E4016 V1 rev

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Meizhou Bay Harbor Administration Bureau

Fujian Provincial Environmental Science Institute

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Chapter 1: General Introduction

1.1 Background

Meizhou Bay is located in the middle of the coastline of Fujian Province in Southeast China. According to the *Fujian Coastal Harbors Planning Layout*, three harbor clusters, (i.e. Fuzhou Harbor, Meizhou Bay Harbor and Xiamen Harbor) will be incrementally established and expanded along coastal Fujian. Located in the middle coastal Fujian Province, facing Keelung (Jilong) Harbor across Taiwan Strait, Meizhou Bay is an ideal transit point for Pacific Ocean transportation. Meizhou Bay is located midway between two major economic centers in China, i.e. “Yangtze River Delta” and “Pearl River Delta” It is the starting point of the corridor to Midwest Fujian with key location advantages, which play an important role in promoting the establishment and development of Strait West Economic Zone (SWEZ), attracting investment from Taiwan and abroad and promotes “Three Direct Links” (trade, travel and post) between Chinese mainland and Taiwan. Development Planning for SWEZ, approved recently by the State Council, ranks Meizhou Bay as the Cultivated Centralized Development Zone. Figure 1.1.1 shows the strategic location of Meizhou Bay.

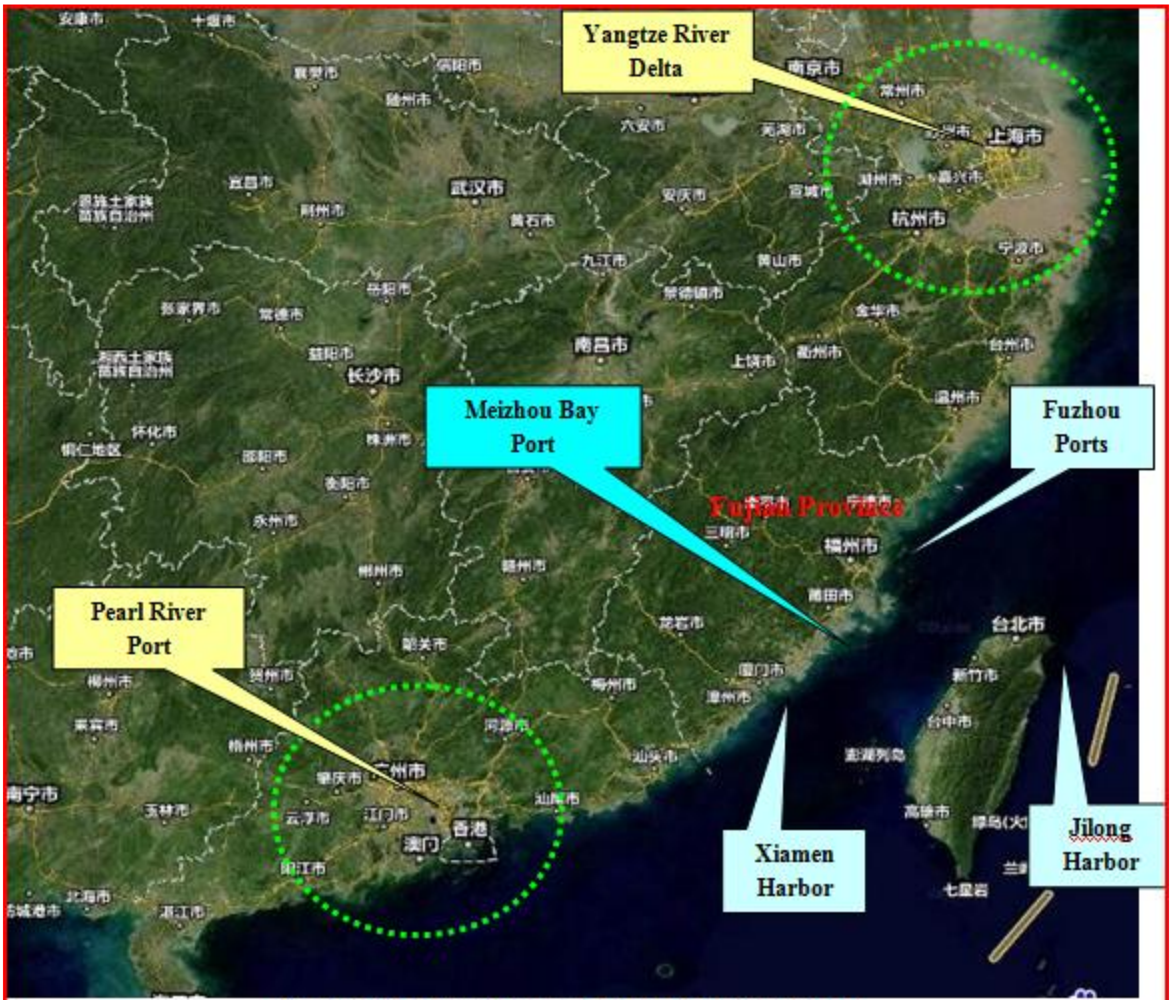


Figure 1.1.1 Strategic Location of Meizhou Bay

Meizhou Bay has key elements for harbour development, deep water, strong tidal currents, large tidal range, limited sediment deposition, stable seabed topography and a long coastline. Meizhou Bay coastline length is 289kmand the harbor water area is 516km^2. Over 374km^2 are under the average low tidemark. This allows for the construction of over one hundred berths above 10,000-DWT level. With maximum depth of water exceeding 40m, the tidal navigation of 100,000-DWT ships is possible. And 300,000-DWT gigantic ships are receivable from bay mouth to Douwei. The Meizhou Bay Harbor is one of the natural deep-water harbors in costal Fujian. Meizhou Bay has only one small fresh water river flowing into it limiting estuarine sedimentation and maintenance dredging.

Meizhou Bay channel development has undergone two construction projects.

1. The Meizhou Bay Navigation Channel Phase-IEngineering Project: The Phase-I completed in 2006project includes 100,000-DWT main channel, 100,000-DWT branch channel of Fujian Oil Refinery, the EA of the Phase-Iproject is incorporated into the assessment of LNG Station and Pipeline of China Sea LNG Company in Fujian, the Phase-I project had completed and put to use.
2. The Meizhou Bay Navigation Channel Phase-II Engineering Project: The Phase-IIproject, commenced Oct. 2008 and is scheduled to complete in the first half of 2012. It includes 250,000-DWT Main channel, 100,000-DWT Dongwu channel, 100,000 DWT Huiyuxi channel and 50,000 DWT Putou channel.

After the Meizhou Bay Navigation Channel Phase-II Engineering Project is complete, the main channel can allow uni-directional tide-dependent navigation of the 250,000-DWT bulk carriers, the all-weather navigation of 130,000m^3 LNG Ships to LNG dock.

To meet development demand, the Meizhou Bay Navigation Channel Phase-III Project is divided into two stages to coincide with implementation schedules and funding availability. Stage 1 includes branch channels, anchorage/crossing zone construction, which will be financed domestically and started in the first half of 2012 ahead of Stage 2. Stage 2 includes construction of the main channel and berth area land reclamation and is proposed to be financed by the World Bank. Stage 2 is scheduled to start in 2013. The details of Stage 1 and Stage 2 of Phase III are summarized in below and Table 1.1.1.

1. Meizhou Bay Navigation Channel Phase-III Engineering Project (Stage 1) includes construction of 4 branch channels, 3 anchorage/crossing zones to be constructed before the improvement of the main channel starts.

2. The Meizhou Bay Navigation Channel Phase-III Engineering Project (Stage 2) is to improve the navigation capacity of Meizhou Bay and enhance the management capacity of Meizhou Bay Harbor Administration Bureau (MBHAB). The project is to expand the main channel to allow uni-directional tidal-navigation of 300,000t bulk carriers, meanwhile allow uni-directional non-tidal navigation of Q-MAX LNG ships. This World Bank funded part is to be constructed within the scope from the sea area in the vicinity of Dazuo outside Jianyu at the mouth of Meizhou Bay to the sea area in the vicinity of Luoyu inside Meizhou Bay with the distance of 52.1km. 21.5 km main channel in two sections need to be deepened and widened through dredging and rock-blasting.

Table 1.1.1 Details of Phase III Meizhou Bay Channel Construction

Phase III – Stage 2 (Bank financed, domestic EIA reviewed and approved by Fujian Provincial Department of Ocean and Fisheries and Fujian Environmental Protection Department in November 2011)	
Main Channel	- 300, 000 DWT channel (52.1 km long, 350-500m wide upon completion) - Two sections totaling 21.5 km need to be dredged
Dredged Materials Disposal	- Meizhou Bay Marine Waste-Dumping Site - 6.7 million m3 - Xiaocuo Backfill Area - 4 million m3 - Putou Backfill Area – 7.2 million m3
Phase III- Stage-1, (Domestic financed, domestic EIA reviewed and approved by Fujian Provincial Department of Ocean and Fisheries and Fujian Environmental Protection Department in November 2011)	
Removal of Linchi Rock	Blasting and removal of sea-bed rock at Linchi area
Xiaocuo Channel	A 2.0 km long 150,000 DWT navigation channel which allows unidirectional tide-dependent navigation from F-point of the main channel to Xiaocuo operation zone.
Putou Channel	A 4.9 km long 70,000 DWT navigation channel which allows unidirectional tide-dependent navigation from G-point of the main channel to #4 berth of Putou operation zone.
Branch channel Dongwu Section	A 6.6km long 50,000 DWT branch channel which allows unidirectional tide-dependent navigation from D4-point of the Dongwu channel to the junction of main channel and Fujian Oil Refinery 100,000-DWT channel.
Putou North Channel	A 2.9km long 10,000 DWT branch channel which allows unidirectional tide-dependent navigation from the end of Putou 50,000 DWT channel to #25 berth of Putou operation zone.
Anchorage/crossing zone	Dredging of #4 and #5 anchorage zone and expansion of an existing crossing zone. (Two other proposed anchorage zones do not need dredging)
Dredged Material Disposal	Putou Backfill Area- 25.3 million m3

1.2 EA Preparation

The project proponent, Meizhou Bay Harbor Administration Bureau (MBHAB) commissioned the Fujian Provincial Environmental Science Institute (FESI) to carry out the EIA of the Meizhou Bay Navigation Channel Phase III Engineering Project (Stage 1&2)Iin accordance with the China EA laws and policies. The FESI conducted site visits, collected data, made forecast analysis and prepared the EIA of Stage 1 & 2 for the project owner to submit for review and approval by provincial marine and environmental protection authorities.

According to the World Bank's safeguard policies, as bothstages are required to realize the project channel improvement objective, the EA submitted to World Bank covers both Stage 1 and Stage 2 of the Phase III. The dredging, transportation, management of dredged materials under the Phase III are assessed. The EA includes a review of the environmental management of the previous channel development phases. The EA report is comprised of three sub-reports, Environmental Impact Assessment (EIA) report, Environmental Management Plan (EMP) and Environmental Assessment (EA) Summary.

The data of marine environment situation in this EA report comes from the *Survey Report on Marine Environment Situation of Meizhou Bay Channel Dredging Project* provided by Fujian Marine Research Institute (Sep. 2011). The data of Marine Hydrodynamics and Oil Spills Risk Assessment comes from the *Research Report of Mathematical Model Calculation for the Meizhou Bay Navigation Channel Phase-III Engineering Project* provided by Hehai University (Oct. 2011). Other project reports, including the project Feasibility Study Report (FSR) and Resettlement Plan (RP), are referenced in the project EA.

1.3 Assessment Objectives

Considering the surrounding environment in project-located sea area and works construction characteristics, EIA and supporting documents investigates and describes:

- national, provincial environmental protection laws, regulations, standards and local environmental functional aims,
- the natural environment and ambient marine environment quality,
- social economy,
- retrospective due diligence review of the previous projects,
- analysis on construction techniques,
- pollutant emission for the proposed projects to be built,
- a forecast of potential environmental impacts fromconstruction,
- environmental protection measures to mitigate or eliminate the negative impacts,
- relevant pollution treatment and ecological protection proposals,,
- conclusions regarding project feasibility from the perspective of environmental protection,
- scientific basis for anypossible policy shortfalls, and
- environmental management plans for project construction and operations.

1.4 Laws and Policies for EA Preparation

The EA complies with the laws, policies and regulations of People's Republic of China, as well as the requirement of World Bank's safeguard policies.

1.4.1 Referred Laws and Regulations of China

1.4.1.1 Laws and Regulations

1) Environmental Protection Law of P.R.C., Dec. 1989;
2) Marine Environmental Protection Law of P.R.C., Dec. 1999;
3) Sea Utilization Management Methods of P.R.C., Jan.2002;
4) EIA Methods of P.R.C., Oct.2002;
5) Water Pollution Treating Methods of P.R.C., Feb.2008;
6) Atmosphere Pollution Treating Methods of P.R.C., Oct.1996;
7) Solid Waste Pollution Treating Methods of P.R.C., Apr.2005;
8) Fishery Law of P.R.C., 2004;
9) Port Law of P.R.C., Jun.2003;
10) Clean Production Promotion Law of P.R.C., Jun.2002;
11) Management Methods of Treating Pollution Damages from Marine Constructive Projects on Sea Environment, 2006；
12) Management Methods of Treating Vessels Pollutions on Marine Environment, Mar.2010;
13) Sea Dumping Management Methods of P.R.C., Mar.1985;
14) Temporary Regulation for Dumping Area Management, Nov.2003;
15) Maritime Transport Safety Law of P.R.C., Jan.1984;

16) Navigation Safety Management Methods for Underwater and Above-water Construction of P.R.C., Apr.1998;

17) Environmental Management Methods for Transport Construction Projects, Jun.2003;

18) Temporary Regulation for EIA Public Participation, Huanfa [2006] No.28；

19) Environmental Management Regulation in Fujian Province, Oct.1995;

20) Sea Environmental Protection Regulation in Fujian Province, Dec.2002;

21) Sea Utilization Management Methods in Fujian Province, Jul. 2006;

22) MARITIME AGREEMENT REGARDIGN OIL POLLUTION OF LIABILITY (MARPOL73/78) and its supplementary articles.

1.4.1.2 Technical Guidelines

1) Technical Guidelines of EIA, General Principle, HJ2.1–2011；

2) Technical Guidelines of EIA, Ecological Impact, HJ19–2011；

3) Technical Guidelines of EIA, Water Environment, HJ/T2.3-93；

4) Technical Guidelines of EIA for Marine Engineering, GB/T19485–2004；

5) Technical Specification of Assessment of Construction Projects Impacts on Marine Bio-resources, SC/T 9110-2007；

6) Technical Specification of Tracking Monitoring of Construction Projects Impacts on Marine Environment, 2002；

7) Technical Guidelines of Environmental Risk Assessment of Construction Projects, HJ/T169-2004；

8) Requirement of Equipping the Port with Oil Spills Emergency Facilities, JT/T451-2009.

1.4.1.3 Related Planning and Others

1) Sea Functional Zoning in Fujian Province, 2005;

2) Environmental Functional Zoning of Offshore Area in Fujian Province, Minzheng[2011] No.45；

3) Ecological Functional Zoning in Fujian Province, Minzheng[2011] No.26；

4) Marine Environmental Protection Planning in Fujian Province (2011~2020);

5) Meizhou Bay (South and North Coast) Port Area Controlling Detailed Planning (2011);

6) Regional Development Plannng of Meizhou Bay Rim, Fujian Province, FPESI, Jun.2011;

7) Overall Planning EIA of Meizhou Bay Harbor (submitted for review), Planning Research Institute under the MOT, Sep.2011;

8) EIA Commission letter of the Meizhou Bay Navigation Channel Phase III Engineering Project(Stage 1), MBHAB, Jul.2011;

9) EIA Commission letter of the Meizhou Bay Navigation Channel Phase III Engineering Project(Stage 2), MBHAB, Jul.2011;

10) FSR of the Meizhou Bay Navigation Channel Phase III Engineering Project(Stage 1 and 2, Fujian Port & Waterway Investigation & Design Institute, May.2011;

11) Official Reply from Fujian Provincial Environmental Protection Department to the EA report of the Meizhou Bay Navigation Channel Phase-III Engineering Project(Stage 1 and 2), Nov.2011;

12) Official Reply from Fujian Provincial Development and Reform Commission to the FSR of the Meizhou Bay Navigation Channel Phase III Engineering Project(Stage 1

and 2);

13) Other technical documents provided by constructors.

1.4.1.4 Key Provisions of Relevant Laws, Regulations and Guidelines and Compliance

Environmental Protection Law is the overarching law governing the environmental protection in China. It stipulates the general requirement for environmental protection for construction projects:

> *"Units constructing project that cause pollution to the environment must observe the state provisions concerning environmental protection for such construction projects. The environmental impact statement on a construction must assess the pollution the project is likely to produce and its impact on the environment and stipulate the preventive and mitigation measures. The EIA statement shall, after initial examination by the authorities in charge of construction project, be submitted by specified procedures to the competent department of environmental protection administration for approval. The department of planning shall not ratify the design plan description of the construction project until after the environmental impact statement on the construction project is approved"*

Environmental Impact Assessment Law is the law specifically governing the environmental impact assessment of plan and construction projects. It formulates the legal basis for EIA preparation, approval and implementation.

> *"Environmental impact assessment should be carried out in accordance with this Law for construction of the projects that produce impact on environment within the territory of the People's Republic of China and all other sea areas under the jurisdiction of the People's Republic of China……. The State encourages relevant units, experts and the public to participate in environmental impact assessment in an appropriate way."*

Marine Environmental Protection Law (MEPL)**.** The primary Chinese national environmental statute governing marine environmental protection is the Marine Environmental Protection Law (MEPL) enacted in 1999. Key provisions relevant to the project include:

> *"Costal construction project proponent must conduct environmental impact assessment. ….EIA shall be reviewed by ocean and fish authorities before submitting to environmental authority for approval."*

> *"Payment must be made to the state for any ocean dump disposal."*

> *"Any entity who wants to dump waste into sea must submit application to relevant marine administrative authority. Any project proponent must obtain a permit(s) from the marine administrative authority before carrying out ocean disposal. "*

> *"Marine administrative authority shall plan ocean disposal zones based on the principle of scientific, rational, economic and safety. The planned zones shall be reviewed by Ministry of Environmental Protection before being approved by the State Council."*

> *"The marine administrative authority is responsible for supervising and organizing environmental monitoring during the use of ocean disposal sites."*

> *"Entity which is approved to implement ocean disposal must record the dumping details*

and provide report to the approval authority after the dumping disposal."

"When blasting operations are needed, effective measures shall be taken to protect marine resources."

"Port, berth, loading station… must be equipped with adequate waste receiving and treatment facilities…..must prepare oil spill response plan and be equipped with facilities and tools to deal with oil spill accidents. ……Ships are not allowed to discharge pollutants, solid wastes and wastewater."

Under the MEPL, there are two implementation regulations, i.e. ***Administrative Regulations for Marine Waste Disposal*** and ***Interim Regulations for Dumping Sties***, which stipulate requirements and procedures on assigning ocean disposal site and supervising the disposal activities.

Regulations for Pollution Prevention from Marine Engineering provide general requirements on strict management of land reclamation and natural habitat protection:

"Land reclamation is forbidden at natural spawning site, reproduction site and feeding sites of economic aquatic life, and at birds habitats…….blasting shall avoid the spawning period of economic fishes and prawns."

Fishery Law requires measures to be taken to minimize impacts on fishery resources affected by underwater blasting and construction.

As to ecological compensation resulted from development activities the ***Technical Regulations for Impact Assessment of Construction Projects on Marine Living Resources*** issued by Ministry of Agriculture in 2007 provides impact assessment methodology and economic evaluation methods for loss of resources for marine and coastal construction projects. In addition, this regulation provides protection options such as habitats protection, fish breeding and release, and establishment and management of protected areas, etc. However, this implementation mechanism is not fully operationalized due to the multi-sectoral nature of marine and costal development. The detailed implementation procedure is being developed, which will specify institutional arrangement, fund management and operational procedures for the ecological compensation measures.

The preparation of EA documents followed these laws, regulations and guidelines. A summary of compliance with most relevant domestic regulations is indicated in the following Table 1.4.1.

Table 1.4.1 Compliance with Chinese Laws, Regulations and Guidelines

China Laws and Regulations	Project Compliance
Environmental Impact Assessment Law	● Full EA prepared by the certified EIA consultant and Project proponent, reviewed and approved by Fujian Provincial Department of Ocean and Fisheries and Fujian Provincial Environmental Protection Department. ● Two rounds of public participation conducted.
Marine Environmental Protection Law	● EA covers dredging, blasting, disposal of dredging materials (both ocean disposal and CDFs), land reclamation, waste management, oil spill risks, ecological protection and compensation, etc. ● Ocean disposal site (Meizhou Bay Marine Waste-Dumping Site) designated by State Ocean Administration ● Oil spill risk emergency response plan prepared

China Laws and Regulations	Project Compliance
	● Ecological compensation plan prepared
Notice on Strengthening EIA Management for Construction Projects Funded by Loans from International Financial Institutions	● EIA and EMP are prepared in compliance with World Bank safeguards policies.
Fishery Law	● EMP incorporates measures to minimize impacts on fishery resources resulted from underwater blasting and construction. Affected aquaculture will be relocated before construction
Harbor Law	● Port development comply with relevant plans ● EA covers the disposal of dredged materials for land reclamation
Marine Traffic Safety Law	● EA considers safety operation zone for construction activities.
Marine Territory Utilization Administrative Method	● EA covers land reclamation using dredged materials ● Occupying sea areas have and will be approved by marine authorities.
Administrative Regulations for Marine Pollution Prevention from Marine Engineering	● Land reclamation using dredged materials covered by the EA. No natural spawning ground, breeding ground and feeding ground will be occupied. ● Quality of the dredged/filling material complies with environmental criteria ● EMP incorporates mitigation measures for blasting
Administrative Regulations for Marine Pollution Prevention from Ship Wastes	● Ship wastewater and solid wastes must be received and treated by port facilities.
Administrative Regulations for Marine Waste Disposal and Interim Regulations for Dumping Site	● Ocean disposal site (Meizhou Bay Marine Waste-Dumping Site) has been assigned by State Ocean Administration ● Dredged Material Disposal Plan prepared ● Before disposal, approval shall be obtained from marine authoriteis
Navigation Safety Regulations for Above- and Under Water Activities	● Construction shall start after approved by relevant authorities.
Technical Regulations for Impact Assessment of Construction Projects on Marine Living Resources	● EA assessed impacts on marine living resources resulted in dredging, blasting and disposal of dredged materials ● EA evaluated the economics value of potential losses affected by the project. ● An ecological compensation plan covering fish reproduction and release and habitats protection prepared.

1.4.2 Safeguard Policies of the World Bank

Among the ten safeguard policies, the following policies are triggered: (1)OP/BP4.01 Environmental Assessment, (2)OP/BP4.04 Natural Habitats, (3)OP/BP4.12 Involuntary Resettlement. The information disclosure of the Project complies with the World Bank's disclosure policy.

Table 1.4.2 Compliance with the World Bank Safeguard Policies

No.	Safeguard Policies	Compliance
1	OP/BP4.01 Environmental Assessment	Category A EA project Full assessment. EIA, EMP and EA summary prepared as per OP4.01.
2	OP/BP4.04 Natural Habitats	The policy is triggered. Ecological survey conducted as part of EIA Mitigation measures developed to mitigate impacts Ecological compensation and habitat offset program developed in EMP
3	OP/BP4.36 Forest	This policy is not triggered. This project will not involve any forests.

4	OP/BP4.09 Pest Management	This policy is not triggered. The project will not procure any pesticides nor will an increased use of pesticides result from the project. No action is required under the policy.
5	OP/BP4.11 Physical Cultural Resources	This policy is not triggered. No cultural relics or other physical cultural resources are found. Chance-find procedure will be strictly followed.
6	OP/BP4.37 Dam Safety	This policy is not triggered. The project area does not include any dams.
7	OP/BP4.10 Indigenous Peoples	This policy is not triggered. There are no indigenous peoples live in project-located area, no impact on the indigenous peoples.
8	OP/BP4.12 Involuntary Resettlement	This policy is triggered. RAP is prepared.
9	OP/BP7.50 Projects on International Waterways	This policy is not triggered. The project doesn't include any international waterways.
10	OP/BP7.60 Projects in Disputed Areas	This policy is not triggered. The project area does not include any disputed areas.

The World Bank Group Environmental, Health and Safety Guidelines (WGB EHS Guidelines) also apply to the project, including the General Guidelines and specific Guidelines for Ports, Harbor and Terminals. The project Environmental Management Plan includes the mitigation measures that are fully in compliance with the general principles and measures in the General Guidelines (especially related to Construction management), as these general requirement in the Guidelines is equally required in Chinese laws, regulations, guidelines and construction management norms. The EMP measures are also fully consistent with the dredged material management practice specified in the EHS Guidelines for Ports, Harbor and Terminals, which is illustrated in the following table:

Table 1.4.3 Compliance with WBG EHS Guidelines for Ports, Harbor and Terminals

IFC Guidelines	EIA /EMP Compliance
Dredging should only be conducted if necessary, and based on an assessment of the need for new infrastructure……	Dredging is needed for the improvement of main channel which is justified. During operation stage, no dredging is envisaged due to advantages of hydrodynamics in Meizhou Bay.
Prior to initiation of dredging activities, materials should be evaluated for their physical, chemical, biological, and engineering properties to inform the evaluation of dredge materials reuse or disposal options. Dredged material should be analyzed in order to select appropriate disposal options (e.g. land reclamation, open water discharge, or contained disposal).	Sediments were monitored and confirmed to be in conformity with national standards of ocean sediments standards (GB18668-2002). Non hazard is conformed.
Excavation and dredging methods should be selected to minimize suspension of sediments, minimize destruction of benthic habitat, increase the accuracy of the operation,……	Alternative dredging methods were compared based on these considerations, and final selected equipment is the one that meet these requirements.
Areas sensitive for marine life such as feeding, breeding, calving, and spawning areas should be identified.	Ecological baseline survey were conducted

	which confirmed that there are no such sensitive sites within the dredging impact scope.
Dredging and blasting should be conducted in a manner so as to avoid fish migration or spawning seasons, routes, and grounds	Dredging and blasting is arranged to avoid fish spawning season.
Inspection and monitoring of dredging activities should be conducted to evaluate the effectiveness of impact prevention strategies, and re-adjusted where necessary.	On-site supervision staff will be arranged to monitor the dredging and blasting impact.
Use of lateral containment in open water disposal should be considered. Use of borrow pits or dikes reduces the spread of sediments and effects on benthic organisms. Use of cap containment sediments with clean materials should be considered Confined disposal facilities should be used.	Dredged material is reused as backfilling material for land reclamation for berth construction. Enclosure dike is to be built to contain the material, and sedimentation and filtration will be deployed to confine the impact on water and benthic organisms. Concrete capping will eventually be applied as part of dock construction.
Port operators should prepare a spill prevention, control, and countermeasure plan	Risk analysis is an integral part of EIA, which comprehensively analyzed the potential risk of spill and conducted scenario simulations, identified impact scope and sensitive areas to be affected. EIA also described the emergence response measures which include management structure, equipment and response team capacity.

The WBG EHS guidelines for Ports, Harbours and Terminals are addressed in Section 7, Cumulative Impacts where applicable linkages exist to the overall Meizhou Bay Port Development and Regional Planning Programs and Strategic Environmental Assessment.

1.5 Assessment Standard and Environmental Quality Standard

1.5.1 Environmental Quality Standard

(1) According to the *Environmental Functional Zoning of Offshore Area in Fujian*, the utilized sea area in Meizhou Bay Navigation Improvement Project mainly involves the Type Ⅲ functional area, the rest involves the Type Ⅳ functional area (port area). As to the Type Ⅲ functional area, the Type Ⅱ sea water standard under the *Sea Water Quality Standard* （GB3097-1997）will be applied and the Type Ⅲ sea water standard under the same *Standard* will be applied for the Type Ⅳ functional area.

Table 1.5.1 Sea Water Quality Standard **(Unit: mg/l，except for pH.)**

No.	Item	TypeⅡ	TypeⅢ
1	pH	7.8-8.5	6.8-8.8
2	DO＞	5	4
3	SPM artificial increment≤	10	100
4	COD≤	3	4

5	Inorganic N≤	0.30	0.40
6	Active phosphate≤	0.030	0.030
7	Petroleum≤	0.05	0.30
8	Cooper≤	0.010	0.050
9	Lead≤	0.005	0.010
10	Cadmium≤	0.005	0.010
11	Zinc≤	0.050	0.10
12	Mercury≤	0.0002	0.0002
13	Arsenic≤	0.030	0.050

(2) According to the *Marine Environmental Protection Planning in Fujian Province* (2011-2020), the sediments quality for monitoring will be assessed by the Type Ⅰ standard in the Sea Sediments Quality (GB18668-2002), see the table 1.5.2 for details.

Table 1.5.2 Sea Sediments Quality Standard (unit: mg/kg)

Item	Indicators		
	Type Ⅰ	Type Ⅱ	Type Ⅲ
Organic C	**2.0**	3.0	4.0
Sulfide	**300.0**	580.0	600.0
Petroleum	**500.0**	1000.0	1500.0
Cooper	**35.0**	100.0	200.0
Cadmium	**0.50**	1.50	5.00
Lead	**60.0**	130.0	250.0
Zinc	**150.0**	350.0	600.0
Mercury	**0.20**	0.50	1.00
Arsenic	**20.0**	65.0	93.0

(3) According to the *Marine Environmental Protection Planning in Fujian Province* (2011-2020), the sea bio-quality assessment for monitoring will follow the Type I standard under the *Sea Bio-quality Standard* (GB18421-2001), see the table 1.5.3 for standard value.

Table 1.5.3 Standard Value of Sea Shellfish Bio-quality (unit: mg/kg)

Item	Type Ⅰ	Type Ⅱ	Type Ⅲ
Sensory Requirement	The growth and activities of shellfish is normal and not polluted by oils, the color, smell of shellfish is normal.		Shellfish can live without strange color, smell in shell meat
Petroleum Hydrocarbon≤	15	50	50(Oyster100)
Cadmium≤	0.2	2.0	5.0
Cooper≤	10	25	100(Oyster 100)
Lead≤	0.1	2.0	6.0
Zinc≤	20	50	100(Oyster 500)
Mercury≤	0.05	0.10	0.30
Arsenic≤	1.0	5.0	8.0

1.5.2 Pollutant Emission Standard

(1) The vessel pollutants discharge will follow the *Vessel Pollutant Discharge Standard* (GB3552-83) and MARPOL73/78 Protocol. See the table 1.5.4 to 1.5.6 for details.

Table 1.5.4 Maximum Permitted Concentration of Vessel Oily Sewage Discharge

Discharge Region	Discharge Concentration(mg/l)
Sea area within 12n.m. to nearest land	No more than 15
Sea area beyond 12n.m. to nearest land	No more than 100

Table 1.5.5 Maximum Permitted Concentration of Vessel Living Sewage (Unit: mg/l)

Item	Coast	
	Within 4n.m. to nearest land	4 to 12n.m. to nearest land
BOD_5	No more than 50	
Suspension	No more than 150	No clear suspended solid
Coliform	No more than 250/100ml	No more than 1000/100ml

Table 1.5.6 Vessel Waste Discharge Regulation

Discharging Items	Coast
Plastics	Dumped into sea is forbidden
Suspension	Within 25n.m. to land, dumped into sea is forbidden
Food and other waste	Those without being crushed can be dumped into the sea within 12n.m. to the nearest land; those after being crushed with the diameter less than 25mm can be dumped into sea beyond 3n.m. to the nearest land.

(2) The treated vessel sewage discharge will follow the Class Ⅰ discharge standard of *Sewage Discharge Standard* (GB8978-1996), see table 1.5.7 for details.

Table 1.5.7 Sewage Discharge Standard (Unit: mg/l)

Item	pH	BOD_5	CODCr	Suspension	NH3-N	Animal and Vegetable Oils	Petroleum
Class Ⅰ standard	6～9	≤20	≤100	≤70	≤15	≤15	≤5

1.6 Enviornmental Protection Targets

According to project development characteristics and surrounding environment, the sensitive environmental protection targets are identified (detailed in Section 1.8) as follows :

1. Ecological function/service of the Meizhou Bay as natural habitats, with particular focuses on waterways along the navigation channels and backfill/reclamation areas.
2. Aquaculture activities to be affected by navigation channel improvement and dredging material disposal.
3. Meizhou Island outside Meizhou Bay, which is both a national level tourism area and a nature reserve.
4. Ship safety of the navigation channel
5. Industrial facilities near/under the waterway, i.e. underwater pipelines, water intake etc.

The site-specific sensitive targets related each Phase III stage of project are as follows.:

1) The geographic and environmental relation between construction area and surrounding environment-sensitive targets for the Phase-III–Stage 1):

a) Putou seawater aquaculture area: laver aquaculture, located in east side of Putou Channel, the shortest distance to dredging area and rock-blasting area of Putou channel is around 1.1km and 0.85km respectively;

b) Luoyu surrounding seawater aquaculture area: abalones in net-cages, kelp and laver aquaculture, the aquaculture area totals around 0.97km^2, locates in west side of the main channel, the shortest distance to 4# dredging area of anchorage zone and rock-blasting area of main channel is around 0.78km and 0.04km respectively;

c) Dongwu seawater aqua^{c}ulture area: mainly cultivate abalones in net-cages, locates in the northeast side of the branch channel, the aquaculture area totals around 1.03km^2, the shortest distance to dredging area and rock-blasting area of branch channel is around 0.41km and 0.4km respectively;

d) Huiyuxi seawater aquaculture area: abalones in net-cages, kelp and laver aquaculture, the aquaculture area totals around 0.83km^2, locates in the Huiyuxi channel area and its two sides;

e) Dock and Submarine oil pipeline of Fujian Oil Refinery: locates in the west side of main channel, the shortest distance to dredging area of meeting area and rock-blasting area of Linchi Rock is around 0.26km and 0.7km respectively;

f) Meizhou Bay LNG Submarine Pipeline: locates between Xiuyu and Putou port area and goes through Putou channel, the shortest distance to dredging area and rock-blasting area of Putou channel is around 0.13km and 0.122km respectively;

g) Water Intake of Meizhou Bay Thermal Power Plant: locates in side of Luoyu Island, the distance to 4# anchorage zone is 2.6km and not in the tidal direction, the shortest distance to rock-blasting area of Luoyuxi is around 1.8km;

h) Water Intake of Nanpu Power Plant: the distance to Putou dredging area and rock-blasting area is 1.6km;

i) Water Intake of LNG Power Plant: the distance to Huiyuxi dredging area and rock-blasting area is 1.2km and 1.5km respectively.

2) The geographic and environmental between construction area and surrounding environment-sensitive targets for the Phase-III – Stage 2):

a) Luoyu surrounding seawater aquaculture area: abalones in net-cages, kelp and laver aquaculture, locates in west side of the main channel, the shortest distance to dredging area and rock-blasting area of main channel is around 0.05km;

b) Dock and Submarine oil pipeline of Fujian Oil Refinery: locates in the west side of main channel, the shortest distance to dredging area and rock-blasting area of main channel is around 0.68km and 0.58km respectively; as the Fujian Oil Refinery introduces, the submarine oil pipeline from 300,000 DWT oil dock to oil storage area is laid by ditching and covered with 1.5m thick sand and gravels.

See the figure 1.6-1 for the targets distribution.

See the table 1.6-2 for the marine environmental protection targets in surrounding sea area of channel projects to be built,

3 The geographic and environmental relation between backfill areas and sensitive targets is listed as follows:

Xiaocuo Backfill area: this area use the 5-6# berths of Xiaocuo operation area, the surrounding involves sporadic net-cage aquaculture;

Putou Backfill area: the area use the 3-25# berths of Putou operation area, the surrounding sensitive target is the Putou alga aquaculture area;

Table 1.6.1 The Position Relation between the Phase-III Engineering Project (Stage Ⅰ) and Environmental Protection targets

No.	Sea Environment-sensitive Area	Status and Planning Function	Position Relation to Project Construction Region(km)		Site Photos
			Shortest Distance to Dredging Area	Shortest Distance to Rock-blasting Area	
1	Putou Sea Aquaculture Area	Mainly cultivate laver presently, planning port area	1.1km to Dredging Area of Putou Channel	0.85km to Rock-blasting area of Putou	
2	Sea Aquaculture Area Surrounding Luoyu	Mainly Cultivate abalones in cages, kelp and laver presently, planning port area	0.78km to 4# Dredging area of anchorage zone	0.04km to Rock-blasting area of main channel	
3	Dongwu Sea Aquaculture Area	Mainly Cultivate abalones in cages and alga presently, planning port area	0.41km to dredging area of branch channel	0.4km to Rock-blasting area of Dongwu Channel	

4	Huiyuxi Sea Aquaculture Area	Mainly Cultivate abalones in cages, kelp and laver presently	Locates in Huiyuxi Channel and two sides		
5	Dock and Submarine oil pipeline of Fujian Oil Refinery	Submarine oil pipeline area of Fujian Oil Refinery	0.26km to dredging area of meeting area	0.7km to Rock-blasting area of Linchi Rock	
6	Meizhou Bay LNG Submarine Pipeline	LNG Submarine Pipeline Area	0.13km to Dredging area of Putou Channel	0.122km to rock-blasting area of Putou Channel	
7	Water Intake of Meizhou Bay Thermal Power Plant	Completed	2.6km to 4# anchorage zone and not in the tidal direction	The shortest distance to Luoyuxi Rock-blasting area is around 1.8km	
8	Water Intake of Nanpu Power Plant	Completed	1.6km to Putou Dredging Area	The shortest distance to Putou Rock-blasting area is around 1.6km	
9	Water Intake of LNG	Under construction	1.2km to Huiyuxi Dredging	The shortest distance to Huiyuxi	

	Power Plant		Area	Rock-blasting area is around 1.5km	

Note: The locations of A-F photos are shown in figure 1.6-1.

Table 1.6.2 The Position Relation between the Phase-III Engineering Project (StageⅡ) and EP targets

No.	Sea Environment-sensitive Area	Status and Planning Function	Position Relation to Project Construction Region(km)		Site Photos
			Shortest Distance to Dredging Area	Shortest Distance to Dredging Area	
1	Sea Aquaculture Area Surrounding Luoyu	Mainly Cultivate abalones in cages, kelp and laver presently, planning port area	0.04km to Dredging Area of Main channel	0.04km to Rock-blasting area of main channel	
2	Submarine oil pipeline of Fujian Oil Refinery	Submarine oil pipeline area of Fujian Oil Refinery	0.68km to Dredging Area of Main channel	0.58km to Rock-blasting area of main channel	

1.7 Assessment Contents and Key Points

The assessment includes the following:

(1)Survey and analysis of environment status, to determine the situation of environment quality of assessed region and determine the environment-sensitive regions, points and environmental protection targets;

(2)Retrospective assessment on the environmental impact of completed projects, to determine the main environmental problems and summarize experience to provide reference for the projects to be built;

(3)According to the works characteristic and analysis, to determine, emission quantity and characteristics of works pollutants, to predict and assess the degree and scope of environmental impact in construction and operation to develop mitigation measures;

(4)Analysis of the potential environmental risk and prediction or impact degree and scope of emergencies to develop accident risk prevention measures and emergency response plans;

(5)Analysis of the coordination between overall planning and site specific planning of construction-located region.

The analysis focuses on engineering analysis, marine environmental impact during construction, environmental protection measures, environmental risk impact and prevention measures based on works characteristics.

1.8 Assessment Level and Scope

1.8.1 Assessment Level

The Project is classified as the Category A project based on the EIA laws and regulations in China and World Bank's OP/BP4.01 Environmental Assessment, which requires full environmental assessment.

According to various domestic technical guidelines for environmental assessment, the assessment levels of each environmental aspect are determined. The Project type is channel engineering, the dredging quantities are over the threshold of 5 million m^3, the assessment level will follow the table 2 of the *Technical Guidelines of EIA for Marine Engineering*, GB/T19485–2004, see the table 1.8.1 for assessment levels and screening of assessed factors. Moreover, the oil, chemical products leakage due to navigating vessels accidents will refer to the *Technical Guidelines of Environmental Risk Assessment of Construction Projects*, HJ/T169-2004, and the risk assessment level is ranked as Class I

Table 1.8.1 Assessment Level and Screening Schedule of Assessed Factors

Factors		Level	Main Assessed Factors Screening
Marine Environment	Hydrodynamics	2	Tides pattern etc.
	Marine Terrain and landform, Erosion and sedimentation	2	Terrain and landform, Erosion and sedimentation
	Water Quality Environment	1	Factors for Present situation: pH, SS, Petroleum, COD, Inorganic N etc.; Factors for Forecast: SS in construction period
	Sediments Environment	1	Sulfide, Petroleum, Organic C etc.
	Ecological Environment	1	Phytoplankton and zooplankton, chlorophyll a, benthos etc.
Environmental Risk Assessment		1	The oil, chemical products leakage due to navigating vessels accidents

1.8.2 Assessment Scope

1) Based on *Technical Guidelines of EIA, Ecological Impact*(HJ19–2011) and the *Technical Guidelines of EIA for Marine Engineering*(GB/T19485–2004) with consideration of ecological system integrity, hydrodynamics, erosion and sedimentation, sea water quality, marine sediments and marine ecology, the Assessment Scope is defined as:
    i) sea area of Meizhou Bay between North to Chongwu, Hui'an and West to Meizhou

Island.

2) The key region for assessing environmental impact of sea water quality, marine sediments and marine ecology locates within 1000m to the construction site.
3) The marine environmental risk assessment covers the whole Meizhou Bay, especially the Meizhou Island.
4) Cumulative impacts assessment scope and targetsative impacts assessment covers the scope involved in Meizhou Bay Rim Regional Development Planning; the involved land covers an area of 1200km^2.
5) The public-participating survey involves Dongpu Town, Dongzhuang Town, Nanpu Town, Shanting Town, Fengwei Town, Jieshan Town and Shanyao Town etc. See Figure 1.8-1 for the EIA scope.

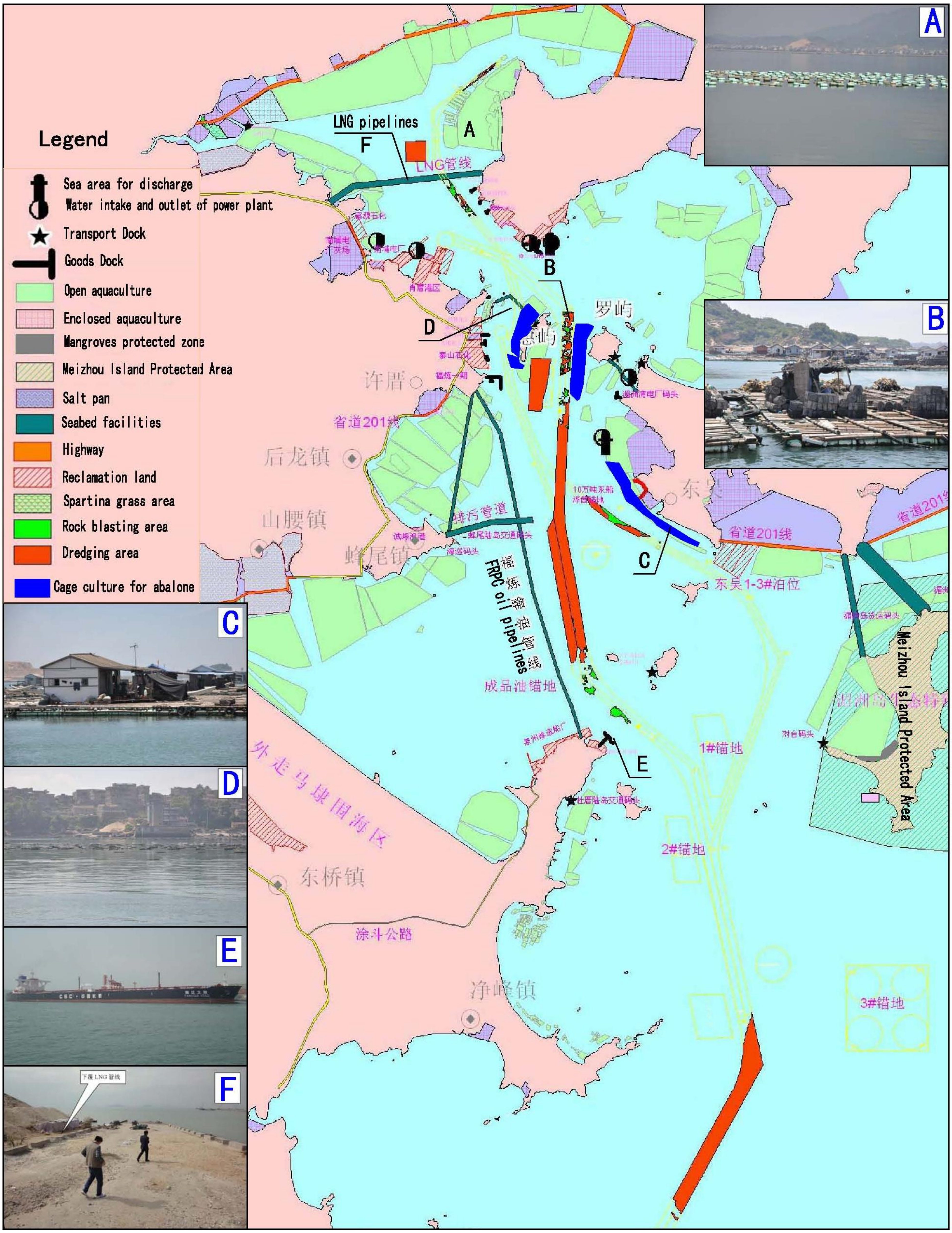


Figure 1.6.1 Environmental Protection Targets

Chapter 2: Project Overview

2.1 Overview

Meizhou Bay Navigation Channel has undergone two times of development. The planned Phase-III project is divided into two stages. Table 2.1.1 summarizes the key activities of the past construction of Phase I, Phase II and proposed Phase III. A due diligence of Phase I and Phase II is presented in Annex A.

Table 2.1.1 Overview of channels in each phase

Phase I (Environmental Assessment Report for Fujian LNG Terminal and Trunk Line Project of CNOOC Fujian Natural Gas Co., Ltd.. EA Approved by MEP in 2004; Construction completed in 2006)	
· 100,000-DWT main channel (31.46km long, 300m wide) · 100,000-DWT branch channel of Fujian Oil Refinery · 50,000-DWT branch channel of Yangyu · Branch channel of Meizhou Bay power plant wharf · Natural water depth meets the designed channel depth. Minor dredging conducted.	
Phase II (Environmental Assessment Report for Meizhou Bay Navigation Channel Phase-Ⅱ Engineering Project. EA approved by Fujian Provincial Environmental Protection Department. Construction completed in June 2012)	
· 250,000-DWT main channel (26.7km long, 300m wide) · 50,000-DWT Putou navigation channel · 100,000-DWT Dongwu channel · 100,000-DWT West Huiyu channel · Dredged materials reused for the development of Dongwu berth	
Phase III – Stage 2 (Bank financed, domestic EIA reviewed and approved by Fujian Provincial Department of Ocean and Fisheries and Fujian Environmental Protection Department in November 2011)	
Main Channel	- 300, 000 DWT channel (52.1 km long, 350-500m wide upon completion) - Two sections totaling 21.5 km need to be dredged
Dredged Materials Disposal	- Meizhou Bay Marine Waste-Dumping Site – 6.7 million m3 - Xiaocuo Backfill Area - 4 million m3 - Putou Backfill Area– 7.2 million m3
Phase III- Stage-1, (Domestic financed, domestic EIA reviewed and approved by Fujian Provincial Department of Ocean and Fisheries and Fujian Environmental Protection Department in November 2011)	
Removal of Linchi Rock	Blasting and removal of sea-bed rock at Linchi area
Xiaocuo Channel	A 2.0 km long 150,000 DWT navigation channel which allows unidirectional tide-dependent navigation from F-point of the main channel to Xiaocuo operation zone.
Putou Channel	A 4.9 km long 70,000 DWT navigation channel which allows unidirectional tide-dependent navigation from G-point of the main channel to #4 berth of Putou operation zone.
Branch channel Dongwu Section	A 6.6 km long 50,000 DWT branch channel which allows unidirectional tide-dependent navigation from D4-point of the Dongwu channel to the junction of main channel and Fujian Oil Refinery 100,000-DWT channel.
Putou North Channel	A 2.9km long 10,000 DWT branch channel which allows unidirectional tide-dependent navigation from the end of Putou 50,000 DWT channel to #25 berth of Putou operation zone.
Anchorage/crossing zone	Dredging of #4 and #5 anchorage zone and expansion of an existing crossing zone. (Two other proposed anchorage zones do not need dredging)
Dredged Material Disposal	Putou Backfill Area- 25.3 million m3

Figure 2.1-1 shows the layout of channels in each phase. It can be seen that the main channel of Meizhou Bay has reached carrying capacity of 250,000 DWT after the Phase II construction. The Stage 1 of Phase III only covers 4 branch channels and 3 anchorage/crossing zones, with

no main channel involved. While, the Stage 2 of Phase-III is designed to expand the capacity of the main channel to 300, 000 DWT through widening and deepening. And only incremental dredging will be needed.

Figure 2.1.1 Meizhou Bay Navigation Channel Development

2.2 Meizhou Bay Navigation Channel Phase-III Project (Stage 1)

2.2.1 Project information

According to the feasibility study report, components of the Meizhou Bay Navigation Channel Phase-III Project (Stage 1) are listed in Table 2.2.1.

Table 2.2.1 Content of Phase-III Stage 1

Ref.	Main content	Details	
1	150, 000 DWT Xiaocuo channel	Length 2.0km	Width 300m
	50,000-DWT Extension of Meizhou Bay branch navigation channel (Dongwu Channel)	Length 6.6km	Width 210 m
	Putou 70,000DWT channel	Length 4.9km	Width 200 m
	10,000DWT Putou North channel	Length 2.9km	Width 100 m
	Linchi rock removal	512,500 m3 rock clearing for bed elevation -21.5m	
	Crossing zone	Crossing zone on west side of Stretch C-D	
2	Anchorage Zone	3# at bay mouth, 4# and 5# inside bay. (The 3# anchorage zone doesn't need dredging.)	
3	Navigation Marks	/	

2.2.2 Channel layout

Figure 2.2-1 shows the Channel layout of the Meizhou Bay Navigation Channel Phase-III Project.

2.2.3 Quantities of Works of Phase-III Stage 1

The quantities of works of Phase III Stage 1 are shown in Table 2.2.2.

Table 2.2.2 Quantities of Works of Phase III Stage 1

Channel name	Dredging quantity (10,000 m^3)	Rock blasting quantity (10,000 m^3)
Xiaocuo channel	0	0.0206
Extension of Meizhou Bay navigation channel	209.87	27.96
70,000-DWT Putou channel	12.07	7.99
Putou Northern operation area 10,000-DWT channel	8.15	0
3# anchorage zone	0	0
4# anchorage zone	632.35	0
5# anchorage zone	687.13	0
Crossing Zone	893.31	0
Linchi rock blasting	0	51.25
Total	2442.88	87.22

In addition, two buoys will be relocated for Xiaocuo channel; six light buoys will be installed at Dongwu channel and Putou channel respectively; and eight light buoys will be installed in anchorage zones.

Dredged materials and rock blasting spoils of the Phase-III Stage 1 will be placed at Putou Backfill Area.

2.3 Meizhou Bay Navigation Channel Phase-III (Stage 2)

2.3.1 Project information

According to the feasibility study report, the planned Meizhou Bay Navigation Channel Phase-III Project (Stage 2) will construct the main channel only. The main channel starts from Dazuo outside the bay mouth and extends to the F point near the Luoyu. The total length of the main channel is about 52.1 km. About 21.5 km long main channel needs dredging. Table 2.6.1 shows the key activities of Phase III Stage 2.

Table 2.3.1 Content of Phase-III Stage 2

Ref.	Main Content	Construction Scale	Details
1	Main channel	Meets unidirectional tide-dependent navigation for 300,000-DWT bulk carriers and the unidirectional navigation for Q-MAX LNG ships.	52.1km long, Inner bay section 350m wide outer bay Section 500m wide
2	Anchorages	A new 2# anchorage zone for 300,000-DWT bulk carriers	A new anchorage zone near Dazuo
3	Navigation marks	Six relocated and three newly set up	

2.3.2 Channel layout

Figure 2.2-1 shows the channel layout of the Meizhou Bay Navigation Channel Phase-III Project.

2.3.3 Quantities of Works of Phase-III Stage 2

The quantities of works of Phase III Stage 2 are shown in Table 2.3.2 .

Table 2.3.2 Quantities of Works of Phase III Stage 2

Channel section	Dredging quantity (10,000 m^3)	Rock blasting quantity (10,000 m^3)
Dasheng Island to Luoyu Section (Inner bay section)	1057.29	72.39
South of Jianyu Anchorage Section (Outer bay section)	656.73	0.07
2# anchorage Zone	0	0
Total	1714.02	72.47

For Phase III Stage 2, the dredged materials and rock blasting spoils inside the bay will backfilled at Xiaocuo Backfill Area. The dredged materials outside the bay will be disposed of in the permitted Meizhou Bay Marine Waste-Dumping Site.

2.4 Construction Equipment and Schedule

2.4.1 Construction equipment

The main operational equipments that will be used for the project is summarized in Table 2.4.1.

Table 2.4.1 Main Operational Equipment

Ref.	Equipment name	Working Area	Specification	Quantity
1	Trailing suction hopper dredger (TSHD) with self-propelled bow-blowing function	3 for the main channel 3 for branch channel, anchorage/crossing zones	$4500m^3$	6
2	Cutter-suction dredger	For Putou North Channel and 5# anchorage zone	$1600m^3$	10
3	Grab bucket dredger	For rock spoils collection	$8m^3$	4
4	Self - propelled barge	For transportation of rock spoils	$1000m^3$	4
5	Drill-burst ship (underwater drilling and blasting ship)	For rock blasting	Fixed with steel piles	7
6	Beacon vessel	/		2

2.4.2 Construction schedule

2.4.2.1 Operation days

(1) Dredging

According to preliminary statistics, the construction area has an average of 13.8 rainy days with precipitation ≥ 25mm per year, an average of 14 foggy days with visibility < level 2 per year and an average of 18 days with heavy wind per year. In the construction area, the measured maximum flood tide rate is 1.00m/s and the maximum ebb tide rate is 1.01m/s, which are both smaller than 2m/s.

After comprehensively considering other factors affecting the construction (like waves, disturbance to navigation, etc.), the annual operation days construction ships will be 265d, with 25%~30% rate of influence from natural reasons.

(2) Rock blasting

Based on preliminary statistics with analysis of natural conditions of wind, current, fog, etc, the annual operation days will be 250d for the rock blasting zone, which is located at the sea area to the west of Luoyu island, southwest of Dasheng island, west of Dongwu and Huiyu and close to Putou, and the area features with huge waves and swift currents.

2.4.2.2 Total construction period

According to the recommended plan of Phase-III Stage-2, the dredging period will be 23 months; and the rock blasting period will be 30 months. The installation period for buoy will be about 2 months; and about one month for survey and work acceptance. The total construction period is planned to be 33 months.

According to the recommended plan of Phase-III Stage-1, the dredging period will be 36 months; and the rock blasting period will be 33 months; The construction period for buoy project will last about 2 months; and about one month for wire-drag survey and work acceptance. The total construction period is planned to last 39 months.

2.5 Summary of Works Quantities of Phase III

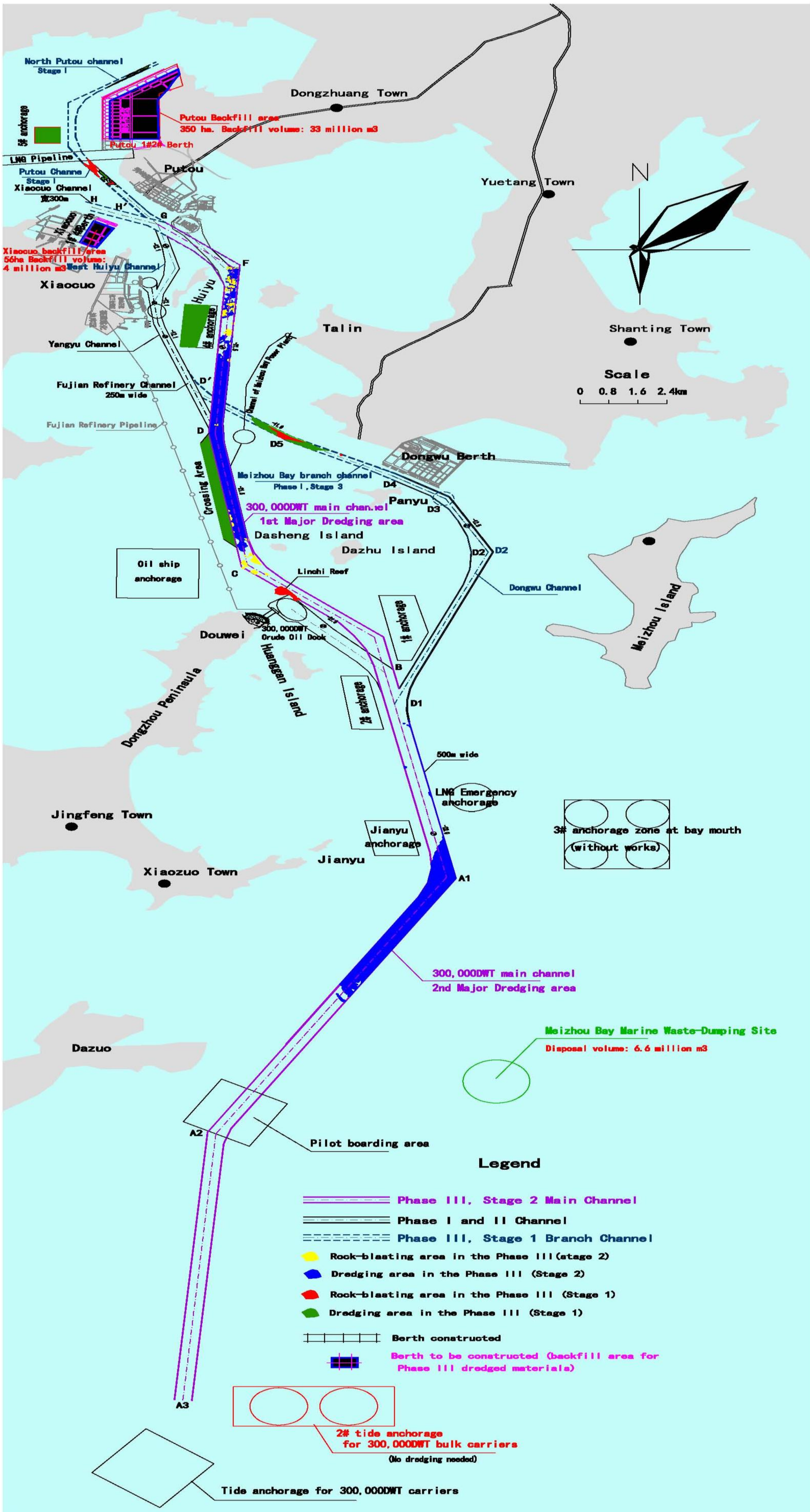
Table 2.5.1 shows the sum of quantities of works generated from dredging and rock blasting of Phase III. In total, 43.2 million m3 of materials will be generated from the Phase III channel construction. The dredged materials will placed in three sites, as shown in Table 2.5.2.

Table 2.5.1 Quantities of Works of Phase III Dredging

Phase	Dredging (million m^3)	Rock blasting (million m^3)	Total (million m^3)
Phase-III (stage 2)	17.2	0.7	17.9
Phase-III (stage 1)	24.4	0.9	25.3
Total	41.6	1.6	43.2

Table 2.5.2 Quantities of Works of Dredged Material Disposal

Disposal Site	Area (hectare)	Disposal Amount (million m3)	Source
Xiaocuo Backfill Area	56	4	Main channel inside bay section
Putou Backfill Area	350	32.5	25.3 million from Stage 1 7.2 million from Stage 2
Meizhou Bay Marine Waste-Dumping Site	/	6.7	Main channel outer bay section
Total	/	43.2	/


North Putou channel
Stage I
5# anchorage
Putou Backfill area
350 ha. Backfill volume: 33 million m3
Putou 1#2# Berth
Dongzhuang Town
LNG Pipeline
Putou Channe
Stage I
Putou
Xiaocuo Channel
H
H'
G
Xiaocuo backfill area
56ha Backfill volume:
4 million m3
West Huiyu Channel
Xiaocuo
Huiyu
F
Yuetang Town
N
Talin
Shanting Town
Yangyu Channel
Fujian Refinery Channel
250m wide
Scale
0 0.8 1.6 2.4km
D'
Fujian Refinery Pipeline
D
D5
Dongwu Berth
Crossing Area
Meizhou Bay branch channel
Phase I, Stage 3
D4
Panyu
D3
300,000DWT main channel
1st Major Dredging area
Dasheng Island
Dazhu Island
D2
Oil ship
anchorage
C
Linchi Reef
Dongwu Channel
1# anchorage
Meizhou Island
300,000DWT
Crude Oil Dock
Douwei
Huanggan Island
B
Dongzhou Peninsula
2# anchorage
D1
500m wide
LNG Emergency
anchorage
Jingfeng Town
Jianyu
anchorage
3# anchorage zone at bay mouth
(without works)
Xiaozuo Town
Jianyu
A1
300,000DWT main channel
2nd Major Dredging area
Meizhou Bay Marine Waste-Dumping Site
Disposal volume: 6.6 million m3
Dazuo
A2
Pilot boarding area
Legend
Phase III, Stage 2 Main Channel
Phase I and II Channel
Phase III, Stage 1 Branch Channel
Rock-blasting area in the Phase III(stage 2)
Dredging area in the Phase III (Stage 2)
Rock-blasting area in the Phase III (Stage 1)
Dredging area in the Phase III (Stage 1)
Berth constructed
Berth to be constructed (backfill area for
Phase III dredged materials)
A3
2# tide anchorage
for 300,000DWT bulk carriers
(No dredging needed)
Tide anchorage for 300,000DWT carriers

Chapter 3: Alternative Analysis and Engineering Analysis

3.1 Alternative Analysis

3.1.1 “With/without Project” scenarios

The “Without Project” scenario means to maintain the status quo of the navigation channel while the “With Project” scenario means to carry out channel construction as required by the feasibility study report and the EIA.

Fujian is a coastal province in southeast China, with long history of ocean trade and fishery industries. Rapid economic development in recent decades boosted the demand for ports facilities along the coastal region. The environmental sustainability of China’s coastline is one of the main motivations of China in adopting the Seaports Plan rather than allowing widespread degradation of the coastline through a proliferation of small port developments. Accordingly, Fujian has developed overall master plan for its port development along coastal line, with focus on a few key major ports which will function as regional development hub for integrated transport, navigation, trade and logistics, and port-oriented industries. Without the overall planning of key ports, the rapid increase of ocean transport demand will certainly boost proliferation of many small ports along the 3700km coast line of Fujian. With concentrated development in a few ports as regional economic engines, vast coastal areas could be remain less disturbed and kept for ecological function and services.

Meizhou Bay is explicitly a key port under Fujian’s port development plan, and contributes to the objective of central port development, avoiding the proliferation of small, under quality ports along the coastal line. Meizhou Bay has a number of advantages for its strategic importance:

Firstly, Meizhou Bay is of great significance to the development of West Strait Economic Zone. Goods transported through Meizhou Bay harbor mainly include crude oil, oil products, constructional materials, coal, iron ore, grain, wood, etc. The development of Meizhou Bay will attract logistics companies and largely shorten the distance of goods transportation from other ports closest to the region towards the hinterland. For instance, a distance of 180km will be saved for transportation of iron ore import/product export of nine large-scale steel plants in Fujian, Jiangxi and Hunan to/from India, Brazil and Australia compared with Xiamen Port as destination; it is 487km shorter than to Ningbo Port and 649km shorter than to Zhanjiang Port. Less transportation distance is of both economic significance and notable environment benefits. Secondly, there are significant benefits of safety and environment risks of Meizhou Bay navigation channel. When large-scale LNG ships enter and exit the harbor, navigation channel need to be fully blocked. On one hand, main channel extension may satisfy the navigation need of large-scale LNG ships. Meanwhile, longer navigation time is available for other transport ships to meet the development and production needs of all harbor areas of Meizhou Bay. On the other hand, channel extension and Linchi rock blasting may reduce vessel collision probability and remove potential problems in safe navigation. Besides, the adjustment of anchorages and crossing zones is very important for safe navigation of vessels. Thirdly, the implementation of this project will cause some impacts on aqua-farm owners within the bay. While, such impacts can be effectively avoided and mitigated with relevant measures.

On the whole, if viewed from such aspects as economic development, regional environment, navigation safety and environmental risks, the "With Project" scenario will be superior to the "Without Project" scenario.

3.1.2 Alternative analysis of Phase-III Stage 1

Restricted by landform and the channels under construction or completed, the channel alignment of Xiaocuo channel, Putou channel and the Putou North Channel are determined. Two alternative alignment were considered for the Meizhou Bay Branch channel (Dongwu Channel extension).

Layout 1: the channel turns about 5° to the south side from the ending of Dongwu Channel to avoid the shallow area of the Dongwu operation zone, after sailing 3.3km, turns about 6° to the deep trough in north side of 100,000-DWT ship-tying buoy anchorage to connect with the 100,000-DWT channel of Fujian Oil Refinery, then turns to West Huiyu sea area to use the on-going Huiyu West Channel of the Phase-Ⅱ near the front of Taishan Petrochemical Dock, see the Figure 3.1-1 for details.

Layout 2: Straightly extends along the axis of Dongwu Channel and connect with the 100,000-DWT channel of Fujian Oil Refinery, then the following is the same with the layout 1, see the Figure 3.1-2 for details.

Figure 3.1-1 Layout Plan 1

Figure 3.1-2 Layout Plan 2

See the Table 3.1.2 for detailed indicators of the two alternatives.

Table 3.1.2 Comparison of Technical Indicators of Navigation Channel

	Branch channel of Meizhou Bay	
	Plan 1	Plan 2
Construction scale	One-way tidal navigation channel for 50,000-DWT vessels	One-way tidal navigation channel for 50,000-DWT vessels
Typical vessels	50,000-DWT container vessels, bulk carriers, oil	50,000-DWT container vessels, bulk carriers, oil tankers

	tankers	
Navigation range(km)	14	14
Effective channel depth(m)	210	210
Channel bed elevation(m)	-11	-11
Dredging quantity(10,000 m3)	209.87	280.77
Rock blasting quantity (10,000 m^3)	27.96	38.86
Navigation marks	Newly establish six light buoys	Newly establish six light buoys
Remarks	Recommended plan	

Advantages and disadvantages of the two plans are detailed as follows:

Plan 1 has such advantages as smaller construction quantity and less investment with dredging quantity of 2.0987 million m^3 and rock blasting quantity of 279.6 thousand m^3. It has a disadvantage of a necessary turning near the 100,000-DWT ship-tying buoy anchorage, nevertheless, the steering angle is small at about 5°. Plan 2 has such advantages as straight sea route extending directly from Dongwu channel to the 100,000-DWT channel of Fujian Oil Refinery. It has a disadvantage of large works quantities with dredging quantity of 2.8077 million m^3 and rock blasting quantity of 388.6 thousand m^3.

With the comprehensive comparison, Plan 1 is recommended.

3.1.3 Alternative analysis of Phase-III Stage 2

3.1.3.1 Overall Channel Layout

The project design takes the natural factors into full consideration like meteorological, hydrology, geology and geomorphology etc., and, combined with the berth planning of the ports as well as Phase-I and II of Meizhou Bay channel. The project takes advantage of existing channels to decrease works quantities of basic construction, maintenance and dredging, and rock blasting etc. and so to shorten construction period, reduce environmental impacts and decrease the engineering cost and the operation cost. Besides, the planned channel route goes smoothly if viewed as a whole and can meet safe navigation requirements. Therefore, the overall layout of the channel of the assessed project is recommended.

3.1.3.2 Alternative Analysis of Channel Bed Elevation

Since the navigation range of the 300,000-DWT Meizhou Bay channel is long (51.9km in total), alternative analysis of two bed elevation plans were considered for this project as follows:

(1) Bottom elevation plan I:

It's about 51.9km (about 28.2n miles) from the beginning point to the front of Luoyu #9 berth of Meizhou Bay 300,000-DWT channel, of which from the beginning point to Point B in the vicinity of Douwei is about 34.7km (about 18.7n miles), from Point B in the vicinity of Douwei to the front of Luoyu #9 berth is about 17.4km (about 9.4n miles). 300,000-DWT(400,000t) bulk carriers, taking the mean speed of 10 knots, require 2.82 hours for the entire trip. Considering conservative factors, the full time would be 3.4 hours, and would be eventually 4 hours in total if counting 0.5 hour docking time. Since the vessels must dock at the beginning of ebb (within 1.5 hours of flood slack), the tidal duration is counted as 6 hours.

According to the aforementioned port entry and departure operation rules, the vessels shall sail for 2.25 hours for the range of 34.7km (about 18.7n miles) from the beginning to Point B in the vicinity of Douwei with reservation coefficient into consideration. Supposing the tidal probability of 90% at Chongwu station, the tidal duration of 6 hours, the tide-bound water level of 3.21m, the bottom elevation of the channel is 3.21 - 26.13 = -22.92m, i.e. taking -23.0m. Because the tide-bound water level in Meizhou Bay sea area taking on a trend of gradual increase from bay-mouth to bay top, the vessels arrive at Point B in the vicinity of Douwei near the flood slack. It's about 17.4km (about 9.4n miles) from Point B in the vicinity of Douwei to the front of wharf. With reservation coefficient and turning in consideration, it needs about 1.6 hours. Supposing the tidal probability of 90% at Douwei, the tidal duration of 3 hours, the tide-bound water level of 4.86m, the bottom elevation from Douwei to the wharf front is 4.86 - 26.34 = -21.48m, i.e. taking -21.5m.

(2)Bottom elevation plan II:

For this plan, the vessels enter the harbor in the same way with Plan I. Supposing the tidal probability of 90% at Chongwu, the tidal duration of 5 hours, the tide-bound water level of 3.69m, the bottom elevation of the channel is 3.69 - 26.13 = - 22.44m, i.e. taking -22.5m. It takes about 2.25 hours to Point B in the vicinity of Douwei. Supposing the tidal probability of 90% at Douwei, the tidal duration of 3 hours, the tide-bound water level of 4.86m, the bottom elevation from Point B in the vicinity of Douwei to the wharf front is 4.86 - 26.34 = -21.48m, i.e. taking -21.5m.

Refer to Table 3.1.3 for key economic and technical indicators as set out in plans for design routes of the assessed project in detail.

Table 3.1.3 Comparison of technical indicators of the assessed project

	Plan 1		Plan 2	
Construction scale	One-way channel for one-way tidal navigation of 300,000-DWT bulk carriers			
Typical vessels	300,000-DWT bulk carriers and Q-MAX type LNG vessels			
Section	Outer bay section (A_3 ~ B)	Inner bay section (B ~ C ~ F)	Outer bay section (A_3 ~ B)	Inner bay section (B ~ C ~ F)
Tide-bound water level(m)	3.21 (Chongwu station)	4.86 (Douwei station)	3.69 (Chongwu station)	4.86 (Douwei station)
Tidal probability	90%	90%	90%	90%
Tidal duration(h)	6	3	5	3
Navigation range(km)	51.1		52.1	

Effective channel depth(m)	500	350	500	350
Designed bed elevation(m)	-23	-21.5	-22.5	-21.5
Dredging quantity(10,000 m3)	1714.02		1512.93	
Rock blasting quantity(10,000 m3)	72.47		72.43	
Navigation marks	Six relocated, three newly set			
Total project period(month)	33		33	
Gross investment (10,000 RMB)	89838.03		86262.75	
Remarks	Recommended plan			

Restricted by water area and landform as well as the completed channel and berth plan of Meizhou Bay, basically no room is left for the alternative plan of the main 300,000-DWT channel. Therefore, only one layout plan is considered. Outside the bay, the channel width has met the requirement, just requiring deepening; inside the bay it requires widening and deepening. For the section outside the bay, two bottom elevation options are proposed and compared as follows:

This section will use the existing entry channel delivered for use of Fujian Oil Refinery 300,000-DWT crude oil tanker, whose width has met the one-way requirement of 300,000-DWT bulk carrier, so only one layout plan is designed. Two bottom elevation options are proposed by adopting current layout plan for navigation channel layout: Option I – bottom elevation of -23.0m, the tidal probability of 90% and the tidal duration of 6 hours; Option II – bottom elevation of -22.5m, tidal probability of 90% and the tidal duration of 5 hours. On the basis that large-sized vessels must dock at the beginning ebb of flood slack (calculated at finishing dock within 1.5 hours after flood slack in this report), the time available for navigation at the channel by vessels is 4.5 hours of Option I and 4 hours of Option II. Due to long range of proposed Meizhou Bay 300,000-DWT channel (about 52.2km long), time reservation available for Option II is less, while the time for Option I is sufficient, which is helpful to safe navigation and docking of large-sized vessels. The disadvantage of Option I is that the works quantities is larger than Option II (dredging quantity: Option II of 4.4564 million m^3, Option I of 6.5673 million $m^{3)}$. But taking navigation safety and navigation condition of large-sized vessels into account, the bottom elevation of Option I is recommended for the construction.

Refer to Table 3.1.4 for advantages and disadvantages of the two Options.

Table 3.1.4 Comparison of Options for the 300,000-DWT Meizhou Bay channel

Section	Option	Dredging quantity (10,000 m3)	Rock blasting quantity (10,000 m3)	Advantages	Disadvantages

Outer bay section	Option 1	663.95	0.07	Time available is sufficient for vessels' navigation and berthing, which is helpful to safe navigation of large-sized vessels, therefore reducing the environmental risk accident probability	Large works quantities, big investment, long project duration
	Option 2	455.64	0.03	Smaller works quantities, less investment, shorter project duration	Time available is less for vessels, which will bring potential safety hazards

In summary, the navigation conditions proposed in Option 1 for Meizhou Bay 300,000-DWT Navigation Channel are superior to Option 2, but the civil works quantities of Option 1 are slightly larger than Option 2. After comprehensively comparing the two options, we recommend Option 1 as the construction plan.

3.1.4 Alternative Analysis of Construction Techniques

3.1.4.1 Dredging Techniques

The FSR report proposes the following dredging equipment and operations.

(1) TSHD (Trailing Suction Hopper Dredger)

- Dredging operations: Dredging and silt loading → self-propelled transporting the silt →dumping the silt at designated silt storage pit →self-propelled return
- Backfilling operations: Cutter suction dredger (berthed at silt storage pit) → silt pipe → blow silt to fill backfill area.

(2) Grab bucket dredger

- Dredging operations: Dredging and loading to barge → self-propelled barge transporting the silt → dumping at designated sand storage pit → self-propelled return.
- Backfilling operations: Cutter suction dredger (berthed at sand storage pit) → silt pipe → blow silt to fill backfill area.

(3) Directly blow silt to backfill area

- Cutter suction dredger (berthed at the dredging area) → dredge pipe →blow silt to fill the built-up land.

The 1# and 2# dredging operation requires silt pits as to temporarily storage dredged materials before it can be blow into backfill area. In the process of dumping silt into the pit, dredged materials would be dumped into the sea in a short time. Large quantities of silt would quickly disperse assisted by tidal current and no effective control measures can be taken. A comparison study shows that such operation would cause excessive suspended solids concentration along 2000m tidal direction up- and downwards respectively. Thus a large sea would be impacted. The 3# dredging operation is cost-effective considering long pipes needed and high energy consumption.

The EA is therefore recommends trailing suction hopper dredger (TSHD) with self-propelled bow-blowing function which can fulfill self- dredging, loading, transportation and filling into backfill area directly. In this way the temporary silt storage pit is not needed, which will avoid the secondary impacts. The recommended dredging equipment and operation would 100% send the dredging materials into backfill area, except minor sediments taken by tail water discharge. The project owner agreed to take the recommendation.

3.1.4.2 Alternative Analysis of Rock Blasting Techniques

The project will use underwater drilling and blasting ship and millisecond delay blasting techniques to carry out rock blasting operation. From environmental perceptively, the explosives charge for single-stage blasting is the key consideration for controlling potential impacts. The FSR doesn't stipulate the maximum explosives charge. In practice, for single-stage blasting, explosives charge ranges from 100 to 1000 kg, and the maximum value is taken at non-sensitive areas. Based on EA study (presented in Chapter 6), peak pressures of surge waves under different amount of explosive charge are listed in Table 3.1.5.

Table 3.1.5 Corresponding distance under peak pressure of surge waves with different amount of explosive charge

Single-section explosive charge (kg)	Radius of influence with different excessive pressure (m)	
	0.05MPa	0.03MPa
25	165	250
50	208	315
75	238	360
100	260	395
150	298	460
200	328	498

According to the analysis result shown in Table 3.1.5, in the case of 100kg explosive charge for single-stage priming, the scope with excessive pressure of over 0.03Mpa is limited to 395m outside the boundary of rock blasting zone while in case of 200kg explosive charge for single-stage priming, the scope with excessive pressure of over 0.03Mpa is extended to 498m outside the boundary of rock blasting zone.

Taken into account the explosive charge for single-stage priming in recent rock blasting at Meizhou Bay sea area, the EA requires to limit the explosive charge for single-stage priming below 100kg, so the scope of influence over aqua-farming can be limited within 395m.

3.1.5 Alternative Analysis of Disposal of Dredged Materials

Around 43 million m3 dredged materials will be generated from dredging and blasting of the entire Phase III navigation channel improvement. Disposal of the large amount of dredged materials would be primary concern from environmental perspective. Worldwide, three common management alternatives may be considered for dredged material" open-water disposal (ocean dumping), confined (diked) disposal and beneficial use. The selection of a preferred alternative for dredged material management must be based on a weighing and balancing of a number of considerations that include environmental acceptability, technical feasibility and economics. It was finally determined that a major part of the dredged materials, about 36.5 million m3, will be reused as filling materials for port expansion of existing Xiaocuo and Putou port area. The remaining 6.6 million m3, will be placed in a permitted ocean dumping site outside the Meizhou Bay, i.e. the Meizhou Bay Marine Waste-Dumping Site.

- Disposal at Putou and Xiaocuo Backfill Area

Direct ocean dumping of large amount of dredged materials would result significant impacts on marine benthic organism and biotope and water quality. Hence reuse of dredged materials is always preferred. In Meizhou Bay, existing Xiaocuo and Putian port area are planning port expansion that need significant amount of materials for foundation building. Xiaocuo port area currently has 1#-4# berth in operation. 5# and 6# berth will be built in coming years. In Putou port area, 1# and 2# berth are substantially built; 3#~25# berth are planned to be built. The project owner, MBHAB, has reached agreement with the port developers to reuse the dredged materials for the foundation building.

The environmental benefits of this arrangement are obvious. By reusing the dredged materials rather than directly dumping into ocean, impacts on marine environment is avoided to the extent possible. It also reduces substantial needs of filling materials (for port development) from other sources, such as new sand mining or material borrow sites. Further, disposal of dredged materials in the Xiaocuo and Putou backfill areas requires building well-structured confined facility (dikes) that would effectively control impacts on environment that would otherwise significant in the case of open or badly controlled dumping.

The negative impacts were also assessed. The dredged material disposal and eventually land reclamation would occupy coastal areas (mudflat moslty) that provides ecological services and livelihood uses. Therefore, sound planning, design, and management are essential if dredged material disposal is to be accomplished with appropriate environmental protection and in an efficient manner. These considerations are fully taken into account during the preparation of the EA.

Around 36.5 million m3 dredged materials will be reused in Putou and Xiaocuo Backfill Area which account for 350ha and 56ha respectively. The materials are from the dredging and rock blasting taking place within the Bay.

- Disposal at Meizhou Bay Marine Waste-Dumping Site

As discussed above, ocean dumping of large amount of dredged materials would pose significant environmental impacts. The ocean dumping is strictly regulated by relevant marine environmental protection laws and regulations. The responsible authority, State Ocean Administration (SOA), issued a permit designating the Meizhou Bay Marine Waste-Dumping Site in 2010 based on a comprehensive technical and environmental study. According to the permit, the dumping site is located about 15km from the Meizhou Bay mouth and has an area of 2.69 km2. The permit stipulates that the site receives waste no more than 4 million m3 annually and 22.68 thousand m3 daily. It is classified as a permanent dumping site.

The dredged materials generated from the main channel outer bay section would amount to 6.6 million m3. The outer bay dredging section of the main channel is only 5.5-10.6km from the permitted dumping site but 23-29 km away from the Xiaocuo Backfill Area. Considering the huge cost for transporting the dredged materials to inner bay (45 yuan/m3 to the Xiaocuo Backfill Area), the 6.6 million m3 dredged material are determined to be dumped in the permitted dumping site. The dredging of the section will take 2 years, meaning annually 3.3 million m3 materials will be generated. It is below the dumping site’s ceiling for receiving dredged materials.

The impact of direct ocean dumping is assessed in Chapter 6. Mitigation measures and monitoring program are developed accordingly. In brief, because the quality of dredged materials is uncontaminated, and is similar to the sediment quality of the waste-dumping site. The controlled dumping will not significantly change the sea bed topography. Once the dumping stops, the impacted benthic organisms and sea bed biotope will be able to recover in a couple of years. Therefore, this option is environmentally acceptable.

3.2 Engineering Analysis and Environmental Screening

The purpose of engineering analysis is to analyze project activities and identify the relationship between the project activities and relevant natural environment and socioeconomic factors, i.e., environmental screening. This process is to ensure that EIA focus on key issues relating to project design, decision-making and public interest.

3.2.1 Engineering analysis

3.2.1.1 Construction period

Main physical activities during the construction period include channel dredging, rock blasting, dredged materials transportation, disposal of dredged materials at Putou and Xiaocuo backfill area and the permitted Meizhou Bay Marine Waste-dumping Site. Details of the project activities and environmental and social impacts possibly envisaged are as follows:

(1) Dredging

Through alternative analysis, the recommended dredging equipment is the 4500 m3 trailing suction hopper dredger (TSHD) with self-propelled bow-blowing function which can fulfill self-dredging, loading, transportation and filling into backfill area directly. Table 3.2.1 shows the dredger used for each channel section and backfill area.

Table 3.2.1 Dredging technology for each channel

Phase	Channel name	Dredging, transportation and disposal	Disposal site
Phase-III (stage 2)	Main Channel inner Bay Section	Dredging operation with the self-propelled 4,500m^3 bow-blowing TSHD whose transfer blowing pump blows silt into backfill area by hydraulic filling	Xiaocuo, Putou backfill area
	Main Channel	Operation with the 4,500m^3 self-propelled	Meizhou Bay

	outer bay section	TSHD. Transported and with hopper barge	dredged materials offshore dumping area
Phase-III (Stage 1)	Extension of Meizhou Bay Branch Navigation Channel	Dredging operation with the self-propelled 4,500m^3 bow-blowing TSHD whose transfer blowing pump blows silt into backfill area by hydraulic filling	Putou backfill area
	＃4 anchorage		Putou backfill area
	Crossing zone		
	70,000-DWT Putou channel		Putou backfill area
	10,000-DWT navigation channel of North Putou operation area	Dredging operation with the 1,600m^3 cutter-suction dredger which directly blows silt into backfill area by hydraulic filling	Putou backfill area
	＃5 anchorage		

The primary impacts caused by the dredging are disturbance to benthic organisms, which is detailed in Chapter 6. Impact on water quality impacts is another concern. The self-propelled bow-blow TSHD is equipped with automatic overflow control system. It will automatically shut its overflow gate in case of silt overflow from the full cabin. The time for overflow control is within 0.5h after the cabin is full as required by dredging operation standard. The discharge concentration of SS in the overflow water is closely connected with geological conditions of the dredged area. Under the condition of same overflow time, the discharge concentration of SS with high silt content is also high. Therefore, different kinds of dredged materials should be taken into consideration in overflow time control so as to put the SS discharge concentration under control.

According to the equipment information provided by the project owner, the TSHD used in the project has more than three compartments. The slurry sucked by the dredging pump enters the compartments for post precipitation layer by layer before entering the last compartment equipped with overflow ports. When the compartment is full of silt deposit, the dredging operation stops, but some slurry will be discharged into the sea area from the overflow ports of the cabin roof, leading to the increase in suspended sediments concentration in the water body in the vicinity of the sea area for operation. According to measured data, the SS concentration at overflow ports of such TSHD is generally at 0.5-1g/L if overflow time is under control.

Table 3.2.2 for the quantity of emerging suspended sediments estimated on analogical basis during channel dredging for Phase-III.

Table 3.2.2 Pollutant sources during dredging operation

Phase	Location of suspended sediments	Dredger type	Silt percentage (R)	Dredged earth quantity(T)	Genetic coefficient(Wo)	Quantity of SS(suspended sediments)

						generated
Phase-III (stag 2)	Dasheng island - Luoyu (inner bay section)	4500m3 self-propelled TSHD	80%			5.56kg/s
	South side of Jianyu anchorage(outer bay section)		80%			5.56kg/s
	Suspended sediments from rock blasting and clearing	8m3 grab bucket dredger	30%	375m^3/h	0.01t/m^3	0.312kg/s
Phase-III (stage 1)	70,000-DWT Putou channel	Self-propelled 4,500m3 bow-blowing TSHD	50%			3.9kg/s
	Extension of Meizhou Bay Navigation Channel		30%			2.78kg/s
	#4 anchorage		50%			3.9kg/s
	Crossing zone		80%			5.56kg/s
	North Potou Channel Area	1,600m3/h cutter-suction dredger				2.4kg/s
	#5 anchorage					2.4kg/s
	Suspended sediments from rock blasting and clearing	Dredging with 8m3 dredger	30%	375m^3/h	0.01t/m^3	0.312kg/s
Suspended sediments at overflow ports of the backfill area	Cofferdam of each backfill area					0.139kg/s

(2) Rock blasting

Based on comprehensive analysis of the project's geological conditions, environmental, safety and economic factors, underwater drilling and blasting will be used in rock blasting to be carried out by an underwater drilling and blasting ship. An 8m^3 grab bucket ship will collect the rock spoils which will be transported to designated area by a 1,000m^3 self-propelled barge. Underwater hole-blasting drills once to the designed hole bottom elevation (plus extra depth for drilling) with the method of millisecond delay blasting.

Positioning of blasting ship → Underwater Drilling → Explosive charge → Networking of explosives points → Retreat of blasting ship → Blasting → Spoils collection

Figure 3.2-1 Operation process of single rock blasting

The blasting shall abide by the requirements of *Specification for Blasting Methods in Waterway Engineering* (JTS204-2008), with special attention paid to safe work practices and construction quality. After rock clearing, rigid sweeping at definite depth or multi-beam full-coverage sweeping shall be performed for the rock blasting area and the rock clearing area; no shallow point allowed.

Environmental impacts associated with rock blasting are mainly the following.

- Blast wave impact on marine ecology: underwater shock waves would impact zooplankton, fish, shrimps and other marine organisms in neighboring sea area.
- Suspended Solids (SS) impact on water quality: Blasting exerts certain influence over the area close to the blasting ship but the influence is limited within neighboring 100m sea area.
- Besises, rock blasting may also impact the passing-by vessels nearby and the underwater operation personnel.

(3) Transportation of dredged materials

The recommended self-propelled bow-blowing TSHD can fulfill self- dredging, loding, transportation and dumping. Properly managed, the transportation of dredged material won’t result in any impacts. But attention should be paid to wastewater discharge.

(4) Material backfill (reclamation) at Xiaocuo and Putou Backfill Area

Dredged materials of the project will be disposed at Xiaocuo and Putou Backfill Area, which will be the foundation for the future port berths. The backfill (reclamation) will require the construction of an embankment intended to protect the backfill material from being hit by waves.

The embankment is composed of sandbags at bottom and layers of gravels above. The embankment is covered with filtering system (400g/m2 geotextile). The filtering system is intended to control suspended solids being brought by seepage. The embankment also serves as a road. Figure 3.2.2 shows embankment and its geotextile filter.

Figure  **3.2-2**

Embankment and Filter System

With embankment built, backfill practice can be carried out. Dredger transports dredged materials and berths by the backfill area, connect to pipe and pumping the dredged materials into the backfill area. As is shown in Figure 3.2.3. The main environmental issues with the backfill are the permanent coverage of mudflat/shallow sea area and impacts on water quality due to SS seepage and discharge from the backfill area.

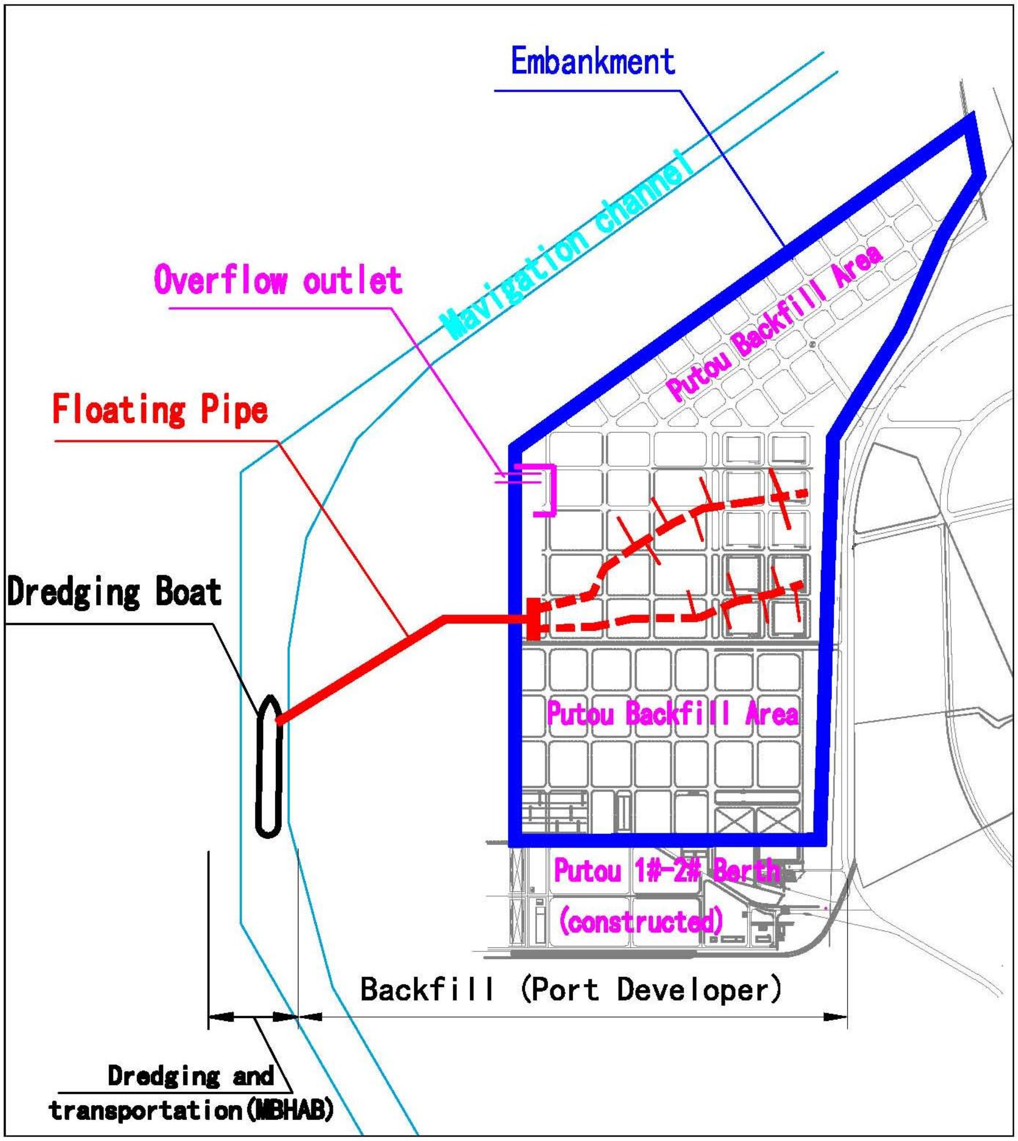


Figure 3.2-3 Backfilling (reclamation) operation

Figure 3.2-4 Hydraulic filling through floating pipe

The backfill area will serve as foundation for future port area, including storage yard, office buildings etc. The EIA for the port development are also prepared.

(5) Material disposal at Meizhou Bay Marine Waste-Dumping Site

The self-propelled bow-blowing TSHD automatically navigates to the Meizhou Bay dredged materials offshore dumping area for dumping.

(6) Waste water and garbage from construction ships

- A total of 36 operational ships are put into service during peak construction period of the Phase-III project. The engine room of each ship generates oil polluted water of about 0.2t/d on average. And such oil polluted water amounts to 7.2t/d in total with oil concentration of about 3,000mg/l, and the amount of oil generated reaches 20.16kg/d during peak period of construction.

- About 400 ship crews work during peak period of the Phase-III project. Suppose each of them produces wastewater of 0.1t/d, the total wastewater they produce would amount to 40t/d.

- With estimated domestic waste of 0.8kg/d generated by each crew member during the Phase-III project, the total domestic waste of 32kg/d will be generated by the crews.

3.2.1.2 Operation period

(1) Maintenance dredging and rock blasting

The 300,000-DWT main channel of Phase-III of Meizhou Bay Channel just widens and deepens the original 100,000-DWT channel. Because Meizhou Bay boasts strong tide motivity with clear water and little sand, the silt quantity in and out with tides is balanced basically. Furthermore, the influx into the groove after channeling and the existence of islands, capes and rocks inside the bay restrict the planimetric swing of the central deep groove. Therefore, under current condition of incoming water and sediment inflow as well as the boundary condition in being, no structural change will emerge between the shoal and the groove as well as the main and branch channels, and the 300,000-DWT channel will keep stable. So it is anticipated that there will be no need for maintenance dredging.

(2) Chemical and oil leakage

During channel construction and navigation operation, oil and chemical leakage may occur in case of vessel collision. If no emergency measure is taken in a timely manner, major impacts will be caused on marine environment and ecology of Meizhou Bay and its surroundings.

3.2.2 Environmental Impacts Screening

Based on alternative analysis and engineering analysis, key environmental issues are identified.

3.2.2.1 Impacts during Construction Period

Key impacts during the construction period include:

- Impacts on ecological resources and habitats due to dredging, rock blasting, disposal of dredged materials at backfill areas and the dumping site;
- Impacts on aqua-farming due to dredging, blasting and backfilling;
- Impacts on water quality and sedimentation environment due to increasing of suspended solids; and
- Impacts on water quality due to improper discharge of ship wastewater, garbage and construction wastewater.

3.2.2.2 Impacts during Operation Period

Key impacts during the operation stage include:

- Impacts on water quality and marine ecology due to potential maintenance dredging
- Impacts on marine hydrodynamics and erosion/siltation due to the change of sea bed topography caused by dredging and rock blasting.
- Oil/chemicals spill risks due to ship accidents inside the Bay

3.2.2.3 Environmental Screening Matrix

Table 3.2.3 summarizes the interactions of project activities and receptors.

Table 3.2.3 Environmental Screening Matrix

Period	Process	Natural environment					Social economy		
		Sediment environment	Marine ecology/habitats	Seawater quality	Navigation safety and environmental risks	Meizhou Bay ecology conservation area(perimeter of Meizhou Island)	Marine aquaculture	Marine transportation	Port-based economy
Construction period	Channel dredging and rock blasting	√	√	√	√		√	√	
	Transportation of dredged materials			√	√				
	Dumping and filling (inner bay)	√	√	√					
	Stockyard forming at the backfill area								
	Dumping and filling (outer bay)	√	√	√					
	Waste water and garbage from construction			√					
Operation period	Maintenance dredging				√				√
	Oil and chemical leakage		√	√	√		√		

Chapter 4: Regional Environmental and Social Baselines

4.1 Physical Environment

4.1.1 Location

Meizhou Bay is located in southeast China in Fujian Province. Fujian Province has a total sea area of 13.6 million ha, and a land coastline of 3,752 km. The province has in total 125 bays, 7 of which are suitable for development of 50,000t plus deep water berth. The geographical location of the province Meizhou Bay navigation channel is illustrated in Fig. 4.1-1.

Fig. 4.1-1 Geographical Location of Meizhou Bay Navigation Channel

Meizhou Bay is located between Putian City in the north and Quanzhou City in the south, and is under the jurisdiction of the two cities. The total land coastline of the two cities is about 812 km, with 8 major bays, including Xinghua Bay, Pinghai Bay, Meizhou Bay, Quanzhou Bay, Jingshan Bey, Shenhu Bay and Weitou Bay, extending from north to south. Meizhou Bay neighbors Pinghai bay and Quanzhou Bay.

The north bank to the Meizhou Bay is under the jurisdiction of Xiuyu District, Chengxiang District and Xianyou County of Putian City while the south bank is under the jurisdiction of Quangang District and Hui’an County of Quanzhou City. Surrounded by land on three sides of the bay, Meizhou Bay has Meizhou Island which provides a natural defense for the bay mouth. It is one of the great natural harbors on the coast of Fujian.

The geographic coordinate is between east longitude 118°51′~119°09′ and north latitude 24°58′~25°18′. The waterway adjoins Fuzou Mawei 132n.mile, Shanghai 510n.mile, Qingdao 885n.mile and Qinhuangdao 1169n.mile on the north, Xiamen 96 n.mile, Shantou 226 n.mile and Hongkong 397n.mile one the south, Keelong 178n.mile and Kaohsiung 194n.mile on the east. The geographic location of Meizhou Bay is illustrated in Fig. 4.1-2.

Fig. 4.1-2 Geographical Location of Meizhou Bay Navigation Channel

4.1.2 Meteorological Characteristics

The project area belongs to south subtropical zone, and is warm and wet all the year around because of the influence of ocean climate. According to the 1997-2006 meteorological statistics of Chongwu meteorological station of Hui'an County, 1985-2001 statistics of Xiuyu meteorological observation station of Meizhou Bay, and July 1998—June 1999 statistics of Douwei temporary wind measurement station, the meteorological characteristics are summarized in below.

4.1.2.1 Air Temperature

Average air temperature of the sea area is between 20.3℃~20.6℃ in years, and its extreme maximum and minimum air temperature is between 36.5℃~36.7℃ and -0.3 ℃~1.3℃ respectively. Average air temperature inside the Meizhou Bay is slightly higher than at its bay mouth. And the characteristic value of air temperature supplied by each station is detailed in

Table 4.1.1.

Table 4.1.1 Characteristic Value of Air Temperature

Item	Chongwu meteorological station		Xiuyu observation station	
	Statistic value	Date	Statistic value	Date
Average air temperature(℃)in years	20.6	1971-2006	20.3	1985-2001
Extreme maximum air temperature (℃)	36.7	August 5, 2005	36.5	
Extreme minimum air temperature (℃)	-0.3	January 31, 1997	1.3	
Highest monthly average temperature (℃)	30.2	August	28.2	July
Lowest monthly average temperature (℃)	10.7	January	11.9	February

4.1.2.2 Precipitation

This sea area has an average annual precipitation of 1,216.4mm~1,300.8mm and maximum precipitation of 1,706.7mm ~1,744.4mm. At an average of 946.6mm, rainfalls in spring and autumn (March-August) account for over 72% of the whole year. And most rainfalls are observed in May and June with average monthly precipitation of over 200.0mm. The rainfalls of the two months occupy 31.5% of the whole year. The period from October to next January is dry season, with precipitation only occupying 7%~10% of the average precipitation of the whole year. Outside the bay, the precipitation is less but more intensive than inside the bay. Characteristic value of precipitation supplied by each station is detailed in Table 4.1.2.

Table 4.1.2 Characteristic Value of Precipitation

Item	Chongwu meteorological station		Xiuyu observation station	
	Statistic value	Date	Statistic value	Date
Average precipitation (mm)	1216.4	1971-2006	1300.8	1985-2001
Annual maximum precipitation (mm)	1706.7	1999	1744.4	
Monthly maximum precipitation (mm)	489.5	1965.6	579.4	
Diurnal maximum precipitation (mm)	311.5	1999.9.10	289.6	
Average in years ≥Days of precipitation of 25mm level	13.8d	1971-2006		

4.1.2.3 Wind Conditions

(1) Wind

North wind prevails in winter while south wind prevails in summer in the area. Both constant wind and strong wind blow in the direction of NNE—NE all the year around. The wind speed is higher at the bay mouth than within the bay, with average wind speed ranging 5.6m/s~6.6m/s in years. Constant wind at frequency of 28% observed by Chongwu station is in the direction of NNE all the year around. Maximum speed of 24m/s and average speed of 6.6m/s were observed for strong wind in the direction of NNE. Constant wind at frequency of 27% observed by Xiuyu station is in the direction of NE all the year around; sub-constant wind at frequency of 13% and 14% in direction of NNE and ENE were observed respectively. Maximum speed of 27m/s and average speed of 9.3m/s were observed for strong wind in the direction of NE.

According to the analysis of short-term wind speed data of Douwei station, both constant wind and strong wind are in the direction of NE with frequency of 35% and maximum wind speed of 19.7m/s all the year around; southwest wind prevails in summer (June~August) at frequency of 16%~33% in summer while NE or NNE wind at frequency of 24%~63% prevails in the three seasons of spring, autumn and winter.

According to data statistics on wind of 8th scale or above, Xiuyu station has 21 days inside the bay, Shanyao station 37 days, Goutouwei station 47 days in vicinity of the bay mouth and Chongwu station 102.9 days outside the bay.

(2) Typhoon

As local major disastrous weather, typhoon is seen during July-September, or typhoon season. According to statistics, typhoon lands on the coast of Fujian twice each year. And there is an average of one typhoon or tropical storm that lands on the coast from Minjiang river mouth to Xiamen and constitutes threats to local sea area. Strong wind will occur on sea areas during typhoon, e.g., Chongwu station actually measured typhoon with maximum wind speed of 28m/s in southward direction. Typhoon may cause particularly huge precipitation and surge wave, e.g., Chongwu station may have maximum surge wave of 1.33m, which is destructive to some extent. During typhoon, all the three stations of Chongwu, Xiuyu and Houyu observe daily average tidal level higher than monthly average tidal level. Impacted by typhoon, the abnormal tidal level of Meizhou Bay does not depend on the change of local wind and air pressure, but is mainly subject to the impact of abnormal flow field throughout Taiwan Strait.

During typhoon period, ships must wait berth at haven shelter anchorage grounds.

4.1.2.4 Fog

The bay is often foggy in March-May in the spring season but little fog in other three seasons (June-November), almost never foggy in July-October and there is lighter fog inside than outside the bay. Chongwu station observed an average of 27 foggy days in years, maximum foggy days amounted to 43 days and minimum ones totaled 13 days.

4.1.2.5 Thunderstorm

Chongwu meteorological station observed an average thunderstorm days of 30 in years, with maximum of 40 days and minimum of 16 days. And there are more thunderstorm days outside than inside the bay.

4.1.3 Regional Hydrology

4.1.3.1 Overview

Surrounded by land on three sides of the bay, with bay mouth facing southeast and Taiwan Island across the strait, Meizhou Bay is a semi-closed bay with strong tides. The coastline of the Bay is indented and mainly bed rocks, with some parts being silt and sand. Its coastline is 186.57km long and covers a maximum area of 516km^2 at high tide level. Intertidal area is 142km^2. The area below mean low tide level is about 374km^2. The average tide accommodation (the volume of water between mean high tide and mean low tide, or the volume of water leaving the bay at ebb tide) is 2.423 billion m^3.

As a tectogenetic bay, Meizhou Bay has a number of bay mouths, of which four big mouths are Wenjia mouth, Caiyu, Dazhu and Houyu, from northeast to southwest. The total breadth of the bay mouths are about 10km.

4.1.3.2 Surrounding Rivers

Meizhou Bay features clear water and little sand. There are no major rivers joining the Bay. A Fengci Creek joins the bay in its northwest corner (see Fig. 4.1-3). Fengci Creek originates in Nankengling, Lingbei Village of Yuanzhuang Town and goes through Yuanzhuang and Fengting to reach the sea. The creek is 30.8 km long with a basin of 136.2km2. The slope is 5.2%, gross head is 260m and the annual average runoff reaches 101 million m3. According to the field survey data of the hydrological test of January 1997 and the previous hydrological sediment measurements, the mean sediment concentration of the water body in the bay is 0.016-0.059kg/m3, the maximum sediment concentration 0.129kg/m3. Therefore, it is considered that Meizhou Bay is basically a clear water bay.

Fig. 4.1-3 River basins surrounding at Meizhou Bay

4.1.4 Seismicity

According to China Ground Motion Parameter Zoning Map (GB18306-2001), the basic earthquake intensity of this region is 7 degree and the designated basic seismic acceleration is 0.15g.

4.1.5 Days of the Channel Open to Navigation

Based on the statistics of the measured wind data from the weather station (mountainside station) in Meizhou Bay, the mean annual days with the annual wind speed larger than 8 grades are 37 days. The strong wind days mostly take place in typhoon season and winter. Based on statistics, the mean annual fog days are 29.6 days. Fog season is during January to May. Non-fog season is during July to October. Most of the fog days are during March to May. According to ship types for which the channel is open to navigation, the annual navigation operation days are about 293 days.

4.1.6 Marine Environmental Management and Sensitive Areas

The development of Meizhou Bay channels and ports must comply with marine environmental management related zoning and plans of Fujian province.

4.1.6.1 Marine Environmental Management

Key zoning and plans include Fujian Province Ocean Function Zoning, The Fujian Provincial Marine Environmental Protection Plan (2011-2020), Fujian Province Offshore Sea Territory Environmental Function Zoning, and Fujian Province Ecological Function Zoning.

- Marine Environmental and Functional Zoning

These zoning and plans present current marine status and issues, stipulate protection objectives, marine functions, development limits and sensitive areas. Therefore, extensive studies were conducted during project development and environmental assessment to ensure project compatibility with the zoning and plans.

Fujian Province Ocean Function Zoning stipulates that the sea area in Meizhou Bay includes Channel Zone, Port Zone, Mudflat Aquaculture Zone, Shallow Sea Aquaculture Zone, Tourism Zone, and Marine Bed Pipeline Zone. The sea area around Meizhou Island (which is located near the bay mouth) is designated Marine Ecological Special Protection Zone. (see Figure 4.1-4)

Fujian Province Offshore Sea Area Environmental Function Zoning stipulates environmental functions of sea areas. According to this Zoning, waters within the Meizhou Bay mainly serve navigation, port, ordinary industrial water, and receiving discharges purposes. (see Figure 4.1-5)

The Fujian Province Ecological Function Zoning stipulates ecological functions of waters in the Meizhou Bay. According to the Zoning, the main ecological services of the Meizhou Bay are deep water port and navigation, and aquaculture. It also indicates that the “important marine biotope” in the Meizhou Bay is “insensitive”. (see Figure 4.1-6)

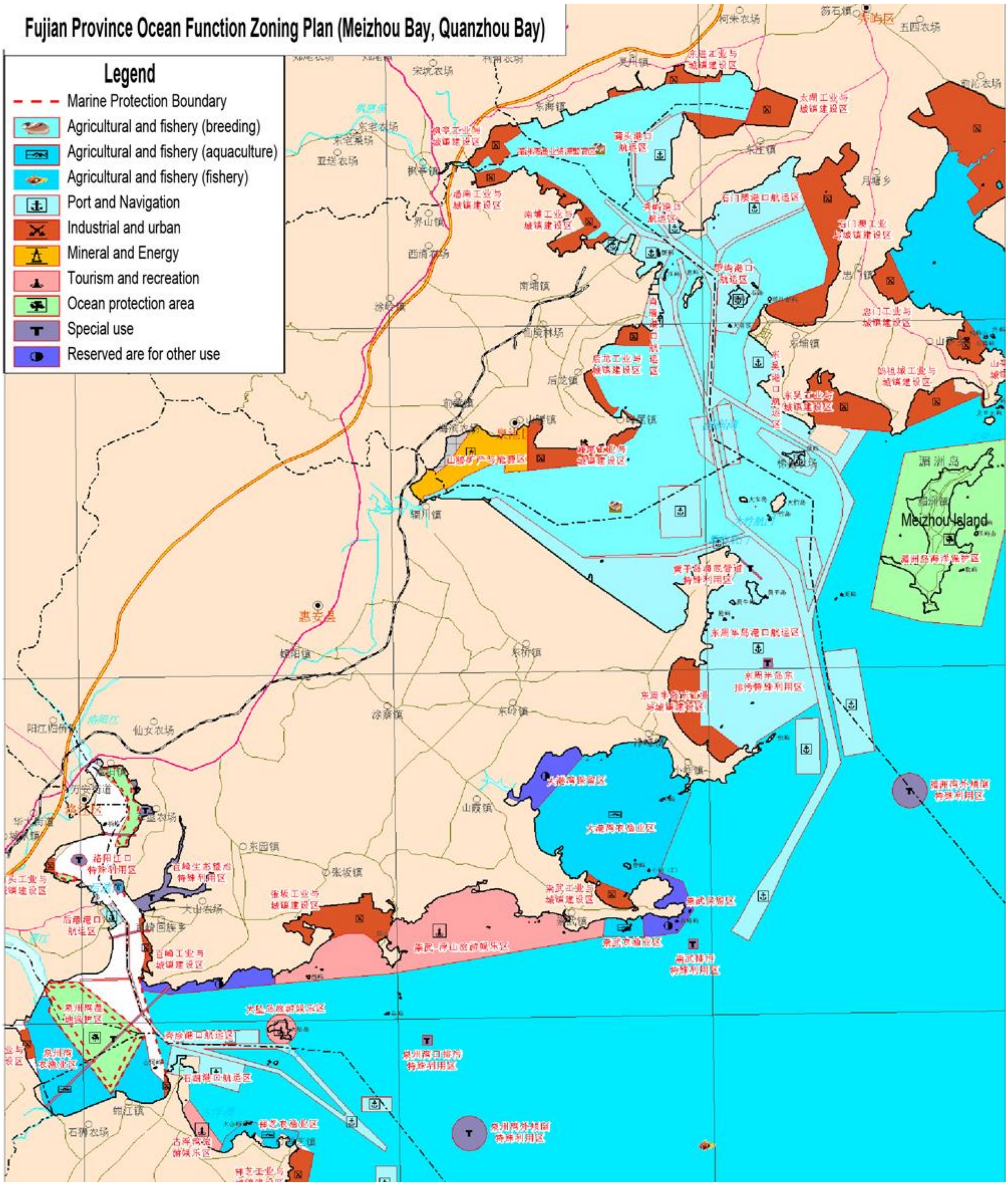


Fig. 4.1-4 Ocean Functional Zones in Fujian Province (Meizhou Bay, Quanzhou Bay)

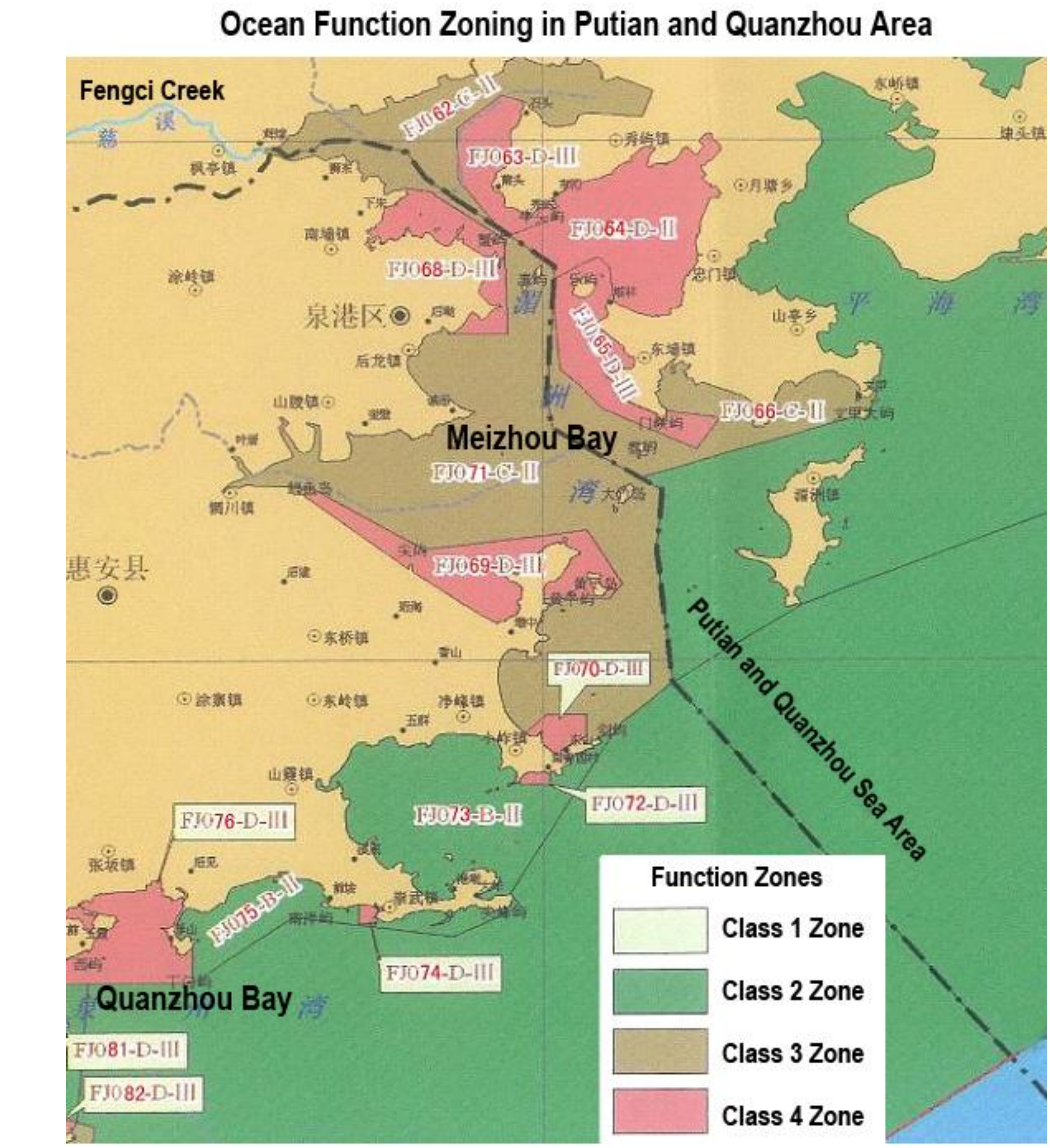


Fig. 4.1-5 Offshore Area Environmental Functional Zones in Fujian Province (revised in 2011)

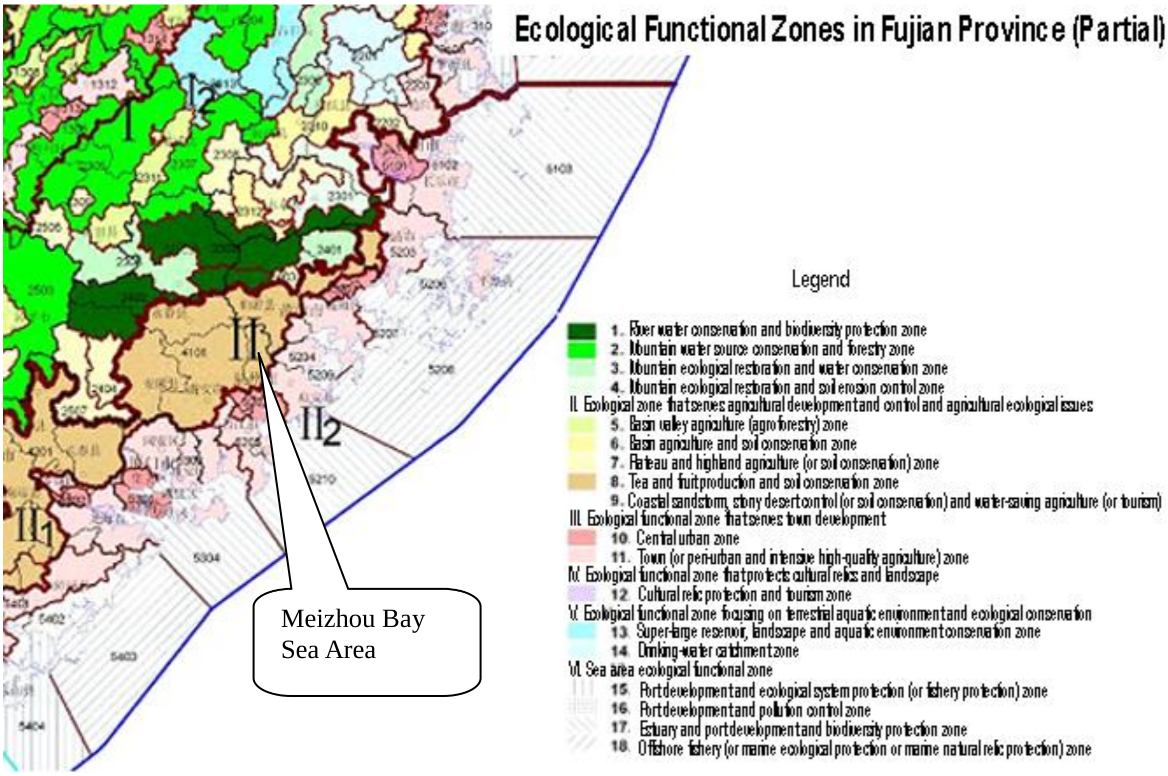


Fig. 4.1-6 Ecological Functional Zones in Fujian Province (Partial)

Fujian Province Marine Environmental Protection Plan

The Fujian Province Marine Environmental Protection Plan (2011-2020), issued by the provincial government in June 2011, is of particular importance. The Plan (2011-2020) classifies the province's marine waters into 3 general levels based on an assessment of marine ecological sensitivity and significance of marine ecological services. The first level includes legally designated protected areas and "important biotope and ecological service area". Protected habitats, fauna and flora include estuary coastal wetland, significant mangroves, coral, white dolphin, lancelet, egret, etc. The Planning also designates 27 sea island special nature reserves. These nature reserves are legally designated protected areas. The second level refers to marine areas that are under "controlled protection and utilization". This level requires reasonable development and utilization on a principle that the main ecological services function will not be harmed. The third level "development supervision area" includes those marine areas that can be used for urban, industrial and port development, and ocean disposal. In this area, development and construction are intensive or frequent. Close supervision shall be given priority to avoid significant ecological damage or environmental pollution. Table 4.1-3shows the 3 levels of marine environmental classification in Fujian Province, and their definition and characteristics.

Table 4.1-3 Marine Environmental Classification in Fujian Province

Key Protected Area	
Marine protected area and other legally designated protected area	A nature reserve's core zone, buffer zone and closely related adjacent sea areas 15 such protected areas totaling 61,000 ha.
Important biotope and ecological service area	Typical original ecological system, habitats for rare species, important wetland, migratory channel, spawning/breeding/feeding ground, protection area for important fishery species/resources, reproduction area and important island. 26 such areas totaling 95,000 ha.
Area under Controlled Protection and Utilization	

Fishery	Areas for fishing, aquaculture, reproduction, salt pan etc. that are related to food safety 34 such areas totaling 3.135 million ha.
Tourism	Marine park, costal tourism area and scenic area 20 such areas totaling 80,000 ha
Ecological Corridor	Refers to the corridor that transport fresh sea water and tide between inner and outer bay 11 such areas totaling 168,000 ha.
Development Supervision Area	
Urban, Industry and Port Supervision Area	Areas for development of urban, industry, port and receiving discharges 61 such areas totaling 114,000 ha.
Marine Waste Dumping Supervision Area	Existing or planned marine waste dumping sites 15 such areas totaling 4000 ha.

Figure 4.1-7 shows the planned marine environmental protection classification for the sea areas of the Putian and Quanzhou City.

Along the 812 km coastline of Putian and Quanzhou City, Meizhou Bay is located in the middle, neighboring Pinghai bay and Quanzhou Bay. In the vicinity of Meizhou Bay, there are two protected marine areas: Meizhou Island Marine Ecological Special Reserve and Quanzhou Bay Estuary Wetland Nature Reserve. According to the plan, the waters within Bay are designated either "urban, industry or port supervision area", or "ecological corridor" which serves the function of a passage for fresh sea water and tide between inner and outer bay. It means that Meizhou Bay is allowed for "reasonable development" or "intensive development" in certain areas within the bay. The environmental function designation of Meizhou Bay is consistent with the facts that the bay presents low to middle sensitivity from ecological perspective, and relative large carrying capacity primarily due to excellent hydrodynamics conditions. A detailed ecological and hydrodynamics baseline assessment of the Meizhou Bay is presented in Chapter 5 of this report.

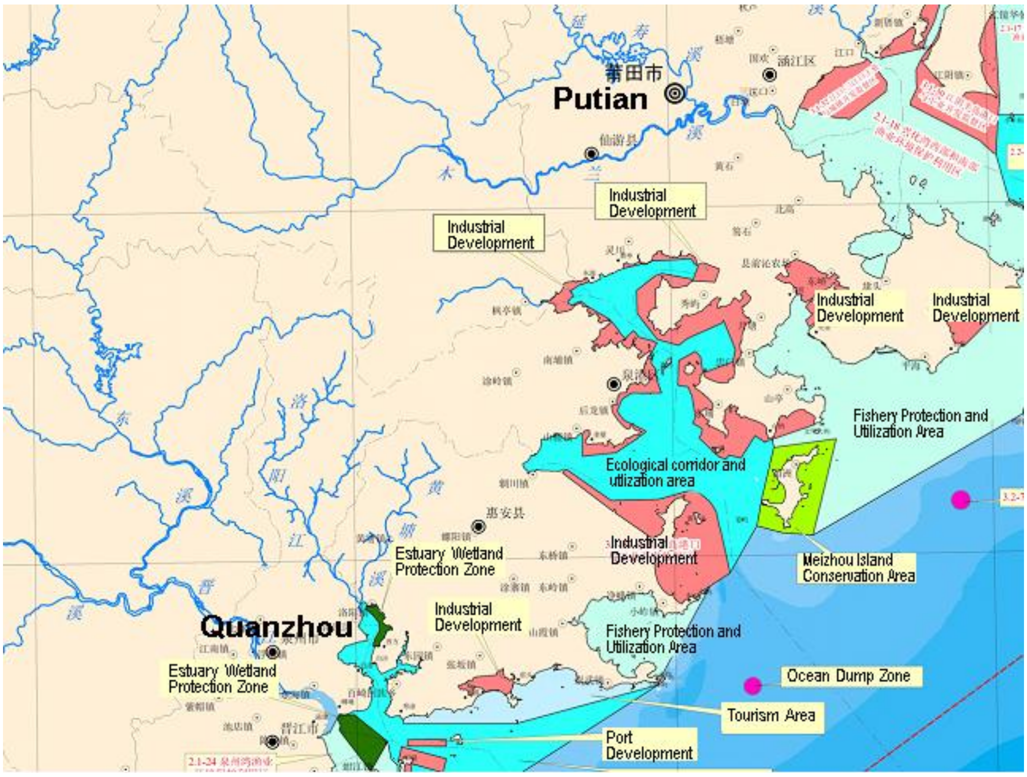


Figure 4.1-7 Fujian Marine Area Environmental Protection Classification

4.1.6.2 Sensitive Areas

- Meizhou Island Marine Ecological Special Reserve

The Meizhou Island is about 42 km away from Putian City and is located to the southeast of Meizhou Bay. The Meizhou Bay Island Marine Ecological Special Reserve (at city level) was officially established in 2005, which has an area of 9,990ha, including the island (15 km2) and adjacent sea area. On the island there are 13 pieces of sand beaches totaling 20 km, and 5km long marine-abrasion rocks. A piece of mangroves is found in the west of the island. According to a field survey made in June 2012, the mangroves have grown for 15 years and are about 20 ha only. Probably due to thin sediments, limited interaction between fresh water and saline, the mangroves has not grown very well (see Figure 4.1-8).


Figure 4.1-8 Mangroves in Meizhou Island

The Meizho Island is also a major tourist attraction because the island is the home to

Mazu (Matsu). Annually some 100,000 pilgrims, mostly from Taiwan, come to the island to visit Heavenly Empress Place – Meizhou Ancestral Temple which commemorates Mazu.

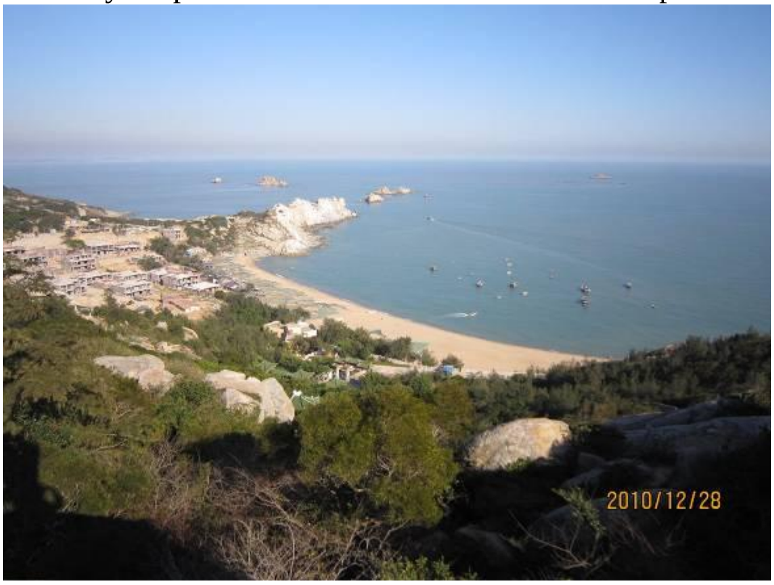


Figure 4.1-9 Meizhou Island Beach

According to a Meizhou Island protection and utilization plan, the island and adjacent sea area are divided into six sub-zones, as described in below and figure. (See Figure 4.1-10)

- Mazu Cultural Protection Zone which centers the Mazu temple and covers surrounding island rocks. The zone is under strict protection.
- Island Vacation and Tourism Zone, which cover the eastern part of the island mainly.
- Sea Entertainment Zone, which is the sea area and a variety of small islands in the east of Meizhou Island.
- Mangroves Ecological Park Zone which is located in the west of the island called Xiting'ao Beach where sediment inter-tidal zone are found.
- Sea Aquaculture zone, which is the sea area in the southwest of Meizhou Island.
- Transport Facility Area, which refers to the northwest sea area where ship channel and port are located.

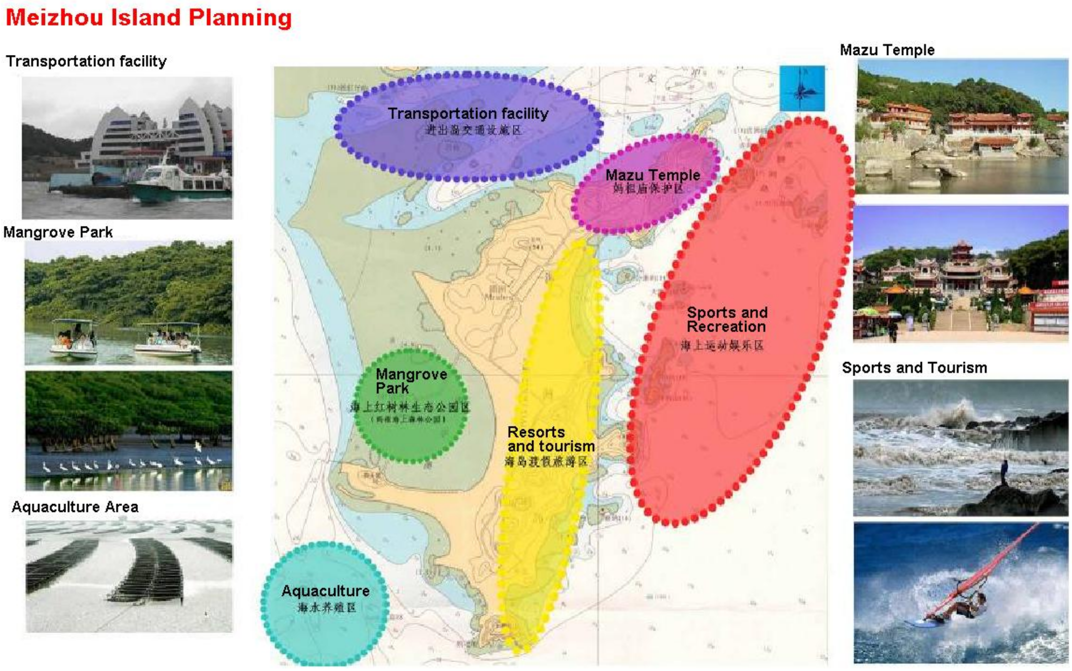


Figure 4.1-10 Meizhou Island Functional Zoning

- Quanzhou Bay Estuary Wetland Nature Reserve

The reserve is located in the estuary of Jin River and Luoyang River which flow into Quanzhou Bay. (See Figure 4.1-11). It is about 30 km south of Meizhou Bay. Estuaries form a transition between river environments and ocean environments and are subject to both marine influences, such as tides, waves, and the influx of saline water; and riverine influences, such as flows of fresh water and sediment. The inflow of both seawater and freshwater provide high levels of nutrients in both the water column and sediment, making estuaries very productive.

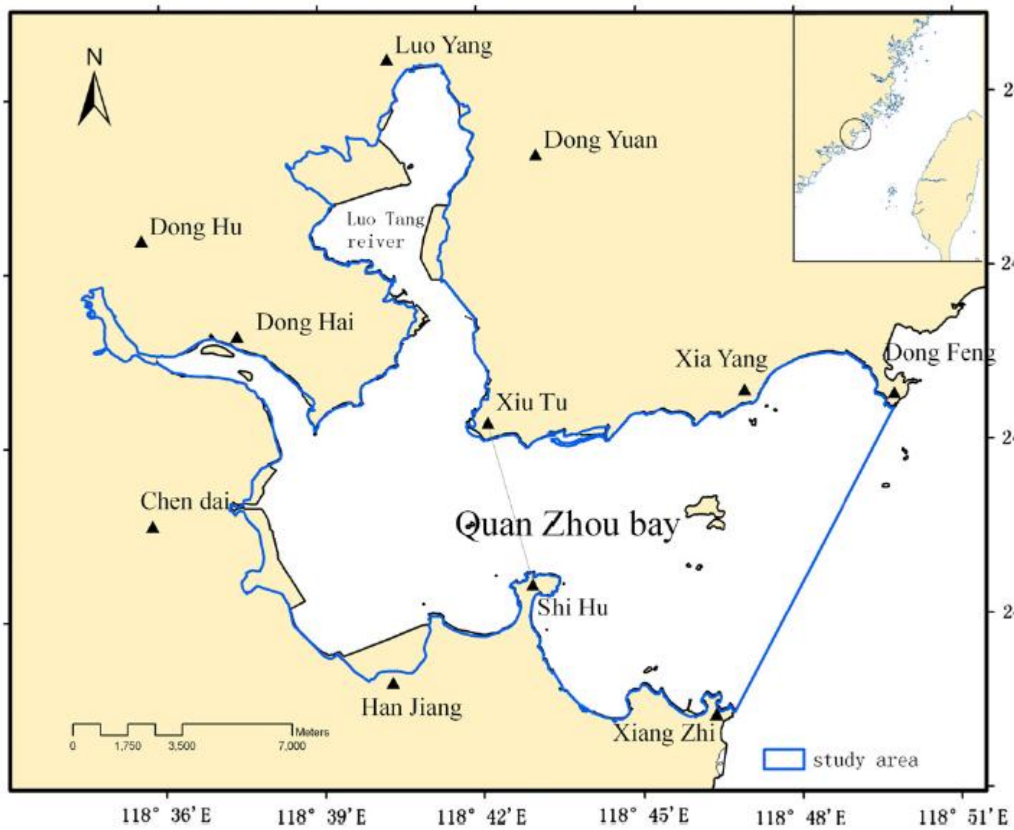


Figure 4.1-11 Quanzhou Bay

The Nature Reserve has been listed as Asian Important Wetland, China Priority Area for Protection and China Important Wetland. It is listed as IUCN Category V area. Primary protected ecosystem includes coastal wetland and mangroves. Quanzhou Bay has a total area of 136.42 km2. It is rich in biodiversity and presents characteristics of typical subtropical estuary biotope, with1000 species reported, including white dolphin and Chinese sturgeon (Acepenser sinensis) at national grade I protection; 24 national grade II protected species such as lancelet and egret; and some 200 other birds.

The Quanazhou Bay Nature Reserve (Figure 4.1-13) has a total area of 7000ha and divided into three 3 zones, i.e core zone (1278ha), buffer zone (800 ha) and experimental zone (4970 ha). The core zone and buffer are under strict protection. According to the ecosystem characteristics, in the nature reserve there are several subzones with different focuses of protection.

- Luoyang Mangroves Zone. It has a core zone of 224 ha; buffer zone of 110 ha. Aegiceras corniculatum and Aricennia marina (Figure 4.1-12) are two main mangroves in the area. Quanzhou Bay is the northern boundary of the two types of mangroves in China and western pacific coastal area. Mangroves wetland features rich and unique biodiversity.
- Taohuashan Coastal Bird Zone. It has a core zone is about 111 ha, buffer zone of about 89 ha. Primary protected birds are 5 types of egrets. 213 inventoried bird species, including 38 at national level protection, 87 of Sino-Japan and Sino-Australia bilateral protection protocol and 90 water bird species.
- Xunpu Qiangcheng Estuary Landscape Zone (Jin River Wetland Ecological Zone) has a zone of 923 ha and buffer zone of 600 ha. The zone primarily protects subtropical estuary wetland ecosystem, including unique Qiangcheng natural bed rock coast, estuary sand island, Xiutu and Dazhui Island landscape. Primary protected fauna is white dolphin and biodiversity at low-tide to subtidal area up to 6 meter deep, notably clam and mussel, etc.

Aegiceras corniculatum   Aricennia marina

Figure 4.1-12 Mangroves Species Living in Quanzhou Bay

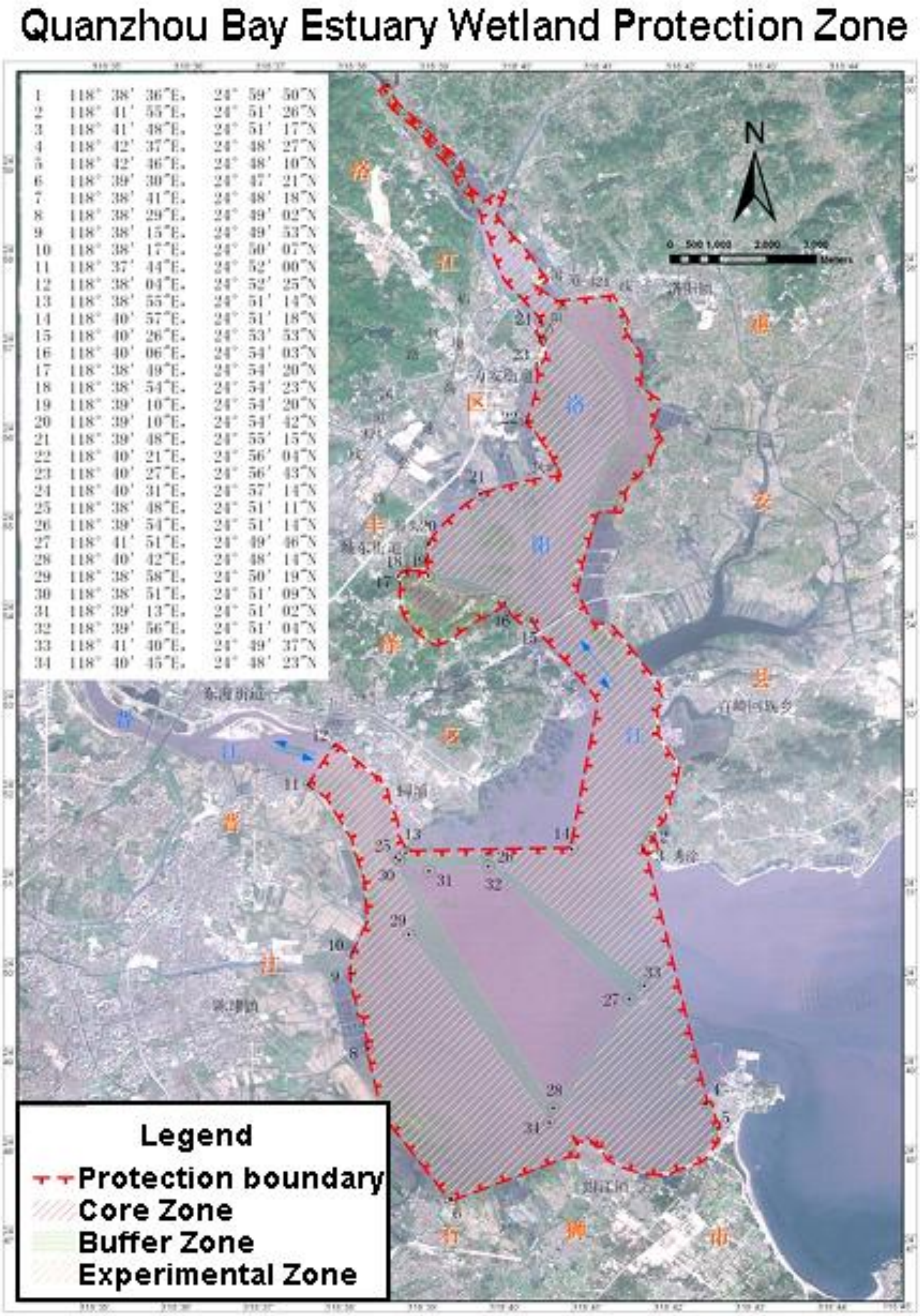


Figure 4.1-13 Quanzhou Bay Estuary Wetland Nature Reserve

According to a study conducted by the Third Institute of Oceanography (Zhao et al; Study on coastal wetland habitat quality evaluation in Quanzhou Bay, Fujian, China), the habitat quality in Quanzhou Bay presents a degrading trend. The region surrounding Quanzhou Bay is one of the fastest economically developed area in Fujian Province. Due to rapid urbanization and industrialization, coastal wetland habitat in Quanzhoou Bay has been degraded gradually. Key issues include 1) nutrients pollution in sea water: concentration of inorganic nitrogen and phosphase exceed th range of grade IV of national sea water quality standard; 2) wetland decreased greatly due to extensive reclamation in inner bay; 3) invasive species, Spartina alterniflora, covers about 237 ha in 2007, which seriously affects the substrate habitat quality for benthos, competes for ecological niche with native plants, and also has negative impact on wading birds' predation and survival.

The five major factors that led decline of habitat quality were phosphate in sea water, lead in sediment, landscape naturalness index and coastline artificialization index and area ratio of invasive alien species. Therefore, in order to improve and maintain habitat quality, it is urgent to control pollution, large-scale reclamation and Spartina invasion (see Figure 4.1-14) in Quanzhou Bay.

Figure 4.1-14 Invasive Spartina in Quanzhou Bay

4.1.7 Existing Environmental Issues

The Fujian Marine Environmental Protection Plan identifies the main challenges the province's marine environment are population increase, urbanization along the coastal areas, and port based industry development. Key issues envisaged are:

- Pollution discharge from domestic, agricultural non-point source and industries. Marine waste dumping, ship and aquaculture discharge.
- Marine ecosystem damage at certain areas due to ecological flow reduction, illegal sea san mining and unreasonable land reclamation, and invasive species.
- Natural disaster such as typhoon and red tides
- Risks of oil and chemical spills increase
- Weak marine environmental supervision capacity.

In facing the challenges and issues, the province aims to strengthen land and marine pollution control and coastal, bay an estuary environmental rehabilitation. Key measures identified include maintaining and establishing marine nature reserves, ecological rehabilitation, enhancing coastal and island ecological protection.

4.2 Socio-Economic Conditions

4.2.1 Administration and Demographics

Meizhou Bay is under the jurisdiction of two municipalities, i.e. Putian City in the north and Quanzou City in the south. Putian has a total land area of 4,199 km2, and a population of approximately 3 million (2010). Quanzhou has a total land area of 11,015 km2, and a population of 8 million (2010).

The north part of Meizhou Bay belongs to Xiuyu District and Xianyou County of Putian City. According to Quanzhou Statistical Yearbook 2010，there are four districts, three county-level cities and four counties under the jurisdiction of Quanzhou City with a total population of 7.86 million. The south bank of Meizhou Bay involves a population of 380,600 from the entire Quangang district (including Shanyao Street, Nanpu Town, Jieshan Town, Houlong Town, Fengwei Town, Qianhuang Town and Tuling Town) and a population of 577,400 from nine towns of Hui’an County (Luocheng Town, Luoyang Town, Zishan Town, Wangchuan Town, Tuzai Town, Dongqiao Town, Dongling Town, Jingfeng Town and Xiaozuo Town).

The south part of Meizhou Bay belongs to the Quangang District and Hui’an County of Quanzhou City. According to Putian Statistical Yearbook 2010，there are Licheng District, Chengxiang District, Hanjiang District, Meizhou Bay North Bank Development Zone of Xiuyu District, Meizhou Island and Xianyu County under the jurisdiction of Putian City with a total population of 3.196 million. The north bank of Meizhou Bay involves a population of 644,000 from Fengting Town of Xianyou County, Lingchuan Town and Donghai Town of Xiangcheng District, Hushi Town, Dongzhuang Tow and Yuetang Tow of Xiuyu District, Zhongmen Town, Dongpu Town and Shanting Town of North Bank Administration Committee of Meizhou Bay and the administrative areas of Meizhou Island Administration Committee.

4.2.2 Economic Conditions

4.2.2.1 Quanzhou Economic Conditions

Quanzhou is one of the three central cities in Fujian Province. Since 1999, its GDP has been ranked the first in the province for 12 years. It is an important economic center of the province. In 2010, Quanzhou’s GDP is RMB356 billion, increasing 12.8% from the previous year. The ratio of primary industry: secondary industry: tertiary industry is 3.7:60.2:36.1. The urban rural resident’s average disposal income is RMB 25,155, increasing 9.8% from 2009. Average disposal income of farmer is RMB9,296, increasing 8.6% from the year 2009. The total financial revenue reached RMB 40 billion, representing a year-on-year increase of RMB 8.413 billion or 26.6%.

Quangang District. Quangang District is under the jurisdiction of Quanzhou City, located on the south side of Meizhou Bay, and is a well-known origin of overseas Chinese and Taiwan compatriots. The district has a territory area of 441.4 km^2, including a land area of 321 km^2 and a sea area of 119.6 km^2 (in which the tidal flat area above the intertidal zone is 47.68 km^2). The district governs 6 towns, one sub-district office, one state salt farm, 96 administrative villages and 4 community committees. In 2010, the district’s population was 392,700, and GDP 19.185 billion yuan, up 18.85% from the previous year; the disposable income of urban residents was 16,362 yuan, up 8.8%, and the per capita net income of farmers 9570 yuan, up 8.68%. The district has an advantaged geographic location and a great port. The coastline suitable for the construction of deep-, medium- and shallow-water harbors is 21.4km long, and that suitable for the construction of 10,000 DWT or above berths is 9.8km long. This is a great group of deepwater berths of Fujian.

Nanpu Town. Nanpu town would be potentially affected by the project. Nanpu Town is located in the northeast of Quangang District and the south side of Meizhou Bay, and is a petrochemical port under construction, and a strong industrial and trading town. The town has a land area of over 40 km^2, and governs 15 administrative villages. At the end of 2010, the town's resident population was 100,000. The town's deepwater coastline is 11 kilometers, and the port is a state Tier-1 port, which has a 50,000 DWT multifunctional dock, a 10,000 DWT bulk dock and a Taiwan trading dock. There are a number of large- and medium-sized enterprises in the town, including the Fujian Refining-Chemical Integration Project, Fujian Grain & Oils Industry Co., Ltd. funded by ADM Inc. (a world top 500 corporation), and NARI Nanpu Power Plant. In 2010, the town's GDP was 7 billion yuan, and the per capita net income of farmers 7,587 yuan.

Hui'an County. Hui'an County is under the jurisdiction of Quanzhou City, located between Quanzhou and Meizhou Bays, and is a major origin of overseas Chinese and Taiwan compatriots. The county ranks 29th among the top 100 counties of China in terms of basic economic competitiveness, 51st among the top 100 medium and small towns of China in terms of overall strength, and 35th among the top 100 medium and small towns of China in terms of investment potential, and is one of the top 100 medium and small towns of China in driving regional economic development. The county's land area is 720 km^2 and sea area 1,833 km^2. The county governs 15 towns, one minority Xiang, 11 communities and 284 administrative villages. At the end of 2010, the county's resident population was 716,200. In 2010, the county's GDP was 39.926 billion yuan, up 12.9%; and the per capita net income of farmers 9,551 yuan, up 9.3%.

Jingfeng Town. Jingfeng town is potentially affected by the project. It is located in the east of Hui'an County, bordering Meizhou Bay on the north, the Taiwan Strait on the east and Dagang Bay on the south. The town has a land area of 51.7 km^2, and governs 21 administrative villages, with a population of 65,000. This town boasts an advantaged geographic location, and convenient sea, land and air traffic. The town has a coastline of 25 kilometers and a sea area of 170,000 mu, and abounds with fishery resources. It is a well-known strong construction town, and has a construction workforce of over 10,000. In 2010, the per capita net income of farmers was 6,980 yuan.

4.2.2.2 Putian Economic Conditions

In 2010, Putian's GDP is RMB81.7 billion, increasing 15.2% from the previous year. The ratio of primary industry: secondary industry: tertiary industry is 10.8:56.6:32.6. The urban rural resident's average disposal income is RMB 19,068. Average disposal income of farmer is RMB7,663. The financial revenue rose by 24% to reach RMB 7.829 billion, including RMB 4.763 billion of local financial revenue, which witnessed an increase of 25.7%. The total investment in fixed assets was RMB 49.652 billion, an increase of 9% over the previous year. Putian is well known as an important area for agricultural products, including rice, sugarcane, peanut, jute, tea, longan, litchi, loquat and seedless pomelo, and sea food.

Xiuyu District. Xiuyu District is under the jurisdiction of Putian City, surrounded by Xinghua, Pinghai and Meizhou Bays. The district has a land area of 390 km^2, a sea area of 4,514.75 km^2, 143 lands, a coastline of 471.19km, including a mainland coastline of 237 kilometers and an island coastline of 233.89 kilometers. The district governs 6 towns and one Xiang, and 147 villages/communities. At the end of 2010, the district's resident population was 479,000. The district abounds with fishery, salt, coastal tourism and marine mineral resources. In 2010, the district's GDP was 12.3 billion yuan, the ratio of primary, secondary and tertiary industries was 16.2: 56.9: 26.8, and the per capita net income of farmers 7,689.3 yuan.

Dongzhuan Town. Dongzhuang Town is potentially affected by the project. Dongzhuang Town is located in the west of Xiuyu District, Putian City, beside Meizhou Bay. The town governs one community committee and 23 administrative villages, and is run through by the

Puxiu Highway. The town has a territory area of 35 km^2, a cultivated area of 28,275.5 mu, including 13,558.5 mu of non-irrigated land and 4,617 mu of irrigated land, a per capita cultivated area of 0.35 mu, a reclamation area of 9,675.9 mu, a shelter forest area of 455 mu, a coastline of 25 kilometers and 17 reclamation areas (including 6 reclamation areas of over 1,000 mu). In 2010, the town's population was 80,112, and the per capita net income of farmers was 11,635 yuan.

Xianyou County. Xianyou County is situated in eastern coastal area of Fujian and upper and middle reaches of Mulan River, Xianyou lies between east longitude 118°27′～118°56' and north latitude 25°11'～25°43′. It neighbors Putian on the east, Yongchun and Dehua on the west, Hui'an, Nan'an and Licheng District on the south, Yongtai on the north and Meizhou Bay on the southeast, respectively. Xianyou County relies on Xiuyu Port and Xiaocuo Port. Stretching 49km east to west and 63km north to south with a coastal line of 5km, the county covers an area of 1815 km2 (equivalent to 2.722 million mu), including 355000 mu of arable land, 2.03 million of mountain and 1.78 mu of forest. In 2009, the county realized GDP of RMB 9.416 billion, increasing by 15.7%. The total industrial output value reached RMB 10.260 billion, representing an .increase of 30.6%. The total investment in fixed assets reached RMB 492 million, which witnessed a rise of 24.7%.

4.2.3 Meizhou Bay Regional Development Planning and Status

4.2. 3.1 Regional Development Planning of Meizhou Bay Rim

Planning location and area. Situated in central coastal area, Meizhou Bay is the junction of Fuzhou Economic Zone and Quanzhou-Xiamen Economic Zone. Meizhou Bay Rim is divided as south and north banks and belongs to Quanzhou and Putian respectively. The planned land area is about 1200Km^2.

Layout of key industries. Meizhou Bay Rim will focus on petrochemical industry, port heavy chemical industry, energy industry, pulping and paper making and equipment manufacturing industry. The layout of key industries in Meizhou Bay Rim is illustrated in Fig. 4.2-1.

Current Conditions of Regional Key Industries. Mainly engaged in "integration of oil refining and chemical industry", Meizhou Bay has attracted a batch of large port industrial projects, including Fujian Lianhe Petrochemical, Chlor-Alkali Industry, Fangxing Chemical, Dongxin Petrochemical, Quanzhou Dockyard, Nanpu Power Plant, Giti Tyre, Meizhou Bay Power Plant, LNG receiving terminal and gas power plant and Sateri Fiber. The port industrial pattern that strengthens petrochemical industry with the balanced development of energy, watercraft and wood processing has taken its initial shape. The layout of key projects is shown in Fig. 4.2-2.

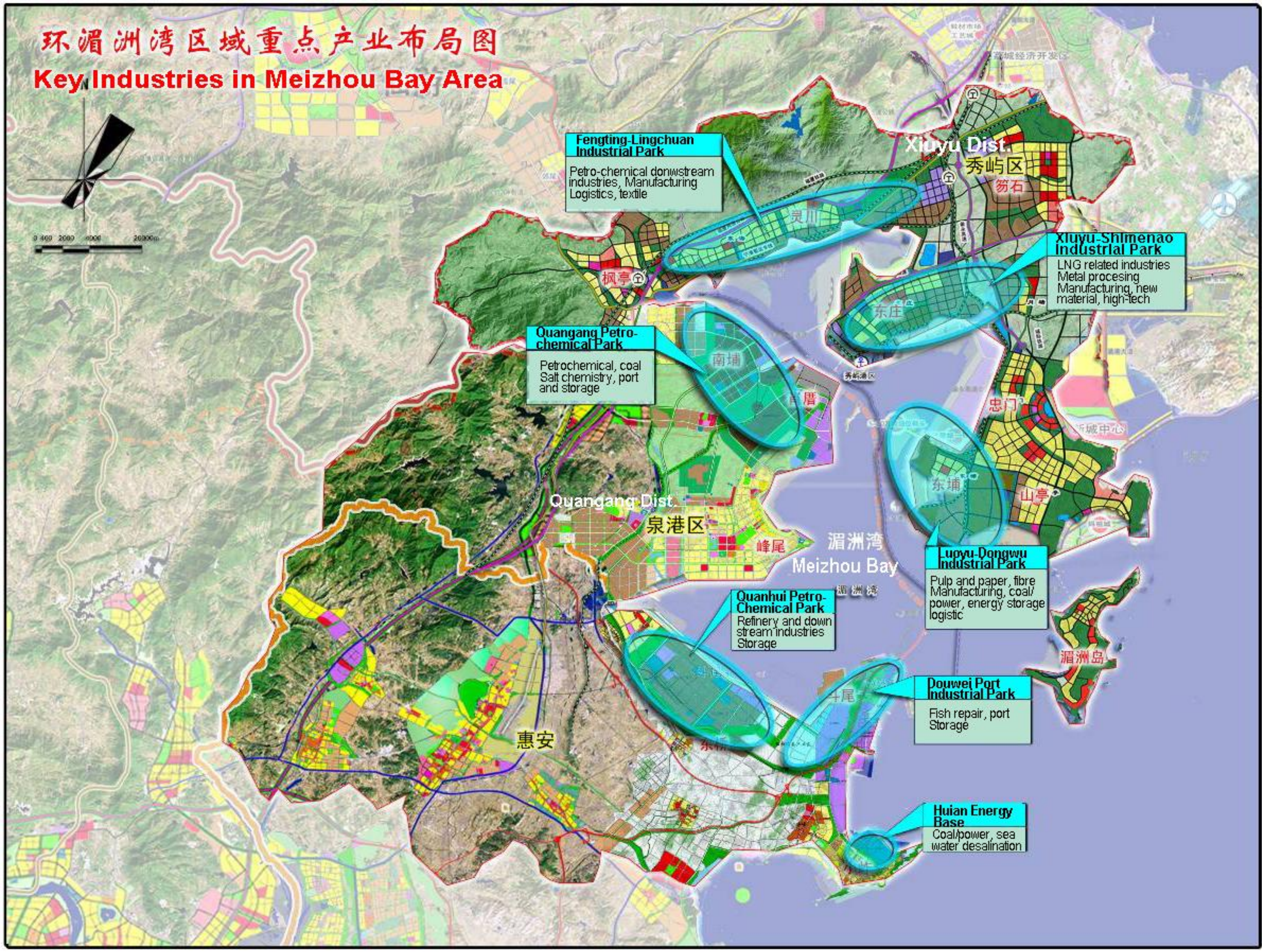


Fig. 4.2-1 Layout of key projects in Meizhou Bay Rim

Fig. 4.2-2 Projects Constructed and Under Construction in Meizhou Bay Rim

Xiuyu Port area

100,000-DWT LNG Ship and Storage Tanks

300,000-DWT Crude Oil Wharf of Fujian Oil Refinery

100,000-DWT Oil Wharf of Fujian Oil Refinery

Taishan Petrochemicals Wharf

Meizhou Bay Thermal Power Plant

4.2.3.1 Existing Road Network

Fuzhou-Xiamen Expressway, National Road 324 and Provincial Road 201 run through the area.

Zhangzhou-Quanzhou-Xiaocuo Railway runs through Quangang District, which starts from Zhangping, via Anxi, Nan'an, Quanzhou, Hui'an and Quangang, and stops at Xiacuo Station of Quangang District. The total length of the railway is 256.674km and the operating distance is 257.214km. Zhangzhou-Quanzhou-Xiaocuo Railway has completely joined up and connects with railway network by Yingtan-Xiamen Railway, which plays a positive role in industries and harbors development of Quangang. Xiangtang-Putian Railway and branch line of Meizhou Bay Port Railway are now being constructed and passengers and cargos transportation of Fuzhou-Xiamen Railway are available.

Please refer to Fig. 4.2-3 for regional road network.

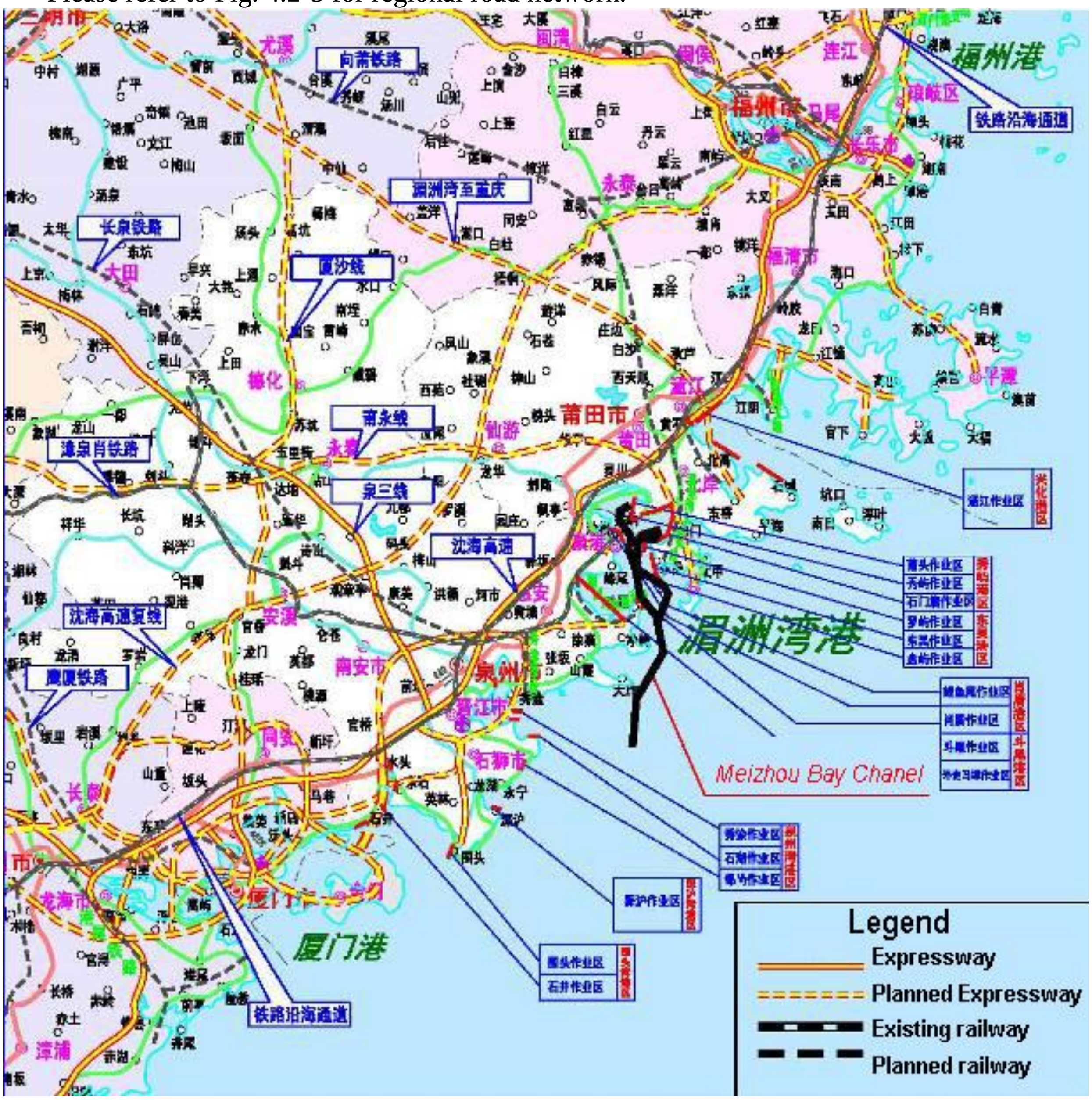


Fig. 4.2-3 Planning Drawing of Regional Road Network

4.2.4 Meizhou Bay Port Planning and Development Status

4.2.4.1 Mezhou Bay Port (South and North Bank) Planning

According to *Fujian Coastal Port Layout Planning*, ports under the jurisdiction of Putian and Quanzhou are universally called Meizhou Bay (South and North Bank) Port Area. This Meizhou Bay (South and North Bank) Port Area covers eight major bays of the two cities. The project specific Meizhou Bay is one of the eight bays.

According to this *Fujian Coastal Port Layout Planning*, Meizhou Bay (South and North Bank) Port Area is an integral part of "Two ***Container*** Ports and Two Bulk Cargo Ports" in Fujian, and will be built into a comprehensive port with functions of reserve, transit and transportation of bulk solid and liquid cargoes

According to *Port Control Detailed Planingn of Meizhou Bay (South and North Bank)* prepared by Fujian Provincial Transport Department and Fujian Provincial Development and Reform Commission, Meizhou Bay (South and North Banks) will set up eight port areas, i.e.,

Xinghua Port Area at Xinghua Bay,

Xiuyu Port Area, Dongwu Port Area, Xiaocuo Port Area, and Douwei Port Area in Meizhou Bay

Quanzhou Bay Port Area in Quanzhou Bay

Shenhu Bay Port Area in Shenhu Bay, and

Weitou Bay Port Area in Shenhu Bay.

Totally, there will be 21 operation areas and 197 berths that are beyond 10,000-DWT in the above-mentioned 8 port areas. Meizhou Bay is apparently the major area for port development.

4.2. 4.2 Meizhou Bay Port Development Status

Meizhou Bay now has four port areas, namely, Douwei Port Area, Dongwu Port Area, Xiuyu Port Area and Xiaocuo Port Area. With the development in recent years, a pattern with petrochemical, energy, wood, food processing and shipbuilding as the mainframe has been formed. Several large *deep*-water berths and a batch of medium and small berths have been built, including oil refining and chemical industry integration 300,000-DWT crude oil wharf, 100,000-DWT crude oil wharf of Fujian Oil Refinery, Xiaocuo 70,000-DWT wharf, Sanmei 10,000-DWT wharf and 50,000-DWT wharf, 50,000-DWT coal wharf of Nanpu Power Plant, Xiuyu 10,000-DWT general cargo *wharf*, *Xiuyu* 50,000-DWT multi-functional wharf, Xiuyu 40,000-DWT wood wharf, 100,000-DWT LNG exclusive wharf, etc. In addition, some large and medium berths are under construction, including 3#～6# berths (10,000-DWT～50,000-DWT liquid and bulk cargo berths) in Douwei Operating Area and 1#～3# berths (50,000-DWT multi-functional berths) in Dongwu Port area. Totally, 46 berths have been built in the four port areas. The wharfs length comes to 6813m with annual throughput *capacity of 68.30 million tons; There are another 21 berths under construction with wharfs length of 5308m and annual* throughput *capacity of 28.15 million tons.*

According to relevant documents, the cargo throughput of Meizhou Bay amounted to 33.1767 million tons in 2009 and 39.069 million tons in 2010. The port throughputs from 2004 to 2010 are illustrated in Fig. 4.2-4.

Fig. 4.2-4 Port Throughputs of Meizhou Bay from 2004 to 2010

4.2. 4.3 Conformity Analysis on Port Planning

Conformity Analysis on Port Planning. The layout of proposed navigation channels conforms with Planning Drawing of Navigation channels and Anchorages of Meizhou Bay (see Fig. 4.4-1). Therefore, Fujian Provincial Development and Reform Commission has *replied and approved the project establishment in Minfagai Transport No.* [2011]1443.

Conformity Analysis on Planning *Environment* Assessment. A Planning Environmental Assessment of Meizhou Bay Port Master Planning was being prepared during the preparation of the project EA. Currently it is being reviewed by provincial Environmental Protection Department. The draft Planning EA reviewed the project EA and does not provide objection. The analysis of the Planning EA was referenced in this project EA for cumulative impact assessment. And the main recommendations of the Planning EA are incorporated into this project EA as appropriate.

Chapter 5: Survey and Assessment of Existing Environmental Quality

This chapter describes the existing environmental quality of Meizhou Bay that are critical for the project implementation, including hydrodynamics, water and sediments quality and marine ecology. The data presented in this chapter were obtained through a dedicated marine study carried out during the project EA preparation. A variety of marine environmental studies at regional and local levels were referenced to complement the study and assessment.

5.1 Hydrodynamics, Erosion and Sedimentation Conditions

5.1.1 Overview

Meizhou Bay is a semi-closed, strong-tide bay surrounded by land on three sides of the bay with its bay mouth facing southeast. Its coastline is indented and mainly bed rocks, with some part being silt and sand. Its coastline is 186.57km long and covers a maximum area of 516km2 at high tide level. Intertidal zone is about 142km2. The area below the mean low tide level is about 374km2. The average tidal prism (the volume of water between mean high tide and mean low tide, or the volume of water leaving the bay at ebb tide) of 2.423 billion m3. Water depth reaches more than 10 meters in most part of the bay, with maximum water depth of 52m. Water depth gradually deepens from north, east and west sides of the bay to central channel, south side and bay mouth. The bay is well-hidden behind several layers of islands, including Panyu, Dazhu, Xiaozhu and Dasheng islands in vicinity of the bay mouth, and Huiyu and Luoyu islands inside the Bay. As a tectotic-formed bay, Meizhou Bay has a number of bay mouths. Its four big mouths scattered from Wenjia mouth in the northeast, Caiyu, Dazhu to Houyu in the southwest, extending a total breadth of 10km. Overall, the Bay features strong tide, deep water, well-hidden and good stability.

Meizhou Bay features clear water and little sand. There are no major rivers flowing into the Bay. A small river Fengci Creek flows in from the northwest corner. The Fenci Creek originates from Nankengling, Lingbei Village, Yuanzhuang Township and flows across Yuanzhuang and Fengting into the Bay sea. Fengci Creek extends 30.8km long, covers a catchment area of 136.2km2. The river a stream channel slope of 5.2‰ and a total drop of 260m. Average yearly runoff is about 101 million m3. According to statistics of sand concentration measurements over years, the mean sediment concentration of the water body within the bay is 0.016-0.059kg/m3, the max sediment concentration 0.129kg/m3. These figures verify that the Meizhou Bay is a clear water bay.

5.1.1.1 Tide

According to statistical analysis of tidal levels actually measured by the typical tidal stations inside and outside Meizhou Bay--Xiuyu station(118°58′59″E, 25°13′09″N), Liyuwei station(118°58′50″E, 25°10′25″N), Douwei station(119°00′35″E, 25°03′33″N), Chongwu station(118°56′E, 24°53′N) and the tidal levels actually measured simultaneously by Dongwu temporary tidal level station and Xiuyu during the three months of April-June, 1984, information on tides inside and outside the bay are detailed in Table 5.1.1.

Table 5.1.1 Characteristic value of tidal level

Station location / Tidal level	Chongwu	Douwei	Liyuwei	Xiuyu	Dongwu
Highest tide level	7.15	7.53	7.67	8.18	7.17
Lowest tide level	-0.03	0.13	0.02	0.04	0.35
Mean high tide	5.57	6.37	6.36	6.66	6.36
Mean low tide	1.37	1.45	1.48	1.55	1.64
Mean tide level	3.54	3.86	3.86	4.02	3.93
Extreme tide range	6.68	6.87	7.20	7.59	6.61
Minimum tide range	1.85	2.32	2.15	2.22	2.65
Mean tide range	4.38	4.60	4.87	5.11	4.72
Period of statistics	1978-1980	Sep. 17-Oct. 16, 1985	June 1985-May 1986	1978-1980	April 1-30, 1984

Unit: m Base level: Theoretically lowest local tidal level

Tides of the sea area is regular semidiurnal tides, however, there are unequal tides on tidal days, more distinct low tides than high tides. The maximum value of low-water inequality may reach over 1.0m while that of high-water inequality is 0.5m. On the basis of simultaneous observation, tidal hour is almost the same inside and outside the bay. Tides basically rise and fall at the same time, and time synchronization of high and low tides is observed. Tidal wave is of standing type. It rises and falls quickly and appears in vicinity of mean tide. And turn of tidal current appears in vicinity of high and low tides. In addition, there are following laws of tidal level and range in Meizhou Bay: From outside to inside the bay mouth, high tide level gradually rises while low tide level gradually falls; there is a wide tide range with mean range of over 4.65m and extreme tide range of over 7.0m, and the tide range gradually widens from outside to inside the bay mouth. Extreme tide range, minimum tide range and mean tide range increase 0.9m, 0.4m and about 0.7m respectively in vicinity of the bayhead as compared with outside the bay mouth. Such rules of tidal level and tide range at Meizhou Bay are determined by the characteristics of local tidal waves.

Figure 5.1-1shows the conversion relationship between tidal level and basal plane.

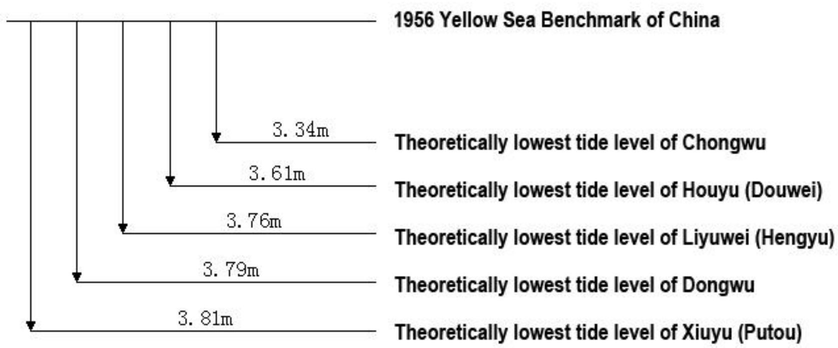


Figure 5.1-1 Conversion Relationship between tidal level and basal plane

5.1.1.2 Tidal current

(1) Huanggan island-Xiuyu sea area

Four simultaneous hydrological and sediment-related tests have been carried out on the main channel of this sea area in June 1984, August 1990, on January 25-26, 1997 (flood tide) and January 30-31, 1997(dead tide), and on March 20-21, 2003 (flood tide) and March 26-27, 2003 (dead tide) respectively. With many times of combined aggregate analysis of flow measurement data: Subject to landform control, reversing current is mostly seen in Meizhou Bay. Tide rises and falls at deep groove basically in the same direction in which the groove runs. The flow direction is slightly dispersed at shallow shoals and bay corners. The flow rate of flood tide is greater than that of dead tide, and surface flow rate is greater than bottom flow rate.

According to flow rate actually measured, peak flow rate of 1.78m/s was observed in vicinity of Linchi rock-Dasheng Island. And there is also high flow rate at the section of Huanggan island-Jianyu with maximum flow rate of 1.12m/s and 1.01m/s. Maximum flow rate is nearly 1.25m/s at Jianyu mouth. Flow rates of rising tide and falling tide may reach 2.4m/s and 1.75m/s respectively at the deep groove of Douwei-Dazhu, belonging to predominant current of rising tide. At the deep groove of Fengwei-Dongwu and Xiaocuo-Xiuyu, flow rate of falling tide is greater than that of rising tide, belonging to predominant current of rising tide. The peak flow rate is actually measured at 2.45m/s. And peak flow rate of 1.85m/s is actually measured at the cross section of Xiaocuo-Xiuyu.

(2) Xiuyu harbor area and Fengting'ao sea area

Relevant departments have conducted observation on ocean current and suspended sand at Xiuyu harbor area and Fengting'ao sea area for three times. In May-June 1994, observation on ocean current and suspended sand was carried out for 26 consecutive hours simultaneously with big, medium and low tides at four measurement stations(A1, A2, A3 & A4)at Xiaocuo-Xiuyu cross section and two measurement stations (B1 & B2) at south bifurcated waterway of Fengting'ao sea area. In March-April 2003, observation on ocean current and suspended sand was conducted for 28 consecutive hours simultaneously with big, medium and low tides at three measurement stations (C1, C2 & F) at the front side of planned LNG dock, ship convolution water area and near the channel. In March 2005, observation on ocean current and suspended sand was made for 26 consecutive hours simultaneously with big, medium and low tides at three measurement stations (M1, M2 & M3) at the sea area in vicinity of the two tidal inlets of east and west bifurcated waterways of Fengting'ao sea area.

Tidal current types are divided on the basis of forms of tidal current F1= (W01+WK1)/ WKM2: If F1 ≤0.5, it will be regular semidiurnal current and 0.5≤F1≤2.0; it will be irregular semidiurnal current. According to the fact that F1, which was calculated on the basis of harmonic constant and oval element of past tidal current actually measured, is always less than 0.5, rotation rate of partial tide M2 always has minus value at small magnitude, tidal currents are regular semidiurnal currents featuring typical reversing current and stable flow direction at both Xiuyu harbor area and Fengting'ao sea area.

5.1.1.3 Residual current

With characteristics of wind-induced current, the residual current of Meizhou Bay has a general tendency of appearing with outward surface layers and inward bottom layers. When southerly wind prevails in late spring and summer, the surface layer residual current flows southeastward at Xiaocuo- Xiuyu sea area, runs down to the south along the east coast of Meizhou Bay and meets with the residual current inflow from North Panyu at the coast near Dongwu. When northeasterly wind prevails in winter, residual current emerges everywhere that flows in the direction of southwest by west at a flow rate of 10cm/s within Meizhou Bay. The residual current at the outer surface layer of bay mouth is larger than that of inner bay and heads towards southwest.

5.1.1.4 Wave

Waves of Meizhou Bay are mixed waves consisting of wind-induced wave and swell. There is some difference in local wave conditions from bay mouth to bay top. Swell is outstanding in vicinity of bay mouth because of the impacts of external sea. According to statistics, average swell in years appeared at frequency as high as 91%. 83% of swell appeared in the direction of southeast and southeast by south; Impacts of swell from the sea area outside bay mouth on Meizhou Bay are limited to Dasheng island-Panyu, and substantially subdued further inward, where local wind-induced wave and minor cycle swell brought over from neighboring water area; Wind-induced wave generally appears at the comparatively narrow water area of bayhead, e.g., the average swell appeared at frequency of only 0.6% at Xiuyu station in 1978-1980, which may be deemed as no swell.

Impacted by monsoons, main wave direction of Meizhou Bay in years is northeast on average. Wind wave frequency totals 60.5%, 53% and 60% in three directions of NNE, NE and ENE at the three stations of Chongwu, Xiaocuo and Xiuyu respectively. Northeast wind prevails in spring, autumn and winter, and corresponding wind waves appear in northeast direction in most occasions and in south direction in summer. According to statistics of Xiuyu station (August 1977~1980), constant wave is in NE direction at frequency of 26%; sub-constant wave is in ENE direction at frequency of 17%; strong wave is in NE direction, sub-strong wave is in ENE direction, and max wave height was actually measured at 1.2m/s in NE direction.

Statistical analysis of field data of the three stations shows that: Constant wave is in NNE-ENE direction at sea area of Meizhou Bay and mostly occurs in autumn, winter and spring. Strong wind is in SE direction at sea area of Meizhou Bay and the maximum wave height of 6.5m was actually measured at Chongwu station. The value of wave characteristics of each station is listed in Table 5.1.2.

Table 5.1.2 Value of wave characteristics of each station

Station	Wave height(m)	Cycle(sec)	Year in which the

location	Maximum	Average	Maximum	Average	information was gathered
Chongwu	6.5	0.9	10.1	4.3	In 1962-1982
Xiuyu	1.4	0.2	4.4	1.8	In 1978-1980
Xiaocuo	1.6	0.2	5.8	3.8	In 1985—1986

5.1.1.5 Seawater semi-exchange time

Meizhou Bay has seawater resource of about 3 billion m3 and average tidal prism of about 2 billion m3. Increasing from bay mouth to bay bottom, seawater semi-exchange time lasts 4-6 days, 17-18 days and 20-22 days at Huanggua Island - Dongwu sea area, Xiaocuo- Xiuyu and bay bottom respectively.

5.1.2 Erosion and Sedimentation

5.1.2.1 Sediment transport

There is no major river flowing into Meizhou Bay. A Fengci Creek joins the bay at the northwest. Fengci Creek is about 30km long, with the annual flow of only 109 million m3. Incoming sediment from the land is about 160,000t in total annually. According to the measurement at Douwei-Dazhu-Dongwu hydrological cross-section, the sediments brought by tides from outside bay is about 2 million tons annually by estimates. Besides, the silts from shore erosion around the bay area are about 130,000t annually by estimates. In sum, annually total incoming sediments are about 2.286 million tons. In terms of outgoing sediments, according to measurements at Douwei-Dazhu-Dongwu hydrological cross-section, it is 2.284 million tons annually by estimates. Compared with the tidal volume, the sediment quantity is rather small. The incoming and outgoing sediments of Meizhou Bay remain balance basically.

Based on the field data of the hydrological test of January 1997 and the hydrological sediment measurements in the past years, the mean sediment concentration of the water body in the bay is 0.016-0.059kg/m3, the max sediment concentration 0.129kg/m3.

In November 1999, Fujian Marine Forecast Station carried out hydrographical measurement after continuous days with strong winds. The results show mean sediment concentration measured at 0.054kg/m3 and 0.029kg/m3 during flood tide and dead tide respectively.

During a hydrographical measurement in 2003, mean sediment concentration was 0.024-0.057kg/m3 with maximum sediment concentration of 0.098kg/m3 and minimum sediment concentration of 0.015kg/m3 at the measuring point. Sediment concentration varies slightly between flood tide and ebb tide. The mean sediment concentration of flood tide is 0.020-0.046kg/m3 while that of ebb tide is 0.019-0.035kg/m3. Vertical sediment concentration varies with tide magnitude. Sediment concentration changes much at flood tide but little at dead tide. During flood tide, the maximum sediment concentration reaches 0.056kg/m3 and 0.14kg/m3 at surface layer and bottom layer respectively, while the figure is only 0.029kg/m3 and 0.031kg/m3 respectively during dead tide.

Based on these sediments measurements over years, it is considered that the Meizhou Bay is a clear water bay.

5.1.2.2 Seabed evolution and stability analysis

The Meizhou Bay 100,000 DWT channel, completed in 1994, was arranged along the natural central deep trench in the Meizhou Bay. The channel construction takes advantage of the natural bathymetry of Meizhou Bay, only carried out dredging at Bainiu Shoal, with no rock blasting. Total dredging work was around 494,000m3. Since then several bathymetry mapping was conducted over the past 10 more years. The results show the navigation trench remains steady with no substantial erosion or sedimentation observed. Since after dredging of Bainiu Shoal, there was barely no sedimentation in the navigation channel; rather, it is observed that certain erosion occurred to the surrounding shoal.

Based on the data analysis and calculation of the drawing of different historical periods as well as the recent bathymetry drawing, Meizhou Bay remains good stability. A variety of navigation channel projects have taken place in the project area, it is anticipated that limited sedimentation will take place based on construction practices. The sea bed will remain steady basically. Since the project will have considerable dredging, it is anticipated that in the first year upon construction completion there will be considerable sedimentation. But the sea bed will remain good stability through flow adjustment.

5.2 Sea Water Quality

During EA preparation, Fujian Marine Research Institute, a specialized marine institute, was engaged to carry out a dedicated marine environmental survey and assessment for Meizhou Bay. The study covers sea water quality, sediment, and ecological aspects, etc. Table 5.2.1 and Figure 5.2.1 shows the sampling location and key aspects for the survey. The following section 5.2, 5.3, 5.4 and 5.5 present the results and analysis for each aspect.

Table 5.2.1 Stations for marine environment conditions survey

Station No.	Longitude	Latitude	Surveyed items
A01	24°55′04.998″	119°00′22.540″	Water quality
A02	24°55′23.668″	119°02′47.818″	Water quality, sediment, plankton and benthic organism, fish egg and fry
A03	24°55′34.291″	119°05′44.606″	Water quality, plankton and benthic organism
A04	24°57′56.567″	119°02′25.958″	Water quality, bio-quality
A05	24°58′01.889″	119°03′53.863″	Water quality, sediment, plankton and benthic organism, fish egg and fry
A06	24°58′29.377″	119°05′59.824″	Water quality
A07	25°04′11.302″	118°58′20.060″	Water quality
A08	25°05′38.404″	119°00′27.842″	Water quality, sediment, plankton and benthic organism, fish egg and fry
A09	25°07′11.503″	119°01′45.145″	Water quality, sediment, plankton and benthic organism
A10	25°07′17.634″	118°58′30.353″	Water quality, plankton and benthic

			organism
A11	25°08′07.066″	119°00′08.795″	Water quality, sediment, plankton and benthic organism
A12	25°08′39.073″	119°01′11.154″	Water quality
A13	25°10′15.719″	118°58′57.094″	Water quality
A14	25°10′22.242″	118°59′54.010″	Water quality, sediment, plankton and benthic organism, fish egg and fry
A15	25°10′38.395″	119°00′36.216″	Water quality, sediment, plankton and benthic organism
A16	25°13′14.570″	119°01′04.271″	Water quality
A17	25°12′33.235″	119°01′35.710″	Water quality, sediment, plankton and benthic organism, fish egg and fry
A18	25°11′46.180″	119°01′57.634″	Water quality, sediment, plankton and benthic organism, fish egg and fry
A19	25°16′04.879″	118°57′58.374″	Water quality
A20	25°15′49.424″	118°58′35.216″	Water quality, sediment, bio-quality, plankton and benthic organism, fish egg and fry

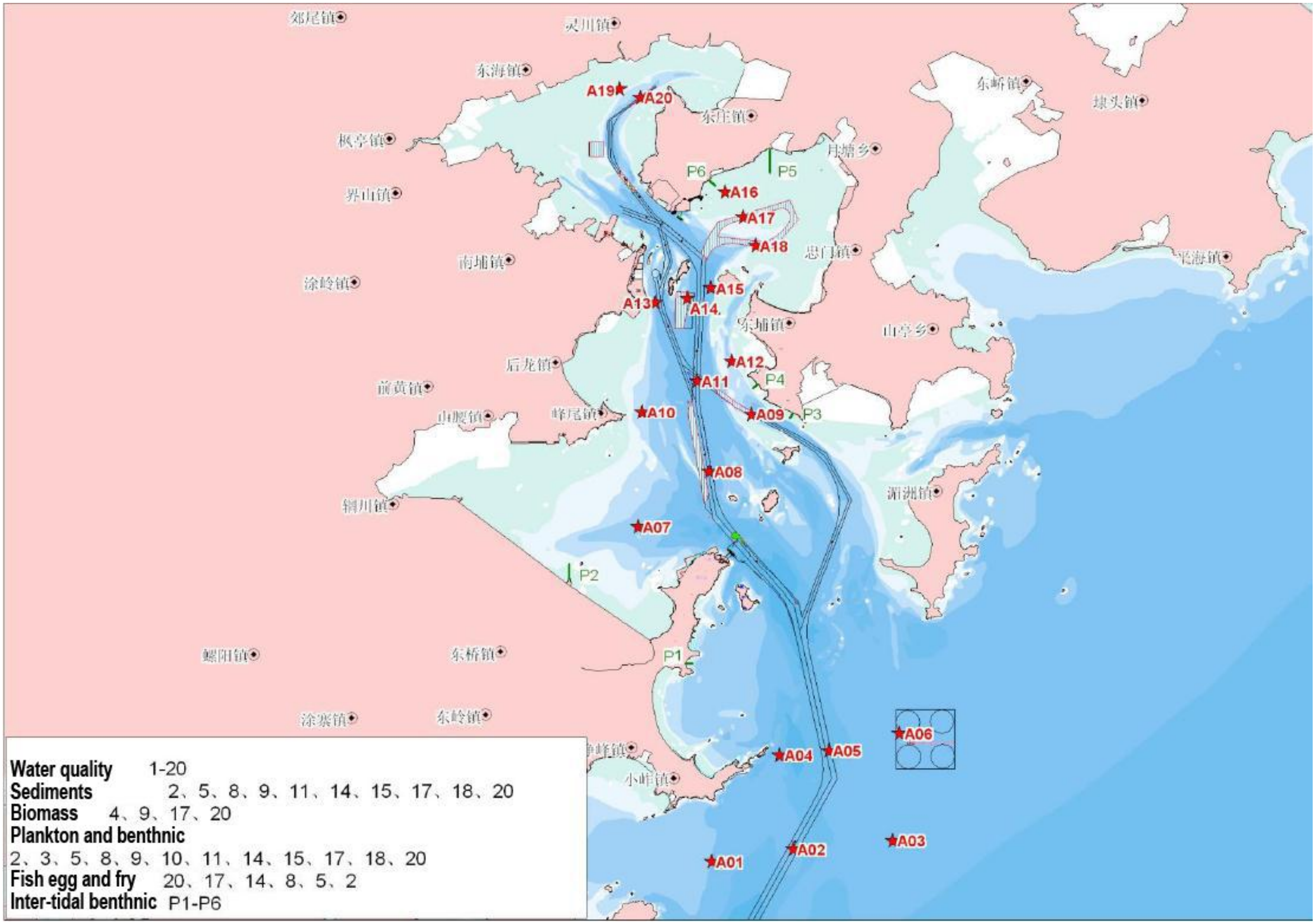


Figure 5.2-1 Marine environment monitoring locations

5.2.1 Monitoring Locations and Survey Content

(1) **Survey time and locations**: On July 8(dead tide) and 14(flood tide), 2011, surface water samples were collected at high tide and low tide respectively. Table 5.2.1 and Figure 5.2-1 shows the locations and parameters for the monitoring. In total 20 locations were selected for sampling.

(2) **Monitored parameters**: Monitored items include water Temperature, Salinity, pH, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Inorganic Nitrogen (nitrite, nitrate, ammonia nitrogen), Reactive Phosphate, Oil, Suspended Solids, Copper, Zinc, Lead, Cadmium, Arsenic, Mercury, etc. Table 5.2.2 shows analysis method.

(3) **Method of sampling**: The surface water samples are collected with an organic glass sampler while oily water samples are collected with a QCC9-1 thrown-to-float surface sampler.

Table 5.2.2 Method of water quality analysis

S/N	Item	Analysis method	Method
1	Water temperature	Water thermometer	GB17378.4-2007
2	pH	PH meter	GB17378.4-2007
3	Salinity	Salinity meter	GB17378.4-2007
4	Dissolved oxygen	Iodometric method	GB17378.4-2007
5	Chemical oxygen demand	Alkaline potassium permanganate method	GB17378.4-2007
6	Nitrate nitrogen	Cadmium column reduction method	GB/T12763.4-2007
7	Nitrite nitrogen	Spectrophotometric method with hydrochloric acid naphthalene ethylene diamine	GB/T12763.4-2007
8	Ammonia nitrogen	Spectrophotometric method with indophenol blue	GB/T12763.4-2007
9	Reactive phosphate	Spectrophotometric method with phosphorus molybdenum blue	GB/T12763.4-2007
10	Oil	Ultraviolet spectrophotometric method	GB17378.4-2007
11	Suspended sediment	Weight method	GB17378.4-2007
12	Copper	Mass spectrography with inductively coupled plasma	EPA-200.8:1995 method of the United States Environmental
13	Zinc		
14	Cadmium		
15	Lead		

16	Arsenic		Protection Agency
17	Mercury		

5.2.2 Assessment Method and Standards

(1) **Assessment method:** The assessment method adopts Single Factor Assessment Method

(2) **Assessment standard**: According to Fujian Provincial Offshore Marine Environmental Function Zoning, #13, #15 and #20 stations of the surveyed area are in Category 4 function zone and shall apply Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while other stations shall apply Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997). Table 1.5.1 shows various categories of water quality standards.

5.2.3 Monitoring Results and Assessment

Table 5.2.4 summarizes the monitoring results of sea water quality.

Table 5.2.4 Summary of seawater quality monitoring results

Monitored items	Monitoring range value	Normal value mg/L		Meeting standards or not
		II	III	
Water Temperature	24.97℃～30.95℃	-	-	-
Salinity	31.70～33.92	-	-	-
pH	7.69～8.24	7.8～8.5		Yes
Dissolved Oxygen	5.92mg/L～8.99mg/L	5	4	Yes
COD	0.26mg/L～0.95mg/L	3	4	Yes
Inorganic Nitrogen	0.011mg/L～0.310mg/L	0.30	0.40	# 19 station no, other stations yes
Reactive Phosphate	0.006mg/L～0.056mg/L	0.030	0.030	#17, #19 and #20 stations no, other stations yes
Suspended Solids	13.9mg/L～48.5mg/L	-	-	-
Oil	0.005mg/L～0.016mg/L	0.05	0.05	Yes
Copper	1.69μg/L～4.99μg/L	0.010	0.050	Yes
Zinc	5.50μg/L～19.3μg/L	0.050	0.10	Yes
Cadmium	0.06μg/L～0.65μg/L	0.005	0.010	Yes
Mercury	0.03μg/L～0.09μg/L	0.0002	0.0002	Yes
Lead	<0.01μg/L～0.75μg/L	0.005	0.010	Yes
Arsenic	1.51μg/L～2.73μg/L	0.030	0.050	Yes

(1)**Water Temperature**: Water temperature of the surveyed sea area varies from 24.97℃ to 30.95℃, all are normal for the surveyed sea area in the season. Water temperature is higher in the north part of the surveyed sea area and gradually decreases from north to south.

(2)**Salinity**: Ranging from 31.70 to 33.92, the salinity surveyed during the survey falls within the normal salinity range of the sea area. Salinity of the northern part of the sea area is slightly lower than that of its southern part.

(3) **pH**: The pH ranges from 7.69 to 8.24 in the surveyed sea area. PH-value of #13, #15 and #20 stations of the surveyed area meets Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while other stations meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

(4) **Dissolved Oxygen**: Dissolved oxygen content varies from 5.92mg/L to 8.99mg/L in the surveyed area, featuring higher in the southern part possibly due to the larger quantity of phytoplankton during the survey. DO-value of #13, #15 and #20 stations of the surveyed area meets Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while other stations meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

(5) **COD**: Chemical oxygen demand of the surveyed sea area is comparatively low, ranging from 0.26mg/L to 0.95mg/L. Chemical oxygen demand of #13, #15 and #20 stations of the surveyed area meets Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while other stations meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

(6)**Inorganic Nitrogen**: Inorganic nitrogen content ranges from 0.011mg/L to 0.310mg/L in the surveyed sea area, whose northern part has higher content than the southern part. Inorganic nitrogen of #13, #15 and #20 stations of the surveyed area meets Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while other stations except #19 meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

(7)**Reactive Phosphate**: Reactive phosphate content varies from 0.006mg/L to 0.056mg/L during the survey and the northern part of the surveyed sea area has the highest content. During the survey, #17 and #19 stations meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while #20 stations could not meet Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

(8)**Suspended Solids**: Content of suspended sediment varies from 13.9mg/L to 48.5mg/L in the surveyed sea area.

(9)**Oil**: the oil content of the surveyed sea area is very low, ranging from 0.005mg/L to 0.016mg/L. Oil of #13, #15 and #20 stations of the surveyed area meets Category 3 seawater quality standard that falls under the Sea Water Quality Standard

(GB3097-1997); while other stations meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

(10)**Copper**: Copper content of the surveyed sea area ranged from 1.69μg/L to 4.99μg/L during the survey. Copper of #13, #15 and #20 stations of the surveyed area meets Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while other stations meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

(11)**Zinc**: Zinc content ranges from 5.50μg/L to 19.3μ g/L. Zinc of #13, #15 and #20 stations of the surveyed area meets Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while other stations meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

(12)**Cadmium**: Cadmium content ranges from 0.06μg/L to 0.65μ g/L. Cadmium of #13, #15 and #20 stations of the surveyed area meets Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while other stations meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

(13)**Mercury**: Mercury content ranged from 0.03μg/L to 0.09μ g/L during the survey. Mercury of #13, #15 and #20 stations of the surveyed area meets Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while other stations meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

(14)**Arsenic**: Arsenic content of the survey sea area ranged from 1.51μg/L to 2.73μ g/L. Arsenic of #13, #15 and #20 stations of the surveyed area meets Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while other stations meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

(15)**Lead**: Lead content ranged from <0.01μg/L to 0.75μ g/L during the survey. Lead of #13, #15 and #20 stations of the surveyed area meets Category 3 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997); while other stations meet Category 2 seawater quality standard that falls under the Sea Water Quality Standard (GB3097-1997).

5.2.4 Summary and Conclusion

The sea water quality monitoring was conducted in July 2011. The analysis of the results is summarized as following.

- At both high tide and low tide period, water samples were collected from 20 locations that cover the project navigation channel, backfill area, disposal area, anchorage/crossing zones inside and outside Meizhou Bay.
- The Sea water monitoring results show that most water quality parameters in most sampling locations meet designated sea water quality standards.
- At sampling location 19#, inorganic nitrogen concentration slightly surpasses the designated standards by 3%; reactive phosphate concentration surpasses

the designated standards by 83%. The 19# location is in the north of Putou, near land and aquaculture farms. It is considered that discharge from land and aquaculture farm contributed the excessive organic nitrogen.

- At sampling location 17# and 20#, reactive phosphate concentrations surpass the designated standards by 83%, and 87%, respectively. The two locations are close to Shimen'ao aquaculture farm. It is considered that discharge from land and aquaculture farm contributed the excessive phosphate.

Other sea water quality monitoring results were also reviewed. The Meizhou Bay Port (Quanzhou-Putian) Master Plan Environmental Assessment presents another water quality monitoring conducted in October 2010 by Xiamen Marine Environmental Monitoring Central Station. 35 locations inside and outside the bay were selected for sampling. The monitoring results are generally consistent with the above-mentioned monitoring conducted for the project EA. In addition, the monitoring results of October 2010 indicate that sulfide, benzene hexachloride (666), DDT or PCB was not detected.

5.3 Sediment Quality

Sediment sampling and analysis was conducted following domestic monitoring protocol during the preparation of the EA.

5.3.1 Monitoring Locations and Survey Content

(1) **Monitoring time and location**: There are a total 10 locations chosen for sediment sampling, as shown Table 5.2.1 and Figure 5.2-1. Stainless steel samplers were used for sampling.

(2) **Monitored parameters**: Monitored parameters include Sulfide, Organic Carbon, Oil, Copper, Lead, Zinc, Cadmium, Arsenic and Mercury, as shown in Table 5.3.1

Table 5.3.1 Sediment analysis method

S/N	Item	Analysis method	Method
1	Organic carbon	Volumetric method through potassium dichromate oxidation-reduction	GB17378.5-2007
2	Sulfide	Iodometric method	
3	Oil	Ultraviolet spectrophotometric method	
4	Copper	Flame atomic absorption spectrophotometer	
5	Cadmium		
6	Lead		
7	Zinc		
8	Arsenic	Method with atomic fluorescence	
9	Mercury		

5.3.2 Assessment method and standard

(1) **Assessment method**: The assessment method adopts Single Factor Index Method.

(2) **Assessment standards**: Corresponding to water quality assessment standards, the sediment quality is assessed according to Category 1 standard (*most clean*) that falls under Quality Standard for Marine Sediment (GB18668-2002).

5.3.3 Sediment monitoring results and assessment

Table 5.3.2 summarizes sediment quality analysis results.

Table 5.3.2 Sediment Quality Analysis Results   Unit: mg/kg

Station No.	Organic carbon (%)	Sulfide	Oil	Copper	Zinc	Cadmium	Mercury	Lead	Chromium	Arsenic
A02	0.71	<4	35	14.5	100	0.083	0.031	37.4	12.1	4.6
A05	0.74	5	40	19.2	139	0.096	0.051	25.6	18.2	7.8
A08	0.59	<4	32	17.6	102	0.067	0.038	26.2	22.3	8.4
A09	0.50	5	28	10.8	59.3	0.070	0.027	18.9	12.0	3.7
A11	0.53	14	32	10.6	67.7	0.366	0.025	20.0	13.2	3.9
A14	0.46	4	28	14.5	86.2	0.061	0.038	31.8	15.8	5.8
A17	0.53	6	29	16.1	100	0.095	0.048	32.0	30.6	6.9
A18	0.71	12	24	17.8	112	0.407	0.040	34.8	18.2	7.0
A20	0.60	10	36	12.7	82.9	0.077	0.037	36.6	13.2	6.6
Category 1 standard that falls under Quality Standard for Marine Sediment	≤2	≤300	≤500	≤35	≤150	≤0.5	≤0.2	≤60	≤80	≤20

(1)**Oil**: During the survey, oil content in the sediment ranged from 24mg/kg to 40mg/kg, averaging at 32mg/kg. Without exception, oil content met the requirements of Category 1 sediment quality standard.

(2)**Sulfide**: Sulfide content of the sediment is low in the surveyed sea area, ranging from <4 mg/kg to 14 mg/kg, averaging at 7mg/kg. Without exception, sulfide content meets the requirements of Category 1 sediment quality standard.

(3)**Organic carbon**: Organic carbon content in the sediment ranges from 0.46% to 0.74%, averaging at 0.60%, all meeting the requirements of Category 1 sediment quality standard.

(4)**Copper**: Copper content in the sediment ranges from 10.6mg/kg to 19.2mg/kg, averaging at 14.9mg/kg, all meeting the requirements of Category 1 sediment quality standard.

(5)**Lead**: During the survey, lead content ranged from 18.9mg/kg to 37.4mg/kg, averaging at 29.3mg/kg, all meeting the requirements of Category 1 sediment quality standard.

(6)**Cadmium**: Cadmium content in the sediment of the surveyed sea area ranges from 0.061mg/kg to 0.407mg/kg, averaging at 0.147mg/kg, all meeting the requirements of Category 1 sediment quality standard.

(7)**Zinc**: During the survey, zinc content ranged from 59.3mg/kg to 139mg/kg, averaging at 94.3mg/kg, all meeting the requirements of Category 1 sediment quality standard.

(8)**Mercury**: Mercury content in the sediment ranges from 0.025mg/kg to 0.051mg/kg, averaging at 0.037mg/kg, all meeting the requirements of Category 1 sediment quality standard.

(9)**Chromium**: During the survey, chromium content in the sediment ranged from 12.0mg/kg to 30.6mg/kg, averaging at 17.3mg/kg, all meeting the requirements of Category 1 sediment quality standard.

(10)**Arsenic**: During the survey, arsenic content in the sediment ranged from 3.7mg/kg to 8.4mg/kg, averaging at 6.1mg/kg, all meeting the requirements of Category 1 sediment quality standard.

5.3.4 Summary and Conclusion

The sediment quality monitoring was conducted in July 2011. The analysis of the results is summarized as following.

- Sediment samples were collected from 10 locations that cover the project navigation channel, backfill area, disposal area, anchorage/crossing zones inside and outside Meizhou Bay.
- All monitoring results universally show that the sediments in Meizhou Bay meet Class I under national standard Sea Sediment Quality Standards (GB18668-2002), meaning the sediments in Meizhou Bay are clean, uncontaminated.

Other sediment quality monitoring results were also reviewed. The Meizhou Bay Port (Quanzhou-Putian) Master Plan Environmental Assessment presents another sediment quality monitoring in Meizhou Bay, conducted in 2009 by Putian Marine and Fishery Bureau. 7 locations were selected for sampling. The monitoring results are consistent with the above-mentioned monitoring conducted in July 2011. The results show all parameters meet Class I standards. The sediments in Meizhou Bay are clean, uncontaminated.

The State Ocean Administration in 2010 issued an official approval for the Meizhou Bay Marine Waste Dumping Site supported by a dedicated study report. The study reviews analysis results of dredged material from a variety of dredging projects taking place in the Meizhou Bay and concluded that the dredged materials are (Class I) clean dredged material. Based on the study the report indicates dredged materials of Meizhou Bay can be dumped at designated dumping sites with ordinary permit issued by responsible authorities.

5.4 Marine Ecology

The marine ecology survey conducted in July 2011 by Fujian Marine Research Institute covers plankton, benthic organisms, fish egg and fry, etc. The sampling and analysis followed domestic marine ecology survey protocol. Other marine ecological studies at regional level and Meizhou Bay were also referenced to complement the ecology survey result in order to understand the ecological significance of the Meizhou Bay.

5.4.1 Monitoring Locations and Survey content

(1) **Survey time and locations**: The survey was conducted in July 2011. Plankton and benthic organism samples were collected from 12 locations. Fish egg and fry samples were collected from 6 locations. Table 5.2.1 and Figure 5.2-1 show the locations of sampling.

(2) **Survey content**: Chlorophyll-a content, primary productivity; phytoplankton, zooplankton, benthic organism, fish egg and fry, and their species, composition and quantity distribution..

(3) **Samples collection method**:

- Plankton: For collection of phytoplankton samples, 500mL water was gathered from surface and bottom layers respectively of each station. Then, the water samples were fixed with Lugol's solution for sedimentation and condensation before the samples of surface and bottom layers are mixed for identification, counting and analysis. Zooplankton samples were collected by trawling vertically from bottom layer to surface layer with a type-Ⅱ shallow water plankton net. Treatment, analysis appraisal and data processing of phytoplankton and zooplankton samples were carried out according to The Specification for Marine Monitoring (GB17378.7-2007).

- Benthic organisms: Macrobenthos samples were collected with a bottom grab of dimensions 0.20m×0.25m (0.05m2). Four consecutive buckets of sediments were collected from each station. Following desilting and sorting with a set of sieves with 0.5mm net mesh, macrobenthos samples were separated from the sediment. Four parallel samples were packed into one bottle for macrobenthos counting, weighing and data processing at the laboratory.

- Fish egg and fry: Horizontal trawling was conducted with a megaplankton net (opening diameter 80cm, length 280cm, screen aperture 0.505mm) equipped with a flow meter at the net opening. At a ship speed of 1 kn-2kn, horizontal trawling was conducted at the seawater surface layer(net opening just below the surface) for 10 minutes.

5.4.2 Method of marine ecology assessment

Four indicators reflecting the characteristics of biocommunity, i.e., Diversity Index (H′), Abundance Degree(d), Homogeneity Degree (J′) and Dominance Degree (D2) as well as Degree of Species Simplicity(∑π2) are used in analyzing the structural characteristics of phytoplankton community.

- The expression for Diversity Index is as follows:

$$H^{'} = -\sum_{i=1}^{t} P_i \cdot \log_2 P \qquad \text{(Shannon - Wiener,1949)}$$

Where, t represents the species of phytoplankton; Pi＝Ni/N represents the ratio between Category i phytoplankton samples and the total samples collected; N represents the number of total individual samples.

- The expression for Abundance Degree is as follows:

d＝(t-1)/L_nN (Margaler, 1958)

- The expression for Homogeneity Degree is as follows:

J′＝H′/$\log_2$t (Pielou,1969)

Within variation range [0,1] , maximal value of J′ is taken when there is equal number of individual species.

- The expression for Dominance Degree is as follows:

P＝(N_1＋N_2)/N (Mchanghton,1969)

Where, N1 and N2 represent the individual numbers of dominant species that rank No.1 and No. 2 respectively in the samples.

The value is taken as [0,1], and when N1 and N2 have overwhelming dominance in the biocommunity, P→1 but J'→0, while in case J'→0 and distribution of individual interspecies tend to be equal, then J'→1, P→0.

5.4.3 Survey and assessment of ecological conditions

5.4.3.1 Chlorophyll-a and primary productivity

(1) Chlorophyll-a

Table 5.4.1 shows the results of Chlorophyll-a survey conducted in July 2011. At the surveyed sea area, Chlorophyll-a content ranged from 1.96mg/m3 to 6.97mg/m3, averaging at 2.98mg/m3.

(2) Primary productivity

- Historical data show that the average assimilatory coefficient Q of Meizhou Bay in summer is about 6.76mgC/mg chla·h.

- At the surveyed sea area in summer, hours of sunshine D (from sunrise to sunset) is 13h.

- Computing formula for primary productivity P(mgc/m3. d) :

$$P = \frac{C \times Q \times E \times D}{2}$$

Table 5.4.1 Chlorophyll-a and primary productivity survey outcome

Station No.	Diaphaneity(m)	Chlorophyl mg/m^3	Primary productivity mgC/m^2.d
A02	1.5	3.91	773.1
A03	1.5	2.67	527.9
A04	1.3	2.12	363.3
A05	1.4	3.20	590.6

A08	1.6	2.16	455.6
A09	1.3	2.17	371.9
A11	1.5	1.96	387.6
A14	1.3	2.32	397.6
A15	1.3	3.00	514.1
A17	1.0	2.30	303.2
A18	1.2	2.93	463.5
A20	1.0	6.97	918.8

During the survey, primary productivity ranged from 303.3mgC/m2.d to 918.8mgC/m2.d, averaging at 505.6mgC/m2.d. The survey was conducted in July 2011 when high water temperature and strong solar irradiance which are favorable for the photosynthesis of phytoplankton. Historical data showed that the primary productivity was averaged at 454mgC/m2.d in Fujian Province in summer. The monitored value shows the primary productivity is at a normal level.

5.4.3.2 Phytoplankton

(1)Species composition and ecologic groups of phytoplankton

a) Composition of phytoplankton species

During the survey, 4 phylums, 53 genuses and 115 species (including variant and derivative, the same below) of phytoplankton were identified and recorded, including 1 genus 2 species of Cyanophyta, 1 genus 1 species of Euglenophyta, 10 genuses 16 species of pyrrophyta and 41 genuses 96 species of Bacillariophyta. There was a large number of recorded phytoplankton species. One reason is that the monitoring range was wide. In addition, A02, A03, A04 and A05 stations faced open sea, which added the species. And Bacillariophyta have the most dominant number.

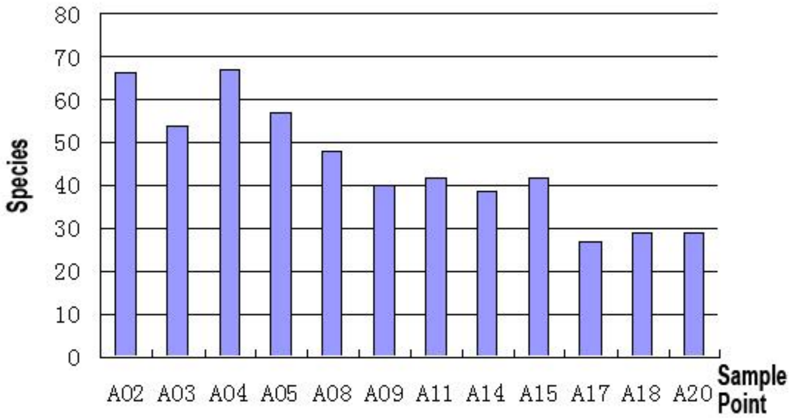


Figure 5.4-1 Phytoplankton species

b) Distribution of phytoplankton species

During the survey, as shown in Figure 5.4-1, the average number of phytoplankton species at all stations reached up to 45, varying from 27 to 67. There are more than 50 species at each of A02, A03, A04 and A05 stations at the southern part of the surveyed sea area. And both A02 and A04 stations have more than 60 species. Relatively smaller numbers of species were found at A17 and A18 stations within Meizhou Bay and A20 station at bayhead, fewer than 30 species at each of the stations. There is a tendency of gradually decreasing number of species from the southern part of the surveyed sea area to the bayhead.

c) Ecological groups of phytoplankton

On the basis of such characteristics as temperature adaptation, the phytoplankton recorded during the survey may be divided into the following main ecologic groups:

①Warm water species: They tend to adapt to higher temperature, and usually grow during seasons with higher water temperature or enter the surveyed area along with warm water. Main species include Trichodesmium erythraeum, Trichodesmium thiebautii, Chaetoceros lorenzianus, Chaetoceros pseudocurvisetus, Dactyliosolen mediterraneus, Ditylum sol, Rhizosolenia robusta, etc that feature small numbers. Trichodesmium erythraeum and Trichodesmium thiebautii only appeared at A02 station among other stations at the mouth of Meizhou Bay.

②Dispersed species: They adapt to a wide range of temperature and can be divided into three categories accordingly, i.e., high salinity species, euryhaline species and low salinity species.
Dispersed high salinity species: The main species include Rhizosolenia styliformis, Thalassiosira subtilis, etc featuring small species and numbers.

Dispersed euryhaline species: Main species include Bacillaria paradoxa, Cerataulina bergonii, Chaetoceros affinis v. willei, Chaetoceros curvisetus, Cylindrotheca closterium, Ditylum brightwellii, Skeletonema costatum, Nitzschia delicatissima, etc that are commonly seen near the coast. And Nitzschia delicatissima was found to be the most dominant species during the survey.

Dispersed low salinity species: Melosira sulcata among others features with small number of species and is also one of the main dominant species at some stations.

③Warm-temperature species: Adapting to a narrow range of temperature, they include Rhizosolenia delicatula, Surirella gemma, etc that feature few species and small numbers.

Dinoflagellate include Alexandrium sp., Gymnodinium sp., Noctiluca scintillans, Prorocentrum micans, Prorocentrum sigmoides, etc among other red tide species that feature small numbers.

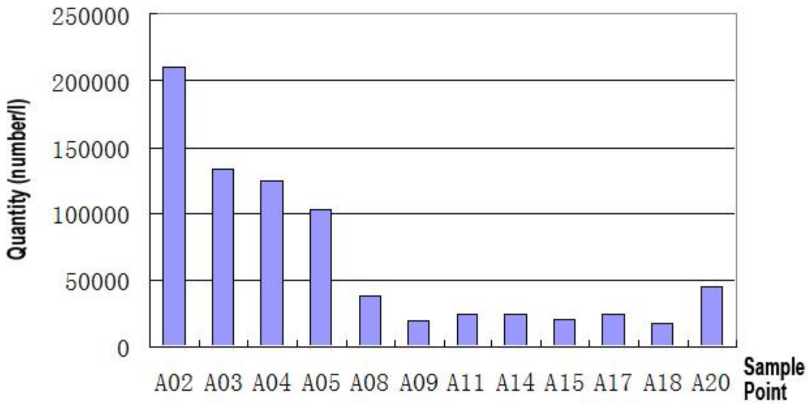


Figure 5.4-2 Distribution of total phytoplankton cells

Table 5.4.2 Numbers and proportional numbers of main dominant phytoplankton species Unit: number/L

Station	Numbers and proportional numbers of main dominant species
A02	Nitzschia delicatissima (114600, 54.7%), Chaetoceros curvisetus (25200, 12.0%)
A03	Nitzschia delicatissima(33600, 25.2%), Chaetoceros curvisetus(30800, 23.1%)
A04	Skeletonema costatum (27200, 21.7%), Nitzschia delicatissima(22800, 18.2%)
A05	Nitzschia delicatissima(41400, 40.0%), Chaetoceros curvisetus(19400, 18.8%)
A08	Melosira sulcata (12800, 34.2%), Skeletonema costatum (9600, 25.7%)
A09	Chaetoceros curvisetus(6000, 29.7%), Melosira sulcata (2000, 9.9%)
A11	Melosira sulcata (7000, 28.7%), Chaetoceros curvisetus(4600, 18.9%)
A14	Melosira sulcata (4200, 17.1%), Rhizosolenia delicatula (2200, 8.9%)
A15	Chaetoceros affinis v. willei (2800, 13.6%), Leptocylindrus danicus (2000, 9.7%)
A17	Pleurosigma (4400, 17.9%), Cylindrotheca closterium (3400, 13.8%)
A18	Bacillaria paradoxa (4600, 26.7%), Melosira sulcata (3000, 17.4%)
A20	Chaetoceros affinis v. willei (11800, 25.8%), Cerataulina bergonii (10400, 22.7%)

(2)Phytoplankton quantity distribution

a) Distribution of total phytoplankton cells

As shown in Figure 5.3-2, the number of phytoplankton is averaged at 65,529/L, including Bacillariophyta averaged at 64,888/L, which occupies 99.0% of total number of phytoplankton. The number of phytoplankton is within normal value range of local sea area. A02 station has the largest number at 209,550/L while A18 station has the fewest number at 17,200/L. There is apparently larger number in A02, A03, A04 and A05 in the south part of the surveyed sea area than station in the bay. Stations at the bay mouth have an average number of 142,888/L, which is more than five times that of stations in the bay with an average number of 26,850/L. Except A20 station at bayhead, the stations in the bay have similar numbers.

b) Quantity distribution of main dominant species

Dominant phytoplankton species mainly include nitzschia delicatissima, chaetoceros curvisetus, skeletonema costatum and melosira sulcata. Dominant species at A02 among other stations at the bay mouth mainly include nitzschia delicatissima and chaetoceros curvisetus; dominant species at A08, A09, A11 and A14 among other stations in the middle of the bay mainly include melosira sulcata and chaetoceros curvisetus; dominant species at A17 and A18 stations featuring shallow water mostly include benthic Pleurosigma and bacillaria paradoxa; and dominant species at A20 station at bayhead is chaetoceros affinis v. willei. The most dominant two species of each station generally occupy 23%-60% of the total (refer to Table 5.3.2).

Nitzschia delicatissima: A species widely spread along the coast; During the survey, the average number is 19,533/L, or 29.8% of the average number of phytoplankton. A02 station has the largest number at 114,600/L, mostly distributed at A02, A03, A04 and A05 at the bay mouth.

Chaetoceros curvisetus: A species widely spread along the coast and belonging to red tide species; During the survey, the average number is 8,983/L, or 13.7% of the average number of phytoplankton, mostly distributed at A02, A03, A04 and A05 at the bay mouth.

Skeletonema costatum: A world-wide dispersed species, eutrophic indicator species and commonly seen red tide species that tends to grow well along the coasts, estuaries and inner bays of Fujian Province. During the survey, the average number is 8,525/L, or 13.0% of the average number of phytoplankton. A02 station has the largest number at 28,200/L, mostly distributed at A02, A03, A04 and A05 among other stations at the bay mouth.

Melosira sulcata: A coastal dispersed benthic species easily intermingled in phytoplankton community when stirred by wind waves, tides, etc. During the survey, the average number is 3,646/L, or 5.6% of the average number of phytoplankton, and is rather evenly distributed among the stations. A08 station has the largest number at 12,800/L.

(3)Diversity index (H ') and homogeneity degree (J) of phytoplankton

Phytoplankton diversity indices (H ') reflects the community diversity and the pollution degree of water bodies to a certain extent. It is said that the area with H 'of 3-4 is clean, the area with H 'of 2-3 is slightly polluted, the area with H 'of 1-2 is moderately polluted and the area with H 'of <1 is heavily polluted. As shown in 5.3-3, phytoplankton diversity indices vary from 2.62 to 4.42, averaging at 3.57, a rather large number. And the phytoplankton diversity index of A15 station is the largest while that of A02 station is the smallest. Except A02 station, all diversity indices are greater than 3 and A14 and A15 stations even greater than 4. Nitzschia delicatissima occupies a proportion of over 50% at A02 station.

With the degree of homogeneity (J), it is possible to judge whether quantity distribution of various species is even or not at the surveyed stations. The value of J ranges from 0 to 1. Larger J reflects the even distribution of species in respect of individual numbers. As shown in Figure 5.4-3, the degree of phytoplankton homogeneity varies from 0.48 to 0.91, averaging at 0.73, a rather large value. And the degree of phytoplankton homogeneity of A15 station is the largest while that of A02 station is the smallest. Except A02 station, the degree of phytoplankton homogeneity of all stations are greater than 0.59.

Both phytoplankton diversity index and degree of homogeneity reflect the monitored sea area has a favorable environment with even quantity distribution of phytoplankton community species and stable phytoplankton community.

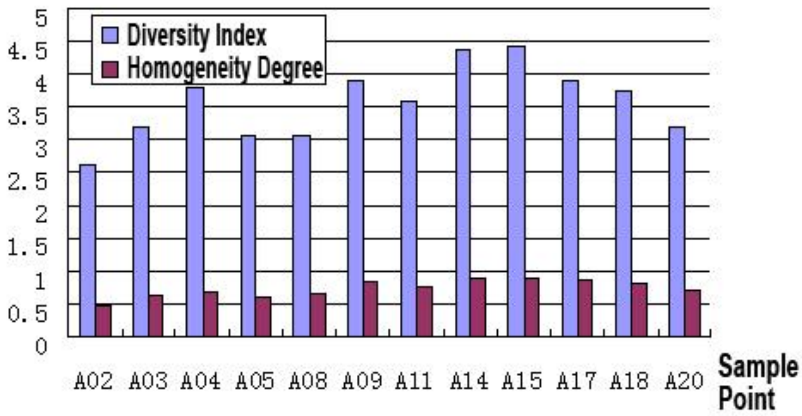


Figure 5.4-3 Diversity index (H ') and degree of homogeneity (J) of phytoplankton

(4) Summary of phytoplankton survey

The phytoplankton survey and assessment conducted in July 2011 is summarized in below.

- During the survey, a total of 4 phylums, 53 genuses and 115 species of phytoplankton were identified and recorded. Bacillariophyta are dominant. Dominant species include nitzschia delicatissima, chaetoceros curvisetus, skeletonema costatum and melosira sulcata.

- Phytoplankton quantity ranges from 17,200/L to 209,550/L, averaging at 65,529/L, falling under the normal range of phytoplankton quantity at inner bays of Fujian coastal areas; while phytoplankton diversity index range from 2.62 to 4.42, averaging at 3.57; the degree of phytoplankton homogeneity ranges from 0.48 to 0.91, averaging at 0.73.

- The numbers of species, quantity and diversity index, and homogeneity dgree of phytoplankton indicate that the phytoplankton community in Meizhou Bay is stable and the marine environment is good.

5.4.3.3 Zooplankton

(1)Species composition and ecological attribute of zooplankton

a) Species composition of zooplankton

A total of 73 zooplankton species were recorded in the survey, including 15 tubularla crocea species (11 Hydromedusae species, 3 siphonophore species, 1 ctenophore species), 2 cladocerans species, 2 Ostracods species, 38 Copepoda species, 1 euphauslid species, 1 Mysidacea species, 1

Cumacea species, 1 Amphipoda species, 2 decapoda species, 2 Pteropoda species, 4 Chaetognatha species and 4 Tunicate species. In addition, there are a number of periodical Ichthyoplankton species. Among those with dominant quantities are paracalans crassirostris (36%), paracalanus parvus(10%), bestiola amoyensis(6%) and acrocalanus gibber(5%).

The number of zooplankton species ranges from 11 to 43 at the surveyed sea area. A02, A03, A04 and A05 stations at the south of Meizhou Bay mouth boast obviously larger number of species. Each of the stations has around 35 and A02 station has the largest number at 43. The number of species substantially decreases at A08, A09, A11, A14 and A15 among other stations in the middle of Meizhou Bay, mostly fewer than 30. Each of A17, A18 and A20 stations at the north of the bay has fewer than 14 species and A20 station has the fewest at 11. Species decrease from south to north on the whole (refer to Figure 5.4-4 for details).

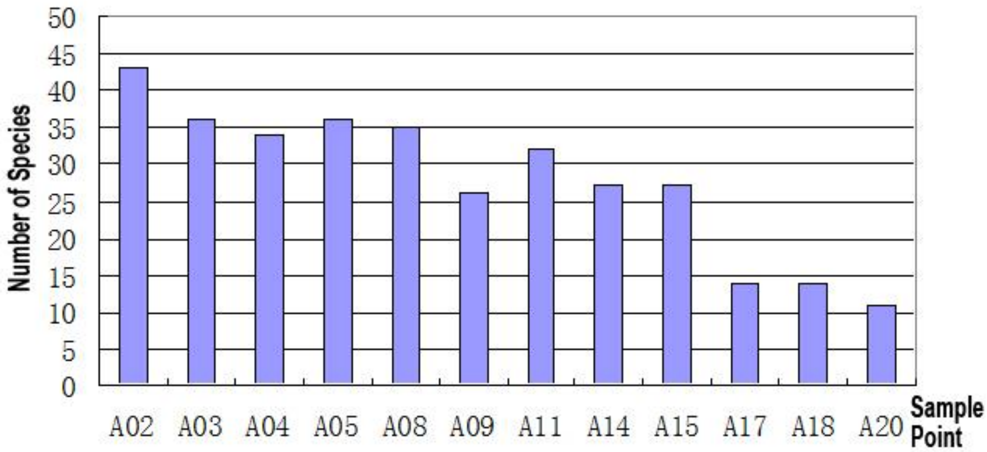


Figure 5.4-4 Species distribution of zooplankton

b) Ecological groups of zooplankton

Zooplankton at the surveyed sea area can be divided into following four ecological groups according to their ecological habits and distributional characteristics:

①Nearshore warm temperature group: an ecological group that adapts to relatively low temperature, like Calanus sinicus and Muggiaea atlantica.

②Nearshore wide temperature range group: As a main group of the sea area, the group features many species and large quantity. Typical species include paracalanus parvus, Centropages tenuiremis, Labidocera euchaeta, Acartia pacifica and Oikopleura dioica.

③Nearshore warm water group: e.g., Cypridina dentata, Diphyes chamissonis, Pleurobrachia globosa, Canthocalanus pauper, Temora turbinata, Calanopia thompsoni, etc.

④Open sea dispersed high salinity group: Typical species include Liriope tetraphylla, Undinula vulgaris, Eucalanus subcrassus, Candacia bradyi and Sagitta enflata.

(2)Total quantity distribution of zooplankton

a) Distribution of total zooplankton biomass (wet weight)

At the surveyed sea area, the average zooplankton biomass is 102.77mg/m3 and its variation range is from 25.00mg/m3 to 225.00mg/m3. A02, A03, A04 and A05 stations at the south Meizhou Bay mouth and A08 station in the middle of the bay have higher biomass, mostly ranging from 100.00mg/m3 to 200.00mg/m3, with A02 boasting the highest at 225.00mg/m3. And the figure is without exception below 100.00mg/m3 at both central and northern parts of the bay, with A20 station the lowest at only 25.00mg/m3. There is a tendency of descending from south to north (refer to Figure 5.4-5 for details).

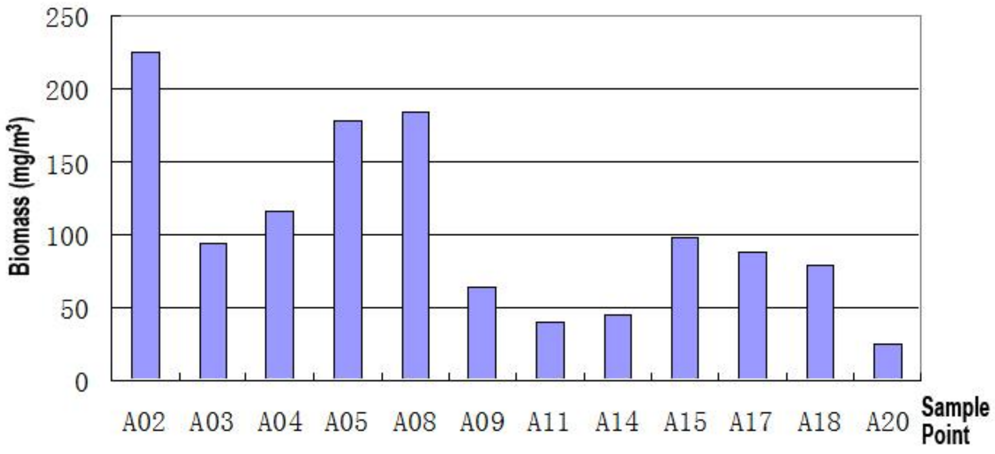


Figure 5.4-5 Distribution of zooplankton biomass

b) Plane distribution of density of overall zooplankton individuals

During the survey, overall zooplankton individuals were averaged at 5,719.47/m3 and its variation range was from 2,829.55/m3 to 9,753.12/m3. A04 station boasted the highest density with paracalans crassirostris taking the most dominant position and A09 boasted the lowest density (refer to Figure 5.4-6 for details).

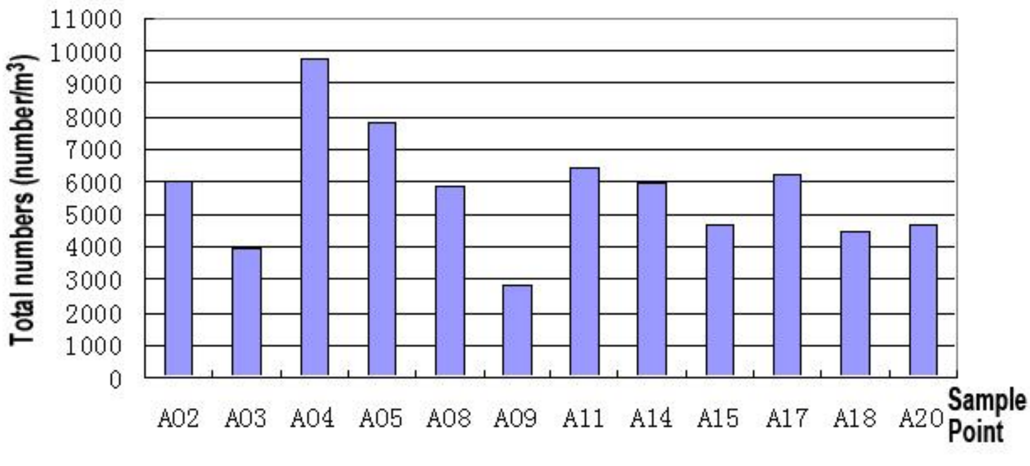


Figure 5.4-6 Distribution of overall zooplankton individuals

总个体数 Overall individual numbers

站位 Station

(3)Diversity index (H ') and degree of homogeneity (J) of zooplankton species

The diversity indices (H ') of the surveyed zooplankton was averaged at 3.00, or ranging from 2.10 to 4.10 at all survey stations, and the degree of homogeneity (J) was averaged at 0.61, or ranging from 0.40 to 0.76 at all survey stations (refer to Figure 5.4-7 for details).

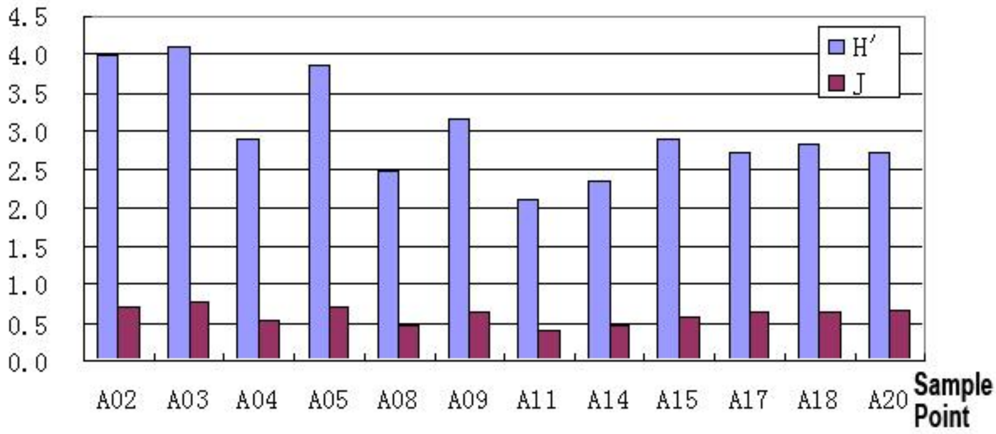


Figure 5.4-7 Diversity index (H ') and degree of homogeneity (J) of zooplankton

Higher diversity index of zooplankton were found at the stations at the southern part of the surveyed sea area and most of them were over 3.0 while those of most inner bay stations were from 2.0 to 3.0.

(4)Summary of zooplankton survey

The zooplankton survey and assessment conducted in July 2011 is summarized in below.

- A total of 73 zooplankton species were recorded in the survey, including 15 tubularla crocea species (11 Hydromedusae species, 3 siphonophore species, 1 ctenophore species), 2 cladocerans species, 2 Ostracods species, 38 Copepoda species, 1 euphauslid species, 1 Mysidacea species, 1 Cumacea species, 1 Amphipoda species, 2 decapoda species, 2 Pteropoda species, 4 Chaetognatha species and 4 Tunicate species. In addition, there are a number of periodical Ichthyoplankton species. Among those with dominant quantities are paracalans crassirostris, paracalanus parvus, bestiola amoyensis and acrocalanus gibber.

- The number of zooplankton species ranged from 11 to 43 in the surveyed sea area. Their number of overall individuals and biomass were averaged at 5,719.47/m3 and 102.77mg/m3 respectively and the quantity value was at normal level in the present season. Diversity index and homogeneity degree of zooplankton were as high as 3.00 and 0.61 respectively, which show good diversity and homogeneity in general.

- The zooplankton survey results indicate that the sea area to the north of Putou and the sea area within Shimen'ao appear to be impacted by the land-sourced pollutants discharge and aquaculture farming. This evaluation is consistent with the water quality monitoring result that the inorganic nitrogen and reactive phosphate in the two areas slightly surpass the designated standards. While, the remaining surveyed area, particularly the southern part of bay, is in good environmental conditions.

5.4.3.4 Benthic Organism

(1) Species composition of benthic organisms

During the survey, a total of 62 benthic organism species were found, belonging to seven phyla of Coelenterata, nemertea, Annelida, Sipunculoidea, Arthropoda, mollusca and Echinodermata. Among them, polychaeta species of Annelida reached up to 41, or 66.1% of total species. Mollusca is the second with 7 species or 11.3% of total species. They were followed by Arthropoda and Echinodermata with 6 species or 9.7% and 4 species or 6.5% of total species respectively. There were other four species, accounting for 6.5% of total species.

Main species include Sternaspis scutata, Tharyx sp., Amphioplus laevis, Scoloplos rubra, Laonice cirrata, Eunice indica, Prionospio queenslandica, Terebellides stroemii, Aglaophamus dibranchis, Amaeana trilobata, Lumbrineris sp., Amaeana occidentalis, etc.

Table 5.4.3 shows the species of benthic organisms found at the surveyed sea area.

Table 5.4.3 Number of species of benthic organisms and their main species at the stations of the surveyed sea area

Station No.	Number of species	Main species
A02	10	Poecilochaetus serpens, Cossurella dimorpha, Aglaophamus dibranchis, Actinia equine, etc
A03	10	lumbrineris sp., Cossurella dimorpha, Glycera onomichiensis, Scoloplos marsupialis Southern, Corophium Sinensis, etc
A04	1	prionospio queenslandica
A05	7	Aglaophamus dibranchis, Gammaridea, sternaspis scutata , etc
A08	19	Neoxenophthalmus obscurus, tharyx sp., Aricidea, Marphysa sanguinea , lumbrineris sp., sternaspis scutata , etc
A09	10	amphioplus laevis, lumbrineris sp., tharyx sp., eunice indica, etc
A11	23	Drilonereis filum, lumbrineris sp., Clam Mactra chinensis, Nitidotellina minuta, scoloplos rubra,Cirratulus, tharyx sp., etc
A14	10	Notomastus latericens, amaeana occidentalis, lumbrineris sp., amphioplus laevis, etc
A15	1	Ophiothrix ciliaris
A17	12	sternaspis scutata , Marphysa sanguinea, Laonice cirrata , eunice indica, lumbrineris sp., etc
A18	7	Glycinde gurjanovae, Nectoeanthes, lumbrineris sp., etc
A20	12	eunice indica, amaeana trilobata, amaeana occidentalis, Cirratulus, tharyx sp., etc

As indicated in Table 5.4.3, there are not abundant species of benthic organisms at the surveyed sea area. The species of benthic organisms appearing at the stations of the surveyed sea area ranged from 1 to 23, averaging at 10. And the largest number or 23 species were found at A11 station while A04 and A15 stations boasted the fewest number with only one species respectively.

(2) Total biomass distribution (wet weight) of benthic organisms

Figure 5.4-8 shows the biomass distribution of benthic organisms at subtidal zones of the surveyed sea area. Biomass of the surveyed sea area ranges from 0.143g/m2 to 26.291g/m2, averaging at 6.986g/m2. A14 station boasts the highest biomass at 26.291g/m2 for large quantities of amphioplus laevis with big wet weight were collected at the station. A04 station boasts the lowest biomass at 0.143g/m2 only.

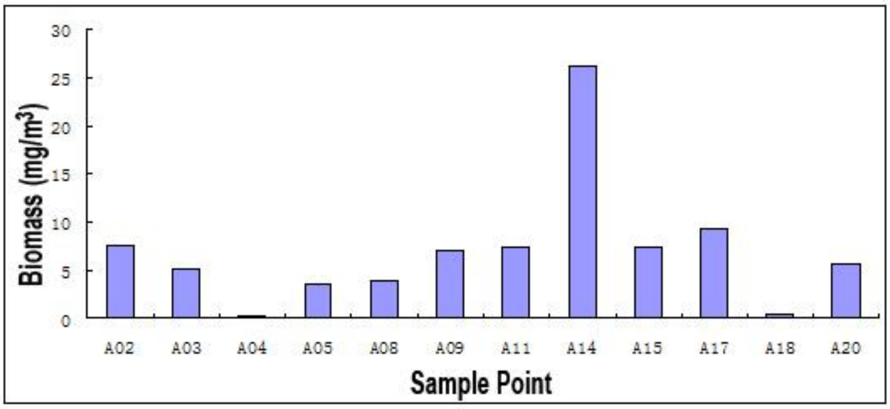


Figure 5.4-8 Biomass of benthic organisms at subtidal zones of the surveyed sea area

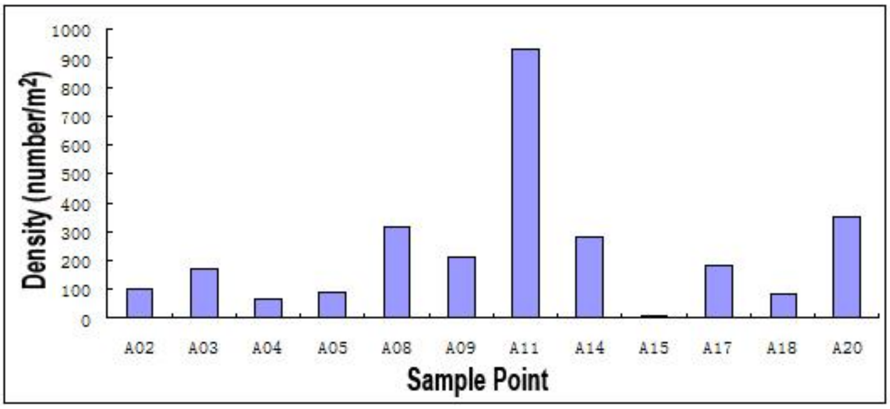


Figure 5.4-9 Density of benthic organisms at subtidal zones of the surveyed sea area

(3)Density distribution of overall individuals of benthic organisms

Please refer to Figure 5.4-9 for the density of benthic organisms. The range of density of the stations is from 10/m2 to 930/m2, averaging at 233/m2. A11 station has the highest density at 930/m2 for large quantities of tharyx sp. have been collected here. The lowest density is 10/m2 of A15 station.

(4)Ecological characteristic index

Abundance degree(d) of benthic organisms ranges from 0 to 5.194, averaging at a rather high value of 3.233 at each stations of the surveyed sea area (refer to Table 5.4.4 for details). The peak value appeared at A08 station.

Diversity index (H′) of benthic organisms of the surveyed sea area are on the low side averaging at 2.552 and ranging from 0 to 3.941 (refer to Table 5.4.4 for details). The peak value of diversity indices H′was found at A08 station.

Homogeneity degree(J′) of benthic organisms of the surveyed sea area is averaged at 0.890, a rather high value. Degree of homogeneity ranges from 0.596 to 1.000 (refer to Table 5.4.4 for details). A02 station has the highest degree of homogeneity while A11 station has the lowest at 0.596.

In terms of Dominance degree of benthic organisms of the surveyed sea area, it range from 0.200 to 1.000(refer to Table 5.4.4 for details). Average dominance degree is 0.521, which is at modest level.

Table 5.4.4 Ecological characteristic index of benthic organisms of the surveyed sea area

Sampling station	Abundance degree *d*	Degree of homogeneity *J′*	Diversity *H′*	Degree of dominance *D*
A02	3.909	1.000	3.322	0.200
A03	3.177	0.885	2.940	0.471
A04	0	--	0	1.000
A05	2.731	0.941	2.642	0.444
A08	5.194	0.928	3.941	0.281
A09	2.956	0.893	2.965	0.476
A11	4.854	0.596	2.697	0.699
A14	2.956	0.835	2.773	0.571
A15	--	--	0	1.000
A17	3.806	0.954	3.419	0.333
A18	2.885	0.980	2.750	0.375
A20	3.094	0.885	3.171	0.400
Average value	3.233	0.890	2.552	0.521

-- No data

(5) Summary and conclusion

The survey conducted in July 2011 is summarized in below.

- The benthic organisms monitoring results show that in total there were 7 phyla and 62 species identified with the largest quantity of polychaeta, which indicates the abundance of benthic organisms at the surveyed sea area is not very high. The species identified range from 1 to 23, averaging at 10. Biomass range from 0.143g/m2 to 26.291g/m2, averaging at 6.986g/m2. The range of density is from 10/m2 to 930/m2, averaging at 233/m2.

- The species diversity index (H′) of benthic organisms range from 0 to 3.941, averaging at 2.552. The abundance degrees (d) range from 0 to 5.194 (refer to Table 5.3.4 for details), averaging at 3.233. Homogeneity degree (J′) ranges from 0.596 to 1.000, averaging at 0.890. And degree of dominance varies from 0.200 to 1.000, averaging at 0.521. The assessment parameters vary significantly from one monitoring location to another.

- There were some areas under dredging during the survey. So the benthic organisms nearby were being disturbed; and the benthic organisms in the areas were at the early stage of community transition. While, other locations present stable community characteristics.

5.4.3.5 Fish egg and Fry

(1)Species composition

A total of 1,331 fish eggs and 134 fry fish were collected during the survey. Accounting for 86.19%

of total fish eggs, Sillago japonica plays the dominant role to be followed by sardinella with 5.35% and others with 8.46%. Among the fry, ambassid plays the dominant role with a proportion of 57.39% to be followed by Omobranchus elegans with 29.72%, then Clupanodon punctatus and Anchoviella sp. with 7.73% together.

(2)Quantity distribution

a) Species distribution

Fish egg species and fry fish range from 1 to 6 and 1 to 5 respectively at the stations of the surveyed sea area. A02 and A05 stations at the south of the surveyed sea area have more species with 5 and 6 fish egg species and 4 and 5 fry fish species respectively. A08 station has 4 fish egg species while other inner bay stations have only 1 or 2 species. And each of the inner bay stations have only 1 or 2 fry fish species. Overall, the fish egg and fry species decrease from south to north.

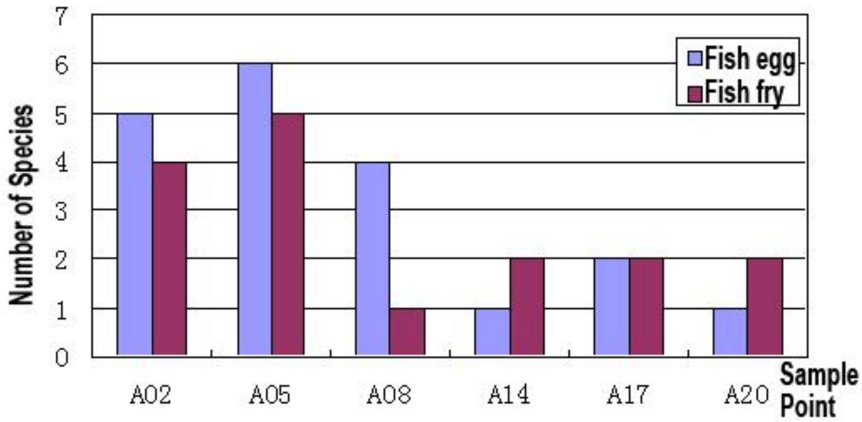


Figure 5.4-10 Distribution of Ichthyoplankton species

(2)Density distribution of fish eggs and fry

Average density of the surveyed sea area is 76.03 fish eggs/100m3 and 7.01 fry fish/100m3. Fish eggs appeared at each station with uneven quantity distribution and range of density from 0.25 fish eggs/100m3 to 255.98 fish eggs/100m3. High density was found at A02 and A05 stations at the south of the surveyed sea area with 255.98 fish eggs/100m3 and 182.58 fish eggs/100m3. Each of inner bay stations has fewer than 9.00 fish eggs/100m3 with A14 station the fewest at 0.25fish eggs/100m3.

There is a similar tendency of fry fish distribution featuring the highest density at A02 and A05 stations at the southern sea area with 6.03 fry fish/100m3 and 28.87 fry fish/100m3 respectively; while inner bay stations have lower density ranging from 1.00 fry fish/100m3 to 3.00 fry fish/100m3. Overall, there is substantial decrease from the bay south to north in terms of the amount of fish eggs and fry (Figure 5.4-11 and Figure 5.4-12).

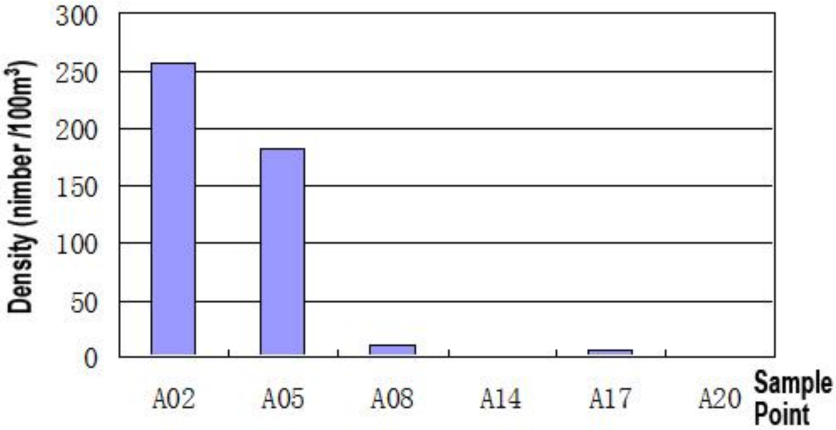


Figure 5.4-11 Density distribution of fish eggs

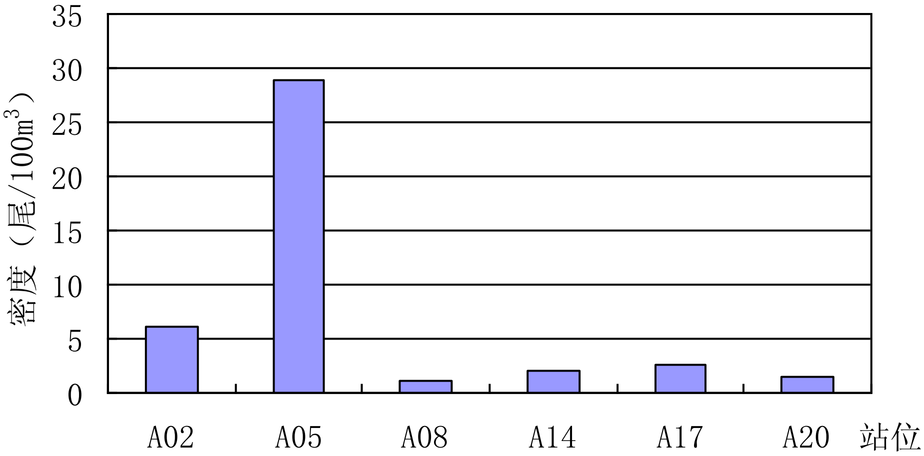


Figure 5.4-12 Density distribution of fry fish

(3)Dominant species

As the dominant species of the horizontally trawled fish eggs, Sillago japonica had average density of 65.53 fish eggs/100m3. It was mainly distributed at the two stations (A02 and A05 stations) at the southern part of the surveyed sea area with density of 239.79 fish eggs/100m3 and 151.53 fish eggs/100m3. It was scarcely seen at the inner bay.

Dominant species of fry fish mainly included ambassid and Omobranchus elegans. Average density of ambassid was 6.01fish/100m3 with A05 station boasting the highest density at 18.63fish/100m3. A05 station also boasted the highest density of Omobranchus elegans at 6.21fish/100m3 while the density of other stations ranged from 1.00fish/100m3 to 3.00fish/100m3.

(4) Summary and Conclusion

- During the survey, a total of 11 fish egg and fry species were identified. They belonged to 8 families and 7 genuses. Dominant fish eggs were those of Sillago japonica and dominant fry fish were ambassid and Omobranchus elegans.

- The density of fish eggs and fry fish was averaged at 76.03fish eeggs/100m3 and 7.01fish/100m3 respectively.

- In the southern part of the Bay there are more species and quantities collected than the sea area to the north of Putou Operation Area at the northern part of the surveyed sea area. The phenomenon is probably due to the more intensive human activities in the northern part of the bay.

5.4.3.6 Fishery Resources

(1) Overview

The fishery resources in Meizhou Bay was studied based on a trawl survey in January 2010 and comparison study at regional level. Historical records show there are used to be some 200 fishery species found in Meizhou Bay, including fishes, shellfish, crustacean, etc. During surveys conducted in 2006 and 2007, 142 fishery species were found, including 88 fish species, 52 crustacean species, and 2 cephalopod species. The surveys in 2006 and 2007 also indicate that the fishery species found in Meizhou Bay are mostly inner-bay or offshore species that live the whole life in the same sea area. No migratory fish or marine mammals were found in the Meizhou Bay.

(2) Survey time, locations and methods

Fujian Marine Research Institute set up three fish trawling stations (M04, M07 and M09) at inner bay sea areas of Meizhou Bay on January 3, 2010. The survey follows Specifications for Oceanographic Survey—Part 6: Marine Biological Survey (GB/T 12763.6-2008) and Technical Regulations for Impact Assessment of Construction Projects on Marine Living Resources (SC/T 9110-2007).

(3) Survey results

① Composition of collected species

According to samples of the trawled catch and samples collected from some fixed fish nets, a total of 42 species of nektonic organisms were identified, including 29 fish species and 13 crustacean species (Table 5.4.5).

Table 5.4.5 Species composition of nektonic organisms caught from at the surveyed sea area

Category group / Number of species	Fish	Crustacea		
		Shrimp	Crab	Squilla
42	29	9	2	2

②

Bottom trawls and catch in number

The average catch was 1.124 kg/net per hour and the average catch in number was 99.34fish/net per hour at the surveyed trawling sea area.

Among the catch, fish make the most part or 82.92% while the remaining 17.08% was made up of crustacean. In respect of catch in number, crustacean plays the dominant role with 84.56%, while fish occupy the other 15.44%. The comparison of catch and catch in number (table 5.4.6) collected by the three trawling stations indicates that M04 trawling station had higher catch and catch in number. Since the survey was conducted in winter, both catch and catch in number was few from each trawling station.

Table 5.4.6 Catch from bottom trawl at the surveyed sea area

Station	Statistical item	Total value	Fish		Crustacean	
			Quantity	%	Quantity	%
Trawl M04	Catch (kg/net per half hour)	0.962	0.909	94.49	0.053	5.51
	Catch in number (fish/net per half hour)	57	11	19.30	46	80.70
Trawl M07	Catch (kg/net per half hour)	0.270	0.142	52.59	0.128	47.41
	Catch in number (fish/net per half hour)	54	4	7.41	50	92.59
Trawl M09	Catch (kg/net per half hour)	0.454	0.346	76.21	0.108	23.79
	Catch in number (fish/net per half hour)	38	8	21.05	30	78.95
On average	Catch (kg/net per half hour)	0.562	0.466	82.92	0.096	17.08
	Catch in number (fish/net per half hour)	49.67	7.67	15.44	42	84.56

(3) Estimation of current resource quantity

According to the results (Table 5.4.7) calculated with the resource density computing formula, density and quantity of current nektonic organism resource of the surveyed sea area was estimated at 78,021fish/km2 and 883kg/km2 respectively. M04 has comparatively higher resource density and quantity, M07 has comparatively lower resource quantity and M09 has comparatively lower resource density.

Table 5.4.7 Estimated resource quantity of current nektonic organisms of the surveyed sea area

Station No.	Catch in number (fish/net per hour)	Fishery resource density (fish/km^2)	Catch (kg/net per hour)	Fishery resource quantity (kg/km^2)
M04	114	89535	1.924	1511
M07	108	84822	0.540	424
M09	76	59690	0.908	713
On	99.34	78021	1.124	883

average				

(4) Fishery resource analysis

According to samples of the trawled catch and samples collected from some fixed fish nets, a total of 42 species were identified, including 29 fish species and 13 crustacean species, including sixteen species with relatively high economic values, such as Clupanodon punctatus, mullet, weever, Silver sillago, silver bream, black porgy, black bream and Platycephalus indicus among other commonly seen fish. Among the crustacean caught were Trachypenaeus curvirostris, Metapenaeus ensis, Metapenaeopsis barbata, Charybdis japonica, Oratosquilla oratoria, etc.

The trawled catch weighed 1.96 G/fish on average and the average weight of fish species was 60.09g/fish. Though fish catch was in small number, some species of fish were big in size, e.g., Weever weighed at 248.5g/fish and black porgy 274.6g/fish. As small as 5cm or so in size, Metapenaeopsis barbata had dominant numbers in the crustacean catch that had the average weight of 2.29g/fish. And among the crustacean catch, Metapenaeus ensis played dominant role in respect of weight.

(5) Analysis and Conclusion

The findings of the trawl survey carried out in January 2010 in Meizhou Bay are summarized in below.

- The fishery species caught were not many, probably because of the winter weather. The other reason was that most of the fixed net were not put into use because in fishermen mostly were engaged in seaweed aquaculture during the survey period. Hence what was caught through fixed net was not many as well.

- According to samples of the trawled catch and samples collected from some fixed fish nets, a total of 42 species of nektonic organisms were identified, including 29 fish species and 13 crustacean species. No cephalopoda mollusc was caught.

- The average catch was 1.124 kg/net-hour and the average catch in number was 99.34fish/net-hour at the surveyed trawling sea area. Among the catch, fish make the most part or 82.92%. In respect of catch in number, crustacean plays the dominant role with 84.56%. Quantity and density of current nektonic organism resource of the surveyed sea area was estimated at 883kg/km2 and 78,021fish/km2 respectively.

The Meizhou Bay Port (Putian-Quanzhou) Master Plan Environmental Assessment made fishery species comparison between Meizhou Bay and neighboring Quanzhou sea area. Records show that in Quanzhou sea area some 600 fisheries species were found, including 291 fish species, 68 crab species, 24 cephalopoda species, 128 shellfish species and 116 other species. Apparently by comparison the fishery resources are much less abundant in Meizhou Bay than in Quanzhou. In addition, marine mammals such as white dolphin and Chinese sturgeon were found in Quanzhou Bay.

The reasons that there is much less fishery species in Meizhou Bay are considered the following.

- Nutrients brought by fresh water to sea and the interaction between freshwater and saline are particularly favorable for habitat formation, and growth and reproduction of fish and other species. In this regard, the two neighboring bays, i.e. Xinghua Bay in the north and Quanzhou Bay, are much more advantageous than Meizhou Bay. There is a major river Mulan Creek flowing into Xinghua Bay and forms important fish habitats. Likewise, two major river Jin River and Luoyang River join the Quanzhou Bay and form a significant estuary wetland. While, as previously noted, there is only a small river Fengci Creek that brings very limited sediments and nutrients into Meizhou Bay.

- Meizhou Bay lacks important habitats such as mangroves, estuary wetland to support significant fishery resources.

- Meizhou Bay has enjoyed a long history of important navigation and port development. The industrial development in the Meizhou Bay area has been significant in the past decade. Intensive human activities and development has posed impacts on the abundance and diversity of fishery resources.

5.4.3.7 Inter-tidal Zone

As previously noted, the total inter-tidal area in Meizhou Bay is about 142 km2. The two backfill areas, i.e. Putou and Xiaocuo Backfill Area, will be built on top to inter-tidal area that amount to about 5 km2 in total. A survey of inter-tidal zone conducted October 2010, as presented in the Meizhou Bay Port (Putian-Quanzhou) Master Plan Environmental Assessment, was reviewed. Another study on the Putou inter-tidal zone conducted during December 2009-January 2010 was also reviewed. Both study show that the inter-tidal zone have been modified by aquaculture farm activities. The environmental conditions at the studied inter-tidal zones are at normal level.

Figure 5.4.13 shows the intertidal zone in Meizhou Bay.

Figure 5.4.13 shows the intertidal zone in Meizhou Bay.

5.5 Baselines and Assessment on Marine Organism Quality

5.5.1 Stations layout and survey content

(1) Monitoring Locations and time: here were 2 marine organism quality survey stations as shown in Table 5.2.1 and Figure 5.2-1. One was close to A04 and A20 stations, near which Ostrea cucullata suspended in seawater was collected. The other was close to A20 station, near which bed-sown Ruditapes philippinarum(Short necked clam) was collected. Survey time was on July 8,

2011.

(2) Monitored items: There were seven monitored items including copper, lead, zinc, cadmium, arsenic, mercury and petroleum hydrocarbon. Please refer to Table 5.5.1 for the analysis method.

Table 5.5.1 marine organism analysis method

S/N	Item	Analysis method	Method source
1	Copper	Flame atomic absorption spectrophotometer	GB17378.6-2007
2	Lead	Non-flame atomic absorption spectrophotometer	
3	Cadmium	Flame atomic absorption spectrophotometer	
4	Zinc	Flame atomic absorption spectrophotometer	
5	Arsenic	Method with atomic fluorescence	
6	Mercury	Method with atomic fluorescence	
7	Petroleum hydrocarbon	Fluorescence spectrophotometry	

5.5.2 Marine organisms monitoring results and assessment

Table 5.5.2 shows the survey results of marine organisms.

Table 5.5.2 Organism quality survey outcome

Station No.	Species of organisms	Copper	Cadmium	Lead	Zinc	Chromium	Mercury	Arsenic	Petroleum hydrocarbon
		(mg/kg)							
A20	Ostrea cucullata	102	0.625	0.224	298	0.296	0.024	0.61	26.8
A20	Ruditapes philippinarum (Short necked clam)	0.85	0.167	0.054	8.97	0.223	0.010	0.53	11.0
A04	Ostrea cucullata	100	0.372	0.555	266	0.417	0.012	0.85	8.40
Category A standard of Marine Biological Quality		≤10	≤0.2	≤0.1	≤20	≤0.5	≤0.05	≤1	≤15

(1)Ruditapes philippinarum (Short necked clam): During the monitoring period, as indicated in Table 5.5.2, all Ruditapes philippinarum contents of copper, cadmium, lead, zinc, chromium, mercury, arsenic and oil meet requirements of Category A standard of Marine biological quality.

(2)Ostrea cucullata: During the monitoring period, as indicated in Table 5.5.2, Ostrea cucullata contents of all except arsenic, mercury and chromium meet requirements of Category A standard of Marine biological quality.

Chapter 6: Environmental Impacts Assessment and Mitigation Measures

6.1 Construction Stage

6.1.1 Impacts on Marine Ecology

The main construction activities include dredging/rock blasting, transportation and disposal of dredged materials at two backfill areas and the Meizhou Bay Marine Waste-dumping Site. Based on the environmental impacts scoping and screening, the key impacts on marine ecology during construction stage include:

(1) Dredging will damage the benthic organisms at the dredged section;
(2) Dredging will cause turbidity of sea water which will have impact on marine life;
(3) Rock blasting wave will have negative impacts on marine life;
(4) Backfilling the dredged materials (land reclamation) at Xiaocuo and Putou Backfill Area will cause loss of coastal wetland, and its ecosystem service function for aquaculture cultivation.
(5) Ocean dumping of dredged materials will have impacts on benthic organisms and water quality.

These impacts have been thoroughly assessed in this EIA. In summary, it can be concluded that the impacts associated with dredging/blasting and ocean dumping are of temporary nature and manageable. The habitats loss can be recovered in a short period of time. In terms of the backfilling, it will result in permanent loss of around 400 ha inter-tidal zone that are important habitats. However, compared with the overall 142 km2 inter-tidal zone in the context of Meizhou Bay, the loss is minor. With proper mitigation measures and ecological compensation (offset) measures, these impacts can be minimized and mitigated to acceptable level.

6.1.1.1 Dredging

(1) Impacts on benthic organisms

Dredging exerts direct impact on benthic organisms within dredging range which will be thoroughly damaged or destroyed. The channel to be dredged under Phase III –Stage 2 covers a total area of about 6.88km^2, and benthic organisms within the dredging area will be destroyed. Based on the ecological baseline survey conducted during the EA, the richness of the benthic organisms in Meizhou Bay is of low level, with an average biomass of only 6.896g/m^2 (samples in July 2011). It is estimated that the direct loss quantity of benthic organisms will be about 47.44t in areas to be dredged. Furthermore, secondary sedimentation of suspended sediments stirred up in dredging will also bury the benthic organisms on both sides of the dredging area and bring certain impacts on benthic organisms close to the dredging area as a result. According to relevant research references, about 30% benthic organisms within 100m to both sides of the dredging area will also be damaged and the damaged sea area covers about 2.75km^2. The loss quantity of benthic organisms is estimated at about 5.69t. Therefore, the total benthic organism loss of Phase III –Stage 2 will be about 53.13t. According to *Environmental Impact Statement on Phase III- Stage-1,* the total dredged area is about 4km^2, with total loss of benthic organisms of 28.3t. In summary, both Stage 1 and Stage 2 of Phase III would cause loss of benthic organism of 81.43 t.

The total dredged area of both stages is about 10.88km^2. This is only around 2% of the total Meizhou Bay area. Furthermore, according to historical data, the loss of benthic organism in the dredged area will gradually restore to the previous level in 2 years. Therefore, the impact on dredging will not significantly convert or degrade the natural habitat for benthic organisms in the Meizhou Bay. The impact is of temporary nature and will be fully recovered in relatively short time period.

(2) Water turbidity and impacts on planktons, fish eggs and fry

Sediments scattered to the sea during dredging will transport and diffuse with tides. During the process, large particles quickly settle down to the seabed while plenty of fine particles (mostly with diameter of less than 0.063mm) will suspend in water to impact sea water quality or may be transported to tidal-flat areas by tidal flood currents to cause local sedimentation and affect neighboring sea areas or tidal-flat aquaculture. Modeling was conducted to assess the scope of such impacts.

Pollution Source Intensity

According to engineering analysis and research data, suspended sediments from construction stem from silt dredging and clearing. The source intensity density is shown in Table 6.1.1.

Table 6.1.1 Sediment Source Intensity of Dredging Process

Phase	Location of suspended sediments	Dredger type	Suspended sediments (SS) Quantity-frequency (Qf)
Stage-2, Phase III	Dasheng Island - Luoyu (inner bay section)	4500m3 self-propelled TSHD	5.56kg/s
	South side of Jianyu anchorage(outer bay section)		5.56kg/s
	Suspended sediments from rock blasting and clearing	8m3 grab bucket dredger	0.312kg/s
Stage-1, Phase III	70,000dwt Putou channel	4500m3 self-propelled TSHD	3.9kg/s
	Extension of Meizhou Bay Navigation Channel		2.78kg/s
	#4 anchorage		3.9kg/s
	Crossing zone		5.56kg/s
	North Putou channel area	1,600m^3/h cutter suction dredger	2.4kg/s
	#5 anchorage		2.4kg/s

Modeling

The modeling process is the summary of the special report on *Research Report on Numerical Modeling-based Calculation for Phase III* (August 2011) prepared by Hohai University. The forecast mode adopts the equation of 2D suspended sediment transport and diffusion. In modeling-based calculation, a variety of calculation points (standing for dredging sites) were deployed along the channel according to different operation areas. Figure 6.1-1, Figure 6.1-2 and 6.1-3 show calculation points layout. (Yellow points in the figures stand for the forecast points in mathematical modeling)

Table 6.1.2 Forecast points in dredging simulation according to different locations

Phase	Construction area location	Forecast points
Stage-2, Phase III	Dasheng Island - Luoyu Island (inner bay section)	136
	South side of Jianyu anchorage(outer bay section)	107
Stage-1, Phase III	70,000dwt Putou channel	21
	Suspended sediments from rock blasting and clearing	34
	Extension of Meizhou Bay Navigation Channel	41
	#4 anchorage	28
	Crossing zone	86
	North Putou channel area	20
	#5 anchorage	21

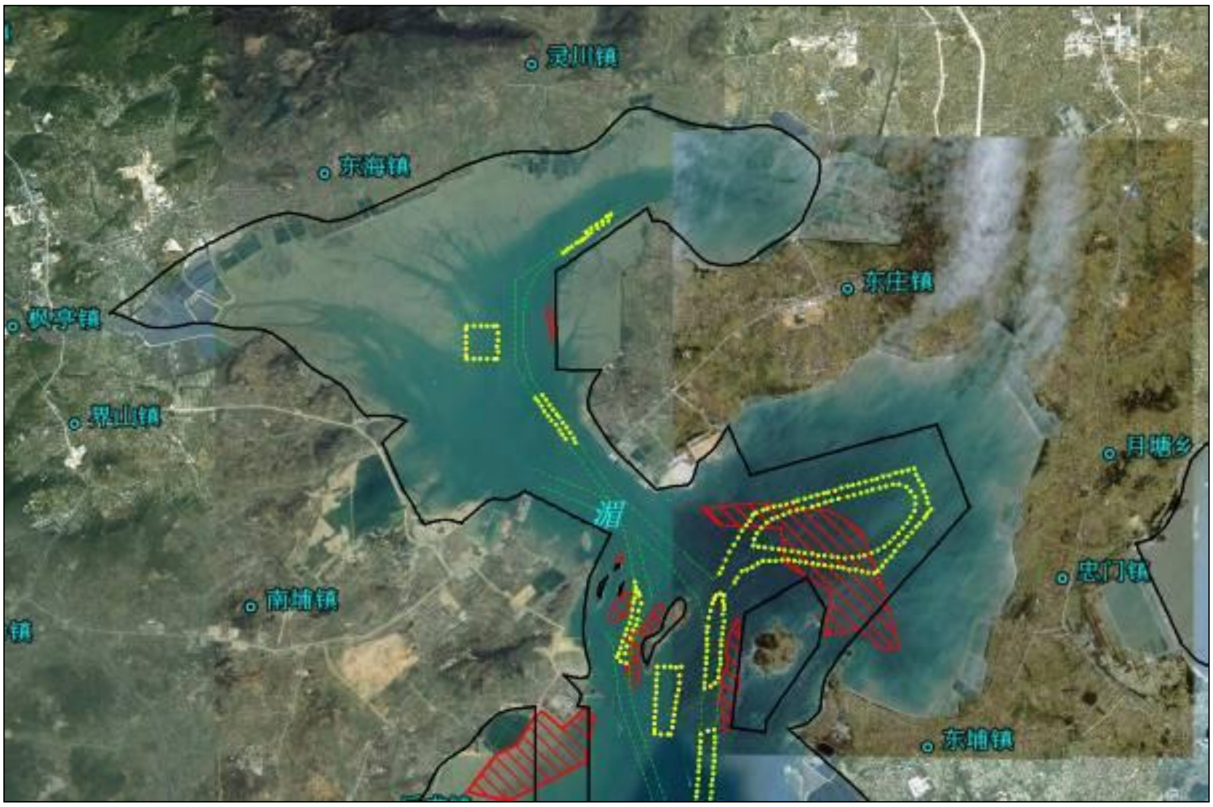


Figure 6.1-1 Layout 1 of calculation points in dredging simulation

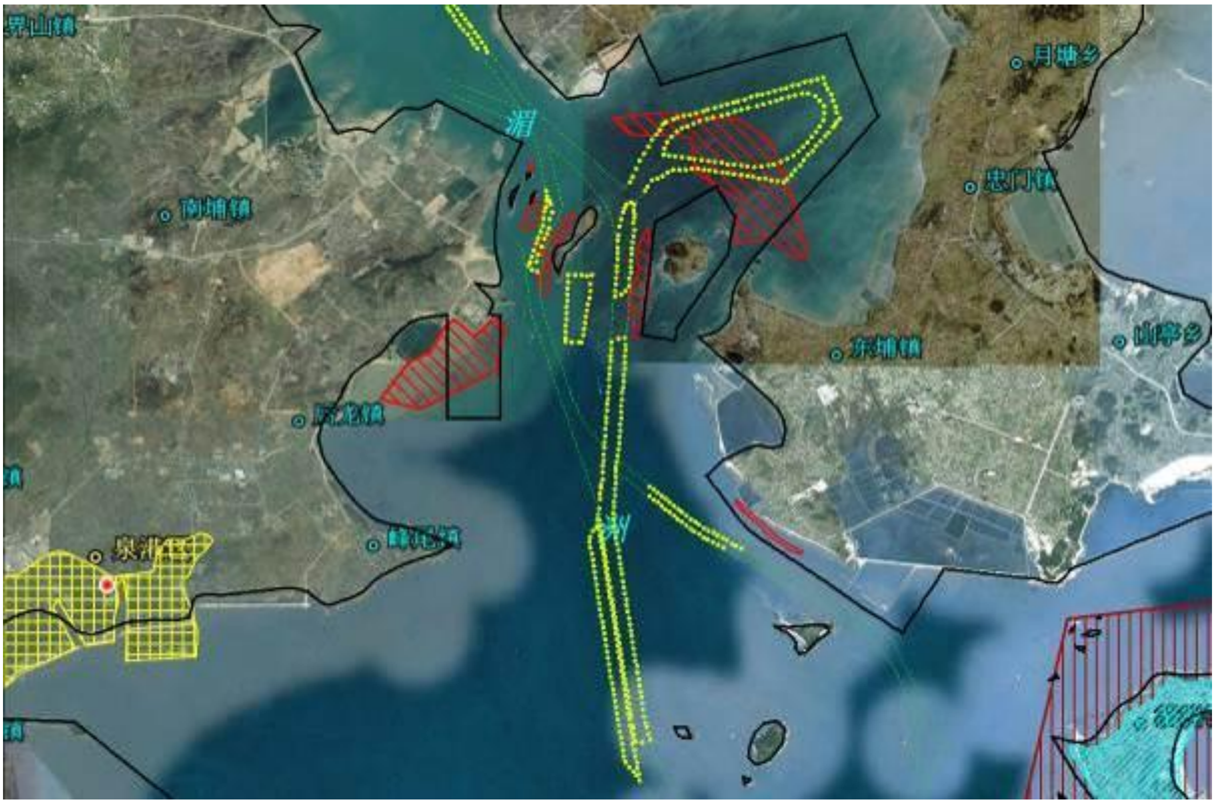


Figure 6.1-2 Layout 2 of calculation points in dredging simulation

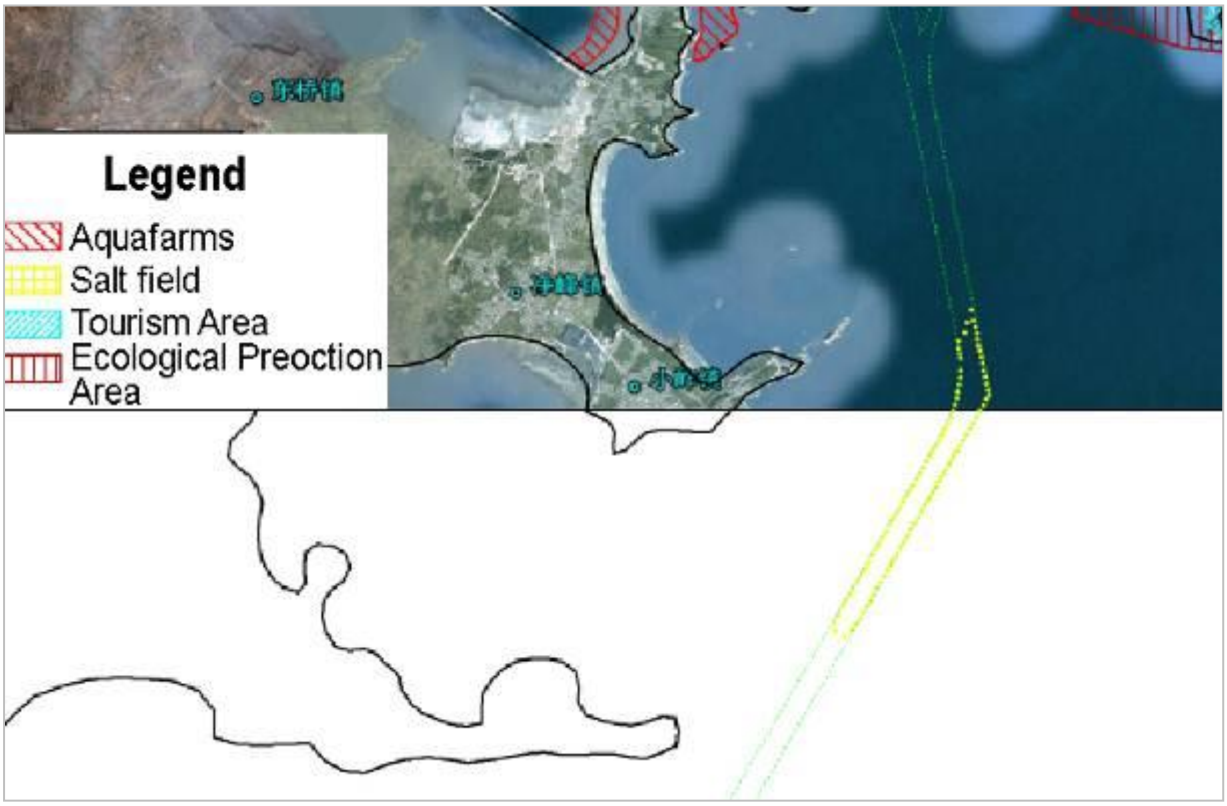


Figure 6.1-3 Layout 3 of calculation points in dredging simulation

Flood slack, ebb slack, flood tide and ebb tide are taken as construction commencement time for different calculation points when forecasting the widest range of possible impact of suspended sediments diffusion. Construction is carried out for 8 consecutive hours to identify the corresponding impact range. Then, according to the widest impact range calculated on the basis of four different points of initial time, an envelope diagram will be drawn to indicate the largest potential impact area caused by dredging. Finally, through superimposing largest impact area of suspended sediments on suspended sediments caused by overflow, the potential largest impact area of sediments diffusion can be identified.

Modeling Results

Figure 6.1-4 indicates the largest potential impacted area of suspended sediments caused by dredging. Table 6.1.3 indicates the corresponding areas of different concentration ranges.

Simulation results show that during dredging, the impact range of suspended sediments increment is mainly close to the dredging area. Adverse impact would mainly happen at the top of inner bay and central bay where there are aquaculture activities.

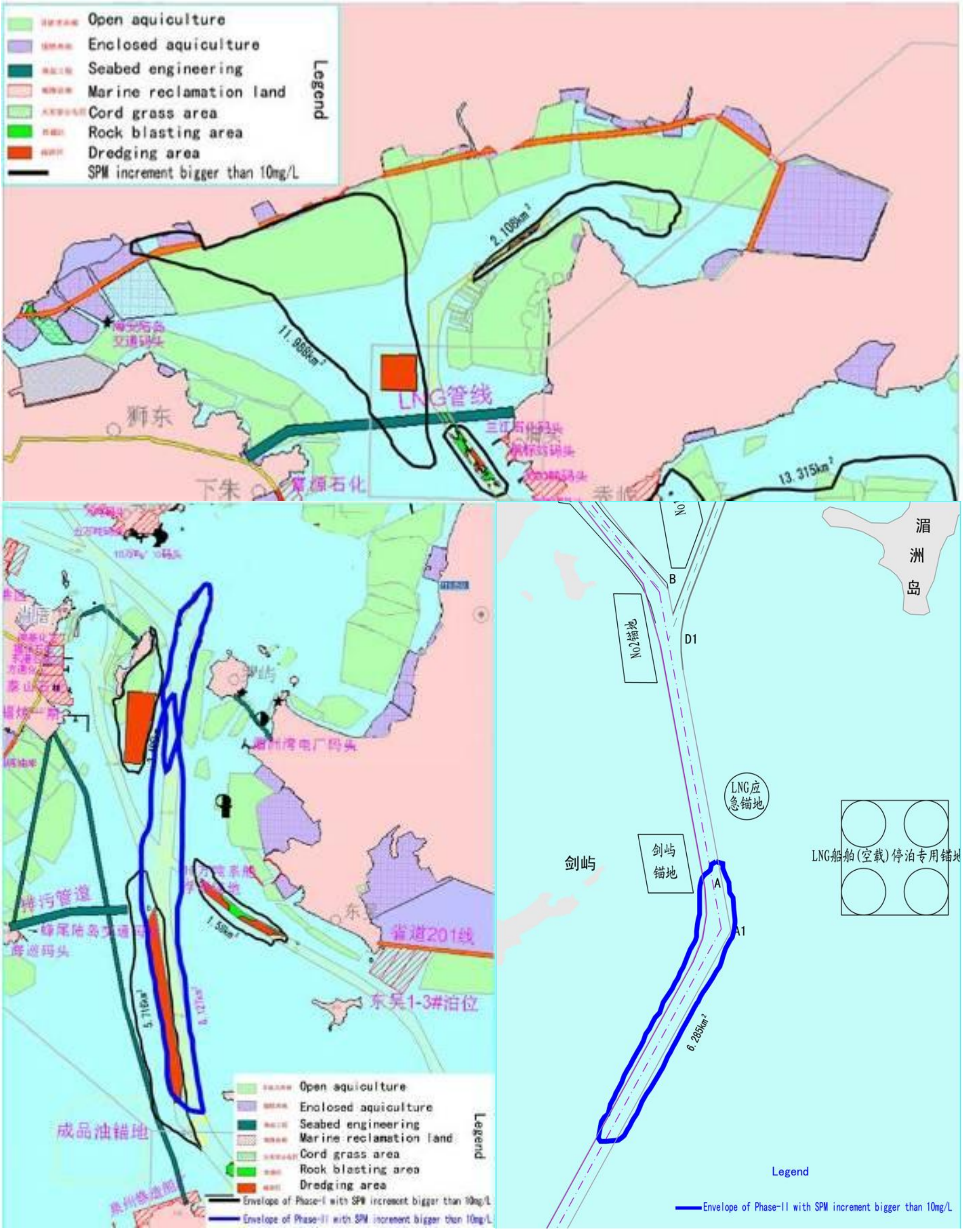
Table 6.1.3 Impact range of suspended sediments increments during full tide (km^2)

Phase	Construction area location	>10mg/l
Stage-2, Phase III	West Luoyu channel	2.393
	Dasheng Island - Luoyu Island(inner bay section)	8.127
	Main channel at south side of Jianyu anchorage(outer bay section)	6.285
Stage-1, Phase III	70,000dwt Putou channel	0.256
	Suspended sediments from rock blasting and clearing	
	Extension of Meizhou Bay Navigation Channel	1.580
	#4 anchorage	2.485
	Crossing zone	5.716
	North Putou channel area	2.108
	#5 anchorage	11.988

Impacts

Impacts on plankton - Dredging impacts on phytoplankton are firstly reflected in higher turbidity and lower diaphaneity of sea water caused by suspended sediments, which are unfavorable for the reproduction and growth of phytoplankton. Additional impacts include those on zooplankton in respects of growth rate, feeding rate, etc. According to the test on toxic effects of suspended sediments from channel dredging on aquatic organisms at the estuary of Yangtze River, zooplanktonic survival rate and phytoplanktonic photosynthesis will be affected under suspended sediment concentration of up to 9mg/L. Since the dredging activity is only a temporary impact, and is of small scale for the whole Meizhou Bay area, such impact is limited, and will quickly recover when dredging operation stops.

Impacts on fish eggs and fry - Suspended sediments will form a high concentration field of suspended sediments diffusion within a certain range. Suspended particles will directly harm the fry of marine organisms mainly in respect of embryonic development. Death of organisms may be caused by suffocation from gill choking, severe oxygen deficiency in water bodies with large quantities of suspended



K_{ij} —— Resource loss fate of Species *i* organisms at Category *j* concentration increment area of a certain pollutant (%);

n —— Total subareas of concentration increment area of a certain pollutant.

Figure 6.1-4 Scope of Suspended Sediments during Dredging at Full Tide

Loss of marine living resources due to sediments re-suspension – According to SC/T 9110-2007 *Technical Regulations for Impact Assessment of Construction Projects on Marine Living Resources*, the marine living resources losses is presented in Table 6.1.3, the sea area where SPM (suspended particle matters) increment during construction of Stage-2, Phase III exceeds the category II standard covers an area of 16.81km^2 and the sea area where SPM increment during construction of Stage-1, Phase III exceeds the category II standard covers an area of 24.1 km^2. The average number of cycles for continual impact of suspended sediments takes 2 and the mean water depth takes 15m. The average resource density is taken according to survey of current conditions of the sea area for engineering. The estimate of marine living resource is shown in Table 6.1. 4 and Table 6.1.5.

Table 6.1.4 Loss quantity of marine living resources caused by construction-induced suspended sediments at Stage-1, Phase III

S/N	Biological species	Standard-exceeding area (km^2)	Average resource density	Resource loss rate (%)	T	Quantity of resource loss
1	Fish eggs	24.1	0.7603/m^3	30	2	1.65×10^8
2	Fry	24.1	0.0701fish/m^3	30	2	1.52×10^7 fish
3	Phytoplankton	24.1	65.53×10^6/m^3	30	2	1.42×10^{16}
4	Zooplankton	24.1	102.77mg/m^3	30	2	22.3t

Table 6.1.5 Loss quantity of marine living resources caused by construction-induced suspended sediments at Stage-2, Phase III

S/N	Biological species	Standard-exceeding area (km^2)	Average resource density	Resource loss rate (%)	T	Quantity of resource loss
1	Fish eggs	16.81	0.7603/m^3	30	2	1.15×10^8
2	Fry	16.81	0.0701fish/m^3	30	2	1.06×10^7 fish
3	Phytoplankton	16.81	65.53×10^6/m^3	30	2	0.991×10^{16}
4	Zooplankton	16.81	102.77mg/m^3	30	2	15.55t

Impacts on fishes. Sediments re-suspension would impact the growth of food (such as plankton) for fish and normal breath of fish. However, since fish are active in moving, dredging activities would firstly drive fishes away. A small amount of fish staying in the vicinity of high concentration suspended sediments may be affected. Overall, the impacts of dredging on fish are considered minor and of temporary nature. In addition, baseline ecological survey concluded that fish resource in Meizhou Bay is relative less than other bays along Fujian costal area, (e.g. Quanzhou Bay) due to lack of feeding rivers, important fish habitats and intensive use as navigation channel for many years. Maizhou Bay is not an important habitat for any rare or endangered fish species. Due to less fish resources, there is no commercial fishery activity within the Meizhou Bay area. Therefore, the temporary turbidity increase within the vicinity of limited dredging area would result in little loss of fish resources.

In summary, modeling has confirmed that the dredging operation will cause increase water turbidity limited to the vicinity of dredging areas which is small scale in the whole Meizhou bay context. This limited and temporary nature of such impact will have limited and temporary impacts on the marine living resources in the area.

6.1.1.2 Underwater Rock Blasting

Underwater explosion has always been in the focus of national and international experts during their research on marine organisms particularly fish. According to researches, blast waves will create instantaneous high pressure to spread in the form of waves and impact nearby organisms. Impacting animals in a way different from those from explosion in the air, blast waves from under-water explosion usually spread forward right through fish body since fish body and water have similar density. However, when air cavities exist in fish body, blast waves getting through will result in the avulsion or fragmentation of cavity walls due to air condensability. The main reason for death of fish is that explosion causes fish bladders to burst (in terms of fish with air bladders). In addition to fish bladders, other inner organs are also easily damaged. The longer distance from the explosion site, the smaller impact of explosion on fish will be brought. Fish without air bladders have much greater chance of survival under the same conditions. The lighter the fish of same species, the bigger impacts they will get from explosion.

To prevent fish eggs and fries of spawning areas from being hurt by explosion, the Canadian instruction manual for using explosive materials at fishing zones provides the minimum distance of explosive materials in different quantities away from spawning areas for blasting operation (Please refer to Table 6.1.8).

Table 6.1.8 Safe distance for fish in blasting operation

Quantity of explosive (kg)	Distance (m)
5	45
10	65
25	100
50	143
100	200

Chinese scholars have also conducted a series of on-site tests to find out the impacts of underwater blasting on marine organisms (by taking fish as the research subject).

In 1982 and 1983, Yellow Sea Fishery Research Institute, Chinese Academy of Fishery Sciences conducted tests in Jiaozhou Bay and Laizhou Bay of Shandong Province to find out the impacts of underwater blasting on fish and benthic organisms.

Test results indicate that under the condition of 3kgTNT and hole depth of 30m, marine organisms within 60m from the explosion site were damaged to a greater or less extent.

During underwater blasting for the Meizhou Bay thermal power plant project in April 1998, abalone in net-cage cultivation 600-700m away from the blasting site died continually to various extent. Substantial impacts were brought to the fish within 1,000m or so around the blasting site, mostly fish eggs and larval fish, particularly Sciaenidae (like yellow croaker).

According to the rock blasting test carried out by East China Sea Fishery Research Institute, Chinese Academy of Fishery Sciences among other organizations at the project site of Yangshan Port channel in November 2003, the mortality rate of organisms during blasting with total quantity of explosive charge of 980kg and single-stage priming of 250kg gradually lowers with the increase in the distance from the blasting center (as shown in Figure 6.6-1). Fish, particularly Sciaenidae (like yellow croaker) are the most sensitive to blasting-induced effect. Shrimp and crab are less sensitive and molluscs boast the weakest sensitivity. The mortality rate of organisms is about 25% at a distance of 300m from the blasting center, 10% at 500m and almost zero at 1,000m. Underwater drilling and blasting was used in rock blasting tests. Since explosive charge blast inside rocks, surge waves aroused with the energy bursting from the blast orifice features strong directionality. A large part of the energy is perpendicular to water surface and escapes to the atmosphere or cast water to form high penniform water columns. Therefore, excessive pressure of surge wave increases with water depth. It was observed that there was a comparatively high rate of mortality among bottom fish, which received greater pressure of surge wave than surface fish. Taking the high mobility of fish into consideration, it is an effective measure to lessen the impact of rock blasting operation on local fish by dispelling fish to a place far from blast areas before rock blasting commences. Suitable periods of time other than spawning seasons may be chosen for blasting operation to reduce the adverse impact on fish eggs and other marine organisms with limited mobility.

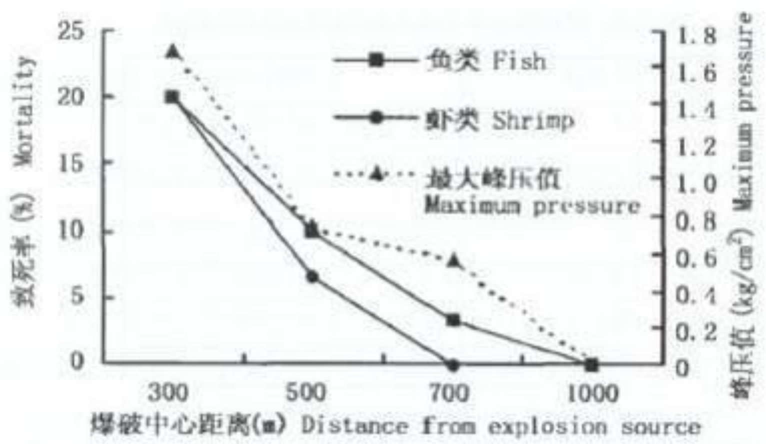


Figure 6.1-5 Relation between the explosion-induced mortality of marine life and the distance from explosion source

The underwater blasting will result in marine life resources near the vicinity of the blasting spot. An estimate of such loss is calculated following the national *Technical*

Regulations for Impact Assessment of Construction Projects on Marine Living Resources, with the following formula:

$$W_i = \sum_{j=1}^{n} D_{ij} ij \times S_i \times K_{ij} \times T \times N$$

Where:

W_i —— One-off average loss quantity of Category *i* living resources, unit: fish, number, and kg;

D_{ij} —— Resource density of Species *i* organisms at Category *j* affected area, unit: fish/km^2, number/km^2, and kg/km^2;

S_j ——Coverage of Category *j* affected area, unit: km^2;

K_{ij} ——Mortality rate (%) of Category *i* living resources in Category *j* affected area;

T —— Number of blasting impact cycles (taking 15 days as a cycle);

N ——Accumulation coefficient of blasting times with 15 days included in a cycle, taking 1.0 for blasting once and increasing by 0.2 with each additional time;

n ——Total subareas of peak pressure value of blast waves.

According to calculation results of peak pressure induced by underwater rock blasting with 100kg explosive charge of single-stage priming, relevant regulations in Annex C of *Technical Regulations for Impact Assessment of Construction Projects on Marine Living Resources(SC/T 9110-2007)* provide reference on loss rate of marine organism resource including fish and shrimp within 260m from the rock blasting site. Please see Table 6.1.9 for the relation between the maximum peak value of pressure and the mortality rate of tested organisms.

Table 6.1.9 Relation between the maximum peak value of pressure and the mortality rate of tested organisms

Maximum peak value (MPa)	0.17	0.075	0.058
Fish (excluding Sciaenidae) (%)	20	10	3
Mortality rate of shrimps (%)	20	6.6	0

The marine living resources loss due to underwater rock blasting is estimated in Table 6.1.10.

Table 6.1.10 Estimated Marine Living Resource Loss by Underwater Rock Blasting

	Stage-1,Phase III	Stage-2, Phase III
One-off loss quantity of fish (t)	0.49	0.58
One-off loss quantity of shrimps (t)	0.08	0.11
Total one-off loss quantity (t)	0.57	0.69

Underwater rock blasting during Stage-1 of Phase III will cause a potential one-off loss quantity of nektonic organisms including fish and shrimps of 0.57t and the figure is 0.69t for Stage-2 of Phase III. Construction cycle of rock blasting lasts 33 months and T takes 66. In case of 5 blasting times during one such cycle and the blasting times accumulation factor N is 1.8, total loss quantity of nektonic organisms reaches 149.69t during the project construction, including 67.72t of Stage-1of Phase III and 81.97t of Stage-2 of Phase III.

Nektonic organisms usually possess strong capability of migration. The project construction will result in the temporary migration of nektonic organisms to other sea areas. After the project construction is completed and the marine environment of the project area basically stabilize can the nektonic organisms be moved back to the project area and neighboring areas. Therefore, the actual loss quantity of nektonic organisms will be less than estimated.

During blasting operation, a series of measures will be adopted to minimize the impact on marine life. These include strict control of explosive load, small-load prior blasting to drive away fish, run noisy equipment (drilling machine or air compressor) for 10 min. to drive away fish before blasting, avoid end of spring and early summer time to minimize the impacts on spawning, deploy large fish monitoring program around 2000m perimeter of blasting and establish first aid system for large fish. With effective implementation of these measures, the potential impact on marine life will be significantly minimized and mitigated.

6.1.1.3 Ocean Dump of Dredged Material

According to the zoning plan announcement made by State Oceanic Administration (SOA), the location of Meizhou Bay Marine Waste-dumping Site is indicated in Figure 2.2-1 and its general situation is indicated in Table 6.1.11.

Table 6.1.11 Information on Meizhou Bay dredged materials offshore dumping area

Sea area located	Position of central point	Radius (nautical mile)	Area (hm^2)	Dumping quantity per year (unit: million m^3)
Meizhou Bay	119º04´48"E 24º52´33"N	0.5	269	4

This ocean dumping area is officially designated as dredged material dumping area according to the ocean water zoning plan of the State Oceanic Administration. Since the outer bay dredged area of the assessed project is about 23-29km from the nearest Xiaocuo backfill area but only 5.5-10.6km from the offshore dumping area for materials dredged from Meizhou Bay, the feasibility study report suggests that 6.6 million m3 dredged from outer bay enter the Meizhou Bay dredged materials offshore dumping area.

Xiamen Central Ocean Station of State Oceanic Administration prepared the *Report on the Zoning Plan of Meizhou Bay Dredged Materials Offshore Dumping Area* (August 2010) based on comprehensive technical, social, environmental and economic analysis. Main findings and conclusions of the report is referenced in below.

(1) Physical and chemical analysis shows the dredged materials in Meizhou Bay are clean, uncontaminated, and is categorized as Clean (Class I) dredged

materials. With proper dumping frequency and other management measures implemented, the dumping will not result in significant negative impacts on water quality. During dumping, suspended solids concentration will increase within the dumping site. However, the impacted area is limited. Since the dumping will conducted in an intermittent and temporary manner, the suspended solids concentration will recover to baseline value in a short period of time upon completion of the dumping.

(2) Hydrodynamics modeling result show that the dumping area is subject to strong hydrodynamics conditions, i.e. deep water, strong tide and rapid current. Most of the dumping sediments will move and disperse outward against the Meizhou Bay under rapid ebb tide. Therefore, sedimentation will be limited and will not result in significant impacts on sediments quality and seabed topography in the vicinity of the dumping area.

(3) Main negative impacts would be the damage to benthic organisms covered by dredged materials. It is estimated that the total loss of benthic organisms would amount to 16 ton; the total loss of fry and fish eggs would amount to 4.6 t. It will take a period of time for the benthic organisms to fully recover upon completion of the dumping operation. Increased suspended solids will impact fishery resources directly and indirectly. However, the impact is reversible and localized in the dumping area.

(4) Hydrodynamics modeling result show the impact zone of the dumping suspended sediments is about 6.3 km southward and 4.7 km northward. The impact zone is far away from nearest sensitive areas such as Meizhou Island reserve, Dahu Bay and Dagang Bay aquaculture area. The sensitive areas won't be impacted by the dumping operation.

(5) The dumping site is 6 nautical miles from nearest coastline and belongs to offshore fishing zone. Trailer fish catching is not allowed in the area. Main fishing operations in the zone are fixed net etc. Therefore the dumping won't impact fishing activities.

(6) The erosion and sedimentation in the duping area is currently at balance. It is anticipated that, after receiving all the dredged materials, the seabed elevation in the dumping area would increase less than 1 m, and mostly below 0.2 m outside the dumping area. Hydrodynamics and sedimentation modeling result show the changes won't result in significant impacts on nearby channel and anchorage zones.

(7) The dumping area is located in deep-water and spacious sea area outside Meizhou Bay. Dredged materials will be transported to the dumping site by self-propelled barge. At maximum daily dumping load, 16 barges will be used. Such transportation operation won't result in disturbance to navigation channel. With proper navigation management in place, navigation accidents can be avoided.

Main environmental management measures include the following.

(1) Limit the volume of dumping materials. According to the report and permit issued by the SOA, the maximum annual dumping should not exceed 4 million m3, and maximum daily dumping should not exceed 22.68 thousand m3. Since the total amount of dredged materials from outer bay channel section dredging is amount to 6.6 million m3. By spreading the dredging/dumping to two years, approximately 3.3 million m^3 dredged materials can be dumped per year, which meets the SOA's requirement.

(2) Dumping operation shall be carried out under the supervision of marine and marine affairs authority. Dumping operation can be started after specific dumping operation plan and evaluation report are approved by the responsible authorities. Dumping operation shall strictly follow the approved plan at designated location.

(3) Dumping operation shall be carried out in an even manner and to the extent possible, avoid spawning period or optimize dumping volume during the spawning period in order to minimize fishery resources losses. Dumping shall be carried out at ebb tide period to the extent possible to facility the dispersion of suspended sediments.

(4) Safety measures shall be implemented, including strictly limiting the loading volume, strengthen operation safety, avoid bad weather or ocean conditions, suspending operation during low visibility, and remain updated with weather and ocean forecast.

(5) Ecological compensation to offset the loss of marine living resources is recommended. An ecological compensation plan has been prepared and included in the Environmental Management Plan.

(6) A follow-up monitoring program for the dumping operation is prepared, which is incorporated into the EMP.

6.1.1.4 Disposal of Dredged Material for Land Reclamation

Besides the dredged material disposed of in the off-shore ocean dump area, the remaining 36.5 million m3 dredged material will be placed in Poutou Backfil Area (32.5 million m3) and Xiaocuo Backfill Area (4 million m3) respectively. In Putou and Xiaocuo there are existing port area (also referred to as operational area), namely, #1 and #2 Putou Berth and #1~#4 Xiaocuo Berth. Upon completion of the backfilling operation, Putou and Xiaocuo Backfill Area will be constructed to expand the existing port areas by port developers, i.e. Putou Port Development Company and Xiaocuo Port Development Company respectively.

The two backfill areas are mainly inter-tidal zone. On one hand, by reusing the dredged materials rather than directly dumping into ocean, this disposal option substantially reduces materials needs for filling materials that would otherwise needed for port development from other sources, thus reducing substantial impacts results of ocean dumping and the potential environmental concerns from materials exploitation. On the other hand, the backfill will permanently occupy the inter-tidal zone which provides important ecological services and livelihood uses.

Figure 6.1.6 (a) shows current coastal line (blue), low tide line (light blue) in Meizhou Bay and the two backfill areas (yellow line). Inter-tidal zone refers to the area between high tide line (roughly the coastal line in this case) and low tide line. The intertidal zone of Meizhou Bay is about 142 km2 in total, while the two backfill area totaling 406 ha, i.e. 2.9% of the total inter-tidal zone of Meizhou Bay.

Figure 6.1.6 (a) Meizhou Bay intertidal zone and backfill areas

(1) Putou Backfill Area

As is shown in Figure 6.1.6 (a), in Putou currently #1 and #2 Putou Berth have been built. The Putou Backfill Area is located in the north of #2 Poutou Berth. The backfill area will serve as the foundation of #3~#25 berth. Eventually, the 25 berths will form the Putou operational area.

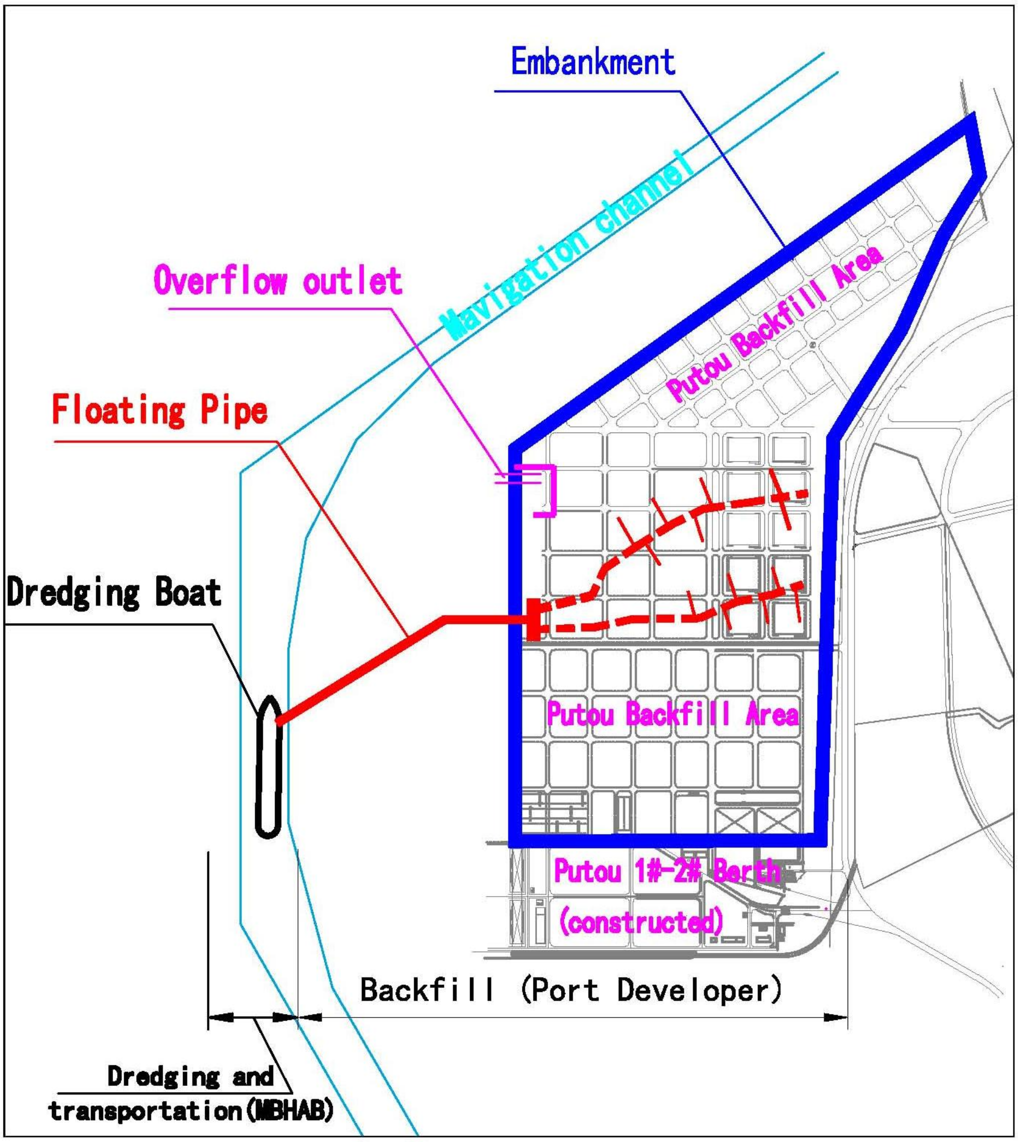


Figure 6.1.6 (b) Putou Backfill Area

(2) Xiaocuo Backfill Area

As is shown in Figure 6.1.6 (c), in Xiaocuo, #1 ~ #4 Xiaocuo Berth have been built. The Xiaocuo Backfill Area is located in the southeast of #4 Xiaocuo Berth. The backfill area will serve as the foundation of #5~#6 berth. Eventually, the 6 berths will form the new Xiaocuo operational area.

Impacts

During construction, main ecological impacts are loss of living resources and intertidal habitats due to reclamation and impacts on adjacent marine ecological environment due to sediments discharge from the backfill area. The former is irreversible while the latter is of short-term and reversible.

Loss of intertidal habitats - The Poutou Backfill Area will occupies 350 ha of intertidal zone, thus result in permanent change of the ecological function in the area. The Xiaocuo Backfill Area will occupies 56ha of intertidal zone. In total, the loss is 2.9% of the 142km2 intertidal zone of Meizhou Bay. This loss is minor and will not result in significant change of local biodiversity.

Loss of inter-tidal zone living resources – By estimates, reclamation will result in loss of 24.1 t benthic organism in the Putou Backfill Area, and 3.9 t in Xiaocuo Backfill Area, as Table 6.1.12 shows.

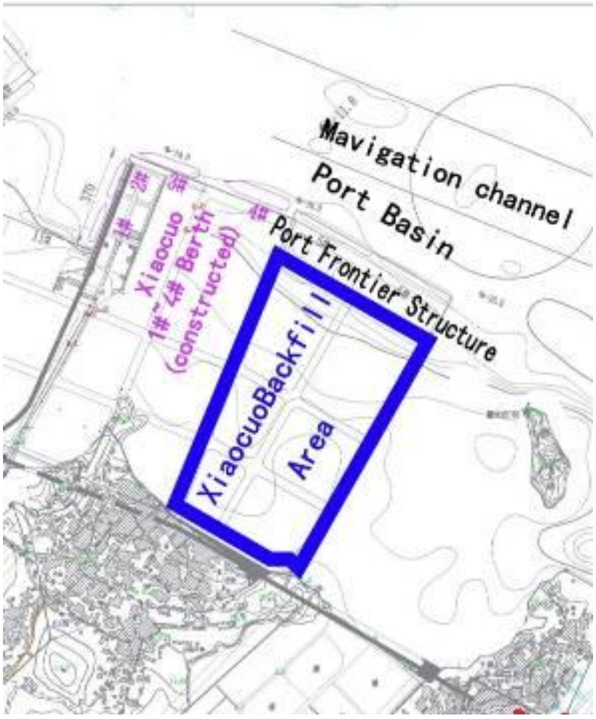


Figure 6.1.6 (c) Xiaocuo Backfill Area

Table 6.1.12 Calculation of living resources loss at backfill areas

Backfill area	Total inter-tidal area of occupation (ha)	Quantity of benthic organisms	Loss quantity of resources (t)
Putou backfill area	350	$6.896 g/m^2$	24.1
Xiaocuo backfill area	56		3.9

Impacts on ecological services – The backfilled intertidal zone belongs to coastal wetland. Reclamation will result in the change of wetland ecological services function. Based on the characteristics of the intertidal zone, three aspects are analyzed.

- Productivity of organisms. The area is mainly used as aquaculture cultivation of seaweed, mussel, and oyster, etc., meaning the direct ecological services of the wetland is the production of organic matters. Reclamation will result in loss of the function in the 350ha area totally.
- Biodiversity. According to marine ecological survey, there is no endangered or rare marine species identified in the area. The various benthic organisms and plankton in the area are common species and widespread in the Meizhou Bay. Therefore, biodiversity will not decrease significantly as result of the project.
- Coastal wetland carrying capacity. The coastal wetland plays an important role in global and regional water cycle system. It slows down water movement, facilitate the sedimentation process. Meanwhile, through its metallization and physical-chemical function various organic and inorganic matters are decomposed or transferred to non-hazardous or beneficial matters. Coastal wetland provides substantial economic, social and health value through its cleaning function. The Meizhou Bay coastal wetland, in the form of mudflat, presents certain levels of carrying capacity. Since Meizhou Bay is a tidal bay that lacks significant sediments and nutrient input being brought by rivers, its carrying capacity is much less compared to the mangroves wetland in Quanzhou Bay. However, it still provides important ecological services at local level.

According to the ecological baseline survey, the Meizhou Bay is not a critical habitat. The biodiversity and biomass in the inter-tidal zone is less significant compared to the estuary wetland or mangroves wetland in neighboring Xinghua Bay and Quanzhou Bay. Furthermore, the total inter-tidal area in Meizhou Bay is about 142 km^2, in comparison, the two backfill areas of Putou and Xiaocuo will occupy about 4 km^2 inter-tidal area, which is only about 2.8% of the total Meizhou bay inter-tidal zone. A survey of inter-tidal zone conducted October 2010, as presented in the Meizhou Bay Port (Putian-Quanzhou) Master Plan Environmental Assessment, was reviewed. Another study on the Putou inter-tidal zone conducted during December 2009-January 2010 was also reviewed. Both study show that the inter-tidal zone in Meizhou Bay has been intensively modified by aquaculture farm activities, rather than habitats for natural species. Therefore, the reclamation of Putou and Xiaocuo area would not result in significant degradation or conversion of natural habitat in the context of whole Meizhou Bay area.

Impacts of sediments discharge – As analyzed in the environmental screening section, backfill disposal of dredged material will also have impact on water quality around the discharge outlet of the enclosure dike. For land reclamation, dikes are firstly built at backfill areas and paved with geotextile for reversed filtration before the dredged materials are backfilled. Since the amount of suspended sediments discharge reaches 139g/s in the tail water during backfilling, according to estimation, the impact range of suspended sediments is widest at ebb tide. The area where concentration of suspended sediments exceeds the limitation of 10mg/L is at the discharge outlets to extend 100m long and 20m wide in tidal direction. Due to tidal lockup, the area where concentration of suspended sediments exceeds the limitation of 10mg/L is at the sea area around the discharge outlets. The impact is short-term and will not significantly impact water quality and marine ecology.

6.1.1.5 Economic Evaluation of Ecological Impacts and Compensation Plan

The Technical Regulations for Impact Assessment of Construction Projects on Marine Living Resources (SC/T9110-2007) issued by Ministry of Agriculture in 2008 provides economic evaluation methods for the losses of marine living resources. According to this regulation, the economic value of marine living resources losses due to dredging/blasting and reclamation are calculated.

Table 6.1.6 presents the economic evaluation of marine living resources losses due to dredging. The unit price is an estimation and subject to change.

Table 6.1.6 Economic Evaluation of Marine Living Resources loss due to Dredging and Blasting Construction

Project	S/N	Species of organisms	Quantity of resource loss	Rate of fish fry conversion	Quantity of fish fry loss	Unit price of fish fry	Economic value (10,000 RMB)
Stage-1,Phase III	1	Fish egg	1.65×10^8	1%	1.65×10^6fish	0.5RMB/fish	82.5
	2	Fry fish	1.52×10^7 fish	5%	2.57×10^5fish	0.5RMB/fish	38.0
	3	Nektonic organism	67.72t	--	--	25RMB/kg	203.2
	4	Benthic organism	28.3t	--	--	10,000RMB/t	28.3
		Subtotal					318.1
Stage-2, Phase III	1	Fish egg	1.15×10^8	1%	1.15×10^6fish	0.5RMB/fish	57.5
	2	Fry fish	1.06×10^7fish	5%	1.06×10^5fish	0.5RMB/fish	26.5
	3	Nektonic organism	81.97t	--	--	25RMB/kg	204.9
	4	Benthic organism	53.13t	--	--	10,000RMB/t	53.1
		Subtotal					342.1
Total							660.1

Based on the above calculation and following the national regulation (SC/T 9110-2007), the economic compensation for the losses shall be 3 times the economic value of the one-off damage, because the dredging/blasting impacts are considered temporary. The result is shown Table 6.1.7.

Table 6.1.7 Economic Compensation for Marine Living Resources Loss due to Dredging and Blasting Construction

Project	One-off damage loss(10,000 RMB)	Compensation (10,000 RMB)
Stage-1,Phase III	318.1	954.2

Stage-2, Phase III	342.1	1026.2
Total		1980.4

Table 6.1.13 presents the economic evaluation of marine living resources losses due to land reclamation. The unit price is based on estimation and subject to change.

Table 6.1.13 Economic Evaluation of Marine Living Resources loss due to Reclamation

Backfill area	Total inter-tidal area of occupation (ha)	Quantity of benthic organisms	Loss quantity of resources (t)	Unit price of Fish Fry (10,000 RMB/t)	Economic Value (10,000 RMB)
Putou backfill area	350	$6.896 g/m^2$	24.1	1.0	24.1
Xiaocuo backfill area	56		3.9	1.0	3.9

Based on the above calculation and following the national regulation (SC/T 9110-2007), the economic compensation for the losses shall be 20 times of the economic value of one-off loss, because the impacts of reclamation is permanent. The result is shown in Table 6.1.13.

Table 6.1.13 Compensation for Ecological Damage Loss

Backfill area	One-off damage loss(10,000 RMB)	Compensation for one-off living resources loss(10,000 RMB)
Putou backfill area	24	480
Xiaocuo backfill area	3.9	78
Total	27.9	558

To further mitigate the habitat loss, the project has designed an ecological compensation (offset) program, including fish production and habitats restoration. The habitats restoration plan is intended to enhance the mangroves wetland in Quanzhou Bay which is located in the project region. Quanzhou Bay has an estuary wetland where mangroves are of good natural habitat quality but under imminent threat. Details of the offset program are included in Chapter X and EMP.

In the context of the Meizhou Bay Navigation Channel Improvement Project, the Putou and Xiaocuo Backfill Area are the disposal sites. Developers of Putou operational area and Xiaocuo operational area have prepared EIA reports for new berths. According to the EIAs and approvals issued by the Fujian Provincial Environmental Department, ecological compensation plan including fish production and artificial fish rocks building will need to be implemented. This ecological compensation plan to be carried out by Putou Port Development Company and Xiaocuo Port Development Company will complement the above mentioned fish production and mangroves habitat enhancement plan.

6.1.2 Impacts on Aquaculture Cultivation

6.1.2.1 Dredging

The dredging impacts on water quality may have adverse impacts on the yields of aquaculture farms in the vicinity of the dredging areas. According to previous analysis in Table 6.1.3 and Figure 6.1.4, Specific analysis for each channel section is as follows:

Phase III – Stage 2

①West Luoyu channel dredging

The west Luoyu abalone cultivation area covers an area of 0.97km^2. As indicated in Figure 6.1-4, the range where Suspended Particulate Matter (SPM) increment in seawater during dredging exceeds the limitation of 10mg/L for category II marine water quality standard covers the construction area that is in the same direction as flux and reflux. The affected aqua-farms cover an area of 0.09km^2 which is mostly used for abalone cultivation.

②Dredging at Dasheng Island - Luoyu Island

As indicated in Figure 6.1-4, the range where SPM increment in seawater during dredging exceeds the limitation of 10mg/L for category II marine water quality standard covers the construction area that is in the same direction as flux and reflux. There is no aqua-farm in either side of the main channel at Dasheng Island section and the main channel dredging brings no impact to local marine farming.

③Dredging at main channel outer bay section

As indicated in Figure 6.1-4, the range where SPM increment in seawater during dredging exceeds the limitation of 10mg/L for category II marine water quality standard covers the construction area that is in the same direction as flux and reflux. There is no aquafarm in either side of the main channel outer bay section and the main channel dredging brings no impact over local marine farming.

Phase III - Stage-1

① North Putou channel dredging

As indicated in Figure 6.1-4, the range where SPM increment in seawater during dredging exceeds the limitation of 10mg/L for category II marine water quality standard may reach the east end of the bay with an impact area of up to 2.108km^2. The affected aqua-farms may cover an area of 0.591km^2 which is mainly for kelp cultivation.

Rock blasting and clearing is carried out within the dredging area where the impact range is smaller than the dredged area thanks to the small quantity of suspended sediments generated.

②Putou channel dredging

As indicated in Figure 6.1-4, the range where SPM increment in seawater during dredging exceeds the limitation of 10mg/L for category II marine water quality standard covers an impact area of up to 0.256km^2. But the aquaculture farm is not affected.

③#5 anchorage dredging

As indicated in Figure 6.1-4, the range where SPM increment in seawater during dredging exceeds the limitation of 10mg/L for category II marine water quality standard may reach the north end of the bay with an impact area of up to 11.988km^2. The affected aqua-farms may cover an area of 5.66km^2 with mainly kelp cultivation.

④#4 anchorage dredging

As indicated in Figure 6.1-4, the range where SPM increment in seawater during dredging exceeds the limitation of 10mg/L for category II marine water quality standard covers an impact area of up to 2.485km^2. The affected aquafarms may cover an area of 0.95km^2 with mainly kelp cultivation.

⑤Branch channel dredging

Dongwu abalone cultivation area covers an area of 1.03km^2. As indicated in Figure 6.1-4, the range where SPM increment in seawater during dredging exceeds the limitation of 10mg/L for category II marine water quality standard covers an impact area of up to 1.580km^2. But the Dongwu aquaculture area is not affected.

⑥Crossing zone dredging

As indicated in Figure 6.1-4, the range where SPM increment in seawater during dredging exceeds the limitation of 10mg/L for category II marine water quality standard covers an impact area of up to 5.716km^2. But the aquaculture is not affected.

Dredging is planned to last 8 consecutive hours in the daytime and pause for 12 hours or a tide period. During the period, the suspended sediments from dredging will be transported with water before they are gradually diluted and settled. And twelve hours later, local water quality will basically restore to its pre-project state.

Alternative dredging methods have been carefully compared to ensure the minimum water quality disturbance. Strict operation rules will be enforced to minimize the disturbance and control the spills. Affected the aquafarms will be consulted and adequately compensated under the framework of Resettlement Action Plan. With effective implementation of these measures, the temporary impact of dredging operation on aquaculture farms can be adequately mitigated and compensated.

6.1.2.2 Underwater Rock Blasting

Underwater rock blasting will have adverse impact on the aqua-farms in the vicinity of the blasting points. Impacts of underwater blasting mainly come from surge waves, seismic waves and the flying rocks in blasting. Compared with land blasting, underwater blasting is more difficult and the blast waves generated by underwater blasting features immense impulsion and slow attenuation, which may constitute a major threat to aquatic organisms, near-shore and in-water structures, vessels and underwater operation personnel.

According to the theoretical calculation, surge wave spreads in the water and its excessive pressure can be calculated with the following equation:

$$P = K\left(\frac{Q^{1/.3}}{R}\right)^{\alpha}$$

Where: P stands for the peak pressure (0.1MPa) of blast waves; Q for quantity of explosive (kg), simultaneous blasting takes total quantity of explosive while short delay blasting or millisecond delay blasting takes the maximum quantity of explosive charge of single-stage priming; R for the distance (m) from the blasting site to the measuring point; K and α for the actual measurement coefficient and the attenuation index respectively.

Under conditions of low drilling depth (underwater shallow blasting), the following empirical formula is used:

$$P = 68\left(\frac{Q^{1/.3}}{R}\right)^{1.22}$$

Researches show that fish are likely to die under the pressure of 0.05MPa, while will find themselves safe when the pressure is less than 0.03MPa. Crustaceans are less sensitive to blast wave and molluscs are further less sensitive. The assessment conservatively takes 0.03Mpa as the safe pressure for net-cage cultivation in the aquafarms.

Table 6.1.14 indicates the peak pressures of surge waves under different quantities of explosive charge, which is calculated with empirical formula. It should be noted that underwater blasting surge waves have very complicated influential factors, which are not only related to the quantity of explosive charge but also connected with water depth, blocking length and quality, degree of rocks fragmentation and free surface conditions. Therefore, calculation of the explosive charge for single-stage control on the basis of the above empirical formula is for reference only. Qualified and experienced construction units should be entrusted to develop rock blasting plans, and the plan will be approved by relevant authority before implementation. Blasting test should be conducted prior to blasting operation, so as to determine the explosive charge and safe distance, thus avoiding the damage to neighboring net-cage cultivation.

Table 6.1.14 Corresponding distance under peak pressure of surge wave with different quantities of explosive charge

Quantity of explosive charge of single-stage priming(kg)	Corresponding radius of impact with different excessive pressure (m)	
	0.05MPa	0.03MPa
25	165	250
50	208	315

75	238	360
100	260	395
150	298	460
200	328	498

The feasibility study report comes up with the rock blasting technology of millisecond delay blasting method, but provides no maximum quantity of explosive charge of single-stage priming. It can be seen from Table 6.1.14 that in case of 100kg explosive charge of single-stage priming, the scope with excessive pressure of over 0.03Mpa is limited to 395m outside the boundary of rock blasting areas while in case of 200kg explosive charge of single-stage priming, the scope with excessive pressure of over 0.03Mpa is extended to 498m outside the boundary of rock blasting areas. With reference to the explosive charge of single-stage priming in recent rock blasting at Meizhou Bay sea area, it is necessary to control the quantity of explosive charge of single-stage priming in the channel rock blasting below 100kg and the scope of impact over marine farming within 395m. The EIA is conducted on the basis of maximum quantity of 100kg for explosive charge of single-stage priming with impact range as indicated in Figure 6.1.7 – 6.1.9.

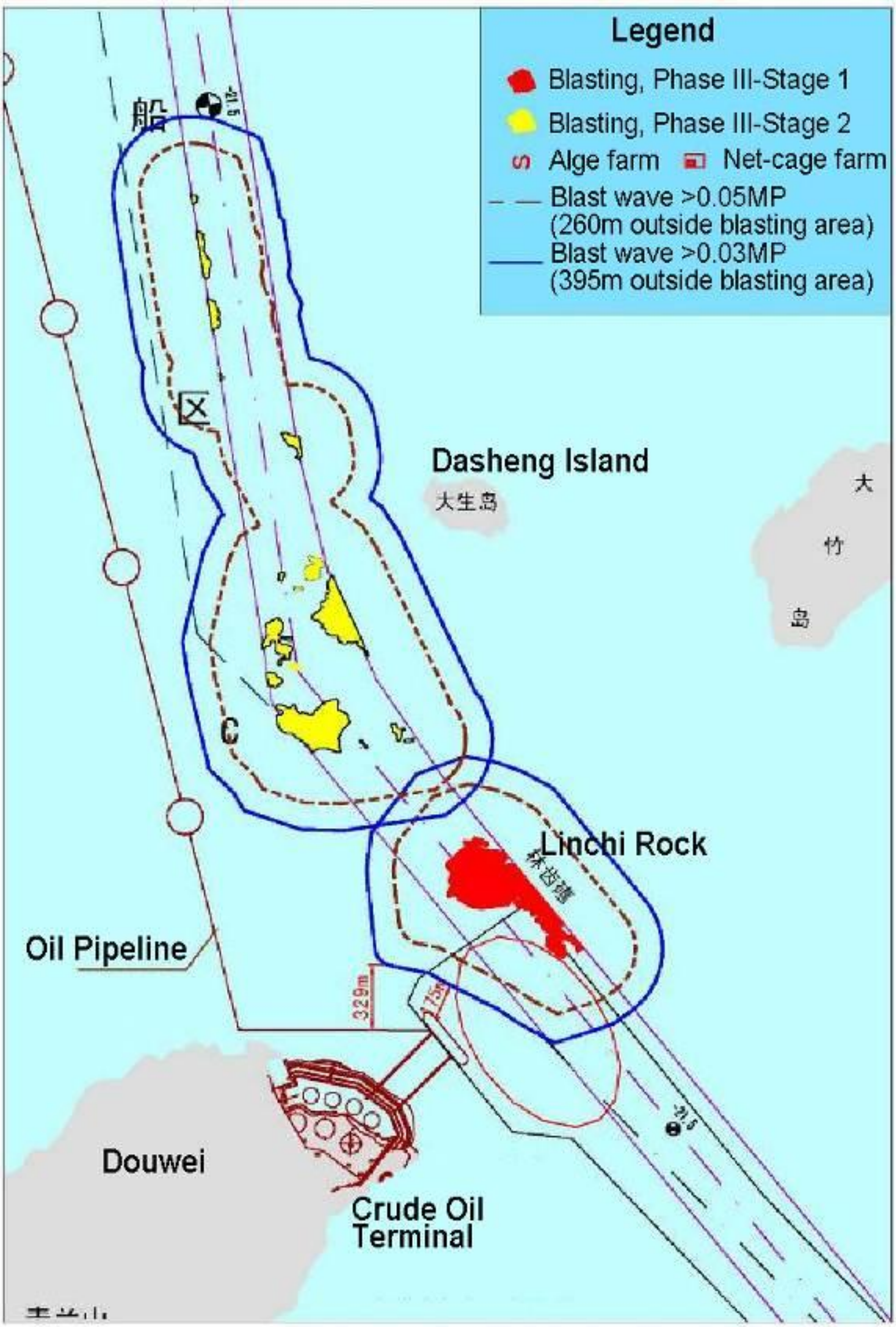


Figure 6.1.7 Impact range of blast waves from the main channel rock blasting areas near Dasheng Island

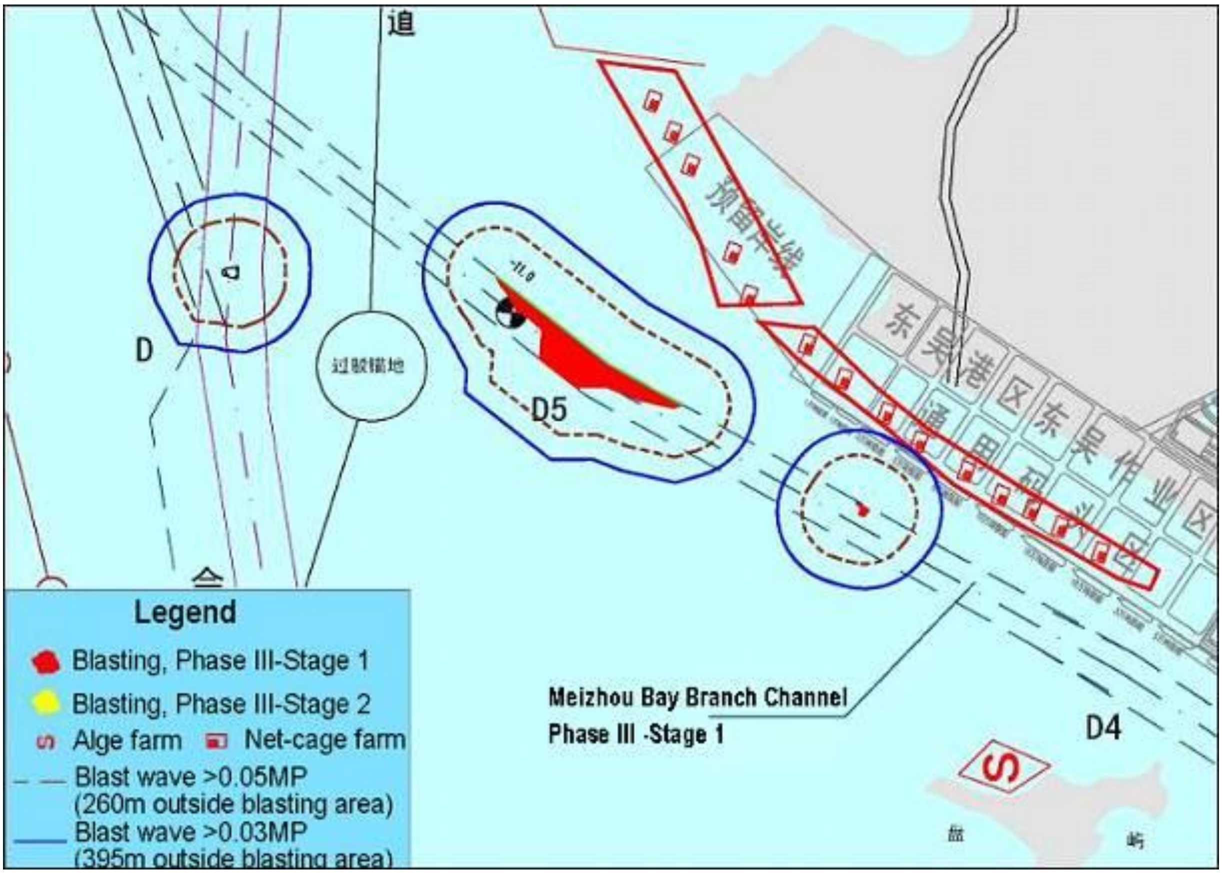


Figure 6.1.8 Impact range of blast waves from rock blasting areas at the main channel and branch channel

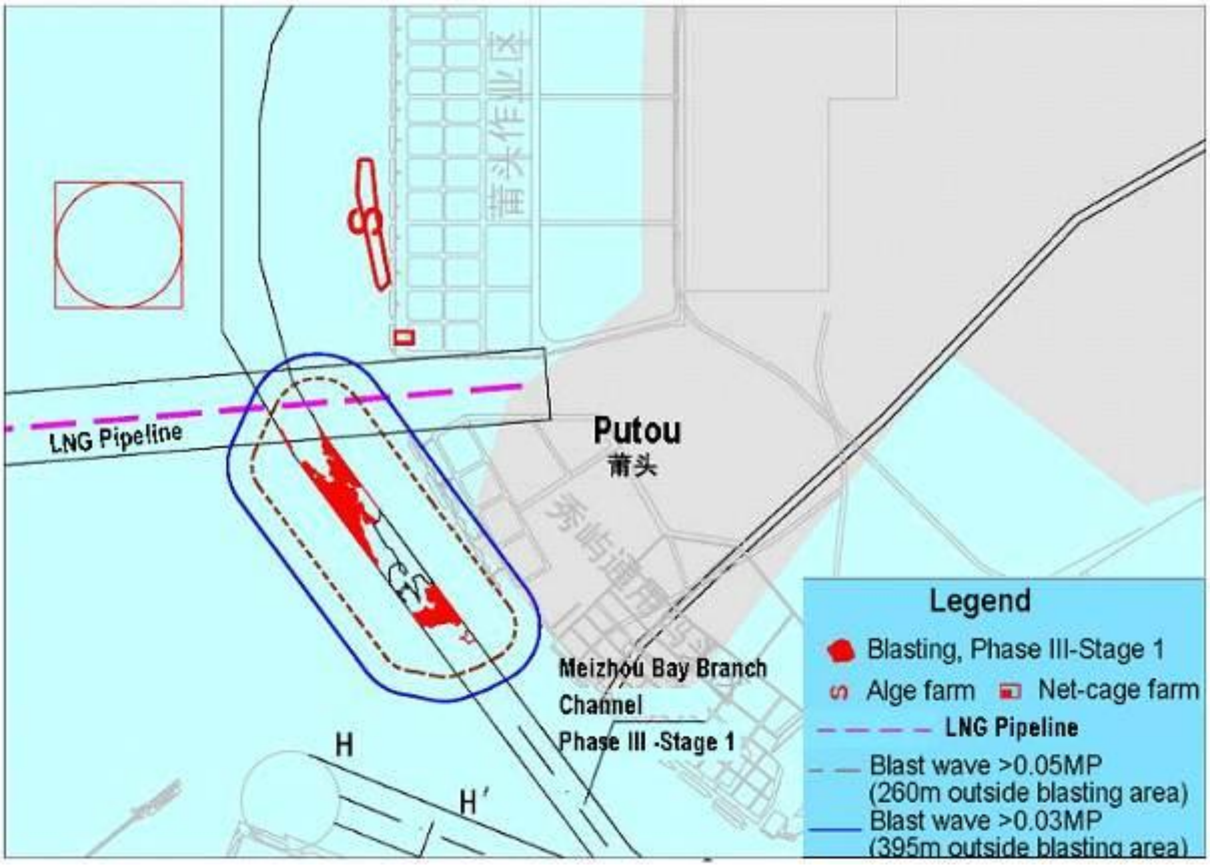


Figure 6.1.9 Impact range of blast waves from the Putou channel rock blasting area

Rock blasting at Dasheng Island - Luoyu Island

As indicated in Figure 6.1.7, there is no aquaculture farming at current sea areas in the vicinity of Dasheng Island. Therefore, it is feasible when maximum quantity of explosive charge of single-stage priming is no bigger than 100kg.

Rock blasting at west Luoyu channel

As indicated in Figure 6.1.8, abalone and kelp cultivation areas are distributed at the sea area to the west of Luoyu Island, which is 40m from the channel at the shortest distance. And the abalone cultivation area is in the direction of south-to-north, about 2,500m long and 350-400m wide.

Due to the short distance from the rock blasting areas and the aquaculture farming areas, even 25kg of explosive charge of single-stage priming will bring damage to the abalone in an area 250m wide. West Luoyu abalone cultivation area is mostly situated within the damage range. Therefore, it is necessary to temporarily relocate the west Luoyu aquaculture area before the blasting commences. After rock blasting is completed, the relocated abalone can be moved back to the outside of the channel for cultivation. Accordingly, rock blasting with maximum quantity of explosive charge of single-stage priming of no bigger than 100kg is required after the abalone aquaculture area is successfully relocated.

Rock blasting of Phase III, Stage-1

(1) Impacts of the rock blasting areas at the branch channel

As indicated in Figure 6.1.9, there are two areas for rock blasting at the branch channel. One covers a comparatively large area of 1.39ha and the other is smaller at only 0.23ha. Neighboring sea farming is carried out mainly by the abalone cultivation area to the south of Dongwu Village.

The larger rock blasting area is 0.57km away from Dongwu abalone cultivation area. As indicated by Figure 6.1.9, maximum quantity of 100kg for explosive charge of single-stage priming will exert little impact over the abalone cultivation area to the south of Dongwu Village. Therefore, it is feasible when maximum quantity of explosive charge of single-stage priming is no bigger than 100kg. The smaller rock blasting area is 0.4km away from Dongwu abalone cultivation area. As indicated by Figure 6.1.9, maximum quantity of 100kg for explosive charge of single-stage priming will exert acceptable impact with excessive pressure of 0.03Mpa over the abalone cultivation area to the south of Dongwu Village. Therefore, it is feasible when maximum quantity of explosive charge of single-stage priming is no bigger than 100kg.

(2) Impacts of Putou rock blasting areas

Neighboring aquaculture is carried out mainly by the kelp cultivation area to the north with the shortest distance of 0.85km. The rock blasting has little impact on the kelp. Therefore, it is feasible when maximum quantity of explosive charge of single-stage priming is no bigger than 100kg.

(3) Impacts of the Linchi rock blasting areas

As indicated in Figure 6.1.7, there is no marine farming at current sea areas in the vicinity of the Linchi rock blasting areas. Therefore, it is feasible when maximum quantity of explosive charge of single-stage priming is no bigger than 100kg.

Based on above analysis, there are some aquafarms near Luoyu island, north of Putou channel and #4/#5 anchorage areas which will be subject to severe impact. See Table 6.1.15.

Table 6.1.15 Impacts of dredging operation on aquaculture

Stage	Channel name	Impact on aquaculture		
		Y/N	Impact area (km2)	Impacted species
Stage-2, Phase III	West Luoyu channel	Y	0.09	Abalone
	Dasheng Island - Luoyu Island (inner bay section)	N		
	Main channel at south side of Jianyu anchorage(outer bay section)	N		
Stage-1, Phase III to be constructed	North Putou channel area	Y	0.591	Kelp
	70,000dwt Putou channel	N		
	#5 anchorage	Y	5.66	Kelp
	#4 anchorage	Y	0.95	Kelp, abalone
	Extension of Meizhou Bay Navigation Channel	N		
	Crossing zone	N		

In order to avoid such impact, the cultivation aquafarms at these area are scheduled to be relocated and the sea water cultivation area will be acquired, which will be compensated following the RAP. The project proponent has signed compensation agreements on the cultivation relocation with the local governments and committed to compensate the relocated following the national and local regulations on the basis of final survey result (see the attachment). The local government will allocate new cultivation area based on marine economic growth planning to ensure the restoration of the normal operation of local aquafarms.

6.1.2.3 Land Reclamation in Putou and Xiaocuo

The land reclamation in Putou and Xiaocuo will occupy inter-tidal zones which are currently mainly used for aquaculture cultivation.

Xiaocuo Backfill Area

The Xiaocuo #5 and #6 berth will affect 83 ha aqua-farm area (including 56 ha for backfill area and adjacent sea area for port structure and ship berthing), with 35 households affected (133 people). By May 2012, the sea water area acquisition and resettlement compensation have been completed. Meizhou Bay Harbor Administration Bureau and RAP consultant have conducted due diligence review of the resettlement compensation and concluded that it complies with national and the World Bank policy requirements. (Details see *Due Diligence Report of Resettlement from #5 and #6 Berth in Xiaocuo*.)

Putou Backfill Area

In Putou, the dredged material will be backfilled in the #1 and #2 berths where dikes have been already constructed and land certain backfilling has been done. These two berths occupied 73ha aquafarm area, with 49 households affected (190 people). By August 2011, sea area and land acquisition have been completed, and resettlement compensation to aquatic farmers have been paid. Meizhou Bay Port Development Company has been granted the use license for the sea water area acquired. Meizhou Bay Harbor Administration Bureau and RAP consultant have conducted due diligence review of the resettlement compensation and concluded that it complies with national and the World Bank policy requirements. (Details see *Due Diligence Report of Resettlement from #1 and #2 Berth in Putou*.)

For the future development of #3-25 berths, a Resettlement Action Plan has been developed fully in compliance with World Bank's OP4.12.

Therefore, it can be concluded that the land reclamation impact on the aquafarms and livelihoods of affected people can be adequately mitigated and compensated in line with national and World Bank policy requirements.

6.1.3 Impacts on Sensitive Ecological Protection Area

Based on ecological baseline survey, there is only one ecological protection site in the project area, i.e. Meizhou Island. The island is located to the southeast of Meizhou Bay. The Meizho Island is firstly famous for its home to Mazu (Matsu, a sea goddess). Annually some 100,000 pilgrims, mostly from Taiwan, come to the island to visit Heavenly Empress Place – Meizhou Ancestral Temple which commemorates Mazu. It has been designated as a sacred site by many emperors since Song Dynasty (ca. 1000 years ago) until now.

The Meizhou Bay Island Marine Ecological Special Reserve (at city level) was officially established in 2005, which has an area of 9,990ha, including the island (15 km^2) and adjacent sea area. On the island there are 13 pieces of sand beaches totaling 20 km, and 5km long marine-abrasion rocks. A piece of mangroves is found in the west of the island. According to a field survey made in June 2012, the mangroves have grown for 15 years and are about 20 ha only. Probably due to thin sediments, limited source of fresh water feeding in, the mangroves has not grown very well. The key protection objectives of the reserve include the marine abrasion topography, the island, beach, mangrove and freshwater ecosystem.

From Figure 4.1.4, it can be seen that Meizhou Island boundary is more than 5 km away from the Phase III channels, even farer from the backfill areas. The water quality impact simulation and marine life impact analysis in previous sections has confirmed that the dredging, blasting and backfilling will have no impact on the ecological sensitivity of the Meizhou Island during the project construction stage.

6.1.4 Impacts on Infrastructures

6.1.4.1 Water Intake Facilities

There are three water intakes in the Meizhou Bay area:

- Water Intake of Meizhou Bay Thermal Power Plant: 2.6km to 4# anchorage zone and not in the tidal direction. The shortest distance to Luoyuxi Rock-blasting area is around 1.8km.
- Water Intake of Nanpu Power Plant: 1.6km to Putou Dredging Area. The shortest distance to Putou Rock-blasting area is around 1.6km.
- Water Intake of LNG Power Plant: 1.2km to Huiyuxi Dredging Area. The shortest distance to Huiyuxi Rock-blasting area is around 1.5km.

According to the dredging impact analysis and Figure 6.1-4 dredging impact scope, the scope of suspended sediments concentration exceeding Category 2 water quality standard will not reach water intakes of any water intake in the Meizhou Bay. Therefore, suspended sediments increment brought by construction has little impact on the quality of inlet water of the power plants.

6.1.4.2 Impact of Putou 70,000t Channel on LNG Pipeline

The 70,000dwt Putou channel of Stage-1of Phase III needs to cross the seabed LNG pipeline. As a gas pipeline, Fujian LNG Meizhou Bay submarine pipeline is located along the trunk line of Xiuyu originating station- Zhangzhou terminal station. It goes under the sea at Houxiong Village, Xiuyu, Putian and goes ashore at Xiazhu Village, Jieshan Town, Quangang District, Quanzhou. With a design life of thirty years, its horizontal length is about 5.5 km. The structural design of the submarine pipeline is as follows:

- Submarine pipeline route is indicated in the Figure 6.1-10, from Point A to Landing Point B, there is Route Turning Point C.
- Submarine pipeline specification: φ813mm (outside diameter)× 17.5mm(wall thickness), API5L-X65, LSAW pipes. Counterweight is achieved with concrete 49 mm ×2,950kg/m^3. After pipe installation is ready, back trenching and burying of the pipeline will be carried out with depth of burial at 1.5m (from pipeline top to seabed).

According to the LNG pipeline design and construction drawing provided by Fujian LNG Terminal and Trunk line Project of CNOOC Fujian Natural Gas Co., Ltd., pipeline location at the Putou channel area is indicated in Figure 6.1-10 and Figure 6.1-11.

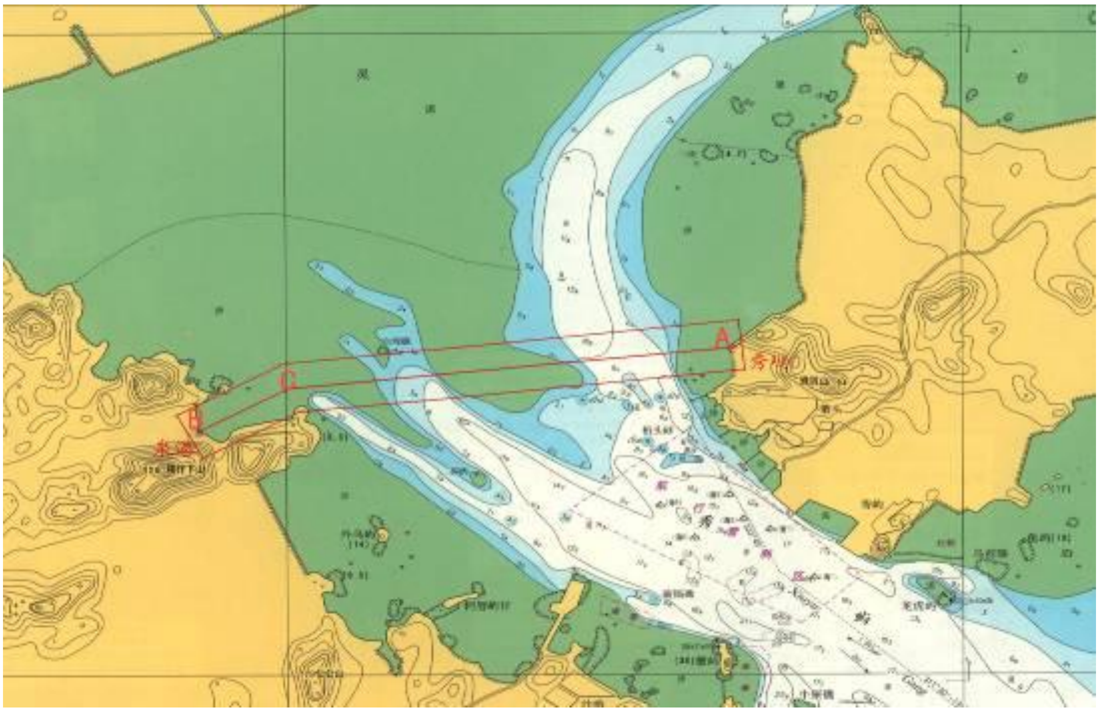


Figure 6.1-10 LNG pipeline plane layout

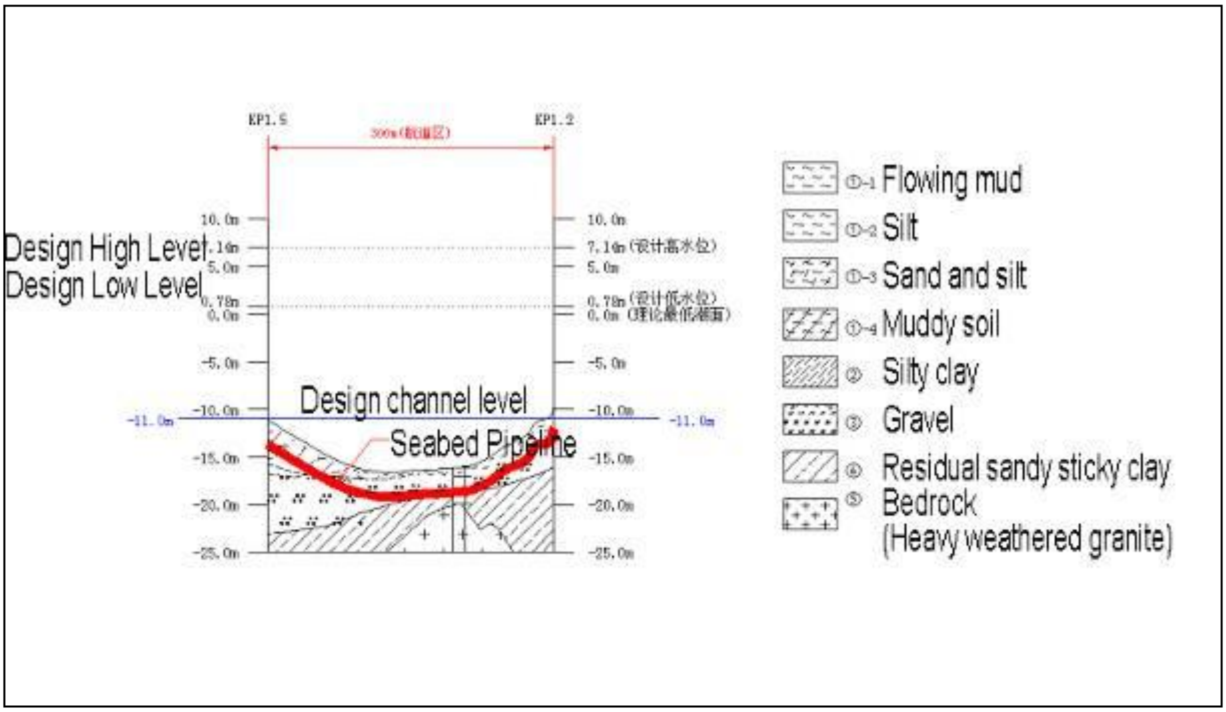


Figure 6.1-11 Vertical position of pipeline at the Putou channel area

As indicated in Figure 6.1-11, design bottom elevation of the 70,000dwt Putou channel is -11.0m (the lowest tide surface in theory) and LNG pipeline elevation ranges from -19.1 to - 11.98m, or 0.98-8.1m below the design bottom elevation of the

70,000dwt Putou channel.

There is no dredging over the channel of the LNG pipeline, as shown Figure 6.1-4. During the project implementation, the project owner will closely consult with CNOOC Fujian Natural Gas Co., Ltd, and strengthen the specific location survey before dredging in the vicinity of the LNG pipeline. Warning buoys will be placed along the LNG pipeline to guide the dredging operation to avoid the safety risk.

6.1.4.3 Impact on Submarine Oil Pipeline of Fujian Oil Refinery

According to Fujian Oil Refinery, the submarine oil pipeline extending from its 300,000dwt oil terminal to its oil depot area was laid by trenching and capping with a layer of gravels 1.5m thick.

As shown in Figure 6.1-4, the navigation channel will not cross the submarine oil pipeline, and is at least 500m away from the pipeline. The nearest distance between the Linchi rock blasting areas and the oil pipeline is about 570m. Given the far distance and its well buried under the sea bed, it can be concluded that channel dredging and rock blasting will have no impact on the submarine oil pipeline. Warning buoys will be placed along the oil pipeline to guide the dredging and rock blasting operation in order to avoid any safety risk.

6.1.4.4 Impact on Buildings and Docks

Rock blasting will have potential adverse impact on other buildings and docks. According to national technical guidelines of *Safety Regulations for Blasting (GB6722-2003)*, safety distance of blasting vibration may be calculated and shown in Table 6.1.16.

Table 6.1.16 Safety distance of seismic shock from underwater drill-blasting

Nature of buildings	V (cm/s)	R(m)					
		Q=25	Q=50	Q=75	Q=100	Q=150	Q=200
Rubble, adobe	1.0	83	104	119	131	150	165
Ordinary brick house, bank revetment and oilcan	2.0	52	66	75	83	94	104
Reinforced concrete, framed building, ordinary gravity wharf	5.0	28	36	41	45	51	56
Gravity type quake-proof wharf	8.0	21	26	30	33	37	41

Q=explosive load (kg)

On the basis of calculation, safety distance of bank revetment and piled wharf is 45m from underwater blasting with maximum quantity of 100kg for explosive charge of single-stage priming.

The potential sensitive structures and docks in the vicinity of rock blasting is shown in Table 6.1.17.

Table 6.1.17 Layout of sensitive structures closest to rock blasting areas

Phase	Navigation section	Sensitive structures closest to rock blasting	Distance (m)	Vibration impact

		areas		
Stage-2, Phase III	The main channel at Dasheng Island section	Submarine oil pipeline of Fujian Oil Refinery	568	Little impact
Stage-1, Phase III to be constructed	Putou channel	LNG pipeline	122	Little impact
		Protected area on both sides of LNG pipeline	Within the protected area	Little impact
		Xiuyu chemical terminal	251	Little impact
	Linchi rock	300,000*dwt* oil terminal of Fujian Oil Refinery	576	Little impact
		Water area for ship maneuvering at 300,000*dwt* oil terminal of Fujian Oil Refinery	At the outside fringe of the water area for ship maneuvering	Certain impact
		Submarine oil pipeline of Fujian Oil Refinery	658	Little impact

As shown in Figure 6.1-12, Linchi rock is located at the outside fringe of the water area for ship maneuvering towards the 300,000dwt oil terminal of Fujian Oil Refinery, rock blasting may cause potential risk for the oil tanker in that water area.

To mitigate such risk, only with the approval of the oil terminal of Fujian Oil Refinery can the construction unit carry out rock blasting at a given time when 300,000dwt oil tanker is not at the harbor basin or operating at dockside.

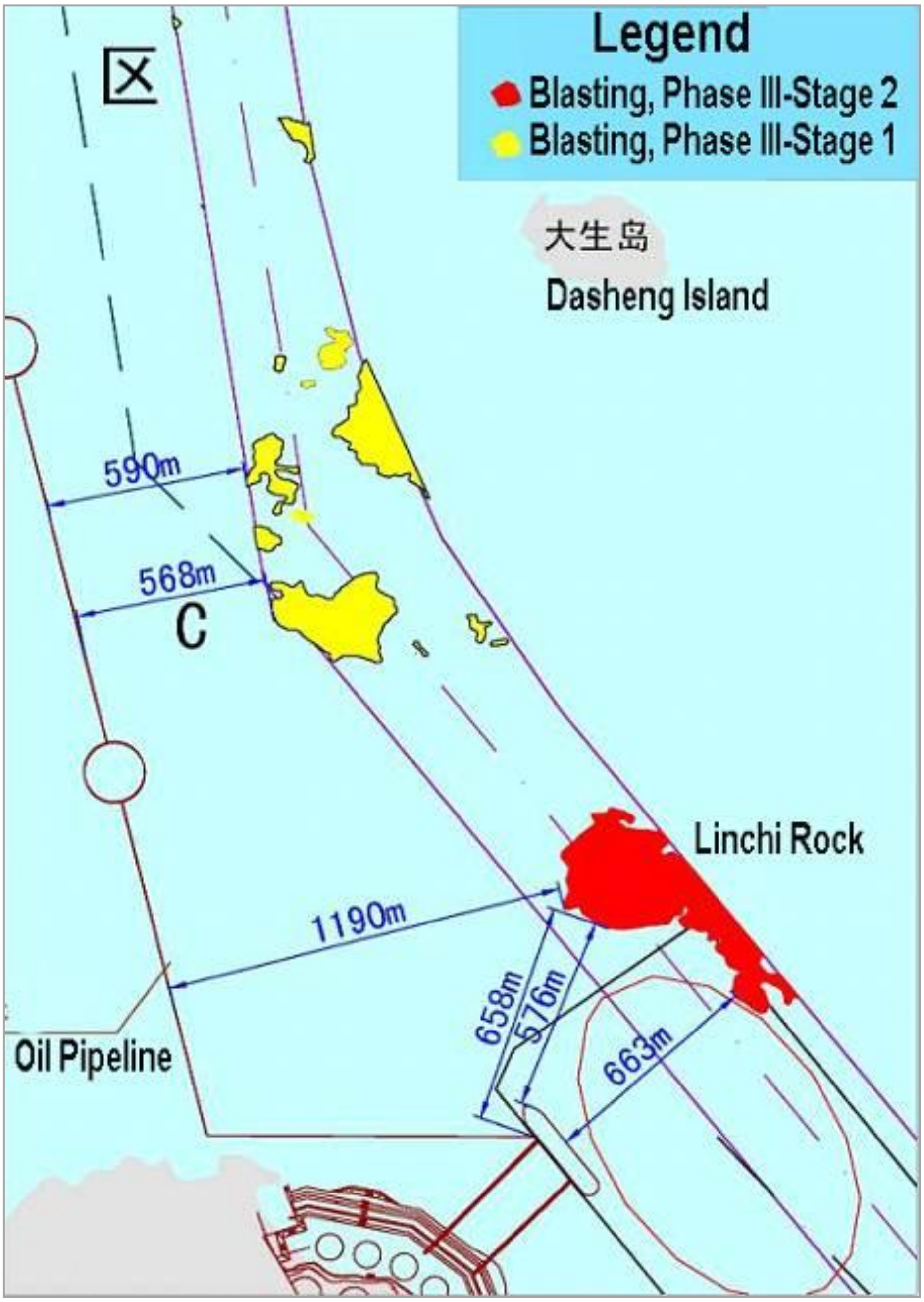


Figure 6.1.12 Rock blasting areas and nearby infrastructure

6.1.5 Waste from Construction Ships

During dredging and rock blasting operation, there will be small amount of wastewater and solid waste generated from the operation ships. If directly discharged into the Meizhou Bay, it may have adverse impact on the water quality and ecological environment of the Bay.

According to *Management Regulations on Preventing Vessels from Polluting Marine Environment*, *Fujian Marine Environmental Protection Regulations* and other relevant laws and regulations, construction vessels must be equipped with oily soil storage cabins (or containers) and for oil polluted water to be received and disposed by receiving organizations authorized by maritime authorities. And discharge of oil-polluted water to the harbor area is prohibited. By unloading the wastewater and solid waste to the central treatment facility in the port, the impact of construction ship waste can be adequately mitigated.

6.1.6 Impacts on Navigation Safety during Construction

A major safety concern during construction is related to the rock blasting. According to *Safety Regulations for Blasting (GB6722-2003)*, the safety distance of drill-blasting-induced underwater blast waves for operation personnel and vessels underwater is indicated in Table 6.1.18.

Table 6.1.18 Safety distance of blasting-induced underwater blast waves for operation personnel and vessels

Quantity of explosive (kg) Shortest distance (m) Personnel or vessels		≤50	>50≤200
Personnel	Swimmers	500	700
	Divers	600	900
Vessels	Wooden vessel	100	150
	Iron vessel	70	100

The safety distance for non-construction vessels: 1,000m when they are at the upstream of the blasting site, and 1,500m when they are at the downstream of the blasting site or at stagnant area.

To mitigate such risk, security watch will be deployed during underwater blasting operation. Restricted area will be established, all vessels and personnel are forbidden to enter the restricted area. Prior notification will be made in advance to vessels to avoid the area, in particular, the safety of construction personnel, vessels berthed at the harbor area and vessels passing by neighboring docks and channels.

6.1.7 Disturbance to Navigation

At the construction stage, the navigation channel will be occupied from time to time, and the regular operation, berthing and departing of the navigation sections in Meizhou Bay will be affected for a certain time.

At the construction stage, the FPMO will urge the contractor to minimize the negative impact on the traffic of the navigation channels by adopting a sectionalized construction approach and performing construction within the specified hours, improve construction efficiency and shorten the construction period.

For small-displacement boats, channel construction will have no impact no their navigation, because their waterline is as low as 1m, so that such boats can enter the sea easily. On the other hand, the navigation of large-displacement boats may be affected to some extent. According to the interviews with the local maritime bureau, and ocean and fishery bureau, at the construction stage, the local maritime bureau will usually issue a navigation notice in advance to specify the construction period, area and scope, and the relevant precautions in detail. 1) The notice will specify that operating vessels should signal in accordance with the Regulations on Coastal Port Signaling, and impose traffic control measures on the water area of construction. 2) In case of blasting, the contractor should report the local traffic control center one hour in advance, and blasting should not be implemented until the local maritime bureau has issued a VHF navigation alarm. 3) The constractor will report the piloting and construction scheme of the next day to the local traffic control center by 16:00 of each day, and the local maritime bureau will release information on blasting time, navigation hours and entry/exit arrangements on its website on a daily basis.

6.1.8 Impacts on fishing

According to the consultation with the municipal ocean and fishery bureau, some fishermen in the project area have fishing licenses and fishing boats. For example, in the Putian, there are 420 fishing boats on Meizhou Island, while, only 82 on the north bank including 44 in Dongzhuang Town.

It is learned that since there is a very small amount of commercial fish in the Meizhou Bay, it is not economical to capture wild fish stocks in the bay. In pursuit for economic benefits, people would carry out offshore fishing. In addition, since the channel construction of Meizhou Bay has a history of over 30 years, all nearby fishermen know that they should no longer fish in the channel for the sake of safety. Therefore, impacts of channel construction on fishing is minor.

6.2 Operation Stage

6.2.1 Marine Hydrodynamics

The content of this marine hydrodynamics simulation is summarized from the special study of *Research Report on Numerical Modelling-based Calculation for Phase III (August 2011)* prepared by Hohai University for the project.

6.2.1.1 Numerical modeling and validation of tidal flow field

The simulation used the model of non-structural FV array of difference put forward by Casulli and Zanolli. Backward-tracing and interpolation techniques were adopted. The proper handling of convection term in the momentum equation will affect the model-based computing efficiency and precision. To avoid the limiting factor of Courant number, the model uses Lagrangian method in handling the convection term. Initial state is traced through backward-tracing along the typical line from given points with different time steps.

Due to certain changes of inner bay hydrodynamic environment after project implementation, the calculation scope covers Meizhou Bay, Pinghai Bay and Quanzhou Bay by modelling with the non-structural triangular grid to objectively reflect the variation characteristics of gravitational field. There are a total of 99,166 grids with 50,480 nodes. There are more dense grids near the inner bay project area and the smallest grid has a space step of 15m. Please refer to Figure 6.2-1 and Figure 6.2-2 for water depth distribution and grids layout of the bay respectively.

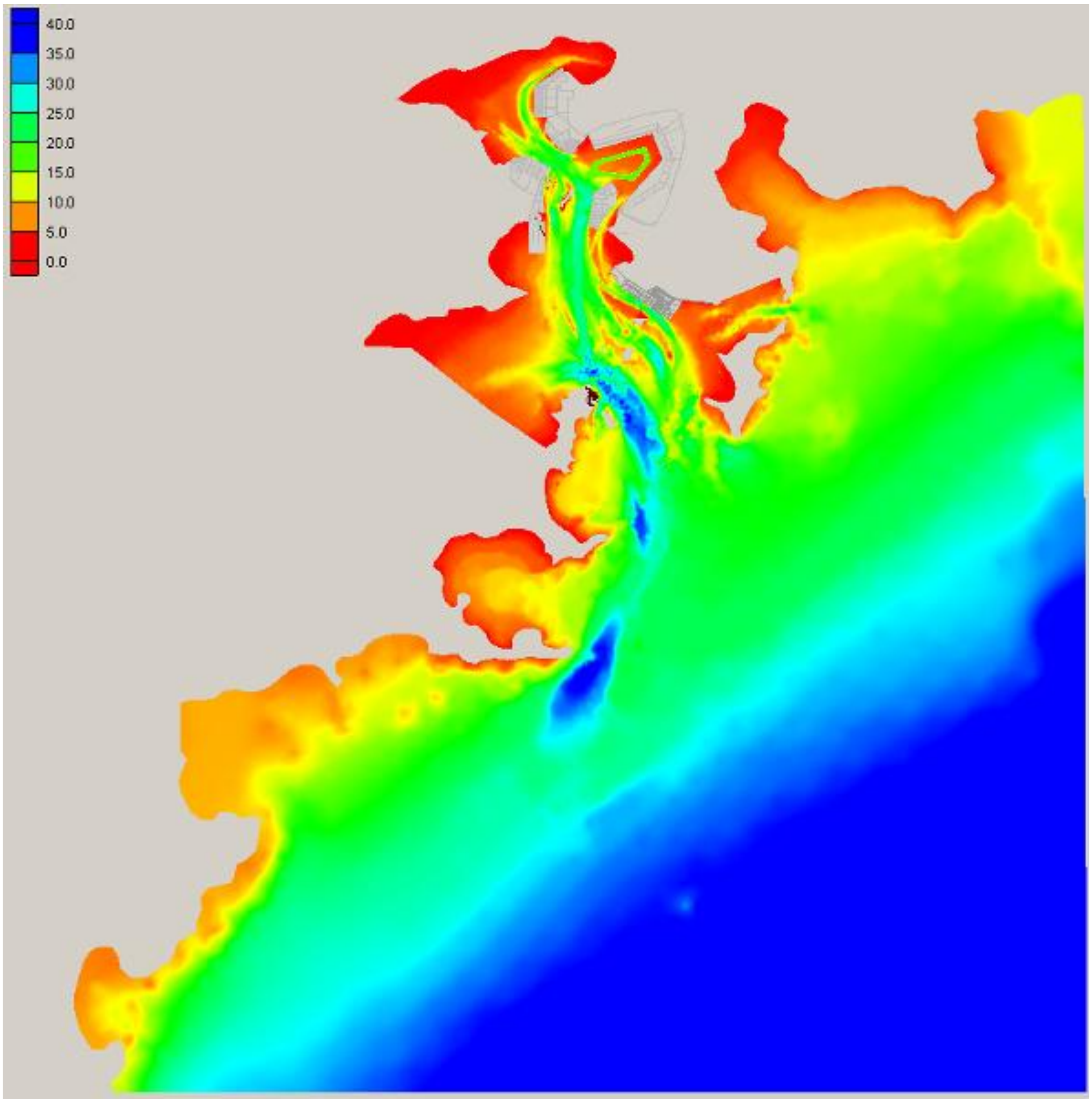


Figure 6.2-1 Water depth of computational area

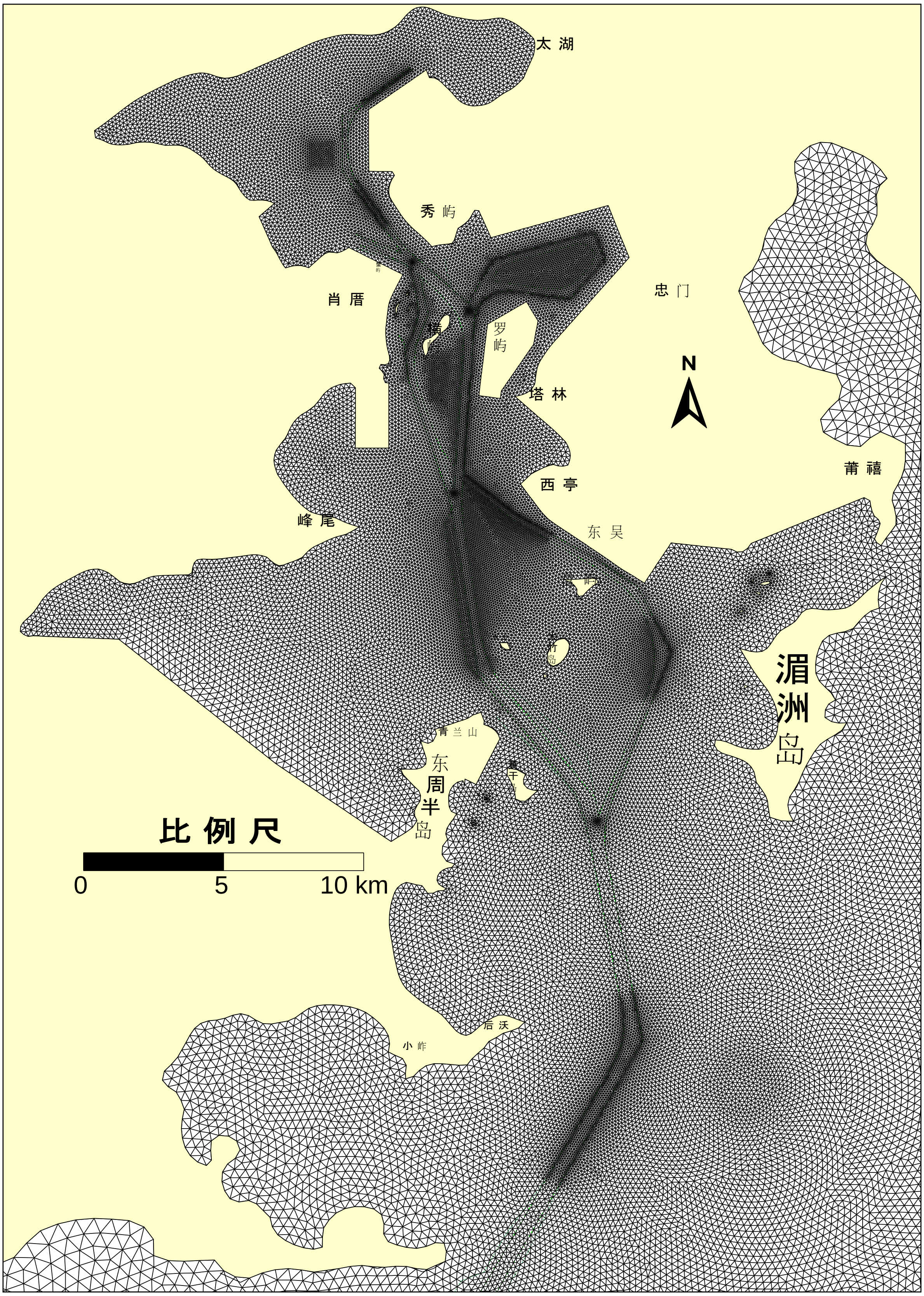


Figure 6.2-2 Computational grid of partial inner bay sea areas

6.2.1.2 Boundary conditions

With the implementation of Phase III, according to Meizhou Bay Harbor Master Plan, land reclamation will be carried out successively in all operation areas within Meizhou Bay mainly including Zoumadai land reclamation, Putou Operation Area, Luoyu Island, Xiaocuo Operation Area, Dongwu Operation Area, Shimen'ao land reclamation, etc. The research on numerical modelling of hydrodynamics of Meizhou Bay sea area covers Stage-1 and Stage-2 of Phase III as well as the aforementioned reclamation sites. In other words, the computed coastline is the same as that planned in the long run in Meizhou Bay Harbor Master Plan. Please refer to Figure 6.2-3 for boundary calculation in detail.

6.2.1.3 Validation of modeling

Hydrologic data of flood tide and dead tide measured in October 2005 were used for validation of mathematical modelling of tidal current. As the result turned out, tidal volume, tidal level, flow rate and flow direction were well validated. And its accuracy satisfies requirements on relevant regulations and technology guidelines.

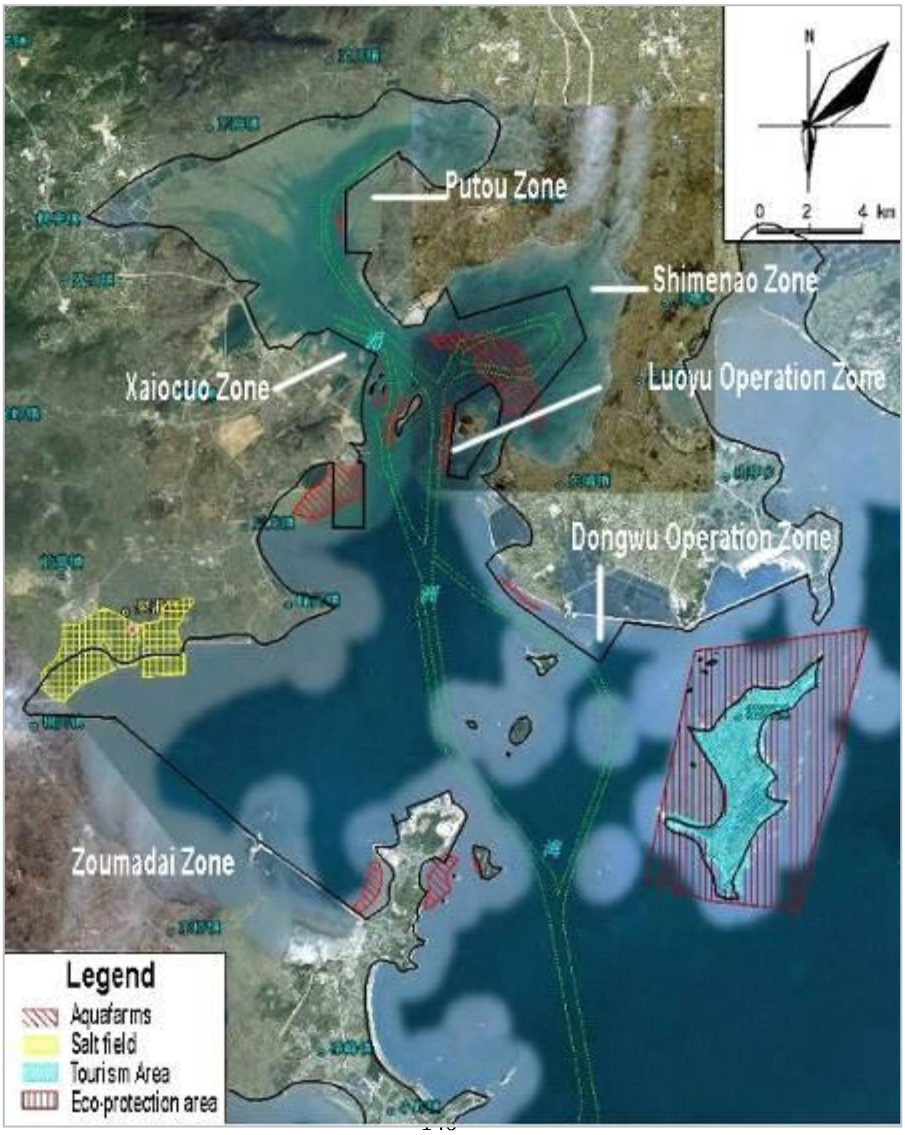
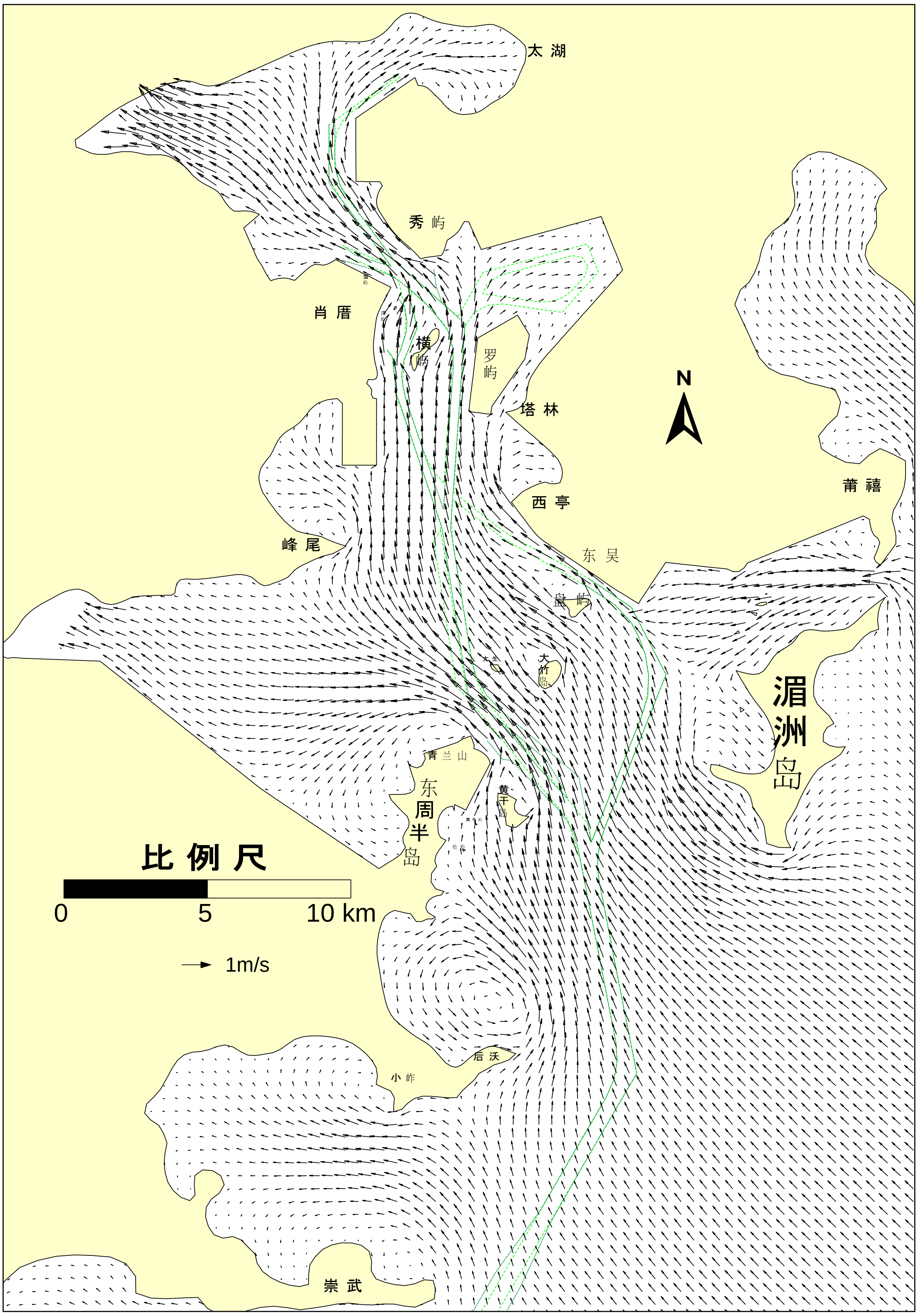


Figure 6.2-3 Boundary conditions of numerical modelling-based calculation

(Note: The black lines refer to the coastline after the planned land reclamation project)

6.2.1.4 Tidal flow field

The tidal flow field in Meizhou Bay is shown in Figure 6.2-4, Figure 6.2-5 and Figure



6.2-6.

Figure 6.2-4 Up rapids flow field of Meizhou Bay sea area at flood tide before construction

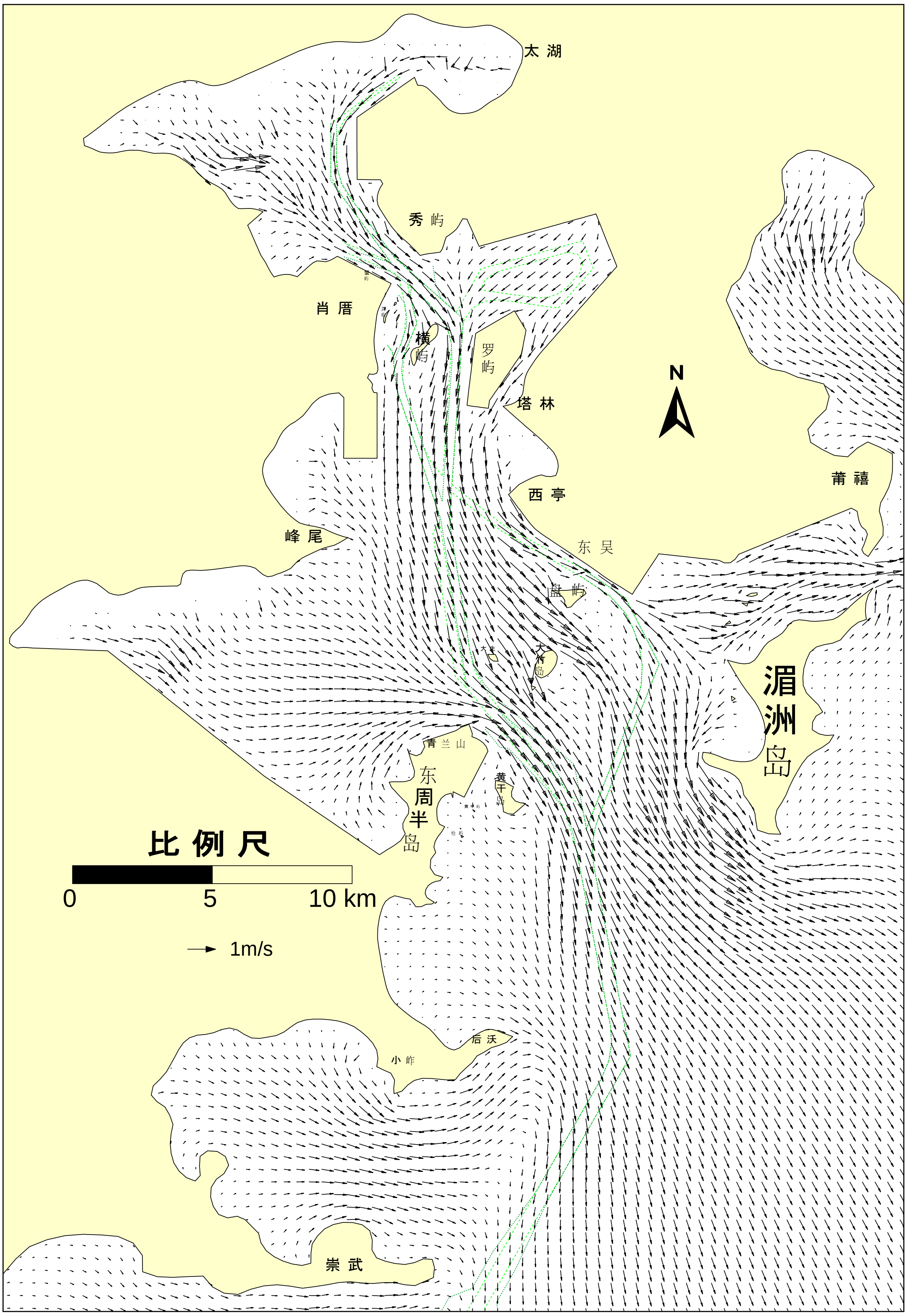


Figure 6.2-5 Down rapids flow field of Meizhou Bay sea area at flood tide before construction

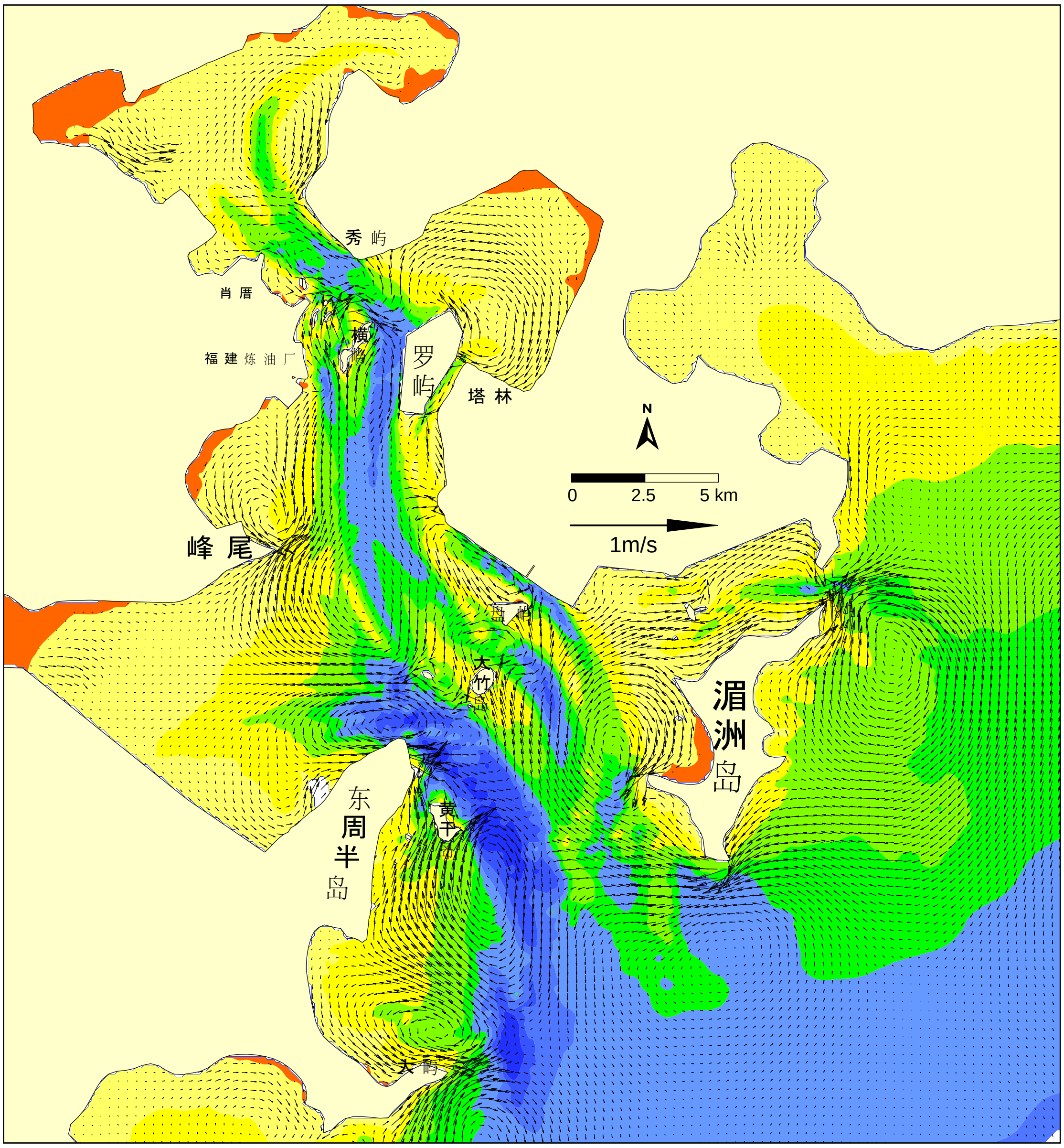


Figure 6.2-6 Flow field of tide-induced residual currents before construction

6.2.1.5 Hydrodynamic Impact Analysis

(1) Layout of Modeling Cross-sections and measuring points

To conduct quantitative analysis of the dynamic impact of Meizhou Bay navigation project on surrounding water areas, four cross-sections were deployed within the bay for analyzing the quantity variation of tide rise and fall during the numerical modelling test. The four cross- sections were located at the inner bay estuary (Cross-section 1), Dongwu-Fengwei (Cross-section 2), Meizhou Island-Da'antou, Dongzhou Peninsula (Cross-section 3) and Wenjiakou (Cross-section 4) respectively. Please refer to 6.2-7 for the cross-sections layout.

To compare typical flow rates before and after project implementation, 80 measuring points were deployed at inner bay sea areas out of the channel as indicated in Figure

6.2-8. In addition, 97 special measuring points were deployed within the channel as indicated in Figure 6.2-9.

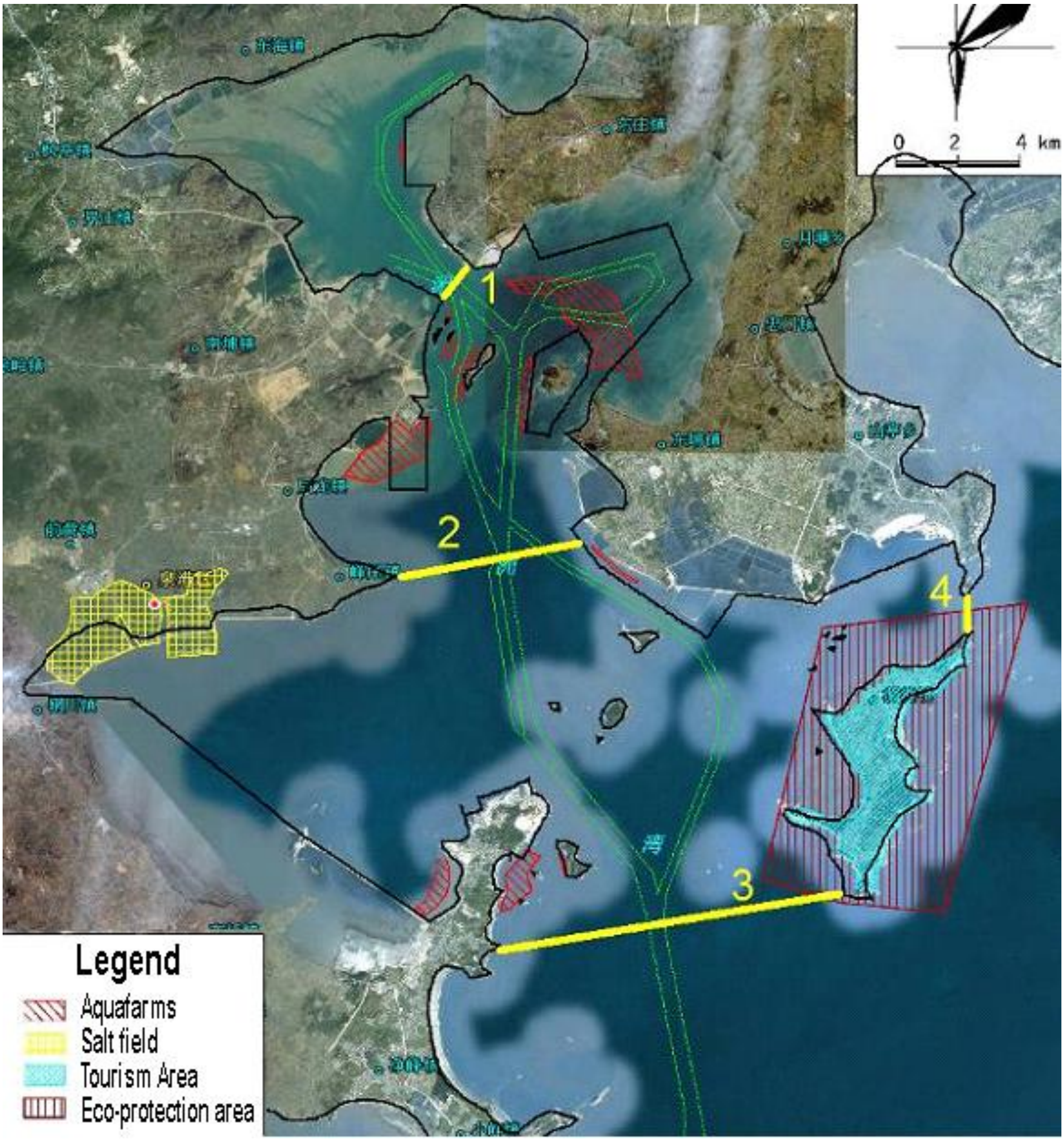


Figure 6.2-7 Sections layout for tidal volume analysis during flood and ebb tides

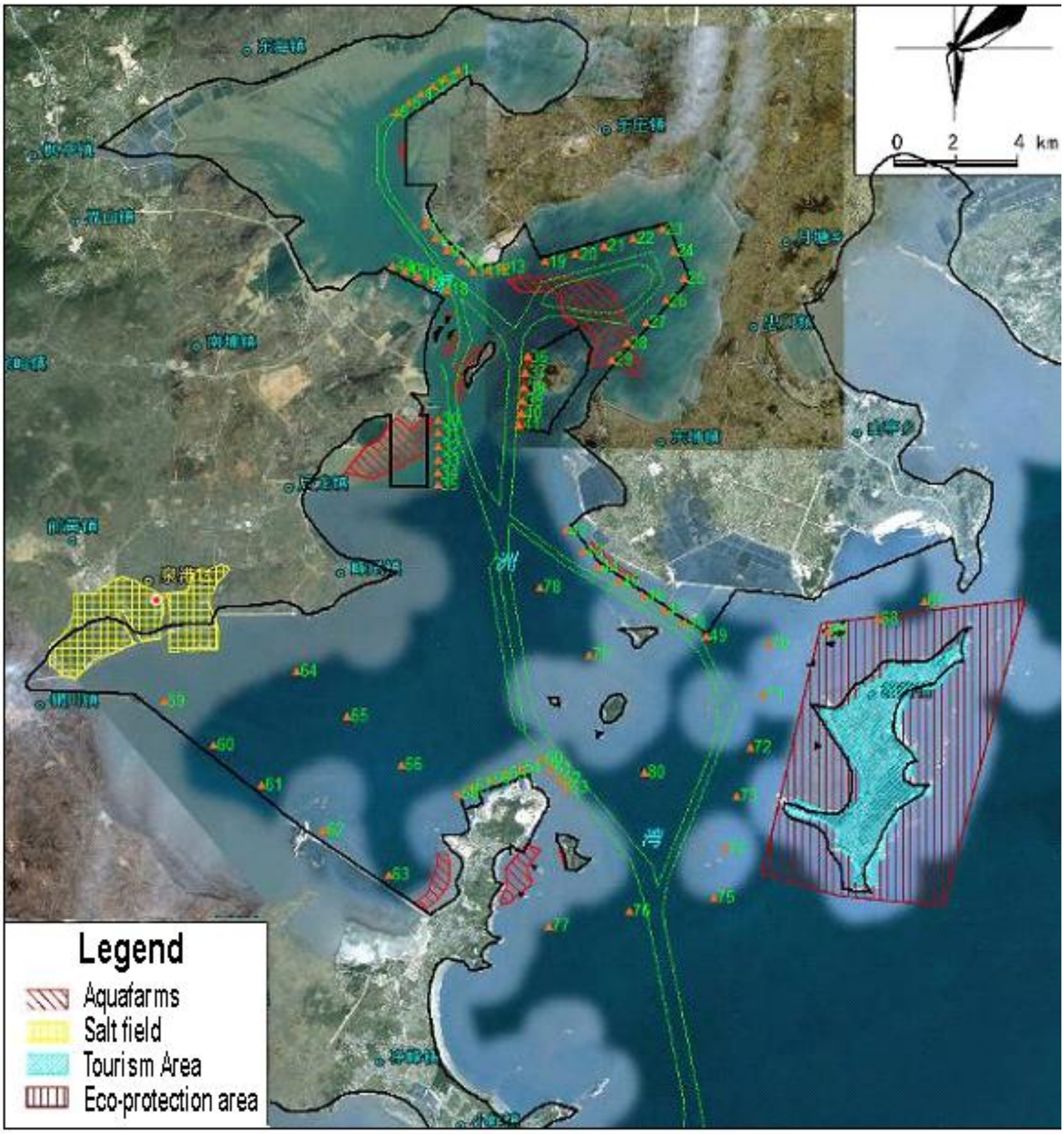


Figure 6.2-8 Layout of flow rate analyzing points (at non-channel areas)

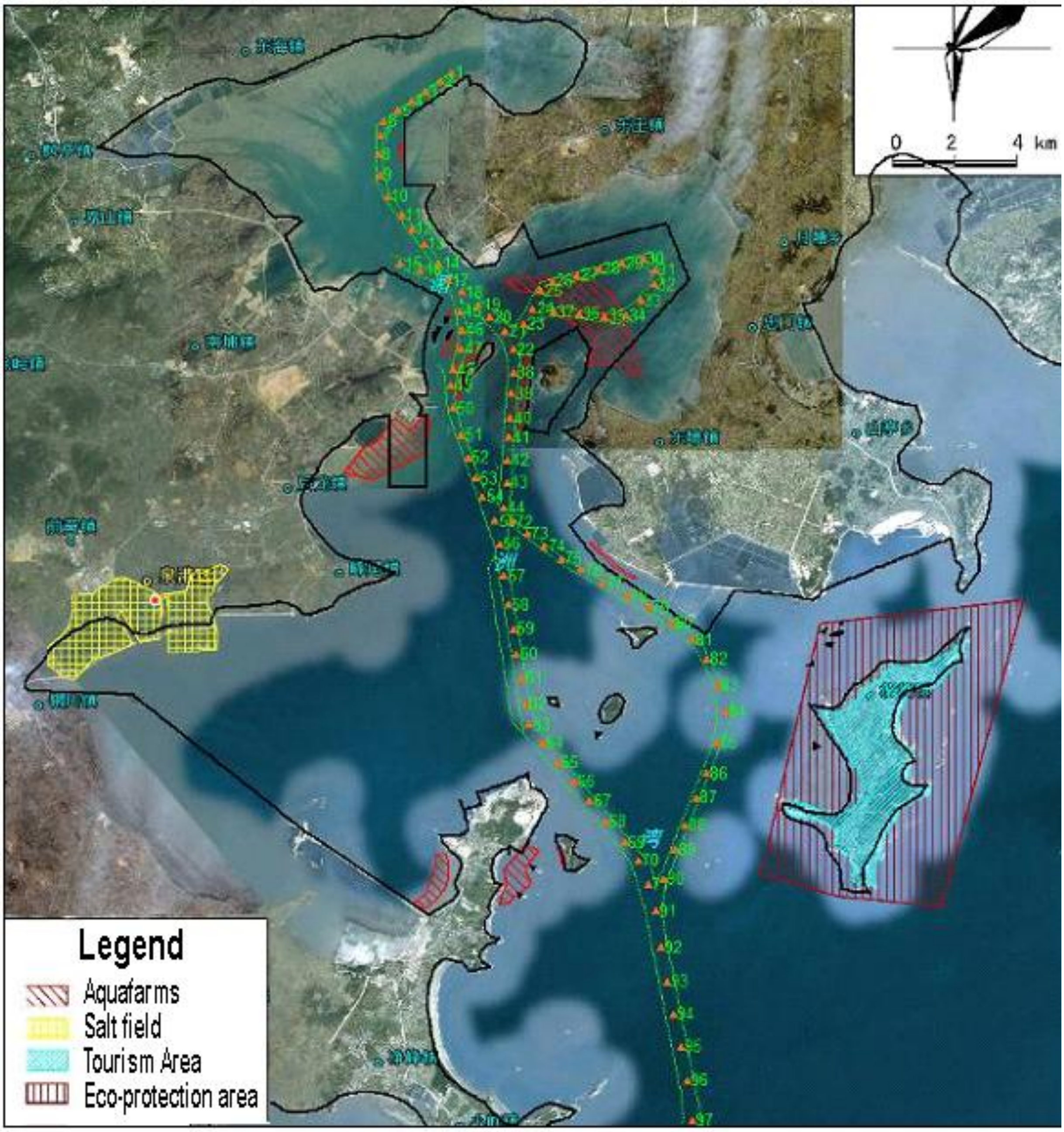


Figure 6.2-9 Layout of flow rate analyzing points (at channel areas)

(2) Analysis of tidal volume variation

As a bay with strong tides, Meizhou Bay features large areas of tidal inlet, big tide range and huge tidal volume. The immense tidal volume is vital for maintaining the water depth at Meizhou Bay. By taking into consideration the medium- and long-range plans of Meizhou Bay and the post-dredging natural conditions, the tidal volume variation characteristics of the bay were analyzed before and after project implementation.

Table 6.2.1 shows the tidal volume variation at the main sections during flood tide before and after project implementation. Following project implementation, as indicated in Table 6.2.1, tidal volume at Cross-section 1 decreases by 0.04 million-0.06 million m^3 or 0.15%-0.21% during flood and ebb tides; The numbers are 2 million m^3 and 0.30%-0.35% respectively for Cross-Section 2; 0.09 million -0.36 million m^3 and 0.05%- 0.20% for Cross-Section 3; and 0.04 million-0.08 million m^3 and 0.20%- 0.59% respectively for Cross-Section 4.

There is slight decrease in tidal volume during flood and ebb tides within Meizhou Bay after project implementation mainly because when forecasting with hydrodynamic numerical modelling, Shimen'ao land reclamation, Zoumadai land reclamation and construction of neighboring docks that result in some decrease in water area have been taken into consideration. However, the change of tidal volume after project implementation is little. Therefore, it is concluded that project implementation will not lead to the characteristic change in tidal waves and tidal currents of Meizhou Bay. Basically, it will not lead to the restructuring of shoals and grooves of neighboring sea areas, either.

Table 6.2.1 Tidal volume variation at main sections within the bay

Working condition	Cross-section 1		Cross-section 2		Cross-section 3		Cross-section 4	
	Flood tide	Ebb tide	Flood tide	Ebb tide	Flood tide	Ebb tide	Flood tide	Ebb tide
Pre-project	2.825	2.785	6.706	6.801	17.656	18.547	1.849	1.443
Post-project	2.819	2.781	6.682	6.781	17.620	18.537	1.846	1.435
Volume change	-0.006	-0.004	-0.023	-0.020	-0.036	-0.009	-0.004	-0.008
Change (%)	-0.213	-0.153	-0.350	-0.291	-0.205	-0.051	-0.202	-0.586

(3) Flow rate variation

Table 6.2.2 indicates the flow rate variation of up and down rapids during flood tide at the testing points before and after project implementation.

Following Phase III implementation, as indicated in Table 6.2.2, the hydrodynamic conditions remain basically unchanged except at some project areas that were impaired to some extent because of channel dredging. There is little decrease in the flow rate, which indicates that the planned project is limited to local specific site and its implementation will hardly cause any impacts on the flow rate of other bay areas. The hydrodynamics of neighboring water areas will be hardly affected. Basically, the slightly weakened hydrodynamic force will not lead to the restructuring of shoals and grooves of neighboring sea areas, either. Furthermore, no change of flow rate contrast characteristics of flood and ebb tides occurs at the calculation points within the main channel of Meizhou Bay.

Table 6.2.2 Flow rate variation of up and down rapids during flood and ebb tides before and after project implementation

Subarea	Location	Flow rate change (m/s)
Non-channel areas	#1- 6 points at the north side of Putou channel	-0.1
	#14-16 points at the front of Xiaocuo Operation Area	-0.01
	#7-10 points at the front of Xiuyu Operation Area	-0.01~-0.02
	#11-13 points at the front of LNG dock	-0.01
	#30-35 points at Liyuwei Operation Area	-0.01
	#36-41 points at the front of Luoyu Island	-0.01
	#59-63 points at the front of Zoumadai Operation Area	-0.01
	#54-58 points at the front of Douwei ship building and repairing yard	-0.01~-0.02
Channel areas	#1- 6 points within the north Putou channel	-0.23
	#10-14 points at the front of Xiuyu Operation Area	-0.15
	#23-37 points within the Shimen'ao channel section	-0.3
	#38-43 points within the west Luoyu channel	-0.02
	#73-81 points of Dongwu dock channel	-0.2
	#56-63 points of the channel near the crossing zonein the central bay	-0.12
	#63-68 points at the front of 300,000dwt channel of Dongzhou Peninsula	-0.1
	#91-97 points of the main channel	-0.01

Note: The sign of "-" stands for flow rate decrease.

(4) Analysis of flow pattern variation

Following the channel dredging, no obvious change of flow pattern characteristics occurs throughout the bay and there is no big change in flow field characteristics. Flow coming into main channel is seen near the channel area and its flow direction gradually inclines towards the channel direction. For example, the tidal flow is more in the direction of south-north at Dasheng Island-Luoyu channel section. And the flow route of up and down rapids in Shimen'ao also gradually goes in parallel with the channel direction. At the same time, the flow rate weakens to some extent because of deep-water excavation at the channel section and it weakens substantially at the north Putou Operation Area, Shimen'ao channel area, etc at bayhead. Please refer to Figure 6.2-10 and Figure 6.2-11 for the up and down rapids flow field following channel dredging and Figure 6.2-12 and Figure 6.2-13 for the contrast flow pattern before and after project implementation. Generally, slight change of flow pattern only occurs near the project area before and after project implementation while basically no change occurs to the flow pattern of flow fields of neighboring water areas.

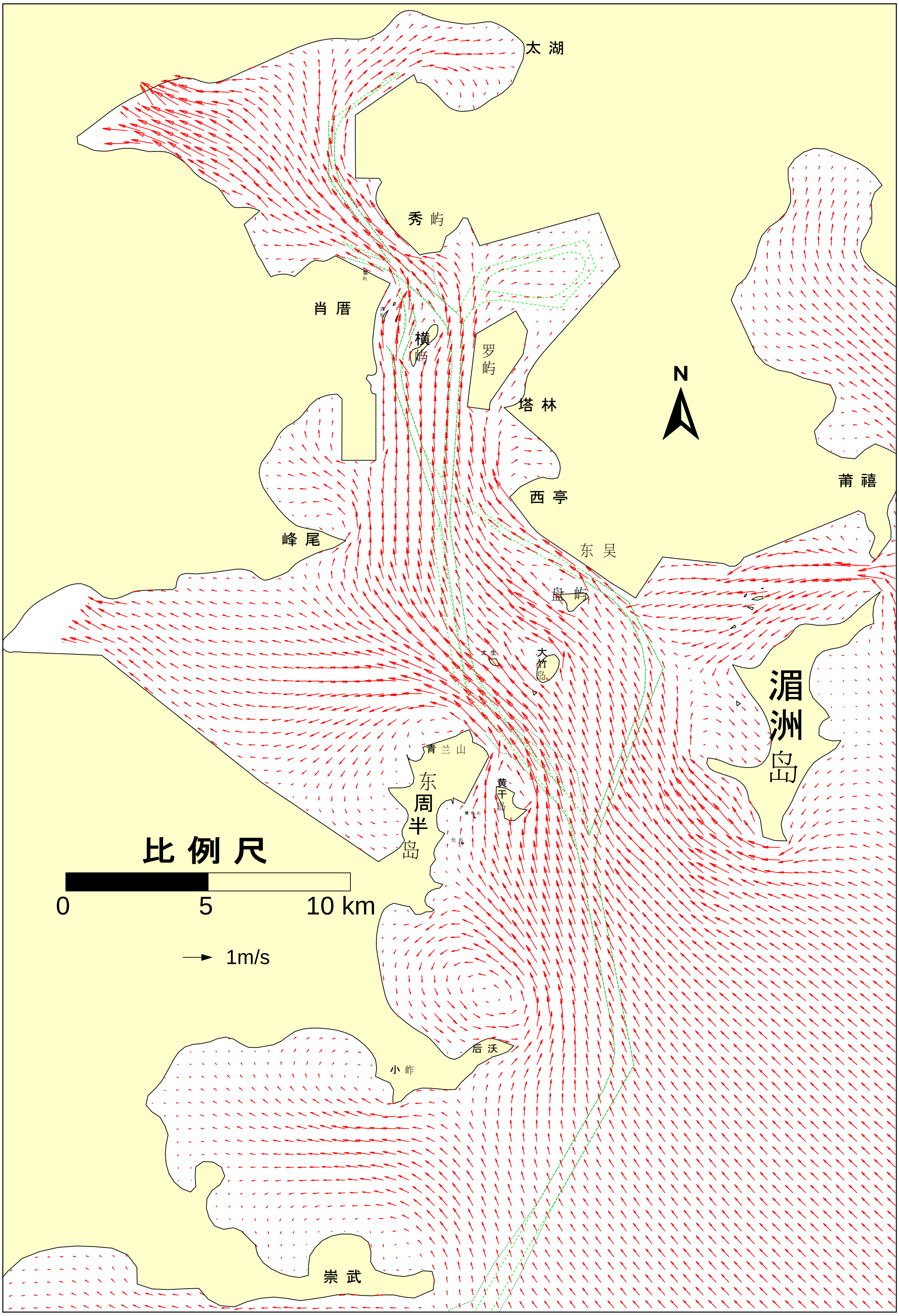


Figure 6.2-10 Up rapids flow field at flood tide following channel dredging

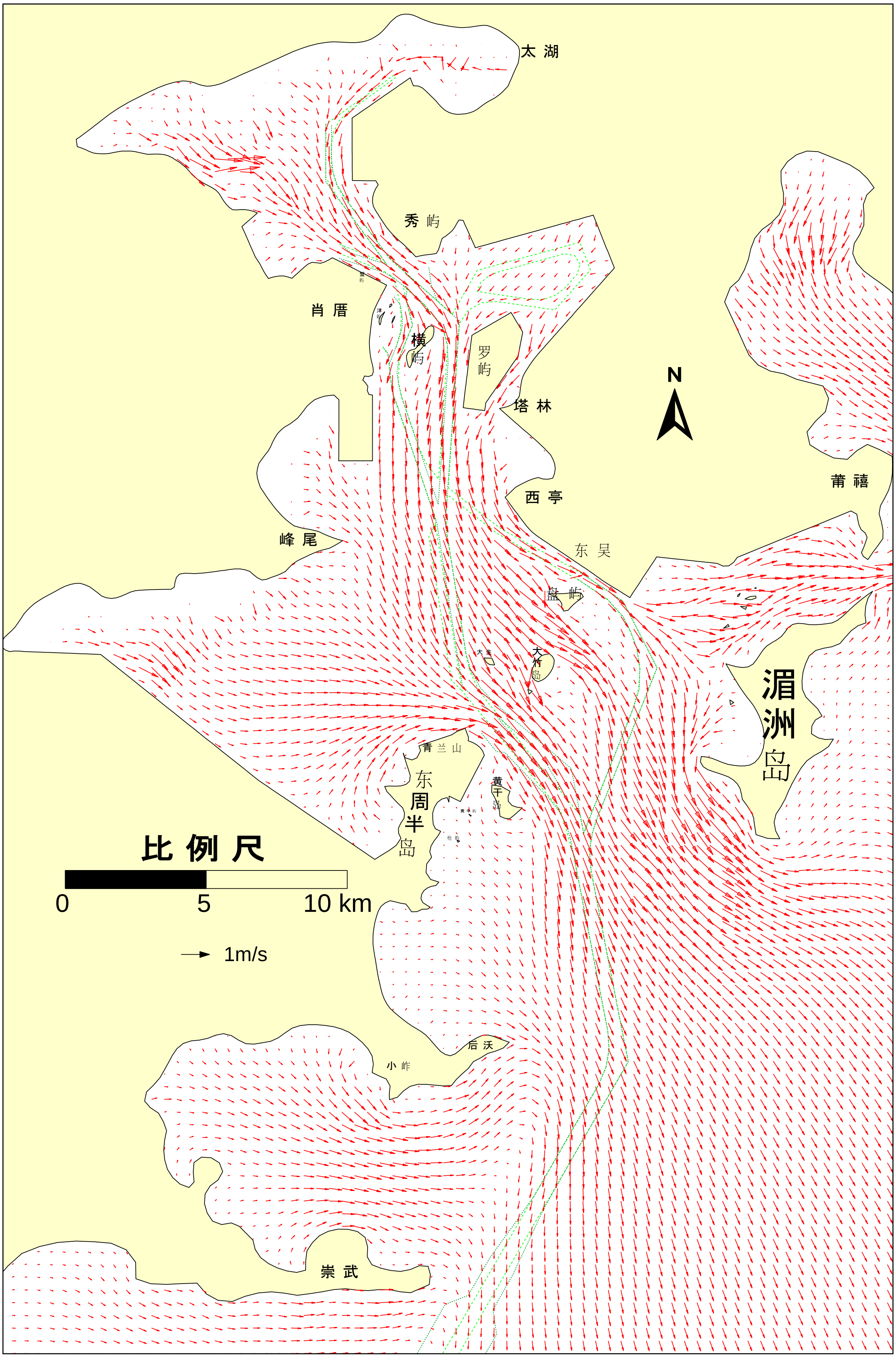


Figure 6.2-11 Down rapids flow field at flood tide following channel dredging

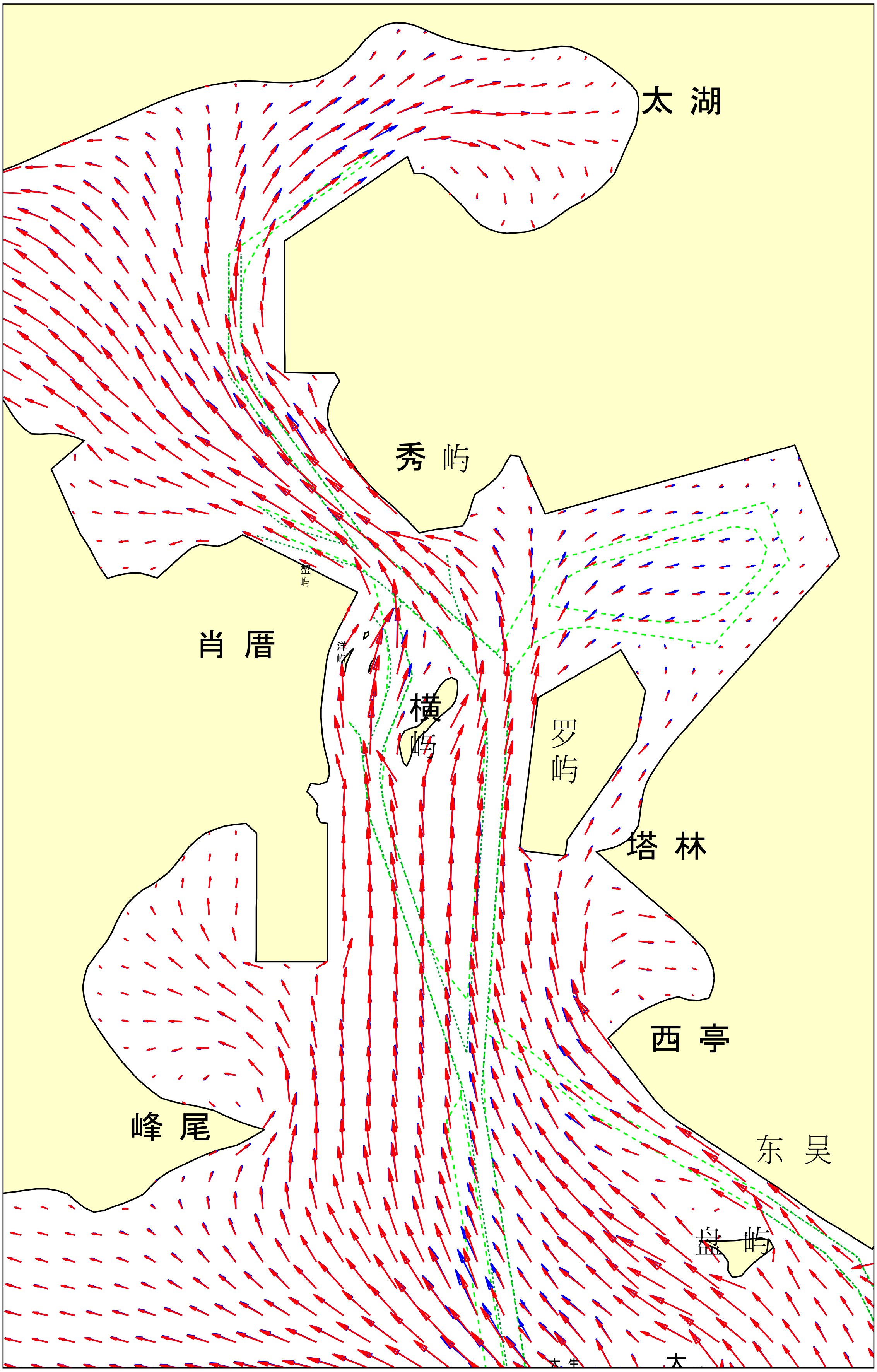


Figure 6.2-12 Comparison of up rapids flow fields before and after project

implementation (red arrows for post-project and blue arrows for pre-project)

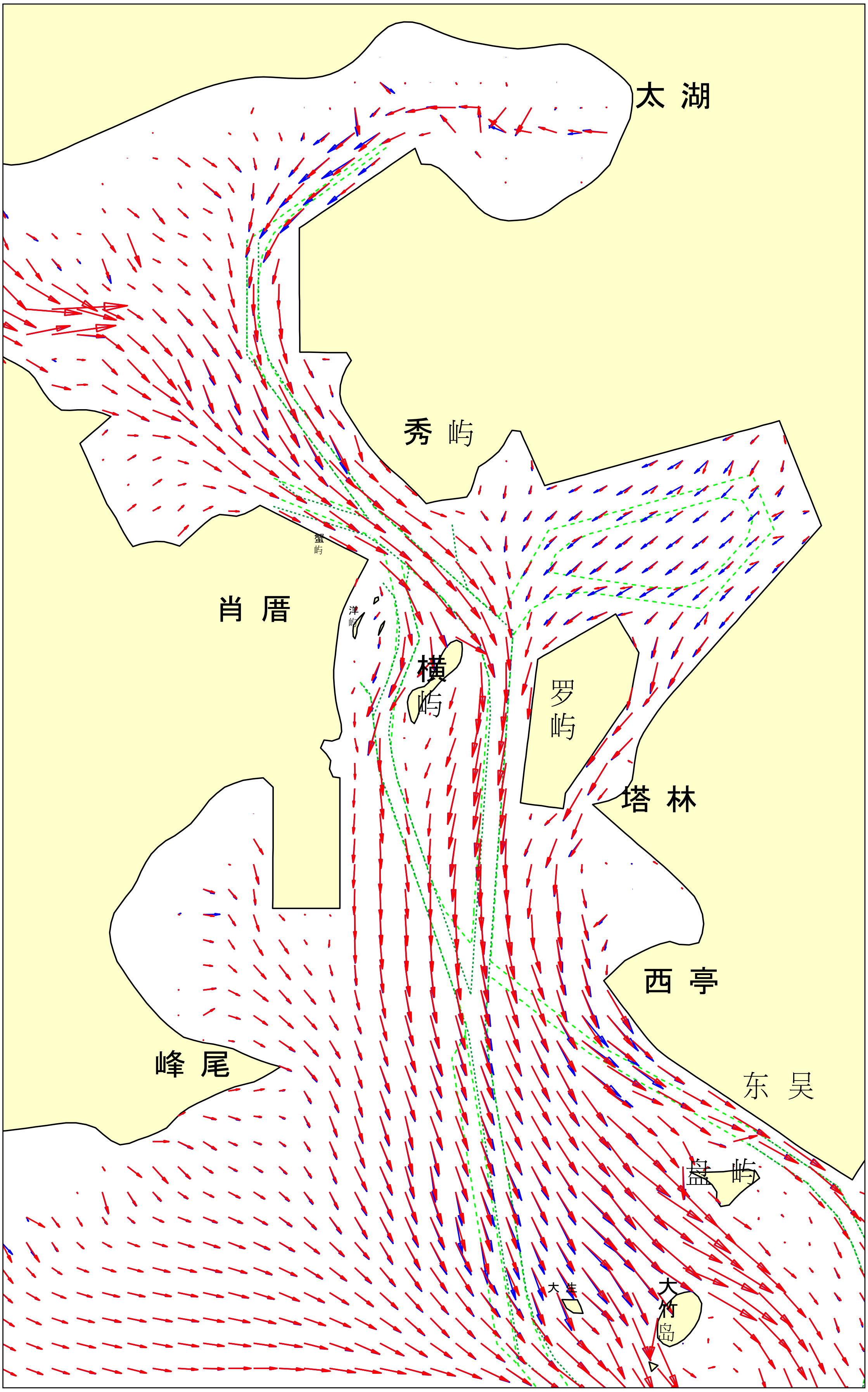


Figure 6.2-13 Comparison of down rapids flow fields before and after project

implementation (red arrows for post-project and blue arrows for pre-project)

6.2.2 Impact on Marine Erosion and Sedimentation

6.2.2.1 Forecast model

Studded with islands and islets and surrounded by low hills, Meizhou Bay sea area features shore stabilization with limited sediment of incoming runoffs since there is no large river flowing into the bay and the hills boast luxuriant plants and good conditions of soil conservation. Therefore, there is little incoming sediment from land. Due to its strong tidal force and clear water, Meizhou Bay maintains a basic balance between incoming and outgoing sediments with tidal flow. Inner bay sedimentation is partly caused by suspended sediment transport. It is currently estimated that there are a number of semi-empirical and semi-rational relations on silting rate of suspended sediments along the coast. Calculation is conducted with the following formula recommended by Committee of Water Transportation, CECS:

$$P = \frac{w_0 sT}{\gamma_0}\left\{K_1\left[1-\left(\frac{H_1}{H_2}\right)^3\right]\sin\theta + K_2\left[1-\frac{V_2}{2V_1}\left(1+\frac{H_1}{H_2}\right)\right]\cos\theta\right\}$$

Where, P—annual sedimentation intensity (m/s);

W_0—Settling velocity of cohesive fine grain sediment flocculation (m/s), 0.00027～0.00042m/s;

S—Local average sediment concentration per year (kg/m^3), taking 0.14kg/m^3;

T—Duration of settlement, total seconds in a year (s);

H_1, H_2—Water depth of a project area before and after excavation;

V_1, V_2—Flow rate of a measuring point before and after project implementation;

K_1, K_2—Empirical coefficient, taking 0.35 and 0.13 respectively;

θ—The included angle between water flow direction and navigation channel direction (°);

γ_0—Dry bulk density of sediment (kg/m^3);

$\gamma_0 = 1750 d_{50}^{0.183}$, d_{50} stands for median sediment size. According to data analysis of suspended sediment measured in 2006, the median sediment size of suspended sediments of Meizhou Bay is averaged at 0.0148mm.

In calculating sediment accumulation, the value of mean sediment concentration is taken by referring to the sediment concentration of neighboring measuring points.

6.2.2.2 Analysis of sedimentation impacts

Main sedimentation areas were located at channel sections after dredging. Therefore, a total of 76 points were deployed along the channel sections to analyze their sedimentation intensity. Please refer to Figure 6.2-14 and Table 6.2.3 for the points layout and sedimentation intensity respectively.

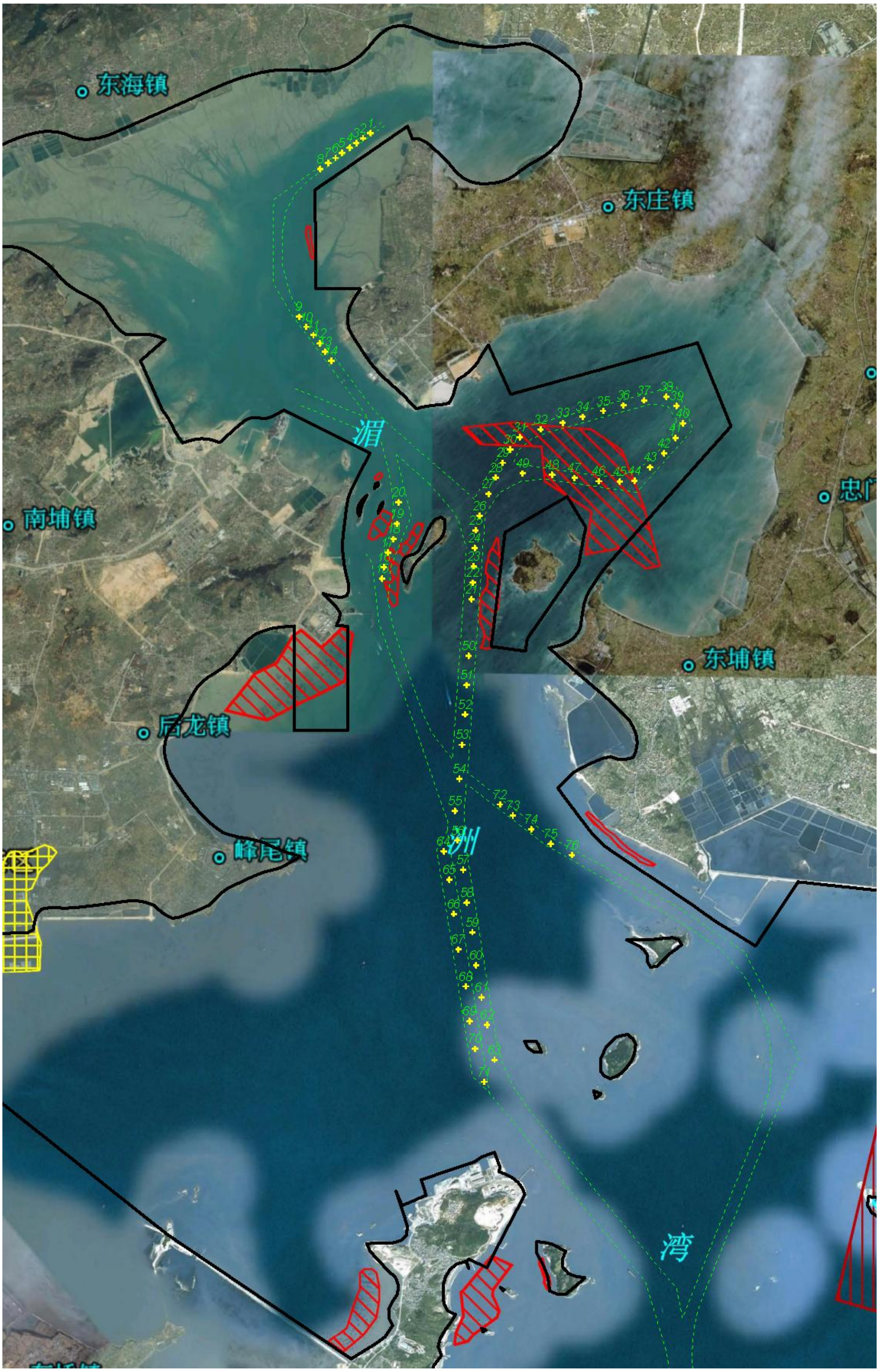


Figure 6.2-14 Points' layout for analyzing the sedimentation intensity of dredged areas in Meizhou Bay

Table 6.2.3 Sedimentation intensity of the channel areas following project implementation (unit: m/a)

Location	Point No.	Sedimentation intensity	Location	Point No.	Sedimentation intensity
Putou Operation Area	1	0.05	Shimen'ao channel section	39	0.11
	2	0.06		40	0.10
	3	0.05		41	0.09
	4	0.06		42	0.08
	5	0.04		43	0.09
	6	0.05		44	0.08
	7	0.04		45	0.07
	8	0.04		46	0.07
Putou channel section	9	0.02		47	0.06
	10	0.02		48	0.07
	11	0.01		49	0.06
	12	0.01	Dasheng Island - Luoyu Island	50	0.01
	13	0.03		51	0.01
	14	0.01		52	0.01
West Huiyu channel section	15	0.01		53	0.01
	16	0.01		54	0.01
	17	0.01		55	0.01
	18	0.02		56	0.02
	19	0.03		57	0.02
	20	0.01		58	0.02
West Luoyu channel section	21	0.01		59	0.02
	22	0.01		60	0.02
	23	0.01		61	0.04
	24	0.01		62	0.02
	25	0.01		63	0.01
Shimen'ao channel section	26	0.01	Crossing zone	64	0.02
	27	0.01		65	0.01
	28	0.02		66	0.01
	29	0.05		67	0.01
	30	0.06		68	0.04
	31	0.07		69	0.02
	32	0.07		70	0.02
	33	0.07		71	0.01
	34	0.08	Meizhou Bay branch channel section	72	0.01
	35	0.08		73	0.01
	36	0.09		74	0.03
	37	0.09		75	0.04
	38	0.10		76	0.02

Inner bay areas whose dynamic environments have changed following project implementation are mainly centered upon the dredged channel section. The comparative analysis on flow rate and flow direction before and after project implementation indicates that no obvious change has occurred to the flow route of flood and ebb tides in the bay. There is more flow coming into main channel than before project implementation. The flow gradually goes in the same direction of channel. And sedimentation in dredged sections may occur a result of channel excavation.

Inner estuary sea areas at the far north side of the bay and at the front of Putou Operation Area have maximum sedimentation intensity of 0.06m/a, averaging at 0.05m/a; the 70,000dwt Putou channel section has post-project sedimentation intensity of about 0.02m/a per year; the West Huiyu channel section has average sedimentation intensity of 0.02m/a; Intensity of sedimentation within the West Luoyu channel section is about 0.015m/a. Sedimentation is slightly more obvious at the Shimen'ao channel section, particularly at #38-#41 points, with up to 0.11m/a at the most and averaged at about 0.07m/a throughout the full range (#26-#49). The highest sedimentation intensity of Dasheng island - Luoyu Island is 0.04m/a near #61 point with the full range (#50-#63) averaged at 0.02m/a. The highest sedimentation intensity of the crossing zoneis 0.04m/a near #68 point and averaged at 0.03m/a found at the central water area of the passing zone. The highest sedimentation intensity of the Meizhou Bay branch channel section is 0.04m/a near #75 point with the full range averaged at 0.02m/a. Calculation outcome indicates that there is lower sedimentation intensity at the water area around the dredged area and that the sedimentation intensity of main dock operation areas without exception does not exceed 0.01m/a.

In general, the sedimentation intensity following project implementation is low except that of the dredging area. The water body of Meizhou Bay features low sediment concentration and limited sediment sources. Its sedimentation intensity tends to weaken gradually and reach a new balance following a period of readjustment and adaptation. There is no regular maintenance dredging is envisaged for Meizhou Bay navigation channels.

6.2.3 Waste Management

The waste water, oil-containing ballast water and solid waste from the ships, if not well managed, may pose a potential pollution that is harmful to the marine environment and ecology.

While, such impacts are strictly regulated by both national and international regulations. A number of national regulations, e.g. *Management Regulations on Preventing Vessels from Polluting Marine Environment*, *Fujian Marine Environmental Protection Regulations* and other relevant laws and regulations, strictly require that wastewater and solid waste are forbidden to be discharged into the coastal sea area. These wastes must be unloaded to the waste treatment facilities in the port for treatment. Therefore, with sound enforcement of waste management regulations, the potential impacts of ship wastes can be properly mitigated.

6.2.4 Navigation Safety during Operation

During operation stage, safety is the most important thing for the normal operation of Meizhou Bay ports. There are various ships navigating in the channels, including LNG carrier, oil tankers and other vessels that may carry dangerous or hazardous materials. Therefore, navigation safety is a paramount priority for MBHAB. It is also an important concern for the marine ecological environment, in particular for the possible spill of oil or hazardous materials. This risk is further assessed in detail in the

Chapter 8.

The improvement of Phase III channel improvement project itself is aiming to improve the navigation infrastructure in order to improve the operation safety of Meizhou Bay. Furthermore, since Meizhou Bay has been intensively used for navigation for decades, there have been well established management and operational procedures in MBHAB and relevant enterprises. There are also well established emergency response system and capacity within MBHAB regime, which is described in more detail in Chapter 8.

Chapter 7 Cumulative Impact Assessment
7.1 Cumulative Impacts and Integrated Coastal Management

The Meizhou Bay area is experiencing rapid socio-economic growth and expanding use of coastal resources. While proposed development projects are subject to compulsory Environmental Impact Assessment (EIA), a set of project-specific EIAs may not be sufficient to deal with cumulative impacts, and are unlikely to assess fully the potential impacts to ecosystems from incremental environmentally degradation as a result of a series of marine large-scale engineering projects and decades dramatic economic development. Therefore Cumulative Impacts Assessment (CIA), or equivalently Cumulative Effects Assessment (CEA), is needed to broaden the single-project EIA to examine "the accumulation of human-induced changes in valued environmental components over time and across space in an additive or interactive manner."

It is internationally accepted that successful 'integrated' coastal management requires understanding of the environmental impacts arising from relevant coastal activities (shipping, port development, waste disposal, fishing, aquaculture, etc). Integrated Coastal Management (ICM) seeks to "maximize the benefits provided by the coastal zone and to minimize the conflicts and harmful effects of activities on social, cultural and environmental resources". It seeks to "ensure that development and management plans for coastal zones are integrated with environmental and social goals, and are developed with the participation of those affected."(World Bank, 2002). Successful ICM needs to incorporate a process to monitor and assess cumulative impacts to address the impacts of interactions among activities, and the accumulation of impacts over time. In this sense, the ICM approach is fundamental to the management and mitigation of cumulative impacts in the Meizhou Bay area experiencing such rapid urban, industrial and transport sector growth.

The decision for development of Meizhou Bay as a key deep sea port has been completed as part of an ICM approach. The background for this approach for this coastal area was set through work completed by a number of authorities and described in the work of Hong and Xue, *"Cumulative environmental impacts and integrated coastal management: the case of Xiamen, China. 2004"*. In this work cumulative environmental impacts and the implementation of integrated coastal management is examined within the harbour of Xiamen, China, where similarly, the coastal zone is under increasing pressure as a result of rapid economic growth. The Xiamen harbor is one of the three major harbor clusters in Fujian Province and located to the south of Meizhou Bay.

The Fujian Province has employed the ICM, outlined in the Hong et al work at Xiamen (*Cumulative Environmental Impacts and Integrated Coastal Management: the case of Xiamen, China, Journal of Environmental Management 71, 2004*), to meet relevant requirements for 'integration' as laid out in the literature, and has explicitly incorporated consideration of cumulative impacts within its management and monitoring processes, including inter-sectoral and governmental coordination, legislative and enforcement, scientific support mechanism such as marine functional zoning and environmental protection planning.

Notably, the Meizhou Bay (Quanzhou - Putian) Master Plan Environmental Impact Assessment Report (Master Plan SEA hereafter), 2011 by the Transport Planning and Research Institute was prepared in this context and assesses the surrounding coastal environment. The SEA makes specific reference that the development of Meizhou Bay Port facilities will lessen development pressure on the surrounding bays. This concentration of development effort will allow for increased protection and rehabilitation of natural habitats in neighbouring Quanzhou and Xinghua Bay. Another Planning EA for Meizhou Bay Rim Regional Development (Regional Planning SEA hereafter) was also prepared in 2011 by Fujian Provincial Environmental Science Institute to examine the regional and cumulative impacts on Meizhou Bay.

7.2 Components of Cumulative Effects Assessment

After completing the assessment of potential Project level environmental impacts, where residual environmental effects are identified, a cumulative environmental effects assessment is conducted for those project level impacts that may overlap with other projects and activities that have been or will be carried out.

As a common practice, a cumulative effects assessment is to identify past, present and reasonably foreseeable future actions/projects that will be carried out that overlap spatially and temporally with the proposed project and act in combination with the Project to create environmental effects. Key components of cumulative effects assessment include: scoping of key cumulative impacts issues, establishment of spatial and temporal boundaries for the analysis, identification of “valued ecosystem components (VECs)” and indicators, identification of underlying sources of environmental impacts and the pathways through which impacts are likely to occur, and assessment of environmental impacts on the VECs arising through the identified pathways. Further, CEA shall include recommendations and management plans to mitigate the impacts.

For the purposes of the assessment, the following assumptions are made:

- The existing status or condition of each VEC reflects the influence of other past and current projects and activities occurring within or outside of the Project area.
- The existing activities will continue to be carried out in the future and to have similar effects as currently observed.

In this context, after initial scoping and boundary-setting, the cumulative impacts assessment focused on the following components.

- Identification of sources of environmental impacts, notably port development, land reclamation, expansion of industries, shipping, waste disposal, and coastal construction, etc;
- Selection of the major categories of impacts (which may be seen as proxies for the ‘valued ecosystem components’), such as circulation and siltation, water quality, the benthic community.
- use of a set of key indicators to examine cumulative impacts arising from the aggregate of human activities.

The assessment therefore integrates the cumulative effects of these ongoing projects and activities. It also recognizes that future projects and activities in addition to the Project may result in additional effects on the VECs in the Project area. The effects of these other projects and activities are considered and assessed for each VEC. The method used in assessing cumulative effects for this Project follows current common practice and rationale of environmental impact assessment and borrow the assessment framework presented in the Cumulative Effects Assessment Practitioners Guide[1].

7.3 Scoping Cumulative Impacts

The project EIA has identified that main environmental issues arising from navigation improvement include: 1) potential changes to the hydrodynamics conditions that is fundamental to the Bay's environmental and ecological aspects, notably carrying capacity, siltation and erosion, etc. 2) ecological impacts such as loss of benthic organisms and inter-tidal zone which is considered natural habitats; 3) water quality degradation; 4) impacts on aquaculture.

Meizhou Bay port development Master Plan and regional development plans were then reviewed to scope other potentially significant environmental issues and affected resources from cumulative impacts perspective. In a broad sense, all the impacts on affected resources are probably cumulative; however, the role of the scoping is to narrow the focus on the cumulative effects analysis to important issues of national, regional, or local significance. In addition to above mentioned issues, ambient air quality shall be consider an important cumulative impact issue given the planned industrial development in Meizhou Bay area. While others, such as fishing, is not considered a significant issue because Meizhou Bay is not an economical fishing area due to relevant low abundance of fishing resources compared to offshore and nearby fisheries waters (e.g. Meizhou Island and Xinghua Bay), and a long history of navigation and port development.

7.3.1 Spatial and temporal boundaries

Analyzing cumulative impacts differs from the traditional approach to environmental impact assessment because it requires the analyst to expand the geographic boundaries and extend the time frame to encompass additional effects on the resources, ecosystems, and human community of concern. In this assessment, the spatial scope and time frame of cumulative impact analysis coincides with the study area and period of Regional Development Planning of Meizhou Bay Rim, as is shown in Figure 7.3.1.

The planning area specified in the Regional Development Planning of Meizhou Bay Rim in Fujian Province is 1,200 km2, which has a population of 1.6 million in the year of 2010. The assessment periods specified in the Regional Development Planning of Meizhou Bay Rim in Fujian Province are as follows: 2010-2015 is the recent assessment period, 2016-2020 is the middle period and 2020-2030 is the future period.

[1] Hegmann, G., C. Cocklin, R. Creasey, S. Dupuis, A. Kennedy, L. Kingsley, W. Ross, H. Spaling and D. Stalker. 1999. *Cumulative Effects Assessment Practitioners Guide*. Prepared by AXYS Environmental Consulting Ltd. and the CEA Working Group for the Canadian Environmental Assessment Agency, Hull, Quebec.

Figure 7.3.1 Study area of Cumulative Impacts Assessment

7.3.2 Sources of Cumulative Impacts

Sources of cumulative impacts involve past, present and reasonably foreseeable future activities/projects. These projects and activities which may potentially interact cumulatively with the Project have been identified through a scoping process which includes a review of regional activity, relevant results of assessment of project specific effects from other projects that have been assessed, and professional judgment.

Major sources of anthropogenic impacts on Meizhou bay area include: overall population and economic growth, industrial development, ports and shipping, land reclamation, and waste disposal.

- Overall growth

Since 1980, and especially since 2000s, Quanzhou City and Putian City has developed rapidly, with annual GDP growth rate of 10~20%. The Regional Development Planning predicts that in the study area of Meizhou Bay Rim, between 2010 and 2030, the annual GDP growth would be 12.5%; the total population would rise from 1.58 million to 1.92 million (an annual growth rate of 9.8 %); the built-up area would rise from 270 km2 to 488 km2 (an annual growth rate of 3.0%). The area is expecting significant urbanization and industrialization.

- Industrial development

Exiting and developing industrial facilities are shown in Figure 7.3.1. Apparently, most industrial production is distributed along the coastal area of Meizhou Bay. The Fujian Integrated Refinery and Chemical project and LNG station plays a leading role to support development of these industries, such as petro-chemical, ship making, energy sector, etc.

The Regional Development Planning predicts agglomerating and production chain development based on current port- and petro-based industries at the planning horizon. As Figure 7.3.2 shows the spatial distribution of key industrial parks.

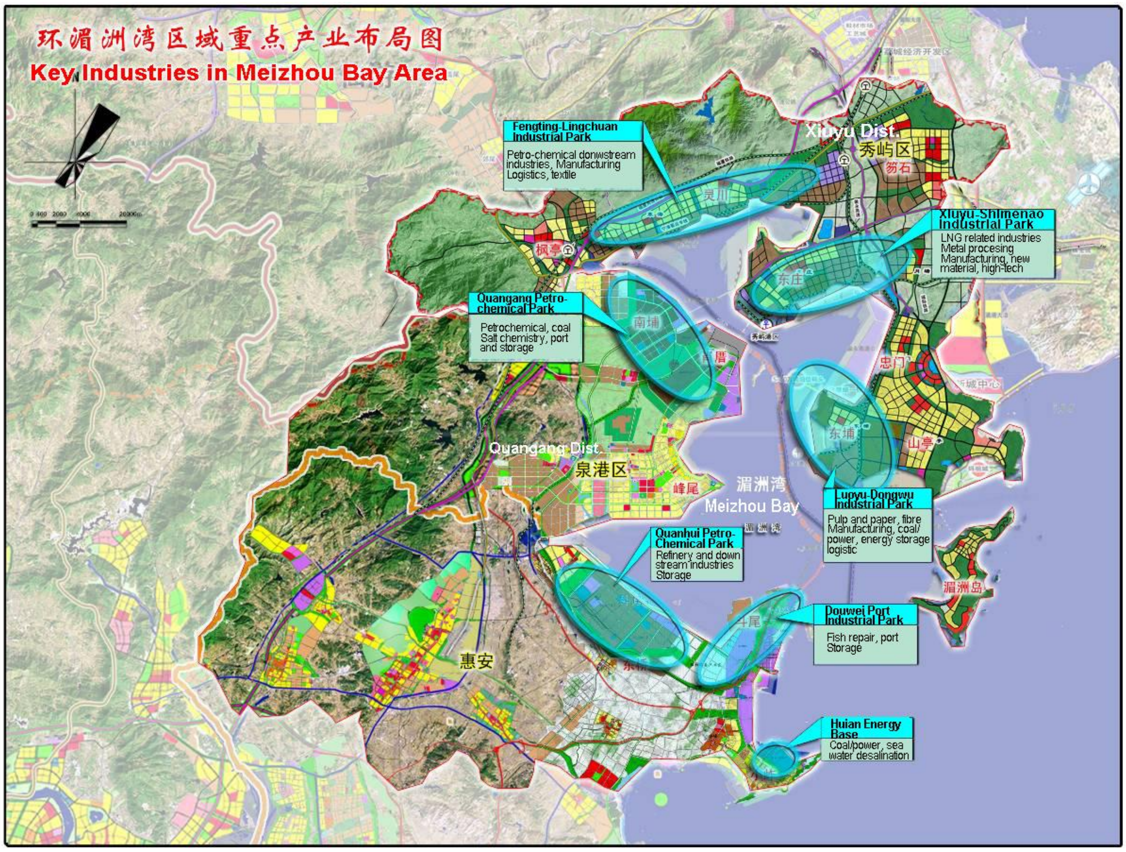


Figure 7.3.2 Spatial Distribution of Planned Key Industries in Meizhou Bay area.

- Ports and shipping

Ports and shipping plays a fundamental role to the Meizhou Bay regional economy. Under Putian and Quanzhou City there are five major bays, including Xinghua Bay, Meizhou Bay, Quanzhou Bay, Shenhu Bay and Weitou Bay. There are eight Port Areas distributed in the five bays, of which four Port Areas are located in Meizhou Bay, as is shown in Figure 7.3.3. In 2009, the Meizhou Bay port areas handled around 40% of the total goods of the five bays.

The Master Plan for Meizhou Bay Port (Quanzhou-Putian) was prepared in the context that the eight Port Areas will be integrated and managed by one port authority (previously they are managed by Putian and Quanzhou port authority respectively). The Master Plan predicts that by 2030 there will be 286 berths in the eight Port Areas, of which 196 berths will be located within Meizhou Bay. Notably, the four Port Areas in Meizhou Bay will be able to handle 76.7% of the total goods handled by the eight Port Areas. The concentrated development in Meizhou Bay indicates that the development pressure on the surrounding bays will be lessened relatively.

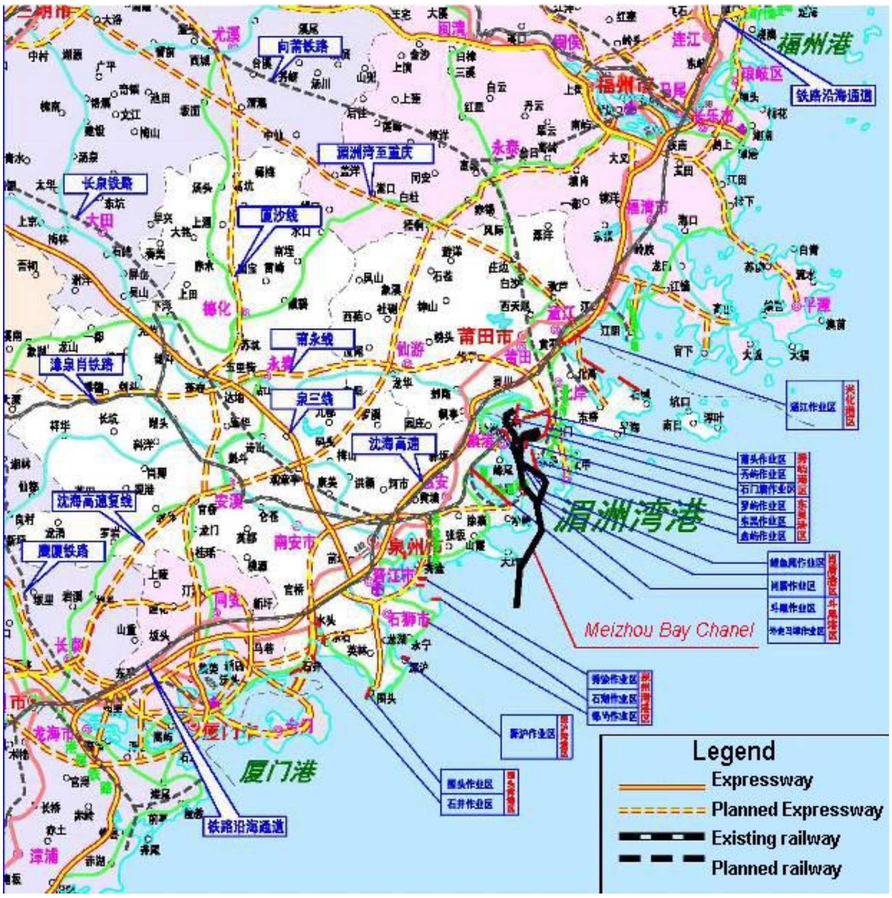


Figure 7.3.3 Port Areas in Meizhou Bay Port and other bays in Putian and Quanzhou City

- Land Reclamation and Channel Dredging

In Meizhou Bay, a series of projects have taken place involving reclamation of coastal areas, notably the in Putou, Dongwu, Xiaocuo, and Xiuyu. Table 7.3.1 presents past land reclamation information provided by MBHAB in 2012.

Table 7.3.1 Past Land Reclamation in Meizhou bay

Location	Reclamation Area (ha.)	Note
Putou	35	Putou #1 and #2 berth
Xiuyu	60	LNG terminal
Xiaocuo	70	Xiaocuo 1#~4# berth
Dongwu	60	/
Douwei	90	/
Total		

The reclamation took place largely over the past 20 years. The latest are the reclamation for the construction of Putou 1 and 2# berth that were just finished in mid-2012. As presented in the Table 7.3.1 above, the previous land reclamation took a minor amount of the coastal area of Meizhou Bay.

Meanwhile, the navigation channels within the Meizhou Bay have undergone improvement through dredging several times. As noted earlier in this EIA report, the Phase II navigation channel improvement was just finished in mid-2012. Dredged materials were disposed of at Dongwu area for berth development.

According to the Master Plan, under the maximum development scenario of 2030, around 2914 ha sea areas will be reclaimed. The proposed Meizhou Bay Navigation Improvement Project would involve the reclamation of around 400 ha at Xiaocuo and Putou area, as has been analyzed in the previous section in the EIA report.

Beyond the proposed project, major channel dredging and land reclamation activities would take place in Shimen’ao. The dredged materials of planned Shimen’ao channels would be used for land reclamation for the construction of Shimen’ao operational area. Besides, the eastern and southern part of Shimen’ao will be reserved for development. Shimen’ao operational area will be developed on a gradual basis depending on the economic development in the planning horizon, 2020-2030. The shimen’ao channels, serving the construction and operation of the Shimen’ao operational area, would be able to handle 20,000~150,000 DWT ships.

Reclamation activities demonstrate well the nature of cumulative impacts: the various reclamation have had cumulative impacts over time, which has led to potentially detrimental effects, e.g. accelerated erosion or siltation patterns, siltation of drainage outlets, loss of fish spawning grounds, and hindrance of commercial activities dependent on navigation.

- Waste Disposal

Regular monitoring conducted during 2003-2010 show the water quality in Meihzou Bay remain clean, meeting Class I or II water quality standards despite rapid economic development in the Bay area. The reasons are 1) good water quality baseline and large assimilation capacity of the Bay, 2) wastewater collection and treatment facilities have been developed to meet the development needs; and 3) land-based industrial and domestic waste discharge have been effectively controlled.

Considering the maximum Meizhou Bay port development scenarios over the next 10-20 years, the most important pollution sources at sea are from port operations, including domestic wastewater, container washing wastewater, runoff, and wastewaters from vessels.

Table 7.3.2 Wastewater Prediction for 2020 and 2030.

Port Area	2020 wastewater prediction (10^4 ton/a)	2030 Wastewater prediction (10^4 ton/a)	Sum (10^4 ton/a)
Dongwu Port Area	41.87	67.94	109.81
Xiuyu Port Area	13.98	19.17	33.15
Xiaocuo Port Area	43.75	45.44	89.19
Douwei Port Area	45.63	57.91	103.54
Total	145.23	190.46	

7.4 Assessment of Cumulative Impacts

The likely future projects to be assessed including potential cumulative interactions and relevant VECs are summarized in the previous section. In addition to the proposed navigation Project future development is planned for other terminal projects as identified in areas zoned for port industrial development. The cumulative effects of these projects are therefore predicted to have a positive effect on land use, as the development will “improve” the land in accordance with regional development plan. Regulatory requirements, EA commitments and permit conditions (*e.g.*, for dust and noise control, sewage and waste management) associated with the Meizhou Bay and other projects will reduce the potential for adverse cumulative effects on land use.

7.4.1 Cumulative Impacts on Sedimentation and Erosion

The navigation channel dredging and reclamation activities result in direct impacts on geomorphology and reduction in water surface area. Since the direction and velocity of the tidal current are controlled by geomorphology, indirect impacts occurred in terms of changes in the hydrological circulation pattern and sedimentation velocity. If the tidal influx volume is reduced significantly, the tidal flushing capacity would be weakened and sedimentation process would be accelerated.

Hydrological and sediment monitoring since 1997 show that the average sediment concentration in the Meizhou Bay ranges from 0.016~0.059 kg/m3, indicating the bay remain as a low-sediment, clear water bay. Bathymetry surveys over the years also indicate that the bay remain good stability. There is no evidence that the past dredging and reclamation activities have resulted in significant impacts on natural sedimentation/erosion process.

Mathematical modeling taking into account the proposed Meizhou Bay Navigation Improvement Project, planned future navigation channel dredging and coastline reclamation (such as Shimen'ao channel and operational area development described in the Master Plan) have been conducted. The details are presented in Chapter 6.2 of this EIA report. In summary, 1) the tidal influx and efflux volume will decrease 0.05%~0.59%. Such minor changes will not change the current and tidal characteristics or the layout of beach, trench of the Meizhou Bay sea area substantially; 2) flow regime and flow field of the Meizhou Bay will not change substantially; 3) sedimentation flux is about 0.02-0.05m/a along dredged navigation channels. Sedimentation flux is below 0.1m/a near main port operational areas. Considering the low-sediment concentration in the bay, it is expected that the sedimentation process will weaken gradually and reach a balance eventually.

7.4.2 Cumulative Impacts on Water Quality

According to the regular monitoring results during 2003~2010, the water quality of Meizhou Bay remains good. DO, COD, inorganic nitrogen, phosphorus, oils and heavy metals met China Class I or II seawater quality standards.

As previously noted, wastewater generated in 2020 and 2030 in Meizhou Bay are predicted to reach 1.45 and 1.9 million m3/a. The wastewater would be mainly produced in Dongwu, Xiaocuo and Douwei Port Area. As to Xiuyu Port Area, it would produce less than 10% of the total. Another feature of the predicted wastewater is that domestic wastewater would account for around 85% of the total. COD and oils would be the primary pollutants to impact the seawater quality, because wastewater from port production and vessels contains considerable oils.

The wastewater will be collected and treated in wastewater treatment plants (WWTP). Douwei's wastewater will be sent to Huidong WWTP, Xiaocuo's wastewater will be sent to Quangang WWTP, and Dongwu's wastewater will be sent to Gangkou Xincheng WWTP. The outlets of these WWTPs are located at middle to lower bay areas that are close to the bay mouth and subject to strong tidal movement. To meet the planned ocean functional zoning and water quality targets in Meizhou Bay in 2030, the effluents from the WWTPs will have to meet national standards Class II, i.e. COD 120mg/L and oils 10mg/L.

Seawater quality monitoring results show the seawater quality in Meizhou Bay remains stable over the years. Based on the monitoring results, for water quality prediction purpose the COD baseline concentration is set at 0.85 mg/L; oils baseline concentration is 0.018 mg/L.

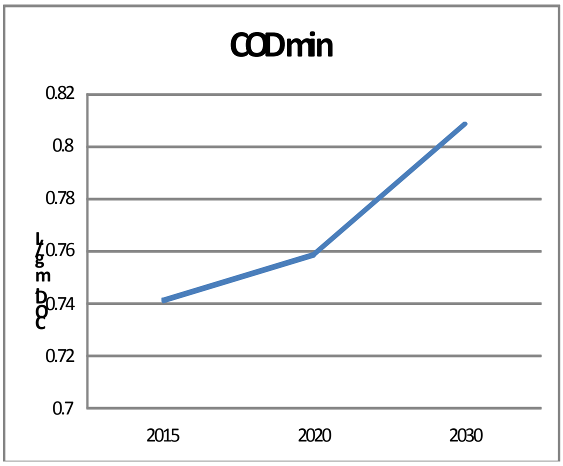
Water quality modeling was then conducted, taking into account tidal characteristics in the Meizhou Bay, sensitive receptors near the wastewater outlets, temporal and spatial overlapping of wastewater discharge from those outlets. Modeling results gave the spatial and temporal distribution of COD and oils concentrations. Based on the results, the COD and oils concentration in the vicinity of wastewater outlets varies with the tidal flooding and ebbing in the Meizhou Bay. The maximum values are COD 0.995 mg/L and oils 0.030 mg/L, respectively, a small increase of 0.145 mg/L and 0.012 mg/L from the baseline concentrations. The increase will not change the original water quality functional targets.

Modeling results also show that in the vicinity of sensitive receptors such as Meizhou Island reserve, the COD and oils concentration would have minor increase, but the maximum concentration would be far below COD 2 mg/L and oils 0.05 mg/L the Class I water quality standards. Therefore, it is concluded that the planned wastewater discharge in 2030 would not result in significant impacts on the seawater quality in the Meizhou Bay and nearby seawaters.

A similar study on the cumulative impact on water quality from port and regional development was conducted and presented in the Environmental Impact Assessment for the Regional Development Planning for Meizhou Bay Rim. The study takes into account the industrial layout and the marine hydrodynamics study, eight wastewater outlets as planned by marine environment capacity research and planning each level year. The predicted COD and oils (petroleum) in Meizhou Bay sea areas are as shown in Table 7.4.1

Table 7.4.1 Forecast Results of Pollutant Concentration in the Entire Bay (mg/L)

Pollutant	**2015**		**2020**		**2030**	
	Average Concentration	**Increment**	**Average Concentration**	**Increment**	**Average Concentration**	**Increment**
COD_{Mn}	0.741	0.041	0.759	0.059	0.808	0.108
Petroleum	0.019	0.004	0.021	0.006	0.027	0.012



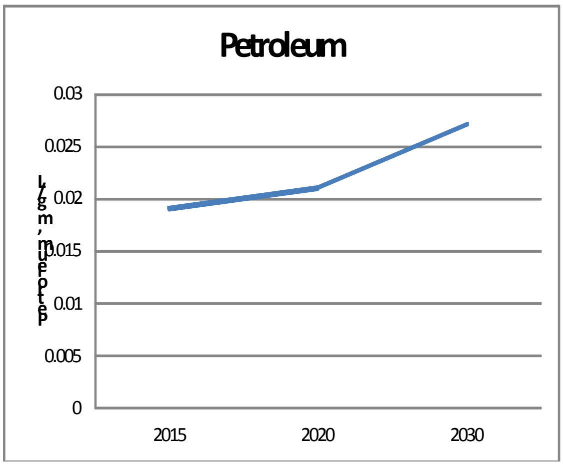


Figure 7.4.1 Prediction of COD and oils concentration in Meizhou Bay

The sea water quality prediction is generally consistent with the cumulative impacts assessment results described in the Master Plan. Due to the low baseline pollutants concentration in Meizhou Bay, the strong diffusion conditions, and relative large carrying capacity, the cumulative impacts on the water quality of Meizhou Bay sea areas from the discharge of wastewater in each planning year (2015, 2020, and 2030) is not significant and the water quality of Meizhou Bay sea areas will remain the functional water quality target of Class II.

7.4.3 Cumulative Impacts on Marine Ecology

Cumulative impacts that are resulted from land reclamation, port and navigation development and operation, and wastes discharge may also affect the marine ecology in terms of benthic communities, inter-tidal zone, marine living resources and their ecological services.

According to the Master Plan, under the maximum development scenario of 2030, around 2,194 ha sea areas would be reclaimed in the Meizhou Bay. The reclaimed sea areas would be primarily coastal wetlands which by definition refer to 1) permanent water bodies whose depth is less than 6 meters, 2) inter-tidal area, and 3) coastal low lying land. As noted earlier, the inter-tidal area in Meizhou Bay is about 142 km2. Therefore, by estimate, the loss of inter-tidal area under the 2030 maximum development scenario would account for around 10-15% of the total inter-tidal area in the Meizhou Bay.

The proposed Meizhou Bay Navigation Improvement Project would involve the land reclamation of Putou and Xiaocuo that account for around 400 ha coastal wetlands, namely less than 2.8 % of the total in Meizhou Bay. The project impact is not considered significant. However, the long term Meizhou Bay port development that is temporally and spatially cumulative will result in significant impacts to the Meizhou Bay. This finding reveals the nature of cumulative impacts, i.e. although individual development activity may result in minor or insignificant impacts, the overall development activities over broader geographical area and long term may pose significant cumulative impacts.

- Cumulative impacts on benthic organisms

Port development, including the backfilling and excavation activities, will damage the habitats for benthic organisms and may result in the temporary or permanent loss of benthic organisms.

Land reclamation will turn coastal sea areas into land that would lead to permanent loss of benthic organisms and their habitats in the reclaimed areas. As noted above, around 2,194 ha additional coastal sea areas within Meizhou Bay would be reclaimed by 2030. According to the Chinese regulations on impacts assessment on marine ecology (SC/T9110-2007), land reclamation impacts will result in 100% loss of benthic organisms, and the amount of loss is calculated as 20 times of the loss. Therefore, assuming the average biomass is 68 g/m2 (based on the inter-tidal zone and marine area survey), the total amount of benthic losses would be 22, 773 ton.

Underwater excavation such as channel dredging and port basin dredging would result in total loss of benthic organisms during construction. Restoration of the benthic communities is fast when the impact zone is small, and the impact timing is not spawning period. Normally it takes 5-6 months the key community structure parameters (such as species numbers, abundance and biodiversity index) will be restored substantially. Complete restoration will take longer time because the larvae of benthic organisms are zoonplankton which follow tidal movements will regain growth in the impacted zone eventually. In the cases of large impacted area and spawning period, the natural restoration of benthic communities may take as long as 5-7 years without artificial restoration measures taken.

Excavation or disposal activities may result in increase of suspended solids in the vicinity of construction sites. It will lead to decrease of seawater transparency that affects the biological process of benthic organisms, particularly to sensitive species. But once the construction is completed, the impacts would disappear.

Each project developer must follow this principle set in the regulation to assess the temporary or permanent impacts on marine ecology and earmark budget to implement ecological compensation measures.

- Cumulative impacts on ecological services function

The cumulative impact of the Master Plan implementation is reflected through the damage to the coastal wetland ecological services by port development. These ecological services functions include supply function, adjustment function (such as handling waste, atmosphere adjustment), supporting function (primary production, nutrient recycling, habitats) and cultural function (such as research, education and entertainment). Among them, the supporting function is fundamental.

There are numerous methods to evaluate the losses of ecological services, through the relationship between primary productivity between mollusks and their market prices, or substitutable products, etc. The Master Plan EA and Regional Planning EA made such evaluation accordingly and concluded the valuation of lost ecological services can range from 110~580 million RMB per year.

Cumulative impacts on sensitive areas
According to the Master Plan, the port development in the Meizhou Bay is far away from nearest ecological sensitive area, i.e. Meizhou Island Ecological Nature Reserve. The nearest port area to Meizhou Island is Dongwu Port Area, which is 6.7 km away. As noted previously, the predicted wastewater discharge in 2030 will not result in significant water quality change in the Meizhou Island area. Therefore, cumulative impacts on the Meizhou Island are considered minimal.

7.4.4 Cumulative Impacts on Terrestrial Ecology

According to the Master Plan, the port development till 2030 within Meizhou Bay will need to use 62 ha of land area in total, among which 61 ha belongs to the Huanggan Island at Douwei. Key impacts resulted from port development include those impacts related to port construction, change from coastal line to artificial landscape, and induced roads, infrastructures, and industrial development. Eventually, land use pattern will be changed substantially.

Port construction often involves vegetation clearance, soil erosion, dust and noises. Terrestrial ecology survey shows in the Meizhou Bay terrestrial area, the vegetation coverage is low, e.g. the vegetation coverage of Huanggan Island is about 20~40%. There was no endangered fauna or flora identified. Overall, the construction impacts on terrestrial ecology are limited. It should be noted that each port facility development activity is subject to environmental impact assessment. The environmental management plan will need to be prepared to avoid and mitigate the construction impacts to acceptable levels.

In terms of the regional urbanization and industrialization in the Meizhou Bay Rim area in 2030, it is predicted that the average growth rate of land use for industrial purposes reaches 9.73% and the average growth rate of land used for residential purposes is 2.42%. By comparison, the area of farmland will reduce from 35.37% to 20.37%. By implementing the regional development planning, the land used for development will become the largest landscape patch in the Meizhou Bay Rim area. The cumulative impacts resulted from the urbanization and industrialization were closely studied in the context of maintaining current environmental quality in the Meizhou Bay Rim planning EA, which requires that by 2020, the drinking water source, surface water quality, ambient air quality, municipal and industrial wastewater treatment rate, municipal and industrial solid treatment rate will need to reach 95-100%; and by 2030, all parameters need to reach 100%. Meanwhile, land use for development shall be strictly controlled to ensure farmland in Quanzhou and Putian will be no less than 140.8 thousand ha and 69.6 thousand ha, respectively.

7.4.5 Cumulative Impacts on Ambient Air Quality

Key air pollutants associated with the Meizhou Bay port operation are dust and oils evaporation, because coal and petroleum products are the main goods the port will be handling.

By estimates, the maximum dust discharge in Meizhou Bay in 2020 and 2030 will be 13370 t and 18788 ton/a, respectively. Dongwu Port Area will be the primary source of dust discharge as it account for around 80% of the total. Assuming the baseline TSP concentration is 0.1 mg/Nm3, based on regular air quality monitoring results; and the dust prevention rate 75%, based on actual dust prevention practices in China; the cumulative impacts associated with the dust discharge is predicted using mathemathical modeling. The results show that the under the maximum dust discharge scenario in 2020 and 2030, ambient air quality will not be significantly impacted by the dust discharge.

Oils evaporation from oil loading and transportation operations is normal. Oils evaporation is non-point source emissions that are subject to the type of oils, storage and transportation facilities, weather conditions and their interactions. To predict the emissions of oils, NHHC (Non-Methane Hydrocarbon) is selected as the pollutants parameter. Mathematical modeling shows that oils evaporation under the 2015, 2020 and 2030 maximum emission scenarios will not result in significant impacts on ambient air quality.

7.4.6 Cumulative Impacts on Aquaculture

Marine aquaculture in Meizhou Bay includes shallow seas, inter-tidal mudflats. Currently, mudflat aquaculture is mainly oysters, clams. Shallow sea aquaculture is mainly seeweed and oyster. Cage aquaculture is mainly for abalone that is located in the vicinity of Yangyu, Huiyu and the area between Luoyu and the main channel.

A variety of environmental impacts can be attributed to aquaculture, large as a result of high breeding densities and poor distribution of the farming activities. For example, for cage aquaculture in shallow seas, the combination of residual food and fish excrement produces sulfides which consume large amount of oxygen.

With the implementation of the Meizhou Bay port development plan and regional industrial development, the aquaculture has been decreasing over the years and will continue the momentum. In this sense, the environmental impacts on water quality associated with aquaculture will be reduced. It is anticipated that the livelihood of local people will gradually turn to industries and services associated with the port operation. During the development of port, actual aquaculture area will need to be quantified through project environmental impact assessment and livelihood survey process. Economic compensation to the loss of aquaculture will have to be agreed upon with aquaculture owners.

7.5 Mitigation Measures for Cumulative Impacts

While cumulative impact mitigation relates primarily to Project impacts and their additive or subtractive nature, there is a fundamental need to put Project impacts into regional and sectoral development planning. The following sections review the initiatives necessary to accomplish this as well as defining specific compensation measure to offset losses from Project impacts.

7.5.1 Compliance with National Regulations

In order to avoid, minimize and offset potential environmental and management problems arising from port operations, the port management authority should comply with national environment and safety legislation to avoid or minimize potential impacts from vessel movements and operational emissions and wastes and liaise closely with national and provincial agencies to facilitate early identification of potential impacts.

Mitigation measures specific to the Project includes the development and implementation of an EMP and adherence to applicable regulations, guidelines and conditions of permit. It is assumed that the other projects that could act cumulatively will be held to similar environmental standards which may include fish and habitat compensation, and adherence to applicable regulations, guidelines and conditions of permit.

As per mitigative and regulatory requirements and it is not expected that project will cause significant adverse effects to the marine VECs either individually or cumulatively. It is not expected that suspended sediments in the water column will exceed natural conditions (*e.g.,* severe storm events) in Meizhou Bay Port (Section 4.6 of the EIA).

The reasonably foreseeable projects have relatively small marine footprints (*e.g.,* piled jetty structure, berths) which will minimize the potential cumulative effects of these projects on benthic habitats and sediment quality, and marine fish and water quality. The cumulative effects will be a loss of benthic habitats from infilling in port and operational area building and short term increases in turbidity due to any dredging or marine construction. Indeed the removal of cage aquaculture to complete Channel development, while a social impact, will likely have a positive environmental impact due to decrease in waste discharge from the cage sites.

Xue et al (2004)[2] found out the efficient ways to mitigate the cumulative impacts of harbor development through integrated coastal management approach for Xiamen port development which is a close by port harbor with Meizhou Bay. This approach proposed the following perspectives:

- Intersectional integration for coordinated management of the various sectors of coastal activity;
- Legislative framework and enforcement mechanisms;
- Scientific support mechanism linking assessment and management; and
- Marine functional zoning: a tool for mitigating cumulative impacts.

7.5.2 The Integrated coastal management framework

Cumulative environmental benefits are expected to occur with respect to enhanced industrial land use for port development in Meizhou Bay port from the combination of the Meizhou Bay Navigation Improvement Project and other relevant ports and terminal development consistent with the China national, provincial and local economic development master plan. The proposed project with other regional development project is not likely to have significant adverse residual effects on the environment. Adverse environmental effects will be reduced to acceptable levels through the use of technically and economically feasible design and mitigation measures plus the sufficient environmental management approach.

The individual project EIAs for the Project and related projects addresses the port development issues including cumulative impact assessment and provides an integrated coastal management framework can be used by the port developers to manage associated environmental issues. The Integrated Coastal Management framework shall be consistent with shoreline area land development plans, and watershed management plan including the inventory of the solid waste management policy and procedures.

Following the Project two backfilled operational areas i.e. Putou and Xiaocuo backfill Areas will be built. Within these backfilled areas, the major logistic facilities will be located. No industrial development is planned. Additional functions of the logistics might be related to supply chain management practices and strategies that reduce the environmental and energy footprint of freight distribution. It focuses on material handling, waste management, packaging and transport.

In order to mitigate the impacts of the existing logistics land uses on the residents, the following measures can be taken:

[2] Xiongzhi Xuea,*, Huasheng Honga, Anthony T. Charles, Cumulative environmental impacts and integrated coastal management: the case of Xiamen, China, Journal of Environmental Management 71 (2004) 271–283.

- A clear distinction should be made between urban and residential land uses and logistics land uses. If possible, logistics facilities with high emissions should be located further away from urban and residential areas than logistics facilities with less emissions and a sufficient setback distance should be provided.
- Residential and mixed use areas should be protected from truck traffic generated by the logistics facilities. Therefore, adequate access roads to the logistics areas need to be provided and their usage be enforced by a truck guiding system or a local environmental zone. Parked trucks have to be catered for by offering dedicated parking space for trucks or making sure that trucks can be parked on company sites.
- Logistics companies shall take technical measures that reduce noise from container handling and even to consider some design standards. Such measures would enhance their integration into the urban landscape. Infrastructure, too, should be built or maintained aiming at an appealing urban design. The logistics sector is diverse and thus has a varying compatibility with functional land use by the size, noise emissions and traffic generation of the logistics facilities. The area should be zoned for different types of logistics facilities and measures should be taken to mitigate the impacts of the logistics facilities on the residents and commercial users as well as to create a mutual identity of the port-city interface. According to a specific local situation, generally, a sound assessment of impacts from possible future uses and their truck traffic generation is necessary during the routine operation. The details see the Section 11 of the environmental management plan.

7.5.3 Ocean Functional Zoning

Ocean function zoning is a crucial instrument for effective mitigation of cumulative impacts. The ocean function zoning is the zoning of natural resource uses through han integrated approach to consider ecosystem and socio-economic factors. A zoning approach seeks to determine multi-use priorities, reduce use conflicts and increase the socio-economic benefits to society as a whole obtained from the various uses, while sustaining the resource base and ecosystem functions. Ocean functional zoning is an important component of ICM, providing a base for managing multiple use prioritization and coordination, and for effectively minimizing adverse environmental impacts through allocation of sea space based on functional characteristics of a given area.

Key zoning and plans include Fujian Province Marine Function Zoning, The Fujian Provincial Marine Environmental Protection Plan (2011-2020), Fujian Province Offshore Sea Territory Environmental Function Zoning, and Fujian Province Ecological Function Zoning. In facing the challenges and issues, the province aims to strengthen land and marine pollution control and coastal, bay and estuary environmental rehabilitation. Key measures identified include maintaining and establishing marine nature reserves, ecological rehabilitation, enhancing coastal and island ecological protection.

The Marine Environmental and Functional Zoning and plans present current marine status and issues, stipulate protection objectives, marine functions, development limits and sensitive areas. Therefore, extensive studies were conducted during project development and environmental assessment to ensure project compatibility with the zoning and plans. The following functional zoning existed in the Meizhou Bay area:

Fujian Province Ocean Function Zoning stipulates that the sea area in Meizhou Bay includes Channel Zone, Port Zone, Mudflat Aquaculture Zone, Shallow Sea Aquaculture Zone, Tourism Zone, and Marine Bed Pipeline Zone. The sea area around Meizhou Island (which is located near the bay mouth) is designated Marine Ecological Special Protection Zone as shown on Figure 7.5.1.

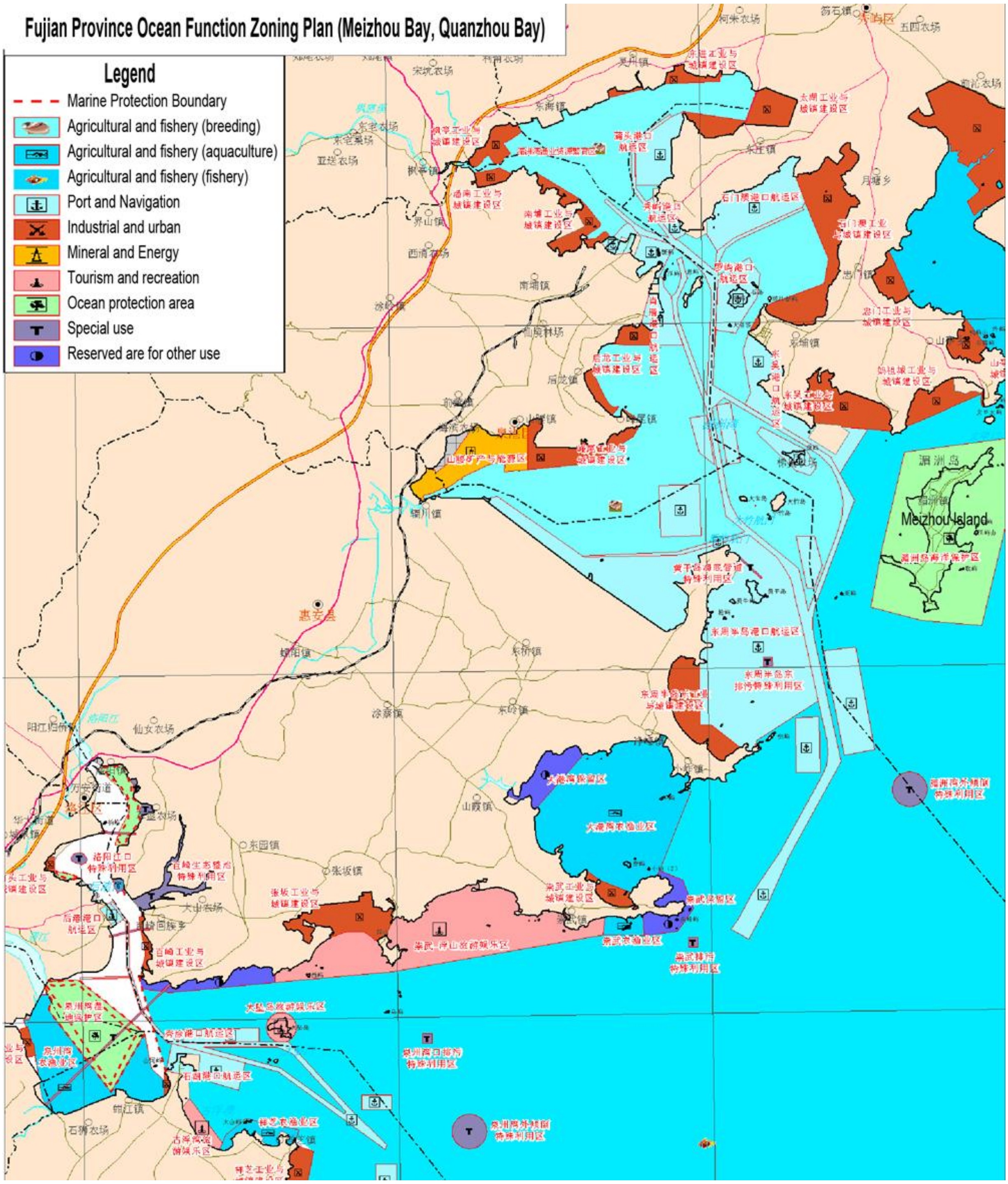


Figure 7.5.1 Fujian Province Ocean Functional Zoning (Meizhou Bay and Quanzhou Bay)

Fujian Province Offshore Sea Area Environmental Function Zoning stipulates environmental functions of sea areas. According to this Zoning, waters within the Meizhou Bay mainly serve navigation, port, ordinary industrial water, and receiving discharge purposes as shown on Figure 7.5.2.

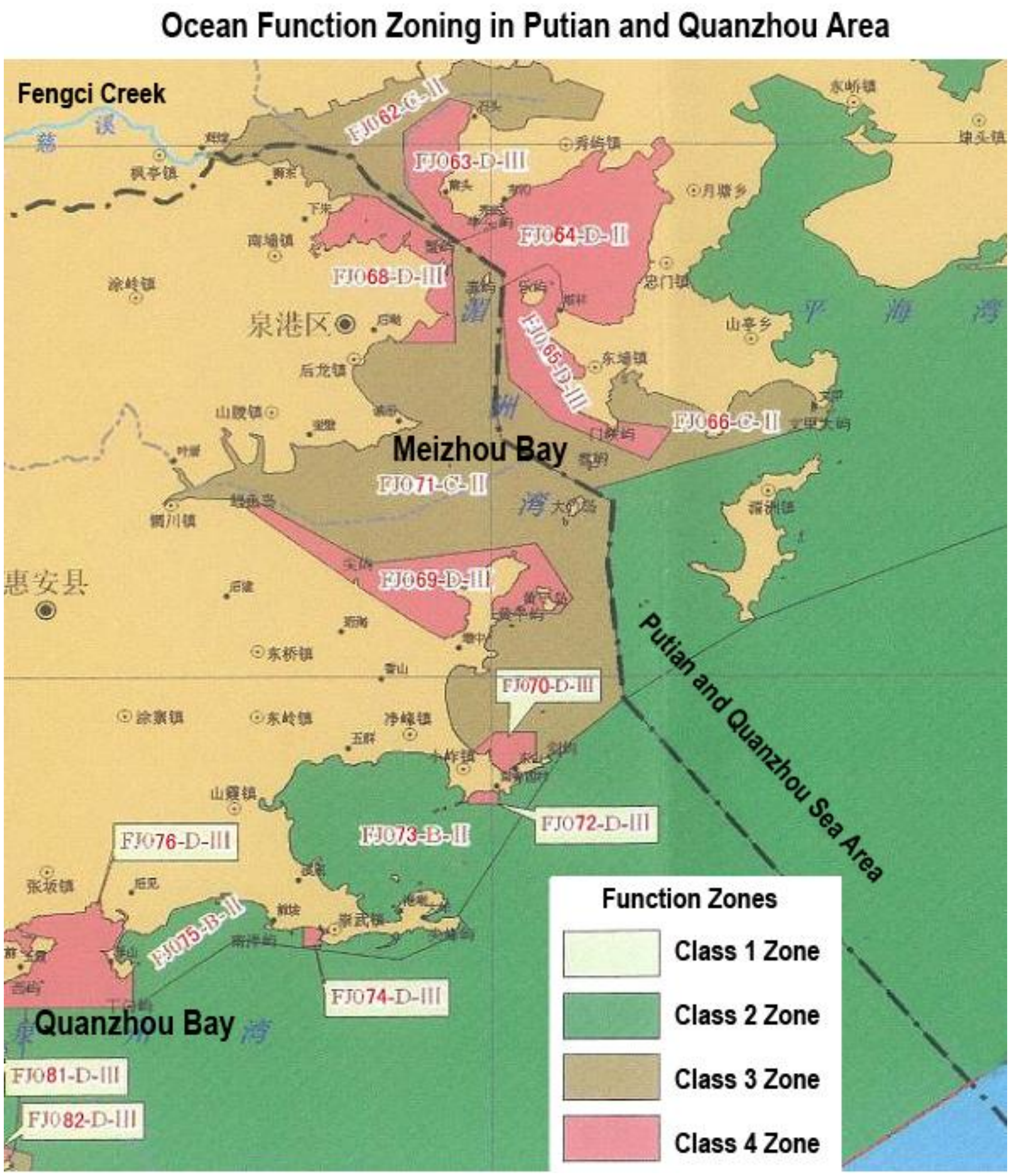


Figure 1.5.2 ***Fujian Province Offshore Sea Area Environmental Function***

The Fujian Province Ecological Function Zoning stipulates ecological functions of waters in the Meizhou Bay. According to the Zoning, the main ecological services of the Meizhou Bay are deep water port and navigation, and aquaculture as shown in Figure 7.5.3.

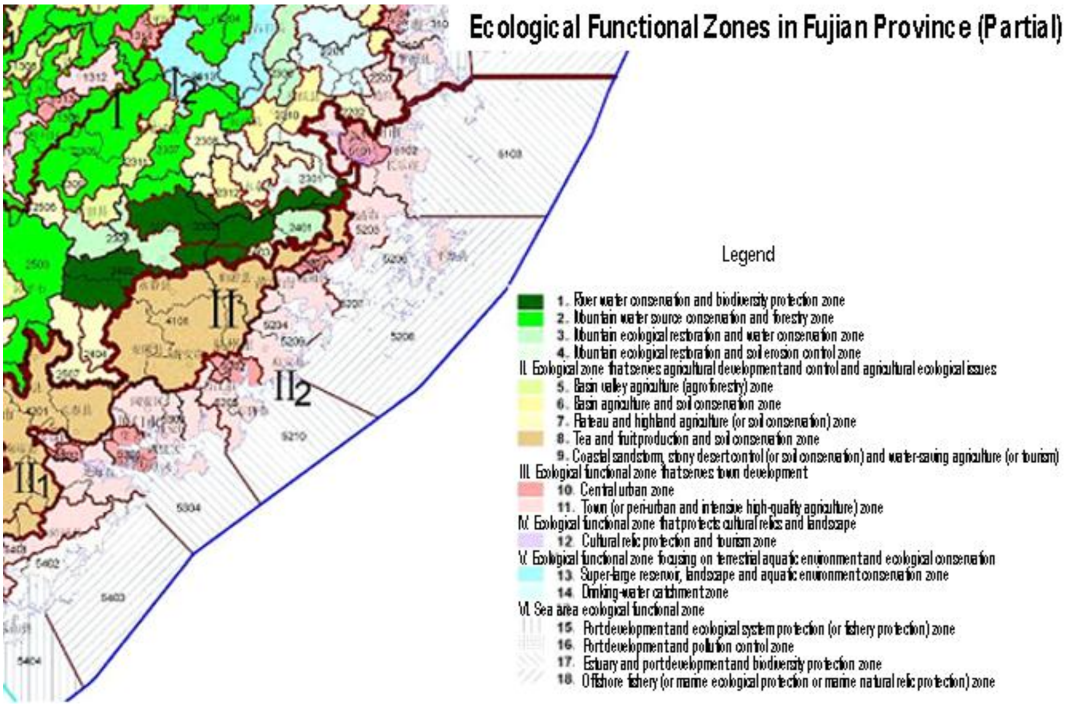


Figure 7.5.3 ***Fujian Province Ecological Function Zoning***

Fujian Province Marine Environmental Protection Plan (2011-2020), issued by the provincial government in June 2011, is of particular importance. According to the plan, the waters within Bay are designated either “urban, industry or port supervision area”, or “ecological corridor” which serves the function of a passage for fresh sea water and tide between inner and outer bay. It means that Meizhou Bay is allowed for “reasonable development” or “intensive development” in certain areas within the bay. The environmental function designation of Meizhou Bay is consistent with the facts that the bay presents low to middle sensitivity from ecological perspective, and relative large carrying capacity primarily due to excellent hydrodynamics conditions. As is shown in Figure 7.5.4.

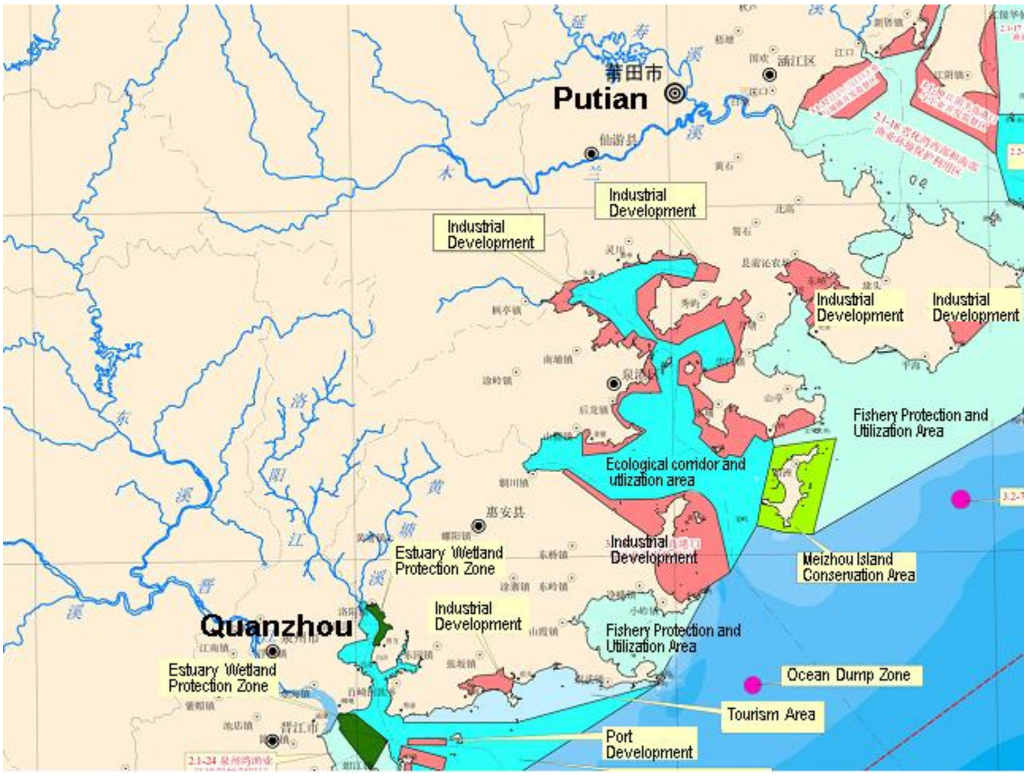


Figure 7.5.4 Fujian Marine Environmental Protection Plan (2011-2020)

7.5.4 Conformity with Port Planning

Conformity Analysis on Port Planning

The layout of proposed navigation channels conforms with Planning Drawing of Navigation channels and Anchorages of Meizhou Bay (see From Fig. 4.4-1). Therefore, Fujian Provincial Development and Reform Commission has replied and approved the project establishment in Minfagai Transport No. [2011]1443.

Conformity Analysis on Planning Environment Assessment

A Planning Environmental Assessment of Meizhou Bay Port Master Planning was being prepared during the preparation of the project EA. Currently it is being reviewed by provincial Environmental Protection Department. The draft Planning EA reviewed the project EA and does not provide objection. The analysis of the Planning EA was referenced in this project EA for cumulative impact assessment. And the main recommendations of the Planning EA are incorporated into this project EA as appropriate.

7.5.5 Recommendations of Planning EA

The Master Plan SEA made the following recommendation to be incorporated into the updated Master Plan. These measures will be able to help mitigate cumulative impacts resulted from the long-term Meizhou Bay port development.

- Coastline utilization:
    a. Comprehensive ecological impacts assessment for the development of Liyuwei Dapu coastline and Liyuwei Huiyudao coastline shall be conducted prior to the development is implemented in the future.

b. For Panyu Island coastline, the coastline development shall be conducted on a step by step manner. Meanwhile, resettlement, compensation, livelihood restoration and training shall be provided to the resettled people properly.

- Port area layout
  a. For Dongwu Port Area, wastewater treatment plant shall be taken into account in the port area design; safety design of petro-chemicals port must follow applicable national regulations and the safe buffer zone must be reserved; spraying and dust removal facilities must be provided to bulk port to effectively control dust emissions.
  b. For Xiuyu Port Area, Putou and Shimen’ao operational area shall be developed based on actual transportation demand; spraying and dust removal facilities must be provided to the Putou bulk port to effectively control dust emissions; emergency facilities and safety buffer zone shall be in place for Xiuyu liquid bulk port.
  c. For Xiaocuo Port Area, safety design, emergency facilities warehouse and safety buffer zone shall be in place for Liyuwei operational area petro-chemical ports
  d. For Douwei Port Area, further study on coastline development will need to be conducted before development of Waizoumadai operational area; wastewater treatment plant will need to be taken into account in the port area design; emergency facilities warehouse and safety buffer zone shall be in place.
- Supporting facilities
  a. Environmental emergency response plan will need to be prepared for the constructed or planned pipeline, liquid bulk and petro-chemical port
  b. Wastewater treatment techniques will need to be in place for Xiuyu Shimen’
- Environmental protection.
  a. Principles for ecological compensation measures will need to be provided. During project implementation, actual land reclamation area will need to be clarified and the ecological compensation measures shall be implemented.
  b. Principles for compensation for livelihood loss and resettlement shall be provided.
  c. General requirement for the emergency response system for port operation shall be provided. Controlling requirement for the port area and vessels wastewater shall be provided.

It should be noted that in general the above recommendations have been addressed by the Meizhou Bay Navigation Project EIA or Resettlement Action Plan (RAP) where applicable. In particular, Project EIA includes a detailed ecological compensation program comprised of fish and habitat offset components that demonstrate a model for ecological compensation to offset the ecological impacts resulted from navigation channel dredging and coastal land reclamation.

Chapter 8: Risk Assessment and Emergency Response

8.1 Risk Identification

Upon the implementation of Phase-III project, the navigation conditions in the sea area of Meizhou Bay will be improved significantly, thus contributing to navigation safety and reducing the occurrence of vessel contamination accidents. However, certain objective or man-induced factors, such as the damage of navigation facilities, severe climatic conditions or the fault of navigating vessels may result in ship stranding, collision, or rock-striking that would potentially cause the leakage of oil products or chemicals into the ocean, thus result in significant impacts to the ocean environment and ecological system.

Taking in to account the navigation channel improvement and overall port development of Meizhou Bay, the traffic, oil and related projects input/output will increase significantly in coming years. In addition, historical statistics of shipping traffic accidents indicate that the oil/chemical spill risks exist in the Putian and Quanzhou sea areas. Although the risk level of oil spills is rather low, the resulting impacts can be huge. Therefore, this risk assessment considers the marine oil/chemical spill as the maximum credible accident (MCA).

For channel navigation, normally oil/chemical spills accidents take place at heavy-traffic channel section and turning point of channel. According to the nature, size and principal commodities of navigating vessels in respective operating zones, major hazardous articles may include liquefied benzene products (benzene, toluene, xylene), alcohols (methanol, glycol), acids (acetic acid), DMF (N,N - dimethylformamide), and other categories. Oil products include crude oil, gasoline, diesel oil, coal oil, naphtha, and admiralty fuel oil.

8.2 Introduction to Oil Spill Accidents Cases

8.2.1 Global and Domestic Oil Spill Accidents

Along with the development of shipping industry, there have been thousands of oil spill accidents incurred successively around the world and causing serious oil pollution. According to the statistical analysis of numerous oil spill & contamination accidents, rough weather, strong wind, swift current, and high wave are the major causes of stranding, collision and grounding of oil tanks, thus leading to oil spill and contamination. The International Tanker Owners Pollution Federation Limited (ITOPF) has taken a statistics of 9,522 oil spill accidents of oil tankers, mammoth tankers and lighter barges incurred from 1974 through 2009 according to different oil-spill classes and accident causes (please refer to Table 8.2.1).

Table 8.2.1 Global Oil Spill Accidents of Oil Tankers (1974-2009)

Accident cause	<7t	7 - 700t	>700t	Total
Handling operation	3155	383	36	3574
Fueling	560	32	0	593
Other operations	1221	62	5	1305
Collision	176	334	129	640
Stranding	236	265	161	662
Hull damage	205	57	55	316

Equipment failure	206	39	4	249
Fire, explosion	87	33	32	152
Others/unknown cause	1983	44	22	2049
Total	7829	1249	444	9522

From statistics of 1976~2009, it can be concluded that:

(1) There are totally 7,829 accidents with oil spill quantity less than 7 tons, including 4,936 operational accidents (63%) and 910 marine accidents (12%).

(2) There are totally 1,249 accidents with oil spill quantity ranging from 7 to 700 tons, including 477 offshore operational accidents (38%) and 728 marine accidents (58%).

(3) There are totally 444 accidents with oil spill quantity greater than 700 tons, including 41 operational accidents (9%) and 381 marine accidents (86%).

These figures indicate that the proportion of marine accidents rises along with the increase in oil spill quantity, and oil spill accidents with spill quantity greater than 700 tons are mainly caused by marine accidents.

Domestically, according to the coastal pollution accident statistics (1997-2003) reported by respective marine affairs bureaus of China, the 309 oil pollution accidents are found to be following the same rule reflected in ITOPF's statistics.

(1) There are totally 268 accidents with oil spill quantity less than 7 tons, including 140 operational accidents (52%) and 19 marine accidents (7%).

(2) There are totally 22 accidents with oil spill quantity ranging from 10 to 50 tons, including 2 operational accidents (9%) and 17 marine accidents (77%).

(3) There are totally 16 accidents with oil spill quantity ranging from 50 to 700 tons, including zero optional accident and 13 marine accidents (81%).

(4) There are totally 3 accidents with oil spill quantity greater than 700 tons, all being marine accidents.

According to ITOPF and China's statistical analysis of oil spill accidents by oil spill quantity and accident cause, we can conclude that major and serious oil spill accidents are mainly caused by marine accidents.

8.2.2 Statistical Analysis of Accidents in Central Fujian Sea Area

According to statistical data, totally 80 vessel accidents took place in Central Fujian sea area from 1996 through 2008 (incomplete data). Details are given in Table 8.2.2.

Table 8.2.2 Vessel Accidents Incurred in Central Fujian Sea Area

SN	Date	Name of vessel	Location	Gross ton (ton)	Type	Cause	Oil spill
1	1996.2.25	Anfu (oil tanker)	Sea area nearby Wuqiuyu outside Meizhou	36417	Rock striking	No fault accident	632 tons of crude oil

			Bay				
2	1996.3.12	Quandong 118 (cargo vessel)	Najiangao on north side of Weitoujiao	499	Stranded	Fog, Radar malfunction	No
3	1996.5.2	Nanhu (cargo vessel) Guanchuan 803 (cargo vessel)	Sea area outside Quanzhou Bay	4996	Collision of two vessels	Faulty operation	No
4	1996.5.4	Minyou 18	Great Wall Petrification's dock in Jinjiang	1596	Collision damage	Fault in berthing velocity control	NA
5	1996.5.6	Changfayou 8 (oil tanker)	Outside Quanzhou Port	699	Fire damaged	Faulty operation	No
6	1996.8.7	Jiangxinglong (cargo vessel)	Outside Quanzhou Port	449	Sunk	Billow surging	No
7	1996.8.8	Changdayou 7 (oil tanker)	Banyang Rock nearby Shenhu Bay	498	Rock striking	NA	Slight leakage
8	1996.10.10	MYRE oil tanker	Fujian Oil Refinery's dock in Meizhou Bay	55924	Collision damage	Improper towing	NA
9	1996.12.10	Guanji 33 (general cargo carrier)	24-30-56 N 118-33-54 E	198	Stranded	Faulty operation causing yawing	NA
10	1997.1.30	Zhonggang 28 (cargo vessel)	Jinzhong sea area in Weitou Bay	1296	Sunk	Gale & billow	No
11	1997.2.22	Haijiu (oil tanker)	Fujian Oil Refinery's dock in Meizhou Bay	769	Collision damage	Faulty operation	NA
12	1997.2.25	Chunyuan (LPG)	Fujian Oil Refinery's dock in Meizhou Bay	2064	Collision damage	Faulty operation	NA
13	1997.10.1	Liaoying 109	Outside	908	Strande	Faulty	NA

	3		Weitou Bay		d	operation	
14	1998.1.3	Huamao 6	Dock #5 in Houzhu port area	5389	Collision damage	Faulty operation	NA
15	1998.1.11	Zhezhou 308	32-20N、122-33E	1259	Gale damage	Gale damage	
16	1998.2.1	Fengshan (cargo vessel)	Nearby Xiaoningyu	398	Rock striking	Faulty operation	No
17	1998.4.1	Tongsheng 202 (cargo vessel) Minshiyu 3697 (fishing vessel)	Off-lying sea of Shenhu Bay	82563	Collision of two vessels	Fog Faulty operation	No
18	1998.8.27	Guowang (cargo vessel)	Water channel of Xiaozhiu Island, Quanzhou Bay	1197	Rock striking	Faulty operation	No
19	1998.9.30	Andexing (cargo vessel) Minhuiyu 8049 (fishing vessel)	Eastern sea of Chongwujiao, outside Quanzhou Bay	3099	Collision of two vessels	Faulty operation	No
20	1998.10.3	Zheningji 511 (cargo vessel)	Eastern sea of Chongwujiao, outside Quanzhou Bay	135	Sunk	Billow surging	No
21	1998.12.10	Maolong (cargo vessel)	Daban Rock of Weitou Bay	398	Rock striking	Faulty operation	No
22	1999.1.3	Diyuan (cargo vessel)	Quanzhou Bay	2844	Rock striking	Faulty operation	No
23	1999.1.11	Quanxing (cargo vessel)	Xiangzhi	903	Others	Others	No
24	1999.3.16	Jinghai 102 (cargo vessel)	Weitou Bay	359	Stranded	Faulty operation	No
25	1999.3.5	Hongyi (cargo vessel)	Off-lying sea	498	Collision of two vessels	Faulty operation	No
		Dayi (cargo vessel)		499			
26	1999.3.3	Zhehuang 53 (cargo vessel)	Downstream of	499	Stranded	Faulty operation	No

			Jinjiang				
27	1999.5.16	Zhening 103 (cargo vessel)	Downstream of Jinjiang	629	Collision	Faulty operation	No
28	1999.9.26	Zhehai 1101 (cargo vessel)	Sea area to the east of Chongwu	462	Gale damage	Gale	No
29	1999.9.28	Yuxing 98 (cargo vessel)	Sea area of Chongwu	346	Rock striking	Faulty operation	No
30	1999.10.20	Nanrun (cargo vessel)	Xiangzhi	397	Others	Others	No
31	1999.10.2	Shunxiang (cargo vessel)	Off-lying sea	442	Fire damaged	Fire damage	No
32	1999.12.15	Zheyuji 26 (cargo vessel)	Sea area of Chongwu	198	Others	Objects impeding navigation	No
33	2000.3.13	Lanxing 101 (cargo vessel)	Xiangzhi	299	Collision	Faulty operation	No
34	2000.5.22	Jinglong (cargo vessel)	Weitou	198	Stranded marine loss	Objects impeding navigation	No
35	2000.6.23	Zhuguang 1 (cargo vessel)	Downstream of Jinjiang	974	Stranded	Pilot's fault	No
36	2000.10.25	Sand carrier	Downstream of Jinjiang	Below 20	Collision	Faulty operation	No
37	2000.11.2	TOWA (oil tanker)	High seas	1202	Others	Others	No
38	2000.12.9	Qiangquansheng (cargo vessel)	Weitou	997	Collision	Faulty operation	No
39	2001..2.28	Yiyuan	Inside Weitou Bay	299	Collision	Negligence in observation	
40	2001.3.23	Lianji 317	24-31-07 N 118-32-55 E	199	Collision	Safe speed not applied	
41	2001.3.23	Hengxing 138	24-32-30 N 118-40-24 E	342	Collision	Negligence in observation	
42	2001.3.23	Heyuan	24-35-35 N 118-44-58 E	380	Collision	Improper swerve	

43	2001.3.27	Zheningji 587	Seaward channel of Shuitou Port	745	Swell damage	Faulty operation	
44	2001.3.31	Xinglong 16	Baiyu Rock inside Weitou Bay	198	Rock striking	Blind navigation	
45	2001.4.8	Wanshengji 01	Downstream of Jinjiang	137	Others	Faulty operation	
46	2001.8.19	Suxinsheng	Dongshi dock	1390	Fire damaged	Illegal hot work	
47	2001.9.2	Fanfu 5	Weitoujiao Island	199	Collision damage	No chart correction	
48	2001.9.24	Xinxing 2	24-47-40 N 118-48-26 E	9715	Others	Heavy weather	
49	2001.11.3	Minlian 138	24-38-45 N 118-41-21 E	393	Gale damage	Faulty operation	
50	2001.11.12	Zhemingzhu 8	24-33-36 N 118-28-37 E	295	Rock striking	Wrecked on unknown rock	
51	2001.12.15	Shengxing 185	Sea area nearby Weitou Bay	277	Gale damage	Wave surging	
52	2002.1.8	Xinsha	Inside Quanzhou Bay	212	Others	Violation of safe operation specifications	
53	2002.4.13	Changhai 266	Shunda Dock of Shuitou	396	Fire damaged	Circuit aging	
54	2002.4.27	Yongfa 32 Daqing 422 (oil tanker)	Inside Weitou Bay	498 3792	Collision	Steering engine or main engine out of control	
55	2002.8.14	Nanhe 18 (oil tanker)	Weitou Bay	2335	Rock striking	Unknown rock	
56	2003.1.5	FRONG GRANITE	Fujian Oil	77931	Collisio	Hawser	

		(oil tanker)	Refinery's dock		n damage	broken	
57	2003.6.13	Yongqing	Inside Quanzhou Bay	277	Collision	Negligence in observation	
58	2003.10.18	Sentai 68	24-55-75 N 119-02-55 E	496	Sunk	Heavy weather	
59	2004.2.22	Yiyou 268	Intra-port dock	878	Collision	Faulty operation	
60	2004.2.23	Xinbaoxiang	Sea area of Shanyao Dock	431	Stranded	Unauthorized steering by crew	
61	2004.3.12	Daqing 93 (oil tanker)	Quanzhou Bay mouth	39154	Collision	Negligence in observation	
62	2004.4.2	Wujiazui 1	10,000-DWT dock of Weitou	2992	Collision damage	Fast velocity	
63	2004.4.19	POLAR ENDEVAOUR (Jili)	Meizhou Bay mouth	85387	Collision	Negligence in observation	
64	2004.7.8	Genmar Transporter (oil tanker) Cape Bowen (oil tanker)	Meizhou Bay mouth	77870 81310	Collision	Negligence in observation/safe speed not applied	
65	2005.1.7	DOLPHINA	Pingyu	7195	Rock striking	Failure in timely positioning	No
66	2005.2.18	Fujingtong 1	Sea area to the east of Quanzhou Bay mouth	2894	Others	Damage of rudder and steering gear	No
67	2005.4.3	Shuangning 188	Sea area to the east of Quanzhou Bay mouth	499	Collision	Unknown cause	No
68	2005.6.10	Daqing 733	Sea area	2549	Explosi	Failure of	No

			to the east of Quanzhou Bay mouth		on	the HV protection unit for air conditioning compressor	
69	2005.7.25	Decong	North-east of Fenliu Rock of Weitou Bay	207	Sunk	Aging of sand carrier	No
70	2005.8.14	Anhai 129	Shoal in front of Jiangbin Park, downstream of Jinjiang	480	Stranded	Water lettuce and other floating materials	No
71	2005.9.10	Zhongxing 1	Wharf apron of Weitou, Quanzhou	3873	Collision	Faulty operation	No
72	2005.11.1	Xinshekou	Nearby Qixing Rock inside Quanzhou Bay	33267	Stranded	Faulty operation	No
73	2005.11.18	Changming 8	Sanmei Dock	29137	Collision damage	Insufficient starting air pressure	No
74	2006.5.19	Tongxin	Nearby Qixing Rock inside Quanzhou Bay	4192	Stranded	Underestimation of current pressure/faulty operation	No
75	2006.12.3	Zhening 538	Sea area to the northeast of Xiaobai Island	980	Stranded	Broken hawser causing drifting	No
76	2006.12.5	Xiangzhuzhou Cargo 0555	Sea area nearby Weitoujiao	480	Others	Hull broken and sunk	No
77	2006.12.14	VULTURNUS	#3 Fuyu and #5	18374	Stranded	Vessel inclined to	No

			Fudi navigation segment of Quanzhou Bay			the left edge of navigation channel	
78	2007.4.15	Jinchang 39	Sea area to the east of Weitoujiao	496	Collision	Inconsistent swerve	No
79	2007.5.27	Xingan Vessel	Sea area inside Weitou Bay	885	Collision	Violation of the action rules in case of low visibility	No
80	2008.3.27	Nantai 17 Vessel	9.6 sea miles east by south to Chiyu, Chongwu, Quanzhou	1417	Collision	Violation of the action rules in case of low visibility	No

Analyzing the statistics of the accident incurred in the vicinity of Meizhou Bay Port from 1991 through 2008, it is concluded that:

(1) Oil spill accidents causing great losses

Totally 120 vessel accidents incurred nearby Meizhou Bay Port from 1991 through 2008 (statistics of incomplete data), among which there were 3 oil spill accidents (2.5%) and resulted in RMB 160 million direct economic losses. The average loss of oil spill accident reached as high as RMB 55 million/accident, which is far higher than the average loss of other vessel accidents.

- On Feb 25, 1996, "Anfu" Vessel, owned by Fujian Shipping Company, ran against an unknown object in the sea area of Wuqiu Island off Meizhou Bay, Quanzhou Port and leaked 632.139 tons of crude oil, causing severe contamination to more than 30 kilometers of coastline of 23 costal administrative villages. The prawn, red drum and abalone farms, as well as over 3,333 hectares of tidal-flat farms, were significantly polluted, with direct economic loss hitting RMB 130 million and compensation for damages reaching RMB 3 million. 130,000 people were affected.

- On July 8, 2004, two 150,000-DWT crude carriers, GENMA TRANSPORTER and CAPE BOWEN (registered in Marshall Islands), collided 1.6 nautical mile east of Koujian Island, Meizhou Bay, Quanzhou Port, leading to the hull damage of both vessels and direct economic losses of

RMB 32 million. Fortunately, both vessels were not loaded with crude oil, thus avoiding a severe oil pollution accident. The collision of two 150,000-DWT crude carriers off the port was also unusual in the world shipping history. If there was an oil spill accident, disastrous pollution will jeopardize the marine ecosystem of Quanzhou sea area and the peripheral areas.

(2) Increasing probability of vessel accidents

According to statistics, the number of incoming and outgoing vessels increased continuously at Quanzhou Port from 1991 to 2008, especially those large-tonnage vessels. According to the statistical data of Quanzhou Maritime Safety Administration, the number of incoming/outgoing vessels above 3,000-DWT increased by 29.3 times in 2008 compared to 1991, with oil tanker increasing by over 40 times. In Table 10.4-1, among the 80 accidents incurred off Quanzhou Port from 1995 through 2008, the oil tankers accounted for 20%. Therefore, the increase in the number of vessels, especially the number of large-tonnage vessels, oil tankers and those carrying bulk chemicals, liquefied gas and other dangerous articles, will increase the probability of vessel accidents within this sea area.

(3) Causes of risk accidents

By analyzing the causes of risk accidents off Meizhou Bay Port, the following major causes can be concluded:

①Improper steering, weak safety awareness or rule-violating operation of certain small- and medium-sized vessels;

②Irregular berthing, lack of berthing attendant;

③Poor equipment status of certain small- and medium-sized vessels;

④Over loading causing performance reduction in ship steering and vessel collision;

⑤Underestimation of tides by deck officer;

⑥Increase in the number of vessels in the nearby sea area.

8.2.3 Analysis of Oil Spill Probability

According to the overall planning of Meizhou Bay Port (which includes 5 bays and 8 operational areas under the jurisdiction of Putian and Quanzhou City), the throughput of petroleum and related products in 2015, 2020 and 2030 is 38-39.5 million tons, 67-81.5 million tons and 97.5-121.5 million tons respectively.

According to the conclusion of global oil spill accidents analysis, a 100-ton oil spill accident will probably incur for every 77.33 million tons of petroleum shipped. Given the throughput of petroleum and related products described in the short-term and long-term planning of Meizhou Bay Port, we can calculate the probability of 100-ton oil spill accidents (the result is given in Table 8.2.3). We can see that there might be 0.5, 1.0 and 1.6 100-ton oil spill accident by 2015, 2020 and 2030 respectively at Meizhou Bay Port. Since petroleum handling will mainly be carried out at Dongwu port area, Xiuyu port area, Xiaocuo port area and Douwei port area within Meizhou Bay in the future years, the potential oil spill accidents will mainly incur within Meizhou Bay and along the main entrance channels. Risk accidents are unlikely to take place at other port areas.

Table 8.2.3 Probability of 100-ton Oil Spill Accidents Incurred at Meizhou Bay Port

Year	Throughput of petroleum and related products (10,000 tons)	Probability of occurrence	
		Frequency (times/year)	Cycle (Year)
2015	3950	0.5	2.0
2020	8150	1.0	1.0
2030	12150	1.6	0.6

8.3 Maximum Credible Accident Determination

8.3.1 Hazardous Substances

With the increase in navigation density, Meizhou Bay navigation channels are faced with the risk of vessel collision accidents which may lead to the leak of liquid chemicals or the damage to submarine oil pipeline and LNG pipeline of Fujian Oil Refinery. Since the oil pipeline and gas pipeline are laid beneath the seabed and covered with gravels, they are unlikely to be damaged. Therefore, this assessment will mainly consider the potential leakage of liquid chemicals into the ocean during the collision of vessel carrying liquid chemicals

Given the present status of chemicals handling at Meizhou Bay, this assessment will make forecasts for the insoluble chemicals of crude oil and diesel oil and those soluble chemicals of DMF and methanol.

8.3.2 Leak Location

The main channel and branch channels intersect at many points, which the probability of accidents is higher than elsewhere. Therefore, the leakage location for risk assessment is selected at the junctions of navigation channels (see Figure 8.3-1).

8.3.3 Wind Conditions

The following three different wind condition combinations are selected for modeling study.

(1) Perennial Predominant Wind Direction: NE, mean wind speed: 5.6m/s;
(2) Summer Predominant Wind Direction: SSW, mean wind speed: 5.0m/s;
(3) Calm wind.

8.3.4 Design Tidal Pattern and Calculation Duration

Oil Particle Model, full tide forecasts for 36 hours.

8.3.5 Prediction Scenarios

Overall risk prediction scenarios are outlined in Table 8.3.1.

Table 8.3.1 Leakage Point and Leakage Rate at Channel Junctions

Leakage point	Location	Ship type	Wind conditions	Single-hatch leakage volume (ton)

A	Junction of main channel and Dongwu branch channel	First junction upon entry, 300,000-DWT oil tanker	NE+5.6m/s SSW+5.0m/s Calm wind	Crude oil: 10,000
B	Junction of branch channel, Liyuwei channel and main channel	100,000-DWT oil tanker	NE+5.6m/s SSW+5.0m/s Calm wind	Diesel oil: 2,000
		Liquid chemical carrier of Titan Petrochemicals, Douwei chemical carrier		DMF500 Methanol: 500
		250,000-DWT bulk vessel		Diesel oil: 1,000
C	End of main channel (F point, junction with planned Shimen'ao channel)	250,000-DWT bulk vessel	NE+5.6m/s SSW+5.0m/s Calm wind	Diesel oil: 1000
D	Junction of Putou channel, Xiaocuo channel and main channel	70,000-DWT bulk vessel	NE+5.6m/s SSW+5.0m/s Calm wind	Diesel oil: 500

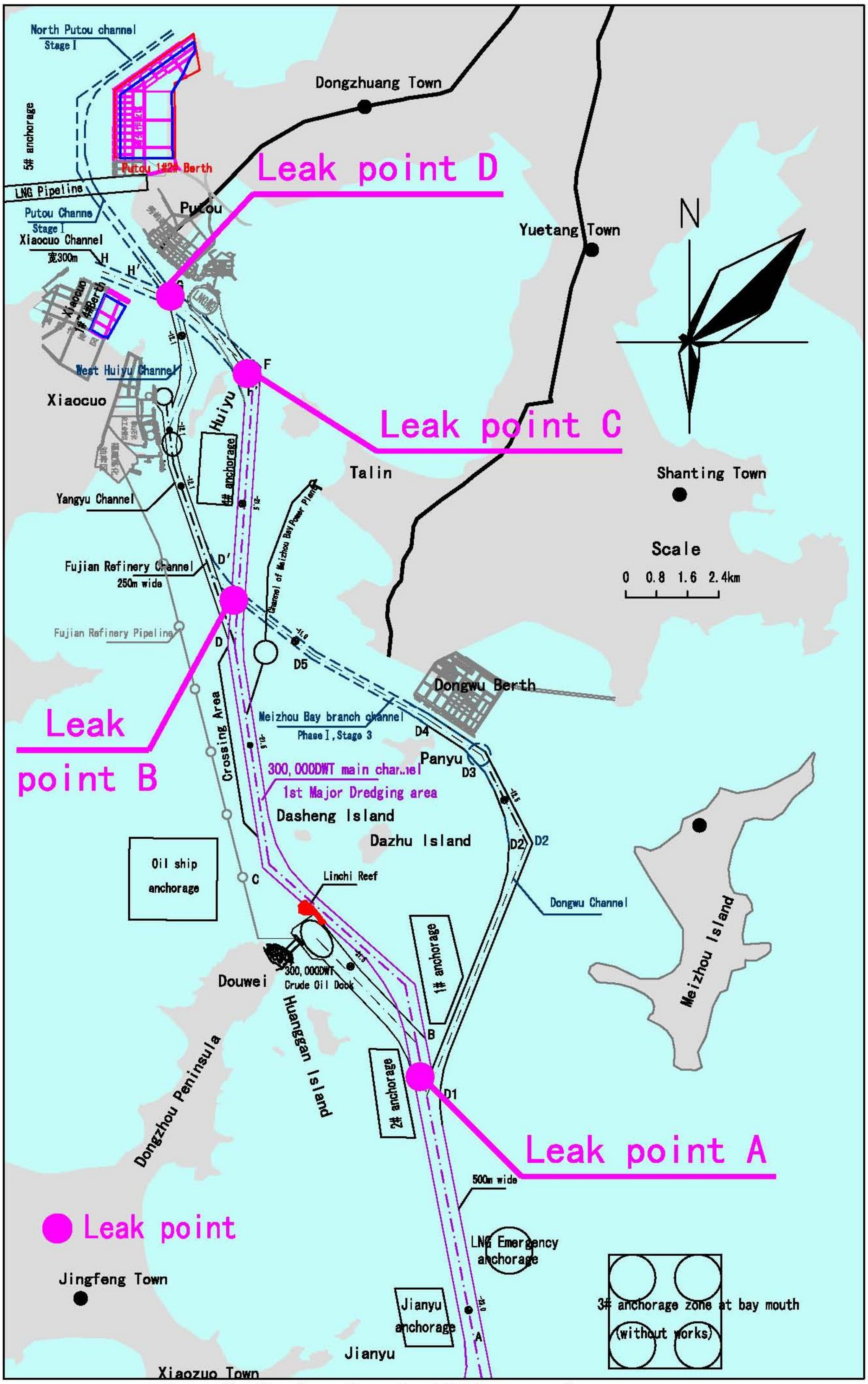


Fig 8.3-1 Leak Points Arrangement

8.4 Prediction of Oil Slick Pollution Impact Area

This assessment summarizes the key contents contained in "Study of the Mathematical Model for Environmental Impact Assessment of Meizhou Bay Navigation Channel Phase-III Engineering Project (August, 2011), which was prepared by Hohai University.

8.4.1 Model Introduction

The "Oil Particle" model is a probabilistic model different from the hydrodynamics model and other models. The "Oil Particle" approach divides spilled oil into numerous diffused small oil particles to simulate the diffusion process of oil in seawater, instead of directly solving a diffusion equation.

The movement distance of oil particles is jointly influenced by tidal flow field, wind field and turbulent diffusion. Without taking account of turbulent diffusion and basing on the mathematical simulation of tidal flow field, the Lagrangian method is applied to track the drifting process of particles and obtain the track of particle movement under the influence of tidal current (including wind current).

The number of oil particles is obtained using the following formula:

$$Corc(\min) = \frac{M_{total}}{N_{total} \times A_{cell} \times h_{layer}}$$

In which $Corc(\min)$ is the minimum concentration calculated (kg/m3), M_{total} is the oil spill quantity (kg), N_{total} is the number of oil particles, A_{cell} is the minimum grid cell area (m2), and h_{layer} is the layer thickness (m).

The initial oil pill area is calculated via the oil spill quantity, oil spill model and oil spill properties.

The drift of surface oil slicks is driven by wind current and tidal current. The velocity of wind generated currents is estimated to be 2.5-4.4% of wind speed, with average value being 3.5%.

The oil evaporation can be considered as a primary attenuation process, and the attenuated part can be defined through the attenuation constant.

$$\frac{dm}{dt} = -k_E t$$

in which k_E represents evaporation rate (1/d), while t represents the number of days (d).

During the movement, oil particles may stick to the shore or seabed. Taking a random number between 0 and 1 for each oil particle: if this number is smaller than the given probability value, then this oil particle will stick to the shore or sea bed. After that, this oil particle will no longer participate in the movement. The sticking as mentioned here is a cumulative process. During analog calculation, for safety considerations, the weathering and emulsion process of oil particles is not considered.

8.4.2 Prediction Results

As noted the Table 8.3.1, four potential leakage points and three wind conditions are selected for modeling. Taking into account four tide periods (i.e. flood slack, ebb slack, flood tide, and ebb tide), in total 48 scenarios were modeled. Section 8.4.2.1 to 8.4.2.2 summarizes all the scenarios. The scenarios of the maximum impact area are summarized in section 8.4.2.5.

8.4.2.1 Prediction for Leakage Point A

(1) Calm wind

The vessel leaks at point A, and the movements of oil slicks on different tidal currents in case of calm wind are shown in Figure 8.4-1 through Figure 8.4.12, with impact scope shown in Table 8.4.1 through 8.4.4.

In case of calm wind, movement of oil slicks under four tide conditions are described in below.

- *Flood Slack* - upon the occurrence of oil spill accident in flood slack period, due to the influence of flood and ebb tides, oil slicks will gradually move towards the southern side of bay-mouth along the navigation channel, with minor impact to the peripheral sensitive areas.

- *Ebb Slack* - Upon the occurrence of oil spill accident in ebb slack period, the oil slicks will be prone to move towards the bay. Due to the influence of complicated hydrodynamic environment, the oil slicks will gradually diffuse within the sea area. Certain oil slicks will reach Dazhu Island, and due to its influence, oil slicks may separate into pieces, thus broadening the scope of impact. The oil slicks will be mainly moving along the navigation channel. In about 30 hours, the oil slicks will intrude the aquaculture area on the west side of Luoyu. In about 36 hours, the oil slicks will intrude the ecological farming area of Meizhou Island.

- *Flood Tide* - If the oil spill accident takes place in flood tide period, due to the influence of reversing currents, the oil slicks will gradually move in northwest direction towards the bay-mouth. In about 12-15 hours, the oil slicks will intrude Meizhou Ecological Protection Zone.

- *Ebb Tide* - If the oil spill accident takes place in ebb tide period, the oil slicks will move in northeast direction towards the bay-mouth with the flood/ebb current, with minor impact to the bay.

(2) Perennial Predominant Wind Direction

The movements of oil slicks on different tidal currents in case of the Perennial Predominant Wind Direction are shown in Figure 8.4.13 through Figure 8.4.17, with impact scope shown in Table 8.4.5 through 8.4.8.
Under the influence of NE wind, upon the occurrence of oil spill accident at point A, the oil slicks will be prone to move in southwest-of-Meizhou Bay direction.

- *Flood Slack* - If the accident takes place in flood slack period, the oil slicks will intrude Douwei aquaculture area on the east side of Qinglanshan Island in 9-12 hours.

- *Ebb Slack* - If the accident takes place in ebb slack period, the oil slicks will reach the sea area off Qinglanshan Douwei Dockyard in 6 hours and intrude the port area, causing certain pollution to the local water area.

- *Flood Tide* - If the accident takes place in flood tide period, the oil slicks will intrude Douwei aquaculture area on the east side of Qinglanshan Island in 3-6 hours, and stay in this sea area for quite a long time.

- *Ebb Tide* - If the accident takes place in ebb slack period, the oil slicks will intrude Douwei aquaculture area on the east side of Qinglanshan Island in about 9 hours.

(3) Summer Predominant Wind Direction

The movements of oil slicks on different tidal currents in case of the Summer Predominant Wind Direction are shown in Figure 8.4.18 through Figure 8.4.21, with impact scope shown in Table 8.4.9 through 8.4.12.

- *Flood Slack* - Due to the influence of SSW wind, if oil spill accident takes place at point A in flood slack period, the oil slicks will intrude Meizhou Island Ecological Protection Zone in 9-12 hours.

- *Ebb Slack* - If the accident takes places in ebb slack period, the oil slicks will move in northeast direction towards the bay and stick to the south shore of Panyu Island in 9 hours.

- *Flood Tide* - If the accident takes place in flood tide period, the oil slicks will move in northeast direction towards bay-mouth and intrude the southwest region of Meizhou Island Ecological Protection Zone in 9-12 hours.

- *Ebb Tide* - If the accident takes place in ebb tide period, the oil slicks will move in northeast direction towards bay-mouth and intrude the northwest region of Meizhou Island Ecological Protection Zone in 9-12 hours.

Table 8.4.1 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Slack Period in Case of Calm Wind (unit: km2)

After flood slack Duration (h)	>0.002kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area >0.001kg/m^2
1	0.021	0.021	0.021	0.018	0.024
2	0.078	0.072	0.07	0.07	0.082
3	0.141	0.136	0.134	0.123	0.152
4	0.211	0.203	0.2	0.187	0.226
5	0.282	0.274	0.264	0.245	0.301
6	0.331	0.317	0.302	0.28	0.36
7	0.338	0.32	0.317	0.286	0.373
8	0.362	0.344	0.331	0.307	0.382
9	0.386	0.379	0.363	0.341	0.419
10	0.403	0.389	0.379	0.347	0.438
11	0.362	0.342	0.333	0.312	0.392
12	0.338	0.32	0.314	0.285	0.357
13	0.366	0.347	0.336	0.312	0.394
14	0.443	0.422	0.418	0.384	0.491
15	0.526	0.51	0.491	0.453	0.568
16	0.656	0.632	0.608	0.566	0.714
17	0.832	0.802	0.774	0.722	0.906
18	0.901	0.861	0.827	0.771	0.979
19	0.901	0.864	0.835	0.773	1.005
20	0.933	0.894	0.867	0.786	1.026
21	0.954	0.907	0.872	0.8	1.03
22	0.946	0.901	0.872	0.811	1.022
23	0.978	0.93	0.899	0.837	1.059
24	0.763	0.723	0.698	0.65	0.832
25	0.742	0.714	0.685	0.645	0.818
26	0.829	0.792	0.766	0.712	0.901
27	1.003	0.97	0.925	0.859	1.088
28	1.062	1.01	0.981	0.912	1.187
29	1.229	1.184	1.144	1.058	1.368
30	1.432	1.366	1.325	1.227	1.557
31	1.453	1.389	1.349	1.25	1.606
32	1.488	1.41	1.349	1.27	1.629
33	1.493	1.422	1.373	1.274	1.645
34	1.469	1.394	1.342	1.243	1.595
35	1.387	1.314	1.269	1.186	1.501
36	1.178	1.112	1.086	1.016	1.278
Envelope area >0.001kg/m^2	27.920				

Table 8.4.2 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Slack Period in Case of Calm Wind (unit: km2)

After ebb slack Duration (h)	>0.002kg/m²	>0.003 kg/m²	>0.005 kg/m²	>0.010kg/m²	Swept area>0.001kg/m²
1	0.006	0.006	0.006	0.006	0.006
2	0.043	0.043	0.042	0.038	0.046
3	0.15	0.149	0.147	0.134	0.165
4	0.48	0.466	0.448	0.418	0.512
5	0.762	0.738	0.717	0.674	0.835
6	1.09	1.048	1.018	0.938	1.171
7	1.216	1.157	1.13	1.038	1.312
8	1.24	1.182	1.147	1.064	1.323
9	1.04	0.986	0.93	0.848	1.157
10	1.765	1.67	1.603	1.478	1.912
11	2.238	2.125	2.054	1.899	2.469
12	2.424	2.299	2.224	2.014	2.683
13	2.618	2.461	2.365	2.16	2.882
14	3.238	3.077	2.957	2.709	3.547
15	4.682	4.454	4.301	3.989	5.066
16	5.329	5.051	4.89	4.483	5.883
17	5.339	5.04	4.85	4.384	5.889
18	5.32	5.034	4.856	4.387	5.877
19	5.595	5.297	5.12	4.678	6.144
20	5.573	5.301	5.12	4.701	6.101
21	5.989	5.721	5.515	5.016	6.59
22	7.545	7.172	6.854	6.094	8.304
23	10.099	9.558	9.144	8.113	11.205
24	11.898	11.189	10.662	9.44	13.204
25	12.461	11.603	10.965	9.526	14.031
26	12.027	11.163	10.57	9.03	13.709
27	13.02	12.101	11.435	9.894	14.645
28	14.236	13.26	12.591	10.934	16.042
29	14.428	13.248	12.514	10.618	16.463
30	14.215	13.079	12.319	10.571	16.316
31	14.039	12.948	12.157	10.438	16.097
32	15.206	14.031	13.26	11.434	17.516
33	18.062	16.684	15.748	13.498	20.723
34	21.839	20.101	18.901	15.977	24.948
35	22.155	20.574	19.475	16.686	25.719
36	22.898	21.143	19.952	17.086	26.671
Envelope area>0.001kg/m²	108.078				

Table 8.4.3 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Tide Period in Case of Calm Wind (unit: km2)

After flood tide Duration (h)	>0.002kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.102	0.099	0.096	0.091	0.115
2	0.19	0.181	0.174	0.163	0.202
3	0.219	0.211	0.21	0.192	0.238
4	0.203	0.195	0.19	0.181	0.219
5	0.264	0.259	0.254	0.234	0.299
6	0.366	0.354	0.346	0.322	0.398
7	0.664	0.642	0.614	0.573	0.715
8	0.83	0.79	0.765	0.707	0.899
9	0.885	0.854	0.834	0.768	0.971
10	0.882	0.85	0.821	0.768	0.974
11	0.789	0.757	0.739	0.683	0.872
12	0.952	0.909	0.888	0.827	1.035
13	0.946	0.896	0.872	0.803	1.029
14	0.99	0.928	0.898	0.816	1.106
15	1.072	1.011	0.984	0.909	1.17
16	0.947	0.893	0.866	0.802	1.04
17	1.032	0.99	0.957	0.875	1.146
18	1.267	1.206	1.174	1.07	1.392
19	1.424	1.333	1.298	1.187	1.566
20	1.576	1.502	1.45	1.32	1.714
21	1.675	1.586	1.53	1.402	1.85
22	1.747	1.654	1.59	1.469	1.925
23	1.822	1.726	1.672	1.53	2
24	1.896	1.792	1.736	1.614	2.102
25	1.91	1.802	1.72	1.586	2.085
26	1.822	1.749	1.68	1.56	2.026
27	1.795	1.69	1.638	1.523	1.984
28	1.827	1.734	1.677	1.533	2.014
29	1.963	1.854	1.797	1.659	2.178
30	2.234	2.12	2.046	1.872	2.466
31	2.514	2.394	2.302	2.099	2.754
32	2.722	2.565	2.474	2.274	2.984
33	2.766	2.637	2.547	2.307	3.037
34	2.81	2.648	2.555	2.346	3.088
35	2.826	2.669	2.589	2.386	3.106
36	2.874	2.728	2.632	2.424	3.162
Envelope area>0.001kg/m^2	88.568				

Table 8.4.4 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Tide Period in Case of Calm Wind (unit: km2)

After ebb tide Duration (h)	>0.002kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.192	0.184	0.178	0.162	0.205
2	0.274	0.256	0.251	0.234	0.293
3	0.323	0.309	0.298	0.278	0.349
4	0.354	0.339	0.326	0.301	0.382
5	0.394	0.373	0.363	0.333	0.422
6	0.496	0.47	0.446	0.418	0.534
7	0.61	0.587	0.565	0.528	0.651
8	0.445	0.434	0.418	0.392	0.496
9	0.434	0.416	0.4	0.373	0.483
10	0.39	0.363	0.354	0.336	0.432
11	0.459	0.442	0.427	0.394	0.51
12	0.685	0.646	0.624	0.592	0.754
13	0.867	0.834	0.8	0.738	0.965
14	0.982	0.928	0.894	0.824	1.066
15	1.014	0.958	0.912	0.853	1.115
16	1.022	0.971	0.93	0.861	1.146
17	0.99	0.954	0.899	0.827	1.094
18	0.954	0.901	0.869	0.81	1.053
19	0.957	0.917	0.872	0.803	1.067
20	1.23	1.173	1.141	1.054	1.333
21	1.149	1.083	1.046	0.968	1.251
22	1.238	1.186	1.139	1.029	1.354
23	1.4	1.33	1.294	1.194	1.499
24	1.448	1.371	1.318	1.221	1.56
25	1.621	1.533	1.483	1.362	1.754
26	1.792	1.704	1.642	1.522	1.954
27	1.88	1.797	1.739	1.586	2.058
28	1.923	1.84	1.79	1.64	2.11
29	1.989	1.888	1.816	1.682	2.166
30	2.064	1.971	1.888	1.752	2.269
31	2.122	2.019	1.934	1.776	2.309
32	2.042	1.958	1.894	1.739	2.229
33	2.003	1.926	1.842	1.702	2.21
34	2.037	1.941	1.874	1.714	2.229
35	2.184	2.064	2.024	1.861	2.389
36	2.459	2.314	2.24	2.08	2.685
Envelope area>0.001kg/m^2	69.791				

Table 8.4.5 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Slack Period in Case of a NE Wind (unit: km2)

After flood slack Duration (h)	>0.002kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.022	0.022	0.022	0.022	0.026
2	0.072	0.07	0.07	0.064	0.074
3	0.109	0.106	0.101	0.088	0.11
4	0.126	0.122	0.118	0.109	0.13
5	0.144	0.141	0.134	0.128	0.152
6	0.157	0.152	0.149	0.142	0.16
7	0.25	0.237	0.227	0.211	0.272
8	0.402	0.382	0.373	0.346	0.429
9	0.997	0.962	0.928	0.864	1.077
10	1.405	1.347	1.296	1.221	1.523
11	1.112	1.066	1.034	0.96	1.202
12	1.027	0.997	0.976	0.917	1.134
13	1.126	1.074	1.048	0.99	1.206
14	1.317	1.282	1.254	1.186	1.421
15	1.446	1.398	1.365	1.299	1.571
16	1.576	1.528	1.482	1.386	1.715
17	1.76	1.686	1.627	1.533	1.88
18	1.981	1.907	1.851	1.736	2.16
19	2.104	2.03	1.981	1.848	2.248
20	2.038	1.963	1.915	1.81	2.166
21	1.426	1.37	1.334	1.251	1.523
22	0.618	0.594	0.581	0.536	0.656
23	0.136	0.128	0.126	0.112	0.149
24	Reaches shore				
Envelope area>0.001kg/m^2	33.499				

Table 8.4.6 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Slack Period in Case of a NE Wind (unit: km2)

After ebb slack Duration (h)	>0.002kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.016	0.016	0.016	0.014	0.016
2	0.088	0.083	0.082	0.08	0.093
3	0.294	0.282	0.277	0.256	0.326
4	0.502	0.483	0.472	0.421	0.538
5	0.64	0.614	0.6	0.557	0.704
6	0.53	0.507	0.485	0.445	0.568
7	0.309	0.285	0.261	0.227	0.362
8	0.149	0.125	0.112	0.09	0.195
9	0.018	0.016	0.014	0.013	0.027
10	0.034	0.03	0.03	0.022	0.05
11	0.038	0.034	0.029	0.021	0.045
12	0.035	0.032	0.027	0.024	0.051
13	0.04	0.037	0.032	0.026	0.048
14	0.029	0.027	0.027	0.022	0.034
15	0.048	0.043	0.04	0.034	0.061
16	0.07	0.061	0.056	0.046	0.078
17	0.04	0.04	0.034	0.027	0.042
18	0.003	0.003	0.003	0.003	0.006
19	Reaches shore				
Envelope area>0.001kg/m^2	8.096				

Table 8.4.7 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Tide Period in Case of a NE Wind (unit: km2)

After flood tide Duration (h)	>0.002kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.104	0.101	0.099	0.094	0.114
2	0.202	0.194	0.187	0.181	0.221
3	0.248	0.242	0.227	0.211	0.269
4	0.434	0.422	0.411	0.382	0.464
5	0.499	0.486	0.472	0.448	0.539
6	0.59	0.57	0.549	0.512	0.643
7	0.638	0.616	0.608	0.562	0.685
8	0.778	0.75	0.73	0.682	0.824
9	0.736	0.71	0.691	0.654	0.79
10	0.592	0.574	0.568	0.515	0.646
11	0.456	0.434	0.426	0.382	0.502
12	0.181	0.173	0.162	0.141	0.211
13	0.042	0.038	0.034	0.026	0.051
14	Reaches shore				
Envelope area>0.001kg/m^2	7.962				

Table 8.4.8 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Tide Period in Case of a NE Wind (unit: km2)

After ebb tide Duration (h)	>0.002kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.187	0.174	0.17	0.166	0.2
2	0.221	0.211	0.206	0.19	0.238
3	0.272	0.254	0.246	0.23	0.291
4	0.526	0.493	0.482	0.454	0.566
5	0.715	0.683	0.653	0.605	0.778
6	0.741	0.702	0.686	0.632	0.819
7	0.672	0.634	0.622	0.576	0.757
8	0.611	0.573	0.56	0.509	0.688
9	0.352	0.322	0.31	0.266	0.395
10	0.469	0.446	0.43	0.384	0.51
11	0.504	0.48	0.456	0.421	0.562
12	0.426	0.398	0.389	0.365	0.482
13	0.358	0.325	0.318	0.296	0.405
14	0.214	0.205	0.202	0.189	0.232
15	0.259	0.25	0.243	0.227	0.275
16	0.174	0.17	0.163	0.158	0.184
17	0.054	0.054	0.051	0.05	0.056
18	0.016	0.016	0.016	0.016	0.016
19	0.019	0.019	0.019	0.014	0.021
20	Reaches shore				
Envelope area>0.001kg/m^2	19.122				

Table 8.4.9 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Slack Period in Case of a SSW Wind (unit: km2)

After flood slack Duration (h)	>0.002kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.019	0.018	0.018	0.018	0.021
2	0.075	0.069	0.069	0.066	0.086
3	0.168	0.16	0.155	0.142	0.179
4	0.28	0.27	0.262	0.245	0.304
5	0.365	0.354	0.338	0.317	0.394
6	0.41	0.389	0.37	0.35	0.438
7	0.414	0.398	0.386	0.358	0.453
8	0.437	0.413	0.395	0.373	0.464
9	0.429	0.411	0.4	0.374	0.466
10	0.488	0.472	0.456	0.429	0.547
11	0.757	0.725	0.701	0.653	0.819
12	0.163	0.146	0.134	0.11	0.206
13	0.08	0.075	0.067	0.056	0.101
14	0.088	0.083	0.077	0.064	0.104
15	0.122	0.109	0.106	0.09	0.142
16	0.162	0.152	0.141	0.107	0.184
17	0.206	0.178	0.163	0.128	0.248
18	0.246	0.219	0.192	0.141	0.306
19	0.334	0.29	0.256	0.186	0.413
20	0.466	0.379	0.325	0.23	0.579
21	0.437	0.368	0.333	0.246	0.552
22	0.786	0.613	0.518	0.315	1.048
23	0.734	0.6	0.502	0.293	1.046
24	0.253	0.202	0.171	0.11	0.378
25	Reaches shore				
Envelope area>0.001kg/m^2	49.783				

Table 8.4.10 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Slack Period in Case of a SSW Wind (unit: km2)

After ebb slack Duration (h)	>0.002kg/ m^2	>0.003 kg/ m^2	>0.005 kg/ m^2	>0.010kg/ m^2	Swept area>0.001kg/ m^2
1	0.008	0.008	0.006	0.006	0.008
2	0.034	0.032	0.032	0.027	0.035
3	0.134	0.131	0.126	0.118	0.147
4	0.165	0.157	0.154	0.144	0.178
5	0.229	0.218	0.211	0.198	0.25
6	0.203	0.195	0.19	0.178	0.211
7	0.219	0.216	0.21	0.194	0.23
8	0.093	0.09	0.085	0.077	0.101
9	0.016	0.013	0.013	0.01	0.022
10	Reaches shore				
Envelope area>0.001kg/ m^2	5.581				

Table 8.4.11 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Tide Period in Case of a SSW Wind (unit: km2)

After flood tide Duration (h)	>0.002kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.096	0.09	0.088	0.083	0.107
2	0.168	0.162	0.158	0.144	0.176
3	0.19	0.184	0.179	0.168	0.21
4	0.194	0.186	0.184	0.176	0.211
5	0.23	0.218	0.214	0.2	0.254
6	0.43	0.41	0.386	0.366	0.477
7	0.598	0.566	0.549	0.504	0.648
8	0.864	0.824	0.8	0.739	0.928
9	0.787	0.75	0.722	0.659	0.845
10	0.869	0.822	0.802	0.728	0.939
11	0.872	0.826	0.795	0.717	0.981
12	0.426	0.394	0.368	0.314	0.501
13	0.475	0.44	0.421	0.354	0.568
14	0.499	0.453	0.424	0.354	0.557
15	0.538	0.488	0.461	0.382	0.624
16	0.754	0.71	0.675	0.598	0.851
17	0.982	0.923	0.886	0.773	1.112
18	1.126	1.032	0.955	0.784	1.306
19	1.128	1.006	0.942	0.704	1.322
20	0.458	0.406	0.366	0.28	0.53
21	0.208	0.187	0.17	0.133	0.253
22	0.19	0.166	0.155	0.131	0.237
23	0.115	0.106	0.099	0.088	0.138
24	0.054	0.051	0.048	0.042	0.066
25	Reaches shore				
Envelope area>0.001kg/m^2	18.289				

Table 8.4.12 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Tide Period in Case of a SSW Wind (unit: km2)

After ebb tide Duration (h)	>0.002kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.198	0.187	0.182	0.171	0.21
2	0.261	0.256	0.253	0.23	0.283
3	0.314	0.294	0.278	0.266	0.344
4	0.357	0.334	0.322	0.294	0.394
5	0.36	0.354	0.333	0.309	0.4
6	0.354	0.338	0.333	0.314	0.389
7	0.576	0.552	0.538	0.502	0.632
8	0.501	0.475	0.464	0.442	0.555
9	0.528	0.496	0.48	0.462	0.582
10	0.634	0.605	0.574	0.546	0.698
11	0.683	0.651	0.637	0.594	0.722
12	1.109	1.061	1.03	0.947	1.226
13	1.845	1.789	1.75	1.634	1.965
14	1.41	1.366	1.354	1.259	1.485
15	0.322	0.299	0.277	0.242	0.366
16	0.099	0.088	0.083	0.053	0.12
17	Reaches shore				
Envelope area>0.001kg/m^2	16.977				

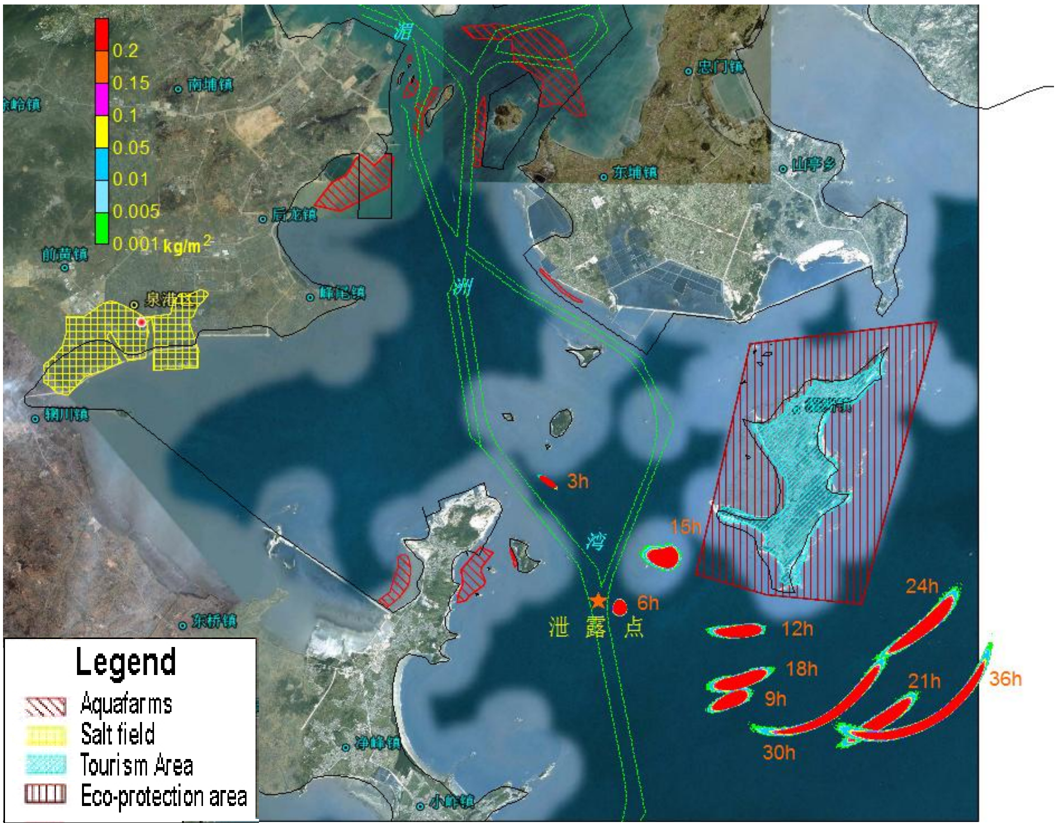


Figure 8.4.1 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Tide Period in Case of Calm Wind (after 3-36 hours)

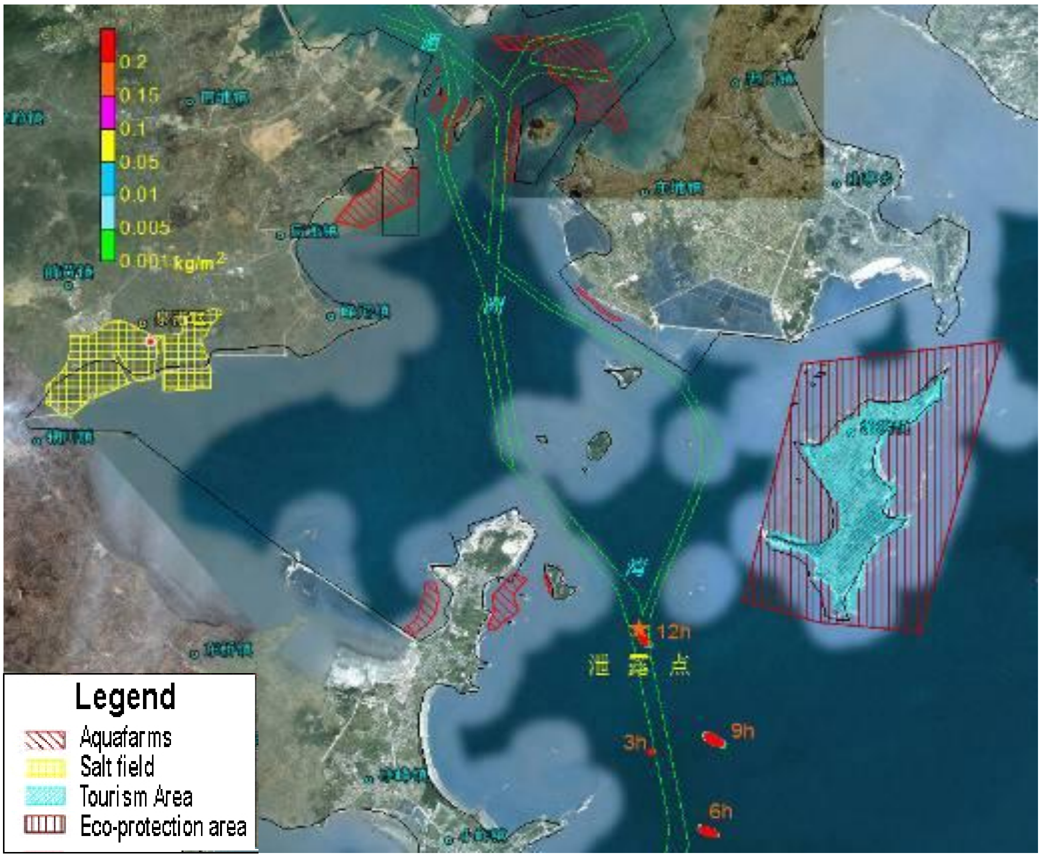


Figure 8.4.2 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Slack Period in Case of Calm Wind (after 3-12 hours)

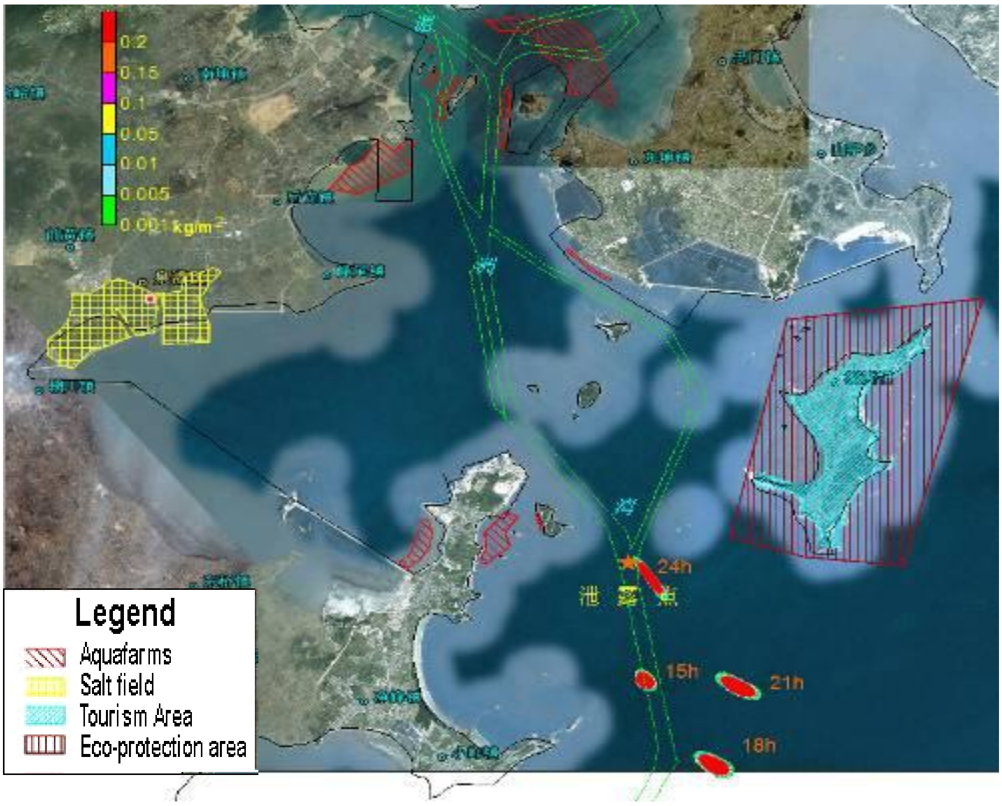


Figure 8.4.3 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Slack Period in Case of Calm Wind (after 15-24 hours)

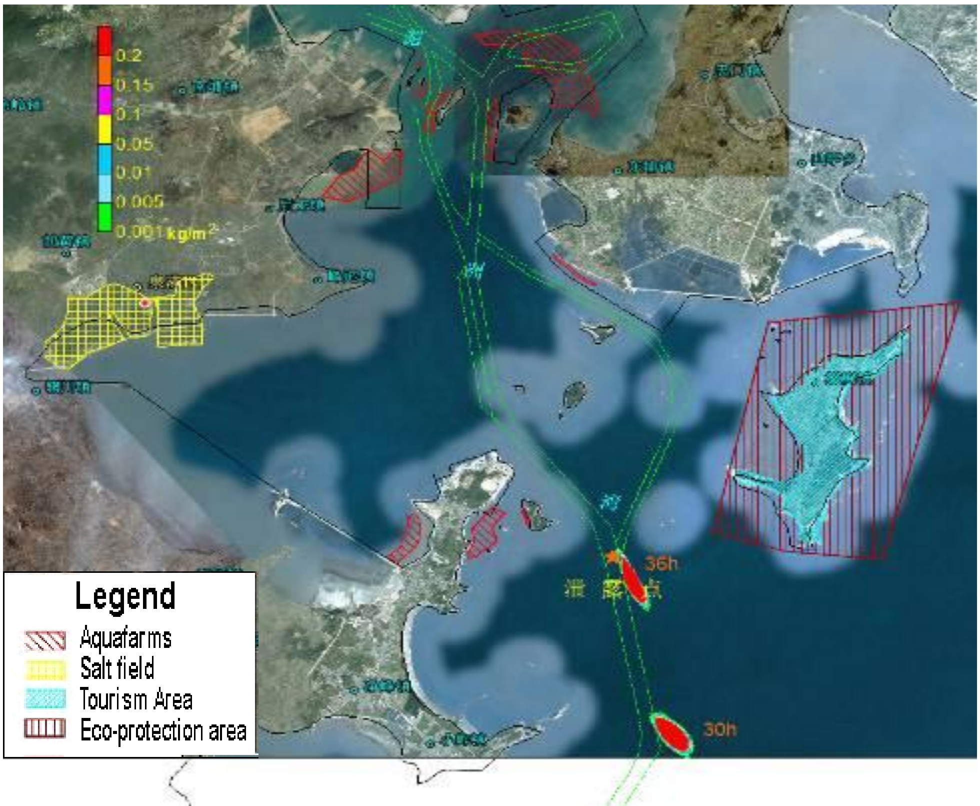


Figure 8.4.4 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Slack Period in Case of Calm Wind (after 30-36 hours)

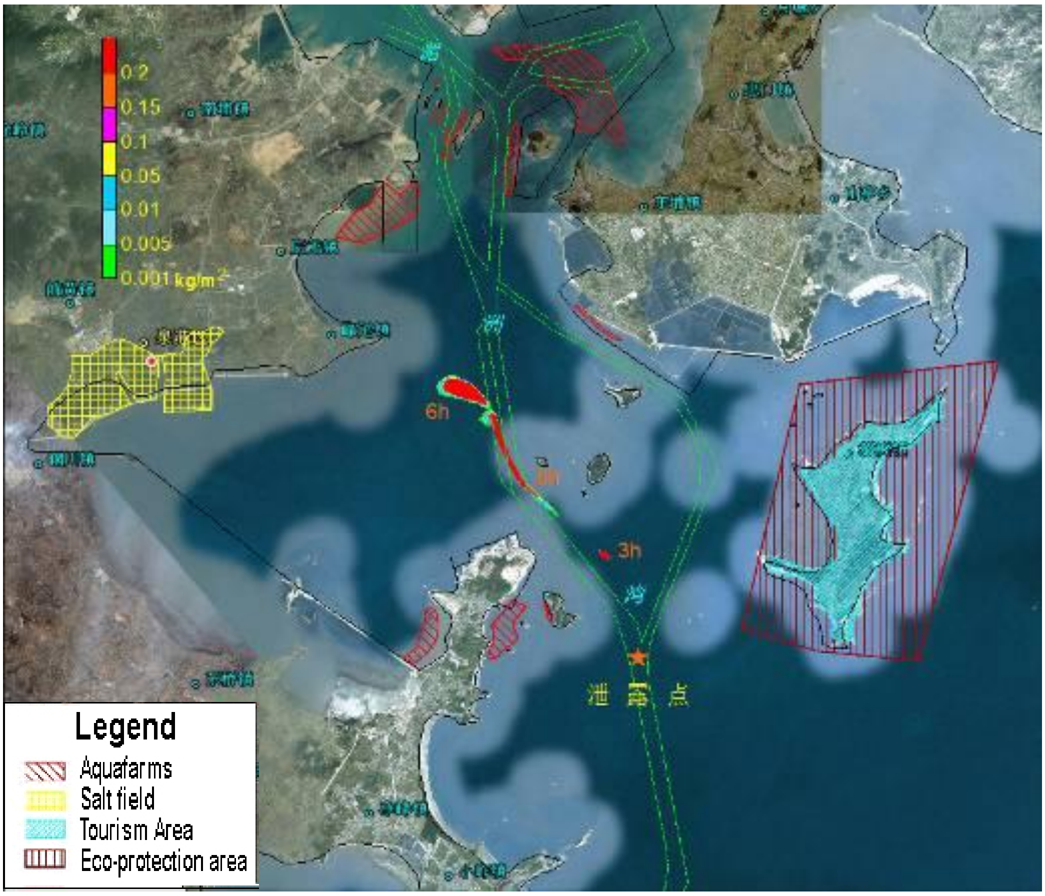


Figure 8.4.5 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Slack Period in Case of Calm Wind (after 3-9 hours)

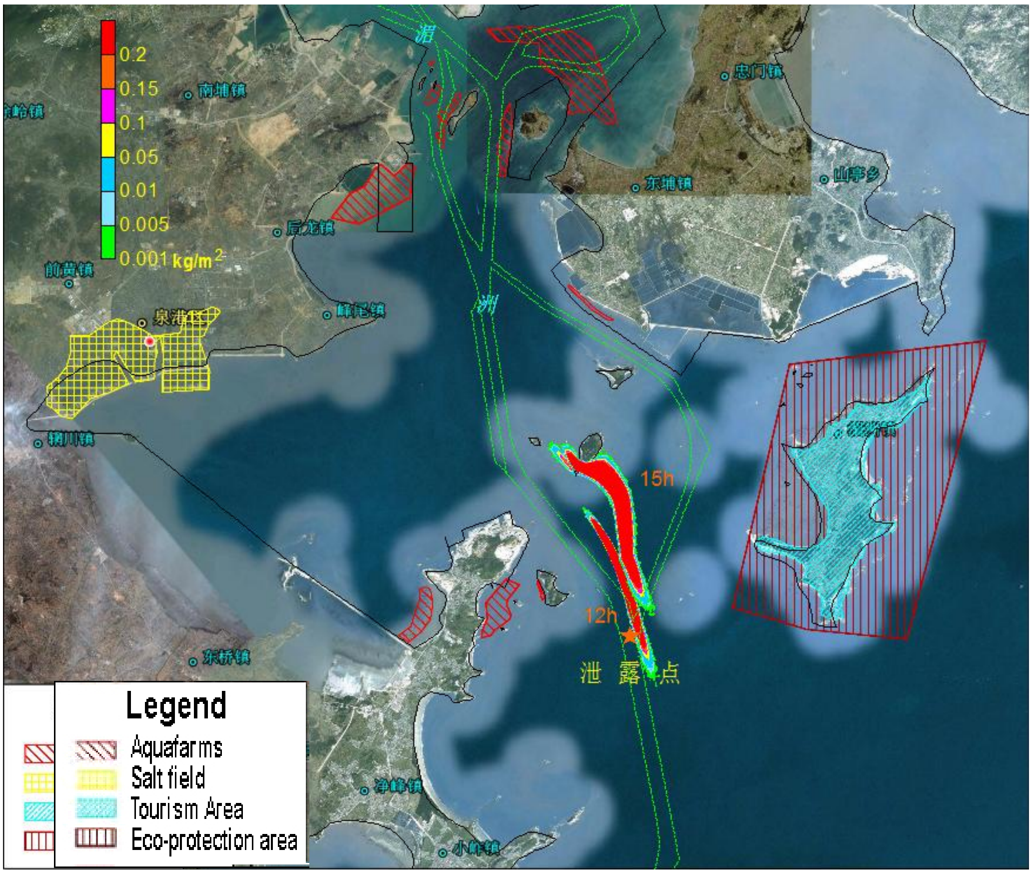


Figure 8.4.6 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Slack Period in Case of Calm Wind (after 12-15 hours)

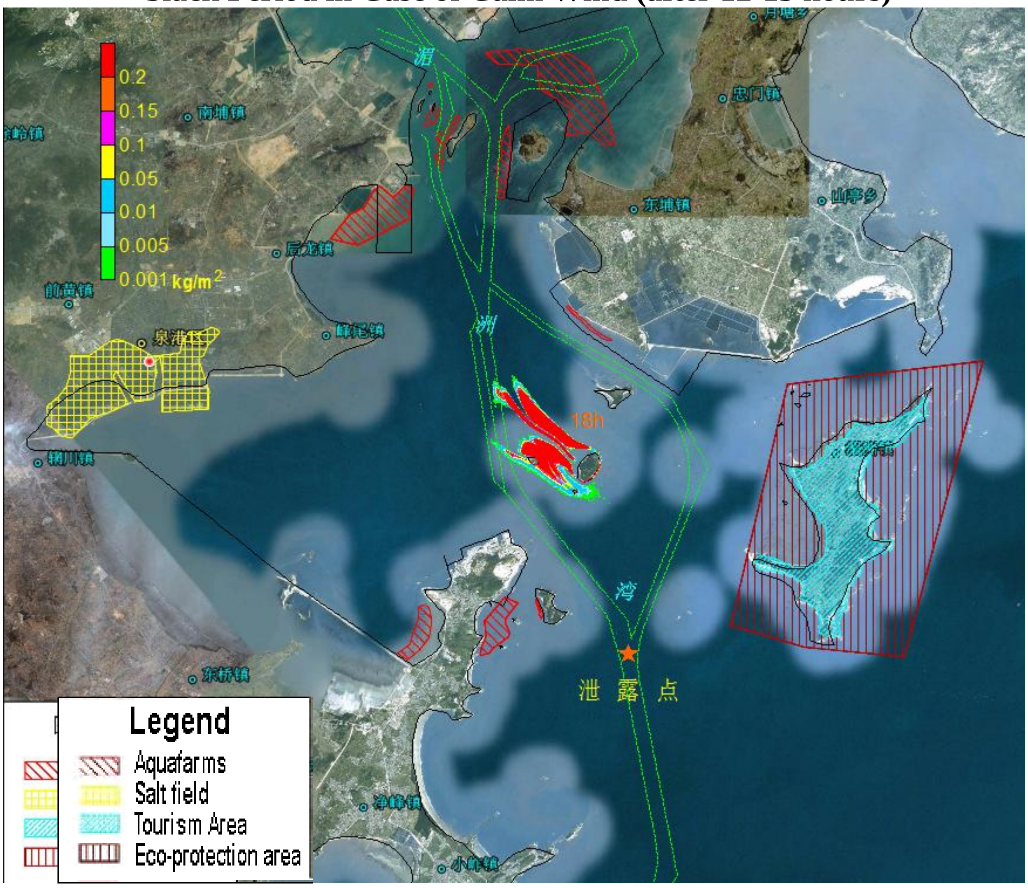


Figure 8.4.7 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb

Slack Period in Case of Calm Wind (after 18 hours)

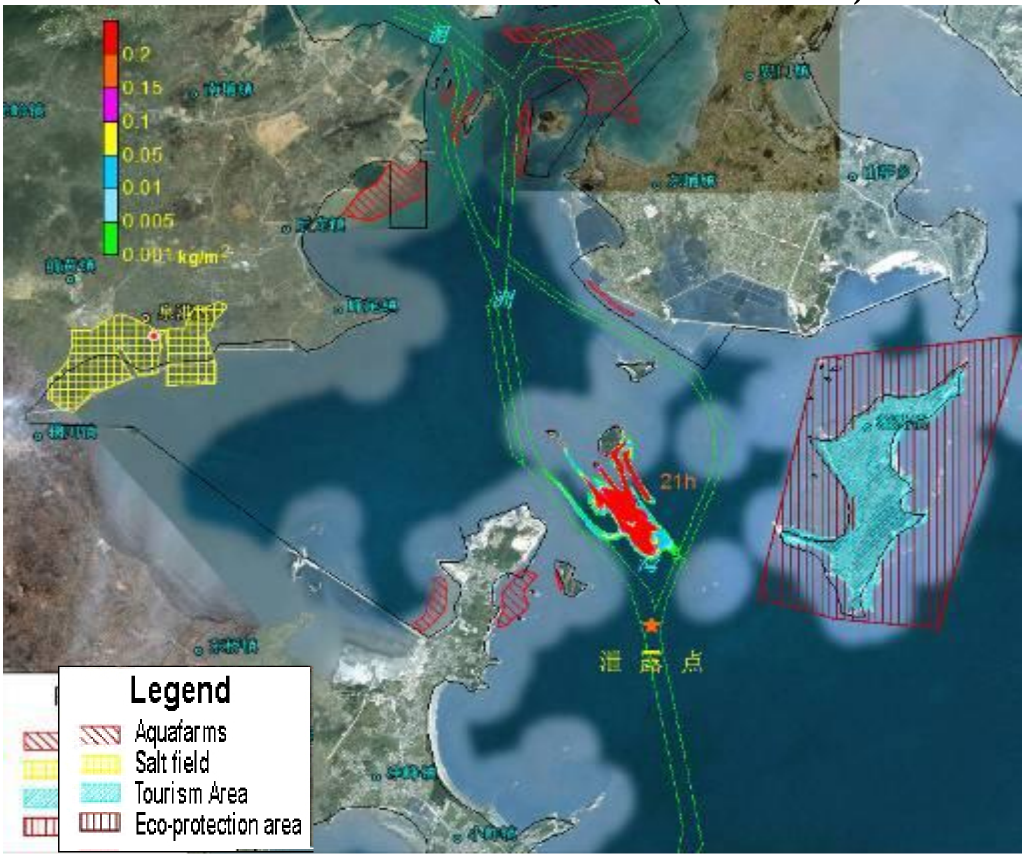


Figure 8.4.8 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Slack Period in Case of Calm Wind (after 21 hours)

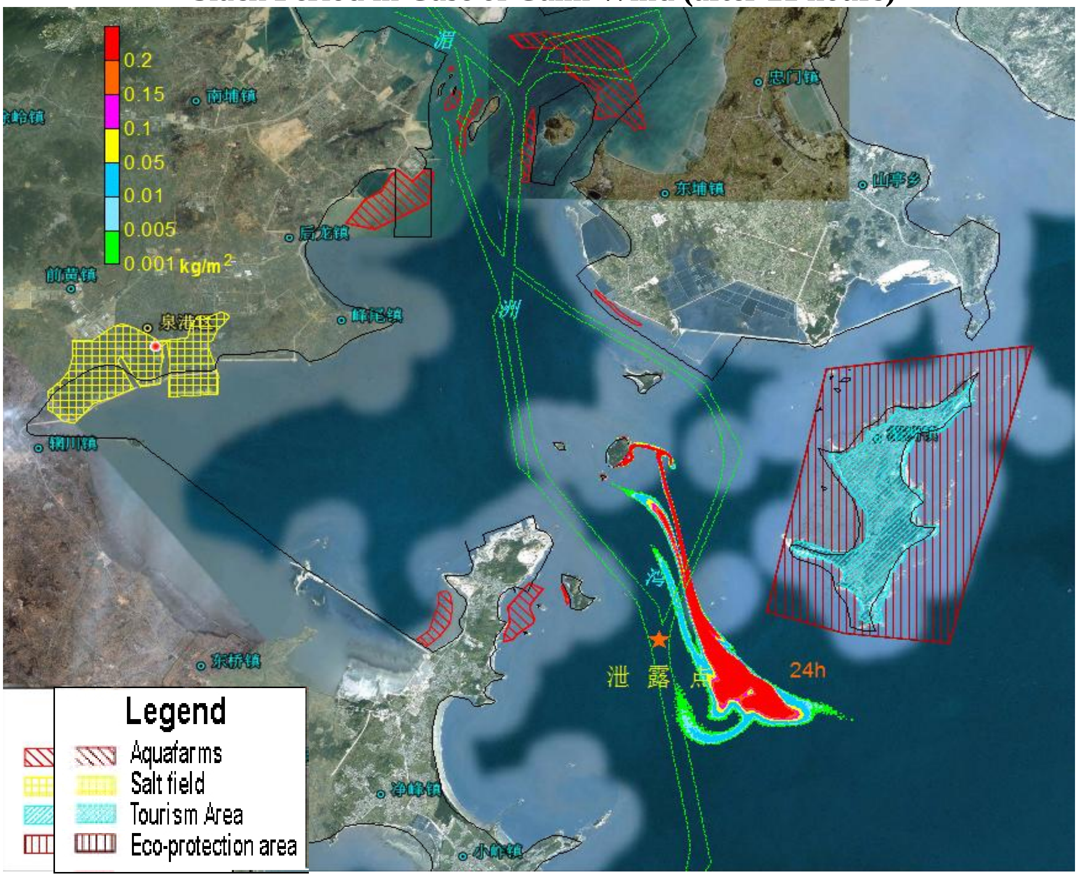


Figure 8.4.9 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb

Slack Period in Case of Calm Wind (after 24 hours)

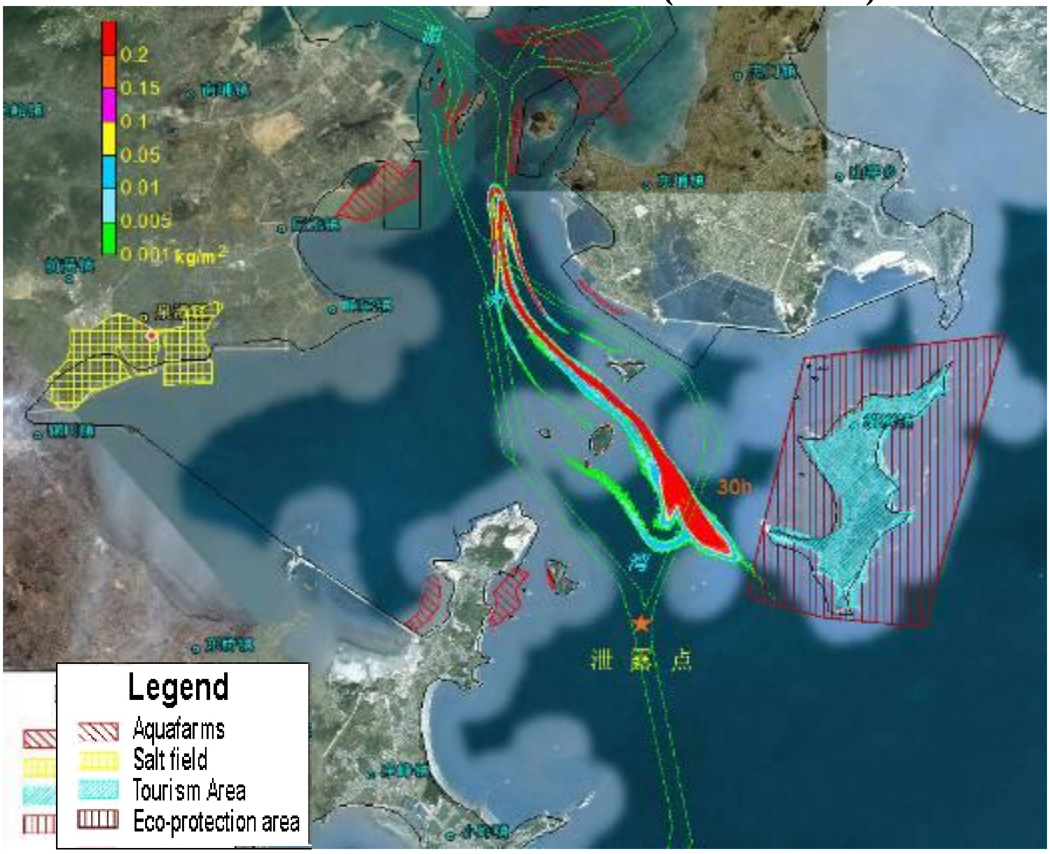


Figure 8.4.10 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Slack Period in Case of Calm Wind (after 30 hours)

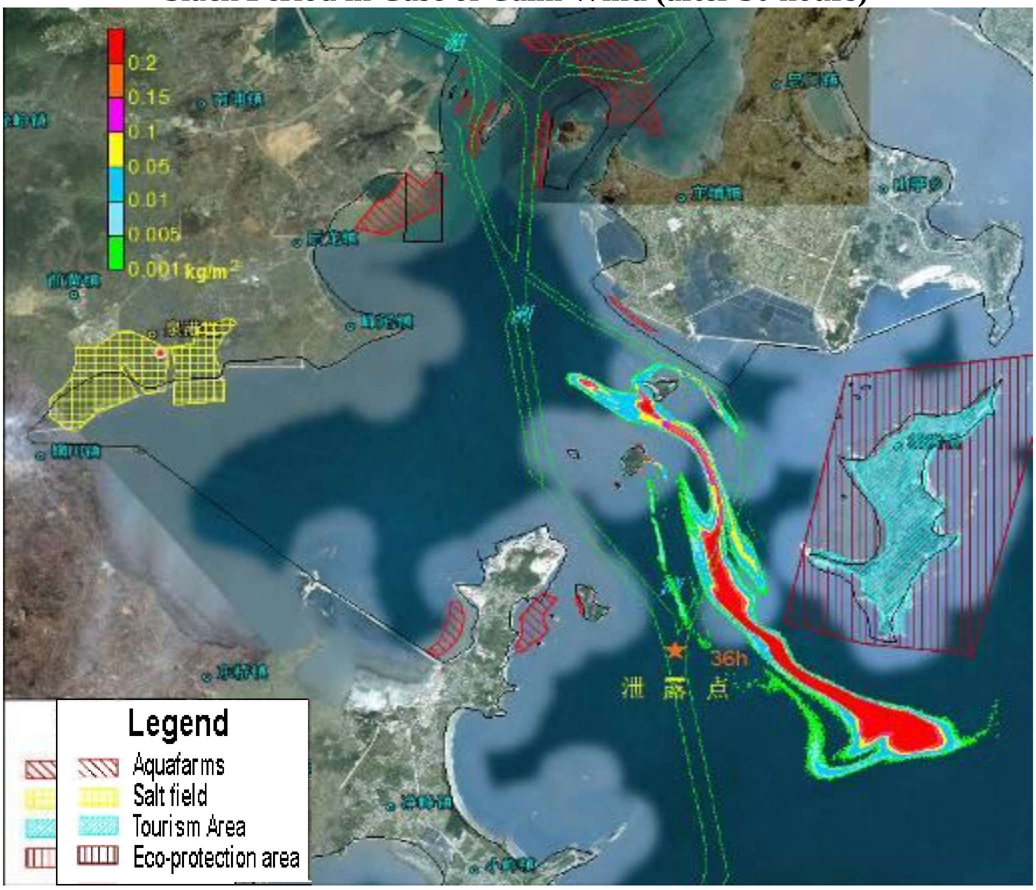


Figure 8.4.11 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Slack Period in Case of Calm Wind (after 36 hours)

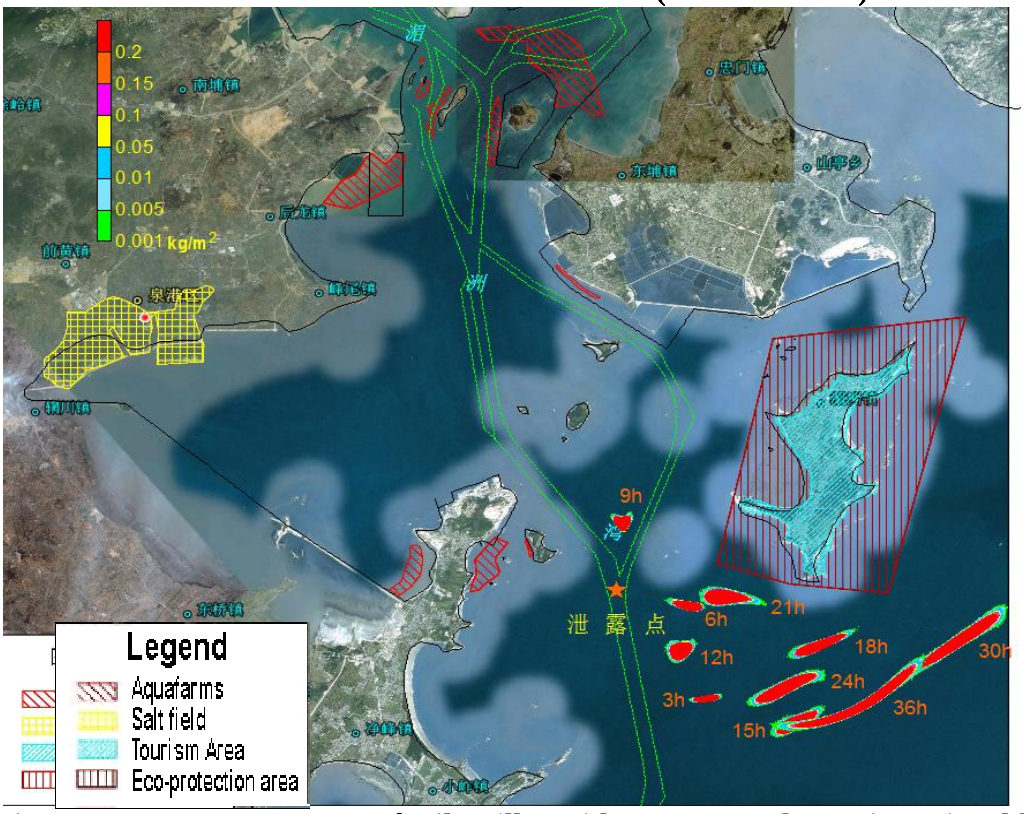


Figure 8.4.12 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Tide Period in Case of Calm Wind (after 3-36 hours)

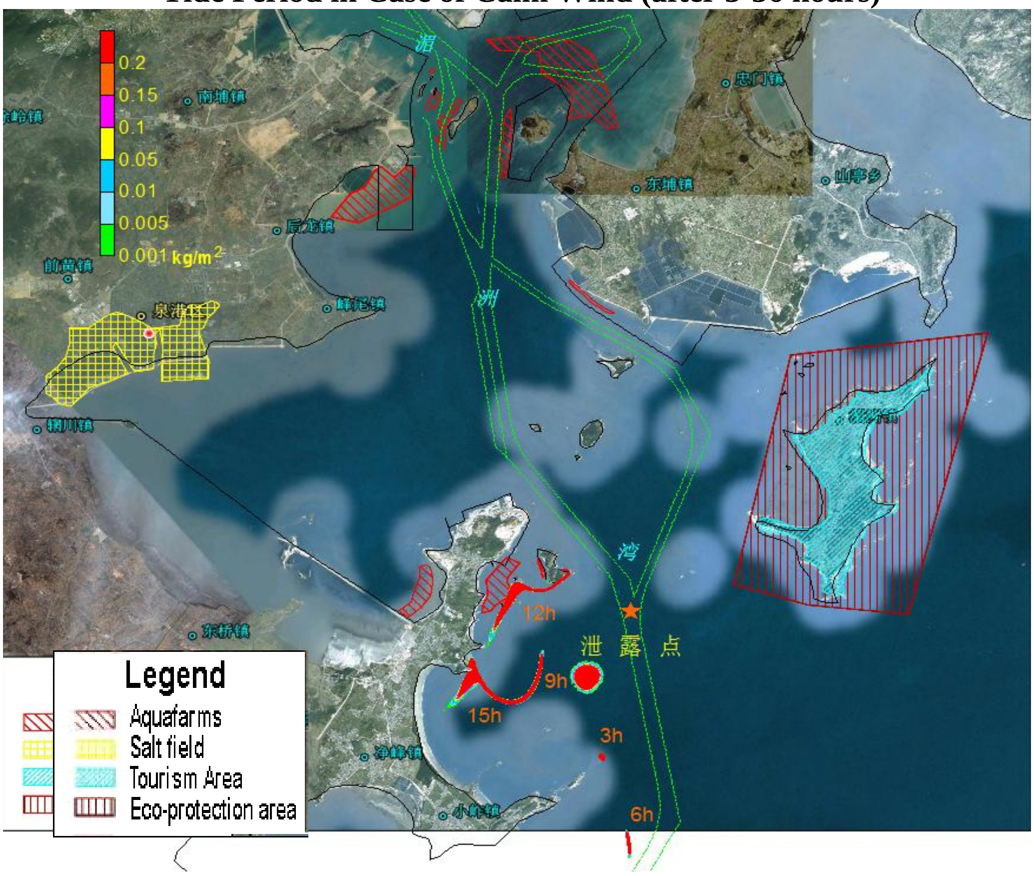


Figure 8.4.13 Impact Scope of Oil Spill Accident Occurred at Point A in Flood

Slack Period in Case of a NE Wind (after 3-15 hours)

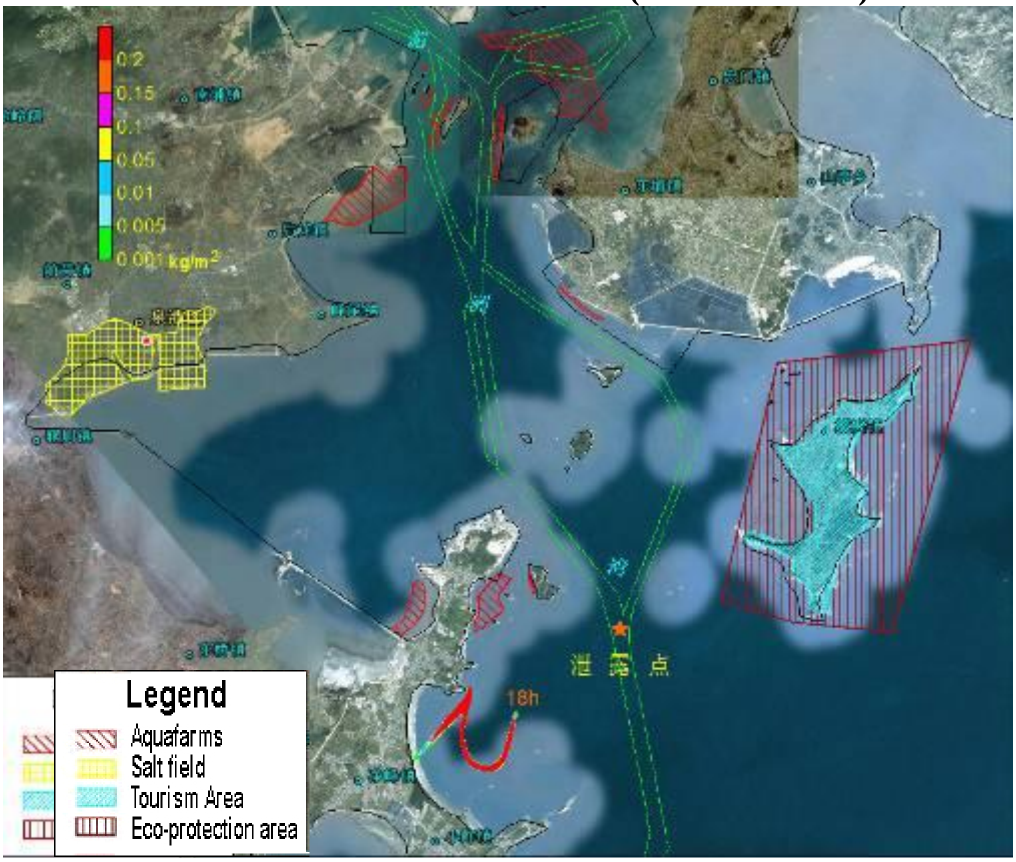


Figure 8.4.14 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Slack Period in Case of a NE Wind (after 18 hours)

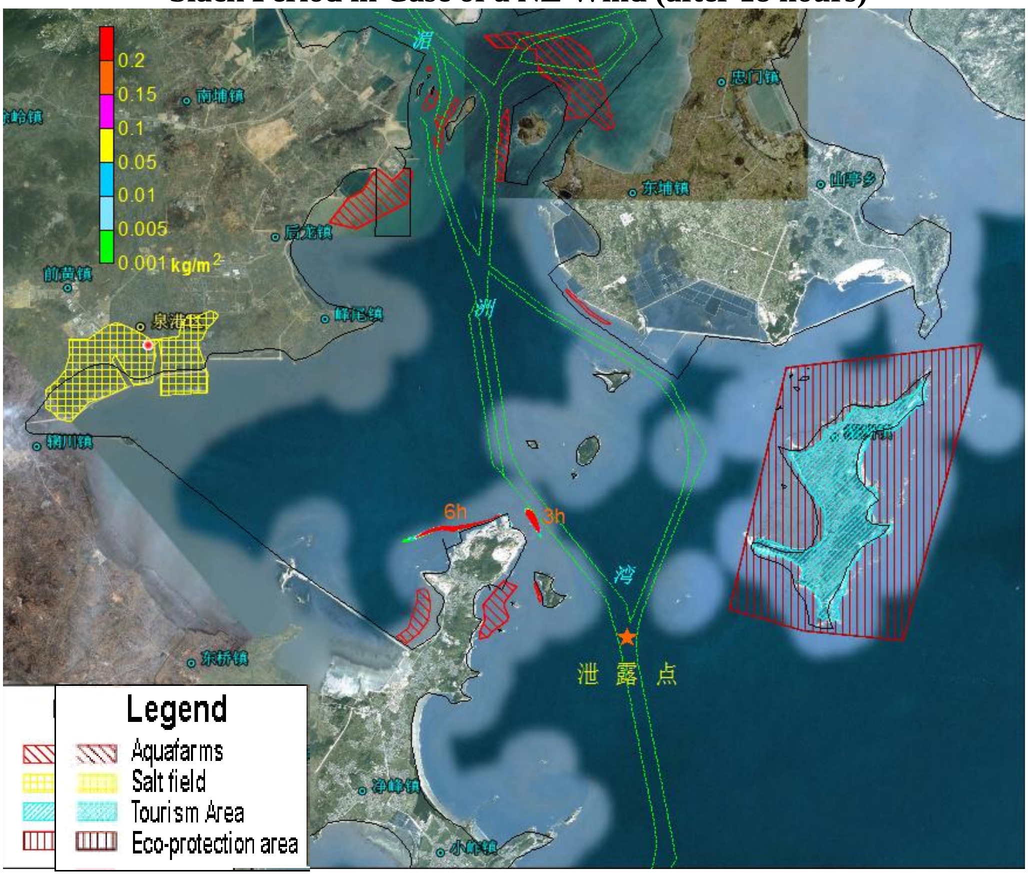


Figure 8.4.15 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb

Slack Period in Case of a NE Wind (after 3-6 hours)

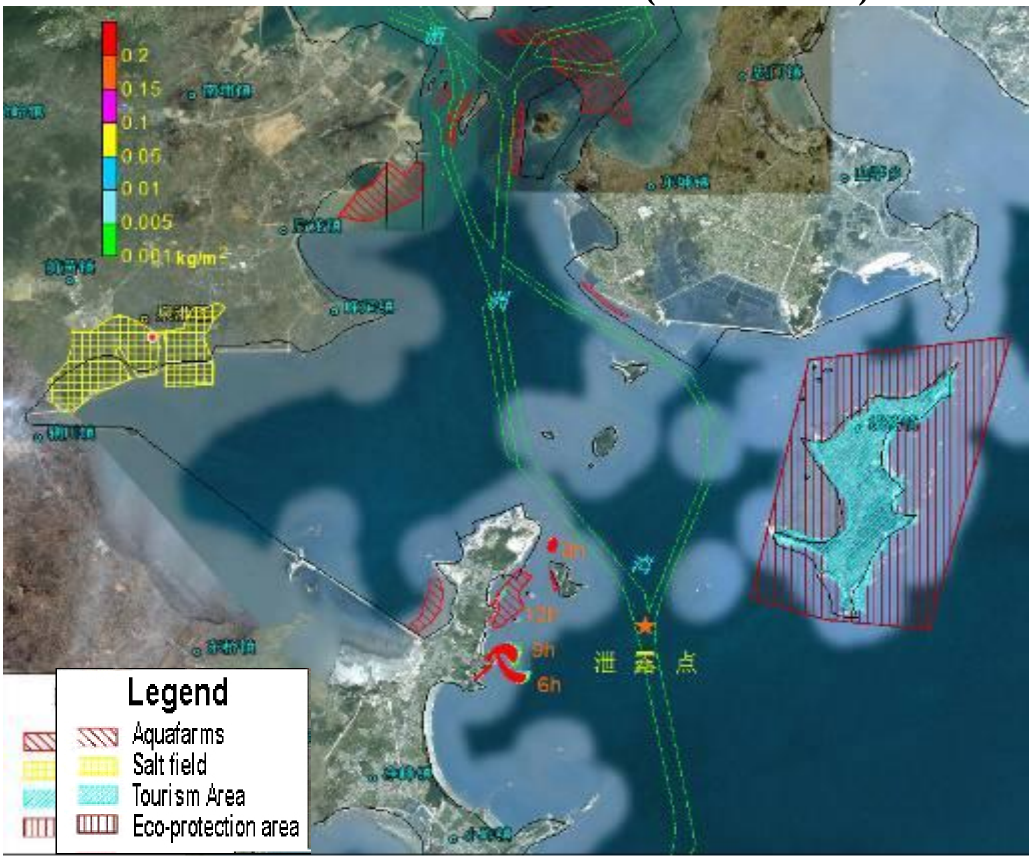


Figure 8.4.16 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Tide Period in Case of a NE Wind (after 3-12 hours)

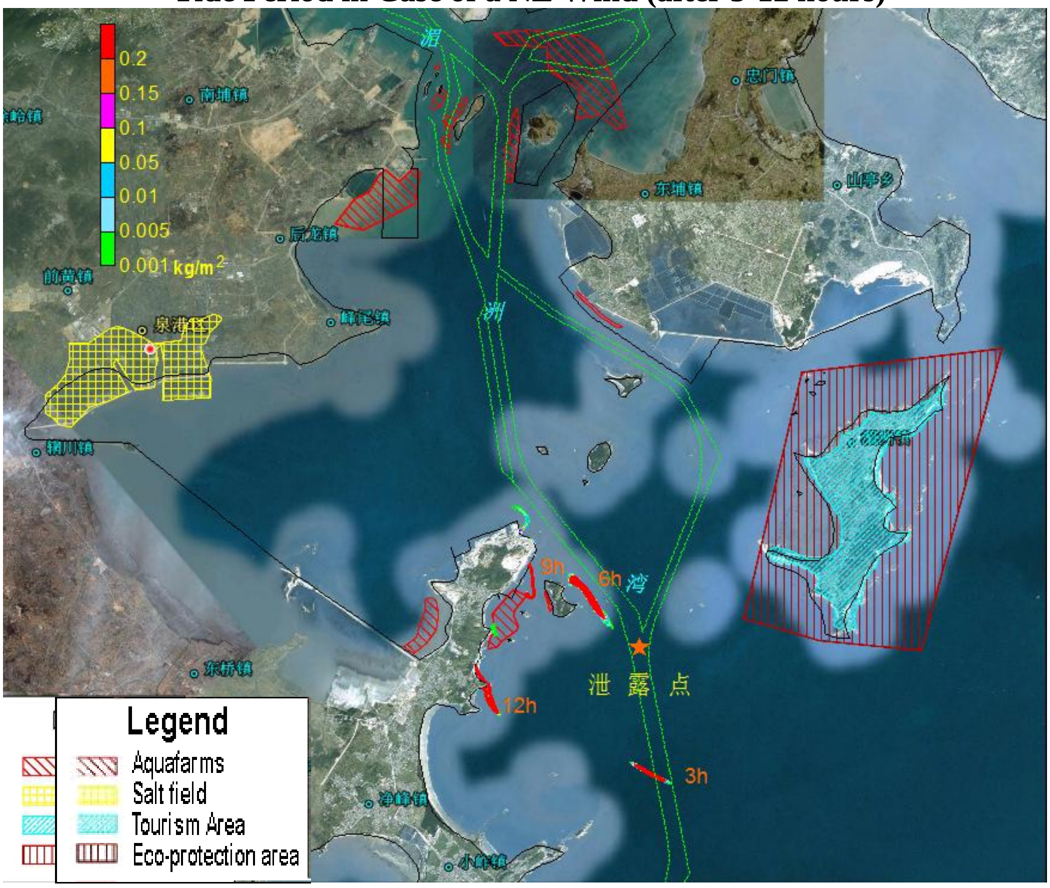


Figure 8.4.17 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Tide Period in Case of a NE Wind (after 3-12 hours)

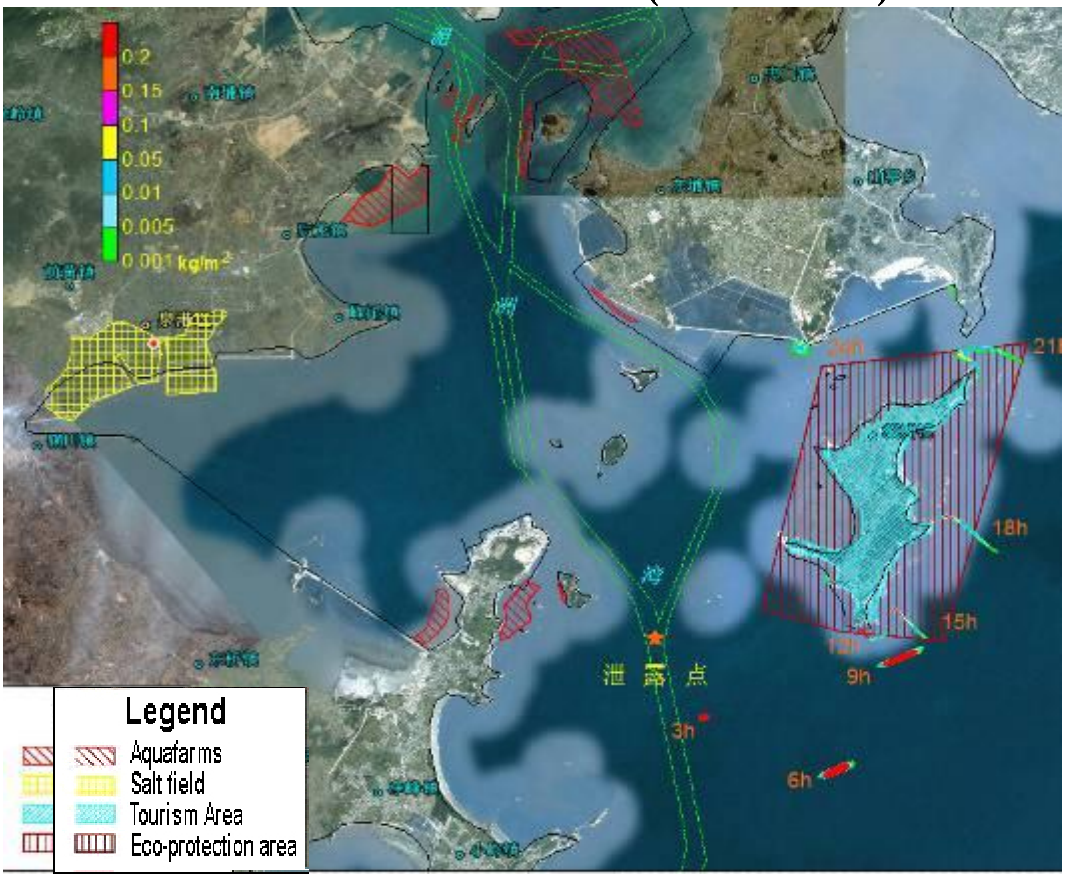


Figure 8.4.18 Impact Scope of Oil Spill Accident Occurred at Point A in Flood Slack Period in Case of a SSW Wind (after 3-24 hours)

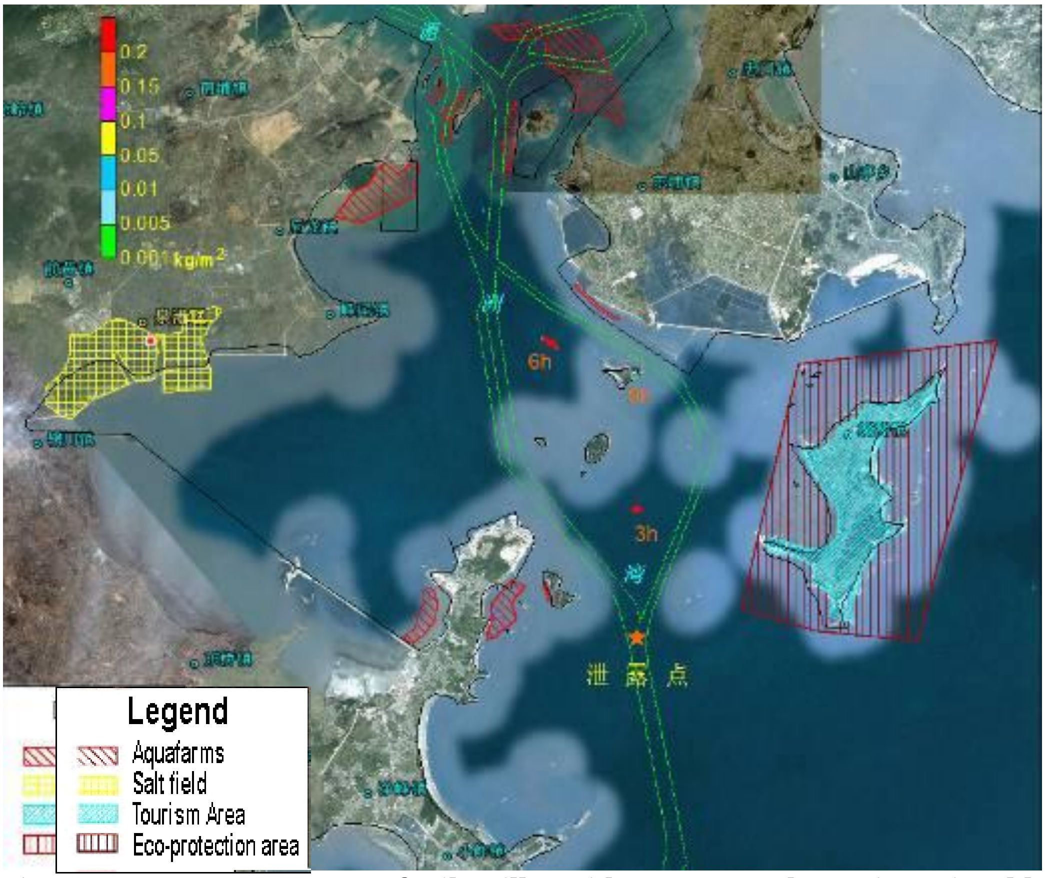


Figure 8.4.19 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Slack Period in Case of a SSW Wind (after 3-9 hours)

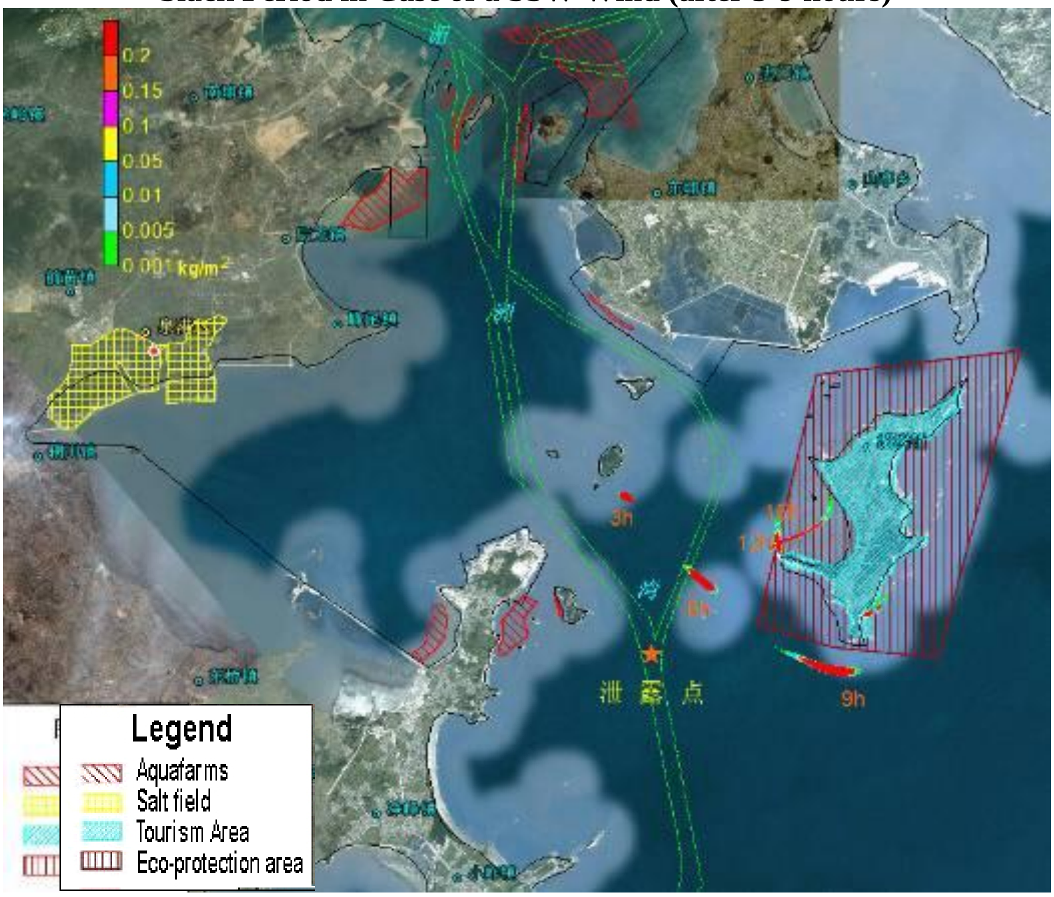


Figure 8.4.20 Impact Scope of Oil Spill Accident Occurred at Point A in Flood

Slack Period in Case of a SSW Wind (after 3-15 hours)

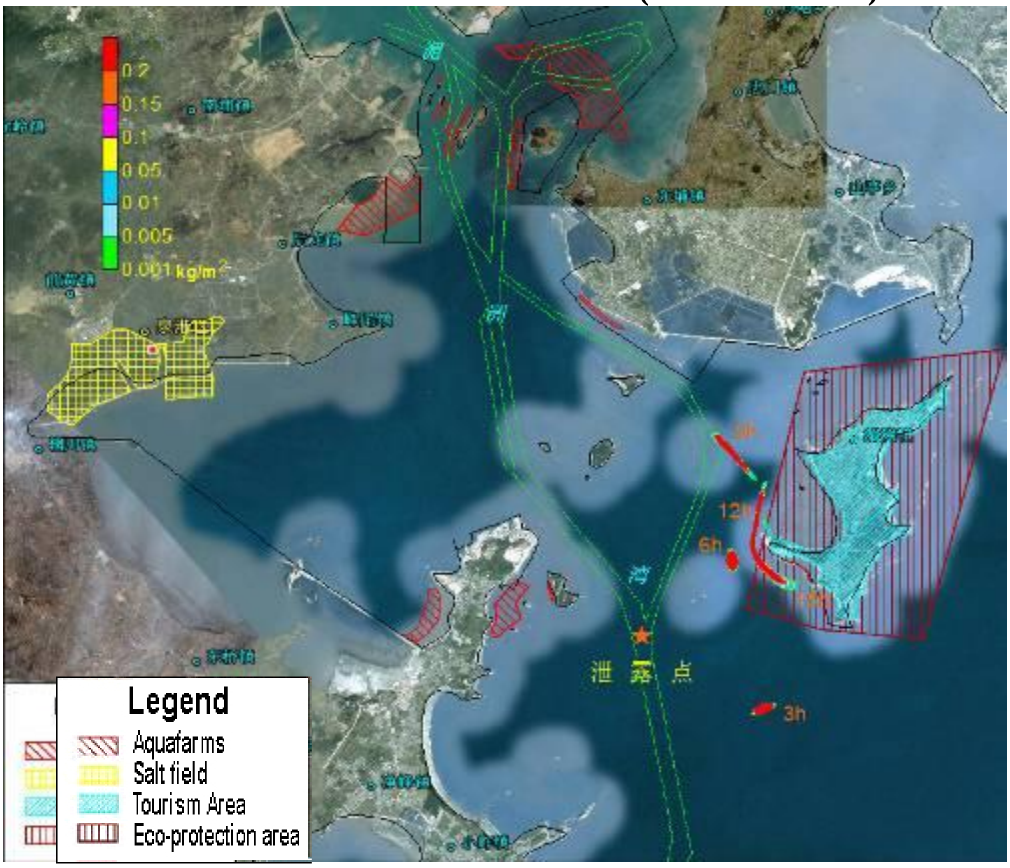


Figure 8.4.21 Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Tide Period in Case of a SSW Wind (after 3-15 hours)

8.4.2.2 Prediction for Leakage Point B

(1) Calm wind

The vessel leaks at point B, and the movements of oil slicks on different tidal currents in case of calm wind are shown in Figure 8.4.22 through Figure 8.4.39, with impact scope shown in Table 8.4.13 through 8.4.16.

In case of calm wind, movement of oil slicks under four tide conditions are described in below.

- *Flood Slack* - upon the occurrence of oil spill accident at point B in flood slack period, due to the influence of flood and ebb tides, oil slicks will gradually move towards one side of bay-mouth and intrude Meizhou Island Ecological Protection Zone in 18-21 hours.
- *Ebb Slack* - Upon the occurrence of oil spill accident in ebb slack period, the oil slicks will intrude Luoyu aquaculture area in 3-6 hours, and will be distributed in strip form along the navigation channel. The oil slicks will intrude Shimenao sea area in 15 hours, Putou aquaculture area in 30 hours and Dongwu aquaculture area 36 hours.
- *Flood Tide* - If the oil spill accident takes place in flood tide period, the oil slicks will move back and forth in south-north direction, and intrude Luoyu aquaculture area in 15 hours.
- *Ebb Tide* - If the oil spill accident takes places in ebb tide period, the oil slicks

will intrude western Huiyu aquaculture area in about 21 hours.

(2) Perennial Predominant Wind Direction

The movements of oil slicks on different tidal currents in case of the Perennial Predominant Wind Direction are shown in Figure 8.4.40 through Figure 8.4.43, with impact scope shown in Table 8.4.17 through 8.4.20.

- *Flood Slack* - In case of a NE wind, upon the occurrence of oil spill accident in flood slack period, the oil slicks will move towards the bay-mouth. Due to the influence of wind generated currents, the oil slicks will reach the shore nearby Douwei Dockyard in about 9 hours.
- *Ebb Slack* - Upon the occurrence of oil spill accident in ebb slack period, the oil slicks will move towards the bay-head and intrude the sea area in the north of Houlong aquaculture area in about 6 hours.
- *Flood Tide* - If the accident takes places in flood tide period, due to the influence of wind generated currents, the oil slicks will gradually swerve to Madai sea area and intrude Shanyao salt-field area in 15 hours and then reach the shore of Madai reclamation site in about 24 hours.
- *Ebb Tide* - If the accident takes places in ebb tide period, due to the joint influence of wind generated currents and flood currents, the oil slicks will reach the sea area off Fengwei Town in around 6 hours.

(3) Summer Predominant Wind Direction

The movements of oil slicks on different tidal currents in case of the Summer Predominant Wind Direction are shown in Figure 8.4.44 through Figure 8.4.48, with impact scope shown in Table 8.4.21 through 8.4.24.

In case of an SSW wind, upon the occurrence of oil spill accident at point B, the oil slicks will be prone to move in northeast direction to the bay.

- *Flood Slack* - If the accident takes place in flood slack period, due to the joint influence of ebb currents and wind generated currents, the oil slicks will intrude Dongwu aquaculture area in about 3 hours.
- *Ebb Slack* - If the accident takes places in ebb slack period, due to the influence of flood currents, the oil slicks will intrude Luoyu aquaculture area in about 3 hours, Shimenao sea area in about 6 hours and reclamation site on the east side of Shimenao in 9 hours.
- *Flood Tide* - If the accident takes place in flood tide period, the oil slicks will intrude the western aquaculture area of Luoyu in 1-2 hours and stick to the shore.
- *Ebb Tide* - If the accident takes place in ebb tide period, the oil slicks will first move in southeast direction and then enter into the eastern navigation channel of Luoyu along with flood currents. The oil slicks will intrude Shimenao sea area in about 9 hours, reach the south shore of Luoyu in 12 hours, intrude the western aquaculture area of Luoyu along with the flood currents in 15 hours, move to the east side of Shimenao in 18-24 hours, and gradually reach and stick to the shore.

Table 8.4.13 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Slack Period in Case of Calm Wind (unit: km2)

After flood slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.014	0.014	0.014	0.013	0.016
2	0.046	0.045	0.045	0.042	0.05
3	0.123	0.118	0.115	0.099	0.131
4	0.142	0.134	0.133	0.126	0.155
5	0.242	0.23	0.224	0.203	0.269
6	0.278	0.262	0.256	0.23	0.304
7	0.282	0.272	0.261	0.24	0.309
8	0.264	0.25	0.238	0.219	0.288
9	0.232	0.211	0.203	0.186	0.254
10	0.384	0.362	0.35	0.32	0.429
11	0.627	0.595	0.582	0.533	0.69
12	0.562	0.538	0.522	0.466	0.611
13	0.582	0.555	0.542	0.496	0.646
14	0.651	0.613	0.597	0.536	0.714
15	0.614	0.586	0.568	0.501	0.69
16	1.072	0.994	0.954	0.846	1.218
17	1.155	1.059	1.006	0.885	1.35
18	1.131	1.038	0.987	0.877	1.312
19	1.227	1.162	1.13	1.008	1.394
20	1.198	1.125	1.082	0.982	1.339
21	1.413	1.314	1.258	1.147	1.602
22	1.458	1.365	1.299	1.182	1.618
23	1.381	1.29	1.218	1.093	1.581
24	1.21	1.125	1.07	0.958	1.389
25	1.245	1.146	1.094	0.984	1.43
26	1.422	1.336	1.274	1.126	1.598
27	1.658	1.542	1.493	1.35	1.883
28	1.938	1.813	1.736	1.586	2.184
29	1.946	1.843	1.765	1.598	2.186
30	1.901	1.79	1.704	1.51	2.146
31	2.018	1.891	1.821	1.638	2.262
32	2.202	2.069	1.992	1.792	2.475
33	2.398	2.246	2.139	1.934	2.67
34	2.434	2.302	2.205	1.957	2.773
35	2.579	2.421	2.302	2.027	2.987
36	2.699	2.514	2.379	2.104	3.048
Envelope area>0.001kg/m^2	40.368				

Table 8.4.14 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period in Case of Calm Wind (unit: km2)

After ebb slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.003	0.003	0.003	0.003	0.003
2	0.018	0.016	0.016	0.014	0.019
3	0.046	0.045	0.045	0.043	0.05
4	0.09	0.083	0.082	0.077	0.093
5	0.166	0.16	0.157	0.147	0.187
6	0.208	0.2	0.194	0.184	0.232
7	0.264	0.248	0.238	0.229	0.293
8	0.286	0.278	0.277	0.259	0.323
9	0.248	0.238	0.23	0.214	0.261
10	0.592	0.573	0.56	0.514	0.638
11	1.008	0.966	0.934	0.87	1.08
12	1.128	1.093	1.058	0.978	1.237
13	1.152	1.112	1.075	0.995	1.235
14	1.19	1.134	1.109	1.024	1.277
15	1.363	1.299	1.243	1.138	1.461
16	1.755	1.675	1.618	1.475	1.925
17	2.464	2.371	2.262	2.088	2.715
18	3.243	3.085	2.992	2.77	3.525
19	3.47	3.31	3.2	2.894	3.818
20	3.637	3.437	3.278	2.946	3.997
21	3.998	3.771	3.581	3.125	4.442
22	4.816	4.384	4.074	3.4	5.537
23	5.413	4.84	4.458	3.635	6.347
24	5.576	5.064	4.664	3.81	6.582
25	5.691	5.198	4.79	3.853	6.624
26	5.832	5.326	4.907	4.006	6.718
27	6.126	5.619	5.317	4.584	6.969
28	6.939	6.414	6.077	5.313	7.774
29	8.201	7.595	7.206	6.147	9.285
30	9.473	8.718	8.22	6.894	10.73
31	9.969	9.161	8.657	7.265	11.296
32	10.618	9.822	9.278	7.88	12.048
33	11.357	10.494	9.849	8.179	12.981
34	11.848	10.75	10.117	8.395	13.791
35	13.188	11.984	11.237	9.349	15.305
36	13.961	12.709	11.879	9.889	16.262
Envelope area>0.001kg/m^2	53.118				

Table 8.4.15 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Tide Period in Case of Calm Wind (unit: km2)

After flood tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.05	0.045	0.045	0.045	0.051
2	0.077	0.072	0.067	0.067	0.085
3	0.074	0.072	0.069	0.067	0.082
4	0.083	0.082	0.078	0.07	0.091
5	0.109	0.106	0.101	0.098	0.118
6	0.16	0.154	0.147	0.131	0.174
7	0.267	0.256	0.246	0.224	0.29
8	0.358	0.338	0.323	0.293	0.381
9	0.358	0.342	0.322	0.301	0.39
10	0.326	0.309	0.301	0.283	0.357
11	0.309	0.285	0.275	0.256	0.331
12	0.28	0.267	0.256	0.238	0.312
13	0.302	0.285	0.28	0.256	0.333
14	0.373	0.355	0.328	0.304	0.405
15	0.339	0.322	0.312	0.293	0.387
16	0.347	0.333	0.318	0.291	0.39
17	0.354	0.333	0.322	0.296	0.386
18	0.414	0.389	0.371	0.336	0.448
19	0.552	0.52	0.504	0.458	0.602
20	0.731	0.702	0.682	0.624	0.816
21	0.869	0.822	0.792	0.734	0.954
22	0.8	0.75	0.736	0.67	0.875
23	0.634	0.6	0.579	0.533	0.694
24	0.542	0.512	0.488	0.448	0.603
25	0.539	0.51	0.493	0.45	0.602
26	0.686	0.656	0.627	0.568	0.757
27	0.749	0.714	0.698	0.626	0.837
28	0.733	0.696	0.68	0.618	0.818
29	0.709	0.672	0.645	0.594	0.792
30	0.65	0.619	0.592	0.546	0.738
31	0.728	0.68	0.666	0.597	0.819
32	0.806	0.747	0.722	0.653	0.917
33	0.851	0.806	0.779	0.704	0.955
34	0.835	0.784	0.76	0.688	0.93
35	0.8	0.749	0.712	0.65	0.896
36	0.79	0.746	0.728	0.653	0.912
Envelope area>0.001kg/m^2	12.457				

Table 8.4.16 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Tide Period in Case of Calm Wind (unit: km2)

After ebb tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.058	0.054	0.053	0.05	0.058
2	0.07	0.066	0.066	0.066	0.086
3	0.078	0.074	0.072	0.064	0.083
4	0.075	0.074	0.074	0.07	0.078
5	0.08	0.075	0.074	0.067	0.083
6	0.107	0.106	0.104	0.093	0.115
7	0.163	0.158	0.155	0.146	0.178
8	0.202	0.19	0.186	0.173	0.219
9	0.182	0.181	0.173	0.162	0.203
10	0.211	0.208	0.202	0.19	0.237
11	0.282	0.266	0.254	0.235	0.304
12	0.294	0.278	0.266	0.243	0.31
13	0.358	0.334	0.317	0.293	0.384
14	0.381	0.357	0.339	0.312	0.421
15	0.395	0.378	0.363	0.32	0.432
16	0.381	0.357	0.336	0.312	0.411
17	0.405	0.378	0.368	0.339	0.43
18	0.414	0.394	0.378	0.347	0.446
19	0.531	0.498	0.469	0.435	0.574
20	0.643	0.603	0.579	0.528	0.718
21	0.674	0.632	0.616	0.56	0.744
22	0.63	0.602	0.579	0.517	0.701
23	0.747	0.706	0.682	0.622	0.826
24	0.958	0.888	0.845	0.773	1.07
25	1.101	1.024	0.987	0.875	1.242
26	1.109	1.034	0.979	0.877	1.28
27	1.134	1.05	1.002	0.896	1.301
28	1.17	1.088	1.022	0.91	1.283
29	1.243	1.166	1.109	0.978	1.398
30	1.454	1.344	1.288	1.142	1.65
31	1.533	1.437	1.355	1.197	1.706
32	1.459	1.366	1.293	1.146	1.661
33	1.618	1.515	1.446	1.226	1.819
34	1.597	1.485	1.413	1.227	1.789
35	1.73	1.626	1.554	1.354	1.96
36	2.106	1.963	1.867	1.64	2.365
Envelope area>0.001kg/m^2	20.303				

Table 8.4.17 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Slack Period in Case of a NE Wind (unit: km2)

After flood slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.013	0.013	0.013	0.013	0.013
2	0.037	0.037	0.037	0.035	0.042
3	0.07	0.069	0.067	0.064	0.077
4	0.146	0.136	0.131	0.126	0.158
5	0.234	0.229	0.216	0.202	0.251
6	0.238	0.224	0.221	0.205	0.256
7	0.187	0.176	0.173	0.155	0.208
8	0.296	0.286	0.283	0.267	0.312
9	0.107	0.098	0.094	0.082	0.117
10	0.014	0.014	0.011	0.01	0.022
11	Reach shore				
Envelope area>0.001kg/m^2	4.410				

Table 8.4.18 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period in Case of a NE Wind (unit: km2)

After ebb slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.006	0.006	0.006	0.006	0.006
2	0.019	0.019	0.019	0.019	0.019
3	0.048	0.045	0.042	0.042	0.051
4	0.053	0.053	0.05	0.048	0.056
5	0.013	0.011	0.011	0.01	0.016
6	reaches shore				
Envelope area>0.001kg/m^2	1.247				

Table 8.4.19 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Tide Period in Case of a NE Wind (unit: km2)

After flood tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.051	0.05	0.048	0.045	0.053
2	0.085	0.083	0.08	0.075	0.096
3	0.09	0.086	0.085	0.083	0.098
4	0.12	0.114	0.112	0.104	0.133
5	0.133	0.126	0.125	0.112	0.146
6	0.16	0.152	0.152	0.146	0.178
7	0.218	0.206	0.2	0.189	0.238
8	0.221	0.213	0.205	0.194	0.243
9	0.272	0.259	0.256	0.235	0.285
10	0.323	0.31	0.298	0.285	0.346
11	0.358	0.346	0.342	0.322	0.4
12	0.498	0.474	0.459	0.416	0.536
13	0.549	0.522	0.501	0.458	0.594
14	0.598	0.576	0.562	0.518	0.662
15	0.618	0.589	0.571	0.528	0.68
16	0.704	0.68	0.659	0.603	0.781
17	0.821	0.771	0.752	0.694	0.907
18	1.038	0.984	0.946	0.861	1.157
19	1.2	1.142	1.085	0.99	1.328
20	1.099	1.037	0.987	0.888	1.229
21	1.106	1.043	0.974	0.87	1.165
22	1.098	1.038	1	0.91	1.186
23	1.021	0.946	0.914	0.818	1.115
24	0.834	0.789	0.747	0.658	0.934
25	0.485	0.45	0.41	0.338	0.574
26	0.253	0.202	0.158	0.101	0.334
27	0.062	0.026	0.016	0	0.133
28	reaches shore				
Envelope area>0.001kg/m^2	46.307				

Table 8.4.20 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Tide Period in Case of a NE Wind (unit: km2)

After ebb tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.051	0.05	0.043	0.04	0.053
2	0.051	0.051	0.051	0.05	0.058
3	0.061	0.053	0.053	0.051	0.066
4	0.062	0.061	0.059	0.054	0.066
5	0.094	0.088	0.086	0.085	0.109
6	0.109	0.104	0.093	0.086	0.114
7	0.118	0.11	0.109	0.096	0.123
8	reaches shore				
Envelope area>0.001kg/m^2	2.562				

Table 8.4.21 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Slack Period in Case of a SSW Wind (unit: km2)

After flood slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.014	0.014	0.014	0.014	0.016
2	0.082	0.077	0.075	0.069	0.088
3	0.114	0.11	0.107	0.104	0.126
4	reaches shore				
Envelope area>0.001kg/m^2	1.218				

Table 8.4.22 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period in Case of a SSW Wind (unit: km2)

After ebb slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/ m^2	Swept area>0.001kg/ m^2
1	0.003	0.003	0.002	0.002	0.003
2	0.022	0.019	0.019	0.018	0.022
3	0.05	0.05	0.048	0.045	0.059
4	0.102	0.096	0.093	0.083	0.106
5	0.128	0.123	0.122	0.107	0.138
6	0.155	0.149	0.141	0.13	0.17
7	0.2	0.194	0.189	0.174	0.211
8	0.248	0.242	0.235	0.221	0.258
9	0.264	0.254	0.254	0.248	0.27
10	0.301	0.291	0.282	0.262	0.315
11	0.325	0.315	0.302	0.291	0.346
12	0.28	0.274	0.27	0.258	0.293
13	0.205	0.195	0.192	0.192	0.211
14	0.083	0.083	0.082	0.08	0.085
15	reaches shore				
Envelope area>0.001kg/ m^2	6.787				

Table 8.4.23 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Tide Period in Case of a SSW Wind (unit: km2)

After flood tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/ m^2	Swept area>0.001kg/ m^2
1	0.048	0.048	0.048	0.045	0.051
2	0.072	0.069	0.067	0.064	0.078
3	0.078	0.078	0.074	0.067	0.078
4	0.093	0.09	0.09	0.082	0.096
5	0.216	0.208	0.206	0.19	0.237
6	0.506	0.48	0.464	0.435	0.528
7	0.642	0.626	0.597	0.547	0.682
8	0.333	0.318	0.309	0.286	0.373
9	0.157	0.154	0.146	0.126	0.178
10	0.043	0.04	0.04	0.034	0.048
11	reaches shore				
Envelope area>0.001kg/ m^2	2.910				

Table 8.4.24 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Tide Period in Case of a SSW Wind (unit: km2)

After ebb tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.054	0.053	0.05	0.045	0.058
2	0.054	0.05	0.048	0.048	0.056
3	0.056	0.051	0.05	0.048	0.067
4	0.05	0.045	0.043	0.043	0.053
5	0.061	0.061	0.058	0.054	0.067
6	0.077	0.077	0.072	0.064	0.08
7	0.082	0.078	0.078	0.075	0.094
8	0.082	0.08	0.077	0.07	0.086
9	0.059	0.058	0.058	0.05	0.066
10	0.088	0.083	0.082	0.077	0.101
11	0.099	0.094	0.091	0.083	0.102
12	0.298	0.277	0.27	0.235	0.331
13	0.648	0.61	0.587	0.523	0.725
14	0.531	0.515	0.51	0.48	0.578
15	0.496	0.464	0.45	0.422	0.528
16	0.402	0.381	0.37	0.325	0.456
17	0.397	0.37	0.349	0.31	0.446
18	0.317	0.301	0.285	0.259	0.352
19	0.253	0.242	0.229	0.205	0.28
20	0.243	0.235	0.219	0.198	0.254
21	0.253	0.245	0.23	0.203	0.274
22	0.299	0.282	0.277	0.242	0.325
23	0.406	0.382	0.358	0.272	0.438
24	0.461	0.402	0.362	0.248	0.55
25	0.522	0.403	0.342	0.261	0.704
26	0.525	0.406	0.342	0.277	0.725
27	0.496	0.413	0.358	0.28	0.648
28	0.368	0.32	0.288	0.218	0.464
29	0.238	0.189	0.163	0.109	0.309
30	0.091	0.07	0.04	0.016	0.125
31	0.056	0.037	0.019	0.003	0.08
32	0.04	0.026	0.018	0.003	0.051
33	0.008	0.005	0.003	0	0.014
34	reaches shore				
Envelope area>0.001kg/m^2	15.310				

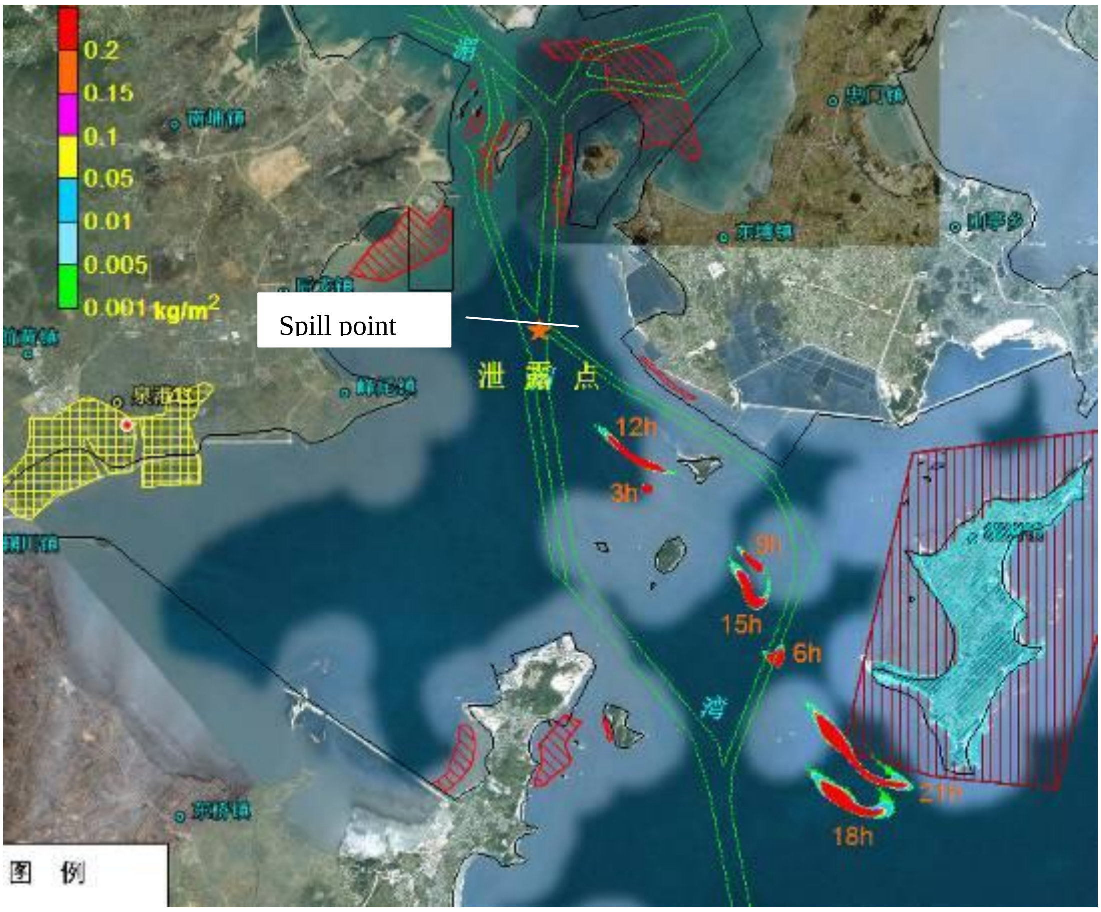


Figure 8.4.22 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Slack Period in Case of Calm Wind (after 3-21 hours)

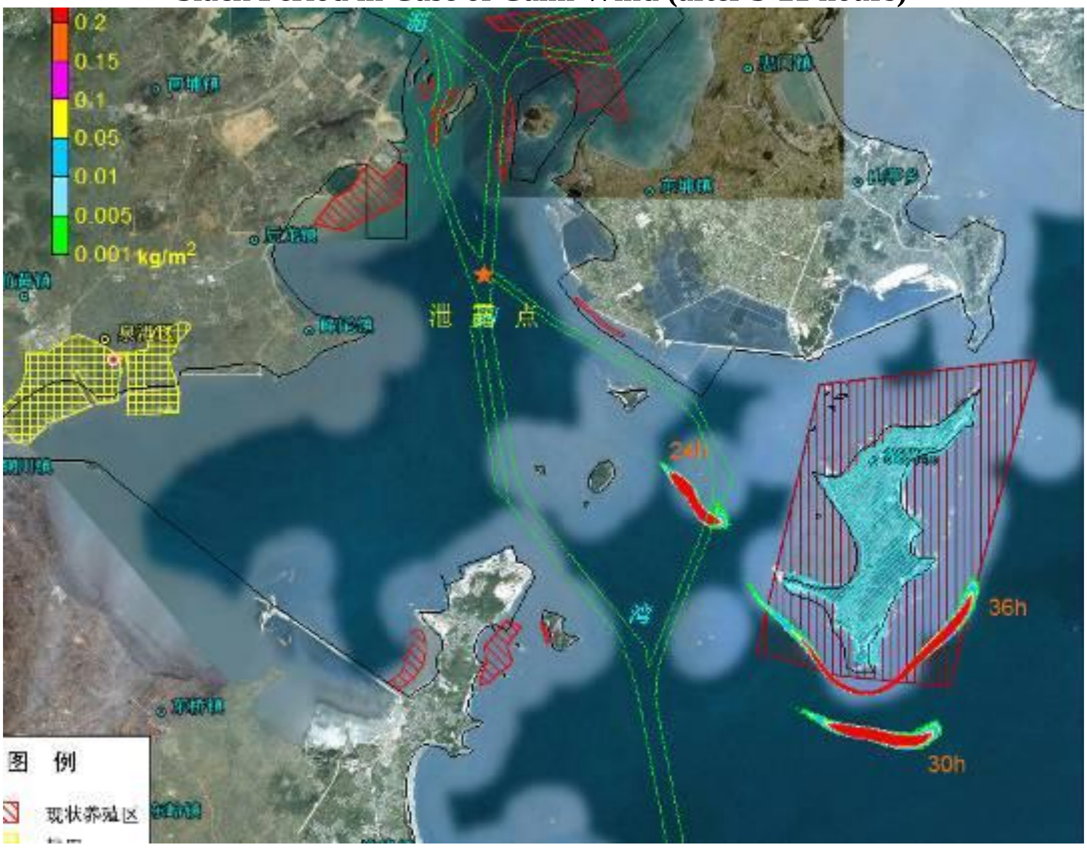


Figure 8.4.23 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Slack Period in Case of Calm Wind (after 24-36 hours)

Figure 8.4.24 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period in Case of Calm Wind (after 3-9 hours)

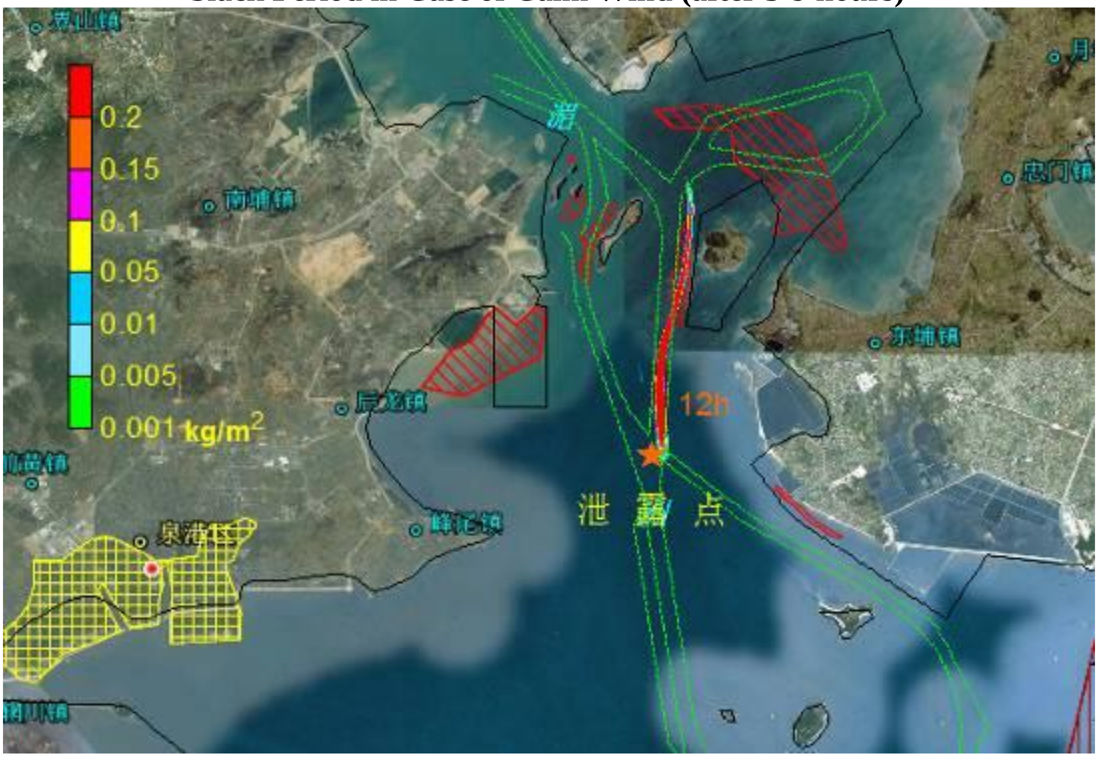


Figure 8.4.25 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period in Case of Calm Wind (after 12 hours)

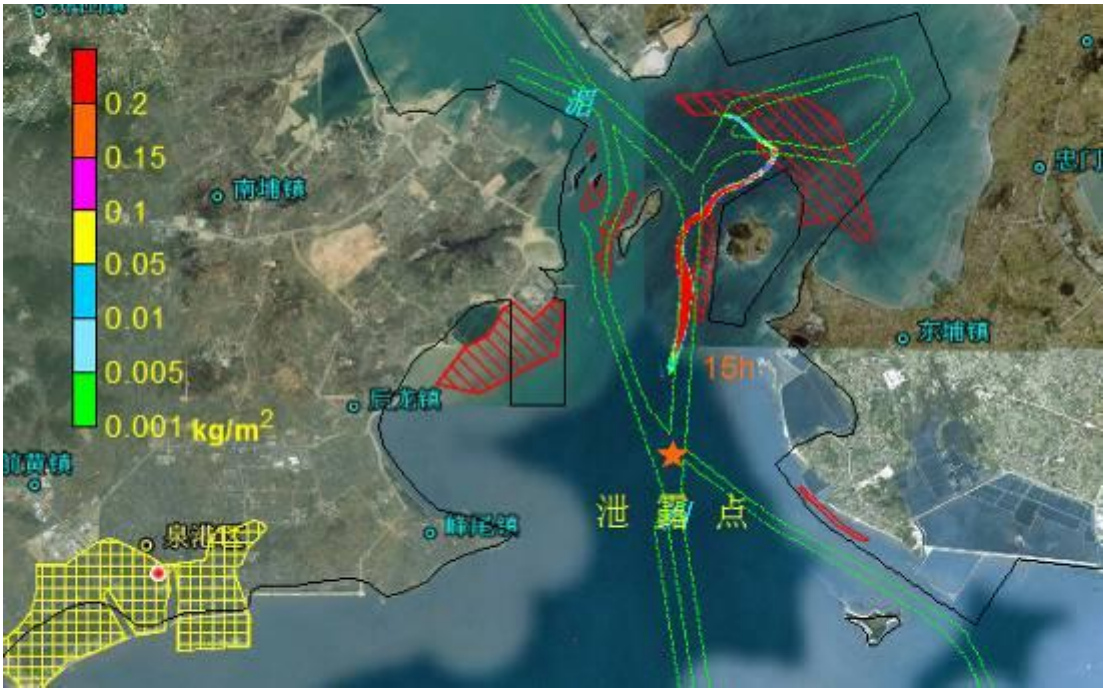


Figure 8.4.26 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period in Case of Calm Wind (after 15 hours)

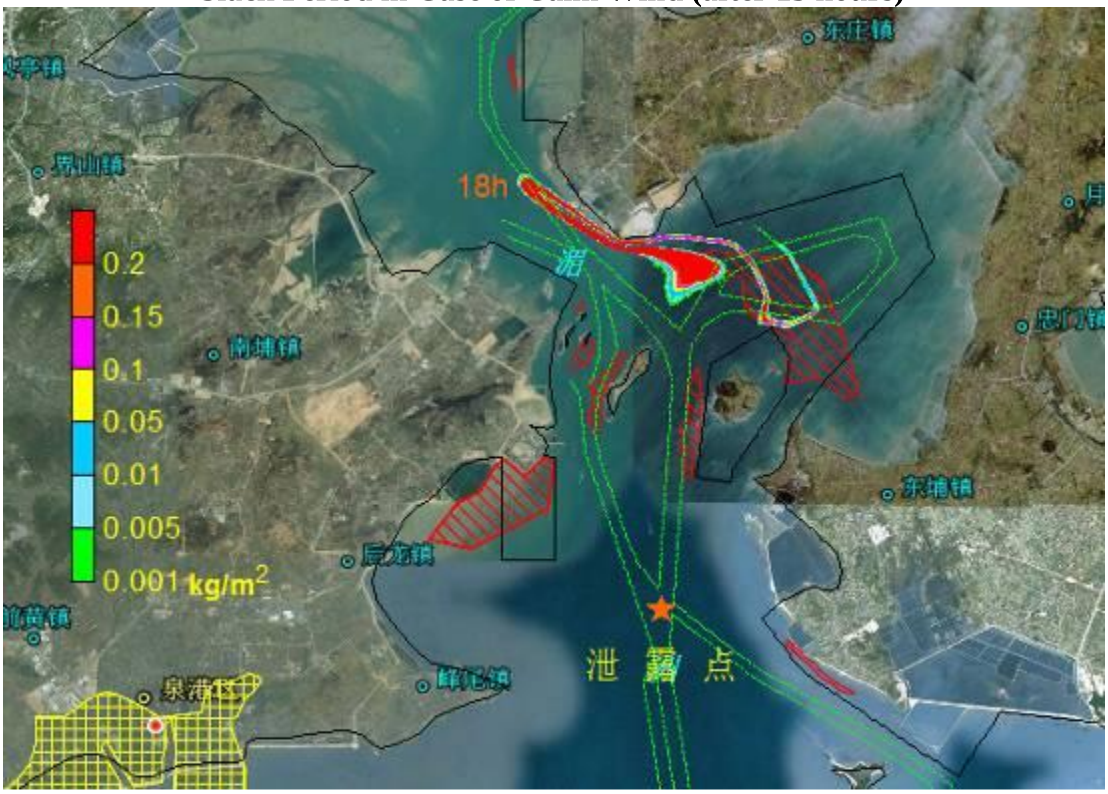


Figure 8.4.27 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period in Case of Calm Wind (after 18 hours)

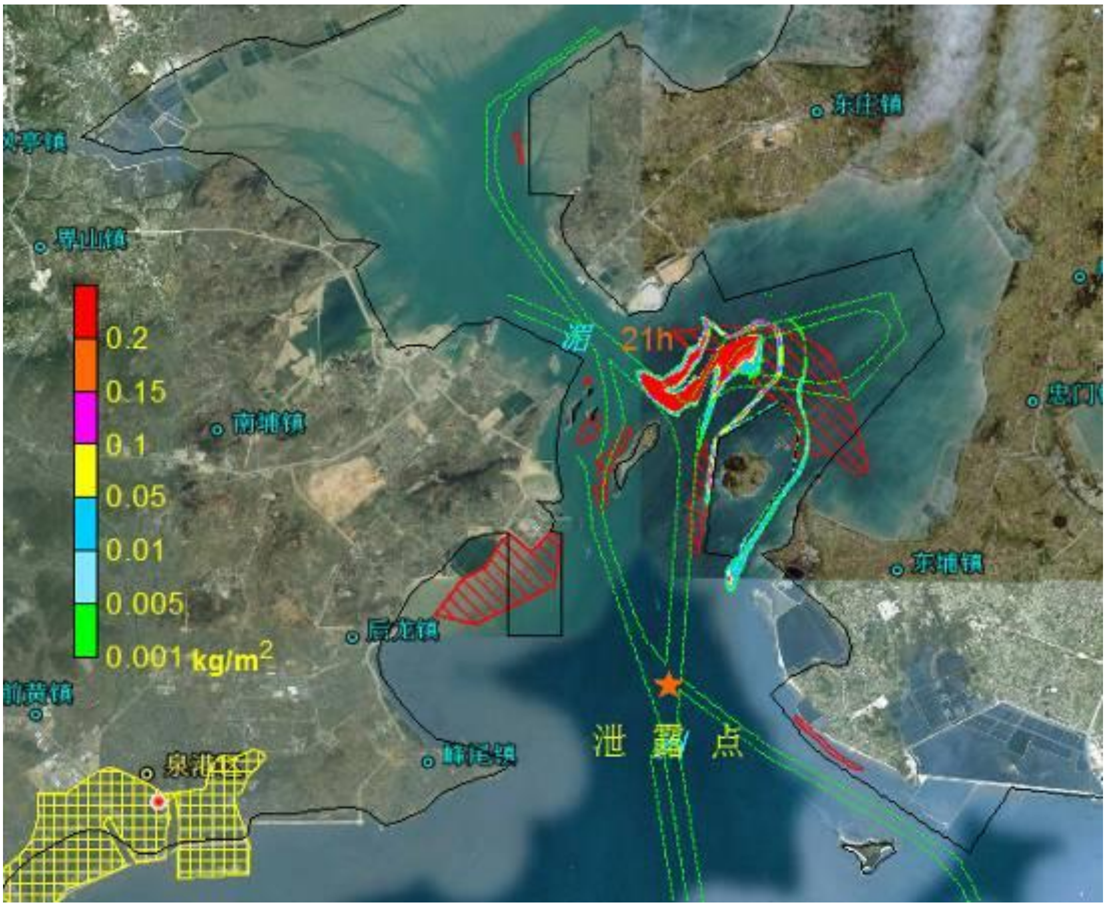


Figure 8.4.28 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period in Case of Calm Wind (after 21 hours)

Figure 8.4.29 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb

Slack Period in Case of Calm Wind (after 24 hours)

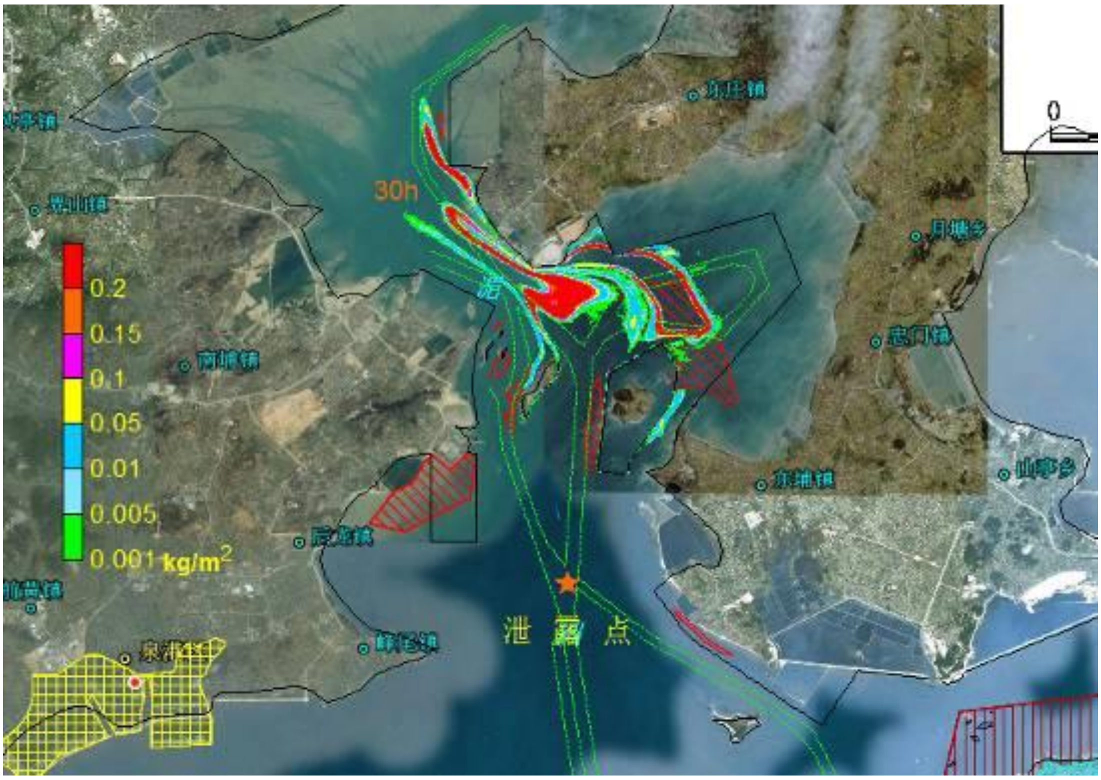


Figure 8.4.30 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period in Case of Calm Wind (after 30 hours)

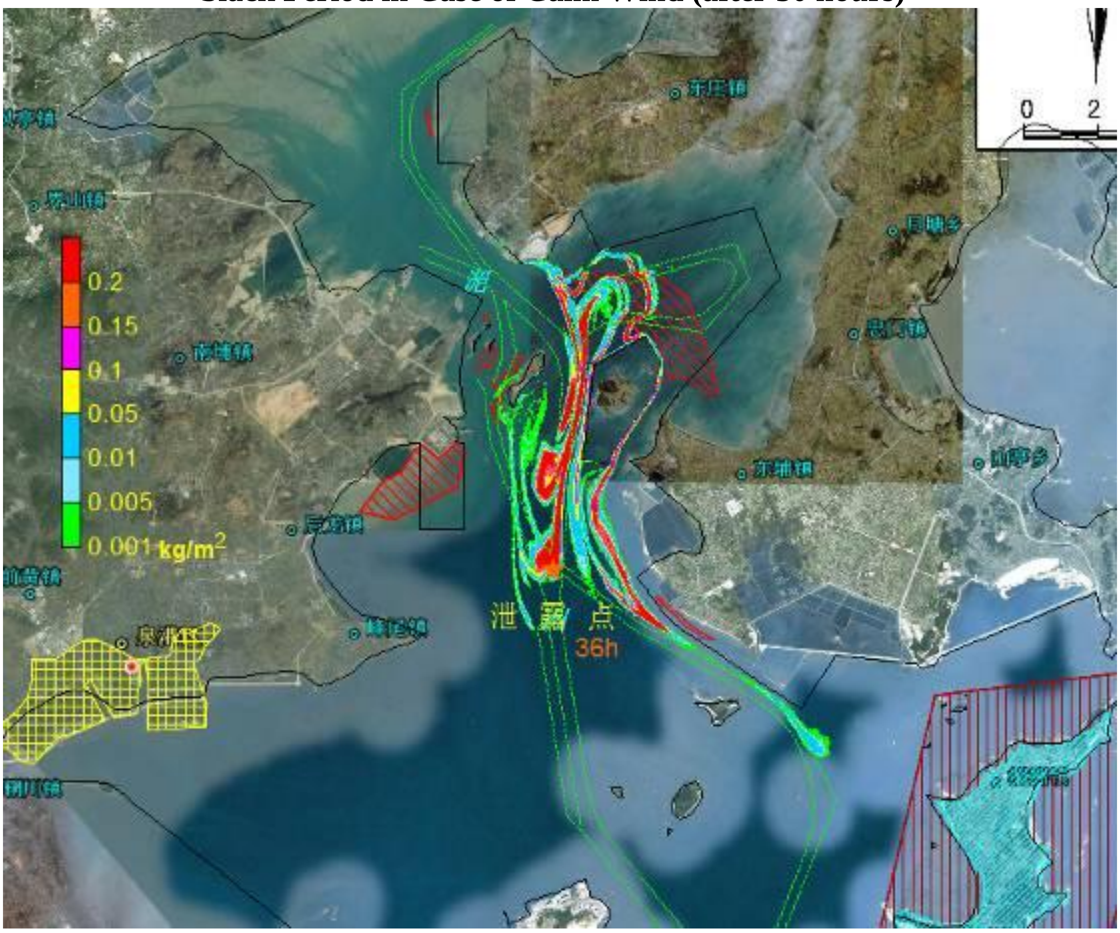


Figure 8.4.31 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period in Case of Calm Wind (after 36 hours)

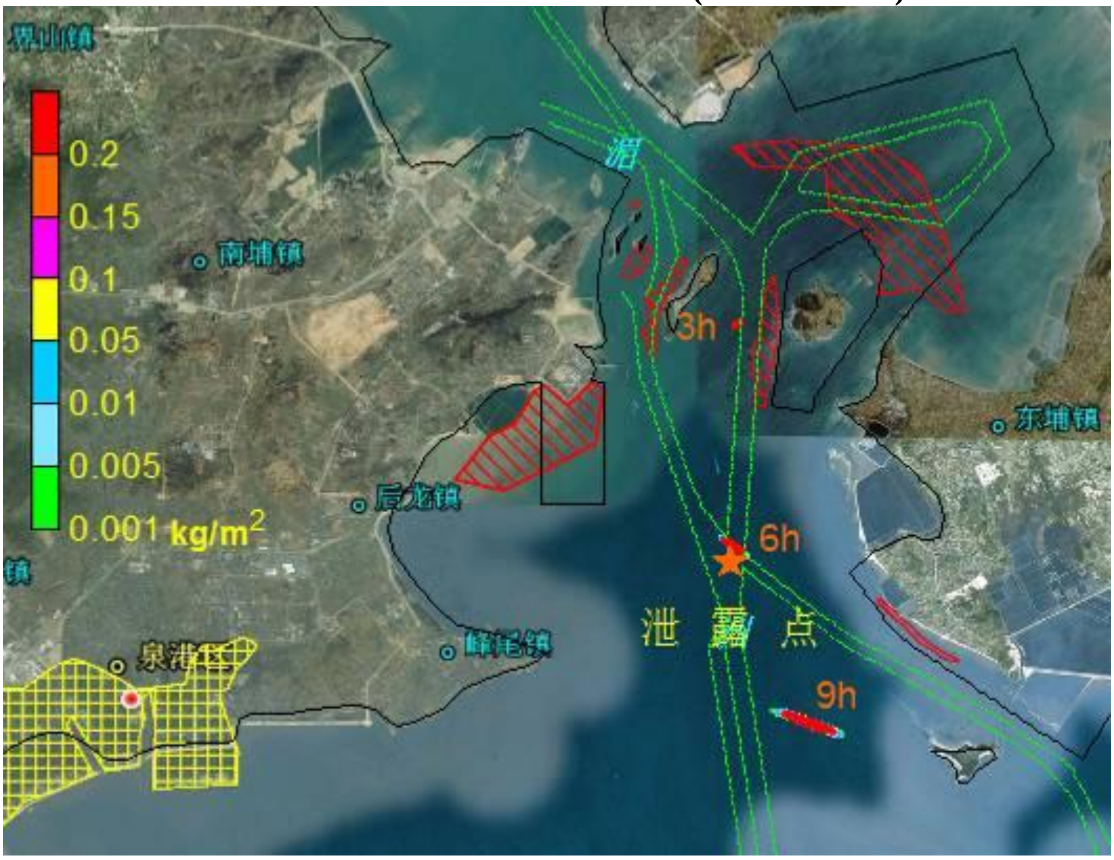


Figure 8.4.32 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Tide Period in Case of Calm Wind (after 3-9 hours)

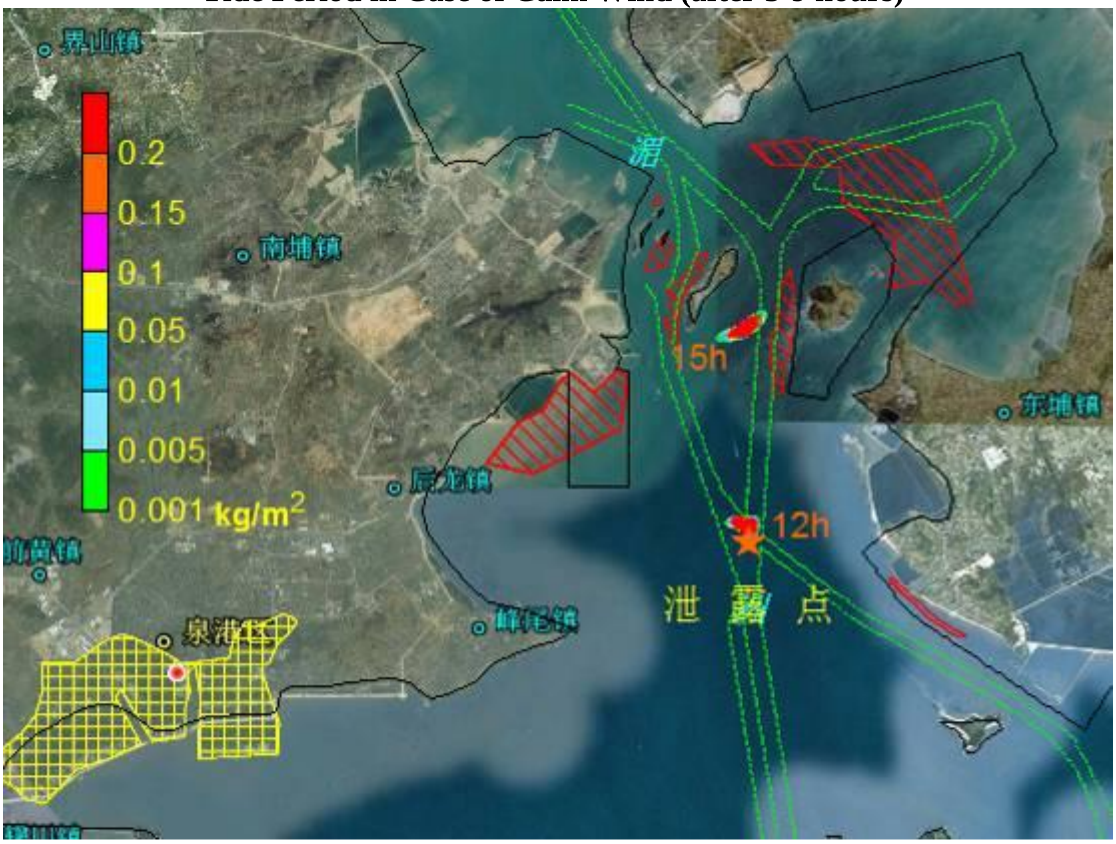


Figure 8.4.33 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Tide Period in Case of Calm Wind (after 12-15 hours)

Figure 8.4.34 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Tide Period in Case of Calm Wind (after 18-30 hours)

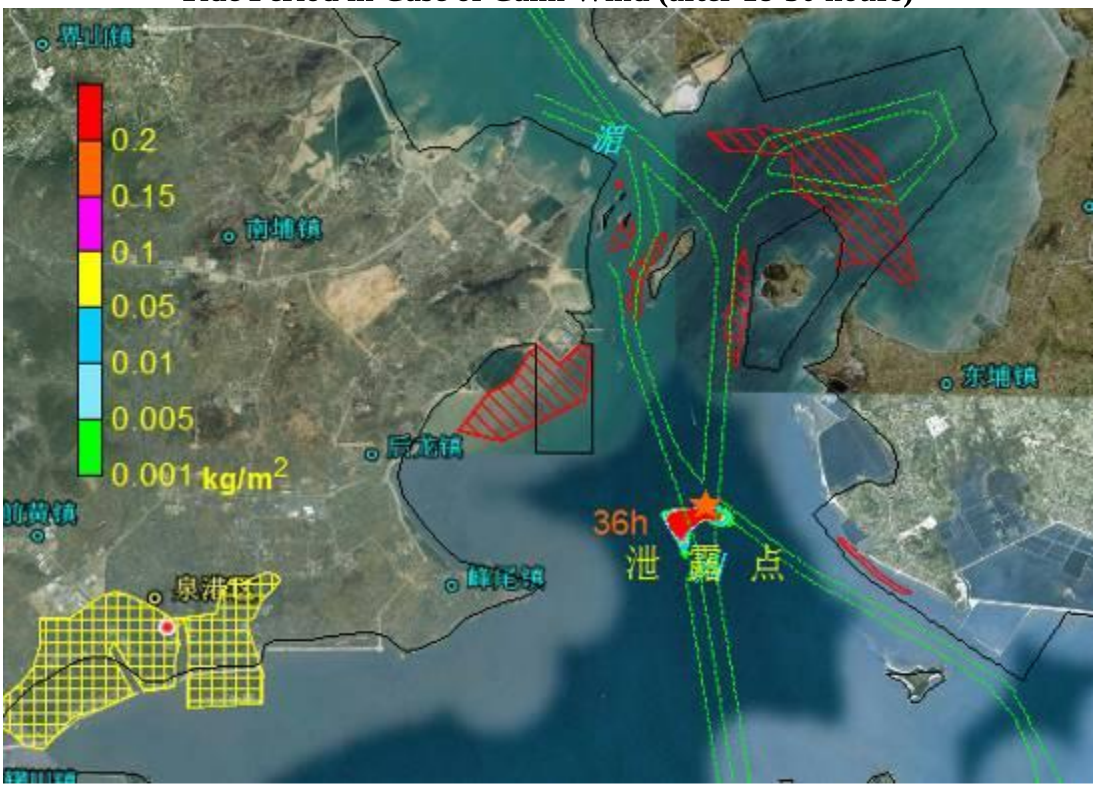


Figure 8.4.35 Impact Scope of Oil Spill Accident Occurred at Point B in Flood

Tide Period in Case of Calm Wind (after 36 hours)

Figure 8.4.36 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Tide Period in Case of Calm Wind (after 3-9 hours)

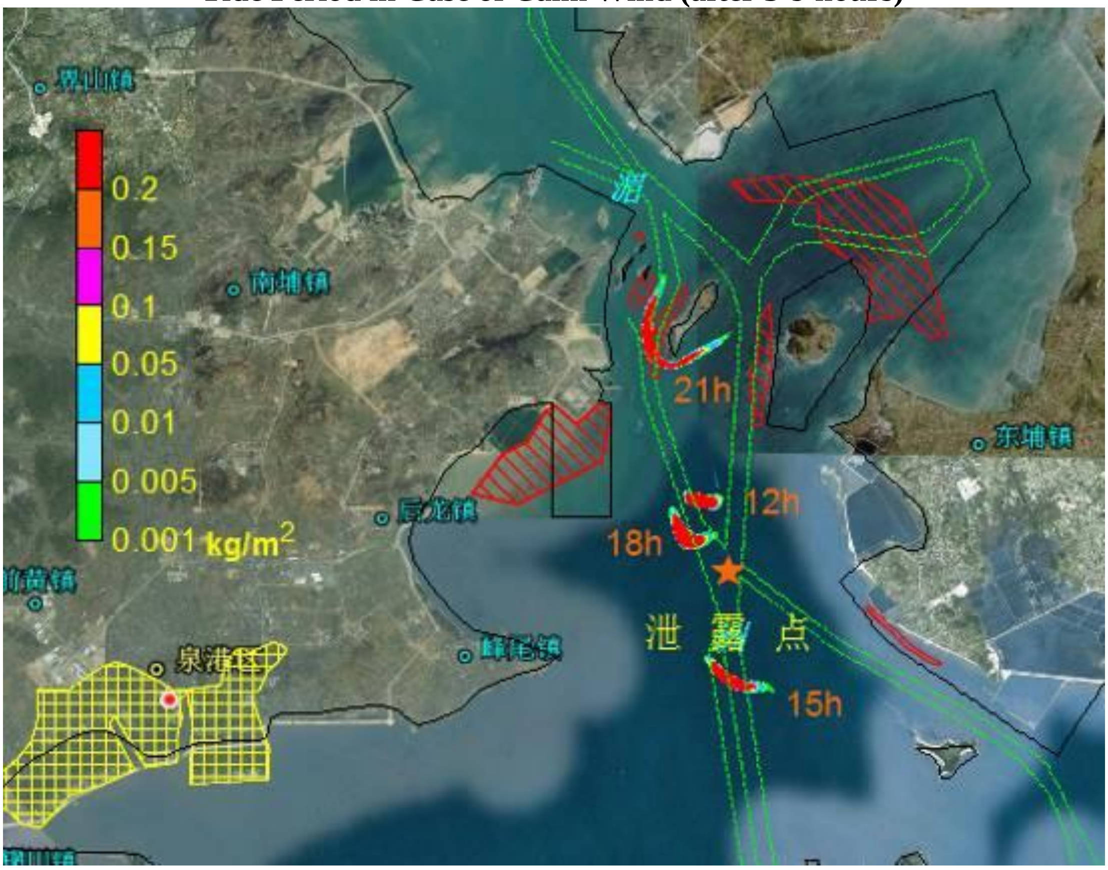


Figure 8.4.37 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Tide Period in Case of Calm Wind (after 12-21 hours)

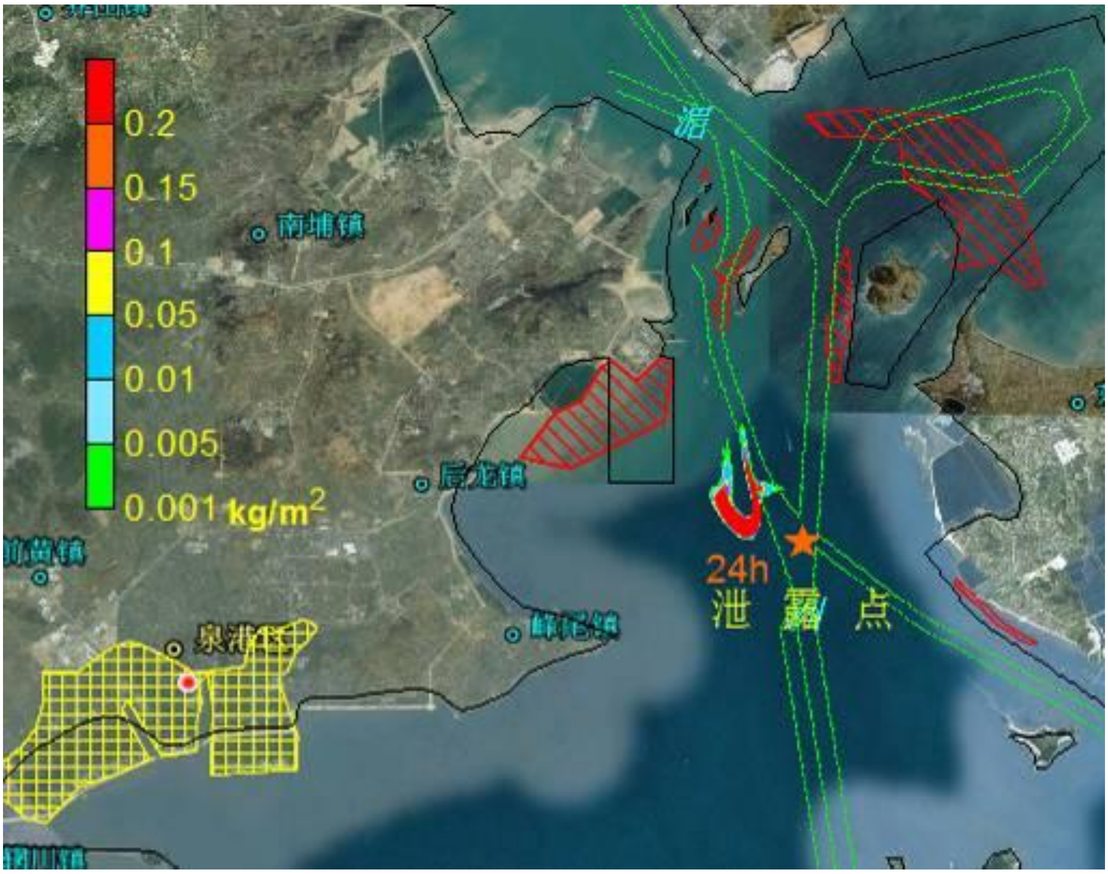


Figure 8.4.38 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Tide Period in Case of Calm Wind (after 24 hours)

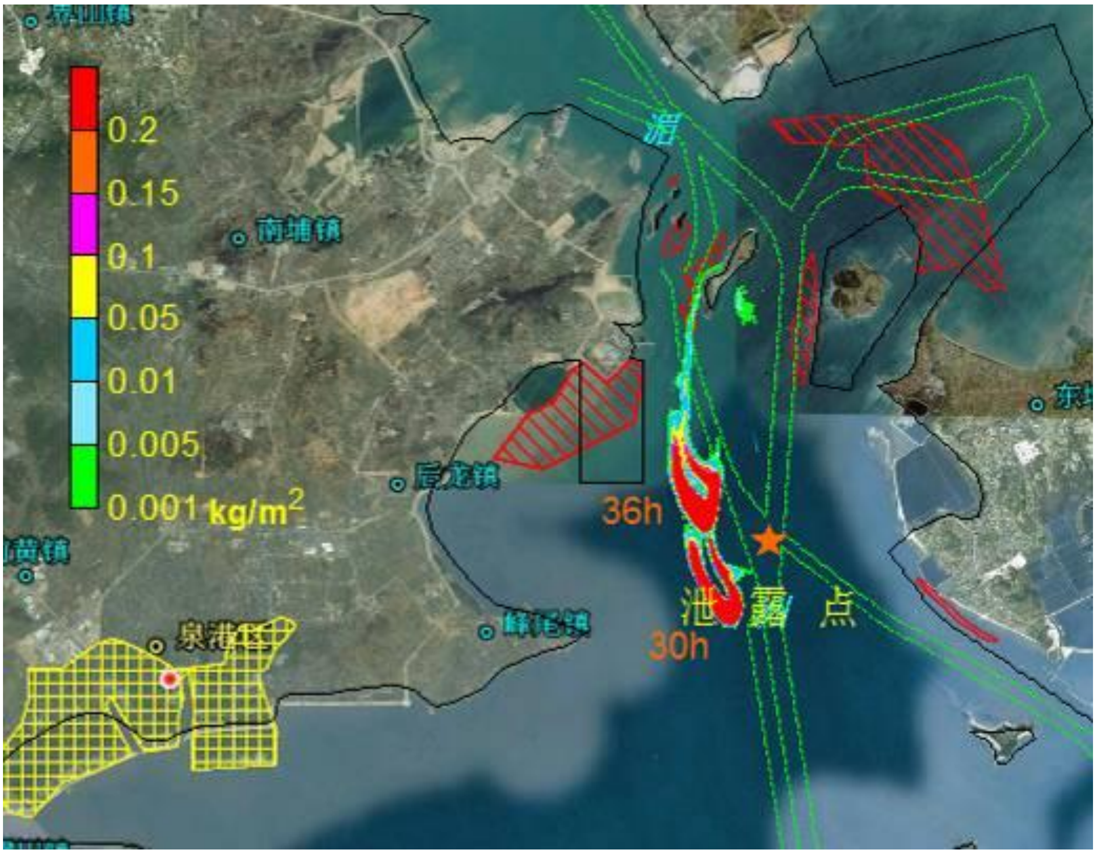


Figure 8.4.39 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Tide Period in Case of Calm Wind (after 30-36 hours)

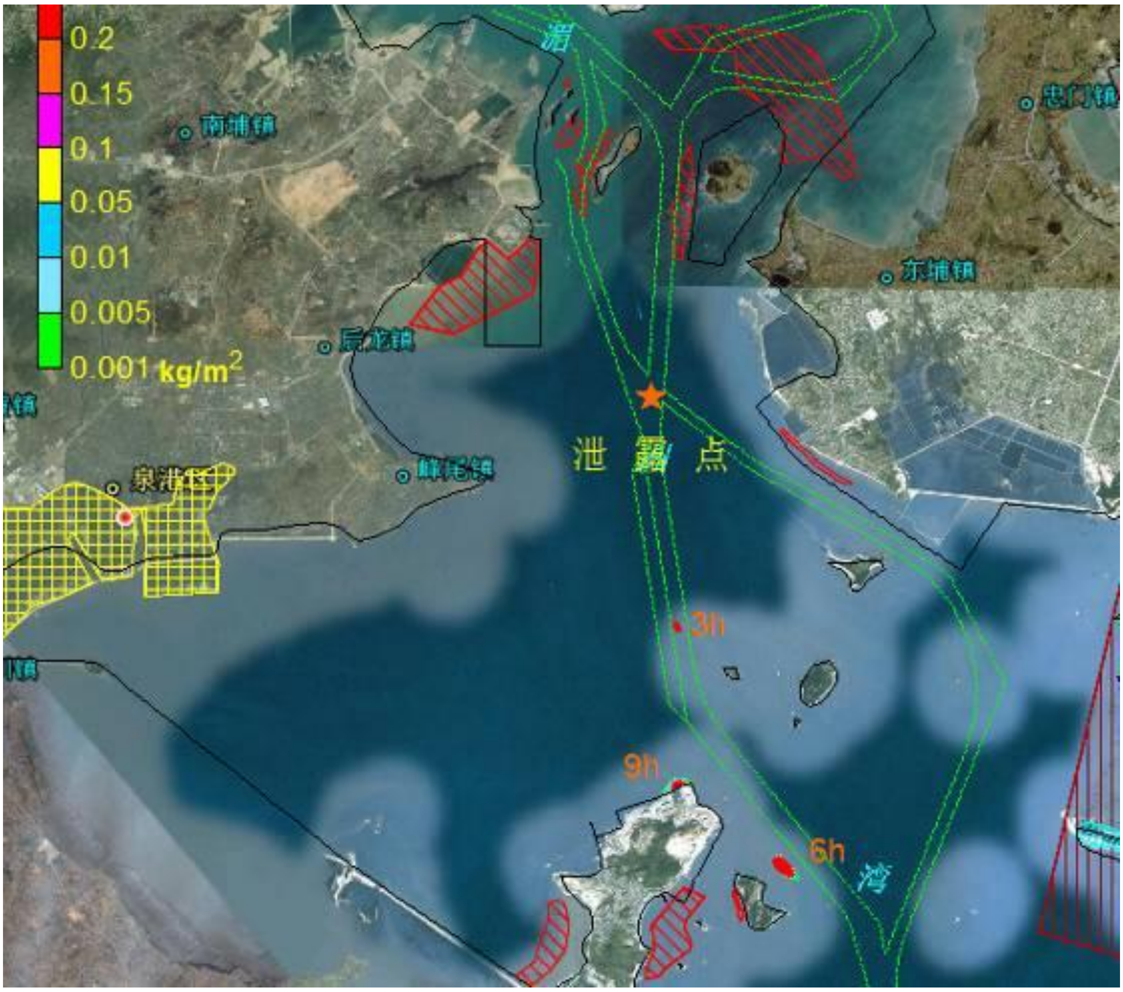


Figure 8.4.40 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Slack Period in Case of a NE Wind (after 3-9 hours)

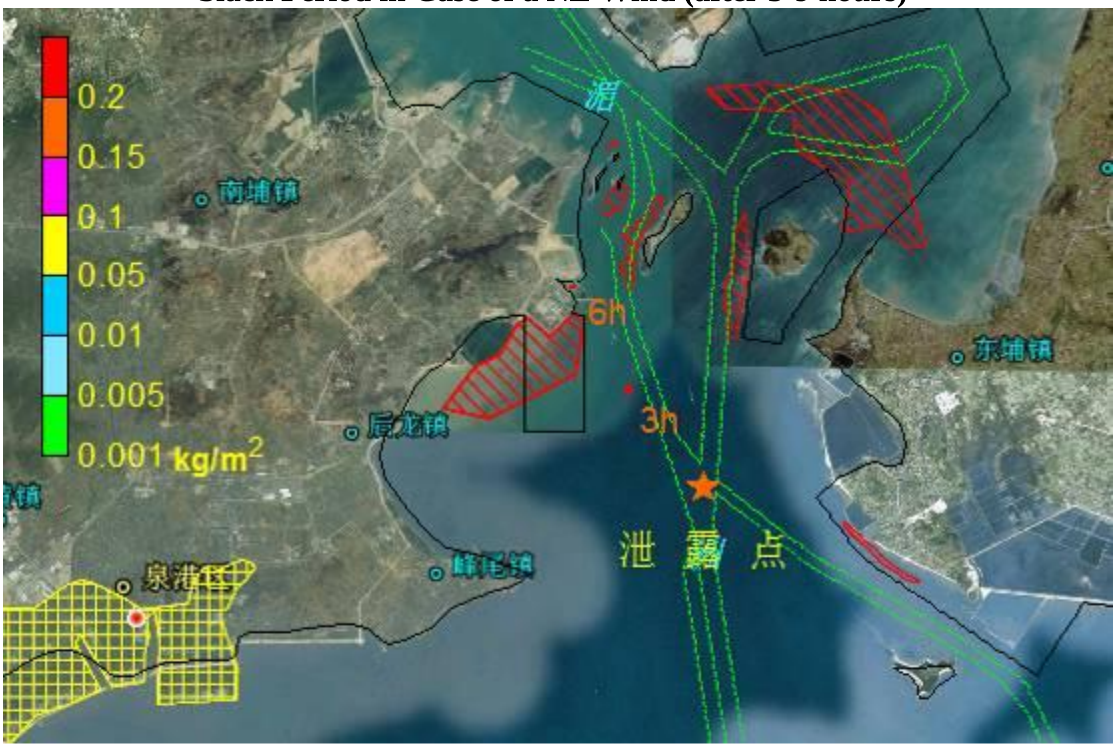


Figure 8.4.41 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb

Slack Period in Case of a NE Wind (after 3-6 hours)

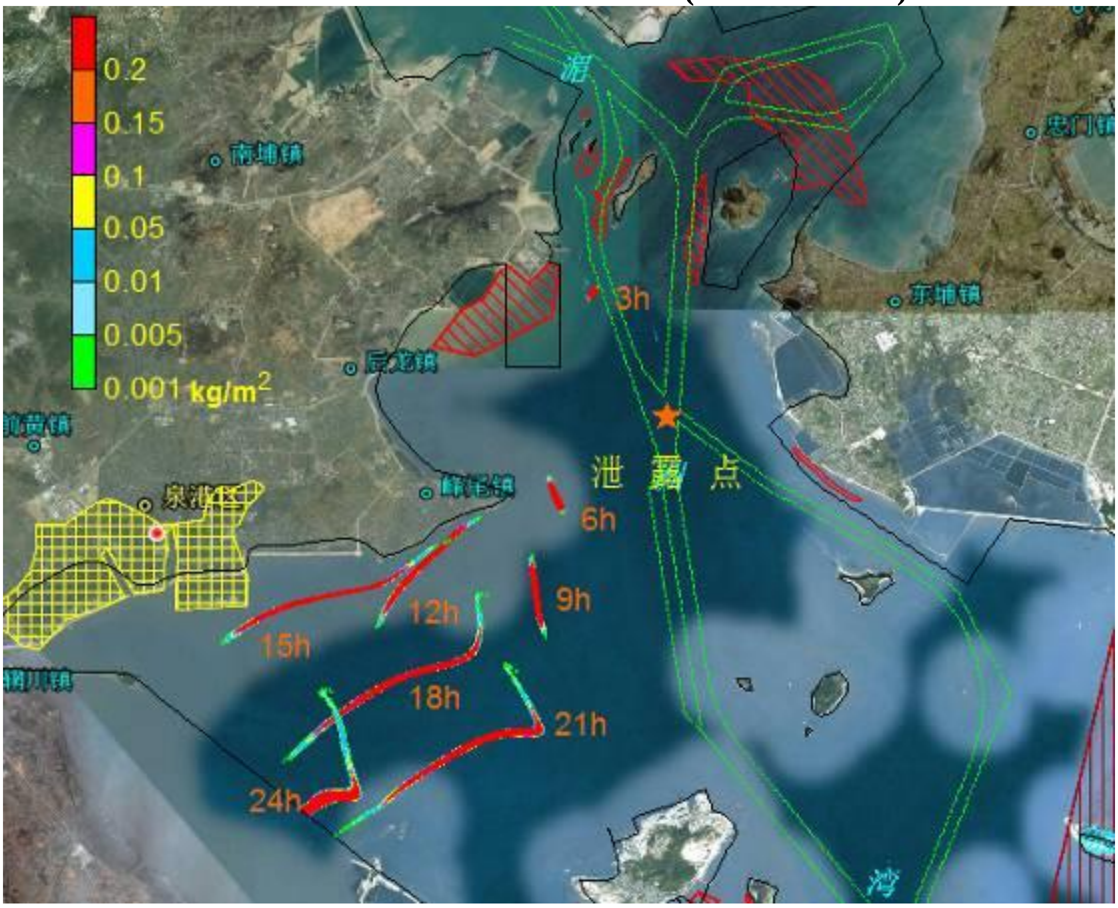


Figure 8.4.42 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Tide Period in Case of a NE Wind (after 3-24 hours)

Figure 8.4.43 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Tide Period in Case of a NE Wind (after 3-6 hours)

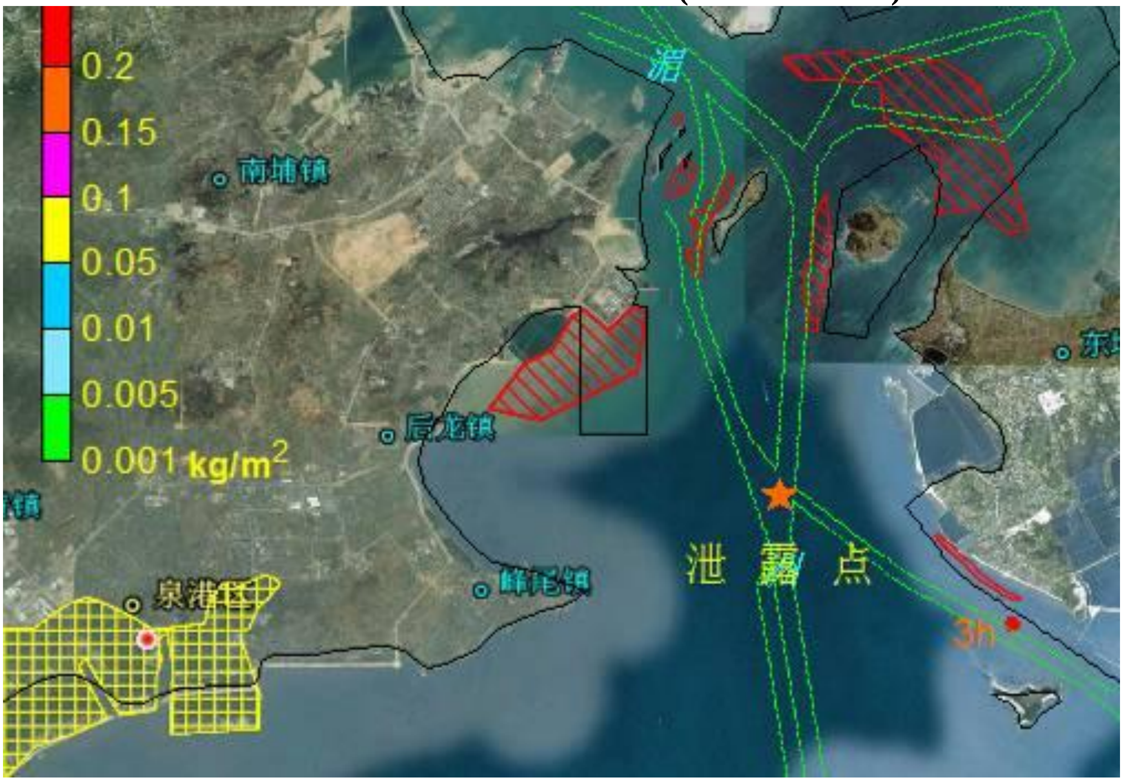


Figure 8.4.44 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Slack Period in Case of a SSW Wind (after 3 hours)

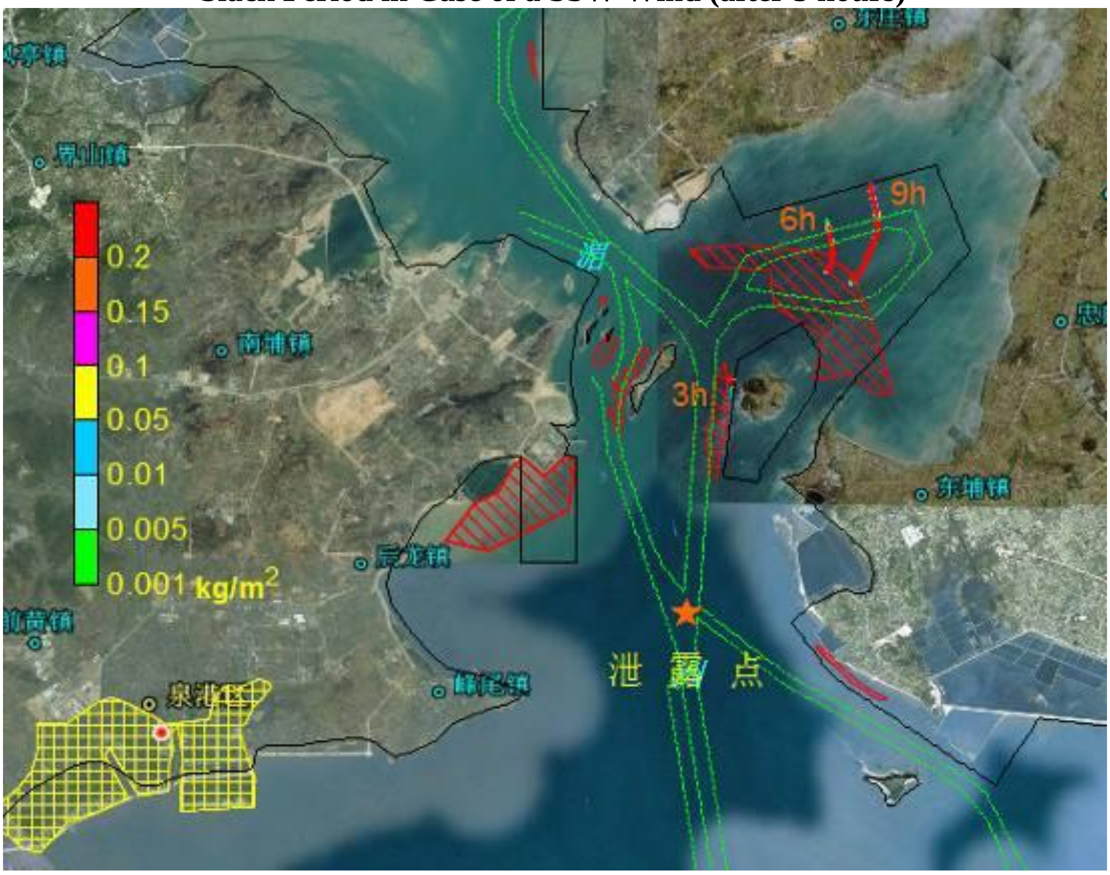


Figure 8.4.45 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period in Case of a SSW Wind (after 3-9 hours)

Figure 8.4.46 Impact Scope of Oil Spill Accident Occurred at Point B in Flood Tide Period in Case of a SSW Wind (after 3-6 hours)

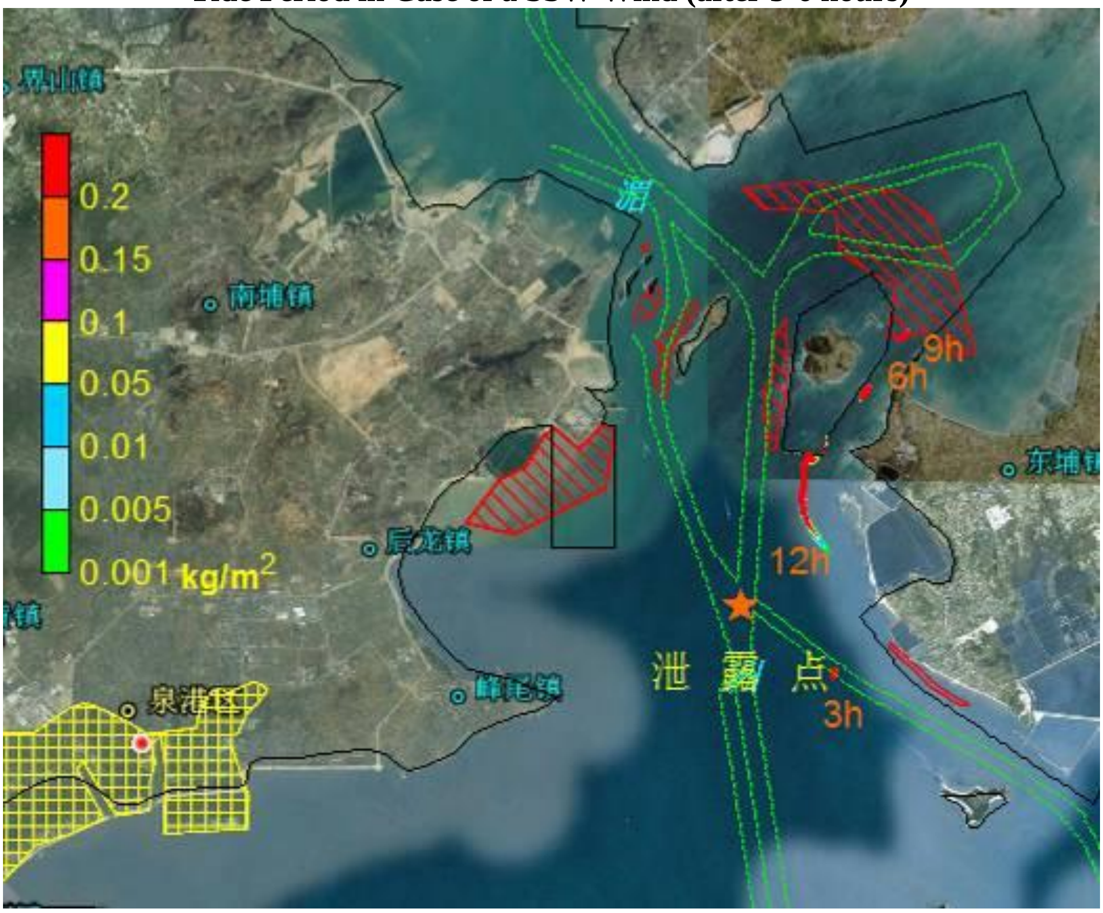


Figure 8.4.47 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb

Tide Period in Case of a SSW Wind (after 3-12 hours)

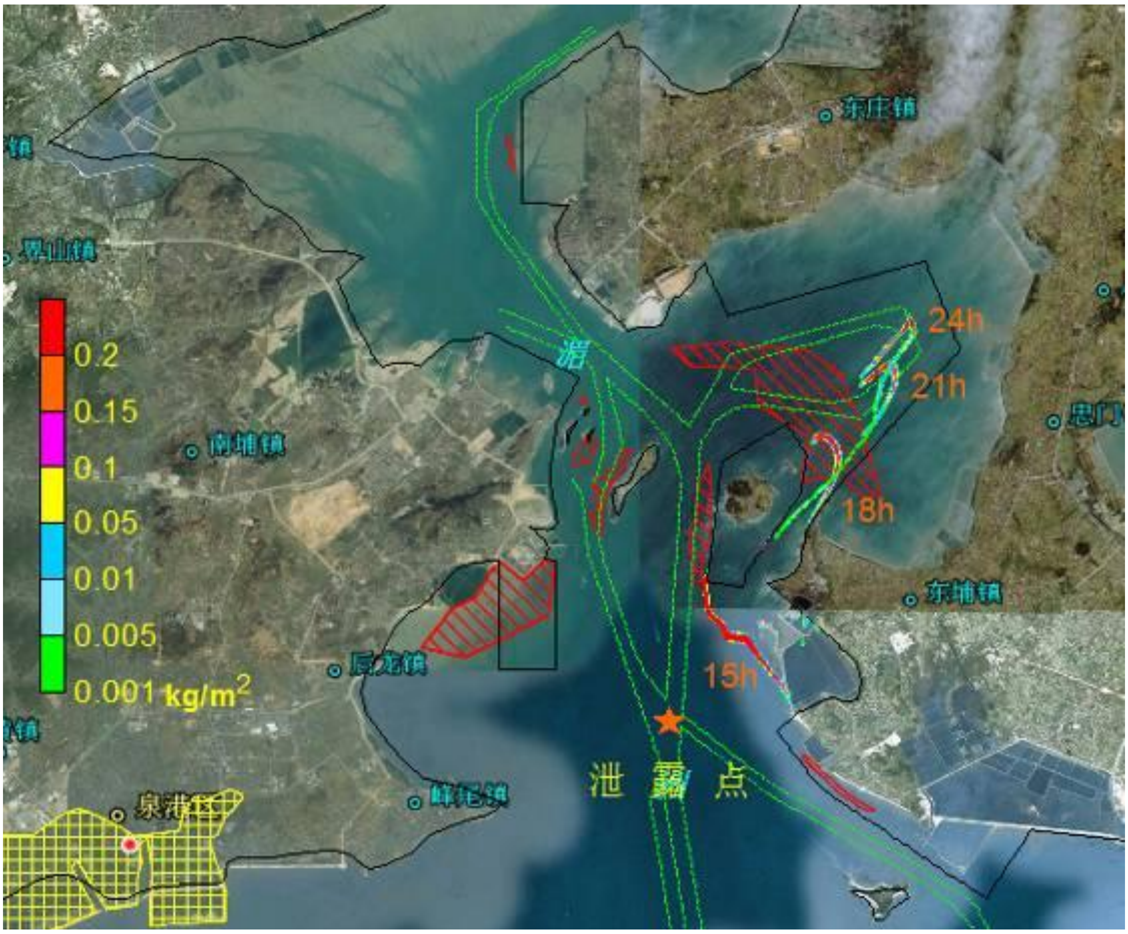


Figure 8.4.48 Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Tide Period in Case of a SSW Wind (after 15-24 hours)

8.4.2.3 Prediction for Leakage Point C

(1) Calm wind

The vessel leaks at point C, and the movements of oil slicks on different tidal currents in case of calm wind are shown in Figure 8.4.49 through Figure 8.4.67, with impact scope shown in Table 8.4.25 through 8.4.28.

In case of calm wind, movement of oil slicks under four tide conditions are described in below.

- *Flood Slack* - upon the occurrence of oil spill accident at point C in flood slack period, the oil slicks will first move along the navigation channel with the ebb current in the direction of bay-mouth. Since the moving route of oil slicks in ebb tide period is adjacent to the western Luoyu aquaculture area, the oil slicks might intrude this area in the first 1-2 hours of ebb tide, and then intrude the western Huiyu aquaculture area in about 24 hours along with the flood current.
- *Ebb Slack* - If the accident takes places in ebb slack period, the oil slicks will intrude Shimenao sea area in about 3 hours. Certain oil slicks will reach and stick to the near-shore zone on the northeast side of Luoyu in 12 hours. The oil

slicks will flow out of Shimenao along the eastern navigation channel of Luoyu with the ebb currents in about 21 hours, intrude Dongwu aquaculture area in 24 hours, return to Shimenao sea area in 30 hours, and form into a long strip in 36 hours, causing broader impact.

- *Flood Tide* - If the accident takes place in flood tide period, the oil slicks will first move towards the bay-head and then return along with the ebb currents. In about 6 hours, the oil slicks will intrude the western Luoyu aquaculture area.
- *Ebb Tide* - If the accident takes place in ebb tide period, the oil slicks will go down south along the navigation channel, pass through Luoyu aquaculture area and intrude the western Luoyu aquaculture area in about 2 hours.

(2) Perennial Predominant Wind Direction

The movements of oil film on different tidal currents in case of the Perennial Predominant Wind Direction are shown in Figure 8.4.68 through Figure 8.4.71, with impact scope shown in Table 8.4.29 through 8.4.32.

In case of a NE wind, upon the occurrence of oil spill accident at point C, the oil slicks will be prone to move in southwest direction into the bay.

- *Flood Slack* - If the accident takes place in flood slack period, the oil slicks will reach the shore of Fengwei Town in 9 hours.
- *Ebb Slack* - If the accident takes place in ebb slack period, due to the influence of wind generated currents and flood currents, the oil slicks will reach the north shore f Xiaocuo in 6 hours.
- *Flood Tide* - If the accident takes place in ebb tide period, the oil slicks will be blown to Doulong aquaculture area in 6 hours and cause pollution.
- *Ebb Tide* - If the accident takes place in flood tide period, due to the joint influence of flood currents and wind generated currents, the oil slicks will reach and stick to the north shore of Xiaocuo in 3 hours.

(3) Summer Predominant Wind Direction

The movements of oil slicks on different tidal currents in case of the Summer Predominant Wind Direction are shown in Figure 8.4.72 through Figure 8.4.74, with impact scope shown in Table 8.4.33 through 8.4.36.

- *Flood Slack* - In case of a SSW wind, upon the occurrence of oil spill accident at point C in flood slack period, the oil slicks will intrude the western Luoyu aquaculture area in 2 hours.
- *Ebb Slack* - If the accident takes place in ebb slack period, due to the joint influence of flood currents and wind generated currents, the oil slicks will reach the shore of Shimenao in 3 hours.
- *Ebb Tide* - If the accident takes place in ebb tide period, due to the joint influence of ebb currents and wind generated currents, the oil slicks will intrude the western Luoyu aquaculture area in 2 hours, intrude Shimenao sea area in 6 hours, gradually move towards the eastern sea area of Shimenao, and reach and stick to the shore in 12 hours.

Table 8.4.25 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Slack Period in Case of Calm Wind (unit: km2)

After flood slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/ m^2	Swept area>0.001kg/ m^2
1	0.006	0.006	0.006	0.006	0.006
2	0.027	0.027	0.027	0.024	0.03
3	0.061	0.059	0.053	0.051	0.067
4	0.115	0.115	0.109	0.101	0.126
5	0.17	0.165	0.158	0.146	0.189
6	0.182	0.174	0.168	0.155	0.195
7	0.178	0.173	0.162	0.155	0.194
8	0.174	0.168	0.158	0.15	0.187
9	0.171	0.166	0.158	0.141	0.182
10	0.195	0.192	0.182	0.17	0.216
11	0.24	0.234	0.226	0.198	0.274
12	0.246	0.24	0.226	0.198	0.266
13	0.251	0.246	0.224	0.211	0.267
14	0.27	0.266	0.24	0.227	0.296
15	0.306	0.302	0.29	0.261	0.338
16	0.39	0.382	0.36	0.326	0.43
17	0.493	0.482	0.456	0.422	0.531
18	0.587	0.57	0.53	0.498	0.65
19	0.573	0.56	0.539	0.498	0.632
20	0.507	0.49	0.466	0.434	0.558
21	0.454	0.443	0.421	0.39	0.504
22	0.462	0.445	0.424	0.39	0.498
23	0.6	0.587	0.55	0.507	0.651
24	0.694	0.675	0.642	0.586	0.77
25	0.682	0.662	0.63	0.581	0.746
26	0.702	0.686	0.64	0.594	0.752
27	0.742	0.722	0.682	0.629	0.814
28	0.861	0.837	0.789	0.723	0.939
29	1.093	1.059	0.978	0.88	1.198
30	1.126	1.093	1.024	0.922	1.232
31	1.146	1.109	1.037	0.918	1.25
32	1.158	1.128	1.056	0.933	1.277
33	1.248	1.208	1.13	1.002	1.35
34	1.346	1.291	1.211	1.05	1.541
35	1.701	1.64	1.506	1.315	1.92
36	1.845	1.765	1.65	1.453	2.122
Envelope area>0.001kg/	17.536				

m^2	

Table 8.4.26 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Slack Period in Case of Calm Wind (unit: km2)

After ebb slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/ m^2	Swept area>0.001kg/ m^2
1	0.003	0.003	0.003	0.003	0.003
2	0.016	0.016	0.013	0.013	0.018
3	0.026	0.022	0.019	0.019	0.029
4	0.029	0.027	0.026	0.024	0.034
5	0.032	0.032	0.032	0.03	0.034
6	0.048	0.046	0.042	0.042	0.05
7	0.093	0.09	0.088	0.086	0.099
8	0.112	0.11	0.106	0.102	0.117
9	0.096	0.091	0.086	0.08	0.106
10	0.128	0.123	0.112	0.099	0.146
11	0.178	0.168	0.166	0.152	0.206
12	0.173	0.17	0.16	0.146	0.205
13	0.181	0.173	0.155	0.141	0.198
14	0.173	0.166	0.158	0.133	0.202
15	0.261	0.25	0.235	0.21	0.299
16	0.258	0.253	0.24	0.214	0.296
17	0.251	0.242	0.226	0.218	0.28
18	0.258	0.254	0.24	0.224	0.282
19	0.312	0.302	0.282	0.264	0.339
20	0.552	0.534	0.502	0.477	0.598
21	1.09	1.064	0.998	0.891	1.171
22	1.798	1.749	1.645	1.427	1.971
23	2.384	2.334	2.208	2.008	2.533
24	2.698	2.637	2.523	2.341	2.862
25	2.846	2.779	2.629	2.437	3.042
26	2.488	2.406	2.256	2.035	2.749
27	2.059	1.998	1.835	1.621	2.328
28	2.238	2.173	2.038	1.862	2.458
29	2.421	2.358	2.194	1.987	2.659
30	2.41	2.339	2.2	1.994	2.651
31	2.234	2.155	2.014	1.771	2.466
32	2.915	2.808	2.597	2.325	3.317
33	3.178	3.061	2.845	2.515	3.595
34	3.486	3.37	3.141	2.794	3.869
35	3.882	3.742	3.52	3.117	4.299
36	4.77	4.594	4.23	3.634	5.329
Envelope area>0.001kg/ m^2	33.84				

Table 8.4.27 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Tide Period in Case of Calm Wind (unit: km2)

After flood tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/ m^2	Swept area>0.001kg/ m^2
1	0.048	0.048	0.048	0.045	0.05
2	0.122	0.12	0.11	0.101	0.126
3	0.126	0.125	0.114	0.104	0.138
4	0.122	0.12	0.114	0.107	0.134
5	0.179	0.178	0.174	0.157	0.195
6	0.2	0.198	0.19	0.176	0.216
7	0.389	0.379	0.357	0.322	0.429
8	0.454	0.442	0.43	0.379	0.498
9	0.467	0.458	0.427	0.392	0.504
10	0.458	0.446	0.416	0.381	0.493
11	0.438	0.429	0.405	0.373	0.486
12	0.48	0.464	0.438	0.4	0.525
13	0.574	0.557	0.518	0.472	0.632
14	0.806	0.782	0.728	0.667	0.88
15	0.893	0.869	0.822	0.736	0.994
16	1.038	1.014	0.95	0.832	1.146
17	0.771	0.742	0.696	0.627	0.859
18	0.845	0.822	0.774	0.706	0.936
19	1.29	1.251	1.189	1.106	1.418
20	1.589	1.542	1.443	1.326	1.709
21	1.702	1.654	1.563	1.454	1.85
22	1.685	1.64	1.563	1.421	1.845
23	1.622	1.571	1.474	1.344	1.774
24	1.736	1.699	1.592	1.41	1.92
25	2.139	2.09	1.966	1.792	2.355
26	3.006	2.922	2.731	2.458	3.262
27	4.05	3.952	3.696	3.291	4.442
28	4.371	4.21	3.96	3.496	4.739
29	4.238	4.094	3.795	3.243	4.722
30	4.341	4.168	3.72	3.133	4.92
31	4.189	3.992	3.664	3.134	4.792
32	4.378	4.168	3.773	3.173	4.986
33	4.515	4.302	3.909	3.261	5.168
34	4.688	4.47	4.053	3.445	5.411
35	5.093	4.883	4.429	3.829	5.851
36	5.955	5.742	5.28	4.63	6.734
Envelope area>0.001kg/ m^2	33.8				

Table 8.4.28 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Tide Period in Case of Calm Wind (unit: km2)

After ebb tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/ m^2	Swept area>0.001kg/ m^2
1	0.05	0.046	0.045	0.043	0.056
2	0.077	0.077	0.072	0.069	0.08
3	0.08	0.08	0.074	0.067	0.085
4	0.082	0.077	0.07	0.067	0.093
5	0.088	0.086	0.085	0.075	0.093
6	0.117	0.115	0.112	0.102	0.13
7	0.21	0.205	0.187	0.171	0.226
8	0.238	0.232	0.214	0.2	0.253
9	0.259	0.253	0.24	0.224	0.286
10	0.259	0.253	0.238	0.216	0.285
11	0.355	0.347	0.328	0.307	0.394
12	0.317	0.31	0.293	0.261	0.347
13	0.478	0.462	0.424	0.397	0.523
14	0.554	0.536	0.504	0.459	0.621
15	0.57	0.554	0.52	0.458	0.629
16	0.555	0.539	0.507	0.458	0.618
17	0.534	0.525	0.498	0.453	0.614
18	0.579	0.554	0.518	0.466	0.635
19	0.626	0.6	0.557	0.498	0.691
20	0.91	0.874	0.798	0.717	1.018
21	1.048	1.002	0.93	0.811	1.189
22	1.133	1.082	0.992	0.866	1.291
23	0.843	0.818	0.758	0.672	0.955
24	0.99	0.962	0.906	0.816	1.093
25	1.474	1.432	1.358	1.238	1.611
26	1.821	1.771	1.659	1.507	1.942
27	1.96	1.925	1.802	1.659	2.136
28	1.965	1.914	1.811	1.638	2.133
29	1.862	1.797	1.667	1.501	2.038
30	1.91	1.842	1.722	1.536	2.12
31	2.24	2.17	2.013	1.768	2.48
32	2.939	2.837	2.643	2.31	3.28
33	4.019	3.856	3.488	2.978	4.387
34	4.344	4.19	3.763	3.221	4.81
35	4.206	4.013	3.626	3.05	4.803
36	4.354	4.122	3.661	3.024	5.048
Envelope area>0.001kg/ m^2	25.617				

Table 8.4.29 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Slack Period in Case of a NE Wind (unit: km2)

After flood slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.006	0.006	0.006	0.006	0.006
2	0.029	0.029	0.029	0.026	0.034
3	0.043	0.043	0.042	0.038	0.043
4	0.07	0.069	0.069	0.061	0.078
5	0.106	0.104	0.101	0.094	0.118
6	0.112	0.112	0.104	0.101	0.115
7	0.13	0.126	0.117	0.11	0.133
8	0.142	0.141	0.138	0.125	0.154
9	0.152	0.15	0.141	0.138	0.16
10	0.021	0.021	0.019	0.013	0.024
11	reaches shore				
Envelope area>0.001kg/m^2	3.927				

Table 8.4.30 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Slack Period in Case of a NE Wind (unit: km2)

After ebb slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.003	0.003	0.003	0.003	0.003
2	0.016	0.016	0.014	0.014	0.019
3	0.024	0.024	0.024	0.024	0.026
4	0.171	0.168	0.158	0.149	0.192
5	0.064	0.064	0.061	0.056	0.072
6	reaches shore				
Envelope area>0.001kg/m^2	1.261				

Table 8.4.31 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Tide Period in Case of a NE Wind (unit: km2)

After flood tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.048	0.048	0.046	0.045	0.048
2	0.086	0.082	0.074	0.069	0.091
3	0.022	0.021	0.019	0.018	0.024
4	reaches shore				

Envelope area>0.001kg/ m^2	1.006

Table 8.4.32 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Tide Period in Case of a NE Wind (unit: km2)

After ebb tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.053	0.053	0.05	0.046	0.056
2	0.072	0.072	0.069	0.066	0.078
3	0.094	0.094	0.088	0.082	0.099
4	0.11	0.109	0.104	0.098	0.118
5	0.122	0.12	0.112	0.102	0.131
6	0.003	0.002	0	0	0.005
7	reaches shore				
Envelope area>0.001kg/m^2	1.825				

Table 8.4.33 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Slack Period in Case of a SSW Wind (unit: km2)

After flood slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.003	0.003	0.003	0.003	0.003
2	0.01	0.01	0.01	0.01	0.01
3	0.038	0.037	0.035	0.03	0.042
4	0.122	0.115	0.109	0.098	0.125
5	0.128	0.126	0.125	0.117	0.136
6	0.077	0.075	0.074	0.072	0.078
7	0.037	0.037	0.037	0.035	0.038
8	0.021	0.021	0.021	0.018	0.024
9	0.002	0.002	0.002	0	0.003
10	reaches shore				
Envelope area>0.001kg/m^2	1.179				

Table 8.4.34 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Slack Period in Case of a SSW Wind (unit: km2)

After ebb slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.003	0.003	0.003	0.003	0.003
2	0.01	0.01	0.01	0.01	0.01
3	0.019	0.019	0.019	0.019	0.019
4	reaches shore				
Envelope	0.574				

area>0.001kg/ m^2	

Table 8.4.35 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Tide Period in Case of a SSW Wind (unit: km2)

After flood tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/ m^2	Swept area>0.001kg/ m^2
1	0.058	0.054	0.05	0.05	0.061
2	reaches shore				
Envelope area>0.001kg/ m^2	0.510				

Table 8.4.36 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Tide Period in Case of a SSW Wind (unit: km2)

After ebb tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/ m^2	Swept area>0.001kg/ m^2
1	0.059	0.058	0.058	0.056	0.064
2	0.075	0.072	0.069	0.064	0.078
3	0.083	0.08	0.075	0.064	0.086
4	0.066	0.061	0.058	0.056	0.069
5	0.046	0.043	0.04	0.037	0.054
6	0.077	0.072	0.067	0.058	0.086
7	0.104	0.101	0.091	0.077	0.112
8	0.107	0.104	0.098	0.091	0.125
9	0.13	0.123	0.114	0.107	0.136
10	0.155	0.15	0.142	0.131	0.171
11	0.162	0.162	0.149	0.133	0.174
12	0.158	0.158	0.154	0.141	0.174
13	0.163	0.158	0.146	0.122	0.173
14	0.112	0.102	0.099	0.093	0.146
15	0.117	0.109	0.104	0.093	0.122
16	0.046	0.043	0.042	0.037	0.053
17	reaches shore				
Envelope area>0.001kg/ m^2	6.093				

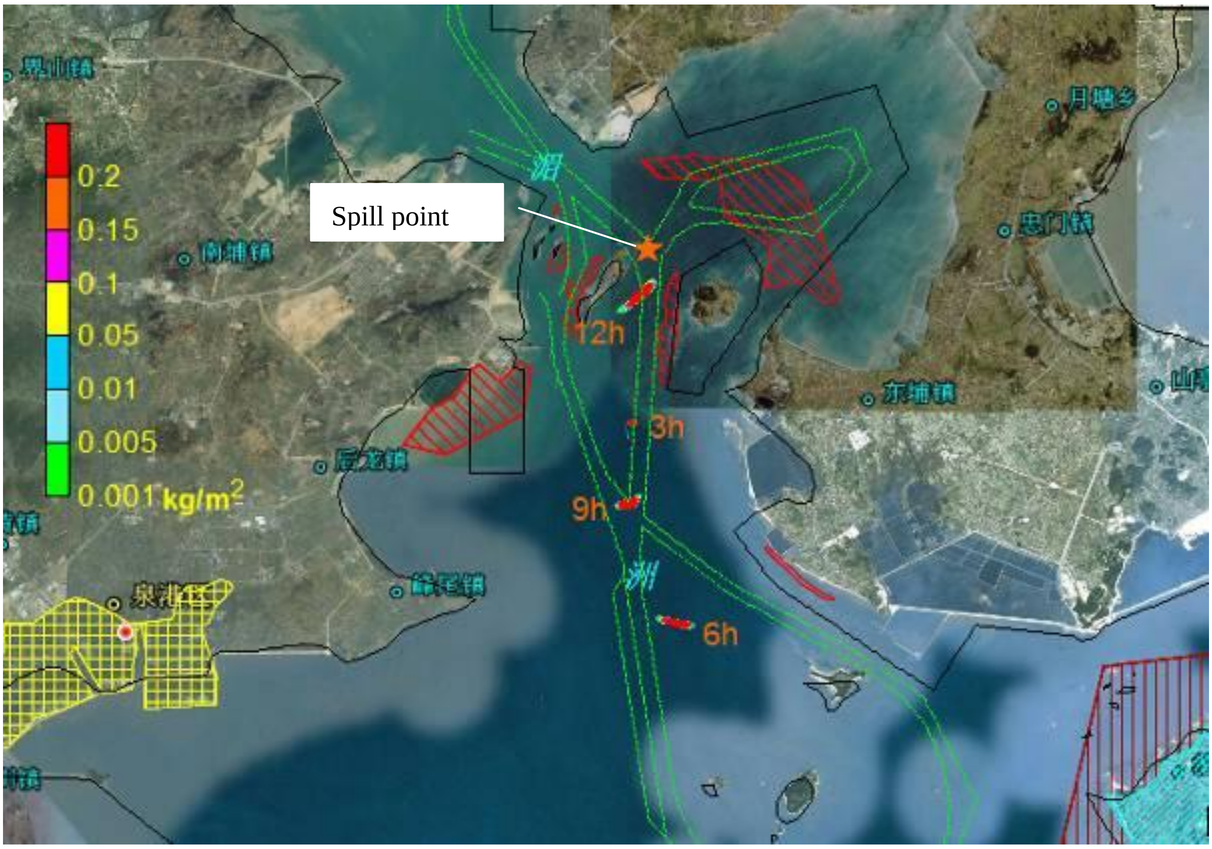


Figure 8.4.49 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Slack Period in Case of Calm Wind (after 3-12 hours)

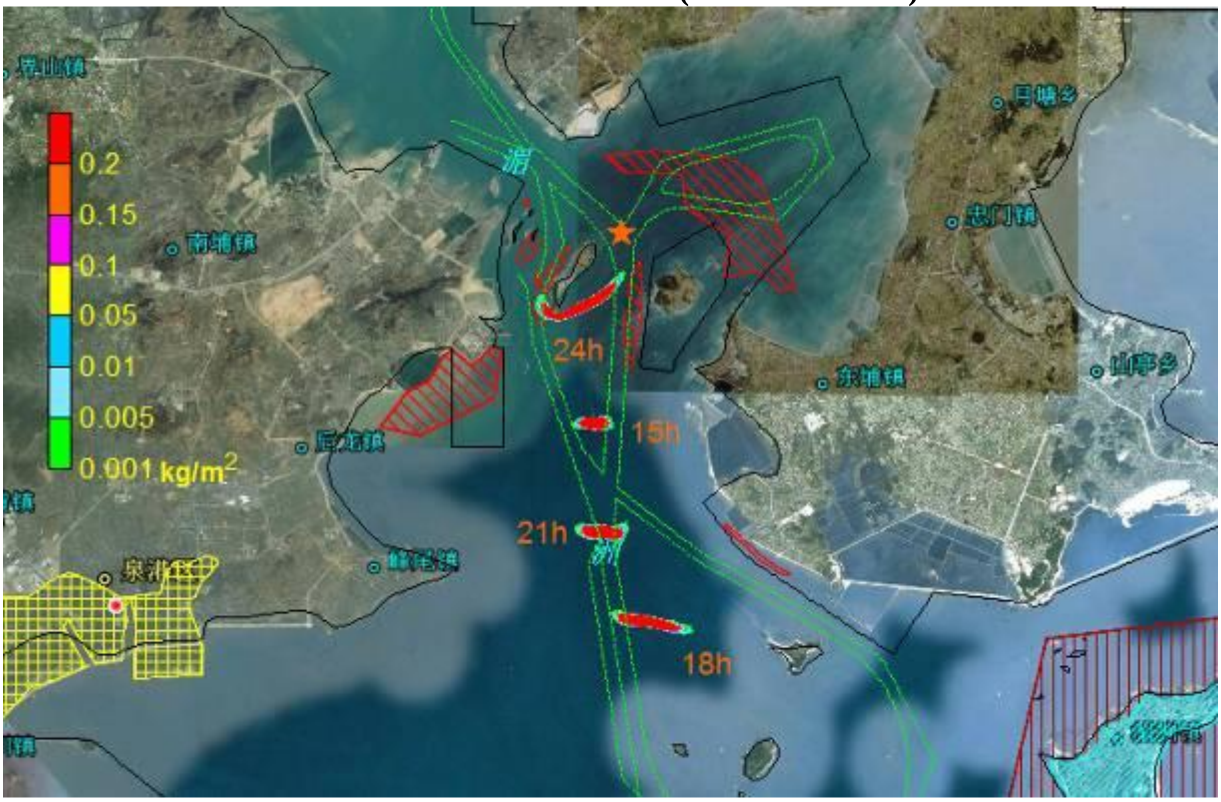


Figure 8.4.50 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Slack Period in Case of Calm Wind (after 15-24 hours)

Figure 8.4.51 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Slack Period in Case of Calm Wind (after 30-36 hours)

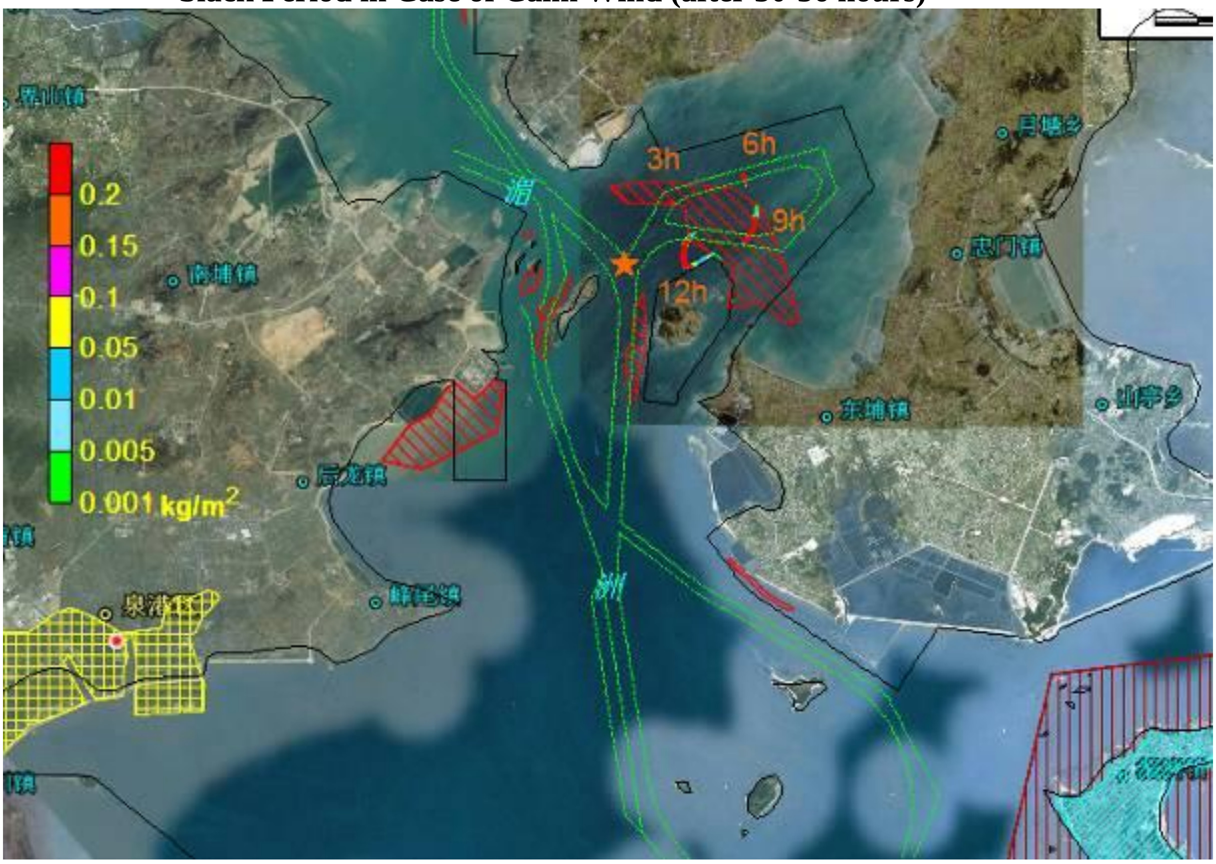


Figure 8.4.52 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Slack Period in Case of Calm Wind (after 3-12 hours)

Figure 8.4.53 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Slack Period in Case of Calm Wind (after 15-21 hours)

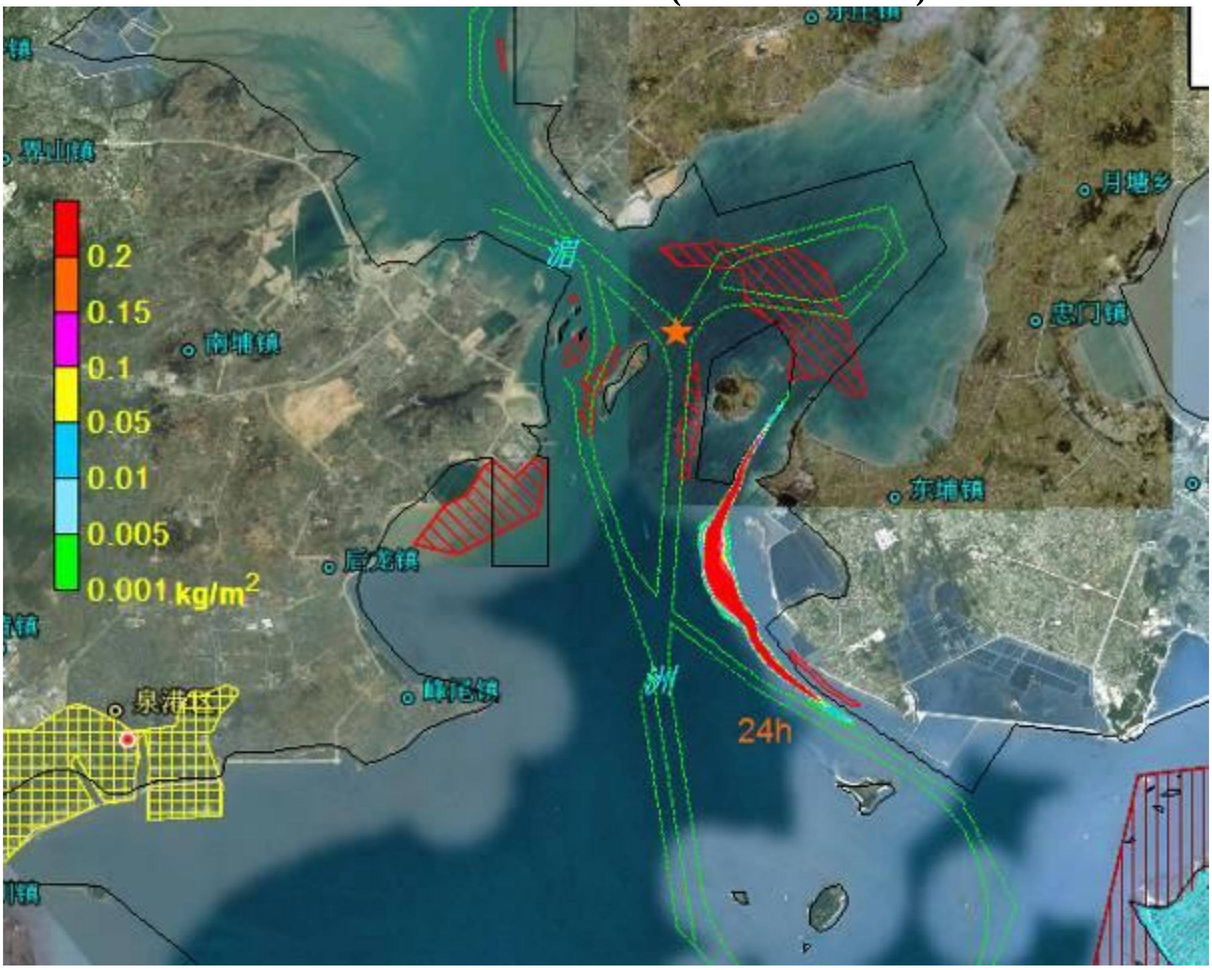


Figure 8.4.54 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb

Slack Period in Case of Calm Wind (after 24 hours)

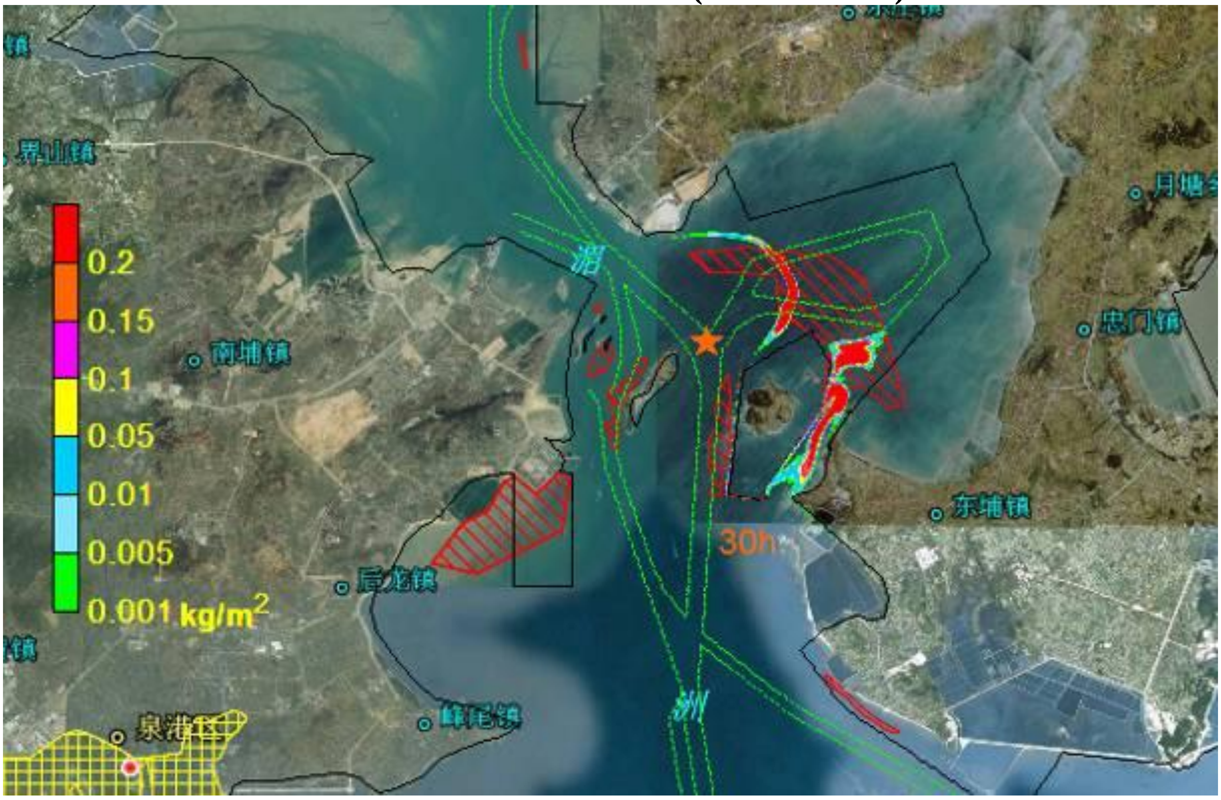


Figure 8.4.55 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Slack Period in Case of Calm Wind (after 30 hours)

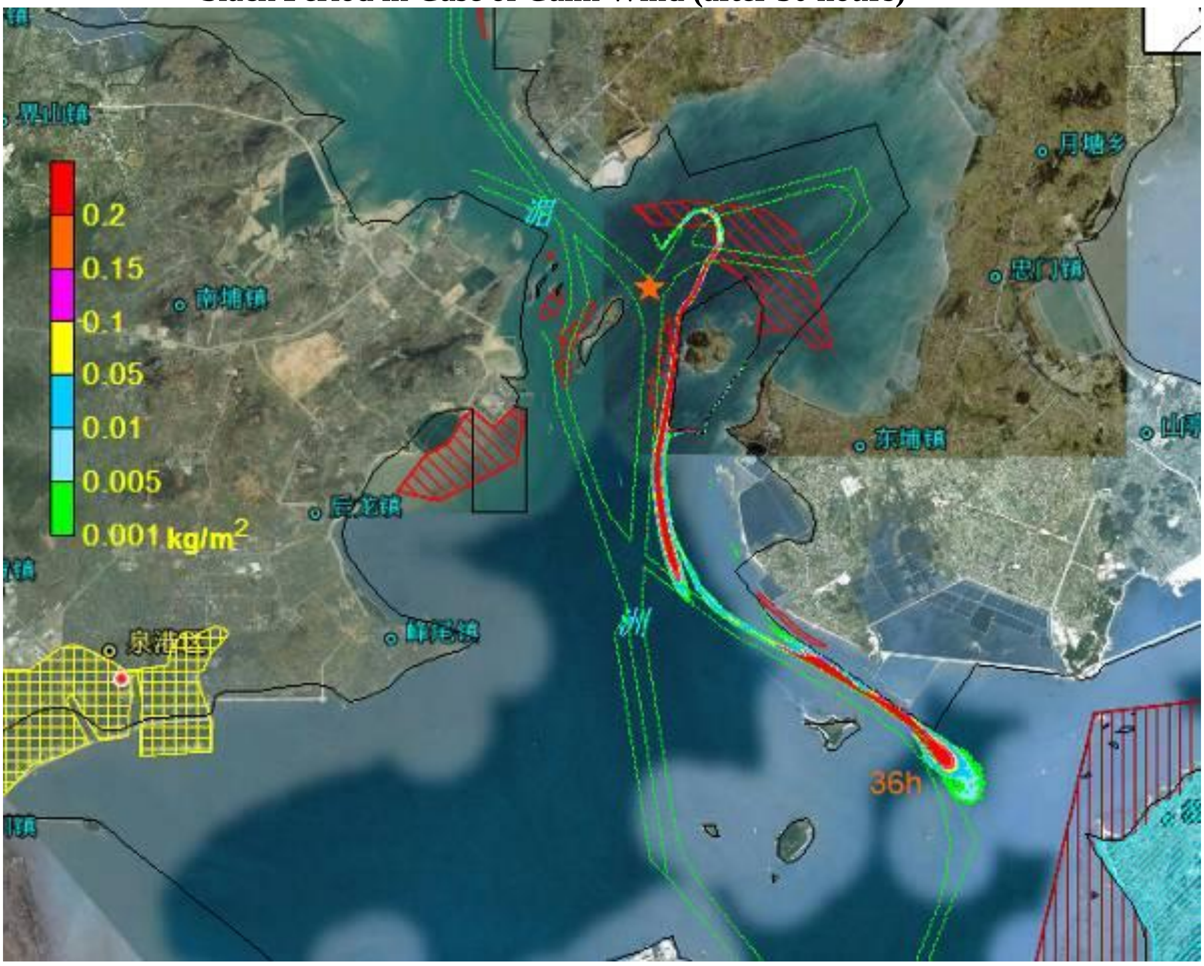


Figure 8.4.56 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Slack Period in Case of Calm Wind (after 36 hours)

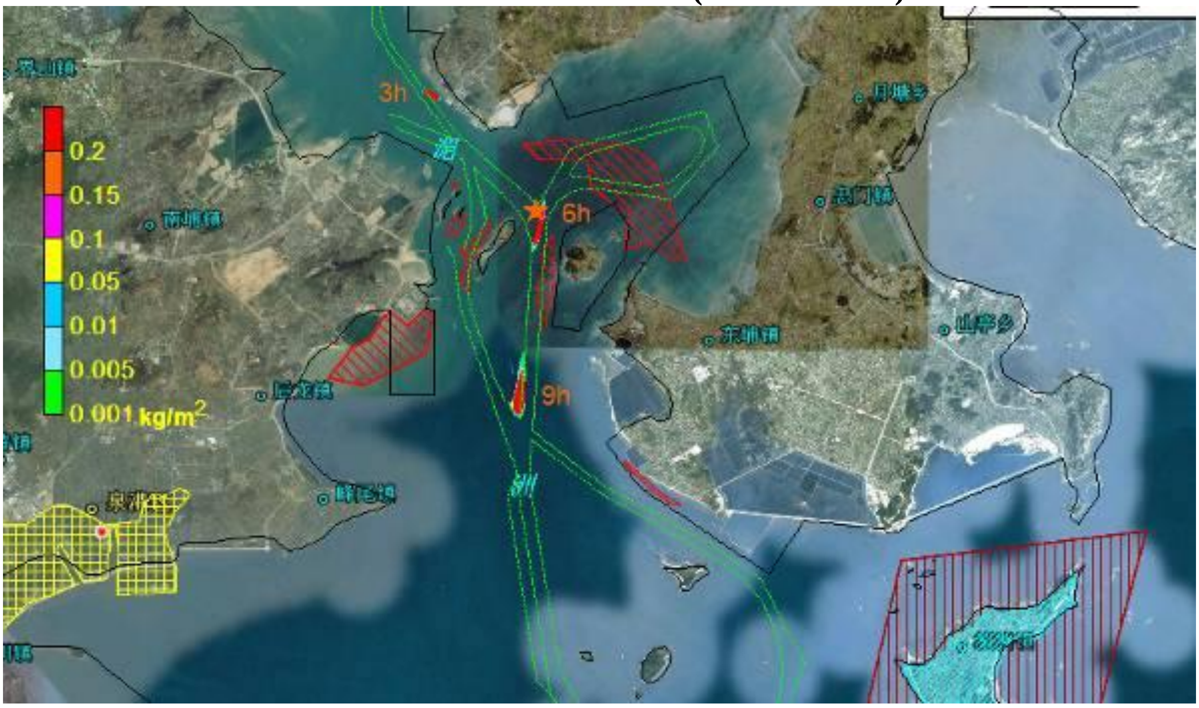


Figure 8.4.57 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Tide Period in Case of Calm Wind (after 3-9 hours)

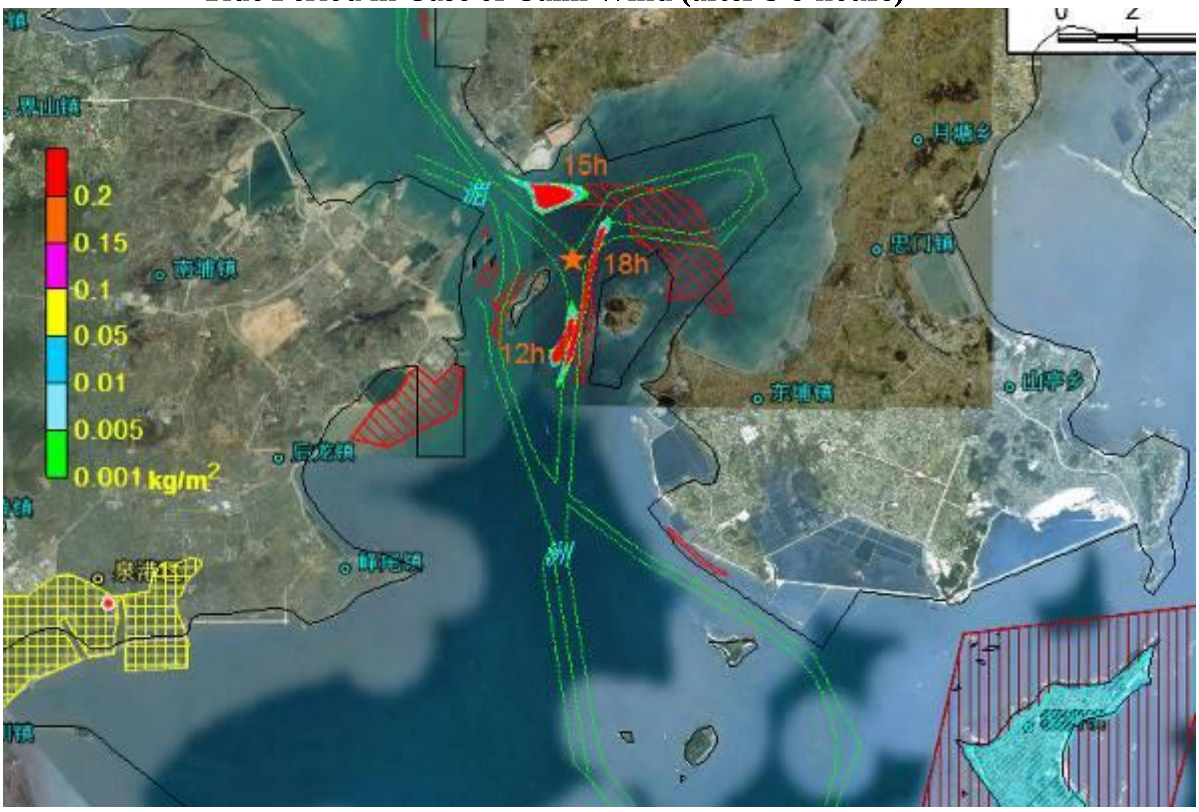


Figure 8.4.58 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Tide Period in Case of Calm Wind (after 12-18 hours)

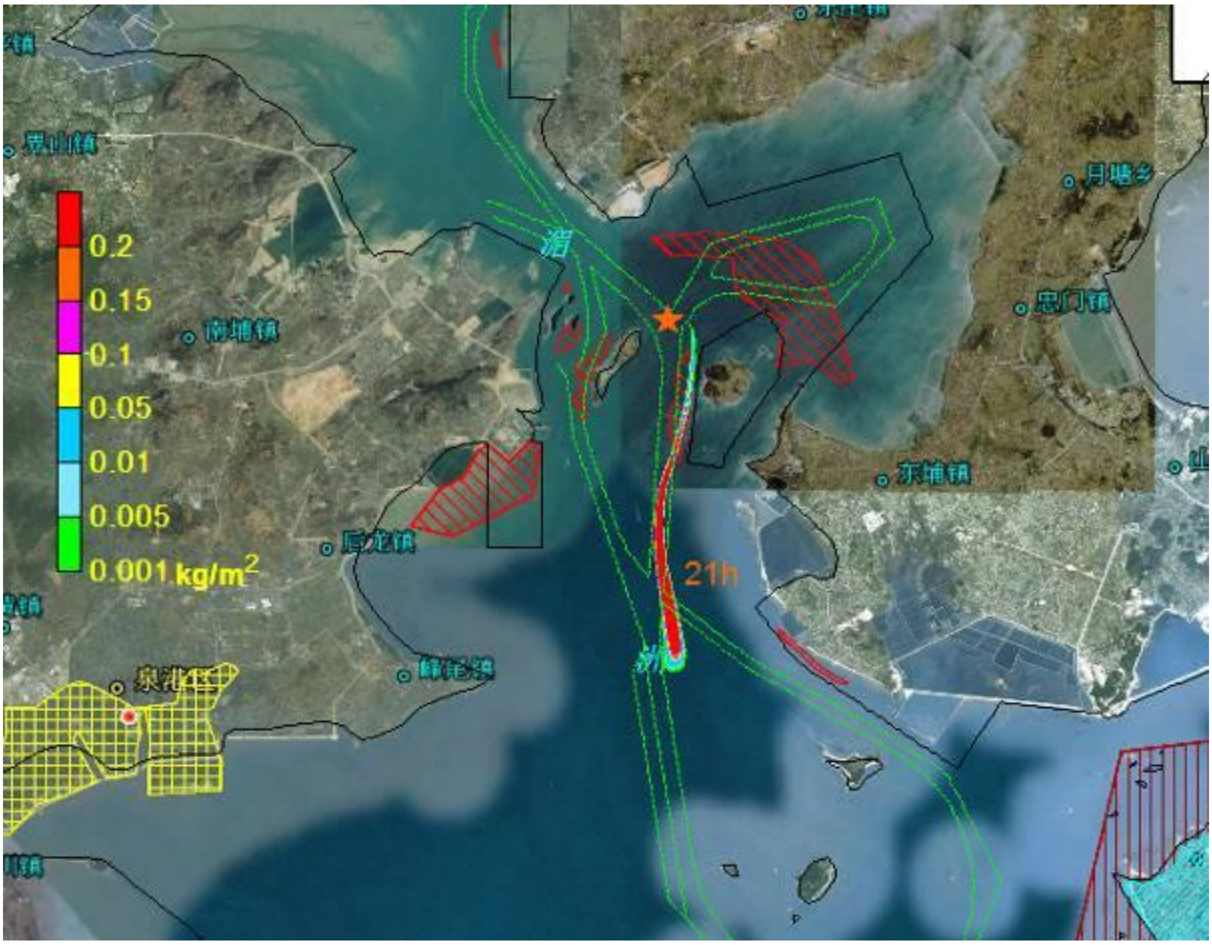


Figure 8.4.59 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Tide Period in Case of Calm Wind (after 21 hours)

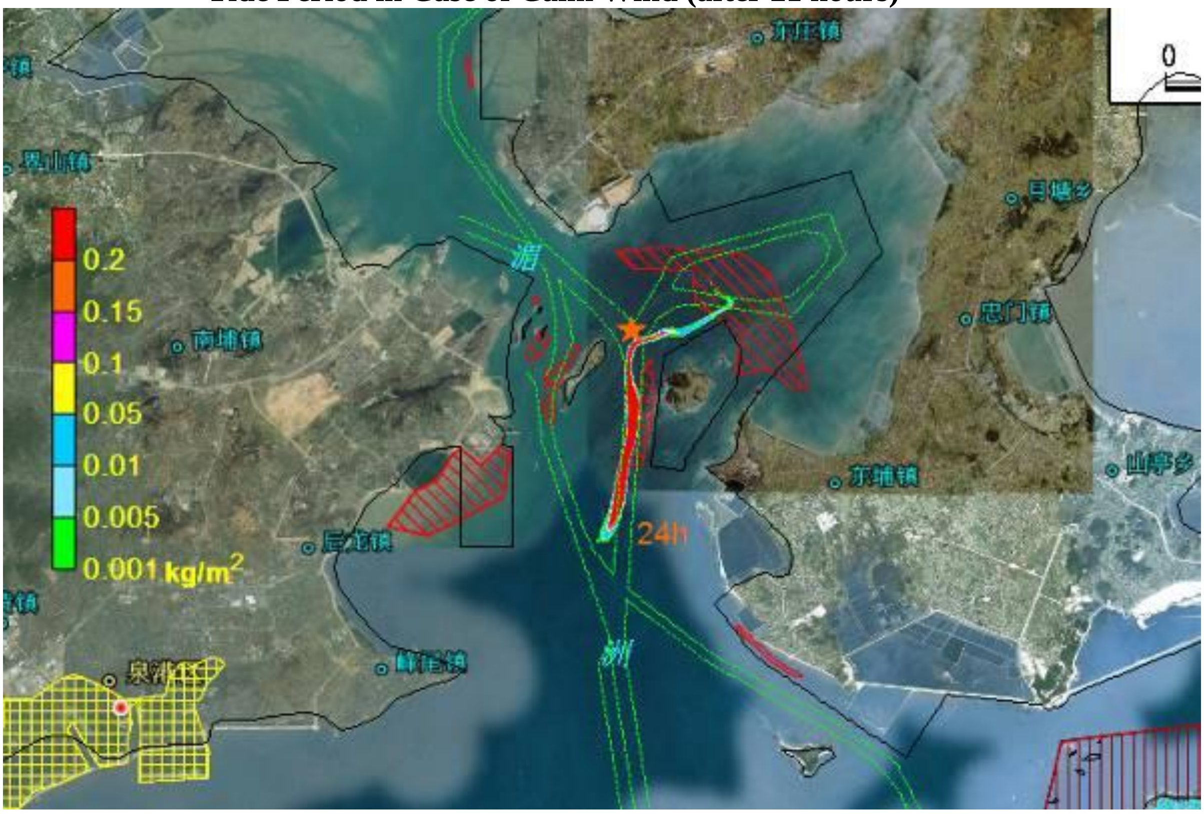


Figure 8.4.60 Impact Scope of Oil Spill Accident Occurred at Point C in Flood

Tide Period in Case of Calm Wind (after 24 hours)

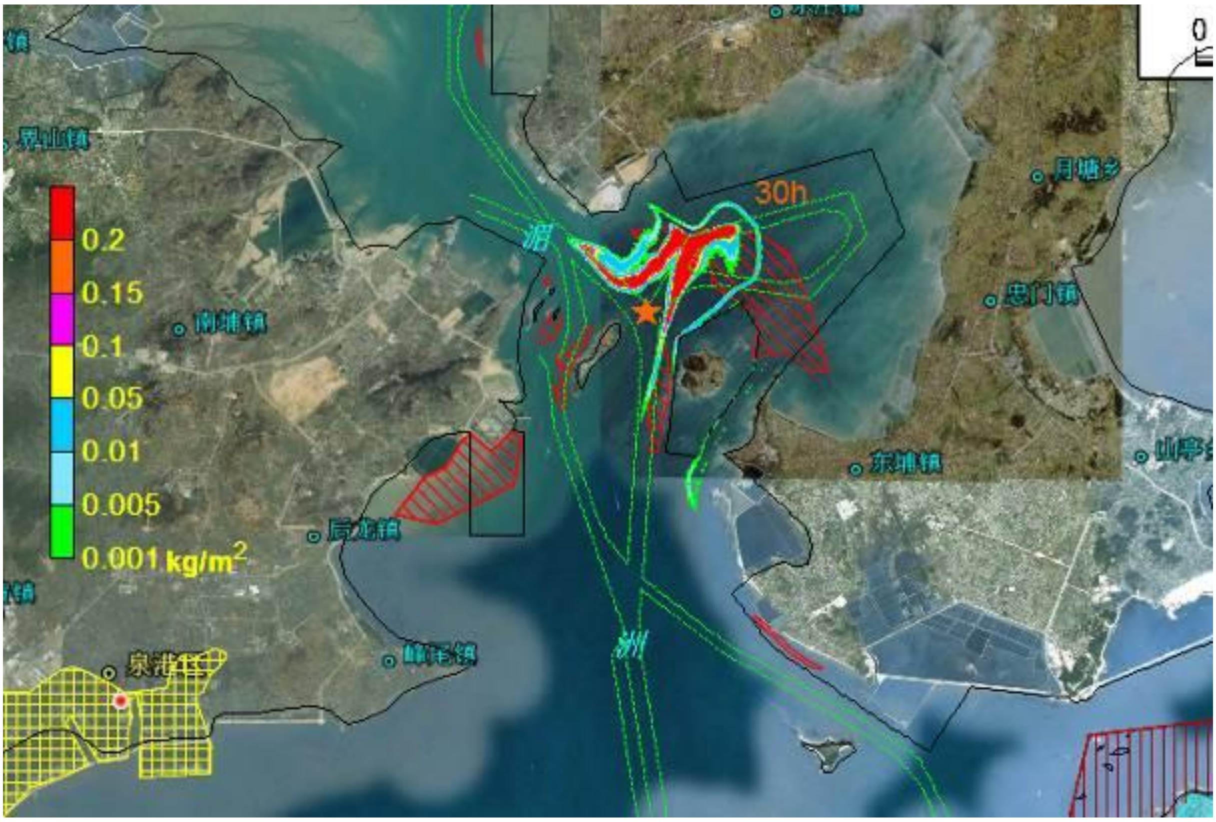


Figure 8.4.61 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Tide Period in Case of Calm Wind (after 30 hours)

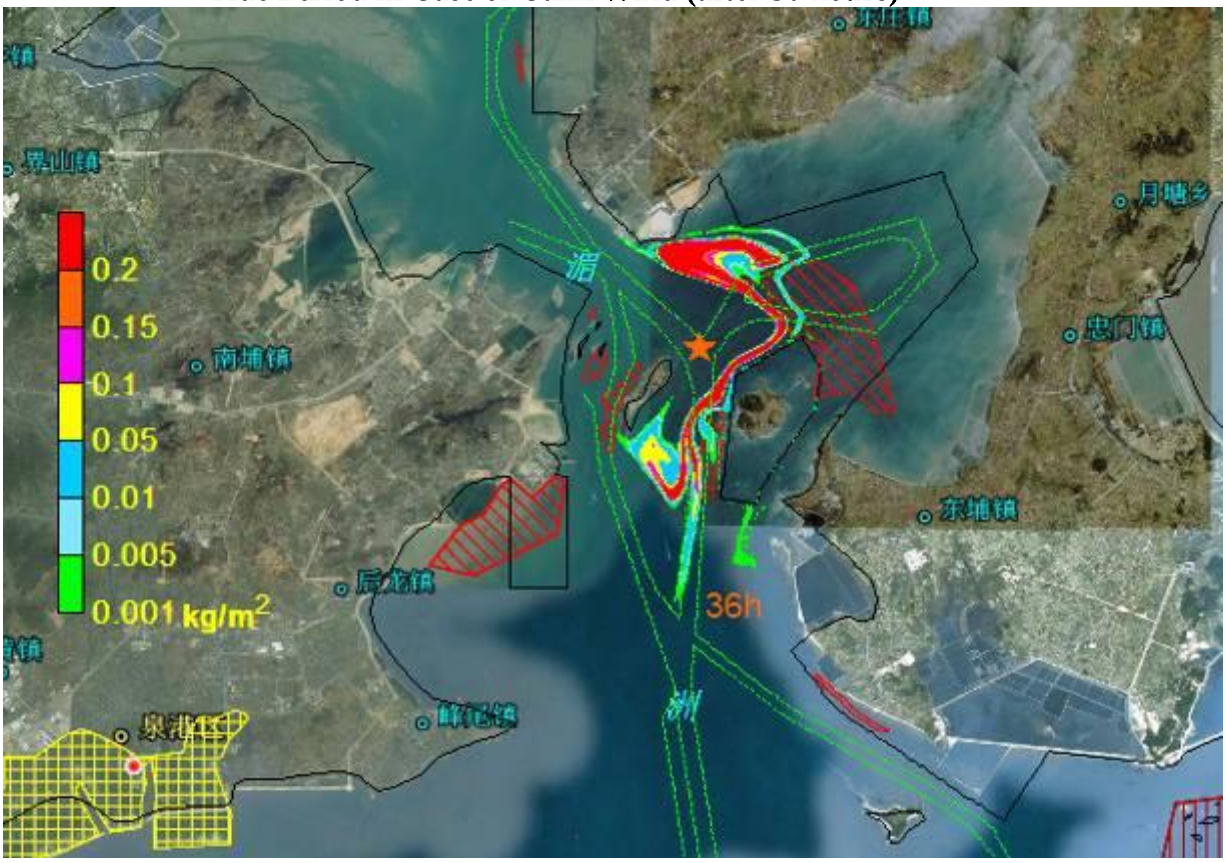


Figure 8.4.62 Impact Scope of Oil Spill Accident Occurred at Point C in Flood

Tide Period in Case of Calm Wind (after 36 hours)

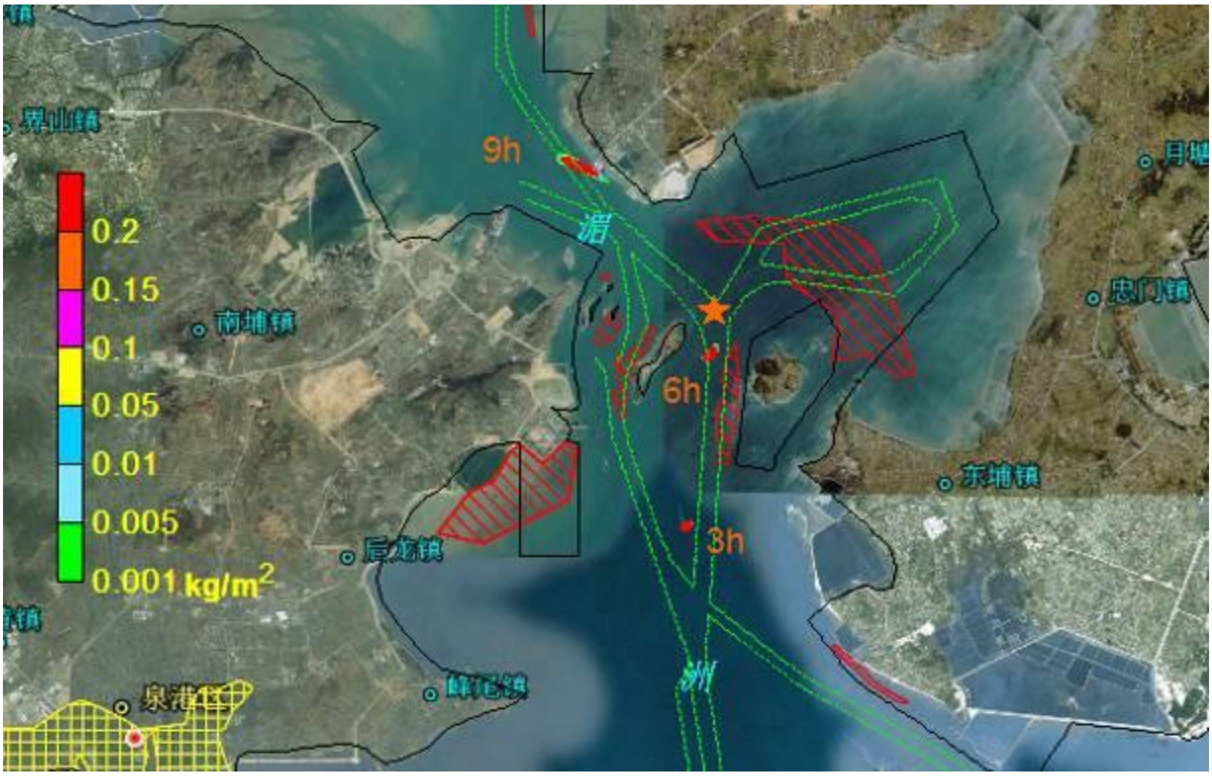


Figure 8.4.63 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Tide Period in Case of Calm Wind (after 3-9 hours)

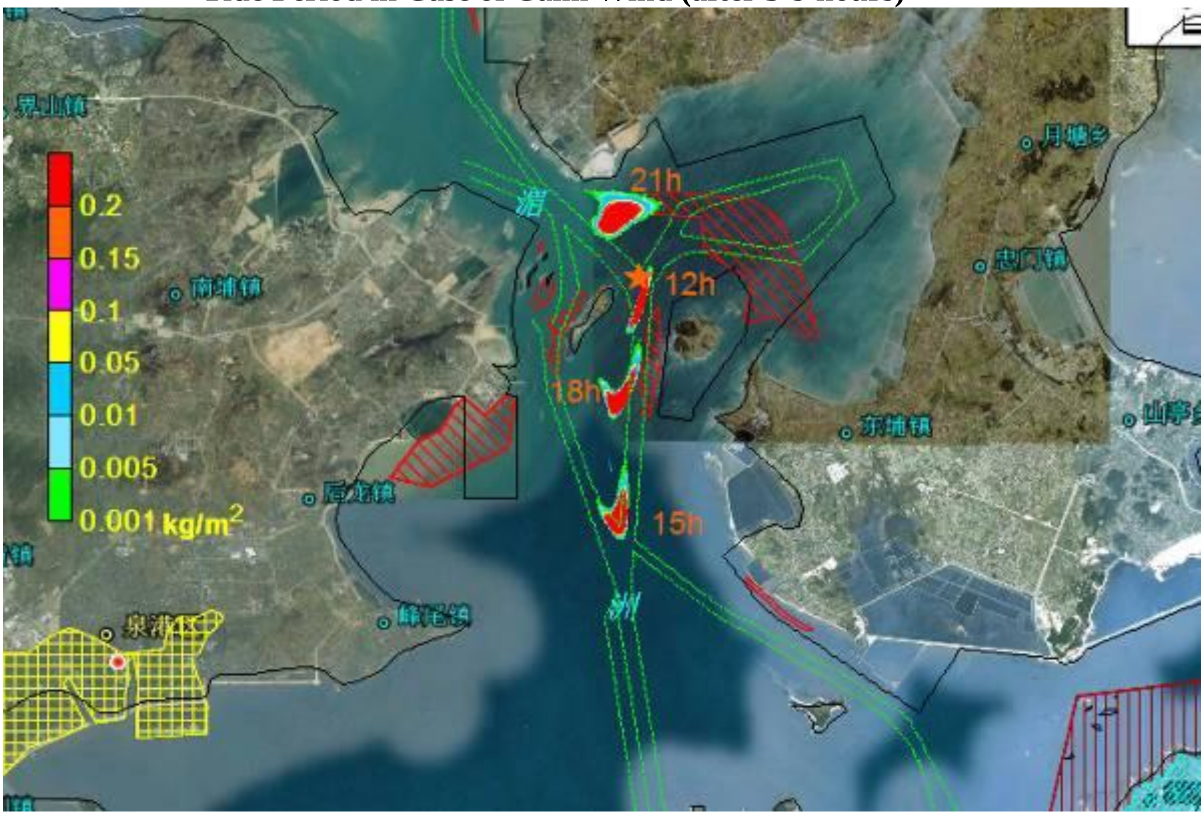


Figure 8.4.64 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Tide Period in Case of Calm Wind (after 12-21 hours)

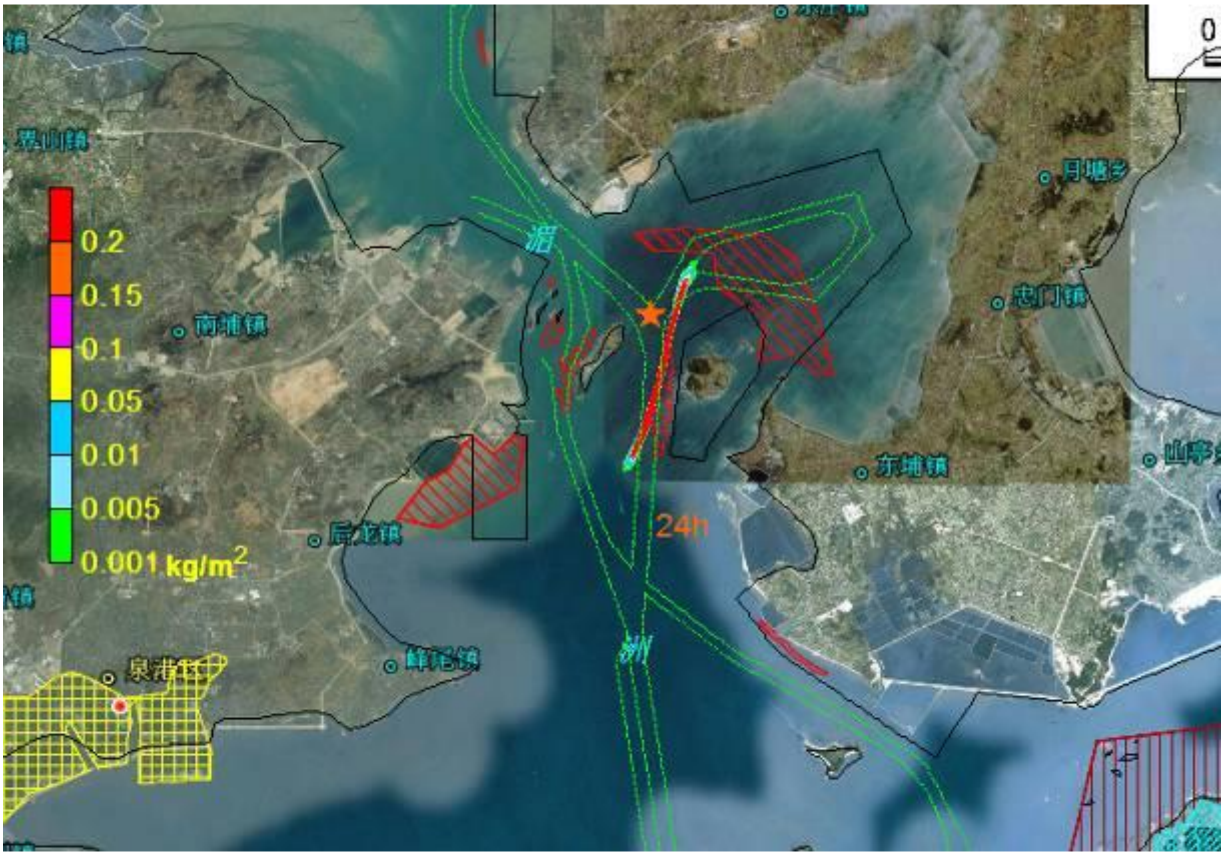


Figure 8.4.65 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Tide Period in Case of Calm Wind (after 24 hours)

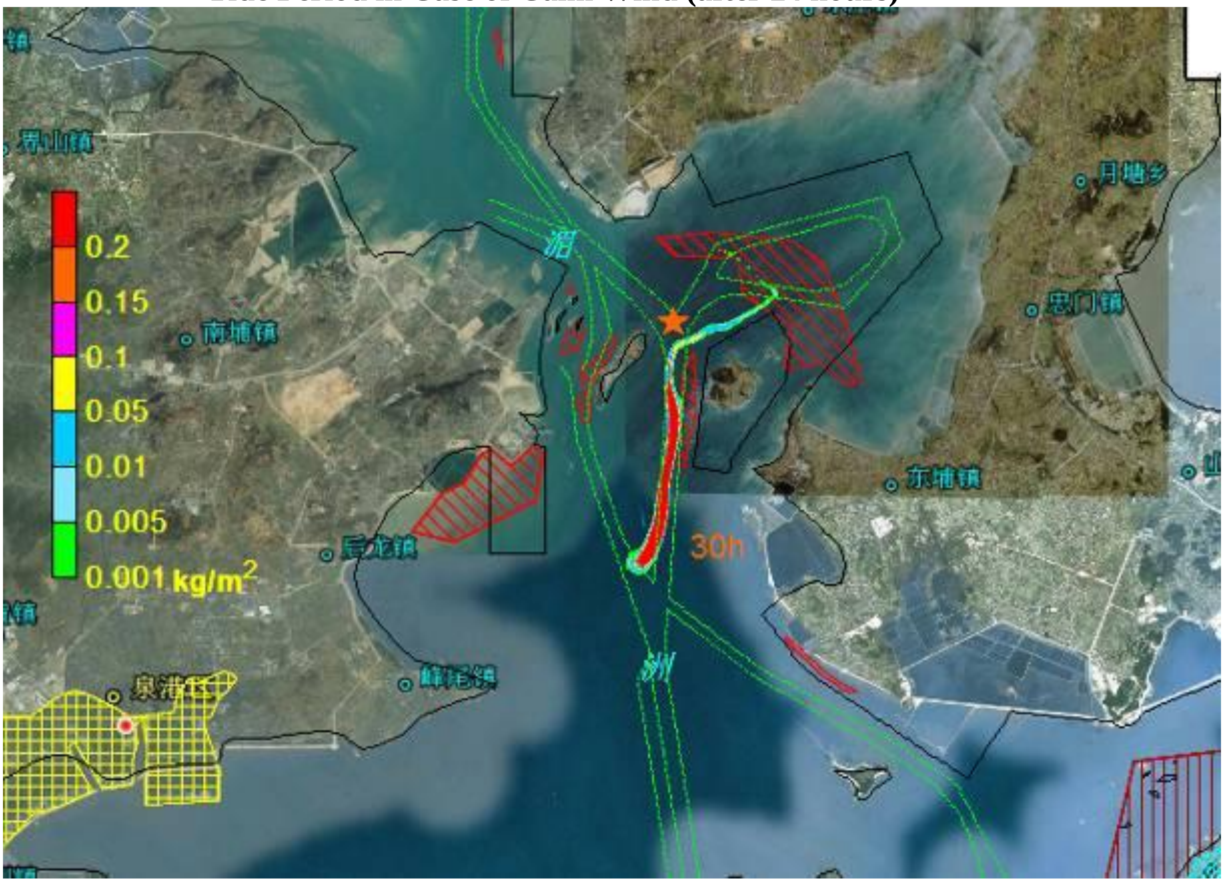


Figure 8.4.66 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb

Tide Period in Case of Calm Wind (after 30 hours)

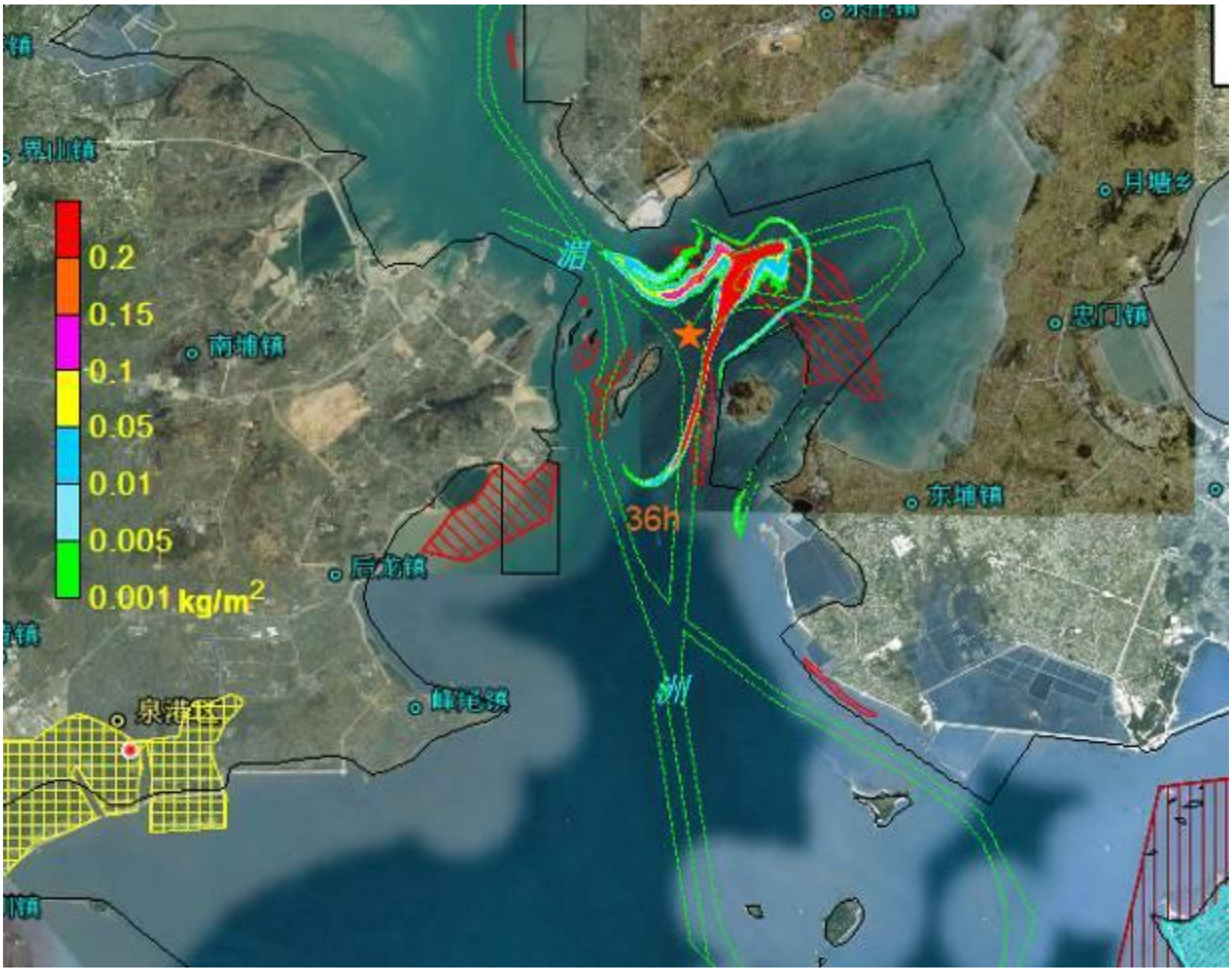


Figure 8.4.67 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Tide Period in Case of Calm Wind (after 36 hours)

Figure 8.4.68 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Slack Period in Case of a NE Wind (after 3-9 hours)

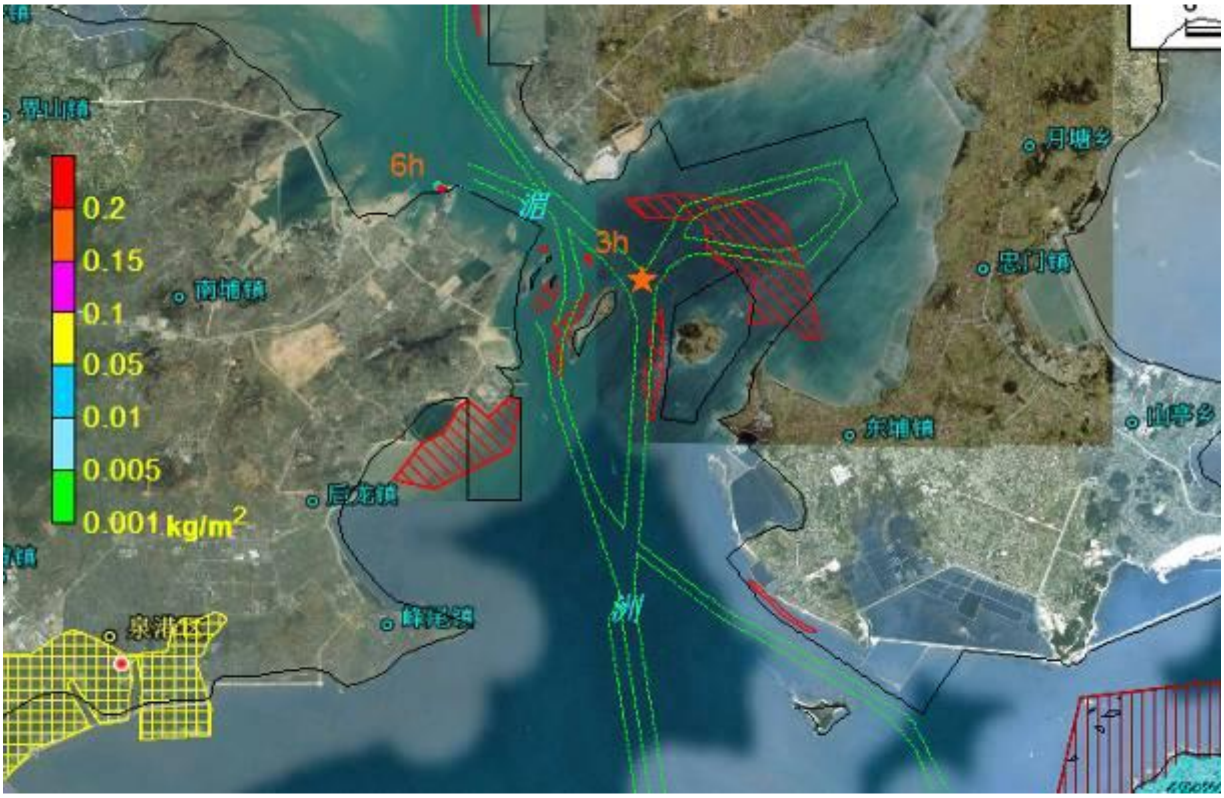


Figure 8.4.69 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Slack Period in Case of a NE Wind (after 3-6 hours)

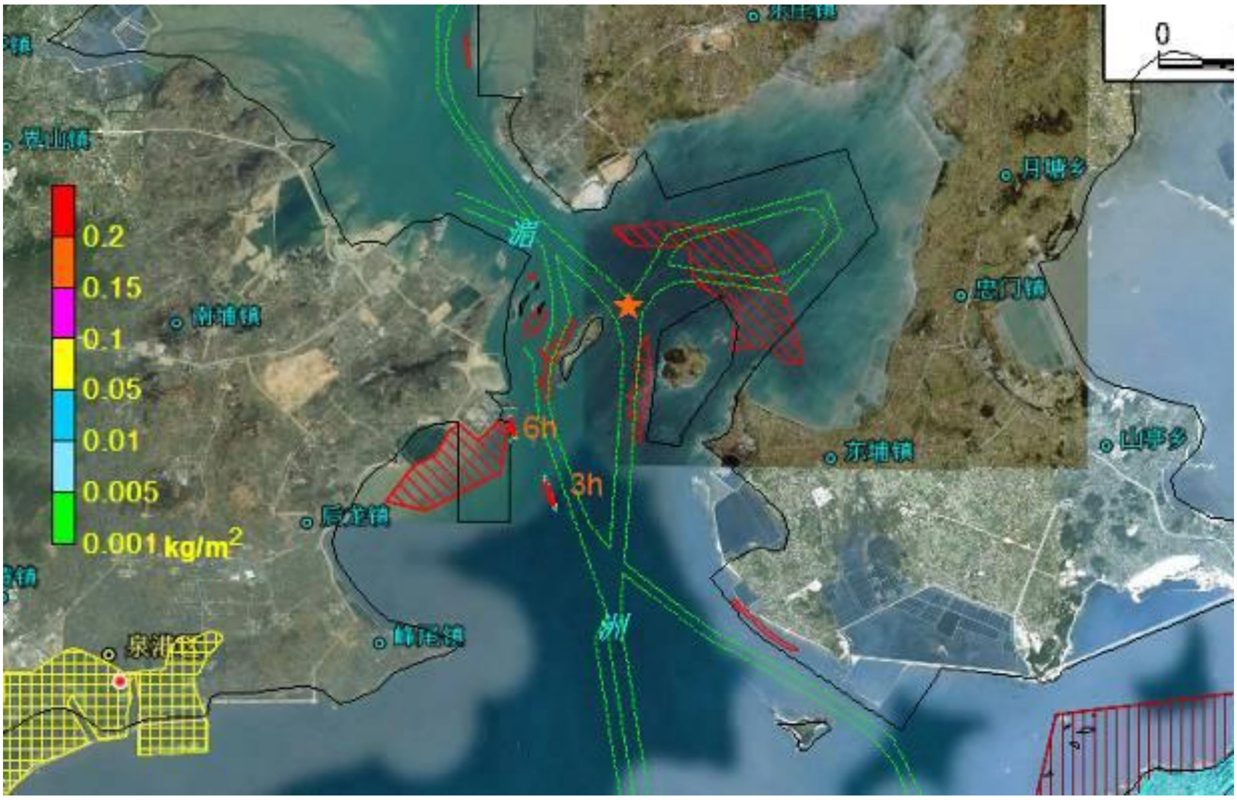


Figure 8.4.70 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Tide Period in Case of a NE Wind (after 3-6 hours)

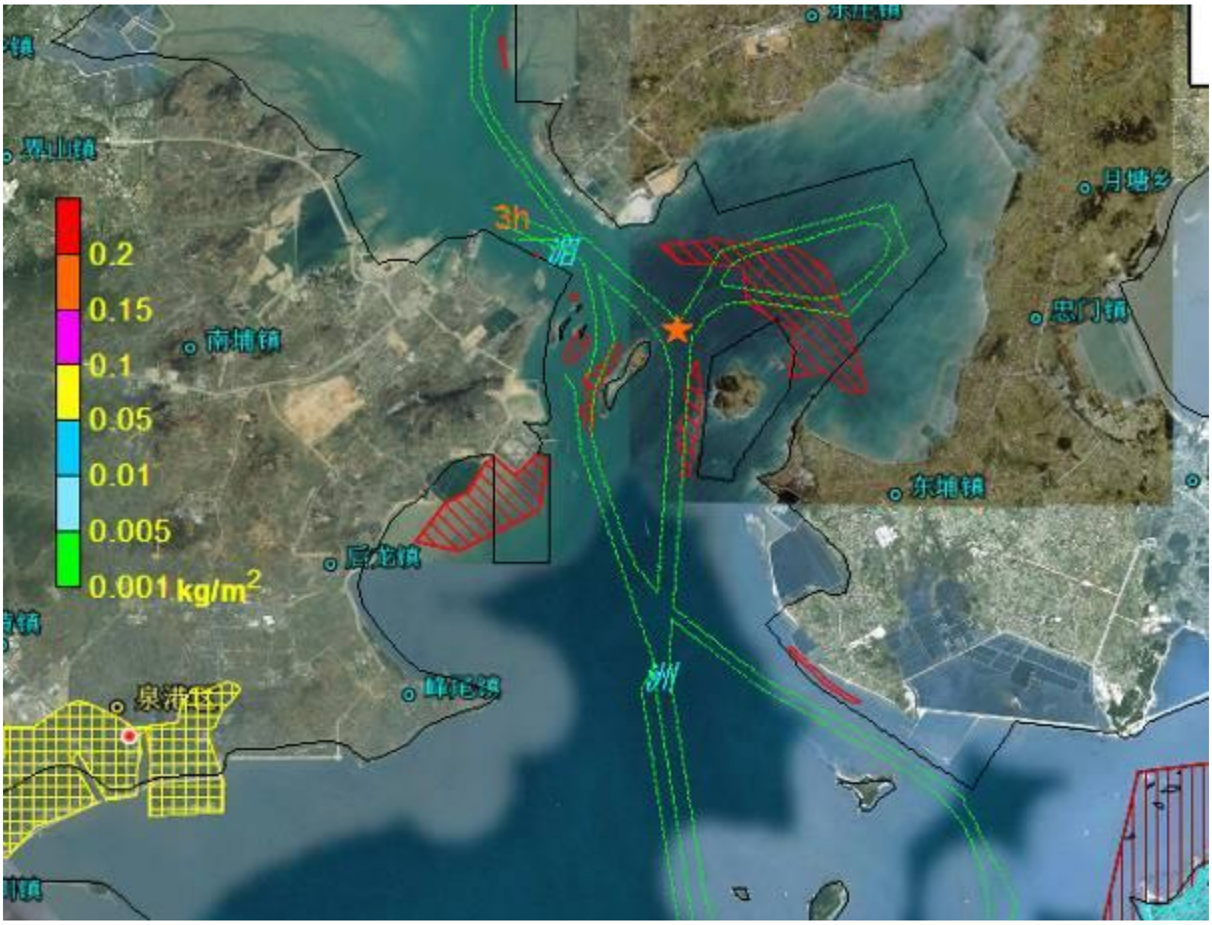


Figure 8.4.71 Impact Scope of Oil Spill Accident Occurred at Point C in Flood

Tide Period in Case of a NE Wind (after 3 hours)

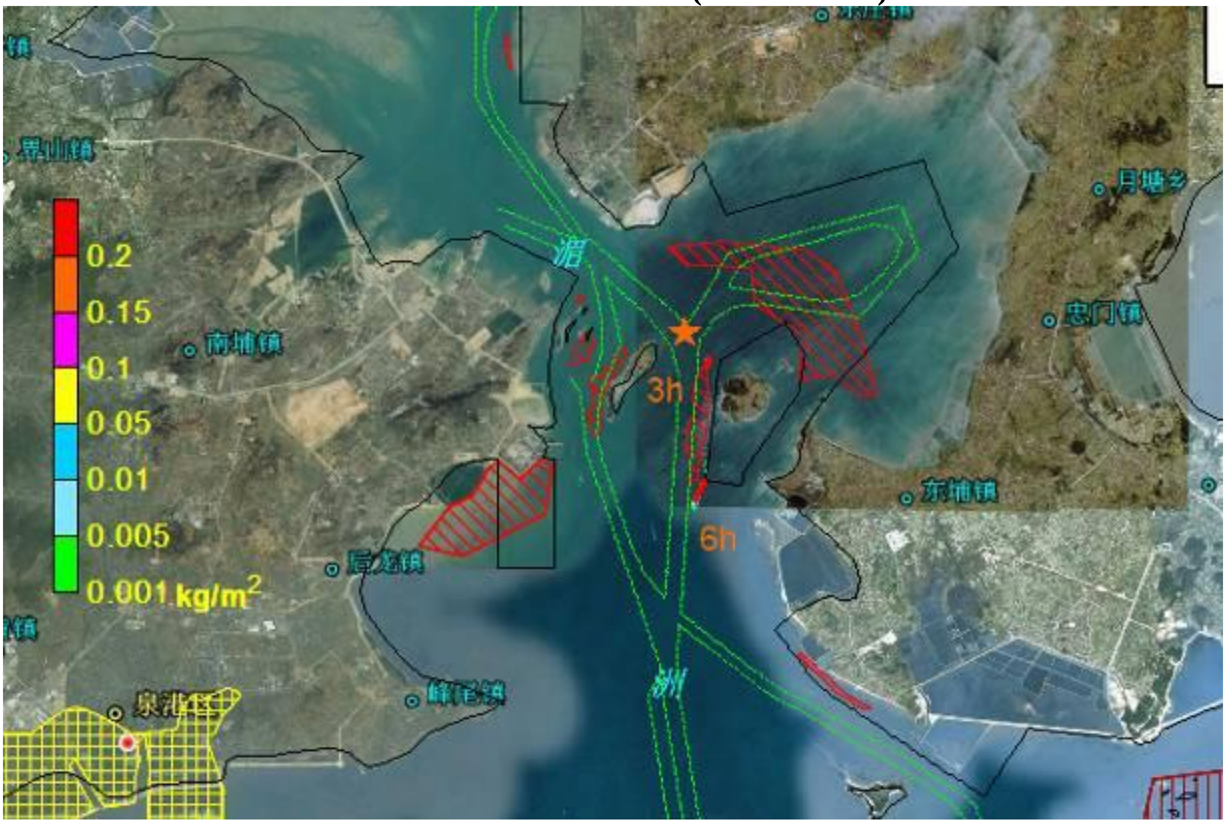


Figure 8.4.72 Impact Scope of Oil Spill Accident Occurred at Point C in Flood Slack Period in Case of a SSW Wind (after 3-6 hours)

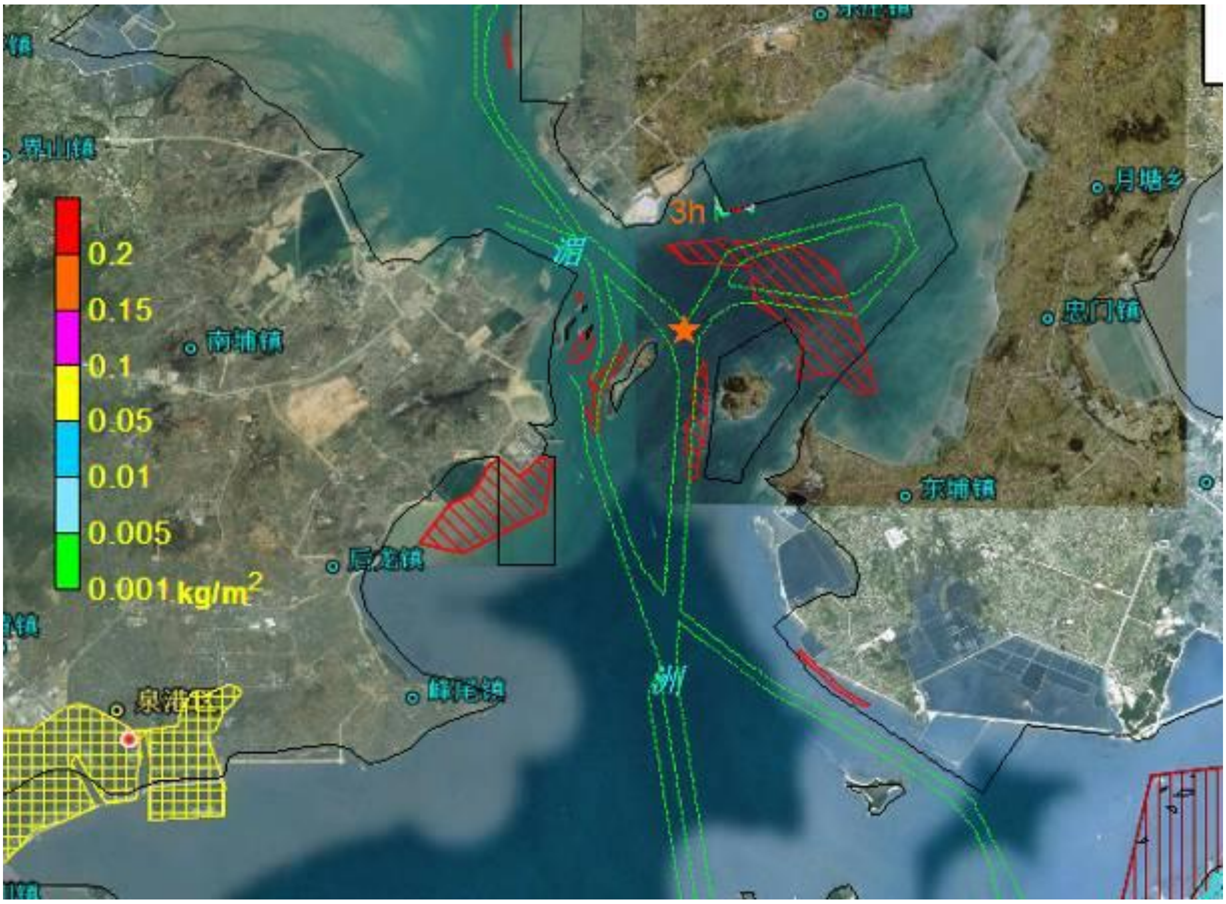


Figure 8.4.73 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Slack Period in Case of a SSW Wind (after 3 hours)

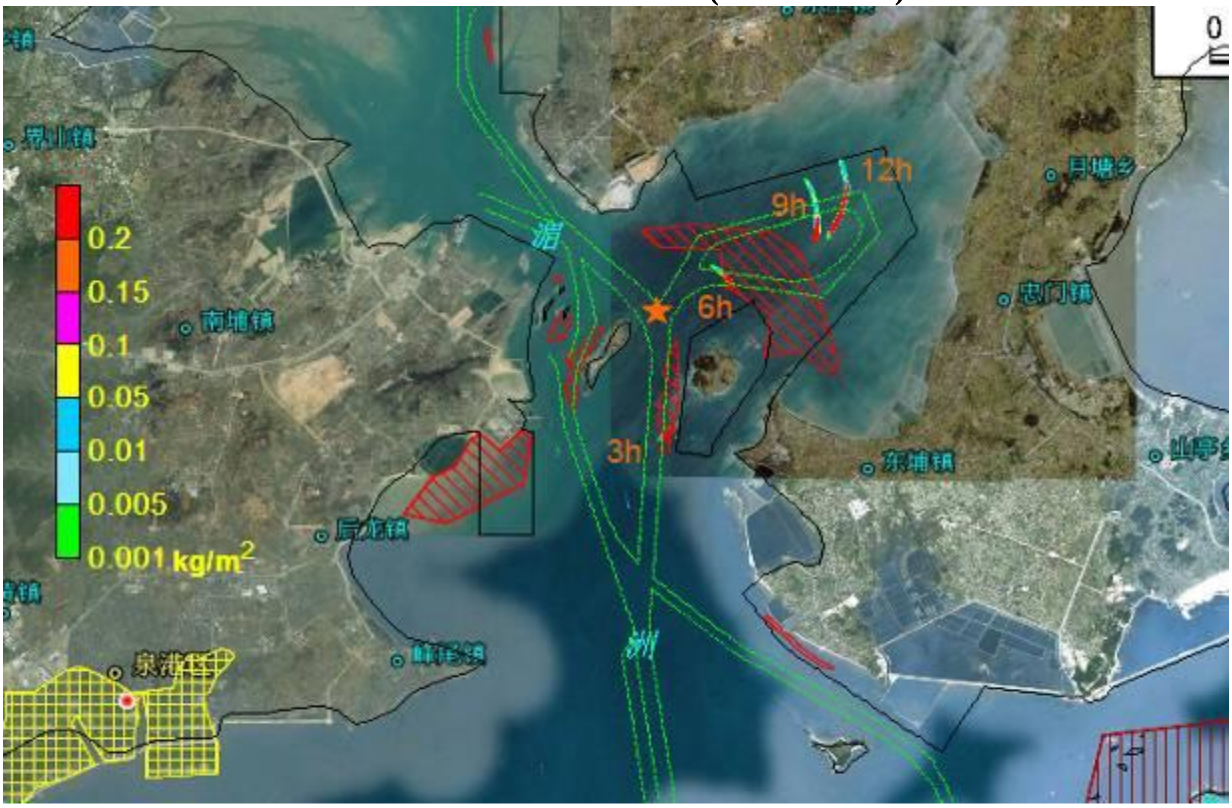


Figure 8.4.74 Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Tide Period in Case of a SSW Wind (after 3-12 hours)

8.4.2.4 Prediction for Leakage Point D

(1) Calm wind

The vessel leaks at point D, and the movements of oil slicks on different tidal currents in case of calm wind are shown in Figure 8.4.75 through Figure 8.4.96, with impact scope shown in Table 8.4.37 through 8.4.40.

In case of calm wind, movement of oil slicks under four tide conditions are described in below.

- *Flood Slack* - upon the occurrence of oil spill accident at point D in flood slack period, the oil slicks will intrude the western Huiyu aquaculture area and western Luoyu aquaculture area in about 2 hours under the influence of ebb currents.
- *Ebb Slack* - If the accident takes place in ebb slack period, the oil slicks will move along the navigation channel with the flood currents towards the bay-head and reach the shallow shoal of bay-head in around 6 hours. With the reciprocating action of flood and ebb currents, the oil slicks will gradually expand their impact scope, and extensive substrate sludge in the sea area of shallow shoal of bay-head might be polluted.
- *Flood Tide* - If the accident takes place in flood tide period, the oil slicks will first move towards the bay-head along with the flood currents and then go down south with the ebb currents. In about 8 hours, the oil slicks will intrude western Huiyu aquaculture area and western Luoyu aquaculture area. In about

12 hours, the oil slicks will begin to intrude Shimenao sea area. In about 15 hours, certain oil slicks will be distributed in strip form along the north coast of Shimenao. Some will stick to the shore and some will intrude Putou aquaculture area. After 21 hours, the sea area between Luoyu and Huiyu will be occupied by the oil slicks.

- *Ebb Tide* - If the accident takes place in ebb tide period, the oil slicks will intrude the western Luoyu aquaculture area in 3 hours, Shimenao sea area in 6 hours and Dongwu aquaculture area in 36 hours.

(2) Perennial Predominant Wind Direction

The movements of oil slicks on different tidal currents in case of the Perennial Predominant Wind Direction are shown in Figure 8.4.97 through Figure 8.4.99, with impact scope shown in Table 8.4.41 through 8.4.44.

- *Flood Slack* - In case of a NE wind, upon the occurrence of oil spill accident at point D in flood slack period, the oil slicks will intrude the western Huiyu aquaculture area in 2 hours and reach the shore of Xiaocuo in 3 hours.
- *Flood Tide* - If the accident takes place in flood tide period, due to the joint influence of flood currents and wind generated currents, the oil slicks will reach the north shore of Xiaocuo in 3 hours.
- *Ebb Tide* - If the accident takes place in ebb tide period, the oil slicks will intrude the western Huiyu aquaculture area in 3 hours and reach the east shore of Xiaocuo in 6 hours.

(3) Summer Predominant Wind Direction

The movements of oil slicks on different tidal currents in case of the Summer Predominant Wind Direction are shown in Figure 8.4.100 through Figure 8.4.102, with impact scope shown in Table 8.4.45 through 8.4.48.

- *Flood Slack* - In case of a SSW wind, upon the occurrence of oil spill accident at point D in flood slack period, the oil slicks will intrude Shimenao sea area in 3 hours and reach the north shore of Shimenao in 6 hours.
- *Flood Tide* - If the accident takes place in flood tide period, due to the joint influence of flood currents and wind generated currents, the oil slicks will intrude Putou aquaculture area in 3 hours and reach the near shore in 6 hours.
- *Ebb Tide* - If the accident takes place in ebb tide period, the oil slicks will intrude Shimenao sea area in 3 hours and reach the north shore of this sea area in 6 hours.

Table 8.4.37 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Slack Period in Case of Calm Wind (unit: km2)

After flood slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.014	0.014	0.013	0.013	0.014
2	0.045	0.045	0.042	0.04	0.046
3	0.115	0.11	0.099	0.094	0.123
4	0.133	0.13	0.126	0.114	0.142

5	0.224	0.216	0.203	0.197	0.242
6	0.256	0.248	0.23	0.205	0.278
7	0.261	0.253	0.24	0.219	0.282
8	0.238	0.23	0.219	0.203	0.264
9	0.203	0.194	0.186	0.173	0.232
10	0.35	0.339	0.32	0.286	0.384
11	0.582	0.56	0.533	0.49	0.627
12	0.522	0.501	0.466	0.432	0.562
13	0.542	0.52	0.496	0.443	0.582
14	0.597	0.57	0.536	0.498	0.651
15	0.568	0.541	0.501	0.448	0.614
16	0.954	0.917	0.846	0.76	1.072
17	1.006	0.971	0.885	0.797	1.155
18	0.987	0.957	0.877	0.768	1.131
19	1.13	1.093	1.008	0.922	1.227
20	1.082	1.054	0.982	0.883	1.198
21	1.258	1.214	1.147	1.043	1.413
22	1.299	1.259	1.182	1.062	1.458
23	1.218	1.174	1.093	1.002	1.381
24	1.07	1.042	0.958	0.87	1.21
25	1.094	1.056	0.984	0.882	1.245
26	1.274	1.232	1.126	1.032	1.422
27	1.493	1.445	1.35	1.206	1.658
28	1.736	1.688	1.586	1.421	1.938
29	1.765	1.706	1.598	1.446	1.946
30	1.704	1.642	1.51	1.378	1.901
31	1.821	1.75	1.638	1.478	2.018
32	1.992	1.93	1.792	1.606	2.202
33	2.139	2.08	1.934	1.738	2.398
34	2.205	2.128	1.957	1.76	2.434
35	2.302	2.205	2.027	1.795	2.579
36	2.379	2.299	2.104	1.864	2.699
Envelope area>0.001kg/m^2	33.306				

Table 8.4.38 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Slack Period in Case of Calm Wind (unit: km2)

After ebb slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.003	0.003	0.003	0.003	0.003
2	0.019	0.019	0.018	0.018	0.019
3	0.072	0.072	0.07	0.062	0.08
4	0.173	0.171	0.163	0.141	0.181
5	0.318	0.306	0.298	0.267	0.346
6	0.342	0.326	0.309	0.278	0.366
7	0.342	0.33	0.314	0.293	0.379
8	0.306	0.299	0.283	0.262	0.323
9	0.202	0.192	0.186	0.173	0.224
10	0.226	0.21	0.198	0.181	0.234
11	0.242	0.232	0.213	0.202	0.256
12	0.238	0.234	0.216	0.2	0.259
13	0.25	0.242	0.224	0.208	0.277
14	0.254	0.245	0.229	0.206	0.269
15	0.533	0.51	0.483	0.445	0.56
16	0.624	0.594	0.56	0.507	0.669
17	0.803	0.765	0.717	0.645	0.872
18	0.907	0.861	0.805	0.717	0.987
19	0.901	0.87	0.805	0.723	0.976
20	0.76	0.722	0.669	0.61	0.808
21	0.627	0.603	0.563	0.518	0.67
22	0.522	0.499	0.464	0.426	0.566
23	0.475	0.448	0.424	0.395	0.515
24	0.464	0.438	0.413	0.382	0.514
25	0.464	0.438	0.414	0.379	0.498
26	0.482	0.464	0.438	0.386	0.526
27	0.709	0.672	0.632	0.56	0.771
28	1.006	0.973	0.915	0.827	1.066
29	1.322	1.254	1.166	1.029	1.445
30	1.768	1.664	1.525	1.333	1.922
31	1.77	1.666	1.517	1.336	1.918
32	1.67	1.571	1.442	1.262	1.826
33	1.392	1.323	1.237	1.094	1.506
34	1.035	0.99	0.907	0.805	1.118
35	0.846	0.797	0.741	0.659	0.922
36	0.762	0.717	0.661	0.579	0.834
Envelope area>0.001kg/m^2	17.472				

Table 8.4.39 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of Calm Wind (unit: km2)

After flood tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.045	0.045	0.045	0.045	0.05
2	0.067	0.067	0.067	0.062	0.077
3	0.069	0.069	0.067	0.066	0.074
4	0.078	0.075	0.07	0.067	0.083
5	0.101	0.101	0.098	0.086	0.109
6	0.147	0.144	0.131	0.125	0.16
7	0.246	0.242	0.224	0.211	0.267
8	0.323	0.317	0.293	0.275	0.358
9	0.322	0.312	0.301	0.278	0.358
10	0.301	0.296	0.283	0.25	0.326
11	0.275	0.269	0.256	0.234	0.309
12	0.256	0.25	0.238	0.218	0.28
13	0.28	0.272	0.256	0.234	0.302
14	0.328	0.318	0.304	0.28	0.373
15	0.312	0.306	0.293	0.254	0.339
16	0.318	0.314	0.291	0.262	0.347
17	0.322	0.31	0.296	0.27	0.354
18	0.371	0.358	0.336	0.312	0.414
19	0.504	0.488	0.458	0.421	0.552
20	0.682	0.658	0.624	0.571	0.731
21	0.792	0.773	0.734	0.669	0.869
22	0.736	0.72	0.67	0.621	0.8
23	0.579	0.554	0.533	0.49	0.634
24	0.488	0.472	0.448	0.405	0.542
25	0.493	0.477	0.45	0.414	0.539
26	0.627	0.619	0.568	0.525	0.686
27	0.698	0.674	0.626	0.565	0.749
28	0.68	0.664	0.618	0.56	0.733
29	0.645	0.626	0.594	0.538	0.709
30	0.592	0.574	0.546	0.493	0.65
31	0.666	0.638	0.597	0.534	0.728
32	0.722	0.694	0.653	0.594	0.806
33	0.779	0.752	0.704	0.634	0.851
34	0.76	0.739	0.688	0.621	0.835
35	0.712	0.691	0.65	0.574	0.8
36	0.728	0.701	0.653	0.589	0.79
Envelope area>0.001kg/m^2	65.36				

Table 8.4.40 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period in Case of Calm Wind (unit: km2)

After ebb tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.058	0.054	0.053	0.05	0.058
2	0.07	0.066	0.066	0.066	0.086
3	0.078	0.074	0.072	0.064	0.083
4	0.075	0.074	0.074	0.07	0.078
5	0.08	0.075	0.074	0.067	0.083
6	0.107	0.106	0.104	0.093	0.115
7	0.163	0.158	0.155	0.146	0.178
8	0.202	0.19	0.186	0.173	0.219
9	0.182	0.181	0.173	0.162	0.203
10	0.211	0.208	0.202	0.19	0.237
11	0.282	0.266	0.254	0.235	0.304
12	0.294	0.278	0.266	0.243	0.31
13	0.358	0.334	0.317	0.293	0.384
14	0.381	0.357	0.339	0.312	0.421
15	0.395	0.378	0.363	0.32	0.432
16	0.381	0.357	0.336	0.312	0.411
17	0.405	0.378	0.368	0.339	0.43
18	0.414	0.394	0.378	0.347	0.446
19	0.531	0.498	0.469	0.435	0.574
20	0.643	0.603	0.579	0.528	0.718
21	0.674	0.632	0.616	0.56	0.744
22	0.63	0.602	0.579	0.517	0.701
23	0.747	0.706	0.682	0.622	0.826
24	0.958	0.888	0.845	0.773	1.07
25	1.101	1.024	0.987	0.875	1.242
26	1.109	1.034	0.979	0.877	1.28
27	1.134	1.05	1.002	0.896	1.301
28	1.17	1.088	1.022	0.91	1.283
29	1.243	1.166	1.109	0.978	1.398
30	1.454	1.344	1.288	1.142	1.65
31	1.533	1.437	1.355	1.197	1.706
32	1.459	1.366	1.293	1.146	1.661
33	1.618	1.515	1.446	1.226	1.819
34	1.597	1.485	1.413	1.227	1.789
35	1.73	1.626	1.554	1.354	1.96
36	2.106	1.963	1.867	1.64	2.365
Envelope area>0.001kg/m^2	41.594				

Table 8.4.41 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Slack Period in Case of a NE Wind (unit: km2)

After flood slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.021	0.021	0.021	0.021	0.026
2	0.048	0.046	0.043	0.04	0.048
3	reaches shore				
Envelope area>0.001kg/m^2	0.603				

Table 8.4.42 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Slack Period in Case of a NE Wind (unit: km2)

After ebb slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.005	0.005	0.005	0.005	0.005
2	reaches shore				
Envelope area>0.001kg/m^2	0.367				

Table 8.4.43 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of a NE Wind (unit: km2)

After flood tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.082	0.078	0.069	0.064	0.085
2	0.12	0.112	0.107	0.101	0.125
3	0.096	0.093	0.091	0.085	0.099
4	0.058	0.058	0.056	0.051	0.058
5	0.011	0.011	0.011	0.008	0.013
6	reaches shore				
Envelope area>0.001kg/m^2	2.264				

Table 8.4.44 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period in Case of a NE Wind (unit: km2)

After ebb tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.082	0.077	0.074	0.069	0.085
2	0.085	0.083	0.08	0.072	0.086
3	0.123	0.12	0.114	0.107	0.13
4	0.094	0.09	0.083	0.078	0.101
5	0.138	0.125	0.118	0.078	0.152
6	0.069	0.061	0.05	0.035	0.086
7	0.016	0.016	0.013	0.008	0.019
8	reaches shore				
Envelope area>0.001kg/m^2	2.536				

Table 8.4.45 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Slack Period in Case of a SSW Wind (unit: km2)

After flood slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.013	0.013	0.011	0.011	0.013
2	0.05	0.05	0.043	0.042	0.05
3	0.072	0.072	0.07	0.069	0.075
4	0.107	0.101	0.099	0.091	0.112
5	0.042	0.04	0.038	0.037	0.046
6	0.008	0.008	0.005	0.003	0.011
7	reaches shore				
Envelope area>0.001kg/m^2	1.746				

Table 8.4.46 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Slack Period in Case of a SSW Wind (unit: km2)

After ebb slack Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.006	0.006	0.006	0.006	0.006
2	reaches shore				
Envelope area>0.001kg/m^2	0.163				

Table 8.4.47 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of a SSW Wind (unit: km2)

After flood tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.082	0.078	0.075	0.072	0.086
2	0.101	0.099	0.091	0.085	0.11
3	0.133	0.126	0.117	0.114	0.146
4	0.224	0.218	0.211	0.202	0.238
5	0.147	0.142	0.131	0.115	0.16
6	0.125	0.109	0.098	0.08	0.136
7	0.046	0.046	0.038	0.024	0.05
8	0.003	0.003	0.002	0	0.003
9	reaches shore				
Envelope area>0.001kg/m^2	3.007				

Table 8.4.48 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period in Case of a SSW Wind (unit: km2)

After ebb tide Duration (h)	>0.002 kg/m^2	>0.003 kg/m^2	>0.005 kg/m^2	>0.010kg/m^2	Swept area>0.001kg/m^2
1	0.046	0.046	0.043	0.042	0.046
2	0.05	0.046	0.045	0.043	0.051
3	0.056	0.054	0.05	0.046	0.059
4	0.061	0.061	0.053	0.05	0.062
5	0.032	0.029	0.027	0.026	0.032
6	0.013	0.013	0.013	0.013	0.014
7	reaches shore				
Envelope area>0.001kg/m^2	1.005				

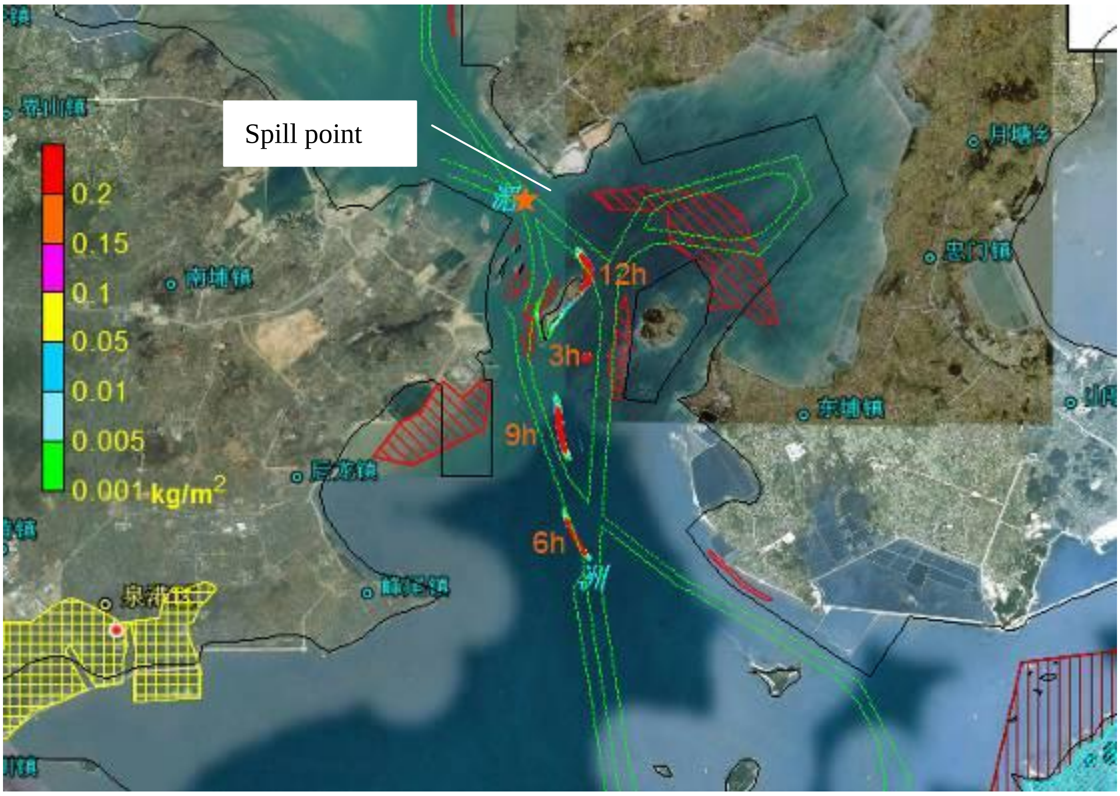


Figure 8.4.75 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Slack Period in Case of Calm Wind (after 3-12 hours)

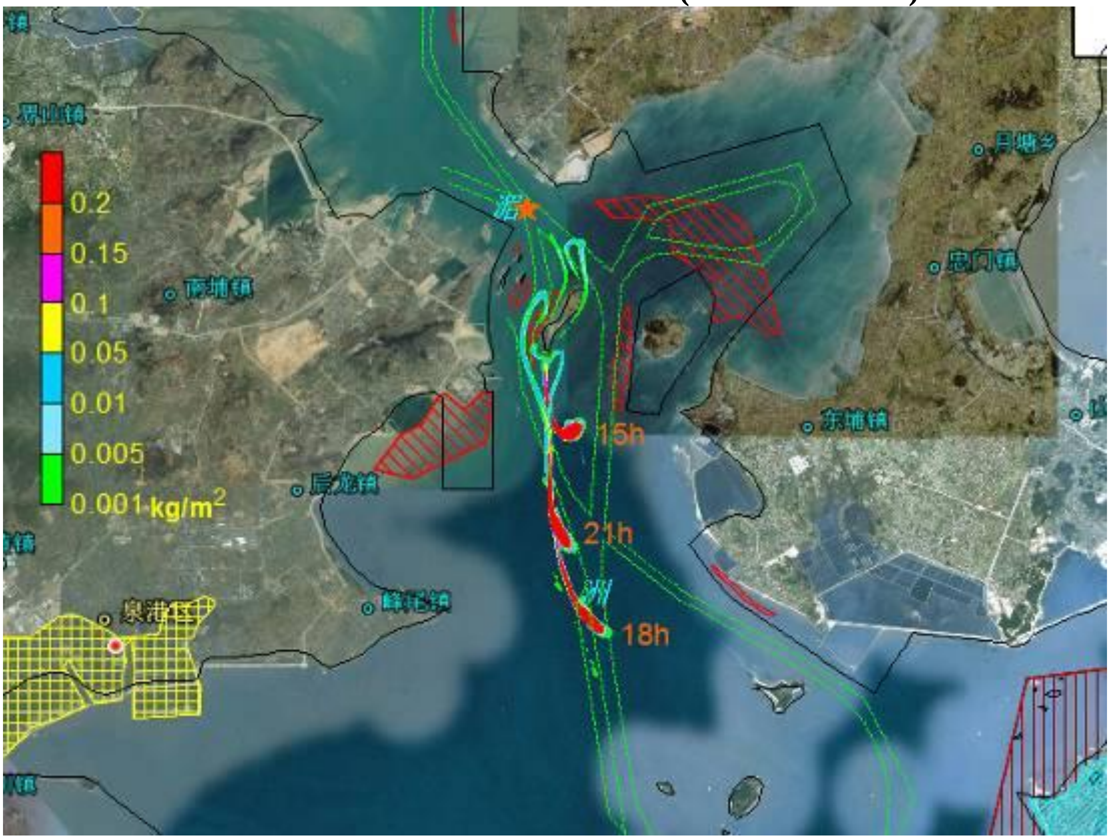


Figure 8.4.76 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Slack Period in Case of Calm Wind (after 15-21 hours)

Figure 8.4.77 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Slack Period in Case of Calm Wind (after 24 hours)

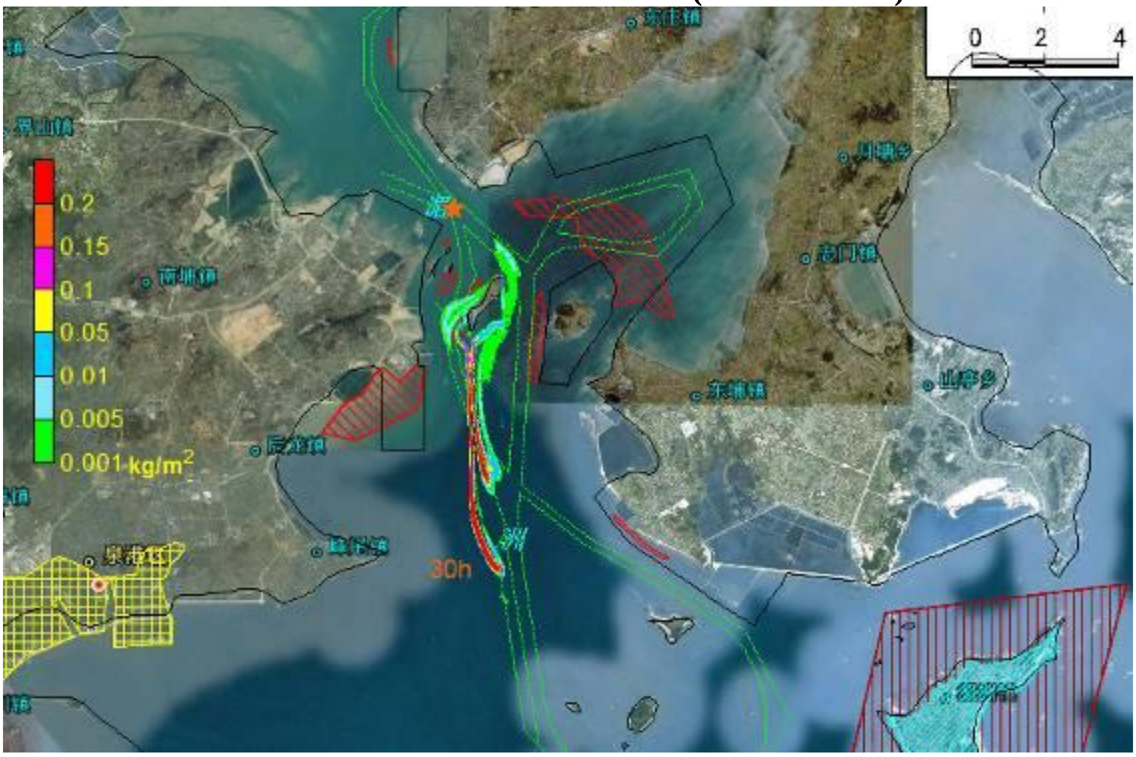


Figure 8.4.78 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Slack Period in Case of Calm Wind (after 30 hours)

Figure 8.4.79 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Slack Period in Case of Calm Wind (after 36 hours)

Figure 8.4.80 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Slack Period in Case of Calm Wind (after 3-12 hours)

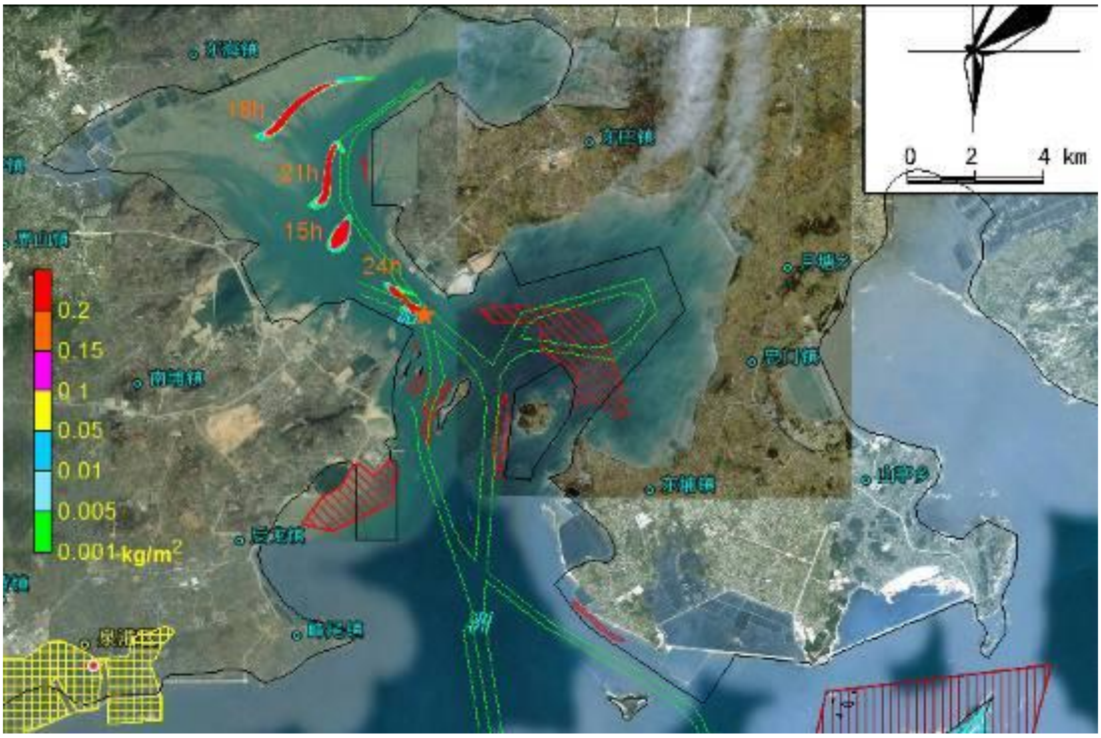


Figure 8.4.81 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Slack Period in Case of Calm Wind (after 15-24 hours)

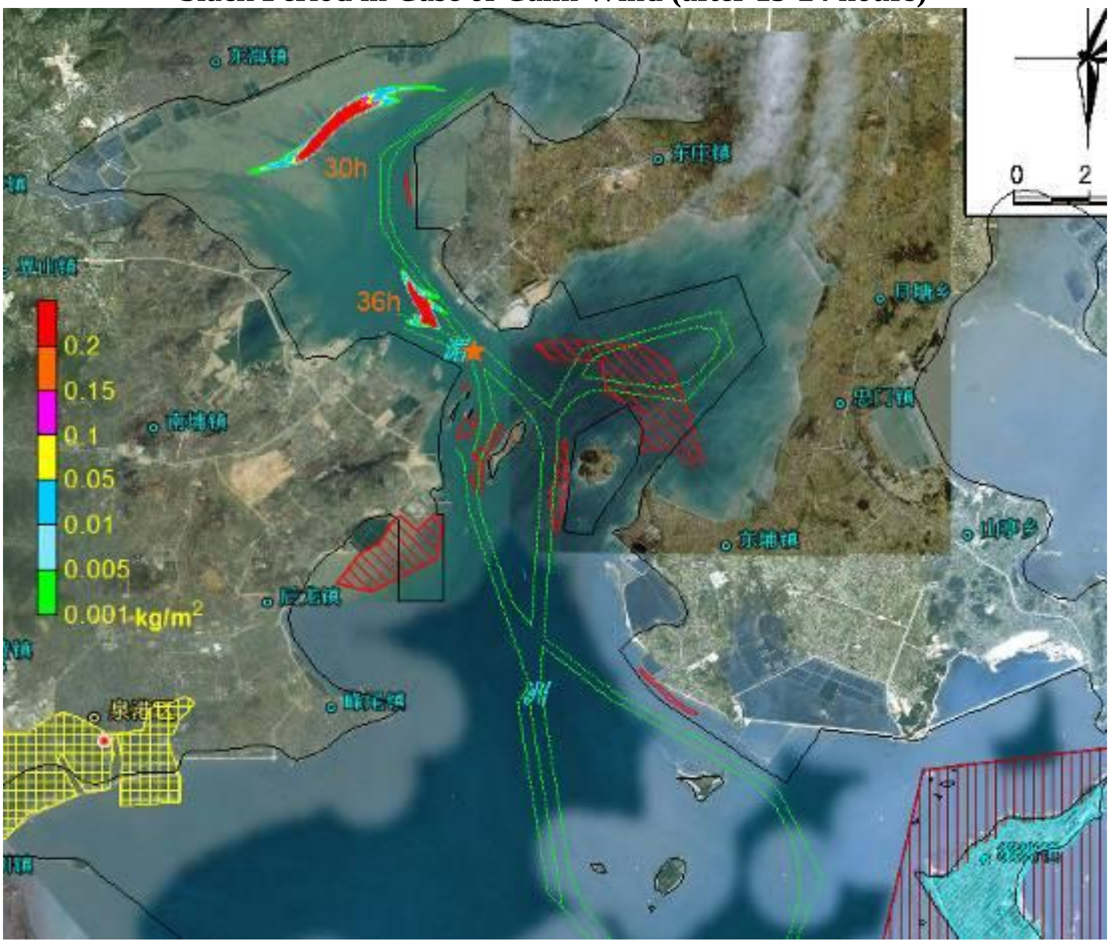


Figure 8.4.82 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Slack Period in Case of Calm Wind (after 30-36 hours)

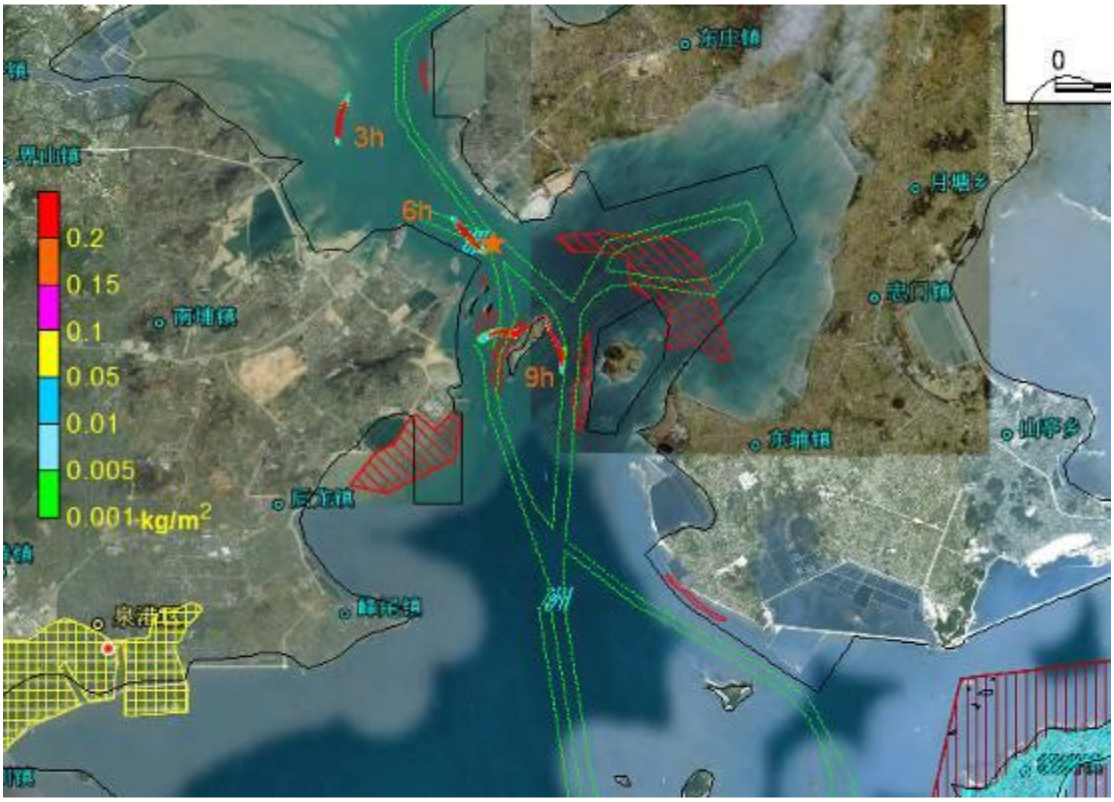


Figure 8.4.83 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of Calm Wind (after 3-9 hours)

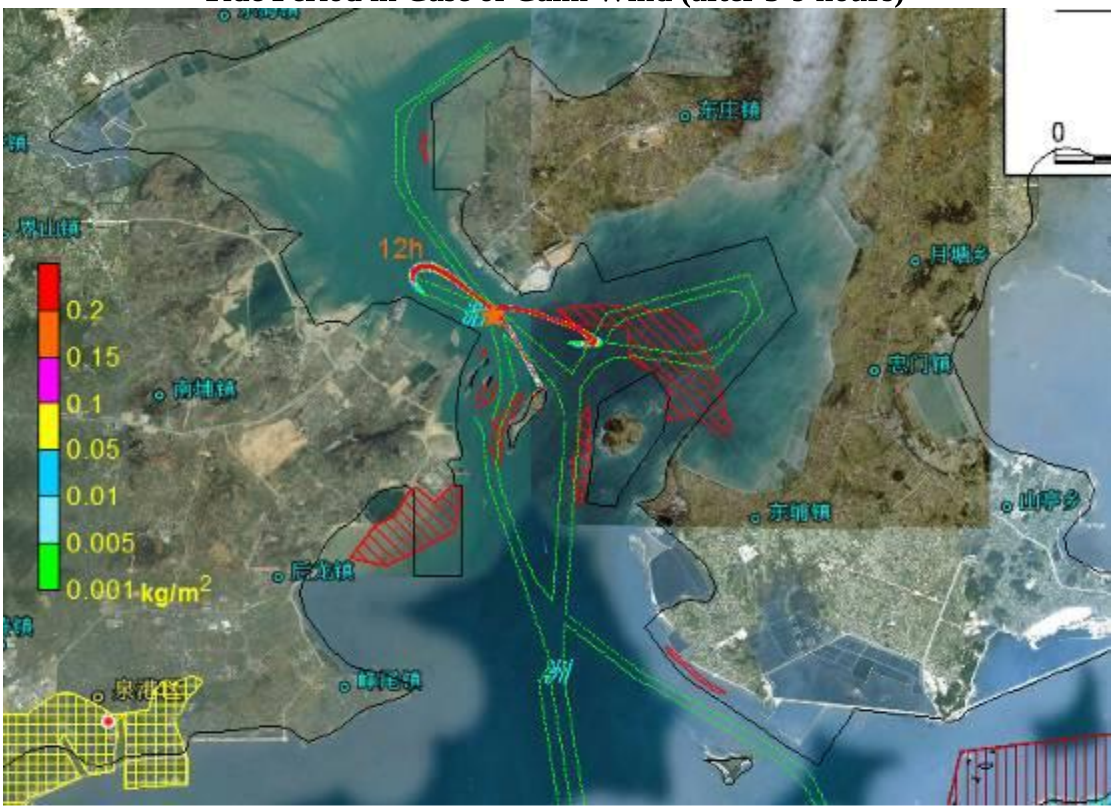


Figure 8.4.84 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of Calm Wind (after 12 hours)

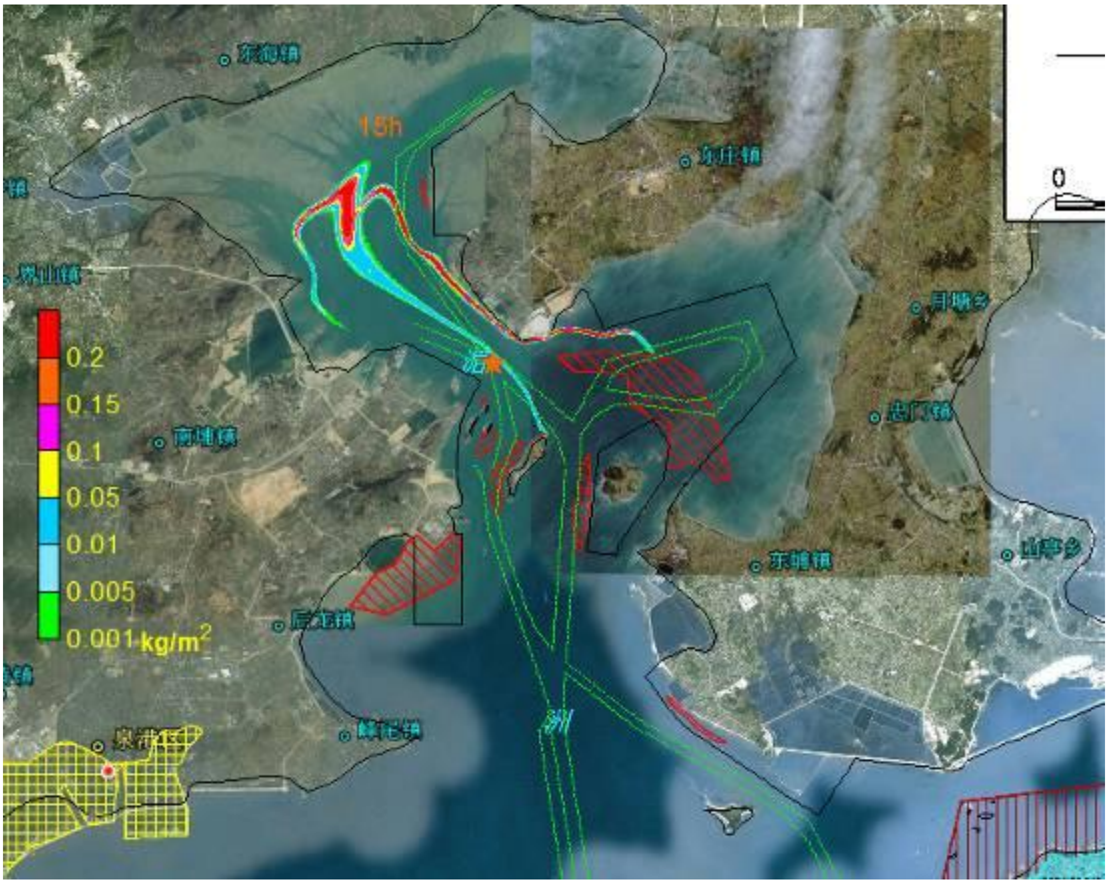


Figure 8.4.85 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of Calm Wind (after 15 hours)

Figure 8.4.86 Impact Scope of Oil Spill Accident Occurred at Point D in Flood

Tide Period in Case of Calm Wind (after 18 hours)

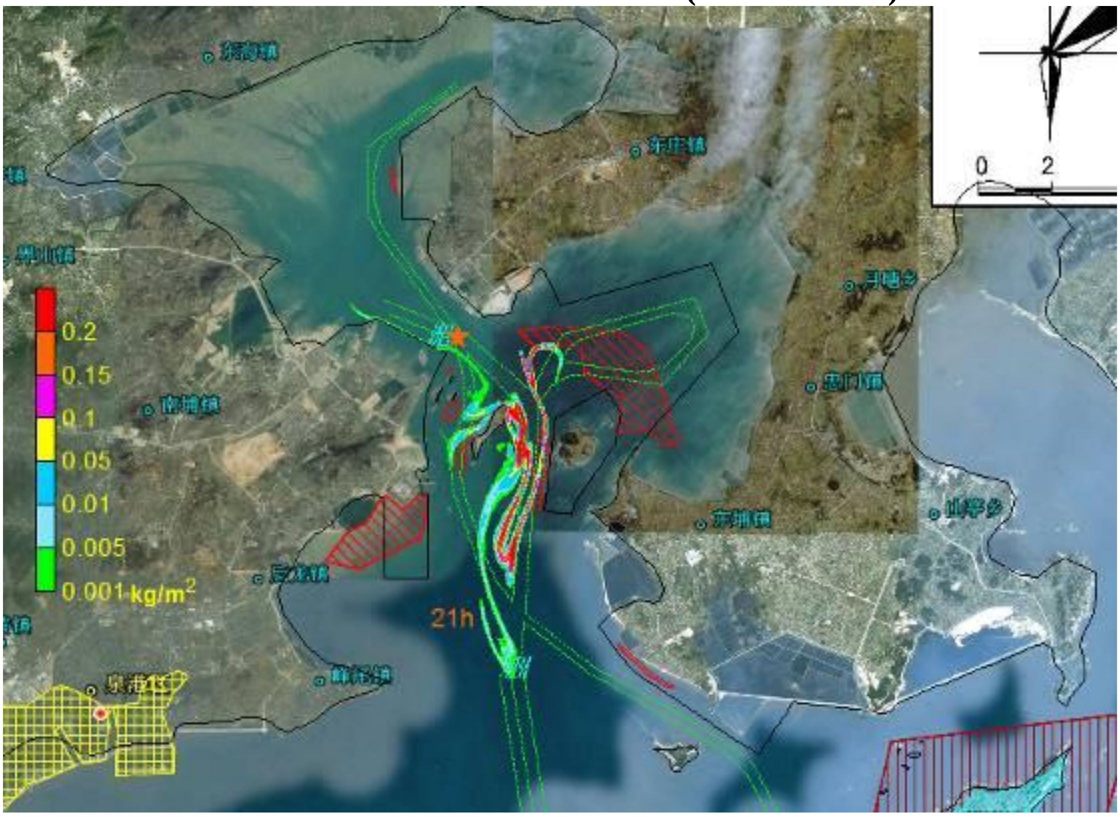


Figure 8.4.87 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of Calm Wind (after 21 hours)

Figure 8.4.88 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of Calm Wind (after 24 hours)

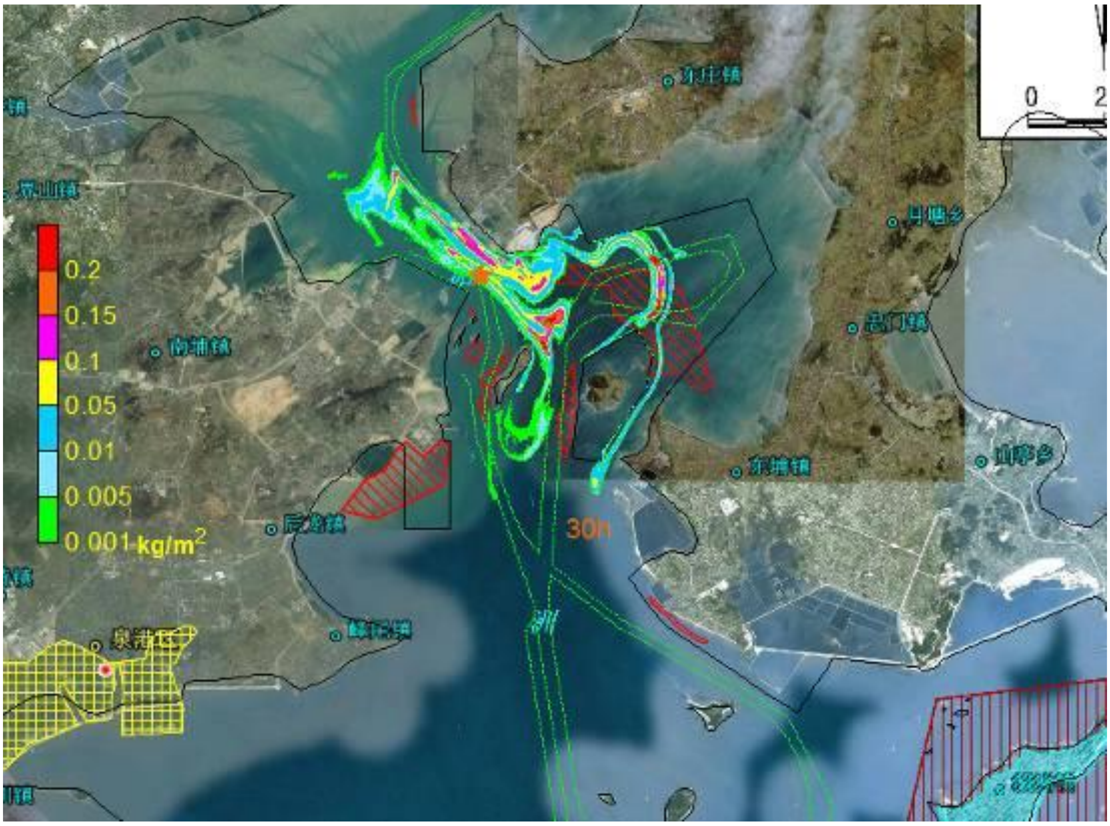


Figure 8.4.89 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of Calm Wind (after 30 hours)

Figure 8.4.90 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of Calm Wind (after 36 hours)

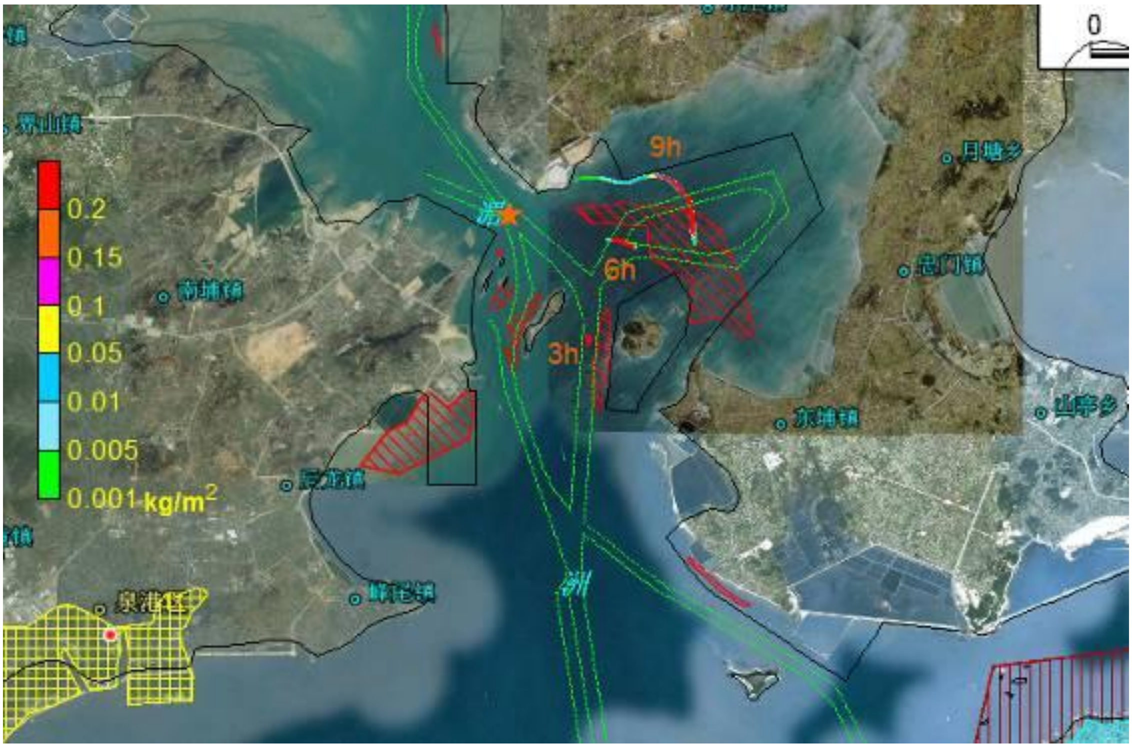


Figure 8.4.91 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period in Case of Calm Wind (after 3-9 hours)

Figure 8.4.92 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period in Case of Calm Wind (after 12-15 hours)

Figure 8.4.93 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period in Case of Calm Wind (after 18-21 hours)

Figure 8.4.94 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period in Case of Calm Wind (after 24 hours)

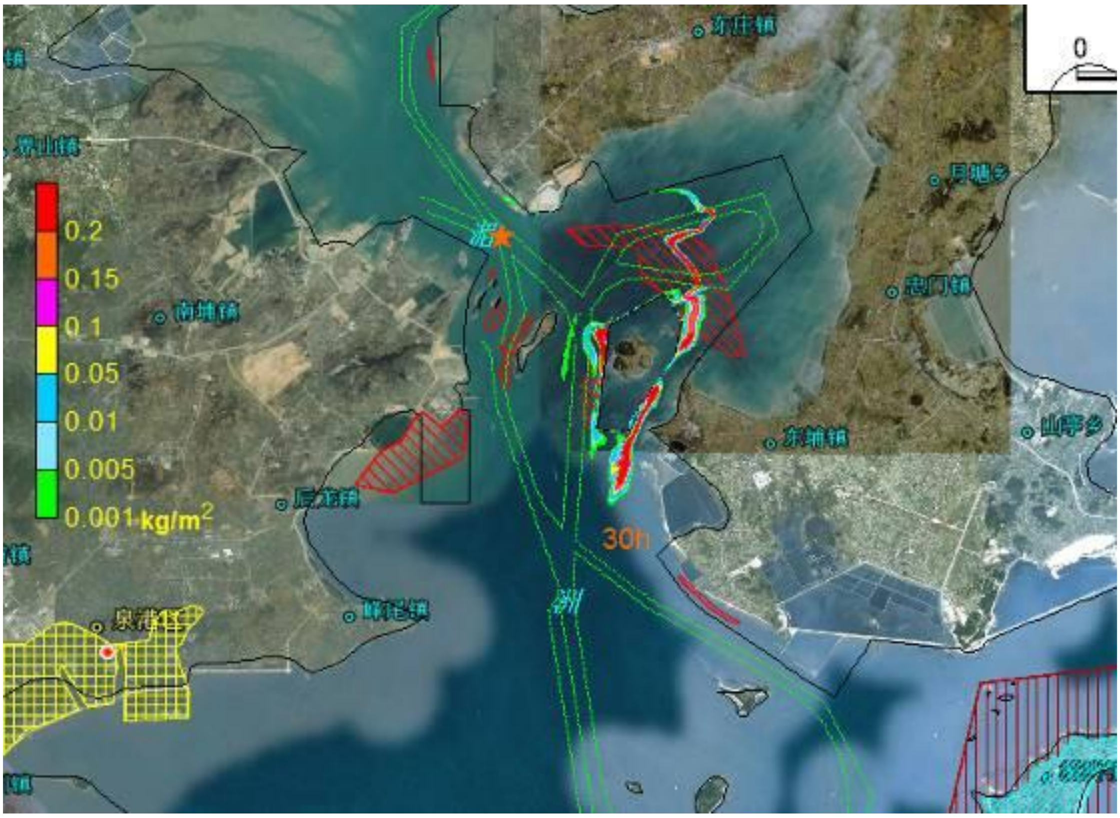


Figure 8.4.95 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period in Case of Calm Wind (after 30 hours)

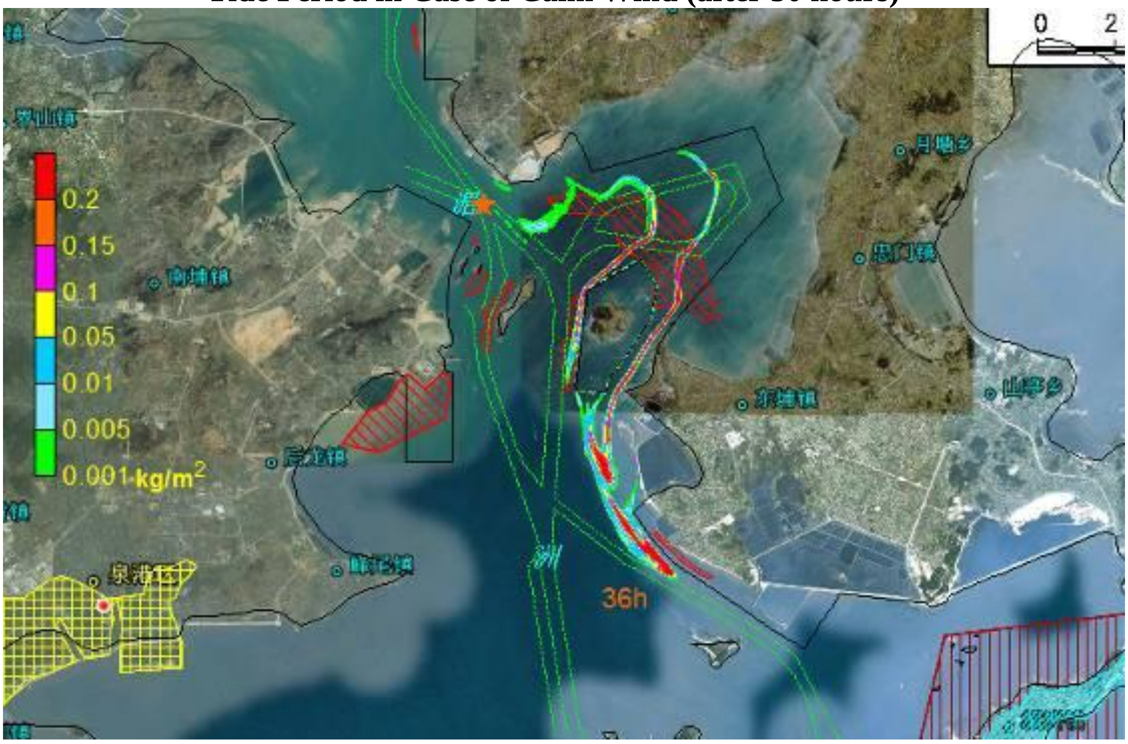


Figure 8.4.96 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period in Case of Calm Wind (after 36 hours)

Figure 8.4.97 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Slack Period in Case of a NE Wind (after 3 hours)

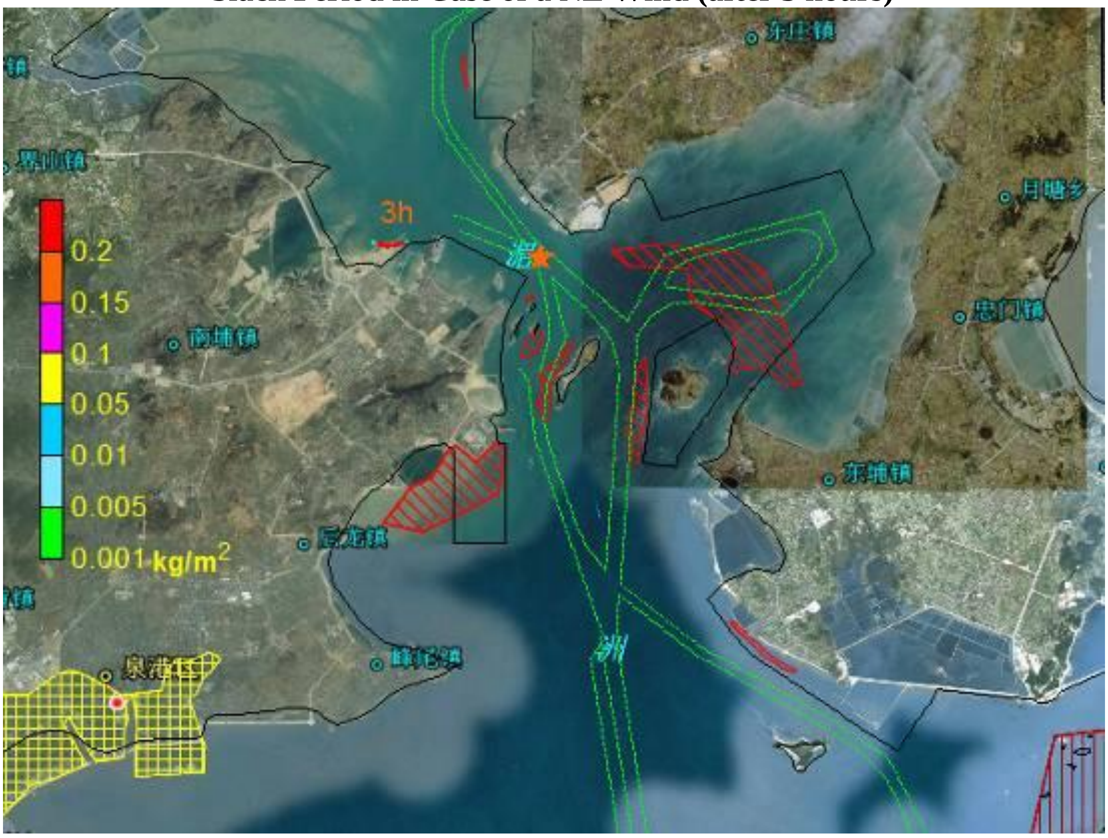


Figure 8.4.98 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of a NE Wind (after 3 hours)

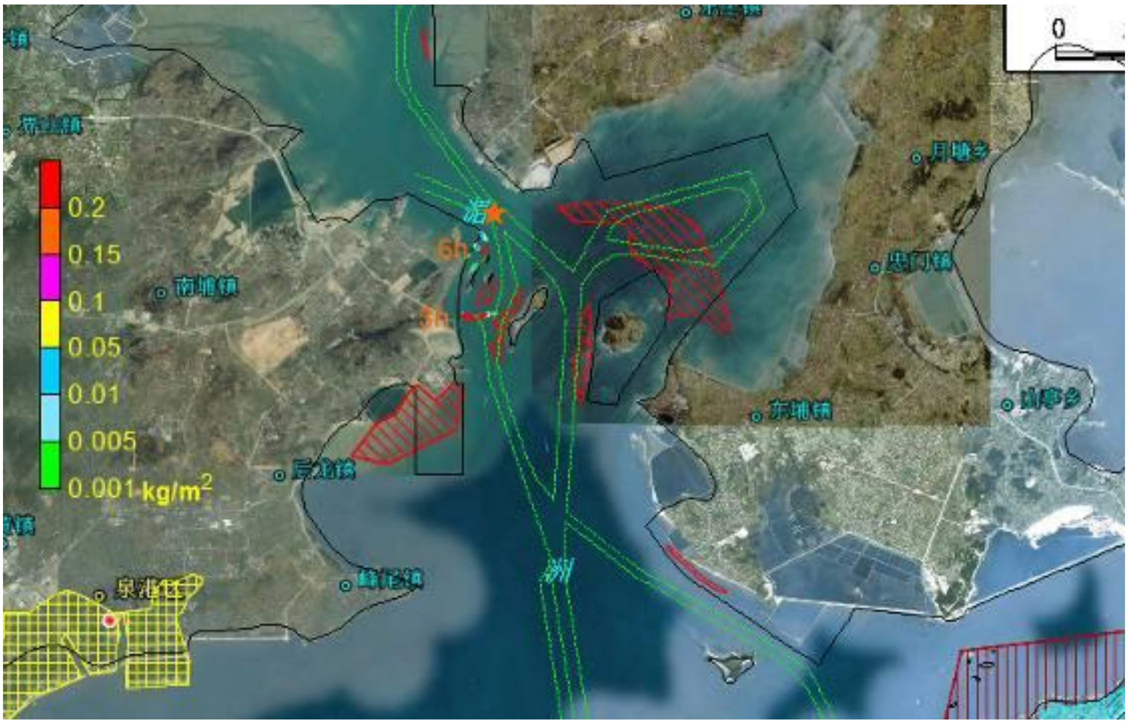


Figure 8.4.99 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period in Case of a NE Wind (after 3-6 hours)

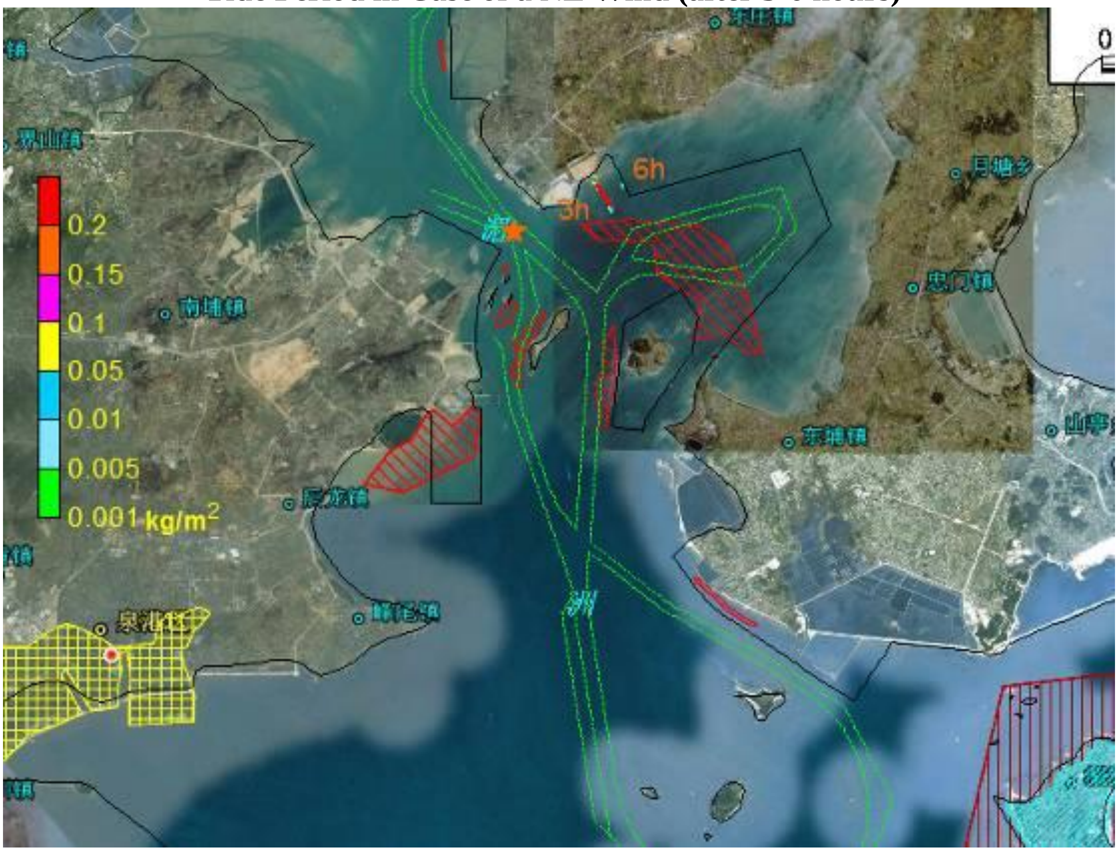


Figure 8.4.100 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Slack Period in Case of a SSW Wind (after 3-6 hours)

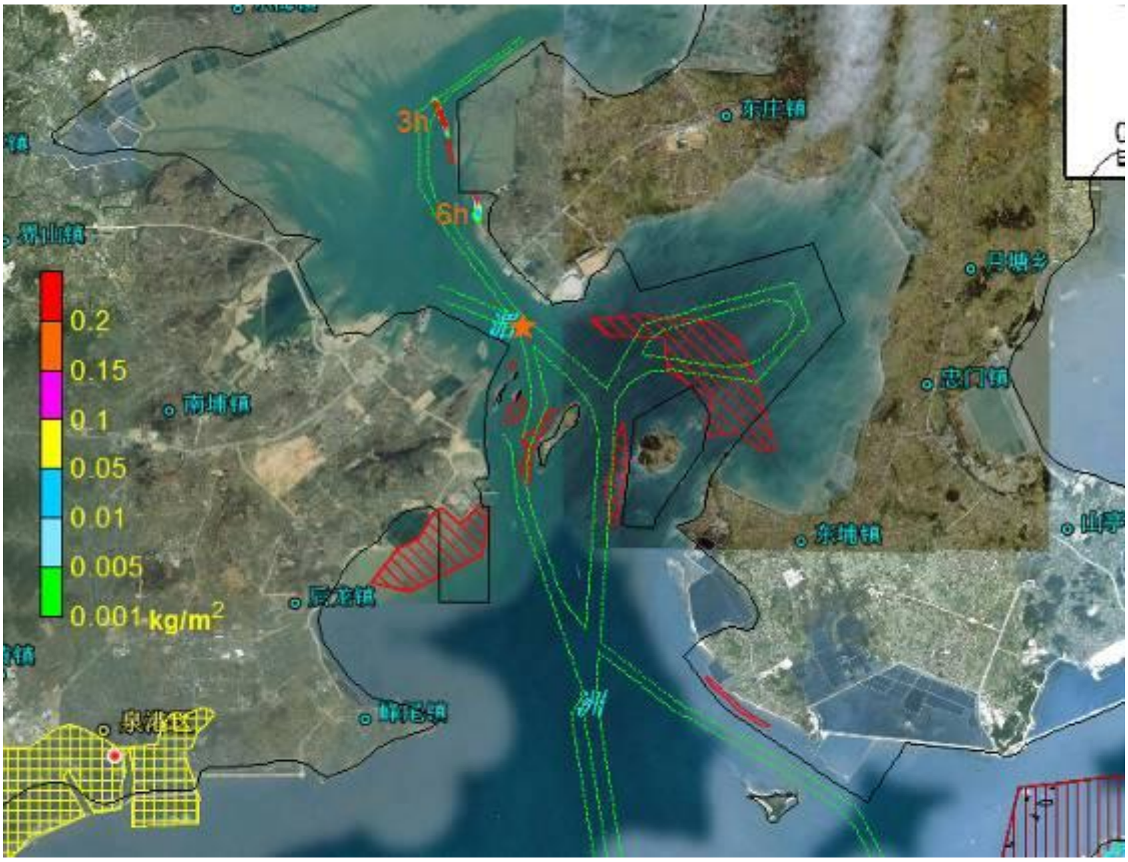


Figure 8.4.101 Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period in Case of a SSW Wind (after 3-6 hours)

Figure 8.4.102 Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period in Case of a SSW Wind (after 3-6 hours)

8.4.2.5 Maximum Impact Scope

According to the above forecasts, Table 8.4.49 provides the maximum impact scope of respective forecast points in different periods after 36 hours.

Table 8.4.49 Maximum Impact Scope after 36 Hours upon the Occurrence of Oil Spill Accident (Unit: km2)
(Concentration> 0.001kg/m^2)

Wind	Calm Wind				NE Wind				SSW Wind			
Period / Location	Flood slack	Ebb slack	Flood tide	Ebb tide	Flood slack	Ebb slack	Flood tide	Ebb tide	Flood slack	Ebb slack	Flood tide	Ebb tide
A	27.92	108.08	88.57	69.79	33.50	8.10	7.96	19.12	49.78	5.58	17.29	16.98
B	40.37	53.12	12.46	20.30	4.41	1.25	46.31	2.56	1.22	6.79	2.91	15.31
C	17.54	33.84	33.80	25.62	3.93	1.26	1.01	1.82	1.18	0.57	0.51	6.09
D	33.31	17.47	65.36	41.59	0.60	0.37	2.26	2.54	1.75	0.16	3.01	1.00

According to Table 8.4.49, it can be concluded that, the oil slicks will make the maximum impact with the concentration greater than 0.001kg/m^2 during calm wind condition universally. Therefore, this assessment gives the maximum impact scope figures in case of calm wind with oil concentration larger than 0.001kg/m^2.

(1) Point A. Figure 8.4.103 through Figure 8.4.106 show the maximum impact scope in different forecast periods.

(2) Point B. Figure 8.4.107 through Figure 8.4.110 show the maximum impact scope in different forecast periods.

(3) Point C. Figure 8.4.111 through Figure 8.4.114 show the maximum impact scope in different forecast periods.

(4) Point D. Figure 8.4.115 through Figure 8.4.118 show the maximum impact scope in different forecast periods.

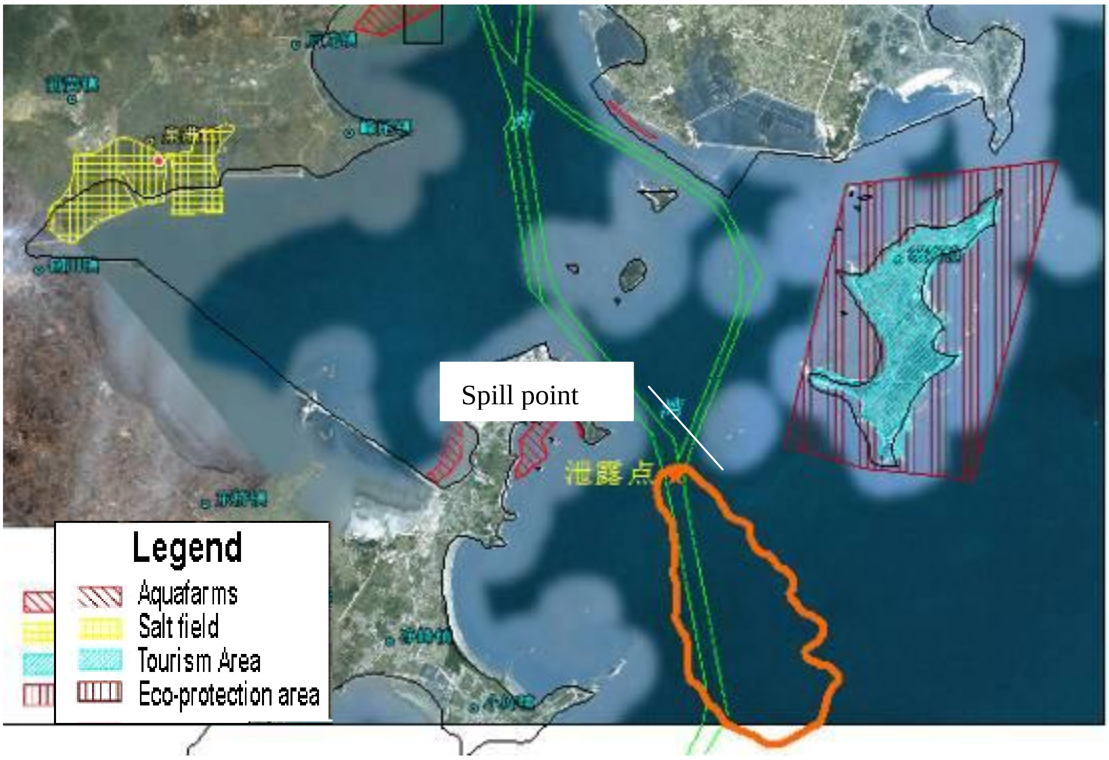


Figure 8.4.103 Maximum Impact Scope of Oil Spill Accident Occurred at Point A in Flood Slack Period After 36 Hours in Case of Calm Wind

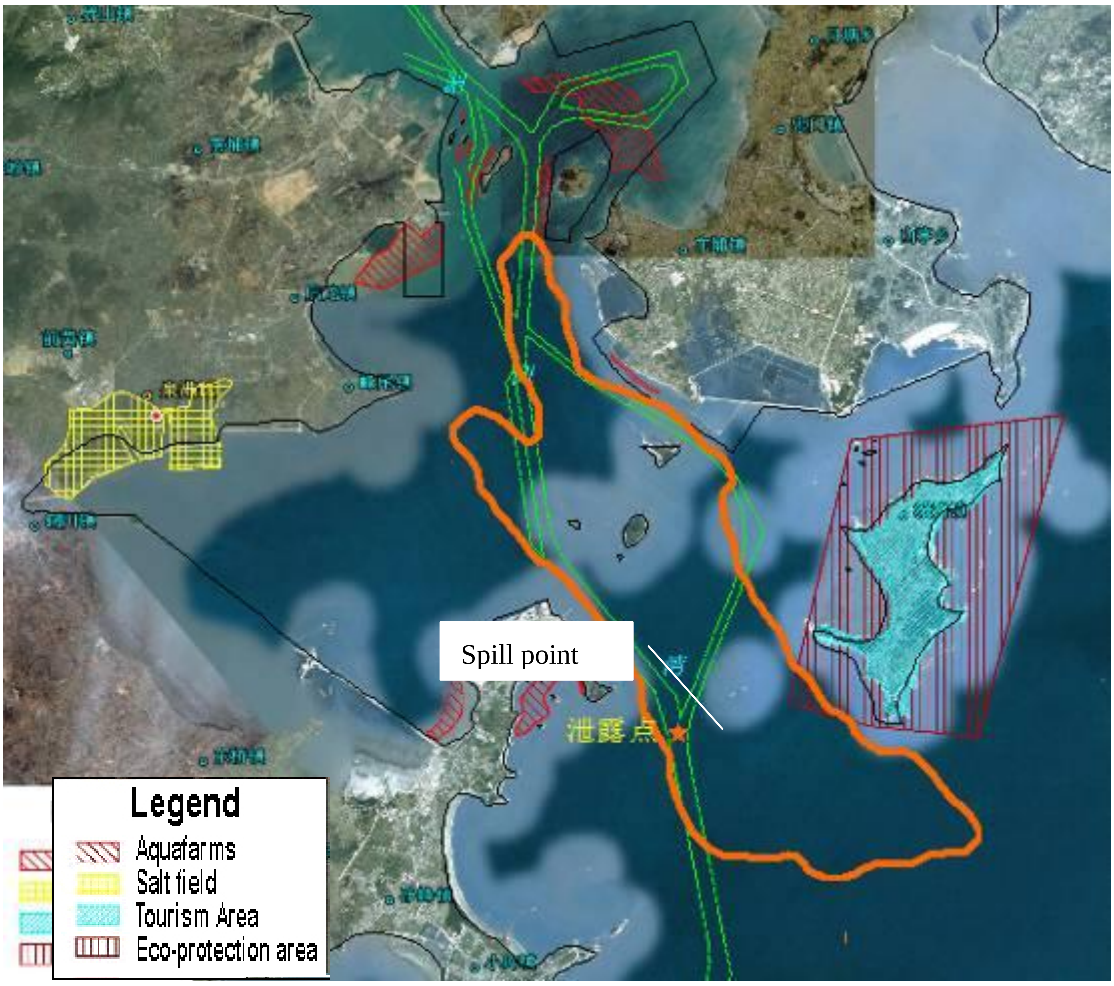


Figure 8.4.104 Maximum Impact Scope of Oil Spill Accident Occurred at Point

A in Ebb Slack Period After 36 Hours in Case of Calm Wind

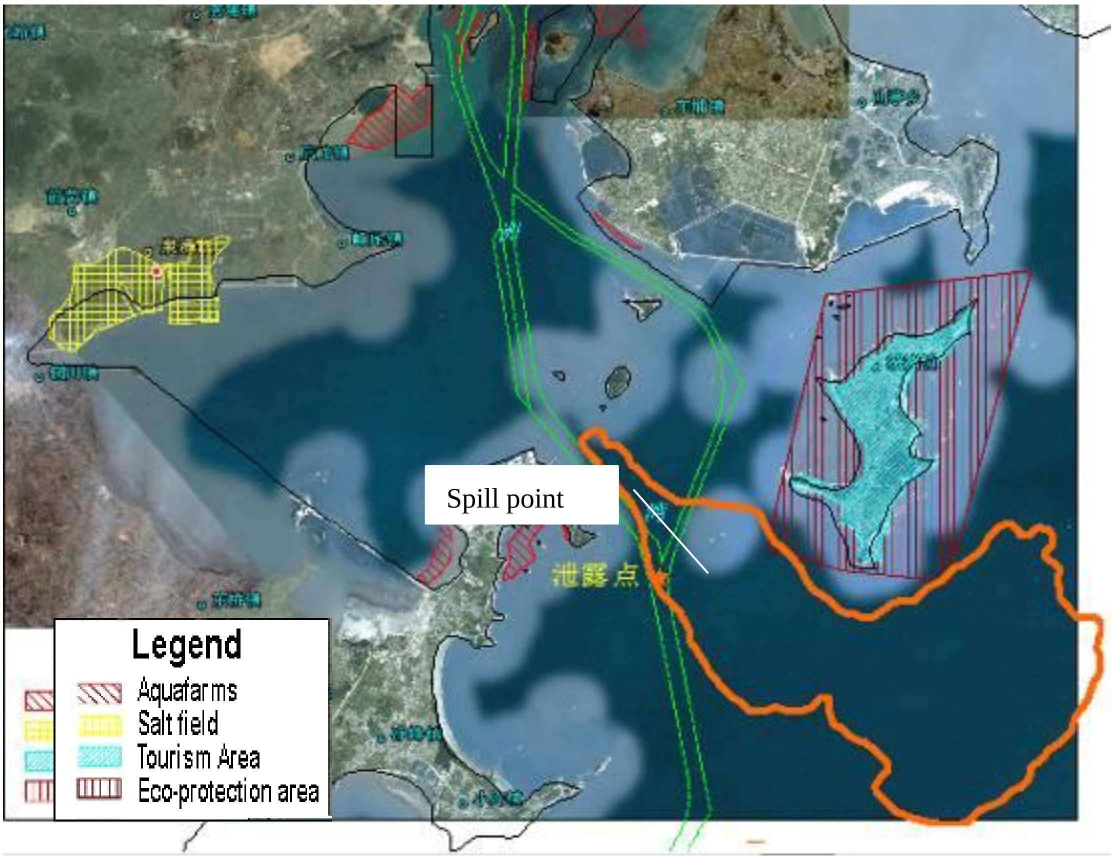


Figure 8.4.105 Maximum Impact Scope of Oil Spill Accident Occurred at Point A in Flood Tide Period After 36 Hours in Case of Calm Wind

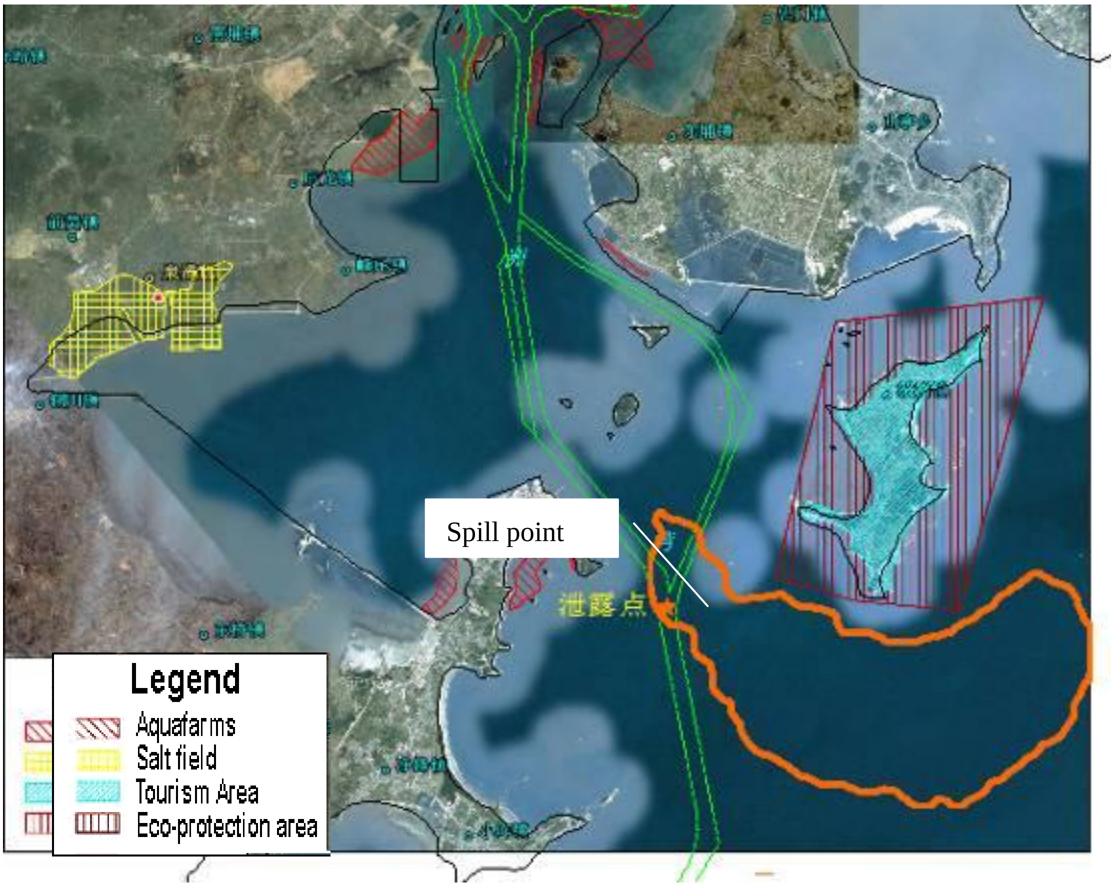


Figure 8.4.106 Maximum Impact Scope of Oil Spill Accident Occurred at Point A in Ebb Tide Period After 36 Hours in Case of Calm Wind

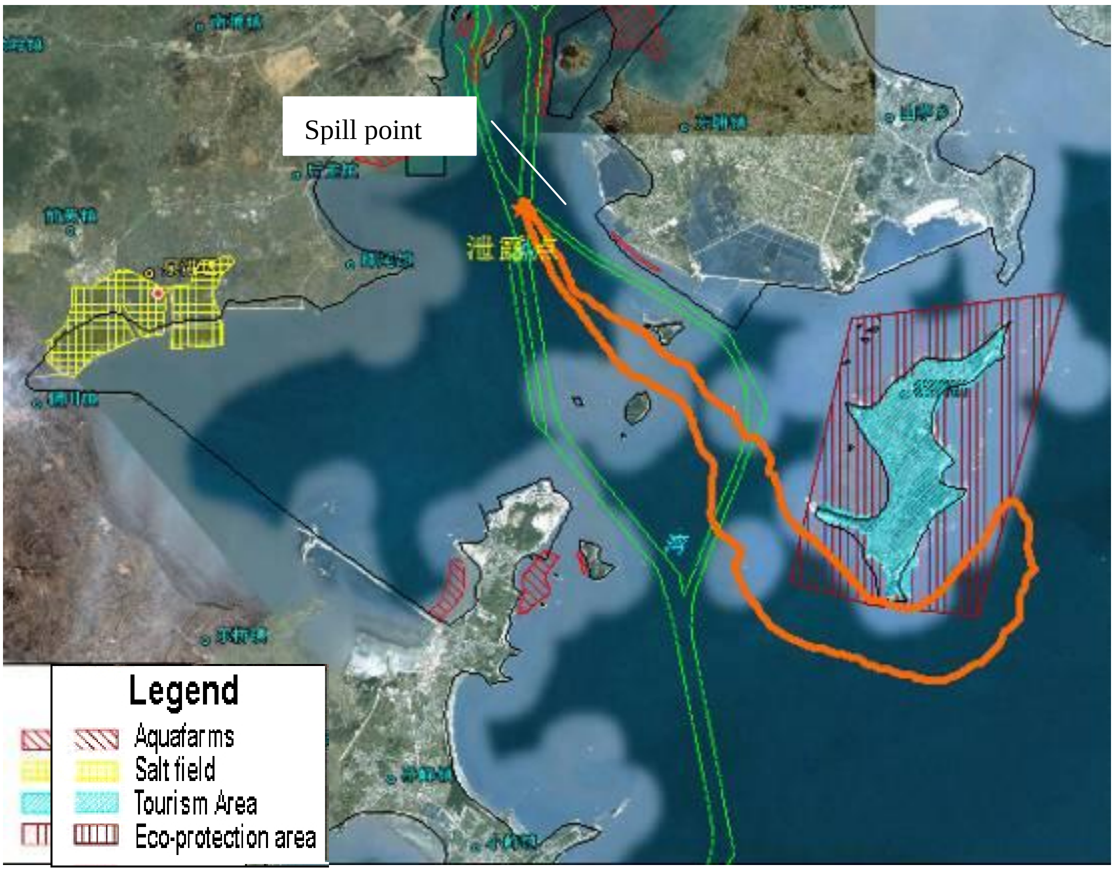


Figure 8.4.107 Maximum Impact Scope of Oil Spill Accident Occurred at Point B in Flood Slack Period After 36 Hours in Case of Calm Wind

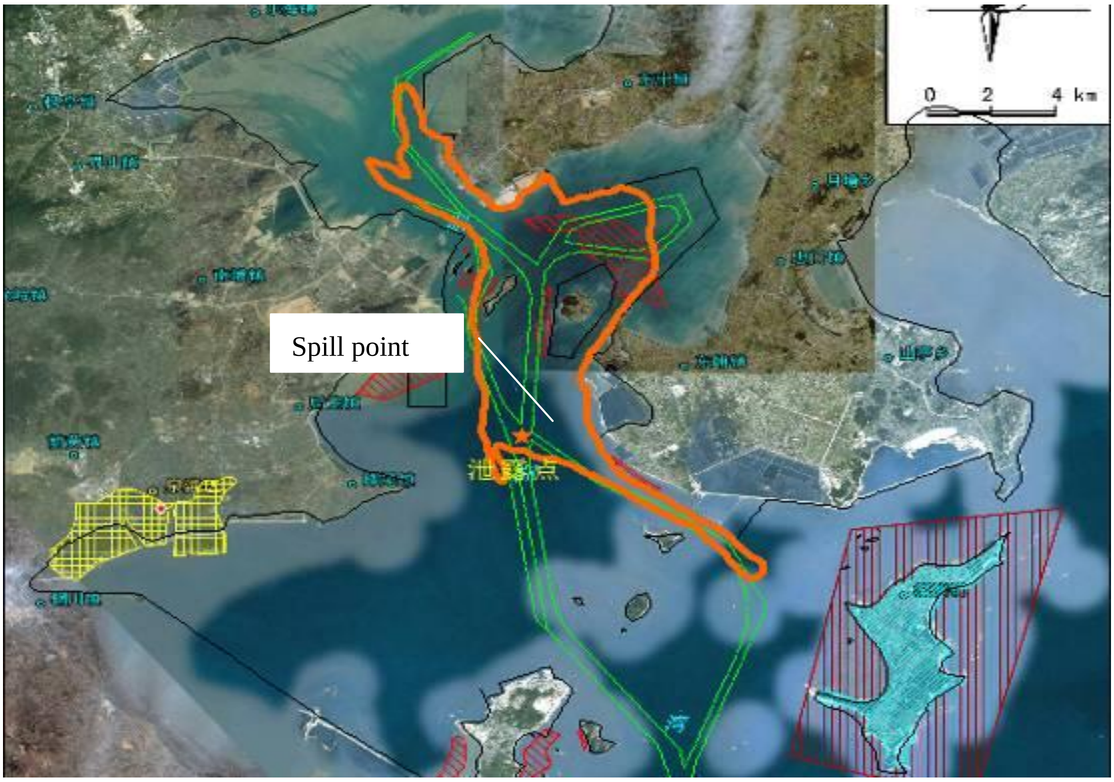


Figure 8.4.108 Maximum Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Slack Period After 36 Hours in Case of Calm Wind

Figure 8.4.109 Maximum Impact Scope of Oil Spill Accident Occurred at Point B in Flood Tide Period After 36 Hours in Case of Calm Wind

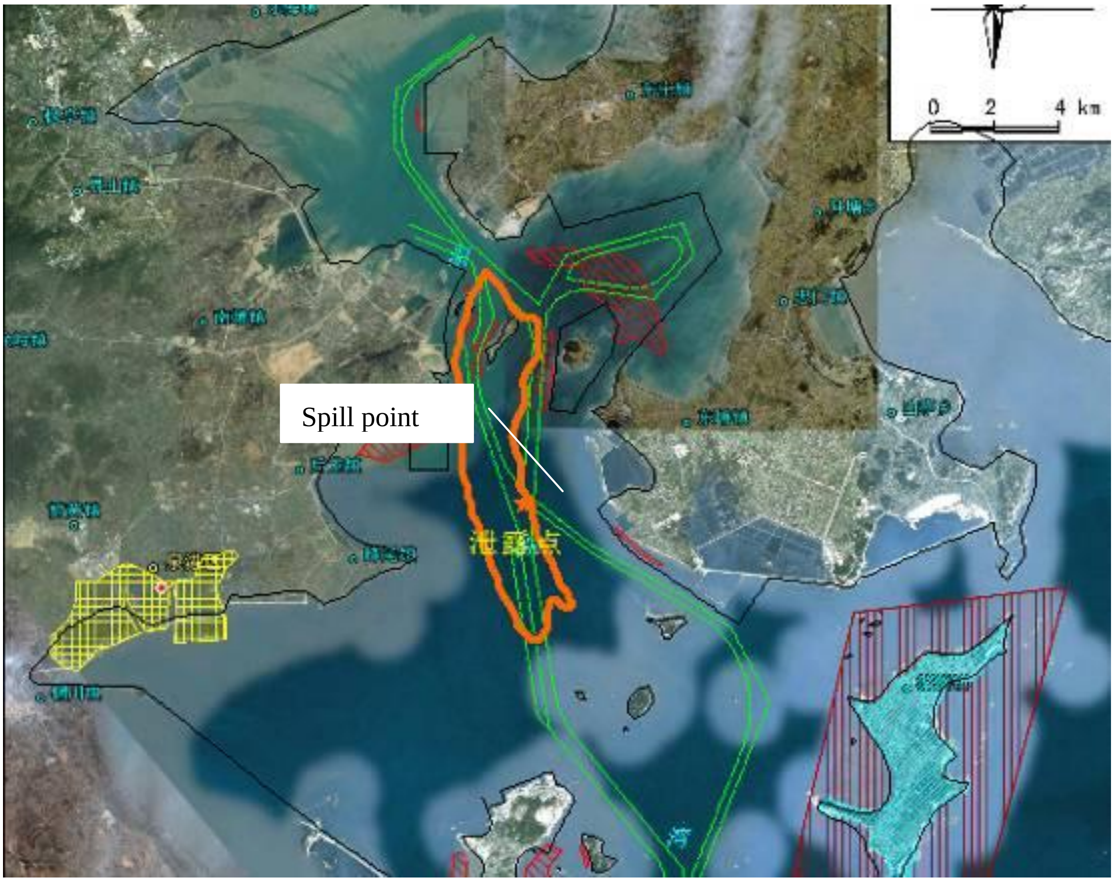


Figure 8.4.110 Maximum Impact Scope of Oil Spill Accident Occurred at Point B in Ebb Tide Period After 36 Hours in Case of Calm Wind

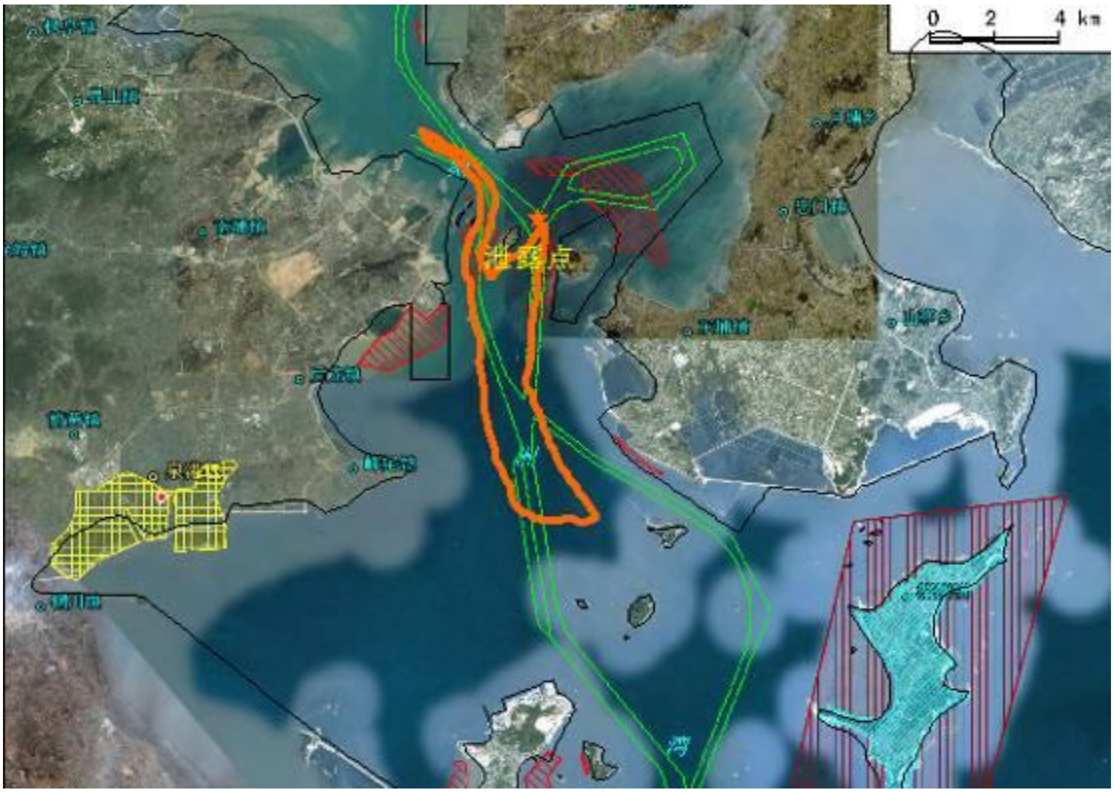


Figure 8.4.111 Maximum Impact Scope of Oil Spill Accident Occurred at Point C in Flood Slack Period After 36 Hours in Case of Calm Wind

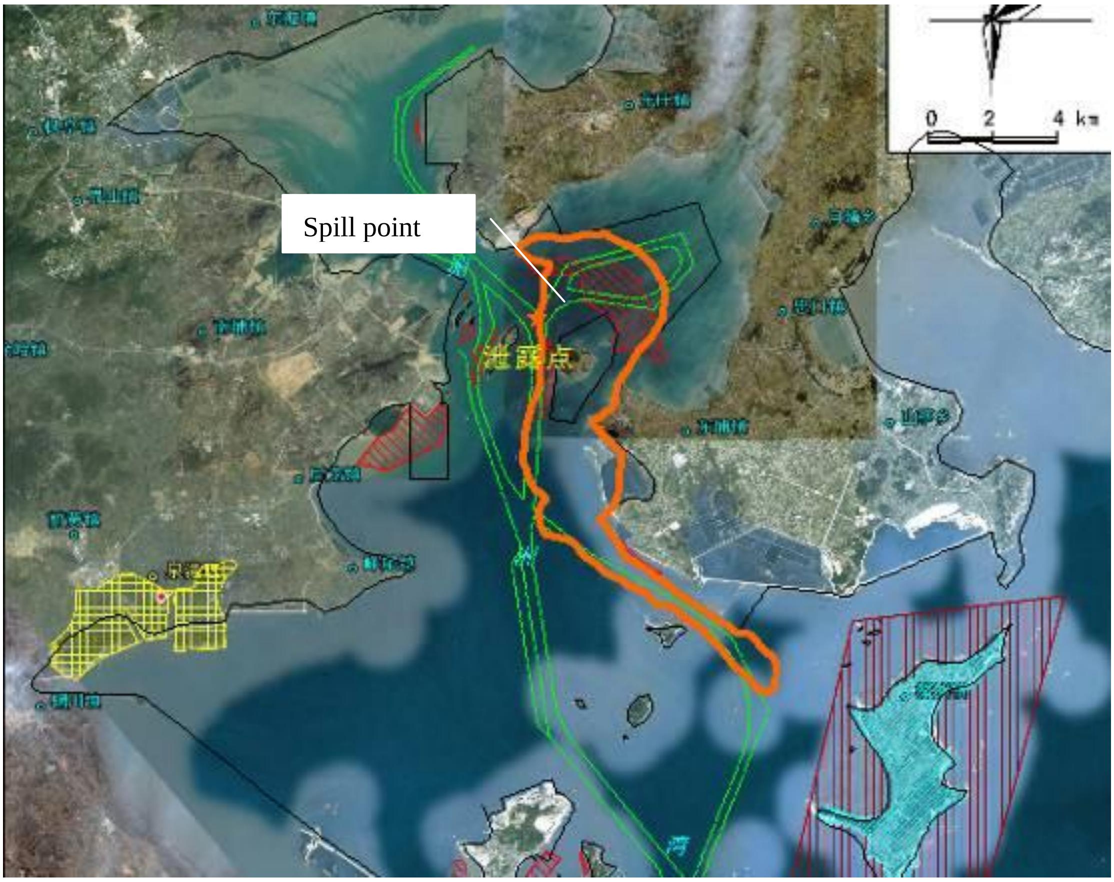


Figure 8.4.112 Maximum Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Slack Period After 36 Hours in Case of Calm Wind

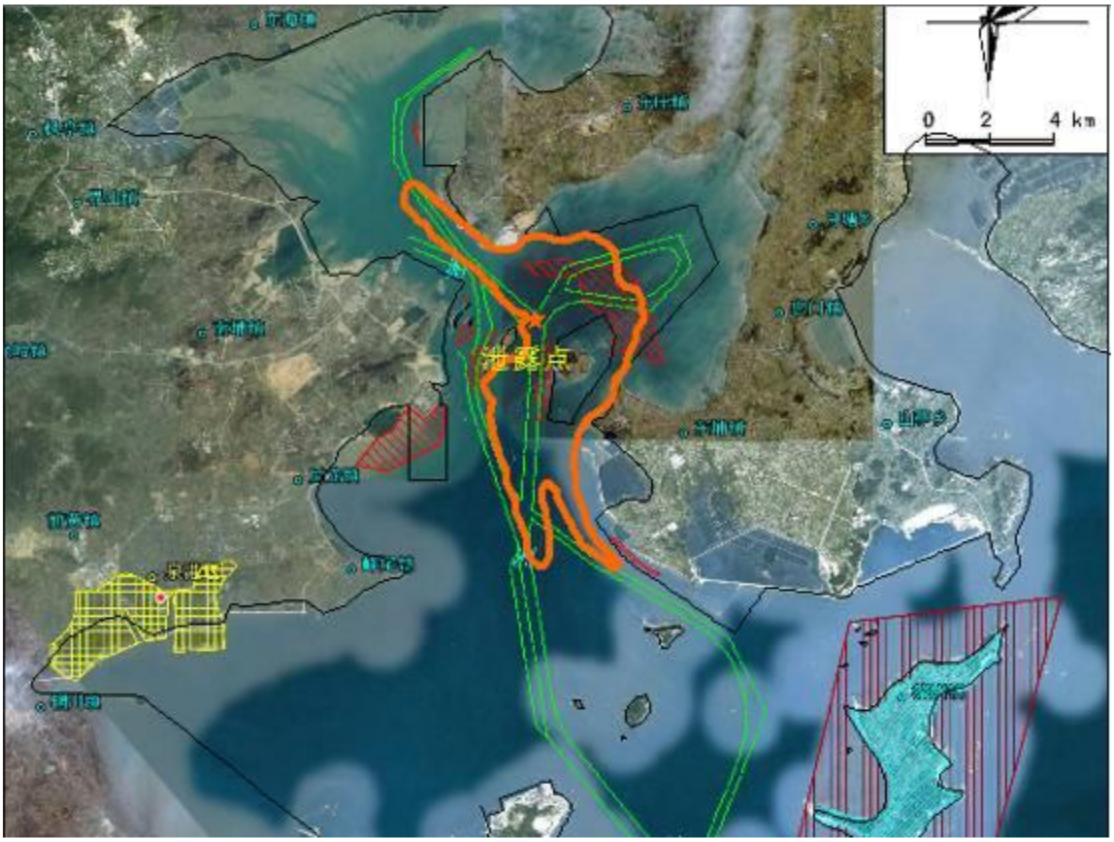


Figure 8.4.113 Maximum Impact Scope of Oil Spill Accident Occurred at Point C in Flood Tide Period After 36 Hours in Case of Calm Wind

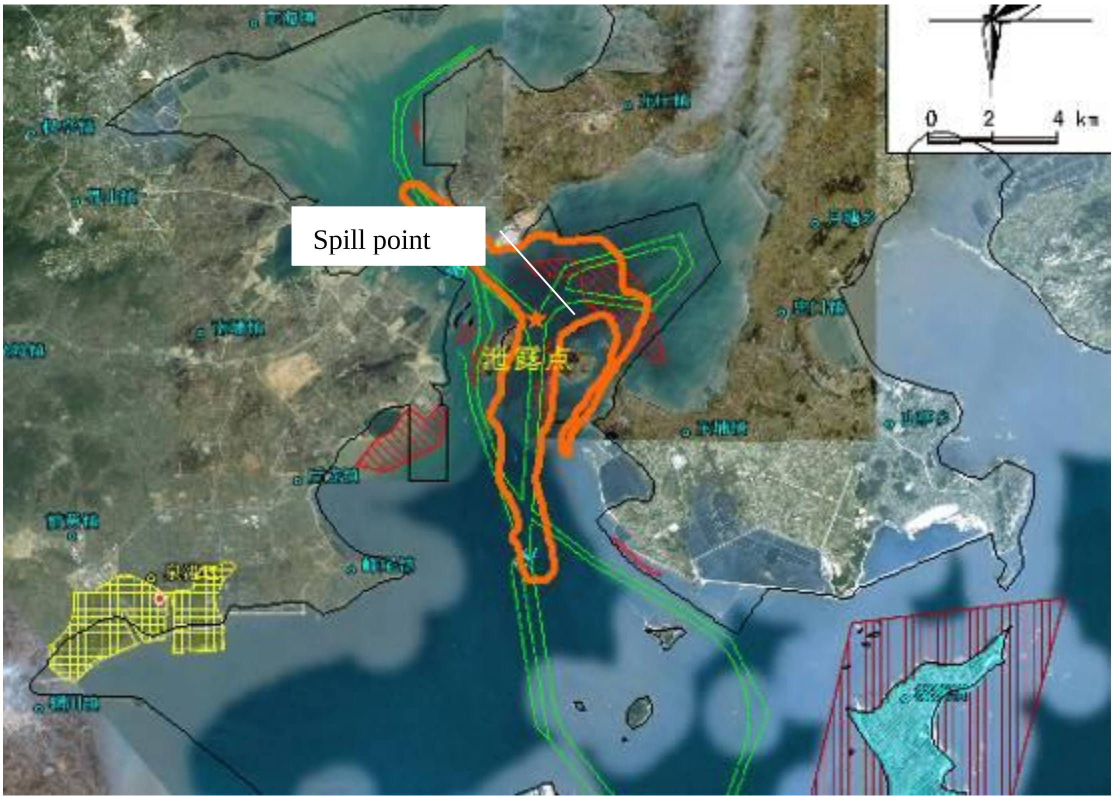


Figure 8.4.114 Maximum Impact Scope of Oil Spill Accident Occurred at Point C in Ebb Tide Period After 36 Hours in Case of Calm Wind

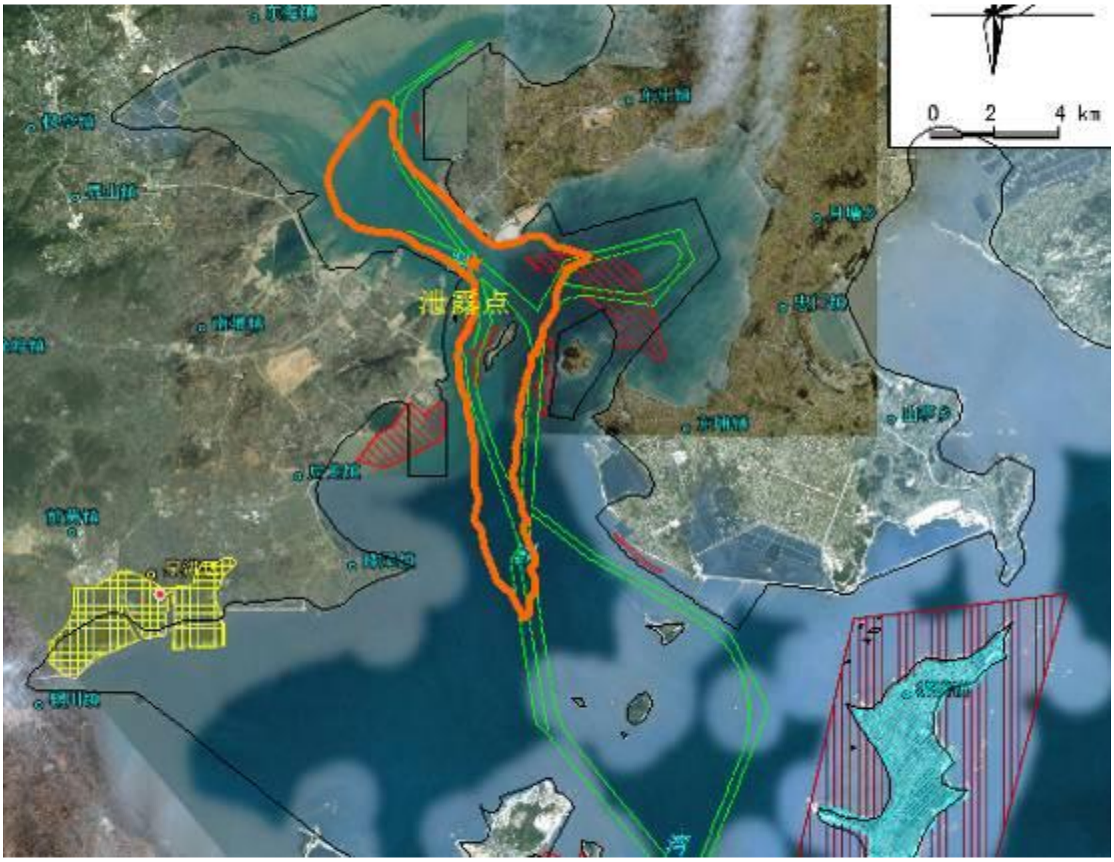


Figure 8.4.115 Maximum Impact Scope of Oil Spill Accident Occurred at Point

D in Flood Slack Period After 36 Hours in Case of Calm Wind

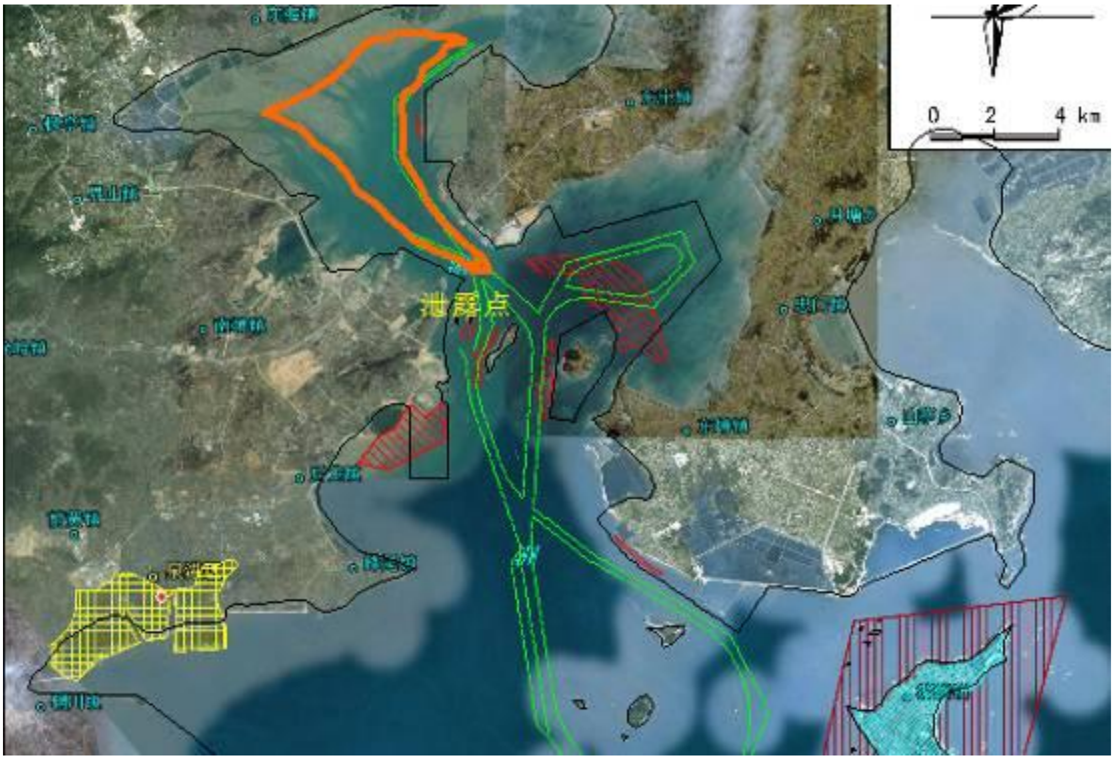


Figure 8.4.116 Maximum Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Slack Period After 36 Hours in Case of Calm Wind

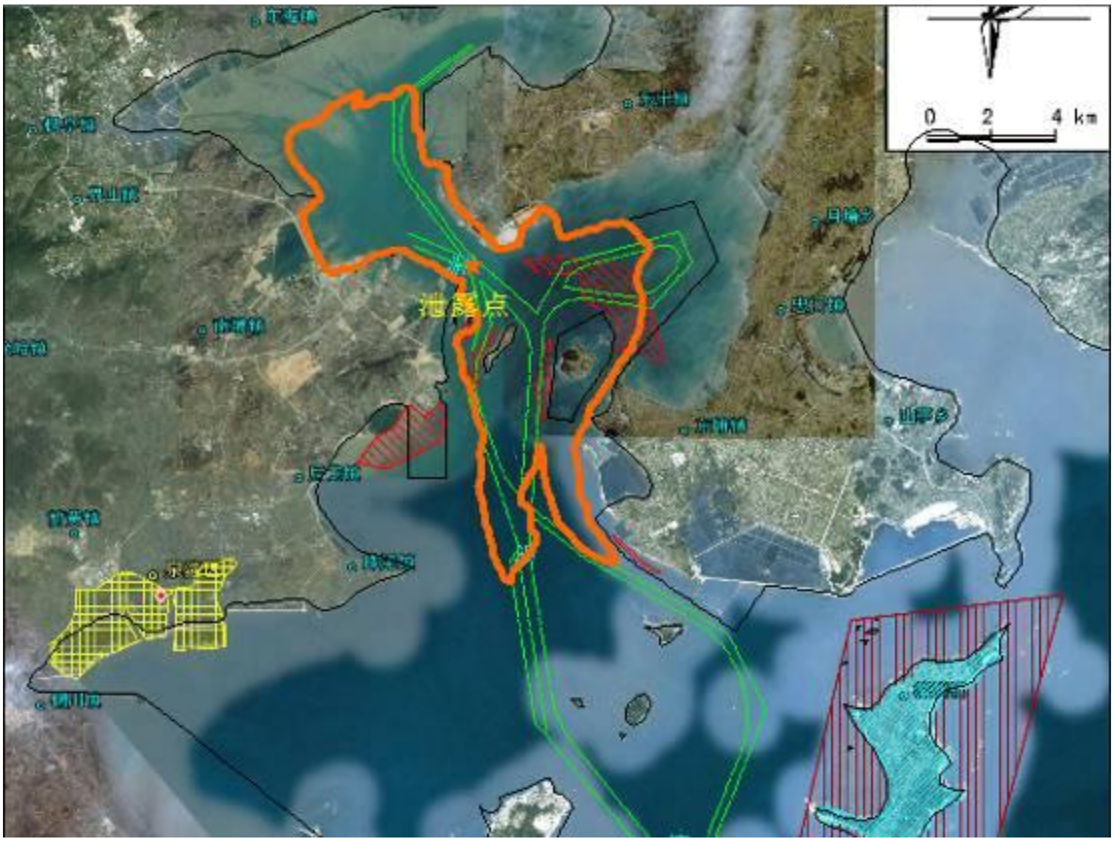


Figure 8.4.117 Maximum Impact Scope of Oil Spill Accident Occurred at Point D in Flood Tide Period After 36 Hours in Case of Calm Wind

Spill point

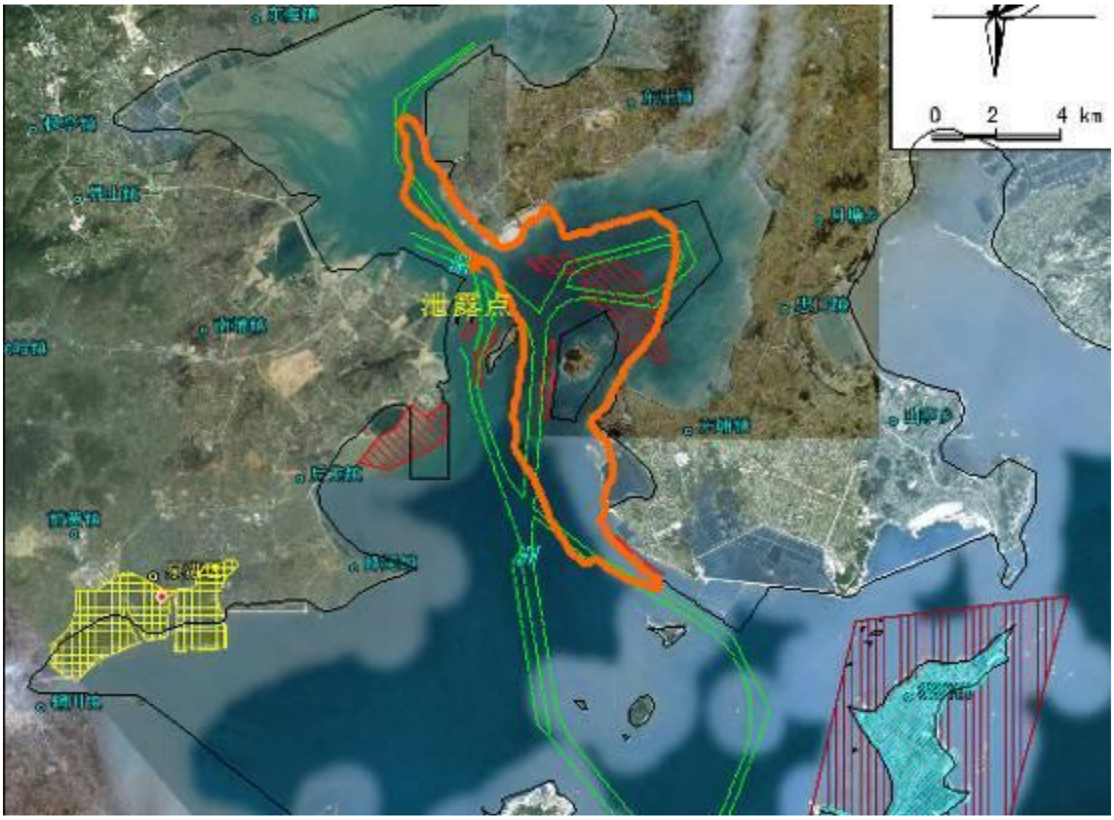


Figure 8.4.118 Maximum Impact Scope of Oil Spill Accident Occurred at Point D in Ebb Tide Period After 36 Hours in Case of Calm Wind

8.4.2.6 Summary of Oil Spill Risk Assessment

The oil spill risk assessment firstly identifies potential oil spill location and predicts oil spill accident probability in the year of 2015, 2020 and 2030 based on statistics analysis of oil spill accidents at global level, domestic level, and Meizhou Bay area. Oil Particle modeling that takes into account current field is employed to predict the oil slick movement, landing timing and location, dispersion distance, impact area and potentially affected sensitive receptors. Based on the analysis, the following conclusions can be made.

- Modeling of typical oil spill accident indicates potentially affected receptors include the Meizhou Island ecological protected area, aquaculture area, channel and anchorage areas, and port area, etc. In case oil spill takes place, oil fence shall be employed to control the movement of oil slicks as early as possible.
- The most sensitive receptors that would be potentially affected by the oil spill accidents is the Meizhou Island ecological protected area, including the mangroves in its western part facing the Meizhou Bay. In case substantial spill accident takes place, the negative impacts on the protected area and mangroves will be long-term and substantial. Strict navigation supervision and emergency response plans must be in place to control and minimize the risks and be able take immediate measures once needed.
- It is recommended that emergency equipments such as offloading, recovery, fencing, oil dispersion and adoption, storage and transportation shall be in place for Meizhou Bay port, which will enable rapid fielding, fencing and control, recovery and clean-up measures implemented once oil spill accidents

take place.

- Prevention measures for oil spill accidents are preferred. It is recommended that traffic management and information communication system to be enhanced to minimize the probability of ship collisions, rock striking, and stranding accidents.
- It is recommended to coordinate regional oil spill response take force to provide effective guarantee for minimizing oil spill pollution.

Oil spill accident prevention and urgency response has been attached great importance at national, domestic and port management level. Along with the development of Meizhou Bay navigation channel and port, tiered management plans have been developed and/or being implemented to address above concerns and recommendations, as presented in section 8.6.

8.5 Prediction of Soluble Chemicals Impact Area

Liyuwei operating zone handles substantial methanol and DMF chemicals. Liquid chemical tankers must pass through the junction of branch channel, Liyuwei channel and main channel. Therefore, the spill prediction will focus on this location (Point B in Figure 8.3.1). The single-hatch spill volume of methanol or DMF is assumed to be 500 tons.

8.5.1 Control Equation

The mass transport diffusion equation in water quality model is:

$$\frac{\partial \phi}{\partial t}+U\frac{\partial \phi}{\partial x}+V\frac{\partial \phi}{\partial y}=\frac{1}{h+\zeta}\frac{\partial}{\partial x}[(h+\zeta)D_x\frac{\partial \phi}{\partial x})]+\frac{1}{h+\zeta}\frac{\partial}{\partial y}[(h+\zeta)D_y\frac{\partial \phi}{\partial y}]+S-E \quad (1)$$

In which: ϕ is the average pollutant concentration by water depth; U,V is the mean velocity in vertical (m/s) in X,Y directions, and can be calculated through the hydrodynamic mathematical-model; S,E are source and sink respectively, namely the discharge amount within the unit time and the transfer amount; h and ζ correspond to still water depth and tidal level (m); D_x and D_y correspond to the diffusion coefficient in X,Y directions, and can be calculated via Elder equation.

$$(D_x,D_y)=\frac{5.93}{C}\sqrt{gh}(|u|,|v|) \quad (2)$$

8.5.2 Calculation Method

Based on the calculation result of hydrodynamics mathematical model and the triangular net, the Unstructured Finite Volume Method is applied to establish the water quality mathematical model. For conservative estimate, the degradation process of the pollutant itself won't be considered. The formula of numerical discrete-model is shown below:

$$\begin{aligned}P_iH_i^{n+1}\phi_i^{n+1}&=P_iH_i^n\phi_i^n-\Delta t\left[\sum_{j\in S_i^+}\left|Q_j^{n+\theta}\right|\phi_j^n-\sum_{j\in S_i^-}\left|Q_j^{n+\theta}\right|\phi_{m(i,j)}^n\right]\\&-\frac{\Delta t}{2}\sum_{j\in S^{+/-}}\psi_j^n\left|Q_j^{n+\theta}\right|\left[\phi_{m(i,j)}^n-\phi_i^n\right]+\Delta t\sum_{j\in S^{+/-}}DIFF_j\lambda_jH_j^n\end{aligned} \quad (3)$$

In the formula: P indicates the area of triangular element; S^+,S^- represent the outflow side and inflow side; λ is the variable length; Δt is the time step; θ refers to weight factor (0.5 generally); $DIFF$ corresponds to the diffusion item in the equation. The flow rate of $Q^{n+\theta}$ is expressed as:

$$Q^{n+\theta} = \theta Q^{n+1} + (1-\theta)Q^n \tag{3}$$

ψ is the maximum number to avoid the diffusion phenomenon occurred during the course of computation, and is determined via Superbee function:

$$r_j^n = \frac{1}{\phi_{m(i,j)}^n - \phi_i^n} \frac{\sum_{l \in S_i^-} \left| Q_l^{n+\theta} \right|}{\sum_{l \in S_i^-} \left| Q_l^{n+\theta} \right|} \tag{4}$$

$$\psi(r) = \max\left[0, \min(1, 2r), \min(2, r)\right] \tag{5}$$

8.5.3 Model Validation

Due to the lack of field data, the analytic solution is used to verify the water quality mathematical model. Assuming the two-dimensional instant point source analytic solution under permanent currents:

$$C(x, y, t) = \frac{M}{4\pi t\sqrt{D_L D_N}} e^{-\left[\frac{(x-ut)^2}{4D_L t} + \frac{(y-vt)^2}{4D_N t}\right]} \tag{6}$$

In which: D_L, D_N correspond to the diffusion coefficients in main current direction and the direction perpendicular to main currents. Assuming the source is $M = 100$, the mass diffusion & transport process is simulated for two groups of diffusion coefficients: $\begin{cases} K_L = 0.5m^2/s \\ K_N = 0.1m^2/s \end{cases}$ and $\begin{cases} K_L = 0.5m^2/s \\ K_N = 0.05m^2/s \end{cases}$, with current velocity being $\begin{cases} u = 0.5m/s \\ v = 0.5m/s \end{cases}$ and flow direction being $\theta = 45^o$.

According to the simulation result, an elliptic diffusion state can be observed, with major axis matching the direction of main currents and minor axis being perpendicular to the direction of main currents. This complies with the actual mass transport phenomena under the environment with currents. In the secondary simulation, given the substantial difference in transverse and longitudinal diffusion coefficients, the pollutant diffusion shape is more prolate than the first scenario, and the impact scope obtained from numerical simulation is basically the same as analytical value.

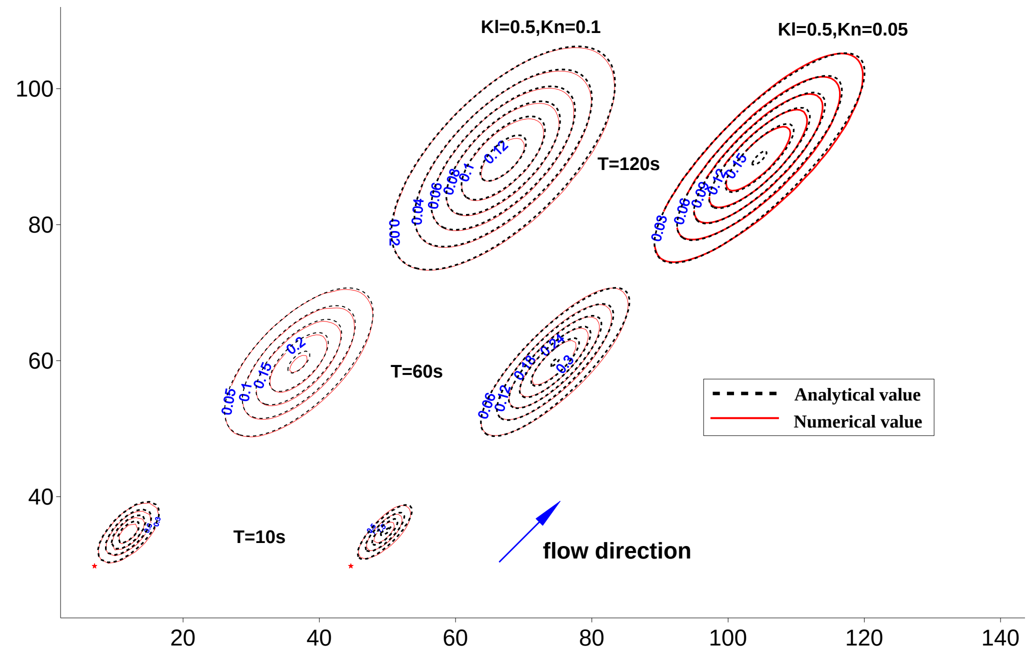


Figure 8.5.1 Comparison between Numerical Value and Analytical Value
(The red lines indicate the numerical value, and the black dotted lines indicate the analytical value)

Taking coordinate (40,60) under the first group of diffusion parameters and coordinate (100,80) under the second group of diffusion parameters to compare the time course of analytical value and numerical value (as shown in Figure 8.5.2 and 8.5.3). According to the results, it can be observed that the numerical value basically matches the analytical value. The model has accurately simulated the mass transport process, indicating that the mathematical model described in this paper can satisfactory meet the requirement for accurate computation.

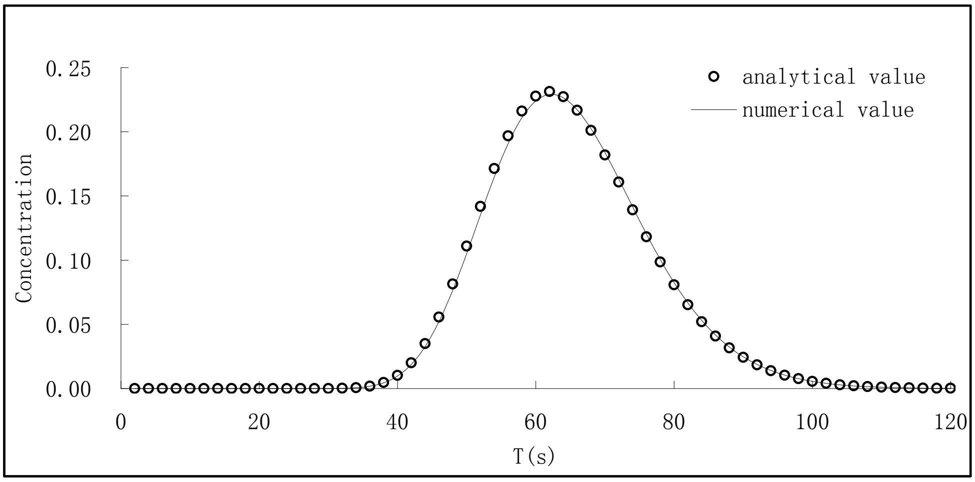


Figure 8.5.2 Concentration Development Curve at Coordinate (40,60) under the First Group of Diffusion Parameters

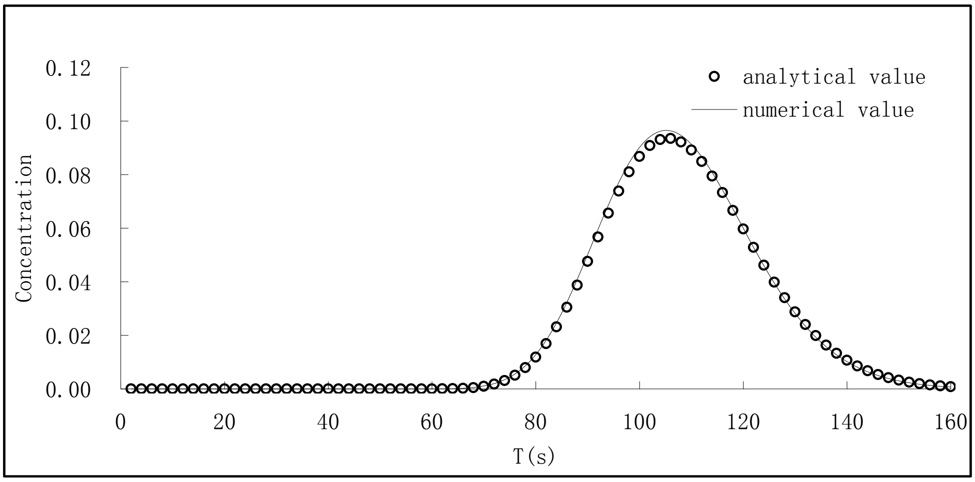


Figure 8.5.3 Concentration Development Curve at Coordinate (100,80) under the Second Group of Diffusion Parameters

8.5.4 Impact Area

During calculation, 48-hour leakage process is simulated for flood tide, ebb tide, flood slack, and ebb slack periods in order to identify the maximum impact scope and draft the corresponding maximum impact envelope scope figures for different pollutants (see Figure 8.5.4 and Figure 8.5.5). Table 8.5.1 and Table 8.5.2 show the impact scope corresponding to different concentrations.

According to the simulation result, it can be observed that: upon the occurrence of accident, due to the convection and diffusion effect of water currents, the pollutant will be distributed in strip form along the navigation channel in south-north direction. Distinctly polluted areas are mainly concentrated in the western aquaculture area of Luoyu and the western aquaculture area of Huiyu. Since the density of methanol is smaller than that of MDF, it will mostly suspend above the water, causing greater impact than the later pollutant. Both pollutants feature the identical impact scope, and polluted aquaculture areas are mainly concentrated around Luoyu and Huiyu.

Table 8.5.1 Maximum Impact Scope upon Methanol Leakage (km2)

Concentration (mg/l)	Flood tide	Ebb tide	Flood slack	Ebb slack	Full tide
>10	14.572	15.623	18.835	13.674	37.604
>20	8.109	10.065	10.598	8.847	23.398
>30	4.992	6.589	6.396	6.433	15.514
>50	2.705	3.706	3.158	3.897	8.810
>100	1.526	1.234	1.575	1.872	3.884
>150	0.903	0.665	0.889	0.952	2.050
>200	0.569	0.462	0.597	0.559	1.325

Table 8.5.2 Maximum Impact Scope upon DMF Leakage (km2)

Concentration (mg/l)	Flood tide	Ebb tide	Flood slack	Ebb slack	Full tide

>10	8.775	10.677	12.840	9.490	26.397
>20	3.837	5.277	6.308	5.349	13.906
>30	2.363	3.263	3.737	3.532	8.825
>50	1.671	1.694	1.662	1.990	4.477
>100	0.631	0.504	0.676	0.609	1.453
>150	0.335	0.290	0.362	0.344	0.823
>200	0.225	0.210	0.221	0.220	0.536

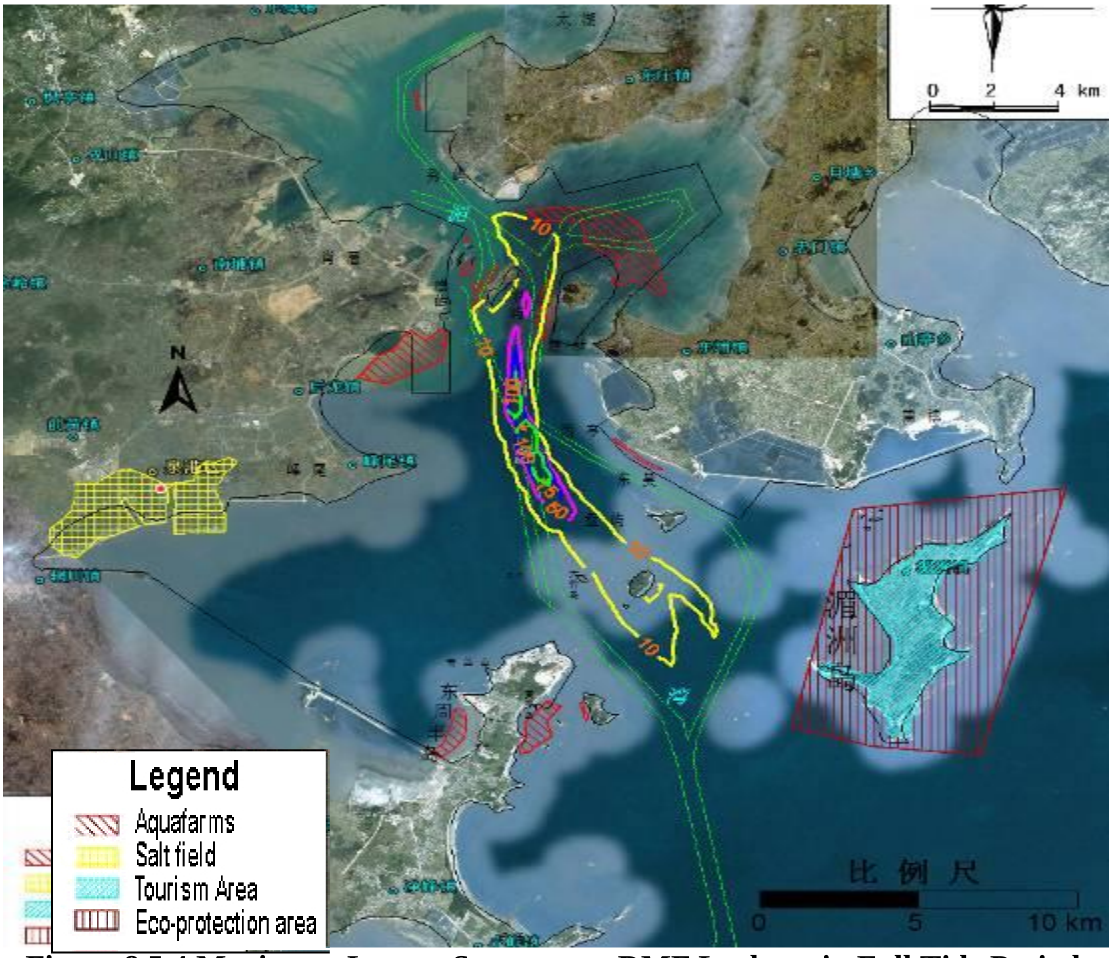


Figure 8.5.4 Maximum Impact Scope upon DMF Leakage in Full Tide Period

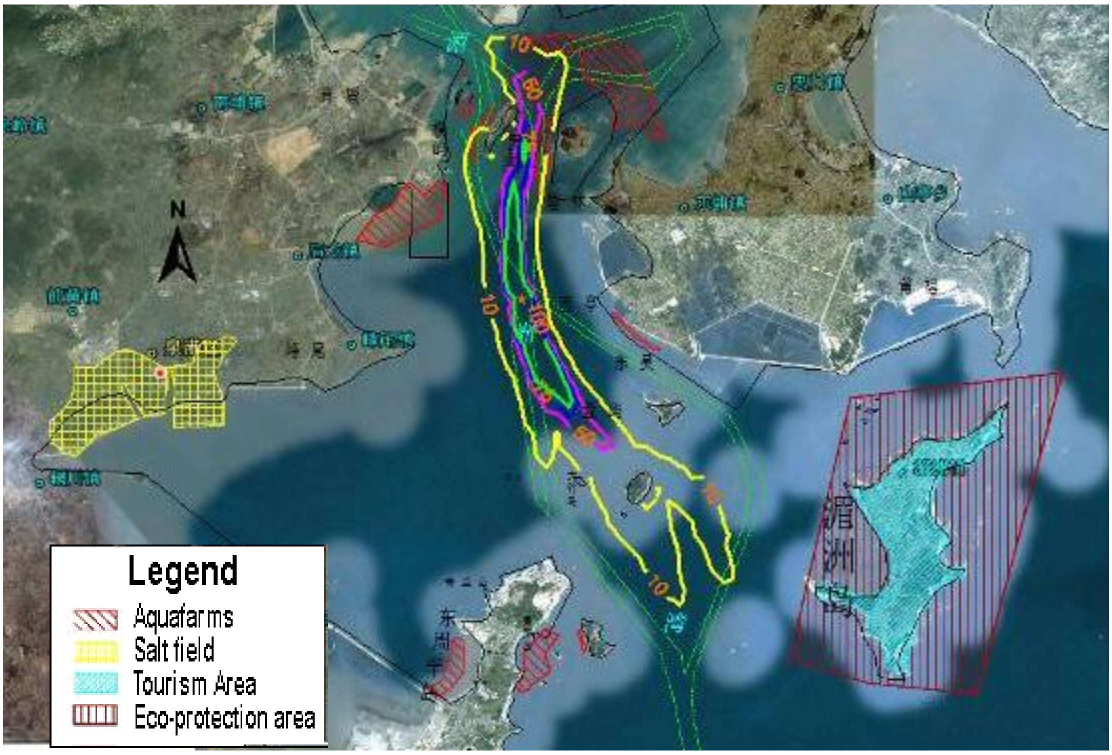


Figure 8.5.5 Maximum Impact Scope upon Methanol Leakage in Full Tide Period

8.5.5 Impact Analysis

(1) Impacts of DMF

Studies show that DMF products likely have no acute harm effect to aquatic organisms. Toxicity to fish: median lethal concentration (96h) 7100mg/L; aquatic invertebrate: median effective concentration (48h) >100mg/L, water flea; aquatic plant: median effective concentration (96h) > 1000mg/L (growth rate); biological concentration factor: 0.3-1.2 (56 days); biological accumulation effect is not foreseen. In case of a DMF spill accident, although the MDF has minor impact on the marine ecosystem, emergency precautions should be taken for chemical leakage and contamination accidents and the corresponding emergency treatment equipment shall be equipped accordingly. Once the accident takes place, containment measures shall be taken instantly and liquid chemicals in the cabin shall be safely transferred.

(2) Impacts of methanol

According to relevant data, methanol has anesthetic effect on the central nervous system of organisms and may cause pathological changes or even metabolic acidosis to the optic nerve and retina. According to PDKTV (a regulation of former Soviet Union), the threshold limit value of methanol in fishery water is 0.1mg/L. From Table 8.5.2, 37.604km2 of sea areas may have a methanol concentration above 10mg/l in full tide period. Since methanol is a soluble chemical, once the methanol spills into the sea, the fishery resources and marine ecosystem of Meizhou Bay will be severely affected.

8.6 Emergency Capacity and Measures
8.6.1 Oil Spill Emergency Capacity at Meizhou Bay
8.6.1.1 Oil spill emergency plans

(1) National-level

In March 2003, national maritime administration authority promulgated and implemented the *Emergency Plan of China against Oil Spills from Ships at Sea* and *Oil Spill Emergency Plan for Taiwan Strait*.

(2) Provincial-level

In August 2010, the General Office of Fujian Provincial People's Government promulgated and implemented the *Emergency Plan against Ship Pollution in the Sea Areas of Fujian*.

(3) Municipal-level

In 2007, Quanzhou developed and implemented the *Emergency Plan for Oil Spills in the Sea Areas of Quanzhou*; Putian also developed and implemented the *Emergency Plan against Oil Spills in the Sea Areas of Putian*.

(4) County-level

In September 2006, Quangang District People's Government of Quanzhou City approved and promulgated the *Emergency Plan against Oil Spills in the Sea Areas of Quangang*.

(5) Corporate-level

All dock-based enterprises at Meizhou Bay have developed their own emergency preparedness and response plans against oil spills.

In conclusion, Meizhou Bay port area has established a three-tier (regional, district and corporate) vessel oil spill emergency system, thus laying a solid foundation for ensuring the navigation safety of incoming and outgoing vessels, avoiding vessel pollution accidents and facilitating the emergency recovery in case of abrupt accidents. On the basis of water area risk evaluation and supervision landscape study, the comprehensive administration patrol brigade of Meizhou Bay is suggested to integrate the emergency resources of entire Meizhou Bay, develop the oil spill emergency plan for the entire bay, and achieve integrated maritime supervision of Meizhou Bay Port, so as to further enhance the oil spill emergency response capacity.

8.6.1.2 Oil spill emergency management capacity building

The hazardous goods handled on the south shore of Meizhou Bay account for one-third of the gross throughput of entire Fujian Province. To strengthen the supervision of Meizhou Bay, RMB 110 million has been invested to build three key maritime supervision projects, namely Meizhou Bay Vessel Traffic System, Quanzhou Maritime Patrol Base of Fujian Maritime Safety Administration and

Taiwan Strait Vessel Oil Spill Emergency Equipment Warehouse.

(1) Meizhou Bay Vessel Traffic System (VTS)

Meizhou Bay Vessel Traffic System (VTS) has been put into preliminary operation since Sept 1, 2011. With investment reaching RMB 27 million, the GPS is applied to carry out radar monitoring of Meizhou Bay sea area and supervisory management of navigating vessels, and provide such services as traffic organization, information, assistance and collaboration for vessels.

This system has 2 stations, 1 center and 2 monitor terminals, namely Huiyu radar station, Yandunshan radar station, Meizhou Bay VTS center, VTS coordination centre of Fujian MSA, and the monitor terminal of Putian MSA, all equipped with CCTV, meteorological monitor system and VHF communication system.

8 CCTV cameras have been deployed at Xiaocuo operating zone on south shore of Meizhou Bay, Liyuwei operating zone and Douwei operating zone. The onshore CCTV system, together with Maritime Patrol 1336 and Maritime Patrol 1325 which are equipped with the mobile video monitoring system, allows the maritime superintendents to monitor the quay port, the near-shore water area and the navigable waters in a real-time manner.

Quanzhou Maritime Safety Administration and Putian Maritime Safety Administration have constructed one VHF control center and deployed one VHF base station at Xiuyu and Meizhou Island respectively to cover the entire Meizhou Bay and adjacent sea areas.

Quanzhou Maritime Safety Administration has also set up the AIS vessel monitoring system to monitor all AIS vessel data received, allowing easy inquiry of the estimated arrival time of incoming/outgoing vessels, vessel information and navigation data.

(2) Building of the enforcement team

For quite some time, the south-shore water area and north-shore water area are governed by Quanzhou City and Putian City respectively, resulting in the functional intersection and repetition of maritime supervision. To achieve centralized and dynamic offshore administration of the same sea area, Fujian MSA established Meizhou Bay Comprehensive Administration Patrol Brigade in January 2005 and authorized Quanzhou MSA to carry out the functions of this brigade.

Upon its establishment, Meizhou Bay Comprehensive Administration Patrol Brigade has integrated various maritime administration resources and basically achieved the goal of "5 Centralization" in the sea area of Meizhou Bay (namely centralized navigation environment management, centralized vessel traffic order maintenance and dynamic supervision, centralized use of administration resources, centralized administration criteria and standards, and centralized emergency treatment of vessel pollution accidents and risks), thus significantly enhancing the maritime administration strength in the sea area of Meizhou Bay, effectively advancing the supervision efficiency and administration level of Fujian MSA with regard to key water areas and key vessels, effectively safeguarding the navigation safety of incoming and outgoing vessels, avoiding water pollution caused by vessels, and making positive contributions to the thriving development Strait West Economic Zone

(3) Maritime supervision capacity

Quanzhou Maritime Patrol Base of Fujian Maritime Safety Administration has been constructed on the south side of the traffic quay of Fengwei Island, and supporting facilities and Vessel Oil Spill Emergency Equipment Warehouse are also provided. Quanzhou Maritime Patrol Base was put into operation in July 2011.

The biggest maritime dock of Quanzhou Maritime Patrol Base in the province provides two berths for berthing 45m patrol ship and 32m patrol ship respectively. It also allows the berthing of 60m patrol ship and 1,000-DWT patrol ship, as well as 4 maritime patrol boats. The base is also provided with roads, yard and base building, and is intended for the berthing, maintenance and material supply of maritime patrol boats and to enhance the efficiency of patrol, administration and rescue.

In April 2011, the largest and leading-edge maritime patrol ship of Quanzhou, Maritime Patrol 133, commenced its service at the dock of Fujian Oil Refinery of Quanzhou Port. Maritime Patrol 133 is a 40m Class-B maritime patrol ship constructed by the Maritime Safety Bureau subordinate to Ministry of Communications and allocated to Quanzhou Maritime Safety Administration. It is by far the best maritime patrol ship in Quanzhou, with total cost reaching RMB 24.79 million. With gross tonnage reaching 362, net tonnage reaching 109, total length reaching 47.4 meters, molded breadth reaching 8 meters, and molded depth reaching 4.7 meters, this steel ship boasts a durability of 1300 sea miles and endurance of 7 days and nights. Given any loading condition, the hull can maintain floating state in case of one-compartment damage. This ship is equipped with state-of-the-art communication and navigation equipment, slipway high-speed rescue and quick-response yawl with independent intellectual property right, and the photoelectric tracing, monitoring and recording system.

Furthermore, the proposed landing and take-off base for the maritime enforcement helicopter of Fujian MSA is close to Quanzhou Maritime Patrol Base. This project covers a total area of 0.333 hectares, with gross investment reaching RMB 20 million. It will be constructed and completed during the "12th Five Years", and will be the first helicopter pad owned by the maritime system of Fujian Province.

8.6.1.3 Oil Spill Emergency Equipment Warehouse

With gross investment reaching RMB 39 million, Quanzhou Oil Spill Emergency Equipment Warehouse of Fujian MSA consists of oil spill monitoring system, monitoring system, communication system, information system, oil spill control and removal system, and oil spill emergency training/drill system, allowing the containment and recovery of oil spills in Taiwan Strait and the preliminary cross-straits emergency collaboration.

Upon the completion of aforementioned project, the sea area of Meizhou Bay will realize tri-dimensional maritime supervision. Boasting the emergency handling capacity of up to 500 tons of oil spills, Meizhou Bay will become the top third oil spill emergency response center in China. It has been planned in the 12th Five-Year

Planning of Fujian Province to solicit support from Ministry of Communications, so as to upgrade the oil spill emergency response capacity of Meizhou Bay into a large-sized equipment warehouse with another RMB 50 million. By then, the emergency response capacity of Meizhou Bay will be further strengthened, with one-time comprehensive oil control capacity upgraded to 1,000 tons.

With the increase in the number of large-sized hazardous freight carriers in the sea area of Meizhou Bay, the risk of vessel pollution accident are on the rise. The timely upgrading to a large-size emergency response equipment warehouses during the 12th Five Years highly recommended.

Furthermore, the maritime supervision authority also actively direct relevant petrochemical companies based at Meizhou Bay and relevant docks to establish their oil spill emergency equipment warehouses, which will be subject to the centralized allocation and use of the oil spill emergency command office, such as the oil spill emergency equipment warehouse constructed at the oil terminal of Fujian Oil Refinery and warehouse constructed at Qinglanshan Dock based on the 12 million ton oil refining project of Sinochem Group.

Table 8.6.1 Oil Spill Emergency Equipment Warehouses within Meizhou Bay

Owner	Emergency equipment	Location	Remark
Meizhou Bay Oil Spill Emergency Equipment Warehouse	Emergency handling capacity of up to 500 tons of oil spills (medium-scale); will expand to 1,000 tons (large-scale) in the long-term planning	Fengwei Dock	Funds allocated and construction underway; will complete in 2012.
Emergency equipment warehouse of FREP	Emergency handling capacity of up to 500 tons of oil spills	Sea area off Qinglanshan	Preparing
Emergency equipment warehouse of Sinochem Quanzhou Petrochemical Co., Ltd	Emergency handling capacity of up to 300 tons of oil spills	Sea area to the north of Qinglanshan	Under preparation and will complete before the operation of Sinochem project
Quanzhou Xingtong Port Development Service Co., Ltd	Emergency handling capacity of up to 200 tons of oil spills	Dock of Fujian Oil Refinery	Accepted by Ministry of Communications

According to the local maritime safety administration, Meizhou Bay Oil Spill Emergency Equipment Warehouse is equipped according to the requirements described in National Equipment Provision Management Plan for Vessel Oil Spill Emergency Equipment Warehouses (for trial implementation). Table 8.6.2 shows the equipment necessary for the medium-sized Meizhou Bay Oil Spill Emergency Equipment Warehouse to meet its overall objectives.

Table 8.6.2 Equipment List of Meizhou Bay Oil Spill Emergency Equipment Warehouse (Medium-sized)

Scale indicators	Comprehensive oil control capacity (t)	500
	Emergency service radius (nm)	150
Warehouse area		Greater than $1000m^2$
Equipment type and quantitative indicators	Emergency unloading equipment	3 to 5 unloading pumps with capacity reaching $600m^3/h$
	Mechanical oil spill recovery equipment	3 to 5 skimmers with capacity reaching $350m^3/h$
	Oil-spill booms	Oil-spill booms with total length no less than 1600m
	Dispersant	No less than 100t, including a stock of 11t and the remaining part can be supplied by the supplier through an emergency supply agreement.
	Absorbent	No less than 40t, including a stock of 9t and the remaining part can be supplied by the supplier through an emergency supply agreement.
	Dispersant spraying, storage and transportation facility	Board/manual dispersant spraying equipment, with capacity reaching 11t/h
	Storage and transportation facility	Proper number of vessels and floating oil pockets; at least 8 emergency operation ships and 2 spill storage and transportation ships, with totally storage and transportation capacity exceeding 1000t.
	Supporting facilities	Emergency operation ships, fork trucks, tow trucks, emergency carrier vehicles, containers, pallets, brackets, emergency transport vehicles, dock crane, maintenance/cleaning equipment and site, maritime lighting equipment, and protective devices for the emergency crew.

8.6.1.4 Quanzhou Xingtong Port Development Service Co., Ltd

Invested by Quangang Xingtong Shipping Service Co., Ltd, Xingtong Harbor Oil Spill Emergency Action Center was one of the key projects of Quangang District in 2011 and the biggest harbor oil spill anti-pollution center invested by private enterprise in Fujian Province. It is also the first time for social forces to take part in the construction of oceanic environmental protection project. With gross investment reaching RMB 50 million, Xingtong Harbor Oil Spill Emergency Action Center covers an area of 2 hectares and is located at Houlong Bay, Houlong Town, Quangang District. Its equipment provision situations are detailed in Table 8.6.3.

On Oct 25-30, 2011, a 7-member expert panel assigned by the Maritime Safety Bureau of Ministry of Communications inspected and appraised the vessel pollution clean-up capacity of Quanzhou Xingtong Port Development Service Co., Ltd. Experts believed that the documents submitted and the actual emergency responding capacity of the company are adequate to meet the requirements imposed on a Class-A vessel pollution clean-up operating unit serving Meizhou Bay (Quanzhou, Putian) and the adjacent offshore areas. Quangang Xingtong Shipping Service Co., Ltd has been included into the "List of Approved Vessel Pollution Clean-up Organizations" released on the website of the Maritime Safety Administration of the People's Republic of China.

The completion of Xingtong Harbor Oil Spill Emergency Action Center will provide guarantee for the oil spill emergency response during the construction of Meizhou Bay Navigation Channel. Therefore, the existing oil spill emergency response capacity can ensure the safe construction of the navigation channel. The oil spill response equipment of Xingtong Center is listed in Table 8.6.3.

Table 8.6.3 Equipment Provision of Xingtong Center

Item	Name	Model	Quantity/Power	Storage/Berthing Location	Remark
Ship	Xingtongyou 109	Emergency action ship	500t		Under building and delivery expected in early 2012; multifunctional vessel for spill recovery, fire-fighting and towing
	Xingtongyou 101	Emergency action ship	500t	Meizhou Bay	Oil spill containment, recovery/clean-up, temporary storage, dispersant spraying, and emergency unloading
	Xinghuiyou 1	Auxiliary ship	150t	Meizhou Bay	Oil containment booms deployment, skimmer towing, dispersant spraying, absorbent deployment and recovery, crew and material transportation, auxiliary oil
	Xingtongyou 1	Auxiliary ship	150t	Meizhou Bay	
	Xingtongjiao 1	Auxiliary ship	105KW	Meizhou Bay	
	Xingtongjiao 2	Auxiliary ship	58.8KW	Meizhou Bay	
	Xingtongjiao 3	Auxiliary ship	27.94KW	Meizhou Bay	
	Xingtongdu 1	Auxiliary ship	110KW	Meizhou Bay	
	Minxiaoyu	Auxiliary ship	79.4KW	Meizhou	

	1546			Bay	spill monitoring.
	Minxiaoyu 7049	Auxiliary ship	79.4KW	Meizhou Bay	
	Minxiaoyu 7117	Auxiliary ship	99.3KW	Meizhou Bay	
Oil containment booms	Float-type rubber boom	WGJ1000	1700m	Equipment warehouse B	Suitable for open waters; high strength, wear-resistant, oil-proof and weathering-resistant
		WGJ800	240m	Equipment warehouse B	
		WGJ1000	500m	Qinglanshan dock	
		WGJ1000/WGJ800	1730m	Dock of Fujian Oil Refinery	
		WGJ1000	280m	Taishan Dock	
		WGJ1000	150m	Donggang Port	
		GWJ900	2040m	Equipment warehouse C	
	Solid float PVC boom	WGV900	480m	Equipment warehouse B	Total height being 900mm, suitable for catching oil slicks and other floating materials
	Inflatable rubber boom	QW1500	2000m	Equipment warehouse A	With total height being 1500mm, suitable for open waters; critical facility for containing oil slicks and avoiding diffusion; suitable for emergency response to oil spill accidents.
		WQJ1500			
	Boom container & winding frame	WJQ1500	10 sets	Equipment warehouse A	
		WJ1500			
	Boom power pack	PK1650C	1 set	Equipment warehouse	

				A	
	Inflator	FGC	1 set	Xinghuiyou 1	
	Boom towing connector	QW1500-01 WQJ1500-01	4 sets	Equipment warehouse A	
	Inflatable water-filled beach boom	WQV600T	1000m	Equipment warehouse B	Suitable for coastline protection; high strength, oil-proof, wear-resistant, weathering-resistant, and long service life.
Oil containment booms	Water filling pump	KDP30	2 sets	Equipment warehouse B	
	Inflator	EB-415	2 sets	Equipment warehouse B	
	Fire-resistant oil containment boom	WGJ900H	400m	Equipment warehouse C	High strength and fire-resistant, deployed for handling inflammable oil slicks or burning oil slicks.
	Storage rack for fire-resistant oil containment boom	WGJ900H	10 sets	Equipment warehouse C	
Skimmer	Disc oil skimmer	ZS5	1 set	Equipment warehouse A	Recovering rate being 5m3/h
	Brush oil skimmer	ZSPS30	1 set	Equipment warehouse A	Max. recovering rate being 30m3/h, ideal for recovering oil of various viscosities
		ZSPS60	2 sets	Equipment warehouse A	Max. recovering rate being 60m3/h, ideal for

					recovering oil of various viscosities
	Power pack	ZSPS30-02C	1 set	Equipment warehouse A	
	Towable dynamic inclined plane skimmer	DXS30	1 set	Equipment warehouse A	Max. recovering rate being 30m3/h, ideal for recovering oil of various viscosities
		DXS60	2 sets	Equipment warehouse A	Max. recovering rate being 60m3/h, ideal for recovering oil of various viscosities
	Dynamic inclined plane skimmer	DXS100	1 set	To be delivered	Max. recovering rate being 100m3/h, ideal for recovering oil of various viscosities
	Power pack	PK13120	2 sets	Equipment warehouse A	
Spraying equipment	Board spraying apparatus	PSB140	4 sets	Equipment warehouse A	Spraying rate being 140L/min
	Portable spraying apparatus	PSC40	8 sets	Equipment warehouse A	Spraying rate being 40L/min
Cleaning equipment	Hot-water cleaning device	BCH1217A	2 sets	Equipment warehouse A	Temperature no lower than 80℃ and pressure being 11mpa
	Cold-water cleaning device	BCC0917A	4 sets	Equipment warehouse A	Pressure being 9mpa
Absorbent	Absorbent pad	PP	1 ton	Equipment warehouse C	
		PP-2	11 tons	Equipment warehouse C	

	Oil-sorbent Boom	XTL-Y200	1000m	Equipment warehouse A	Diameter being 200mm
		XTL-Y220	3000m	Equipment warehouse C	Diameter being 220mm
Dispersant	Dispersant	GM-2	8 tons	Equipment warehouse C	
		GM-2	12 tons		Stored at Qingdao Guangming Environmental Technology Co., Ltd
	WP emergency conditioning fluid	WP-J-Y02	1 ton	Equipment warehouse C	
		WP-J-Y02	1.5 tons		Stored at Quanzhou Hairun Marine Service Co., Ltd
Chemical absorbent	Chemical liquid FG adsorbing particles		3 tons	Equipment warehouse C	
Unloading device	Lightering pump	2HM2500-85	1 set	Equipment warehouse A	Unloading capacity being 150m3/h
	Flame-retardant lightering pump	YHCB-100/3	1 set	Equipment warehouse A	Unloading capacity being 100m3/h
	Circarc gear pump	YHCB-60/5	1 set	Xinghuiyou 1	Unloading capacity being 60m3/h
	Unloading pump	XZB300	1 set		Unloading capacity being 300m3/h, not delivered by supplier
	Gear-type transfer pump	KCB200	2 sets	Xinghuiyou 1	Unloading capacity being 12m3/h/set
Oil hose		DN50	55m	Equipment warehouse A	
Oil		DN75	130m	Equipment	

hose				warehouse A	
		DN80	25m	Equipment warehouse A	
		DN100	215m	Equipment warehouse A	
		DN150	215m	Equipment warehouse A	
Oil-water separator		ZYF-Z-1	1 set	Equipment warehouse A	Handling capacity being $1m^3/h$
Storage facility	Xingtongyou 101	Emergency action ship	578.005 m3		
	Xingtongyou 19	Temporary storage	2045.564 m3		
	Xinghuiyou 1	Temporary storage	140 m3		
	Xingtongyou 1	Temporary storage	100 m3		
	Portable oil tank	6 tanks	243 m3	Jinla Dock	
Communication equipment	Walkie-talkie		12 sets	all ships/Equipment warehouse A	
	High frequency		12 set	all ships/Equipment warehouse A	
Logistics	Fire extinguisher	Dry powder, foam	50	all ships/Equipment warehouse A	
	Life jacket	DF86-5	90	all ships/Equipment warehouse A	
	Life buoy	2.5KG	60	all ships/Equipment warehouse A	

	Safety helmet		60	all ships/Equipment warehouse A	
	Raincoat		60	all ships/Equipment warehouse A	
	Rain boots		60	all ships/Equipment warehouse A	
	Work protective suit		180	all ships/Equipment warehouse A	
	Work protective shoes		67	all ships/Equipment warehouse A	
	Gloves		200	all ships/Equipment warehouse A	
	Mask		60	all ships/Equipment warehouse A	
	First-aid kit		4	Equipment warehouse A	Equipped with general medicines
	Anti-poison respirator		58	all ships/Equipment warehouse A	
	Safety goggles		60	all ships/Equipment warehouse A	
	Fireman kit		1	Equipment warehouse	

				A	
	Flashlight		20	all ships/Equipment warehouse A	
	Fire-fighting chemical-proof suit	RHF-01	4	Equipment warehouse A	
	Crane		1	Jinla Dock	
Logistics	Fork truck		1	Jinla Dock	
Crew	Senior commander		3 persons		Macroscopic control of the emergency response to vessel pollution accidents; having received the qualification certificate as a senior emergency action commander
	Field commander		8 persons		Capable of identifying the specific de-contamination plan and organize the implementation thereof according to the countermeasure of commanding office; having received the qualification certificate as a field commander for handling vessel pollutants.
	Oil spill emergency crew		50 persons		Basic knowledge and skill of emergency action; can

					properly use of emergency equipment and facilities and carry out clean-up operations.

8.6.1.5 Construction of rescue station

According to the Overall Planning of Meizhou Bay Port (Quanzhou-Putian) drafted in February 2011, it has been planned to set up Xiuyu Rescue Sub-center at the existing Xiuyu Marine Office, and Dongwu Maritime Patrol Base and Rescue Sub-center at Putian Service Boat Dock of Dongwu port area (under construction). It is also planned to construct Quanzhou Rescue Station in western Xiutu operating zone. This station will be mainly responsible for maritime salvage and rescue in Quanzhou Bay port area.

Existing Equipment of Quangang Xingtong Shipping Service Co., Ltd

Fire-resistant oil containment booms

Float-type rubber booms

Absorbent pads

Dynamic inclined plane skimmer

Oil spill emergency action ship

Oil spill emergency support dock

Equipment Provision of Quangang Xingtong Shipping Service Co., Ltd

	
Brush oil skimmer	**Crew**
	
2011 marine oil spill emergency drill of Fujian	**300,000-DWT crude oil dock drill**
	
Inflatable boom deployment drill	**Skimmer operation drill**

.6.2 Oil spill prevention and response measures for the construction vessels of this project

8.6.2.1 Risk prevention measures

During construction, the construction vessel will occupy the navigation channel and interfere with the navigation of incoming and outgoing vessels. Therefore, the contractor and the construction vessels must properly organize construction works according to the situations of vessels, earnestly follow the *Maritime Traffic Safety Law of the People's Republic of China*, and abide by the *International Regulations for Preventing Collision at Sea 1972* (1989 Rev.), local port regulations and other navigations rules. Major measures include:

(1) During operation, the construction vessels shall hang cresset and signal, which must comply with relevant state rules.

(2) Before construction, the construction vessels must consult with the maritime safety authority and the dispatching department of port authority with respect to the mutual interference between construction vessels and navigation vessels, so as to develop a proper avoidance plan which will be released by the port navigation supervision department.

(3) The maritime safety administration must strengthen the monitoring and management of incoming and outgoing vessels, continuously monitor the position and status of vessels, timely identify problems and take precautionary measures, so as to reduce accident potential and provide favorable conditions for the safe navigation of vessels.

(4) Incoming and outgoing vessels must submit to the coordination, supervision and administration of maritime safety department and port administration department. The port will be equipped with necessary staff and maritime safety support facilities to provide safety and supervision services such as marine communication, marine navigation, piloting, navigational aid, beacon guidance, warning, meteorological/oceanic forecast and etc.

(5) The dock berthing and anchorage anchoring system shall be implemented. This shall include anchorage application, anchoring density (spacing), navigation speed for entering/exiting the anchorage, and the observation system under various weather conditions, so as to avoid the clubbing, collision, squeezing, grounding, and stranding of vessels at the anchorage.

(6) The deck officer shall be qualified. According to the Regulations of the People's Republic of China respond on Administration of Prevention and Control of Pollution to the Marine Environment by Vessels (2010), the port shall impose rigid written management requirements on vessels and crew, and stipulate their responsibilities and obligations to prevent oil spills of vessels, while measures related to pollution prevention as stipulated therein shall be implemented. The crew shall study and understand the human factors and natural factors of potential oil spill accidents, and enhance their understanding of oil spill impacts and the consciousness of safe transportation.

8.6.2.2 Oil spill response measures

According to the physical circumstances of this project, the oil spill contingency plan for the construction period shall be prepared under the guidance of existing oil spill emergency plan, so as to prepare for the possible oil spill accidents occurred during the construction period. Oil spill response measures include:

(1) Deployment of oil containment booms

The method of oil spill recovery with oil containment booms involves the operating ship and two towing ships. The steps are shown below:

① Deploy the operating ships at one end of the oil polluted water area and deploy the towing ship at the other end of oil polluted water area. Prepare for towing the oil containment booms and pump oil slicks.

② Two towing ships tow the oil containment booms from one end of the oil polluted water area to the operating ship at the other end. In the meantime, activate the skimmers on the operating ship.

③ When the both ends of oil containment booms pass the telescopic guide arm mounted to the operating ship, use the guiding device to guide the oil booms and pull the inner side of oil booms to the sealing brush of guide arm.

④ The towing ships continue towing at the set speed and gradually narrow the containment area until reaching the predetermined minimal value.

⑤ Upon completion of oil recovery, the guide arm will release the oil booms and the skimmers will stop operation.

(2) Oil spill recovery and clean-up

By containing the oil spills with the oil booms, the recovery and clean-up devices will then the applied to quickly recover the oil, or the dispersant will be used to clean up oil spills (or through biological degradation), so as to prevent other areas from being polluted.

Currently, recovery and clean-up facilities applied in China include: skimmers for recovering various oil products, oil recovery net, submersible pump, absorbent, oil spill recovery vessel and etc.

Chapter 9: Public Consultation and Information Disclosure

9.1 Objectives and Methods

The objectives of public participation is not only to win the public's understanding and support to project, but also to: (1) Protect the public's legal environmental interest and embody the human-oriented principle in EIA; (2) Understand the project background and seek for the potential problems, to make the EIA more scientific and pertinent; (3) Propose the practical mitigation measures through the public participation; (4) Balance the stakeholders interests and resolve the contradiction possibly resulted from negative environment impact; (5) Promote the public's concern and support to environmental protection; (6) Facilitate democratic and scientific policy-making.

Public consultation and information disclosure of the project were conducted according to the national regulations (i.e. *Interim Procedures of Public Participation for EIA)* and the World Bank policy *OP4.01 Environmental Assessment*. During the EIA preparation, consultation has been conducted through public notice, internet disclosure, newspaper announcement, report disclosure, interview and questionnaire survey, and public meetings. People consulted include project-affected people in the project area and relevant governmental agencies.

9.2 Public Consultation Process

Two rounds of public consultation were conducted during July-September 2011 and February 2012 respectively, through individual interview/questionnaire survey and public meetings, supported by information disclosure in local newspaper, internet and community bulletin board. A summary of consultation and information disclosure is provided in Table 9.2.1.

Table 9.2.1 Course of Public Participation

	Date	Methods	Location
1st Round	Jul.1-15, 2011	Newspaper disclosure of EA commencement	Strait Metro News
	Jul.1-15, 2011	Project information disclosure	Community bulletin boards in Xiuyu and Quangang Districts
	Jul.1-15, 2011	Internet disclosure	Fujian Academy of Environmental Science (http://www.fjaes.com/) and the Meizhou Bay Harbor Administration Bureau (http://www.mzwgk.gov.cn/)
	Sep.14-28, 2011	On-site disclosure for simplified EA	Community offices in villages of Xiuyu and Quangang Districts
	Sep.14-28, 2011	Internet disclosure of Simplified EA	Fujian Academy of Environmental Science (http://www.fjaes.com/) and the Meizhou Bay Harbor Administration Bureau (http://www.mzwgk.gov.cn/)
	Sep.28-29, 2011	Public meetings combined with questionnaire	Public meetings held in Dongzhuang Town, Dongpu Town and Nanpu Town

		survey	
2nd Round	Feb.18,2012-	Announcement of full EIA disclosure	Strait Metro News
	Feb.18,2012-	Full EIA internet disclosure	Fujian Academy of Environmental Science (http://www.fjaes.com/) and the Meizhou Bay Harbor Administration Bureau (http://www.mzwgk.gov.cn/)
	Feb.20,2012-	Public meetings combined with questionnaire survey	Public meetings held in Nanpu Town (Quangang District), Dongzhuang Town, Dongpu Town.
	July 10, 2012	Updated full EIA internet disclosure with newspaper announcement	Fujian Academy of Environmental Science (http://www.fjaes.com/) and the Meizhou Bay Harbor Administration Bureau (http://www.mzwgk.gov.cn/) Strait Metro News

9.2.1 First Round Consultation

The first round of public consultation was conducted during July-September 2011 when initial field survey was conducted at the early stage of environmental impact assessment. Various local government agencies, enterprises involved and/or potentially affected by the project, and individual households in the project area were visited. Consultations were conducted through meetings, individual interviews combined with questionnaire survey.

Prior to consultation, brief project information and environmental impact assessment related information were disclosed on July 1, 2011 in local newspaper (*Strait Metro News*), internet websites (Fujian Academy of Environmental Science, http://www.fjaes.com/ and the Meizhou Bay Harbor Administration Bureau http://www.mzwgk.gov.cn/), as well as the bulletin boards in local communities in Xiuyu and Quangang districts.

福建省湄洲湾港口管理局

首页 | 港口概况 | 组织机构 | 规划建设 | 港航管理 | 港航文化 | 政策法规

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湄洲湾航道三期工程（Ⅱ阶段）环境影响报告书简本公示

[日期：2011-09-14]

湄洲湾航道三期工程(Ⅱ阶段)环境影响报告书
简本公示

福建省环境科学研究院已完成《湄洲湾航道三期工程(Ⅱ阶段)环境影响报告书》的编制工作。根据《中华人民共和国环境影响评价法》和《环境影响评价公众参与暂行办法》，现向公众公示如下内容：

1.公众索取信息的方式和期限

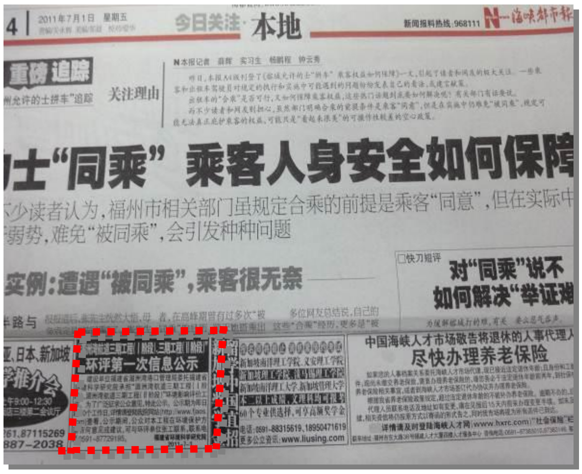
公众可以在相关信息公开后，以电子邮件、信函方式向环评单位或建设单位咨询并提出相关意见和建议。
公示期限：2011年9月14日-2011年9月28日。

2.联系方式

建设单位名称：福建省湄洲湾港口管理局
联系地址：福建省泉州市泉港区泉五中路328号
联系人：陈工
联系电话：0595-87777115
评价单位名称：福建省环境科学研究院（国环评证甲字第2202号）
联系地址：福州市茶园小区环北三村10号　邮政编码：350013
咨询及联系人：张先生　Email：zwx98@sohu.com
联系电话：13705022548　传真：0591-87739252

3.征求公众意见的范围和主要事项

征询对象：主要为秀屿区、泉港区的利益相关者，欢迎社会各界对本项目环境保护工作发表意见和建议。
主要事项，本次公众参与的目的在于征求有关本项目建设的环境保护方面的事项，请公众就与环境有关的问题客观、公正地发表意见。



During the consultation, the following people were consulted:

1) Relevant institutions, enterprises and governmental agencies: Luoyu Port Developing Ltd., Fujian, China Sea LNG Ltd., Fujian, Fujian Bafang Port Developing Ltd., Xiaocuo Port Developing Ltd., Fujian, Bureau of Ocean and Fisheries in Xiuyu District, Maritime Affairs Administration in Putian, Management Committee of North Coast of Meizhou Bay.
2) Individuals: Residents in villages of Talin, Dongwu, Jicheng, Leyu under the Dongpu Town, Villages of Daxiang, Putou under Dongzhuang Town, Villages of Nanpu, Houlong under the Quangang District. These individuals include civil servants, government officers, aquaculture fisherman, farmers, crew and workers etc. The age varies from 30 to 60 years old, the male accounts for 76% and the female accounts for 24%. The educational background varies from primary school to undergraduate degree. These individuals could fairly represent the local communities.

Meetings were held with relevant institutions, enterprises and governmental agencies to collect project information, as well as collect opinions and concerns from these stakeholders. For the consultation with project-affected people, meetings were organized by MBHAB on September 28-29 in the several communities, including Dongzhuang Town, Dongpu Town, Nanpu Town), with more than 50 participants.

In addition, individual interviews were conducted during field investigation where project information was briefly introduced to the public, and questionnaires were sued to collect feedback from these people. Total 100 questionnaires were distributed, 99 copies were returned. See the Table 9.2.2 for the public composition of the questionnaire survey.

Table 9.2.2 Public composition of the First-time Public-participating Survey

Surveyed Institutions and Public		Survey Copies
Bureau of Ocean and Fisheries in Xiuyu District, Maritime Affairs Administration, Agriculture, Forestry and Water Resources Bureaus in Quangang District		8
Surrounding Port Companies and China Sea LNG Ltd., Fujian,		5
Dongpu Town	Town Government	9
	Talin Village	3
	Dongwu Village	5
	Jicheng Village	2
	Leyu Village	8
	Others	4
Dongzhuang Town	Shiwei Village	6
	Daxiang Village	5
	Putou Village	8
Nanpu Town	Nanpu Town	3
	Shage Village	3
Shanting Town	Town Government	2
Fengwei Town	Guocuo Village	6
Quangang District	Kecuo Village	2
	Shidong Village, Jieshan Town	2
	Xucuo Village, Houlong Town	5
	Chenzhuang Village	2
Others (Not listed in this table)		11
Total		99

The concerns received from the public consultation include:
Dredging and blasting impact on aquaculture farming, and ocean ecology
Land acquisition and livelihood impact due to future port development
Compensation to the loss of aquaculture production
Construction noise impact
Navigation safety, oil spill risk and emergency response measures.

These concerns were well taken, and were closely followed-up in the preparation of EIA and development EMP mitigation measures.

The specific statistics of questionnaire survey analysis is as follows:

Table 9.2.3 First-Round Public Opinion Questionnaire Survey Result

No.	Survey Content	Options	Rate (%)
1	Source of Construction Information	News	21.2
		Meeting	29.3
		Constructor	13.1
		Public Comments	24.2
		Network	6.1
		Others	5.1

			Never Heard	1.0
2	Construction Impact on local economy and social development		Very Positive	41.4
			Positive	51.5
			Normal	4.0
			Negative	2.0
			Pussyfoot	1.0
3	Environmental Problems possibly resulted from construction (Multiple Choices)		Dredging	30.3
			Vessel Waste Water	27.3
			Construction Noise	32.3
			Vessel Waste	20.2
			Ecological Destruction	28.3
			Construction Atmosphere	4.0
			No problems	34.3
			Others	0.0
4	Impacts possibly resulted after project completion	Negative Impacts	Ecological Destruction	29.3
			Sea Pollution	36.4
			Vessel Accidents Impacts	7.1
			Others	4.0
		Positive Impacts	Spur Economic Development	81.8
			Improve Navigation Capacity	39.4
			Others	2.0
5	Public's Attitude on Project Impacts		Accept	56.6
			Basically Accept	40.4
			Indifferent	2.0
			Can't accept	1.0
6	Degree of Impacts on Public Interest		Positive impacts	38.4
			No impacts	56.6
			Negative impacts	3.0
	Public Interests impacted		Living environment	16.2
			Fishery Cultivation	23.2
			Employment	19.2
			Others	8.1
7	Requirement on constructors		Take environmental protection measure	46.5
			Engineering alternative measures	3.0
			Compensation based on national policies and regulations	66.7
			Compensation not required	0.0
			Pussyfoot	10.1
			Others	1.0
8	Public's attitude on engineering construction		Approve	74.7
			Basically approve	24.2
			Indifferent	0.0
			Not approve	1.0

(1) Knowledge of proposed project and information sources

99% of people are fully aware of the proposed project. The sources of obtaining information are different, among which, the source from project related public meetings and the information provided by project proponent, accounting for 29.3% and 24.2%, then followed by the source from news media accounting for 21.2%.

(2) Socio-economic development impact

41.4% public considers the project construction impact is very positive to local economy and social development, 51.5% thinks it is positive, 2.0% thinks the impact will be negative.

(3) Potential environmental problems resulted from construction (multiple choices)

32.3% public thinks the main environmental problems emerging during construction period is noise, 30.3% thinks it is dredging, 28.3% thinks it is ecological destruction, and 34.3% thinks there are no problems.

(4) Impacts possibly resulted after project completion (multiple choices)

Negative impacts: 36.4% public thinks the negative impacts include sea pollution, 29.3% and 7.1% thinks it include ecological destruction and vessel accidents respectively;

Positive impacts: 81.8% public thinks it will spur the economic development after completion and 39.4% thinks it will improve the navigation capacity.

(5) Public's Attitude on Project Impacts

The survey result shows that 56.6% public thinks the impact from project construction is acceptable, 40.4% thinks it is basically acceptable, while 1.0% thinks they can't accept, the main concern is the environmental problems may emerge after the channel completion.

(6) Impacts from engineering construction on public interest

Impact degree: 38.4% public indicates the project construction will have positive impacts on their interest, 56.6% indicates there are not impacts and 3.0% indicates the impacts will be negative.

Type of Impacts: 23.2% public indicates the interest impacted is aquaculture cultivation, 16.2% and 19.2% thinks the interest impacted are living environment and employment respectively.

(7) Requirements on project proponent

As to the impact from the project, 66.7% public hope the compensation standard could be set based on national policies, 46.5% hope the project proponent could take environmental protection measures to reduce the impacts and 10.1% are indifferent.

(8) Public's attitude on engineering construction

74.7% public holds positive attitude to project construction, 24.2% holds basic positive attitude, 1.0% holds negative attitude since he think the project will have negative impact on environment after completion, his details is listed as follows:

9.2.2 Second Round Consultation

The second round of public consultation was conducted during February 2012 when draft EIA was available. Prior to consultation, full draft environmental impact assessment report has been disclosed on February 18, 2012 in the websites of Fujian Academy of Environmental Science (http://www.fjaes.com/) and the Meizhou Bay Harbor Administration Bureau (http://www.mzwgk.gov.cn/), with disclosure announcement published in local newspaper (*Strait Metro News*).

News Paper Announcement of Full EIA Report on February 18, 2012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湄洲湾航道改进项目环境影响报告书公示
开始时间：2012-02-20 结束时间：2012-03-01 发布者：环科院 点击：87次
湄洲湾航道改进项目环境影响报告书公示
福建省环境科学研究院已完成《湄洲湾航道改进项目环境影响报告书》的编制工作，根据《中华人民共和国环境影响评价法》、《环境影响评价公众参与暂行办法》和世界银行有关规定的要求，现向公众公示如下内容：
1. 公众索取信息的方式
公众可以在相关信息公开后，以电子邮件、信函方式向环评单位或建设单位咨询并提出相关意见和建议。
2. 联系方式
建设单位名称：福建省湄洲湾港口管理局
联系地址：福建省泉州市泉港区泉五中路329号
联系人：陈工
联系电话：0595-87777140
评价单位名称：福建省环境科学研究院 （国环评证甲字第2202号）
联系地址：福州市茶园小区环北三村10号 邮政编码：350013
咨询及联系人：张先生 Email：zwx98@sohu.com
联系电话：13705022548 传真：0591-87739252
3. 征求公众意见的范围和主要事项
征询对象：主要为秀屿区、泉港区的利益相关者，欢迎社会各界对本项目环境保护工作发表意见和建议。
主要事项：本次公众参与的目的在于征求有关本项目建设的环境保护方面的事项，请公众就与环境有关的问题客观、公正地发表意见。
4. 征求公众意见的具体形式
网上公众意见调查。
5. 相关链接：
报告书完整版本下载
（责任编辑：环科院）
【点击下载】： /uploads/soft/
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估计剩余时间： 11 秒（已复制 12.5 MB，共 19.6 MB）
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相关公示

During the consultation, the following people were consulted:

1) Relevant institutions, enterprises and governmental agencies: National Investment Group Meizhou Bay Development Company, Fujian Bafang Port Development Company, Fujian LNG Ltd. Station, Xiaocuo Port Developing Ltd., Xiuyu District Bureau of Ocean and Fisheries, Maritime Affairs Administration in Quangang, Quangang Agrciutlral, Forestry and Aqua-product Bureau.
2) Individuals: Residents in villages of Talin, Dongwu, Jicheng, Leyu under the Dongpu Town, Villages of Daxiang, Putou under Dongzhuang Town, Villages of Nanpu, Houlong under the Quangang District, the careers of surveyed individuals include: civil servant, government officers, fishers, farmers, crew and workers etc. The age varies from 30 to 60 years old, the male accounts for 76% and the female accounts for 24%. The educational background varies from primary school to undergraduate degree. The total distributed questionnaires are 110 copies and the collected questionnaires are 105 copies (collecting rate 95.5%).

Key public-concerned problems and feedbacks during the second round of consultation:

1) Construction Impacts on sea cultivation, sea ecology and water quality

   As to the public-concerned problems of construction impacts on sea cultivation, sea ecology and water quality, the project proponent committed to strictly take the pollution treatment, ecological protection measures developed in EIA/EMP during the construction and operation period, to strengthen environment management and reduce the construction impact on sea water quality and sea ecology.

2) Livelihood loss of aquaculture farmers due to sea area acquisition

   A RAP has been developed following national regulations and World Bank OP4.12. The project proponent committed to implement the compensation to requisitioned sea cultivation waters based on the RAP. The local government will plan new aquaculture zones according to the overall Meizhou Bay Development Plan, which will solve the livelihood of local farmers through new aquaculture zones and off-shore marine fishery.

   During the survey, the public expressed the expectation of the new sea utilization zoning plan and the aquaculture farm relocation plan ASAP, in order to prevent the unnecessart loss of improper relocation. Before blasting the rocks, the surrounding cultivation households will be well negotiated to reach the agreement on blasting time and reduce the relevant impact to the lowest extent.

3) Safety impact of channel construction on dock loading and unloading

As to the safety impact of channel construction on dock loading and unloading, the project proponent committed to apply scientific construction techniques and planning based on national regulations and take safe safety precautions to prevent the emergence of vessel accidents possibly resulted from channel construction.

The statistic details of second-round consultation are shown in the following table.

Table 9.2.4 Second-time Public Opinion Survey Result

<table>
<tr><td>No.</td><td colspan="2">Survey Content</td><td>Options</td><td>Rate (%)</td></tr>
<tr><td rowspan="7">1</td><td colspan="2" rowspan="7">Source of Construction Information</td><td>News</td><td>26.4</td></tr>
<tr><td>Meeting</td><td>47.1</td></tr>
<tr><td>Constructor</td><td>26.4</td></tr>
<tr><td>Public Comments</td><td>21.8</td></tr>
<tr><td>Network</td><td>0.0</td></tr>
<tr><td>Others</td><td>3.4</td></tr>
<tr><td>Never Heard</td><td>1.1</td></tr>
<tr><td rowspan="5">2</td><td colspan="2" rowspan="5">Construction Impact on local economy and social development</td><td>Very Positive</td><td>41.4</td></tr>
<tr><td>Positive</td><td>40.2</td></tr>
<tr><td>Normal</td><td>12.6</td></tr>
<tr><td>Negative</td><td>2.3</td></tr>
<tr><td>Pussyfoot</td><td>4.6</td></tr>
<tr><td rowspan="8">3</td><td colspan="2" rowspan="8">Environmental Problems possibly resulted from construction
(Multiple Choices)</td><td>Dredging</td><td>35.6</td></tr>
<tr><td>Vessel Waste Water</td><td>42.5</td></tr>
<tr><td>Construction Noise</td><td>12.6</td></tr>
<tr><td>Vessel Waste</td><td>27.6</td></tr>
<tr><td>Ecological Destruction</td><td>26.4</td></tr>
<tr><td>Construction Atmosphere</td><td>5.7</td></tr>
<tr><td>No problems</td><td>26.4</td></tr>
<tr><td>Others</td><td>1.1</td></tr>
<tr><td rowspan="7">4</td><td rowspan="7">Impacts possibly resulted after project completion</td><td rowspan="4">Negative Impacts</td><td>Ecological Destruction</td><td>44.8</td></tr>
<tr><td>Sea Pollution</td><td>57.5</td></tr>
<tr><td>Vessel Accidents Impacts</td><td>17.2</td></tr>
<tr><td>Others</td><td>2.3</td></tr>
<tr><td rowspan="3">Positive Impacts</td><td>Spur Economic Development</td><td>81.6</td></tr>
<tr><td>Improve Navigation Capacity</td><td>50.6</td></tr>
<tr><td>Others</td><td>0.0</td></tr>
<tr><td rowspan="4">5</td><td colspan="2" rowspan="4">Public’s Attitude on Project Impacts</td><td>Accept</td><td>41.4</td></tr>
<tr><td>Basically Accept</td><td>48.3</td></tr>
<tr><td>Indifferent</td><td>1.1</td></tr>
<tr><td>Can’t accept</td><td>8.0</td></tr>
<tr><td rowspan="3">6</td><td colspan="2" rowspan="3">Degree of Impacts on Public Interest</td><td>Positive impacts</td><td>36.8</td></tr>
<tr><td>No impacts</td><td>44.8</td></tr>
<tr><td>Negative impacts</td><td>18.4</td></tr>
</table>

	Public Interests impacted	Living environment	16.1
		Fishery Cultivation	64.4
		Employment	23.0
		Others	9.2
7	Requirement on constructors	Take environmental protection measures	31.0
		Engineering alternative measures	1.1
		Compensation based on national policies and regulations	69.0
		Compensation not required	2.3
		Pussyfoot	9.2
		Others	0.0
8	Public's attitude on engineering construction	Approve	58.6
		Basically approve	37.9
		Indifferent	1.1
		Not approve	1.1

(1) Knowledge of proposed project and information sources

The popular rate of this project reaches 99%, the sources of obtaining information are different, among which, the source from public meetings and project owner respectively accounts for 47.1% and 26.4%, then the source from news accounts for 26.4%.

(2) Construction Impact on economy and social development

41.4% public thinks the project construction impact is very positive to local economy and social development, 40.2% thinks it is positive, 2.3% thinks the impact will be negative.

(3) Environmental Problems possibly resulted from construction (multiple choices)

42.5% public thinks the main environmental problems emerging during construction period is vessel waste water, 35.6% thinks it is dredging, 27.6% thinks it is vessel waste, and 26.4% thinks there are no problems.

(4) Impacts possibly resulted after project completion (multiple choices)

Negative impacts: 57.5% public thinks the negative impacts include sea pollution, 44.8% thinks it include ecological destruction;

Positive impacts: 81.6% public thinks it will spur the economic development after completion and 50.6% thinks it will improve the navigation capacity.

(5) Public's Attitude towards Project Impacts

The survey result shows that 48.3% public thinks the impact from project construction is acceptable, 41.4% thinks it is basically acceptable, while 8.0% thinks they can't accept, the main concern is the problems of fishers unemployment and economic losses may emerge after the channel completion.

(6) Impacts from engineering construction on public interest

36.8% public indicates the project construction will have positive impacts on their interest, 44.8% indicates there are not impacts and 18.4% indicates the impacts will be negative. 64.4% public indicates the interest impacted is fishery cultivation, 16.1% and 23.0% thinks the interest impacted are living environment and employment respectively.

(7) Requirements on Project Proponent

As to the impact from engineering construction, 69.0% public hope the compensation standard could be set based on national policies, 31.0% hope the constructors could take environmental protection measures to reduce the impacts.

(8) Public's attitude towards engineering construction

61% public holds positive attitude to project construction, 37.9% holds conditional
positive attitude, 1.1% holds negative attitude due to fear of losing present cultivation waters. Responding to such concern, detailed explanation of RAP and livelihood restoration measures were provided to clarify the situation, and convinced those concerned that adequate compensation and livelihood restoration measures have been built into the project design and RAP.

9.3 Summary of Key Issues in Public Consultation

Based on the consultation meetings and the 204 collected questionnaires, we have collected various public opinions in the project area. Local public have expressed strong enthusiasm in participating in environmental protection, although some feedback opinions are general, it also shows public's attention to environment and plays a role in monitoring projects.

Table 9.3.1 – Key Public Opinions and EA Responses

Public Opinions	How these are addressed
Enforce the pollution treatment, ecological protection measures proposed in EIA during the construction and operation period and strengthen environment management	EMP is developed and will be incorporated into legal documents, bidding documents and contracts.
Solve the local aquaculture livelihood issue through exploiting new cultivation waters and developing marine fishery, the surrounding cultivation households shall be well negotiated to reach the agreement on blasting time.	Measures have been built into EMP and RAP.
The pollutants shall be discharged after being treated to meet the national standard	Included in the EIA/EMP measures
Apply scientific construction techniques and planning based on national regulations	Included in the environmental specifications of EMP

9.4 Complaints Procedures

During the EIA preparation, the public participation has been given great importance all along and the complaints system will be established. The complaints procedure is listed as follows:

Stage 1: If the affected people are not satisfied with the indirect influence due to construction, they can file oral or written complaints to Dongzhuang Town, Dongpu Town, Nanpu Town governments, the oral complaints shall be handled and kept records by corresponding town governments and the handling decision will be made by

↓

Stage 2: If the affected people are still not satisfied with the handling decision made in the stage 1, they can advance complaints to Ocean and Fisheries Bureau, Xiuyu District, Agriculture and Forestry Bureau, Quangang District and Ocean and Fisheries Bureau, Hui'an District after receiving the decision, the handling decision will be made

↓

Stage 3: If the affected people are still not satisfied with the handling decision made in the stage 2, they can sue to civil court based on the Civil Procedure Law after receiving the decision.

The complaints of the project-affected people shall be received without charges, the incurred fee shall be paid from the contingencies by the Land Acquisition Office.

The complaint procedure remains effective during the whole construction period to make sure the affected people use it to deal with relevant problems. The cultivation requisition administration shall register and manage the documents of complaints and treatment results and submit to the PMO in written form every month. The PMO will accordingly carry out periodic checks. In order to completely record the influence people's complaints and treatment status for relevant problems, the PMO will formulate the registration form to reflect the influenced people's complaints and corresponding treatment status. The format of form is attached below:

Table 9.4.1 Registration Form for Environmental Impact Complaints (Sample Form)

Name of complainant		Time	
Receiving Institution		Place	
Content of Complaints			
Requested Solution			
Planned Solution			

Actual treatment status			
Complainant (Signature)		Recorder (Signature)	
Note: 1. The recorder shall truthfully record the content and request of complainant; 2. The complaints shall not be disturbed; 3. The planned solution shall be informed to complainant within regulated time.			

9.5 Conclusion

The public consultation shows that over 97.8% public support the project construction, most of the surveyed people think the project completion will be great beneficial to local economic development and the impacts resulted can be mitigated to the level acceptable.

As to the public-concerned problems of construction impacts on sea cultivation, sea ecology and water quality environment, the project owner committed to strictly take the pollution treatment, ecological protection measures proposed in EIA/EMP during the construction and operation period, to strengthen environment management and reduce the construction impact on sea water quality and sea ecology to a greatest extent. In terms of the possibly existing environmental risks, the project will take effective precautions to avoid the accidents and formulate emergencies plan to control the risks' environmental impacts to a greatest extent.

The project owner and local governments shall strengthen the propaganda and communication, making the local people aware of the necessity of construction and significance to local social-economy, at the same time, the local governments shall appropriately plan the fishery industries based on Meizhou Bay harbor development and economic growth and solve the local aquaculture farmers' livelihood through exploiting new cultivation waters and developing marine fishery, to eliminate their worries and win more understandings and support from public.

Chapter 10 Environmental Management Plan

The Environmental Management Plan is prepared in a stand alone report.

Annex A Due Diligence Review

of

Phase I and II of Meizhou Bay Navigation Channel Project, and current backfilling in Putou and Xiaocuo

Note: Figure at the end of the document shows the Phase I and Phase II Channel alignment.

1. Phase I

The key components of Phase I project are listed in the following table.

	Phase-I
Main channel	Improvement of 100,000-DWT main channel 31.46km long, 300m wide
Branch channels	The 100,000-DWT branch channel of Fujian Oil Refinery, the 50,000-DWT branch channel of Yangyu, the branch channel of Meizhou Bay power plant wharf

The Meizhou Bay Navigation Channel Phase-I Project is a supporting project of Fujian LNG Terminal and Trunkline Project of CNOOC Fujian Natural Gas Co., Ltd. The environmental impact assessment of Phase I was built into the LNG project EIA, which has been approved by State Environment Protection Agency in 2004 through SEPA Review [2004] No.147.

Therefore, the Phase I project is fully in compliance with national EIA regulations and procedures. The Phase I project has been successfully completed in 2006.

There are no legacy issues from environmental perspective, and there is no evidence of any environmental disaster or pollution events during the operation over the years.

2. Phase II

The key components of Phase I project are listed in the following table.

	Phase-II
Main channel	250,000-DWT main channel 26.7km long , 300m wide
Branch channels	The 50,000-DWT navigation channel of Putou, The 100,000-DWT channel of Dongwu, The 100,000-DWT branch channel of West Huiyu

EIA Approval

The EIA for the Phase II has been approved by Fujian Environmental Protection Bureau approved in 2011 through FEPB Review [2011] No.135. The project is fully in compliance with national EIA regulations and procedures.

Phase II project implementation

The construction of the Meizhou Bay Navigation Channel Phase-II Engineering Project kicked off in October 2008. Currently, except the Huiyu Channel which has not started yet, all other components have all been successfully completed. Overall, the environmental management is satisfactory, there is no environmental pollution event, and there is no evidence of any significant ecological impacts observed. This is proved by the baseline survey and monitoring of ecological environment and water quality during the EIA preparation for the Phase III project which confirmed the overall sound environmental quality of Meizhou Bay area.

The implementation of Phase II is illustrated in Figure 2.4-1. The specific details of project implementation are as follows:

Dredging

Dredging has been completed by the end of August 2011, including the main channel dredging, Putou channel dredging, temporary channel and Dongwu channel dredging; West Huiyu channel is the only one remaining to start construction.

①The 250,000-DWT navigation channel: the total design width is 300m, and the design bed elevation is -18.3m. The dredging work is divided into Zone 1, Zone 2 and piecemeal engineering with total engineering quantities of 4.0456 million m^3 and dredging area of about $208hm^2$. It was commenced on October 14, 2008 and completed on June 12, 2009. The dredging was carried out by $10,080m^3$ self-propelled bow-blowing TSHD. During the process, hard seabed with rocks was found in Dredging Zone 2. So, grab bucket dredger was used instead. 13m3 grab bucket dredger "Andrew 028" joined the hopper barge in operation. All dredged silt was dumped to Dongwu #1-3 berths by hydraulic filling and clearing. And the dredging has now been completed.

②Putou channel: commenced on October 18, 2008 and completed in March 2010. Engineering quantities of the dredging amounted to 80.5 thousand m^3. Since all dredging was carried out in the vicinity of rocks that are scattered around in small areas, it was not proper to use TSHD but the operational technology combining the grab bucket dredger with the hopper barge instead. $13m^3$ grab bucket dredger "Hengshunda 1" and two $1,000m^3$ hopper barges were used in the simultaneous operation of dredging and clearing. The hopper barges carried silt and spoil to Dongwu #1-#3 berths for dumping and filling within the reclamation dam.

③Temporary channel: It provides a passage for dredgers to carry silt to Dongwu #1-3 berths for transfer blowing. The work commenced on November 1, 2008 and $10,080m^3$ bow-blowing TSHD (Trailing Suction Hopper Dredger) “Chang Jing 2” was used in the dredging of a total of 269 thousand m3.

④Dongwu channel: The dredging work is divided into Zone 1, Zone 2 and piecemeal engineering with total engineering quantities of 2.8 million m^3. Bow-blowing TSHD should be used according to design. However, Dongwu channel dredging is difficult since its surface layer consists of silt and sand while under layer consists of flinty clay. In actual operation, grab bucket dredger was used in dredging and the dredged was directly for transfer blowing on the hopper barge.

⑤West Huiyu channel: The construction of West Huiyu channel has not kicked off because of the undecided plan for aquaculture farms relocation.

Rock blasting

Project implementation in detail:

①Main channel: Crib cultivation of abalone is near the rock area in the vicinity of Luoyu. The main channel cannot be put under construction due to the unsettlement of the problem of aquaculture farm relocation while other rock blasting engineering have all been completed.

②Rock blasting for Dongwu channel: The work is widely distributed with about

27 rocks totaling 186 thousand m^3. Drill-burst ship "Changlu 2" was used in the work that commenced on August 6, 2009 and has been completed by now.

③West Huiyu channel: The rock blasting for West Huiyu channel could not kick off due to the unsettlement of the relocation problem of aquaculture farms surrounding the channel.

④Putou channel rock blasting: 84.6 thousand m^3 of rock blasting was designed while actual rock blasting quantity was 104 thousand m3. The rock blasting started on February 17, 2009 and completed in March 2010 and is now ready for completion and acceptance. Drill-burst ship "Hengshunda 2", 13m3 grab bucket dredger and hopper barge were used. And the rock ballast was for backfill on land at Dongwu #1-#3 berths.

Navigation marks

None of the navigation marks for the 250,000-DWT navigation channel, Putou channel, Dongwu channel and West Huiyu channel has been put under construction. What is under construction is the temporary channel navigation marks.

Four main navigation marks with two on both left and right sides were established on December 29, 2008. They are now under to-be-accepted condition.

TSHD "Chang Jing 2"

Drag head of TSHD "Chang Jing 2"

TSHD "Chang Jing 2" in hydraulic filling

Transfer blowing vessel

Transfer blowing from the hopper barge

Hydraulic filling within the reclamation dam

Figure 2.4-1 Photos of main operational equipments on the spot

Drill-burst ship 1

Drill-burst ship 2

Clearing with the grab bucket

Clearing vessel and the barge

Grab bucket sludge-carrying vessel and the hopper barge

Beacon vessel

Figure 2.4-1 (continued) Photos of main operational equipments on the spot

Environmental impacts and management

Dredging impacts review

According to survey, channels already dredged include the temporary channel, Putou channel and the 250,000-DWT main channel while Dongwu channel has been partially dredged. 13m^3 grab bucket dredger was used in Putou channel dredging; 10,080 m^3 bow-blowing TSHD was used in dredging the 250,000-DWT main channel, part of which was dredged with 13m^3 grab bucket dredger ; the dredging of all temporary channels was carried out by 10,080m^3 bow-blowing TSHD ; and Dongwu channel was dredged with bow-blowing barge unloading suction dredger. Impacts of dredged silt flow on marine water environment vary with different dredging technologies and equipment as well as different kinds of dredged materials and marine environment.

(1) Temporary operation channel

10,080 m^3 bow-blowing TSHD was used in dredging the channel. Self-propelled TSHD automatically dredges for self loading before navigating to the backfill area for hydraulic filling. When dredging, the self-propelled TSHD, which is equipped with automatic overflow control system, will automatically shut its overflow gate in case of silt overflow from the full compartment and the time for overflow control is within 0.5h after the compartment is full as required by dredging operation standard. The discharge concentration of SS in the overflow water is closely connected with geologic conditions of the dredged area. Under the condition of same overflow time, the discharge concentration of SS with high silt content is also high. Therefore, different kinds of dredged materials should be taken into consideration in overflow time control so as to put the SS discharge concentration under control.

According to the equipment information provided by the construction organization, the TSHD used in the project has multiple compartments. The slurry sucked by the dredging pump enters the compartments for post precipitation layer by layer before entering the last compartment equipped with overflow ports. When the compartment is full of silt deposit, the dredging operation stops, but some slurry will be discharged into the sea area from the overflow ports of the cabin roof, leading to the increase in suspended solids concentration in the water body in the vicinity of the sea zone for operation. According to measured data, the SS concentration at overflow ports of such TSHD is generally under 3g/l if overflow time is under control. Field survey results indicate that the seabed sediment of the dredged temporary channels mainly consists of sand with little silt. Based on analogical estimation, about 5.6Kg of suspended solids will be generated in each second of channel dredging. Suspended solids have a sphere of influence (SPM greater than 10mg/L) at 1,000m along fair tide and 150m wide at the dredged area. According to the aquafarm owners' response to the field investigation, certain water turbidity impacts occurred to the abalone cultivation area in the vicinity of the channel during low-tide dredging, however, there is incidents of abalone loss.

(2) Putou channel

Grab type dredging features with low intensity of operation and relatively less silt flow, therefore, closed type grab bucket may be used to further decrease the silt flow into the sea. The enclosed 13m^3 grab bucket is used and its dredging intensity is normally at about 600-700m^3/s and its silt flow is about 1.6-2.0kg/s. The suspended solids have a sphere of influence (SPM greater than 10mg/L) at 300m along fair tide and 80m wide at the dredged area of Putou channel. According to field survey, the nearest marine aquaculture farm is 650m to the northeast of the dredged area and for floating cultivation of kelps among other alga. Thus it can be seen that the Putou channel dredging generates small impacts on neighboring marine aquaculture. Opinion survey among aquafarm owners shows that no pollution damage has been caused by the Putou channel dredging to their marine farming.

(3) The 250,000-DWT main channel

10,080m^3 bow-blowing TSHD was used in dredging the channel. Field survey results indicate that the seabed sediment of the dredged temporary channels mainly consists of sand with little silt. Based on analogical estimation, about 5.6Kg of suspended solids will be generated in each second of channel dredging. Suspended solids usually have a sphere of influence (SPM greater than 10mg/L) at 700m along fair tide and 100m wide at the dredged area. According to field survey, the marine aquaculture farm nearest to the Dredging Zone 1 is the algal cultivation area which is 2,700m to the NNE of the dredged area. Thus it can be seen that Dredging Zone 1 of the main channel generates small impacts on neighboring marine aquaculture. Opinion survey among aquafarm owners shows that no pollution damage has been caused by the Dredging Zone 1 of the main channel to neighboring marine farms.

Review on rock blasting impacts

Putou channel rock blasting has been completed; rock blasting for the main channel except the rock in the vicinity of Luoyu has been completed; rock blasting is undergoing for Dongwu channel; and the rock blasting is yet to commence for West Huiyu channel. Drill-burst ships are used in all rock blasting and the 13m^3 grab bucket dredger is joined by the hopper barge in rock clearing by means of millisecond delay blasting with maximum explosive charge of 200kg for single-stage priming.

Researches show that fish are likely to die under the pressure of 0.05MPa while find themselves safe when the pressure is less than 0.03MPa and that crustaceans are less sensitive to blast wave and molluses are further less sensitive. Based on the estimation according to experience and equation, 0.03Mpa peak pressure of surge wave has a corresponding distance of about 500m with maximum explosive charge of 200kg for single-stage priming. According to field survey, no fish or abalone cultivation is seen within the scope. Opinion survey among aquafarm owners shows that no damage has been caused by the rock blasting to neighboring marine farms.

The rock blasting has impacts on wild fish in the vicinity of the blasting area, however, such impact is limited to the small area around the blasting point. The baseline survey has confirmed that there is no rare, protected or endangered fish species in the project area. Mitigation measures have been implemented, i.e. small load prior blasting to drive away fish and monitoring of fish shoals around the blasting point. Therefore, it can be concluded that the blasting has little impact on wild fish, which is limited to small scope immediately adjacent to the blasting point and is insignificant compared to the vast area of the whole Meizhou Bay.

Impacts review on backfill process

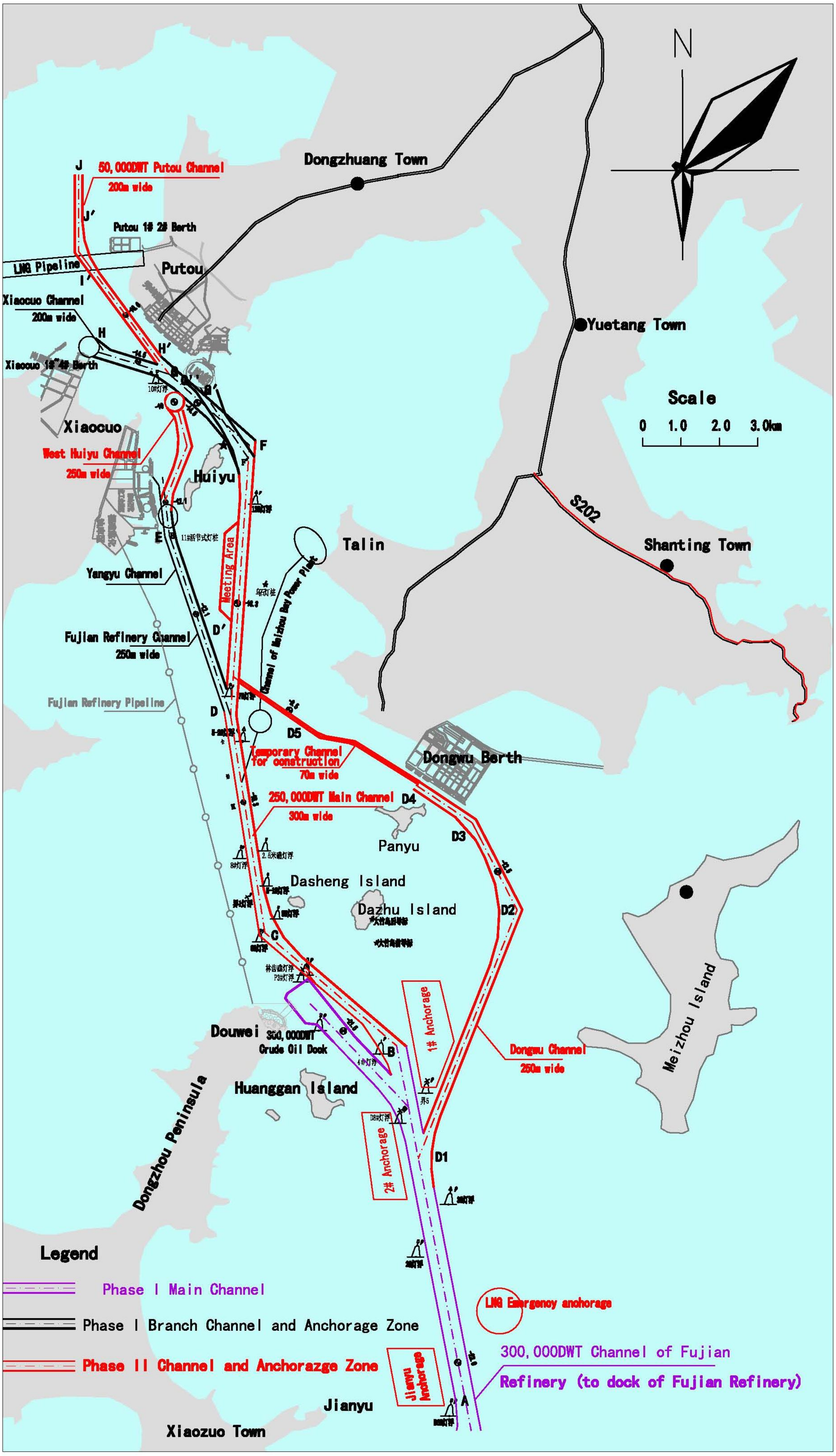
Dredged materials and rock blasting spoils are reused as backfill material for land reclamation at the Dongwu #1-#3 docks, where the reclamation dam and reversed filter have been constructed. The reclamation dam needs backfill of about nine million m3. Therefore, the rear side of Dongwu wharf is available to hold the dredged materials generated from Phase-II Project. During the refilling process, according to enquiry survey, the sea area where suspended solids concentration is excessively high and cannot meet the standard for category II water quality is limited to 100m outside the reclamation dam of the backfill area, and no pollution is caused to the marine aquaculture.

In conclusion, channel dredging and rock blasting for the Meizhou Bay Navigation Channel Phase-II Project did not cause any significant environmental and social impacts in Meizhou Bay. Mitigation measures have been effectively implemented to mitigate the temporary impact during the dredging and blasting operations. Public survey confirmed that the project implementation did not cause substance loss of aqua-cultural industries. Ecological survey during the preparation Phase III EIA also confirmed that there are no legacy environmental issues from the Phase II project. Therefore, there is no reputational risk envisaged from Phase II project from environmental perspective for the Bank’s funding in Phase III project.

3. Putou and Xiaocuo Operational Area

In Putou Operational Area, currently the #1 and #2 berths are substantially finished. Dike were built already and backfilling has been done. Consultation with Putou Dock Development Company has confirmed that the current backfilling material of sand and gravels were purchased from designated material suppliers in the Putian city. Construction material supply is regulated by environmental authority in China. These suppliers are legally operated entities, with business license and environmental permit. The operation of these entities is subject to routine supervisions of local environmental authority. Therefore, the source of backfill materials in the #1 and #2 berth sites is fully in compliance with national environmental regulations and procedures, and will not cause reputational risk for the disposal of dredged material from the Phase III project.

For Xiaocuo, Phase III dredged material will be disposed of in the #5 and #6 berth sites. Currently, since Phase III dredging has not started yet. Backfill is yet to start. Xiaocuo Dock Development Company has provided a statement indicating the willingness to receive the dredged material from the proposed Phase III project for land reclamation. Besides the dredged material, the Company would also need additional filling materials to prepare the land for berth construction. Like Putou, these additional sand and gravel will be purchased from commercial suppliers which are under regulation and supervision of environmental authorities. Purchasing materials from legally operated and environmentally permitted suppliers will not cause reputational risk for the use of Phase III dredged material for #5 and #6 berth construction in Xiaocuo.



N
50,000DWT Putou Channel
200m wide
Dongzhuang Town
Putou 1# 2# Berth
LNG Pipeline
Putou
Xiaocuo Channel
200m wide
Xiaocuo 1#~4# Berth
Yuetang Town
Scale
0 1.0 2.0 3.0km
Xiaocuo
West Huiyu Channel
250m wide
Huiyu
S202
Talin
Shanting Town
Yangyu Channel
Meeting Area
Channel of Meizhou Bay Power Plant
Fujian Refinery Channel
250m wide
Fujian Refinery Pipeline
Temporary Channel for construction
70m wide
Dongwu Berth
250,000DWT Main Channel
300m wide
Panyu
Dasheng Island
Dazhu Island
1# Anchorage
Douwei
300,000DWT Crude Oil Dock
Dongwu Channel
250m wide
Meizhou Island
Huanggan Island
2# Anchorage
Dongzhou Peninsula
Legend
Phase I Main Channel
Phase I Branch Channel and Anchorage Zone
Phase II Channel and Anchorazge Zone
LNG Emergency anchorage
300,000DWT Channel of Fujian Refinery (to dock of Fujian Refinery)
Jianyu Anchorage
Jianyu
Xiaozuo Town

Annex B Ecological Baseline Information

Table 1 Survey of Water Quality Indicators under high tide during the neap season

Station No.	Water Temperature (℃)	Salinity	pH	Dissolved oxygen	Saturation Capacity of Dissolved oxygen	Chemical oxygen demand	Inorganic nitrogen	Reactive phosphate
				(mg/L)				
A01	26.26	33.56	7.99	6.67	6.68	0.44	0.019	0.009
A02	25.45	33.49	8.04	6.66	6.78	0.40	0.027	0.011
A03	25.46	33.56	8.05	6.69	6.77	0.34	0.024	0.010
A04	25.12	33.46	7.99	6.57	6.82	0.36	0.035	0.011
A05	25.50	33.48	8.00	6.53	6.77	0.26	0.033	0.010
A06	25.51	33.52	8.04	6.67	6.77	0.34	0.039	0.010
A07	28.54	33.31	7.99	6.27	6.44	0.36	0.119	0.020
A08	28.54	33.32	8.01	6.35	6.44	0.48	0.111	0.020
A09	28.99	33.25	7.99	6.41	6.40	0.73	0.127	0.022
A10	28.60	33.29	7.98	6.32	6.44	0.53	0.123	0.021
A11	28.76	33.16	7.98	6.30	6.42	0.73	0.136	0.023
A12	28.80	33.09	7.97	6.28	6.42	0.69	0.135	0.021
A13	28.99	33.07	7.97	6.22	6.40	0.61	0.154	0.025
A14	28.95	32.99	7.96	6.24	6.41	0.77	0.158	0.025
A15	28.68	33.07	7.95	6.23	6.44	0.44	0.144	0.022
A16	29.53	32.94	7.84	6.21	6.35	0.40	0.160	0.024
A17	29.78	32.96	7.87	6.17	6.33	0.73	0.179	0.055
A18	29.59	33.05	7.95	6.21	6.34	0.61	0.167	0.024
A19	30.87	31.70	7.69	6.20	6.26	0.65	0.310	0.055
A20	30.92	31.70	7.71	6.15	6.26	0.69	0.272	0.050

Station No.	Suspended sediment	Oil	Copper	Zinc	Cadmium	Mercury	Lead	Arsenic
	(mg/L)		(μg/L)					
A01	17.6	0.014	3.81	11.5	0.14	0.07	0.20	1.95
A02	18.1	0.008	2.07	7.77	0.10	0.07	0.14	1.93
A03	22.9	0.010	4.99	15.2	0.14	0.05	0.34	2.05
A04	23.2	0.011	2.50	12.1	0.13	0.07	0.12	2.07
A05	20.3	0.010	2.03	7.30	0.09	0.06	0.18	1.95
A06	23.2	0.014	4.28	19.3	0.15	0.05	0.75	1.97
A07	26.3	0.010	1.99	7.36	0.09	0.05	<0.01	2.27
A08	22.7	0.012	2.23	9.86	0.07	0.05	<0.01	2.37
A09	22.1	0.011	2.08	8.61	0.11	0.06	<0.01	2.20
A10	21.7	0.011	2.06	7.19	0.10	0.05	<0.01	2.16
A11	21.6	0.014	2.29	6.93	0.10	0.05	<0.01	2.25
A12	21.8	0.009	1.98	6.21	0.11	0.05	<0.01	2.12
A13	24.5	0.008	1.91	6.62	0.09	0.06	<0.01	2.34
A14	29.0	0.010	2.19	10.3	0.08	0.06	<0.01	2.23
A15	28.1	0.012	1.93	5.76	0.09	0.05	<0.01	2.24
A16	19.0	0.014	2.01	7.19	0.08	0.05	<0.01	2.17

A17	21.1	0.013	2.09	8.02	0.11	0.06	<0.01	2.48
A18	22.7	0.013	2.00	6.00	0.10	0.05	<0.01	2.38
A19	24.4	0.010	2.28	7.57	0.12	0.05	<0.01	2.64
A20	23.1	0.015	2.50	11.1	0.13	0.06	0.10	2.64

Table 2 Survey of Water Quality Indicators under low tide during the neap season

Station No.	Water Temperature (℃)	Salinity	pH	Dissolved oxygen	Saturation Capacity of Dissolved oxygen	Chemical oxygen demand	Inorganic nitrogen	Reactive phosphate
				(mg/L)				
A01	26.40	33.61	8.07	6.65	6.66	0.32	0.032	0.013
A02	26.41	33.54	8.12	6.70	6.66	0.37	0.032	0.015
A03	26.45	33.57	8.13	6.66	6.66	0.28	0.047	0.010
A04	27.54	33.81	8.04	6.60	6.53	0.39	0.024	0.009
A05	25.61	33.60	8.11	6.73	6.75	0.37	0.030	0.010
A06	26.10	33.57	8.14	6.68	6.70	0.28	0.031	0.011
A07	28.77	33.32	8.01	6.45	6.42	0.28	0.110	0.019
A08	26.68	33.69	8.05	6.43	6.63	0.28	0.069	0.014
A09	27.41	33.63	8.07	6.43	6.55	0.32	0.075	0.015
A10	29.27	33.59	8.03	6.47	6.36	0.65	0.119	0.019
A11	27.22	33.62	8.01	6.48	6.57	0.28	0.067	0.016
A12	28.37	33.34	8.05	6.38	6.46	0.34	0.102	0.017
A13	29.31	33.29	8.00	6.23	6.36	0.48	0.147	0.023
A14	28.80	33.22	7.98	6.37	6.42	0.31	0.133	0.021
A15	28.54	33.26	7.94	6.39	6.44	0.44	0.149	0.022
A16	28.94	33.02	7.98	6.24	6.41	0.44	0.171	0.025
A17	29.08	33.09	7.98	6.23	6.39	0.57	0.177	0.026
A18	29.31	33.11	7.97	6.36	6.37	0.64	0.153	0.023
A19	30.95	31.75	7.88	6.28	6.25	0.66	0.303	0.055
A20	30.93	31.75	7.85	6.17	6.25	0.68	0.304	0.056
Station No.	Suspended sediment	Oil	Copper	Zinc	Cadmium	Mercury	Lead	Arsenic
	(mg/L)		(μg/L)					
A01	24.5	0.011	3.62	10.0	0.12	0.04	0.20	2.05
A02	25.9	0.014	1.79	11.1	0.09	0.05	<0.01	2.06
A03	29.5	0.011	1.98	12.1	0.09	0.06	<0.01	2.00
A04	24.6	0.009	2.36	17.8	0.10	0.04	0.12	2.12
A05	29.9	0.008	1.82	13.4	0.11	0.04	<0.01	1.94
A06	25.9	0.011	1.95	9.37	0.09	0.04	<0.01	1.85
A07	22.5	0.010	2.24	8.41	0.12	0.04	0.01	2.20
A08	20.5	0.010	1.70	5.87	0.11	0.07	<0.01	2.11
A09	19.9	0.010	2.14	7.07	0.10	0.06	0.03	1.97
A10	23.7	0.014	1.96	6.82	0.09	0.05	<0.01	2.26
A11	20.1	0.013	1.69	5.50	0.09	0.04	<0.01	2.15

A12	18.4	0.016	1.75	5.81	0.07	0.04	<0.01	2.00
A13	28.1	0.013	1.91	6.77	0.10	0.06	<0.01	2.08
A14	21.0	0.009	1.91	6.45	0.09	0.06	<0.01	2.22
A15	21.0	0.009	1.93	6.82	0.06	0.06	<0.01	2.06
A16	25.5	0.008	2.12	6.98	0.11	0.04	<0.01	2.33
A17	21.4	0.011	2.50	8.24	0.10	0.06	0.02	2.21
A18	20.9	0.008	1.87	6.00	0.09	0.05	<0.01	2.12
A19	26.0	0.010	2.46	9.60	0.13	0.06	<0.01	2.72
A20	25.8	0.012	2.18	6.51	0.09	0.04	<0.01	2.53

Table 3 Survey of Water Quality Indicators under high tide during the spring season

Station No.	Water Temperature (℃)	Salinity	pH	Dissolved oxygen	Saturation Capacity of Dissolved oxygen	Chemical oxygen demand	Inorganic nitrogen	Reactive phosphate
				(mg/L)				
A01	26.96	33.60	8.15	7.74	6.60	0.60	0.012	0.008
A02	26.38	33.65	8.13	7.77	6.66	0.50	0.012	0.008
A03	25.94	33.63	8.10	7.47	6.71	0.59	0.014	0.008
A04	26.11	33.56	7.99	7.29	6.70	0.54	0.014	0.008
A05	24.97	33.89	7.97	6.73	6.82	0.58	0.016	0.008
A06	26.38	33.63	8.11	7.74	6.66	0.66	0.013	0.007
A07	25.69	33.69	8.00	6.50	6.74	0.48	0.012	0.011
A08	26.58	33.57	8.05	6.39	6.64	0.62	0.015	0.010
A09	27.32	33.50	8.06	6.52	6.57	0.54	0.022	0.011
A10	27.39	33.46	8.02	6.30	6.56	0.70	0.027	0.011
A11	26.94	33.56	8.04	6.45	6.60	0.42	0.017	0.010
A12	27.05	33.58	8.04	6.42	6.59	0.66	0.027	0.013
A13	28.23	33.35	7.97	6.48	6.47	0.74	0.065	0.015
A14	28.10	33.30	8.00	6.56	6.49	0.68	0.069	0.016
A15	27.71	33.40	8.01	6.57	6.53	0.70	0.038	0.014
A16	28.46	33.39	7.99	6.39	6.45	0.81	0.091	0.018
A17	28.21	33.48	8.00	6.40	6.47	0.58	0.085	0.016
A18	28.03	33.54	8.00	6.49	6.49	0.52	0.070	0.017
A19	29.35	33.04	7.90	6.26	6.37	0.58	0.153	0.028
A20	29.13	33.11	7.91	6.25	6.39	0.73	0.151	0.028
Station No.	Suspended sediment	Oil	Copper	Zinc	Cadmium	Mercury	Lead	Arsenic
	(mg/L)		(μg/L)					
A01	19.4	0.008	2.46	9.10	0.10	0.06	2.46	9.10
A02	17.8	0.007	2.38	11.0	0.11	0.07	2.38	11.00
A03	18.4	0.008	2.17	10.9	0.10	0.05	2.17	10.90
A04	21.6	0.012	2.05	7.88	0.10	0.06	2.05	7.88
A05	16.6	0.007	1.82	8.93	0.07	0.06	1.82	8.93
A06	19.7	0.007	2.31	8.17	0.11	0.07	2.31	8.17

A07	18.7	0.011	2.59	11.2	0.12	0.07	2.59	11.20
A08	22.5	0.005	2.56	13.5	0.10	0.05	2.56	13.50
A09	24.1	0.006	2.47	9.12	0.13	0.06	2.47	9.12
A10	25.0	0.007	2.13	10.9	0.11	0.06	2.13	10.90
A11	25.1	0.007	2.23	10.7	0.10	0.07	2.23	10.70
A12	25.7	0.007	2.03	6.92	0.08	0.05	2.03	6.92
A13	24.5	0.014	3.19	6.80	0.65	0.07	3.19	6.80
A14	18.4	0.009	2.53	8.70	0.12	0.09	2.53	8.70
A15	20.4	0.007	2.45	9.83	0.08	0.06	2.45	9.83
A16	13.9	0.008	2.70	7.27	0.11	0.06	2.70	7.27
A17	24.6	0.006	2.13	6.16	0.09	0.06	2.13	6.16
A18	21.8	0.007	2.67	6.16	0.10	0.04	2.67	6.16
A19	28.7	0.010	2.59	7.38	0.11	0.04	2.59	7.38
A20	27.1	0.010	2.70	8.22	0.10	0.06	2.70	8.22

Table 4 Survey of Water Quality Indicators under low tide during the spring season

Station No.	Water Temperature (℃)	Salinity	pH	Dissolved oxygen	Saturation Capacity of Dissolved oxygen	Chemical oxygen demand	Inorganic nitrogen	Reactive phosphate
				(mg/L)				
A01	27.38	33.51	8.24	8.99	6.56	0.95	0.015	0.006
A02	27.29	33.56	8.20	8.54	6.57	0.76	0.014	0.009
A03	25.02	33.92	8.00	6.40	6.81	0.40	0.015	0.010
A04	26.60	33.53	8.10	8.14	6.64	0.91	0.011	0.008
A05	25.27	33.81	8.02	6.72	6.78	0.58	0.013	0.009
A06	25.30	33.90	8.04	6.71	6.78	0.62	0.013	0.010
A07	27.71	33.48	7.89	6.33	6.52	0.60	0.022	0.010
A08	28.00	33.46	8.05	6.21	6.49	0.66	0.028	0.011
A09	28.69	33.28	8.06	6.26	6.43	0.78	0.061	0.015
A10	28.50	33.26	7.96	6.15	6.45	0.50	0.061	0.015
A11	28.47	33.20	8.01	6.36	6.45	0.27	0.089	0.018
A12	28.87	33.13	8.02	6.37	6.41	0.50	0.103	0.022
A13	28.72	33.08	8.00	6.15	6.43	0.42	0.116	0.021
A14	28.87	33.10	8.00	6.20	6.41	0.42	0.117	0.022
A15	28.79	32.97	8.00	6.19	6.43	0.46	0.105	0.024
A16	30.55	32.24	7.93	6.14	6.27	0.52	0.122	0.023
A17	30.48	33.27	7.94	6.16	6.25	0.54	0.109	0.023
A18	29.5	33.26	7.96	6.19	6.34	0.40	0.116	0.022
A19	30.24	32.54	7.86	5.92	6.29	0.70	0.264	0.051
A20	30.38	32.47	7.88	6.09	6.28	0.82	0.268	0.053
Station No.	Suspended sediment	Oil	Copper	Zinc	Cadmium	Mercury	Lead	Arsenic
	(mg/L)		(μg/L)					
A01	21.7	0.008	2.38	5.87	0.11	0.06	<0.01	1.55
A02	19.3	0.009	2.43	6.42	0.10	0.05	<0.01	1.51
A03	23.8	0.007	2.09	7.17	0.09	0.05	<0.01	2.10
A04	23.4	0.006	2.24	9.37	0.08	0.05	<0.01	1.64
A05	20.2	0.006	2.29	8.42	0.10	0.05	<0.01	2.10
A06	20.8	0.007	2.41	8.67	0.08	0.06	0.21	1.97
A07	15.9	0.008	3.86	14.1	0.18	0.05	0.17	2.30
A08	17.5	0.006	2.71	7.93	0.09	0.06	<0.01	2.28
A09	21.6	0.008	2.28	6.13	0.10	0.06	<0.01	2.27
A10	18.5	0.006	2.31	6.08	0.10	0.05	<0.01	2.26
A11	19.9	0.006	1.94	5.80	0.09	0.06	<0.01	2.23
A12	23.0	0.009	2.25	5.92	0.11	0.06	<0.01	2.34
A13	18.6	0.006	2.34	6.26	0.11	0.06	<0.01	2.21
A14	18.9	0.006	2.38	6.18	0.11	0.06	<0.01	2.33
A15	20.9	0.006	3.17	6.11	0.11	0.07	<0.01	2.42

A16	22.6	0.007	2.34	6.02	0.11	0.06	<0.01	2.56
A17	31.3	0.007	2.52	7.41	0.12	0.03	<0.01	2.60
A18	48.5	0.008	2.62	7.70	0.11	0.07	<0.01	2.48
A19	28.9	0.008	2.49	6.67	0.10	0.06	<0.01	2.64
A20	30.8	0.008	2.52	6.34	0.08	0.06	<0.01	2.73

1. Phytoplankton

No.	Chinese Name	Scientific Name
	蓝藻门	CYANOPHYTA
1	红海束毛藻	*Trichodesmium erythraeum* Ehrenberg
2	铁氏束毛藻	*Trichodesmium thiebautii* Gom.
	裸藻门	EUGLENOPHYTA
3	裸藻(未定种)	*Euglena* sp.
	甲藻门	PYRROPHYTA
4	亚历山大藻(未定种)	*Alexandrium* sp.
5	叉角藻	*Ceratium furca* (Ehr.) Claparede et Lachmann
6	纺锤角藻	*Ceratium fusus* (Ehr.) Dujardin
7	三角角藻	*Ceratium tripos* (O. F. Muller) Nitzsch
8	具尾鳍藻	*Dinophysis caudata* Saville-Kent
9	倒卵形鳍藻	*Dinophysis fortii* Pavillard
10	裸甲藻(未定种)	*Gymnodinium* sp.
11	环沟藻(未定种)	*Gyrodinium* sp.
12	夜光藻	*Noctiluca scintillans* (Macartney) Kofoid et Swezy
13	扁平多甲藻	*Peridinium depressum* Bailey
14	叉分多甲藻	*Peridinium divergens* Ehrenberg
15	海洋多甲藻	*Peridinium oceanicum* Vanhoffen
16	闪光原甲藻	*Prorocentrum micans* Ehrenberg
17	反曲原甲藻	*Prorocentrum sigmoides* Bohm
18	二角原多甲藻	*Protoperidinium bipes* (Pauls) Balech
19	钟扁甲藻	*Pyrophacus horologicum* Stein
	硅藻门	BACILLARIOPHYTA
20	爱氏辐环藻	*Actinocyclus ehrenbergii* Ralfs
21	波状辐裥藻	*Actinoptychus undulatus* (Bailey) Ralfs
22	翼茧形藻	*Amphiprora alata* (Ehr.) Kuetzing
23	茧形藻(未定种)	*Amphiprora* sp.
24	双眉藻(未定种)	*Amphora* sp.
25	日本星杆藻	*Asterionella japonica* Cleve
26	加拉星杆藻	*Asterionella kariana* Grunow
27	扇形星脐藻	*Asteromphalus flabellatus* (Breb.) Greville
28	粗星脐藻	*Asteromphalus robustus* Castracane
29	奇异棍形藻	*Bacillaria paradoxa* Gemlin
30	透明辐杆藻	*Bacteriastrum hyalinum* Lauder

31	小辐杆藻	*Bacteriastrum minus* Karsten
32	锤状中鼓藻	*Bellerochea malleus* (Brightwe.) Van Heurck
33	活动盒形藻	*Biddulphia mobiliensis* (Bailey) Grunow
34	美丽盒形藻	*Biddulphia pulchella* Gray
35	菱状盒形藻	*Biddulphia rhombus* (Ehr.) W. Smith
36	中华盒形藻	*Biddulphia sinensis* Greville
37	马鞍藻(未定种)	*Campylodiscus* sp.
38	柏氏角管藻	*Cerataulina bergonii* Peragallo
39	窄隙角毛藻等角变种	*Chaetoceros affinis* v. *willei* (Gran) Hustedt
40	短孢角毛藻	*Chaetoceros brevis* Schuett
41	旋链角毛藻	*Chaetoceros curvisetus* Cleve
42	并基角毛藻单胞变型	*Chaetoceros decipiens* f. *singularis* Gran
43	密连角毛藻	*Chaetoceros densus* (Cleve) Cleve
44	双突角毛藻	*Chaetoceros didymus* Ehrenberg
45	垂缘角毛藻	*Chaetoceros laciniosus* Schuett
46	罗氏角毛藻	*Chaetoceros lauderi* Ralfs
47	洛氏角毛藻	*Chaetoceros lorenzianus* Grunow
48	拟弯角毛藻	*Chaetoceros pseudocurvisetus* Mangin
49	聚生角毛藻	*Chaetoceros socialis* Lauder
50	冕孢角毛藻	*Chaetoceros subsecundus* (Grun.) Hustedt
51	角毛藻(未定种)	*Chaetoceros* sp.
52	海洋环毛藻	*Corethron pelagicum* Brun
53	星脐圆筛藻	*Coscinodiscus asteromphalus* Ehrenberg
54	有翼圆筛藻	*Coscinodiscus bipartitus* Rattray
55	离心列圆筛藻	*Coscinodiscus excentricus* Ehrenberg
56	格氏圆筛藻	*Coscinodiscus granii* Gough
57	海南圆筛藻	*Coscinodiscus hainanensis* Kuo
58	琼氏圆筛藻	*Coscinodiscus jonesianus* (Grev.) Ostenfeld
59	线形圆筛藻	*Coscinodiscus lineatus* Ehrenberg
60	小形圆筛藻	*Coscinodiscus minor* Ehrenberg
61	辐射圆筛藻	*Coscinodiscus radiatus* Ehrenberg
62	温和圆筛藻	*Coscinodicus temperei* Brun
63	圆筛藻(未定种)	*Coscinodiscus* sp.
64	扭曲小环藻	*Cyclotella comta* (Ehr.) Kuetzing
65	条纹小环藻	*Cyclotella striata* Grunow
66	小环藻(未定种)	*Cyclotella* sp.
67	新月筒柱藻	*Cylindrotheca closterium* (Ehr.) Reimann et Lewin
68	地中海指管藻	*Dactyliosolen mediterraneus* (Perag.) Peragallo
69	蜂腰双壁藻	*Diploneis bombus* Ehrenberg
70	双壁藻(未定种)	*Diploneis* sp.
71	布氏双尾藻	*Ditylum brightwellii* (West) Grunow

72	太阳双尾藻	*Ditylum sol* Grunow
73	短角弯角藻	*Eucampia zoodiacus* Ehrenberg
74	大洋脆杆藻	*Fragilaria oceanica* Cleve
75	脆杆藻(未定种)	*Fragilaria* sp.
76	柔软几内亚藻	*Guinardia flaccida* (Castr.) Peragallo
77	薄壁半管藻	*Hemiaulus membranaceus* Cleve
78	中华半管藻	*Hemiaulus sinensis* Grunow
79	楔形半盘藻	*Hemidiscus cuneiformis* Wallich
80	哈德半盘藻	*Hemidiscus hardmannianus* (Grev.) Mann
81	北方劳德藻	*Lauderia borealis* Gran
82	丹麦细柱藻	*Leptocylindrus danicus* Cleve
83	楔形藻(未定种)	*Licmophora* sp.
84	波状石丝藻	*Lithodesmium undulatus* Ehrenberg
85	具槽直链藻	*Melosira sulcata* (Ehr.) Kuetzing
86	膜状舟形藻	*Navicula membranacea* Cleve
87	舟形藻	*Navicula* spp.
88	柔弱菱形藻	*Nitzschia delicatissima* Cleve
89	长菱形藻	*Nitzschia longissima* (Breb.) Grunow
90	长菱形藻弯端变种	*Nitzschia longissima* v. *reversa* Grunow
91	洛伦菱形藻	*Nitzschia lorenziana* Grunow
92	钝头菱形藻	*Nitzschia obtusa* W. Smith
93	尖刺菱形藻	*Nitzschia pungens* Grunow
94	弯菱形藻	*Nitzschia sigma* (Kuetz.) W. Smith
95	菱形藻	*Nitzschia* spp.
96	斜纹藻	*Pleurosigma* spp.
97	翼根管藻	*Rhizosolenia alata* Brightwell
98	翼根管藻纤细变型	*Rhizosolenia alata* f. *gracillima* (Cleve) Grunow
99	克氏根管藻	*Rhizosolenia clevei* Ostenfeld
100	粗刺根管藻	*Rhizosolenia crassispina* Schroeder
101	柔弱根管藻	*Rhizosolenia delicatula* Cleve
102	脆根管藻	*Rhizosolenia fragilissima* Bergon
103	钝棘根管藻半棘变型	*Rhizosolenia hebetata* f. *semispina* (Hansen) Gran
104	覆瓦根管藻	*Rhizosolenia imbricata* Brightwell
105	粗根管藻	*Rhizosolenia robusta* Norman et Ralfs
106	刚毛根管藻	*Rhizosolenia setigera* Brightwell
107	斯氏根管藻	*Rhizosolenia stolterforthii* Peragallo
108	笔尖形根管藻	*Rhizosolenia styliformis* Brightwell
109	笔尖形根管藻长棘变种	*Rhizosolenia styliformis* v. *longispina* Hustedt
110	笔尖形根管藻粗径变种	*Rhizosolenia styliformis* v. *latissima* Brightwell
111	中肋骨条藻	*Skeletonema costatum* (Grev.) Cleve

112	掌状冠盖藻	*Stephanopyxis palmeriana* (Grev.) Grunow
113	扭鞘藻	*Streptotheca thamesis* Schrubsole
114	流水双菱藻	*Surirella fluminensis* Grunow
115	芽形双菱藻	*Surirella gemma* Ehrenberg
116	菱形海线藻	*Thalassionema nitzschioides* (Grun.) Van Heurck
117	细弱海链藻	*Thalassiosira subtilis* (Ostenf.) Gran
118	伏氏海毛藻	*Thalassiothrix frauenfeldii* (Grun.) Grunow

2. Zooplankton

No.	Chinese Name	Scientific Name
	腔肠动物门	Coelenterata
1	鳞茎高手水母	*Bougainvillia muscus* (Allman)
2	短柄灯塔水母	*Turritopsis lata* Von Lendenfeld
3	锥形面具水母	*Pandea conica* (Quoy et Gaimaed)
4	真囊水母	*Euphysora bigelowi* Mass
5	锡兰和平水母	*Eirene ceylonensis* Browne
6	短柄和平水母	*Eirene brevistylis* Wang et Xu
7	短柄侧丝水母	*Helgicirraha brevistyla* Xu et Huang
8	薮枝螅水母	*Obelia* spp.
9	四叶小舌水母	*Liriope tetraphylla* (Chammiso et Eysenhardt)
10	异距小帽水母	*Petasiella asymmetrica* Uchida
11	两手框水母	*Solmundella bitentaculata* (Quoy et Gaimard)
12	双生水母	*Diphyes chamissonis* Huxley
13	拟细浅室水母	*Lensia subtiloides* (Len et Van Riemsdijk)
14	五角水母	*Muggiaea atlantica* Cunningham
	栉水母门	Ctenophora
15	球形侧腕水母	*Pleurobrachia globosa* Moser
	节肢动物门	Arthropoda
16	鸟喙尖头溞	*Penilia avirostris* Dana
17	史氏三角溞	*Podon schmackeri* Poppe
18	齿形海萤	*Cypridina dentata* (Muller)
19	针刺真浮萤	*Euconchoecia aculeata* (Scott)
20	中华哲水蚤	*Calanus sinicus* Brodsky
21	微刺哲水蚤	*Canthocalanus pauper* (Giesbrecht)
22	普通波水蚤	*Undinula vulgaris*(Dana)
23	强真哲水蚤	*Eucalanus crassus* Giesbrecht
24	亚强真哲水蚤	*Eucalanus subcrassus* Giesbrecht
25	小拟哲水蚤	*Paracalanus parvus* (Claus)
26	强额拟哲水蚤	*Paracalans crassirostris* Dahli
27	厦门矮隆哲水蚤	*Bestiola amoyensis* Li et Huang
28	驼背隆哲水蚤	*Acrocalanus gibber* Giesbrecht
29	精致真刺水蚤	*Euchaeta concinna* Dana

30	长刺小厚壳水蚤	*Scolecithricella longispinosa* Chen et Zhang
31	锥形宽水蚤	*Temora turbinata* (Dana)
32	瘦尾胸刺水蚤	*Centropages tenuiremis* Thompson et Scott
33	海洋伪镖水蚤	*Pseudodiaptomus marinus* Sato
34	伯氏平头水蚤	*Candacia bradyi* A. Scott
35	汤氏长足水蚤	*Calanopia thompsoni* A. Scott
36	椭形长足水蚤	*Calanopia elliptica* (Dana)
37	双刺唇角水蚤	*Labidocera bipinnata* Tanaka
38	真刺唇角水蚤	*Labidocera euchaeta* Giesbrecht
39	太平洋纺锤水蚤	*Acartia pacifica* Steuer
40	红纺锤水蚤	*Acartia erythraea* Giesbrecht
41	小纺锤水蚤	*Acartia negligens* Dana
42	钳形歪水蚤	*Tortanus forcipatus* (Giesbrecht)
43	瘦歪水蚤	*Tortanus gracilis*(Brady)
44	拟长腹剑水蚤	*Oithona similis* Claus
45	小长腹剑水蚤	*Oithona nana* Giesbrecht
46	简长腹剑水蚤	*Oithona simplex* Farran
47	短角长腹剑水蚤	*Oithona brevicornis* Giesbrecht
48	羽长腹剑水蚤	*Oithona plumifera* Baird
49	中隆剑水蚤	*Oncaea media* Giesbrecht
50	近缘大眼剑水蚤	*Corycaeus affinis* Mcmurrichi
51	平大眼剑水蚤	*Corycaeus dahli* Tanaka
52	红大眼剑水蚤	*Corycaeus erythraeus* Cleve
53	灵巧大眼剑水蚤	*Corycaeus catus* F.Dahl.1894
54	大眼剑水蚤(未定种)	*Corycaeus* sp.
55	挪威毛猛水蚤	*Microsetella norvegica* (Boeck)
56	小盘盔头猛水蚤	*Clytemnestra scutellata* Dana
57	尖额真猛水蚤	*Euterpina acutifrons* Dana
58	中华假磷虾	*Pseudeuphausia sinica* Wang et Chen
59	宽尾刺糠虾	*Acanthom ysis laticauda* Liu et Wang
60	涟虫	*Cumacea* sp.
61	钩虾	*Gammaridea*
62	孟加拉蛮戎	*Lestrigonus bengalensis* Giles
63	日本毛虾	*Acetes japonicus* Kishinouye
64	中型莹虾	*Lucifer intermedius* Hansen
	软体动物门	Mollusca
65	尖笔帽螺	*Creseis acicula* Rang
66	明螺	*Atlanta peroni* Lesueur
	毛颚动物门	Chaetognatha
67	肥胖箭虫	*Sagitta enflata* Grassi
68	美丽箭虫	*Sagitta pulchra* Doncaster
69	凶形箭虫	*Sagitta ferox* Doncaster
70	小箭虫	*Sagitta neglecta* Aida
	尾索动物门	Urochordata

71	长尾住囊虫	*Oikopleura longicauda* (Vogt)
72	异体住囊虫	*Oikopleura dioica* Fol
73	住筒虫	*Fritillaria* sp.
74	小齿海樽	Doliolum denticulatum Quiy et Gaimard
	浮游幼体	larvae
75	长尾类幼体	Macrura larva
76	短尾类幼体	Brachyura larva
77	磁蟹幼体	Porcellana larva
78	阿利玛幼体	Alima larva
79	多毛类幼体	*Polychaeta* larva
80	蔓足类幼体	Balanus nauplius
81	双壳类幼体	Bivalve larva
82	帽形幼虫	Pilidium larva
83	辐轮幼虫	Actinotrocha larva
84	鱼卵	fish egg
85	仔鱼	Fish larva

3. Fish Egg and Fry

No.	Chinese Name	Scientific Name
	鲱科	Clupeidae
1	鲱科之一种	*Clupeidae* sp.
2	小沙丁鱼	*Sardinella* sp.
3	斑鰶	*Clupandon punctatus*(Temminck & Schlegel)
	鳀科	Engraulidae
4	小公鱼	*Stolephorus* sp.
	鲉科	Scorpaenidae
5	鲉科之一种	*Scorpaenidae* sp.1
6	鲉科之一种	*Scorpaenidae* sp.2
	锯盖鱼科	Centropomidae
7	眶棘双边鱼	*Ambassis gymnocephalus* Lacepede
	鱚科	Sillaginidae
8	少鳞鱚	*Sillago japonica* Temminck & Schlegel
	鳚科	Blenniidae
9	美肩鳃鳚	*Omobranchus elegans*
	鰕虎鱼科	Gobiidae
10	鰕虎鱼科之一种	*Gobiidae* sp.
	舌鳎科	Cynoglossidae
11	舌鳎属之一种	*Cynoglossus* sp.

4. Benthic Organisms

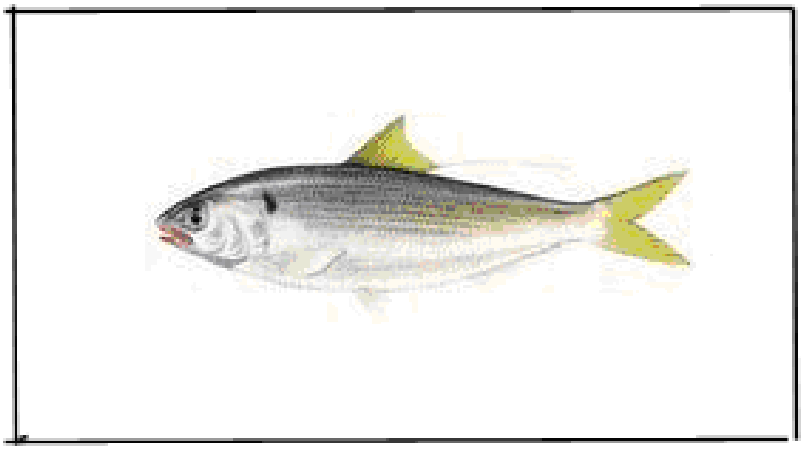
No.	Chinese Name	Scientific Name
	腔肠动物门	COELENTERA

1	指海葵	*Actinia sp.*
	纽形动物门	NEMERTINEA
2	脑纽虫	*Cerebratulina sp.*
	环节动物门	ANNELINA
3	背鳞虫	*Lepidonotus sp.*
4	背蚓虫	*Notomastus latericeus*
5	不倒翁虫	*Sternaspis scutata*
6	才女虫	*Polydora sp.*
7	独毛虫	*Tharyx sp.*
8	独指虫	*Aricidea fragilis*
9	饭岛全刺沙蚕	*Nectoneanthes ijimai*
10	寡节甘吻沙蚕	*Glycinde gurjanovae*
11	海扇虫	*Pherusa sp.*
12	红刺尖锥虫	*Scoloplos rubra*
13	后指虫	*Laonice cirrata*
14	花冈钩毛虫	*Sigambra hanaokai*
15	滑指矶沙蚕	*Eunice indica*
16	加州中蚓虫	*Mediomastus californiensis*
17	昆士兰稚齿虫	*Prionospio queenslandica*
18	鳞腹沟虫	*Scolelepis squamata*
19	毛盲蟹	*Thphlocarcinus villosus*
20	膜囊尖锥虫	*Scoloplos marsupialis*
21	拟特须虫	*Paralacydonia paradoxa*
22	奇异稚齿虫	*Paraprionospio pinnata*
23	强壮顶须虫	*Acrocirrus validus*
24	全刺沙蚕	*Nectoneanthes oxypoda*
25	日本强刺鳞虫	*Sthenolepis japonica*
26	蛇杂毛虫	*Poecilochaetus serpens*
27	梳鳃虫	*Terebellides stroemii*
28	树蛰虫	*Pista cristata*
29	树栉虫	*Samytha sp.*
30	双腮内卷齿蚕	*Aglaophamus dibranchis*
31	双形拟单指虫	*Cossurella dimorpha*
32	双栉虫	*Ampharete acutifrons*
33	丝鳃虫	*Cirratulus sp.*
34	丝线沙蚕	*Drilonereis filum*
35	似蛰虫	*Amaeana trilobata*
36	索沙蚕	*Lumbrineris sp.*
37	太平洋长手沙蚕	*Magelona pacifica*
38	西方似蛰虫	*Amaeana occidentalis*
39	新三齿巢沙蚕	*Diopatra neotridens*
40	岩虫	*Marphysa sanguinea*
41	隐头卷虫	*Bhawania goodei*

42	真节虫	*Euclymene sp.*
43	锥唇吻沙蚕	*Glycera onomichiensis*
	星虫动物门	SIPUNCULA
44	戈芬星虫	*Golfingia sp.*
45	毛头梨体星虫	*Apionsoma trichocephala*
	节肢动物门	ARTHROPODA
46	扁足异对虾	*Atypopenaeus stenodactylus*
47	仿对虾	*Parapenaeopsis sp.*
48	蜾蠃蜚	*Corophium sp.*
49	马耳他钩虾	*Melita sp.*
50	模糊新短眼蟹	*Neoxenophthalmus obscurus*
51	沙钩虾	*Byblis sp.*
	软体动物门	MOLLUSCA
52	被角樱蛤	*Angulus vestalioides*
53	豆形胡桃蛤	*Nucula faba*
54	菲律宾蛤仔	*Ruditapes philippinarum*
55	蛤蜊	*Mactra sp.*
56	虹光亮樱蛤	*Nitidotellina iridella*
57	小亮樱蛤	*Nitidotellina minuta*
58	锈色朽叶蛤	*Coecella turgida*
	棘皮动物门	ECHINODERMATA
59	光滑倍棘蛇尾	*Amphioplus laevis*
60	星刺蛇尾	*Ophiothrix ciliaris*
61	阳遂足	*Amphiura sp.*
62	翼手参	*Colochirus sp.*

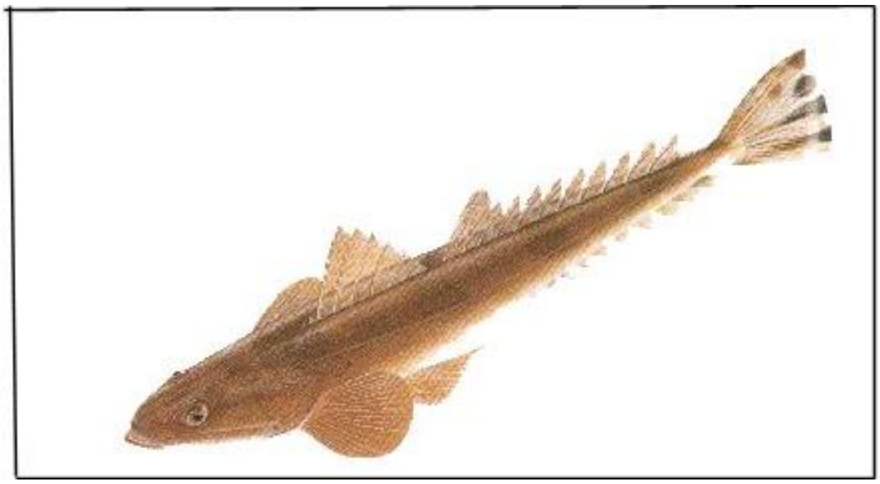
5. Fish

Silver sillago



Clupanodon punctatus

Mullet



Flathead fish


Trachypenaeus curvirostris


Metapenaeus ensis


Oratosquilla oratoria

Annex C Public Announcement for Ocean-Dumping Site by State Oceanic Administration

The State Oceanic Administration of People's Republic of China issued the public announcement for approving Meizhou Bay Marine Waste-Dumping Site on October 29, 2010.

The announcement indicates the site was officially approved by State Council. The site is located in 24.52'33"N, 119.04'48"E, a circle with radius 0.5 nm. The total area is 2.69km2.

Annex D Public Consultation

D.1 Directory of Participants in Public Consultation during Information Disclosure

序号 No.	被调查者姓名 Name	性别 Sex	单位或住址 Address	职业 Occupation
1	林玉荣 Lin Yurong	男 Male	莆田海事局 Putian Marine Affairs Bureau	干部 Officer
2	江 涛 Jiang Tao	男 Male	福建省罗屿港口开发有限公司 Luoyu Port Development Co. Ltd, Fujian	干部 Officer
3	许国扬 Xu Guoyang	男 Male	中海福建天然气有限公司 CNOOC in Fujian	船长 Captain
4	陈锦峰 Chen Jinfeng	男 Male	福建八方港口发展有限公司 Bafang Port Development Co. Ltd, Fujian	干部 Officer
5	廖古清 Liao Guqing	男 Male	福建省莆头港口开发有限公司 Putou Port Development Co. Ltd, Fujian	工程师 Engineer
6	林云安 Lin Yun’an	男 Male	福建省肖厝港口开发公司 Xiaocuo Port Development Co. Ltd, Fujian	干部 Officer
7	黄 荣 Huang Rong	男 Male	秀屿区海洋与渔业局 Ocean and Fisheries Bureau of Xiuyu District	科员 Staff member
8	徐 拯 Xu Zheng	男 Male	秀屿区海洋与渔业局 Ocean and Fisheries Bureau of Xiuyu District	助工 Assistant engineer
9	郑剑飞 Zheng Jianfei	男 Male	湄洲湾北岸经济开发区交通局 Communications Bureau of Economic Development Zone in North Bank of Meizhou Bay	干部 Officer

10	林志鹏 Lin Zhipeng	男 Male	北岸管委会 North Bank Administrative Committee, Meizhou Bay	干部 Officer
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12	黄浩平 Huang Haoping	男 Male	秀屿区环保局 Environmental Protection Bureau of Xiuyu District	科员 Staff member
13	赵远清 Zhao Yuanqing	男 Male	泉港海事处 Maritime Affairs Division of Quangang district	海事监督 Marine Supervisor
14	陈朝晖 Chen Chaohui	男 Male	东埔镇政府 Dongpu Town Government	公务员 Civil servant
15	王秀娟 Wang Xiujuan	女 Female	东埔镇政府 Dongpu Town Government	干部 Officer
16	陈　锋 Chen Feng	男 Male	东埔镇政府 Dongpu Town Government	干部 Officer
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19	柯风 Ke Feng	男 Male	东埔镇政府 Dongpu Town Government	公务员 Civil servant
20	严梦媛 Yan Mengyuan	女 Female	东埔镇政府 Dongpu Town Government	职工 Staff
21	陈群英 Chen Qunying	女 Female	东埔镇政府 Dongpu Town Government	干部 Officer
22	蒋婷 Jiang Ting	女 Female	东埔镇政府 Dongpu Town Government	会计 Accountant
23	戴文盛 Dai Wensheng	男 Male	东埔镇塔林村 Talin Village, Dongpu Town	农民 Peasant

24	林金森 Lin Jinsen	男 Male	东埔镇塔林村 Talin Village, Dongpu Town	干部 Officer
25	张仁坤 Zhang Renkun	男 Male	东埔镇塔林村 Talin Village, Dongpu Town	农民 Peasant
26	陈亚纸 Chen Yazhi	男 Male	东埔镇东吴村 Dongwu Village, Dongpu Town	养殖户 Farmer
27	吴秉 Wu Bing	男 Male	东埔镇东吴村 Dongwu Village, Dongpu Town	农民 Peasant
28	吴阿来 Wu Alai	男 Male	东埔镇东吴村 Dongwu Village, Dongpu Town	养殖户 Farmer
29	吴振添 Wu Zhengtian	男 Male	东埔镇东吴村 Dongwu Village, Dongpu Town	干部 Officer
30	陈玉昭 Chen Yuzhao	男 Male	东埔镇东吴村 Dongwu Village, Dongpu Town	养殖户 Farmer
31	王进付 Wang Jinfu	男 Male	东埔镇吉城村 Jicheng Village, Dongpu Town	农民 Peasant
32	黄文财 Huang Wencai	男 Male	东埔镇吉城村 Jicheng Village, Dongpu Town	农民 Peasant
33	吴金珍 Wu Jinzhen	男 Male	东庄镇石尾村 Shiwei Village, Dongzhuang Town	养殖户 Farmer
34	吴文舍 Wu Wenshe	男 Male	东庄镇石尾村 Shiwei Village, Dongzhuang Town	农民 Peasant
35	吴伟新 Wu Weixin	男 Male	东庄镇石尾村 Shiwei Village, Dongzhuang Town	农民 Peasant
36	吴国瑞 Wu Guorui	男 Male	东庄镇石尾村 Shiwei Village, Dongzhuang Town	农民 Peasant
37	吴凤莺 Wu Fengying	女 Female	东庄镇石尾村 Shiwei Village, Dongzhuang Town	农民 Peasant

38	张国昌 Zhang Guochang	男 Male	东庄镇石尾村 Shiwei Village, Dongzhuang Town	农民 Peasant
39	廖数华 Liao Shuhua	女 Female	东埔镇乐屿村 Leyu Village, Dongpu Town	农民 Peasant
40	郭少海 Guo Shaohai	男 Male	东埔镇乐屿村 Leyu Village, Dongpu Town	农民 Peasant
41	郑剑堂 Zheng Jiantang	男 Male	东埔镇乐屿村 Leyu Village, Dongpu Town	农民 Peasant
42	郭秀荣 Guo Xiurong	男 Male	东埔镇乐屿村 Leyu Village, Dongpu Town	农民 Peasant
43	郑元兴 Zheng Yuanxing	男 Male	东埔镇乐屿村 Leyu Village, Dongpu Town	农民 Peasant
24	肖燕尖 Xiao Yanjian	男 Male	东埔镇乐屿村 Leyu Village, Dongpu Town	农民 Peasant
45	郑明煌 Zheng Minhuang	男 Male	东埔镇乐屿村 Leyu Village, Dongpu Town	农民 Peasant
46	消清明 Xiao Qingming	男 Male	东埔镇东屿村 Leyu Village, Dongpu Town	农民 Peasant
47	陈庆清 Chen Qingqing	男 Male	东埔镇下坑村 Xiakeng Village, Dongpu Town	干部 Officer
48	陈峰秀 Chen Fengxiu	男 Male	东埔镇西山路 Xishan Road, Dongpu Town	工人 Worker
49	黄建通 Huang Jiantong	男 Male	东埔镇 Dongpu Town	干部 Officer
50	刘华 Liu Hua	男 Male	东埔镇 Dongpu Town	干部 Officer
51	朱志平 Zhu Zhiping	男 Male	山亭镇政府 Shanting Town Government	干部 Officer
52	刘志华	男	山亭镇政府	干部

	Liu Zhihua	Male	Shanting Town Government	Officer
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54	李金秋 Li Jinqiu	男 Male	东庄镇大象村 Daxiang village, Dongzhuang town	农民 Peasant
55	李文章 Li Wenzhang	男 Male	东庄镇大象村 Daxiang village, Dongzhuang town	养殖户 Farmer
56	林清秀 Lin Qingxiu	男 Male	东庄镇大象村 Daxiang village, Dongzhuang town	农民 Peasant
57	李天粦 Li Tianlin	男 Male	东庄镇大象村 Daxiang village, Dongzhuang town	农民 Peasant
58	王永庆 Wang Yongqing	男 Male	东庄镇莆头村 Putou village, Dongzhuang town	养殖户 Farmer
59	王金虎 Wang Jinhu	男 Male	东庄镇莆头村 Putou village, Dongzhuang town	养殖户 Farmer
60	王先云 Wang Xianyun	男 Male	东庄镇莆头村 Putou village, Dongzhuang town	养殖户 Farmer
61	黄开元 Huang Kaiyuan	男 Male	东庄镇莆头村 Putou village, Dongzhuang town	养殖户 Farmer
62	王德兴 Wang Dexing	男 Male	东庄镇莆头村 Putou village, Dongzhuang town	农民 Peasant
63	王瑞柘 Wang Ruizhe	男 Male	东庄镇莆头村 Putou village, Dongzhuang town	农民 Peasant
64	吴金连 Wu Jinlian	女 Female	东庄镇莆头村 Putou village, Dongzhuang town	农民 Peasant
65	游国瑞 You Guorui	男 Male	东庄镇莆头村 Putou village, Dongzhuang town	农民 Peasant
66	陈建法 Chen Jianfa	男 Male	南埔镇沙格村 Shage village, Nanpu town	个体户 Self-employed Household
67	陈鳌	男	南埔镇沙格村	农民

	Chen Ao	Male	Shage village, Nanpu town	Peasant
68	王秋强 Wang Qiuqiang	男 Male	南埔镇沙格村 Shage village, Nanpu town	农民 Peasant
69	肖清友 Xiao Qingyou	男 Male	南埔镇 Nanpu town	农民 Peasant
70	肖宗全 Xiao Zongquan	男 Male	南埔镇 Nanpu town	农民 Peasant
71	柯顺成 Ke Shuncheng	男 Male	南埔镇 Nanpu town	农民 Peasant
72	刘宗代 Liu Zhongdai	男 Male	峰尾镇郭厝村 Guocuo village, Fengwei Town	农民 Peasant
73	郭株芳 Guo Zhufang	女 Female	峰尾镇郭厝村 Guocuo village, Fengwei Town	个体 Self-employed Household
74	刘秀琴 Liu Xiuqin	女 Female	峰尾镇郭厝村 Guocuo village, Fengwei Town	农民 Peasant
75	郭碧兰 Guo Bilan	女 Female	峰尾镇郭厝村 Guocuo village, Fengwei Town	农民 Peasant
76	林珠娘 Lin Zhuniang	女 Female	峰尾镇郭厝村 Guocuo village, Fengwei Town	农民 Peasant
77	黄惠强 Huang Huiqiang	男 Male	泉港区后龙镇 Houlong Town, Quangang District	干部 Officer
78	柯马朱 Ke Mazhu	男 Male	泉港区柯厝村 Kecuo village, Quangang district	经商 Businessman
79	柯风坤 Ke Fengkun	男 Male	泉港区柯厝村 Kecuo village, Quangang district	渔民 Fishman
80	陈雷英 Chen Leiying	女 Female	泉港区界山镇狮东村 Shidong village, Jieshan town, Quangang district	农民 Peasant
81	吴含文 Wu Hanwen	男 Male	泉港区界山镇狮东村 Shidong village, Jieshan town, Quangang district	自由职业 Liberal professional
82	刘玲玲	女	泉港区峰尾镇城峰村	自由职业

	Liu Lingling	Female	Chengfeng village, Fengwei town, Quangang district	Liberal professional
83	沈钦敏 Shen Qinmin	男 Male	泉港区界山镇下朱尾村 Xiazhuwei village, Jieshan town, Quangang district	自由职业 Liberal professional
84	许蓉芳 Xu Rongfang	女 Female	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	农民 Peasant
85	黄顺珠 Huang Shunzhu	女 Female	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	农民 Peasant
86	黄美香 Huang Meixiang	女 Female	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	农民 Peasant
87	许蓉梅 Xu Rongmei	女 Female	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	农民 Peasant
88	许星星 Xu Xingxing	男 Male	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	农民 Peasant
89	刘林 Liu Lin	男 Male	泉港区后龙镇委员会 Committee of Houlong town, Quangang district	公务员 Civil servant
90	连云 Lian Yun	女 Female	泉港区后龙镇后龙村 Houlong village, Houlong town, Quangang district	农民 Peasant
91	庄雯 Zhuang Wen	女 Female	泉港区山腰陈庄村 Chenzhuang village, Quangang district	教师 Teacher
92	林丽 Lin Li	女 Female	泉港区山腰陈庄村 Chenzhuang village, Quangang district	教师 Teacher
93	郭洪 Guo Hong	女 Female	峰尾镇郭厝村 Guocuo village, Fengwei town	农民 Peasant
94	柳小梅 Liu Xiaomei	女 Female	南埔镇柳厝村 Liucuo village, Nanpu town	医生 Doctor
95	肖惠阳 Xiao Huiyang	男 Male	肖厝村 Xiaocuo Village	农民 Peasant

96	陈顺珍 Chen Shunzhen	男 Male	梯亭村 Titing village	干部 Officer
97	杨明锋 Yang Mingfeng	男 Male	泉港区 Quangang District	农民 Peasant
98	林秀成 Lin Xiucheng	男 Male		农民 Peasant
99	杨学娥 Yang Xue’e	女 Female	前黄镇政府 Qianhuang Town	女 Female

D.2 Directory of Participants in Public Consultation during EA Documents Disclosure

序号 No.	被调查者姓名 Name	性别 Sex	单位或住址 Address	职业 Occupation
1	黄荣 Huang Rong	男 Male	莆田秀屿区海洋渔业局 Ocean and Fisheries Bureau of Xiuyu District	科员 Section member
2	凌智伟 Ling Zhiwei	男 Male	莆田秀屿区海洋渔业局 Ocean and Fisheries Bureau of Xiuyu District	驾驶员 Driver
3	林永荣 Lin Yongrong	男 Male	泉港海事处 Maritime Affairs Division of Quangang district	干部 Officer
4	庄月云 Zhuang Yueyun	女 Female	泉港农林水局 Water Resources Bureau of Quangang District	干部 Officer
5	曾志辉 Zeng Zhihui	男 Male	莆头公司 Putou Port Development Co. Ltd.	工程师 Engineer
6	陈贵发 Chen Guifa	男 Male	福建八方港口发展有限公司 Bafang Port Development Co. Ltd., Fujian	工程师 Engineer
7	陈少大 Chen Shaoda	男 Male	国投湄洲湾发展有限公司	办事员 Clerk
8	王珍珍 Wang Zhenzhen	女 Female	福建省肖厝港口有限公司 Xiaocuo Port Development Co. Ltd, Fujian	文员 Clerk
9	郑成立 Zheng Chengli	男 Male	福建 LNG 接收站 Fujian LNG Receiving Station	职员 Staff
10	吴敏 Wu Min	男 Male	福建石化 Fujian Sinopec. Co.	工人 Worker

			Ltd.	
11	郑丽华 Zheng Lihua	女 Female	东庄镇人民政府 Dongzhuang Town Government	工人 Worker
12	李珠英 Li Zhuying	女 Female	东庄镇人民政府 Dongzhuang Town Government	干部 Officer
13	陈新云 Chen Xinyun	男 Male	东庄镇人民政府 Dongzhuang Town Government	干部 Officer
14	唐朝晖 Tang Chaohui	男 Male	东埔镇人民政府 Dongpu Town Government	干部 Officer
15	康国疆 Kang Guojiang	男 Male	东埔镇人民政府 Dongpu Town Government	公务员 Civil servant
16	陈贤荣 Chen Xianrong	男 Male	东埔镇人民政府 Dongpu Town Government	渔民 Fisherman
17	黄瑞 Huang Rui	男 Male	东埔镇人民政府 Dongpu Town Government	干部 Officer
18	唐秀红 Tang Xiuhong	女 Female	东埔镇人民政府 Dongpu Town Government	干部 Officer
19	陈金勇 Chen Jinyong	男 Male	东埔镇人民政府 Dongpu Town Government	公务员 Civil servant
20	林兴坚 Lin Xingjian	男 Male	东埔镇人民政府 Dongpu Town Government	干部 Officer
21	陈群花 Chen Qunhua	女 Female	东埔镇人民政府 Dongpu Town Government	公务员 Civil servant
22	郑珍 Zheng Zhen	女 Female	东埔镇人民政府 Dongpu Town Government	公务员 Civil servant
23	王秀娟 Wang Xiujuan	女 Female	东埔镇人民政府 Dongpu Town Government	干部 Officer
24	郭金太 Guo Jintai	男 Male	东埔镇人民政府 Dongpu Town Government	干部 Officer

25	王先天 Wang Xiantian	男 Male	东庄镇莆头村 Putou village, Dongzhuang Town	渔民 Fisherman
26	吴金连 Wu Jinlian	女 Female	东庄镇莆头村 Putou village, Dongzhuang Town	农民 Peasant
27	王永庆 Wang Yongqing	男 Male	东庄镇莆头村 Putou village, Dongzhuang Town	农民 Peasant
28	王金葵 Wang Jinkui	男 Male	东庄镇莆头村 Putou village, Dongzhuang Town	渔民 Fisherman
29	黄开元 Huang Kaiyuan	男 Male	东庄镇莆头村 Putou village, Dongzhuang Town	渔民 Fisherman
30	王往兴 Wang Wangxing	男 Male	东庄镇莆头村 Putou village, Dongzhuang Town	农民 Peasant
31	王瑞和 Wang Ruihe	男 Male	东庄镇莆头村 Putou village, Dongzhuang Town	农民 Peasant
32	游国瑞 You Guorui	男 Male	东庄镇莆头村 Putou village, Dongzhuang Town	渔民 Fisherman
33	吴文先 Wu Wenxian	男 Male	东庄镇石尾村 Shiwei village, Dongzhuang Town	农民 Peasant
34	卓凤莺 Zhuo Fengying	女 Female	东庄镇石尾村 Shiwei village, Dongzhuang Town	农民 Peasant
35	吴玉荣 Wu Yurong	男 Male	东庄镇石尾村 Shiwei village, Dongzhuang Town	农民 Peasant
36	吴国瑞 Wu Guorui	男 Male	东庄镇石尾村 Shiwei village, Dongzhuang Town	农民 Peasant
37	吴伟新 Wu Weixin	男 Male	东庄镇石尾村 Shiwei village, Dongzhuang Town	农民 Peasant
38	吴金珍 Wu Jinzhen	男 Male	东庄镇石尾村 Shiwei village, Dongzhuang Town	农民 Peasant

39	张同昌 Zhang Tongchang	男 Male	东庄镇石尾村 Shiwei village, Dongzhuang Town	农民 Peasant
40	李屿贤 Li Yuxian	男 Male	东庄镇大象村 Daxiang village, Dongzhuang Town	农民 Peasant
41	林清秀 Lin Qingxiu	男 Male	东庄镇大象村 Daxiang village, Dongzhuang Town	农民 Peasant
42	李天粦 Li Tianlin	男 Male	东庄镇大象村 Daxiang village, Dongzhuang Town	农民 Peasant
43	李金秋 Li Jinqiu	男 Male	东庄镇大象村 Daxiang village, Dongzhuang Town	农民 Peasant
24	李钦英 Li Qinying	男 Male	东庄镇大象村 Daxiang village, Dongzhuang Town	农民 Peasant
45	郭文兵 Guo Wenbing	男 Male	东埔镇乐屿村 Leyu village, Dongpu town	农民 Peasant
46	蒋文耀 Jiang Wenyao	男 Male	东埔镇乐屿村 Leyu village, Dongpu town	农民 Peasant
47	肖顺远 Xiao Shunyuan	男 Male	东埔镇乐屿村 Leyu village, Dongpu town	渔民 Fishman
48	肖剑民 Xiao Jianmin	男 Male	东埔镇乐屿村 Leyu village, Dongpu town	农民 Peasant
49	肖文和 Xiao Wenhe	男 Male	东埔镇乐屿村 Leyu village, Dongpu town	农民 Peasant
50	肖玉发 Xiao Yufa	男 Male	东埔镇乐屿村 Leyu village, Dongpu town	农民 Peasant
51	肖燕尖 Xiao Yanjian	男 Male	东埔镇乐屿村 Leyu village, Dongpu town	农民 Peasant
52	郑开兴 Zheng Kaixing	男 Male	东埔镇乐屿村 Leyu village, Dongpu town	渔民 Fishman
53	珠清华	男	东埔镇乐屿村 Leyu	职员

	Zhu Qinghua	Male	village, Dongpu town	Staff
54	吴金国 Wu Jinguo	男 Male	东埔镇东吴村 Dongwu village, Dongpu town	渔民 Fishman
55	陈金付 Chen Jinfu	男 Male	东埔镇东吴村 Dongwu village, Dongpu town	渔民 Fishman
56	吴金章 Wu Jinzhang	男 Male	东埔镇东吴村 Dongwu village, Dongpu town	渔民 Fishman
57	肖玉昭 Xiao Yuzhao	男 Male	东埔镇东吴村 Dongwu village, Dongpu town	干部 Officer
58	吴文味 Wu Wenwei	男 Male	东埔镇东吴村 Dongwu village, Dongpu town	农民 Peasant
59	肖行 Xiao Xing	男 Male	东埔镇东吴村 Dongwu village, Dongpu town	农民 Peasant
60	吴振添 Wu Zhentian	男 Male	东埔镇东吴村 Dongwu village, Dongpu town	农民 Peasant
61	陈亚狮 Chen Yashi	男 Male	东埔镇东吴村 Dongwu village, Dongpu town	农民 Peasant
62	吴名鹏 Wu Mingpeng	男 Male	东埔镇东吴村 Dongwu village, Dongpu town	农民 Peasant
63	陈圣杰 Chen Shengjie	男 Male	东埔镇东吴村 Dongwu village, Dongpu town	农民 Peasant
64	孙情芝 Sun Qingzhi	女 Female	东埔镇东埔村 Dongpu village, Dongpu Town	农民 Peasant
65	蒋婷 Jiang Ting	女 Female	东埔镇东埔村 Dongpu village, Dongpu Town	农民 Peasant
66	陈福顺 Chen Fushun	男 Male	东埔镇吉城村 Jicheng village, Dongpu town	农民 Peasant
67	林文太 Lin Wentai	男 Male	东埔镇西山村 Xishan village, Dongpu town	农民 Peasant
68	林文忠	男	东埔镇西山村	农民

	Lin Wenzhong	Male	Xishan village, Dongpu town	Peasant
69	陈毅力 Chen Yili	男 Male	南埔镇沙格村 Shage village, Nanpu town	农民 Peasant
70	王学燕 Wang Xueyan	女 Female	南埔镇沙格村 Shage village, Nanpu town	教师 Teacher
71	王春宵 Wang Chunxiao	女 Female	南埔镇沙格村 Shage village, Nanpu town	文员 Clerk
72	蔡晓梅 Cai Xiaomei	女 Female	南埔镇沙格村 Shage village, Nanpu town	文员 Clerk
73	王清章 Wang Qingzhang	男 Male	南埔镇沙格村 Shage village, Nanpu town	
74	柯厝 Ke Cuo	男 Male	南埔镇柯厝村 Kecuo village, Nanpu Town	经商 Businessman
75	柯成 Ke Cheng	男 Male	南埔镇凤翔村 Fengxiang village, Nanpu town	经商 Businessman
76	郭碧兰 Guo Bilan	女 Female	峰尾镇郭厝村 Guocuo village, Fengwei town	农民 Peasant
77	林珠娘 Lin Zhuniang	女 Female	峰尾镇郭厝村 Guocuo village, Fengwei town	农民 Peasant
78	刘秀琴 Liu Xiuqin	女 Female	峰尾镇郭厝村 Guocuo village, Fengwei town	家庭主妇 Housewife
79	刘宗代 Liu Zhongdai	男 Male	峰尾镇诚平村 Chengping village, Fengwei town	农民 Peasant
80	刘水珠 Liu Shuizhu	女 Female	峰尾镇诚平村 Chengping village, Fengwei town	农民 Peasant
81	许秀珍 Xu Xiuzhen	女 Female	后龙镇许厝村 Xucuo village, Houlong town	农民 Peasant
82	张林斌 Zhang	男 Male	后龙镇上西村 Shangxi village,	教师 Teacher

	Linbin		Houlong town	
83	林玉荣 Lin Yurong	男 Male	秀屿区 Xiuyu district	公务员 Civil servant
84	肖玉坤 Xiao Yukun	男 Male		渔民 Fishman
85	肖秀和 Xiao Xiuhe	男 Male		渔民 Fishman
86	陈桂林 Chen Guilin	男 Male	东庄镇营边居委会 Yingbian committee, Dongzhuang Town	渔民 Fishman
87	陈朝阳 Chen Chaoyang	男 Male	东埔镇 Dongpu town	工程师 Engineer
88	许华山 Xu Huashan	男 Male	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	农民 Peasant
89	许蓉梅 Xu Rongmei	女 Female	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	职员 Staff
90	许芳 Xu Fang	女 Female	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	农民 Peasant
91	黄阿香 Huang A’xiang	女 Female	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	农民 Peasant
92	黄美香 Huang Meixiang	女 Female	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	个体户 Self-employed Household
93	黄研珠 Huang Yanzhu	女 Female	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	农民 Peasant
94	陈琴 Chen Qin	女 Female	泉港区后龙镇许厝村 Xucuo village, Houlong town, Quangang district	职员 Staff
95	庄芦荟 Zhuang Luhui	女 Female	后龙镇 Houlong town	职员 Staff
96	庄一冰 Zhuang Yibin	男 Male	泉港区山腰镇 Shanyao town, Quangang district	农民 Peasant

97	庄梅鸿 Zhuang Meihong	女 Female	泉港区山腰镇 Shanyao town, Quangang district	职员 Staff
98	庄小娥 Zhuang Xiao’e	女 Female	泉港区山腰镇 Shanyao town, Quangang district	护士 Nurse
99	庄小燕 Zhuang Xiaoyan	女 Female	泉港区山腰镇 Shanyao town, Quangang district	个体户 Self-employed Household
100	李婷芬 Li Tingfen	女 Female	泉港区峰尾镇 Fengwei town, Quangang district	工程师 Engineer
101	刘国印 Liu Guoyin	男 Male	泉港区后龙镇土坑村 Tukeng village, Houlong town, Quangang district	农民 Peasant
102	柴文启 Cai Wenqi	男 Male	泉港区后龙镇土坑村 Tukeng village, Houlong town, Quangang district	农民 Peasant
103	范锋其 Fan Fengqi	男 Male	泉港区后龙镇土坑村 Tukeng village, Houlong town, Quangang district	农民 Peasant
104	如风 Ru Feng	女 Female	泉港区后龙镇土坑村 Tukeng village, Houlong town, Quangang district	个体户 Self-employed Household
105	岑远飞 Cen Yuanfei	男 Male	泉港区后龙镇割山村 Geshan village, Houlong town, Quangang district	农民 Peasant

Overview of Meizhou Bay Navigation Channel Phase-III Engineering Project (Stage-II)

Project Name	Meizhou Bay Navigation Channel Phase-III Engineering Project (Stage-II)
Location	See the attached drawing.
Brief Introduction	This project involves the upgrade of main navigation channel to allow for unidirectional tide-dependent navigation of up to 300,000 DWT bulk cargo ships, as well as unidirectional tide-independent navigation of Q-MAX LNG ships. It involves dredging quantity of 18,259,100 m3 and reef blasting quantity of 931,000 m3. It is proposed to transport dredged materials to Luoyu, Putou, Shimenao, Dongwu, and Xiaocuo backfill areas, as well as the disposal areas approved by the State Council.
Main Environmental Problems during Construction Period and Counter Measures	Main environmental problems: impacts of dredging to the environment and impacts of reef explosion to aquaculture farms. The corresponding protective measures mainly include: (1) Applying advanced dredging equipment and technique; (2) The overflow period of trailing suction hopper dredger shall be controlled within 0.5 hour to reduce the leak of suspended sediment into the sea to a minimum; (3) During construction, close attention shall paid to any leakage, in which case the corresponding measures shall be taken immediately; (4) Dredged materials shall be transported to the designated backfill area; (5) The reef explosion can only be implemented after all aquaculture farms within 400m reach of the reef explosion area have been relocated; (6) Millisecond short delay underwater blasting process shall be adopted and the explosive quantity for a single section is controlled to be less than 100kg, so as to reduce the impact of underwater blasting on the eco-system of the nearby sea area;
Main Environmental Problems during Operation Period and Counter Measures	Main environmental problems: The leakage of fuel oil into the sea as a result of any vessel accident incurred at the navigation channel may impose serious impacts on the marine environment and the eco-system for marine organisms. The corresponding protective measures mainly include: (1) The navigation aiding facilities shall be improved and close attention shall be paid to beacon setup and routine maintenance; (2) The pilot system shall be implemented; (3) The deck officer shall be qualified; (4) The port contingency plans shall be developed by the local maritime authority; (5) The vessel encountering accident shall instantly report to the local marine bureau and take the counter measures.

信息公开阶段公众参与调查表

姓名	[illegible]	性别	男	文化程度	高中	职业	经商
年龄	□18~30 ☑30~45 □45~50 □50 以上					联系电话	13506019100
单位或住址	柳港村5组						

一、请您在下列征询意见项目中以√方式选择、发表意见

1.本项目建设信息，您从以下哪方面得到的？

□报纸新闻 ☑有关会议 □建设单位 □公众议论 □网络新闻 □其它 □没有听说

2.您认为本工程建设对当地经济建设和社会发展是否有利？

☑很有利 □有利 □一般 □不利 □不表态

3.您认为本工程建设施工期可能带来哪些环境问题？(可多选)

☑疏浚挖泥 □船舶废水 ☑施工噪声 □船舶垃圾 □生态破坏

□施工大气 □无影响 □其它（ ）

4.您认为本工程建成后可能带来哪些影响？(可多选)

(1) 不利影响：☑生态破坏 □海水污染 □船舶事故影响 □其它（ ）

(2) 有利影响：☑促进经济发展 ☑提高通航能力 □其它（ ）

5.您对该项目产生影响的基本态度是：

□接受 ☑基本接受 □无所谓 □不能接受（理由： ）

6.您的利益所受影响程度：

□有利影响 ☑无影响 □不利影响

你的利益受影响，请继续选择受影响类型：

□生活环境 □渔业养殖 □劳动就业 □其它

7.如果您的利益受到影响，对建设方有何要求？

☑采取环保措施 □工程代替措施 □按国家规定补偿

□不要求补偿 □不表态 □其它（ ）

8.您对该项目的基本态度是：

☑赞成 □基本赞成 □无所谓 □不赞成（理由： ）

注：不赞成者请说明理由，否则本调查表视为无效。

二、请您对该项目建设及其环境保护工作发表意见和建议：

保护好生态环境下，提高通航能力，促进经济发展

调查人：[illegible]　　　　填表日期：2011年9月1日

信息公开阶段公众参与调查表

姓名	[illegible]	性别	男	文化程度	本科	职业	干部
年龄	□18~30 □30~45 □45~50 □50 以上			联系电话	0595-87971612		
单位或住址	泉港区农林水局						

一、请您在下列征询意见项目中以√方式选择、发表意见

1.本项目建设信息，您从以下哪方面得到的？

□**报纸新闻** ☑**有关会议** □**建设单位** □**公众议论** □**网络新闻** □**其它** □**没有听说**

2.您认为本工程建设对当地经济建设和社会发展是否有利？

☑**很有利** □**有利** □**一般** □**不利** □**不表态**

3.您认为本工程建设施工期可能带来哪些环境问题？(可多选)

□**疏浚挖泥** □**船舶废水** □**施工噪声** □**船舶垃圾** ☑**生态破坏**

□**施工大气** □**无影响** □**其它( )**

4.您认为本工程建成后可能带来哪些影响？(可多选)

(1) 不利影响：□**生态破坏** ☑**海水污染** □**船舶事故影响** □**其它( )**

(2) 有利影响：□**促进经济发展** □**提高通航能力** □**其它( )**

5.您对该项目产生影响的基本态度是：

□**接受** ☑**基本接受** □**无所谓** □**不能接受(理由：)**

6.您的利益所受影响程度：

□**有利影响** ☑**无影响** □**不利影响**

你的利益受影响，请继续选择受影响类型：

□**生活环境** □**渔业养殖** □**劳动就业** □**其它**

7.如果您的利益受到影响，对建设方有何要求？

□**采取环保措施** □**工程代替措施** ☑**按国家规定补偿**

□**不要求补偿** □**不表态** □**其它( )**

8.您对该项目的基本态度是：

☑**赞成** □**基本赞成** □**无所谓** □**不赞成(理由：)**

注：不赞成者请说明理由，否则本调查表视为无效。

二、请您对该项目建设及其环境保护工作发表意见和建议：

一、按规定造价报批，应取得相关部门批复；

二、对涉及沿海滩涂养殖和种植户应给予合理补偿，补偿后方可动工建设.

调查人： 填表日期：2011 年 9 月 1 日

信息公开阶段公众参与调查表

姓名	刘论珏	性别	女	文化程度	本科	职业	自由职业
年龄	☑18~30 □30~45 □45~50 □50 以上			联系电话	13685920850		
单位或住址	泉港区峰尾镇诚峰村						

一、请您在下列征询意见项目中以 √ 方式选择、发表意见

1.本项目建设信息，您从以下哪方面得到的？

□报纸新闻 □有关会议 □建设单位 ☑公众议论 □网络新闻 □其它 □没有听说

2.您认为本工程建设对当地经济建设和社会发展是否有利？

☑很有利 □有利 □一般 □不利 □不表态

3.您认为本工程建设施工期可能带来哪些环境问题？(可多选)

□疏浚挖泥 ☑船舶废水 ☑施工噪声 □船舶垃圾 ☑生态破坏

□施工大气 □无影响 □其它（ ）

4.您认为本工程建成后可能带来哪些影响？(可多选)

(1) 不利影响：☑生态破坏 □海水污染 □船舶事故影响 □其它（ ）

(2) 有利影响：☑促进经济发展 □提高通航能力 □其它（ ）

5.您对该项目产生影响的基本态度是：

□接受 ☑基本接受 □无所谓 □不能接受(理由：)

6.您的利益所受影响程度：

□有利影响 ☑无影响 □不利影响

你的利益受影响，请继续选择受影响类型：

☑生活环境 □渔业养殖 □劳动就业 □其它

7.如果您的利益受到影响，对建设方有何要求？

☑采取环保措施 □工程代替措施 ☑按国家规定补偿

□不要求补偿 □不表态 □其它（ ）

8.您对该项目的基本态度是：

□赞成 ☑基本赞成 □无所谓 □不赞成(理由：)

注：不赞成者请说明理由，否则本调查表视为无效。

二、请您对该项目建设及其环境保护工作发表意见和建议：

首先必须保护生态平衡，赔偿一定要到位，采用最~~新~~先进仪器来检测是否会造成污染的影响。

调查人：刘论珏　　　　填表日期：2011 年 9 月 1 日

湄洲湾航道三期工程（II阶段）环评报告书公示阶段公众参与调查表

姓名	肖燕光	性别	男	文化程度	高中	职业	农民
年龄	☐18~30 ☑30~45 ☐45~50 ☐50 以上			联系电话	13850242829		
单位或住址	东峤镇崠峙村					是否参加过信息公示座谈会	否

一、请您在下列征询意见项目中以√方式选择、发表意见

1.本项目建设信息，您从以下哪方面得到的？

☐报纸新闻 ☑有关会议 ☐建设单位 ☐公众议论 ☐网络新闻 ☐其它 ☐没有听说

2.您认为本工程建设对当地经济建设和社会发展是否有利？

☐很有利 ☑有利 ☐一般 ☐不利 ☐不表态

3.您认为本工程建设施工期可能带来哪些环境问题？(可多选)

☑疏浚挖泥 ☑船舶废水 ☐施工噪声 ☑船舶垃圾 ☑生态破坏

☑施工大气 ☐无影响 ☐其它(　　　)

4.您认为本工程建成后可能带来哪些影响？(可多选)

(1)不利影响：☑生态破坏 ☑海水污染 ☑船舶事故影响 ☑其它(养殖影响

(2)有利影响：☑促进经济发展 ☑提高通航能力 ☐其它(　　　)

5.您对该项目产生影响的基本态度是：

☐接受 ☐基本接受 ☐无所谓 ☑不能接受(理由：　　　)

6.您的利益所受影响程度：

☐有利影响 ☐无影响 ☑不利影响

你的利益受影响，请继续选择受影响类型：

☐生活环境 ☑渔业养殖 ☐劳动就业 ☐其它

7.如果您的利益受到影响，对建设方有何要求？

☑采取环保措施 ☐工程代替措施 ☑按国家规定补偿

☐不要求补偿 ☐不表态 ☐其它(　　　)

8.您对该项目的基本态度是：

☐赞成 ☑基本赞成 ☐无所谓 ☐不赞成(理由：　　　)

注：不赞成者请说明理由，否则本调查表视为无效。

二、请您对湄洲湾航道三期工程（II阶段）建设及其环境保护工作发表意见和建议：

充分评估工程建设对周边各种养殖的影响程度，制定合理的补偿要求。

湄洲湾航道三期工程（Ⅱ阶段）环评报告书公示阶段 公众参与调查表

姓名	[illegible]	性别	男	文化程度	初中	职业	养殖户
年龄	□18~30 □30~45 □45~50 □50 以上			联系电话	13338522017		
单位或住址	东浦镇东[illegible]村				是否参加过信息公示座谈会	是	

一、请您在下列征询意见项目中以 √ 方式选择、发表意见

1.本项目建设信息，您从以下哪方面得到的？

□报纸新闻 ☑有关会议 □建设单位 □公众议论 □网络新闻 □其它 □没有听说

2.您认为本工程建设对当地经济建设和社会发展是否有利？

□很有利 ☑有利 □一般 □不利 □不表态

3.您认为本工程建设施工期可能带来哪些环境问题？(可多选)

□疏浚挖泥 ☑船舶废水 □施工噪声 □船舶垃圾 □生态破坏

□施工大气 □无影响 □其它（ ）

4.您认为本工程建成后可能带来哪些影响？(可多选)

(1) 不利影响：□生态破坏 ☑海水污染 □船舶事故影响 □其它（ ）

(2) 有利影响：☑促进经济发展 □提高通航能力 □其它（ ）

5.您对该项目产生影响的基本态度是：

□接受 ☑基本接受 □无所谓 □不能接受（理由： ）

6.您的利益所受影响程度：

☑有利影响 □无影响 □不利影响

你的利益受影响，请继续选择受影响类型：

□生活环境 ☑渔业养殖 □劳动就业 □其它

7.如果您的利益受到影响，对建设方有何要求？

□采取环保措施 □工程代替措施 ☑按国家规定补偿

□不要求补偿 □不表态 □其它（ ）

8.您对该项目的基本态度是：

□赞成 ☑基本赞成 □无所谓 □不赞成（理由： ）

注：不赞成者请说明理由，否则本调查表视为无效。

二、请您对湄洲湾航道三期工程（Ⅱ阶段）建设及其环境保护工作发表意见和建议：

补偿方面多替养殖户考虑

湄洲湾航道三期工程（Ⅱ阶段）环评报告书公示阶段
公众参与调查表

姓名	陈金才	性别	男	文化程度	初中	职业	养殖 捕渔
年龄	□18~30 □30~45 ☑45~50 □50 以上			联系电话	15599462812		
单位或住址	山腰镇 下溪村				是否参加过信息公示座谈会	是	

一、请您在下列征询意见项目中以√方式选择、发表意见

1.本项目建设信息，您从以下哪方面得到的？

□报纸新闻 ☑有关会议 □建设单位 □公众议论 □网络新闻 □其它 □没有听说

2.您认为本工程建设对当地经济建设和社会发展是否有利？

□很有利 ☑有利 □一般 □不利 □不表态

3.您认为本工程建设施工期可能带来哪些环境问题？(可多选)

□疏浚挖泥 ☑船舶废水 □施工噪声 □船舶垃圾 □生态破坏

□施工大气 □无影响 □其它（ ）

4.您认为本工程建成后可能带来哪些影响？(可多选)

(1)不利影响：□生态破坏 ☑海水污染 □船舶事故影响 □其它（ ）

(2)有利影响：☑促进经济发展 □提高通航能力 □其它（ ）

5.您对该项目产生影响的基本态度是：

□接受 ☑基本接受 □无所谓 □不能接受(理由：)

6.您的利益所受影响程度：

☑有利影响 □无影响 □不利影响

你的利益受影响，请继续选择受影响类型：

□生活环境 ☑渔业养殖 □劳动就业 □其它

7.如果您的利益受到影响，对建设方有何要求？

☑采取环保措施 □工程代替措施 ☑按国家规定补偿

□不要求补偿 □不表态 □其它（ ）

8.您对该项目的基本态度是：

☑赞成 □基本赞成 □无所谓 □不赞成(理由：)

注：不赞成者请说明理由，否则本调查表视为无效。

二、请您对湄洲湾航道三期工程（Ⅱ阶段）建设及其环境保护工作发表意见和建议：

1.建设对海上的养殖方面给予多赔偿一些。

2.对海面污水要做好处理。

END
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