



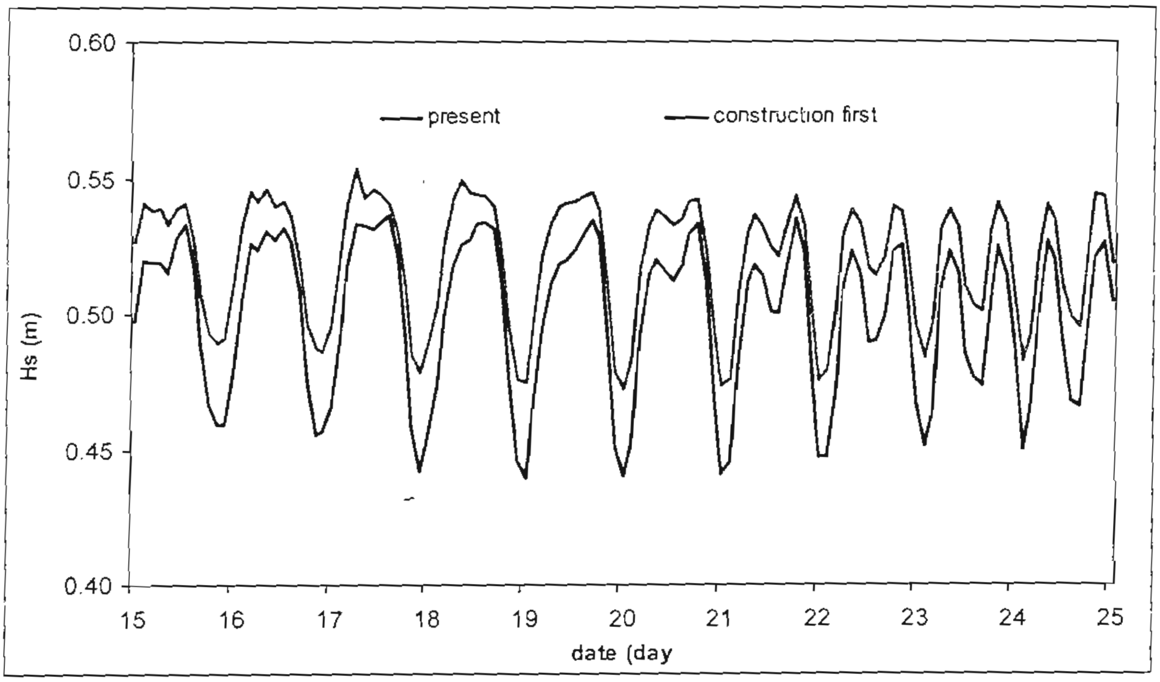


Figure 49. Variation of wave height in the southwestern of the leveling site (V9; a – rainy season; b- dry season)

6.2. Influences on sediment transport condition

The characteristics of sediment transport at Binh Thuan coastal area and Vinh Tan area depend on the integrated hydrodynamics – wave process. Analysis results have revealed that sediment transport characteristics alter seasonally due to strong alteration of these factors.

Sediments source from the river to the coastal zone in this area is very small. Therefore, sediment transport is mostly caused by re-suspension due to wave activities and integrated current. Suspended sediment concentration is relative small with prevalent value less than 0.001 kg/m^3 and decreasing gradually from near-shore to offshore. The difference in sediment concentration between rainy and dry seasons is not considerable. (Figure 50 - 51 and Figure 54 - 55).

Sediment flux and distribution in this area slightly change with phase of tide oscillation owing to change in moving direction of water flow at the coastline. Suspended sediment distribution is similar between dry season and rainy season.

To assess the impacts of the leveling work, calculation on the distribution and transport of total suspended sediment (TSS) was performed before, during and after the leveling process after construction phase. The results presented in Figure 50 to Figure 57 reveal certain impacts on the distribution of TSS in the study area during the leveling process. However, the spreading of suspended sediments is limited in the small area because suspended sediment surrounded by the constructions.

In the case of leveling after construction (leveling after, scenario 3-4)

During leveling work in Southwest monsoon, the activities generate turbid area with TSS value of about 0.012-0.018 kg/m^3 on an area of 1.3km^2 around the leveling site and inside the port. This turbid water spreads to the eastern-northeastern parts of leveling area during flood tide stage (Figure 52) and south southwest parts during the ebb tide period (Figure 53). The concentration of sediment decreases at the outside of the leveling area and hardly depends on distance. Similar to the case of performing leveling works before construction phase, the impact of turbid water on Cu Lao Cau coastal zone, Breda sandbar area is insignificant (figure 52-53).

During leveling work in Northeast monsoon, the activities generate turbid area with TSS value of about 0.008-0.02 kg/m^3 on an area of 1.0km^2 around leveling site and inside the port . his turbid water spreads to the eastern-northeastern parts of leveling area during flood tide stage (figure 56) and the south-southwest during the ebb tide period (figure 57). The concentration of sediment decreases at the outside of the leveling area and hardly depends on distance. The impact of turbid water on Cu Lao Cau coastal zone, Breda sandbar area is insignificant (Figure 56-57).

Consequently, influence of the leveling activities on water quality is very small. To be more specific, the influence is insignificant in rainy season and very small in the western-northwestern parts of Cu Lao Cau island in the northeast monsoon, compared with the National regulation for coastal water quality QCVN 10: 2008/BTNMT at 0,05 kg/m3.

In order to assess variation of sediments flux due to impact of leveling activities in some place of the study area (figure 10), result of the models was analyzed and assessed. These results show:

- In areas far from leveling site, influence of leveling works on the increasing of suspended sediment is not significant. In Breda sandbar area (figure 58-59), suspended sediments concentration at V1 and V2 are not much different before and during performing leveling works after construction phase. This happens in both rainy and dry season. Similarly, in coastal zone of western and northwest Cu Lau Cau (V3, V4 and V5) influence of leveling works on the sediment concentration is very small (figure 60-62).

- In the eastern leveling site (V6), suspended sediment concentration increases slightly during leveling process between 0.012-0.017 kg/m^3 (figure 63) with a small range. The similar tendency happens at V7 (figure 64).

- In the southeastern leveling site (V8), suspended sediment concentration increases slightly and varies between 0.016-0.018kg/m^3 with a small range (Figure 65). This similar tendency happens in southwestern leveling site (figure 66).

Consequently, suspended sediment concentration increases slightly during performing leveling works, compared with those at the present. However, increasing of concentration is not big with a range of 0.02kg/m^3. In most cases, suspended sediment concentration is still smaller than the allowance value of 0.05kg/m^3 stipulated in the Vietnamese water quality standard for coastal water (QCVN 10: 2008/BTNMT). With regard to other areas, influence of leveling works on the increasing of TSS concentration is not significant.

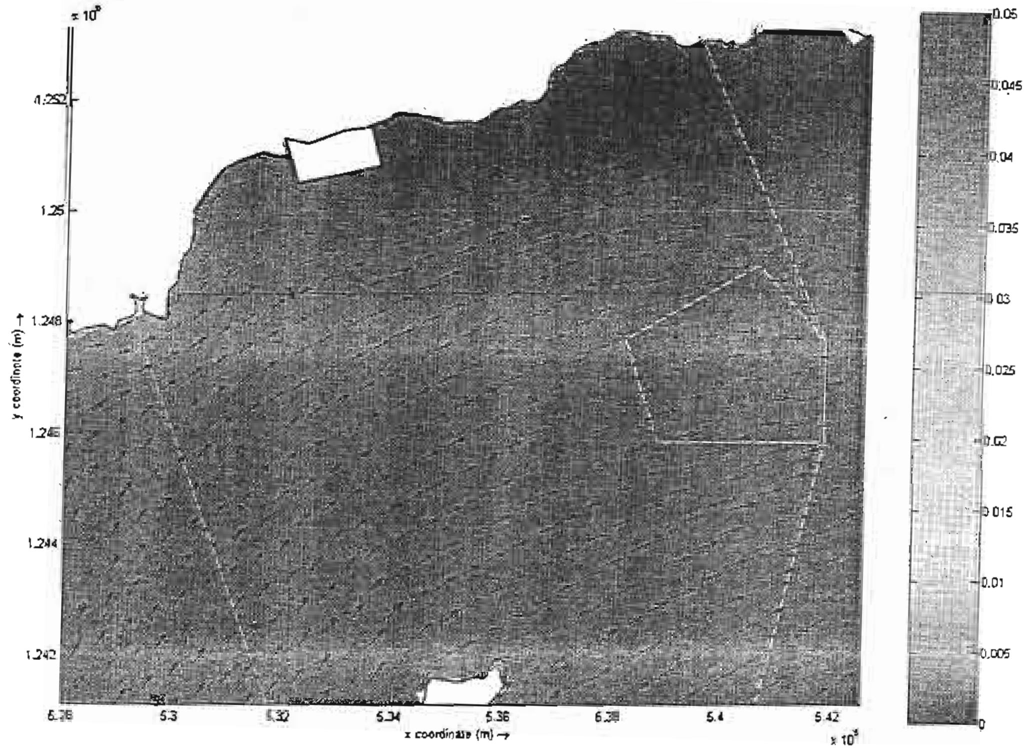


Figure 50. Distribution of Total Suspended Solid (TSS) in Vinh Tan coastal area (middle layer, southwest wind, flood tide – before leveling)

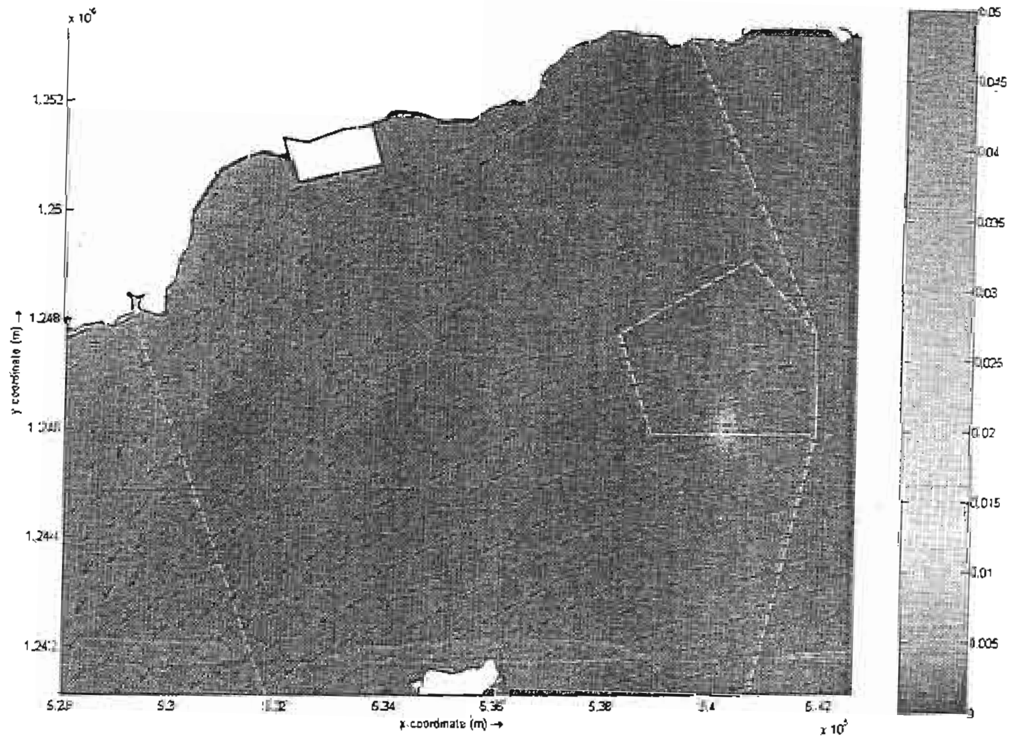


Figure 51. Distribution of Total Suspended Solid (TSS) in Vinh Tan coastal area (middle layer, southwest wind, ebb tide – before leveling)

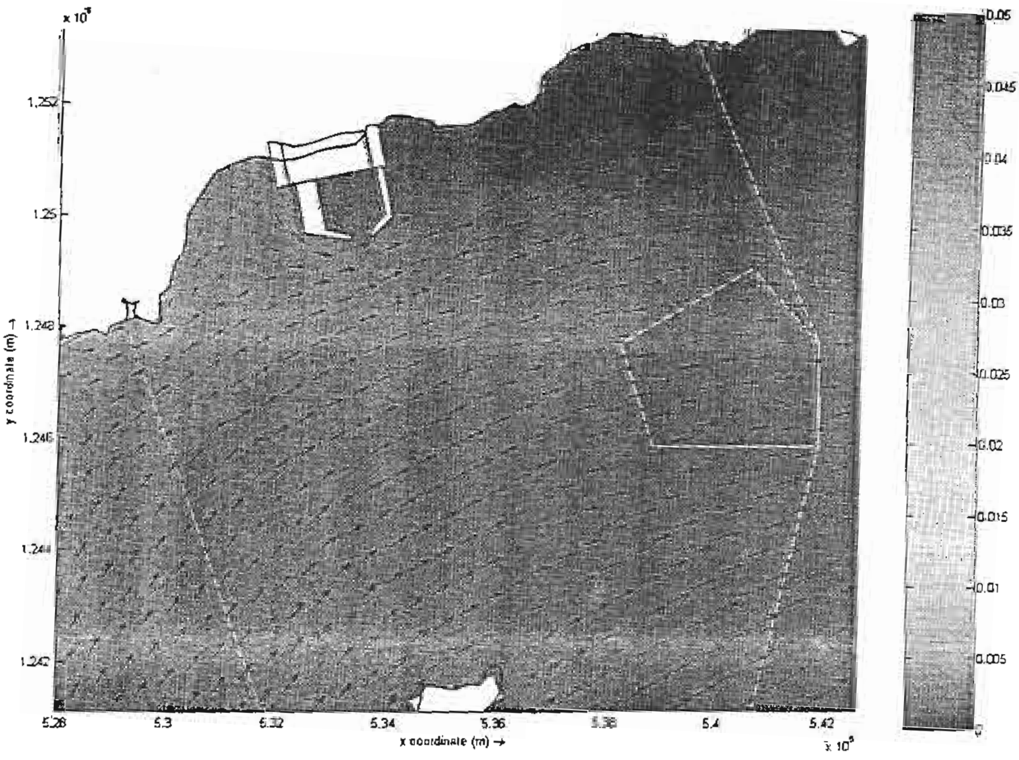


Figure 52. Distribution of TSS in Vinh Tan coastal area (middle layer, southwest wind, flood tide – leveling after construction)

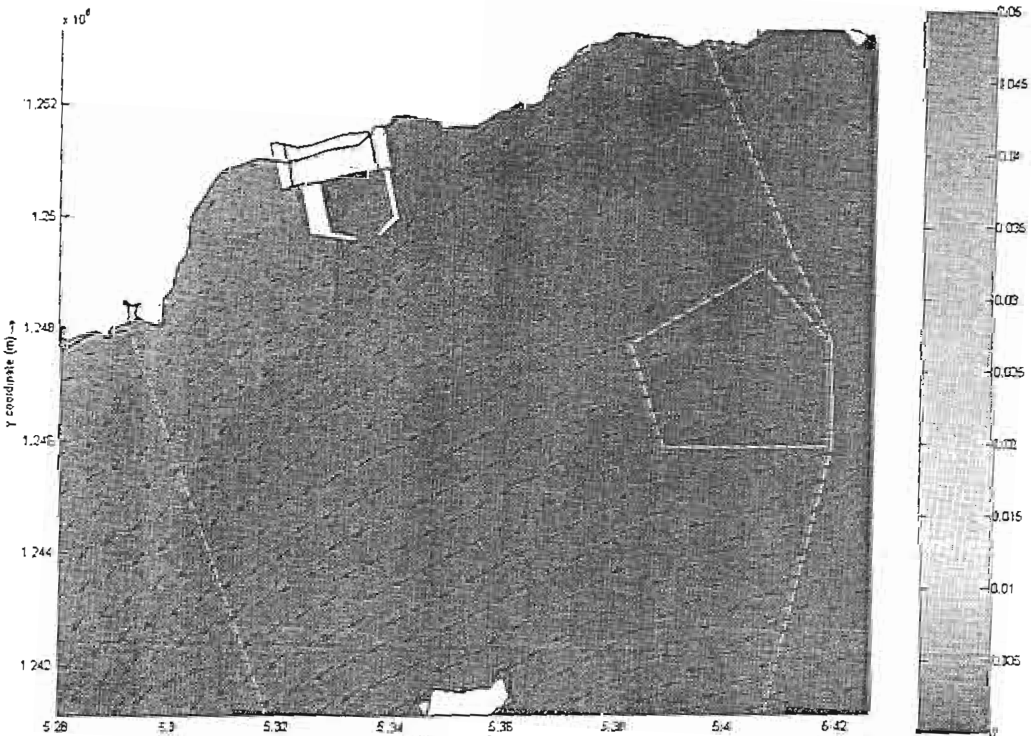


Figure 53. Distribution of TSS in Vinh Tan coastal area (middle layer, southwest wind, ebb tide – leveling after construction)

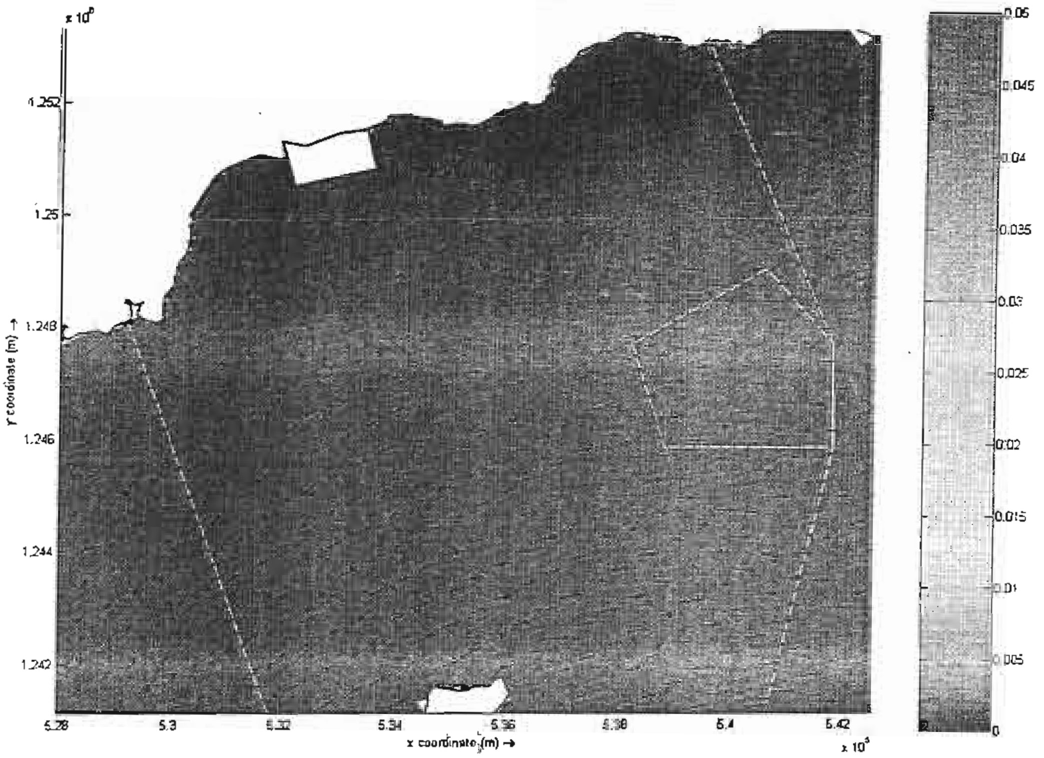


Figure 54. Distribution of TSS in Vinh Tan coastal area (middle layer, northeast wind, flood tide –before leveling)

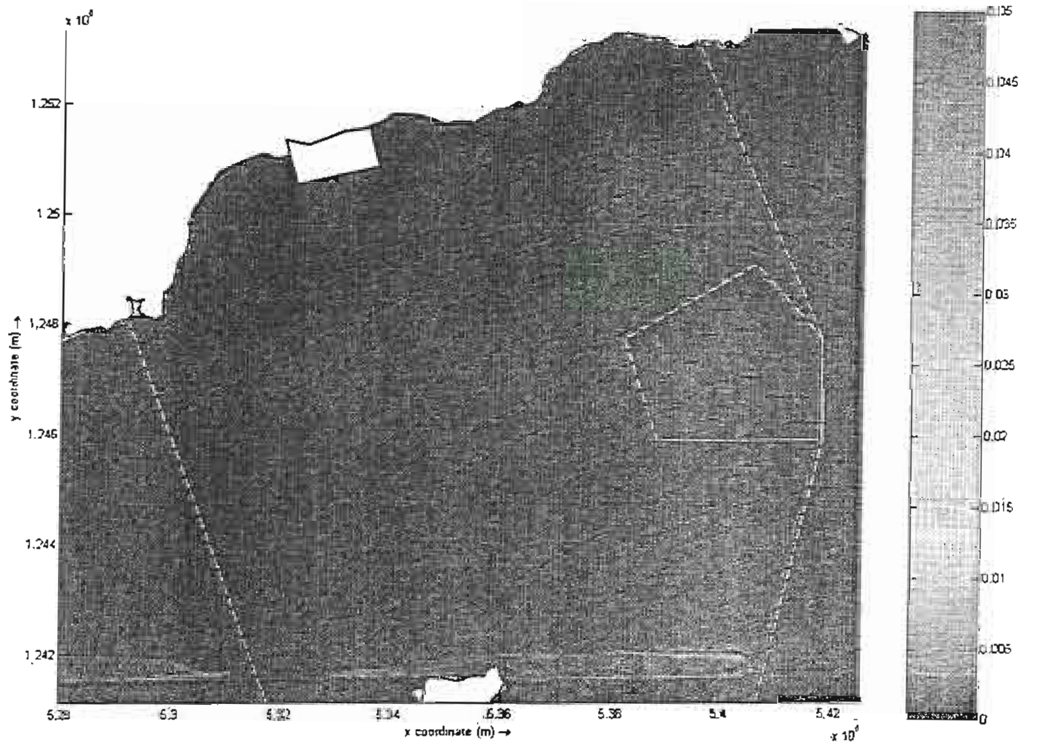


Figure 55. Distribution of TSS in Vinh Tan coastal area (middle layer, northeast wind, ebb tide –before leveling)

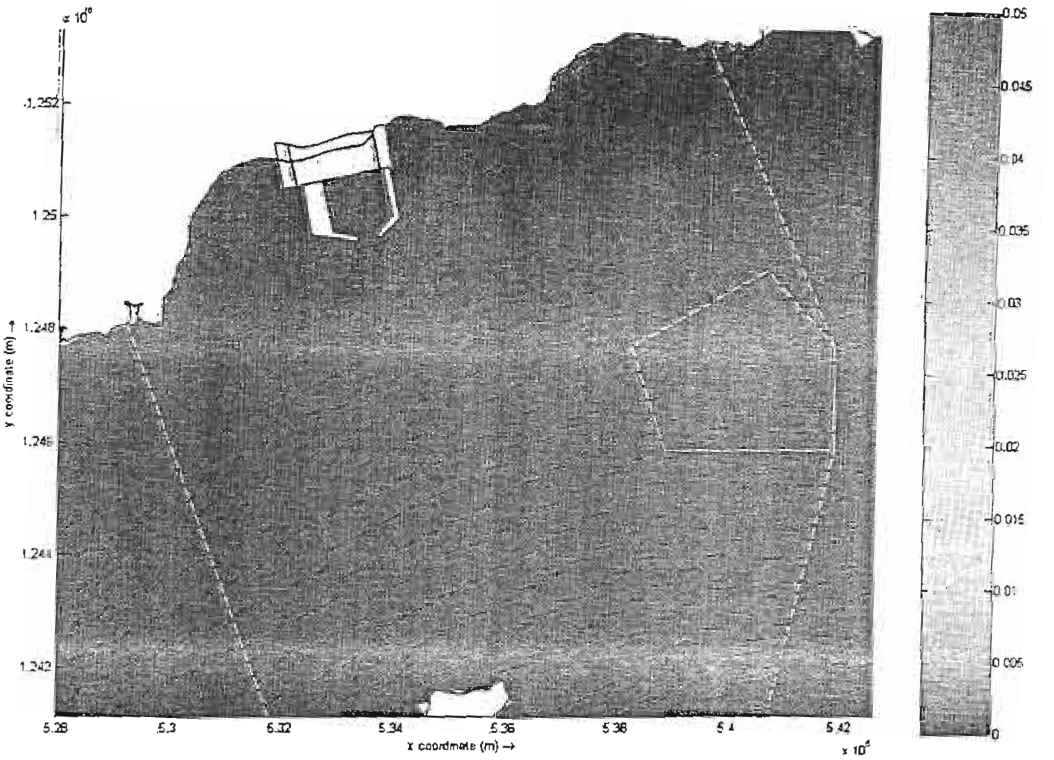


Figure 56. Distribution of TSS in Vinh Tan coastal area (middle layer, northeast wind, flood tide – leveling after construction)

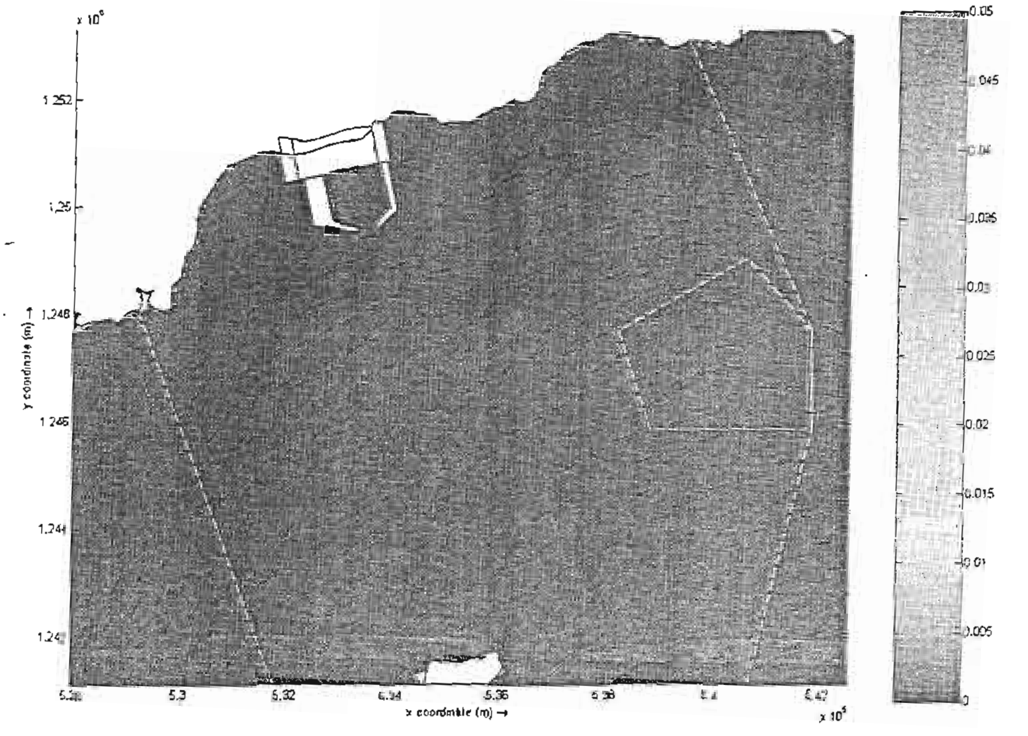


Figure 57. Distribution of TSS in Vinh Tan coastal area (middle layer, northeast wind, ebb tide – leveling after construction)

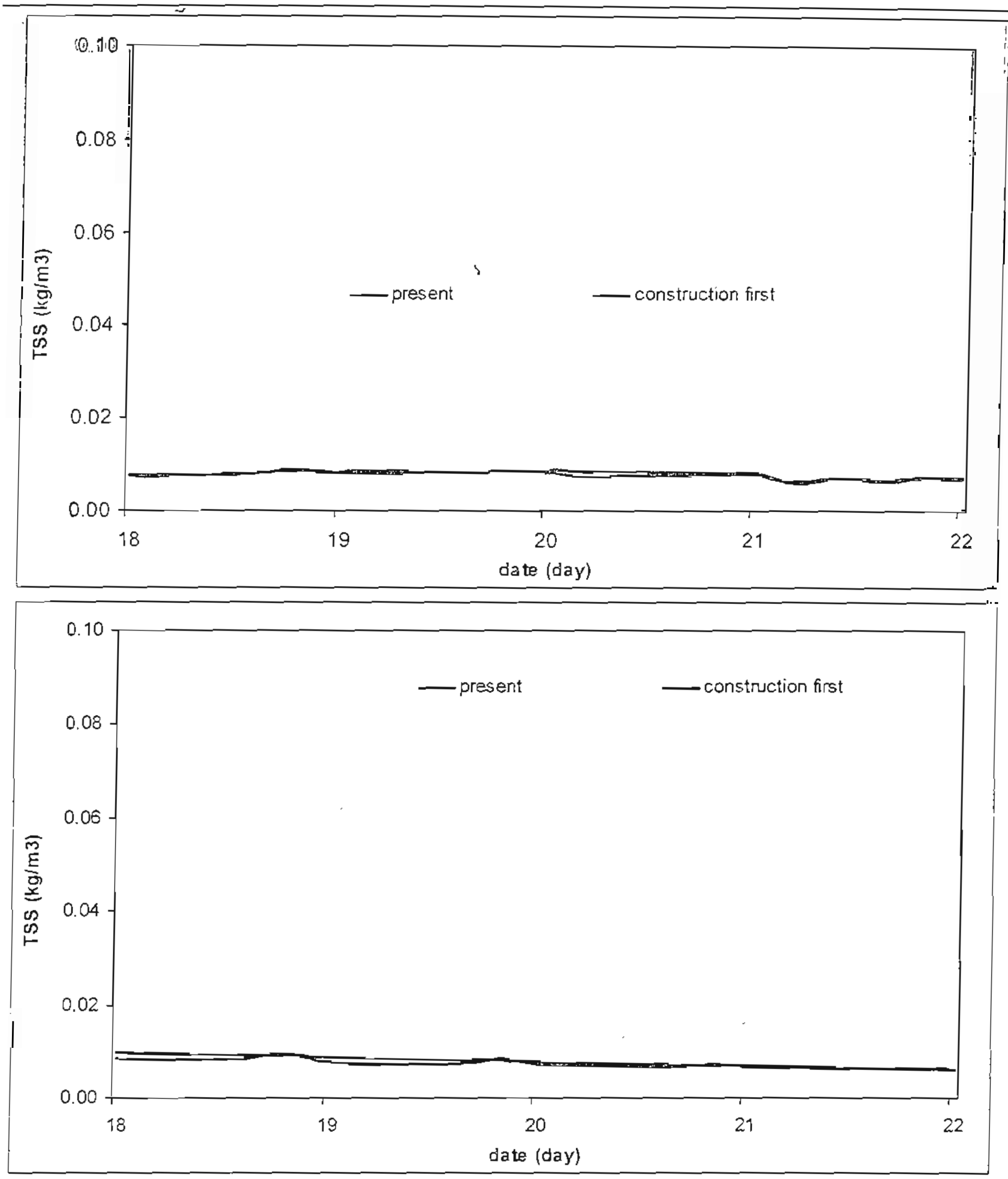
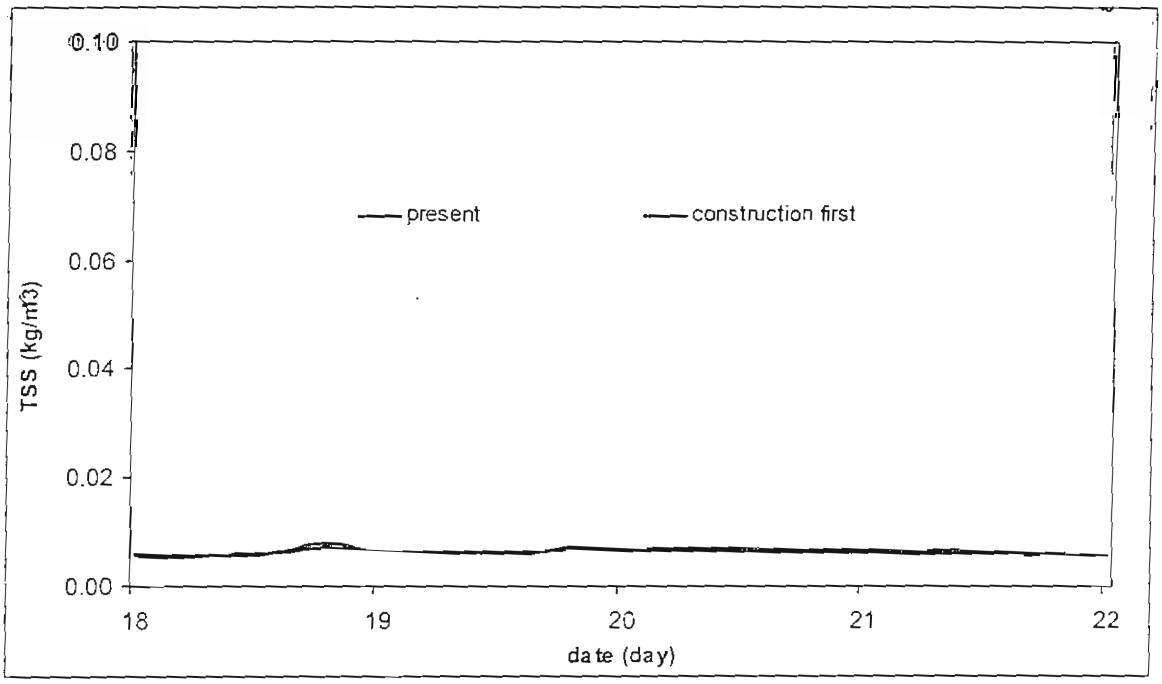


Figure 58. Variation of TSS concentration (kg/m3) in Breda sandbar
(V1; a – rainy season; b- dry season)



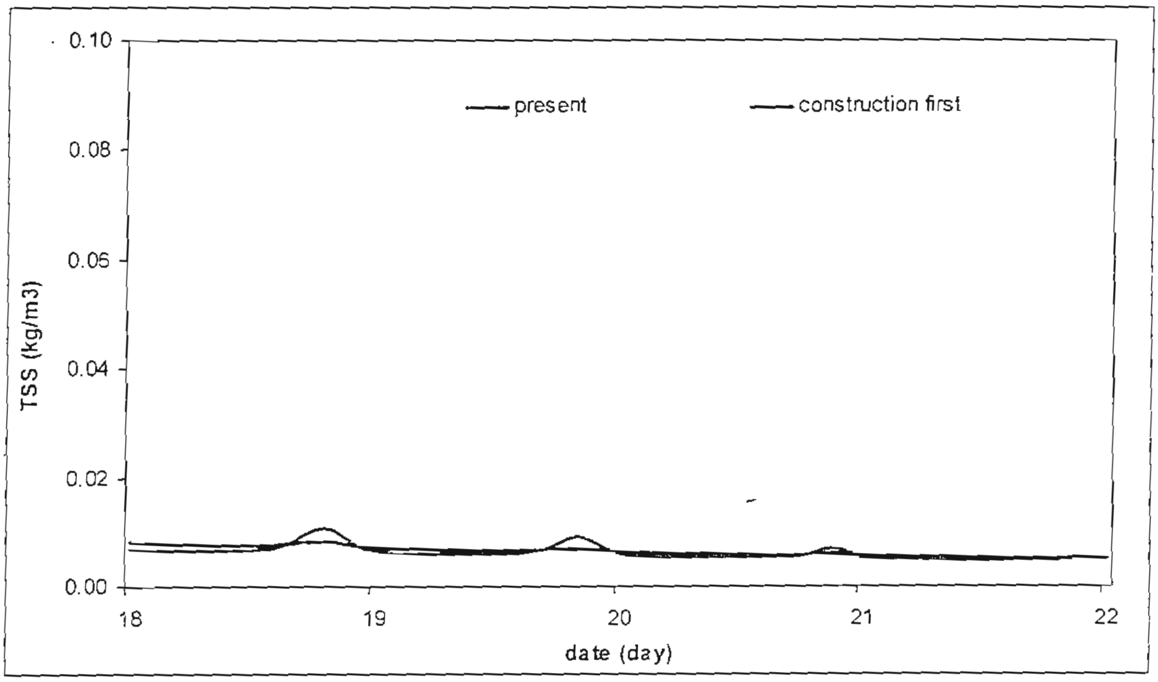


Figure 59. Variation of TSS concentration (kg/m3) in Breda sandbar
(V2; a – rainy season; b- dry season)

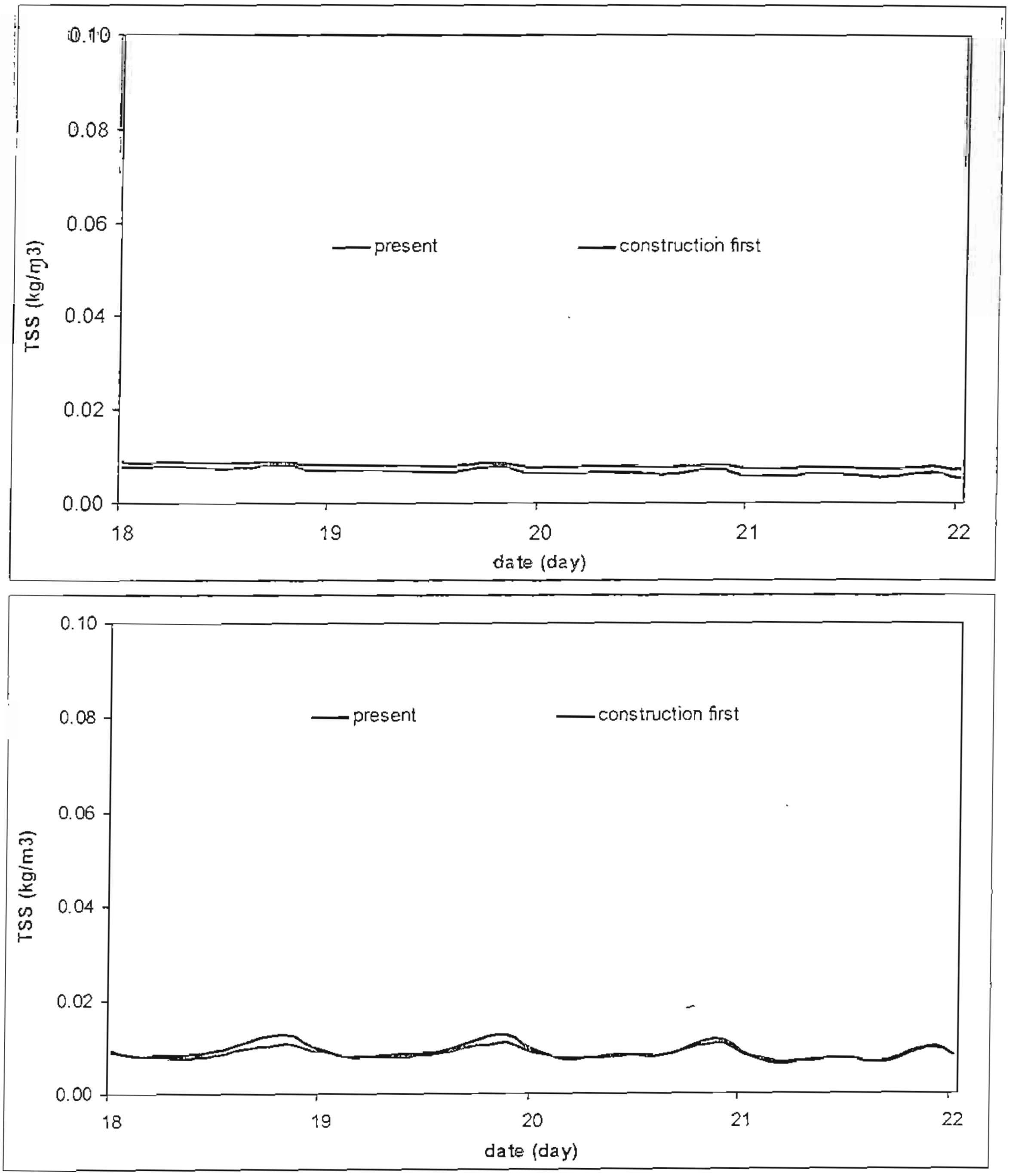


Figure 60. Variation of TSS concentration (kg/m3) in Cu Lao Cau coastal area (V3; a – rainy season; b- dry season)

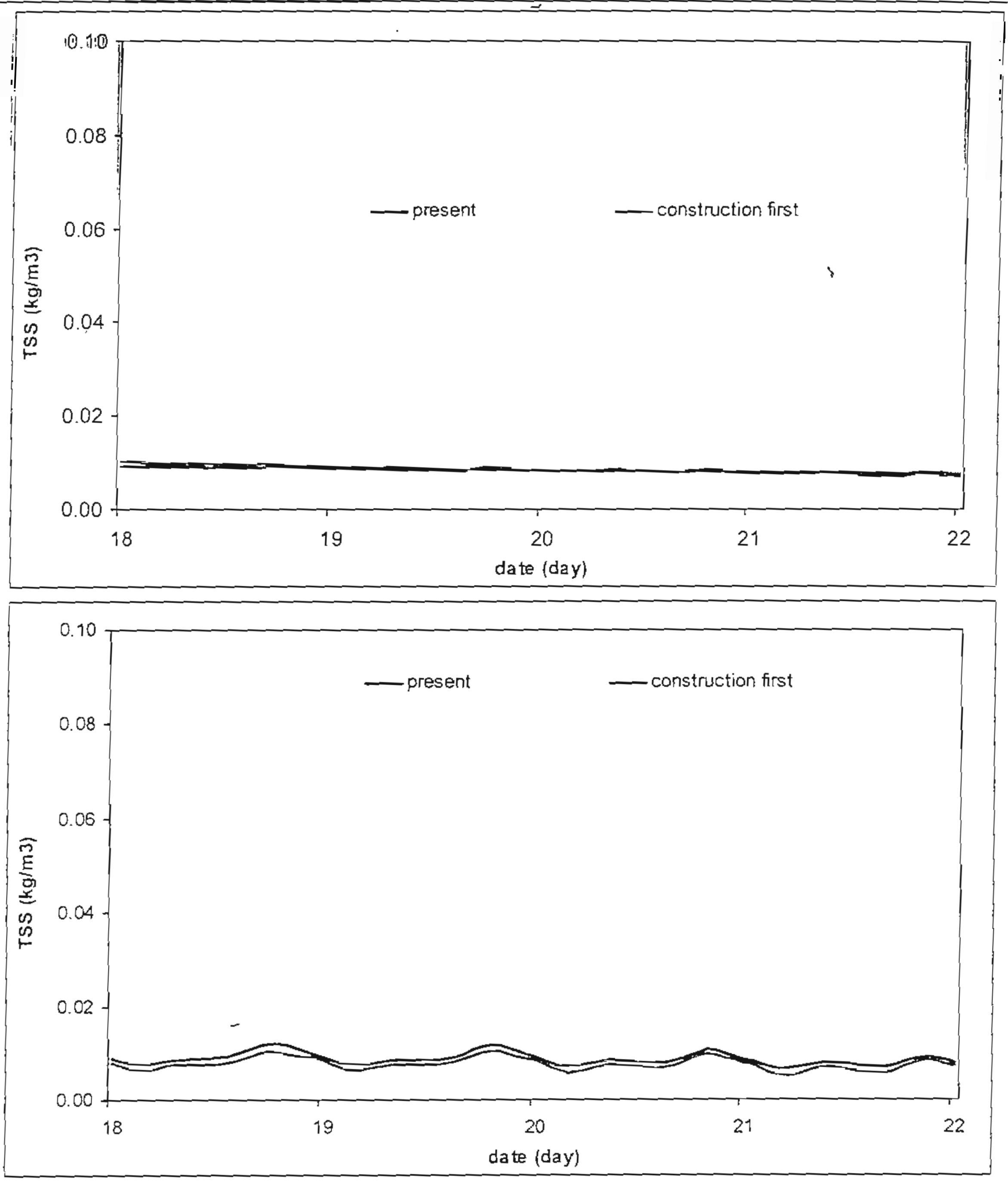


Figure 61. Variation of TSS concentration (kg/m3) in Cu Lao Cau coastal area (V4; a – rainy season; b- dry season)

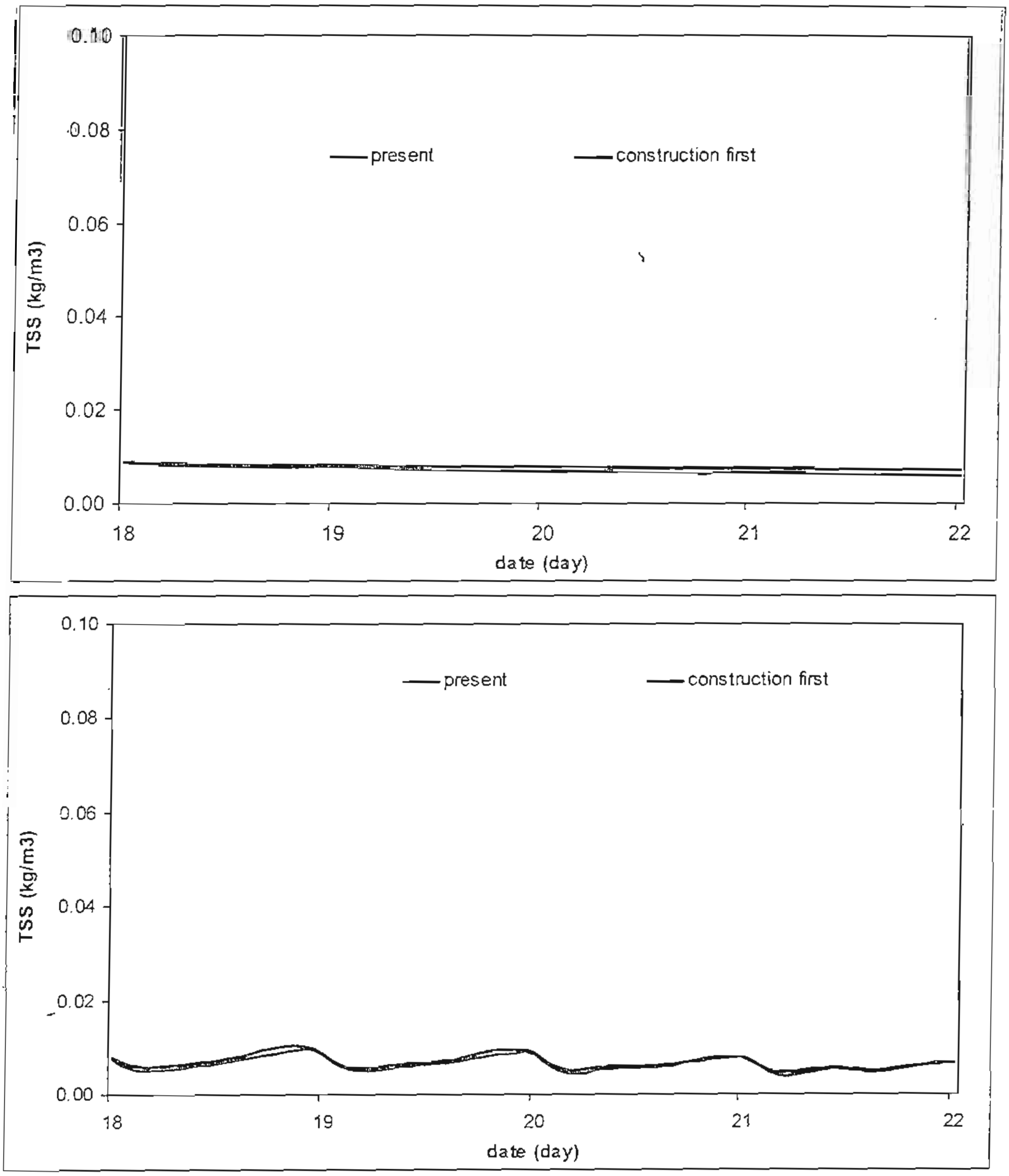


Figure 62. Variation of TSS concentration (kg/m3) in Cu Lao Cau coastal area. (V5; a – rainy season; b- dry season)

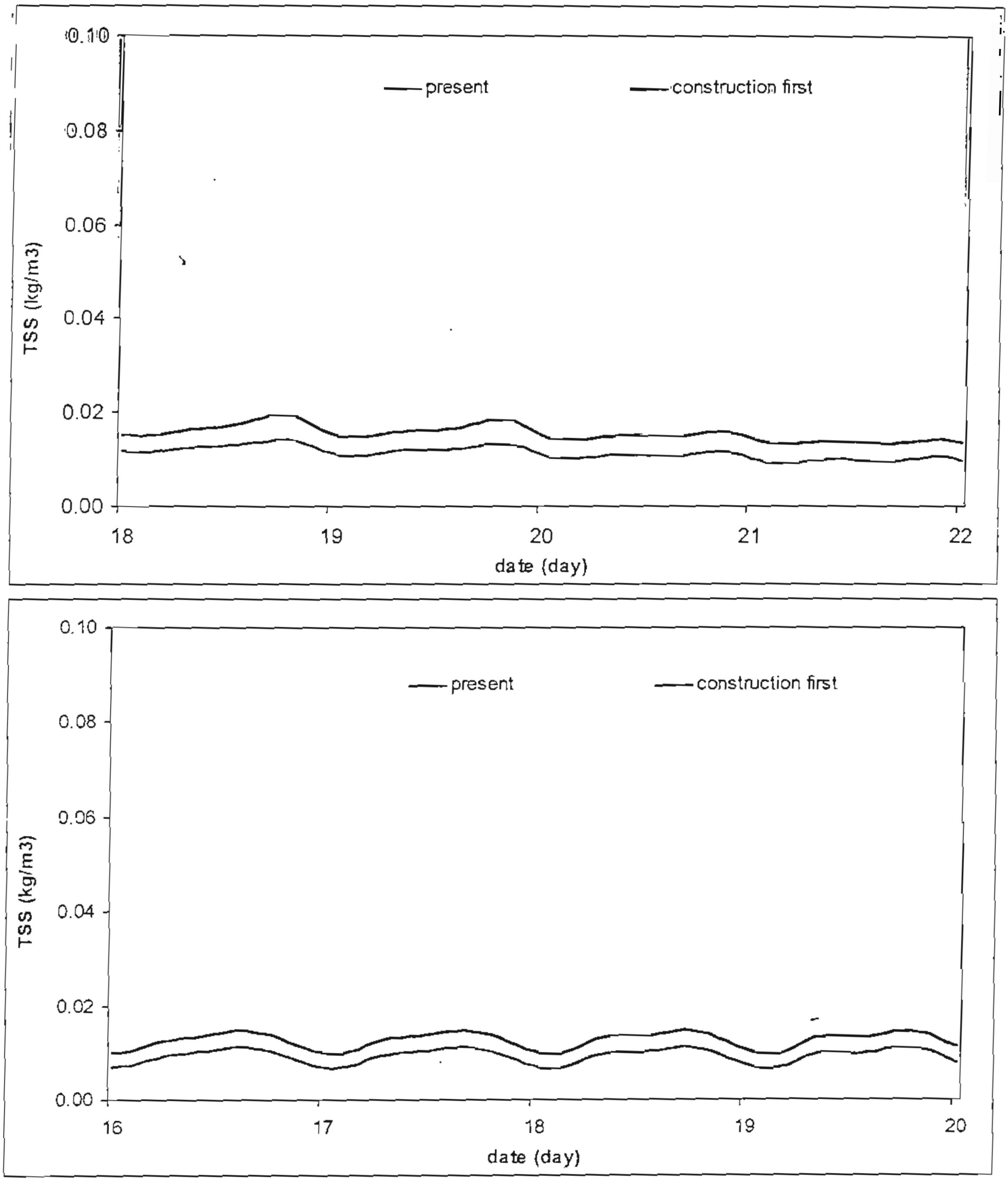


Figure 63. Variation of TSS concentration (kg/m3) in the eastern of the leveling site (V6; a – rainy season; b- dry season)

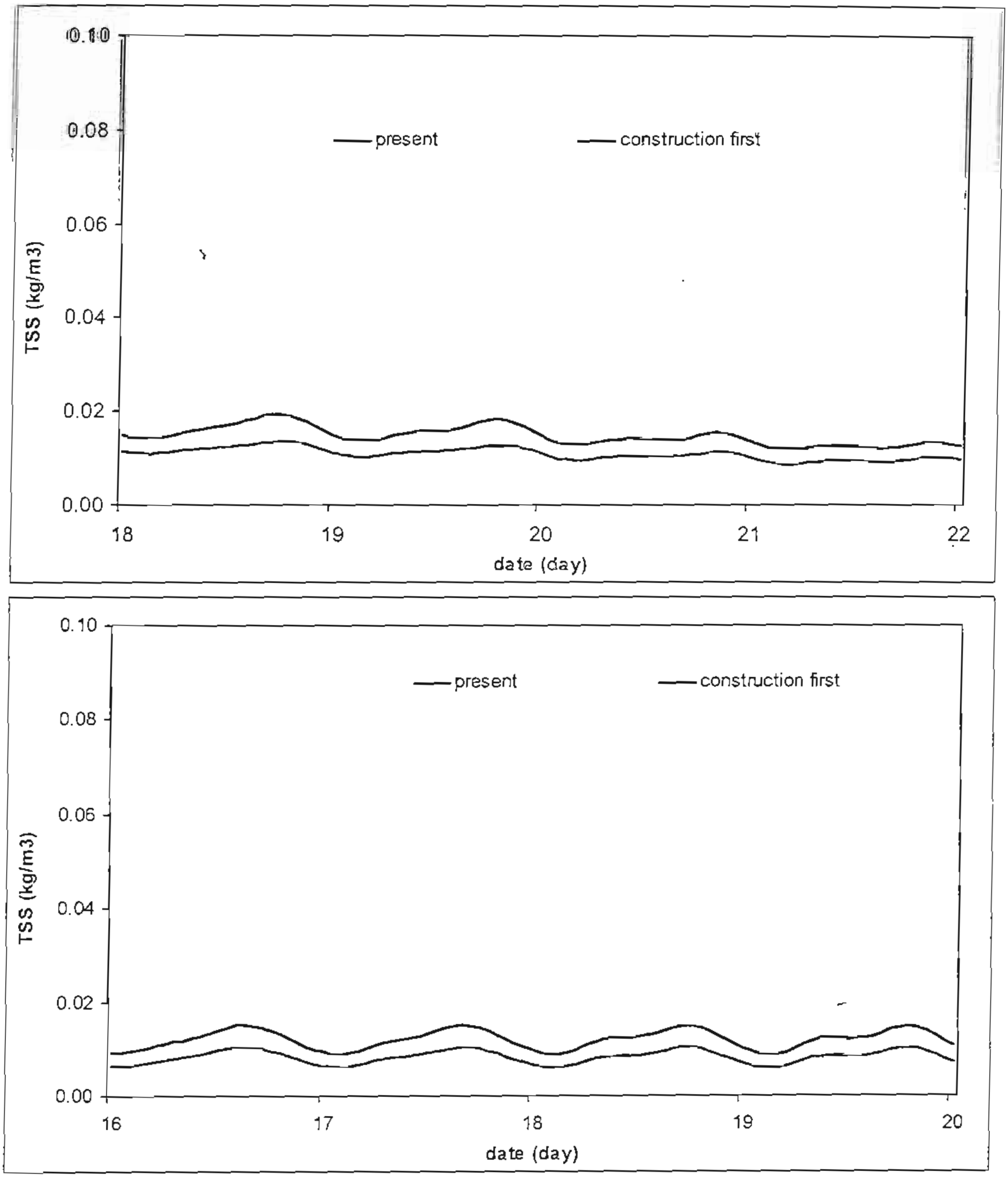
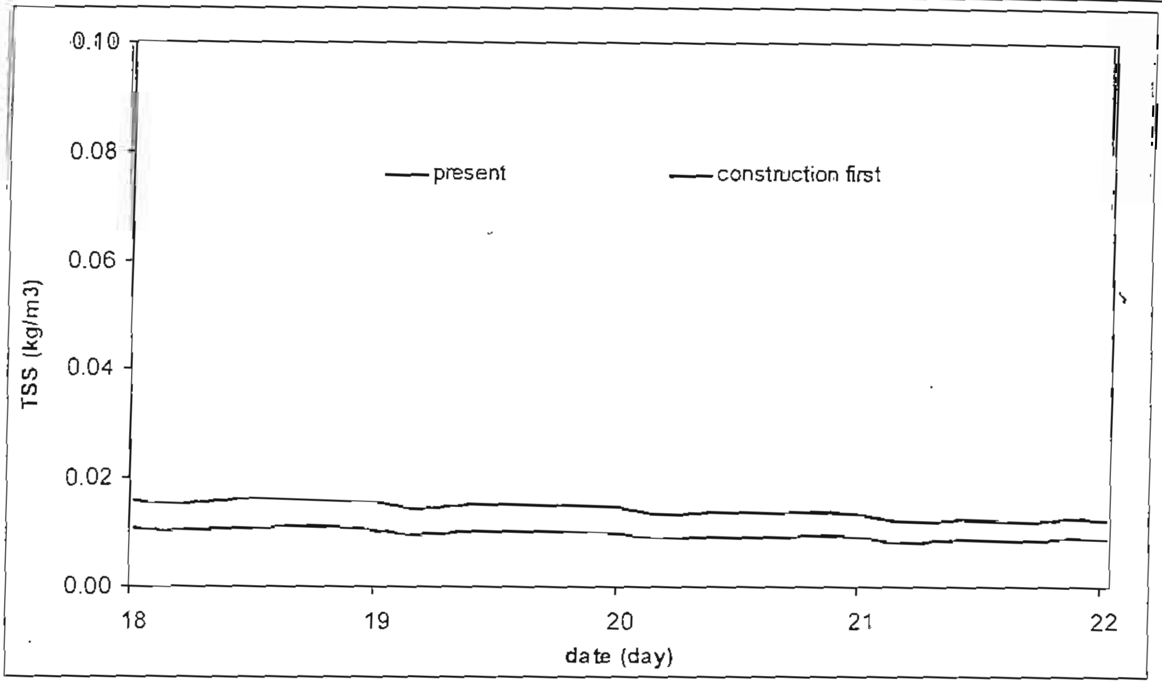


Figure 64. Variation of TSS concentration (kg/m3) in the eastern of the leveling site (V7; a – rainy season; b- dry season)



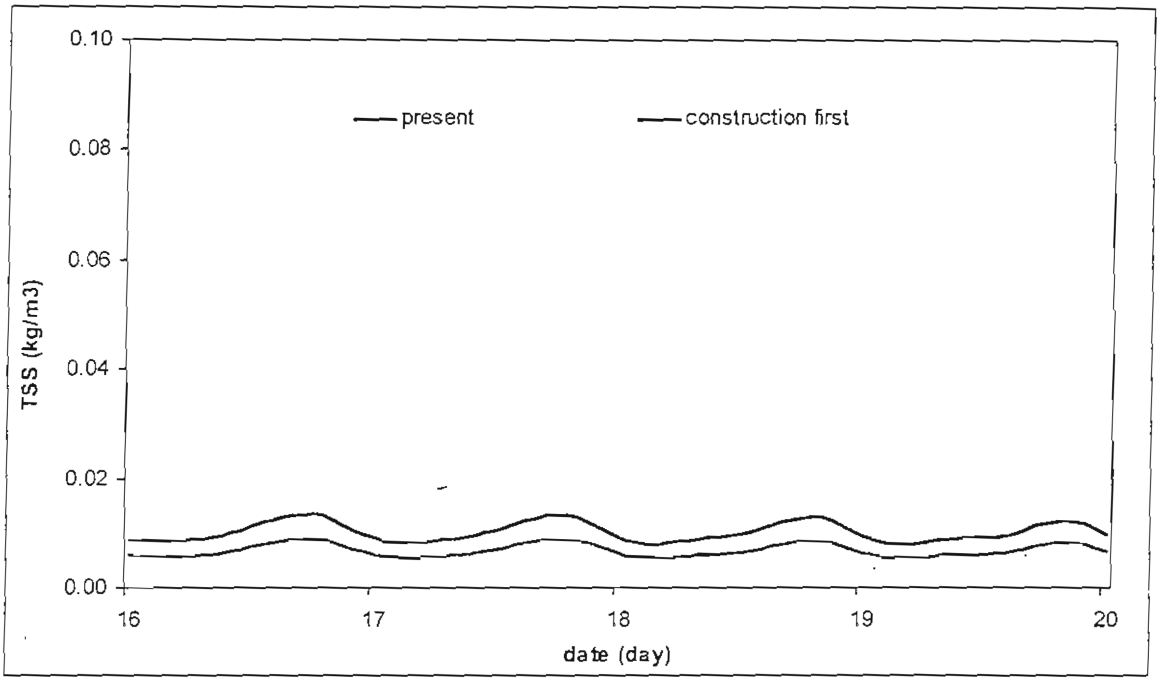


Figure 65. Variation of TSS concentration (kg/m3) in the southeastern of the leveling site (V8; a – rainy season; b- dry season)

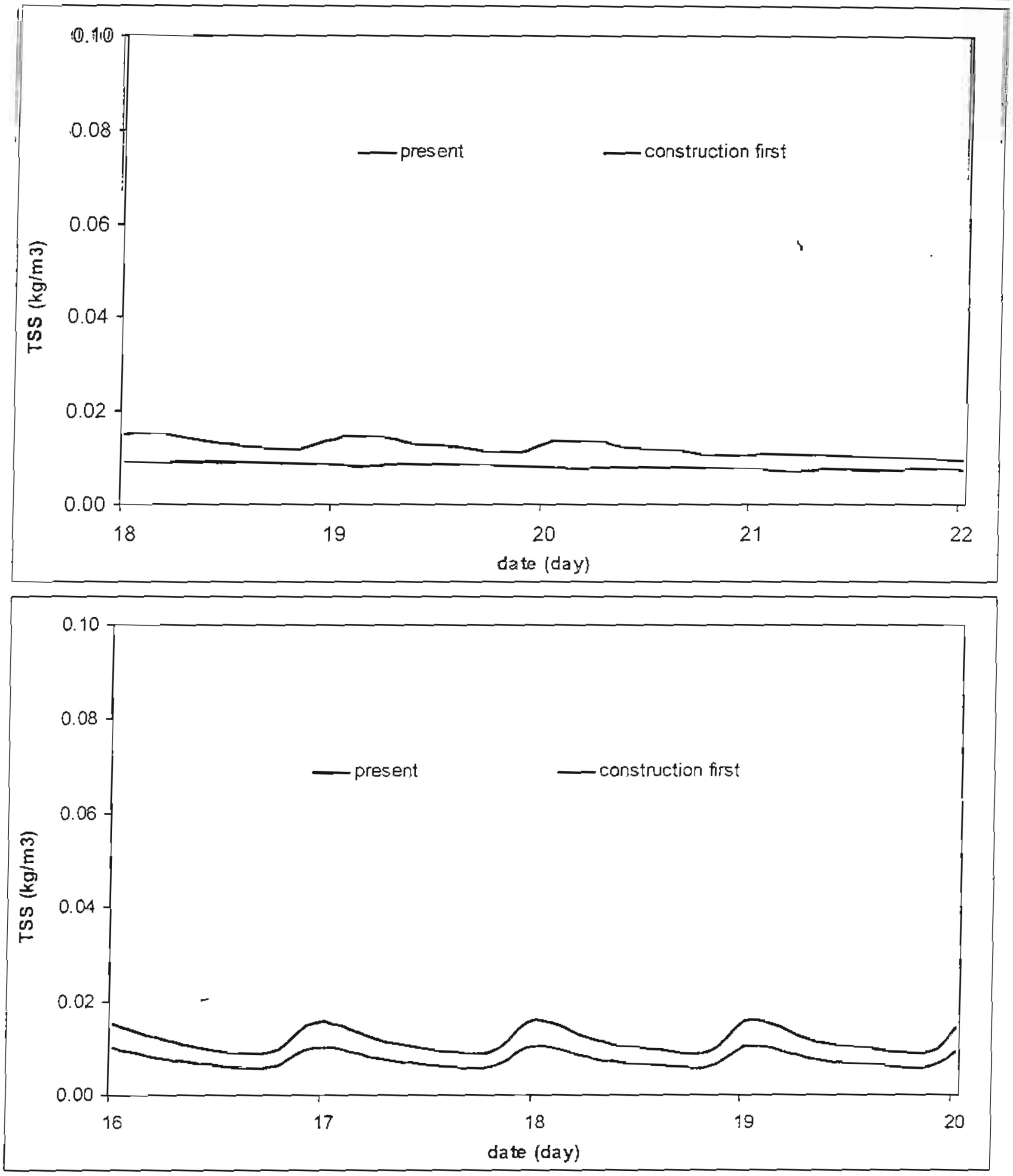


Figure 66. Variation of TSS concentration (kg/m3) in the southwest of the leveling site (V9; a – rainy season; b- dry season)

Sediment transport in across-sections at present

Calculated results of sediment flux at cross - sections in the study area (Figure 11) reveal that the sediment in this area mostly moves alongshore. In southwest wind monsoon, the local sediment flux moves up (from southwest to northeast). Day-averaged sediments flux in rainy season at cross-sections, which are perpendicular with the coastline (VT1-VT4), fluctuates between 22.1-77.7 kg/day northeastward

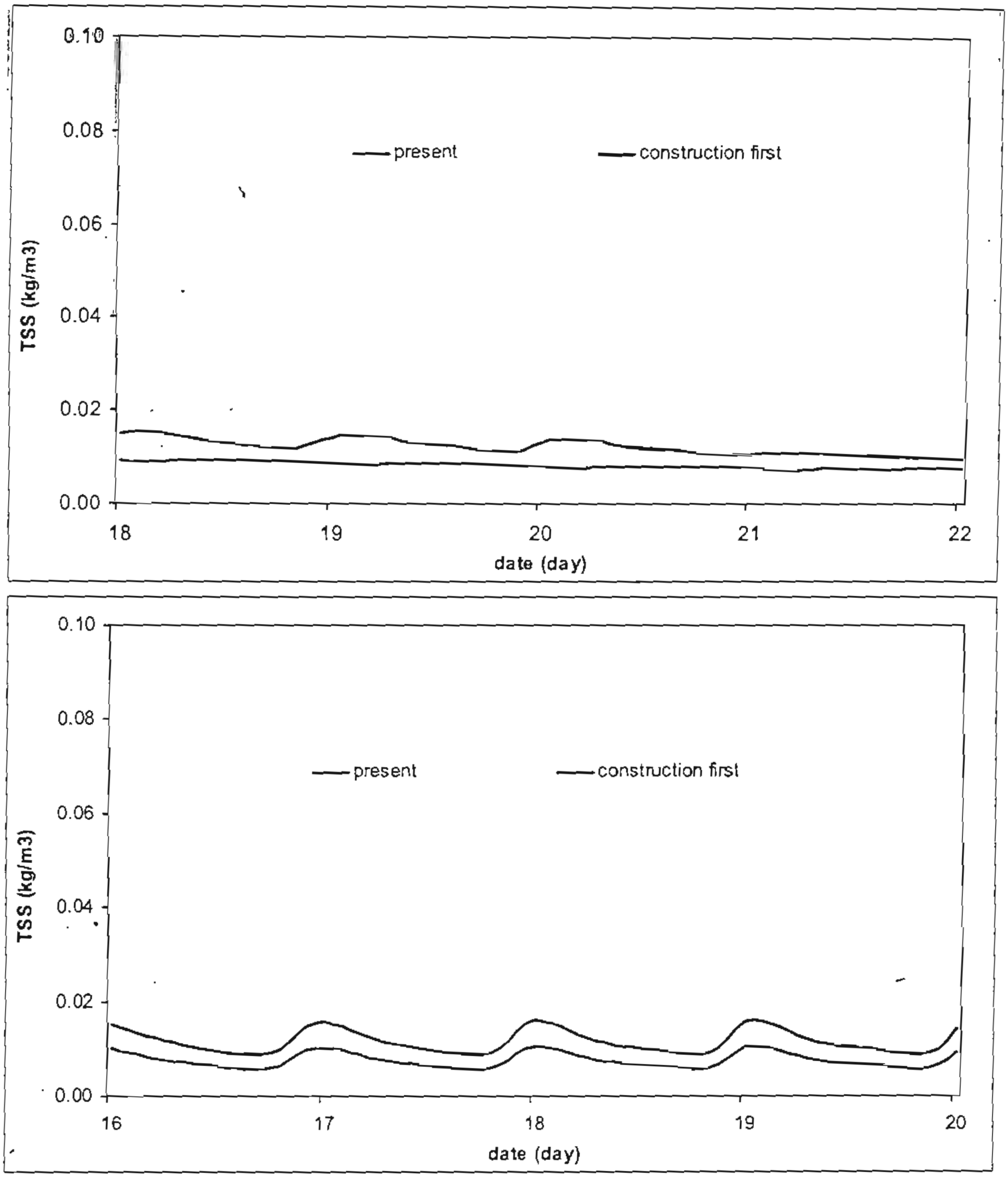


Figure 66. Variation of TSS concentration (kg/m3) in the southwest of the leveling site (V9; a – rainy season; b- dry season)

Sediment transport in across-sections at present

Calculated results of sediment flux at cross - sections in the study area (Figure 11) reveal that the sediment in this area mostly moves alongshore. In southwest wind monsoon, the local sediment flux moves up (from southwest to northeast).

Day-averaged sediments flux in rainy season at cross-sections, which are perpendicular with the coastline (VT1-VT4), fluctuates between 22.1-77.7 kg/day northeastward (Table 7). Similar trend was found at cross- sections perpendicular with the northern shore (VT10) and southern shore (VT5). At the parallel cross-section with the coastline, sediment flux more likely moves offshore than the opposite direction: sediment flux at VT7 is about 13.8kg/day; while VT8 and VT6 have respectively 97.2 and 45.2 kg/day (Table 7).

Table 7. Averaged sediment flux (kg/day) at across-section in the rainy season

Across-section	present			Leveling after construction		
	up (out)	down (in	averaged	up (out)	down (in	averaged
Vt1	557.8	-402.4	77.7	559.1	-395.4	**81.9**
Vt2	432.0	-313.5	**59.2**	415.2	-300.8	**57.2**
Vt3	693.9	-604.7	**44.6**	719	-618.5	**50.3**
Vt4	164.8	-120.6	**22.1**	138	-124.8	**6.6**
Vt5	735.7	-695.5	**20.1**	752.9	-715	**19.0**
Vt6	-1390.1	1195.7	**-97.2**	-1429.8	1228	**-100.9**
Vt7	-141.5	169.1	**13.8**	-111.3	122.5	**5.6**
Vt8	-327.7	237.3	**-45.2**	-317.1	221.9	**-47.6**
Vt9	360.7	-492.0	**-65.7**	366.4	-502.1	**-67.9**
Vt10	181.1	-83.1	**49.0**	172.5	-77.8	47.4

Annotate: up – from south to north; out – from onshore to offshore.

Table 8. Averaged sediment flux (kg/day) at across-section in the dry season

Across-	present	Leveling after construction

section	up (out)	down (in	averaged	up (out)	down (in	averaged
Vt1	11.4	-15.2	**-1.9**	10.5	-16.3	**-2.9**
Vt2	8.2	-12.1	**-2.0**	6.7	-12.0	**-2.6**
Vt3	60.0	-130.3	**-35.2**	66.9	-139.3	**-36.2**
Vt4	4.5	-5.5	**-0.5**	4.2	-4.6	**-0.2**
Vt5	80.1	-129.9	**-24.9**	97.6	-156.2	**-29.3**
Vt6	-403.5	318.4	**-42.6**	-453.7	356.9	**-48.4**
Vt7	-66.7	76.4	**4.8**	-57.8	61.8	**2.0**
Vt8	-14.1	22.5	**4.2**	-12.6	19.7	**3.5**
Vt9	35.3	-44.5	**-4.6**	39.5	-53.3	**-6.9**
Vt10	10.6	-22.1	**-5.7**	11.0	-21.7	**-5.4**

Annotate: up – from south to north; out – from onshore to offshore.

In northeast wind monsoon, the sediment flux likely moves down to the southwest more than moving up to the northeast). Day-averaged sediments flux in dry season at cross-sections, which are perpendicular with the coastline (VT1-VT4), fluctuates between 0.48 - 35.2 kg/day northeastward. The absolute and average values in dry season are relatively lower than that in rainy season (Table 8). Similar trend was found at cross- sections perpendicular with the northern shore (VT10) and southern shore (VT5) of Vinh Tan coastal area in rainy season. At the parallel cross-section with the coastline, sediment flux tends to move toward the cross-section VT7 (4.8 kg/day) and VT8 (4.2 kg/day) yet away from VT6 (42.6 kg/day).

Influence of leveling activities on sediment transport conditions

At across-section VT1 in rainy season, upward sediments fluxes increases slightly but opposite direction decreases (due to impact of construction). Therefore, the balance of sediments flux in the rainy season increases, compared with one at present (averagely 81.9kg/day compared with 77.7kg/day, respectively) with an upward motivation (table 7). At across-section VT2 and VT4 (due to impact of construction) sediment flux in both directions drops dramatically, compared with those at present. Sediment flux in VT2 and VT4 are still move to northeastward in the rainy season with a smaller value. In across-sections VT5, VT9 and VT10, sediments flux have almost no significant variation, showing the weaker impact in area which are further from leveling area. Sediment flux from seaward to outside in this case tends to reduce, compared with the present scenario (especially at VT7). However, general balances of sediment flux still presents a trend as same as the present scenario.

In the dry season, sediments fluxes in alongshore in the case of performing leveling works after construction phase tends to decrease, compared with the present scenario. This is because works do shield and hinder motivation of water bodies and sediment flux alongshore. In comparison to scenario of performing leveling works after construction phase in rainy season, sediment flux in the dry season with a small range (Table 8)/ Sediment flux coming from the seaward also deceases slightly at VT7 and VT8 but increases at VT6 (table 8).

The fluctuation of sediment flux alongshore and coming from shore in Vinh Tan coastal zone in the case of leveling is not much large, compared with the present scenario and scenario of leveling before construction phase. The reduction of sediment flux alongshore and variation of sediment flux (increase or decrease) in seaward have not significant influence on ongoing statute of erosion-deposition in this study area.

The influence on erosion-deposition in around of the leveling site

The influence on erosion- deposition at inshore area nearby the construction site was calculated and analyzed by some monitoring point in the coastal zone of northeast and southwest of Vinh Tan port (figure 67).

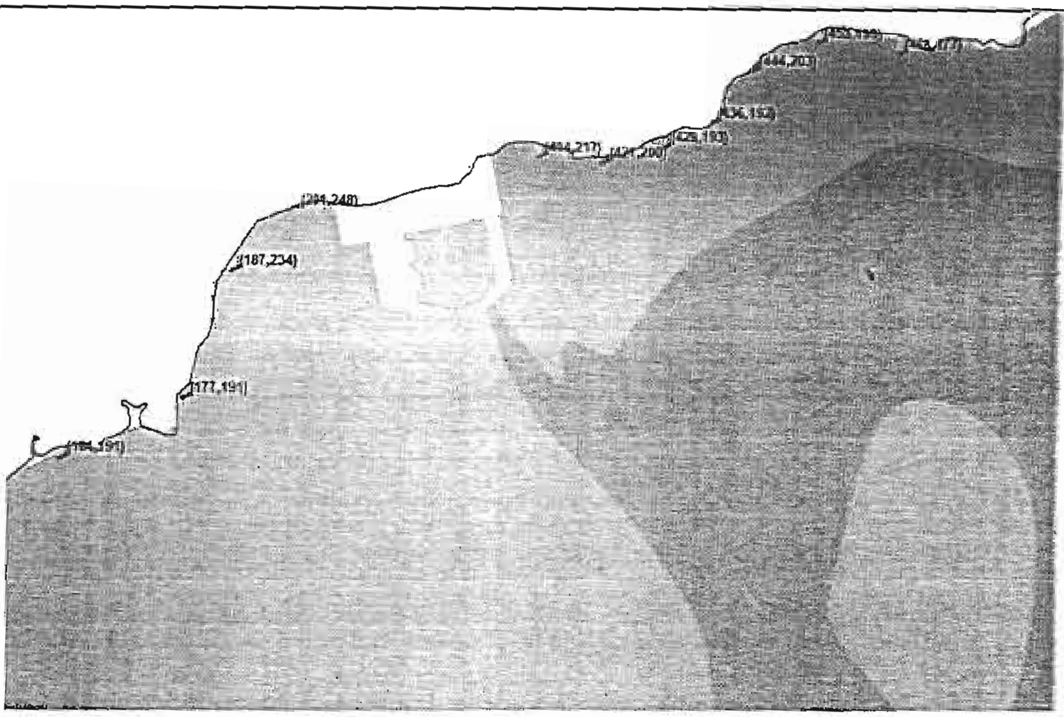


Figure 67. Position of monitoring point erosion – deposition due to influences of leveling activities

The result reveals that the monthly fluctuation of erosion-deposition is quite small, changing seasonally due to the variation of wave-wind field. The currently average erosion rate in surrounding construction site varies with the range of 0.0115-0.04982m/month. Meanwhile, the currently average deposition at present in surrounding construction site varies with the range of 0.00517-0.03103m/month. In inshore areas from B1 to B9, erosion trend occurs in the rainy season due to direct influence of wave actions under southwest wind field . However in the northeast monsoon season, when weaker impact of southwest monsoon and stronger impact of northeast monsoon, there is tendency of light deposition at B1- B7 (table 9). At B10 and B11, there is deposition in the rainy season and erosion in the dry season with velocity of 0.02-0.03m/month and 0.012-0.013m/month, respectively. At B8 and B9 there is light erosion in both rainy and dry seasons (table 9).

Table 9. Averaged rate of erosion- deposition (m/month) at some palace near the construction

Position	Scenarios	
	Scenario 1-2	Scenario 3-4

name	Position(m,n)	rainy	dry	rainy	dry
B1	463, 177	-0.01965	0.01230	-0.02056	0.01234
B2	453,199	-0.02167	0.01353	-0.02357	0.01358
B3	444,203	-0.03271	0.00405	-0.03242	0.00427
B4	436,192	-0.03711	0.00480	-0.03655	0.00476
B5	429,193	-0.04343	0.01019	-0.04365	0.01019
B6	421,200	-0.04034	0.00517	-0.00330	0.00529
B7	414,217	-0.04982	0.01032	-0.03359	0.01243
B8	201,248	-0.01150	-0.00329	0.00459	0.00234
B9	187,234	-0.04586	-0.02017	-0.01009	0.02455
B10	177,191	0.03103	-0.01302	0.02893	-0.01130
B11	164,191	0.02474	-0.01215	0.02606	0.01209

Annotate: - (minus) mean erosion

In the case of leveling after construction phase, works performance influences deposition and erosion owing to the fact that spreading of suspended sediment is restricted by the construction. Influences are clearer in some areas nearby the construction site such as B6, B7, B8 and B9. These points witness an increasing of deposition rate and decreasing of erosion rate. Because of influence of leveling performance in southwestern construction site, erosion tendency changes to deposition with rate of about 0.00234-0.02455m/month (table9). In areas far from the construction site, influence of leveling performance is very small due to spatial decrease of the spreading of suspended sediment. (table 9).

According to analysis results above, it is shown that any scenarios also has certain influence on happening of erosion-deposition around leveling site. However, these influences are quite small and clearer in some areas nearby the construction site and they are positive influence on happening of erosion –deposition in the study area.

7. Conclusions and recommendation

Hydrodynamic conditions of Vinh Tan coastal zone are affected by factors such as water level oscillation, wind and wave activities. Current velocity in the study area has a prevalent value between 0.1-0.3 m/s. Current field as well as wave fluctuate following sea level oscillation and direction of the wind field. Modeling results reveal that dredging activities hardly have significant effects on the hydrodynamics, wave pattern in the study area. After dredging process, the hydrodynamics and wave condition at places far from the dredging area mostly stay unchanged compare to present stage. On the other hand, at areas nearby the dredging site, current velocity, wave height slightly decrease compare to that at present. These impacts are positive for the sediment transport as well as erosion - deposition pattern at the area.

Recent researches on erosion-deposition in the study area show that erosion in Phuoc The and Lien Huong coastline are caused by combined affect of hydrodynamics, sediment transport and human activities. In which, the main cause is natural factor due to high slop bathymetry of this area which subsequently leads to the loss of sediment in near the coastline moving offshore without making up.

The characteristics of sediment transport in the coastal zone of Binh Thuan as well as Vinh Tan have integrated impact from hydrodynamic condition including wave. The sediment flux mostly moves alongshore and the direction alters between rainy and dry seasons. Particularly, sediment flux at cross-sections in rainy season is higher than that in dry season.

Leveling activities in the study area increase the turbidity of water around dredging area. However, highly turbid water accounts for only a small area alongside Vinh Tan coastline and no significant impact was found at Breda sandbar and Cu Lao Cau coastal area. After leveling process, impacts on Leveling activities on the local turbidity is almost negligible.

Leveling activities increase the sediment flux alongshore and from the outside of some cross-sections to the offshore in comparison to present scenario. However, spreading of suspended sediment is not restricted by the construction. Variation pattern of sediment flux does not impact on happening of erosion –deposition in the study area.

Result on impact assessment of different scenarios of happening of erosion – deposition in the study area and surrounding area do show that there is certain influence on happening of erosion –deposition in inshore areas nearby the construction site. However, these influences are positive: decreasing of erosion rate and increasing of deposition rate. The nearer construction site is, the clearer influence is. In some areas far from the construction site, influences is very small and cannot make a trend.

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Appendix 3.2: Substance dispersion modeling due to dredging of coal port of 100000DWT for Vinh Tan 4 Power Plant

TABLE OF CONTENT

1. Introduction

Despite the different scale and level the results have shown, any topographical change has certain impact on hydrodynamics, sediment transport as well as local environment. Therefore, in the context of the mission: ***Study and prediction impact of dredging in Vinh Tan port area on hydrodynamics, sediment transport condition and erosion-deposition in Vinh Tan coastal area,*** we carried out an assessment of the impact of dredging activities on Vinh Tan coastal area and its surroundings. Impacts include hydrodynamics, turbid water area, and characteristics of sediment transport during and after the dredging and construction activities. In order to implement such contents, we collected related hydrometeorological data, setting up a numerical model to simulate hydrodynamics and sediment transport in the study area with various scenarios. This report will present those results with structure as follows:

- Introduction: give a summary of the objectives of the study
- Part 2 supplies information about methods and materials used to implement the study.
- Since mathematical models were mainly used for the study, Part 3 of the report presents mathematical backgrounds of modelling concept including hydrodynamics, wave and sediment transport models.
- Part 4 introduces overall natural conditions of the project site including geography, topography, hydrometeorology and erosion-sedimentation characteristics.
- Part 5 presents content related to modeling setup (hydrodynamics, wave, sediment transport) according to the scenarios and forecasts for the studying site.
- Analyses on the impacts of dredging activities on hydrodynamic conditons, sediment transport are presented in Part 6 of the report.

Finally, conclusions and recommendation are presented in Part 7 of the report.

1.1. Object and target of the study

In order to predict the impact of dredging activities on Cu Lao Cau Marine Protected Area (MPA), main objects of the study are:

- Flow condition

- Characteristic of TSS (total suspended solids) distribution
- Characteristics of sediment transport and morphological alteration

1.2. Approaches and methods

To gain the above targets, key approaches and methods include:

-Collect and process related data:

- Model studied objects on the basic application of hydrodynamics, wave transition, and sediment transport models in the study area.

-Setting up the model according to various scenarios: southwest wind monsoon and northeast wind monsoon, before, during and after dredging work.

1.3. Studied area

The studied area includes the entire sea surface and coastal zone around Vinh Tan port. Additionally, the study area was extended to surface water around such as Bai Can (Breda sand bar) and Cu Lao Cau Island (Figure 1). The modeling scope also was extended eastward, northeastward and southwestward (Figure 6).

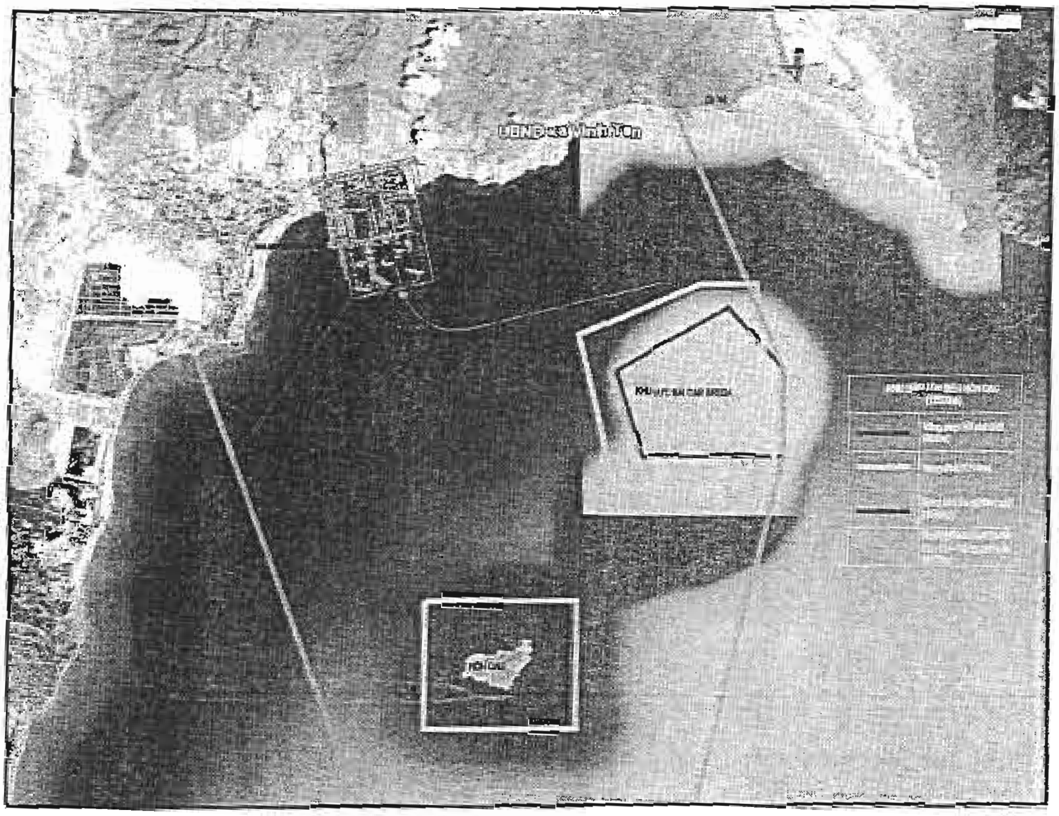


Figure 1. Vinh Tan port and surrounding areas

2. Material and methodology

2.1. Material

In order to implement the target of this study, data below were collected:

- Meteorological data: wind speed and direction, sea level oscillation. These data were measured by National Hydro-Meteorological Central (National Hydro - Meteorology Agency, 1976; National Hydro - Meteorology Agency, 2000; Nguyen The Tuong, 1996).

- Oceanographic data: group of tidal harmonic constant in the coastal zone from database Fes2004 (F. Lyard, F. Lefevre, T. Letellier, and O. Francis, 2006).

- Bathymetry data: bathymetry was digitalized and treated from bathymetry map of Binh Thuan and Ninh Thuan with scale: 1:50000 (published by Department of survey and mapping, Ministry of Environment and resources). Bathymetry in offshore area used bathymetry database of GEBCO -1/8 (General Bathymetric Chart of the Ocean (GEBCO) from British Oceanographic Data Centre (BODC).

- Others data included erosion- deposition, information about dumping activity, Cu Lao Cau MPA…etc.

2.2. Methods

A basic method to implement the above objectives is using mathematic models called Delft3d model which is developed by Delft Hydraulics Institute (Netherlands). Delft3d can closely simulate hydrodynamics condition, wave transition, water quality and sediment transport in the coastal zone (WL|Delft Hydraulics, 1999).

3. Concepts of the model

3.1. Equations of Hydrodynamics model

Delft3D-FLOW solves the Navier Stokes equations for an incompressible fluid, under the shallow water and the Boussinesq assumptions. In the vertical momentum equation the vertical accelerations are neglected, which leads to the hydrostatic pressure equation. In 3D models the vertical velocities are computed from the continuity equation. The set of partial differential equations in combination with an appropriate set of initial and boundary conditions is solved on a finite differences grid.

The depth-averaged continuity equation is given by:

$$\frac{\partial \zeta}{\partial t}+\frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)U\sqrt{G_{\eta\eta}}\right]}{\partial \xi}+\frac{1}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)V\sqrt{G_{\xi\xi}}\right]}{\partial \eta}=Q \qquad (1)$$

with Q representing the contributions per unit area due to the discharge or withdrawal of water, precipitation and evaporation:

$$Q = H\int_{-1}^{0}(q_{in} - q_{out})d\sigma + P - E$$

here:

ζ, η: Horizontal, curvilinear co-ordinates

$\sqrt{G_{\zeta\zeta}}, \sqrt{G_{\eta\eta}}$: Coefficients used to transform curvilinear to rectangular coordinates

d: depth below some horizontal plane of reference (datum)

ζ : water level above some horizontal plane of reference (datum)

U, V: velocity component in direction ζ, η

q_{in} và q_{out} local source and local sink per unit volume

H: total water depth (H = d + ζ)

P, E: precipitation and evaporation

The momentum equations in ζ and η direction are given by:

$$\frac{\partial u}{\partial t} + \frac{u}{\sqrt{G_{\xi\xi}}}\frac{\partial u}{\partial \xi} + \frac{v}{\sqrt{G_{\eta\eta}}}\frac{\partial u}{\partial \eta} + \frac{\omega}{d+\zeta}\frac{\partial u}{\partial \sigma} + \frac{uv}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\zeta\zeta}}}{\partial \eta} - \frac{v^2}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\eta\eta}}}{\partial \xi} - fv$$

$$= -\frac{1}{\rho_0\sqrt{G_{\zeta\zeta}}}P_\zeta + F_\zeta + \frac{1}{(d+\zeta)^2}\frac{\partial}{\partial \sigma}\left(v_v\frac{\partial u}{\partial \sigma}\right) + M_\zeta \quad (2)$$

$$\frac{\partial v}{\partial t} + \frac{u}{\sqrt{G_{\xi\xi}}}\frac{\partial v}{\partial \xi} + \frac{v}{\sqrt{G_{\eta\eta}}}\frac{\partial v}{\partial \eta} + \frac{\omega}{d+\zeta}\frac{\partial v}{\partial \sigma} + \frac{uv}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\zeta\zeta}}}{\partial \eta} - \frac{u^2}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\eta\eta}}}{\partial \eta} - fu$$

$$= -\frac{1}{\rho_0\sqrt{G_{\zeta\zeta}}}P_\eta + F_\eta + \frac{1}{(d+\zeta)^2}\frac{\partial}{\partial \sigma}\left(v_v\frac{\partial v}{\partial \sigma}\right) + M_\eta \quad (3)$$

The vertical velocity ω in the adapting σ co-ordinate system is computed from the continuity equation:

$$\frac{\partial \zeta}{\partial t} + \frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)u\sqrt{G_{\eta\eta}}\right]}{\partial \xi} + \frac{1}{\sqrt{G_{\zeta\zeta}}\sqrt{G_{\eta\mu}}}\frac{\partial\left[(d+\zeta)v\sqrt{G_{\zeta\zeta}}\right]}{\partial \eta} + \frac{\partial \omega}{\partial \sigma} = H(q_{in} - q_{out}) \quad (4)$$

In equations (2), (3), (4) :

ω : velocity in the σ direction in the σ co-ordinate system (m/s)

fv, fu: Coriolis force components

M_ζ, M_η: source or sink of momentum in ζ, η direction

ρ_0 : water density

Main process included:

- Coriolis force
- Turbulence closure model: K-epsilon, k-L, algebraic
- Bottom stress formulas:
  + Chézy: C- Chézy coefficient ($m^{1/2}/s$)
  + Manning: $C = \frac{\sqrt[6]{h}}{n}$

In there: h- depth total; Manning coefficient.

+ White Colebrook formula: $C = 18\log_{10}\left(\frac{12h}{k_s}\right)$

k_s- Nikuradse coefficient (m)

- Heat transfer from the study area to outsite (advection – diffusion)
- Surface strain caused by wind

3.2. Grid and bathymetric grid

In the horizontal, grid of the model is alternate (figure 2). In each grid cell has a water level point, depth point, u velocity and v velocity components. Water level point is defined in central of grid cell. The velocity components are perpendicular to the grid cell faces where they are situated.

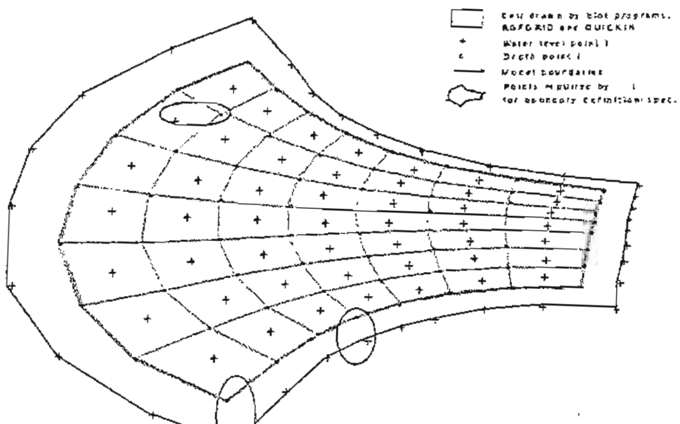


Figure 2. Example of a grid in Delft3D-FLOW

Bathymetric grid is created by model grid and depth point in the model frame. Depth points are measured data and data from digitized map.

3.3. Initial and boundary conditions

The boundaries of the hydrodynamics model include closed and open boundaries. Closed boundaries are natural boundaries between seawater and land. On the other hand, open boundaries are artificial water-water boundaries where water flow can move in and out of the model frame. In hydrodynamics model, the parameters at open boundaries should be defined correctly since it may influence directly to simulated results. These data may be determined from measure or calculation or nesting from bigger-scoped model. The further the open boundaries from concerned positions, the lower noise signals appear.

In specific situation, one of these types of boundary condition can be used for various open boundaries:

- Sea level boundary
- Current boundary
- Flow boundary

3.4. Critical stability of hydrodynamics model

Above equations are solved by ADI (Alternating Direction Implicit) method (WL|Delft Hydraulics, 1999) on curvilinear grid. Courant number, a parameter to assess the accuracy and stability of the model, can be used to estimate the critical stability of the model. In the coastal area with a large change of depth and coastline, Courant number should be between 10-30 (Van Ballegooyen and Taljaard, 2001). According to Stelling (1984), for 2D model, the Courant number may be defined as follows:

$$C = 2\Delta t \sqrt{gh\left(\frac{1}{\Delta x^2} + \frac{1}{\Delta y^2}\right)} \quad (5)$$

Where:

C: Courant number

g: acceleration of gravity (m/s^2)

h: water depth at calculated time (m)

Δt: time step (s)

Δx: grid size in x direction (m)

Δy: grid size in y direction (m)

The Courant number strictly depends on time step (Δt), the water depth and grid size. This is necessary to select suitable time step, which is not too long for each time running yet still ensure the accuracy and stability of the model. The parameters relate to time step include:

- Stability
- Demanded accuracy level
- Minimum grid size
- Depth
- Calculated time

3.5. Wave model

The model used for simulating wave characteristics in this study is Delft3D-WAVE which was developed based on SWAN model (Simulating WAves Nearshore) by TU Delft (Delft University of Technology, Neitherland). SWAN is a typical model for calculation wave characteristics in the coastal zone, estuaries area, lake from wind, bathymetry and current conditions. This model is based on equilibrium equation of wave action (or equilibrium equation of energy in case of no currents) with energy sources and consumption.

Delft3D-WAVE expects input data to be expressed in S.I. unit: m, kg, s, N and W. Consequently, the wave height and water depth are in [m], wave period is in [s] respectively. Wave direction is in degrees [^{0}] but not radians. Delft3D-WAVE can operate in plane or spherical coordinates system.

In the input for Delft3D-WAVE the directions of winds and (incident) waves are defined relative to the maritime or Cartesian coordinate systems. In the Cartesian system, all geographic locations and orientations in SWAN are defined in a common Cartesian coordinate system with a predetermined origin (0,0).

In wave model, the waves are described by a two-dimensional equation of action spectrum density, even when non-linear phenomena dominate. The ratio of using the spectrum in such non-linear conditions is high; wave spectral distribution is in second order moment of the waves. The spectrum that is considered in SWAN is the action density spectrum $N(\sigma,\theta)$ rather than the energy density spectrum $E(\sigma,\theta)$ since in the presence of currents, action density is conserved but not energy density (Whitham, 1974). The independent variables are the relative frequency σ and the wave direction θ. The action density is equal to the energy density divided by the relative frequency (in SWAN, this spectrum is temporally and spatially dependent):

$$N(\sigma,\theta) = E(\sigma,\theta)/\sigma \tag{6}$$

The evolution of the wave spectrum is described by the spectral action balance equation which is written in Cartesian co-ordinates as follows (Hasselmann et al. (1973)):

$$\frac{\partial}{\partial t}N + \frac{\partial}{\partial x}c_x N + \frac{\partial}{\partial y}c_y N + \frac{\partial}{\partial \sigma}c_\sigma N + \frac{\partial}{\partial \theta}c_\theta N = \frac{S}{\sigma} \tag{7}$$

The above equation describes the evolution of wave spectrum, in which the first term in the left-hand side represents the local rate of change of action density as a function of time; the second and third terms represent propagation of action density spectrum in geographical space (with propagation velocities Cx and Cy in x- and y-axes, respectively). The fourth term represents shifting of relative frequency under the influence of depth and current (with propagation velocity C_σ). The fifth term represents depth- and current-induced refraction. The expressions for these propagation speeds were taken from linear wave theory. The term S at the right-hand side of the equation is the value of source equation term in terms of energy density withdrawn from effects of wave generation, dissipation and non-linear wave-wave interactions. Refer to the Delft3d User Manual (WL|Delft Hydraulics, 1999) for more detail on Delft3D – Wave model.

The following processes are also considered in Delft3D – Wave model:

- Wind induced wave,
- Energy dissipation due to falling wave, bottom friction and depth-induced breaking,
- Non-linear wave-wave interaction, wave – current interaction.

3.6. Sediment transport model

Sediment transport model is based on equation of dispersion and diffusion of materials in water:

$$\frac{\partial C}{\partial t} = \frac{\partial}{\partial x}\left(D_x\frac{\partial C}{\partial x} - u_x C\right) - \frac{\partial}{\partial y}\left(D_y\frac{\partial C}{\partial y} - u_y C\right) - \frac{\partial}{\partial z}\left(D_z\frac{\partial C}{\partial z} - u_z C\right) \tag{8}$$

If outside source is considered, equation (8) can be rewritten:

$$\frac{\partial C}{\partial t} = \frac{\partial}{\partial x}\left(D_x\frac{\partial C}{\partial x} - u_x C\right) - \frac{\partial}{\partial y}\left(D_y\frac{\partial C}{\partial y} - u_y C\right) - \frac{\partial}{\partial z}\left(D_z\frac{\partial C}{\partial z} - u_z C\right) + F(C,t) \tag{9}$$

Where:

D_x, D_y, D_z : diffusion coeficients in x, y, z direction

F(C, t) : adding or losing source.

C: concentration of material

For suspended sediment transport model, it is assumed that the concentration of suspended sediment decreases when sedimentation process occurs. On the other hand, erosion process (re-suspension) occurs as the concentration of suspended sediment in the water column increases. Sedimentation process depends on ambient shear stress (Tau) and critical shear stress for sedimentation (Tau_{cr}^{sed}). If Tau is lower than Tau_{cr}^{sed}, the sedimentation process will happen.

The sedimentation flux = P_{sed} x V_{sed} x (IM1) (g/m^2/day)

In which: P_{sed} can be defined by equation:

$$P_{sed} = \max\left(0.1 - \frac{Tau}{Tau_{cr}^{sed}}\right) \quad (0.1) \quad (10)$$

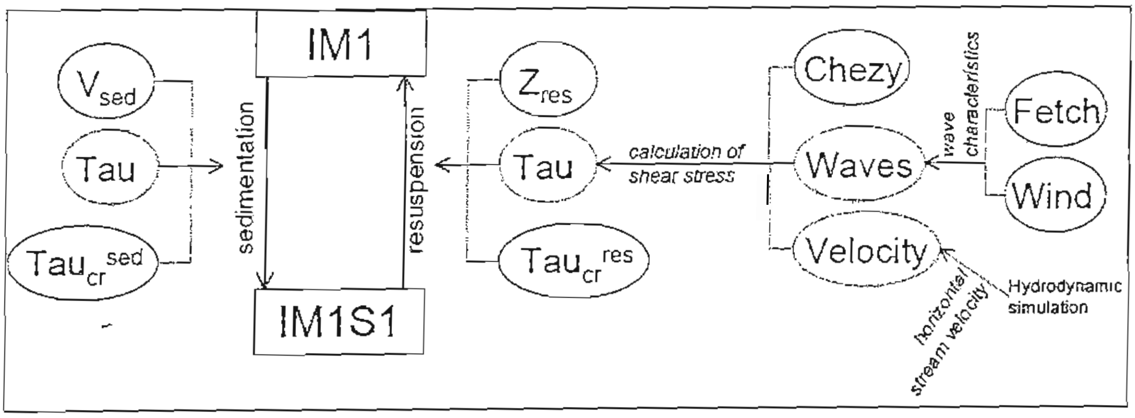


Figure 3. Basic processes in suspended sediment transport model (Delft, 1999)

On the other hand, erosion occurs when ambient shear stress is bigger than critical shear stress for re-suspension process (Tau_{cr}^{res}).

Resuspension flux = P_{res} x Z_{res} (g.m^2/day) (11)

Where: P_{res} is defined by equation:

$$P_{res} = \max\left(0, \frac{Tau_{cr}^{res}}{Tau} - 1\right) \quad (12)$$

With : IM1 is concentration of suspended sediment; P_{sed}- probability of sedimentation; V_{sed}- settling velocity; Tau- ambient shear stress; Tau_{cr}^{sed}- critical shear stress for sedimentation; Tau_{cr}^{res}- critical shear stress for re-suspension; P_{res}-probability of re-suspension process; Z_{res}- rate of resuspension from bottom.

Ambient shear stress depends on dynamic process:

Tau = f (wave, wind, current, sea water level, bottom roughness)

Sediment transport calculation

Delft3D model allows calculating settled and suspended sediments together. By default, the formulas of Van Rijn, which has been used widely, are applied to calculate the transport of suspended and bed load sediment.

As impact of wave is considered, the transport of bed-load "sand" can be calculated using the following equation:

$$|S_b| = 0.006\eta\rho_s w_s d_{50} M^{0.5} M_e^{0.7} \qquad (13)$$

In which:

S_b : bed load transport [kg/m/s]

η : Sediment content in the mixing layer

ρ_s: specific density of sediment [kg/m3]

w_s: settling velocity [m/s]

d_{50} : average particle diameter [m]

M: number of sediment mobility due to waves and currents

M_e: number of excess sediment mobility

And:

$$M = \frac{v_{eff}^2}{(s-1)gd_{50}} \qquad (14)$$

$$M_e = \frac{(v_{eff} - v_{cr})^2}{(s-1)gd_{50}} \qquad (15)$$

$$v_{eff} = \sqrt{v_R^2 + U_{on}^2} \qquad (16)$$

s: relative density of sediment

g: gravity acceleration [m^2/s]

v_{cr}: depth-dependent average velocity for initial motion [m/s]

v_R: integrated velocity obtained from near-bed flow velocities, assuming a logarithmic velocity profile [m/s]

U_{on}: near-bed peak orbital velocity [m/s] in onshore direction (in the direction on wave propagation) based on the significant wave height

The direction of the bed-load transport vector is determined by assuming that it is composed of two parts: current-induced transport ($S_{b,c}$) which acts in the direction of the near bed current, and wave-induced transport ($S_{b,w}$) which acts in the direction of wave propagation. These components are determined as follows:

$$S_{b,c} = \frac{S_b}{\sqrt{1 + r^2 + 2|r|\cos\varphi}} \tag{17}$$

$$|S_{b,w}| = r|S_{b,c}| \tag{18}$$

$$r = \frac{(|U_{on}| - v_{cr})^3}{(|v_R| - v_{cr})^3} \tag{19}$$

with:

φ: angle between current and wave direction (for which Van Rijn suggests a constant value of 90°)

and:

$$S_{b,c} = 0 \text{ if r} < 0.01 \tag{20}$$

$$S_{b,w} = 0 \text{ if r} > 100 \tag{21}$$

Then, the computed sediment transport vectors are relocated from water level points to velocity-calculated points using an "upwind" computational scheme to ensure numerical stability. The transport components are adjusted according to the effect of bed-slope.

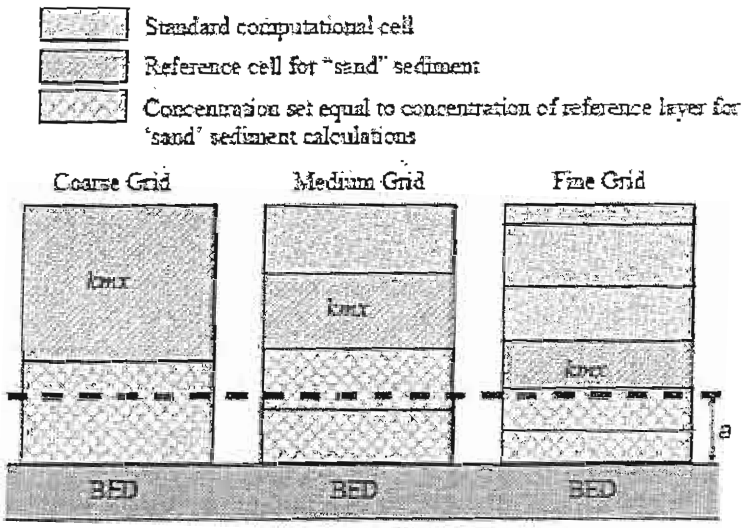


Figure 4. Defined kmx layer

The transfer of sediment between the bed and the flow is modeled using sink and source components at the near-bottom layer with thickness suggested by Van Rijn (*a*). This layer is identified as the reference layer (*kmx* layer in short). The sediment content in layer(s) below the *kmx* layer are assumed to be adjusted equal to that of the reference layer.

At each half time-step, the source and sink components of sediment enter the flow due to upward diffusion from the reference level and the content of sediment dropping out of the flow due to sediment settling. At last, the suspended sediment transport is calculated by the application of turbulence closure modules such as the k – L and the k – ε and by the calculation of the vertical sediment mixing coefficient due to currents and waves.

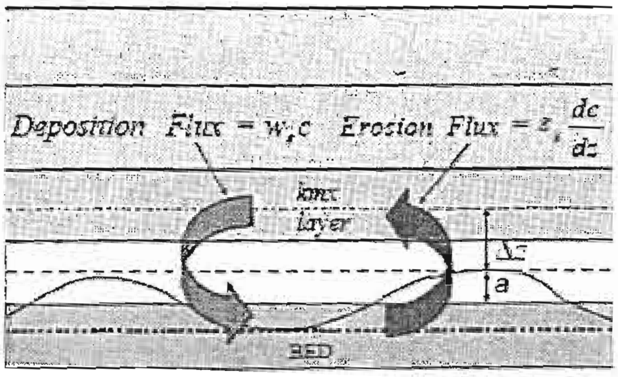


Figure 5. Transformation of sediment between bottom layer and above layers

4. Overall natural conditions of study area

4.1. Site location and terrain

The study area is located in Vinh Hao and Vinh Tan communes, Tuy Phong district – northeastern of Binh Thuan province. This area is limited between $11^0 12'$-$11^0 21'$N latitude and $108^0 44'$-$108^0 56'$E longitude, belonging to central of Vietnam. It is about 92km far from Phan Thiet and 270km far from Ho Chi Minh city.

Terrain of the study area has these typical characteristics of Central coastal region with high bathymetric slope. The bathymetry varies in the range of 2-20m in the near coast and in the range of 30-50m in the further area.

4.2. Meteorology and climate conditions

The climate condition in the study area possesses characteristics of tropical monsoon climate: hot and sunny day, high temperature, and large solar radiation. However, regional humidity is low and its evaporation is high. The rainy season usually comes late and ends soon (rainy season is short).

The average annual air temperature varies from 26.5 to 27.0^{0}C. The maximum air temperature may reach to 40^{0}C and the minimum air temperature stays about 15^{0}C.

Coastal zone of Binh Thuan province has the lowest average rainfall in Vietnam (about 700mm/year).

Binh Thuan coastal area as well as Vinh Tan is governed by two kinds of monsoon system: Northeast monsoon from November to March and Southwest monsoon from May to September. In April, May, October and November, the wind is light, alternating with a long period of calm wind. The result obtained from analysis of observed data in Phan Thiet during 31 year (1978-2009) shows that in May, June, September and October, wind velocity is often small (averagely about 2.4-2.8 m/s) and prevalent wind direction is West/SouthWest. Meanwhile, from November to April, the wind velocity is relatively high (averagely about 2.9-4.0 m/s) with prevalent direction in East – Northeast (Table 1).

Table 1. Frequency of wind and average velocity at Phan Thiet station (1978-2009)

Month	Average velocity	N	NE	E	SE	S	SW	W	NW	Calm
1	3,8	10,5	17,0	43,9	7,5	1,3	0,5	0,7	3,9	14,9
2	4,0	8,0	17,3	46,5	8,5	2,0	0,4	0,6	2,8	13,9
3	3,8	8,8	-16,5	42,7	10,9	5,5	0,6	0,9	2,2	11,9
4	3,3	10,1	11,5	27,7	13,2	12,9	2,4	2,9	2,7	16,7
5	2,8	9,6	5,0	10,5	8,3	13,2	8,8	19,7	8,5	16,5
6	2,8	4,3	1,5	2,9	3,0	8,0	15,5	46,3	8,3	10,1
7	3,1	2,8	1,1	1,0	2,3	8,7	18,5	47,8	7,5	10,3
8	3,1	3,4	0,6	0,8	3,5	6,5	17,8	52,2	7,7	7,5
9	2,7	6,0	1,9	3,4	5,7	8,1	13,2	35,1	11,0	15,4
10	2,4	14,5	6,5	15,1	9,2	6,3	3,2	12,0	10,9	22,4
11	2,9	15,0	14,0	28,1	8,0	2,8	1,0	4,9	7,5	18,7
12	3,1	12,7	15,8	36,7	6,5	2,0	0,6	1,7	5,8	18,4
Average	**3,1**	**8,8**	**9,0**	**21,6**	**7,2**	**6,4**	**6,9**	**18,7**	**6,6**	**14,7**

The averaged wind velocity in years in this study area is 3.1m/s. The prevalent wind directions are E, W, NE, SE and SW. Frequency of the calm wind is about 14.7% (Table 1).

Following statistical data from 1911 to 2011 (100 years), the study area was attacked by 23 typhoons. Typhoon often occurs in the period of October to December. In other months, few or no typhoon occurs (Table 2)..

Table 2. Frequency of typhoon occuring in the coastal zone of Binh Thuan

month	1	2	3	4	5	6	7	8	9	10	11	12	Total
number	0	0	1	1	1	0	0	0	1	7	8	4	23
%	0	0	4.3	4.3	4.3	0	0	0	4.3	30.5	34.9	17.4	100

4.3. Hydrodynamics condition

The average water temperature of Binh Thuan coastal zone varies in the range of 25- 30^{0}C. From June to August, the temperature pattern is relatively high. On the contrary, from December to February, the water temperature is lower (Table 3).

Table 3. Water temperature at surface layer in the Binh Thuan coastal zone

Temperature	Month												Year
	1	2	3	4	5	6	7	8	9	10	11	12	
Maximum	27.2	27.5	28.8	19.1	28.5	31.7	31.1	29.2	29.7	28.2	28.8	27.3	31.7
Minimum	24.6	26.0	27.5	24.9	26.4	28.2	28.0	27.9	26.3	27.1	28.1	24.3	24.3
Average	26.2	26.6	28.0	27.8	27.5	29.4	29.8	28.4	27.9	27.1	28.4	25.6	27.7

Tidal pattern in the coastal zone of Binh Thuan is quite complicated because of its transitional position between diurnal tide (Central of Vietnam) to semidiurnal tide (Southern of Vienam). Every month, there are 5-10 days of diurnal tide (in flood tide period) and 5-10 days of semidiurnal tide (ebb tide period), the remaining days have mixture tidal. Tidal amplitude gradually increases from 1.5-2.0m in Phan Rang area to 2-2.5m in Phan Thiet coastal area. Tidal amplitude in low flow period stays approximately 0.5- 0.7m. Toward the South, the amplitude of tide gradually increases while the number of diurnal tide day decreases.

Wave in this study area depends on wind field and seasonally changes. In months of winter, prevalent wave direction comes from Northeast with common height of 0.7-

1.2m. On the other hand, in months of rainy season, prevalent wave direction comes from southwest with common height of 0.6-1.1 m

4.4. Erosion and deposition

Owing to the fact that the coastline of this area is oriented northeast – southwest, sediment transport and erosion are influenced by hydrodynamic conditions that change seasonally (northeast and southwest monsoon).

In the study area, the coastline is fairly stable, except for Phuoc The and Lien Huong segment (west of Cu Lao Cau island). The material covered this area is medium sand, the bank and the edge is steeply sloping with a height of 3-5m and no vegetation covers. Phuoc The – Lien Huong are coastal zones with ongoing erosion rate of about 5-13 m/year (Bui Hong Long et al., 2001). According to results of recent research, the erosion of Phuoc The and Lien Huong was caused by some following reasons:

Endogenous reasons: the continental shelves to the western and northern are lifting while that of the eastern is sinking. The offshore exist a big sinking zone (about 100m depth). Perhaps, that is a sediment trap zone which increases erosion process in the coastal zone.

Exogenous reasons:

- It is the coastal zone with big slope. Therefore, sediment transported to the offshore is hardly compensated.
- Wave height impacts directly the coastline in both northeast and southwest monsoon.
- The material at the coastline and bottom are light, crumbly so that can be easily transported to other places.
- Other activities in this area include dam, aquaculture, agriculture and so on which do not impact the balance of sediments transport in this area.

Among above reasons, lack of materials due to sediments transportation to the offshore is main factor causing erosion at Phuoc The, Lien Huong coastal areas ((Bui Hong Long et al., 2001).

5. Model setup

5.1. Grid and bathymetry

The grid and bathymetric grid of the model are built base on bathymetry database digitized map in Binh Thuan coastal area. Model frame is extended to the outside of Vinh Tan area in order to reduce influences of open marginal conditions (if any).

Model frame is about 174 km long in northeast – southwest direction (parallel with the coastline) and 92 km long in northwest – southeast direction (perpendicular with the coastline). The total area of sea surface is about 11.7 km^2.

Horizontally, the grid was used in orthogonal curvilinear co-ordinates with model frame split to 668 x 366 grid points with grid size varies between 68.7 and 670m (Figure 6). The σ coordinate was used for vertical grid. In hydrodynamics model, the total depth was divided into 4 layers (each layer account for 25% of the total depth of the water column).

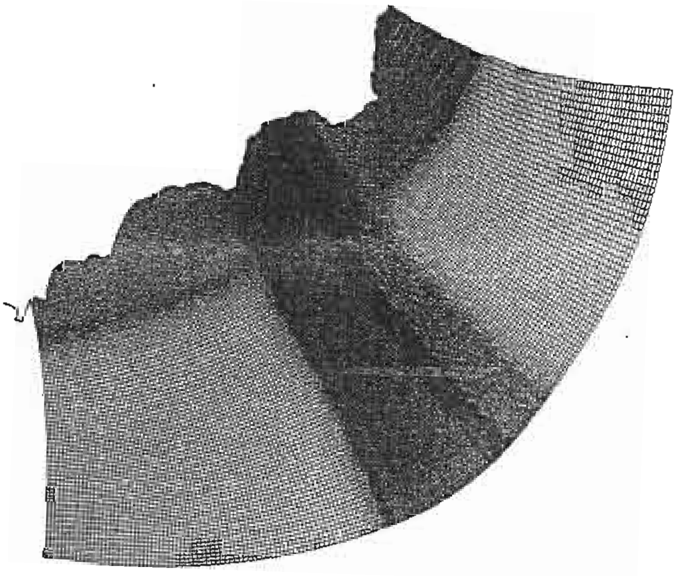


Figure 6. Model frame and grid of the study area

Bathymetric grid for Binh Thuan coastal area is a bathymetric file, which was processed in the Delft3d- QUICKIN associating with model grid. Bathymetric grid of the model is shown in Figure 7.

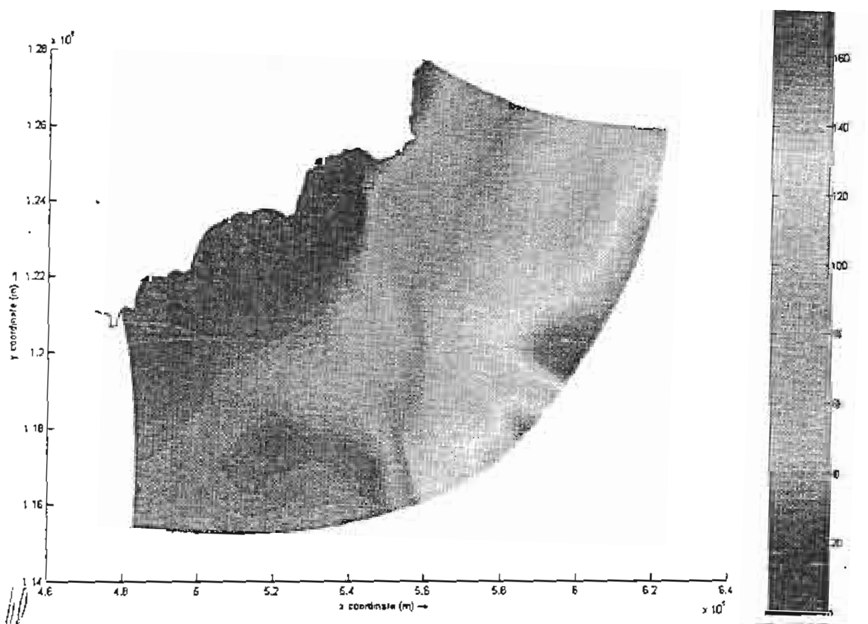


Figure 7. Bathymetric grid of the model

Bathymetric grid and model grid of the wave model are used same as the grids of hydrodynamics model.

5.2. Main processes of the model

In order to assess and predict influences of dredging activities on hydrodynamic conditions, wave and sediment transport at Vinh Tan coastal area and adjacent areas, main processes supporting the calculation of the model were defined. Influences include flow regime, wave and impacts from turbidity area due to dredging, characteristic of sediment transport after the work. Main processes include:

- Hydrodynamics
- Sediment (suspended and settled sediments)
- Wind
- Wave (online coupling with hydrodynamics and sediment transport)
- Dredging activities

5.3. Boundary and initial conditions

Location and boundary conditions

Hydrodynamics, wave - sediment transport models for the studied area have open boundaries at northeastern, southwestern and southeastern sites. These open boundaries are shown in Figure 7.

Initial and boundary conditions

At first-time running, the initial conditions of the model are set as zero (0) for sea level, salinity, and suspended sediment concentration. Initial conditions for next running are results from previous running (restart file).

For open boundaries to the sea: tidal harmonic constants of 4 main constituents O1, K1, M2, S2 are used. Open boundaries for other models are from the database harmonic tidal constants Fes2004. Harmonic tidal constants in near coastal line are based on observational data of sea level at Phan Rang and Phan Thiet ports.

5.4. Model calibration and validation

Model calibration and validation are essential and important in applying the models at the specific area. Results of the model were compared with observational data in order to assess differences between calculation and observation. Accordingly, the model calibration aims to optimize the calculation process and reduce of the variation to a possible level (Donigian A. S., 1999).

For those software have been tested in practical conditions and being used widely, the difference between the modeling and actual observation may occur due to one (or some) of these causes (Mulla D. J and Addiscott T. M., 2000):

- Lack of parameter correction, especially local parameters such as Coriolis force, bottom roughness coefficient, etc.
- Lack or inaccuracy of input data (initial conditions, boundary conditions, bathymetric data)...
- Inaccuracy in parameter selection

Root Mean Square Errors (RMSE) is important indicators to assess the accuracy of the model.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(P_i - O_i)^2}{N}}$$

Where:

i = 1, n is the number of observation

P_i is the predicted value of simulation at time i

O_i is the observed value of observation at time i

Hydrodynamics model

- The bottom roughness coefficients in this study employ spatial Chezy (C) coefficients in the range of 0-1000$m^{-1/2}s$. At the studied area, C=60 was chosen for further calculation.

- The parameters relating to turbulence can be defined and used by users as constants, spatial variables, or calculated values following Horizontal Large Eddy Simulation (HLES). The HLES model has been included in the Delf3D according to the theoretical Uittenbogaard (1998) and discussed in the study of Van Vossen (2000). In this study, the horizontal eddy viscosity and horizontal diffusion were selected with the value of 10 m^2/s. These coefficients in the vertical are 1.0 x 10^{-6} m^2/s. The 2D turbulence model is HLES in the Delft3D and k-ϵ turbulence model was used for 3D turbulence model.

Suspended sediment model

- The settling velocity of suspended sediment was used with value of 0.1mm/s. This value is used in case of fresh water ($w_{s,f}$). In calculation, the settling velocity of suspended sediment (w_s) will take into account effect of salinity.

- The critical shear stress of sediment erosion ($\tau_{c,e}$) is changing in 0.1-1.0 N/m^2 (Van Rijn, 1993). In this study, the value of 0.25 N/m^2 was selected as erosion critical shear stress after calibrations.

- The critical shear stress of sediment deposition ($\tau_{c,d}$) is changing in 0.005-0.25 N/m^2 (Van Rijn, 1993). In this study, the value of 0.2 N/m^2 was selected as deposition critical shear stress after calibrations.

- Erosion rate in the nature was determined changing in 10^{-5}-10^{-3} kg/m^{2}s. With the density of bottom sediment assumed as 2650 kg/m^3, density of suspended sediment in near bed is about 500kg/m^3, the initial rate of natural erosion was assumed as 10^{-3} kg/m^2.s.

Wave model

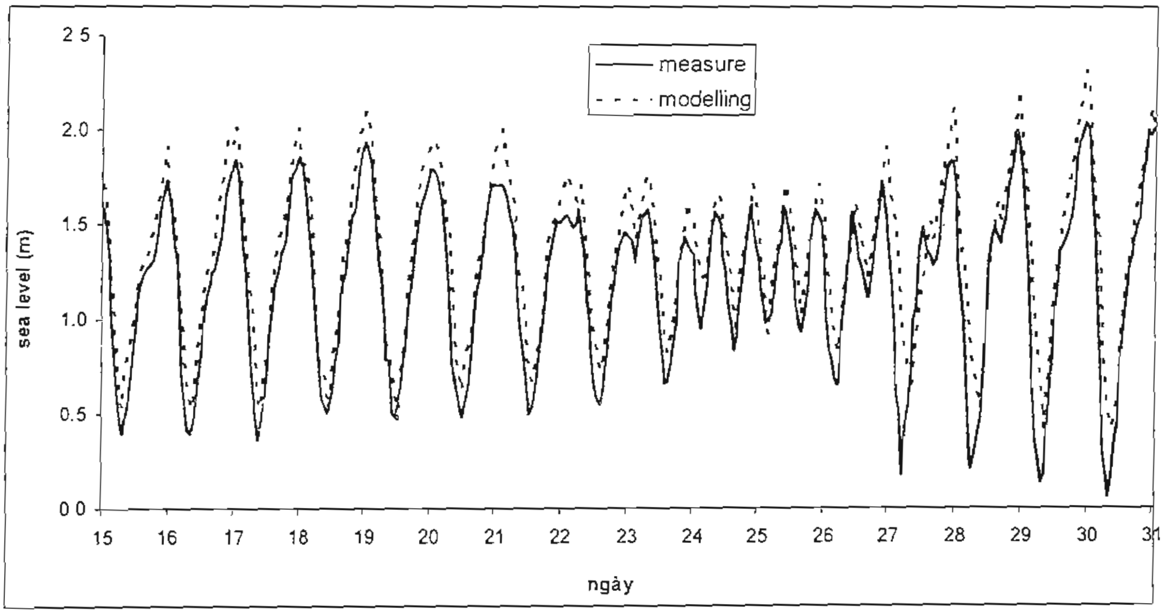
The wave model in this study was setup online coupling with the hydrodynamics and sediment transport models. At each time step, wave model uses the grid, wind filed as well as results of depth, current, water elevation from hydrodynamics model.

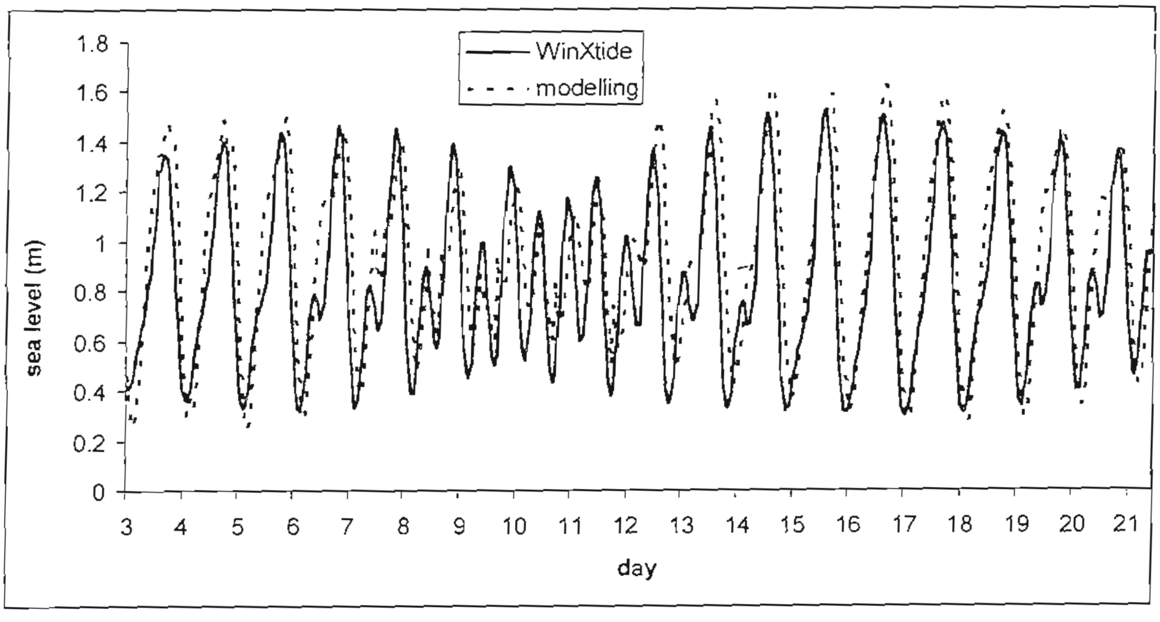
- The open boundary condition of the wave model for the study area was from wave prediction of the wave climate (WaveClimate.com service) in 2009.

- The Alfa coefficients in the wave model changing in 0.1-10, in this study it was used with the values of 1.0. The Gamma coefficient in the wave model changes in the range of 0.55-1.2 and in this study, it was used with the values of 0.73. The Bottom friction of wave model in this study is JONSWAP with value of 0.067. The B&J model (Battjes, J. and J. Janssen, 1978) was used to model the energy dissipation in random waves due to depth induced breaking (Delft Hydraulics, 2003). Other parameters are summarized as in Table 4.

In order to validate the hydrodynamics model at the coastal zone of Binh Thuan and Cu Lao Cau, we compared the calculated sea level with measured value at Vĩnh Tân (14/10-12/12/2007) and data at Mui Dinh (Ca Na Headland, Ninh Thuan

Province) calculated by WinXtide32 in rainy and dry seasons of 2012. After final calibration processing, the comparison reveals a relative agreement in both amplitude and phase between calculated and measured values (Figure 8). Therefore, the results of hydrodynamics model are proposed suitable to setup sediment transport model.





Hình 8. Comparison of resulted water level from the model and measured value at Vinh Tan (a) and calculated by WinXtide32 at Mui Dinh (b)

Main parameters of the models

Main parameters for hydrodynamics, wave and sediment transport modeling are setup based on calibration process and summarized in the following table:

Table 4. Main parameters of the models

Module	Parameters	Values
flow	Number ofameter grid cell	M=668, N=366
	Δx, Δy	68.7-670.0m
	Step time	60 seconds
	Threshold of dry and wet	0.1 m
	Number layer	4(25%/ layer)
	Horizontal eddy viscosity	$1.0 m^2/s$
	Horizontal eddy diffusity	$1.0 \times 10^{-6} m2/s$
	Horizontal diffusion	$1.0 m^2/s$
	Veritical diffusion	$1.0 \times 10^{-6} m2/s$
	Chezy coefision	60
	Turbulence closure model	*k*-e turbulence closure
	Advection scheme	Cyclic method
	Sigma-coordinate correction	On
	Forrester filer vertical	On
	Forrester filter horizontal	Off
wave	Maximum number of iteration	8
	Spectrum	JONSWAP
	Setup	False
	Hydrodynamics (water level, bathymetry, current, wind)	Use and don't extend
	Forcing	Wave energy dissipation
	Friction	Madsen et al. (1978)
	Breaking	Bettjes & Janssen (1978)
	Alfa	1.0
	Gamma2	0.73
	Wind	Komen et al. (1984)
	Quad	Hansselman et al. (1985)
Sediment transport	N	10
	f_{MOR}	10
	EQMBC	True
	Densin	False
	ALFABS	1
	ALFABN	1.5
	f_{SUS}	1
	f_{BEB}	1
	f_{SUSW}	1
	SEDTHR	0.5
	THETSD	0
	RHOSOL	2650
	D_{50} *sand*	150
Dredging	DepthDef (m)	1
	DredgeDepth (m)	7
	MaxVolRate (m^3/ngày)	42960
	MaxVolRate (m^3/năm)	4.200.000

	Dredging time (time/day)	3
	Main component of sediment	mud-9%, sand-84%, rock-7%
	Maximum ratio (%) falling out of dredger	cutter suction dredger: 15 bucket ladder dredger: 10

5.5. Modeling time frame and simulation scenarios

In order to assess influences of dredging activities on hydrodynamics, wave condition and sediment transport as well as erosion condition in coastal zone of Vinh Tan and it surrounding, scenarios simulation have been setup. These scenarios focus on three groups: before dredging activities, dredging activities and after dredging activities (finish dredging and construction). Simulation and prediction scenarios are established. These scenarios include before dreding (no impact), during dredging and after dredging activities and the construction.

Table 2. Scenarios for hydrodynamics and sediment transport simulation

No	Scenario	Wind direction		Annotate
1-2	Present	South-west	North-east	Before dredging activity
3-4	Dredging	South-west	North-east	During dredging process
5-6	After dredging	South-west	North-east	After dredging activities

Time simulation for each scenario: 60 days (30 first days is to stabilize the modelling conditions and to provide initial conditions of the next 30 days).

Time step: 60 seconds

These scenarios are representative for two main wind monsoons: Southwest and Northeast wind monsoons. In the study area, Southwest wind is prevalent in the periods of May to September while Northeast wind is prevalent in the periods of November to March. Other months in the year, wind has scattered direction along with wind-free period (Nguyen The Tuong, 1996; National Hydro - Meteorology Agency, 2000)

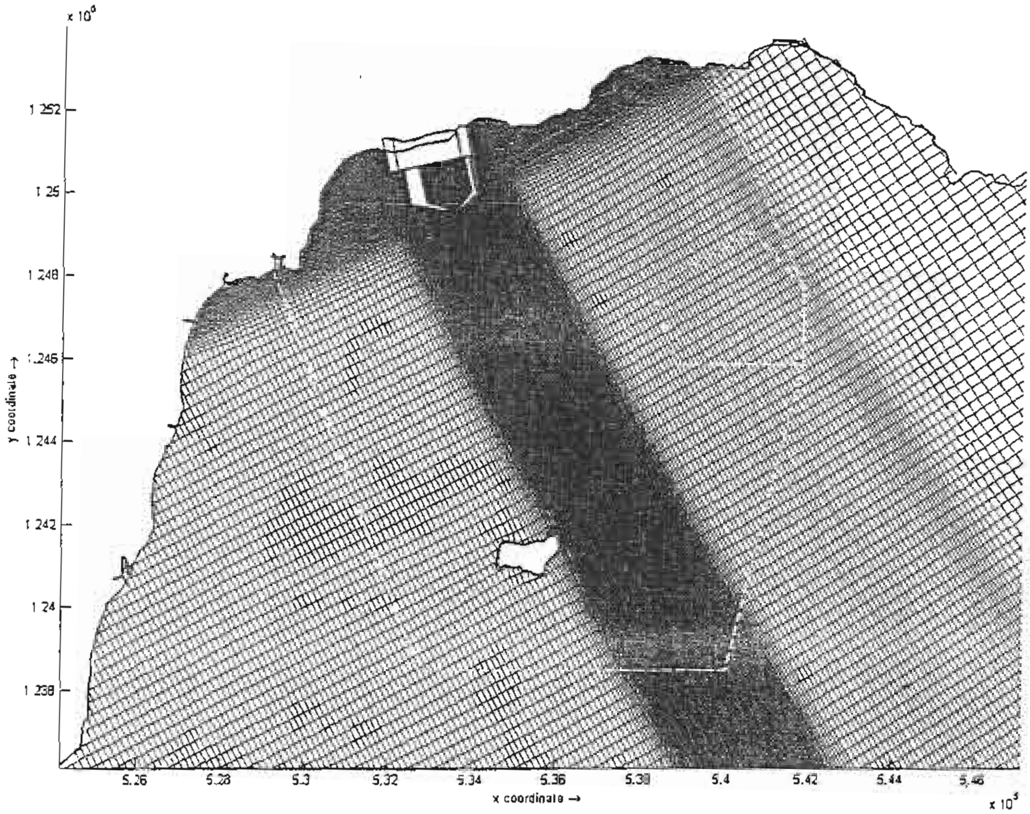


Figure 9. Grid of the model with the dredging area

In addition, monitoring points were added into the model frame to assess the impact of dredging activities the hydrodynamics conditions and sediment transport. The positions of these monitoring points are shown in figure 10.

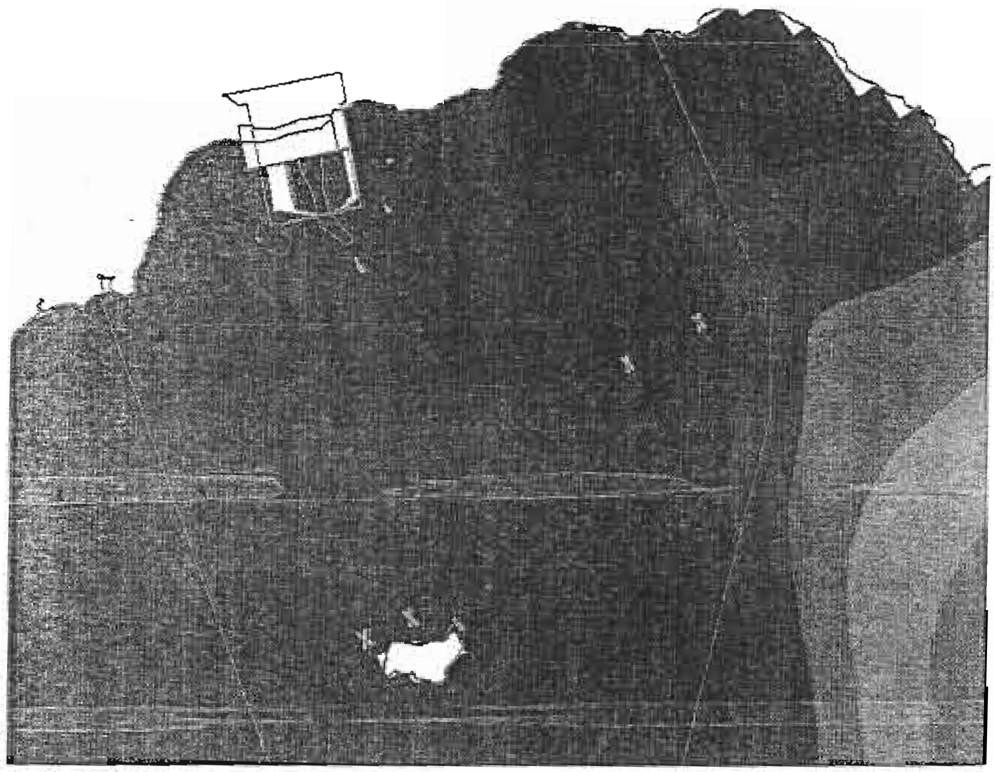


Figure 10. Position of monitoring points in the study area

Table 6. Positions of monitoring points

No.	Position (i, j)		Annotate
	M	N	
V1	447	145	Breda sandbar
V2	432	145	Breda sandbar
V3	183	137	West of Cu Lao Cau Island
V4	190	137	Northwest of Cu Lao Cau Island
V5	201	135	Northeast of Cu Lao Cau Island
V6	410	182	East of the dredging area
V7	384	164	East of the dredging area
V8	305	196	Southeast of the dredging area
V9	199	176	Southwest of the dredging area

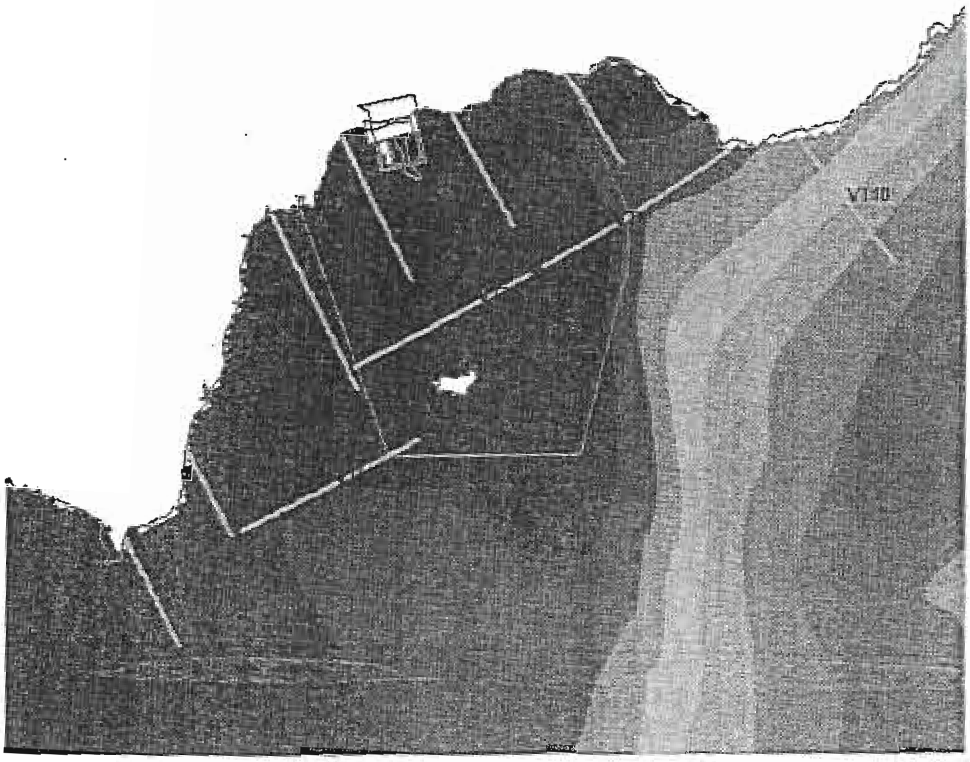


Figure 11. Cross-section of position for sediment transport calculation

To assess the influences of dredging activities on sediment transport in the study area at some cross-sections, during the calculation, cross-sections were added perpendicular and parallel with the coastline. These include:

- Cross-sections control sediment flux alongshore of Vinh Tan coastal zone: VT1, VT2, VT3, VT4
- Cross-sections control sediment flux alongshore at the South of Vinh Tan coastal zone: VT5, VT9
- Cross-section controls sediment flux alongshore at the North of Vinh Tan coastal zone: VT10
- Cross-sections control sediment flux perpendicular to the Vinh Tan coastline: VT6, VT7, VT8.

6. Results and discussions

6.1. Influences on hydrodynamic conditions

Present hydrodynamics conditions

Hydrodynamics of Binh Thuan coastal area in general and Vinh Tan coastal area in particular are impacted by a range of factors such as wind, sea level oscillation and wave action. Results of the model show that integrated currents in this study have not high velocity. Prevalent magnitude of current, which is between 0.1 - 0.3 m /s, alters with water level oscillation (Figure 12-13 and Figure 27-28). Current directions in this area are directional along the seacoast: directional east-northeast (flood tide stage) or directional south-southwest (ebb tide stage).

During the northeast wind season, integrated field velocity is intensified (increase) in the ebb tide stage and restricted (reduce) in the flood tide stage (North - Northeast) (Figure 27-28). On the other hand, in southwest wind season, field velocity with directional north - northeast in the flood tide is increased and decreased in the ebb tide stage (Figure 12-13).

Wave induced currents in the area have low velocity most of which is lower than 0.4 m/s. These currents are almost directional alongshore (similar to integrated current) and alter following tidal oscillation and wind season. During southwest monsoon season, the velocity of the wave induced current increases in flood tide stage and dramatically drops in ebb tide stage (Figure 18 – 19). Meanwhile, during northeast monsoon season, such velocity falls in flood tide stage and raises in ebb tide stage (Figure 33 – 34).

The wave field of Binh Thuan coastal area change largely following the wind velocity and tidal oscillation. Wave height usually reaches maximum value at high tide. During the southwest monsoon season, the wave direction is mostly south and southwest and wave height is in the range of 0.4 – 1.2 m (Figure 24). During the northeast monsoon season, on the other hand, the wave direction is west - southwest and wave height is about 0.3 – 1 m (Figure 39).

Influence of dredging activities on hydrodynamics

Results of modeling reveal that dredging activities mostly have no impact on spatial distribution of integrated currents and wave field in the study area (see Figure 12 to Figure 41).

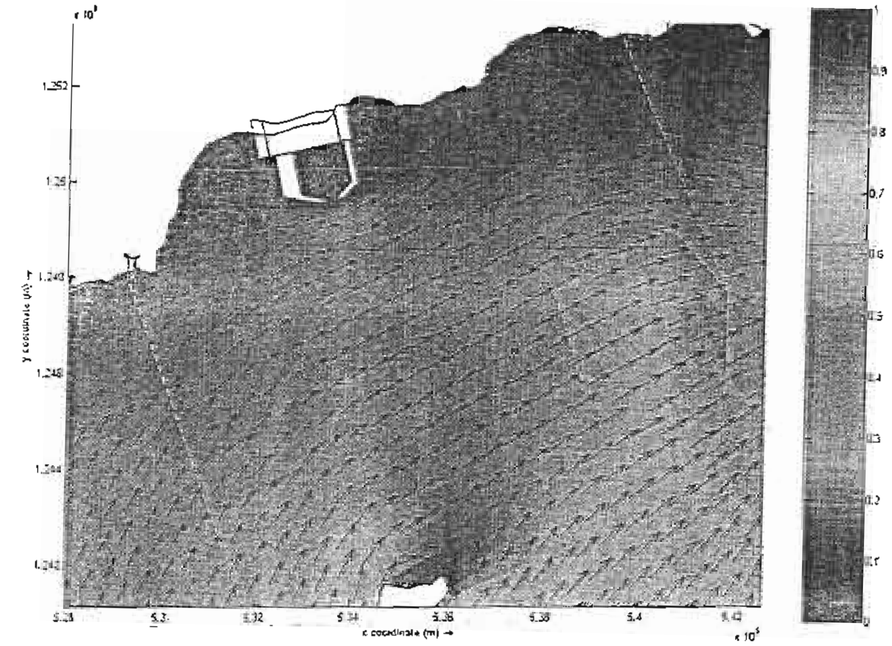


Figure 12. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (southwest wind, flood tide - before dredging)

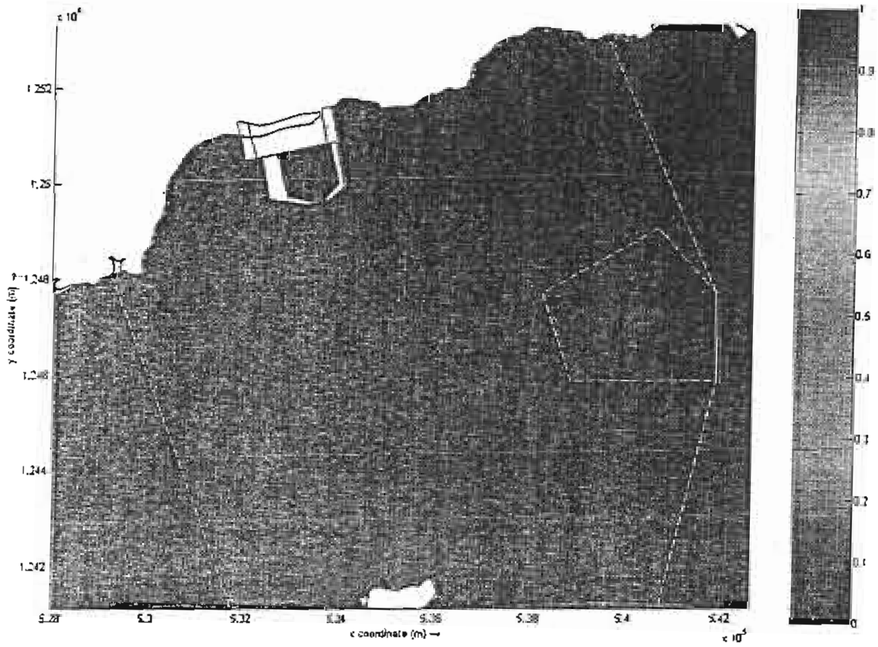


Figure 13. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (southwest wind, end of ebb tide stage - before dredging)

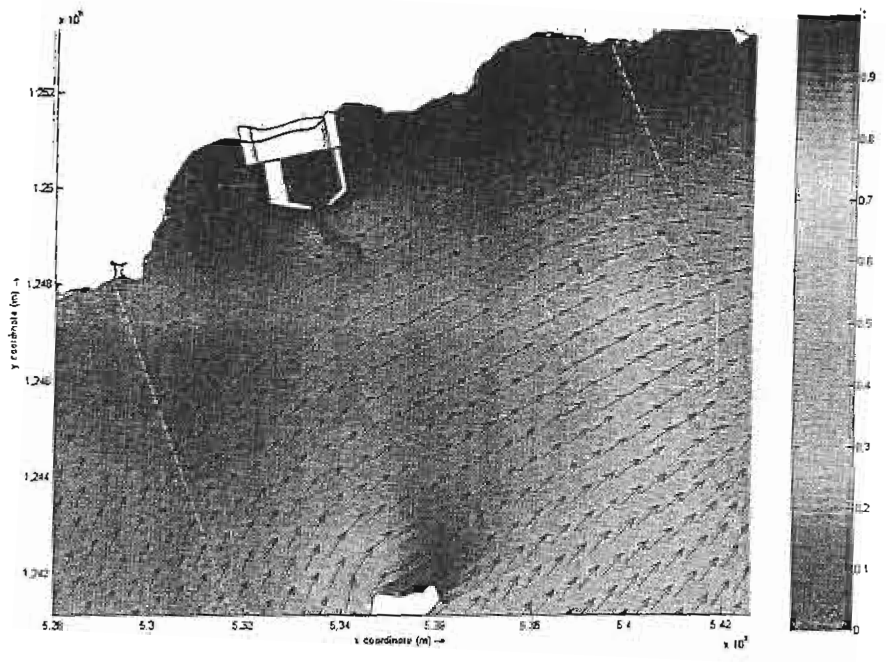


Figure 14. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (southwest wind, flood tide - during dredging)

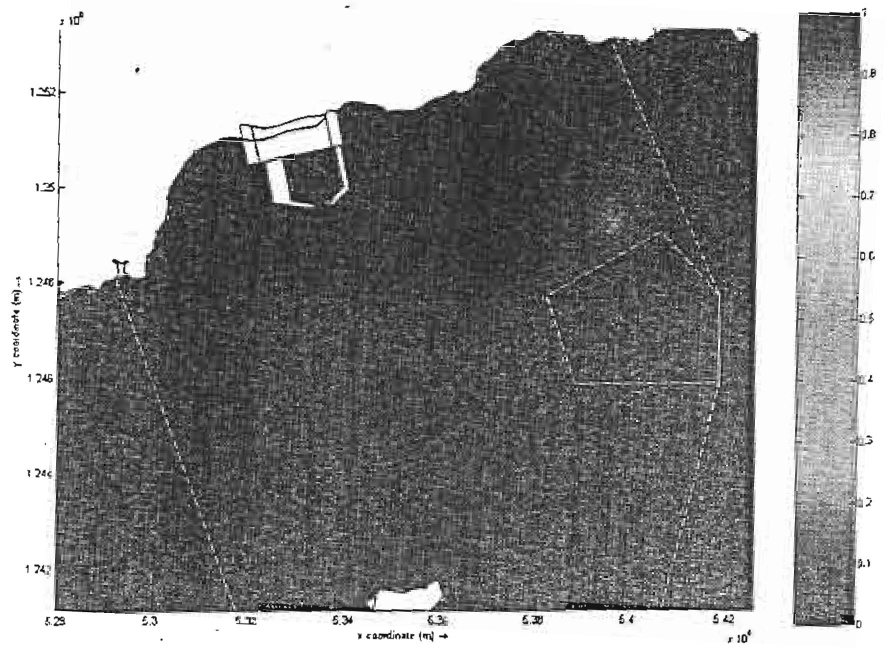


Figure 15. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (southwest wind, end of ebb tide stage - during dredging)

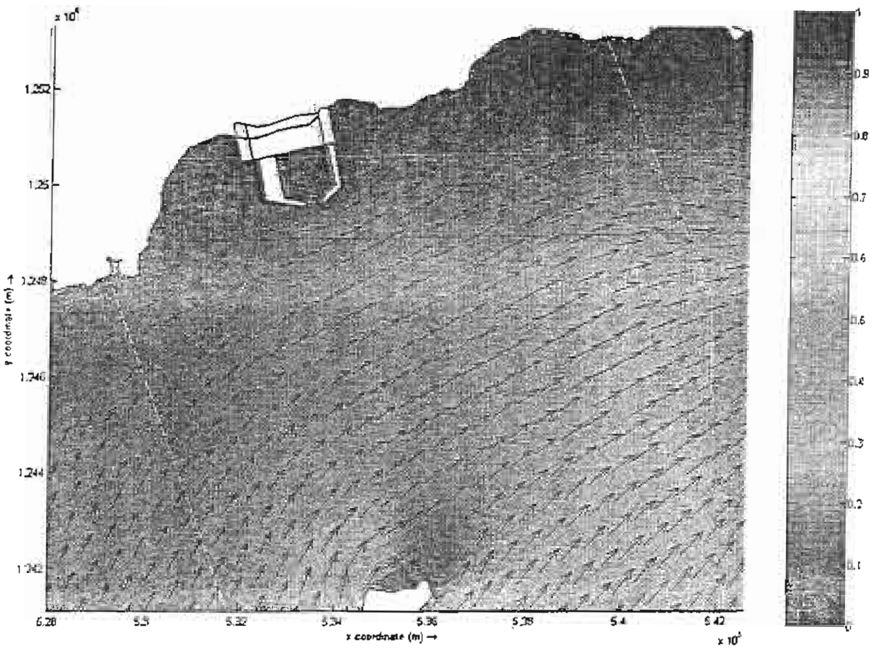


Figure 16. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (southwest wind, flood tide – after dredging)

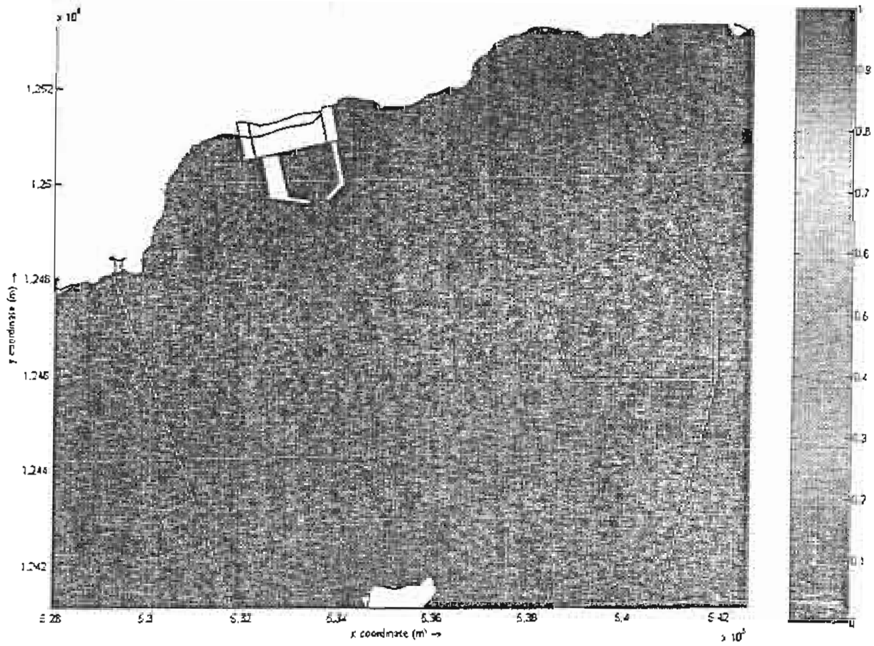


Figure 17. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (southwest wind, end of ebb tide stage – after dredging)

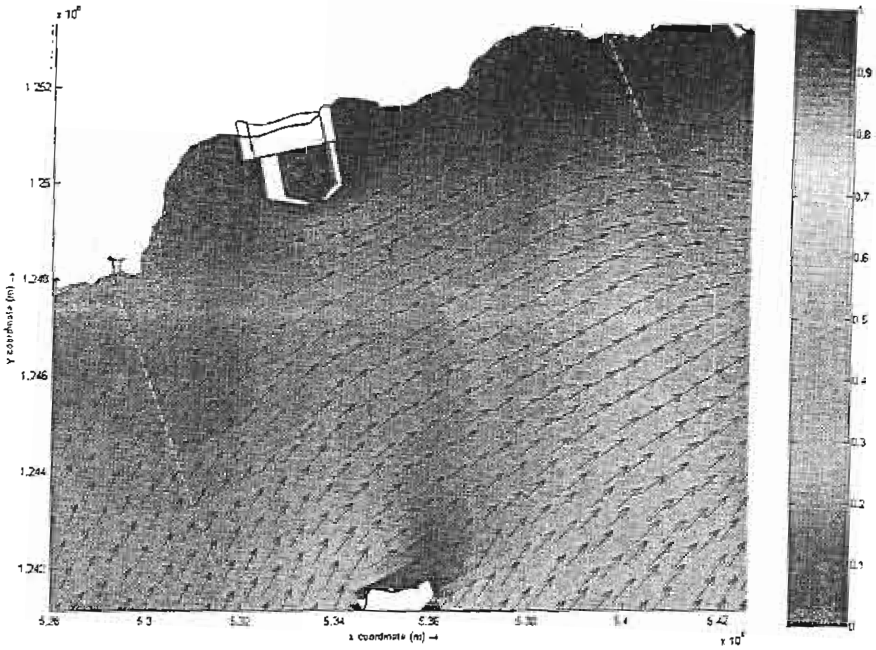


Figure 18. Wave – induced currents at Vinh Tan coastal area (southwest wind, flood tide- before dredging)

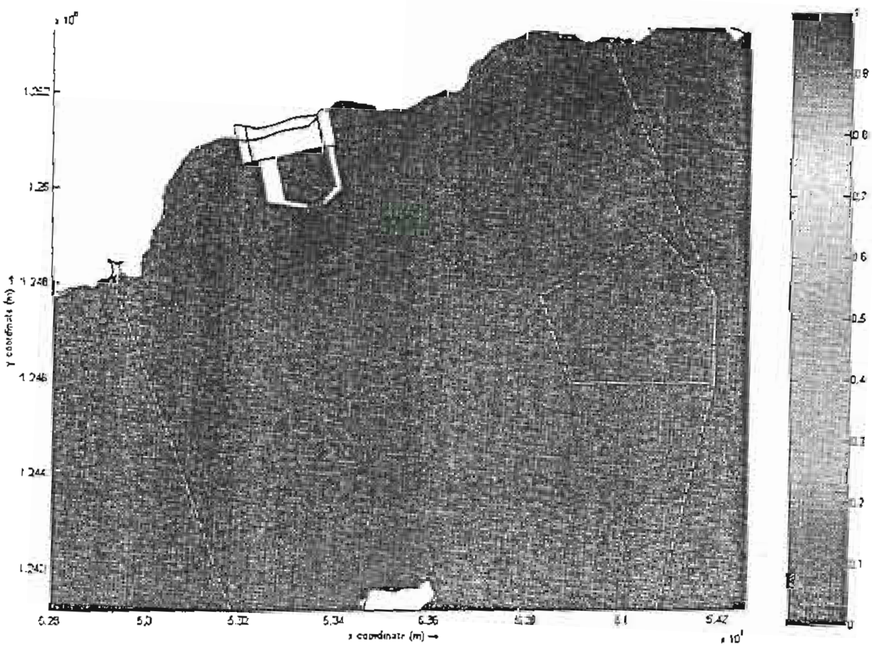


Figure 19. Wave – induced currents at Vinh Tan coastal area (southwest wind, ebb tide - before dredging)

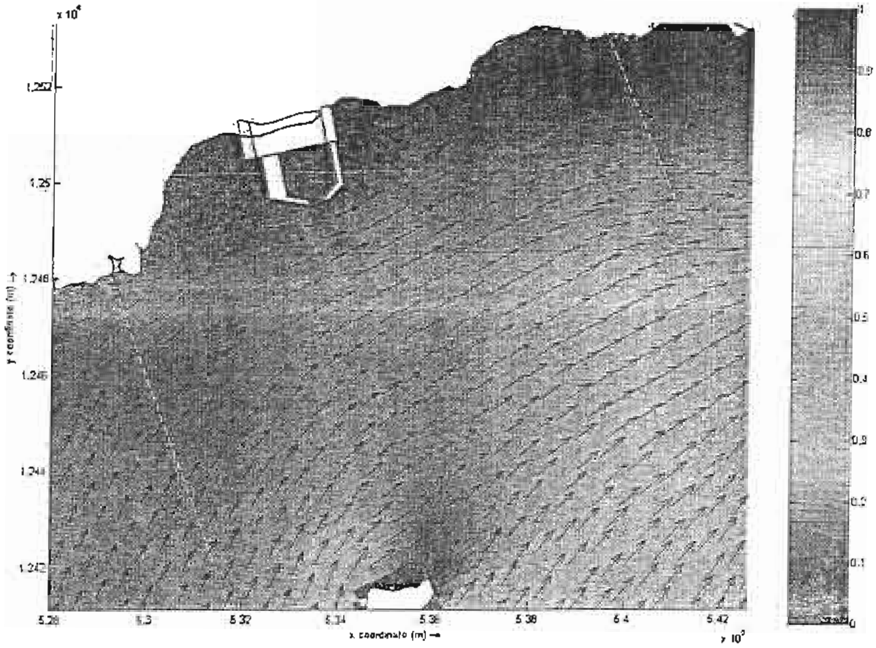


Figure 20. Wave – induced currents at Vinh Tan coastal area (southwest wind, flood tide – during dredging)

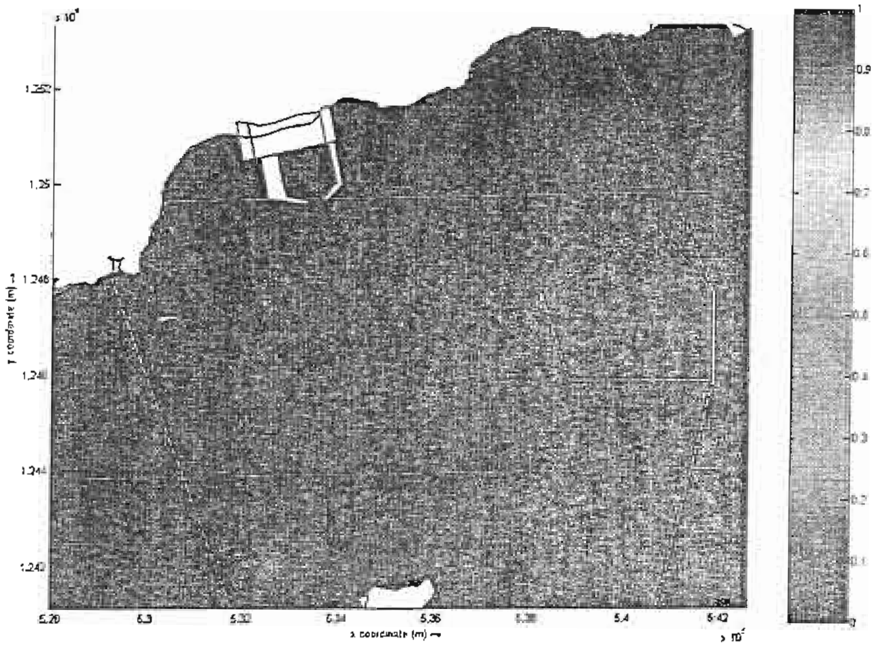


Figure 21. Wave – induced currents at Vinh Tan coastal area (southwest wind, ebb tide – during dredging)

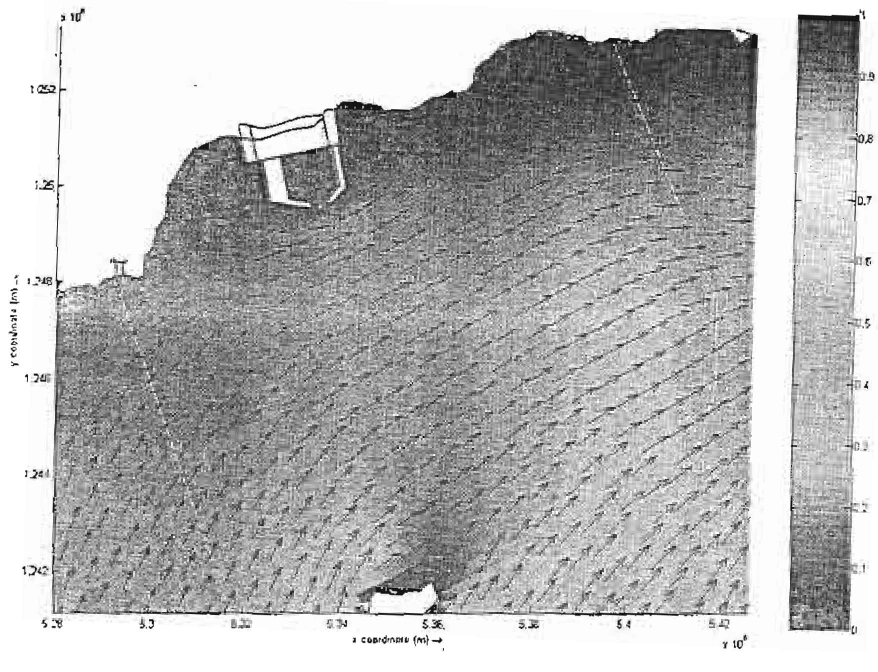


Figure 22. Wave – induced currents at Vinh Tan coastal area (southwest wind, flood tide – after dredging)

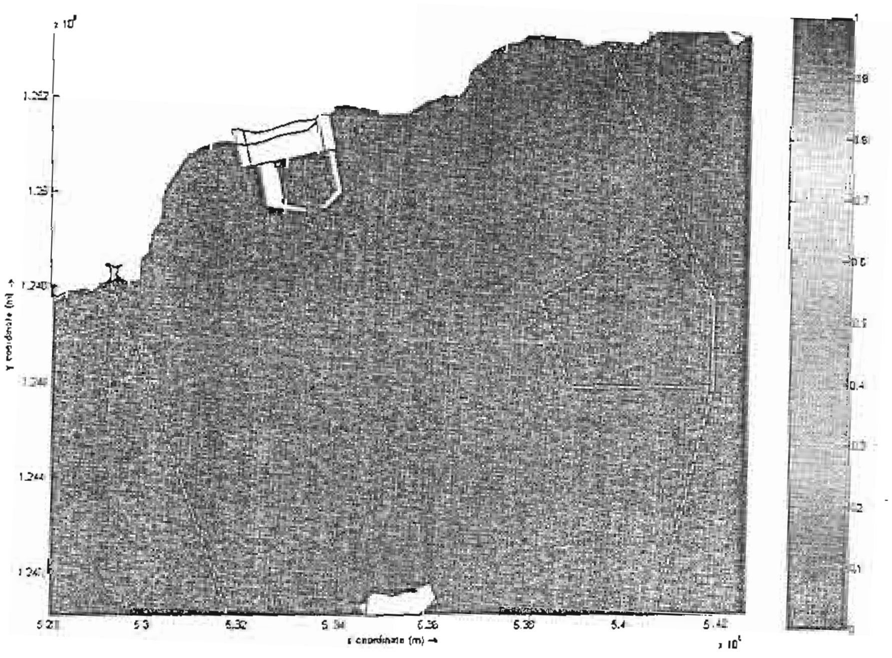


Figure 23. Wave – induced currents at Vinh Tan coastal area (southwest wind, ebb tide – after dredging)

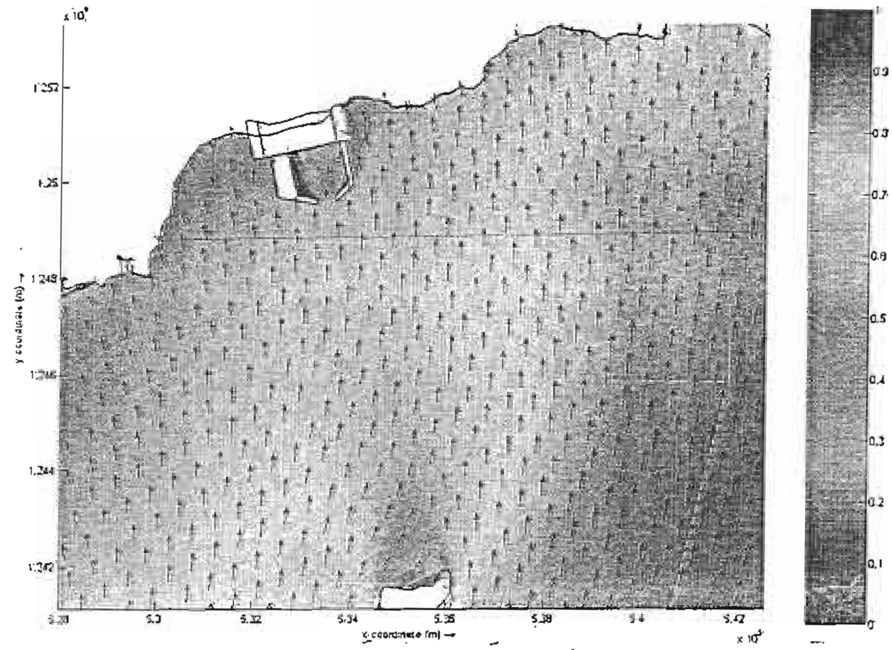


Figure 24. Wave height (m) at Vinh Tan coastal area (southwest wind, high tide - before dredging)

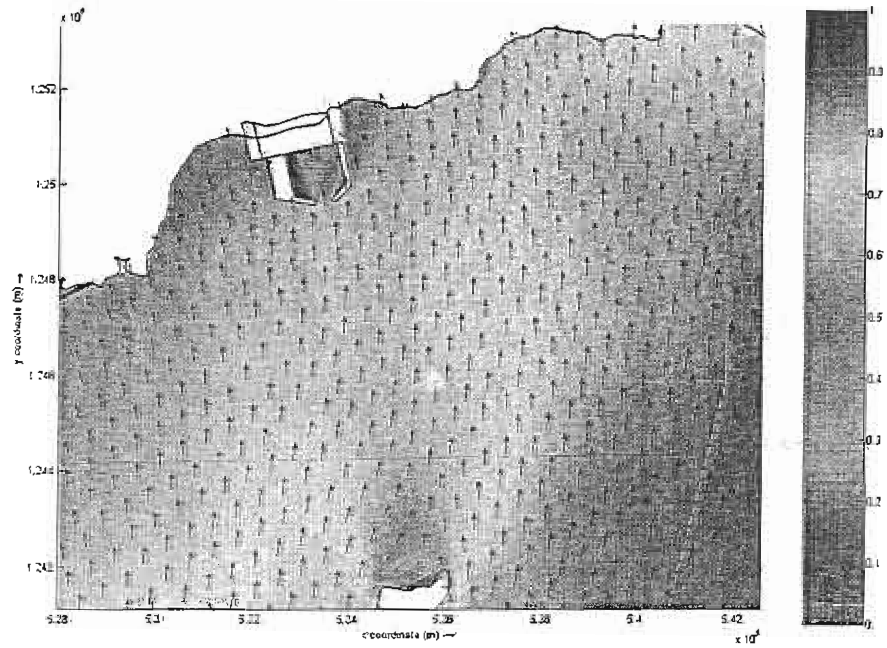


Figure 25. Wave height (m) at Vinh Tan coastal area (southwest wind, high tide - during dredging)

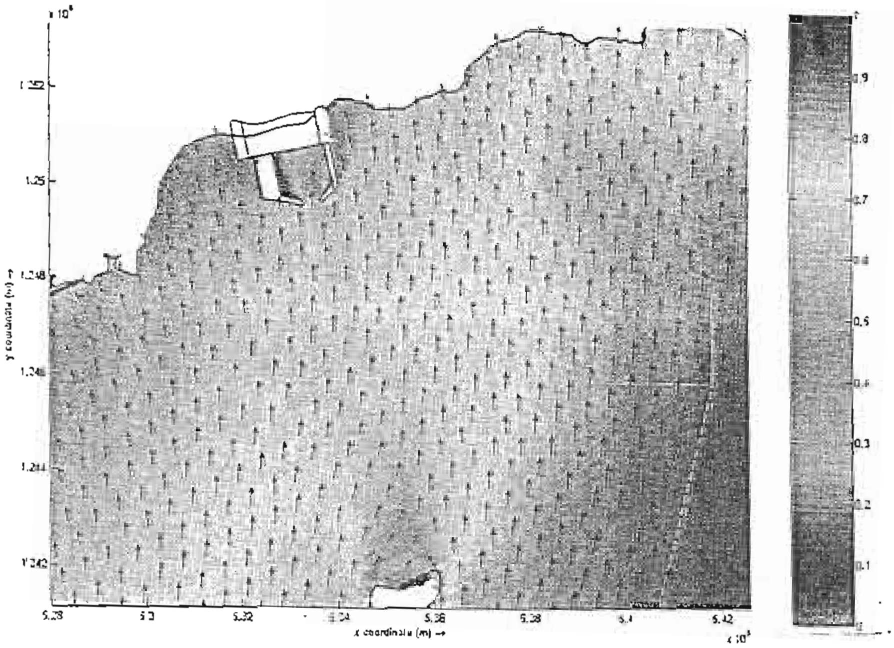


Figure 26. Wave height (m) at Vinh Tan coastal area (southwest wind, high tide - after dredging)

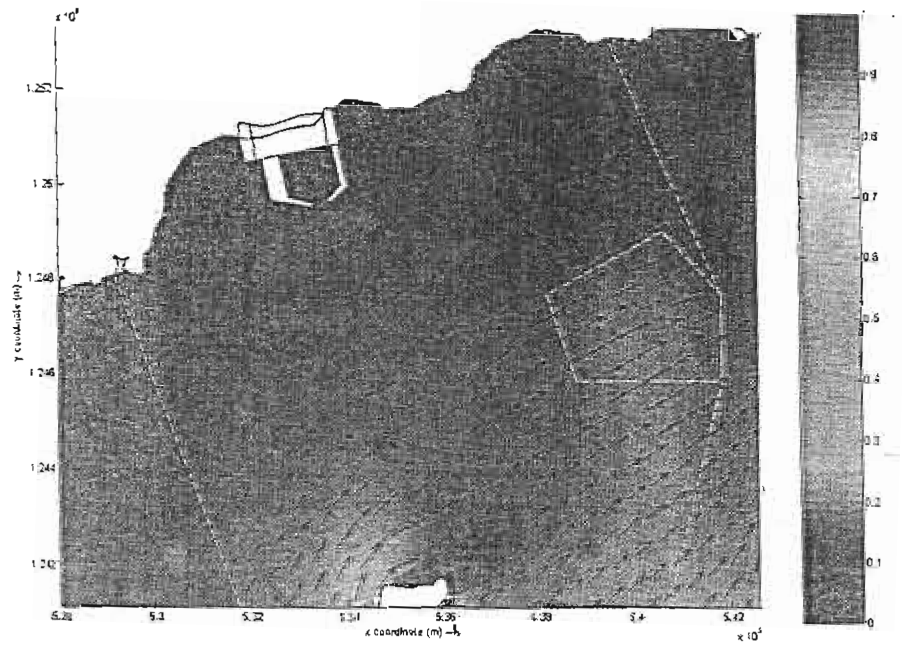


Figure 27. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (northeast wind, flood tide - before dredging)

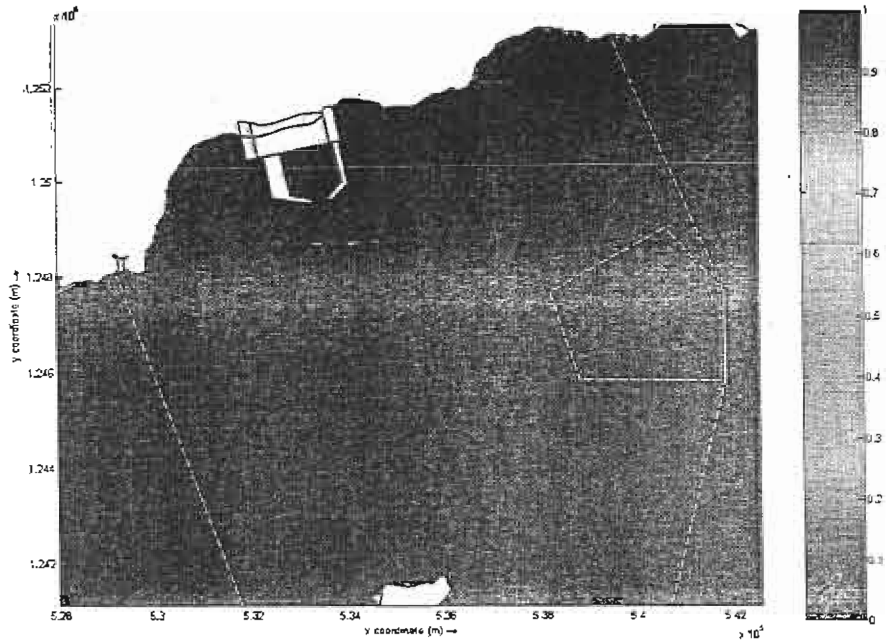


Figure 28. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (northeast wind, ebb tide - before dredging)

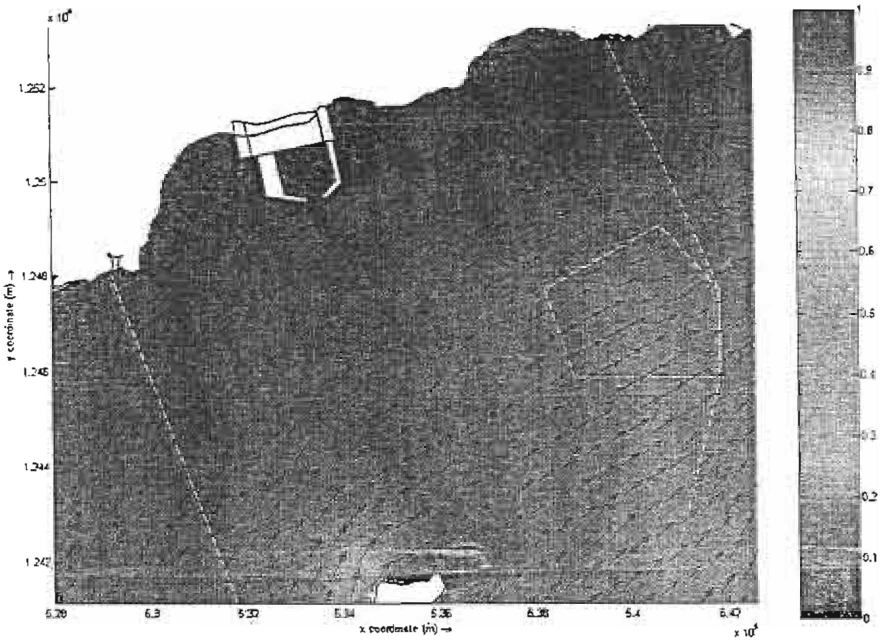


Figure 29. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (northeast wind, flood tide - during dredging)

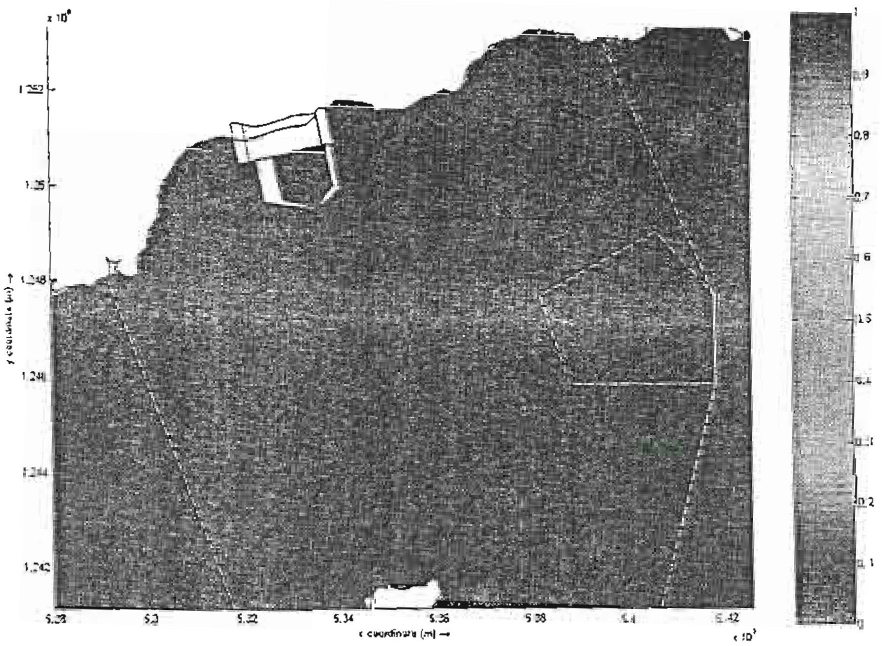


Figure 30. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (northeast wind, ebb tide - during dredging)

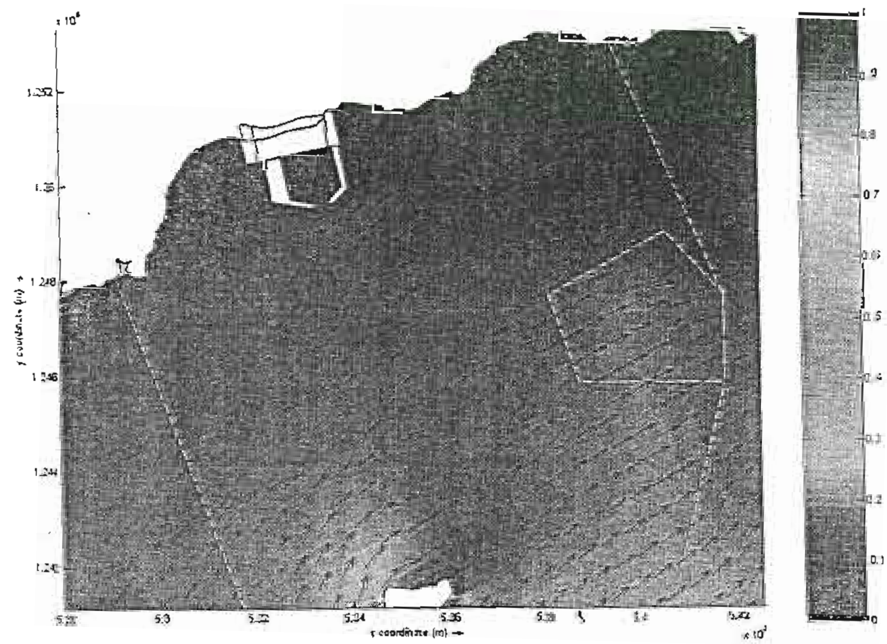


Figure 31. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (northeast wind, flood tide - after dredging)

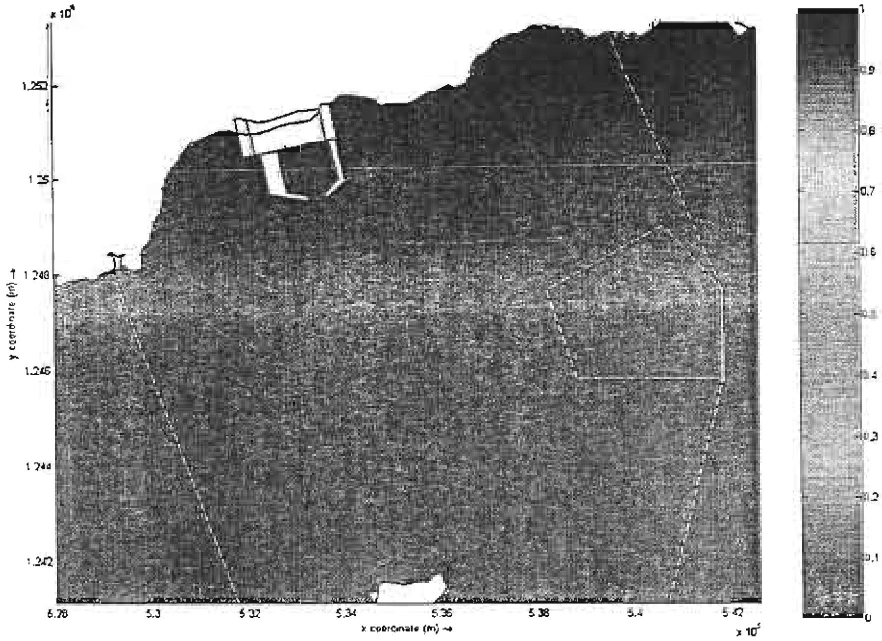


Figure 32. Integrated current field (m/s) at surface layer at Vinh Tan coastal area (northeast wind, ebb tide - after dredging)

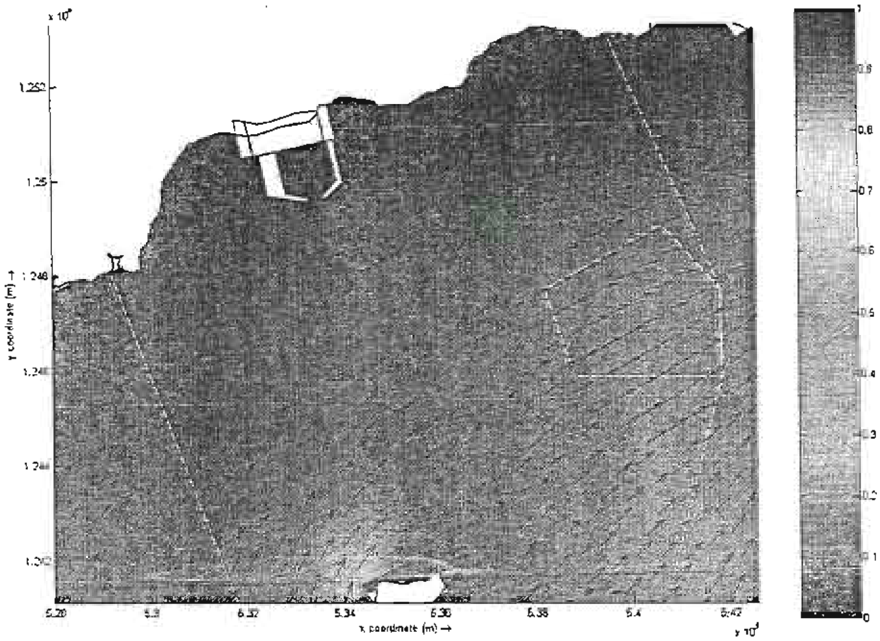


Figure 33. Wave - induced currents at Vinh Tan coastal area (northeast wind, flood tide - before dredging)

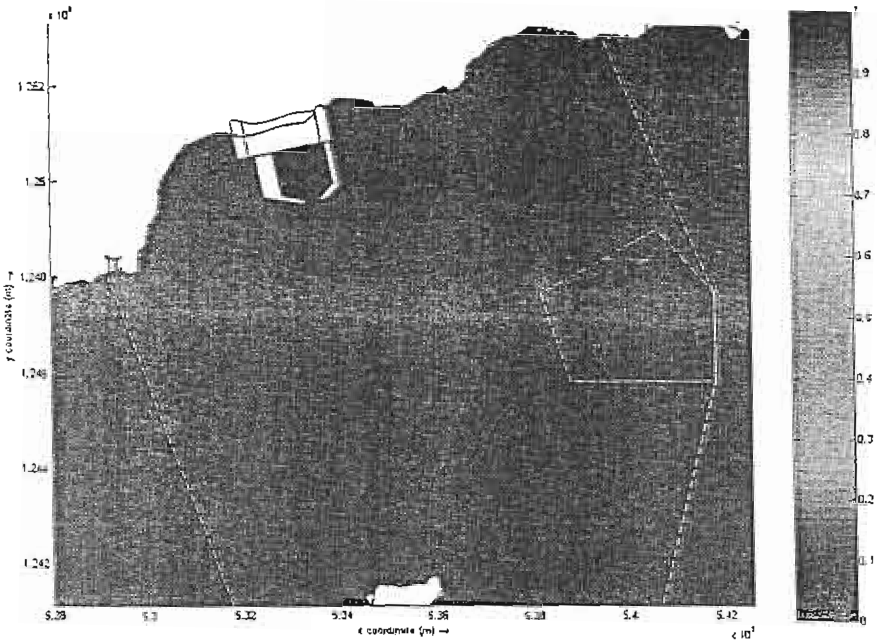


Figure 34. Wave - induced currents at Vinh Tan coastal area (northeast wind, ebb tide - before dredging)

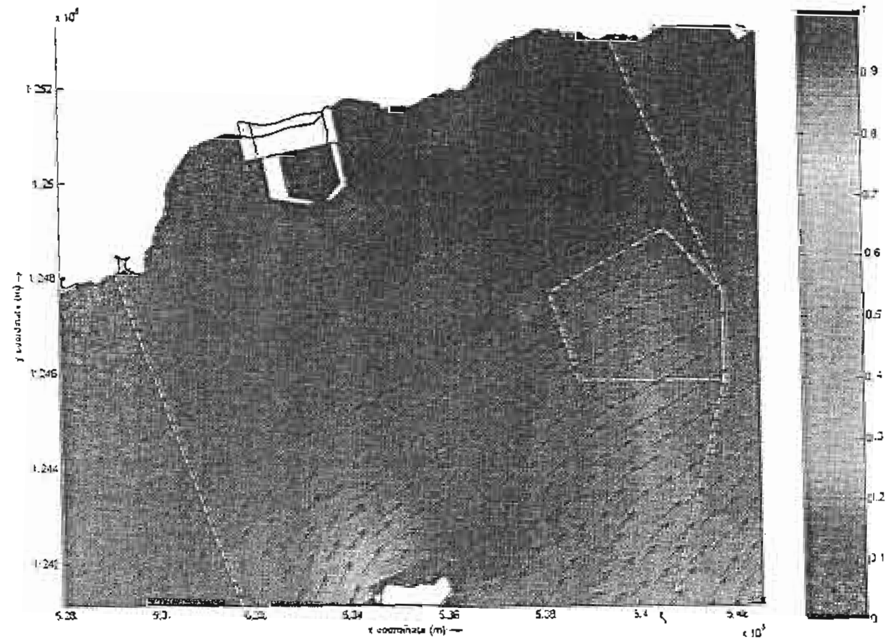


Figure 35. Wave - induced currents at Vinh Tan coastal area (northeast wind, flood tide - during dredging)

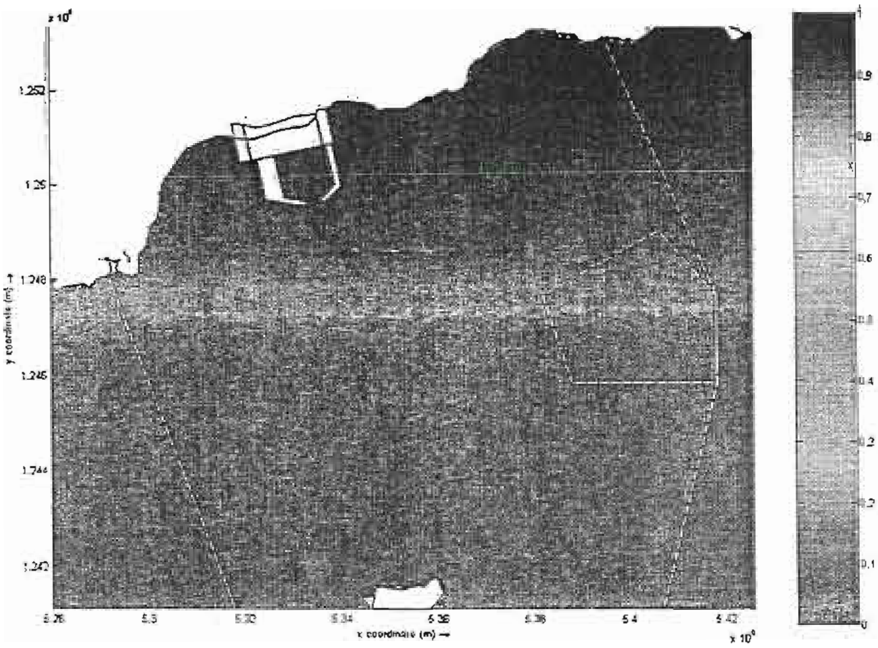


Figure 36. Wave - induced currents at Vinh Tan coastal area (northeast wind, ebb tide - during dredging)

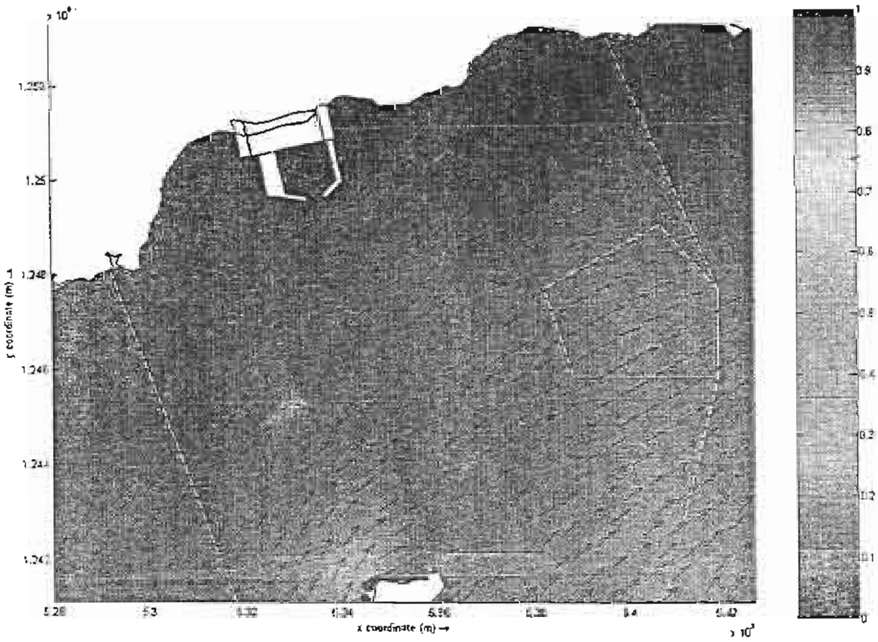


Figure 37. Wave - induced currents at Vinh Tan coastal area (northeast wind, flood tide - after dredging)

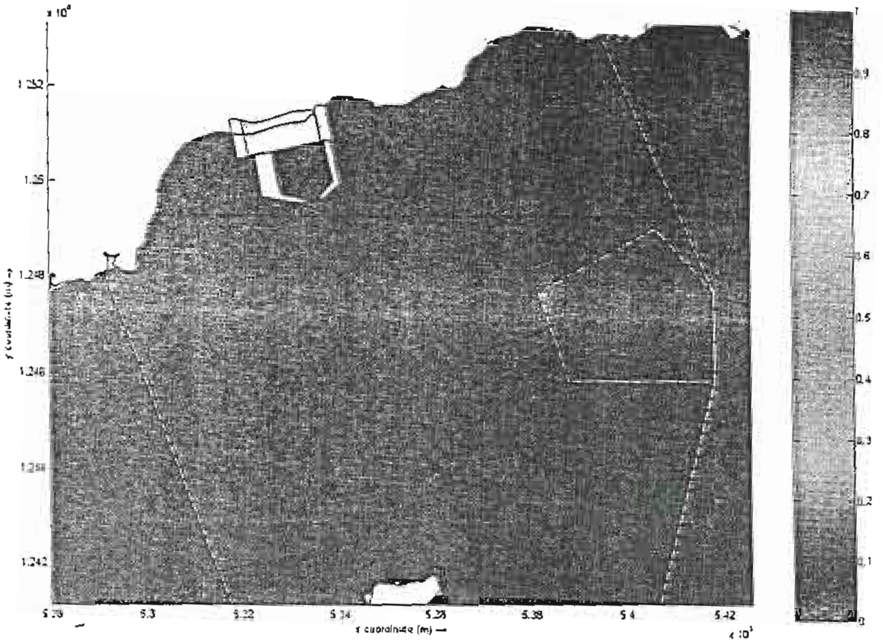


Figure 38. Wave - induced currents at Vinh Tan coastal area (northeast wind, ebb tide - after dredging)

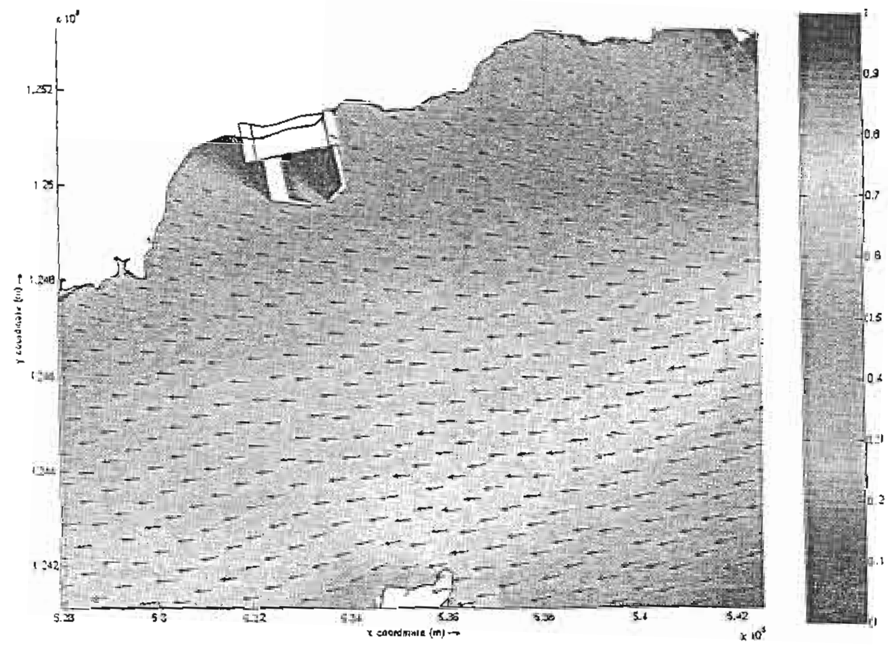


Figure 39. Wave height (m) at Vinh Tan coastal area (northeast wind, high tide- before dredging)

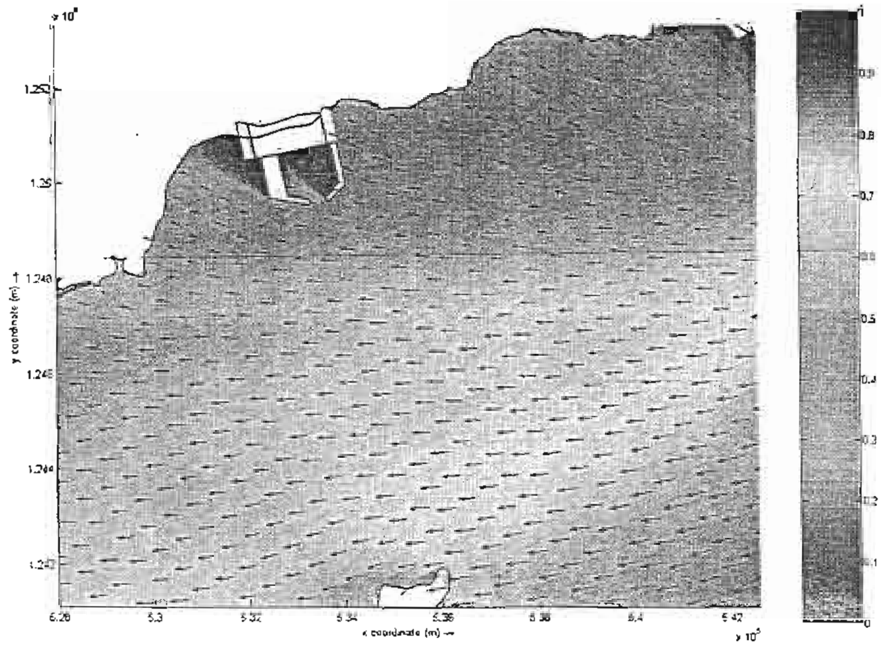


Figure 40. Wave height (m) at Vinh Tan coastal area (northeast wind, high tide - during dredging)

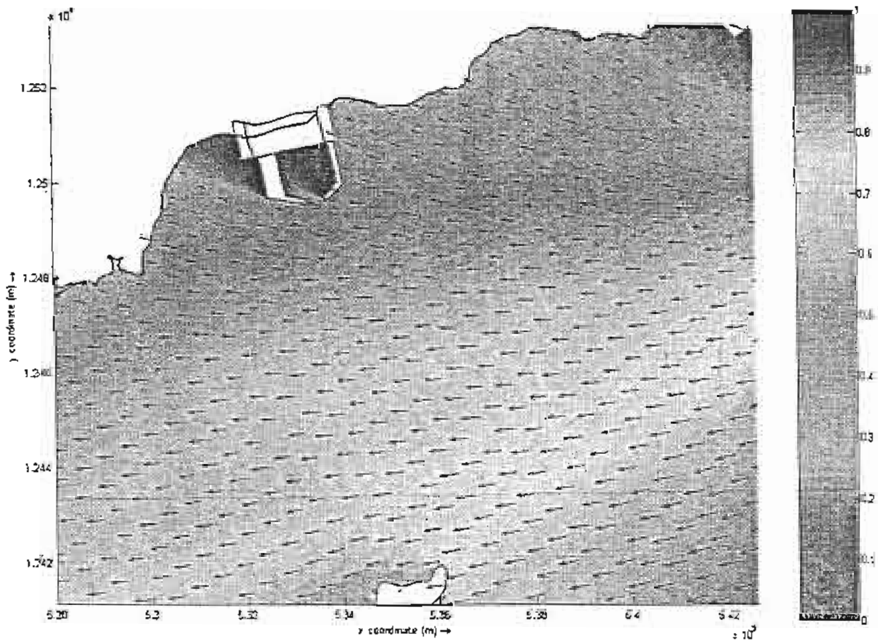


Figure 41. Wave height (m) at Vinh Tan coastal area (northeast wind, high tide - after dredging)

Variation of magnitude current and wave in some monitoring points

The fluctuation of current at Breda shoal (Figure 42 – 43) reveals that the current velocity at V1 and V2 does not change much before, during and after performing dredging work. This happens in both dry and rainny seasons. Similarly, at the west – northwestern site of Cu Lao Cau (V3, V4, V5), the impact of dredging activities on the currents is negligible (Figure 44 - 46).

In the dredging are (V6 to V9), no significant variation of velocity magnitude was observed before, during and after dredging period (Figure 47 - 50).

The wave height at monitoring points around Breda sandbar and Cu Lao Cau Island expresses no difference before, during and after the dredging period (see Figure 51-56).

In places nearby the construction area, the wave height does not significantly change during time of dredging compare with before and after dredging processes (Figure 57-59).

To sum up, the dredging activities hardly affect the hydrodynamic conditions of Cu Lao Cau island, Breda sandbar, northeastern and southwestern of Vinh Tan coastline).

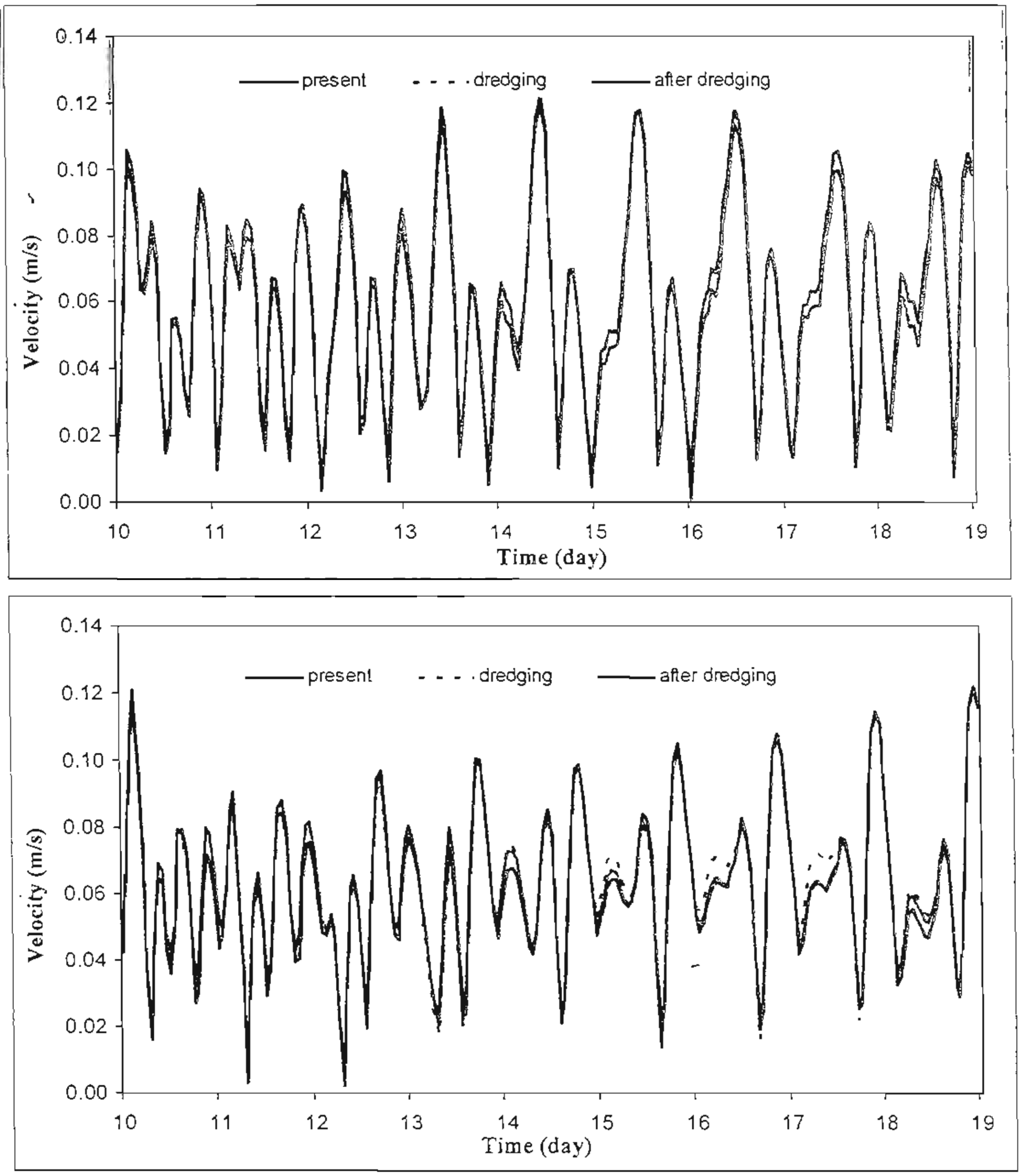
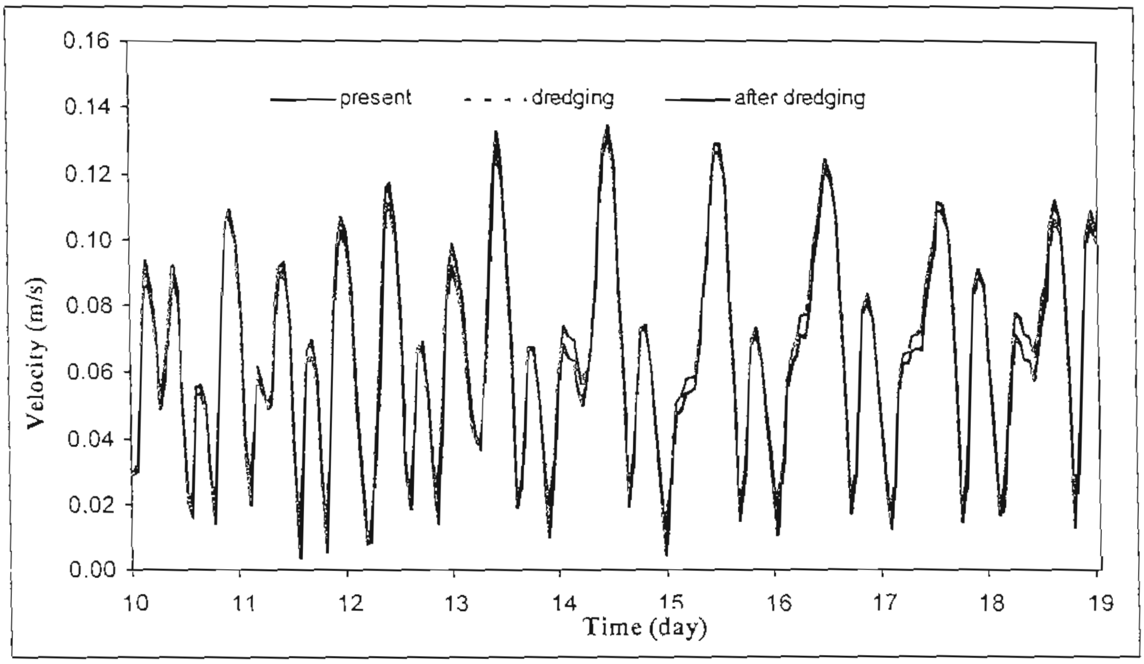


Figure 42. Fluctuation of current magnitude at Breda sand bar (V1; a – rainy season; b-dry season)



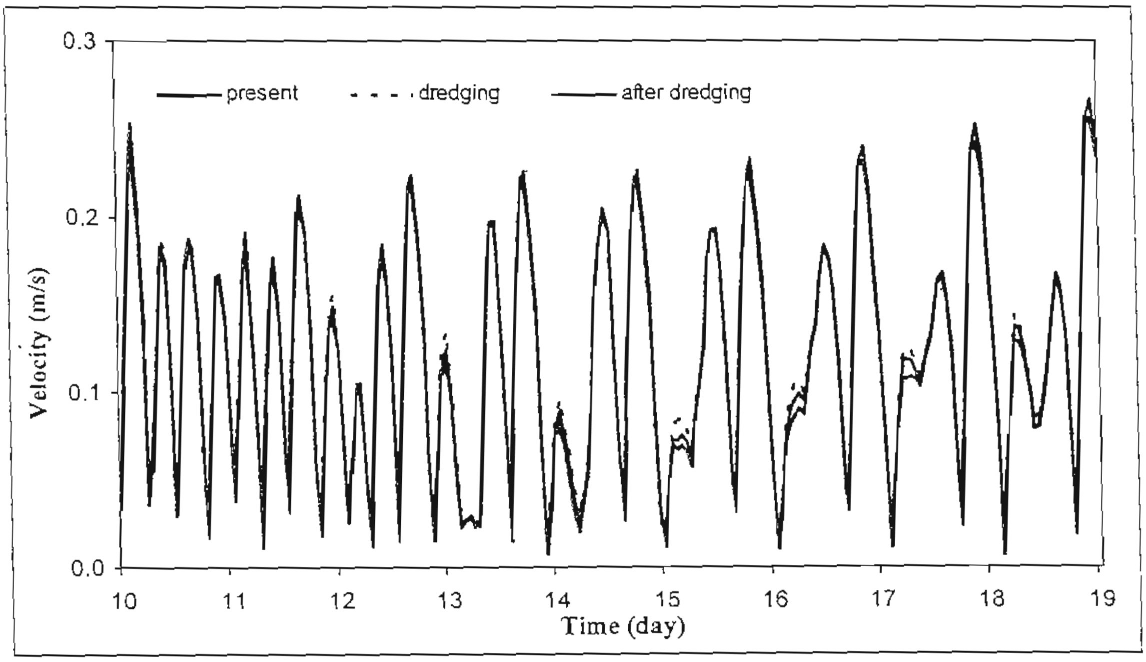


Figure 43. Fluctuation of current magnitude at Breda sand bar (V2; a – rainy season; b- dry season)

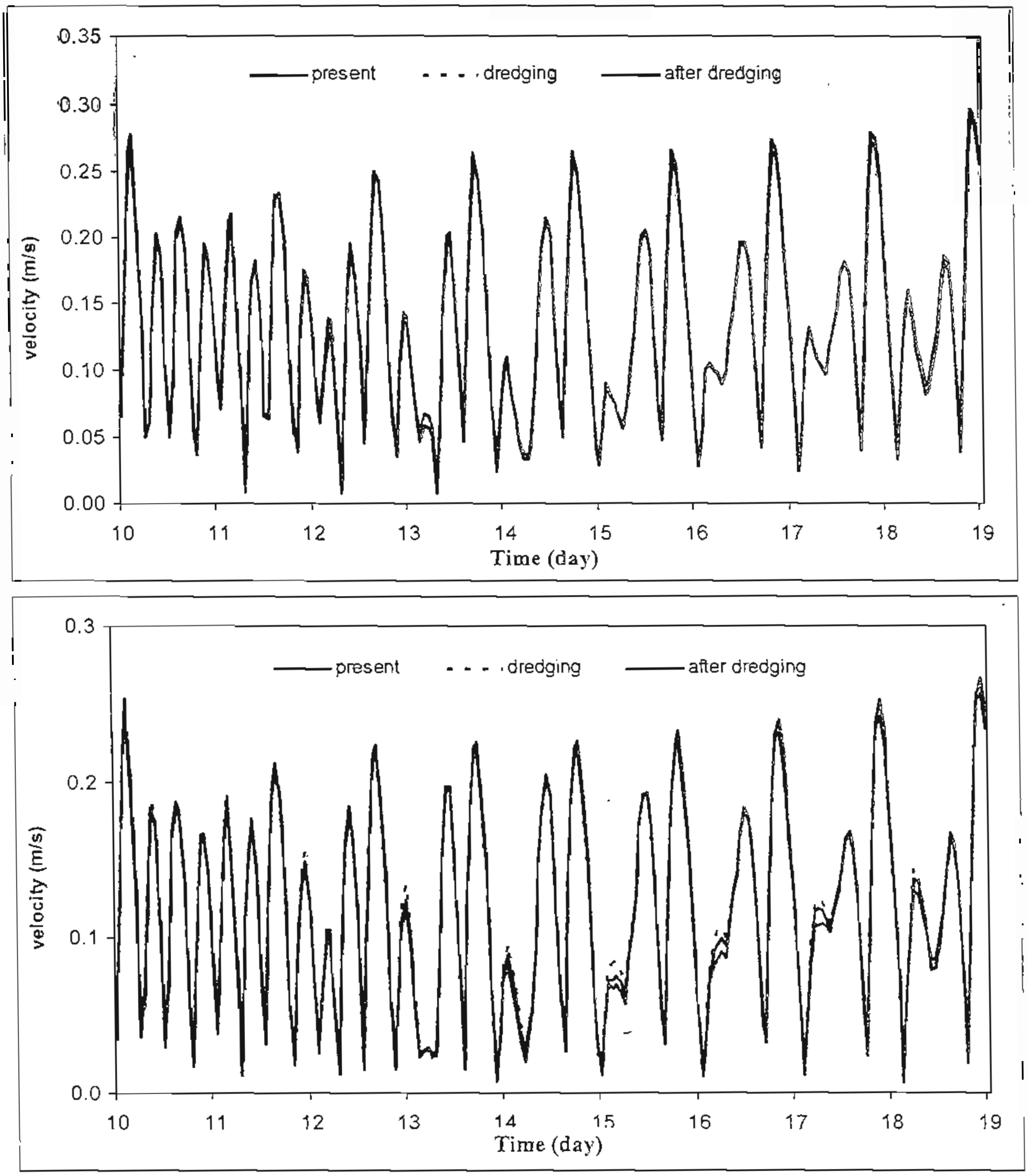
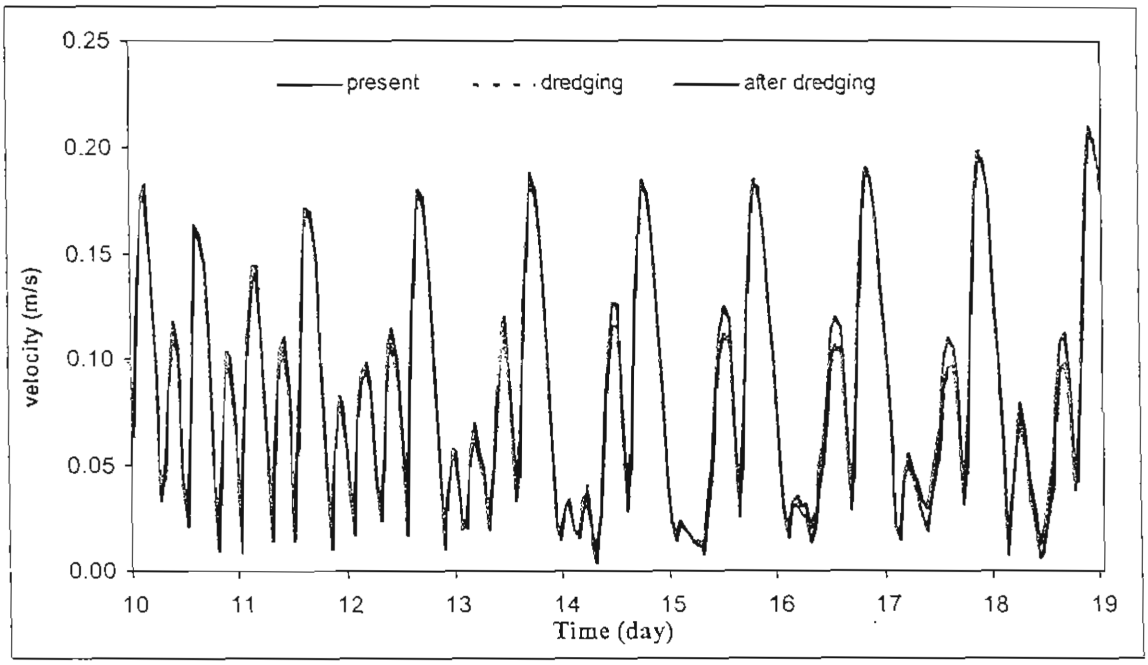


Figure 44. Fluctuation of current magnitude at Cu Lao Cau Island (V3; a – rainy season; b- dry season)



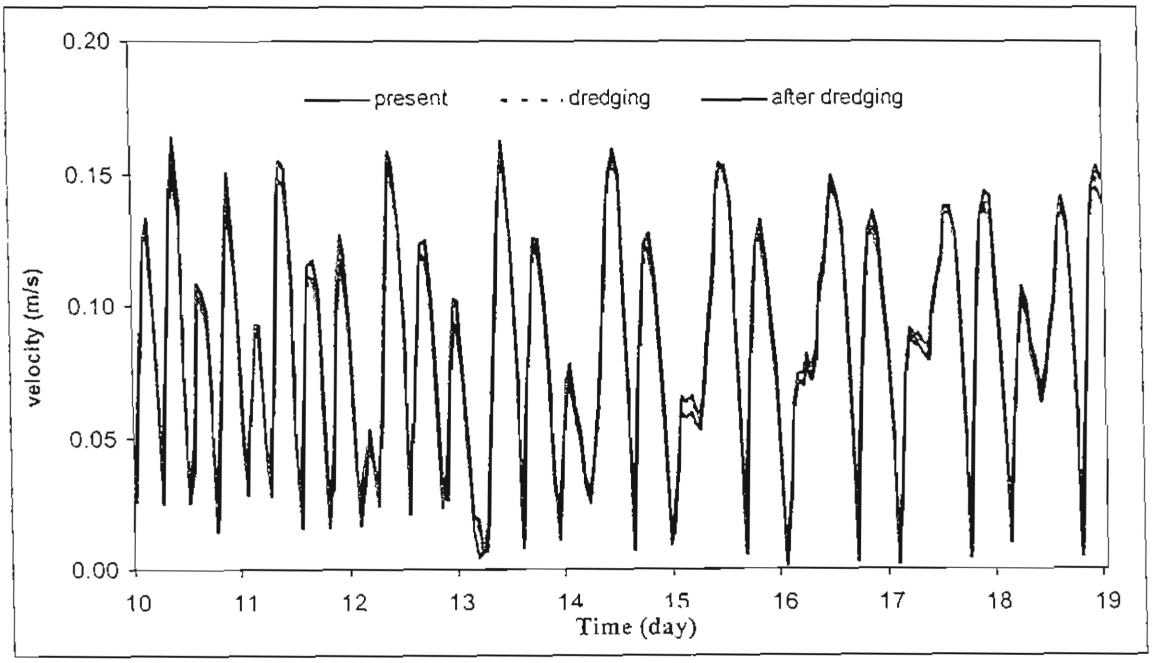


Figure 45. Fluctuation of current magnitude at Cu Lao Cau Island (V4; a – rainy season; b- dry season)

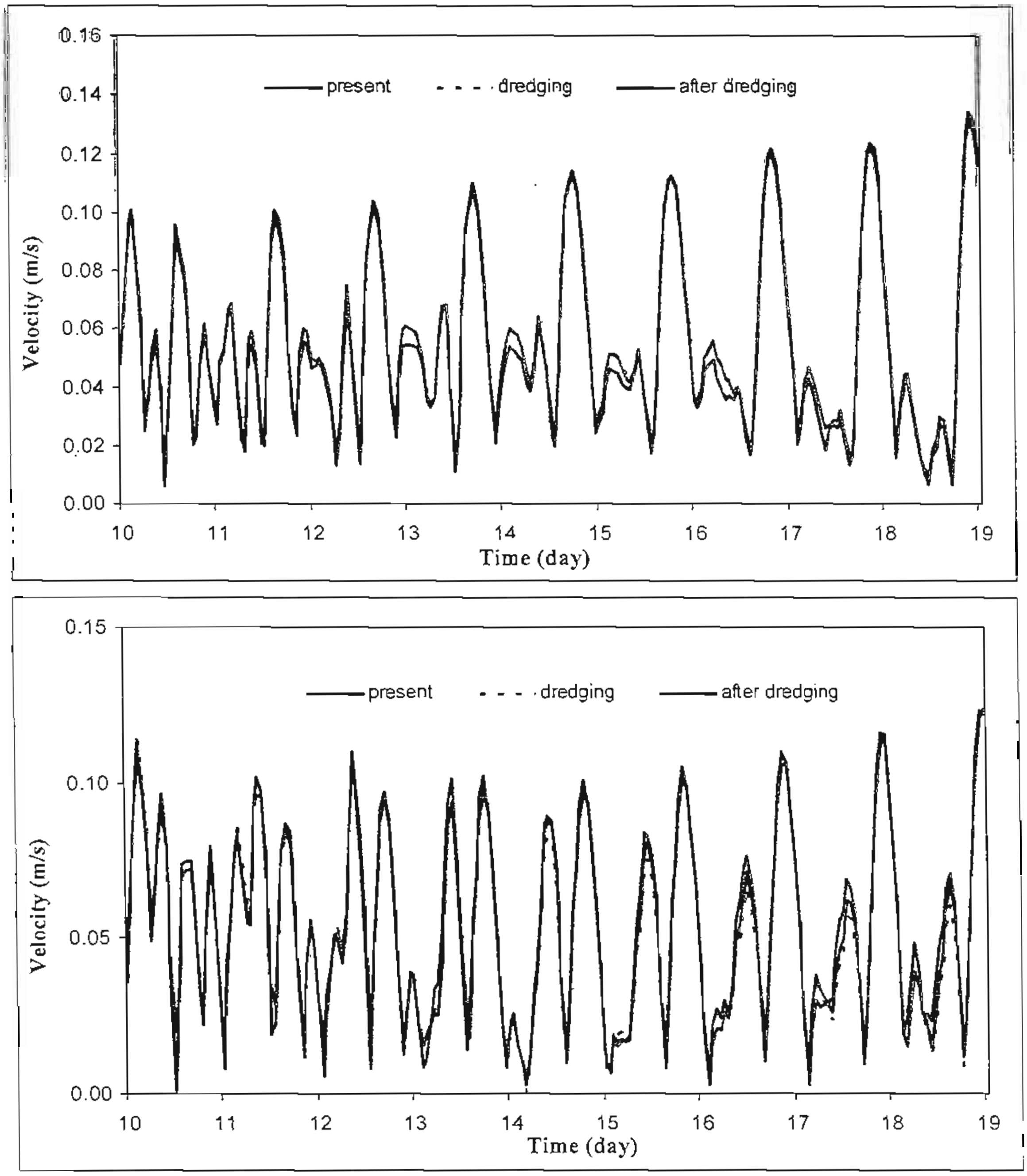


Figure 46. Fluctuation of current magnitude at Cu Lao Cau Island (V5; a – rainy season; b- dry season)

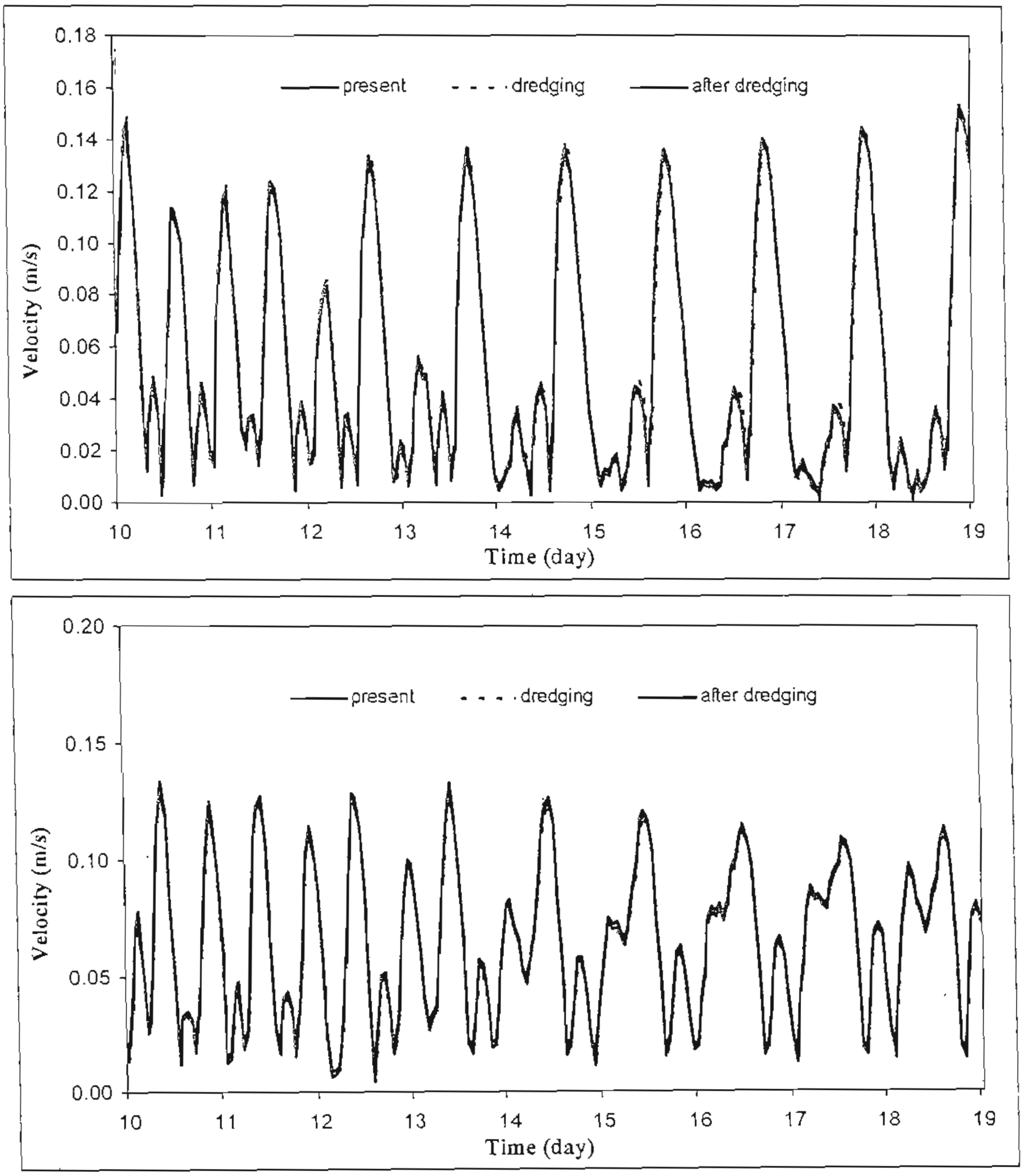


Figure 47. Fluctuation of current magnitude at the Eastern site of dredging area (V6; a – rainy season; b- dry season)

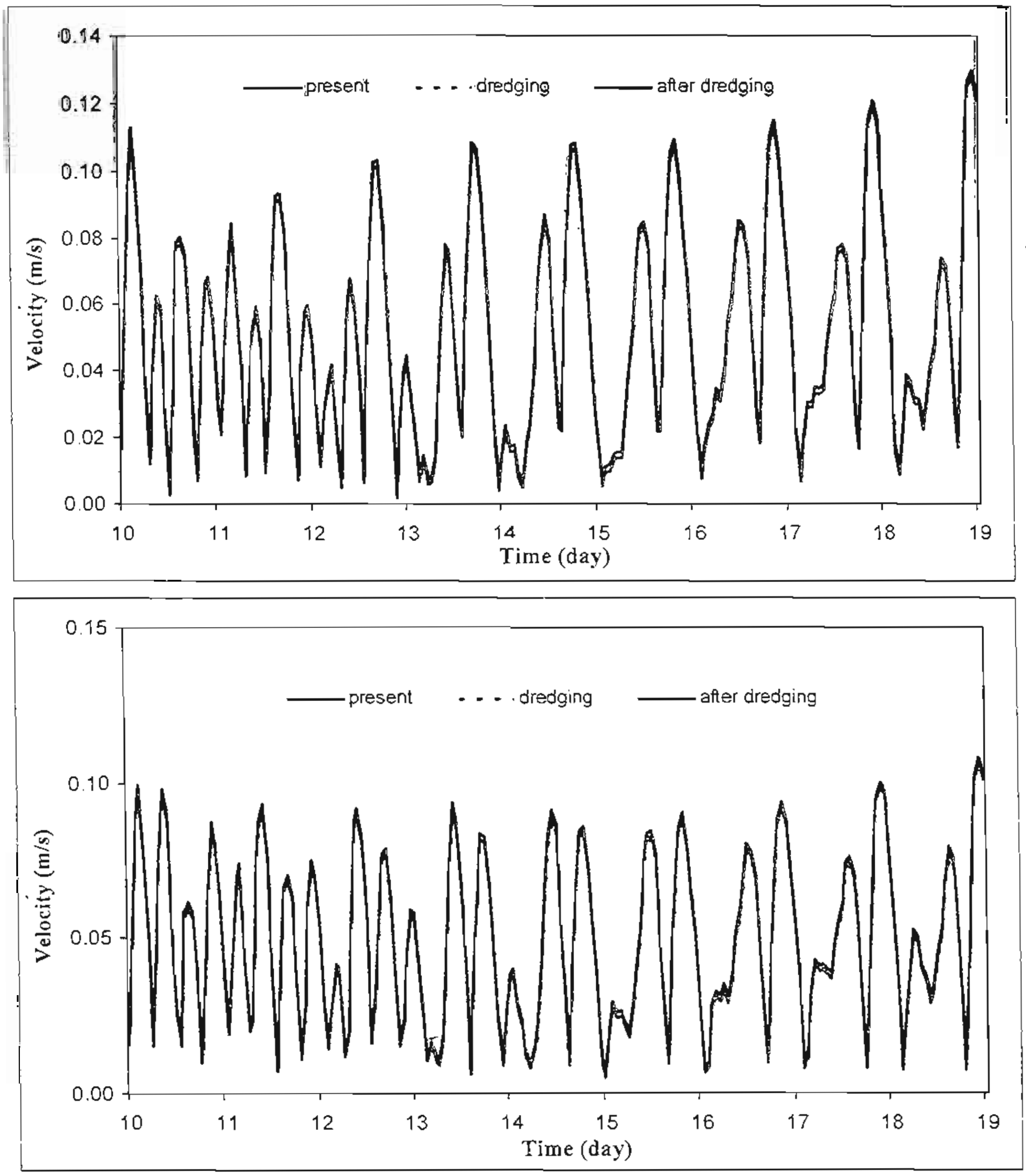
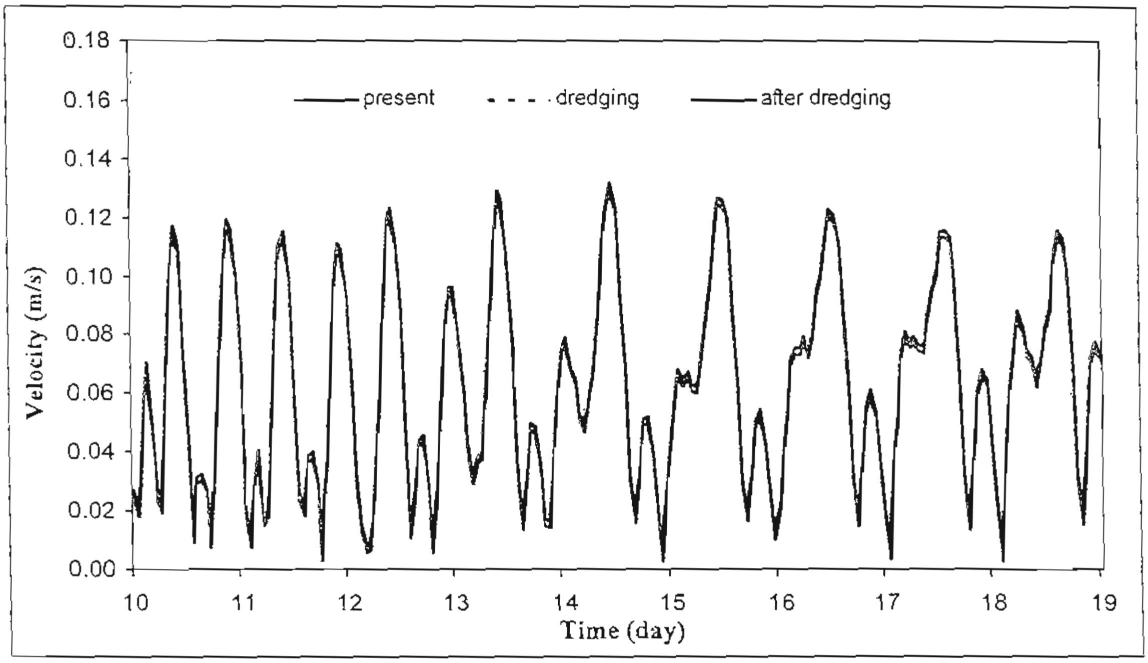


Figure 48. Fluctuation of current magnitude at the Eastern site of dredging area (V7; a – rainy season; b- dry season)



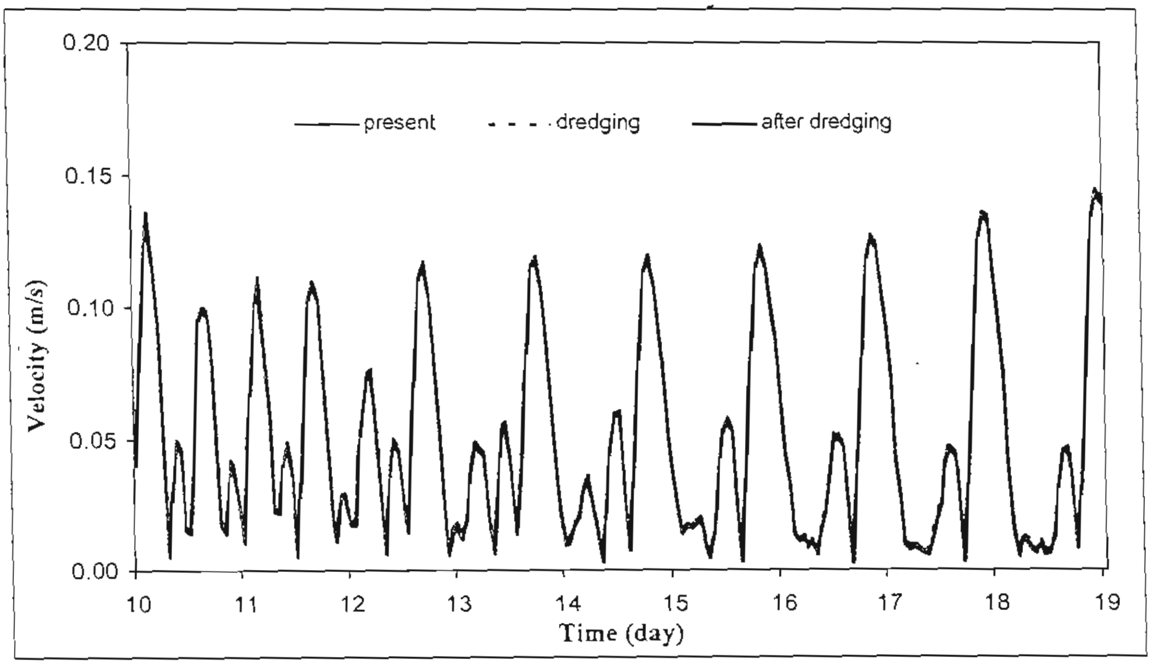


Figure 49. Fluctuation of current magnitude at the Southeastern site of dredging area (V8; a – rainy season; b- dry season)

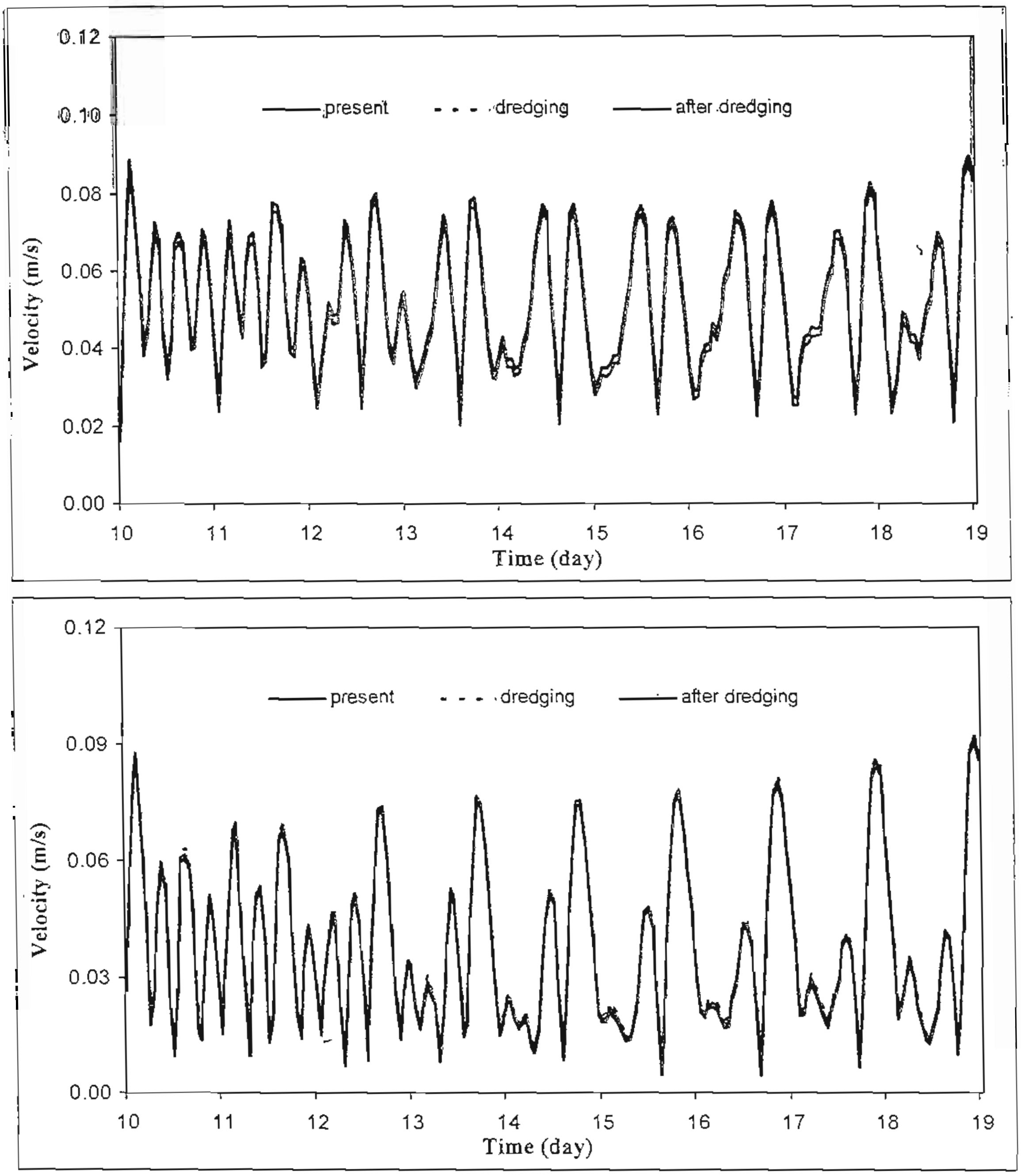


Figure 50. Fluctuation of current magnitude at the Southwestern site of dredging area (V9; a – rainy season; b- dry season)

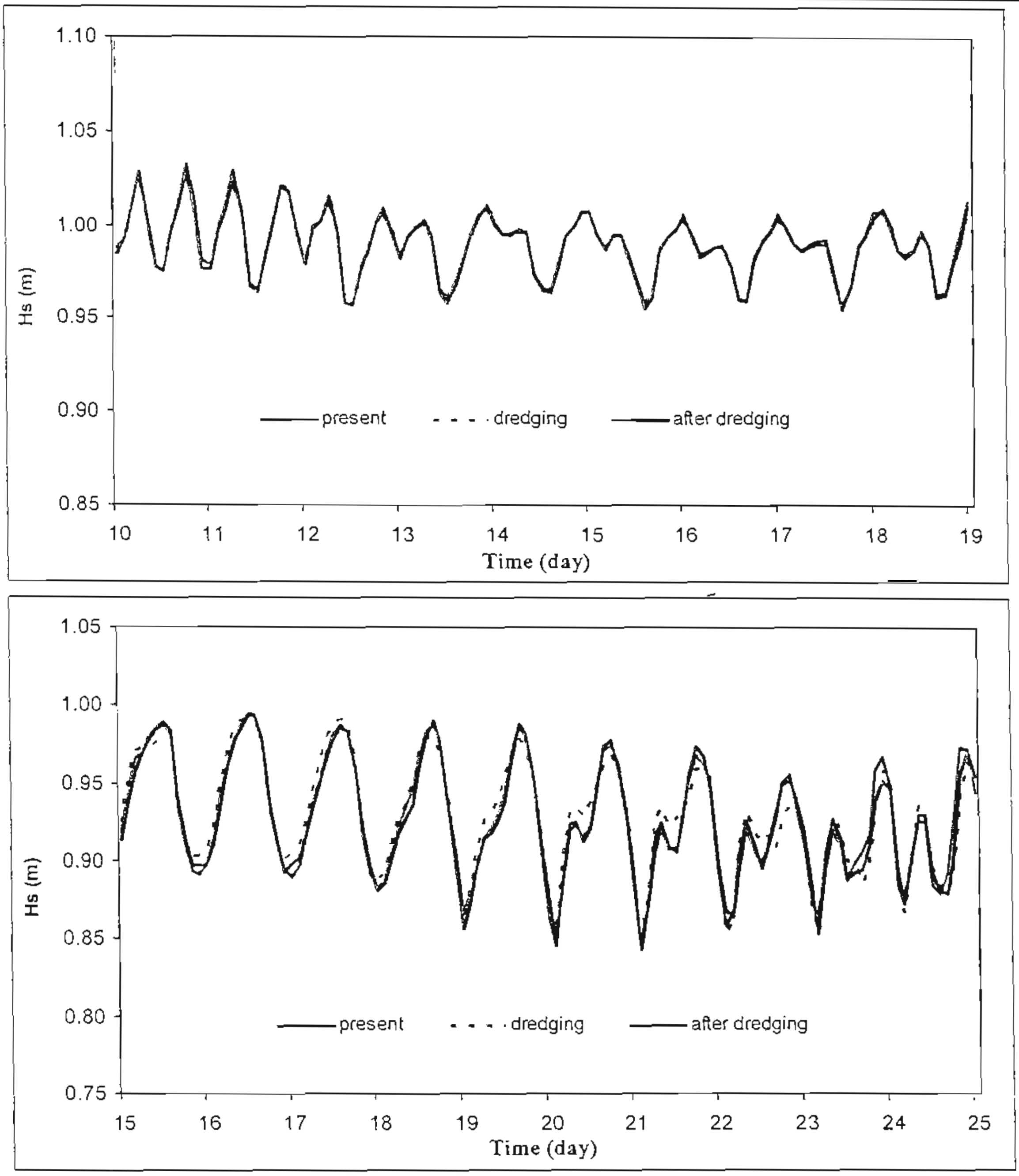
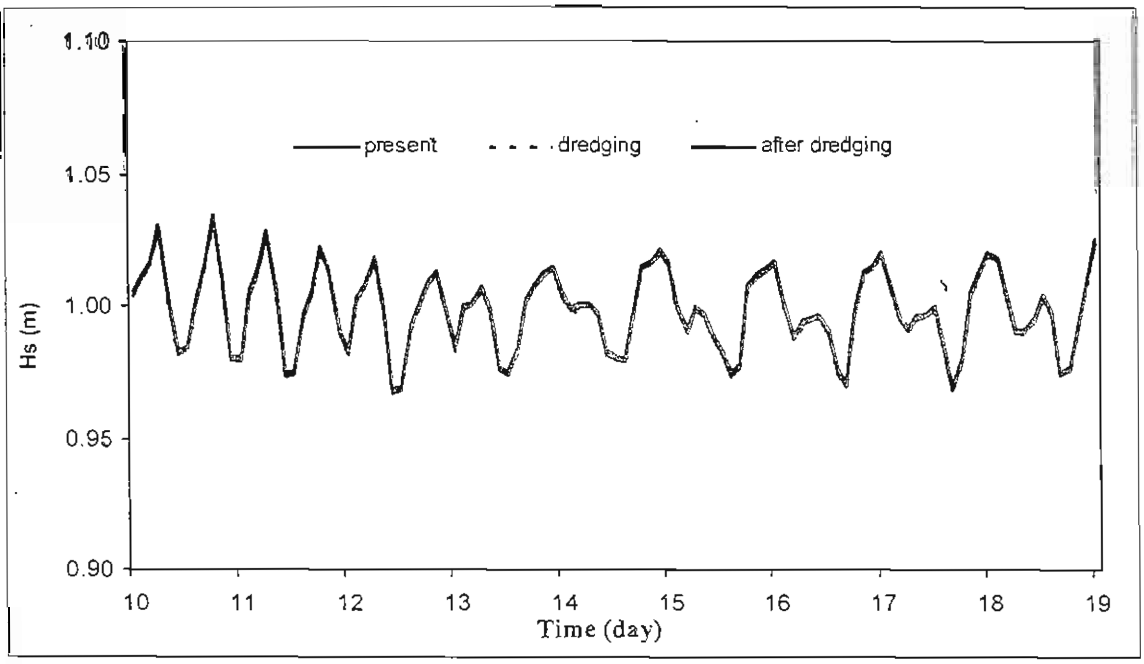


Figure 51. Fluctuation of wave height at the Breda sandbar (V1; a – rainy season; b- dry season)



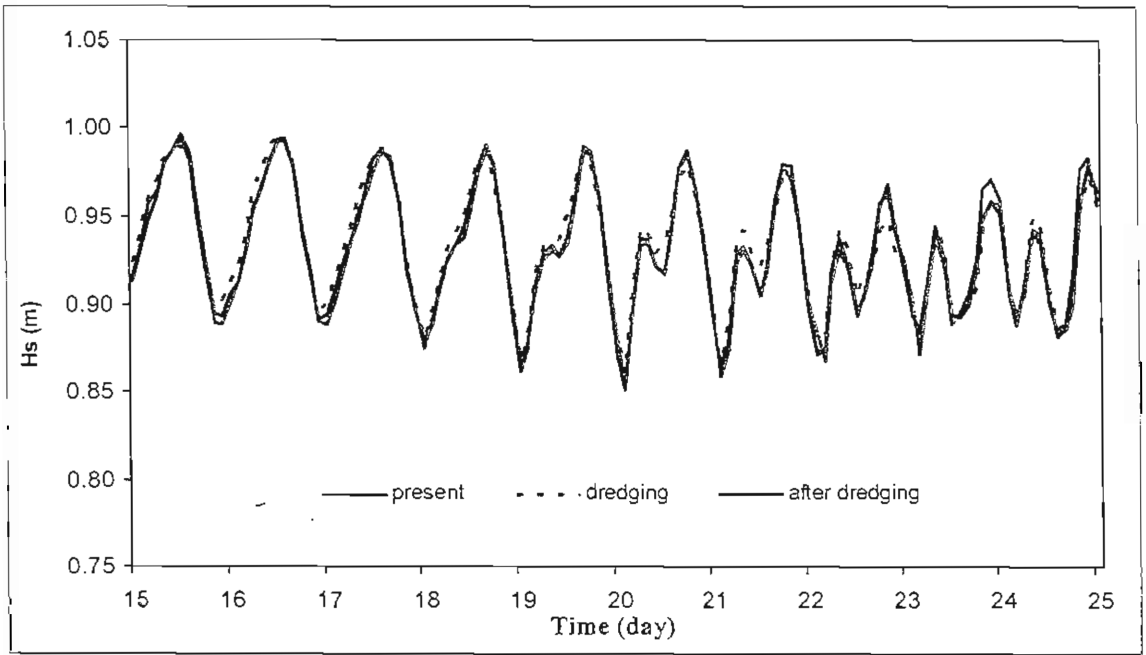


Figure 52. Fluctuation of wave height at the Breda sandbar (V2; a – rainy season; b- dry season)

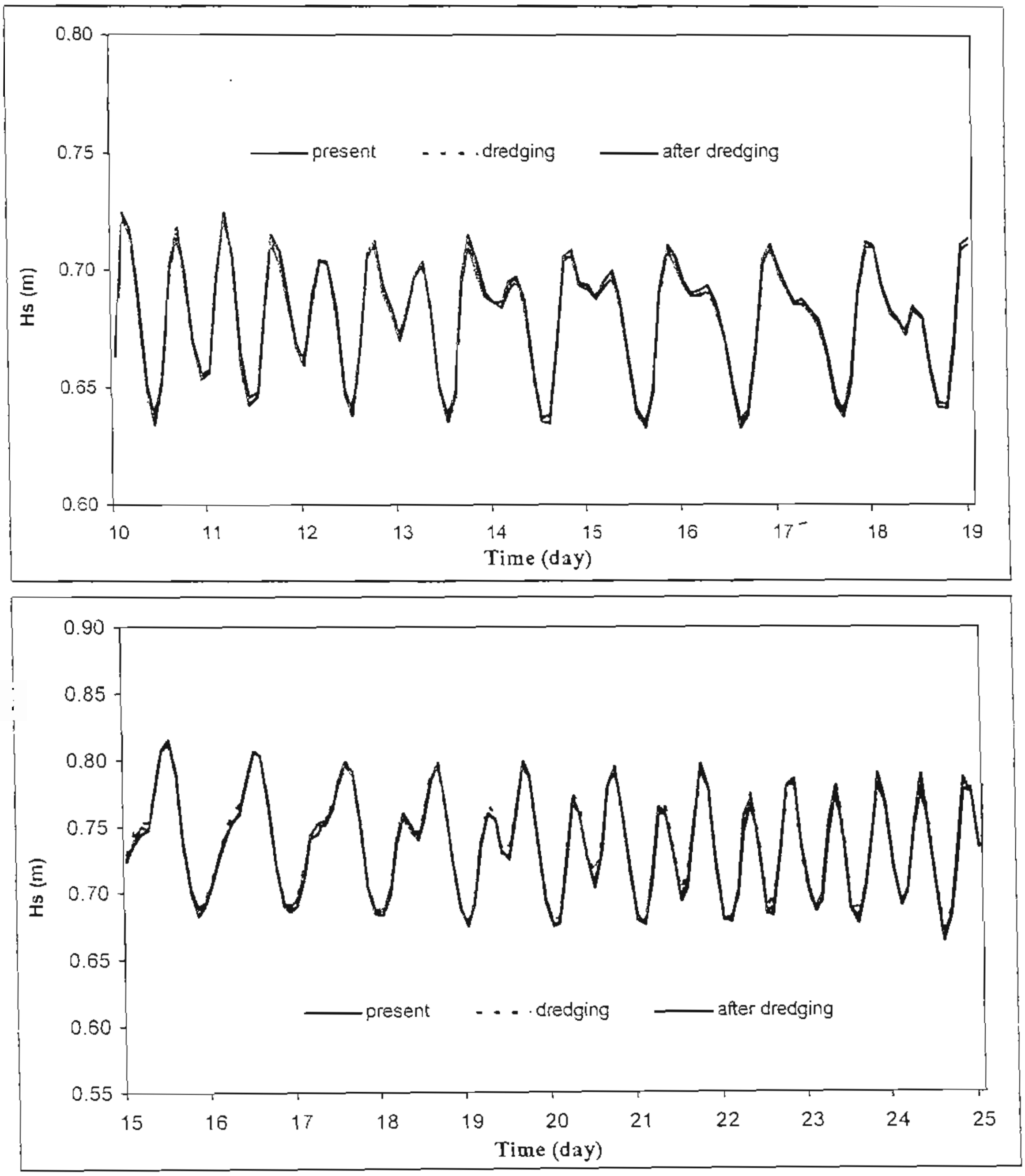


Figure 53. Fluctuation of wave height at Cu Lao Cau Island (V3; a – rainy season; b-dry season)

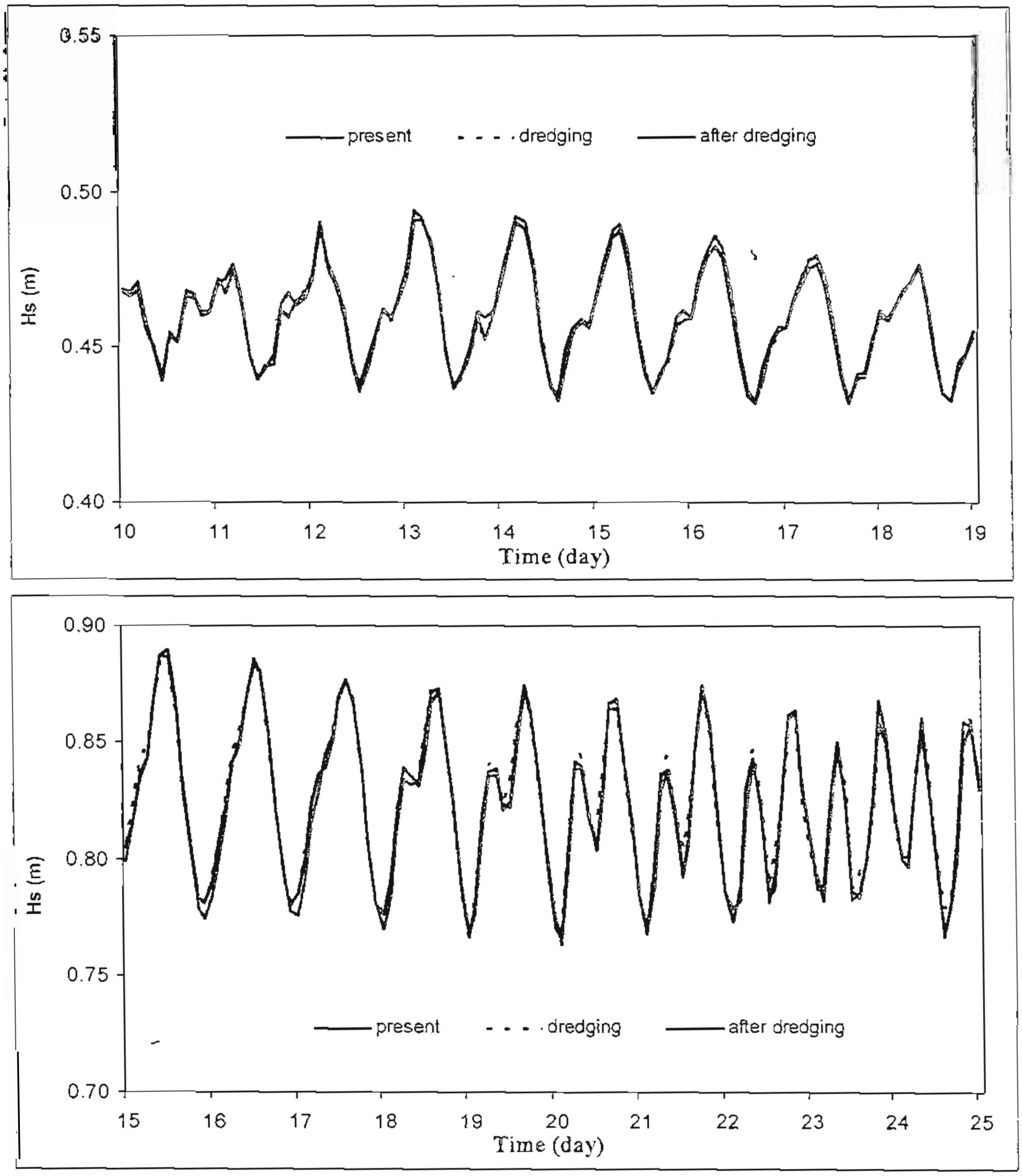


Figure 54. Fluctuation of wave height at Cu Lao Cau Island (V4; a – rainy season; b-dry season)

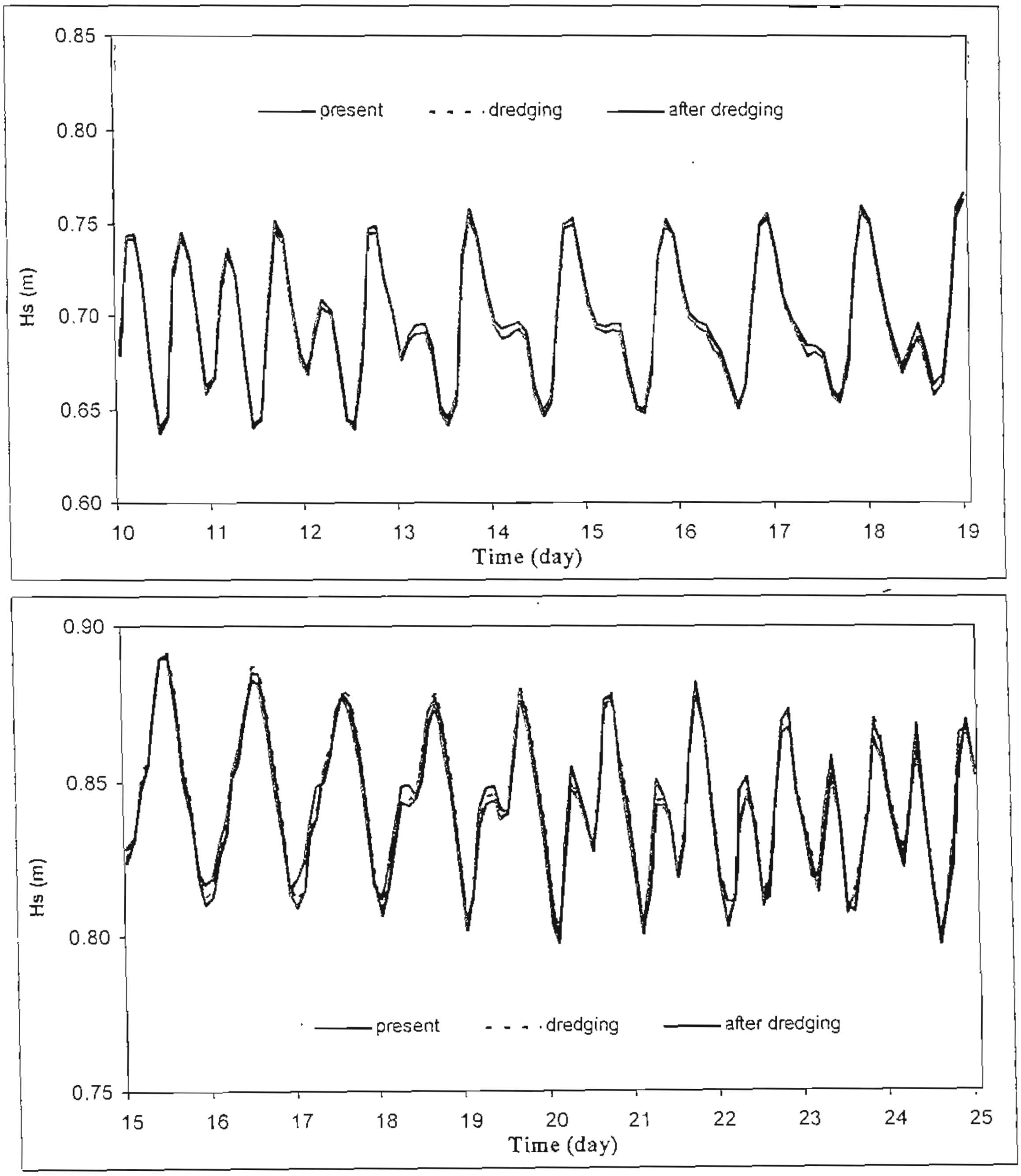


Figure 55. Fluctuation of wave height at Cu Lao Cau Island (V5; a – rainy season; b-dry season)

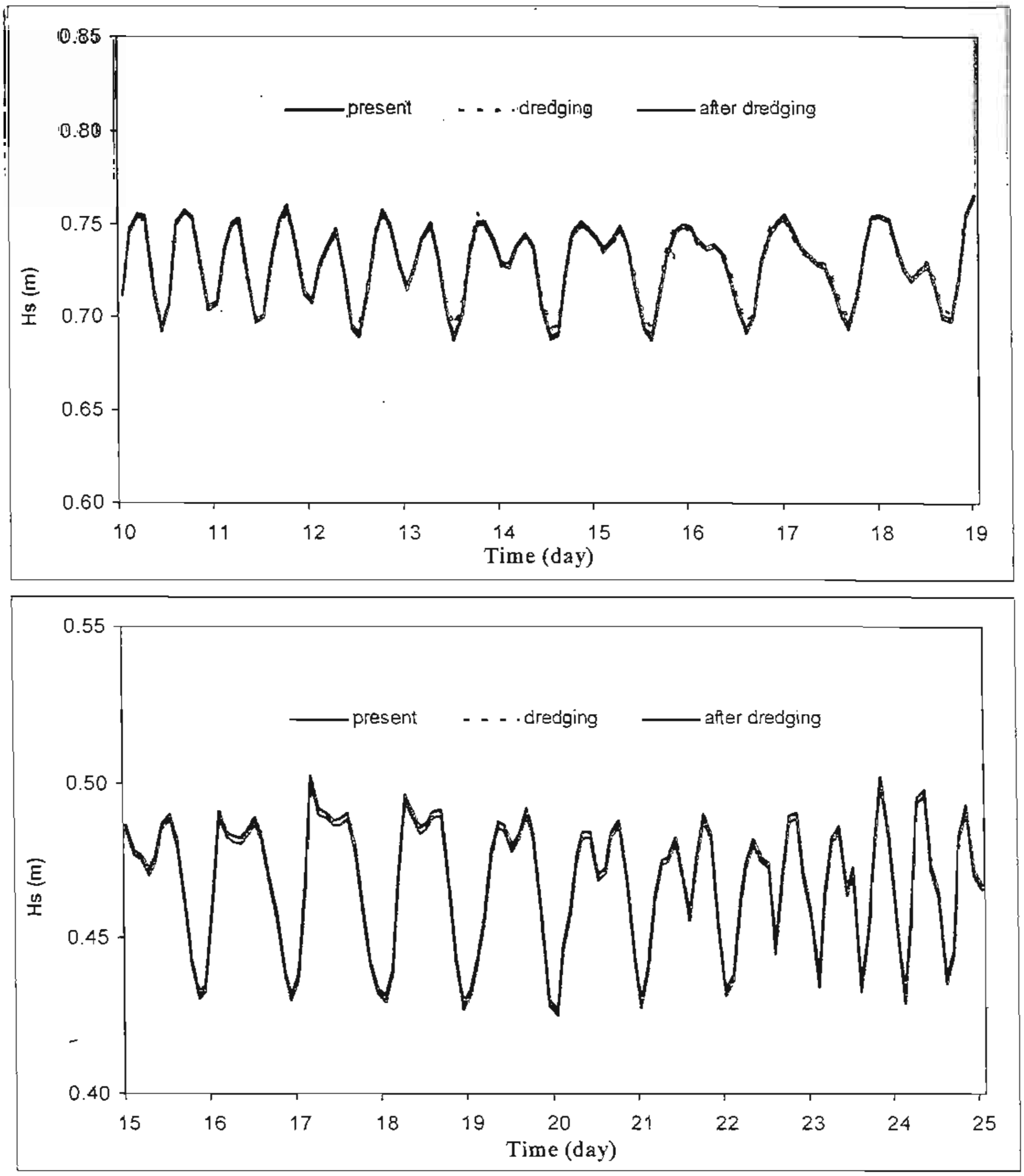


Figure 56. Fluctuation of wave height at the eastern site of dredging place (V6; a – rainy season; b- dry season)

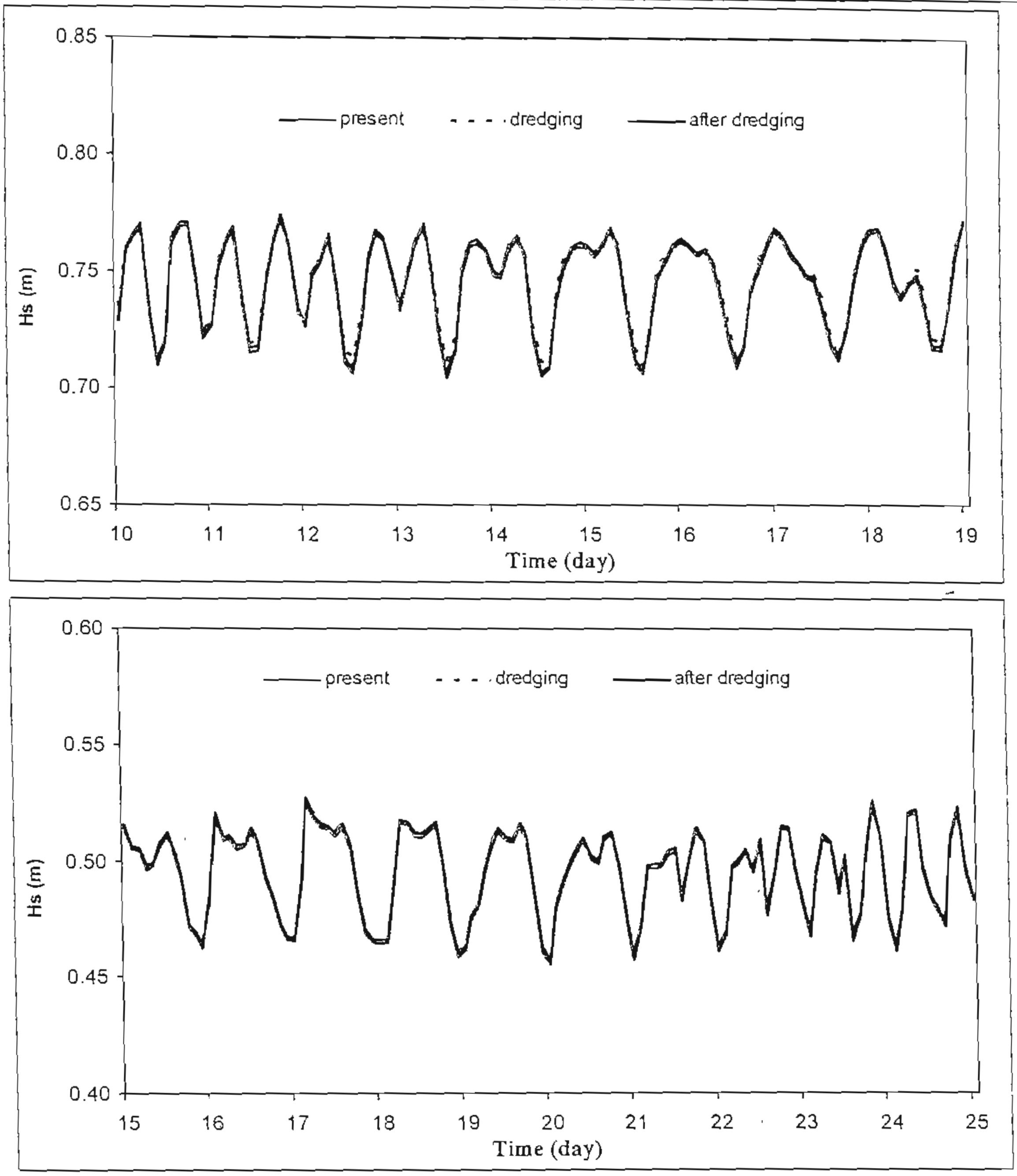


Figure 57. Fluctuation of wave height at the eastern site of dredging place (V7; a – rainy season; b- dry season)

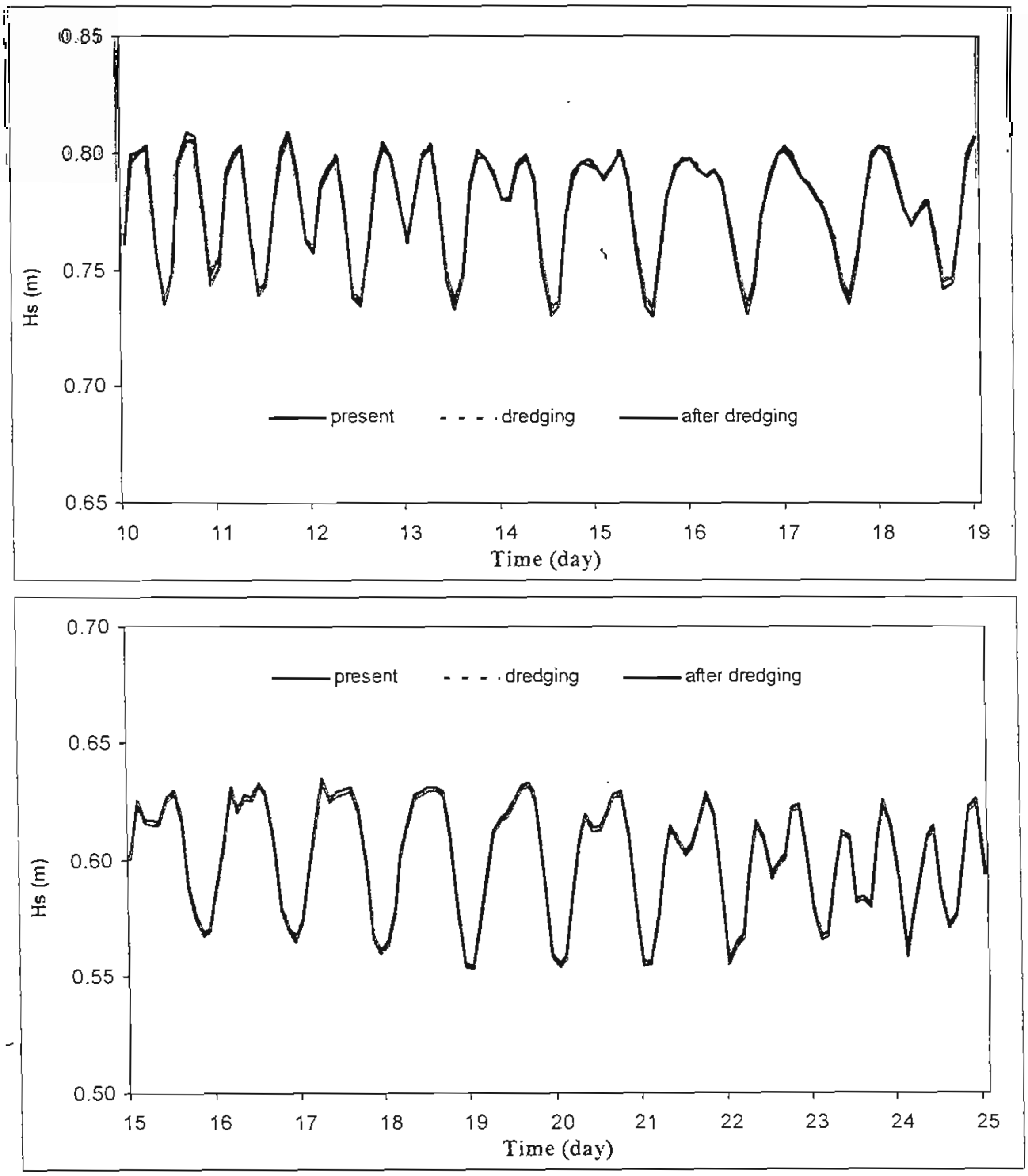


Figure 58. Fluctuation of wave height at the southeastern site of dredging place (V8; a – rainy season; b- dry season)

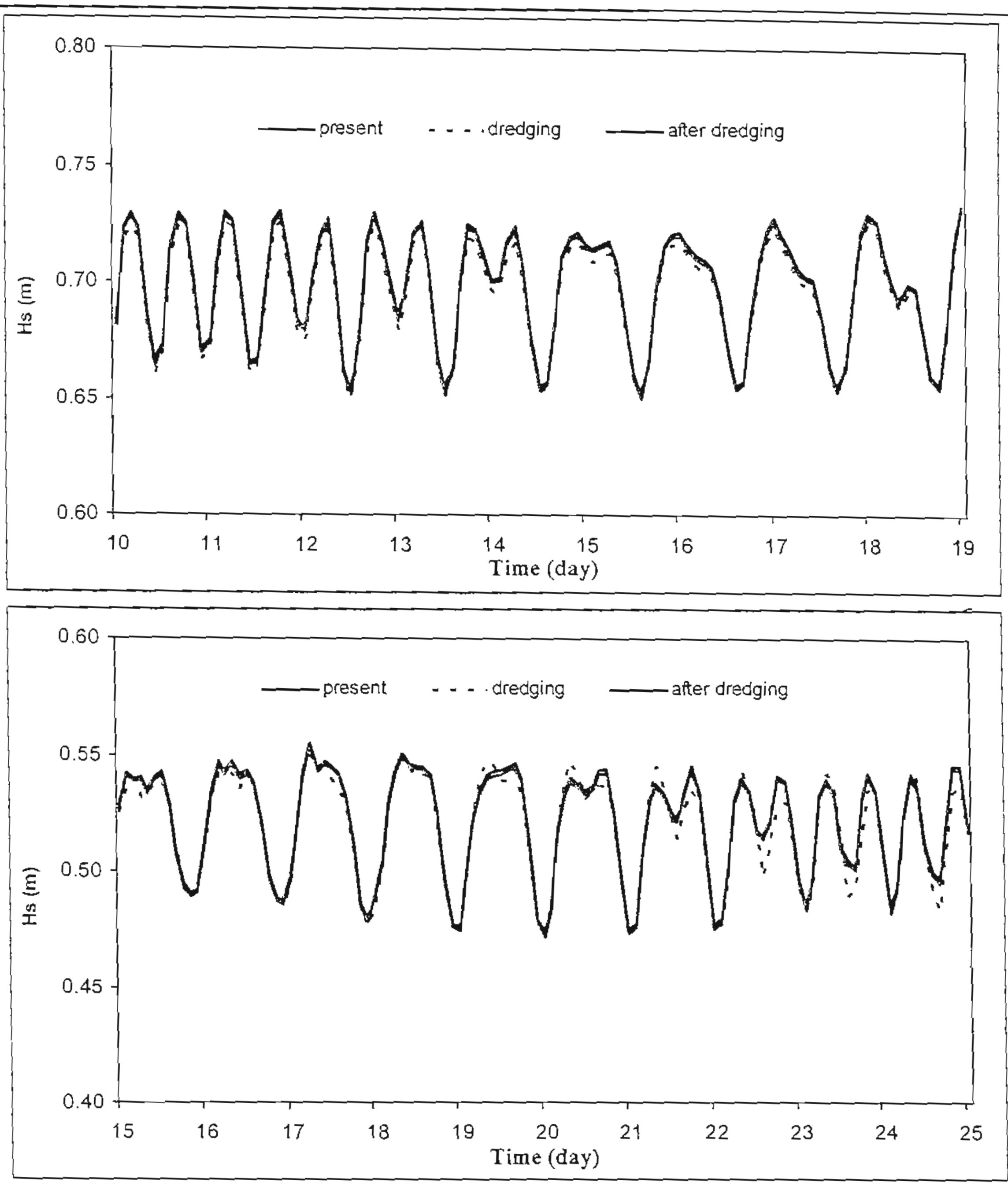


Figure 59. Fluctuation of wave height at the southwestern site of dredging place (V9; a – rainy season; b- dry season)

6.2. Influence on sediment transport

The characteristics of sediment transport at Binh Thuan coastal area and Vinh Tan area depend on the integrated hydrodynamics – wave process. Analysis results have revealed that sediment transport characteristics alter seasonally due to strong alteration of these factors.

Sediments source from the river to the coastal zone in this area is very small. Therefore, sediment transport is mostly caused by re-suspension due to wave activities and integrated current. Suspended sediment concentration is relative small with prevalent value less than 0.008 kg/m^3 and decreasing gradually from near-shore to offshore. The difference in sediment concentration between rainy and dry seasons is not considerable. (Figure 60 - 61 and Figure 66 - 67)

Sediment flux and distribution in this area slightly change with phase of tide oscillation owing to change in moving direction of water flow at the coastline. Suspended sediment distribution is similar between dry season and rainy season.

To assess the impacts of the dredging work, calculation on the distribution and transport of total suspended sediment (TSS) was performed before, during and after the dredging process. The results presented in Figure 60 to Figure 71 reveal certain impacts on the distribution of TSS in the study area during the dredging process (see Figure 62 – 63 and Figure 68 – 69). As the dredging completed, the distribution of TSS was not significantly different from current stage. This means turbid area caused by TSS increase happened only during dredging period.

During dredging work in southwestern wind monsoon, the activities generate turbid area with TSS value about 0.005-0.012 kg/m^3 spreading on an area of 0.9km^2 around the dredging site. This turbid water has higher TSS value at the inner area (0,014-0,015 kg/m^3) and spreads to the eastern parts of dredging area during flood tide stage and south – southwestern parts during the ebb tide period (Figure 62 - 63). The concentration of sediment decreases at the outside of the dredging area and hardly depends on distance. During dredging period, the impact of such turbid water to Cu Lao Cau is negligible. Also, despite close distance to the dredging area, the impact of turbid water on Breda sandbar area is small (Figure 62 – 63). Other areas in Cu Lao Cau MPA are negligibly affected by dredging work.

During dredging work in northeastern wind monsoon, the activities generate turbid area with TSS value about 0.005-0.013 kg/m^3 spreading on an area of 1.0 km^2 around the dredging site. The most turbid area (0,013-0,015kg/m^3) locates inside of the dredging area. This turbid water spreads to the south –eastern parts during flood tide stage (Figure 68) and south – southwestern parts during the ebb tide (Figure 69). However, the spatial difference between the tidal phases is not considerable. The concentration of sediment decreases outside of the dredging area and spatially homogenous. In this case, the west – northwestern part of Cu Lao Cau area and the southern site of Breda sandbar are not affected by dredging activities.

Compare to southwestern wind monsoon, impacts caused by dredging is smaller and the turbid water more likely moves southwestward compare to the northeastward direction in the rainy season. However, these influence on Cu Lao Cau area as well as Breda sandbar is negligible compare to the Vietnamese water on coastal water quality (QCVN 10: 2008/BTNMT) which is 0.05 kg/m^3.

To assess the fluctuation of sediment flux at various cross-sections of the study area (Figure 11) due to the dredging work, the calculation results of these cross-sections were analyzed. The results have revealed:

At Breda sandbar (Figure 72 – 73), the values of sediment concentration at V1 and V2 slightly increase during dredging work. At approximately 12 – 17 days after the accomplishment of dredging work, TSS value returns stable as current stage. This happens in both rainy and dry seasons.

Similarly, at west – northwestern site of Cu Lao Cau (V3, V4 and V5), impact of dredging on sediment content is trivial; difference in TSS values before, during and after dredging process is insignificant (Figure 74 – 76).

At eastern site of the dredging area (V6), the sediment content greatly increases during the dredging work with the variation between 0,005 - 0,012 kg/m^3. Yet, after completing, the concentration of sediment was found not different from current stage (Figure 77). Similar trends were observed at V7 (Figure 78).

At southeastern site of the dredging area (V8), the sediment content also increases greatly during the dredging work with the variation between 0,005 - 0,013 kg/m^3. After dredging, the concentration of sediment was found not different from current stage (Figure 79). Similar trends were observed at southwestern site of dredging area (Figure 80).

Consequently, the sediment content increases significantly during dredging period at areas nearby the dredging area with prevalent value between 0,005 - 0,013 kg/m^3 (lower than the National regulation for coastal water quality QCVN 10: 2008/BTNMT at 0,05 kg/m^3) and trivially affected surrounding area. At other areas, the impact on

TSS content due to dredging activities is not considerable. After completing, TSS value is not different from current stage.

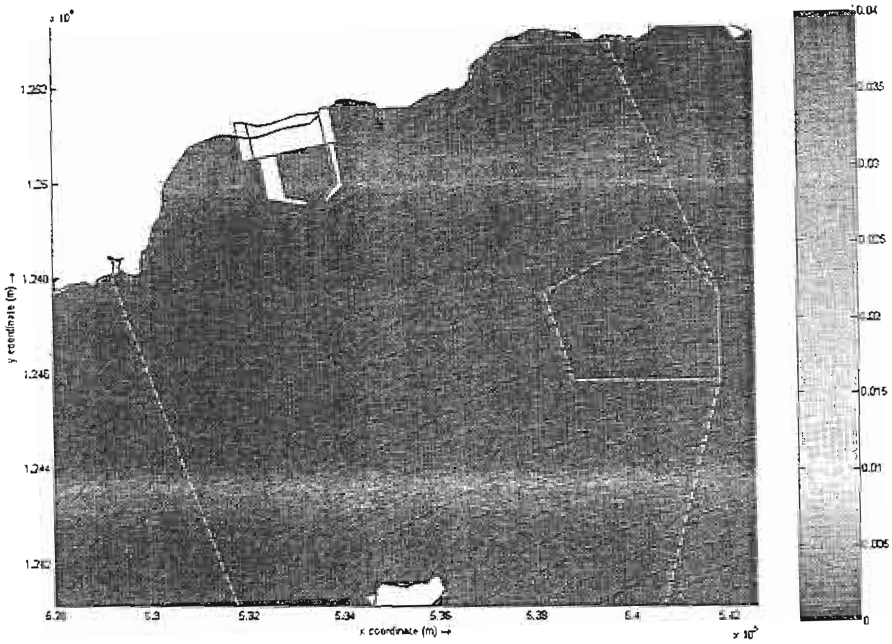


Figure 60. Distribution of Total Suspended Solid (TSS) (kg/m^3) at surface layer at Vinh Tan coastal area (southwest wind, flood tide – before dredging)

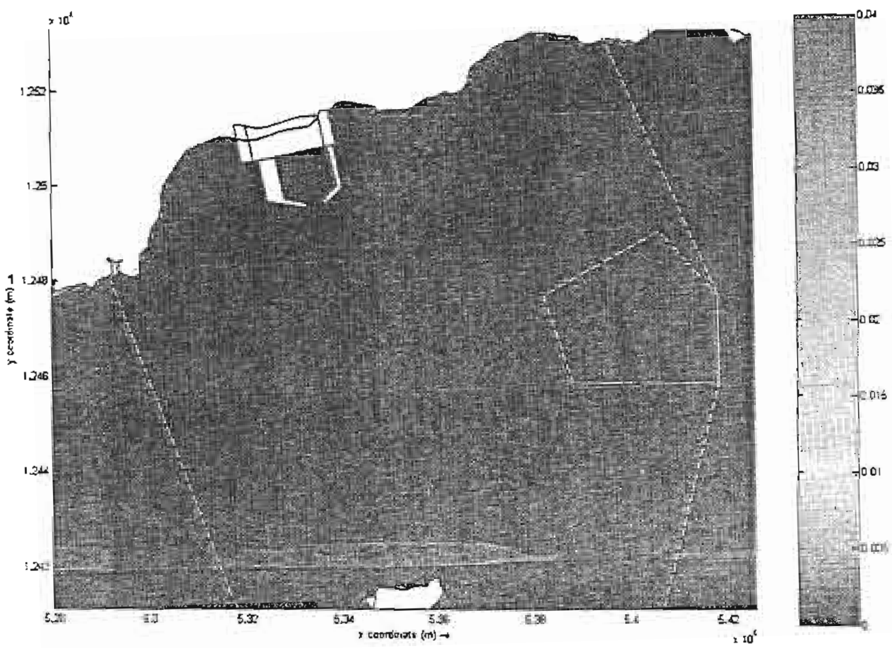


Figure 61. Distribution of TSS (kg/m^3) at surface layer at Vinh Tan coastal area (southwest wind, ebb tide – before dredging)

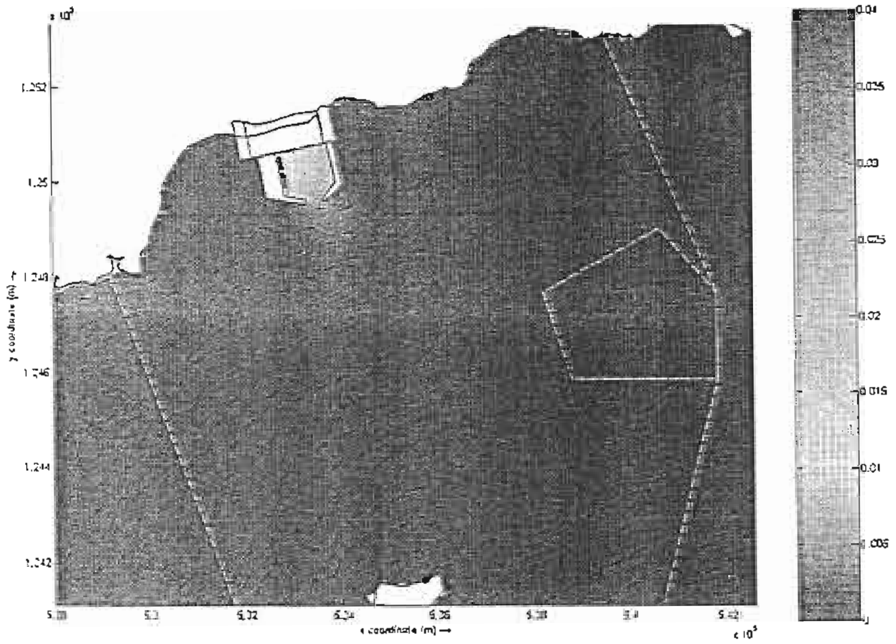


Figure 62. Distribution of TSS (kg/m^3) at surface layer at Vinh Tan coastal area (southwest wind, flood tide – during dredging)

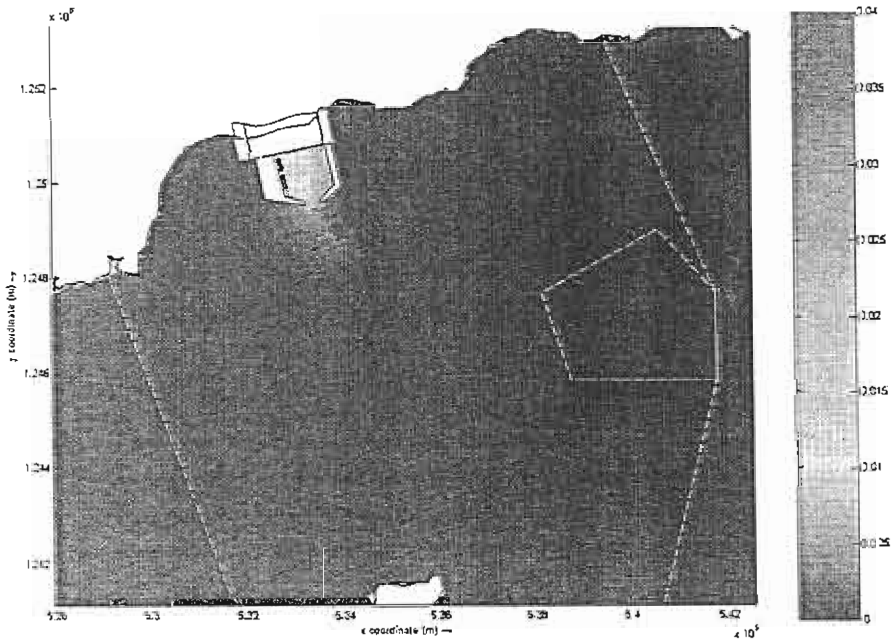


Figure 63. Distribution of TSS (kg/m^3) at surface layer at Vinh Tan coastal area (southwest wind, ebb tide – during dredging)

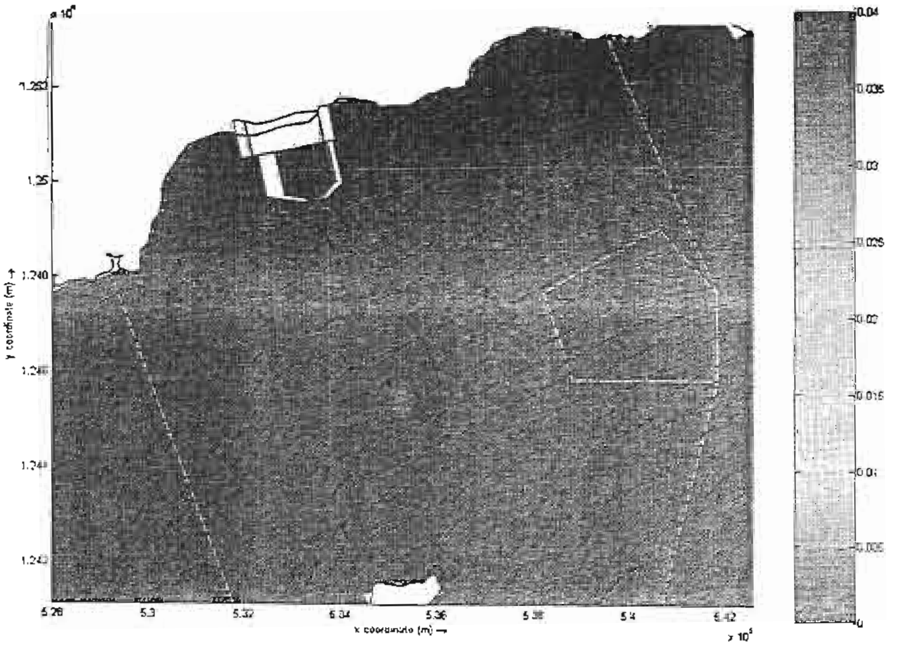


Figure 64. Distribution of TSS (kg/m^3) at surface layer at Vinh Tan coastal area (southwest wind, flood tide – after dredging)

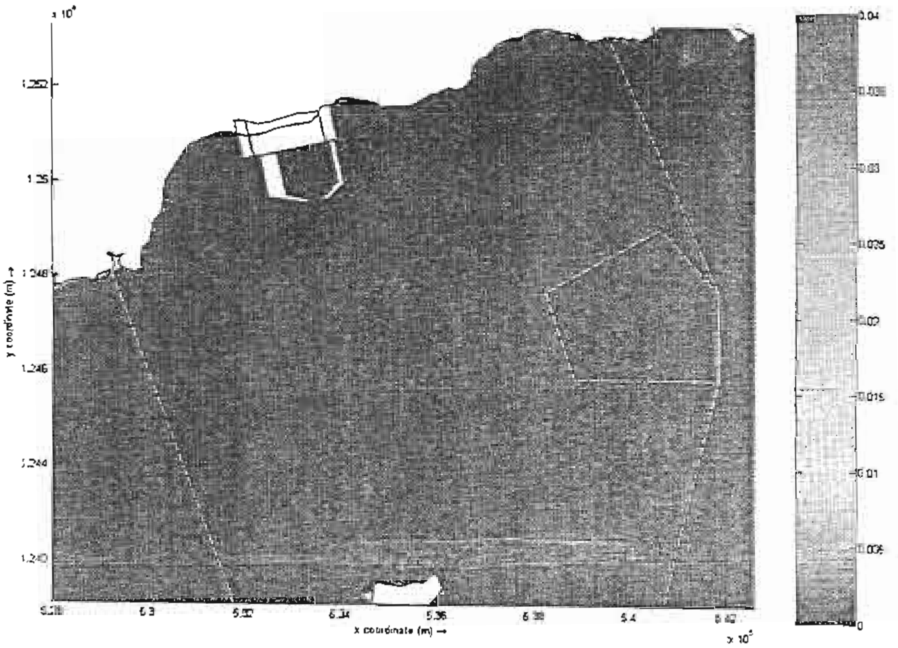


Figure 65. Distribution of TSS (kg/m^3) at surface layer at Vinh Tan coastal area (southwest wind, ebb tide – after dredging)

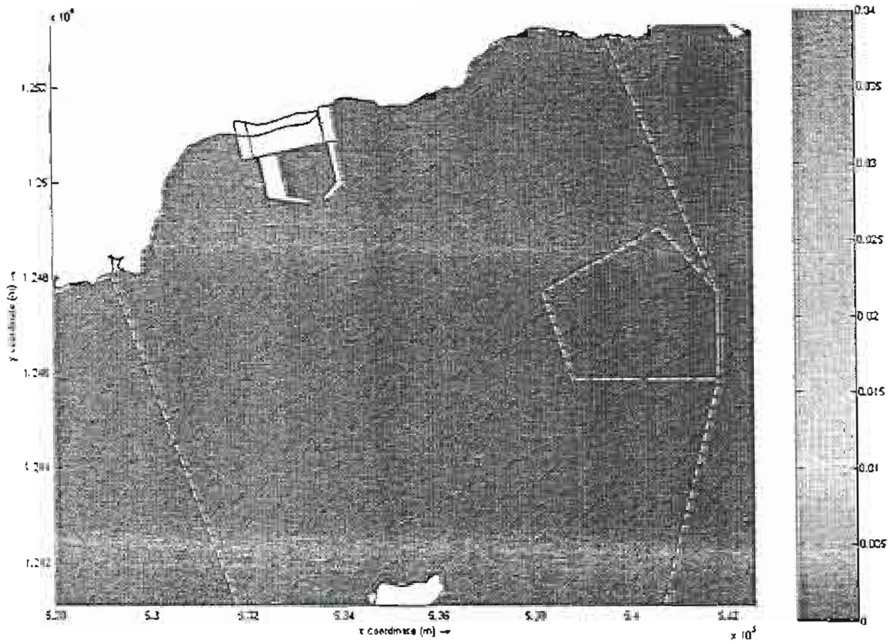


Figure 66. Distribution of TSS (kg/m^3) at surface layer at Vinh Tan coastal area (northeast wind, flood tide – before dredging)

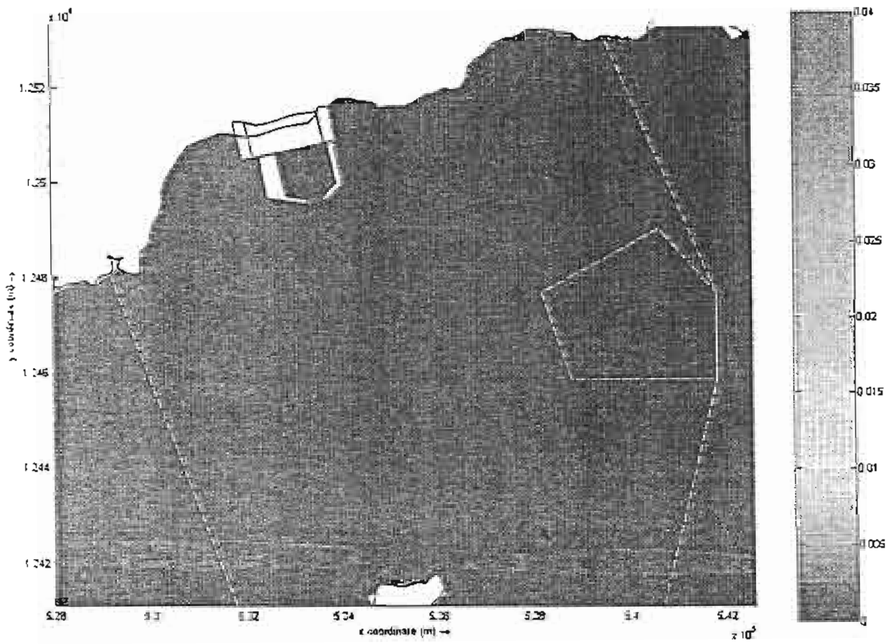


Figure 67. Distribution of TSS (kg/m^3) at surface layer at Vinh Tan coastal area (northeast wind, ebb tide – before dredging)

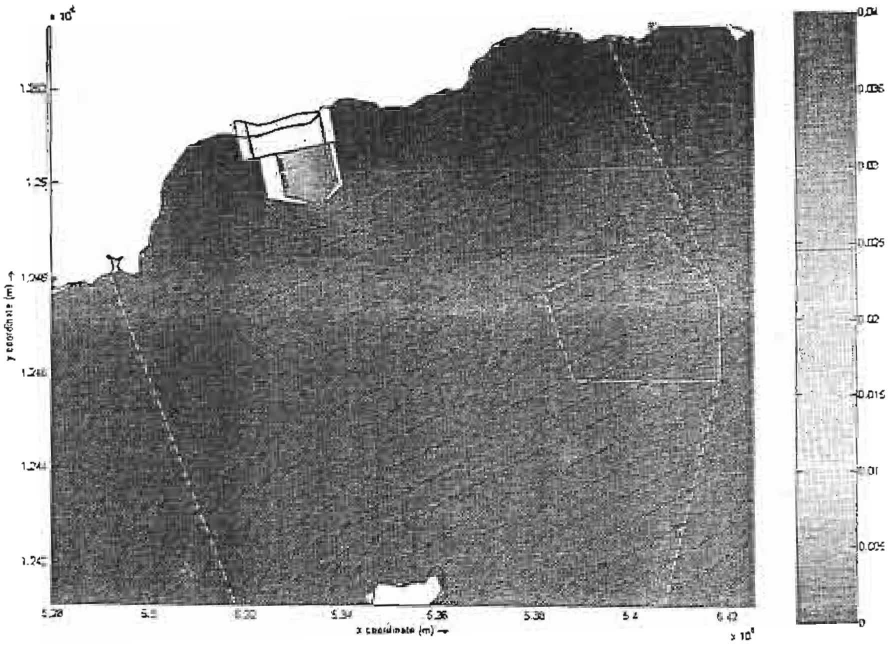


Figure 68. Distribution of TSS (kg/m^3) at surface layer at Vinh Tan coastal area (northeast wind, flood tide – during dredging)

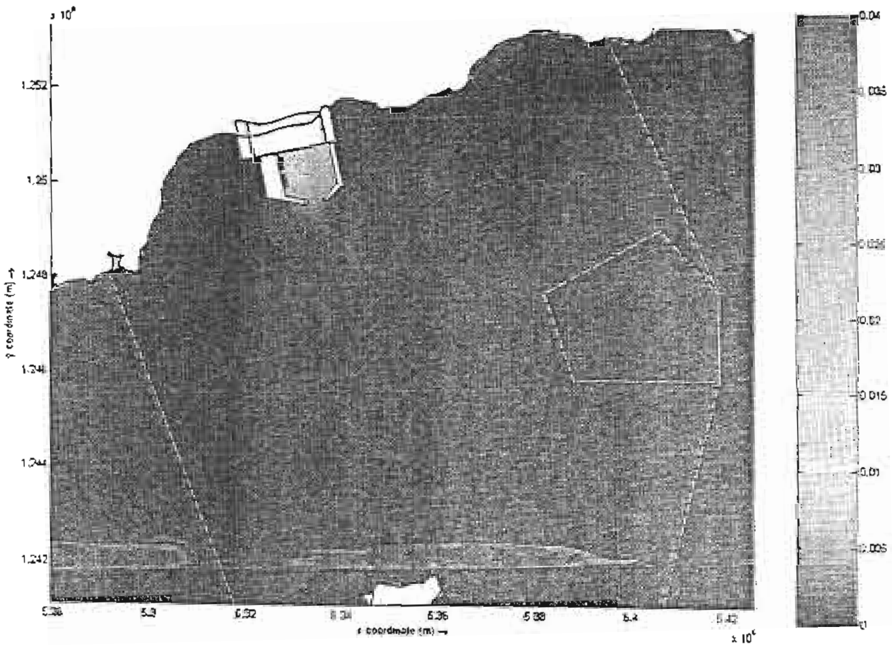


Figure 69. Distribution of TSS (kg/m^3) at surface layer at Vinh Tan coastal area (northeast wind, ebb tide – during dredging)

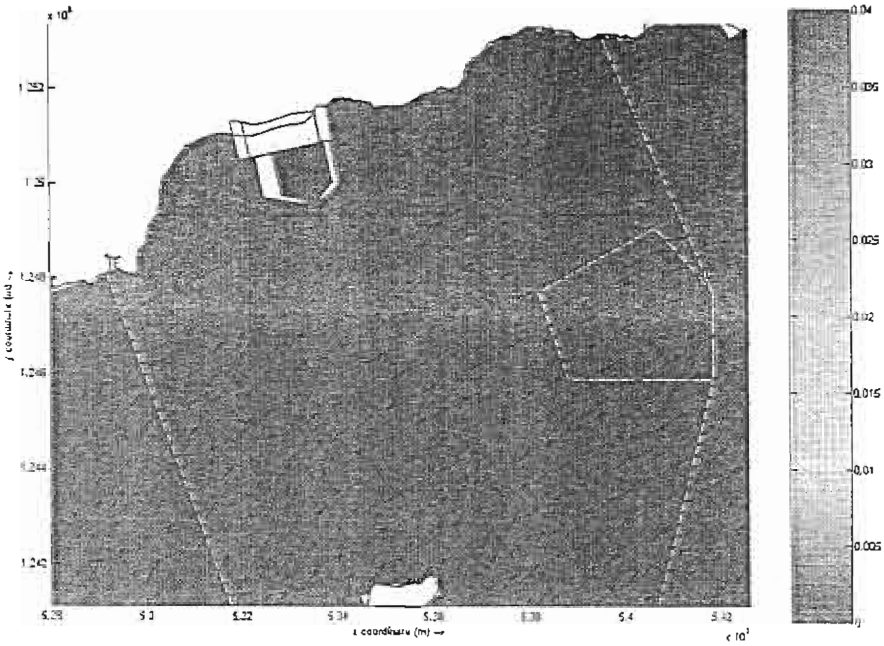


Figure 70. Distribution of TSS (kg/m^3) at surface layer at Vinh Tan coastal area (northeast wind, flood tide – after dredging)

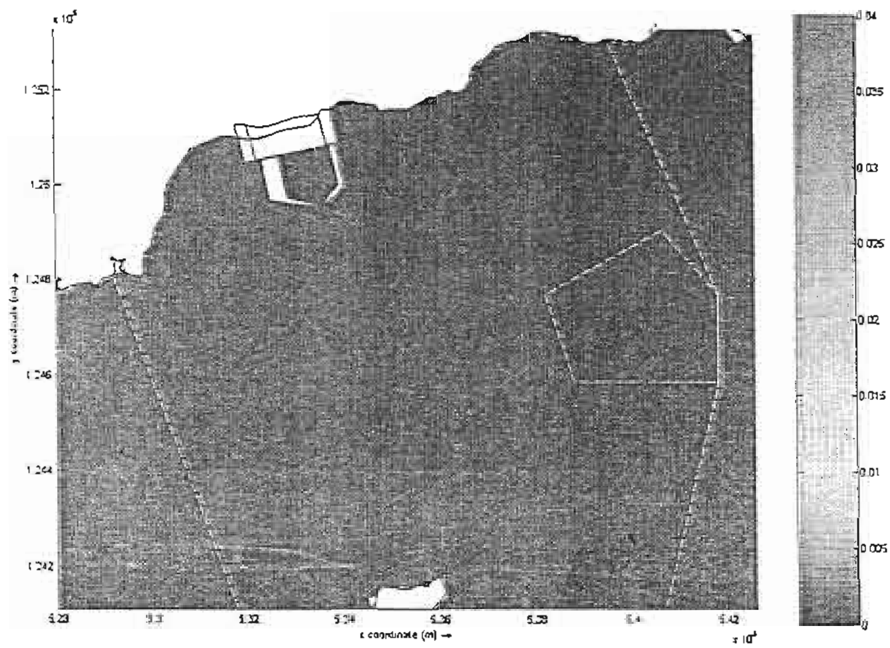
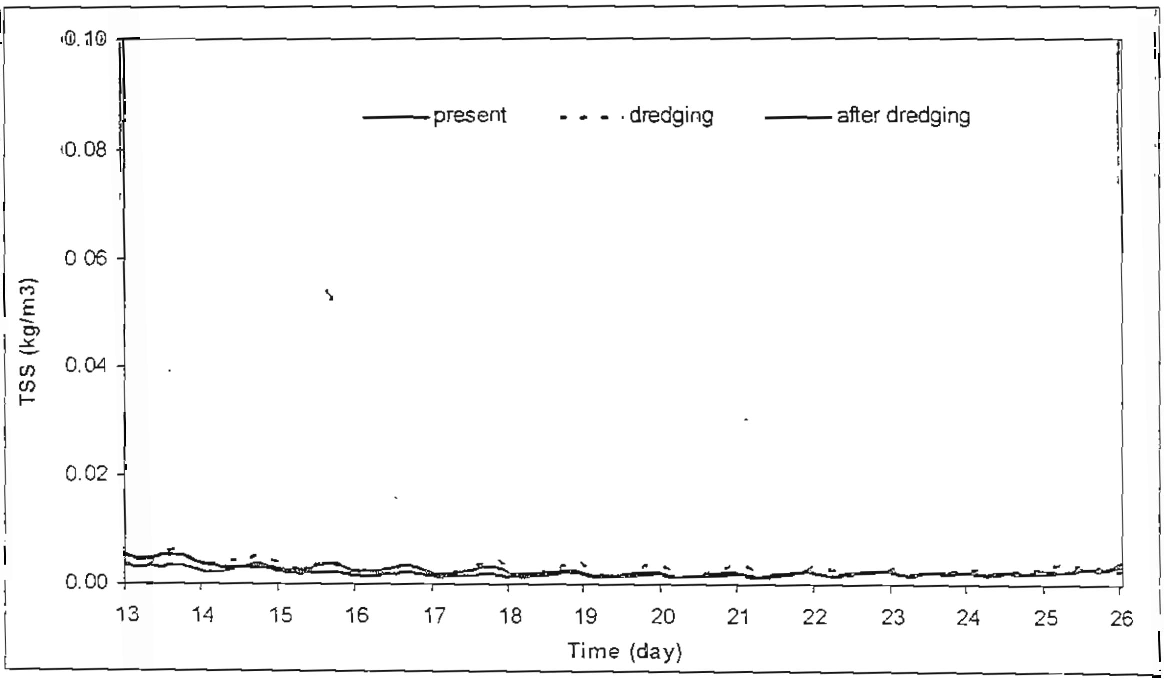


Figure 71. Distribution of TSS (kg/m^3) at surface layer at Vinh Tan coastal area (northeast wind, ebb tide – after dredging)



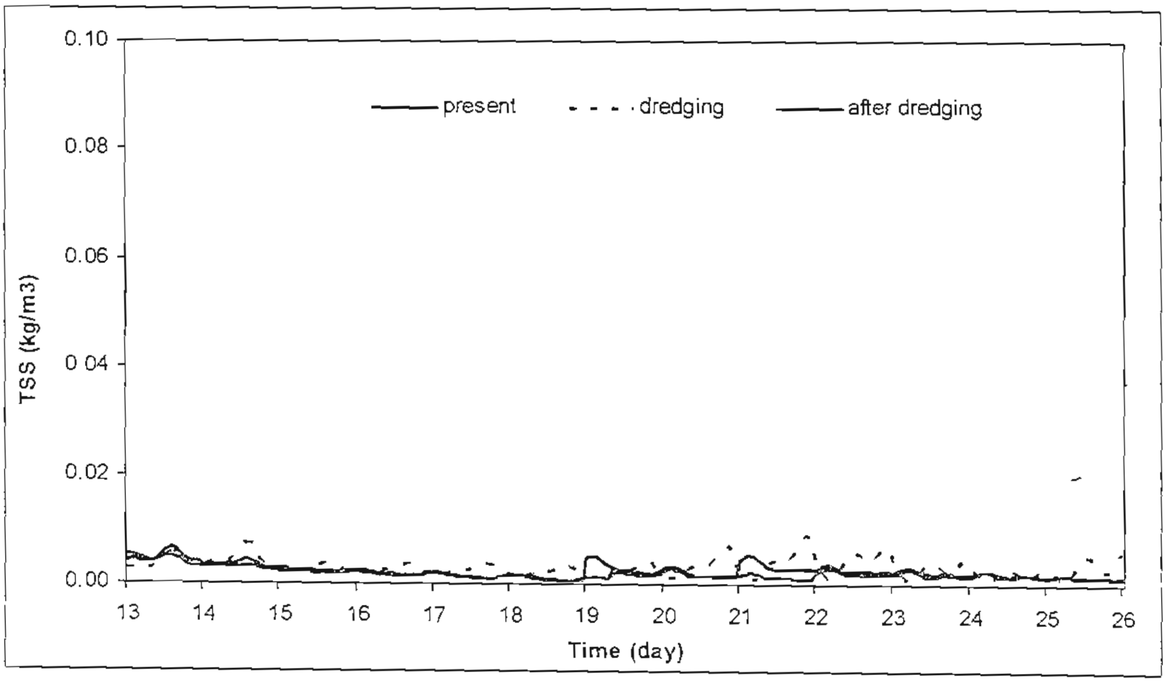
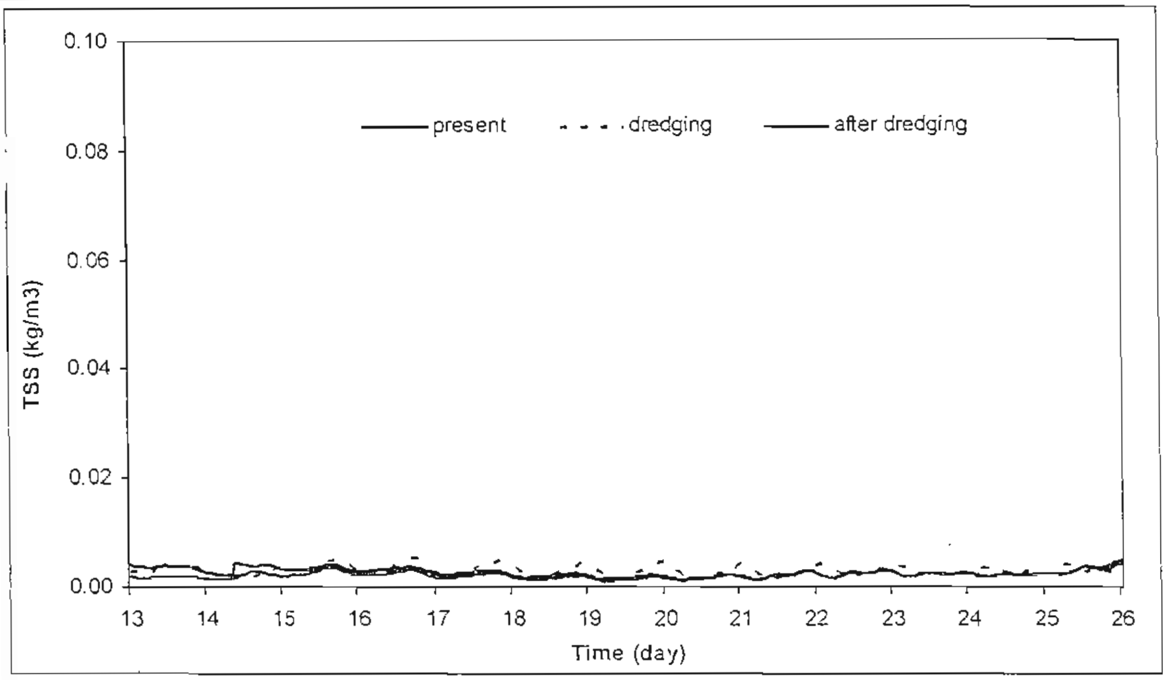


Figure 72. TSS content fluctuation (kg/m^3) at Breda sandbar (V1; a – rainy season; b- dry season)



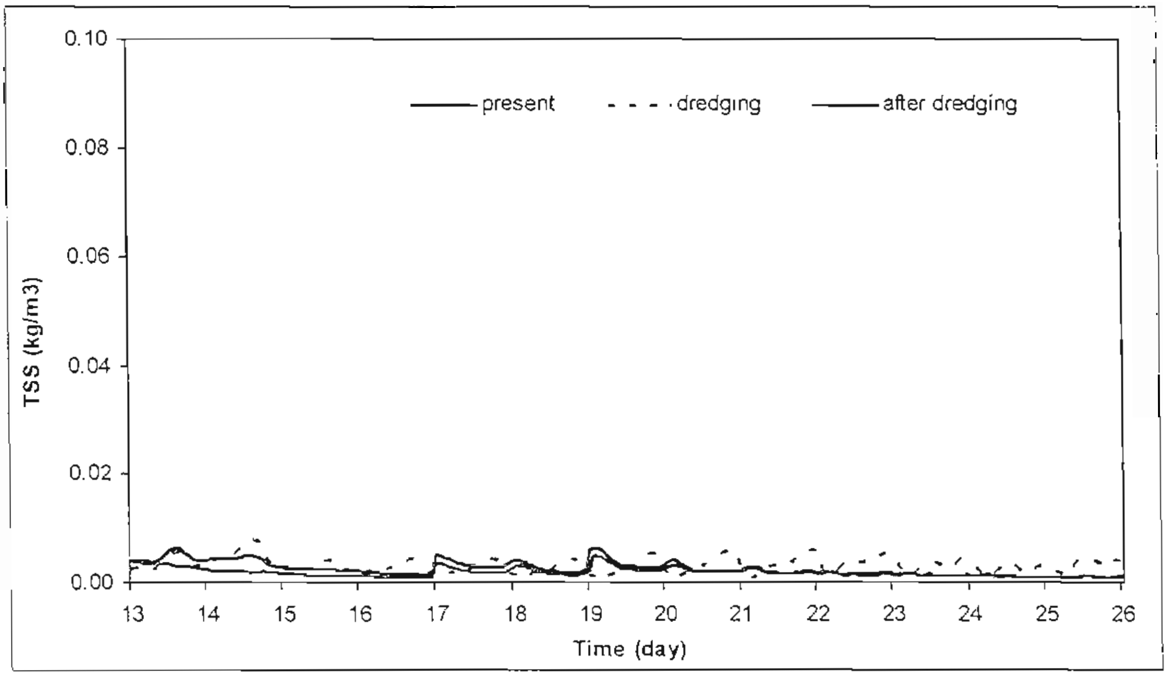


Figure 73. TSS content fluctuation (kg/m^3) at Breda sandbar (V2; a – rainy season; b-dry season)

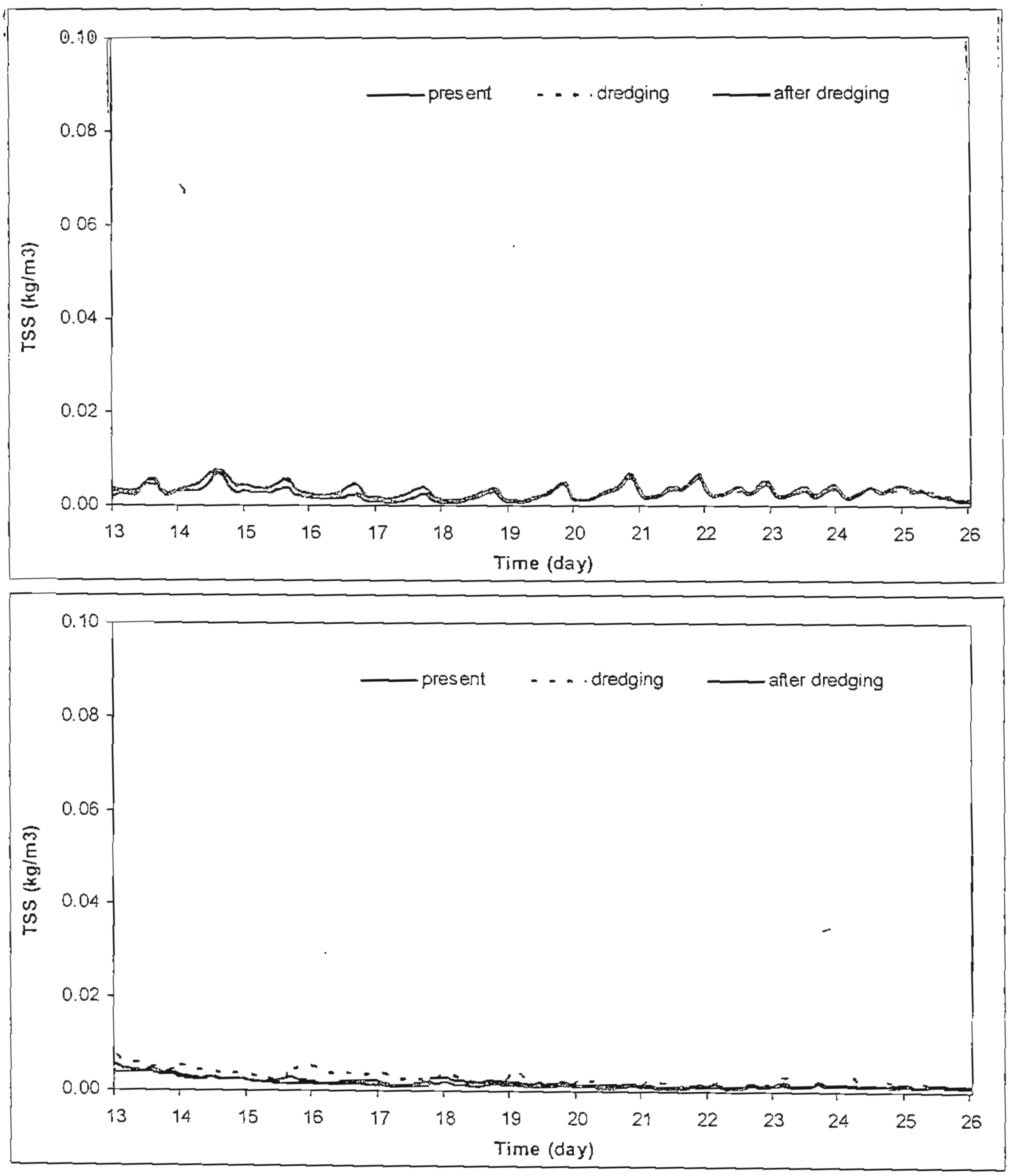
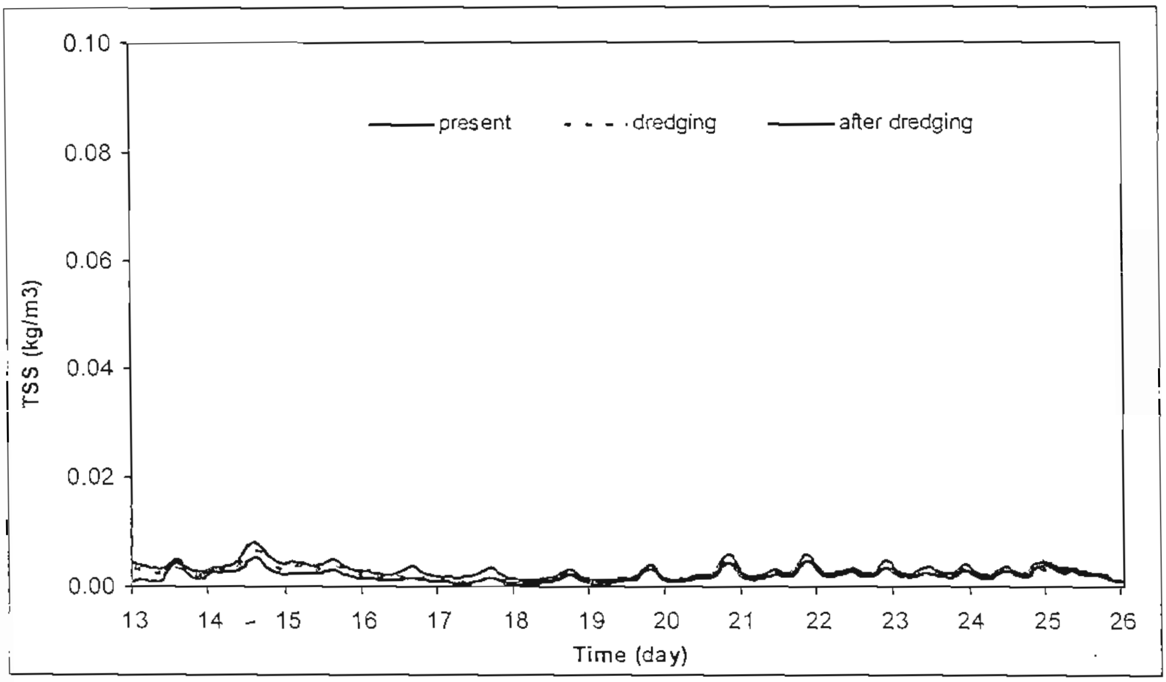


Figure 74. TSS content fluctuation (kg/m^3) at Cu Lao Cau area (V3; a – rainy season; b- dry season)



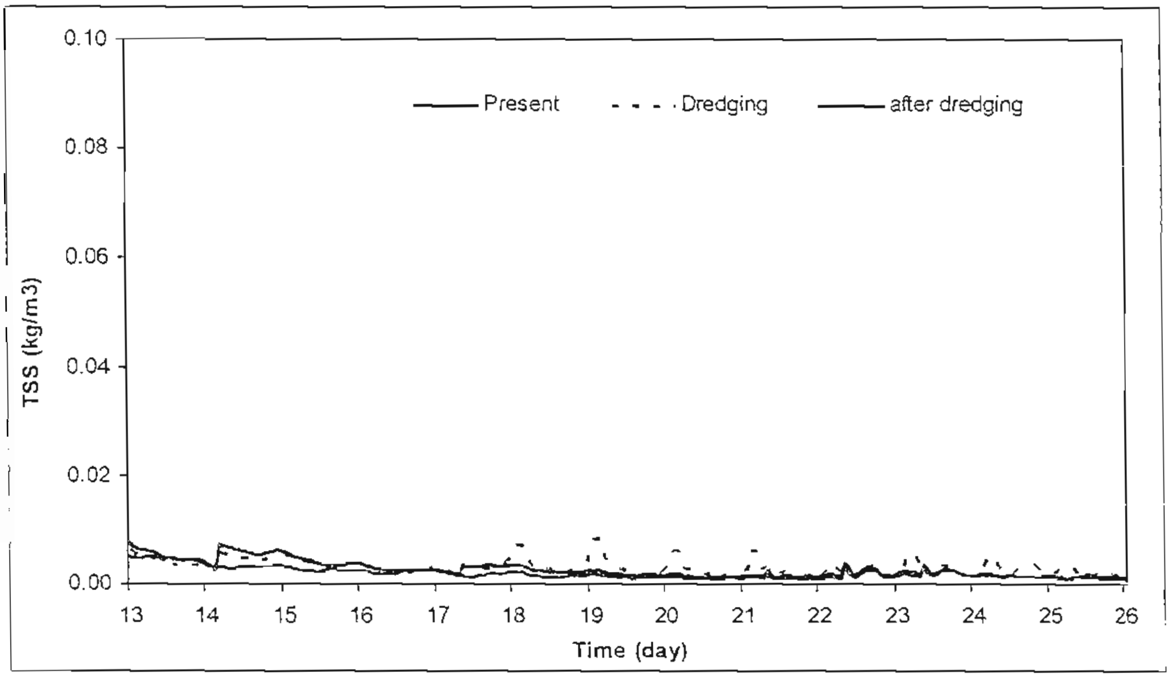
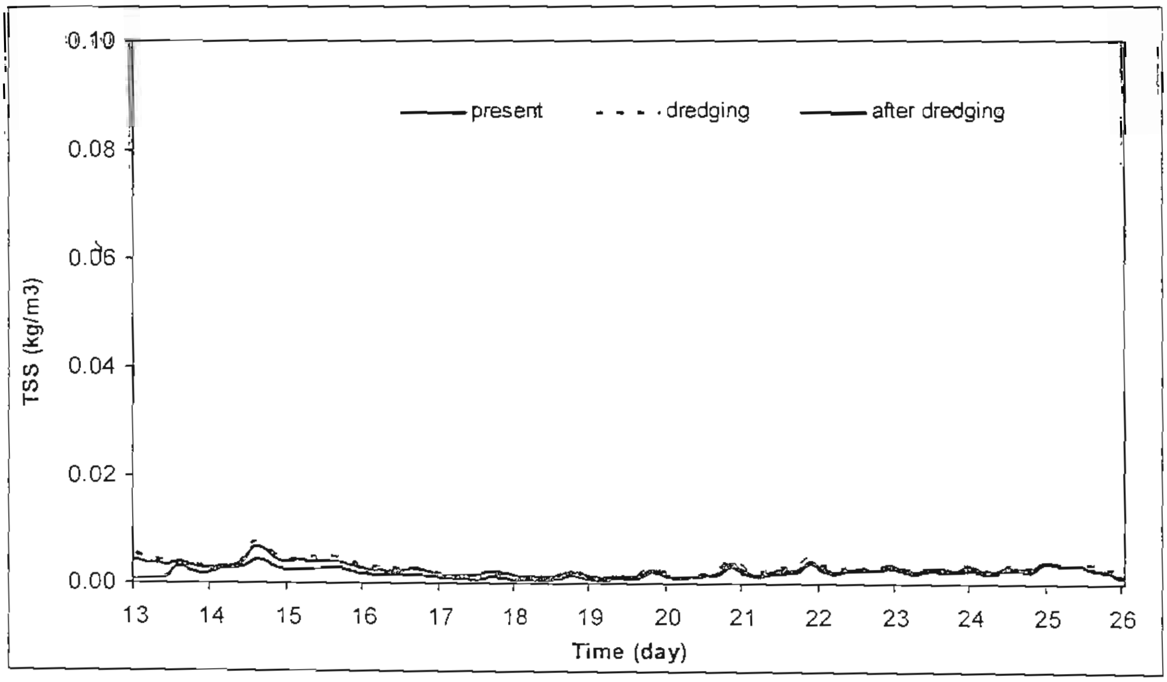


Figure 75. TSS content fluctuation (kg/m^3) at Cu Lao Cau area (V4; a – rainy season; b-dry season)



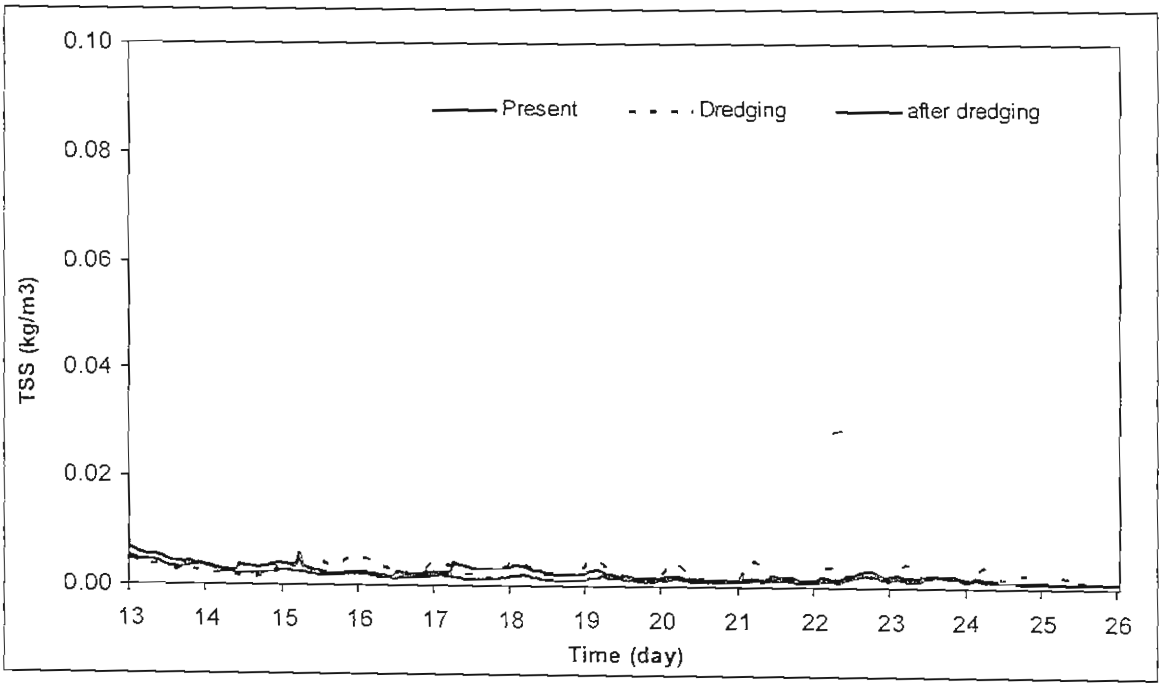


Figure 76. TSS content fluctuation (kg/m^3) at Cu Lao Cau area (V5; a – rainy season; b- dry season)

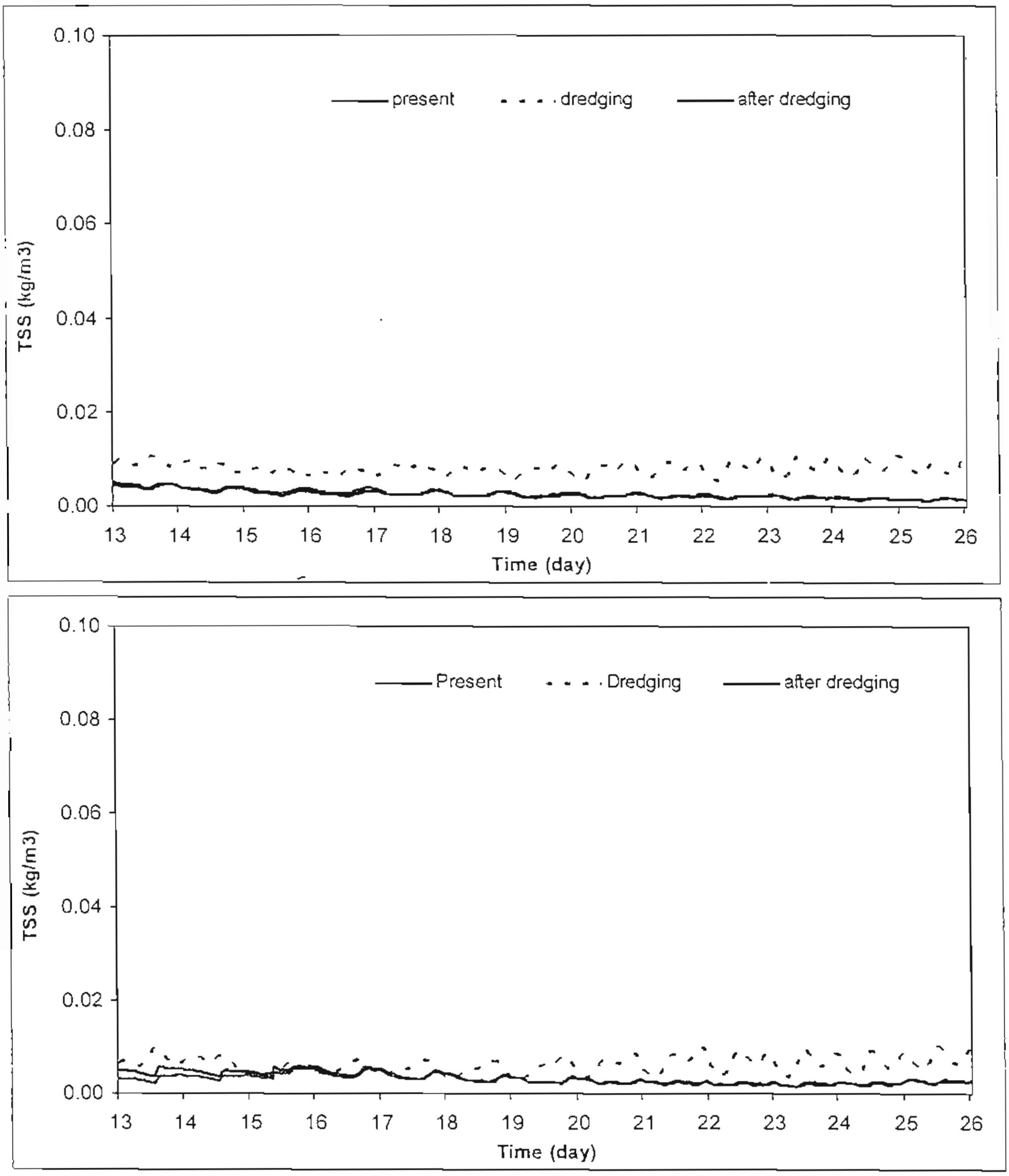


Figure 77. TSS content fluctuation (kg/m^3) at the eastern site of dredging area (V6; a – rainy season; b- dry season)

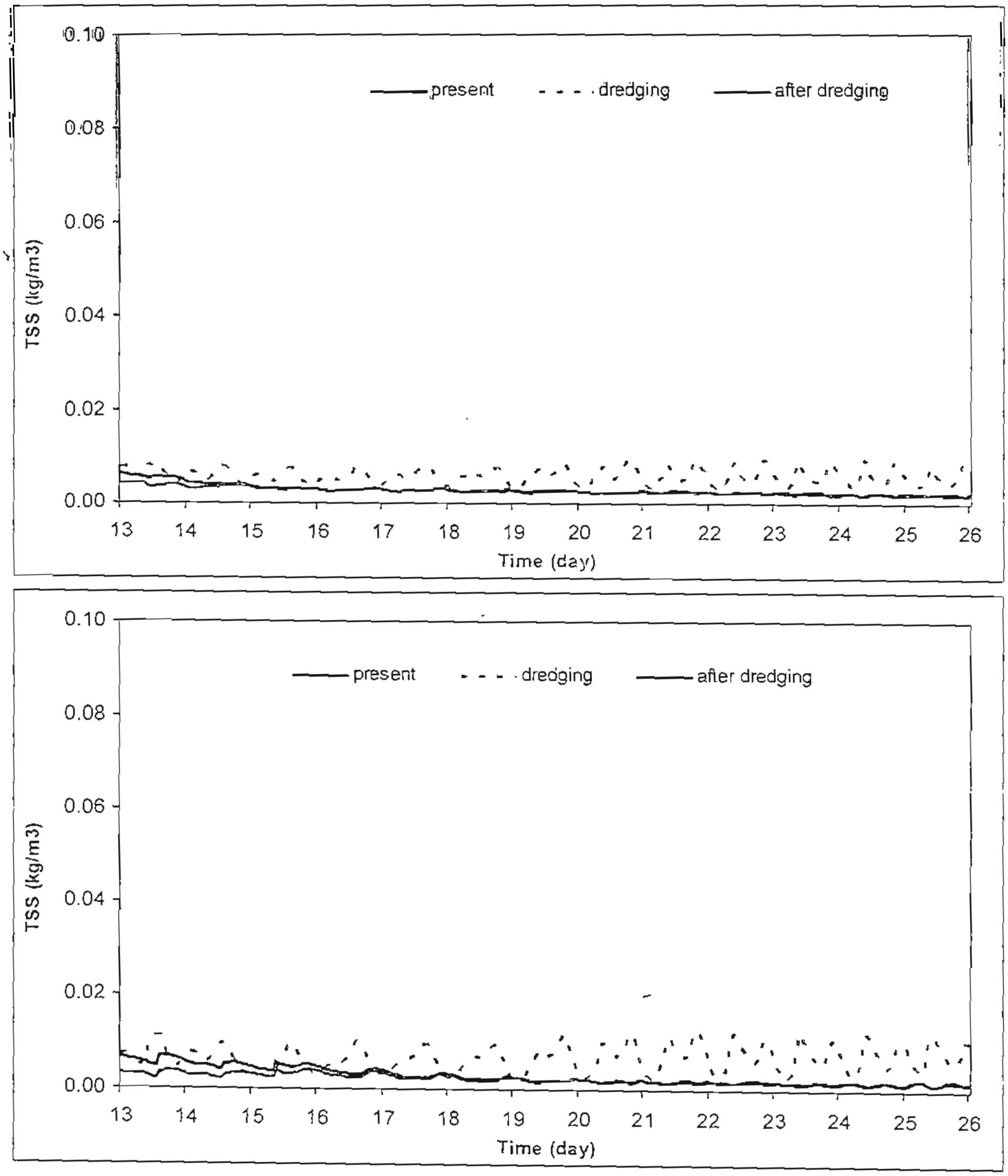
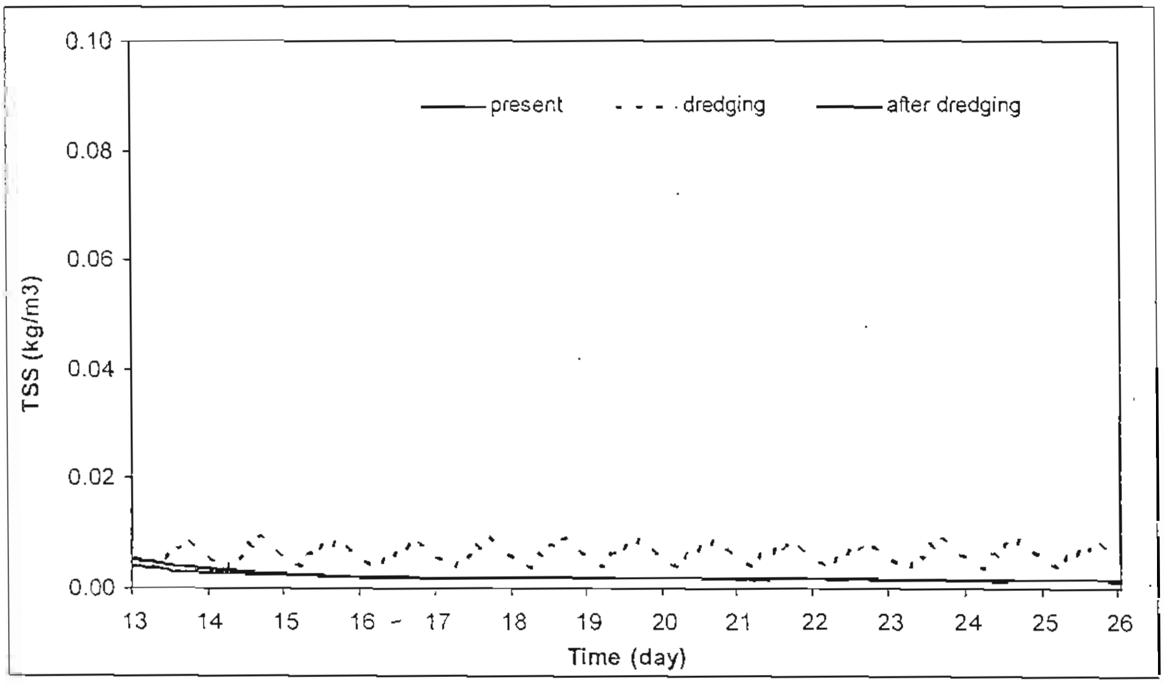


Figure 78. TSS content fluctuation (kg/m^3) at the eastern site of dredging area (V7; a – rainy season; b- dry season)



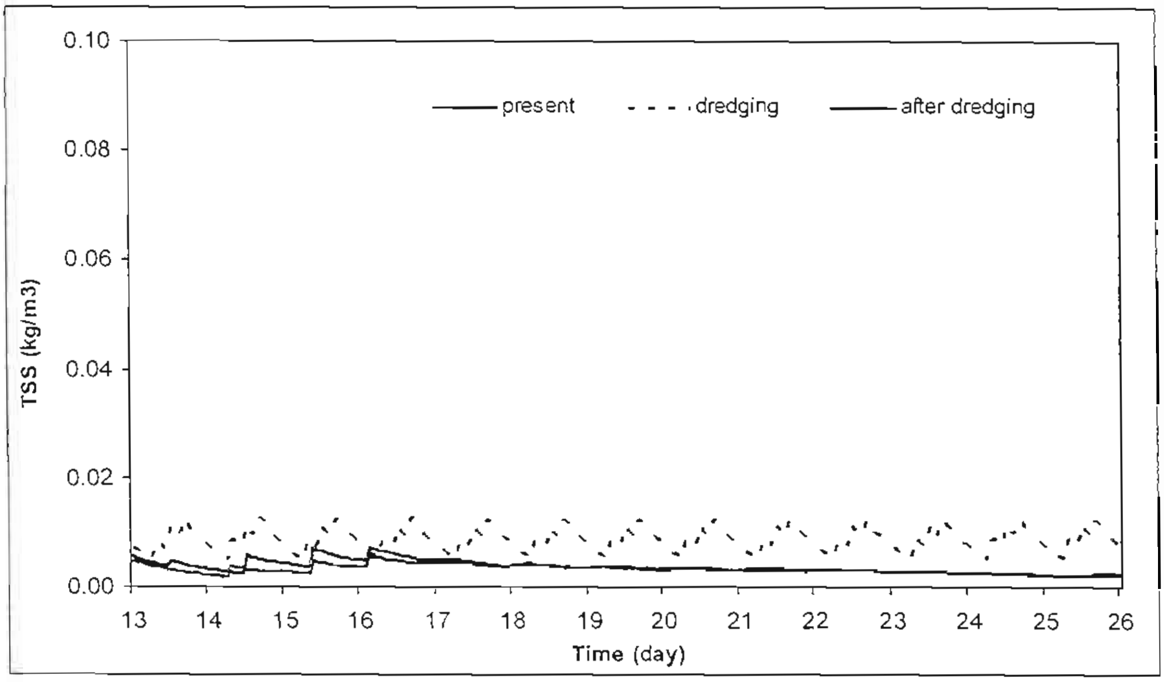
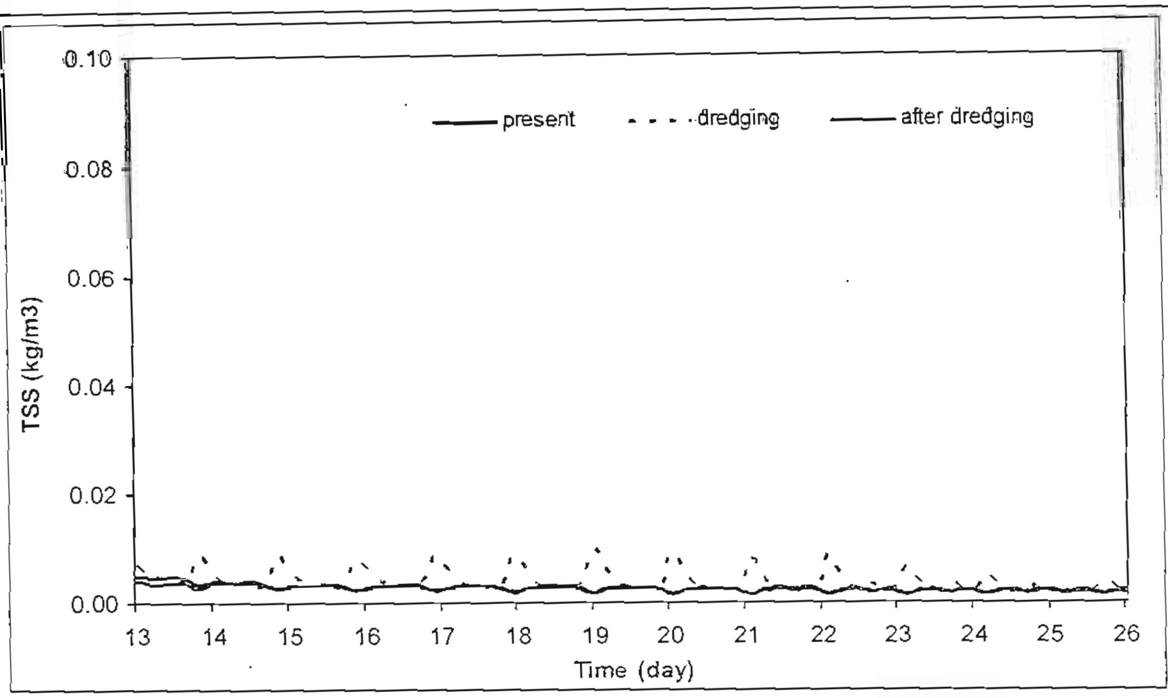


Figure 79. TSS content fluctuation (kg/m^3) at the southeastern site of dredging area (V8; a – rainy season; b- dry season)



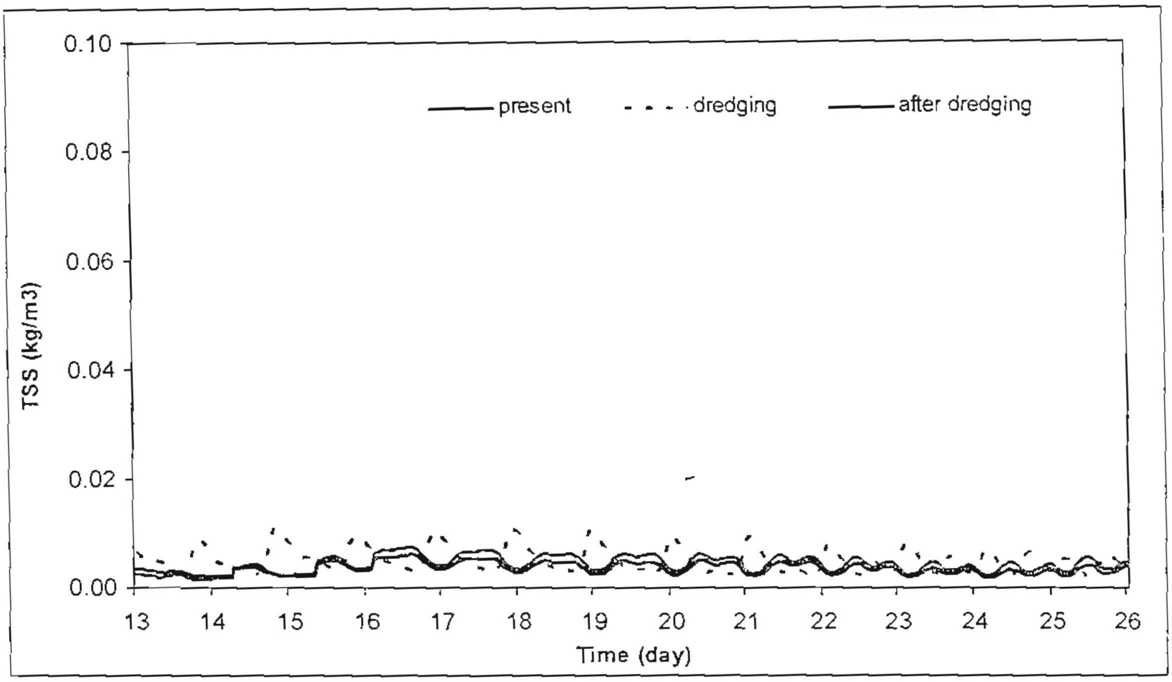


Figure 80. TSS content fluctuation (kg/m^3) at the southwestern site of dredging area (V9; a – rainy season; b- dry season)

Calculated results of sediment flux at cross - sections in the study area (Figure 11) reveal that the sediment in this area mostly moves alongshore. In southwest wind monsoon, the local sediment flux moves up (from southwest to northeast). Day-averaged sediments flux in rainy season at cross-sections, which are perpendicular with the coastline (VT1-VT4), fluctuates between 22.1-77.7 kg/day northeastward

(Table 7). Similar trend was found at cross- sections perpendicular with the northern shore (VT10) and southern shore (VT5). At the parallel cross-section with the coastline, sediment flux more likely moves offshore than the opposite direction: sediment flux at VT7 is about 13.8kg/day; while VT8 and VT6 have respectively 97.2 and 45.2 kg/day (Table 7).

Table 7. Average sediment flux (kg/day) at cross-sections in rainy season

Cross-section	Present			During dredging			After dredging		
	Up (out)	Down (in)	Average	Up (out)	Down (in)	Average	Up (out)	Down (in)	Average
VT1	557.8	-402.4	77.7-	571.5	-429.2	71.15	557.1	-401.8	77.7
VT2	432.0	-313.5	**59.2**	591.4	-455.0	**68.2**	427.2	-312.7	**57.3**
VT3	693.9	-604.7	**44.6**	692.3	-605.6	**43.35**	698.6	-608.2	**45.2**
VT4	164.8	-120.6	**22.1**	230.5	-146.8	**41.85**	167.5	-125.7	**20.9**
VT5	735.7	-695.5	**20.1**	737.5	-698.2	**19.65**	738.9	-696.8	**21.1**
VT6	-1390.1	1195.7	**-97.2**	-1395.3	1191.1	**-102.1**	-1397.8	1189.0	**-104.4**
VT7	-141.5	169.1	**13.8**	-169.8	190.9	**10.55**	-147.2	170.5	**11.7**
VT8	-327.7	237.3	**-45.2**	-411.2	289.0	**-61.1**	-328.4	239.5	**-44.5**
VT9	360.7	-492.0	**-65.7**	360.8	-492.6	**-65.9**	367.7	-495.1	**-63.7**
VT10	181.1	-83.1	**49.0**	179.5	-83.9	**47.8**	181.5	-85.6	**48.0**

Note: up – from south to north; out – from onshore to offshore.

In northeast wind monsoon, the sediment flux likely moves down to the southwest more than moving up to the northeast). Day-averaged sediments flux in dry season at cross-sections, which are perpendicular with the coastline (VT1-VT4), fluctuates between 0.48 - 35.2 kg/day northeastward. The absolute and average values in dry season are relatively lower than that in rainy season (Table 8). Similar trend was found at cross- sections perpendicular with the northern shore (VT10) and southern shore (VT5) of Vinh Tan coastal area in rainy season. At the parallel cross-section with the coastline, sediment flux tends to move toward the cross-section VT7 (4.8 kg/day) and VT8 (4.2 kg/day) yet away from VT6 (42.6 kg/day).

Table 8. Average sediment flux (kg/day) at cross-sections in dry season

Cross-section	Present			During dredging			After dredging		
	Up (out)	Down (in)	Average	Up (out)	Down (in)	Average	Up (out)	Down (in)	Average
VT1	11.4	-15.2	**-1.9**	98.3	-172.0	**-36.9**	11.7	-15.7	**-2.0**
VT2	8.2	-12.1	**-2.0**	102.5	-116.1	**-6.8**	7.2	-11.6	**-2.2**
VT3	60.0	-130.3	**-35.2**	142.5	-275.3	**-66.4**	60.1	-133.4	**-36.7**
VT4	4.52	-5.48	**-0.48**	15.2	-13.1	**1.1**	4.3	-4.9	**-0.3**
VT5	80.09	-129.89	**-24.90**	95.4	-133.6	-19.1	89.6	-128.3	**-19.4**
VT6	-403.54	318.44	**-42.55**	302.5	-389.3	**-43.4**	-405.7	315.6	**-45.1**
VT7	-66.67	76.35	**4.84**	-67.7	74.2	**3.3**	-67.8	78.1	**5.2**
VT8	-14.05	22.49	**4.22**	-17.1	244.5	**113.7**	-13.9	22.7	**4.4**
VT9	35.26	-44.49	**-4.62**	43.7	-55.1	**-5.7**	37.2	-44.5	**-3.7**
VT10	10.64	-22.08	**-5.72**	18.9	-40.8	**-11.0**	10.8	-21.9	**-5.6**

Note: up – from south to north; out – from onshore to offshore.

Influence of dredging activities on sediment transport conditions

In rainy season, dredging activities cause increase in sediment flux at perpendicular cross-section (VT1, VT2, VT3 and VT4) implying the increase of suspended sediment content during the dredging period (Table 7). The similar tendency was found at perpendicular cross-sections, which are far from the dredging area (VT5 and VT10).

At cross - sections parallel with the coastline, sediment flux stays stable at VT6, and greatly increases toward the offshore at VT7, VT8 (Table 7).

In dry season, dredging activities at Vinh Tan coastal area also cause increasing of sediments flux to surrounding areas. Sedimentation flux strongly increases compare to the present stage, especially at cross-section VT1 (average moving-down sediment flux is about 36.9 kg/day compare to 1.9 kg/day at present). At other cross-sections, which are further from dredging area, the sediment flux also increases but at lower extent compare to areas around the dredging site. At shore-parallel cross-sections, the sediment flux increases significantly at VT6, and the absolute value increases slightly at VT7, VT8 (Table 8). Consequently, during dredging process, the sediment flux disperses strongly to the surrounding area; yet in dry season, the flux more likely moves southwestward.

Influence after the accomplishment of dredging process

After completing dredging activities, some small changes of sediment flux at shore parallel and perpendicular cross-sections were found. However, these variations are too small to express as a clear tendency in both rainy (Table 7) and dry seasons (Table 8). Therefore, these variations of sediment flux at Vinh Tan coastal area after dredging are expected not significantly impact local erosion – sedimentation pattern.

The influences on erosion – deposition happening in near the construction

In order to assess the impacts of dredging activities and the construction on erosion-deposition pattern of Vinh Tan coastal area, apart from sediment flux, some monitoring points were added to evaluate the erosion – sedimentation at areas at northeastern shore and southwestern shore of the Vinh Tan port (Figure 81).

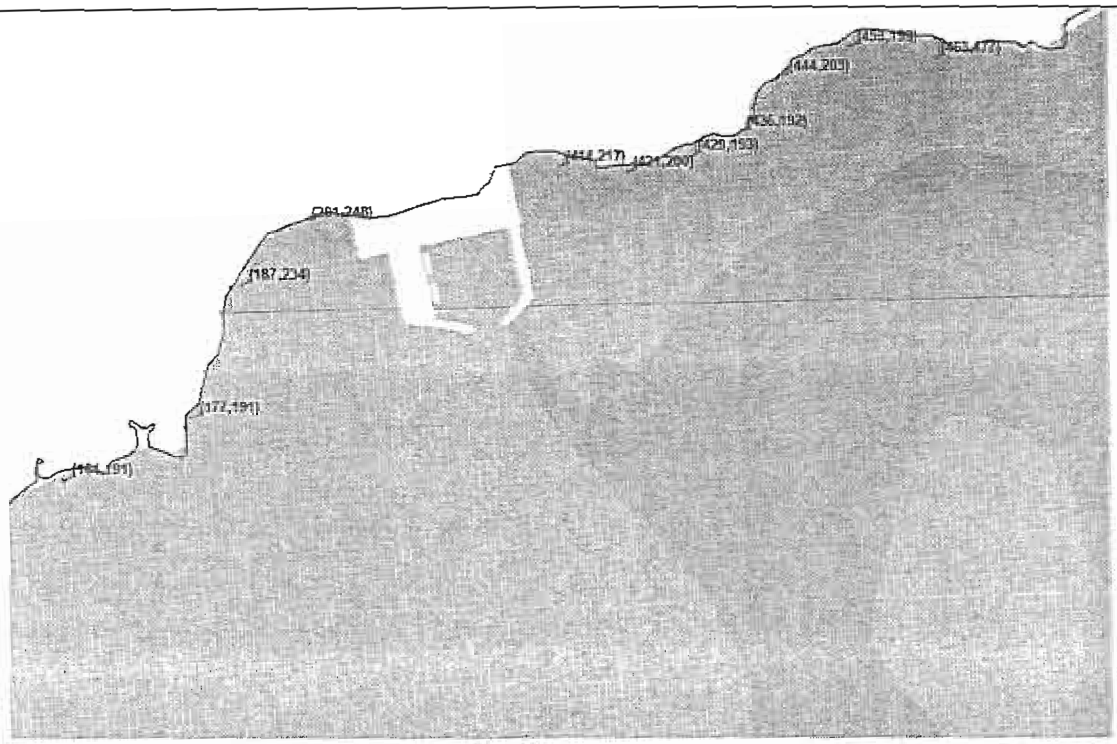


Figure 81. Position of monitoring points for erosion – deposition assessment

The calculation results reveal that monthly fluctuation of erosion – sedimentation at the study area is relatively small and seasonal. The current average erosion rate at areas nearby the construction site varies from 0.0115 - 0.04982 m/month while the average deposition rate differs between 0.00517 - 0.03103 m/month. At coastal points from B1 to B9, erosion tends to occur in rainy season due to direct impact from wave direction induced by southwestern wind. However, in northeast monsoon season, as southwest wind gets weaker and northeast wind gets stronger, slight erosion tends to occur at B1-B7 (Table 9). At B10 and B11, sedimentation occurs in rainy season and erosion in dry season. Meanwhile, at B8 and B9, slight erosion occurs in both rainy and dry season (Table 9).

Table 9. Average erosion – deposition rate (m/month) at some palace nearby the dredging place

Position		Scenario					
		Present		During dredging		After dredging	
Name	Coordinates (m,n)	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season
B1	463, 177	-0.01965	0.01230	-0.01965	0.01230	-0.01965	0.01230
B2	453,199	-0.02167	0.01353	-0.02161	0.01353	-0.02166	0.01354

B3	444,203	-0.03271	0.00405	-0.03270	0.00403	-0.03271	0.00406
B4	436,192	-0.03711	0.00480	-0.03712	0.00484	-0.03710	0.00484
B5	429,193	-0.04343	0.01019	-0.04346	0.01021	-0.04345	0.01018
B6	421,200	-0.04034	0.00517	-0.04030	0.00518	-0.04034	0.00517
B7	414,217	-0.04982	0.01032	-0.04980	0.01033	-0.04984	0.01030
B8	201,248	-0.01150	-0.00329	-0.01143	-0.00330	-0.00115	-0.00325
B9	187,234	-0.04586	-0.02017	-0.04471	-0.02013	-0.04588	-0.02019
B10	177,191	0.03103	-0.01302	0.03105	-0.01302	0.03102	-0.01302
B11	164,191	0.02474	-0.01215	0.02474	-0.01211	0.02476	-0.01215

Note: Minus (-) express erosion tendency

Impacts of dredging process on erosion - deposition rate are small owing to short implementation time. The results show that rate of erosion - deposition slightly increase at some places which are close to the dredging area (B6, B7, B8 and B9) compare to the present. The main reason is because suspended sediment is moved up before spreading to the surrounding areas. At other places, erosion – deposition expresses no clear pattern because of trivial impact (Table 9).

After dredging process, small impacts were observed on erosion – deposition pattern of Vinh Tan coastal area. However, these impacts are too small to express a clear trend (Table 9).

7. Conclusion and recommendation

Hydrodynamic conditions of Vinh Tan coastal zone are affected by factors such as water level oscillation, wind and wave activities. Current velocity in the study area has a prevalent value between 0.1-0.3 m/s. Current field as well as wave fluctuate following sea level oscillation and direction of the wind field. Modelling results reveal that dredging activities hardly have significant effects on the hydrodynamics, wave pattern in the study area. After dredging process, the hydrodynamics and wave condition at places far from the dredging area mostly stay unchanged compare to present stage. On the other hand, at areas nearby the dredging site, current velocity, wave height slightly decrease compare to that at present. These impacts are positive for the sediment transport as well as erosion - deposition pattern at the area.

Recent researches on erosion-deposition in the study area show that erosion in Phuoc The and Lien Huong coastline are caused by combined affect of hydrodynamics, sediment transport and human activities. In which, the main cause is natural factor due to high slop bathymetry of this area which subsequently leads to the loss of sediment in near the coastline moving offshore without making up.

The characteristics of sediment transport in the coastal zone of Binh Thuan as well as Vinh Tan have integrated impact from hydrodynamic condition including wave. The sediment flux mostly moves alongshore and the direction alters between rainy and dry seasons. Particularly, sediment flux at cross-sections in rainy season is higher than that in dry season.

Dredging activities in the study area increase the turbidity of water around dredging area. However, highly turbid water accounts for only a small area alongside Vinh Tan coastline and no significant impact was found at Breda sandbar and Cu Lao Cau coastal area. After dredging process, impacts on dredging activities on the local turbidity is almost negligible.

Dredging activities increase the sediment flux alongshore and from the outside of some cross-sections to the offshore. However, after dredging process, variation pattern of sediment flux does not change significantly.

Result from assessment of the impact of dredging work on erosion – sedimentation rate at some positions alongshore reveals that impacts occurs mostly around the dredging area. Also, these impacts are too small to generate any clear trend.

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APPENDIX 3.3
AIR DISPERSION MODELING

1. Modeling

The modelling used to calculate air dispersion of thermal power plant is AERMOD View. The AERMOD atmospheric dispersion modeling system is an integrated system that includes two modules:

- A steady-state dispersion model designed for short-range (up to 50 kilometers) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data preprocessor (AERMET) that accepts surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.

AERMOD also includes PRIME (Plume Rise Model Enhancements) which is an algorithm for modeling the effects of downwash created by the pollution plume flowing over nearby buildings.

2. Calculation basic

Atmospheric dispersion modeling is the mathematical simulation of how air pollutants disperse in the ambient atmosphere. The Gaussian plume model (e.g., AUSPLUME, ISCST3, Aermod…) is the most commonly developed air dispersion model. It is the base of developing most dispersion calculations for the continuous pollution source in the uniform dispersion field (Arya, 1999). Figure 3.1 shows the approach of a typical point source pollution dispersion in the Gaussian plume modeling. It can be observed from the figure the bell-shaped distribution of the pollution plume is the same in every direction in the three dimensional space.

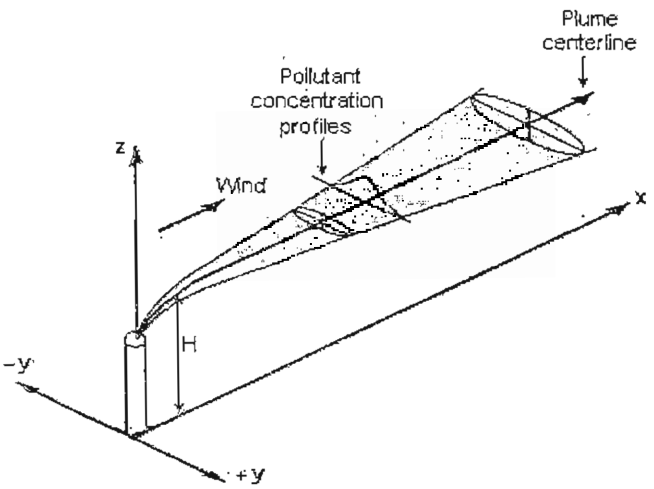


Figure 3.1. A typical plume from an elevated point source in the Gaussian plume modeling

$$C(x,y,z,H)=\frac{Q}{2\pi U\sigma_y\sigma_z}\times\exp\left[-0.5\left(\frac{y}{\sigma_y}\right)^2\right]\times\left[\exp\left[-0.5\left(\frac{z-h}{\sigma_z}\right)^2\right]+\exp\left[-0.5\left(\frac{z+H}{\sigma_z}\right)^2\right]\right]$$

where:

- C(x,y,z, H) – the steady-state concentration at a specific point (x,y,z) (g/m^3).
- Q – emission rate of pollutant (g/s).
- δy và δz – horizontal and vertical standard deviations of plume concentration, which is the function of x.
- U – average wind speed at stack height (m/s).
- y – horizontal distances from plume centerline (m).
- z – vertical distance from ground level (m).
- H – effective stack height (m).

Formula used in Gaussian plume models was derived from the assumption that the whole field where the pollutant disperses is in 'steady-state' condition. Some limitations originally existed because of this assumption (New Zealand National Institute of Water and Atmospheric Research, 2004). For example, when calculating each hour's concentration (most of the Gaussian models calculate concentration for each single hour), it excludes the effect of contaminants of previous hours. Due to limitations, this kind of model can be used under situations where the topography is relatively flat without complicated terrain as hills, rivers, or bumps; the meteorology is "simple", i.e., pretty uniform in spatiality, and without many calm conditions.

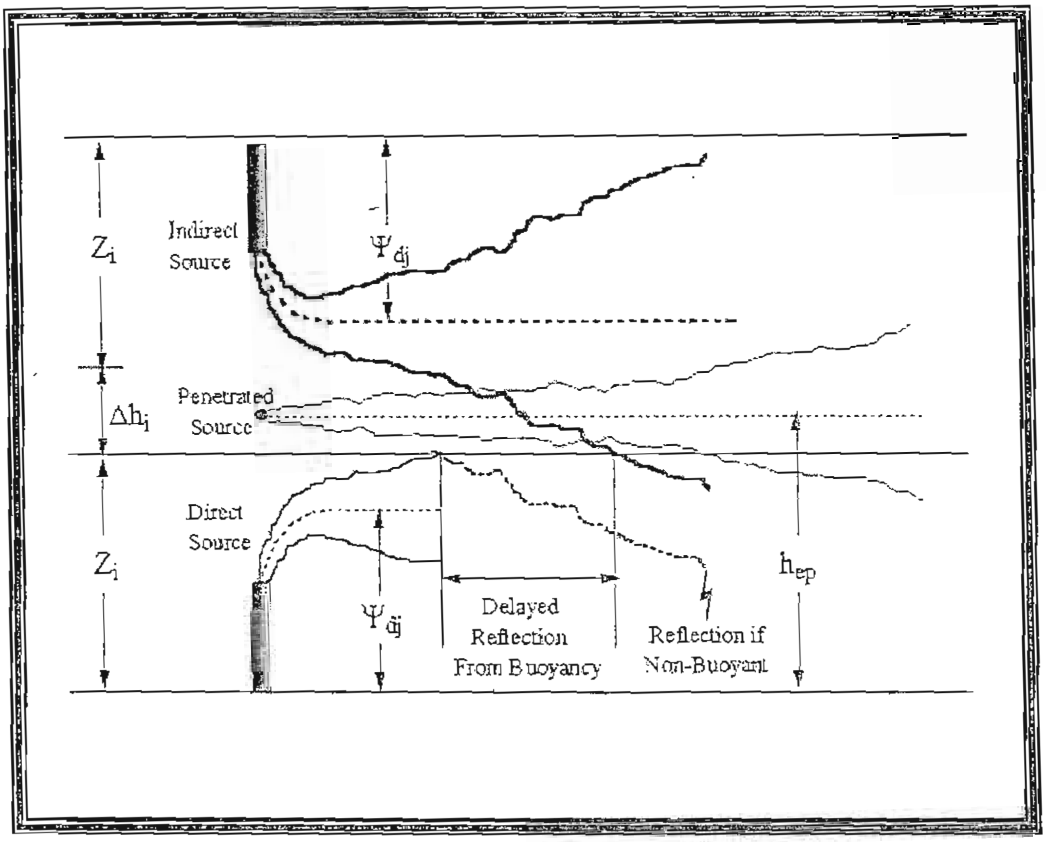


Figure 3.2. Aermod's three plume treatment of the CBL

Using an approach similar to that of Venkatram et al. (1984), and Taylor (1921) the ambient component of the lateral dispersion of the non-dimensional downwind distance X and a non-dimensional height scale as:

$$\sigma_{ya} = \frac{\tilde{\sigma}_v x}{\tilde{u}(1+\alpha X)^p}$$

Where:

- X – the non-dimensional distance with u and δ_v given by effective parameters:

$$X\left(= \tilde{\sigma}_v x / \tilde{u}\, z_i\right)$$

- $\alpha = z_i/l$, the effective parameters (dimensionless) với l is an appropriate length scale for lateral turbulence (α = 78, Brode, 2002)
- p = 0.3 (Brode 2002).
- U – wind speed, m/s
- δv – the root-mean-square lateral turbulence velocity

$$\sigma_{zas} = \left(1 - \frac{h_{es}}{z_i}\right)\sigma_{zgs} + \left(\frac{h_{es}}{z_i}\right)\sigma_{zes}.$$

where:

- h_{es} – stack height corrected for stack tip downwash, m
- δ_{zgs} – surface portion of δ_{zas}, m
- δ_{zes} – elevated portion of δ_{zas}, m

(Detailed calculation please refer to Cimorelli et al., 2004).

Wind speed U at height z as following:

$$u = u\{7z_o\}\left[\frac{z}{7z_o}\right] \qquad for \quad z < 7z_o$$

$$u = \frac{u_*}{k}\left[\ln\left(\frac{z}{z_o}\right) - \Psi_m\left\{\frac{z}{L}\right\} + \Psi_m\left\{\frac{z_o}{L}\right\}\right] \qquad for \quad 7z_o \le z \le z_i$$

$$u = u\{z_i\} \qquad for \quad z > z_i$$

where:

- u_* - surface friction velocity, m/s
- z_0 – surface roughness length, m
- L – Monin-Obukhov length, m
- k – von Karman constant (dimensionless), k = 0.4
- ψ_m – similarity function for momentum (dimensionless)

3. Input data

Emission and dispersion of dust, NOx, SOx from flue gas of the power plant to the environment depends on coal fuel content, boiler technology, capacity and efficiency of the plant. Dispersion of dust and toxic gas is also dependant on the climate conditions and stack height. Hence, the power plant will use technology as well as the operation regime to ensure that toxic substances from stack emissions are lower than the permissive values as regulated in environment regulation of Vietnam.

The boiler used in Vinh Tan 4 TPP is Super Critical, spraying coal, wind – smoke balance. Main fuel is coal imported from Indonesia/Australia. Concentration and tonnage of NOx, SOx, dust, CO from Vinh Tan 4 TPP will be presented in following sections.

Regulation to be applied for the power plant

+ QCVN 22:2009/BTNMT – National technical regulation on Emission of Thermal Power Industry.
+ QCVN 05:2009/BTNMT – National technical regulation on ambient air quality

Basing on parameters of technology, scale of emit sources, the allowable concentration of NOx, SOx, dust for Vinh Tan 4 TPP is in Table 3.1.

Table 3.1 Permissive standard for toxic substances on ground and at source (Unit: mg/Nm3)

Parameters	*At source - Stack*		
Capacity	1200MW		
Coal	Indonesia/ Australia		
Coefficient	QCVN 22:2009/BTNMT Kp = 0,85, Kv = 1		
NOx(calculating as NO2)	552,5 (650)		
SOx	425 (500)		
Dust	170 (200)		
CO(*)	800 (1.000)		
	On the ground: QCVN 05:2009/BTNMT		
	1h average	24h average	Annual average
NOx	0,2	0,1	0,04
SOx	0,35	0,125	0,05
PM 10	-	0,15	0,05
CO	30	5	-

Note: Values stipulated in parentheses ( ) are the ones regulated in QCVN 22:2009/BTNMT without adjustment with correlative factors of the project. Kp – capacity factor, Kv – area factor. Kp=0.85, applied for the plant with capacity of 300<P300<P≤1200.

Kv=1, Vinh Tan 4 TPP is one of four power plants in the Vinh Tan Power Complex with total capacity of 5600MW.

**: Permissive concentration of CO is stipulated in QCVN 19:2009/BTNMT (Kp=0,8, Kv=1).*

Input data

The most important flue gas discharged sources in plants are stacks of each unit. Two stack of power plant is a separate source; specifications of stack in the power plant are in **Error! Reference source not found.**.

Proposed project area is divided to grid cells with distance of 500m x 500m.

Meteorology data: local hourly surface data and upper air data as wind speed, temperature, precipitator, solar radiation (processed by MM5). Time series to run for the model is calculated within one year.

Table 3.2 Input data of the flue gas (each unit) of the power plants in Vinh Tan power complex

Parameter	Vinh Tan 4	Vinh Tan 3	Vinh Tan 2	Vinh Tan 1
Boiler	Supercritical (SC)	Supercritical (SC)	Sub-critical (SSC)	Sub-critical (SSC)
Coal	Imported coal	Imported coal	Domestic coal	Domestic coal
Stack height (m)	210	210	210	210
Number of stack (*)	1	1	1	1
Stack diameter (m)	8.5	9.5	8.5	8.2
Flue gas flow (m^3/s)	1541.29	1952.9	1566.4	1548.25
Concentration of dust in flue gas (post-treated) (mg/Nm^3)	150	50	148	98
Load of dust in flue gas (post-treated) (g/s)	197.98	77.7	179.66	120.76
Concentration of SO_2 in flue gas (post-treated) (mg/Nm^3)	350	200	153	144
Load of SO_2 in flue gas (post-treated) (g/s)	461.94	310.87	185.73	177.45
Concentration of NO_2 concentration in flue gas (mg/Nm^3)	228	228	139	150
Load of NO_2 in flue gas (post-treated) (g/s)	300.26	353.61	168.74	184.84
Concentration of CO in flue gas (mg/Nm^3)	27	42.47	34.27	32.21
Load of CO in flue gas (g/s)	35.63	72	45.42	43.3
Temperature of flue gas post-treated (°C)	75	70	80	70

Sources: Investment report of Vinh Tan 4 TPP (PECC2), 9/2012

Note: *: consider the usable area of 2 small stacks as 1 big stack and calculate as one emission source (point source).

Table 3.3 Concentration of the pollutants at the stack of each working unit before and after treatment system.

No.	Without ESP, FGD, control NOx measures				With ESP, FGD, control NOx measures				QCVN 22:2009/ BTNMT (mg/Nm^3)
	Concentration (mg/Nm3)				Concentration (mg/Nm3)				
	Vinh Tan 4	Vinh Tan 3	Vinh Tan 2	Vinh Tan 1	Vinh Tan 4	Vinh Tan 3	Vinh Tan 2	Vinh Tan 1	
NO_2 (3)	-	-	1200	1200	228(2)	228(2)	139(1)	150(1)	552.5
NOx treatment efficiency of SCR (%)							88.4	87.5	
SO_x (4)	2660	1600	1530	1530	350	200	153	144	425
SOx treatment efficiency of SeaFGD (%)					86.8	88.5	90	90.5	
PM10(5)	6891	7600	36920	36920	150	50	148	98	170
Dust treatment efficiency of ESP (%)					97.8	99	99.5	99.7	
CO	-	-	-	-	27	42.47	34.27	32.21	800

Note:

(1) Using NOx external treatment by SCR

(2) Using Use NOx internal treatment

(3) Conversion factor between NO_2 and NOx: $\frac{NO_2}{NO_x} = 0,5$

(4) Treating SOx by SW-FGD system

(5)Treating particulate by ESP system

4. **Prediction scenarios about PM10, SO2 and NO2 in the ground**

The operation of Vinh Tan 4 power plant and Vinh Tan power complex are proposed scenarios which has been considered to assess the air dispersion of flue gas. The options including as:

Scenario 1: Calculation of flue gas dispersion from Vinh Tan 4 Power Plant (ESP, FGD equipment and NOx treatment measure in flue gas is installed in Vinh Tan 4 Power plant)

Scenario 2: Calculation of flue gas dispersion from Vinh Tan Power Complex (ESP, FGD equipment and NOx treatment measure in flue gas is installed in Vinh Tan 3,4 Power plant and ESP, FGD, SCR equipment is installed in Vinh Tan 1,2 Power plant).

Scenario 3: Calculation of flue gas dispersion from Vinh Tan 4 Power Plant in case of breakdown.

+ Dispersion results of PM10, Nox, CO and SO2 in flue gas is presented in Table 3.4
+ Conclusion: From results in Table 3.4 , it is can be following conclusions. With both options 1 and 2: concentration of PM10, SOx, NOx, CO in stack and in air ambient is

less than the allowable value in QCVN 22:2009/BTNMT and QCVN05:2009/BTNMT (see Table 3.5 and Figure 3.1 and Figure 3.21).

- Scenario 1: considering only operation of Vinh Tan 4 TPP
- In case that Vinh Tan 4 TPP uses Indonesian coal, the dust treatment efficiency of ESP is 97.8%; the SO2 treatment efficiency of FGD is 86.8%; low NOx burner is employed and the stack height is H=210 m, the concentrations of pollutants (dust, NOx, CO and SO_2) at 1 h average and 24h average are all lower than the standards regulated in QCVN 05-2009/BTNMT.
+ The maximum concentration of PM10 – 24h average on the ground is about 0.008 mg/m^3, lower than allowable value regulated in QCVN 05:2009/BTNMT (0.15 mg/m^3).
+ The maximum concentration of SO_2 – 1h and 24h average on the ground is about 0.148 mg/m^3 and 0.019 mg/m^3 respectively, lower than allowable value regulated in QCVN 05:2009/BTNMT (0.35 mg/m^3 and 0.125 mg/m^3).
+ The maximum concentration of NOx – 1h and 24h average on the ground is about 0.096 mg/m^3 and 0.012 mg/m^3 respectively, lower than allowable value regulated in QCVN 05:2009/BTNMT (0.2 mg/m^3 and 0.1 mg/m^3).
+ The maximum concentration of CO – 1h and 24h average on the ground is about 0.014 mg/m^3 and 0.0019 mg/m^3 respectively, lower than allowable value regulated in QCVN 05:2009/BTNMT (30 mg/m^3 and 5 mg/m^3).
+ The annually average concentration of NOx, SOx, CO and PM10 are all lower than allowable value regulated in QCVN 05:2009/BTNMT.
+ The concentration of NOx, SOx, and PM10 in no.7 residential area (which belong toVinh Tien and Vinh Phuc hamlet) and the surrounding areas do not exceed the allowable value specified in QCVN 05:2009/BTNMT.
+ The concentration of NOx, SOx, and PM10 at Hon Cau Island does not exceed the allowable values specified in QCVN 05:2009/BTNMT, the largest concentration in this area is slightly smaller than the allowable value.
- Scenario 2: all the plants in Vinh Tan PC simultaneously operate.
- In such case where the height of all stacks of Vinh Tan 1, 2, 3 and 4 TPP is 210m, load of pollutants (dust, NOx, SO2, CO) 1h and 24h average is described as follows:
+ The maximum concentration of PM10 – 24h average on the ground is about 0.019 mg/m^3, lower than allowable value regulated in QCVN 05:2009/BTNMT (0.15mg/m^3).
+ The maximum concentration of SO2 – 1h average on the ground around the project area is about 0.303 mg/m^3, much lower than allowable value regulated in QCVN 05:2009/BTNMT (0.35 mg/m^3) while the maximum concentration of 24h average is 0.034 mg/m^3 , still lower than allowable value in QCVN 05:2009/BTNMT (0.125 mg/m^3).
+ The maximum concentration of NOx – 1h average is 0.268 mg/m^3, about 1.3 times higher than allowable value in QCVN 05:2009/BTNMT (0.2 mg/m^3). However, the sites where maximum concentration of NOx observed focus mainly at East sea area, around 3.3 km from the project site to the southeast. The sites with NOx concentration about 0.21-0.25 mg/m^3 focus mostly at the mountain area in the Northeast (about 2 km away from the VT4 TPP) and the eastern site (about 3.2 km from VT4 TPP) has the NOx concentration ranging from 0.20-0.21 mg/m^3.
+ The maximum concentration of NOx at Hamlet 7(Vinh Phuc and Vinh Tien

villages) ranges from 0.12-0.15 mg/m^3, about 1.2 – 1.6 time lower than the permissive value and that of the residential area at the eastern site is about 0.19-0.2 mg/m^3, close to the standard.

+ The concentration of NOx at Hon Cau island is about 0.1 mg/m^3 not exceeding the value regulated in QCVN 05:2009/BTNMT.
+ Additionally, the air emission modeling, i.e. AERMOD has predicted the 1h average concentration of NOx at 99.98 percentile is about 0.2 mg/m^3, meets the regulated standard in QCVN 05:2009/BTNMT (0.2 mg/m^3). This means at the northeastern mountain, eastern site and East Sea where the concentration is above 0.2 mg/m3, there are only twice per year, the NOx value exceeds the allowable value.
+ According to the Directive 2008/50/EC of the European Parliament and of the Council of May 21 2008 on Ambient air quality and cleaner air for Europe, the permissive value of 1h average is 200 µg/m^3 (0,2 mg/m^3), and this value must not be exceeded more than 18 time (hour) per year (8760 h) equivalent to percentile 99.79th.
+ According to the calculation for pollutant diffusion of Vinh Tan 4 TPP, at places where the NOx value is over 0.2 mg/m^3, the actual concentration only exceeds the permissive standard about 2 hours per year, less than the allowable 18 hours. Hence, this impact is evaluated as acceptable.
+ Location of the NOx concentrations exceed permitted standards and happening time to be presented in the following table:

Table 3.4 Location and happening time of exceed NOx concentraiotn.

Coordiantion		Time (month, date hour)	Value (mg/m^3)
X	Y		
257466,38	1252413,40	82608	0,2086
257966,38	1252413,40	82608	0,2116
257466,38	1251913,40	82708	0,2172
257966,38	1251913,40	82708	0,2142
257466,38	1251413,40	82708	0,2036
259466,38	1248913,40	90607	0,2341
258966,38	1248413,40	90607	0,2058
259466,38	1248413,40	90607	0,2359
258966,38	1247913,40	90607	0,2054
259466,38	1247913,40	90607	0,2290
259466,38	1247413,40	90607	0,2179
259466,38	1246913,40	90607	0,2054
261466,38	1255413,40	60108	0,2021
260966,38	1254913,40	60108	0,2107
261466,38	1254913,40	60108	0,2050
260966,38	1254413,40	60108	0,2190
259966,38	1253913,40	41008	0,2098
260466,38	1253913,40	33108	0,2191
260966,38	1253913,40	33108	0,2191
261966,38	1253913,40	60308	0,2245
259966,38	1253413,40	41008	0,2252

Coordiantion		Time (month, date hour)	Value (mg/m^3)
X	Y		
260466,38	1253413,40	33108	0,2365
260966,38	1253413,40	33108	0,2233
261466,38	1253413,40	60308	0,2402
261966,38	1253413,40	60308	0,2498
259966,38	1252913,40	41008	0,2110
260466,38	1252913,40	33108	0,2145
260966,38	1252913,40	60308	0,2208
261466,38	1252913,40	60308	0,2545
261966,38	1252913,40	60308	0,2282
260966,38	1250413,40	72107	0,2245
261466,38	1250413,40	72107	0,2573
261966,38	1250413,40	72107	0,2433
260966,38	1249913,40	72107	0,2315
261466,38	1249913,40	72107	0,2776
261966,38	1249913,40	72107	0,2809
259966,38	1249413,40	90607	0,2109
260966,38	1249413,40	72107	0,2013
261466,38	1249413,40	72107	0,2560
261966,38	1249413,40	72107	0,2778
259966,38	1248913,40	90607	0,2287
261466,38	1248913,40	72107	0,2172
261966,38	1248913,40	72107	0,2506
259966,38	1248413,40	90607	0,2304
261966,38	1248413,40	72107	0,2135
259966,38	1247913,40	90607	0,2235
259966,38	1247413,40	90607	0,2126
262466,38	1254413,40	60308	0,2019
262966,38	1254413,40	60308	0,2014
262466,38	1253913,40	60308	0,2262
262966,38	1253913,40	60308	0,2064
262466,38	1253413,40	60308	0,2239
263966,38	1253413,40	41707	0,2076
264466,38	1253413,40	41707	0,2119
262466,38	1252913,40	40908	0,2004
262966,38	1252913,40	41707	0,2278
263466,38	1252913,40	41707	0,2399
263966,38	1252913,40	41707	0,2375
264466,38	1252913,40	41707	0,2276
262466,38	1252413,40	41707	0,2275
262966,38	1252413,40	41707	0,2383
263466,38	1252413,40	41707	0,2331

Coordiantion		Time (month, date hour)	Value (mg/m^3)
X	Y		
263966,38	1252413,40	41707	0,2203
264466,38	1252413,40	41707	0,2046
262466,38	1250413,40	72107	0,2031
262466,38	1249913,40	72107	0,2522
262966,38	1249913,40	72107	0,2099
262466,38	1249413,40	72107	0,2681
262966,38	1249413,40	72107	0,2385
263466,38	1249413,40	72107	0,2013
262466,38	1248913,40	72107	0,2577
262966,38	1248913,40	72107	0,2442
263466,38	1248913,40	72107	0,2185
262466,38	1248413,40	72107	0,2328
262966,38	1248413,40	72107	0,2334
263466,38	1248413,40	72107	0,2201
262466,38	1247913,40	72107	0,2019
262966,38	1247913,40	72107	0,2127
263466,38	1247913,40	72107	0,2109
264966,38	1253413,40	41707	0,2081
265466,38	1253413,40	41707	0,2004
264966,38	1252913,40	41707	0,2137
261796,62	1252514,12	40908	0,2052
262565,88	1252361,38	41707	0,2289
260861,23	1252667,25	60308	0,2038
260806,03	1250013,50	72107	0,2122
261187,27	1250091,12	72107	0,2596
261304,7	1250489,25	72107	0,2443
260996,66	1250052,38	72107	0,2387
261341,3	1250309,62	72107	0,2620
261268,12	1250668,88	72107	0,2174
261377,88	1250130,00	72107	0,2718
260979,78	1252689,88	60308	0,2171
261966,38	1249913,38	72107	0,2809

+ As the table above shows, 1h average concentrations which higher than permitted regulation appears only in the early morning (7-8 am) on the day 31/3, 09-10/4, 17/4, 01-03 / 06, 21/07, 26-27/08, 06/09.

- Scenario 3:

  + As ESP is broken down, the temperature of dust at source will be about 40.5 times higher than the allowable value in QCVN 22:2009/BTNMT (170 mg/m3). Similarly, as SeaFGD is broken down, the concentration of SO2 at source will be about 6.3 time higher than the allowable value in QCVN 22:2009/BTNMT (425 mg/m3).

+ Based on the results from air pollutant diffusion model, the level of dust, SOx at ground during the breakdown will be many fold higher than the allowable level regulated in QCVN 05:2009/BTNMT, refer to **Error! Reference source not found.** for more results.

+ The maximum concentration of 1h average of SOx at ground is 0.72 mg/m3, 2-time higher than the regulated value in QCVN 05:2009/BTNMT (0.35 mg/m3). The point which has highest level of SOx at ground locates about 2.7 km away from stack of Vinh Tan 4 TPP to the Northeast. The entire Vinh Tan commune and a part of Ca Na area will be affected by SOx during the breakdown. The average concentration of SO2 at 24 h and annual value at ground meets the environmental standard.

+ The maximum concentration of 1h average and 24h average of dust at ground are 1.86 mg/m3 and 0.25 mg/m3 respectively; about 1.3 – 6.2 time higher than the regulated value in QCVN 05:2009/BTNMT (0.3 mg/m3). The point which has highest level of dust at ground locates about 2.7 km away from stack of Vinh Tan 4 TPP to the Northeast. The entire Vinh Tan commune and Ca Na area within the radius of 30 km will be greatly affected.

+ From the results of **Error! Reference source not found.**, Figure 3.28 and **Error! Reference source not found.**, as the flue gas treatment systems break down, the entire Vinh Tan commune will be polluted by air emission of the power plant with the concentration of pollutant exceed many folds compare to the regulated value in QCVN 22:2009/BTNMT (and QCVN 05:2009/BTNMT. Therefore, during the breakdown, the plant will stop operating until the systems get fixed.

Table 3.5 Calculation results of substances concentration on ground

Scenario	Calculation results												
	Parameter	QCVN 22:2009	Concentration at stack				Average time	Maximum concentration of air pollutants on the ground		Distance from the stack	QCVN 05:2009 (max. concentration on ground))	Direction	Note
		mg/Nm^3	mg/Nm3					(mg/m3)	(mg/m3) 99.98th Percentile	(km)	(mg/m^3)		
			VT1	VT2	VT3	VT4							
Scenario 1: only operation of Vinh Tan 4 TPP	SOx	425				350	1h	0.148		2.5	0.35	Southeast	
							24h	0.019		1.9	0.125	North	
							Annual	0.003		3.0	0.05	Southwest	
	NO_2	552.5				228	1h	0.096		2.5	0.2	Southeast	
							24h	0.012		1.9	0.1	North	
							Annual	0.0019		3.0	0.04	Southwest	
	PM10	170				150	1h	0.063		2.5	-	Southeast	
							24h	0.008		1.9	0.150	North	
							Annual	0.0012		3.0	0.005	Southwest	
	CO	800				27	1h	0.014		2.5	-	Southeast	
							24h	0.0019		1.9	0.150	North	
							Annual	0.0003		3.0	0.005	Southwest	
Scenario2: operation of all power plant in	SOx	425	144	153	200	350	1h	0.303		3.3	0.35	Southeast	
							24h	0.038		1.5	0.125	North	
							Annual	0.0056		2.5	0.05	Southwest	
	NO_2	552.5	150	139	228	228	1h	0.268	0.2	3.3	0.2	Southeast	

Scenario	Calculation results												
	Parameter	QCVN 22:2009	Concentration at stack				Average time	Maximum concentration of air pollutants on the ground		Distance from the stack	QCVN 05:2009 (max. concentration on ground))	Direction	Note
		mg/Nm³	mg/Nm3					(mg/m3)	(mg/m3) 99.98th Percentile	(km)	(mg/m³)		
			VT1	VT2	VT3	VT4							
Vinh Tan PC							24h	0.034		1.5	0.1	North	
							Annual	0.006		2.5	0.04	Southwest	
	PM10	170	98	148	50	150	1h	0.154		3.3	-	Southeast	
							24h	0.019		1.5	0.150	North	
							Annual	0.0032		2.5	0.05	Southwest	
	CO	800	32.2	34.2	42.4	27	1h	0.055		3.3	30		
							24h	0.0067		1.5	5		
							Annual	0.001		2.5			
Scenario2 3: breakdown of flue gas	SOx	425				2660	1h	0,72		2,7	0,35	North East	
							24h	0,098		2	0,125	North	
							Annual	0,013		3,2	0,05	West	
	Dust	170				6891	1h	1,86		2,7	0,3	North East	
							24h	0,25		2	0,2	North	
							Annual	0,034		3,2	-	West	

Source: PECC2-6/2013

*Note: *: 99.98th percentile: 99.98 % of the observed values is less than 0.2 mg/m³*

Figure 3.1. NOx concentration– maximum 1-hour average - Option 1

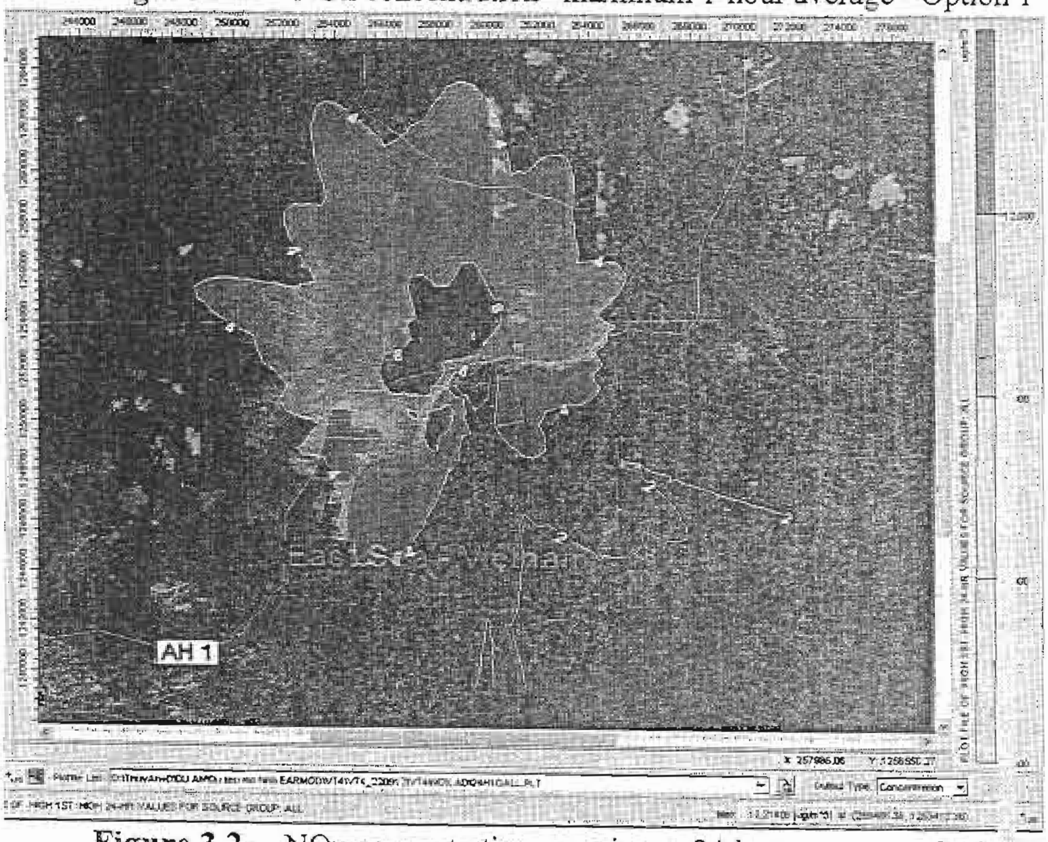


Figure 3.2. NOx concentration– maximum 24-hour average - Option 1

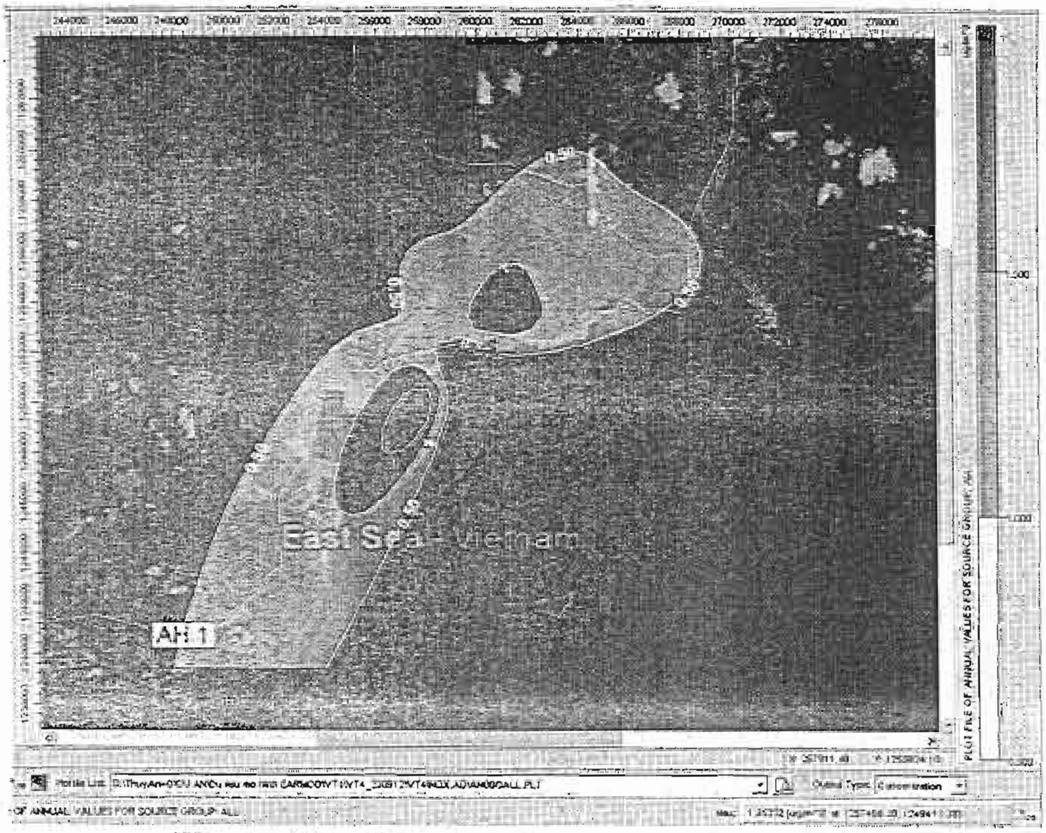


Figure 3.3. NOx concentration– annual average - Option 1

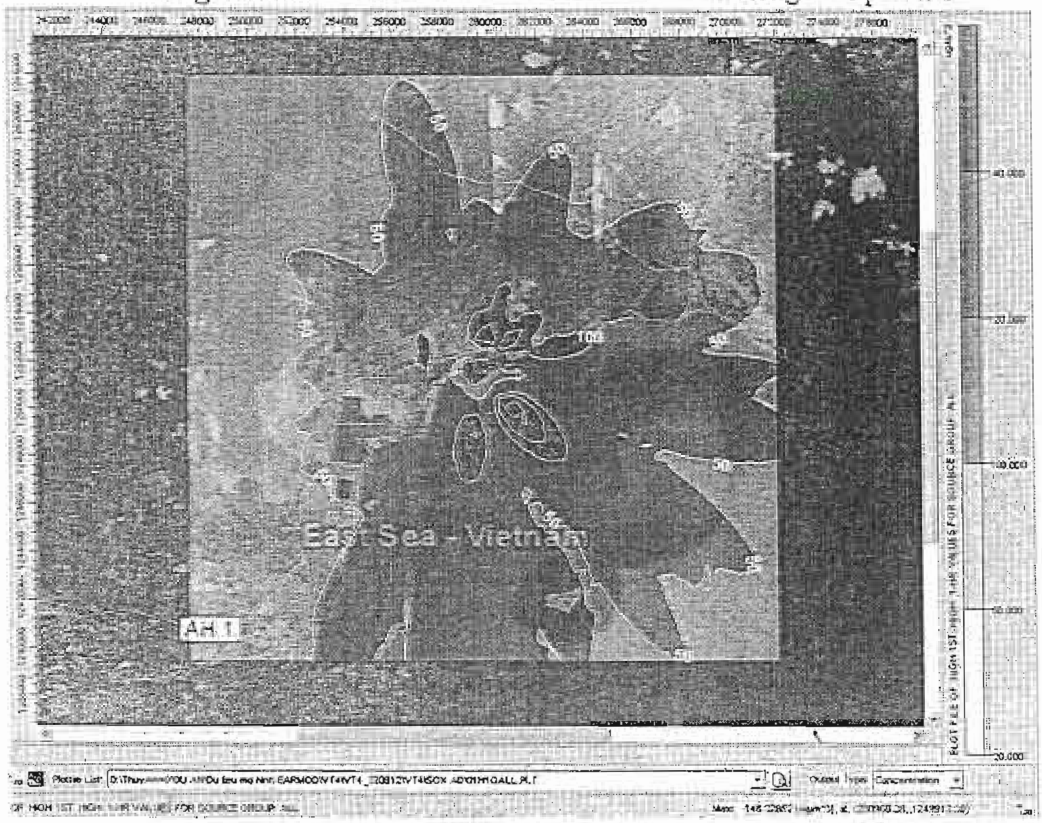


Figure 3.4. SOx concentration– maximum 1-hour average - Option 1

Figure 3.5. SOx concentration– maximum 24-hour average - Option 1

Figure 3.6. SOx concentration– annual average - Option 1

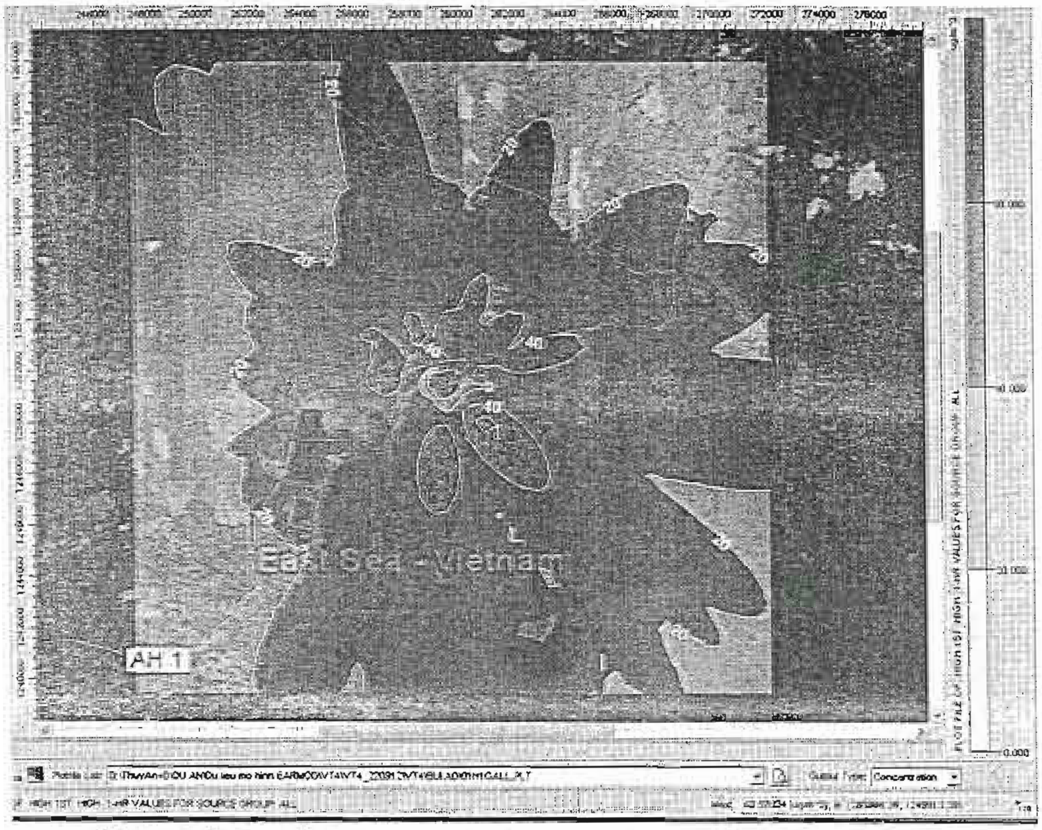


Figure 3.7. PM10 concentration– maximum 1-hour average - Option 1

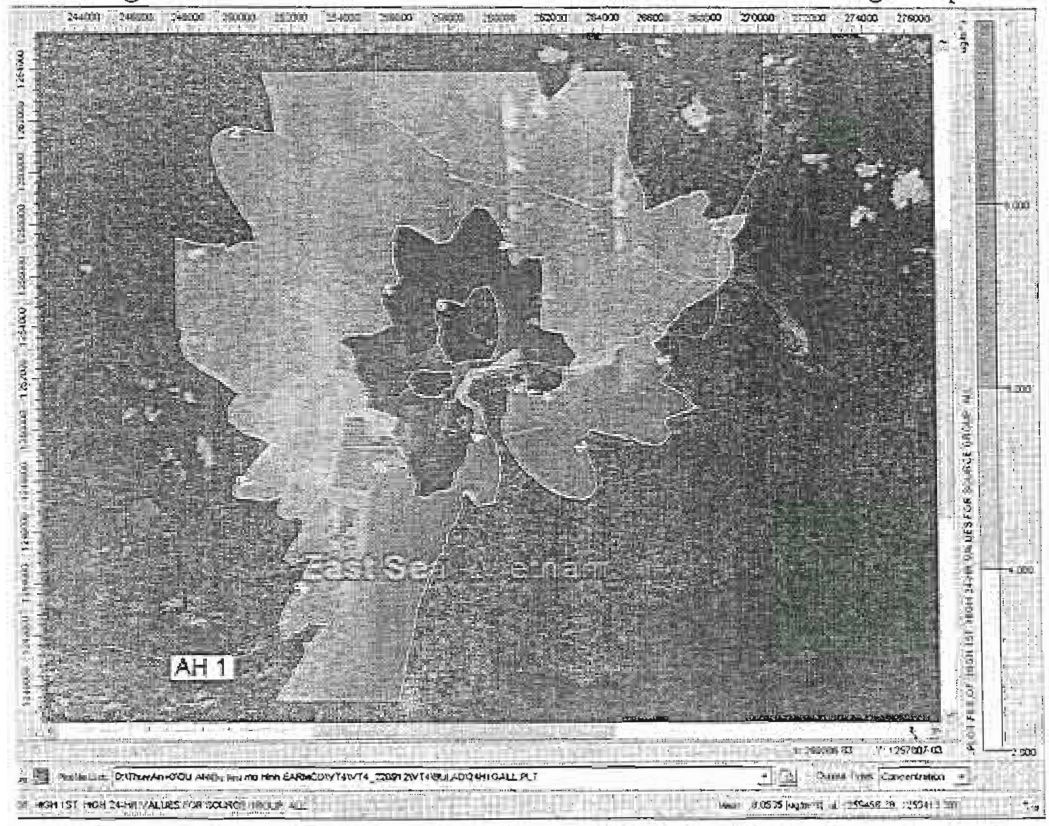


Figure 3.8. PM10 concentration– maximum 24-hour average - Option 1

Figure 3.9. PM10 concentration– annual average - Option 1

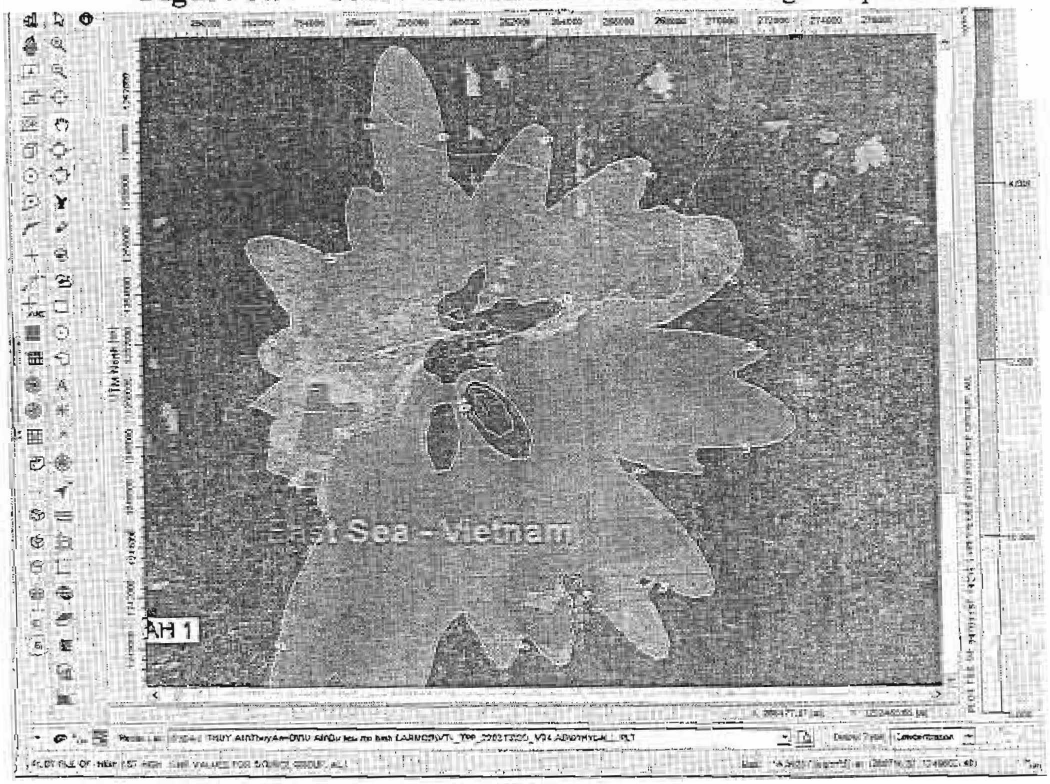


Figure 3.10. CO concentration– maximum 1-hour average - Option 1

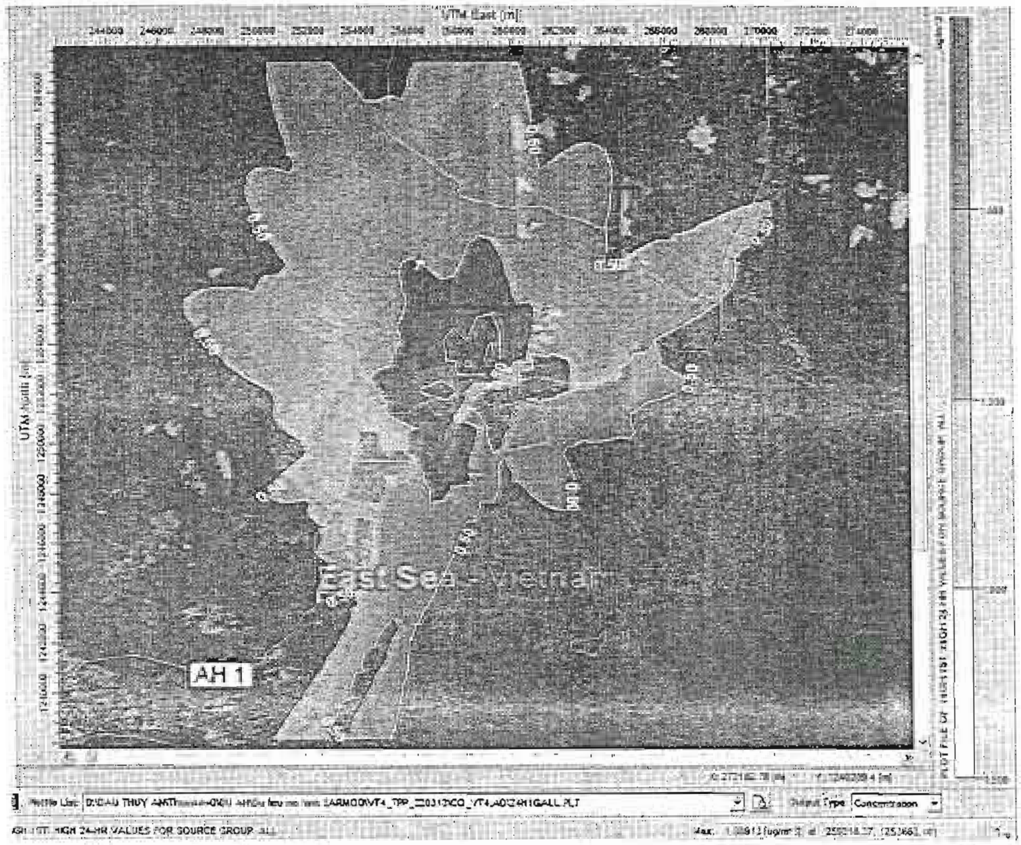


Figure 3.11. CO concentration– maximum 24-hour average - Option 1

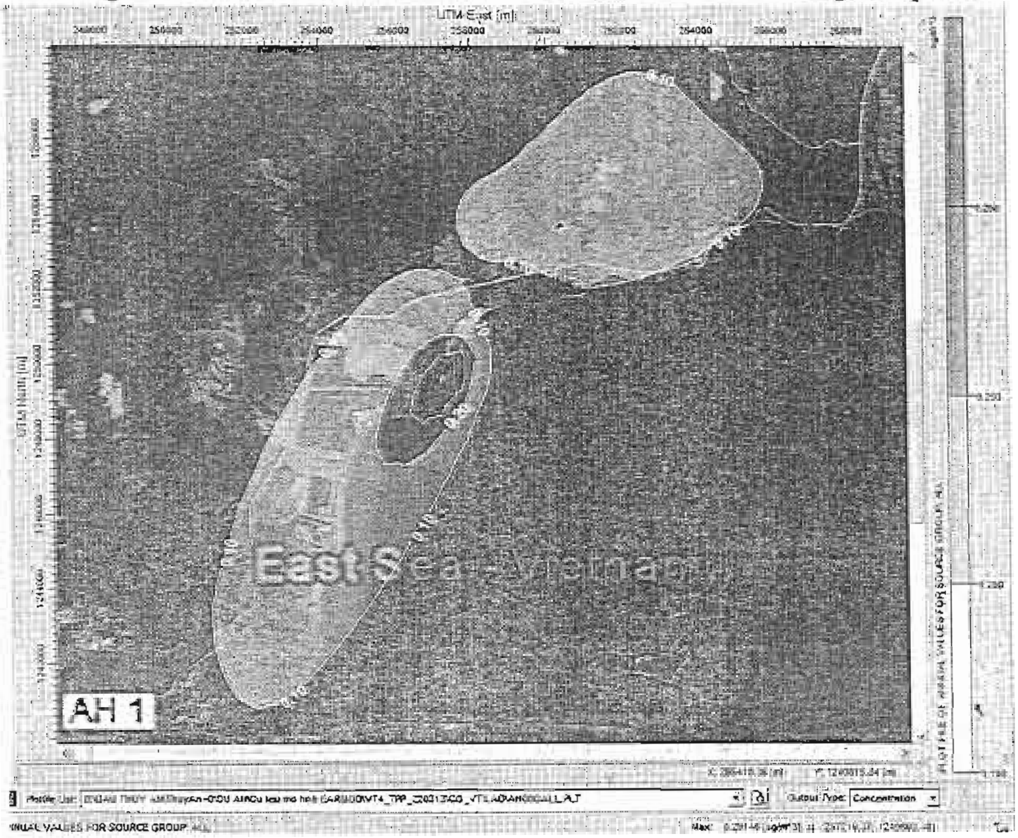


Figure 3.12. CO concentration– maximum annual average - Option 1

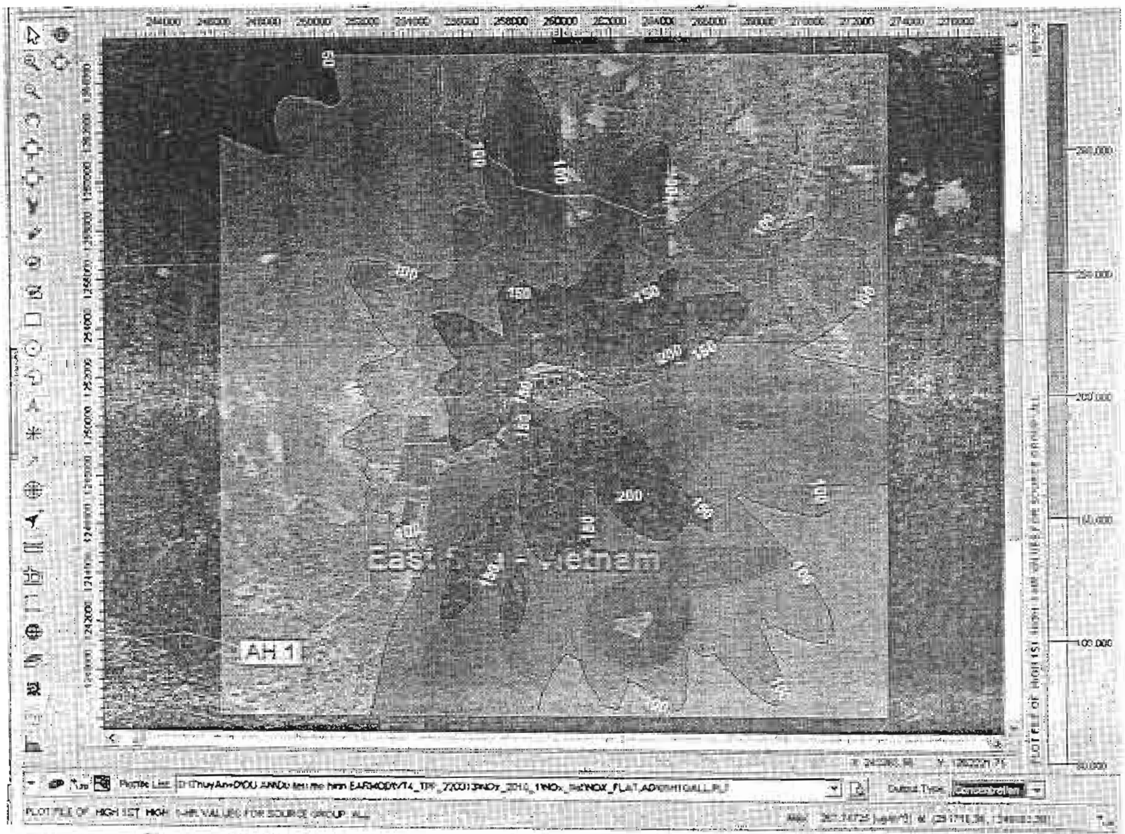


Figure 3.13. NOx concentration– maximum 1-hour average - Option 2

Figure 3.14. NOx concentration– maximum 1-hour average - Option 2– Percentile 99.98%

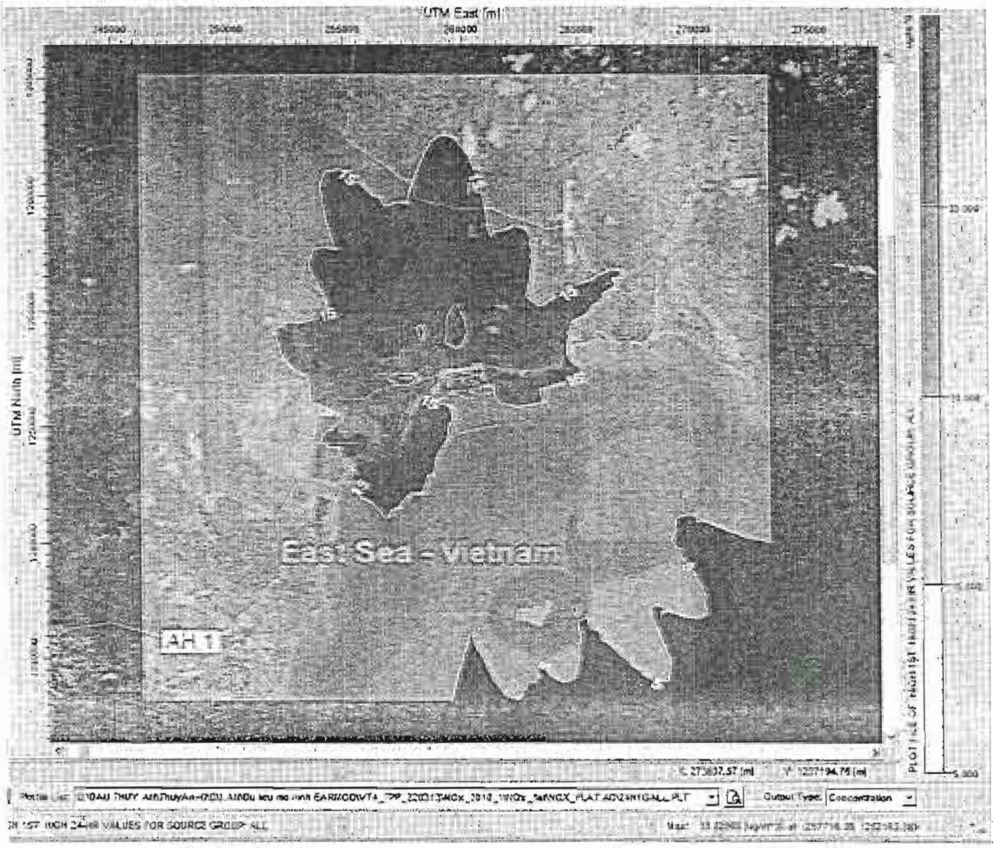


Figure 3.15. NOx concentration– maximum 24-hour average - Option 2

Figure 3.16. NOx concentration– maximum annual average - Option 2

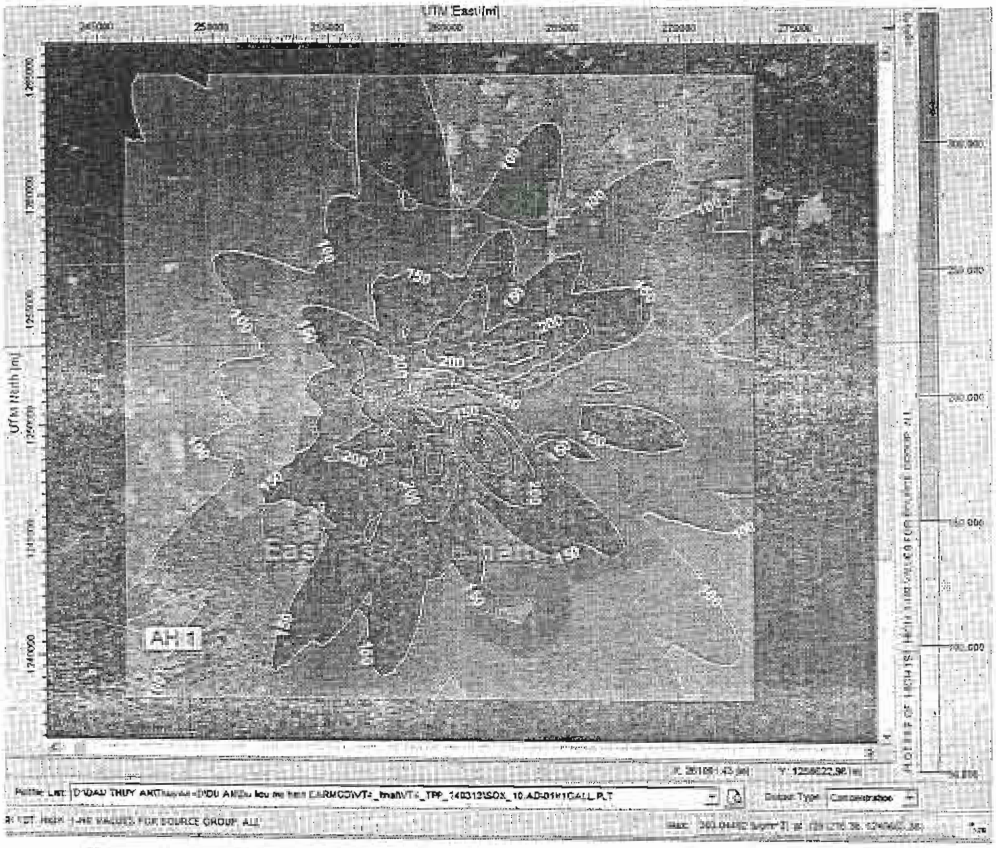


Figure 3.17. SOx concentration– maximum 1-hour average - Option 2

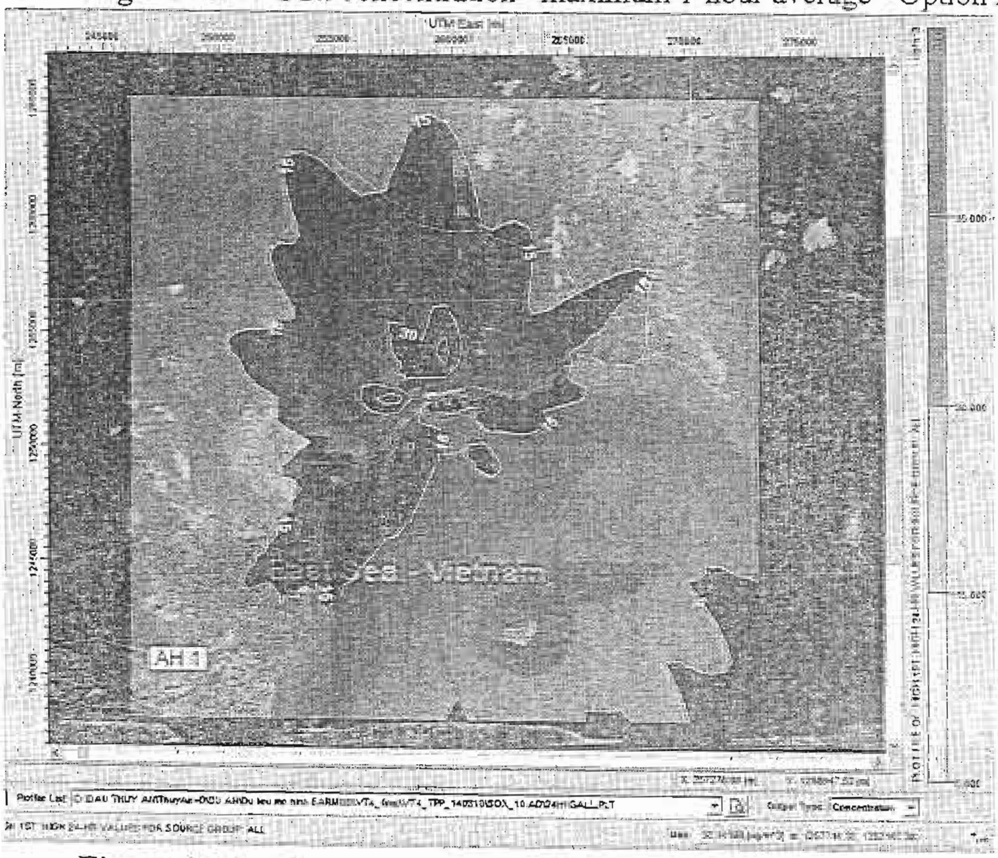


Figure 3.18. SOx concentration– maximum 24-hour average - Option 2

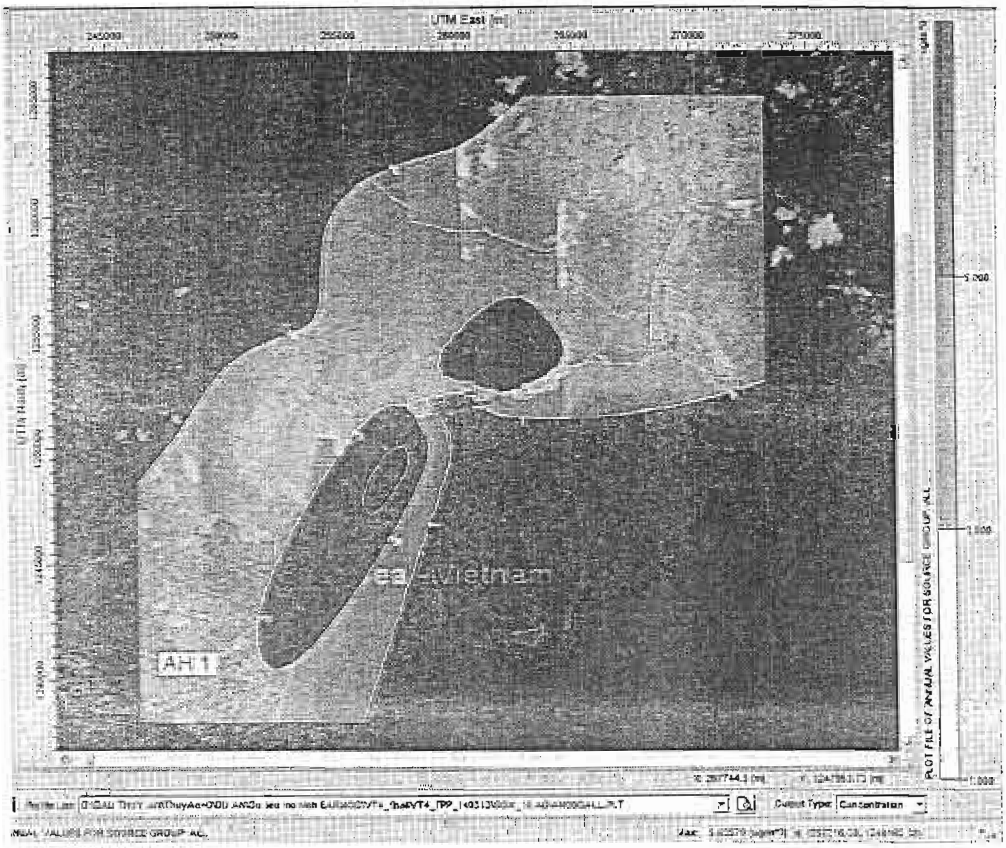


Figure 3.19. SOx concentration– maximum annual average - Option 2

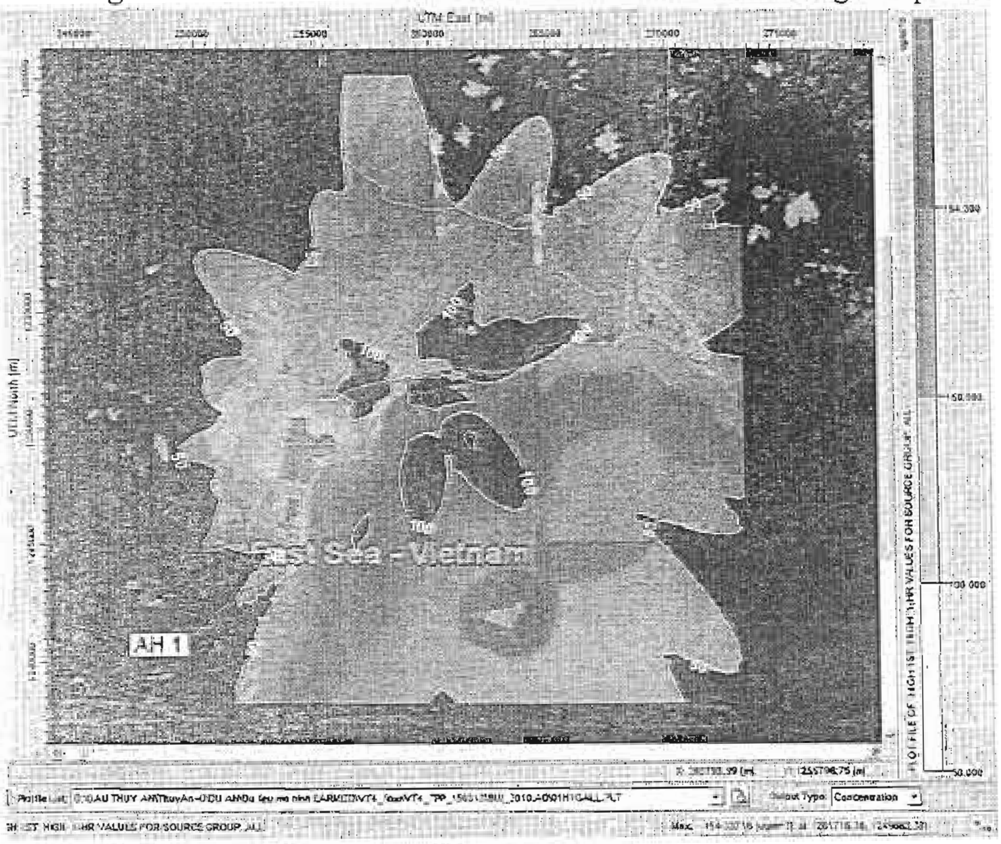


Figure 3.20. PM10 concentration– maximum 1-hour average - Option 2

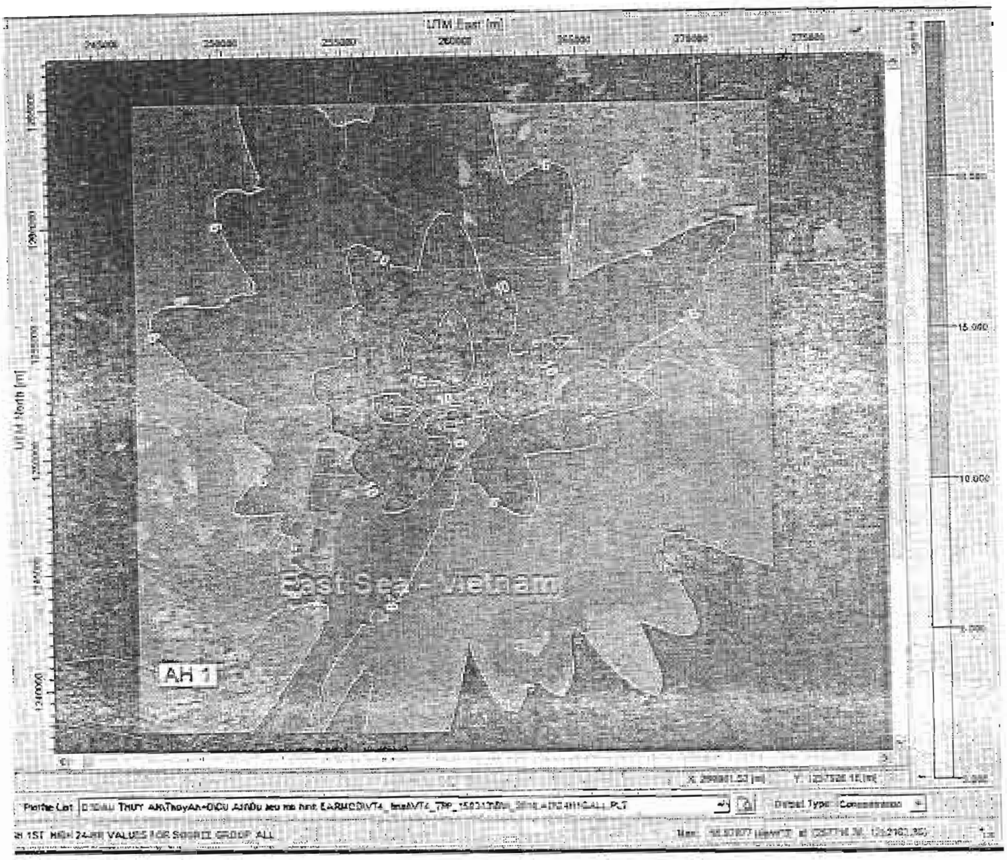


Figure 3.21. PM10 concentration– maximum 24-hour average - Option 2

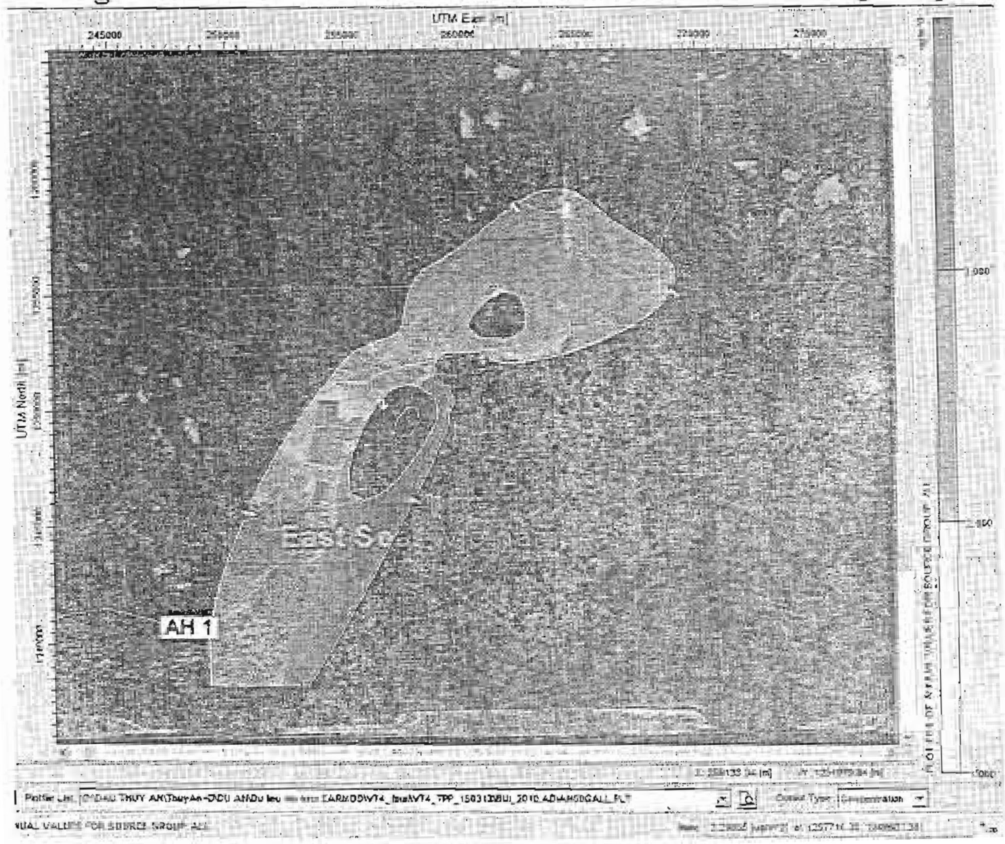


Figure 3.22. PM10 concentration– maximum annual average - Option 2

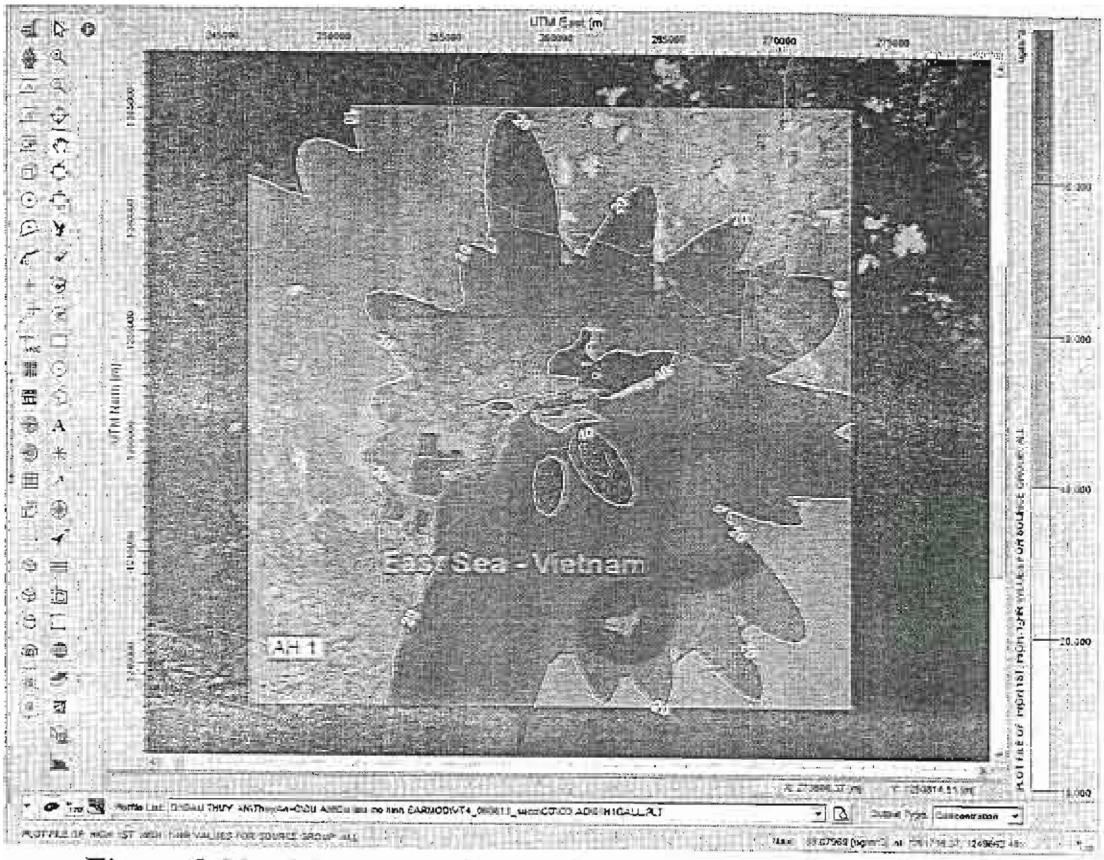


Figure 3.23. CO concentration– maximum 1-hour average - Option 2

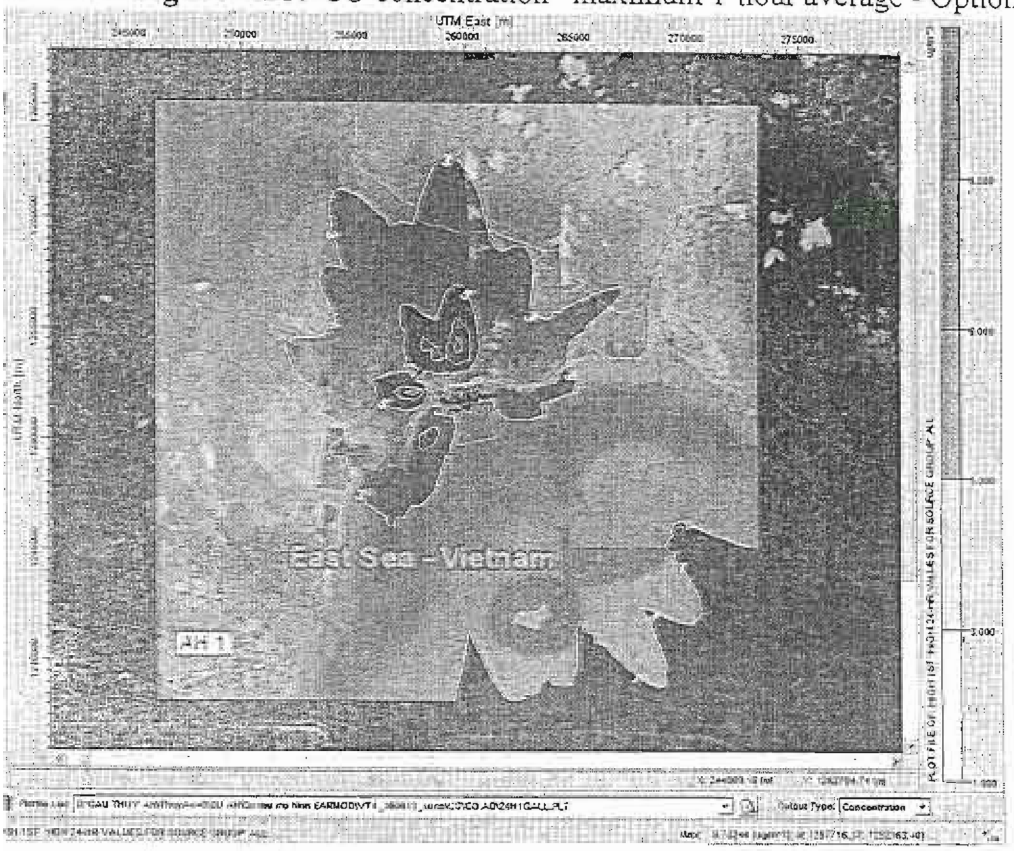


Figure 3.24. CO concentration– maximum 24-hour average - Option 2

Figure 3.25. CO concentration– maximum annual average - Option 2

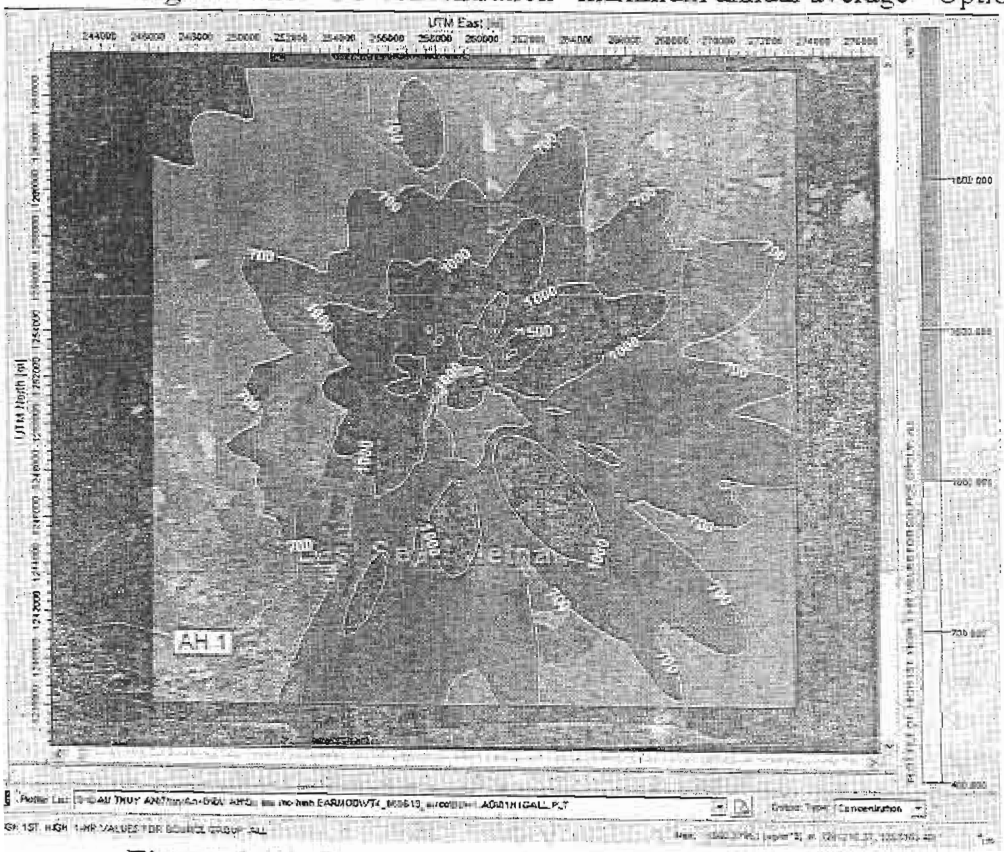


Figure 3.26. Dust concentration– maximum 1-hour average - Option 3

Figure 3.27. Dust concentration– maximum 24-hour average - Option 3

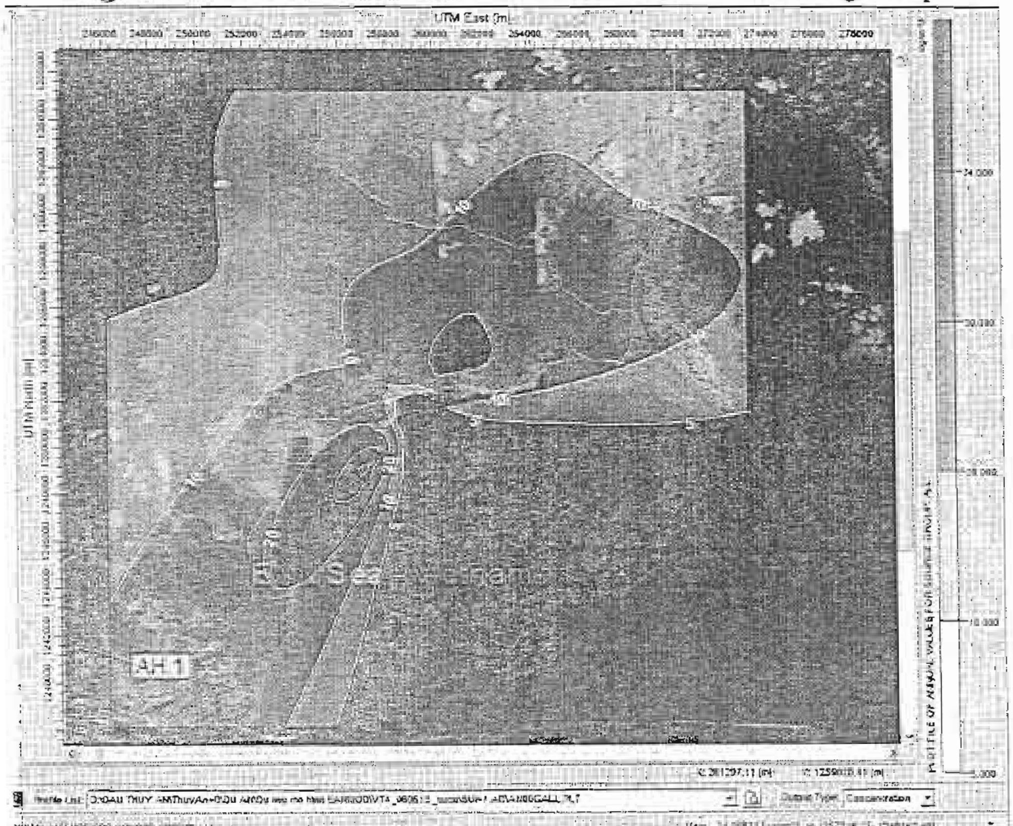


Figure 3.28. Dust concentration– maximum annual average - Option 3

Figure 3.29. SOx concentration– maximum 1 hour average - Option 3

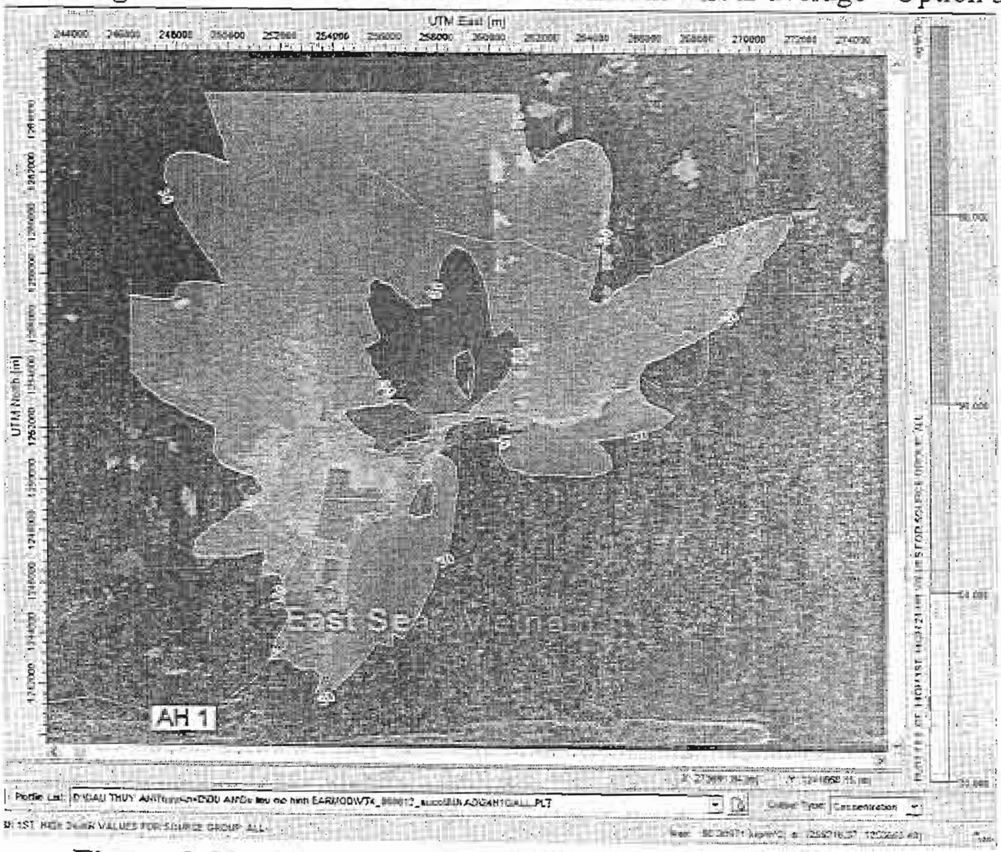


Figure 3.30. SOx concentration– maximum 24 hour average - Option 3

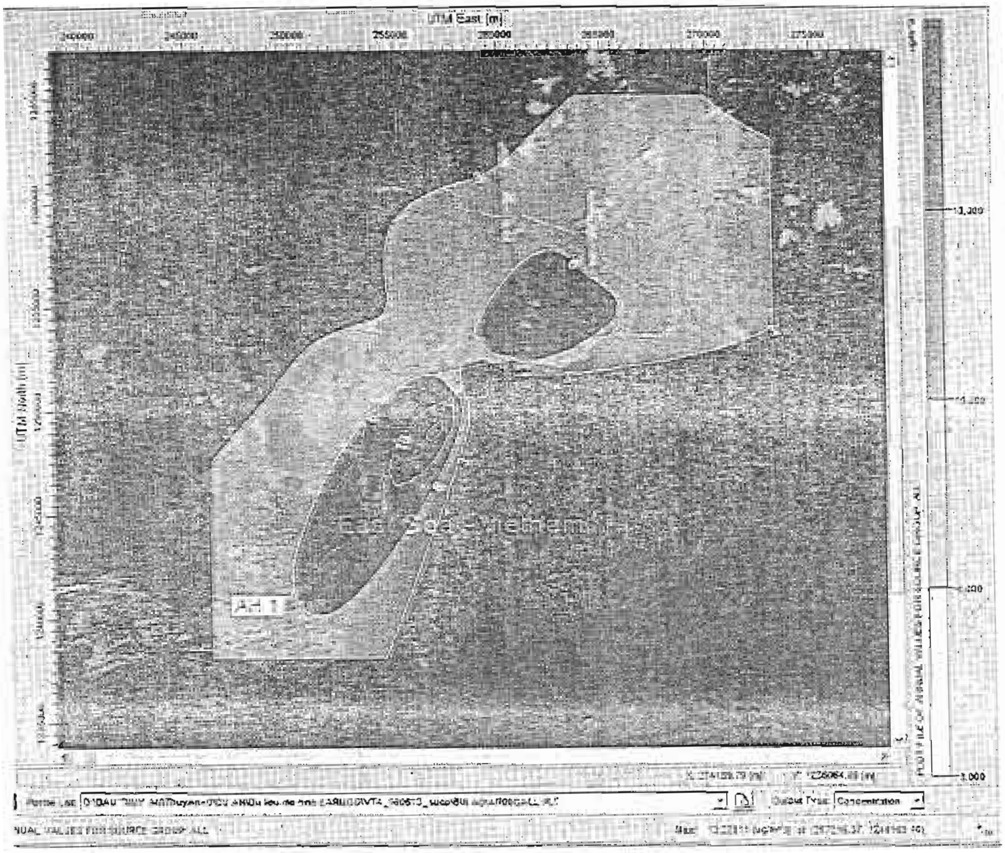


Figure 3.31. SOx concentration– maximum annual average - Option 3

APPENDIX 3.4: CALCULATION OF HEAT PROPAGATION DUE TO THE COOLING WASTEWATER OF THE VINH TAN POWER COMPLEX

CONTENT

3.1 BASIS OF CALCULATION

This section provides the scientific basis used on the MIKE 21 & MIKE 3 softwares. It is a backflow modeling system which is established and developed by the Danish Hydraulic Institute (DHI) - an independent counsulting and research international organization

Flow model MIKE 21 & MIKE 3 are based on flexible mesh approach and developed for other application in oceanography, coastal environment and estuaries. The modeling system has also been applied to study the impacts of socio-economic activities on estuarine water quality, which is influenced by the tidal regime.

The system is based on numerical solution of the Navier-Stokes equation, two and three-dimensional Reynolds equation with Boussinesq assumptions and hydrostatic pressure. Therefore, the model includes equations of density, salinity, temperature, momentum, continuance and is closed by a turbulent closure scheme. For the three dimensional model, the free surface is taken into account using a sigma coordinate transformation approach.

The spatial discretization of the basic equations is performed using a cell-centred finite volume method. The discretized space is non-overlapping continuous constituent. Horizontal plane uses unstructured mesh, while the vertical domain in 3D model uses structured mesh. In the 2D model, elements are triangular or quadrangular. In the 3D model, the element is prismatic or rectangular with respectively triangular or quadrangular cross-sections.

The model is based on the numerical solution of Navier-Stokes equation, three-dimensionally unsuppressed Reynolds with Boussinesq assumptions and hydrostatic pressure.

Continuous equation is written as follows:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = S \qquad (2.1)$$

and the two horizontal momentum equations for the x- and y- component, respectively, are:

$$\frac{\partial u}{\partial t}+\frac{\partial u^2}{\partial x}+\frac{\partial vu}{\partial y}+\frac{\partial wu}{\partial z}=fv-g\frac{\partial \eta}{\partial x}-\frac{1}{\rho_0}\frac{\partial p_a}{\partial x}-$$
$$\frac{g}{\rho_0}\int_z^\eta \frac{\partial \rho}{\partial x}dz-\frac{1}{\rho_0 h}\left(\frac{\partial s_{xx}}{\partial x}+\frac{\partial s_{xy}}{\partial y}\right)+F_u+\frac{\partial}{\partial z}\left(v_t\frac{\partial u}{\partial z}\right)+u_s S \qquad (2.2)$$

$$\frac{\partial v}{\partial t}+\frac{\partial v^2}{\partial y}+\frac{\partial uv}{\partial x}+\frac{\partial wv}{\partial z}=-fu-g\frac{\partial \eta}{\partial y}-\frac{1}{\rho_0}\frac{\partial p_a}{\partial y}-$$
$$\frac{g}{\rho_0}\int_z^\eta \frac{\partial \rho}{\partial y}dz-\frac{1}{\rho_0 h}\left(\frac{\partial s_{yx}}{\partial x}+\frac{\partial s_{yy}}{\partial y}\right)+F_v+\frac{\partial}{\partial z}\left(v_t\frac{\partial v}{\partial z}\right)+v_s S \qquad (2.3)$$

Where: t: time; x, y, z: Cartesian coordinates; η: surface elevation; d: depth of water level; $h=\eta+d$: total depth of water level; u, v, w: flow velocity components; $f = 2\Omega \sin\varphi$: Coriolis parameter; g: gravity acceleration; ρ: water density; s_{xx}, s_{xy}, s_{yx} và s_{yy}: radiant strain; v_t: vertical turbulence; p_a: air pressure; ρ_0: reference water density; S: magnitude of discharge due to point sources; (u_s, v_s): discharged flow velocity

The horizontal strain parameters are defined by using strain Gradient and written as follows:

$$F_u=\frac{\partial}{\partial x}\left(2A\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial y}\left(A\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)\right) \qquad (2.4)$$

$$F_v=\frac{\partial}{\partial x}\left(A\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)\right)+\frac{\partial}{\partial y}\left(2A\frac{\partial v}{\partial y}\right) \qquad (2.5)$$

Where: A: horizontal eddy viscosity.

Surface and bottom boundary conditions for u, v, w are as follows:

At $z = \eta$:

$$\frac{\partial \eta}{\partial t}+u\frac{\partial \eta}{\partial x}+v\frac{\partial \eta}{\partial y}-w=0,\quad \left(\frac{\partial u}{\partial z},\frac{\partial v}{\partial z}\right)=\frac{1}{\rho_0 v_t}\left(\tau_{sx},\tau_{sy}\right) \qquad (2.6)$$

At $z = -d$:

$$u\frac{\partial d}{\partial x}+v\frac{\partial d}{\partial y}+w=0,\quad \left(\frac{\partial u}{\partial z},\frac{\partial v}{\partial z}\right)=\frac{1}{\rho_0 v_t}\left(\tau_{bx},\tau_{by}\right) \qquad (2.7)$$

Where: (τ_{sx}, τ_{sy}) and (τ_{bx}, τ_{by}) are x- and y- components of wind strain at surface and bottom.

Depth of water level can be calculated from surface boundary condition; velocity field is calculated from continuous momentum equations. Integrating this equation by vertical direction:

$$\frac{\partial h}{\partial t} + \frac{\partial h\bar{u}}{\partial x} + \frac{\partial h\bar{v}}{\partial y} = hS + \hat{P} - \hat{E} \tag{2.8}$$

Where: P and E are precipitation speed and evaporation speed, respectively; u and v are average velocity as a function of depth.

$$h\bar{u} = \int_{-d}^{\eta} u dz, \quad h\bar{v} = \int_{-d}^{\eta} v dz \tag{2.9}$$

The liquid is supposed to be an incompressible fluid. Therefore, ρ does not depend on pressure but temperature T and salinity s via the equation of state.

$$\rho = \rho(T, s) \tag{2.10}$$

The equations of the propagation of temperature T and salinity s are written as follows:

$$\frac{\partial T}{\partial t} + \frac{\partial uT}{\partial x} + \frac{\partial vT}{\partial y} + \frac{\partial wT}{\partial z} = F_T + \frac{\partial}{\partial z}\left(D_v \frac{\partial T}{\partial z}\right) + \hat{H} + T_s S \tag{2.11}$$

$$\frac{\partial s}{\partial t} + \frac{\partial us}{\partial x} + \frac{\partial vs}{\partial y} + \frac{\partial ws}{\partial z} = F_s + \frac{\partial}{\partial z}\left(D_v \frac{\partial s}{\partial z}\right) + s_s S \tag{2.12}$$

Where: D_v: vertical diffusion coefficient; $\hat{H}$: source term due to heat exchange with atmosphere; T_s: temperature of heat source. The horizontal diffusion term F is defined by:

$$F_T = \left[\frac{\partial}{\partial x}\left(D_h \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(D_h \frac{\partial T}{\partial y}\right)\right]$$

$$F_s = \left[\frac{\partial}{\partial x}\left(D_h \frac{\partial s}{\partial x}\right) + \frac{\partial}{\partial y}\left(D_h \frac{\partial s}{\partial y}\right)\right]$$

Where: D_h: horizontal diffusion coefficient. Diffusion coefficients can be replaced by turbulent viscous coefficient as follows:

$$D_h = \frac{A}{\sigma_T} \qquad D_v = \frac{\nu_t}{\sigma_T} \tag{2.14}$$

Where: σ_T: Prandtl number. Prandtl number can be used in many application. Surface and bottom boundary conditions for temperature are as follows:

At $z = \eta$:

$$D_h \frac{\partial T}{\partial z} = \frac{Q_n}{\rho_0 c_p} + T_p \hat{P} - T_e \hat{E} \qquad (2.15)$$

At $z = -d$:

$$\frac{\partial T}{\partial z} = 0$$

Where: Q_n: surface temperature, c_p = 4217 J/(kg.°K): water heat capacity

Surface and bottom conditions for salinity are as follows:

At $z = \eta$:

$$\frac{\partial s}{\partial z} = 0 \qquad (2.17)$$

At $z = -d$:

$$\frac{\partial s}{\partial z} = 0 \qquad (2.18)$$

$\hat{E}$: Evaporation participating in the equation.

$$\frac{\partial h}{\partial t} + \frac{\partial (h\bar{u})}{\partial x} + \frac{\partial (h\bar{v})}{\partial y} = hS + \hat{P} - \hat{E}$$

a/ The dependence of $\hat{E}$ on q_v, l_v parameters:

When heat exchange from the atmosphere is included, the evaporation $\hat{E}$ is defined as follows:

$$\hat{E} = \begin{cases} \dfrac{q_v}{\rho_0 l_v} & q_v > 0 \\ 0 & q_v \le 0 \end{cases} \qquad (2.19)$$

Where: q_v: latent heat flux having ($kJ\text{-}kg_m^{-1}$) and lv = $2.5.10^6$ (J/kg) is a latent heat of water vaporisation process.

The dependence of $\hat{H}$

The heat exchange in the atmosphere is calculateded on the basis of four physical processes as follows:

– Latent heat flux (or heat loss due to evaporation)
– Sensible heat flux (or heat flux due to convection)
– Short wave radiation
– Long wave radiation

The latent heat flow, sensible heat flux and longwave radiation are supposed to appear on the surface. The profile of short wave flux will be calculated based on the Beer Law. The decrease of light intensity is described by the modified Beer Law as follows:

$$I(d) = (1-\beta) I_0 e^{-\lambda d}$$

Where I (d) the intensity at the d depth below the surface; I_0 the intensity below water surface; β a fraction of light energy absorbed near the surface; λ light extinction coefficient. The values of β và λ are 0.2-0.6 and 0.5-1.4 m^{-1}. β and λ are constants determined by the user. Default values are β = 0.3 and λ = 1.0 m^{-1}.

The fraction of light energy absorbed near the surface is βI_0. The short wave radiation $q_{sr,net}$ is weakened as described in the advanced Beer Law. Therefore, the heat flux on the surface can be described as follows:

$$Q_n = q_v + q_c + \beta q_{sr,net} + q_{lr,net}$$

For the three-dimensional calculation, $\hat{H}$ can be defined as follows:

$$\hat{H} = \frac{\partial}{\partial z}\left(\frac{q_{sr,net}(1-\beta)e^{-\lambda(\eta-z)}}{\rho_0 c_p}\right) = \frac{q_{sr,net}(1-\beta)\frac{e^{-\lambda(\eta-z)}}{\lambda}}{\rho_0 c_p}$$

For the two-dimensional calculation, $\hat{H}$ can be defined as follows:

$$\hat{H} = \frac{q_v + q_c + q_{lr,net}}{\rho_0 c_p}$$

The calculation of latent heat flux, the sensible heat flux, short wave and long wave radiation is shown in the Mike 3 documents.

3.2. DATABASE

3.2.1. Topography data

Seabed topography data are practically investigated and measured at project site in 2007.

3.2.2. Water level data

There is no tidal monitoring station alongside the Binh Thuan Coast. The only station is a Phu Quy hydrology station located on the Phu Quy Island. This island is about 98 km away from the Phan Thiet city towards the Southeast. In Vung Tau, there is a Vung Tau hydrology station (1978-2010). The typical tidal regime in the project area based on the monitoring data of Vung Tau station is presented in the following table:

Table 1. Typical water level at Vung Tau Station (cm), Period (1978-2010)

Month	1	2	3	4	5	6	7	8	9	10	11	12	Year
Average	-13	-19	-24	-29	-36	-46	-47	-44	-33	-13	-4	-5	-26

Max	143	145	140	121	111	94	101	110	126	142	144	147	147
Min	-297	-281	-256	-282	-314	-333	-324	-311	-274	-256	-291	-289	-333

Source: Vung Tau Hydrologic Station

Note: the water level values at Vung Tau based on the National Elevation System.

According to the real data at the Vung Tau Station (1979-2010), the tidal regime in an area is relatively complex, integrating between even diurnal tide regime and uneven semi-diurnal tide regime. In one day, it can be monitored two tide peaks and two tide bottoms. The elevation of the tide peak and tide bottom, which is adjoining to each other, is normally not equal.

In addition, in the project area whose hour water leveling monitoring data were implemented by PECC2, the monitoring time was from October 14, 2007 to December 14, 2007

Table 2. Typical water level at Vinh Tan Station (Vinh Tan 4 Project area)

Unit: cm

	$H_{average}$	H_{max}	H_{min}
H (cm)	21	151	-100
Apprearing time		21h dated 26/11/2007	7h dated 27/11/2007

Source: Invesment plan for Vinh Tan 1 PP, 11/2007

Based on the above table, the average water level on project area is about 21cm.

3.2.3. Wind data

In Binh Thuan, there are two distinct wind seasons. The East and Northeast wind are prevalent from October to April of the following year and the West and Southwest wind are prevalent from May to September. The typical wind regime at the Phan Rang station through diffirent periods is shown in the following table:

Table 3. The frequency of wind counting on eight directions in year at Phan Rang Station, Period 1993-2010

Direction	Doldrums	N	NE	E	SE	S	SW	W	NW
Frequency (%)	31.6	9.2	24.4	3.6	7.9	3.3	12.0	3.1	5.0

Source: Monitoring data at Phan Rang Station

3.2.4. Seawater temperature

There is no hydrographic station in the project area. Therefore, the seawater temperature will be referred from the Vung Tau hydrographic station. The monthly average temperature value between the two stations has a small difference. The month that has the lowest temperature is December or January. The month that has the highest temperature is April or May. The average temperature is around 28.8°C. The maximum monthly temperature monitored is about 32.5°C (5/1992) at the Vung Tau Station. The minimum monthly temperature monitored at the Vung Tau Station is about 23.8°C (1/1993)

Table 4. Seawater temperature at Vung Tau Station (°C), period (1979-2009).

Month	I	2	3	4	5	6	7	8	9	10	11	12	Year
Average	26.5	26.6	27.8	29.5	30.1	29.5	28.7	28.5	28.6	29.0	28.4	27.3	28.4
Max	29.5	30.0	31.5	32.1	32.5	32.2	31.8	31.4	31.9	31.6	31.0	30.3	32.5

Min	23.8	24.0	24.1	26.9	26.7	26.7	25.8	25.0	24.0	26.5	24.0	24.8	23.8

Source: Monitoring data at the Vung Tau Station

3.2.5. Salinity

The salinity has been measured at the Phu Quy and Vung Tau Station. Since the Vung Tau Station is near the estuary, the salinity during flooding months decreases considerably. At Son My position, far away from the large estuary, it should be referred to the salinity at Phu Quy station to determine for Vinh Tan. The frequency of salinity measurement is four times per day (at 1, 7, 13 and 19h).

Table 5. Seawater salinity of Phu Quy Station (‰), Period 1979-2005

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Average	32.1	32.4	32.5	32.6	32.4	32.2	31.7	31.1	31.2	31.0	31.4	31.5	31.9
Max	35.3	35.2	37.6	35.9	35.2	35.3	35.5	35.7	35.1	34.7	35.3	35.1	37.6
Min	20.6	21.7	21.9	21.7	20.1	20.7	21.0	20.7	21.1	21.3	21.5	21.4	20.1

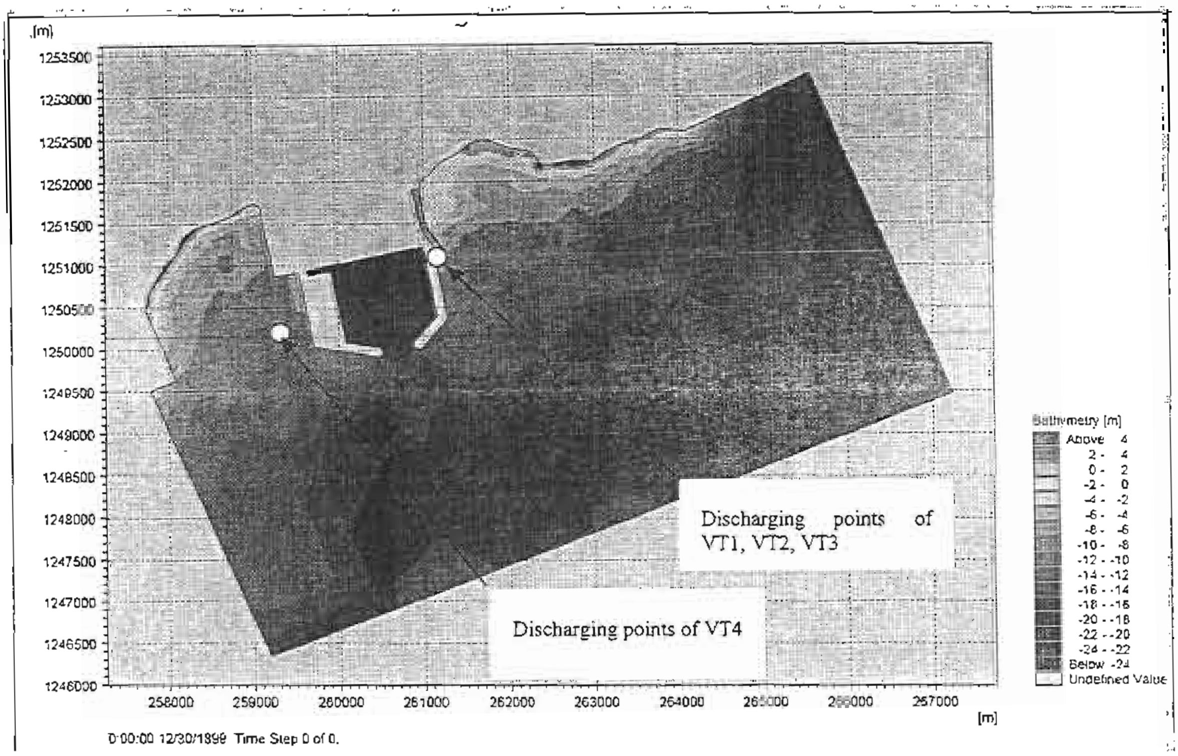
3.3. HYDRAULIC MODEL SETUP

Hydrodynamic model is used to describe accurately the current flow structure near the project area as well as the trusted tidal boundary in the model.

3.3.1. Grid

The grid system developed for this research consists of three grids and spreading around 10km counting from the coast in order to recreate the exact tidal variables. The grid system includes one coarse network with the grid dimension of about 500m and 5km away from the coast. Two finer grids with the size of 100m and 35m were used to separate region in the port area, cooling water intake and discharge areas.

Bathymetric grid for the model in this area is the terrain data file processed in the Bathymetry program, associated with the model grid. Results from processing the bathymetric grid are shown in the following figure.



3.3.2. Boundary conditions

Tide boundaries were imposed on the open boundary of the model, concretely the eastern boundary, south and west boundary. Tide is predicted from global tidal model of 2D MIKE.

3.3.3. Model adjustment

Tide is predicted from global tide model and corrected based on measured data in the project area from October 14, 2007 to December 14, 2007.

3.3.4. Input data of the model

3.3.4.1. Cooling water flow

The power plants in the Vinh Tan Power Complex will take seawater for cooling in the port area. Cooling water of Vinh Tan power plant 1, 2, and 3 will be discharged by channels at the eastern site. Wastewater from Vinh Tan 4 power plant will be discharged by steel pipe in the west of Vinh Tan Power Complex. Flow and coordinates of the cooling water system of the plants in Vinh Tan Power Complex is shown in the following table:

No.	Content	Data			
		Coordinates (VN2000)		Flow (m^3/s)	Temperature Gradient (^oC)
		X	Y		
1	Discharge point of the VT 1, 2, 3 PP	1250845.589	533808.833	187	8
2	Discharge point of the VT 4 PP	1249703.816	532238.071	50	8

3	Average seawater temperature	30°C

3.3.4.2. Calculation time and scenario

Cooling water for the whole Complex has the total flow of 237 m^3/s and a maximum designed seawater temperature is 30°C. The degree of thermal addition between the input and the output of condensers and through FGD is Δt=8°C. Therefore, the cooling water with the maximum temperature of about 38°C will be directly discharged to the inshore area of Vinh Tan Commune - Tuy Phong District. In order to evaluate the temperature distribution at the project area as well as to assess the temperature intermixture from the cooling water discharging from the port. MIKE 3 will calculate the temperature propagation for the whole Vinh Tan Power Complex in both rainy and dry seasons.

Results of the input parameters of the model are summarised as follows:

Parameter	Value
Discharging type of Vinh Tan 1, 2, 3 TPPs	Right parallelepiped discharging channel set perpendicular to the coast, depth of -4m, the width of 12m
Discharging type of Vinh Tan 4 TPP	Discharged by three steel pipes at the depth higher than -7.5m, diameter for each pipe is about 4m
Number of layers and depth of each layer	Imitative region is devided into 10 layers, the depth depending on the depth of terrain. For each position of discharged floodgate which has the depth higher than -7.5 m, the depth of each layer is about 1.9m
Flow	237 m^3/s
Average temperature	30°C
Maximum Salinity	30g/l
Tide	Predicted tide
Wind	Theo
Time	Rainy season: 0h 18/10/2007 – 23h30 17/11/2007 Dry season: 0h 3/2/2007 – 23h30 2/3/2007

The calculation time for each scenario is 30 days in which: trial operation will be conducted during the first three days, then the results of the first three days will be used as the primary condition for the following days. The results in this report are the calculation results based on the later 30 days. Time jump of the model is 30 seconds.

3.3.5. Results

According to the National Technical Regulation on Industrial Wastewater QCVN 40:2011/BTNMT), the wastewater temperature must be lower than 40°C (in the project report, the cooling water source discharging to the environment has the highest temperature of about 38°C). Therefore, the calculation will be based on water temperature value varied on the real temperature whose maximum temperature is about 38°C (it's the most unfavorable circumstance for the water source of the area). Therefore, the influenced scope will be determined.

The hydrodynamic condition of the Binh Thuan coast in general and the Vinh Tan inshore area in particular is influenced by combined impacts such as wind, water level fluctuation, wave. The calculation results from the model shows that the integrated current of the area has small velocity. Prevalent fluctuation is in range of 0.1-0.3m/s and depending on the tide. The current direction is mainly along the river bank: East-Northeast (flood tide phase) or South-Southwest (ebb tide phase)

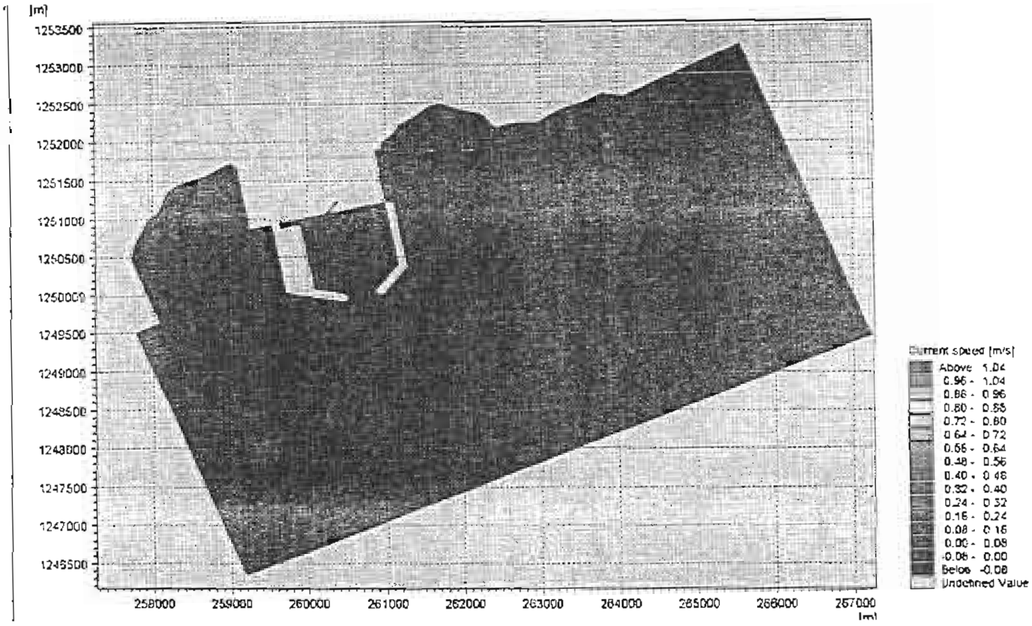


Figure 1. Velocity distribution at the surface layer of the Vinh Tan sea area- flood tide

It can be easily recognized that taking the water in the turning basin of the project area will cause the flow running from the water discharging area to the water taken area. The flow on the sea tends to change its direction when contacting the breakwater. The flow will be changed and follow the breakwater to the sea.

The results are shown based on the depth from the surface to the layers at the flood tide and ebb tide periods. The influenced scope of the heat on the surface and the bottom are particularly presented in the Figure 2 to 13.

3.3.5.1. In rainy season

1. Surface layer

a) Flood tide

i. Vinh Tan 4 TPP

At area which has the temperature in range from 30 to 31°C, the tide tends to move onto the Northwest of the discharging source and discharging point. The affected area is estimated approximately 1.3 km^2. Owing to the discharge point of Vinh Tan 4 TPP is underground at the depth of above-7.5m, it is easy to exchange heat with the seawater environment. Area, which has temperature in range from 31 to 32°C with an area of 0.23 km^2, mainly distributes at the Northwest of the discharging source, approximately 1000m away from the discharging source.

ii. Vinh Tan Power Complex

The area having the temperature of 30-31 °C is mainly distributed to the Southeast of the discharging source; the influenced area is around 2.9 km^2 and away from the discharging source of Vinh Tan Power Complex about 3km towards the East. The area having the temperature of 31- 32°C with an area of about 1.6 km^2 mainly distributes to the East and away from the discharging source about 2.5 km towards the East. The area having the temperature over 32-33°C with an area of about 0.69 km^2 is mainly distributed to the Southeast and away from the discharging source about 1 km. The area having the temperature of 34°C with an area of 0.25km^2 is distributed arround the discharging channel and surrounding the breakwater, away from the discharging point about 500m. The area having the temperature of 35°C is mainly distributed at the discharging source.

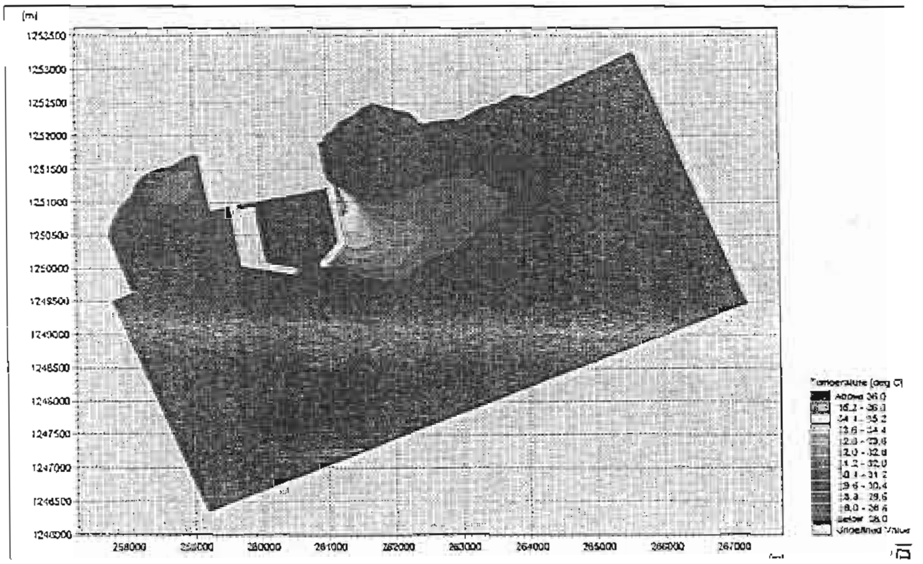


Figure 2. Temperature distribution of the surface layer due to the cooling water of Vinh Tan 4 TPP and the whole Vinh Tan Power Complex - flood tide

In the port area, where the temperature is around 30-31°C, because the power plants in the Vinh Tan Power Complex take cooling water at the surface layer, the temperature at the water taken point will be only considered at the surface layer. In case of flood tide, at the water taken point of Vinh Tan 4, the water temperature is in range of 30.5-31°C (higher than the average temperature approximately 0.5-1°C). The water temperature of the taken point in Vinh Tan 3, Vinh Tan 2, Vinh Tan 1 TPPs is about 30°C.

b) <u>Ebb tide</u>

i. *Vinh Tan 4 TPP*

In case of ebb tide, the area having the temperature in range of 30 – 30.5°C tends to move towards the Southeast and Northwest of the discharging source, spreading to the Vinh Tan sea area. In the discharging area, the temperature is about 30.5-31 °C with an area approximately 0.043km^2 and tends to move to the Northwesten coast. The area having the temperature in range of 31-32°C with an area of about 1.23km^2 (in which the area with highest temperature is nearly 32°C with an area approximately 0.2km^2), mainly distribute to the Northeast, away from the discharging source about 700m.

ii. *Vinh Tan Power Complex*

In ebb tide period, the area having the temperature in range of 31 – 32°C with an area approximately 1.8 km^2 tends to move towards the South of the discharging source, away from the discharging source about 2km. The area having the temperature in range of 32 – 33°C with an area approximately 0.75 km^2, mainly distributed towards the South, away from the discharging source about 1.8 km. The area having the temperature in range of 33 – 34°C with an area approximately 0.14 km^2, follows the breakwater and mainly distributes near the breakwater area, away from the discharging source about 800 km. The area having the temperature over 34°C is mainly distributed in the discharging point and breakwater area with an area approximately 0.12 km^2 away from the discharging source about 700m.

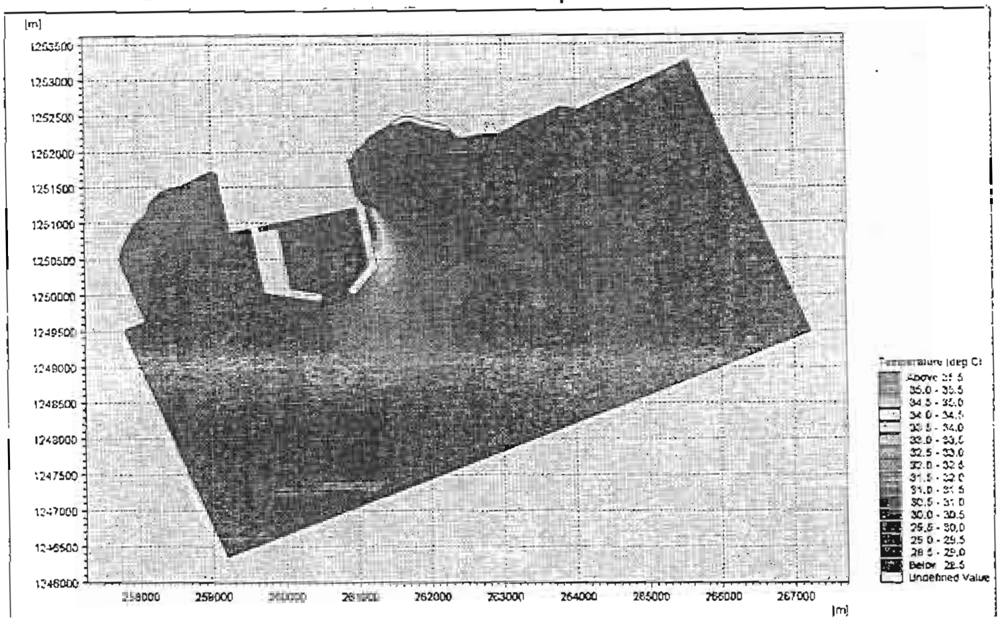


Figure 3. Temperature distribution on the surface layer due to the cooling water of Vinh Tan 4 TPP and the whole Vinh Tan Power Complex - ebb tide

In the port area having the temperature in range of 30-31°C, at the taken water point of Vinh Tan 4, the water temperature is about 30.5-31°C (higher than the average temperature approximately 0.5-1 °C). The temperature of the taken water point of Vinh Tan 3, Vinh Tan 2 and Vinh Tan 1 is about 30 °C.

2. *Median layer*

a) Flood tide

i. *Vinh Tan 4 TPP*

At the depth of about -4m in comparison with the sea level, the area having the temperature in range of 31 – 31.5°C is mainly distributed at the discharging point with an circulated area of about 0.025 km^2. The discharged current tends to move to the Northwest of the discharging source. The temperature of surrounding sea area is lower than 31 °C.

ii. *Vinh Tan Power Complex*

An area having the temperature in range from 31 to 32°C with the area of 0.019km^2, flows alongside the breakwater and distributes near the breakwater area, away from the discharging point approximately 400m. Area having the temperature in range from 32 to 34°C with the area of 0.012km^2, follows the breakwater and away from the discharging point approximately 250m. Area having the temperature over 35°C with an area of 0.019km^2 is mainly distributed within the radius of 100-200m from the discharging point.

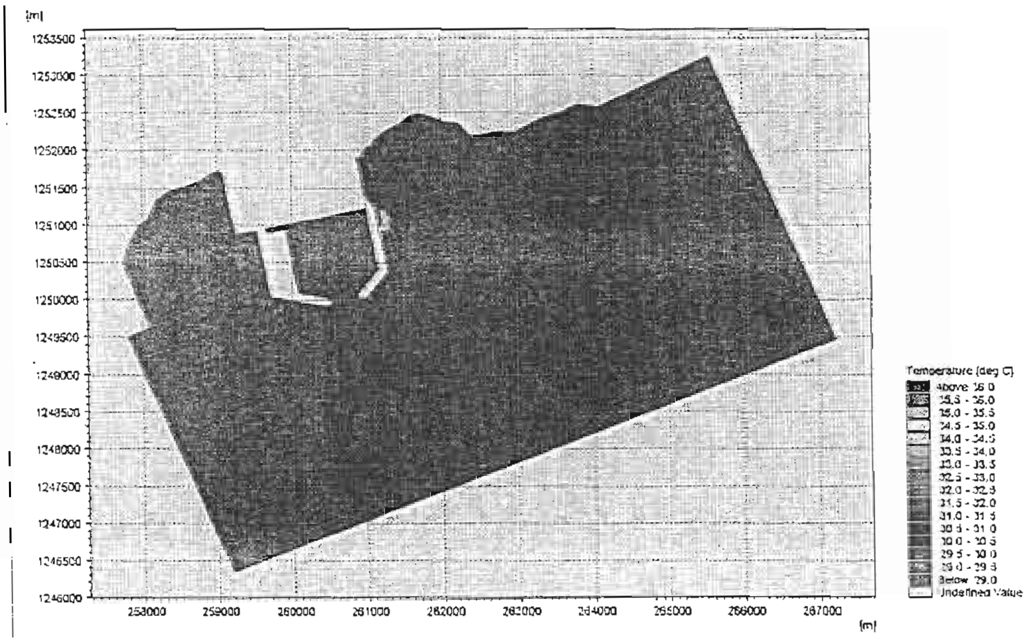


Figure 4. Temperature distribution on the median layer due to the cooling water of Vinh Tan 4 TPP and the whole Vinh Tan Power Complex- flood tide

b) <u>Ebb tide</u>

i. Vinh Tan 4 TPP

At the depth of about -4m in comparison with the sea level, the area having the temperature in range of 31 – 32°C is mainly distributed at the discharging point and along the bank area with a dispersed area of about 0.1km^2. The heat flux tends to move to the West and the Northwest. In the coastal area, there is a small area having temperature of about 31-32°C. The temperature of other area is around 30 °C.

ii. Vinh Tan Power Complex

An area having the temperature in range from 31 to 32°C with the area of 0.035km^2, follows the breakwater and distributes near the breakwater area, away from the discharging point approximately 500m. Area having the temperature over 32°C with the area of 0.27 km^2, flows alongside the breakwater and approximately 200m away from the discharging point. Area having the temperature over 34°C is mainly distributed at discharging source.

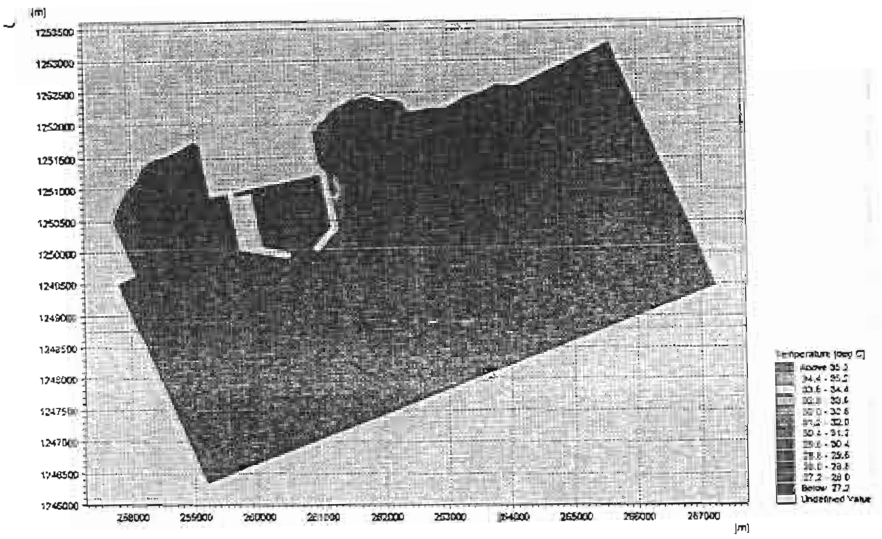


Figure 5. Temperature distribution on the median layer due to the cooling water of Vinh Tan 4 TPP and the whole Vinh Tan Power Complex- ebb tide

3. *Bottom layer*

a) Flood tide

i. *Vinh Tan 4 TPP*

At the depth of about -9m in comparison with the sea level, the area having the temperature in range of 30 – 31°C is mainly distributed at the discharging point with an area of about 0.2km^2. The temperature of the heat flux is about 29 – 30°C tends to follow the breakwater moving from the West to the South into the port area. The temperature of other area is lower than 29 °C.

ii. *Vinh Tan Power Complex*

The depth of the discharging channel of Vinh Tan Power Complex is about -5m. Therefore, the heat flux of the Vinh Tan Power Complex at the depth of -9m is about 29 °C presenting that the heat flux tends to move onto the top water layer.

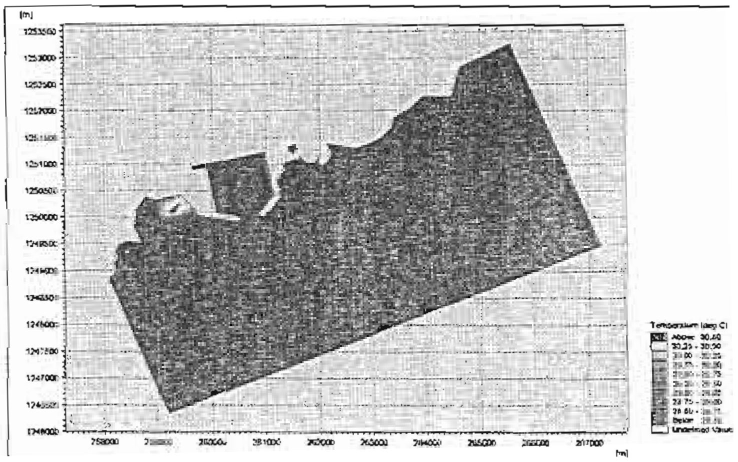


Figure 6. Temperature distribution of the bottom layer due to the cooling water of Vinh Tan 4 TPP and the whole Vinh Tan Power Complex- flood tide.

b) Ebb tide

i. *Vinh Tan 4 TPP*

At the depth of about -9m in comparison with the sea level, the area having the temperature in range of 30 – 31°C is mainly distributed at the discharging point with an area of about $0.2km^2$. The temperature of the heat flux is about 29 – 30°C tends to move to the West of the discharging source. The temperature of other area is lower than 29 °C.

ii. *Vinh Tan Power Complex*

The depth of the discharging channel of Vinh Tan Power Complex is about -5m. Therefore, the heat flux of the Vinh Tan Power Complex at the depth of -9m is about 29°C which presenting that the heat flux tents to move onto the top water layer.

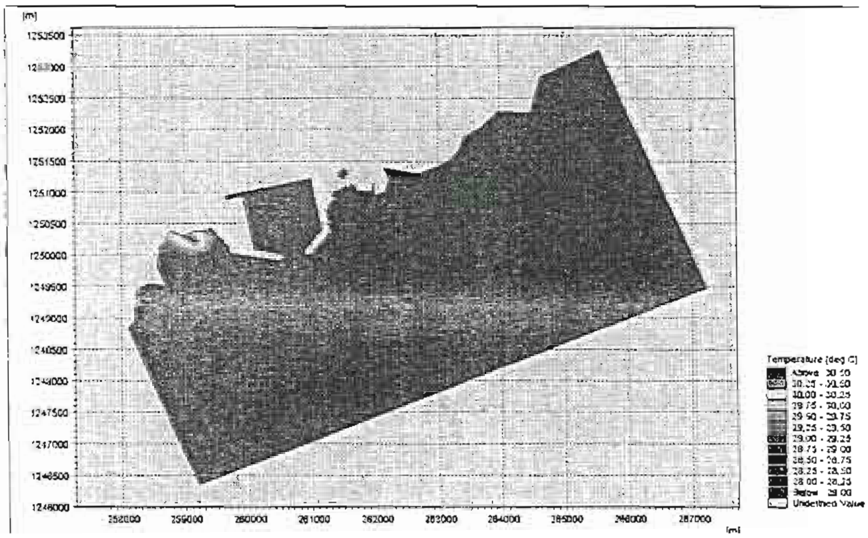


Figure 7. Temperature distribution on the bottom layer due to the cooling water of Vinh Tan 4 TPP and the Vinh Tan Power Complex- ebb tide

3.3.5.2. In dry season

1. *Surface layer*

a) <u>Flood tide case</u>

i. *Vinh Tan 4 TPP*

The area having the temperature in range of 29 – 30°C is in the discharging point area and tends to move towards the Northwest of the discharging point. The influenced area is about $1km^2$. The area having the temperature in range of 30 – 31°C (higher than the average temperature is about 1°C) with an area of $0.55km^2$ mainly distributed to the Northwest of the discharging source, away from the discharging source approximately 1000m.

ii. *Vinh Tan Power Complex*

The area having the temperture of 30 – 31°C is mainly distributed toward the Southeast of the discharging source and tends to move to the port area. The influenced area is about $0.9 km^2$ and away from the discharging source of the Vinh Tan Power Complex approximately 2.2km towards the East. The area having the temperture of 32 – 33°C with an area of about $0.68km^2$ is mainly distributed in the Southeast and 1.2 km away from the discharging source. The area having the temperture of 33 – 34°C with an area of about $0.13km^2$ is mainly distributed near the discharging channel and following the breakwater, away from the discharging source approximately 700m. The area having the temperature from 34-35°C is mainly distributed at the discharging source, approximately 400m towards the South.

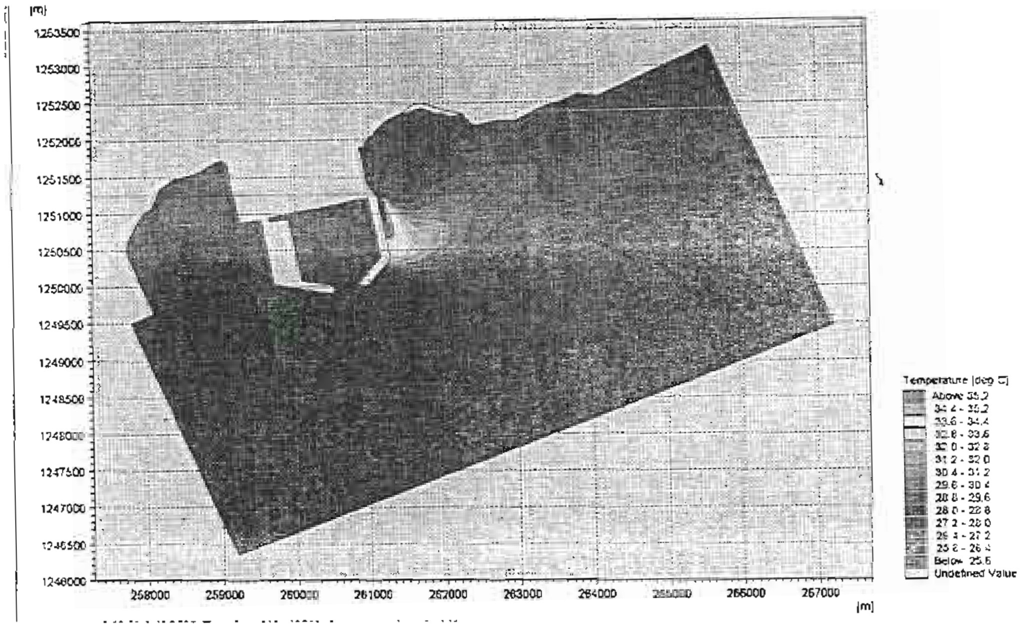


Figure 8. Temperature distribution on the surface layer due to the cooling water of Vinh Tan 4 TPP and the whole Vinh Tan Power Complex- flood tide

In flood tide period, at the water intake points of Vinh Tan 4 and Vinh Tan 3, Vinh Tan 2 and Vinh Tan 1, the sea water temperature is about 29-30°C.

b) Ebb tide

i. *Vinh Tan 4 TPP*

The area having the temperature in range of 29 – 30°C is in the discharging area and tends to move towards the Northwest of the discharging point. The influenced area is about 1km^2. The area having the temperature over 30 – 31°C (higher than the average temperature is about 1°C) with an area of 0.55km^2 mainly distributes to the Northwest of the discharging source, approximately 1000m away from the discharging source.

ii. *Vinh Tan Power Complex*

The area having the temperture of 30 – 31°C is mainly distributed towards the Southeast of the discharging source. The influenced area is about 3.5 km^2 and approximately 3 km away from the discharging source of the Vinh Tan Power Complex towards the Southeast. The area having the temperture of 31 – 32°C with an area of about 0.53km^2 is mainly distributed in the South and away from the discharging source 1.8km. The area having the temperture over 32 – 33°C with an area of about 0.15km^2 is mainly distributed towards Southeast, away from the discharging source approximately 0.9 km. The area having the temperature from 33-34°C with an area of 0.09 km^2 is mainly distributed near the discharging channel and following the breakwater, appoximately 500m away from the discharging source towards the South.

During ebb tide period, at the water taken points of Vinh Tan 4 and Vinh Tan 3, Vinh Tan 2 and Vinh Tan 1 TPPs, the sea water temperature is about 29-30°C.

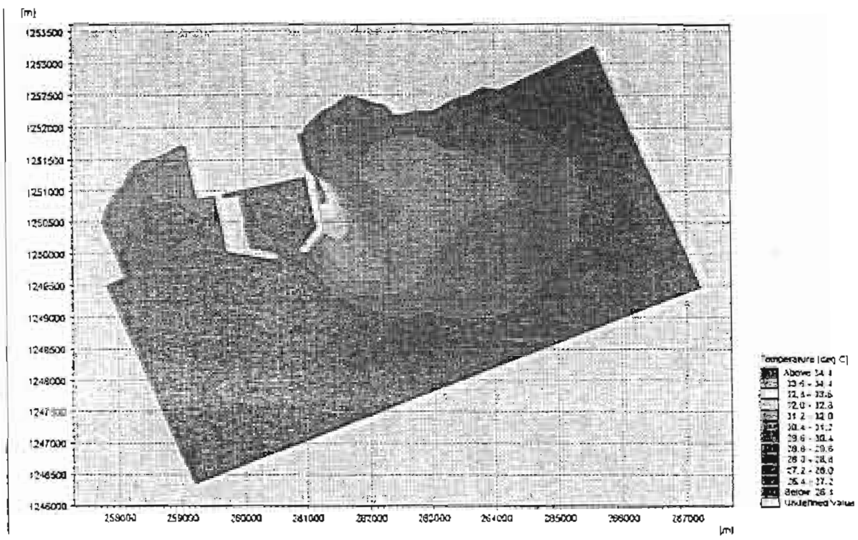


Figure 9. Temperature distribution on the surface layer due to the cooling water of Vinh Tan 4 TPP and the whole Vinh Tan Power Complex- ebb tide

2. *Median layer*

a) Flood tide

i. *Vinh Tan 4 TPP*

Area having the temperature in range from 30 to 30.5°C is in the discharging area tends to move to the Northwest of the discharging source, away from the discharging source approximately 1.5 km with an influenced area is around 1.1 km^2

ii. *Vinh Tan Power Complex*

The area having the temperture of 30 – 30.5°C is mainly distributed toward the Northeast of the discharging source. The influenced area is about 0.47 km^2 and away from the discharging source of the Vinh Tan Power Complex approximately 3 km towards the East. The area having the temperture of 31 – 32°C with an area of about 0.07km^2 is mainly distributed in the Southeast and away from the discharging source 0.5km. The area having the temperture over 32 – 33°C with an area of about 0.02km^2 is mainly distributed towards Southeast, away from the discharging source approximately 0.3 km. The area having the temperature over 34°C is mainly distributed within the radius of appoximately 250m in the discharging area. The area having the temperature lower than 30°C tends to move to the port.

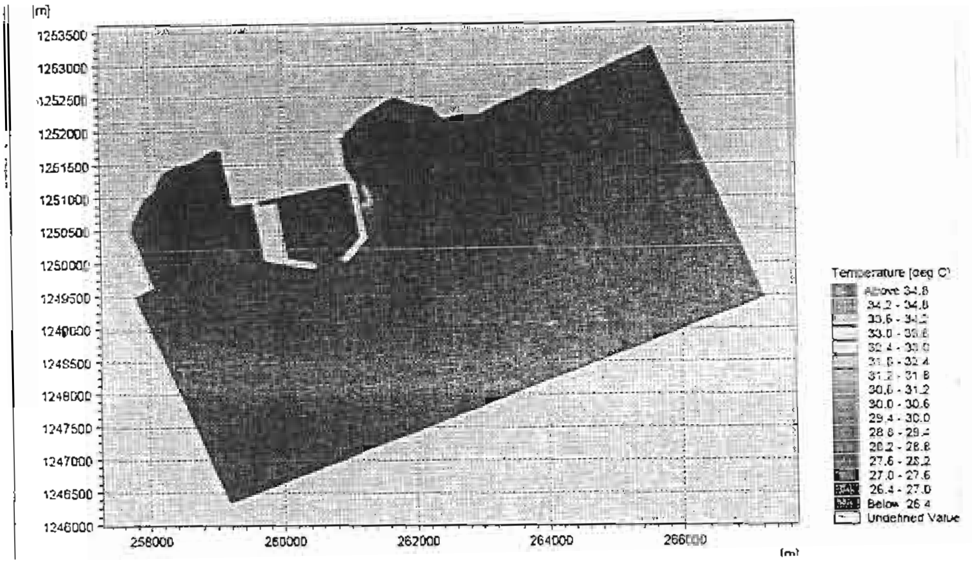


Figure 10. Temperature distribution on the surface layer due to the cooling water of Vinh Tan 4 TPP and the whole Vinh Tan Power Complex-flood tide

b) Ebb tide

i. *Vinh Tan 4 TPP*

The area having the temperature in range from 30 to 30.5°C is in the discharging point area with an influenced area of 0.02km^2. The heat flux tends to move to the Northwest of the discharging source. The temperature of other area is lower than 30 °C.

ii. *Vinh Tan Power Complex*

The area having the temperature in range from 31 to 32°C with an area of 0.025km^2 flows alongside the breakwater and distributes near the breakwater area, about 400m away from the discharging source. The area having the temperature in range from 32 to 33°C with an area of 0.02 km^2, follows the breakwater and approximately 300m away from the discharging source. The area having the temperture over 34°C is mainly distributed in the scope of 200m.

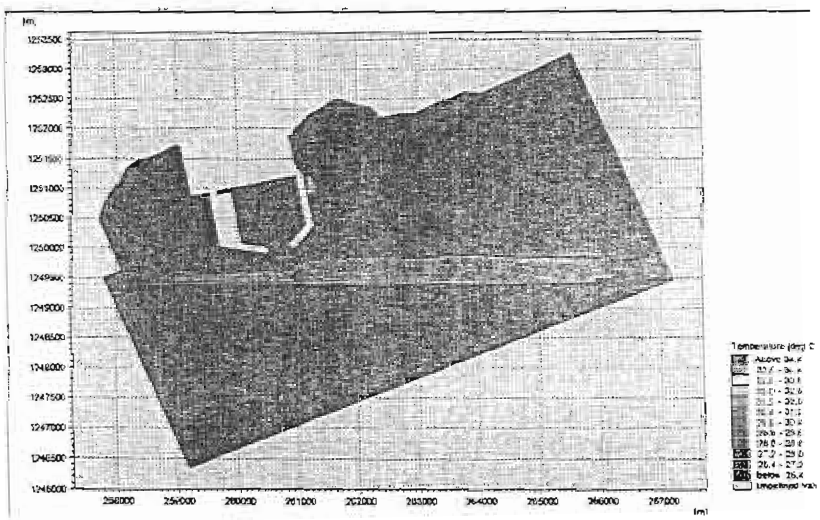


Figure 11. Temperature distribution on the surface layer due to the cooling water of Vinh Tan 4 TPP and the whole Vinh Tan Power Complex-flood tide

3. *Bottom layer*

a) Flood tide

i. *Vinh Tan 4 TPP*

At the depth of about -9m in comparison with the sea level, the area having the temperature over 30°C is mainly distributed around the discharging point with an area of about 0.1km². The discharged heat flux tends to move from the West to the South, alongside the breakwater to the port. The water temperature at port and surrounding area is around 28 °C.

ii. *Vinh Tan Power Complex*

The discharging channel of Vinh Tan Power Complex is about -5m deep. Therefore, the waterv temperature at the Vinh Tan Power Complex at the depth of -9m is about 28 °C which reveals that the heat flux tends to move onto the top water layer.

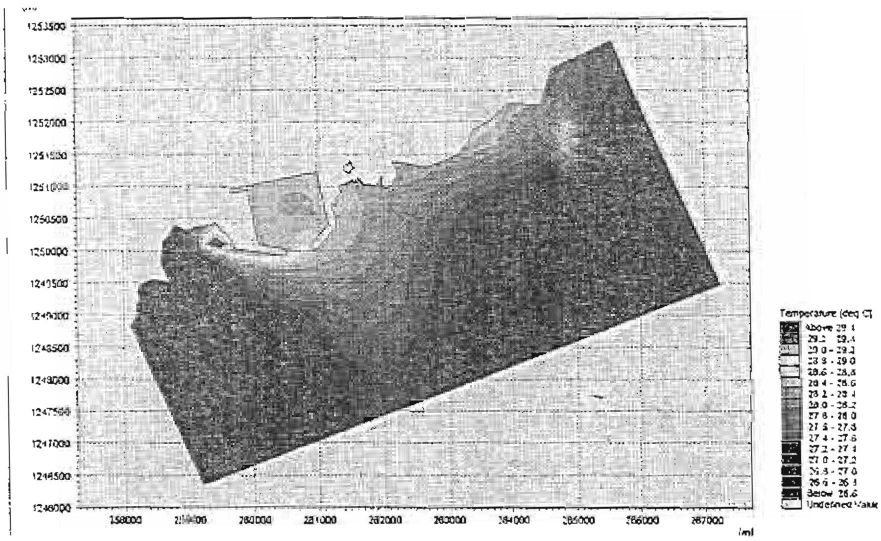


Figure 12. Temperature distribution on the bottom layer due to the cooling water of Vinh Tan 4 TPP and the whole Vinh Tan Power Complex-flood tide

b) <u>Ebb tide</u>

i. *Vinh Tan 4 TPP*

At the depth of about -9m in comparison with the sea level, the area having the temperature over 29-30°C is mainly distributed at the discharging point with an area of about 0.14 km². The heat flux tends to move towards the West of the discharging source, having the temperature of about 29 – 30°C. The temperature of other area is lower than 28 °C.

ii. *Vinh Tan Power Complex*

The depth of the discharging channel of Vinh Tan Power Complex is about -5m. Therefore, the temperature of the heat flux of the Vinh Tan Power Complex at the depth of -9m is about 28 °C presenting that the heat flux tents to move onto the top water layer.

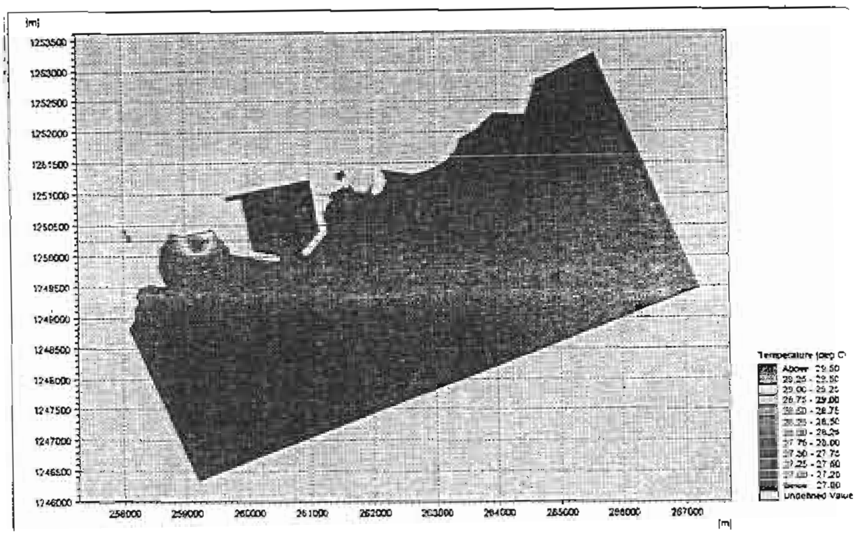


Figure 13. Temperature distribution on the bottom layer due to the cooling water of Vinh Tan 4 TPP and the whole Vinh Tan Power Complex- ebb tide

3.3.5.3. Conclusion

According to the National Technical Regulation on Industrial Wastewater QCVN 40:2011/BTNMT, the wastewater temperature must be lower than 40°C (in the project report, the cooling water source discharging to the environment has the highest temperature of about 38°C). Therefore, the calculation will be based on water temperature value varied on the real temperature value which is about 38°C (it's the most unfavorable circumstance for the water source of the area). In conclusion, the cooling wastewater temperature in both scenarios are lower than 40°C which is satisfied with the National Technical Regulation.

At the discharging point of the Vinh Tan 4 TPP, the water temperature is about 32-31°C (higher than the surrounding environment temperature 1°C). The region having the temperature of 32°C (higher than the surrounding environment temperature 2°C) mainly distributes in the inshore area towards the Northwest because the flow tends to move to the coast.

At discharging point of the Vinh Tan 4 Power Complex, the water temperature is about 34-35°C (increases 4-5°C in comparision with the surrounding average temperature) and decreases slightly to the surrounding environment. The area having the temperature increases about 2-3°C in comparision with the surrounding environment is mainly distributed at the breakwater area, approximately 500m- 1km away from the discharging source.

APPENDIX 3.5. THE IMPACT QUANTITATIVE SYSTEM – IQS

To assess the degree of environmental impact caused by project activities, the Impact Quantitive System –IQS, an advanced comprehensive method, is applied during the EIR report. Furthermore, impacts caused by diffusion of exhaust form the stack or discard of cooling water as well as fuel catching fire are anticipated by using specific simulation models.

The IQS has been based on the combination of EIR guides from E&P Forum, UNEP (The United Nations Environment Programme) and WB (World Bank). With IQS System, each of particular impacts found will be considered on these following features:

Factors	Typical parameters
- Physical, chemical and biological interactions	- Intensity, frequency
- Probability	- Scope of impacts - Time for restoration
- Management	- Laws, cost, community attention

Each parameters is determined based on the classification system listed in Table 3.1

Table 3.1: The Classification System of IQS

	Parameter	Classification system		
		Level	**Definition**	**Marks**
Impacts	*Intensity (M)*	*significant impacts or major impact*	A significant impact is known as the impact causing great change of natural factors or environmental transformation. It can affect to environment or socio-economic zone. In this case of this project, just the concentration of one air or water pollutant is 3 times higher than allowable limitation or environmental degradation caused by the project can be directly endamage to human health and natural resources.	3

	Parameter	Classification system		
		Level	Definition	Marks
		Medium or intermediate impacts	A medium impact is defined as the impact which is able to affect to environmental components. The results of this impact to environment may not be serious. For this project, if concentration of a pollutant from air or water is over the allowable limitation of 2-3 times or in case of environmental deterioration, the human health or surrounding organisms as well as economy can be under bad impacts.	2
		Small impacts or minor impacts	A small or minor impact can slightly affect the natural environment and a small part of local population. In case of this project, if concentration of air or water pollutants is 1.0 - 2.0 times higher than the limits of the relevant Vietnamese standards, or the scope covers only a group of workers without external subject, the impact is considered minor.	1
		Non-impacts	Inconsiderable or non-impact means the effect is none or unclear. In this case, assessment is not detailed but associated with some remarks – "non-impact" or "inconsiderable".	0
Interaction	*Scope of impact (S)*	Inconsiderable	The narrow scope encompasses the source with radius under 100 meters.	0
		Local	Encompassing the resource with radius from 100 to 1000 meters.	1

	Parameter	Classification system		
		Level	Definition	Marks
		Rigional	Within the radius from 1000 to 10.000 meters.	2
		trans-regional	Including both provinces surrounding resource within the radius from 10 to 100 kilometers.	3
		International	The scope of impact covers adjacent neighboring nations	4
	Restoring time (R)	< 1 year	Time for restoration to initial status: less than 1 year.	1
		1 – 2 years	Time for restoration to initial status: 1-2 year.	2
		2 – 5years	Time for restoration to initial status: 2-5 year.	3
		> 5 year	Time for restoration to initial status: more than 5 year.	4
Environmental incident	*Frequency (F)*	Very rare or hard	Very rare or never occur.	0
		Rare	May occur but rare	1
		Relatively high risk	Relatively high risk for environmental incident	2
		Very high risk	Very high risk for environmental incident	3
Management	*Law (L)*	Absent	No regulation	0
		General	General regulation	1
		Specific	Regulation in details	2

	Parameter	Classification system		
		Level	Definition	Marks
	Expense (E)	Small	Small expense on management and implementation of measures for prevention and mitigation	1
		Medium	Medium expense on management and implementation of measures for prevention and mitigation	2
		Large	Large expense on management and implementation of measures for prevention and mitigation	3
	Public concern (P)	Minor	None or few nuisance or concern (complaint) of the community about environmental matters	1
		Medium	Nuisance or concern (complaint) of adjacent communities about environmental matters	2
		High	Widespread nuisance or concern (complaint) of the community about environmental matters.	3

Source: Determination by EIA consultant (VESDEC), October 2008

Impacts are analyzed, evaluated and rated based on their characteristics. The total point is calculated with the formula:

Total point (TS) = (M+S+R) x F x (L+E+P) = Level of overall impact (TS)

Values of each parameter are scaled with 5 levels as follows: minimum, low, medium, high and maximum as shown in *Table 3.2.* The total point of each relating value is also calculated with the formula hereinbefore.**Table 3.2: Scaling of impacts based on total points**

Scaling	M	S	R	F	L	E	P	TS
Minor	0	0	1	0	0	1	1	0
Small	1	1	1	1	1	1	1	9
Medium	2	2	2	2	2	2	2	72
High	3	3	3	2	2	3	3	144

Major	3	4	4	3	2	3	3	264

From *Table 3. 2,* environmental impacts are scaled in 4 levels as follows:

Total Point	**Level of impact**
0 - 9	No or minor
9 - 72	Small
72 - 144	Medium
144 - 264	Major (or severe)

Characteristics of each kinds of impact can be summarized as follows:

- **Major (severe) environmental impacts (total point of 144 to 264)**
  - Severe deterioration the quality of soil, water, the air, bio-systems, construction works, strong influences on ecosystems, human health or economy, or long-term loss (more than 5 years) to the environment;
  - Trans-regional or international scope of impact
  - Very difficult restoration to the initial status
  - Attention (complaint, reaction) by the public of many districts or provinces because of possible influence on community health, or adverse ecological or socio-economic effects.
  - Big expenses for prevention and/or mitigation.
- **Medium environmental impacts (total point of 72 - 144)**
  - Significant reduction of the quality of one environmental component, damages to ecosystems or medium duration of damage (2 - 5 years) to the environment.
  - Regional scope of impact (1 – 10 km).
  - Difficult restoration to the initial status (2 – 5 years).
  - Medium expenses for prevention and/or mitigation.
- **Small (slight) environmental impacts (total point of 9 - 72)**
  - Not big reduction of the quality of one environmental quality, slight damages to ecosystems or short duration of damage (1 - 2 years) to the environment.
  - Local scope of impact (100 – 1000 m).
  - Easy restoration to the initial status (less than 2 years).
  - Reaction by some people because of possible influence on community health, or adverse ecological or socio-economic effects.
  - Small expenses for prevention and/or mitigation.
- **No or minor environmental impacts (total point of 0 - 9)**

- Insignificant reduction of the quality of one environmental quality, minor damages to ecosystems or short duration of damage (less than 1 year) to the environment.
- Limited scope of impact (within the plant).
- Easy self-restoration to the initial status (less than 1 year).
- No matters relating to community health and no negative effect on other socio-economic aspects.
- Inconsiderable expenses on prevention and mitigation.

Based on IQS and analyses and assessment mentioned above, negative environmental impacts of the project are summarized in *Table 3. 3.*

Table 3.3:

Summary of negative impacts of the project for Vinh Tan 4 coal-fired plant on natural and socio-economic environments

Phase of the project	Environmental Impacts	Impact Quantification System (IQS)								
		M	S	R	F	L	E	P	TS	Rating
Pre-construction										
	Socio-economic impacts of land acquisition	2	2	3	2	2	2	3	98	Medium
	Increase in air pollution	2	2	1	1	1	2	2	25	Small
	Increase in noise pollution	2	2	1	1	1	1	2	48	Small
	Impact of vibration	0	0	1	0	0	1	1	0	No impact
	Surface water pollution due to effluents	2	2	2	2	2	2	2	72	Medium
	Pollution of soil and underground water	1	0	1	1	1	2	1	8	No impact
	Impact on bio-resources	2	2	3	2	2	3	3	112	Medium
	Impact on local traffic	2	2	1	2	0	1	2	30	Small
	Impact on cultural or religious works	0	0	1	1	1	2	2	5	No impact
	Matters of safety and health	1	1	1	1	0	1	2	9	Small
	Impact of workers' aggregation	2	1	2	1	0	1	1	10	Small
construction phases										
	Increase in air pollution	2	2	1	1	1	2	2	25	Small
	Increase in noise pollution	2	2	2	2	1	1	2	48	Small
	Impact of vibration	0	0	1	0	0	1	1	0	No impact
	Surface water pollution due to effluents	3	2	2	2	2	2	2	72	Medium
	Pollution of soil and underground water	1	0	1	1	1	2	1	8	No impact
	Impact on bio-resources due to dredging and releasing material	2	2	4	2	2	3	3	128	Medium
	Impact on local traffic	2	2	1	1	0	1	2	15	Small

Phase of the project	Environmental Impacts	Impact Quantification System (IQS)								
		M	S	R	F	L	E	P	TS	Rating
	Impact on cultural or religious works	0	0	1	1	1	2	2	5	Small
	Matters of safety and health	1	1	1	1	0	1	2	9	Small
	Impact of workers' aggregation	2	1	2	1	0	1	1	10	Small
Operation phase										
	Increase in air pollution due to emissions from the plant	3	2	2	2	2	3	3	112	Medium
	Increase in air pollution due to standby generators	1	1	1	0	0	1	1	0	No impact
	Increase in noise pollution	2	2	3	2	2	3	2	98	Medium (inside the factory)
	Impact of vibration	1	1	1	2	0	1	1	12	Small
	Pollution of surface and underground water due to effluent	2	2	2	3	2	2	2	108	Medium
	Impact of solid waste and slag	2	2	3	3	2	1	2	105	Medium
	Impact of hazardous waste	2	1	3	1	2	3	3	48	Small
	Impact on bio-resources	2	2	3	2	2	3	3	112	Small
	Heat pollution	3	3	3	2	1	2	1	72	Small (inside the factory)
	Impact of transport of raw materials and products	2	2	2	2	0	2	2	48	Small
	Fire and explosion at fuel warehouses	4	3	1	1	2	3	1	48	Small
	Work accidents	2	1	1	1	2	2	1	20	Small
	Negative impacts on local society and economy	1	1	1	1	2	1	3	27	Small

Source: PECC2,2012

Legend:

M: Intensity

S:Scope

R: Restoration time

F:Frequency

L: Law

E: Expense

P:Public Attention

APPENDICES OF CHAPTER 6

PUBLIC CONSULTATION OFFICIAL DOCUMENTS

- Public consultation official document of the project owner (Vinh Tan TPMB) sent to People's Committee of Vinh Tan town
- Public consultation official document of the project owner (Vinh Tan TPMB) sent to Fatherland Front's Committee of Vinh Tan town
- Public consultation official document of the project owner (Vinh Tan TPMB) sent to Management Board of Hon Cau Protection Area
- Public consultation official document of the project owner (Vinh Tan TPMB) sent to Binh Thuan Association of Breeding Shrimp
- Official document issued by People's Committee of Vinh tan town in reply to the project owner's letter
- Official document issued by Fatherland Front's Committee of VinH tan town in reply to the project owner's letter
- Official document issued by MB of Hon Cau MPA in reply to the project owner's letter
- Official document issued by Binh Thuan Association of Breeding Shrimp in reply to the project owner's letter

TẬP ĐOÀN ĐIỆN LỰC VIỆT NAM
BAN QUẢN LÝ DỰ ÁN
NHIỆT ĐIỆN VĨNH TÂN

CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập - Tự do - Hạnh phúc

Số: 0459 /ANĐVT-KT

Tp. Hồ Chí Minh, ngày 16 tháng 05 năm 2012

V/v xin ý kiến tham vấn trong quá trình lập báo cáo đánh giá tác động môi trường của Dự án "Nhà máy Nhiệt điện Vĩnh Tân 4"

Kính gửi: Ủy Ban Nhân dân xã Vĩnh Tân, huyện Tuy Phong, tỉnh Bình Thuận

Thực hiện Luật Bảo vệ môi trường và các quy định của pháp luật về đánh giá tác động môi trường (ĐTM), Ban Quản lý Dự án Nhiệt điện Vĩnh Tân đang tổ chức triển khai lập báo cáo đánh giá tác động môi trường của Dự án "Nhà máy Nhiệt điện Vĩnh Tân 4".

Ban Quản lý Dự án Nhiệt điện Vĩnh Tân xin gửi đến Ủy ban Nhân dân xã Vĩnh Tân tài liệu tóm tắt về các hạng mục đầu tư chính, các vấn đề môi trường, các giải pháp bảo vệ môi trường của Dự án .

Thông tin phản hồi, xin quý Ủy Ban gửi về địa chỉ sau:

Ban Quản lý Dự án Nhiệt điện Vĩnh Tân
Địa chỉ: số 260, đường 19/4, phường Xuân An, tỉnh Bình Thuận.
Điện thoại: 062.2461222 Fax: 0623739684

Kính mong nhận được ý kiến tham vấn của Ủy ban nhân dân xã Vĩnh Tân, để Ban Quản lý Dự án Nhiệt điện Vĩnh Tân có thể hoàn thiện hồ sơ trình cấp thẩm quyền phê duyệt, đảm bảo tiến độ dự án.

Nơi nhận:
- Như trên;
- Công ty cổ phần TVXD điện 2 (để phối hợp);
- Lưu: VT.

TRƯỞNG BAN

BAN QUẢN LÝ DỰ ÁN NHIỆT ĐIỆN VĨNH TÂN

Quách Đình Thành

Đính kèm:

Tài liệu tóm tắt về các hạng mục đầu tư chính, các vấn đề môi trường, các giải pháp bảo vệ môi trường của Dự án.

ỦY BAN NHÂN DÂN
XÃ VĨNH TÂN

CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập – Tự do – Hạnh phúc

Số: 39 /CV – UBND
"V/v tham vấn ý kiến về Dự án Nhà máy Nhiệt điện Vĩnh Tân 4"

Vĩnh Tân, ngày 31 tháng 5 năm 2012

Kính gửi: Ban Quản lý Dự án Nhiệt Điện Vĩnh Tân

Ủy ban Nhân dân (UBND) xã Vĩnh Tân nhận được Văn bản số 0459/ANĐVT-KT ngày 16/5/2012 của Ban Quản lý Dự án Nhiệt Điện Vĩnh Tân kèm theo tài liệu tóm tắt về các hạng mục đầu tư chính, các vấn đề môi trường, các giải pháp bảo vệ môi trường của dự án "Nhà máy Nhiệt điện Vĩnh Tân 4". Sau khi xem xét tài liệu này, UBND xã Vĩnh Tân có ý kiến như sau:

1. Về các tác động tiêu cực của Dự án đến môi trường tự nhiên và kinh tế - xã hội: *(Nêu rõ ý kiến đồng ý hay không đồng ý với các nội dung tương ứng được trình bày trong tài liệu gởi kèm; trường hợp không đồng ý thì chỉ rõ các nội dung, vấn đề cụ thể không đồng ý)*

Cơ bản thống nhất với các nội dung được trình bày trong báo cáo nhà máy Vĩnh Tân 4. Tuy nhiên, trong quá trình triển khai xây dự án sẽ có những tác động phát sinh ngoài dự kiến làm ảnh hưởng đến môi trường xung quanh khu vực nhà máy và bãi xỉ như do mưa lũ, lốc xoáy, thiên tai... đề nghị chủ dự án quan tâm.

Xã Vĩnh Tân là vùng trọng điểm cung cấp tôm giống cả nước. Hiện nay, các Nhà máy 1, 2, 3 đang tiến hành san lấp làm ảnh hưởng đến môi trường nước biển gây ảnh hưởng đến việc sản xuất tôm giống của địa phương. Trong quá trình vận hành nhà máy lượng nước làm mát thải ra môi trường về lâu dài sẽ ảnh hưởng đến việc sản xuất tôm giống và các ngành nuôi trồng thủy hải sản khác ảnh hưởng đến tình hình phát triển kinh tế - xã hội của địa phương.

- Phần diện tích nhà máy trên đất liền là 65.76 ha có một phần diện tích đất sông suối khoảng 20 ha, mà đây là cửa sông phục vụ cho việc thoát nước mưa, nước lũ của địa bàn xã Vĩnh Tân và một phần của xã Vĩnh Hảo do đó sẽ tác động tiêu cực đến môi trường khu dân cư.

2. Về các biện pháp giảm thiểu tác động tiêu cực đến môi trường của Dự án: *(Nêu rõ ý kiến đồng ý hay không đồng ý với các nội dung tương ứng được trình bày trong tài liệu gởi kèm; trường hợp không đồng ý thì chỉ rõ các nội dung, vấn đề cụ thể không đồng ý)*

Cơ bản thống nhất với các nội dung được trình bày trong báo cáo nhà máy Vĩnh Tân 4.

Cần nghiên cứu sâu rộng hơn việc ảnh hưởng môi trường do tác động của việc san lấp biển và lượng nước làm mát của nhà máy thải ra môi trường về lâu dài.

3. Kiến nghị đối với chủ dự án: *(Nêu cụ thể các yêu cầu, kiến nghị của cộng đồng đối với các chủ dự án liên quan đến việc cam kết thực hiện các biện pháp, giải pháp giảm thiểu các tác động tiêu cực đến môi trường của Dự án và các kiến nghị khác có liên quan đến Dự án (nếu có)*

- Chủ dự án nên sử dụng lao động xây dựng ở địa phương để hạn chế bớt lượng người từ nơi khác đến nhằm tránh gây mất trật tự do bất đồng về phong tục, văn hóa... giữa người địa phương và người nơi khác đến.
- Chịu trách nhiệm đền bù thiệt hại về môi trường, sức khỏe và sản xuất nếu dự án gây ra các hậu quả về môi trường.
- Có chính sách đền bù giải tỏa hợp lý, hợp lòng dân.
- Trong quá trình thi công phải triển khai thực hiện các biện pháp bảo vệ môi trường, biện pháp giảm thiểu tác động tiêu cực đối với môi trường do dự án gây ra và tiến hành quan trắc môi trường theo đúng yêu cầu đặt ra trong báo cáo đánh giá tác động môi trường được phê duyệt.
- Chủ dự án phối hợp cùng địa phương về việc quản lý hành chính nhằm tránh gây mất trật tự, an ninh trong khu vực do tập trung công nhân ở địa phương.
- Cầnnghiên cứu các giải pháp cho việc thoát nước lũ do việc san lấp cửa sông của Nhà máy.
- Chủ dự án cần có nghiên cứu về lâu dài ảnh hưởng môi trường biển, không khí...do nhà máy, bãi xỉ gây ra.
- Các ngành chức năng chuyên sâu về môi trường phải thường xuyên kiểm tra, giám sát ảnh hưởng môi trường trong quá trình xây dựng, vận hành nhà máy, bãi xỉ.

Trên đây là ý kiến của UBND xã Vĩnh Tân gởi Ban Quản lý Dự án Nhiệt Điện Vĩnh Tân để xem xét và hoàn chỉnh báo cáo đánh giá tác động môi trường của Dự án./.

CHỦ TỊCH

Nguyễn Thanh Sang

Nơi nhận:
- Như trên;
- Cty CP TVXD Điện 3;
- Lưu: VT (Linh), ĐC xã.

TẬP ĐOÀN ĐIỆN LỰC VIỆT NAM
BAN QUẢN LÝ DỰ ÁN
NHIỆT ĐIỆN VĨNH TÂN

CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập - Tự do - Hạnh phúc

Số: 0460 /ANDVT-KT

Tp. Hồ Chí Minh, ngày 16 tháng 05 năm 2012

V/v xin ý kiến tham vấn trong quá trình lập báo cáo đánh giá tác động môi trường của Dự án "Nhà máy Nhiệt điện Vĩnh Tân 4"

CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2
CÔNG VĂN ĐẾN
Số: 3083 Ngày: 18/5/12

Kính gửi: Ủy Ban Mặt Trận Tổ Quốc xã Vĩnh Tân, huyện Tuy Phong tỉnh Bình Thuận

Thực hiện Luật Bảo vệ môi trường và các quy định của pháp luật về đánh giá tác động môi trường (ĐTM), Ban Quản lý Dự án Nhiệt điện Vĩnh Tân đang tổ chức triển khai lập báo cáo đánh giá tác động môi trường của Dự án "Nhà máy Nhiệt điện Vĩnh Tân 4".

Ban Quản lý Dự án Nhiệt điện Vĩnh Tân xin gửi đến Ủy ban Mặt trận Tổ quốc xã Vĩnh Tân tài liệu tóm tắt về các hạng mục đầu tư chính, các vấn đề môi trường, các giải pháp bảo vệ môi trường của Dự án .

Thông tin phản hồi, xin quý Ủy Ban gửi về địa chỉ sau:

Ban Quản lý Dự án Nhiệt điện Vĩnh Tân.
Địa chỉ: số 260, đường 19/4, phường Xuân An, tỉnh Bình Thuận.
Điện thoại: 062.2461222 Fax: 0623739684

Kính mong nhận được ý kiến tham vấn của Ủy ban Mặt trận Tổ quốc xã Vĩnh Tân, để Ban Quản lý Dự án Nhiệt điện Vĩnh Tân có thể hoàn thiện hồ sơ trình cấp thẩm quyền phê duyệt, đảm bảo tiến độ dự án.

Nơi nhận:
- Như trên;
- Công ty cổ phần TVXD điện 2 (để phối hợp);
- Lưu: VT, KT.

TRƯỞNG BAN

BAN QUẢN LÝ DỰ ÁN NHIỆT ĐIỆN VĨNH TÂN

Quách Đình Thành

Đính kèm:

Tài liệu tóm tắt về các hạng mục đầu tư chính, các vấn đề môi trường, các giải pháp bảo vệ môi trường của Dự án.

ỦY BAN MẶT TRẬN TỔ QUỐC XÃ VĨNH TÂN	CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM **Độc lập - Tự do - Hạnh phúc**
Số: 35....../CV-UBMTTQ V/v tham vấn ý kiến về Dự án "Nhà máy Nhiệt điện Vĩnh Tân 4"	*Bình Thuận, ngày 25 tháng 5 năm 2012*

Kính gửi: Ban Quản lý Dự án Nhiệt Điện Vĩnh Tân

Ủy ban Mặt trận Tổ quốc (UBMTTQ) xã Vĩnh Tân nhận được Văn bản số 0460./......ngày 16/5/2012 của Ban Quản lý Dự án Nhiệt điện Vĩnh Tân kèm theo tài liệu tóm tắt về các hạng mục đầu tư chính, các vấn đề môi trường, các giải pháp bảo vệ môi trường của Dự án "Nhà máy Nhiệt Điện Vĩnh Tân 4". Sau khi xem xét tài liệu này, UBMTTQ xã Vĩnh Tân có ý kiến như sau:

1. Về các tác động tiêu cực của Dự án đến môi trường tự nhiên và kinh tế - xã hội:

   (Nêu rõ ý kiến đồng ý hay không đồng ý với các nội dung tương ứng được trình bày trong tài liệu gửi kèm; trường hợp không đồng ý thì chỉ rõ các nội dung, vấn đề cụ thể không đồng ý).

   Đồng ý Theo bảng tóm tắt thông tin dự án Của bên "Nhà Máy Nhiệt Điện Vĩnh Tân 4"

2. Về các biện pháp giảm thiểu tác động tiêu cực đến môi trường của Dự án:

   (Nêu rõ ý kiến đồng ý hay không đồng ý với các nội dung tương ứng được trình bày trong tài liệu gửi kèm; trường hợp không đồng ý thì chỉ rõ các nội dung, vấn đề cụ thể không đồng ý).

   Đồng ý Nội dung tương ứng trong tài liệu đã gửi kèm.

3. Kiến nghị đối với chủ dự án:

(Nêu cụ thể các yêu cầu, kiến nghị của cộng đồng đối với chủ dự án liên quan đến việc cam kết thực hiện các biện pháp, giải pháp giảm thiểu các tác động tiêu cực đến môi trường của Dự án và các kiến nghị khác có liên quan đến Dự án (nếu có).

- Chủ dự án phối hợp cùng địa phương về việc quản lý hành chính nhằm tránh gây mất trật tự, an ninh trong khu vực do tập trung số lượng lớn người ở địa phương.
- Cần phải có công nghệ và kỹ thuật tốt trong thi công cũng như trong hoạt động để giảm thiểu dưới mức quy định việc gây ô nhiễm môi trường do khói, bụi, tiếng ồn, độ rung, nước thải, chất thải rắn, đảm bảo sức khoẻ nhân dân và môi trường sinh thái, không khí, đất, nước ngầm địa phương.
- Có trách nhiệm tham gia và đóng góp tích cực các chương trình nâng cao nhận thức cộng đồng, bảo vệ môi trường cộng đồng.
- Chịu trách nhiệm đền bù thiệt hại về môi trường, sức khoẻ và sản xuất nếu dự án gây ra các hậu quả về môi trường.
- Hàng tháng, quý cả hai bên có thông tin cho nhau để kịp thời tháo gỡ những phát sinh, trong thời gian chưa đề cập đến trong bảng tâm tư.
- Công trình đang thi công nếu có vấn đề xảy ra tình trạng cháy hoặc có những sự mất an toàn đến người dân gần công trình, cơ quan có trách nhiệm báo ngay cho cơ quan, địa phương để kịp thời tháo gỡ.

Trên đây là ý kiến của UBMTTQ xã Vĩnh Tân gửi Ban Quản lý Dự án Nhiệt Điện Vĩnh Tân để xem xét và hoàn chỉnh báo cáo đánh giá tác động môi trường của Dự án.

TM. UBMTTQ XÃ VĨNH TÂN

CHỦ TỊCH

Lê Lương Kiệt

Nơi nhận:

- Như trên;
- Cty CP TVXD Điện 2;
- Lưu VP.

TẬP ĐOÀN ĐIỆN LỰC VIỆT NAM **BAN QUẢN LÝ DỰ ÁN NHIỆT ĐIỆN VĨNH TÂN**	**CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM Độc lập - Tự do - Hạnh phúc**
Số: 0461 /ANĐVT-KT	*Tp. Hồ Chí Minh, ngày 16 tháng 05 năm 2012*

V/v xin ý kiến tham vấn trong quá trình lập báo cáo đánh giá tác động môi trường của Dự án "Nhà máy Nhiệt điện Vĩnh Tân 4"

CÔNG TY CP TƯ VẤN XÂY DỰNG ĐIỆN 2
CÔNG VĂN ĐẾN
Số: 3084 Ngày: 18/5/12

Kính gửi: Ban Quản Lý Khu Bảo Tồn Biển Hòn Cau

Thực hiện Luật Bảo vệ môi trường và các quy định của pháp luật về đánh giá tác động môi trường (ĐTM), Ban Quản lý Dự án Nhiệt điện Vĩnh Tân đang tổ chức triển khai lập báo cáo đánh giá tác động môi trường của Dự án "Nhà máy Nhiệt điện Vĩnh Tân 4".

Ban Quản lý Dự án Nhiệt điện Vĩnh Tân xin gửi đến Ban quản lý khu Bảo tồn biển Hòn Cau tài liệu tóm tắt về các hạng mục đầu tư chính, các vấn đề môi trường, các giải pháp bảo vệ môi trường của Dự án .

Thông tin phản hồi, xin quý Ban gửi về địa chỉ sau:

Ban Quản lý Dự án Nhiệt điện Vĩnh Tân
Địa chỉ: số 260, đường 19/4, phường Xuân An, tỉnh Bình Thuận.
Điện thoại: 062.2461222 Fax: 0623739684

Kính mong nhận được ý kiến tham vấn của quý Ban để Ban Quản lý Dự án Nhiệt điện Vĩnh Tân có thể hoàn thiện hồ sơ trình cấp thẩm quyền phê duyệt, đảm bảo tiến độ dự án.

Nơi nhận:
- Như trên;
- Công ty cổ phần TVXD điện 2 (để phối hợp);
- Lưu: VT,KT.

TRƯỞNG BAN

TẬP ĐOÀN ĐIỆN LỰC VIỆT NAM
BAN QUẢN LÝ DỰ ÁN NHIỆT ĐIỆN VĨNH TÂN

Quách Đình Thành

Đính kèm:

Tài liệu tóm tắt về các hạng mục đầu tư chính, các vấn đề môi trường, các giải pháp bảo vệ môi trường của Dự án.

SỞ NÔNG NGHIỆP & PTNT BÌNH THUẬN
BQL KHU BẢO TỒN BIỂN HÒN CAU

CỘNG HOÀ XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập – Tự do – Hạnh phúc

Số: 42 /KBTBHC

V/v tham vấn ý kiến về Dự án Nhà máy điện Vĩnh Tân 4

Bình Thuận, ngày 30 tháng 05 năm 2012

Kính gửi: Ban QL Dự án Nhiệt điện Vĩnh Tân .

Ban quản lý Khu Bảo tồn Hòn Cau nhận được Văn bản số 461/ANĐVT-KT ngày16 tháng 05 năm 2012 của Ban Quản lý Dự án Nhiệt điện Vĩnh Tân kèm theo tài liệu tóm tắt về các hạng mục đầu tư chính, các vấn đề môi trường, các giải pháp bảo vệ môi trường của Dự án Nhà máy điện Vĩnh Tân 4. Sau khi xem xét tài liệu này, Ban Quản lý KBTB Hòn Cau có ý kiến như sau:

1. Về các tác động tiêu cực của Dự án đến môi trường tự nhiên và kinh tế - xã hội:

   (Nêu rõ ý kiến đồng ý hay không đồng ý với các nội dung tương ứng được trình bày trong tài liệu gửi kèm; trường hợp không đồng ý thì chỉ rõ các nội dung, vấn đề cụ thể không đồng ý).

   Về cơ bản Ban quản lý KBTB Hòn Cau thống nhất các nội dung được nêu ra trong báo cáo. Tuy nhiên đề nghị bổ sung nội dung "các tác động của dự án đến hệ sinh thái ven bờ và rạn san hô trong khu bảo tồn biển Hòn Cau" vào báo cáo.

2. Về các biện pháp giảm thiểu tác động tiêu cực đến môi trường của Dự án:

   (Nêu rõ ý kiến đồng ý hay không đồng ý với các nội dung tương ứng được trình bày trong tài liệu gửi kèm; trường hợp không đồng ý thì chỉ rõ các nội dung, vấn đề cụ thể không đồng ý).

   Đề nghị bổ sung các biện pháp giảm thiểu tác động khi triển khai xây dựng và vận hành dự án đến hệ sinh thái trong khu bảo tồn biển

3. Kiến nghị đối với chủ dự án:

   (Nêu cụ thể các yêu cầu, kiến nghị của cộng đồng đối với chủ dự án liên quan đến việc cam kết thực hiện các biện pháp, giải pháp giảm thiểu các tác động tiêu cực đến môi trường của Dự án và các kiến nghị khác có liên quan đến Dự án (nếu có).

- Bổ sung các biện pháp khắc phục hậu quả khi xây dựng và vận hành dự án đến hệ sinh thái rạn san hô và ven bờ trong khu vực của KBTB Hòn Cau

- Có báo cáo đánh giá tác động môi trường của dự án đến Khu bảo tồn biển

- Chịu trách nhiệm đền bù thiệt hại về môi trường, sức khoẻ và sản xuất nếu dự án gây ra các hậu quả về môi trường.

- Cần tiến hành quan trắc giám sát môi trường theo đúng yêu cầu đặt ra trong báo cáo đánh giá tác động môi trường được phê duyệt.

- Phải thực hiện nghiêm các yêu cầu của quyết định phê duyệt báo cáo đánh giá tác động môi trường đã được thẩm định.

Trên đây là ý kiến của Ban Quản lý KBTB Hòn Cau. Đề nghị Ban Quản lý Nhiệt điện Vĩnh Tân xem xét và hoàn chỉnh báo cáo đánh giá tác động môi trường của Dự án./.

Nơi nhận:
- Như trên;
- Sở NN&PTNT (b/c);
- Cty CP TVXD Điện 2;
- Lưu VP. Đài(4)

GIÁM ĐỐC

BAN QUẢN LÝ KHU BẢO TỒN BIỂN HÒN CAU

Thai

Huỳnh Văn Thái

UBND TỈNH BÌNH THUẬN
HIỆP HỘI TÔM GIỐNG

CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập – Tự do – Hạnh phúc

Số: 18/HHTGBT

V/v Đóng góp ý kiến cho đầu tư mới Dự án "Nhà máy Nhiệt điện Vĩnh Tân 4"

Vĩnh Tân, ngày 20 tháng 07 năm 2013

Kính gửi: Ban Quản lý Dự án Nhiệt điện Vĩnh Tân.

Hiệp hội Tôm giống Bình Thuận có nhận được Văn bản số 0713/ANĐVT-KTGS ngày 12/06/2013 của Ban Quản lý Dự án Nhiệt điện Vĩnh Tân về việc xin ý kiến tham vấn trong quá trình lập báo cáo đánh giá tác động môi trường của dự án Nhà máy Nhiệt điện Vĩnh Tân 4. Gửi kèm văn bản là báo cáo tóm tắt đánh giá tác động môi trường của dự án gồm 21 trang A4 kể cả bìa.

Qua xem xét thông tin trong báo cáo tóm tắt đánh giá tác động môi trường của dự án "Nhà máy nhiệt điện Vĩnh tân 4" nằm trên địa bàn xã Vĩnh Tân, huyện Tuy Phong, Tỉnh Bình Thuận do Ban quản lý dự án nhiệt điện Vĩnh Tân làm chủ đầu tư.

Hiệp hội tôm giống tỉnh Bình Thuận có ý kiến như sau:

1. Việc xây dựng nhà máy nhiệt điện là một chủ trương lớn của Đảng và Nhà nước nhằm góp phần đẩy nhanh quá trình công nghiệp hóa, hiện đại hóa đất nước, xây dựng và phát triển kinh tế xã hội của cả nước ngày càng vững mạnh, hiện đại. Do vậy, Hiệp hội Tôm giống Bình Thuận hoàn toàn nhất trí với chủ trương của Đảng và Nhà nước đã đề ra và đang triển khai thực hiện.
2. Các cơ sở sản xuất tôm giống tại khu vực phát triển nhiều năm đã mang lại tiềm năng, phát triển kinh tế cho địa phương, gắn bó với nghề sản xuất tôm giống tại khu vực huyện Tuy Phong khá lâu; đã chấp hành tốt các chủ trương, chính sách pháp luật của Nhà nước, được các cấp chính quyền địa phương và Trung ương quan tâm, ủng hộ và kết quả đạt được trong thời gian qua đã chứng tỏ, phản ánh sự đóng góp của lĩnh vực sản xuất tôm giống tỉnh Bình Thuận đối với sự phát triển kinh tế xã hội tại địa phương Bình Thuận nói riêng và cả nước nói chung. Được biết tỉnh Bình Thuận đã có quy hoạch bố trí, di dời các cơ sở sản xuất tôm giống vào khu sản xuất tập trung tại khu vực xã Chí Công, huyện Tuy Phong. Tuy nhiên trên thực tế hiện nay vẫn chưa có tác động đầu tư xây dựng quy hoạch mới, cơ sở hạ tầng thiết yếu vẫn chưa có, người dân tại khu quy hoạch mới vẫn đang sản xuất, canh tác và sinh sống,...Do vậy, các cơ sở sản xuất tôm giống không có nơi mới để bố trí sản xuất nếu khu vực sản xuất hiện nay bị tác động ảnh hưởng.

3. Hiện tại các hoạt động san lấp của nhà máy làm tăng độ đục vùng biển khu vực ảnh hưởng môi trường nước biển và hệ sinh thái thủy sinh biển đề nghị nhà máy phải

xem xét kỹ lưỡng có đê bao vững chắc, không được cho lan tỏa dòng nước đục ảnh hưởng đến nhu cầu lấy nước cung cấp cho hoạt động sản xuất tôm giống khu vực nên đề nghị Ban quản lý dự án nhiệt điện Vĩnh Tân kiểm soát, và tuân thủ theo đúng biện pháp đã đề ra.

4. Với lưu lượng nước thải sinh hoạt trong giai đoạn san lấp mặt bằng 68 m^3/ngày và trong giai đoạn thi công nhà máy khoảng 203 m^3/ngày là rất lớn nhưng trong bản tóm tắt báo cáo đánh giá tác động môi trường trình bày xử lý bằng hầm tự hoại liệu kết quả chất lượng nước thải đầu ra có đạt chuẩn không đề nghị với lưu lượng lớn như vậy phải có hệ thống xử lý nước thải sinh hoạt hoàn chỉnh riêng biệt tránh ảnh hưởng đến môi trường nước biển khu vực.

5. Các loại nước thải hóa chất, nước thải nhiễm dầu với lưu lượng lớn 240 m^3/ngày, nước thải nhiễm than, nước thải sản xuất lưu lượng 720 m^3/ngày trước khi thải ra môi trường phải được xử lý đạt tiêu chuẩn không được gây ảnh hưởng đến nguồn nước biển khu vực.

6. Nhà máy nhiệt điện cần lượng nước làm mát khoảng 49 m^3/s và nước thải sau khi làm mát có nhiệt cao hơn 8^0C so với nguồn nước biển yêu cầu chủ đầu tư cần kiểm soát nhiệt độ của nước thải sau khi thải ra môi trường nước vì nếu nước biển tăng nhiệt độ ảnh hưởng đến hệ sinh thái cũng như nguồn nước mà các khu tôm giống cần cho hoạt động sản xuất.

7. Cần phải có biện pháp phòng chống sự cố tràn dầu cũng như biện pháp khắc phục khi tràn dầu xảy ra trong quá trình nhập nguyên nhiên liệu than, xăng dầu...

8. Khối lượng tro xỉ trung bình ước tính khoảng 190601 tấn/năm, với khối lượng này đề nghị chủ đầu tư cần xây dựng kho lưu trữ, xử lý, chuyển giao đúng theo quy định và biện pháp đề ra tránh rơi vãi, gây ảnh hưởng tới nguồn nước biển.

9. Do khu vực gần sát biển nên yêu cầu chủ đầu tư cần kiểm soát lượng chất thải rắn sinh hoạt cũng như chất thải rắn phát sinh trong quá trình sản xuất tránh làm ảnh hưởng đến nguồn nước biển khu vực.

10. Trong quá trình triển khai thực hiện dự án, đề nghị chủ đầu tư thực hiện nghiêm túc đúng các giải pháp đã nêu và kịp thời khắc phục khi có sự cố môi trường xảy ra, đồng thời bảo đảm các tuân thủ các quy định hiện hành và thực hiện đúng luật bảo vệ môi trường đã được Nhà nước ban hành khống chế các tác động liên quan tới môi trường nước khu vực làm ảnh hưởng đến nguồn nước cấp phục vụ cho hoạt động sản xuất tôm giống cũng như đời sống dân cư tại khu vực.

11. Chủ đầu tư cần phối hợp với các cơ quan liên quan quản lý tốt lượng rác thải, xử lý làm mát, khắc phục và khống chế các sự cố rủi ro, giảm thiểu khí thải, khói, bụi (Trong thi công và vận hành). Nhằm bảo vệ tốt dân sinh tại khu dân cư và đời sống kinh tế cũng như hoạt động sản xuất tôm giống tại địa phương.

12. Trên là những tác động nguy hại có ảnh hưởng đến sự biến động môi trường biển có khả năng sẽ làm cho các cơ sở sản xuất tôm giống tại khu vực xã Vĩnh Tân hiện nay rất khó có thể tiếp tục hoạt động sản xuất. Đây là vấn đề rất nghiêm trọng, ảnh hưởng trực tiếp đến sự duy trì, phát triển hoạt động sản xuất của các cơ sở sản xuất tôm giống; cũng như tiền bạc, công sức của các cơ sở đã đầu tư; đời sống công ăn việc làm của người lao động,...

13. Các đánh giá tác động của nhà máy đối với môi trường, kinh tế xã hội và các giải pháp giảm thiểu, phòng ngừa, ứng phó nêu ra trong báo cáo tóm tắt chưa cụ thể, chi tiết mà chỉ đánh giá chung, mang tính chất định tính; nhất là các tác động đến môi trường biển của các tác nhân nước thải, chất thải rắn, rủi ro, sự cố,...Thiết nghĩ cần thiết phải đánh giá, làm rõ, cụ thể hơn về mức độ, phạm vi tác động ảnh hưởng của các tác nhân này.

14. Từ các ý kiến trên cho thấy, khi nhà máy đi vào hoạt vận hành sẽ có tác động ảnh hưởng rất lớn, mang tính sống còn của các cơ sở sản xuất tôm giống hiện nay. Hiệp hội Tôm giống Bình Thuận đề nghị Ban Quản lý Dự án Nhiệt điện Vĩnh Tân và các cấp chính quyền quan tâm cùng Hiệp hội Tôm giống tháo gỡ khó khăn về nơi sản xuất cho ac1c cơ sở sản xuất tôm giống. Trước mắt Ban Quản lý Dự án Nhiệt điện Vĩnh Tân cần tổ chức hội thảo bàn về đánh giá tác động ảnh hưởng của nhà máy khi đi vào hoạt động để các nhà khoa hoc, quản lý và người sản xuất tôm giống trao đổi, thảo luận trực tiếp để làm rõ các tác nhân gây tác động, mức độ, phạm vi tác động, các giải pháp giảm thiểu, phòng ngừa; kinh nghiệm và thực tiễn xử lý ở những nơi khác mang tính tương tự,...

Trên đây là một số ý kiến ban đầu của Hiệp hội Tôm giống Bình Thuận sau khi nghiên cứu dự thảo bản báo cáo tóm tắt đánh giá tác động môi trường dự án nhà máy nhiệt điện Vĩnh Tân 4.

Nơi nhận:
- Như trên;
- Lưu VPHH.

TM. HIỆP HỘI TÔM GIỐNG BÌNH THUẬN
CHỦ TỊCH

HIỆP HỘI TÔM GIỐNG TỈNH BÌNH THUẬN

Trương Hữu Thông