7

Evaluation of Impacts

7 Evaluation of Impacts

7.1 Identification and Prediction Assessment of Impacts

The proposed Project location which is located nearby the Sungai Kuantan river mouth and its navigation channel further intensify the importance of assessing and evaluating any possible impacts that may occur from the Project activities. Thus, the impact assessment begins with identifying the key environmental issues from the baseline information and subsequently predicting the potential impacts resulting from the Project activities. The key environmental issues are:

i) **Hydraulics: Erosion and sedimentation due to reclamation**
The erosion and sedimentation rates will be expected to change upon completion of the proposed Project. The rates will be predicted by using MIKE 21. The amount of sediments contributed will also be considered in determining the rates of erosion and sedimentation.

ii) **Hydraulics: Sediment plume dispersion due to reclamation/dredging work**
All reclamation and dredging activities will create some form of sediment plume in the water column. The potential for migration and dispersion of turbid plumes during the Project activities will be determined using predictive modeling software, MIKE 21.

iii) **Water quality: Existing condition**
It is envisaged that the reclamation and dredging works would certainly affect the existing condition of the marine water quality if is not managed accordingly.

iv) **Land traffic: Traffic dispersion from reclaimed land**
The proposed development will increase the existing land traffic. There will be an influx of vehicles using the existing road to the proposed development which would eventually create new traffic volume internally. Negative impact may occur if the traffic dispersal from the newly created land is not well-catered and mitigated.

v) Socio-economic: Fishermen

Reclamation would have direct socio-economic impacts towards the locals, particularly the fishermen who ply and toil the area. They must divert their routine routes once the reclamation and dredging activities start which incurs additional cost and time.

vi) Socio-economic: Differences in culture and social life

The better-off elites would be among the interested buyers of the properties on the reclaimed land. The existing medium-income locals within the area would be facing socio-economic impacts, either good or otherwise.

vii) Marine traffic and navigation safety

Marine traffic congestion will occur when dredgers and barges enter the dredging area and proceed towards the reclamation site. There will be an increase in marine traffic which may increase the risk of collision and creating negative impact on the safety of fishermen and mariners within the Project area.

viii) Infrastructure and other utilities

The proposed development would definitely require a huge amount of freshwater supply. Other utilities such as power supply, telecommunication would also need to be addressed accordingly.

7.2 Evaluation of Impacts on the Physical and Biological Environment

This section will be addressed according to the following phases of Project activities:

i) Land clearing;
ii) Reclamation and dredging;
iii) Post reclamation;
iv) Operation and maintenance; and
v) Abandonment plan.

7.2.1 During Land Clearing

The Project area which overlaps the Tanjung Lumpur and Kampung Anak Air shorelines has a total area of 12.71 hectares. The area will be cleared off and it is relatively a flat ground with existing vegetation of common herbs, shrubs and disturbed patch of scrub forest. Since the land clearing area is located nearby the shoreline, the bare earth condition could accelerate surface erosion if not mitigated accordingly.

7.2.2 During Reclamation and Dredging

The proposed work involves dredging of Sungai Kuantan navigational channel, Sungai Kuantan river mouth and seafront area within the newly created land. Subsequently, the dredged material will be disposed off at the designated reclamation area. It is estimated that a total of 10 million m^3 fill material are required for the overall reclamation activity.

The process of deepening the seabed will also cause changes in hydrodynamic regime within the Project area, mainly affecting the coastal natural processes. The components involved in addressing the impact are listed below:

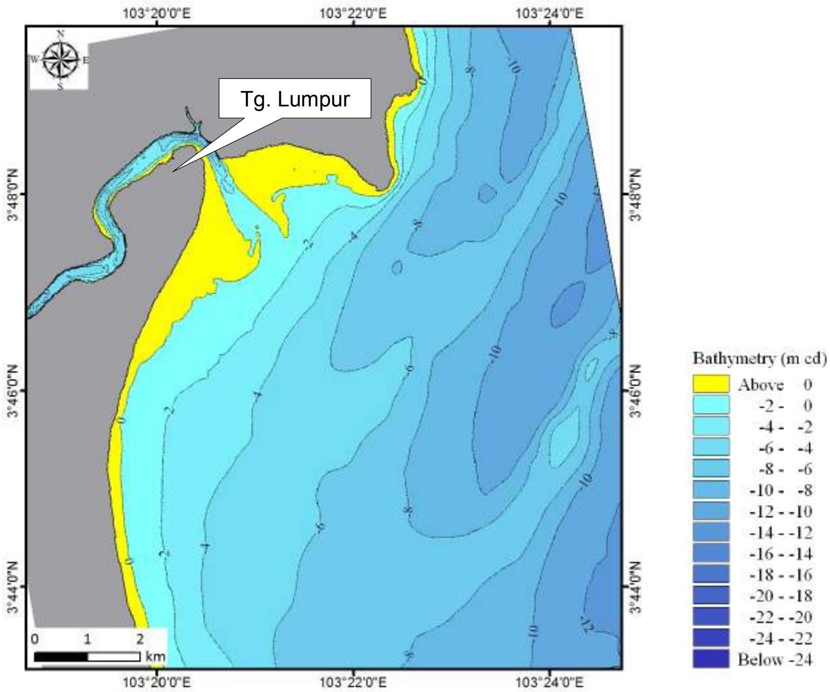
i) Bathymetry;
ii) Geotechnical stability;
iii) Hydraulic i.e. sediment dispersion, current speeds, water level, waves, sedimentation and erosion;
iv) Water quality;
v) Marine biological environment;
vi) Marine traffic and navigation safety;
vii) Air quality; and
viii) Noise.

7.2.2.1 Bathymetry

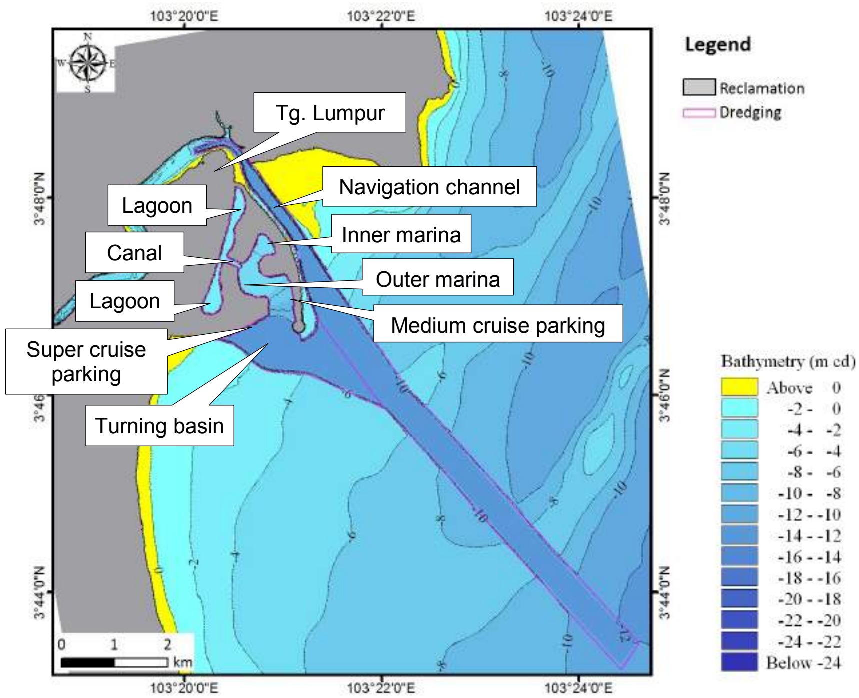
The reclamation and dredging will change the existing bathymetry of the seabed and remove benthic organisms. The change of bathymetric levels before and after reclamation and dredging activities are shown in *Table 7.1* and *Figure 7.1*.

Table 7.1 ► Bathymetric Levels Before and After Reclamation and Dredging Activities

Affected Area	Before (m CD)	After (m CD)
Navigation channel	-2 to -12	-12
Lagoon	0	-3
Canal	0	-4
Inner marina	-2	-4
Outer marina	-2 to -4	-6
Cruise terminal	-2	-6 to -9
Turning basin	-4	-12



a) Before Project



b) After Project

Figure 7.1 ► Bathymetric Conditions: Before and After Reclamation and Dredging Activities

7.2.2.2 Geotechnical Stability

Dredging is to be carried out 100 meters away from the base of Tanjung Lumpur Bridge. The foundation of a bridge structure is normally of spun piles which can mainly resist axial and lateral forces. The lateral force will only be affected when there is a difference in level which normally being formed by dredging activity. Assessing from the neighboring exposed bank of Sungai Kuantan, it can be anticipated that the foundation soil within the river bed consists of clayey, silty and sandy material. This suggest that with a distance of 100 meters from where the dredging starts, the impact of lateral force will not be effected. Thereby, the structure is assumed to be intact.

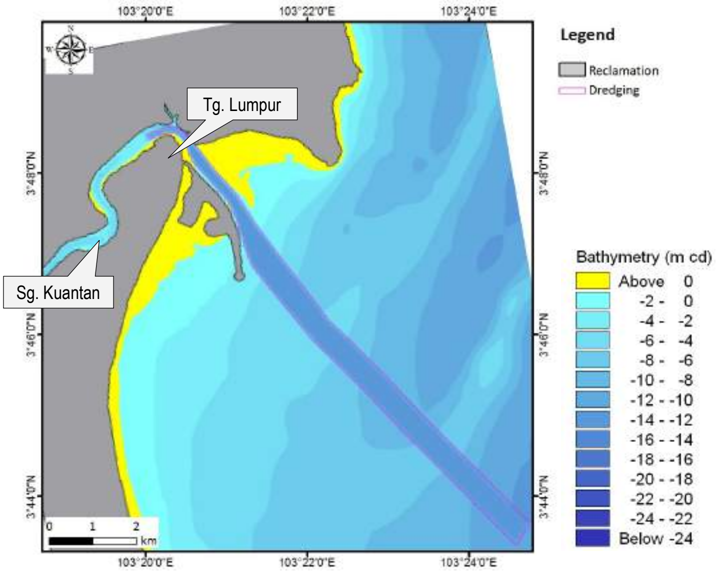
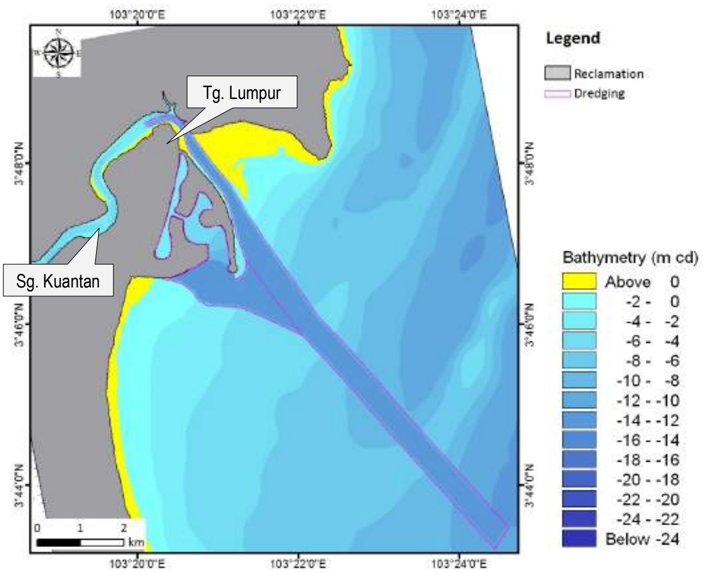
7.2.2.3 Hydraulic

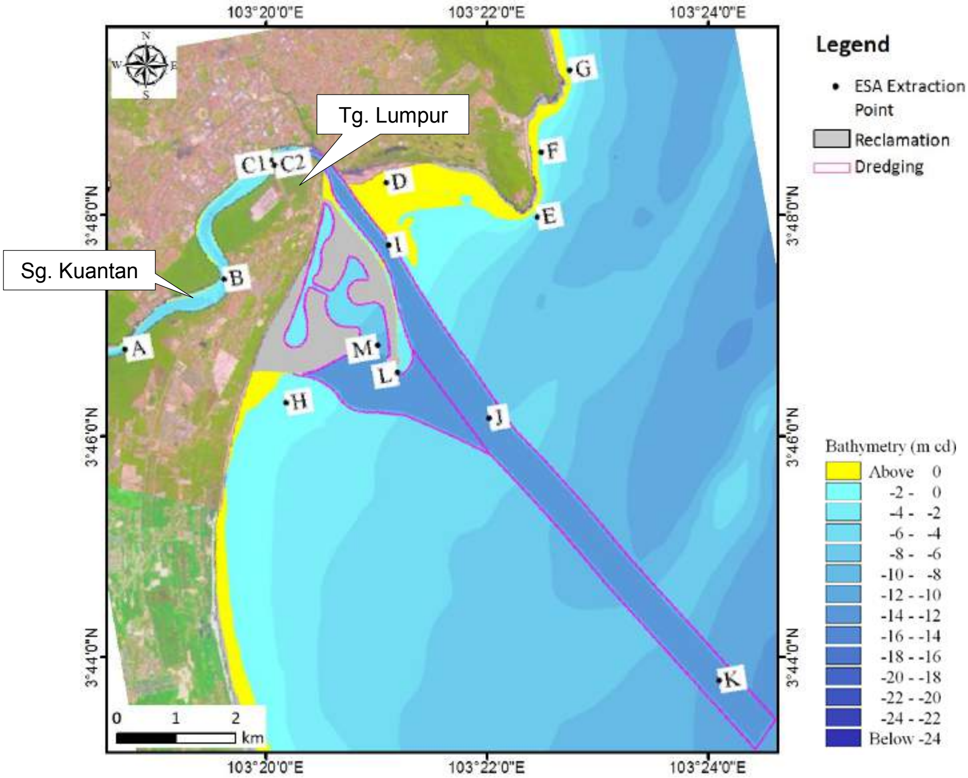
The assessment of impacts due to the proposed Project was done by using MIKE 21, which is a two-dimensional numerical modeling software. Simulation studies were done according to the phasing of the Project (*Table 7.2*) and concurrently for seasonal conditions as followings:

i) Pure tide condition representing inter-monsoon period;
ii) Northeast monsoon condition (December to March); and
iii) Southwest monsoon condition (May to September).

The hydraulic assessment was also made at Environmentally Sensitive Areas (ESAs) within the study area as addressed in *Chapter 6: Existing Environment*. The ESAs include forest reserve, mangroves, shoreline, river mouth, etc. The location of the extraction points surrounding the Project site are as shown in *Figure 7.2*. *Table 7.3* lists the types of analysis and model used for hydraulic assessment.

Table 7.2 ► Description of Each Phase for Hydraulic Simulation

Phase	Description	Profile
Phase 2a	Reclamation of Phase 2a and dredging of Phase 2a	
Phase 2b	Reclamation of Phase 2b and dredging of Phase 2b, with the completed of Phase 2a	



Legend

A	Kuantan Forest Reserve	G	Beserah Forest Reserve
B	Hutan Rizab Paya Laut Kuantan	H	Tanjung Lumpur sandflat
C1	Tanjung Lumpur Bridge (northern pier)	I	Navigation channel (upstream)
C2	Tanjung Lumpur Bridge (southern pier)	J	Navigation channel (midstream)
D	Pantai Tanjung Sisek	K	Navigation channel (downstream)
E	Kuantan Tembeling Resort	L	Southeastern end of development
F	Teluk Cempedak	M	Marina entrance

Figure 7.2 ► Extraction Points at ESAs and around the Project Area

Types of Analysis	Model Used
Current Speeds and Water Levels	MIKE 21 HD
Waves	MIKE 21 NSW
Sediment transport	MIKE 21 ST
Suspended sediment plume	MIKE 21 MT

Table 7.3 ►
Summary of the Types of Analysis and Model Used

7.2.2.3.1 Sediment Dispersion

The purpose of the sediment dispersion study is to investigate the movement of suspended sediments during marine construction activities, i.e. reclamation and dredging as well as during the disposal of dredged materials. This is to simulate conditions where said activities are carried out. The levels of suspended sediment concentration as well as the eventual fate of the re-suspended sediment are assessed. This would represent potential impacts caused by these activities.

A. Reclamation and Dredging Operations

Two (2) trailer suction hopper dredgers (TSHDs) are assumed to be used for the dredging and reclamation works. A cutter suction dredger (CSD) also will be used for the dredging works at shallow areas. Major contributor to suspended sediment generation arises from overflowing during loading. The spill rate and the total spill will be highly dependent upon work procedures, scheduling and dredged material characteristics.

Each TSHD with a capacity of 10,000 m^3 respectively is assumed to operate non-stop without any downtime. The dredger has a pumping rate of 0.1 m^3/s. It is inferred from the bed sampling exercise that the bed material is primarily silt where a sediment density of 1,000 kg/m^3 is adopted. The dredged material is assumed to have 10% fines content with a 15% spill rate of fines. Two (2) scenarios were simulated:

i) **Uncontained condition:**
   - Without placement of any containment or mitigation measures representing a conservative estimate; and
   - Spill concentration of TSHD and CSD was calculated to be 78 kg/m^3 and 31.3 kg/m^3 respectively.

ii) **Contained condition** (will be further explained in *Chapter 8*)**:**
   - With containment bund in place and the deployment of silt curtain during reclamation and dredging works; and
   - The spill concentration of TSHD and CSD was calculated to be 46.8 kg/m^3 and 18.8 kg/m^3 respectively.

The fine sediment released into suspension is assumed to have a settling velocity of 0.0005 m/s. The critical velocity for deposition (i.e. velocity below which sediment deposition occurs) is taken as 0.07 m/s.

Two (2) options were studied for obtaining the fill material:

i) **Option 1** – Suitable dredged material within the Project area is used as reclamation fill; and
ii) **Option 2** – Sand source for the reclamation fill is obtained from a designated source located at Sungai Pahang.

Hence, the travelling time of the dredgers for each option is simulated differently. The typical schedule for sand sourcing and reclamation cycle for each option is shown in *Table 7.4*.

Table 7.4 ► Typical Reclamation and Dredging Cycles for Options 1 and 2

Option	Reclamation and Dredging Cycle
1	a) 1.5 hours to load a trailer suction hopper dredger (TSHD). b) 0.25 hours for the TSHD to travel to the reclamation site. c) 2.5 hours for the TSHD to discharge its load at the reclamation site. d) 0.25 hours for the TSHD to travel back to the dredging site.
2	a) 1.5 hours to load a TSHD. b) 2 hours for the TSHD to travel to the reclamation site. c) 2.5 hours for the TSHD to discharge its load at the reclamation site. d) 1.5 hours for the TSHD to travel back to the sand sourcing site.

The following source points were placed in the model to simulate the reclamation and dredging operations (*Figure 7.3*):

i) Phase 2a – Three (3) sources for dredging activity (i.e. at locations D1, D2 and D3) were placed within the navigation channel and a source (i.e. R1) for filling works was placed at the centre of Phase 2a reclamation area; and
ii) Phase 2b – A source for dredging works (i.e. D4) was placed within the turning basin and a source for filling activity (i.e. R2) at the centre of Phase 2b's reclamation area.

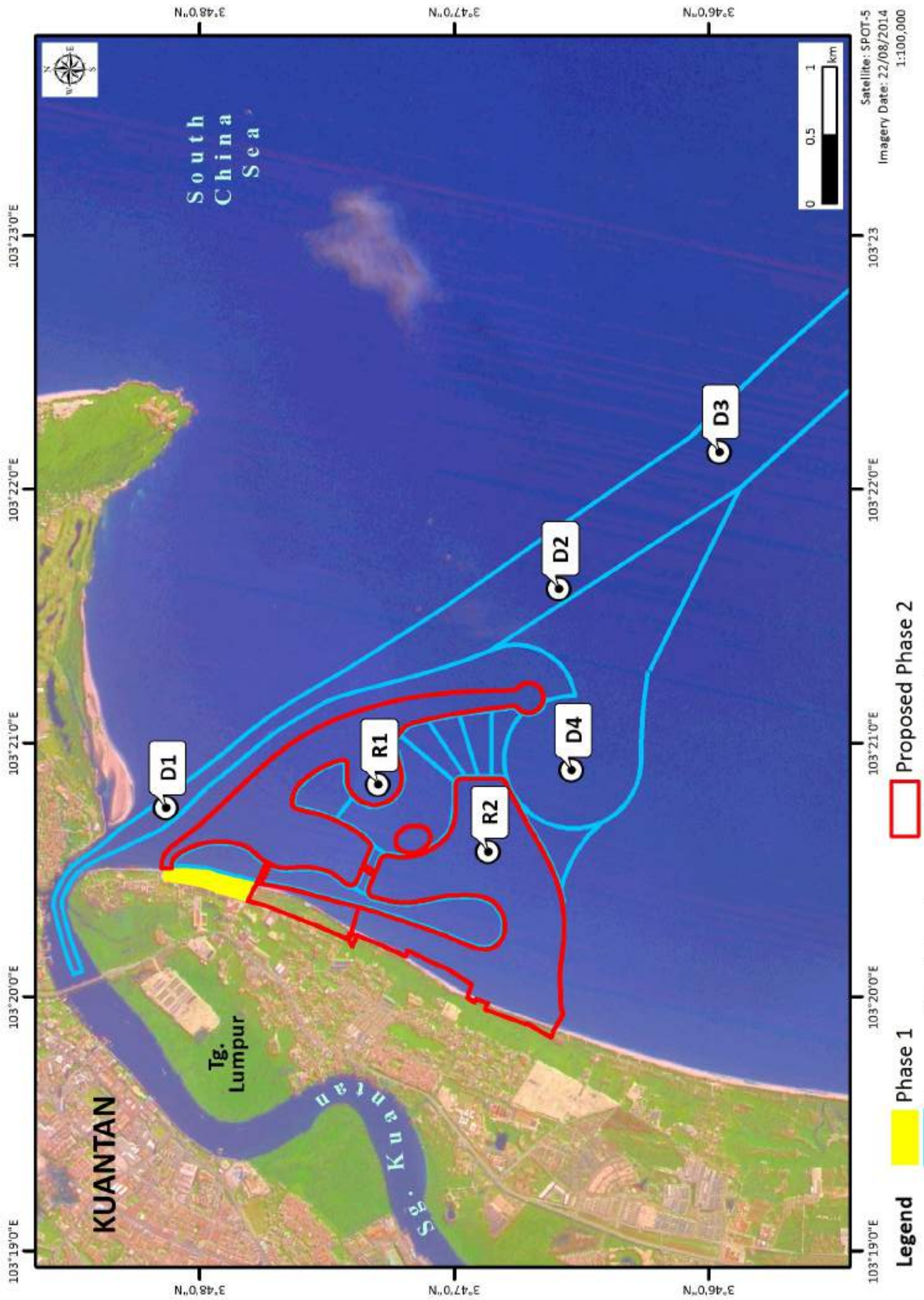


Figure 7.3 ► Location of Source Points for Dredging (D) and Filling (R) Used in the Sediment Spill Modeling

B. Disposal of Dredged Materials

The disposal of dredged materials will be executed by using self-propelled split hopper barges. A typical schedule for a dredging and disposal cycle is as follows:

i) 2 hours to load an empty barge;
ii) 2 hours for a barge to travel to the disposal ground;
iii) 5 minutes for the barge to maneuver and discharge its load at the disposal ground; and
iv) 1.5 hours for a barge to travel back to the dredging site.

It is anticipated that four (4) barges would be used to transport and dispose the dredged material to the disposal area. The interval between each discharge operation at the disposal ground is about 2 hours.

Findings

It is observed from the simulation results that the suspended sediment plumes are primarily influenced by magnitude and direction of prevailing currents as well as the wind conditions during the monsoonal seasons. Total suspended solids (TSS) concentrations of 10, 20 and 50 mg/L corresponding to 0.01, 0.02 and 0.05 kg/m^3 respectively were used in assessing the extent of dispersion. An increase of 10, 20 and 50 mg/L represents an increase of about 14, 29 and 70% above the ambient average TSS concentration respectively based on field measurements.

A. Reclamation and Dredging Operations

The summary of plots of suspended sediment concentration simulations due to dredging and reclamation activities of each scenario are as summarized in *Table 7.5*. The suspended sediment plume excursions during Northeast Monsoon condition are relatively higher as compared to the other seasonal conditions.

Table 7.5 ► Summary of Plots of Sediment Dispersion Simulations

Scenario		Figure No.			
		Mean and Maximum Excess Suspended Sediment Concentration	Percentage Exceedance of Suspended Sediment Concentration Above (mg/L)		
			10	20	50
Option 1	Phase 2a	7.4	7.5	7.6	7.7
	Phase 2b	7.8	7.9	7.10	7.11
Option 2	Phase 2a	7.12	7.13	7.14	7.15
	Phase 2b	7.16	7.17	7.18	7.19

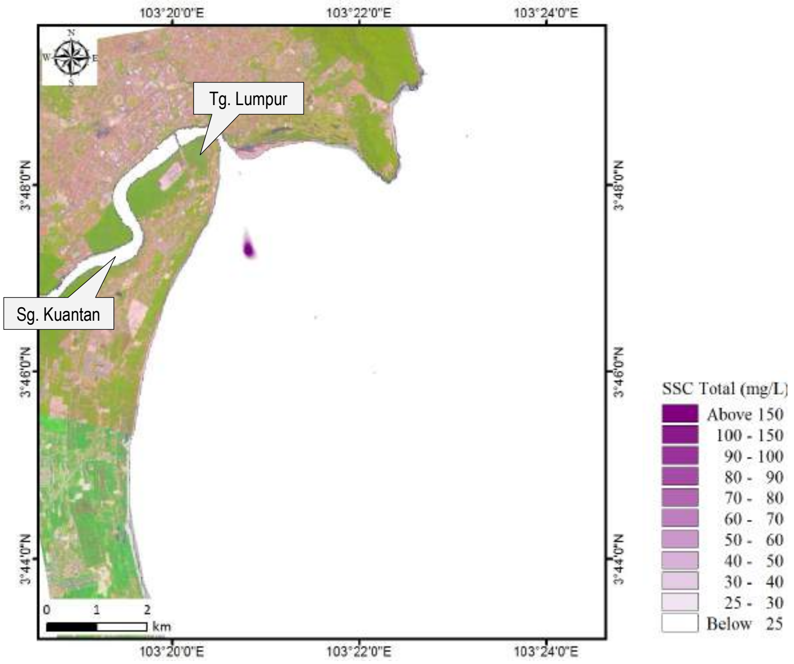
Option 1

For this option, the suitable dredged material within the Project area is assumed to be used as reclamation fill material.

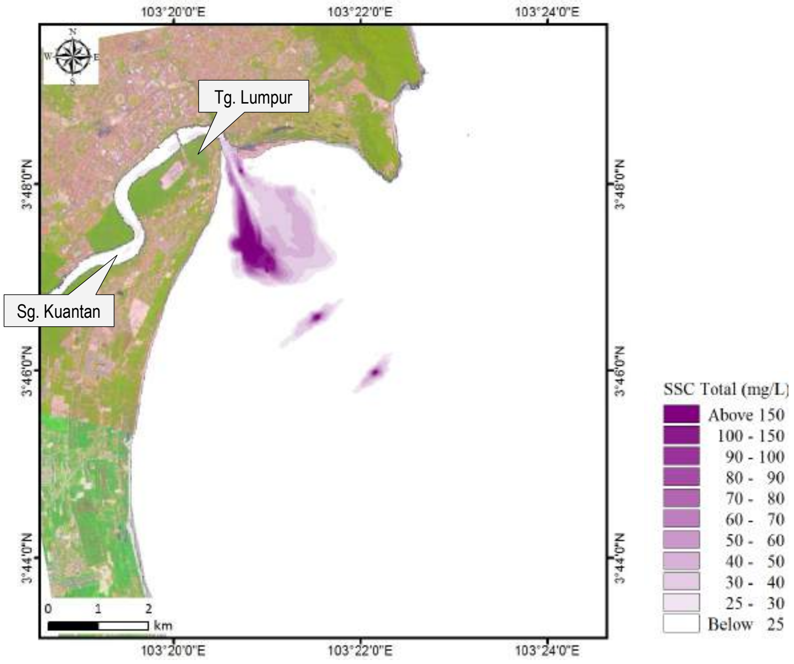
i) Phase 2a

Plots of mean and maximum excess suspended sediment concentrations for seasonal conditions arising from Phase 2a construction activities are shown in *Figure 7.4*. The maximum plume excursions for suspended sediment concentration of more than 25 mg/L are about 2.5 and 1.5 km towards approximately southwest and northeast from the source respectively. The dispersion extends up to about 6 km upstream of the river mouth. The mean excess suspended sediment dispersion for the same concentration is less than 0.6 km from the source.

Plots showing the exceedance of the dispersion above 10, 20 and 50 mg/L of concentration with respect to the percentage of time over the simulation period are shown in *Figures 7.5* to *7.7*. The exceedance probability for 10 mg/L exceeding more than 10% of the time for seasonal conditions would have a spread of less than 2.7 km from the source of dredging and reclamation activities, and 7.5 km into the river mouth. The exceedance probability for 20 mg/L exceeding more than 10% of the time would have a spread of less than 1.5 and 0.7 km from the source of reclamation and dredging operations. The exceedance probability for 50 mg/L exceeding more than 10% of the time would have a spread of less than 0.9 km from the source for both operations.

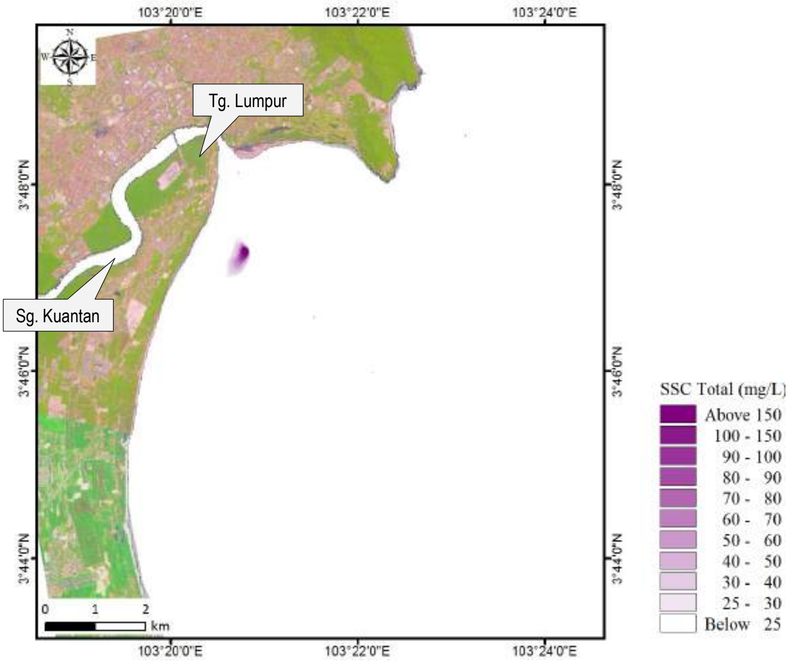


a) Mean excess: Pure tide condition

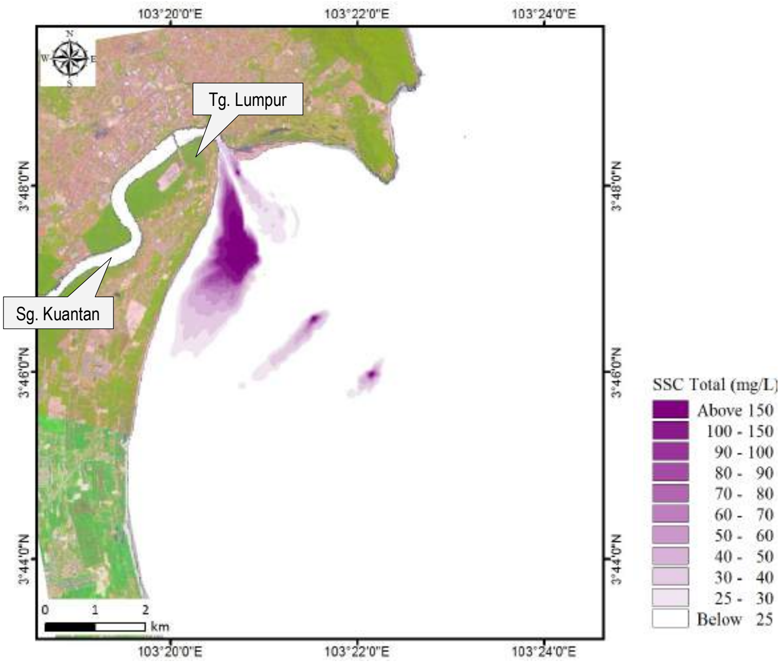


b) Maximum excess: Pure tide condition

Figure 7.4 ► Mean and Maximum Excess Suspended Sediment Concentration for Option 1: Phase 2a

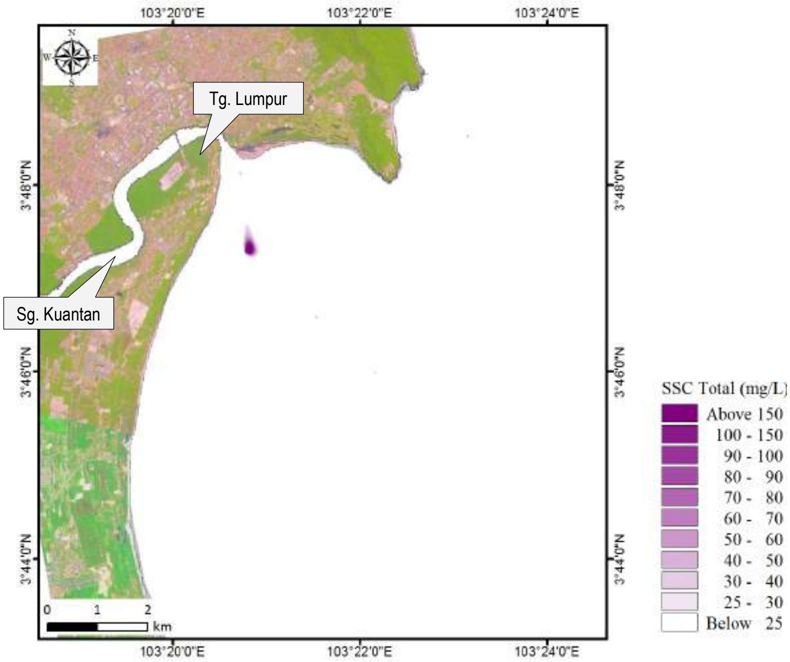


c) Mean excess: Northeast Monsoon condition

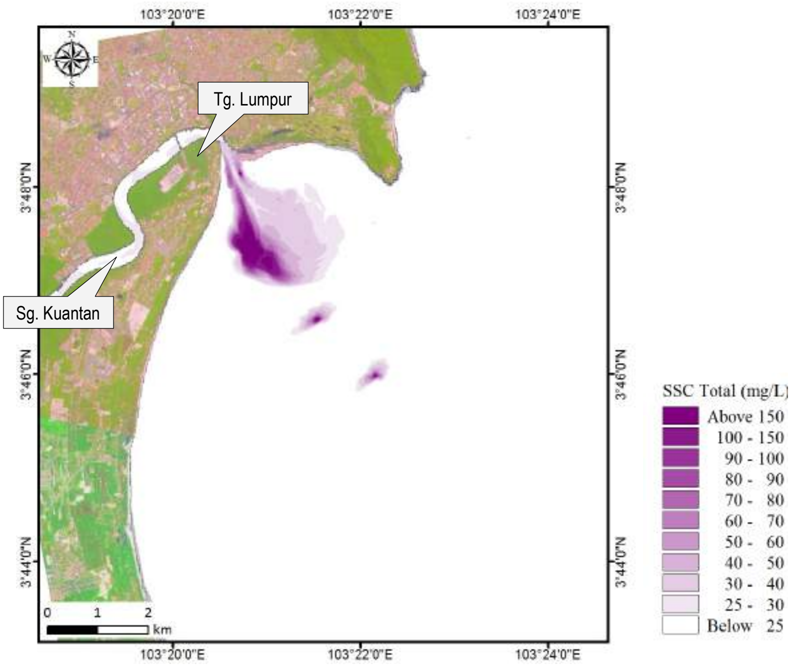


d) Maximum excess: Northeast Monsoon condition

Figure 7.4 *(cont'd)* ► Mean and Maximum Excess Suspended Sediment Concentration for Option 1: Phase 2a

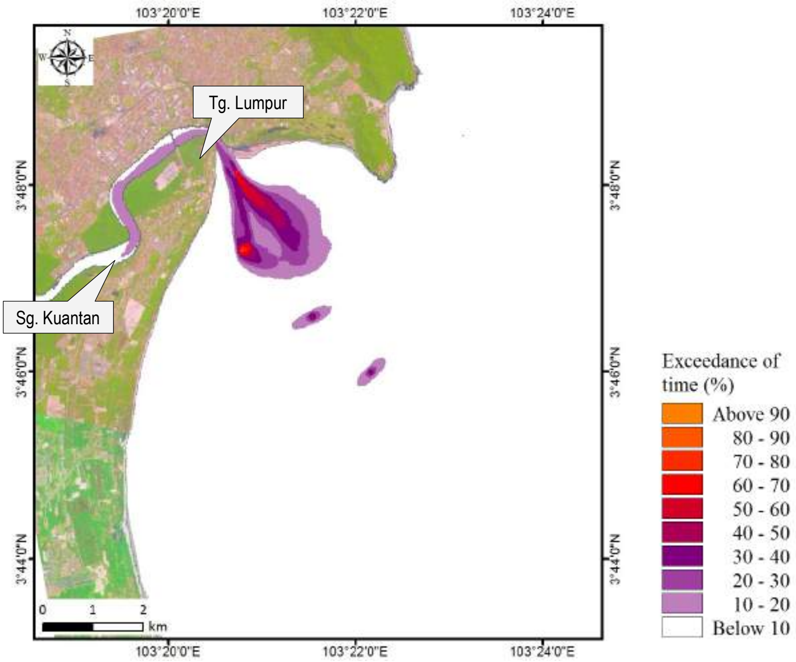


e) Mean excess: Southwest Monsoon condition

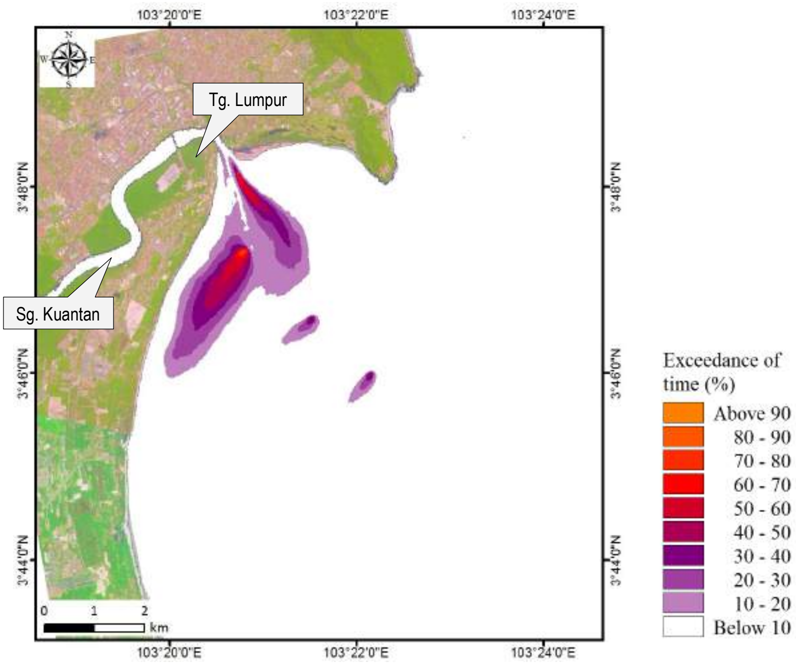


f) Maximum excess: Southwest Monsoon condition

Figure 7.4 *(cont'd)* ► Mean and Maximum Excess Suspended Sediment Concentration for Option 1: Phase 2a

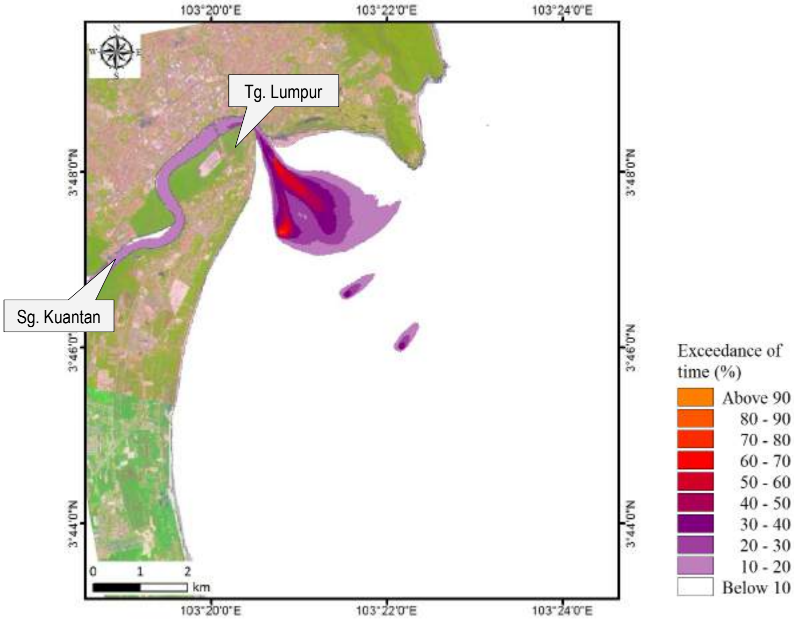


a) Pure tide condition



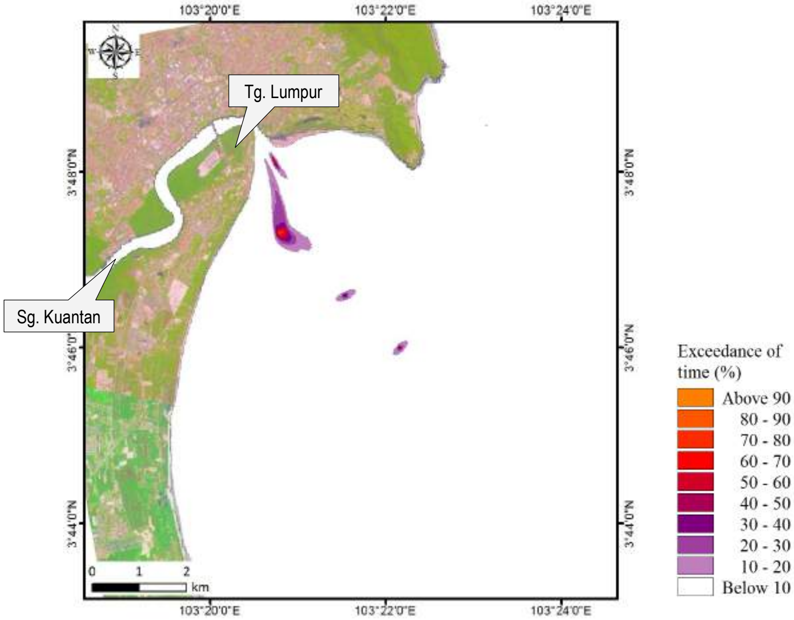
b) Northeast Monsoon condition

Figure 7.5 ► Percentage Exceedance of Suspended Sediment Concentration above 10 mg/L for Option 1: Phase 2a



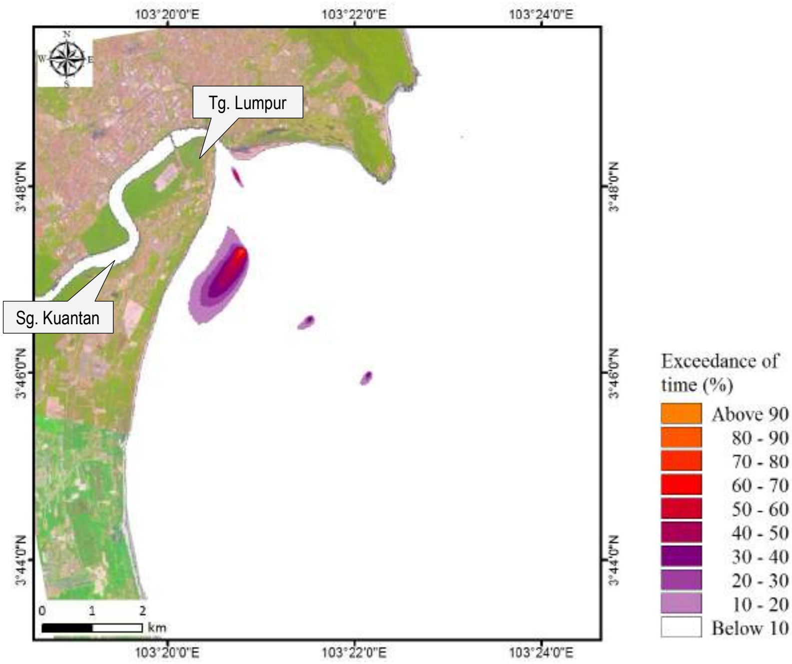
c) Southwest Monsoon condition

Figure 7.5 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 10 mg/L for Option 1: Phase 2a

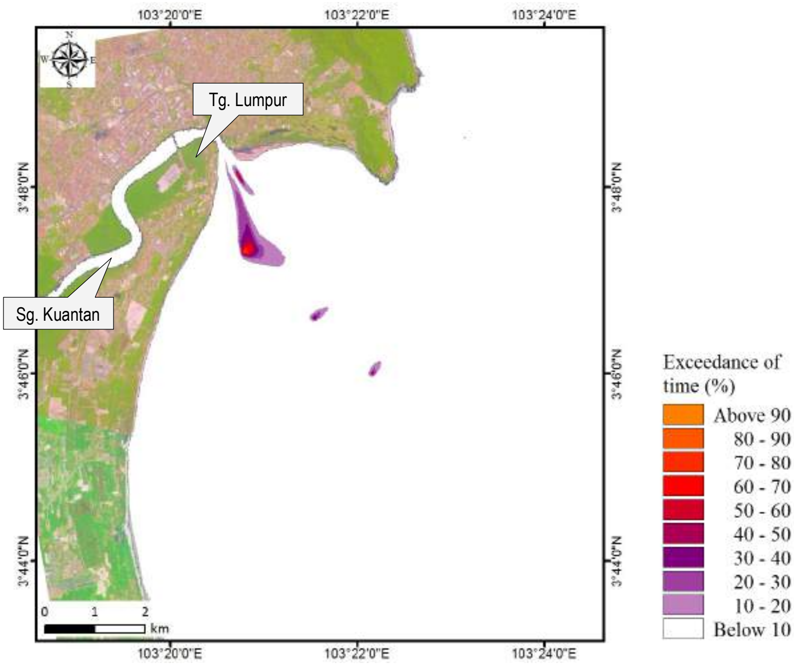


a) Pure tide condition

Figure 7.6 ► Percentage Exceedance of Suspended Sediment Concentration above 20 mg/L for Option 1: Phase 2a

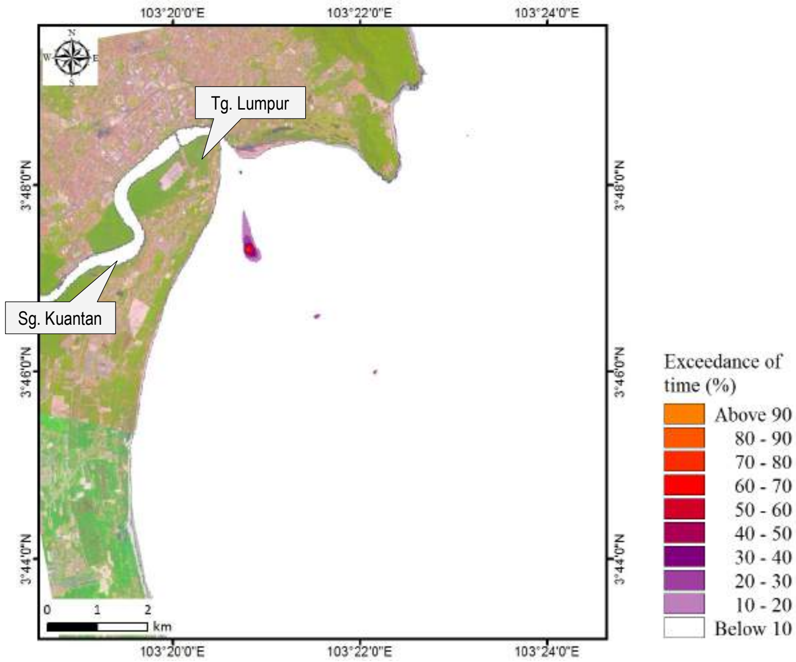


b) Northeast Monsoon condition

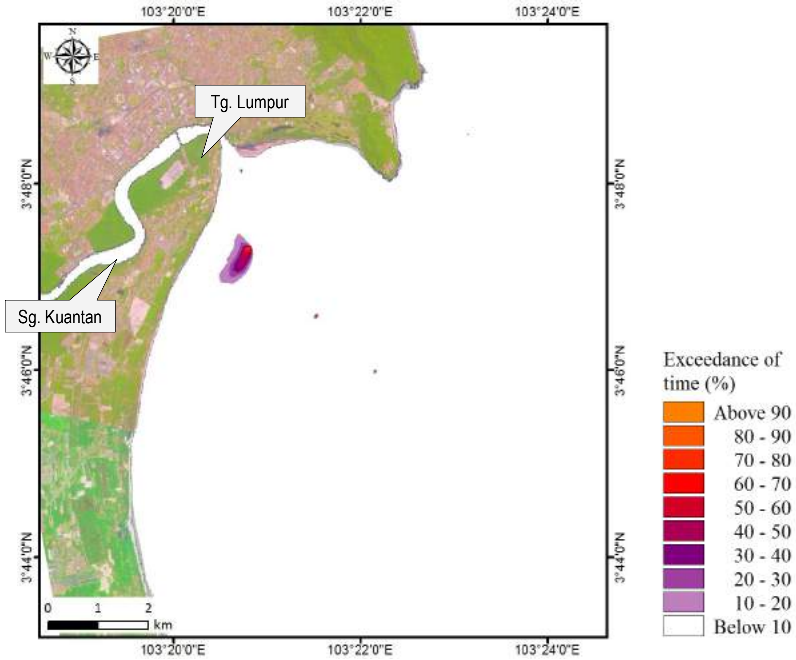


c) Southwest Monsoon condition

Figure 7.6 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 20 mg/L for Option 1: Phase 2a

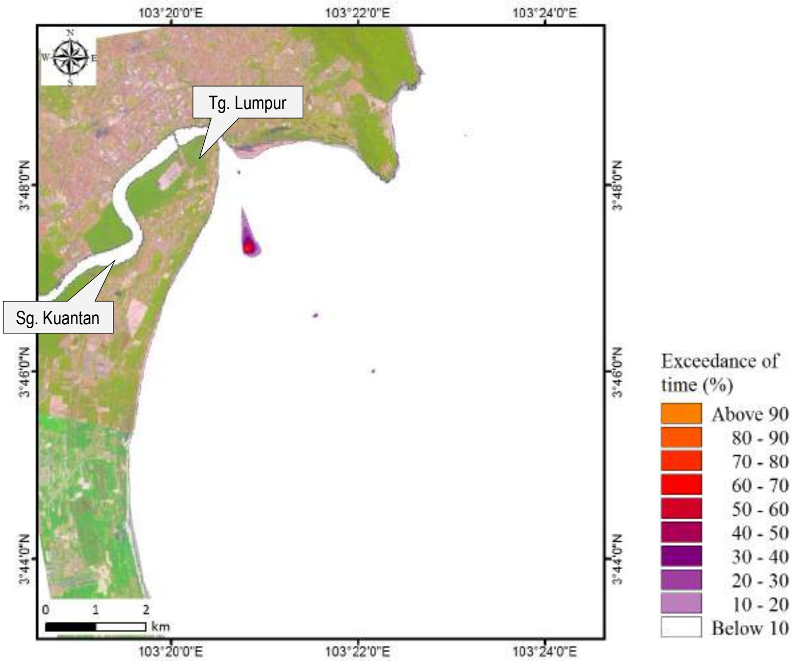


a) Pure tide condition



b) Northeast Monsoon condition

Figure 7.7 ► Percentage Exceedance of Suspended Sediment Concentration above 50 mg/L for Option 1: Phase 2a



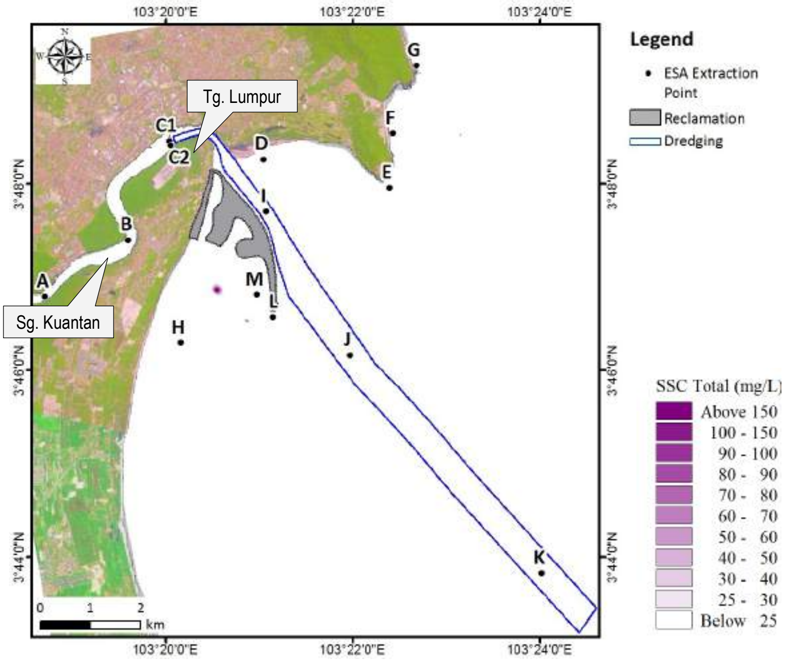
c) Southwest Monsoon condition

Figure 7.7 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 50 mg/L for Option 1: Phase 2a

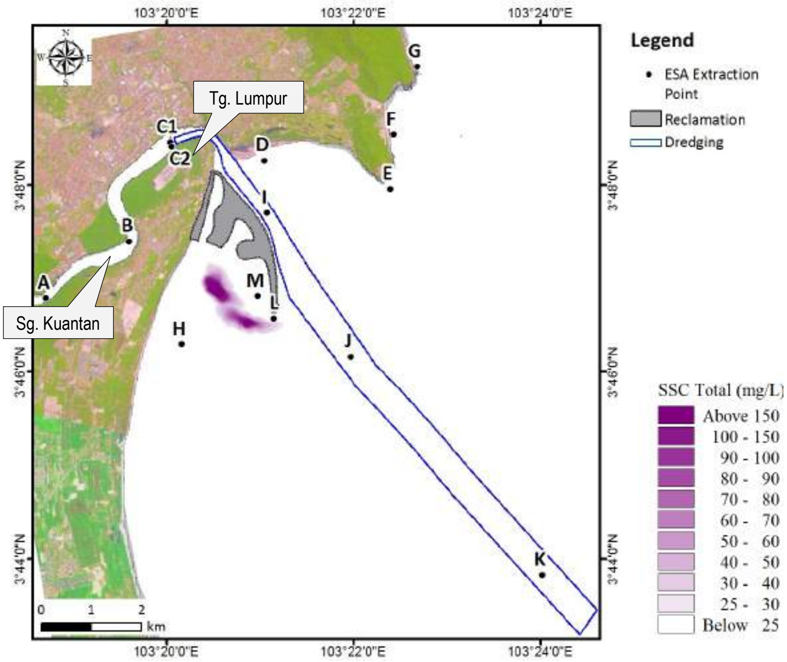
ii) Phase 2b

Plots of mean and maximum excess suspended sediment concentrations for seasonal conditions arising from Phase 2b's construction activities are shown in *Figure 7.8*. The maximum plume excursions for suspended sediment concentration of more than 25 mg/L are about 1 and 1.7 km extending approximately east and southwest from the source respectively. The mean excess suspended sediment dispersion for the same concentration is less than 0.2 km from the source.

Plots showing the exceedance of the dispersion above 10, 20 and 50 mg/L of concentration with respect to the percentage of time over the simulation period are shown in *Figures 7.9* to *7.11*. The exceedance probability for 10 mg/L exceeding more than 10% of the time for seasonal conditions would have a spread of less than 1.2 and 0.7 km from the source of dredging and reclamation activities respectively. The exceedance probability for 20 mg/L exceeding more than 10% of the time would have a spread of less than 0.6 and 0.4 km from the source reclamation and dredging operations respectively. The exceedance probability for 50 mg/L exceeding more than 10% of the time would have a spread of less than 0.3 km from the source for both operations.

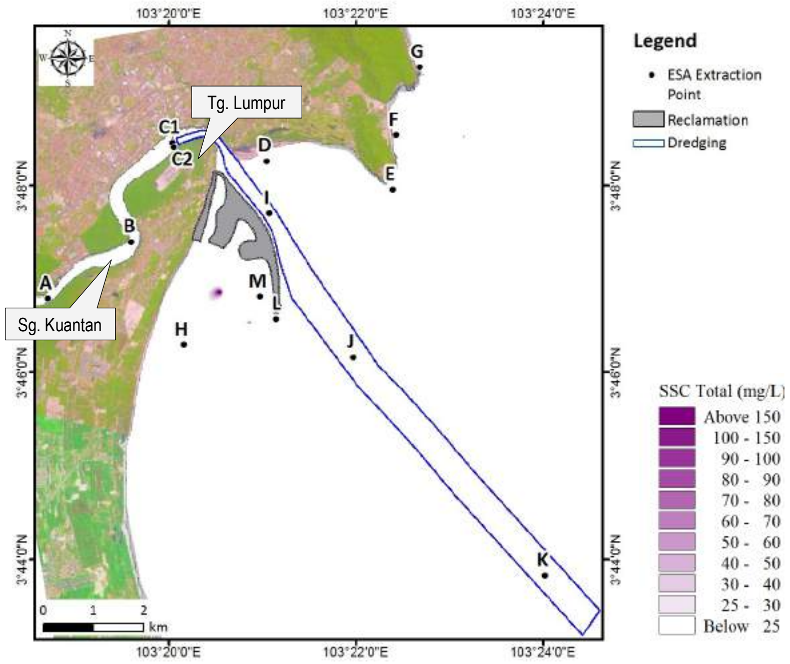


a) Mean excess: Pure tide condition

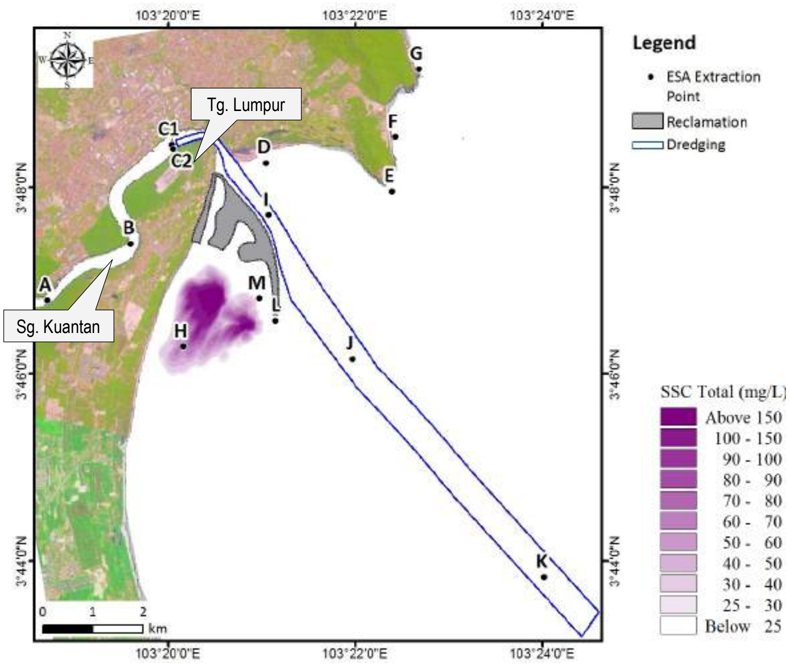


b) Maximum excess: Pure tide condition

Figure 7.8 ► Mean and Maximum Excess Suspended Sediment Concentration for Option 1: Phase 2b

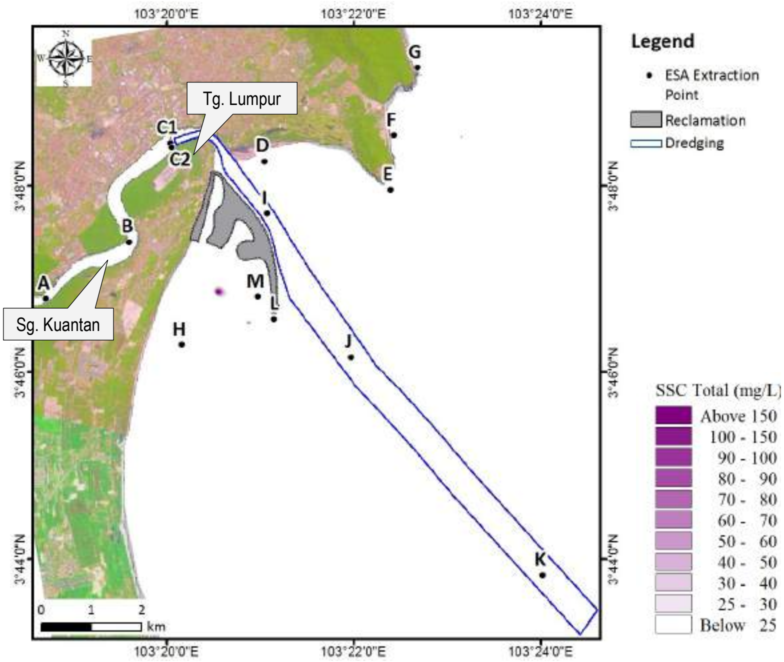


c) Mean excess: Northeast Monsoon condition

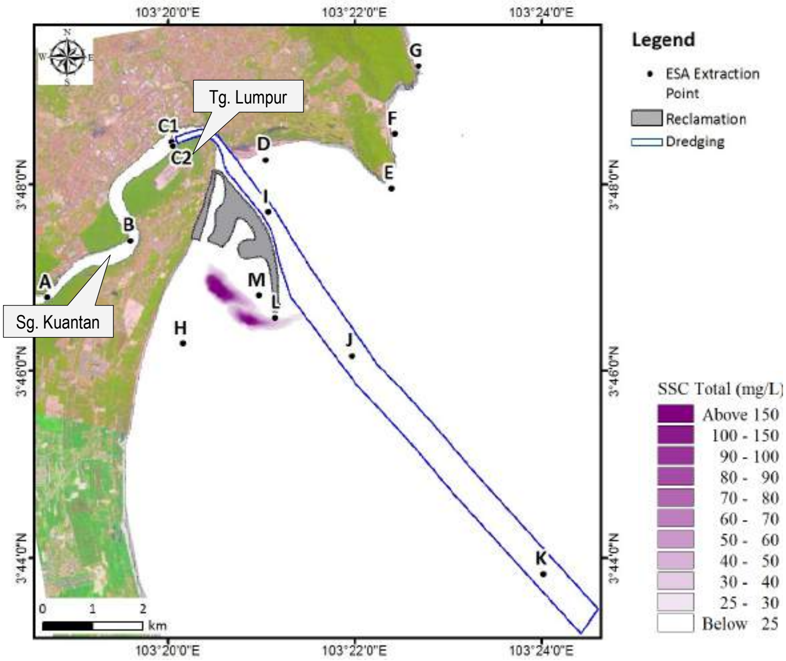


d) Maximum excess: Northeast Monsoon condition

Figure 7.8 *(cont'd)* ► Mean and Maximum Excess Suspended Sediment Concentration for Option 1: Phase 2b

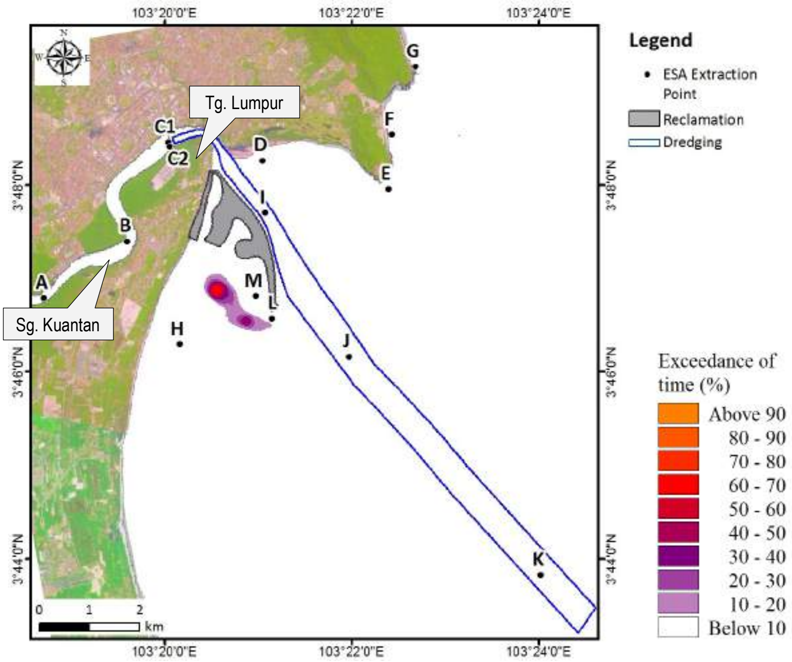


e) Mean excess: Southwest Monsoon condition

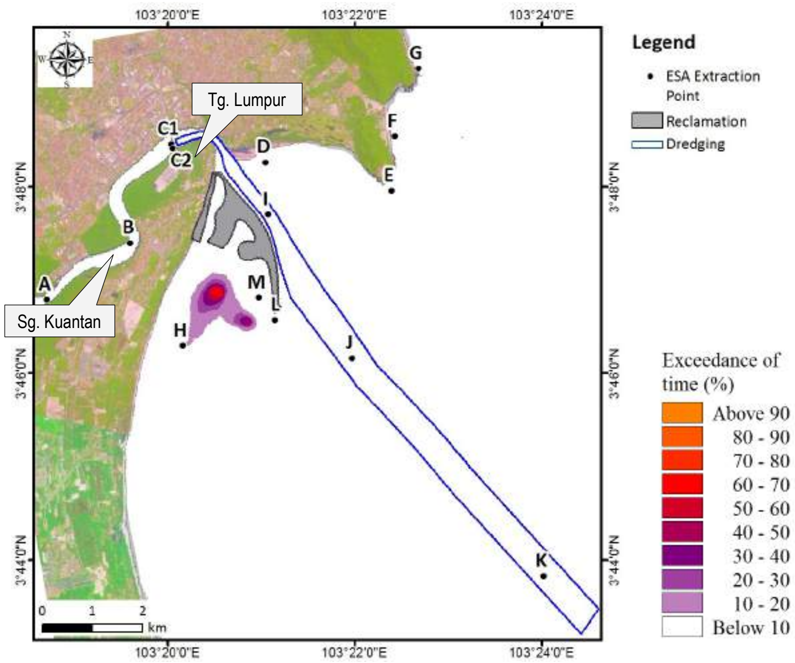


f) Maximum excess: Southwest Monsoon condition

Figure 7.8 *(cont'd)* ► Mean and Maximum Excess Suspended Sediment Concentration for Option 1: Phase 2b

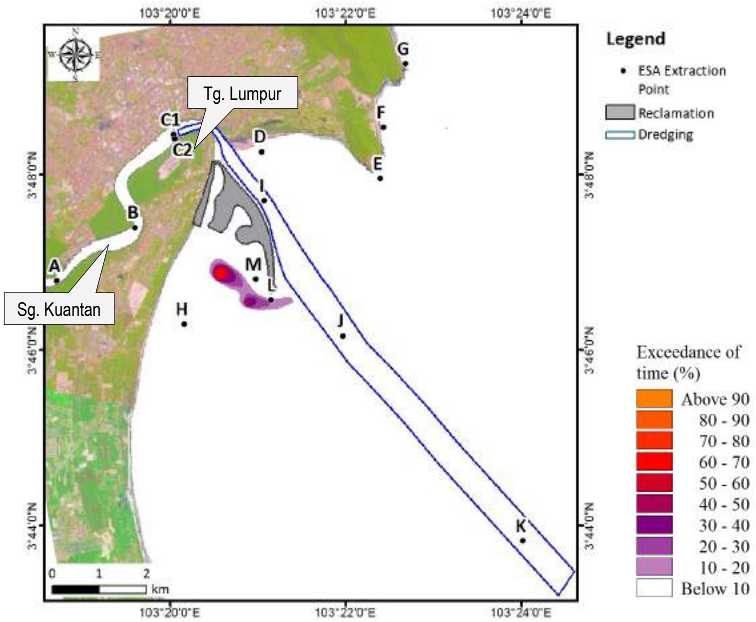


a) Pure tide condition



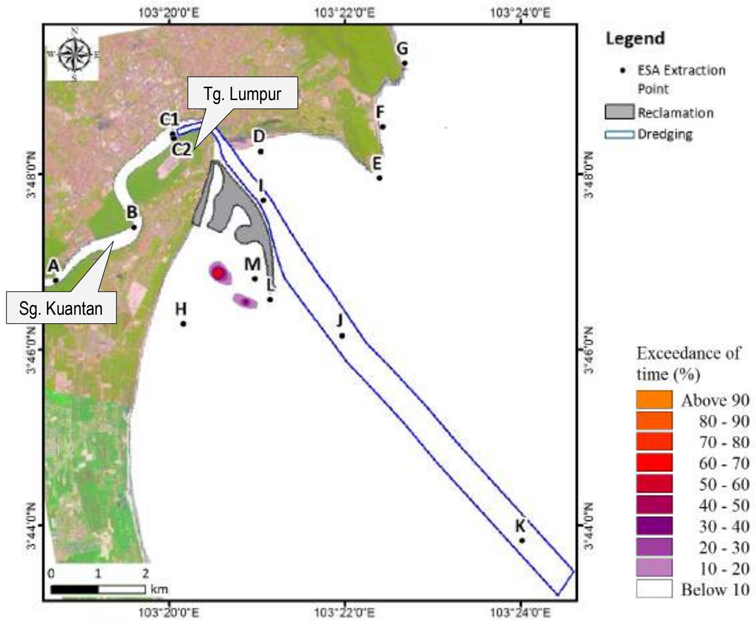
b) Northeast Monsoon condition

Figure 7.9 ► Percentage Exceedance of Suspended Sediment Concentration above 10 mg/L for Option 1: Phase 2b



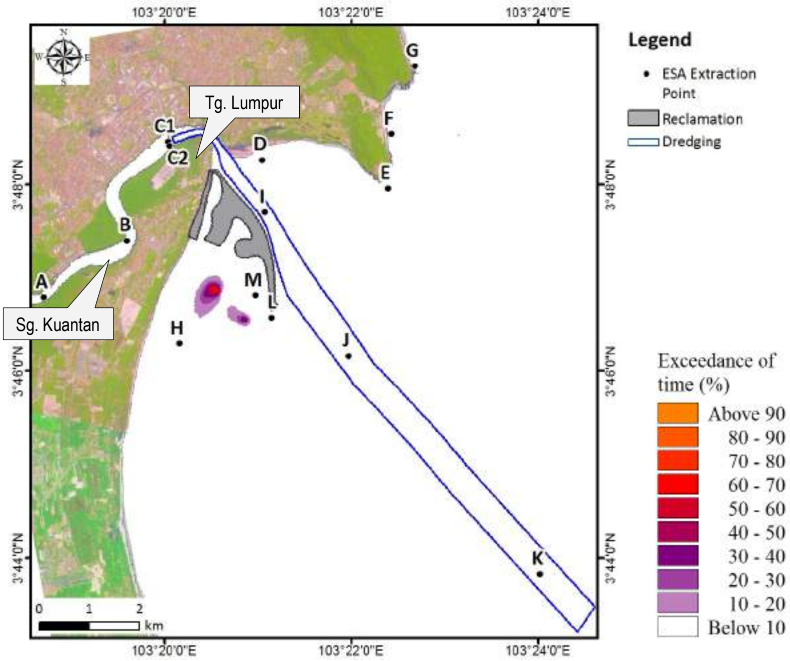
c) Southwest Monsoon condition

Figure 7.9 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 10 mg/L for Option 1: Phase 2b

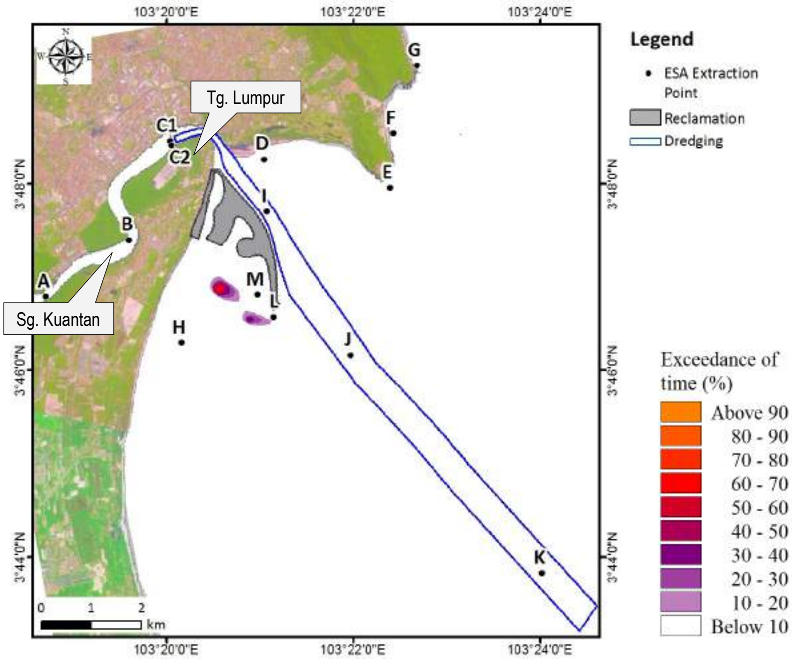


a) Pure tide condition

Figure 7.10 ► Percentage Exceedance of Suspended Sediment Concentration above 20 mg/L for Option 1: Phase 2b

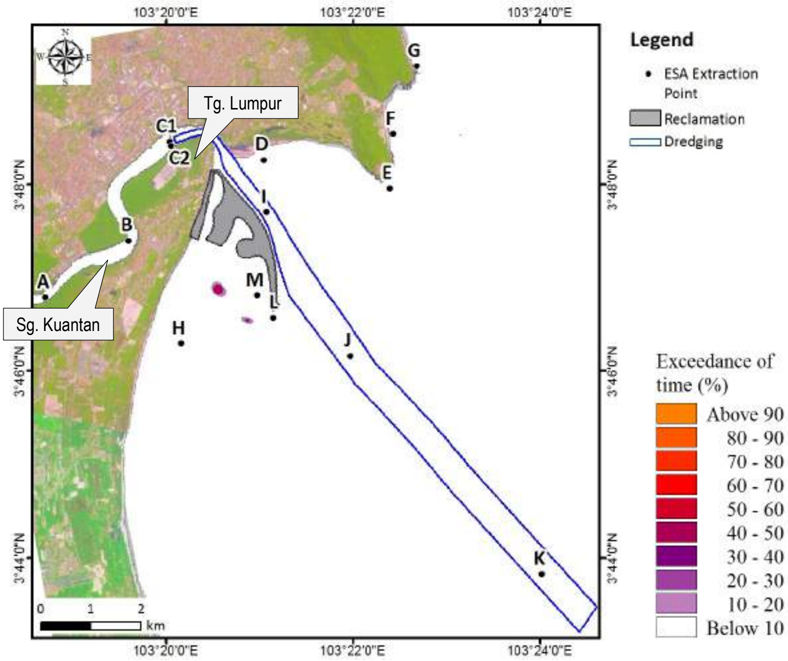


b) Northeast Monsoon condition

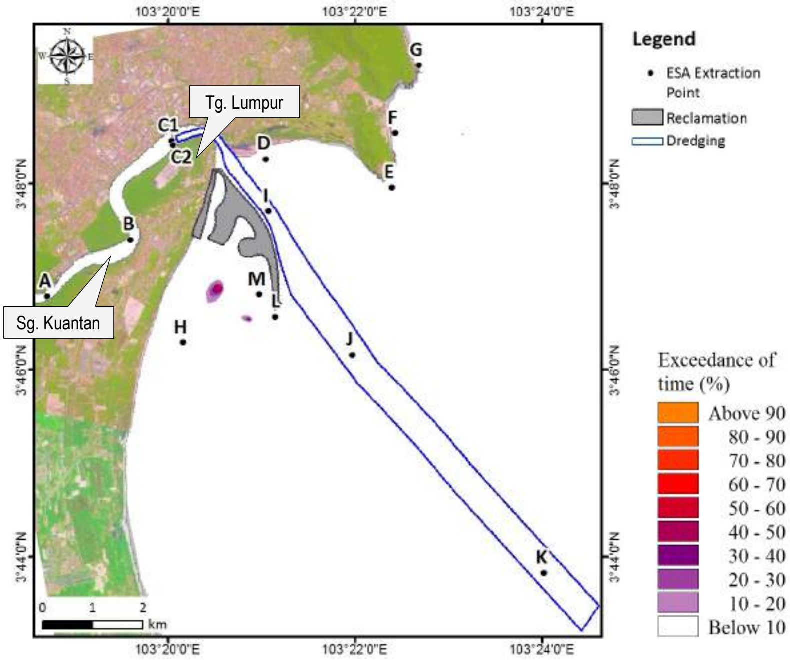


c) Southwest Monsoon condition

Figure 7.10 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 20 mg/L for Option 1: Phase 2b

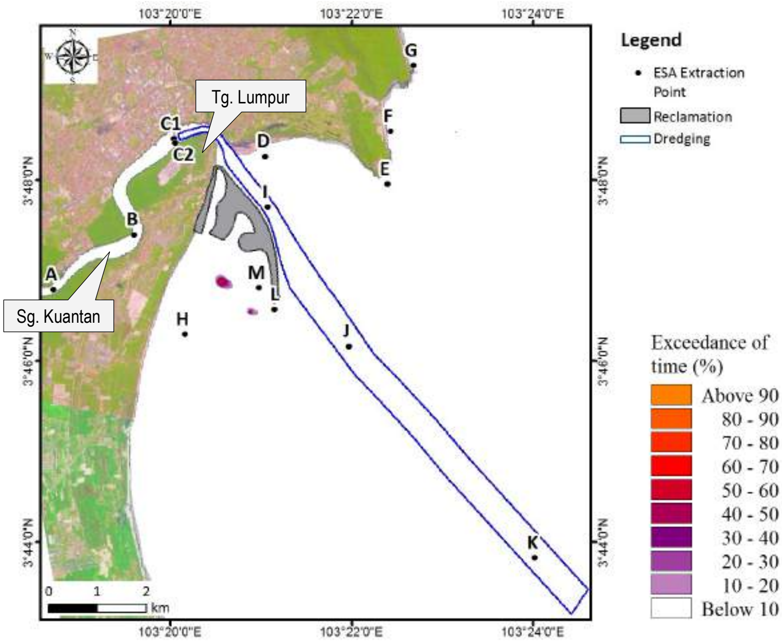


a) Pure tide condition



b) Northeast Monsoon condition

Figure 7.11 ► Percentage Exceedance of Suspended Sediment Concentration above 50 mg/L for Option 1: Phase 2b



c) Southwest Monsoon condition

Figure 7.11 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 50 mg/L for Option 1: Phase 2b

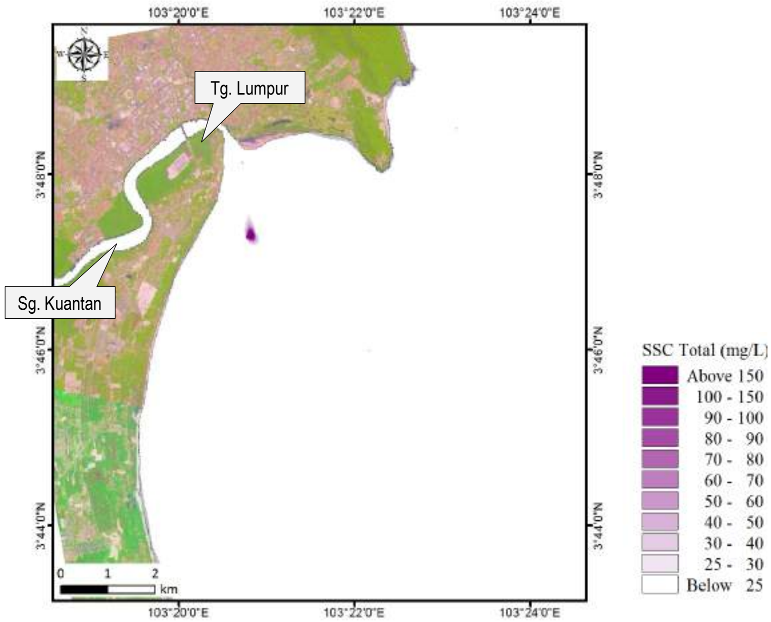
Option 2

This option simulates a condition whereby the reclamation fill material is obtained from a designated source located at Sungai Pahang.

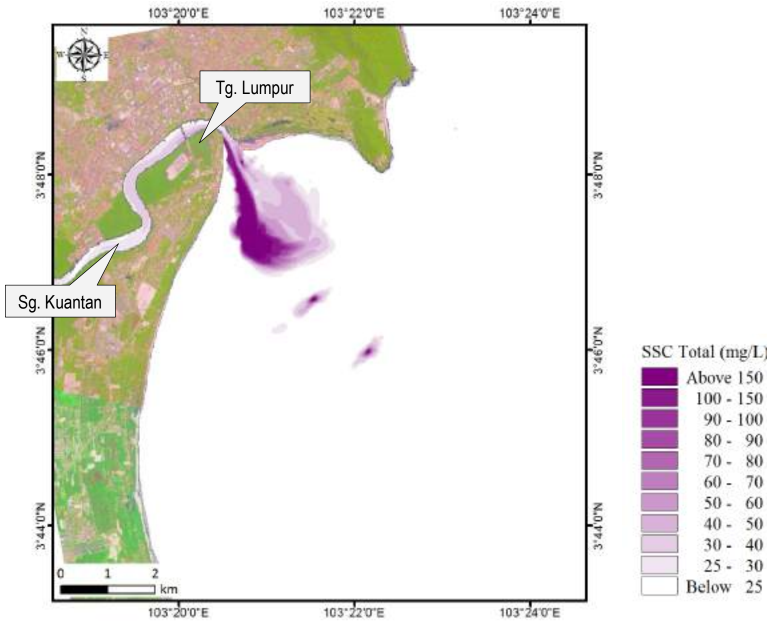
i) Phase 2a

Plots of mean and maximum excess suspended sediment concentrations for seasonal conditions due to Phase 2a construction activities are shown in *Figure 7.12*. The maximum plume excursions for suspended sediment concentration of more than 25 mg/L is about 3.5 km that extends approximately southwest and northeast from the source. The dispersion extends approximately 9 km upstream of the river mouth. The mean excess suspended sediment dispersion for the same concentration is less than 0.5 km from the source.

Plots showing the exceedance of the dispersion above 10, 20 and 50 mg/L of concentration with respect to the percentage of time over the simulation period are shown in *Figures 7.13* to *7.15*. The exceedance probability for 10 mg/L exceeding more than 10% of the time for seasonal conditions would have a spread of less than 2.7 and 2.5 km from the source of operations respectively and 7 km into the river mouth. The exceedance probability for 20 mg/L exceeding more than 10% of the time would have a spread of less than 1.5 and 0.5 km from the source of dredging and reclamation operations respectively. The exceedance probability for 50 mg/L exceeding more than 10% of the time would have a spread of less than 0.8 km from the source for both operations.

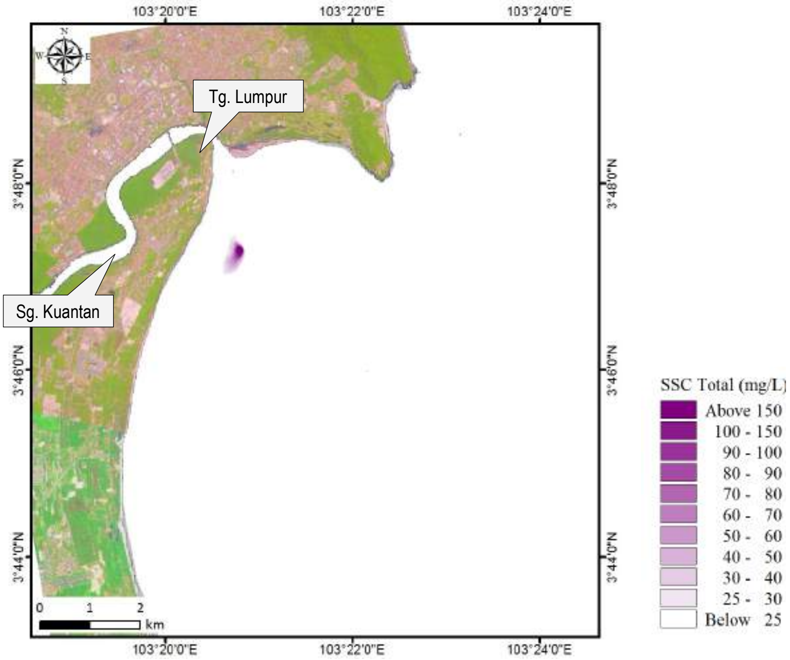


a) Mean excess: Pure tide condition

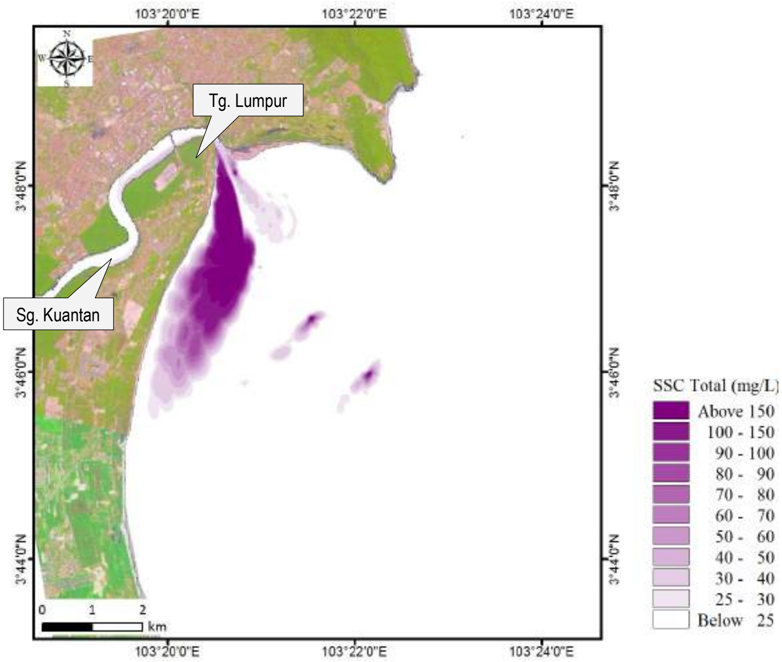


b) Maximum excess: Pure tide condition

Figure 7.12 ► Mean and Maximum Excess Suspended Sediment Concentration for Option 2: Phase 2a

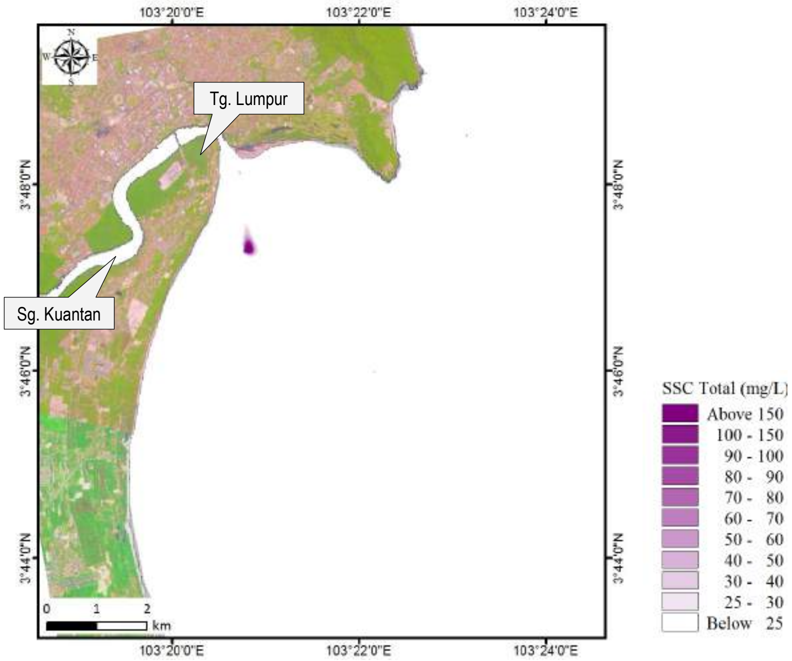


c) Mean excess: Northeast Monsoon condition

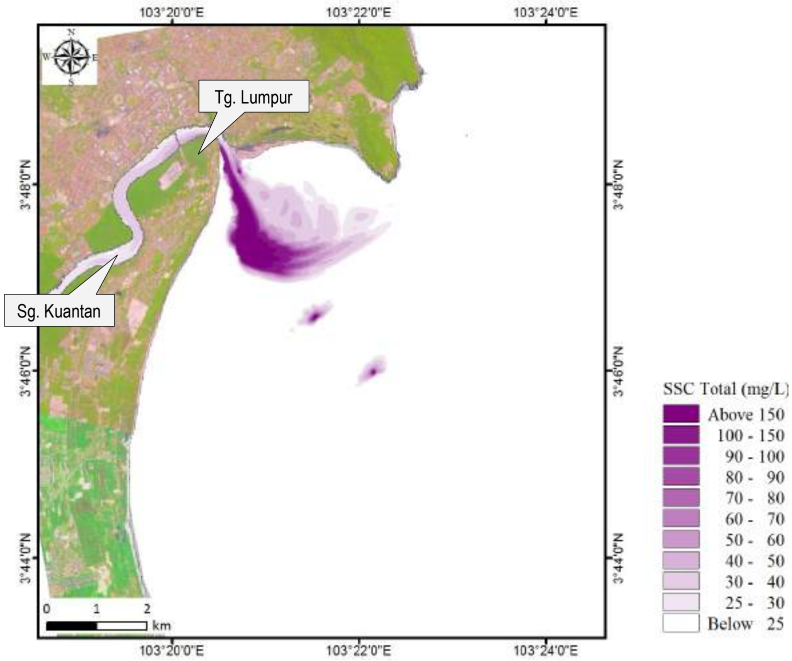


d) Maximum excess: Northeast Monsoon condition

Figure 7.12 *(cont'd)* ► Mean and Maximum Excess Suspended Sediment Concentration for Option 2: Phase 2a

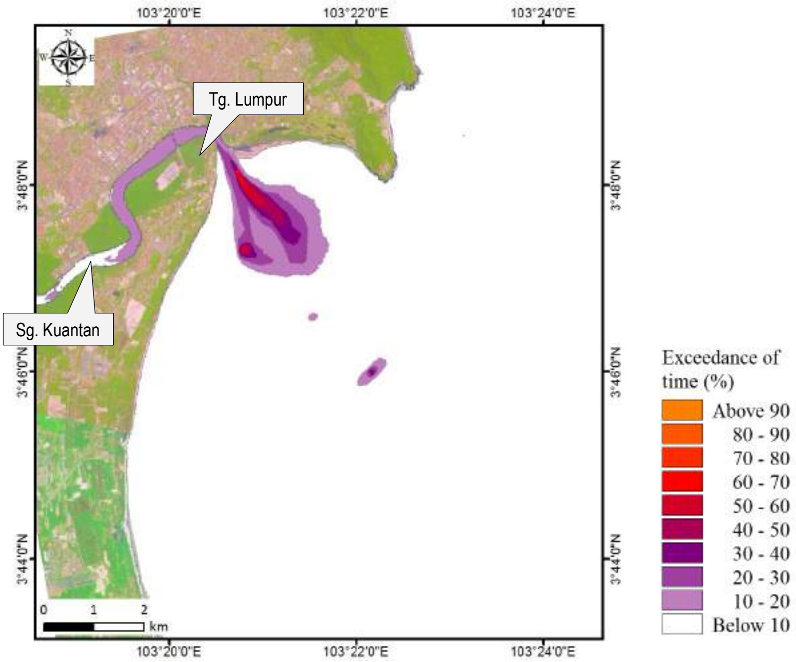


e) Mean excess: Southwest Monsoon condition

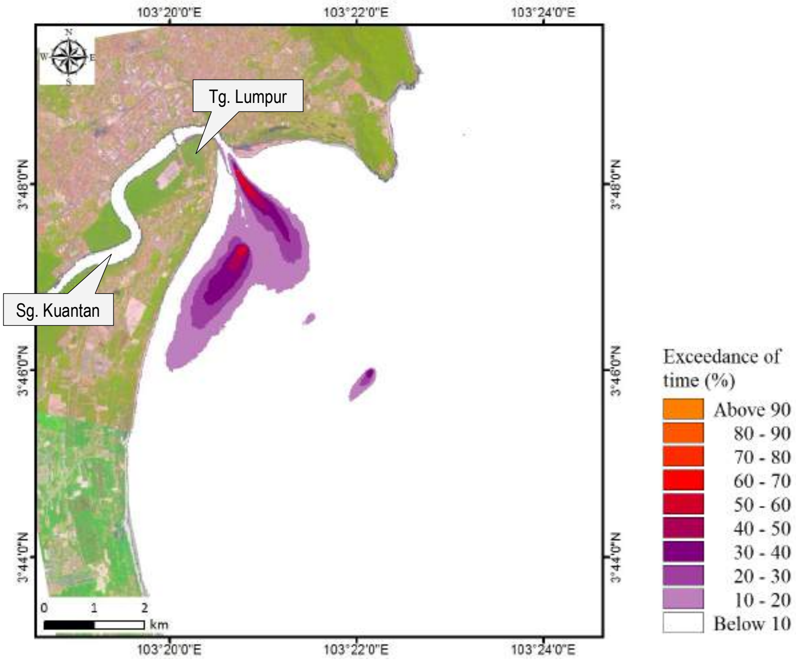


f) Maximum excess: Southwest Monsoon condition

Figure 7.12 *(cont'd)* ► Mean and Maximum Excess Suspended Sediment Concentration for Option 2: Phase 2a

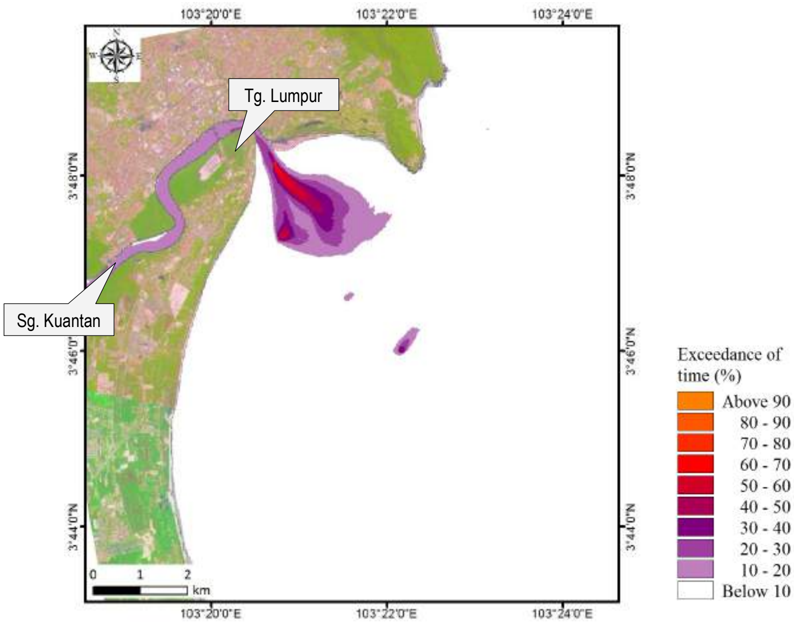


a) Pure tide condition



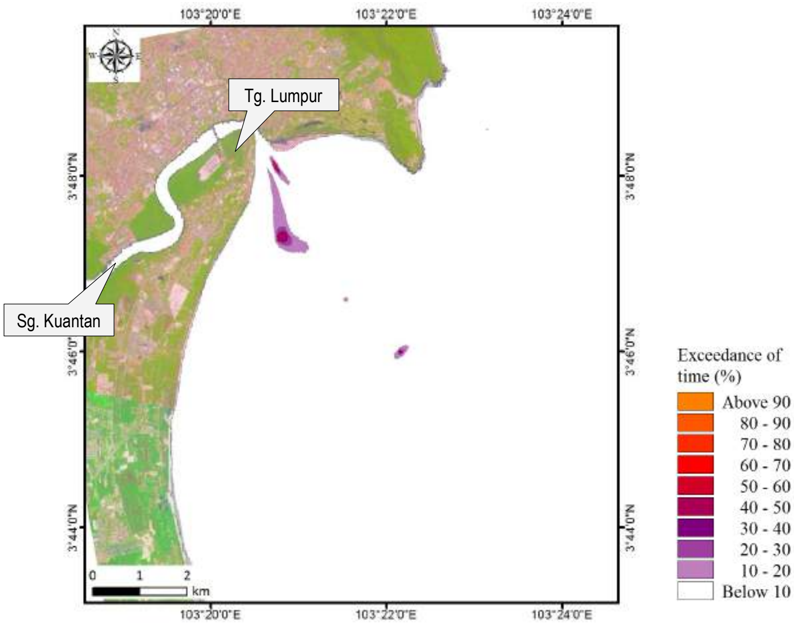
b) Northeast Monsoon condition

Figure 7.13 ► Percentage Exceedance of Suspended Sediment Concentration above 10 mg/L for Option 2: Phase 2a



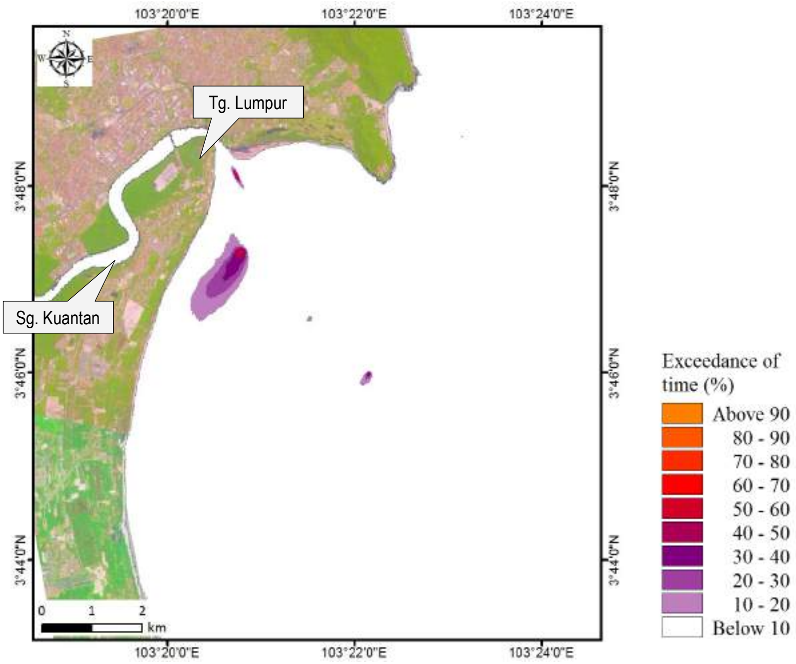
c) Southwest Monsoon condition

Figure 7.13 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 10 mg/L for Option 2: Phase 2a

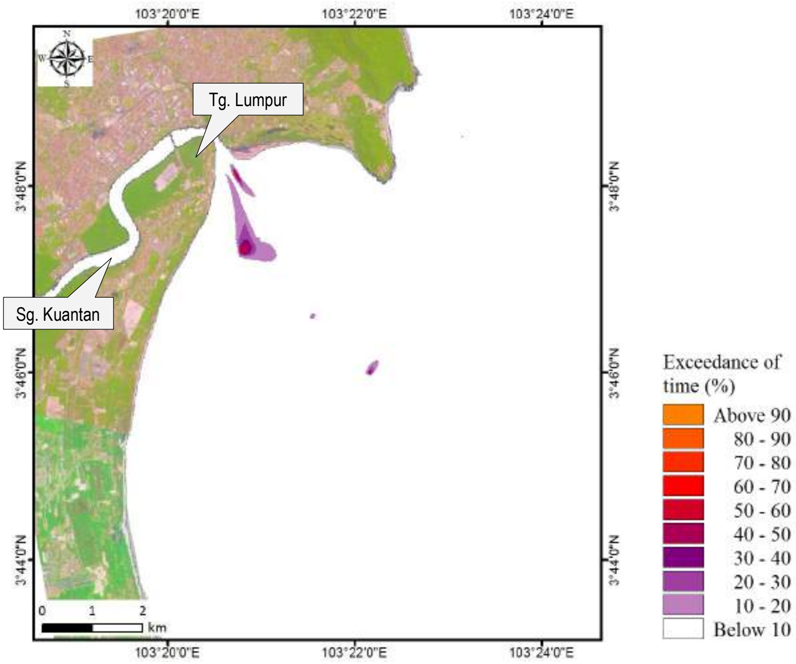


a) Pure tide condition

Figure 7.14 ► Percentage Exceedance of Suspended Sediment Concentration above 20 mg/L for Option 2: Phase 2a

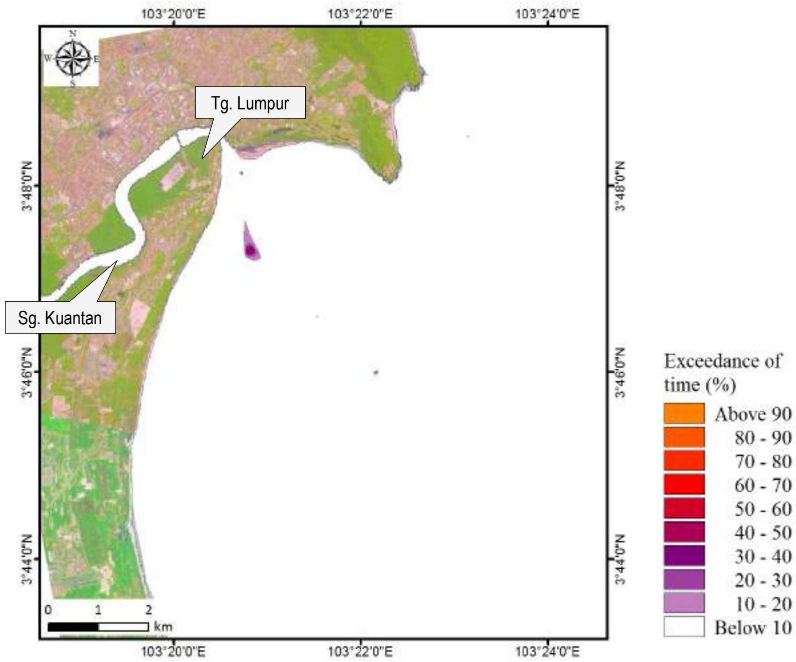


b) Northeast Monsoon condition

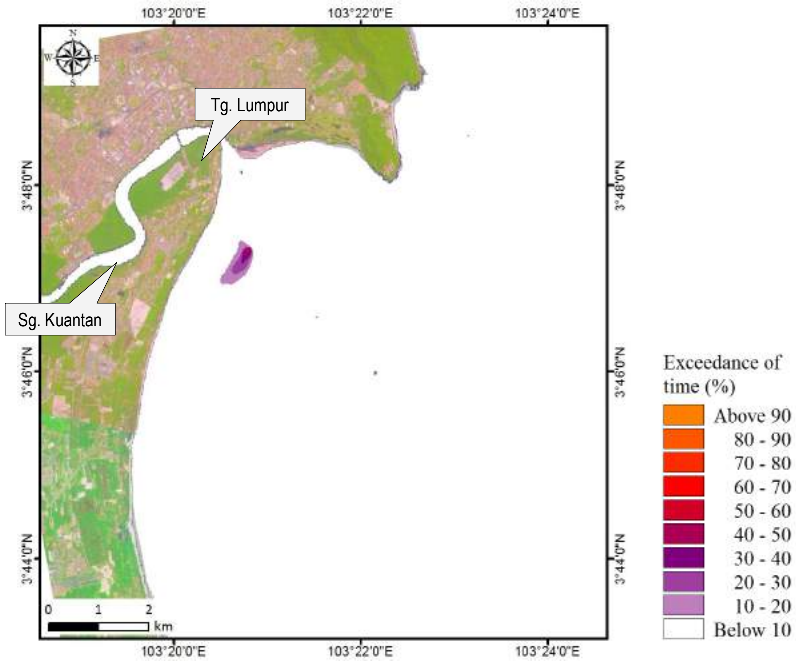


c) Southwest Monsoon condition

Figure 7.14 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 20 mg/L for Option 2: Phase 2a

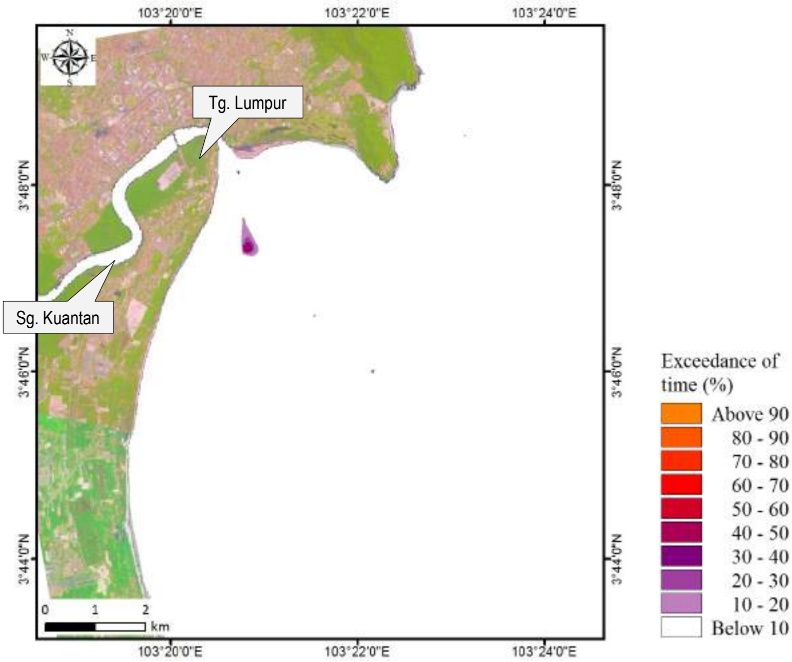


a) Pure tide condition



b) Northeast Monsoon condition

Figure 7.15 ► Percentage Exceedance of Suspended Sediment Concentration above 50 mg/L for Option 2: Phase 2a



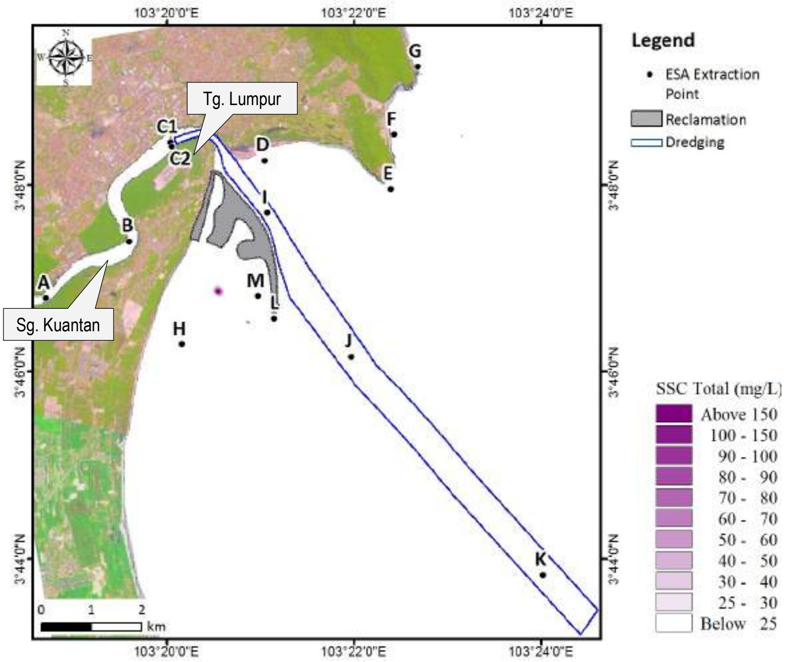
c) Southwest Monsoon condition

Figure 7.15 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 50 mg/L for Option 2: Phase 2a

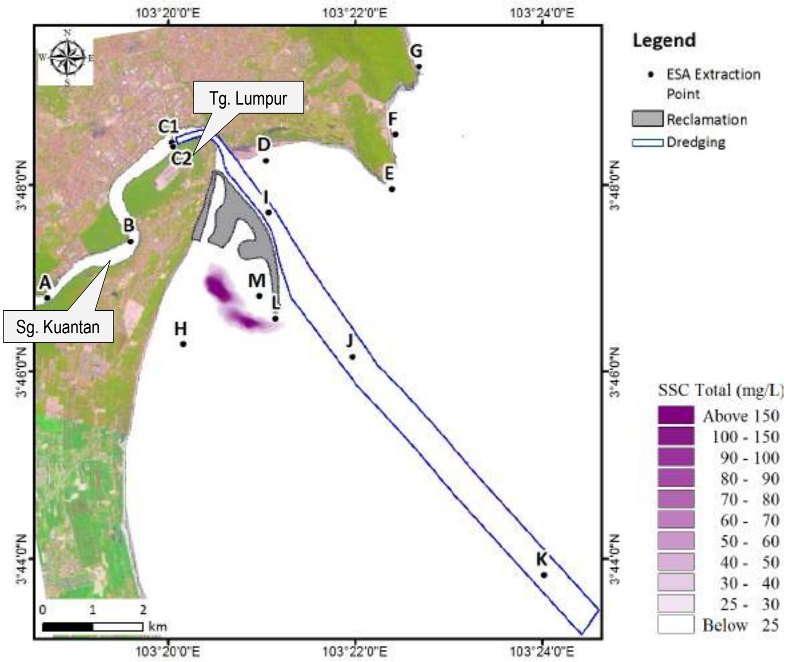
ii) Phase 2b

Plots of mean and maximum excess suspended sediment concentrations for seasonal conditions due to Phase 2B's construction activities are shown in *Figure 7.16*. The maximum plume excursions for suspended sediment concentration of more than 25 mg/L are about 1 and 1.7 km extending approximately east and southwest from the source respectively. The mean excess suspended sediment dispersion for the same concentration is less than 0.2 km from the source.

Plots showing the exceedance of the dispersion above 10, 20 and 50 mg/L of concentration with respect to the percentage of time over the simulation period are shown in *Figures 7.17* to *7.19*. The exceedance probability for 10 mg/L exceeding more than 10% of the time for seasonal conditions would have a spread of less than 1.3 and 1 km from the source of dredging and reclamation activities respectively. The exceedance probability for 20 mg/L exceeding more than 10% of the time would have a spread of less than 0.6 and 0.5 km from the source of dredging and reclamation operations respectively. The exceedance probability for 50 mg/L exceeding more than 10% of the time would have a spread of less than 0.3 km from the source of operations.

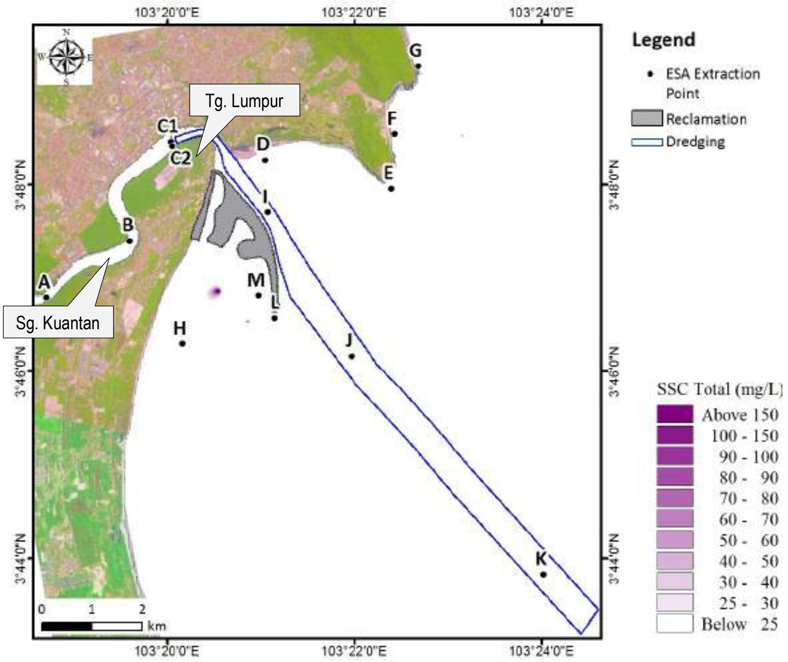


a) Mean excess: Pure tide condition

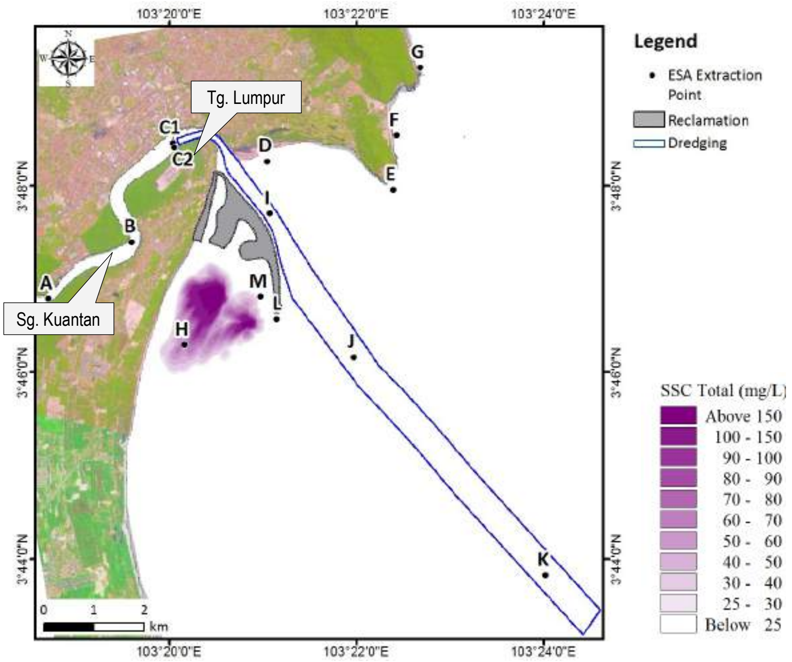


b) Maximum excess: Pure tide condition

Figure 7.16 ► Mean and Maximum Excess Suspended Sediment Concentration for Option 2: Phase 2b

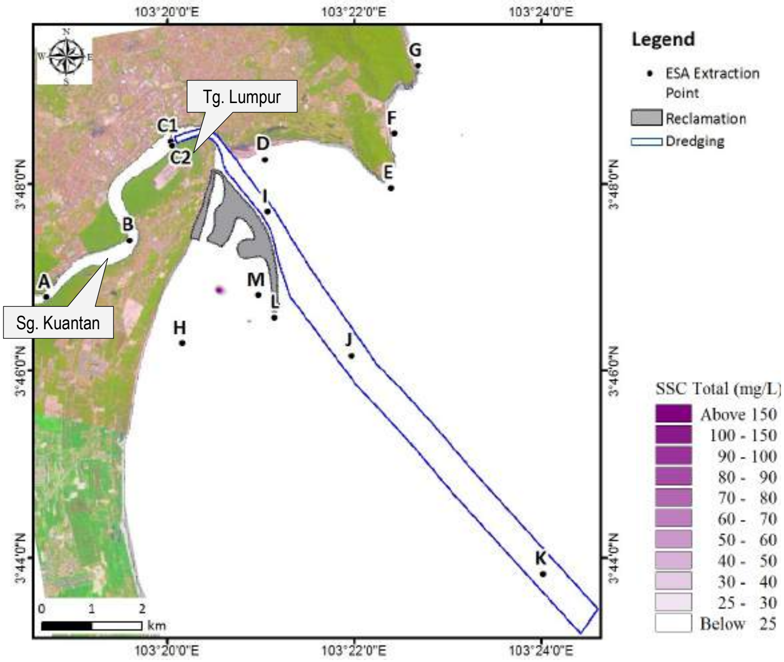


c) Mean excess: Northeast Monsoon condition

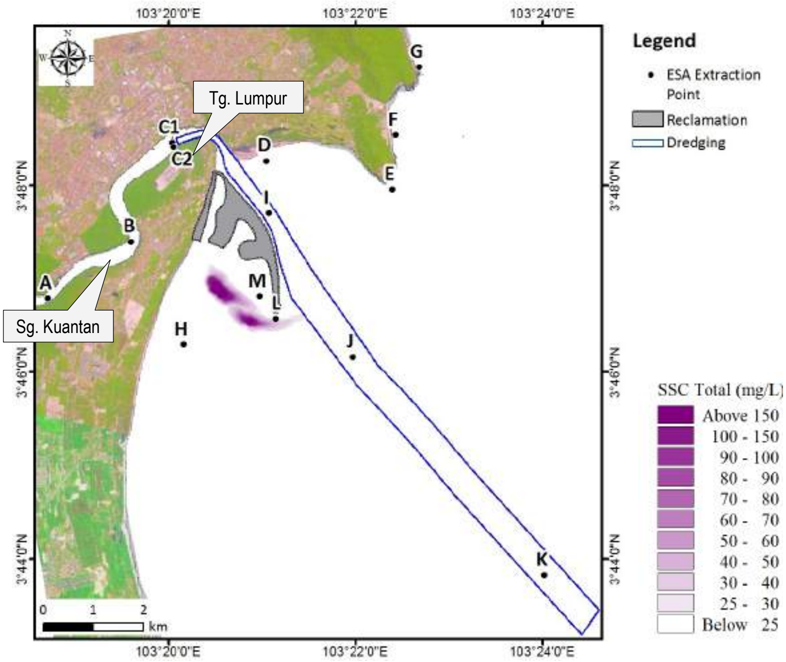


d) Maximum excess: Northeast Monsoon condition

Figure 7.16 *(cont'd)* ► Mean and Maximum Excess Suspended Sediment Concentration for Option 2: Phase 2b

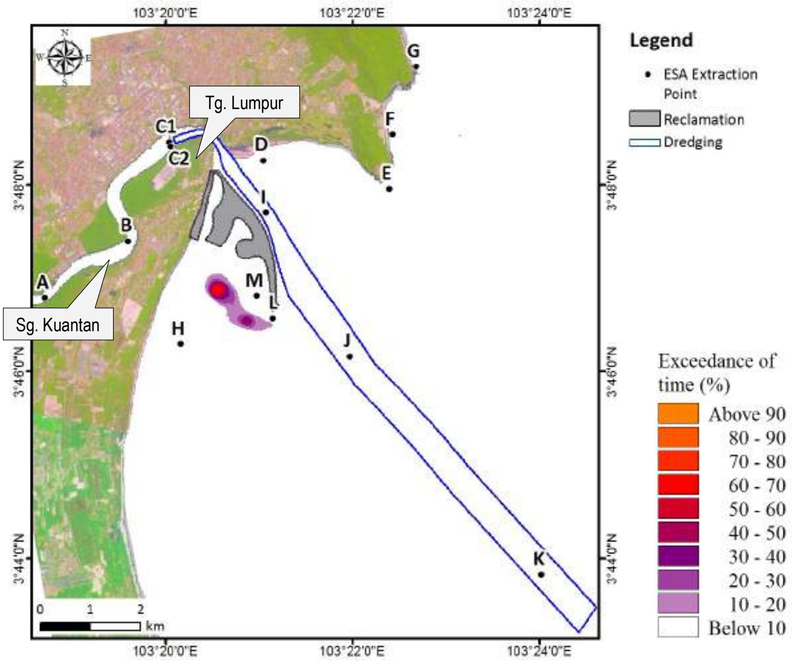


e) Mean excess: Southwest Monsoon condition

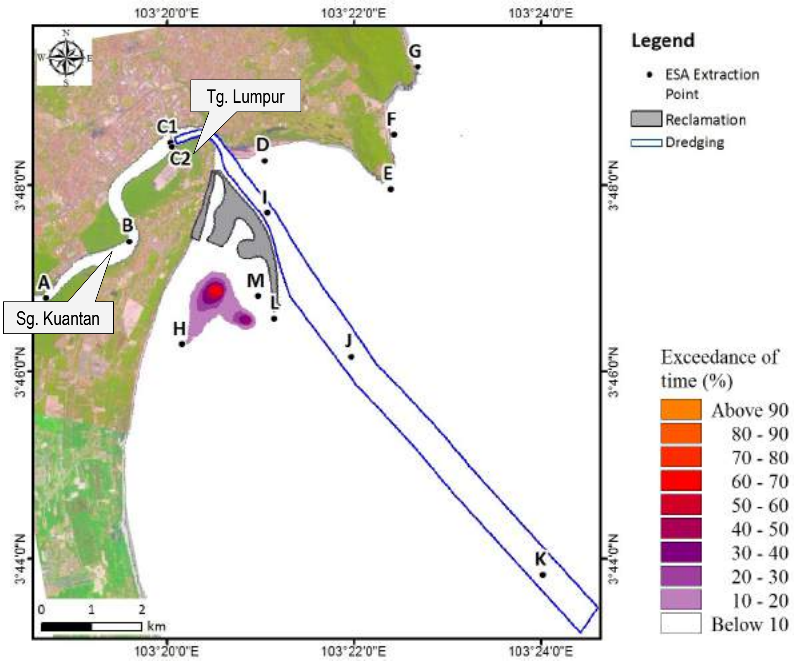


f) Maximum excess: Southwest Monsoon condition

Figure 7.16 *(cont'd)* ► Mean and Maximum Excess Suspended Sediment Concentration for Option 2: Phase 2b

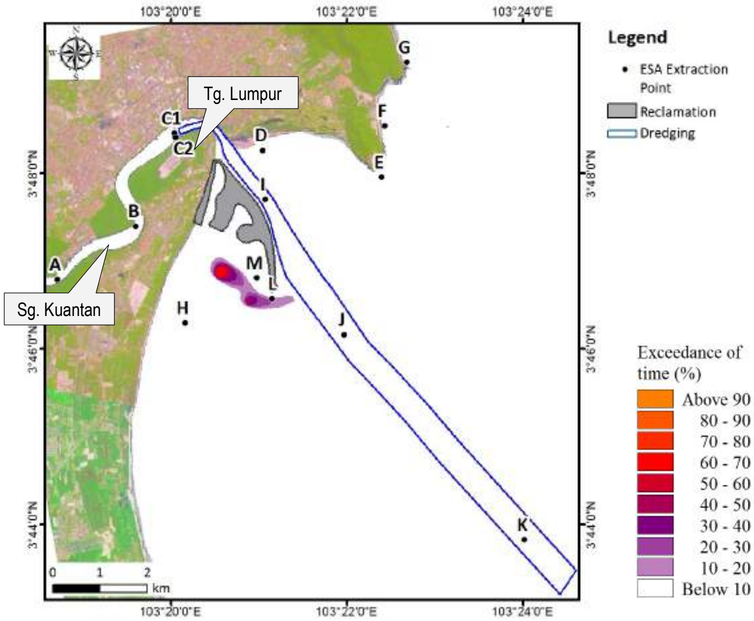


a) Pure tide condition



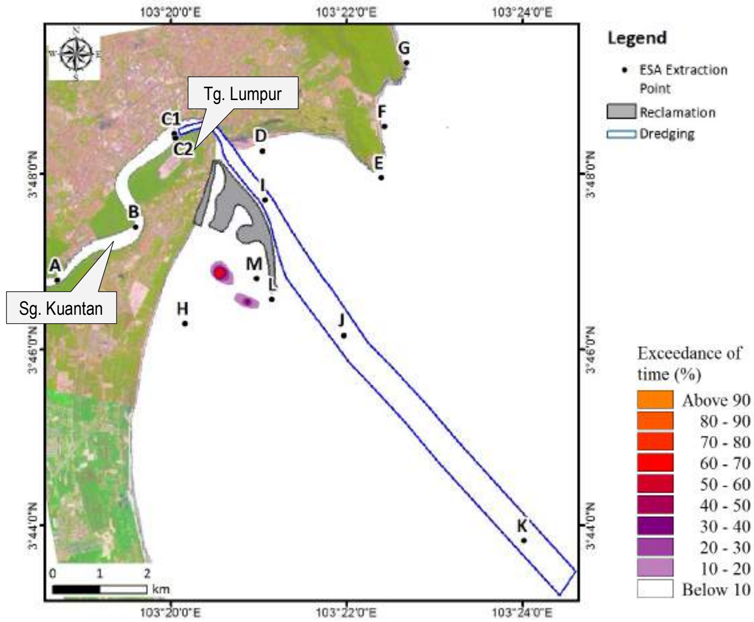
b) Northeast Monsoon condition

Figure 7.17 ► Percentage Exceedance of Suspended Sediment Concentration above 10 mg/L for Option 2: Phase 2b



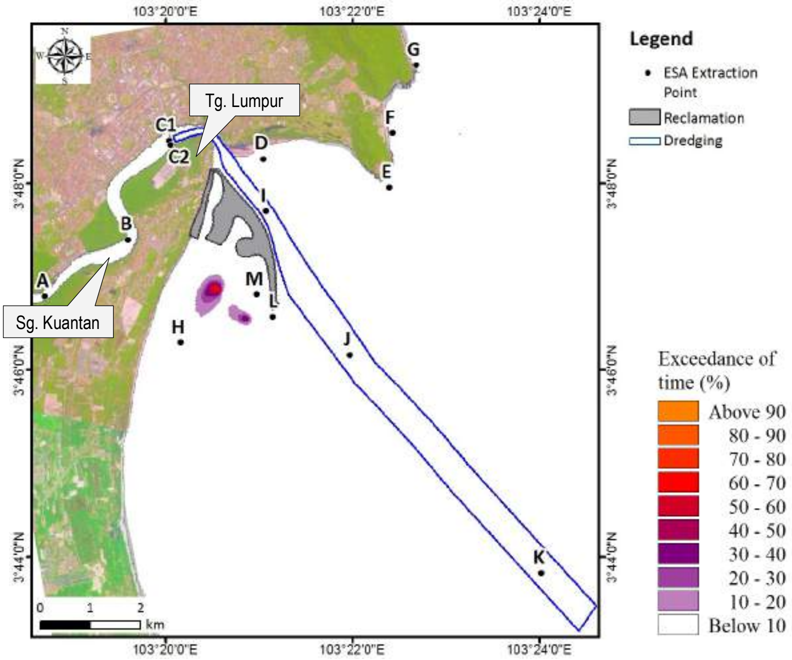
c) Southwest Monsoon condition

Figure 7.17 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 10 mg/L for Option 2: Phase 2b

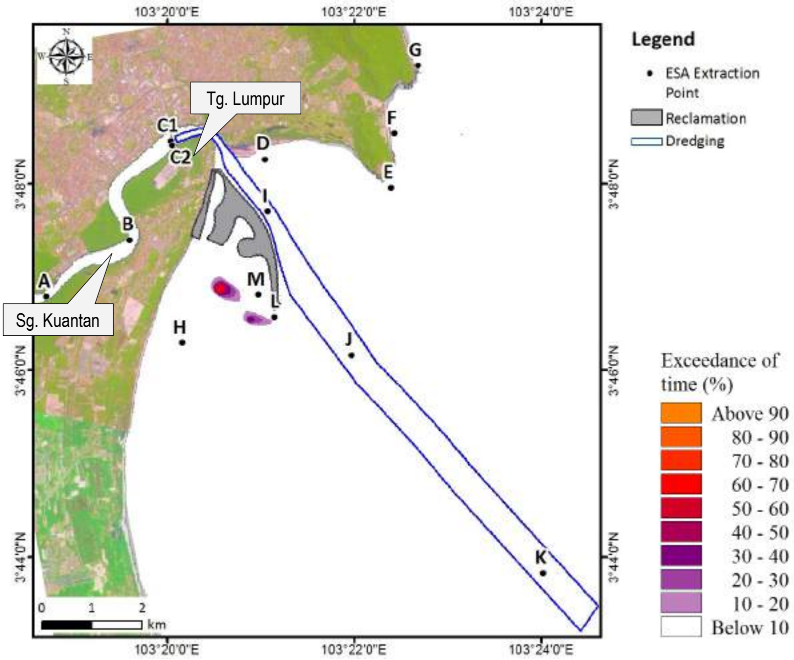


a) Pure tide condition

Figure 7.18 ► Percentage Exceedance of Suspended Sediment Concentration above 20 mg/L for Option 2: Phase 2b

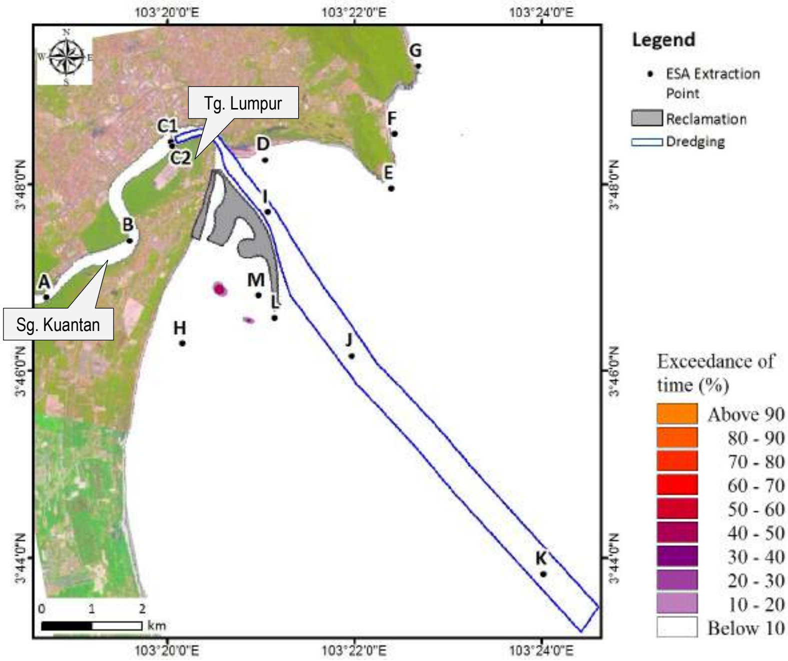


b) Northeast Monsoon condition

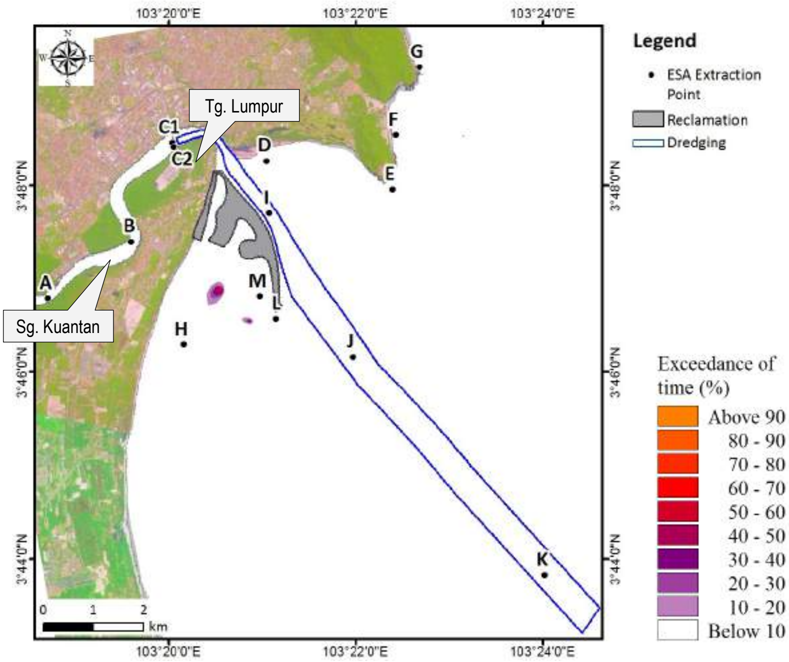


c) Southwest Monsoon condition

Figure 7.18 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 20 mg/L for Option 2: Phase 2b

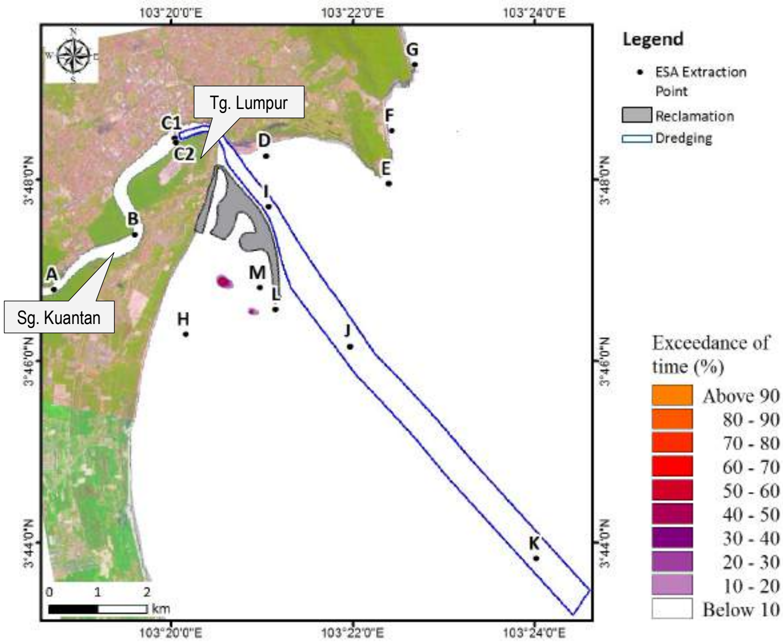


a) Pure tide condition



b) Northeast Monsoon condition

Figure 7.19 ► Percentage Exceedance of Suspended Sediment Concentration above 50 mg/L for Option 2: Phase 2b



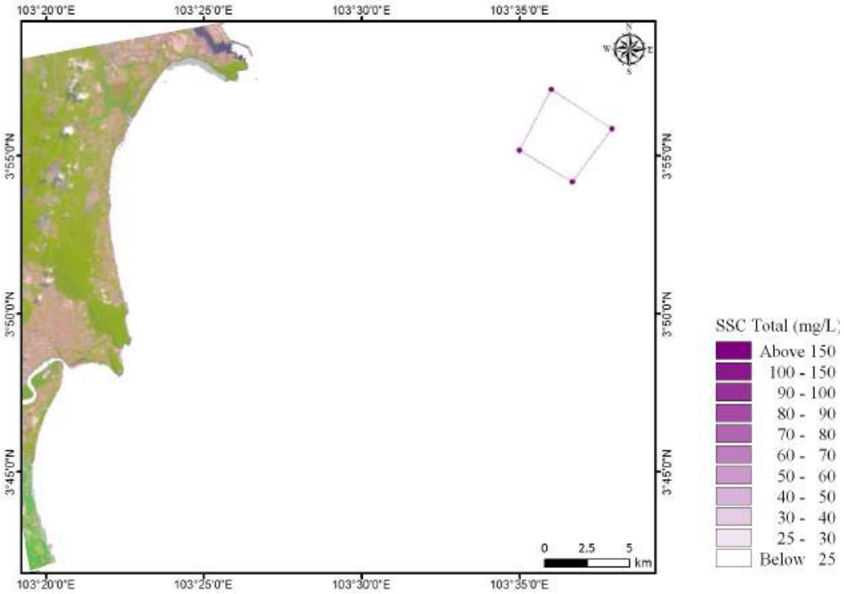
c) Southwest Monsoon condition

Figure 7.19 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 50 mg/L for Option 2: Phase 2b

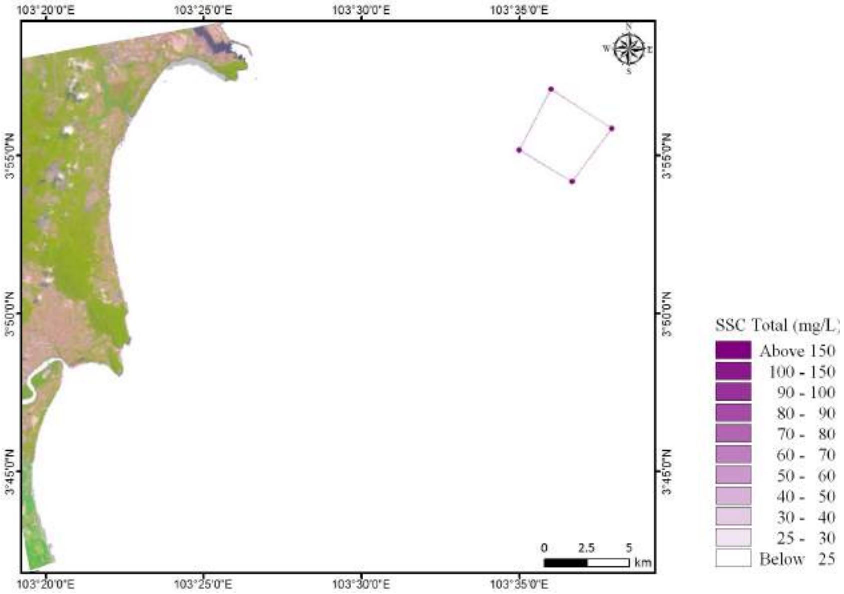
B. Disposal of Dredged Materials

Plots of mean and maximum excess suspended sediment concentrations for seasonal conditions due to disposal activities are shown in *Figure 7.20*. The maximum plume excursions for suspended sediment concentration of more than 25 mg/L are less than 0.05 km from the source respectively. The mean excess suspended sediment dispersion for the same concentration is relatively undetectable in the model due to the short duration of each disposal activity and long interval between each disposal operation. The concentration of the suspended sediment plume reduces rapidly away from the source once the dredged spoils enter the water column.

Plots showing the exceedance of the dispersion above 10, 20 and 50 mg/L of concentration with respect to the percentage of time over the simulation period are shown in *Figures 7.21* to *7.23*. The exceedance probability for 10, 20 and 50 mg/L exceeding more than 10% of the time for seasonal conditions would have a spread of less than 0.05 km from the source of disposal activity.

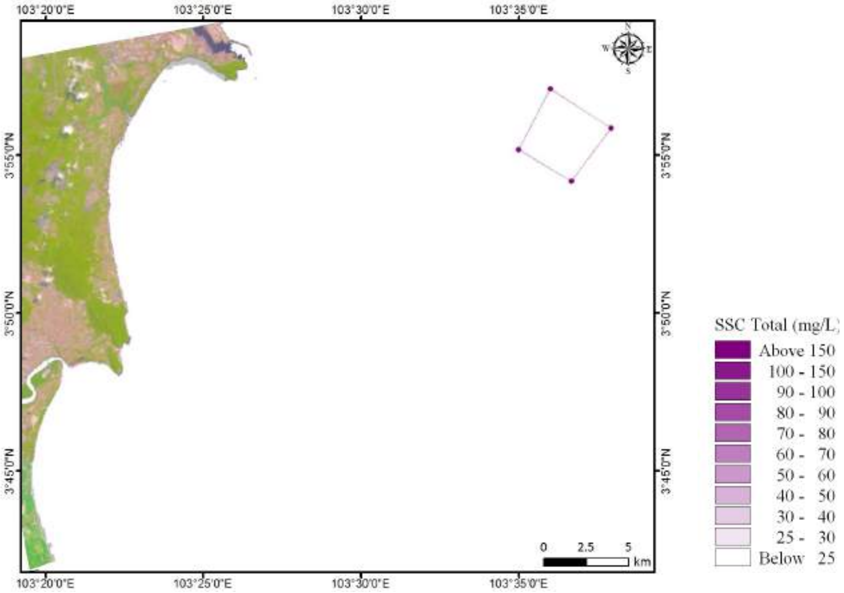


a) Mean excess: Pure tide condition

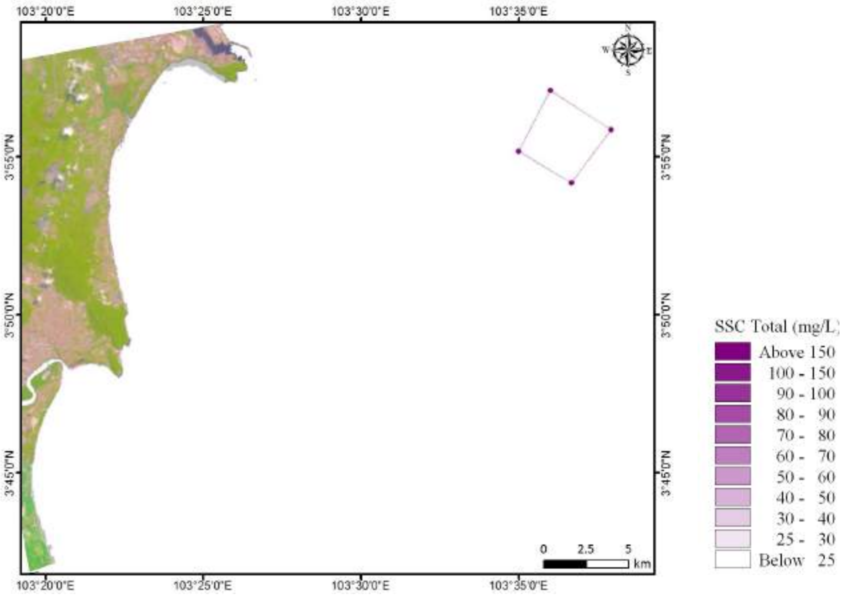


b) Maximum excess: Pure tide condition

Figure 7.20 ► Mean and Maximum Excess Suspended Sediment Concentration due to Disposal Activities

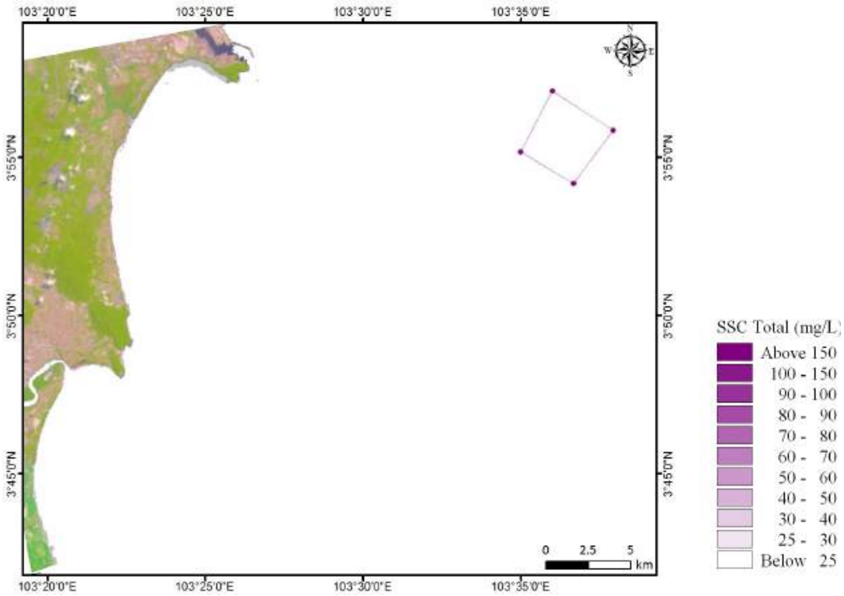


c) Mean excess: Northeast Monsoon condition

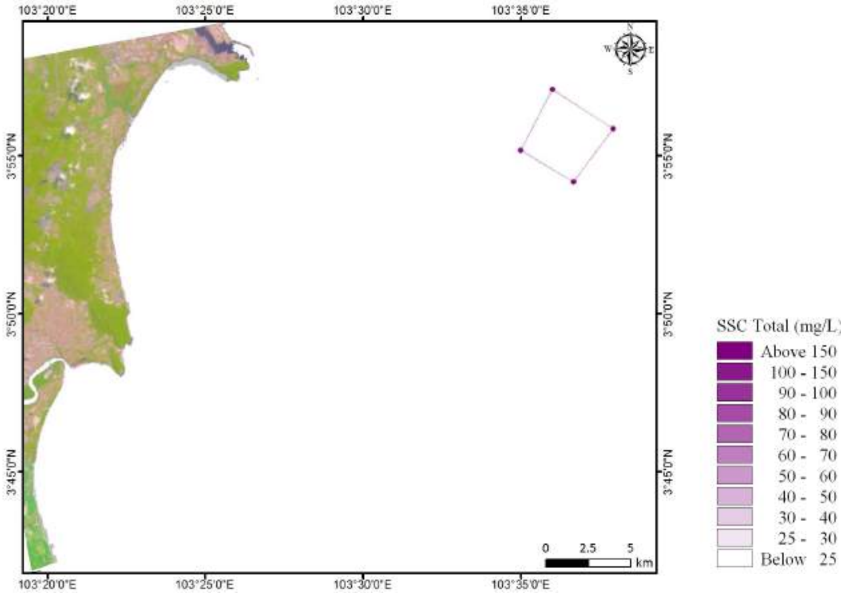


d) Maximum excess: Northeast Monsoon condition

Figure 7.20 *(cont'd)* ► Mean and Maximum Excess Suspended Sediment Concentration due to Disposal Activities

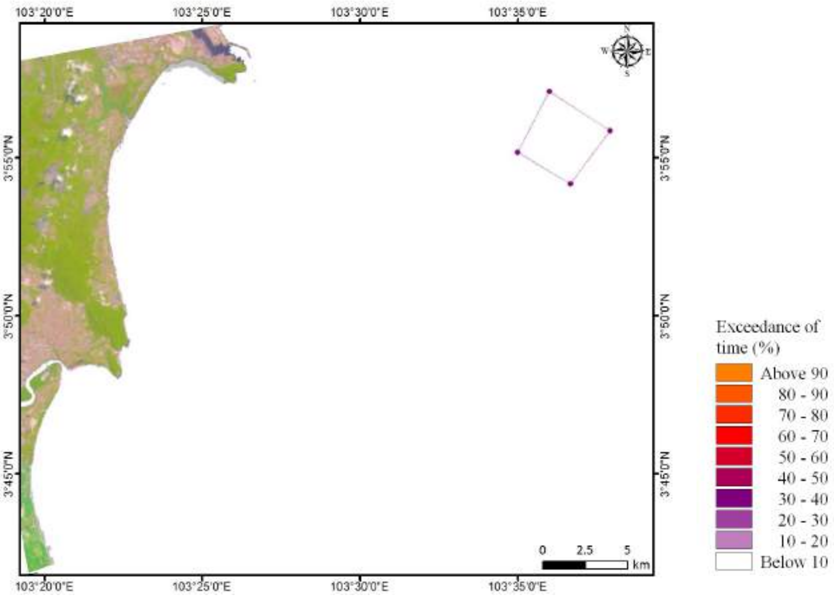


e) Mean excess: Southwest Monsoon condition

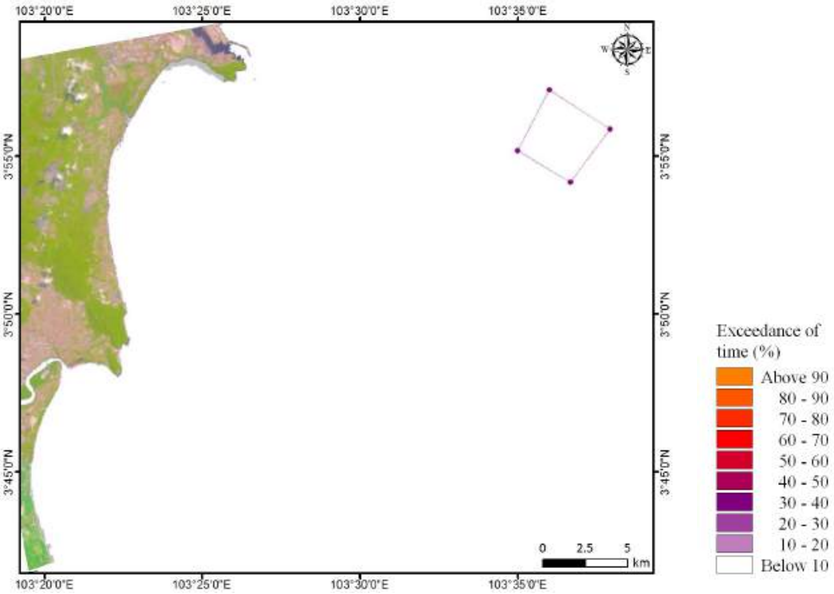


f) Maximum excess: Southwest Monsoon condition

Figure 7.20 *(cont'd)* ► Mean and Maximum Excess Suspended Sediment Concentration due to Disposal Activities

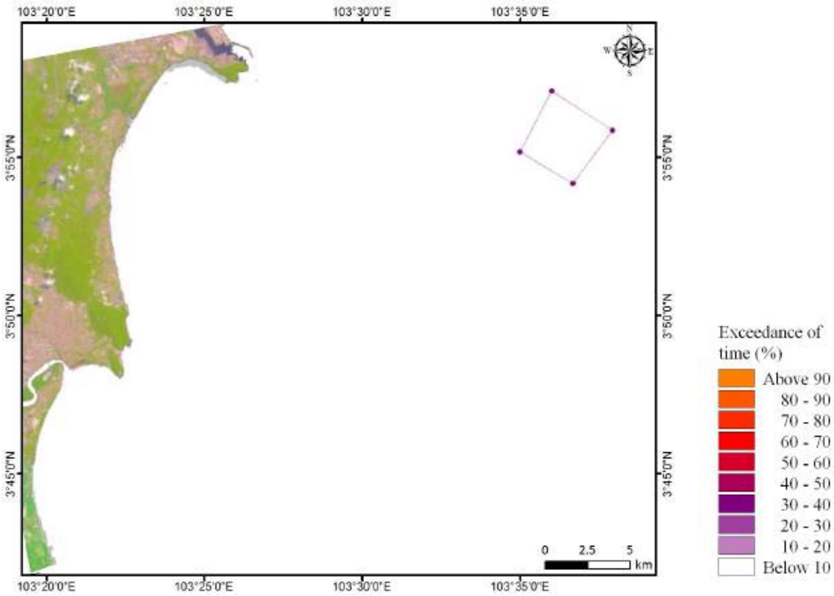


a) Pure tide condition



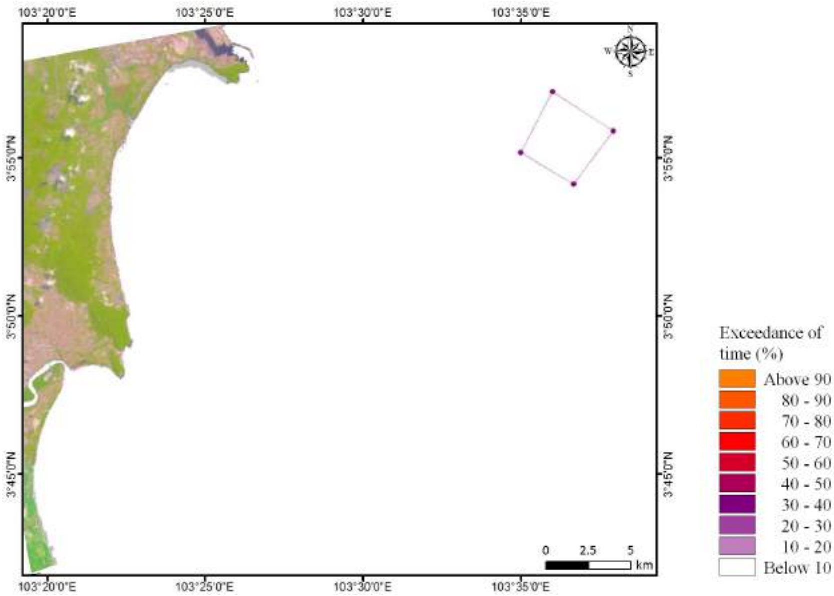
b) Northeast Monsoon condition

Figure 7.21 ► Percentage Exceedance of Suspended Sediment Concentration above 10 mg/L due to Disposal Activities



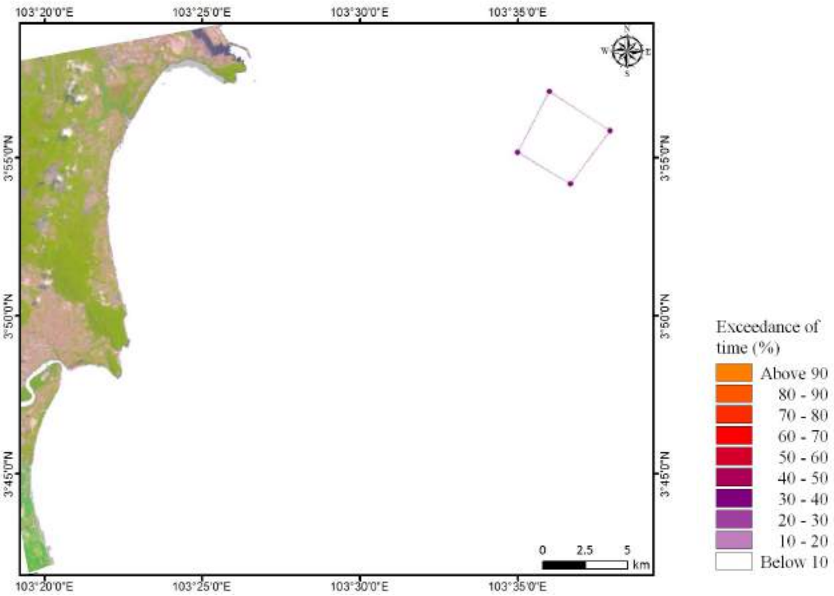
c) Southwest Monsoon condition

Figure 7.21 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 10 mg/L due to Disposal Activities

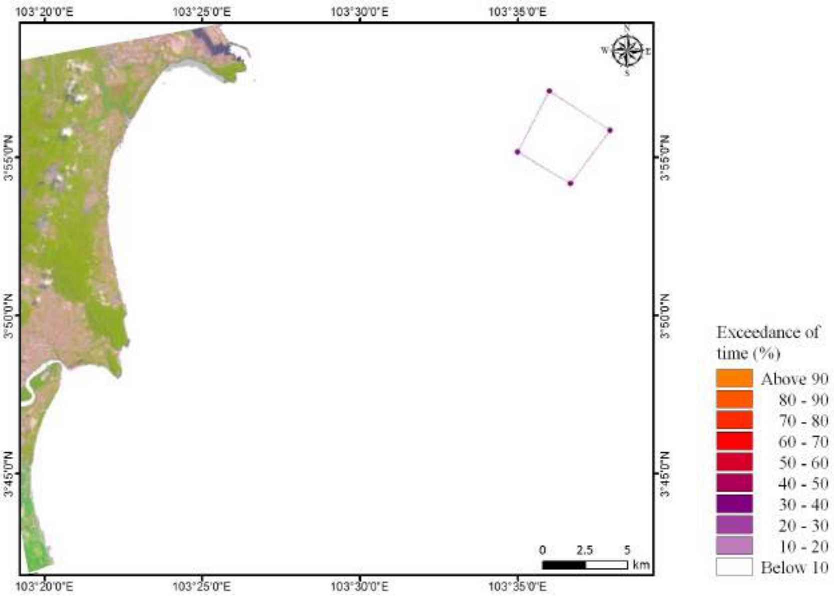


a) Pure tide condition

Figure 7.22 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 20 mg/L due to Disposal Activities

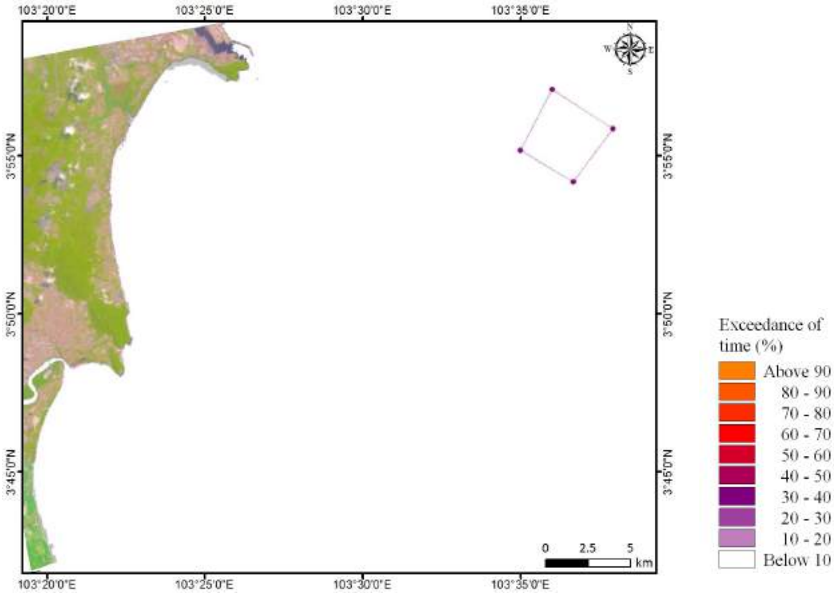


b) Northeast Monsoon condition

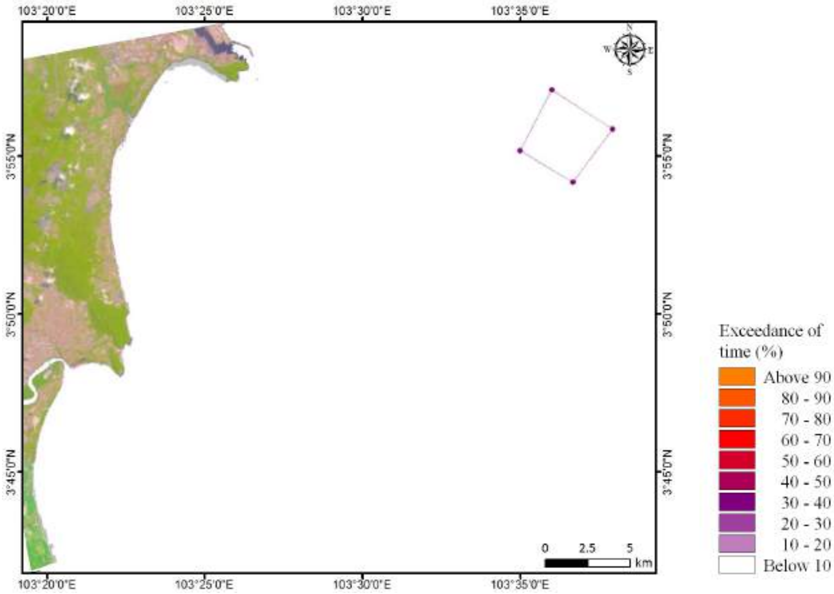


c) Southwest Monsoon condition

Figure 7.22 ► Percentage Exceedance of Suspended Sediment Concentration above 20 mg/L due to Disposal Activities

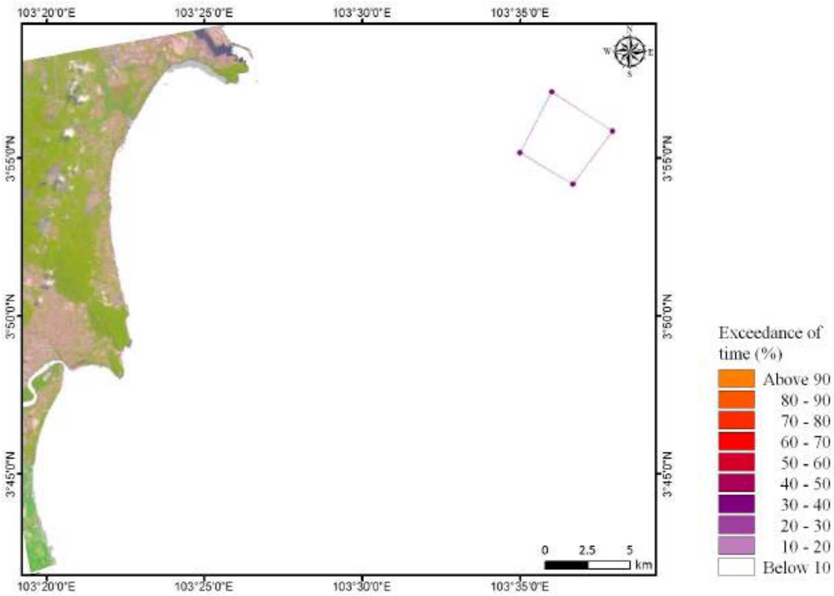


a) Pure tide condition



b) Northeast Monsoon condition

Figure 7.23 ► Percentage Exceedance of Suspended Sediment Concentration above 50 mg/L due to Disposal Activities



c) Southwest Monsoon condition

Figure 7.23 *(cont'd)* ► Percentage Exceedance of Suspended Sediment Concentration above 50 mg/L due to Disposal Activities

<u>Impact of Sediment Dispersion at ESAs and Around the Project Area</u>

Observations were also made based on mean and maximum excess suspended sediment concentration during reclamation and dredging activities. The extractions were made at numerous locations around the Project area representing ESAs (as shown in *Figure 7.2*). Results of the mean and maximum suspended sediment concentration is shown in *Tables 7.6* and *7.7* for Options 1 and 2 respectively. The suspended sediment concentration is highest within the immediate vicinity of the source of operations.

Table 7.6 ► Mean and Maximum Suspended Sediment Concentration for Option 1 at ESAs and Around the Project Area

Point	Location	Phase 2a		Phase 2b	
		Mean Concentration (mg/L)	Maximum Concentration (mg/L)	Mean Concentration (mg/L)	Maximum Concentration (mg/L)
A	Kuantan Forest Reserve	3	24	0	0
B	Hutan Rizab Paya Laut Kuantan	4	25	0	1
C1	Tanjung Lumpur Bridge (northern pier)	5	24	0	1
C2	Tanjung Lumpur Bridge (southern pier)	5	24	0	1
D	Pantai Tanjung Sisek	0	6	0	0
E	Kuantan Tembeling Resort	0	6	0	0
F	Teluk Cempedak	0	0	0	0
G	Beserah Forest Reserve	0	0	0	0
H	Tanjung Lumpur sandflat	0	1	0	0
I	Navigation channel (upstream)	8	32	0	1
J	Navigation channel (midstream)	0	2	0	0
K	Navigation channel (downstream)	0	0	0	0
L	Southeastern end of development	1	9	1	8
M	Marina entrance	1	8	0	3

Table 7.7 ▶ Mean and Maximum Suspended Sediment Concentration for Option 2 at ESAs and Around the Project Area

Point	Location	Phase 2a		Phase 2b	
		Mean Concentration (mg/L)	Maximum Concentration (mg/L)	Mean Concentration (mg/L)	Maximum Concentration (mg/L)
A	Kuantan Forest Reserve	3	26	0	0
B	Hutan Rizab Paya Laut Kuantan	4	31	0	1
C1	Tanjung Lumpur Bridge (northern pier)	5	30	0	1
C2	Tanjung Lumpur Bridge (southern pier)	5	40	0	1
D	Pantai Tanjung Sisek	0	6	0	0
E	Kuantan Tembeling Resort	0	6	0	0
F	Teluk Cempedak	0	0	0	0
G	Beserah Forest Reserve	0	0	0	0
H	Tanjung Lumpur sandflat	0	1	0	0
I	Navigation channel (upstream)	8	36	0	1
J	Navigation channel (midstream)	0	2	0	0
K	Navigation channel (downstream)	0	0	0	0
L	Southeastern end of development	1	9	1	8
M	Marina entrance	1	22	0	3

Option 1

The mean and maximum suspended sediment concentrations near Kuantan Forest Reserve are 3 and 24 mg/L respectively. The mean and maximum suspended sediment concentrations near Hutan Rizab Paya Laut Kuantan are 4 and 25 mg/L respectively. The maximum suspended sediment concentration near Pantai Tanjung Sisek and Kuantan Tembeling Resort are about 6 mg/L. However, the mean suspended sediment concentration near Pantai Tanjung Sisek and Kuantan Tembeling Resort is 0 mg/L. The suspended sediment concentration at Teluk Cempedak, Beserah Forest Reserve and Tanjung Lumpur sandflat is relatively undetectable. Mangroves are the main ESAs near the proposed project site. Mangroves are known to be able to withstand any moderate increase of suspended solids within the water as their ecosystem is naturally muddy. Therefore, the impact on sediment dispersion from the project activities is considered insignificant since the maximum sediment concentration is only 25 mg/L.

Option 2

The mean and maximum suspended sediment concentration near Kuantan Forest Reserve are 3 and 26 mg/L respectively. The mean and maximum suspended sediment concentrations near Hutan Rizab Paya Laut Kuantan are 4 and 31 mg/L respectively. The maximum suspended sediment concentration near Pantai Tanjung Sisek and Kuantan Tembeling Resort are about 6 mg/L. However, the mean suspended sediment concentration near Pantai Tanjung Sisek and Kuantan Tembeling Resort is 0 mg/L. The suspended sediment concenctration at Teluk Cempedak, Beserah Forest Reserve and Tanjung Lumpur sandflat is relatively undetectable. Similar with Option 1, the results indicate that the nearby ESAs are tolerable towards the projected maximum suspended sediment concentration which is less than 31 mg/L.

7.2.2.3.2 Current Speed

Impacts on current speeds due to the Project were done by assessing changes that occur with respect to the existing condition. This is done by analysing mean and maximum current speeds occurring during the modelled period. Current flow plots, mean and maximum current speed plots as well as current speed change plots for all phases of the development are as elaborated in *Table 7.8*.

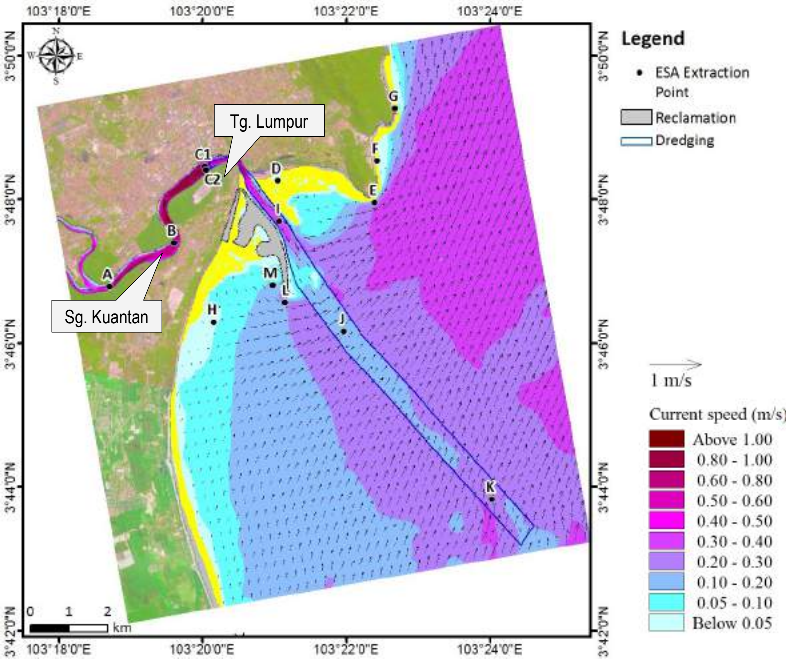
Table 7.8 ► Summary of Plots of Current Speed Simulations for 'with Project' Condition

Scenario	Figure No.			
	Monsoon	**Current Flows**	**Mean and Maximum Current Speed**	**Current Speed Change**
Phase 2a	Pure tide	7.24	7.27(a,b)	7.28(a,b)
	Northeast	7.25	7.27(c,d)	7.28(c,d)
	Southwest	7.26	7.27(e,f)	7.28(e,f)
Phase 2b	Pure tide	7.29	7.32(a,b)	7.33(a,b)
	Northeast	7.30	7.32(c,d)	7.33(c,d)
	Southwest	7.31	7.32(e,f)	7.33(e,f)

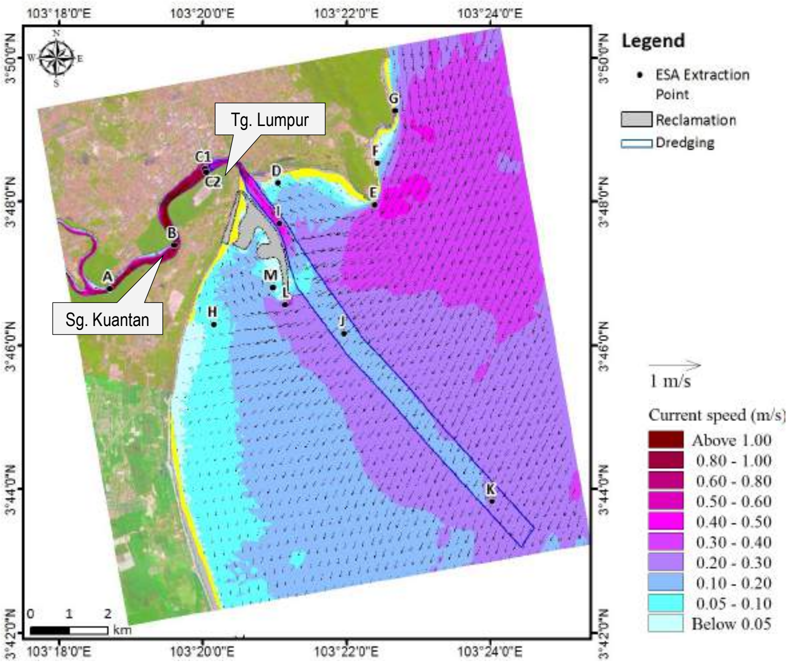
A. Phase 2a

A mean current speed increase of up to about 0.07 m/s occurs at the southeastern end of reclamation area and within the water body bounded by the reclaimed land. The maximum current speed increase of up to about 0.34 and 0.60 m/s occurs at similar areas. Mean current speed decrease of up to about 0.38 and 0.23 m/s occurs within the dredged area and between the reclamation and the mainland respectively. The maximum current speed decrease is up to about 1.28 and 0.79 m/s at the same areas.

However, the changes in current speeds for Phase 2a can be considered temporary as the entire reclamation will come to be realized.

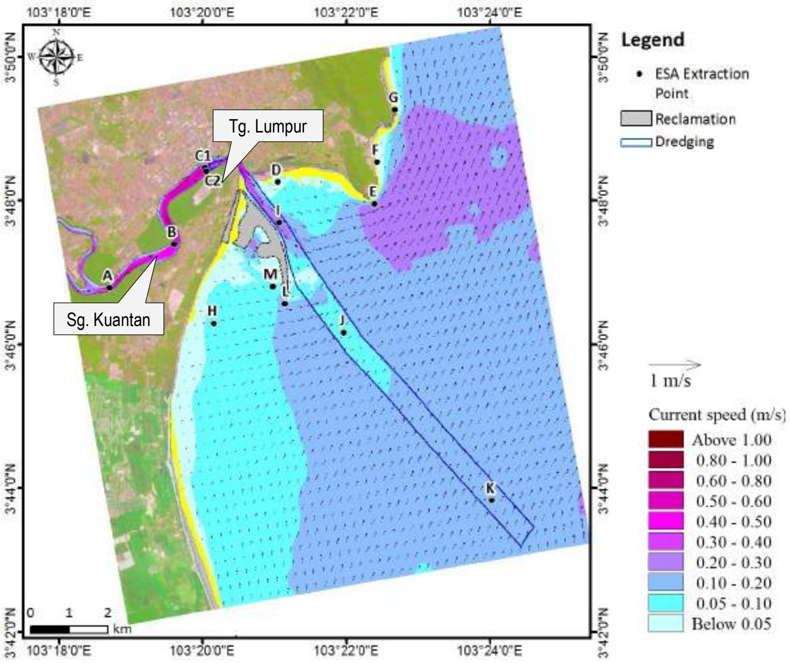


a) Spring period: Ebb flow

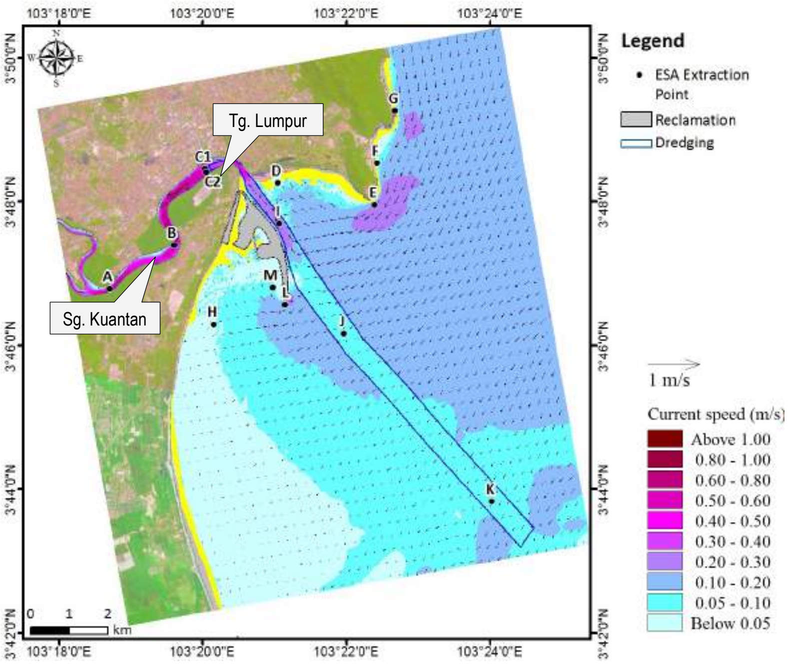


b) Spring period: Flood flow

Figure 7.24 ► Flow pattern for Phase 2a: Pure tide condition

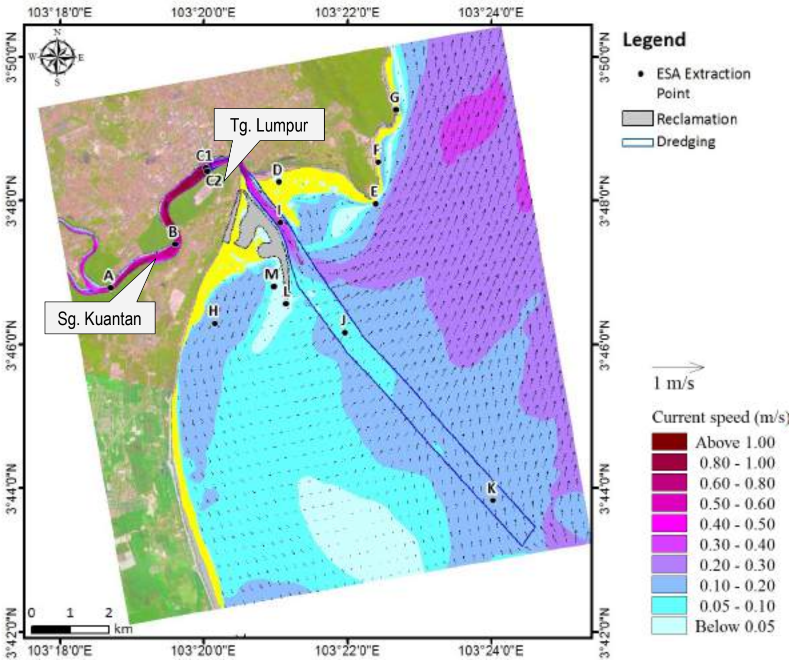


c) Neap period: Ebb flow

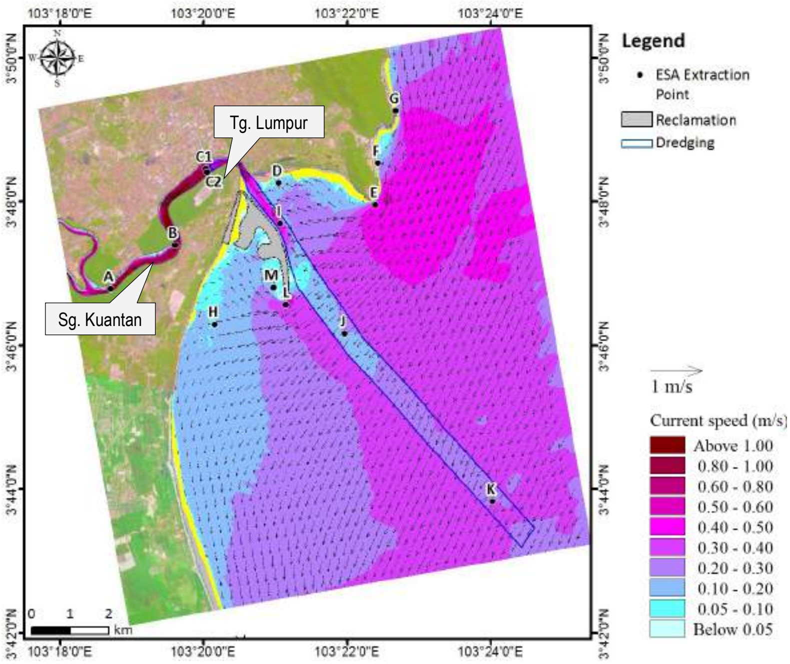


d) Neap period: Flood flow

Figure 7.24 *(cont'd)* ► Flow pattern for Phase 2a: Pure tide condition

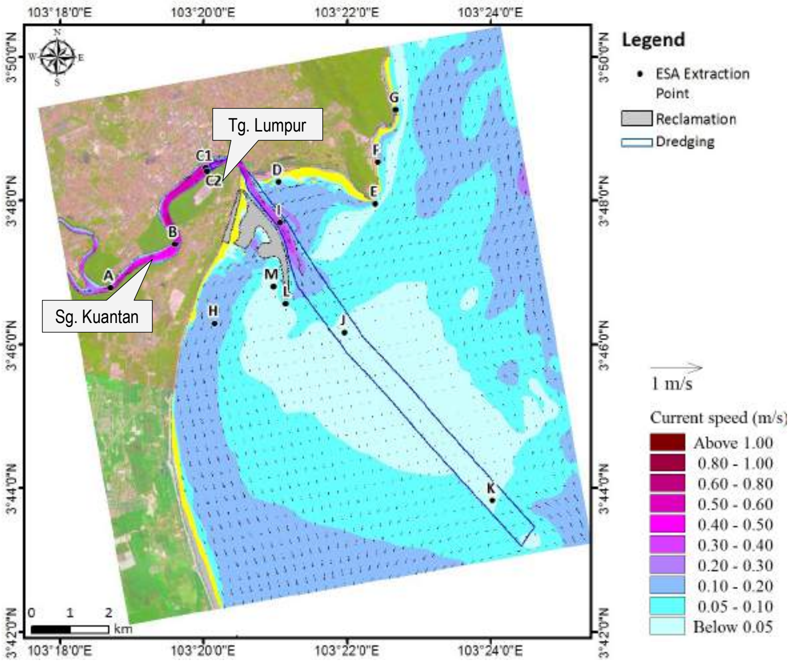


a) Spring period: Ebb flow

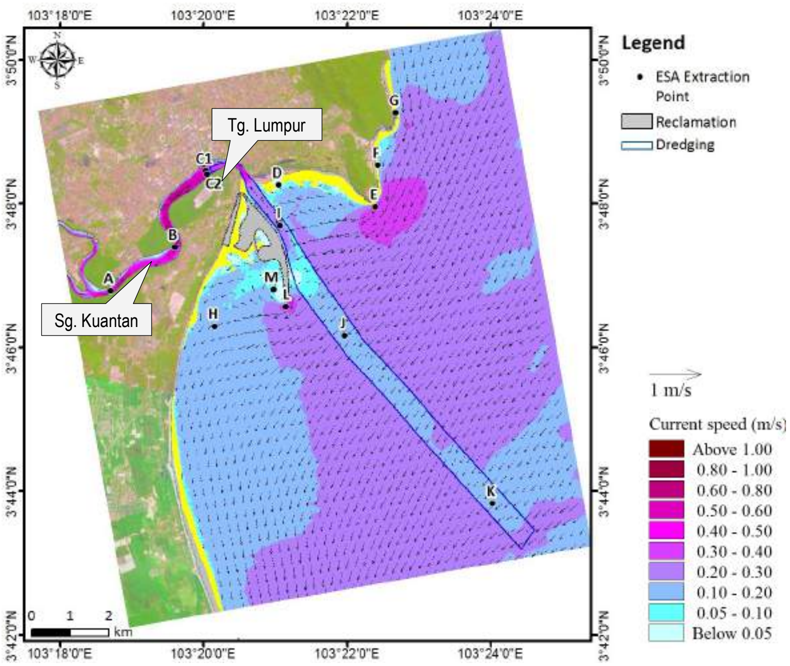


b) Spring period: Flood flow

Figure 7.25 ► Flow pattern for Phase 2a: Northeast monsoon condition

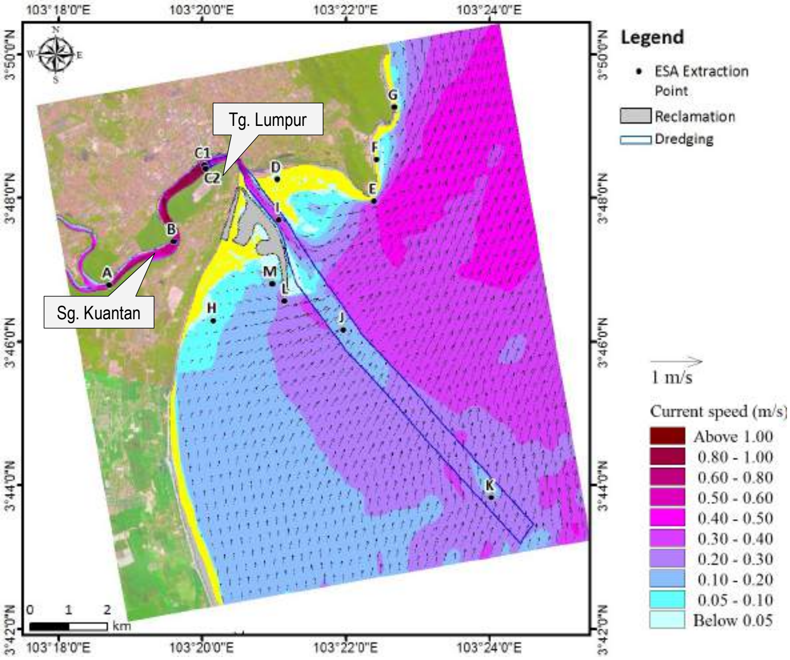


c) Neap period: Ebb flow

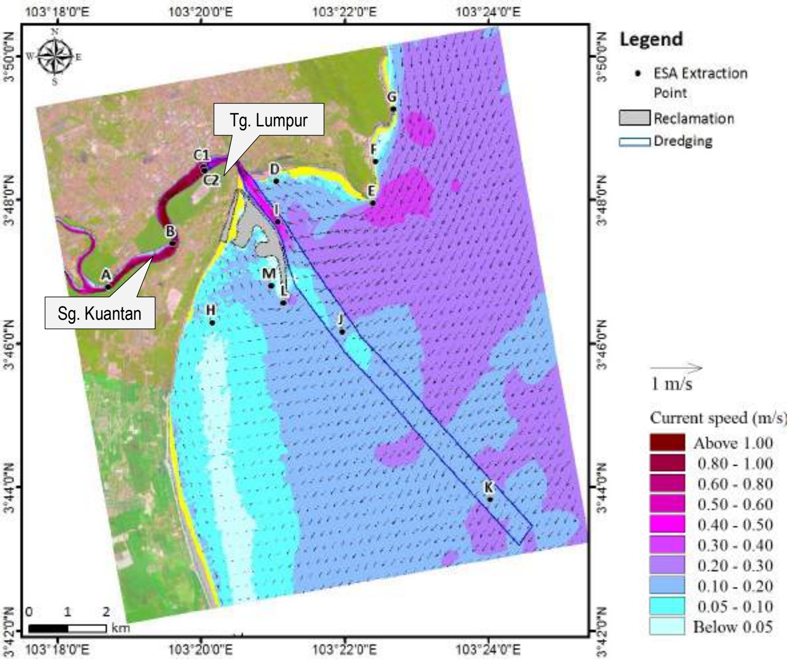


d) Neap period: Flood flow

Figure 7.25 *(cont'd)* ► Flow pattern for Phase 2a: Northeast monsoon condition

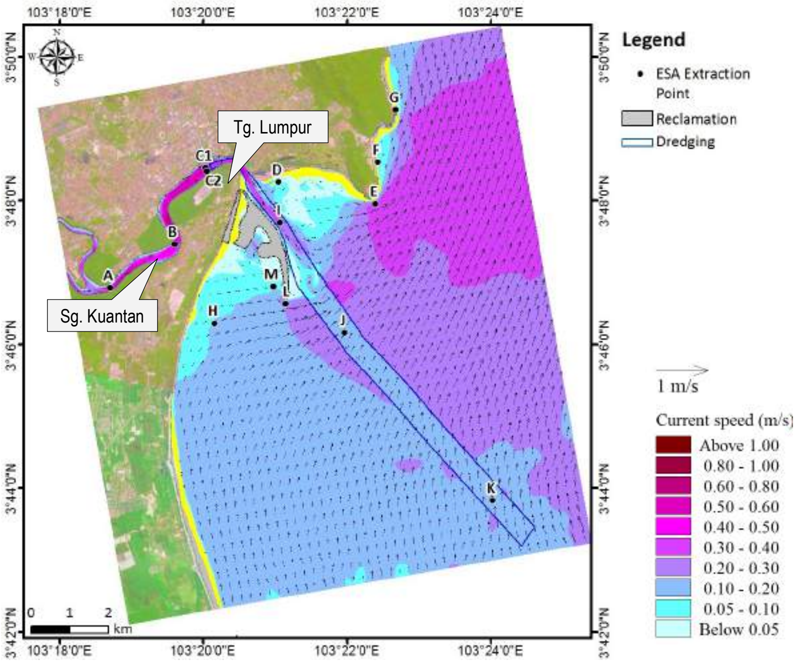


a) Spring period: Ebb flow

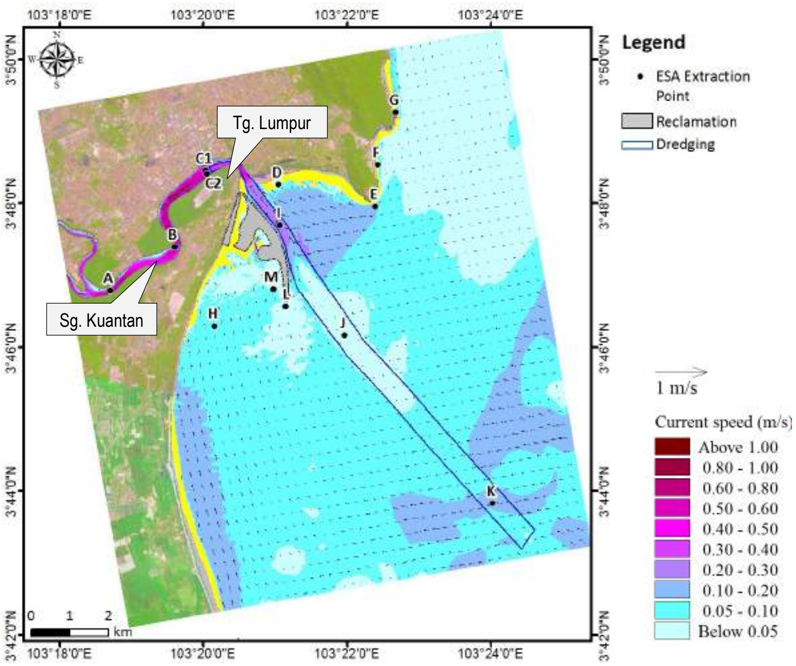


b) Spring period: Flood flow

Figure 7.26 ► Flow pattern for Phase 2a: Southwest monsoon condition

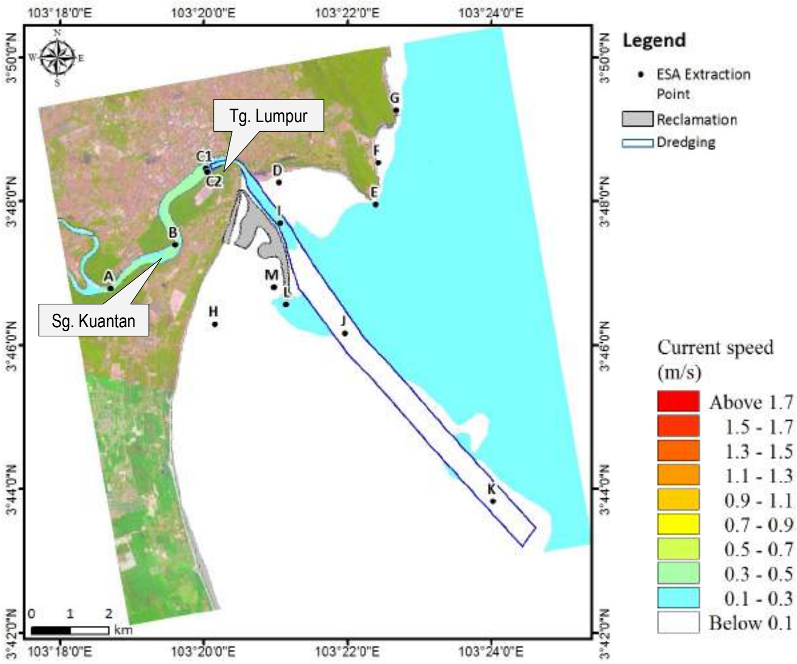


c) Neap period: Ebb flow

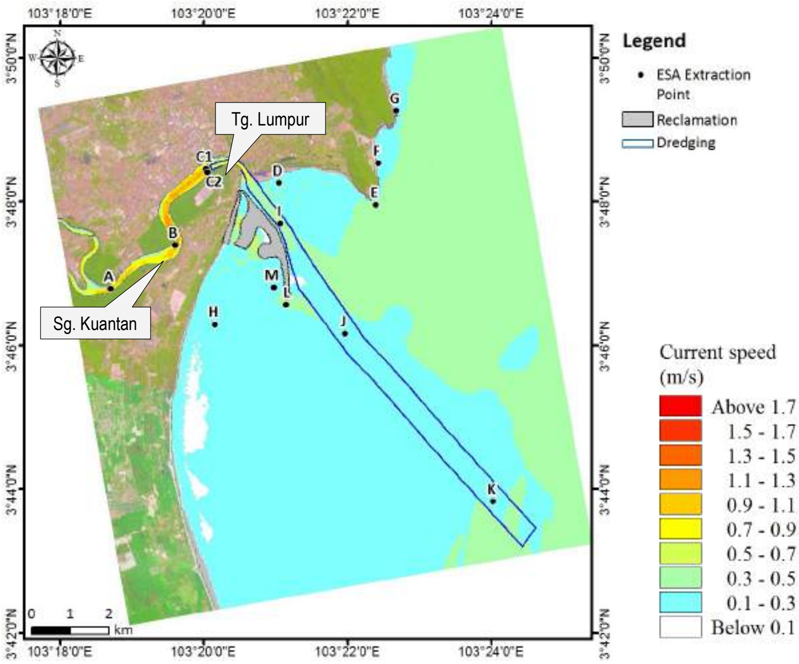


d) Neap period: Flood flow

Figure 7.26 *(cont'd)* ► Flow pattern for Phase 2a: Southwest monsoon condition

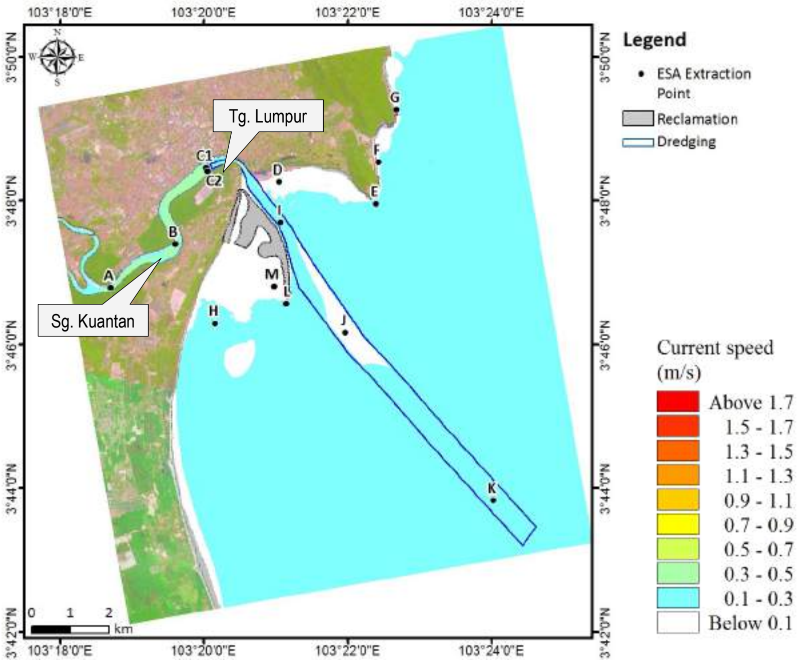


a) Mean speed: Pure tide condition

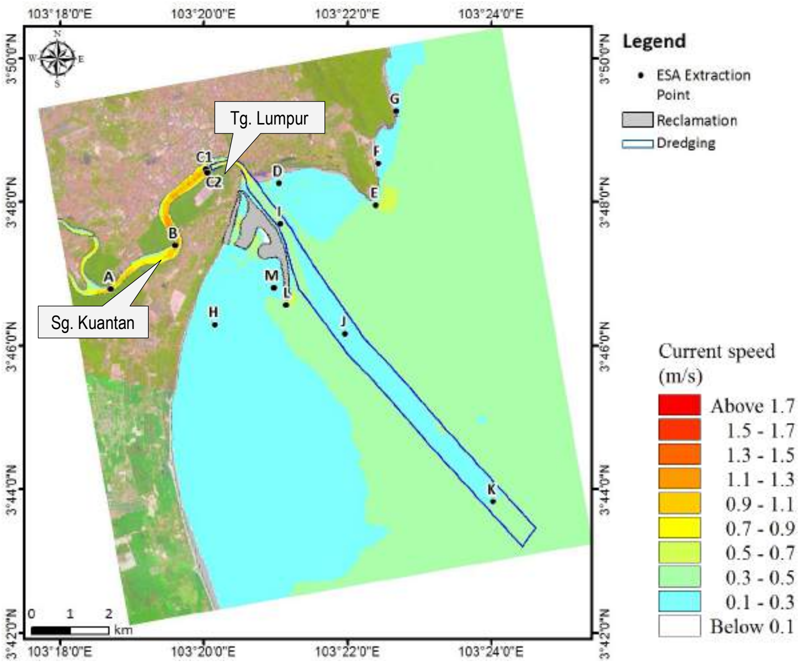


b) Maximum speed: Pure tide condition

Figure 7.27 ► Mean and Maximum Current Speed Plots for Phase 2a

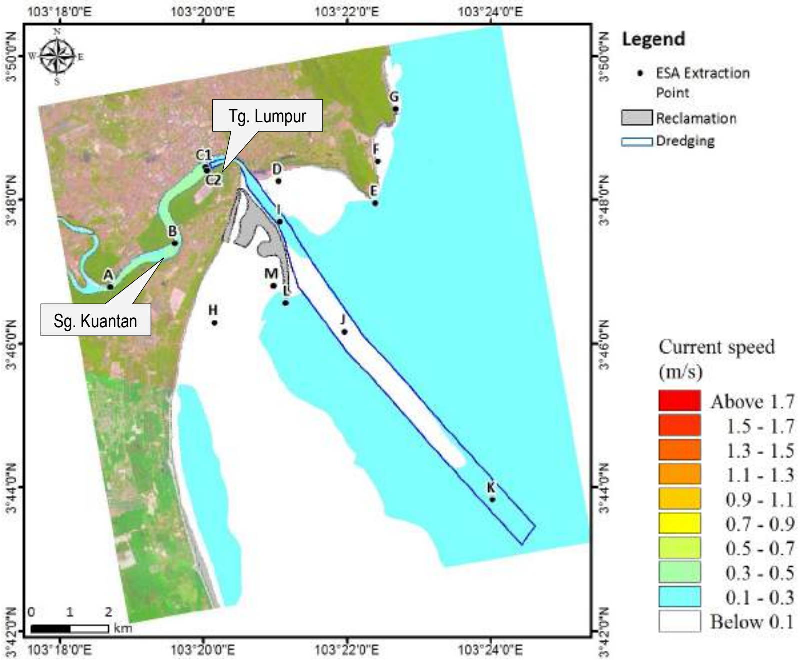


c) Mean speed: Northeast Monsoon condition

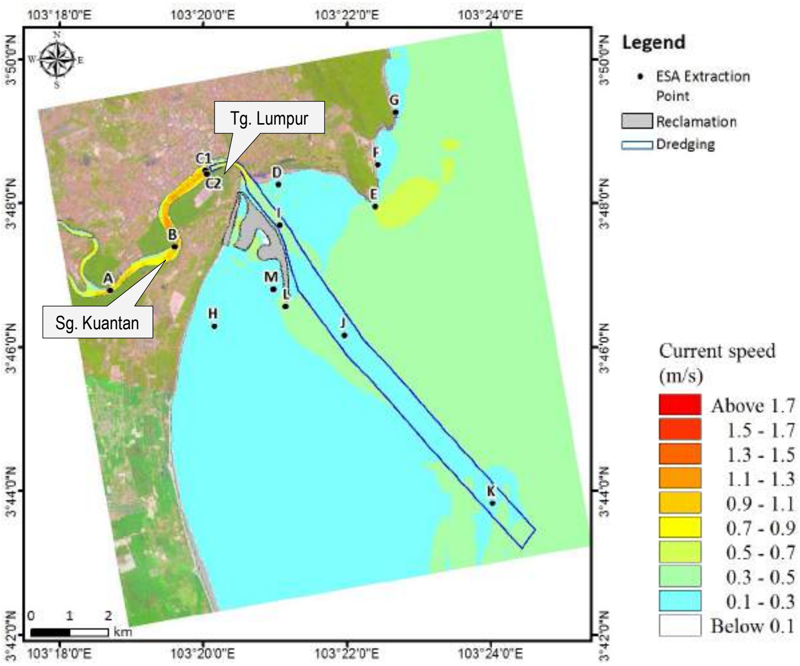


d) Maximum speed: Northeast Monsoon condition

Figure 7.27 *(cont'd)* ► Mean and Maximum Current Speed Plots for Phase 2a

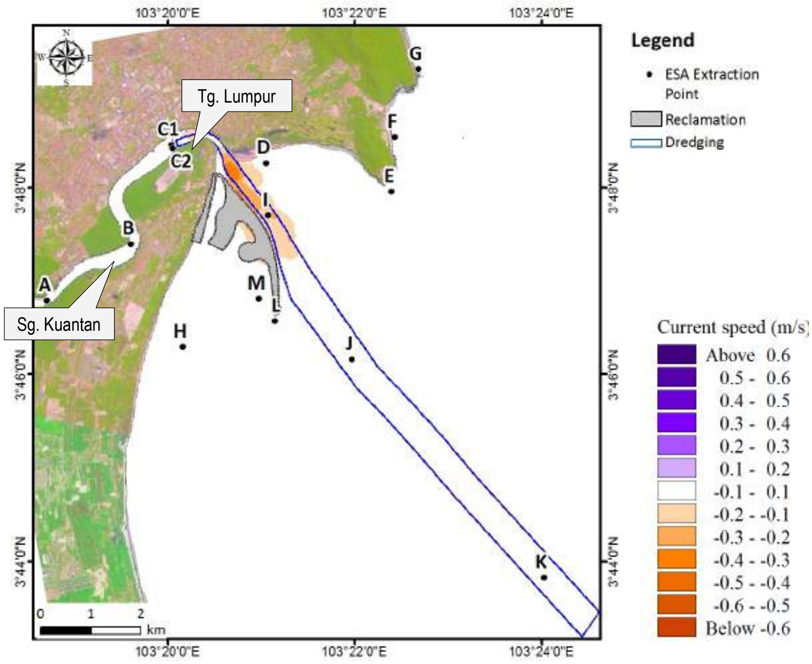


e) Mean speed: Southwest Monsoon condition

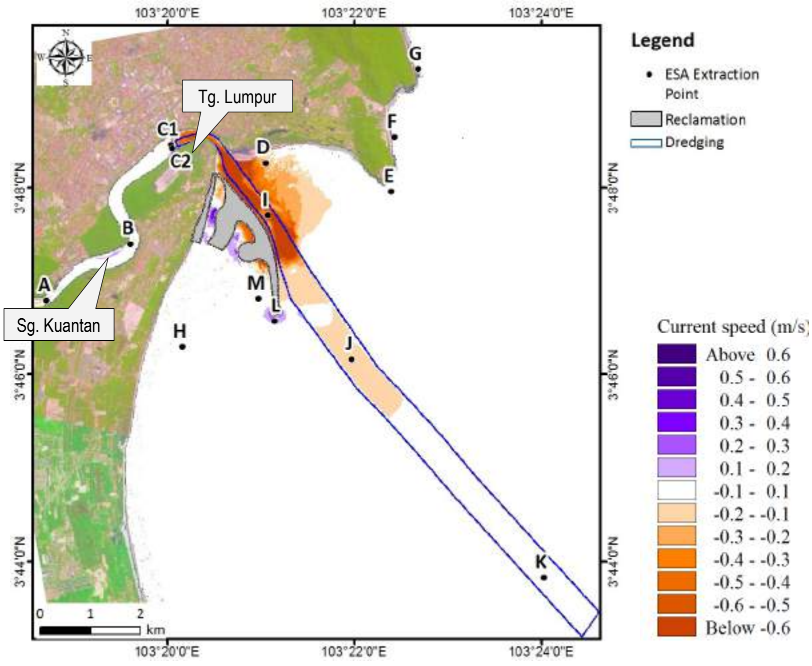


f) Maximum speed: Southwest Monsoon condition

Figure 7.27 *(cont'd)* ► Mean and Maximum Current Speed Plots for Phase 2a

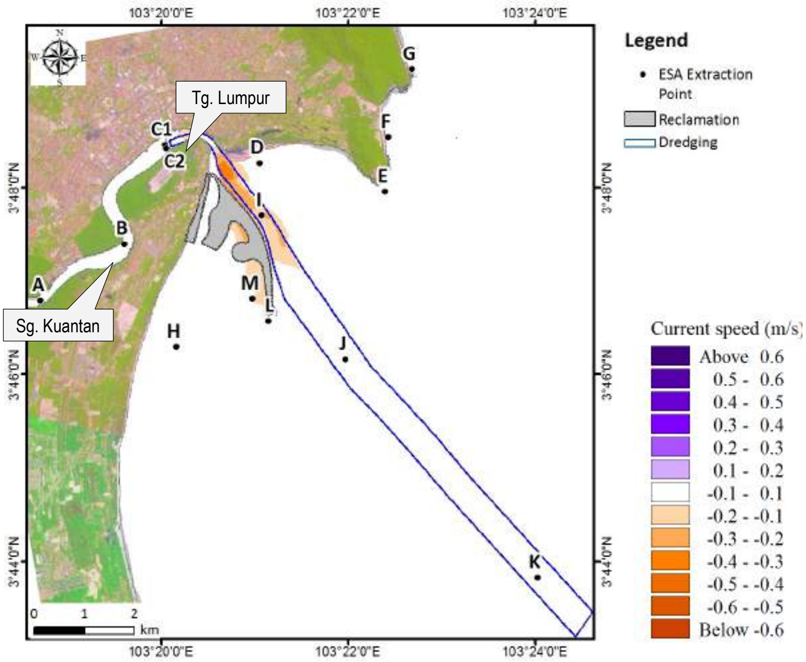


a) Mean speed: Pure tide condition

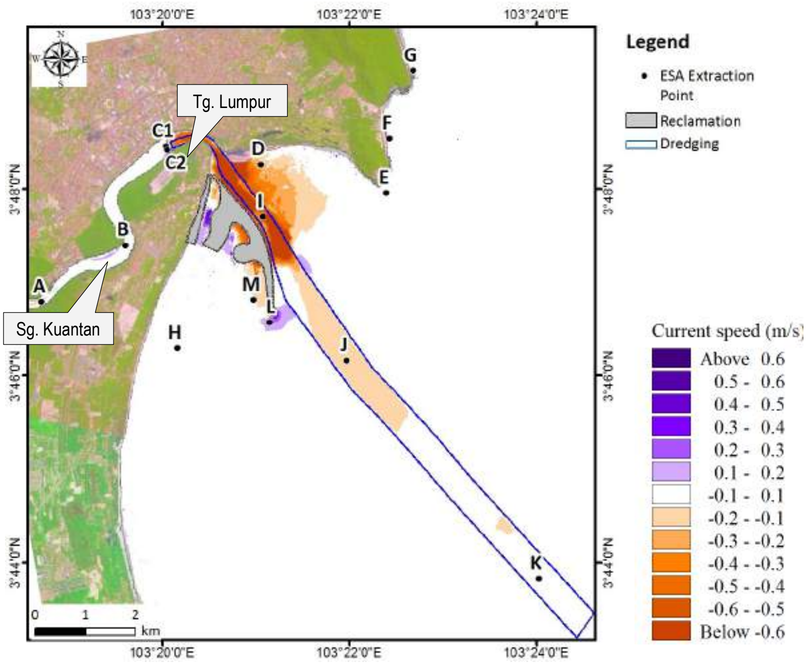


b) Maximum speed: Pure tide condition

Figure 7.28 ► Current speed change: Existing condition vs. Phase 2a

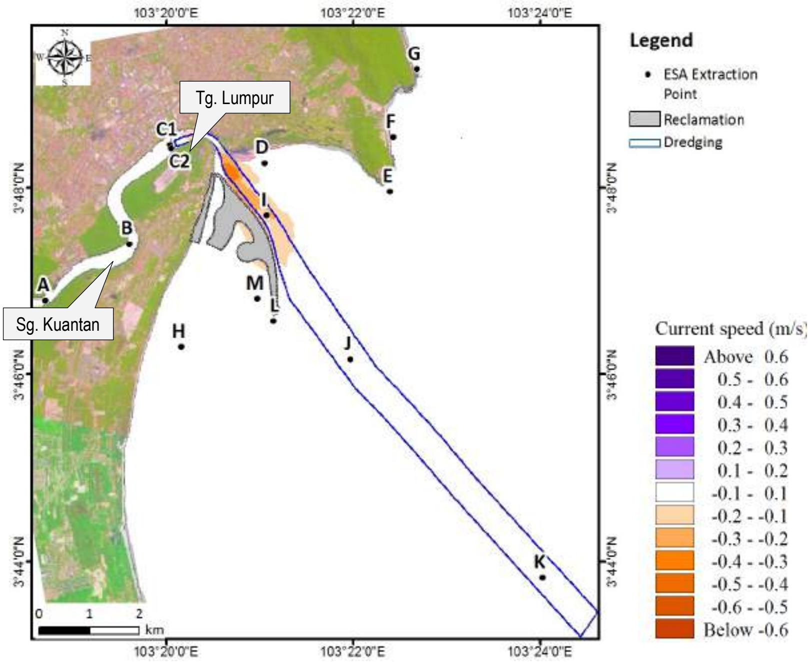


c) Mean speed: Northeast Monsoon condition

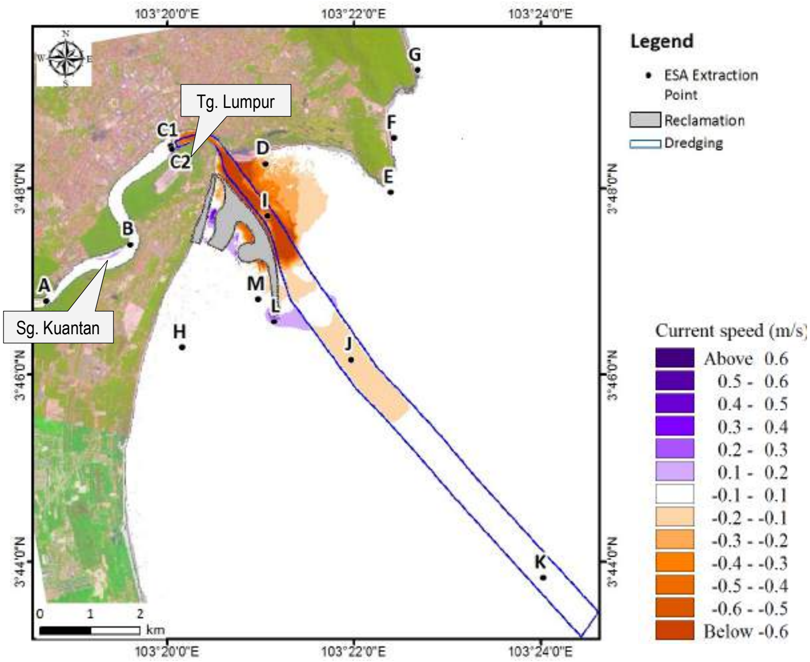


d) Maximum speed: Northeast Monsoon condition

Figure 7.28 *(cont'd)* ► Current speed change: Existing condition vs. Phase 2a



e) Mean speed: Southwest Monsoon condition



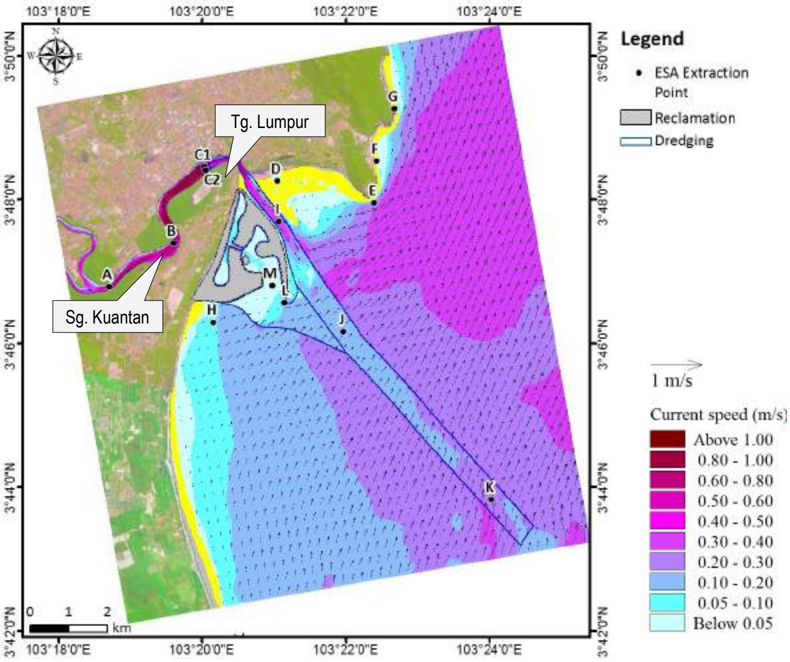
f) Maximum speed: Southwest Monsoon condition

Figure 7.28 *(cont'd)* ► Current speed change: Existing condition vs. Phase 2a

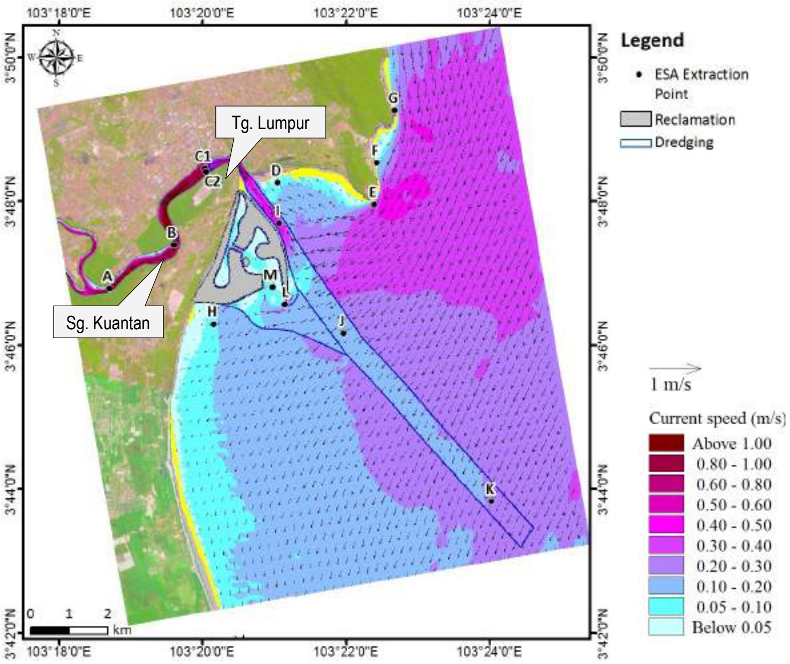
B. Phase 2b

A mean current speed increase of up to about 0.04 and 0.08 m/s occurs at the southeastern end of the reclamation area and water body bounded by the reclaimed land respectively. The maximum current speed increase is up to about 0.16 and 0.28 m/s at the same areas. The mean current speed decrease of up to about 0.38 and 0.24 m/s occurs within the dredged area and within the water body bounded by the reclamation area respectively. The maximum current speed decrease is up to about 1.27 and 0.89 m/s which occurs at the same locations.

Overall, the proposed Project creates local changes to current flow patterns. These changes are localised where acceleration and deceleration of current speed occur. The local changes are generally due to the proposed reclamation and dredging. Current speed decrease occurs at the dredged navigation channel and within reclamation area. The reclamation’s southeastern end experienced current speed increase. Construction of reclaimed land for Phase 2a induced current speed increase within the water body.

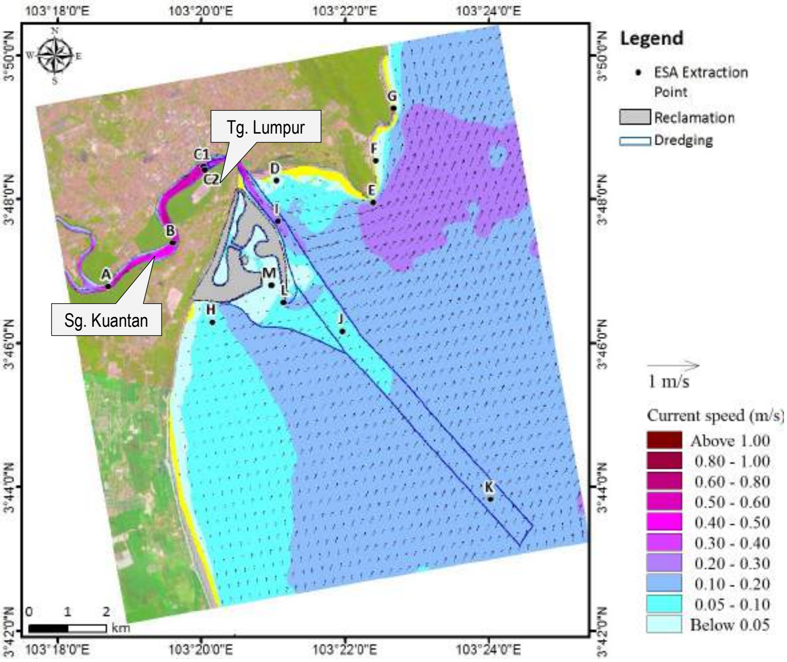


a) Spring period: Ebb flow

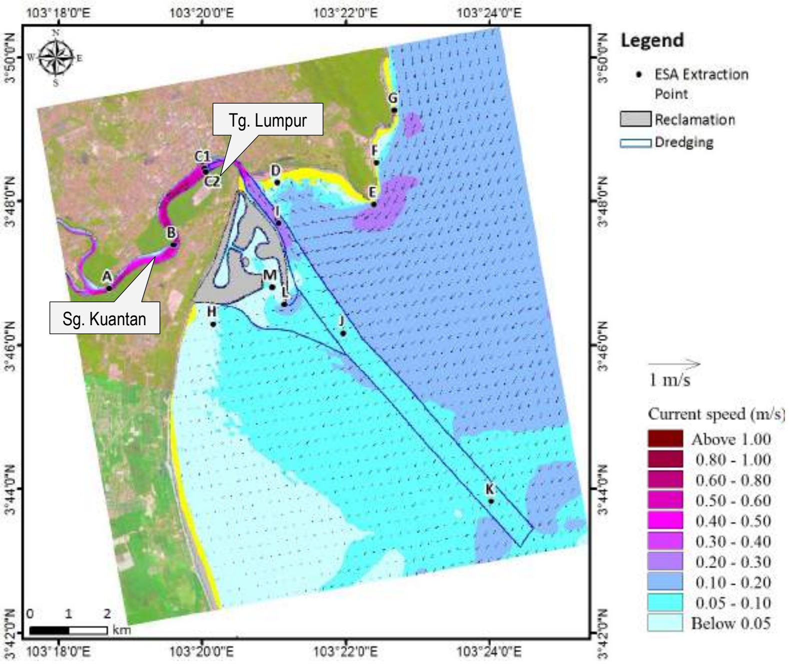


b) Spring period: Flood flow

Figure 7.29 ► Flow pattern for Phase 2b: Pure tide condition

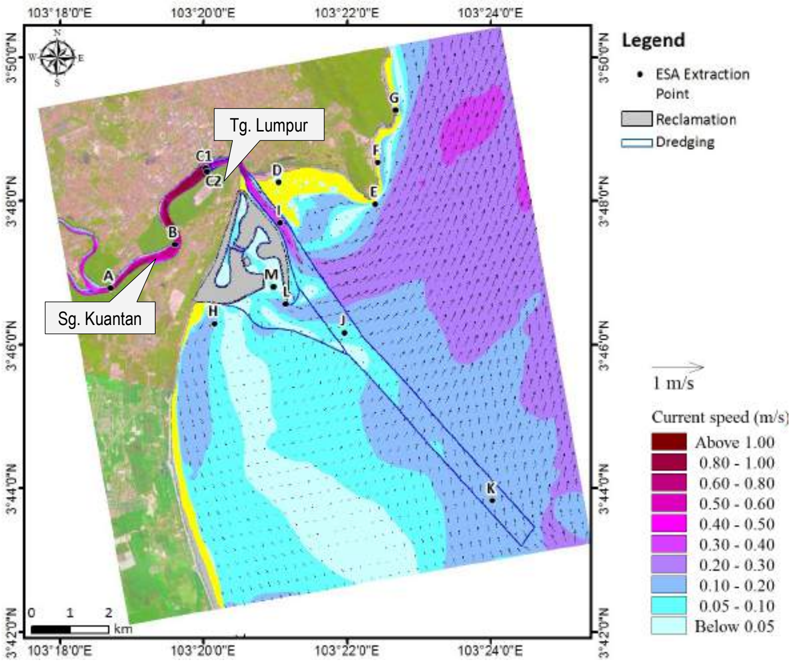


c) Neap period: Ebb flow

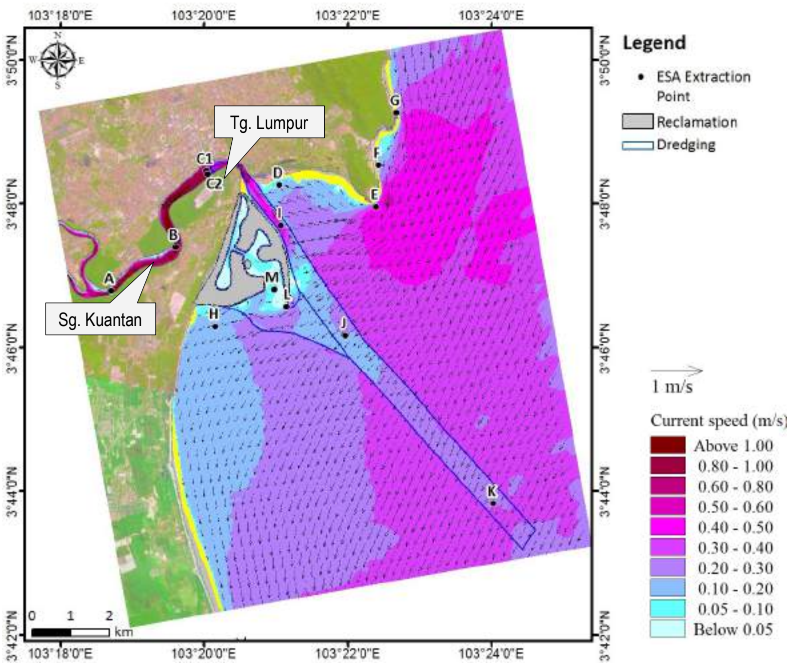


d) Neap period: Flood flow

Figure 7.29 *(cont'd)* ► Flow pattern for Phase 2b: Pure tide condition

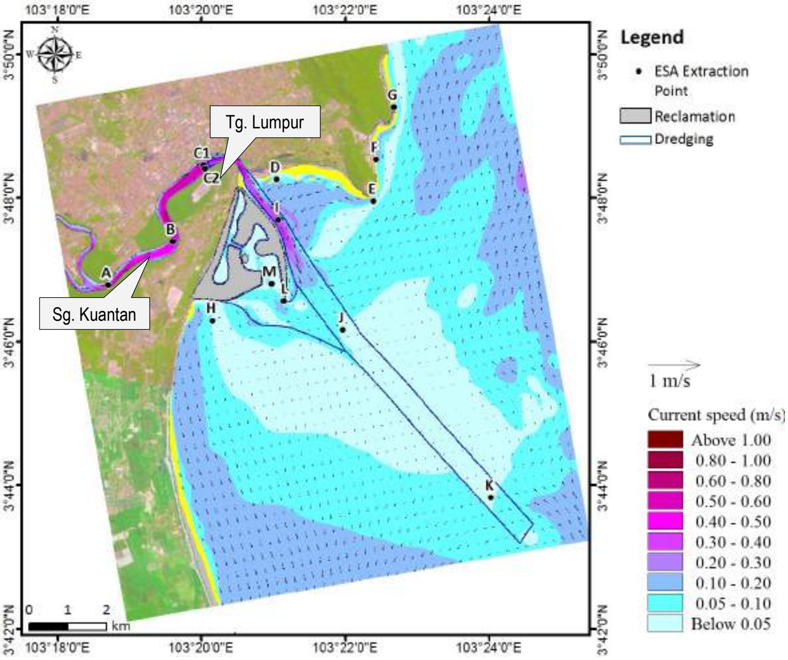


a) Spring period: Ebb flow

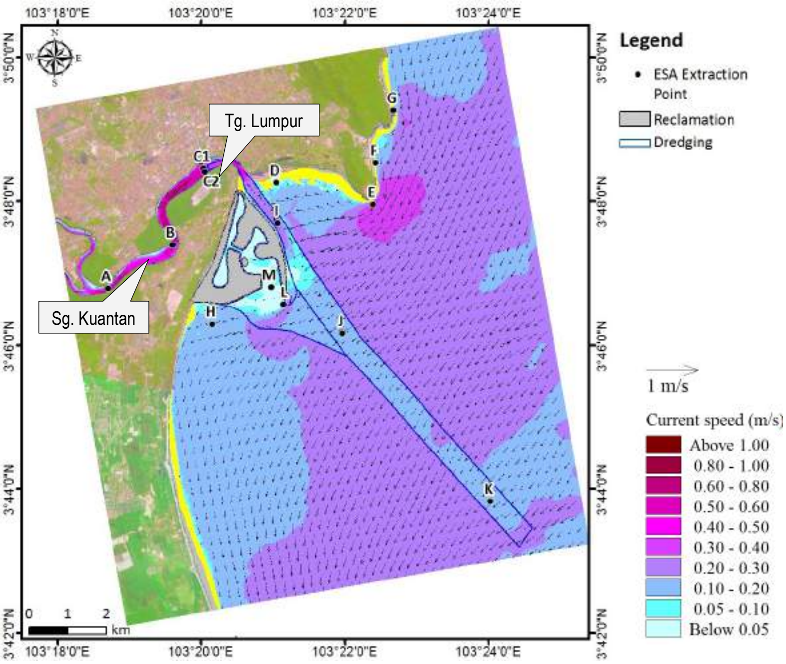


b) Spring period: Flood flow

Figure 7.30 ► Flow pattern for Phase 2b: Northeast monsoon condition

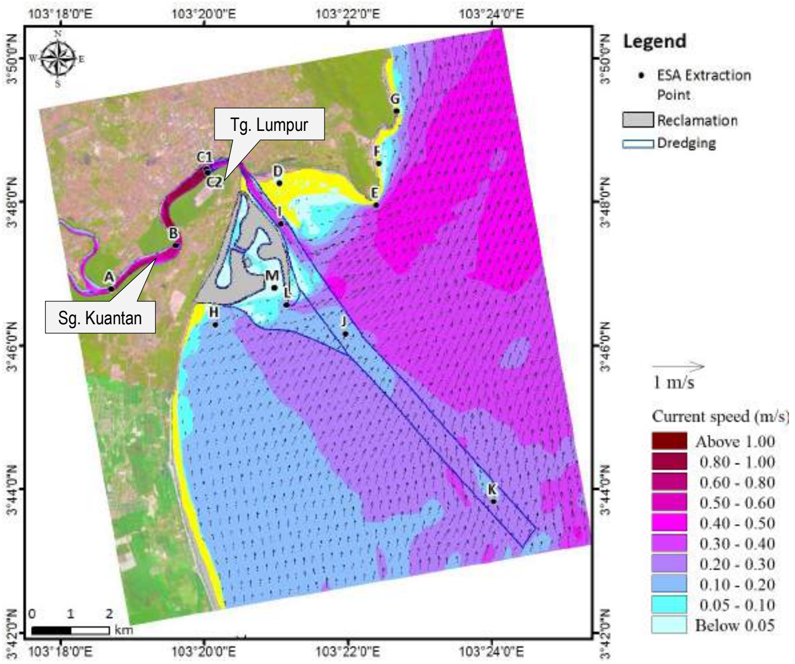


c) Neap period: Ebb flow

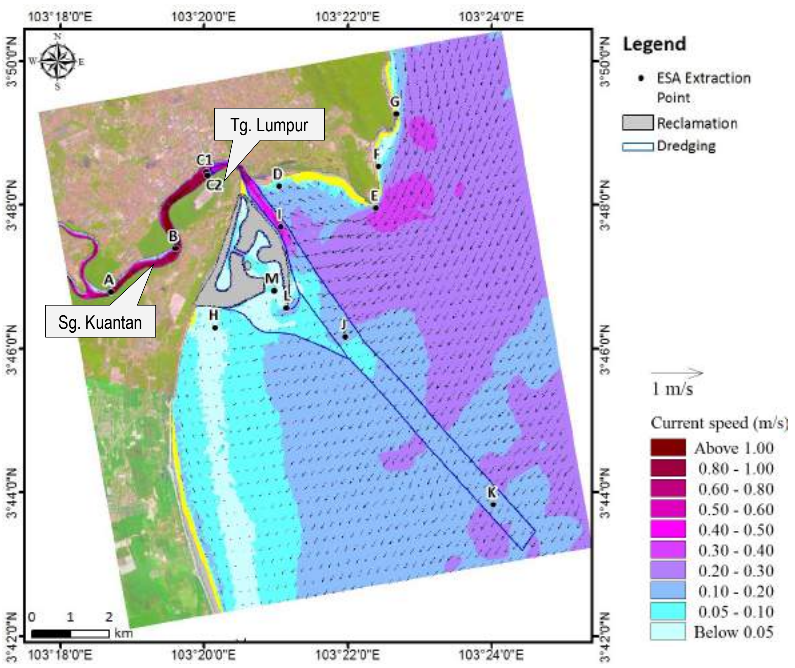


d) Neap period: Flood flow

Figure 7.30 *(cont'd)* ► Flow pattern for Phase 2b: Northeast monsoon condition

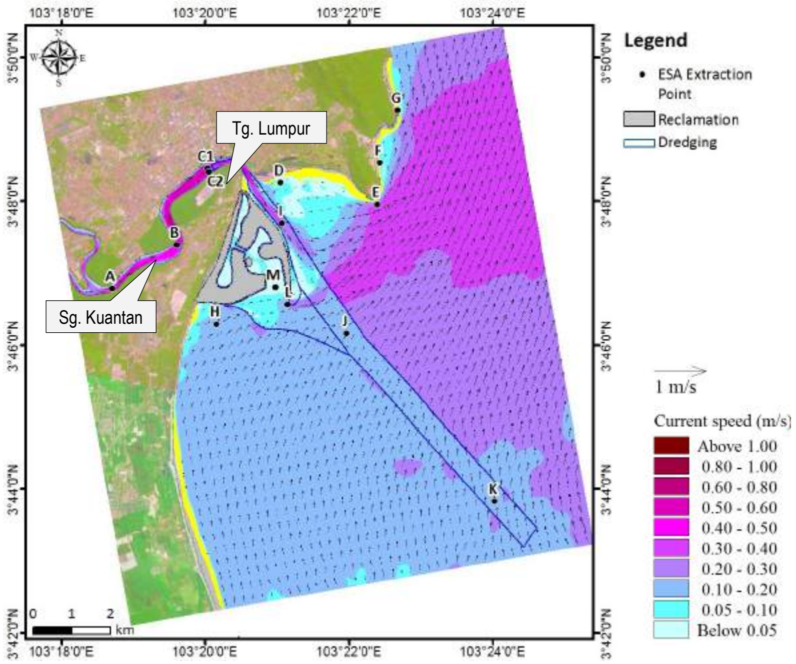


a) Spring period: Ebb flow

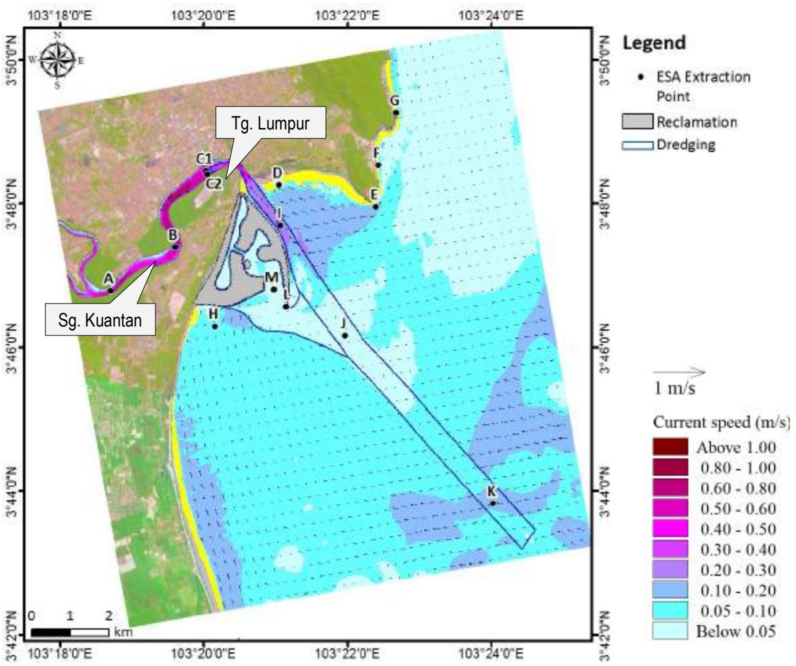


b) Spring period: Flood flow

Figure 7.31 ► Flow pattern for Phase 2b: Southwest monsoon condition

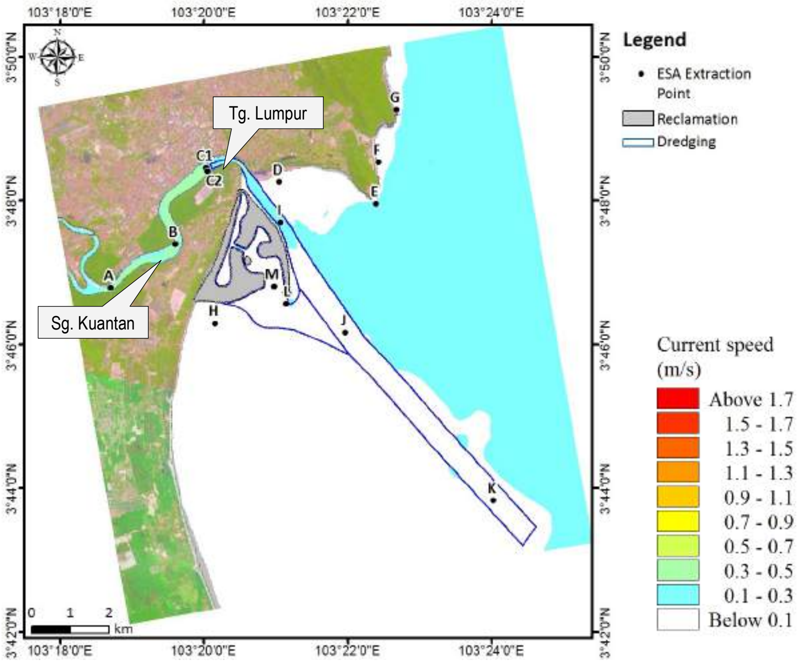


c) Neap period: Ebb flow

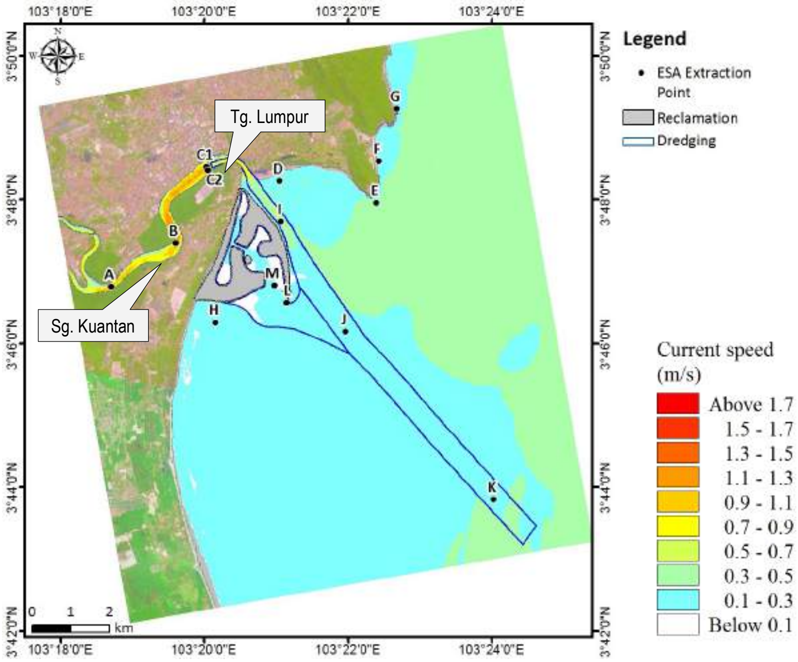


d) Neap period: Flood flow

Figure 7.31 *(cont'd)* ► Flow pattern for Phase 2b: Southwest monsoon condition

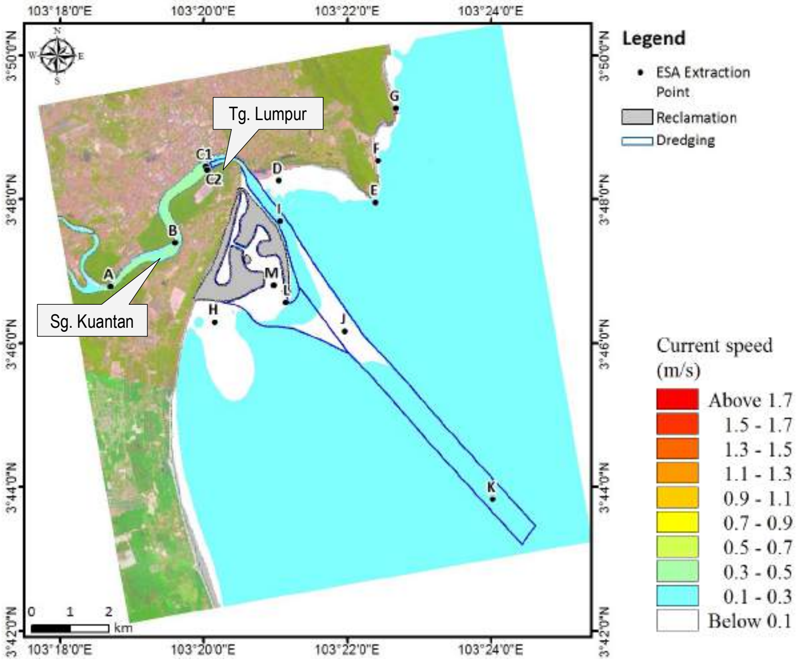


a) Mean speed: Pure tide condition

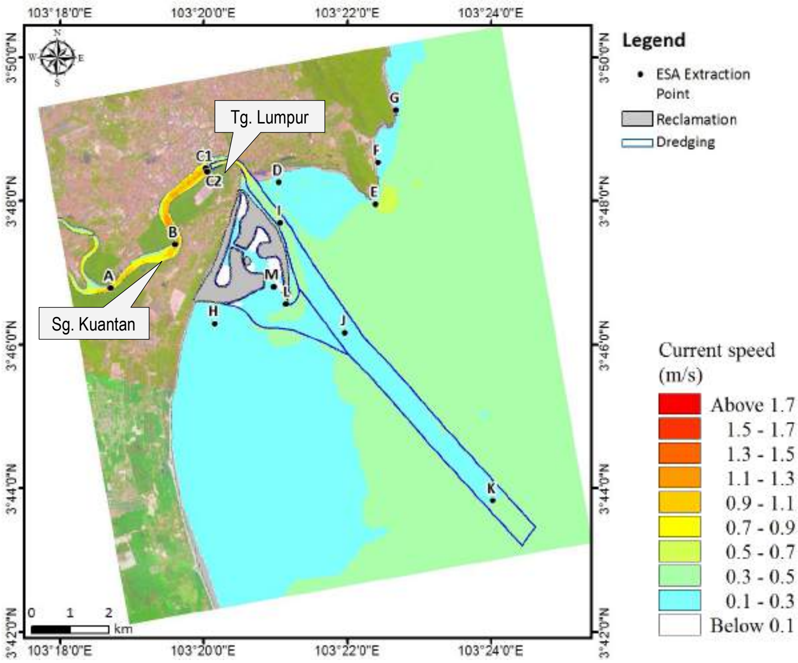


b) Maximum speed: Pure tide condition

Figure 7.32 ► Mean and Maximum Current Speed Plots for Phase 2b

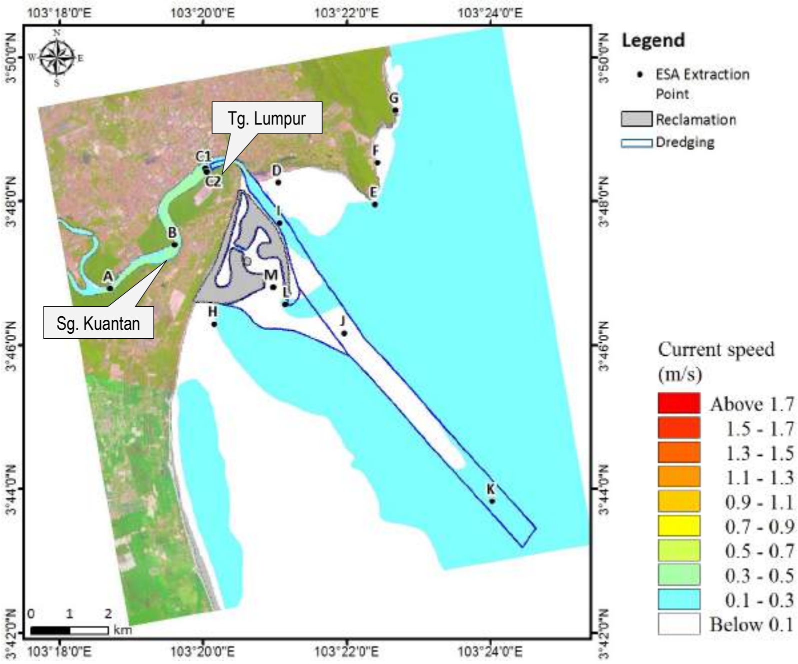


c) Mean speed: Northeast Monsoon condition

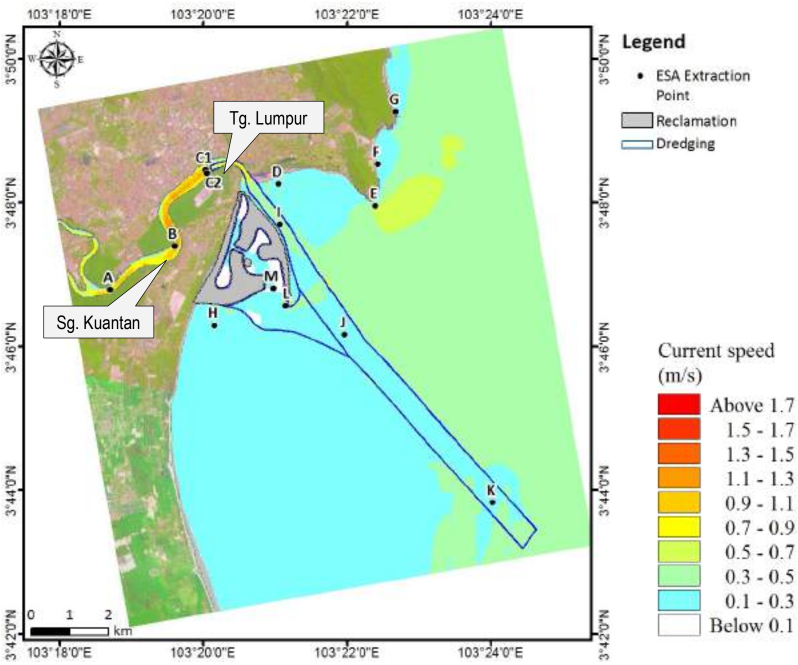


d) Maximum speed: Northeast Monsoon condition

Figure 7.32 *(cont'd)* ► Mean and Maximum Current Speed Plots for Phase 2b

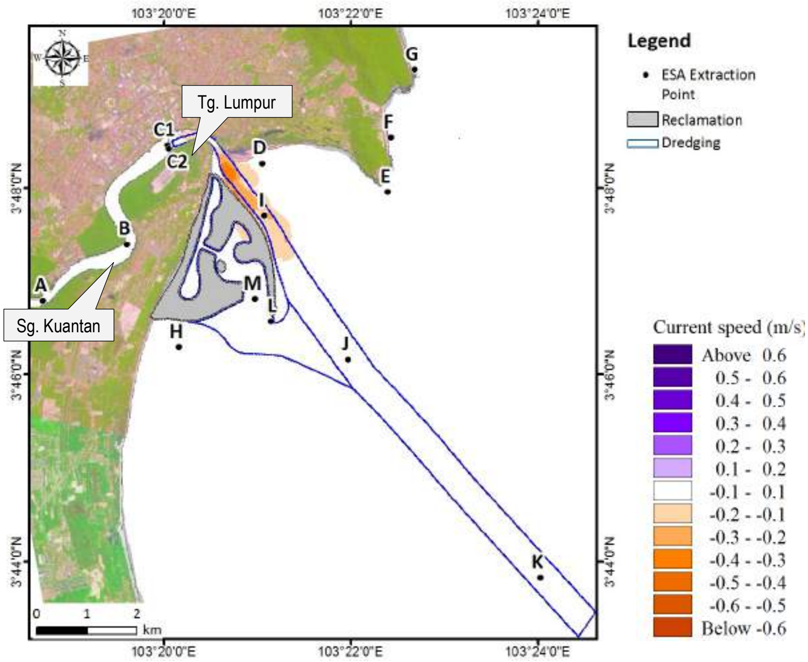


e) Mean speed: Southwest Monsoon condition

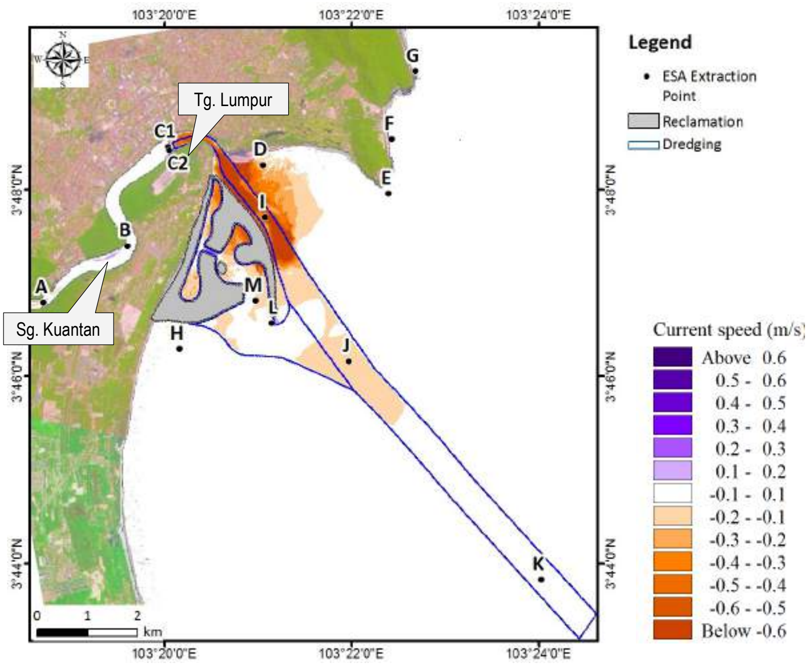


f) Maximum speed: Southwest Monsoon condition

Figure 7.32 *(cont'd)* ► Mean and Maximum Current Speed Plots for Phase 2b

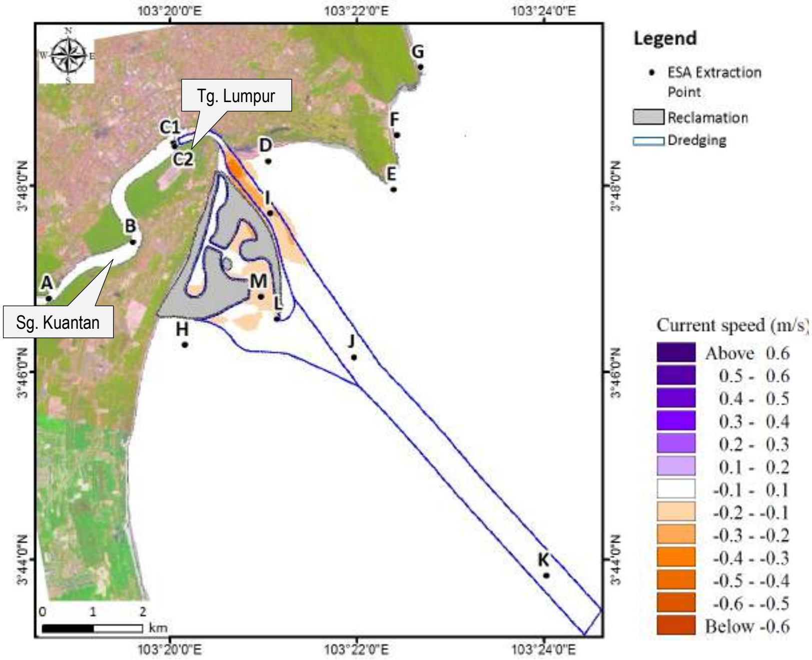


a) Mean speed: Pure tide condition

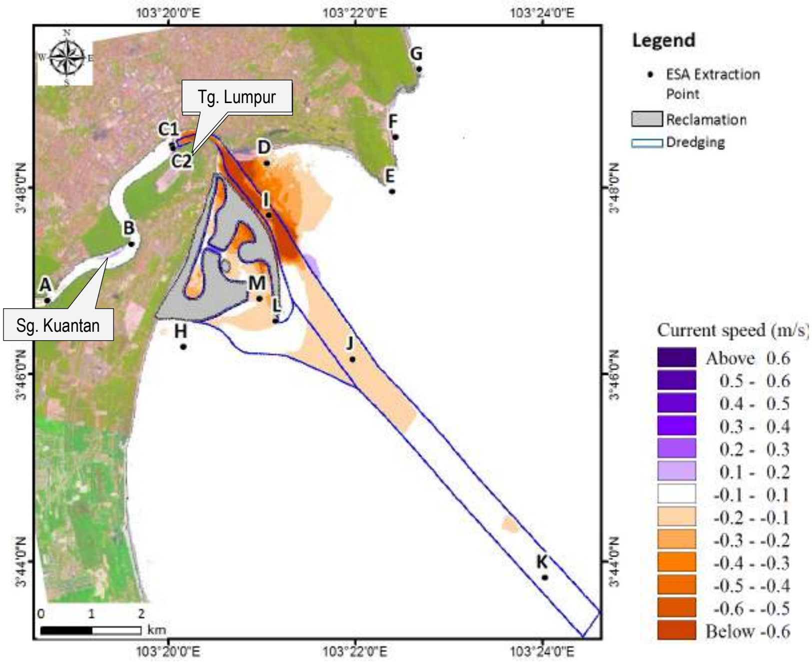


b) Maximum speed: Pure tide condition

Figure 7.33 ► Current speed change: Existing condition vs. Phase 2b

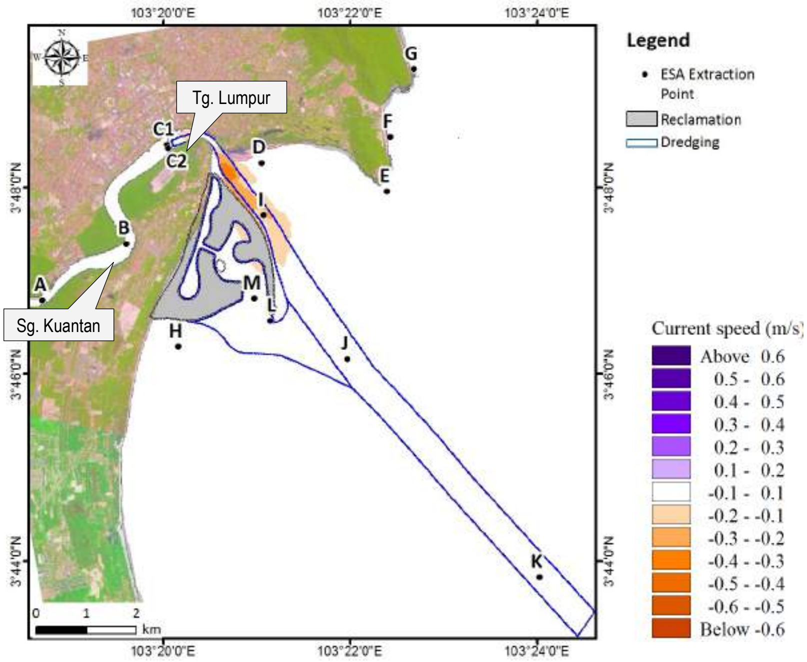


a) Mean speed: Pure tide condition c) Me

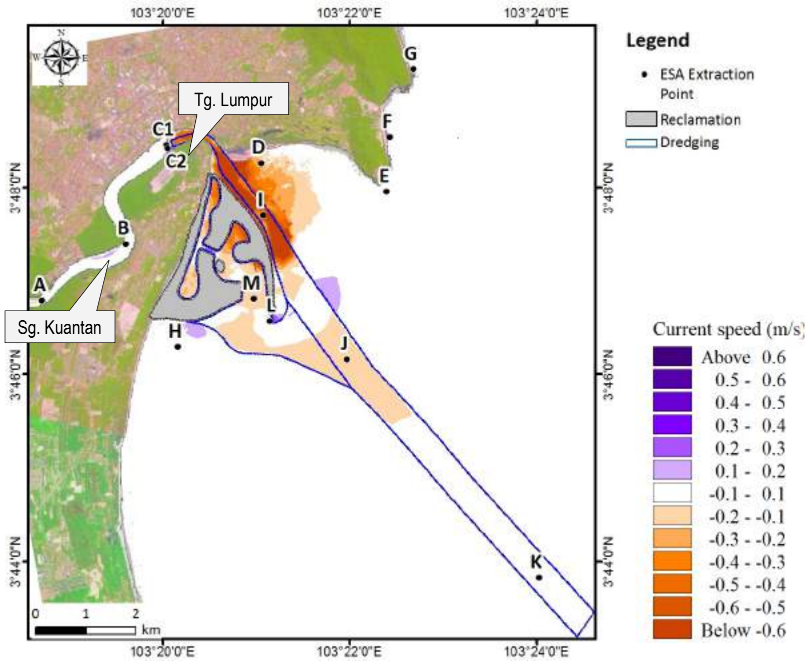


d) Maximum speed: Northeast Monsoon condition

Figure 7.33 *(cont'd)* ► Current speed change: Existing condition vs. Phase 2b



e) Mean speed: Southwest Monsoon condition



f) Maximum speed: Southwest Monsoon condition

Figure 7.33 *(cont'd)* ► Current speed change: Existing condition vs. Phase 2b

Impact of Current Speed at ESAs and Around the Project Area

Observations were made based on mean and maximum current speed plots for the 'with Project' condition with respect to the existing condition for pure tide condition simulations at several sites that include ESAs within the Project area (*Figure 7.2*). Comparisons for mean and maximum current speeds at the extraction locations for the existing, Phase 2a and Phase 2b conditions are tabulated in *Table 7.9*.

Changes in mean and maximum current speeds are generally localised within the Project site. Mean and maximum current speeds increase of up to 0.06 m/s (about 67% change) and 0.15 m/s (60%) respectively can occur at the southern end of the reclamation with the implementation of Phase 2b. The mean and maximum current speed change are relatively similar with the Phase 2a at the same location. For the mean and maximum speed decrease is up to about 0.06 m/s (67%) and 0.13 m/s (62%) respectively at the marina entrance with the implementation of Phase 2b. The mean and maximum current speeds are reduced by almost half with the Phase 2a at the same location. The current speed decrease is variable within the navigation channel for both phases where it is highest within the upstream section of the channel. The mean and maximum current speed decrease is up to 0.2 m/s (59%) and 0.55 m/s (59%) respectively.

Changes in current speed reflects the potential erosion and sedimentation that will affect ESAs. There is no change in current speed at the Teluk Cempedak and Beserah Forest Reserve. The current speed change at Kuantan Tembeling Resort and Tanjung Lumpur coast is less than 0.05 m/s for both phases. The mean and maximum current speeds decrease in front of the Kuantan Forest Reserve and Hutan Rizab Paya Laut Kuantan are less than 0.1 m/s for both phases. The maximum current speed decrease at Tanjung Lumpur's northern and southern bridge piers are up to 0.16 m/s (18%) and 0.12 m/s (13%) respectively for both phases. The decrease in maximum current speed in this case shows that no erosion will occur that could affect the stability of the bridge piers. There is no mean current speed change at the northern bridge pier but a mean speed decrease of up to about 0.03 m/s (9%) occurs near the southern pier for both phases. The mean and maximum current speed fronting Pantai Tanjung Sisek is up to 0.03 and 0.01 m/s respectively. Thus, the increase of maximum current speed is considered insignificant

Table 7.9 ► Mean and Maximum Current Speed Comparison at ESAs and Around the Project Area

Point	Location	Existing Condition		Phase 2a						Phase 2b					
				Mean Difference			Maximum Difference			Mean Difference			Maximum Difference		
		Mean Speed (m/s)	Maximum Speed (m/s)	Speed (m/s)	Difference (m/s)	Difference (%)	Speed (m/s)	Difference (m/s)	Difference (%)	Speed (m/s)	Difference (m)	Difference (%)	Speed (m/s)	Difference (m/s)	Difference (%)
A	Kuantan Forest Reserve	0.35	1.23	0.39	0.04	11	1.15	**-0.08**	**-7**	0.39	0.04	11	1.15	**-0.08**	**-7**
B	Hutan Rizab Paya Laut Kuantan	0.37	1.24	0.41	0.04	11	1.17	**-0.07**	**-6**	0.41	0.04	11	1.17	**-0.07**	**-6**
C1	Tanjung Lumpur Bridge (northern pier)	0.31	0.88	0.31	0	0	0.72	**-0.16**	**-18**	0.31	0	0	0.72	**-0.16**	**-18**
C2	Tanjung Lumpur Bridge (southern pier)	0.32	0.94	0.35	0.03	9	0.82	**-0.12**	**-13**	0.35	0.03	9	0.82	**-0.12**	**-13**
D	Pantai Tanjung Sisek	0.07	0.31	0.04	-0.03	-43	0.32	**0.01**	**3**	0.04	-0.03	-43	0.33	**0.02**	**6**
E	Kuantan Tembeling Resort	0.18	0.42	0.18	0	0	0.4	**-0.02**	**-5**	0.18	0	0	0.40	**-0.02**	**-5**
F	Teluk Cempedak	0.07	0.15	0.07	0	0	0.15	**0**	**0**	0.07	0	0	0.15	**0**	**0**
G	Beserah Forest Reserve	0.08	1.12	0.08	0	0	1.12	**0**	**0**	0.08	0	0	1.12	**0**	**0**
H	Tanjung Lumpur sandflat	0.04	0.14	0.04	0	0	0.12	**-0.02**	**-14**	0.05	0.01	25	0.16	**0.02**	**14**
I	Navigation channel (upstream)	0.34	0.94	0.14	-0.20	-59	0.39	**-0.55**	**-59**	0.14	-0.2	-59	0.39	**-0.55**	**-59**
J	Navigation channel (midstream)	0.1	0.27	0.06	-0.04	-40	0.16	**-0.11**	**-41**	0.06	-0.04	-40	0.15	**-0.12**	**-44**
K	Navigation channel (downstream)	0.1	0.29	0.09	-0.01	-10	0.27	**-0.02**	**-7**	0.09	-0.01	-10	0.27	**-0.02**	**-7**
L	Southeastern end of development	0.09	0.25	0.15	0.06	67	0.4	**0.15**	**60**	0.13	0.04	44	0.36	**0.11**	**44**
M	Marina entrance	0.09	0.21	0.06	-0.03	-33	0.15	**-0.06**	**-29**	0.03	-0.06	-67	0.08	**-0.13**	**-62**

7.2.2.3.3 Water Levels

An analysis on the potential flooding impact due to the Project on the surrounding water body was done. Water levels were extracted and compared before and after the reclamation in the vicinity of the Project site for pure tide condition at the locations as shown in *Figure 7.2*. Comparisons for maximum high water at the different locations and the changes in high water level for the existing and 'with Project' conditions are tabulated in *Table 7.10*. The results do not show any rise in water levels after the reclamation. As such, it can be deduced that there would be no direct changes to the water levels and flood levels at these locations particularly at the ESAs.

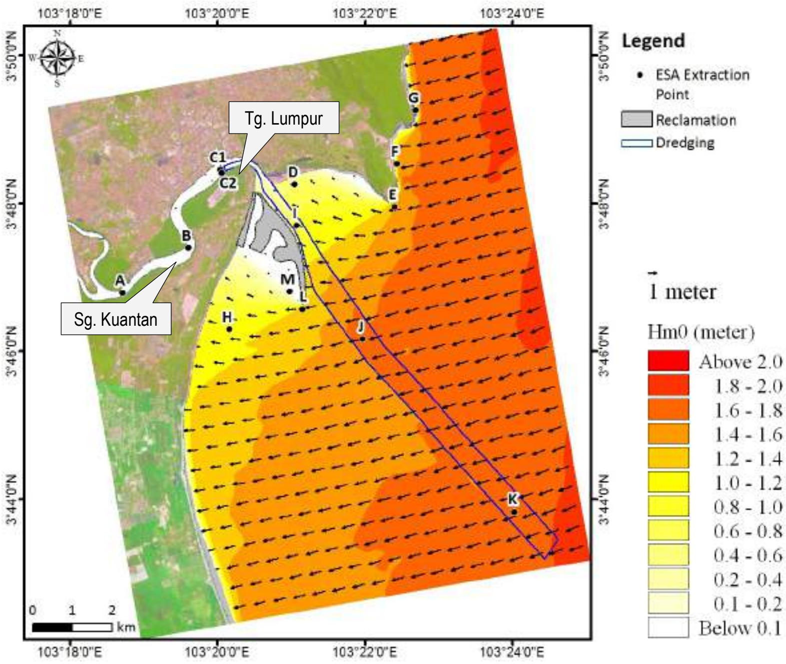
Table 7.10 ► Mean and Maximum High Water Level Comparison at ESAs and Around the Project Area

Point	Location	Water Level (m)			Water Level Difference			
		Existing	Phase 2a	Phase 2b	Phase 2a		Phase 2b	
					Value (m)	Percentage (%)	Value (m)	Percentage (%)
A	Kuantan Forest Reserve	2.12	2.12	2.12	0	0	0	0
B	Hutan Rizab Paya Laut Kuantan	2.1	2.1	2.1	0	0	0	0
C1	Tanjung Lumpur Bridge (northern pier)	2.05	2.05	2.05	0	0	0	0
C2	Tanjung Lumpur Bridge (southern pier)	2.05	2.05	2.05	0	0	0	0
D	Pantai Tanjung Sisek	2	2	2	0	0	0	0
E	Kuantan Tembeling Resort	1.99	1.99	1.99	0	0	0	0
F	Teluk Cempedak	1.98	1.98	1.99	0	0	0	0
G	Beserah Forest Reserve	1.97	1.97	1.97	0	0	0	0
H	Tanjung Lumpur sandflat	2	2	2	0	0	0	0
I	Navigation channel (upstream)	2	2	2	0	0	0	0
J	Navigation channel (midstream)	1.99	1.99	1.99	0	0	0	0
K	Navigation channel (downstream)	1.97	1.97	1.97	0	0	0	0
L	Southeastern end of development	1.99	1.99	1.99	0	0	0	0
M	Marina entrance	1.99	1.99	1.99	0	0	0	0

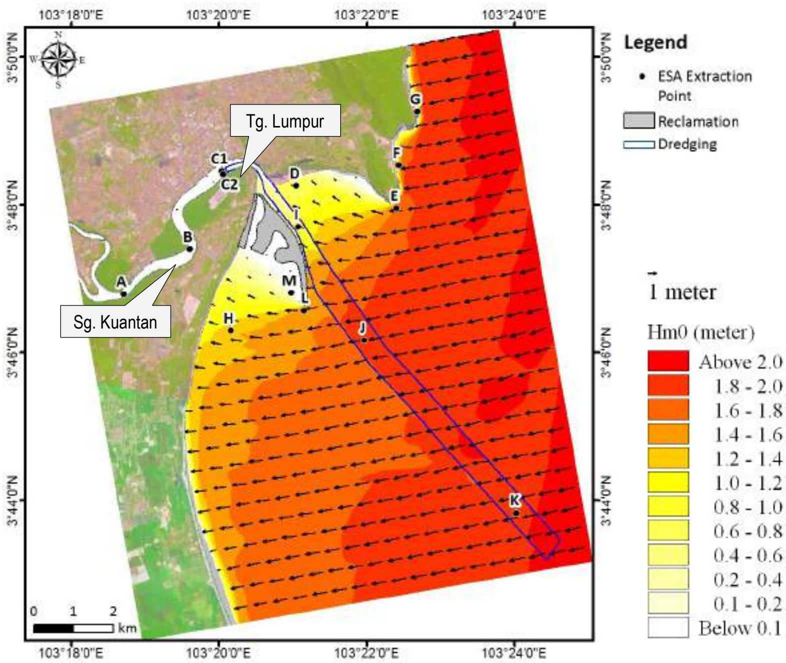
7.2.2.3.4 Waves

Impacts of wave activity due to the presence of the proposed Project were assessed by determining the difference in wave height before and after the Project. Results of wave simulations for ‘with Project’ conditions are shown in *Figures 7.34 to 7.35* for the Phase 2a and *Figures 7.36 and 7.37* for the Phase 2b. The changes in wave heights due to the proposed Project are localised and do not affect the adjacent southern and northern coastlines.

It can be inferred from the results that an insignificant increase in wave height of up to about 0.2 m occurs in front of the river mouth for waves propagating from 150°N with wave heights of up to 1.2 m. A localised wave height decrease of up to about 1.6 m occurs in the marina for waves propagating from 90°N. The wave height changes after the dredging works inside the navigation channel are insignificant.

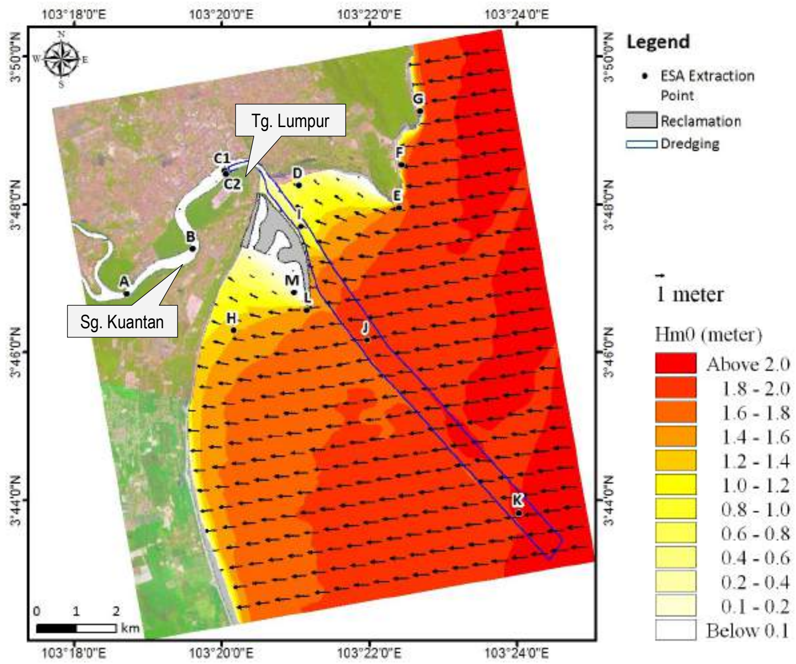


a) θ = 30°N

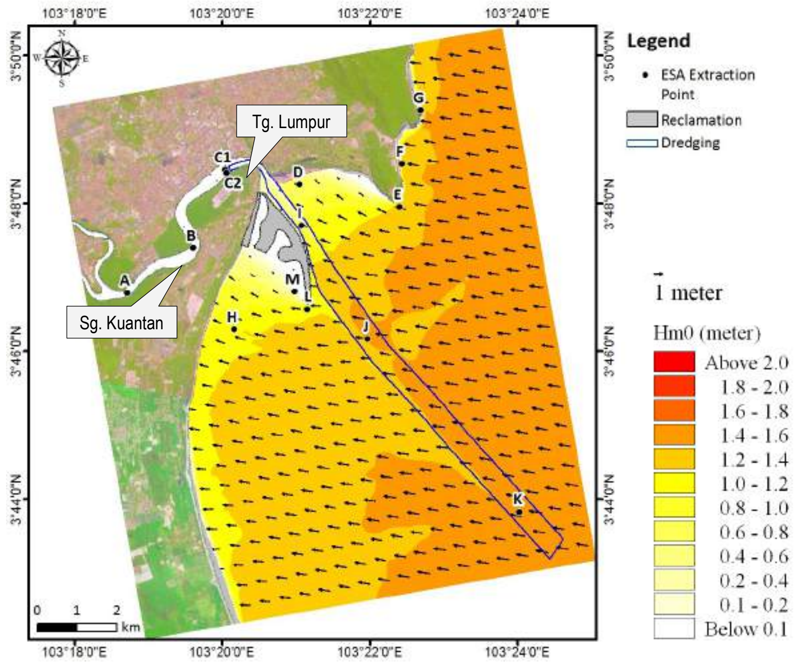


b) θ = 60°N

Figure 7.34 ► Wave Simulations for with Project' Condition: Phase 2a

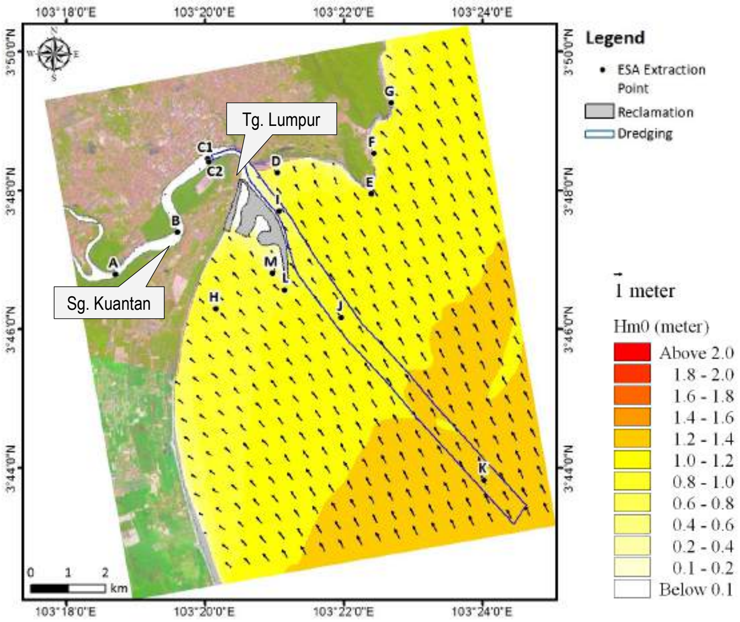


c) θ = 90°N



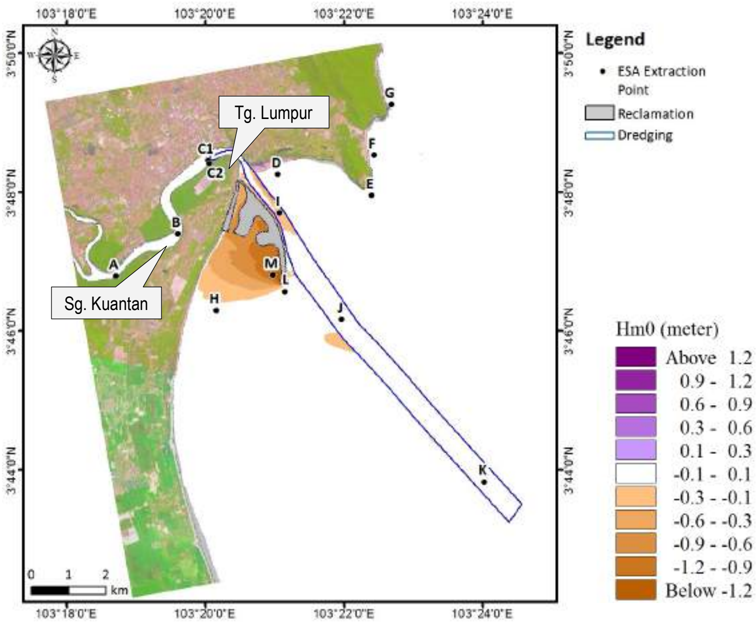
d) θ = 120°N

Figure 7.34 *(cont'd)* ► Wave Simulations for 'with Project' Condition: Phase 2a



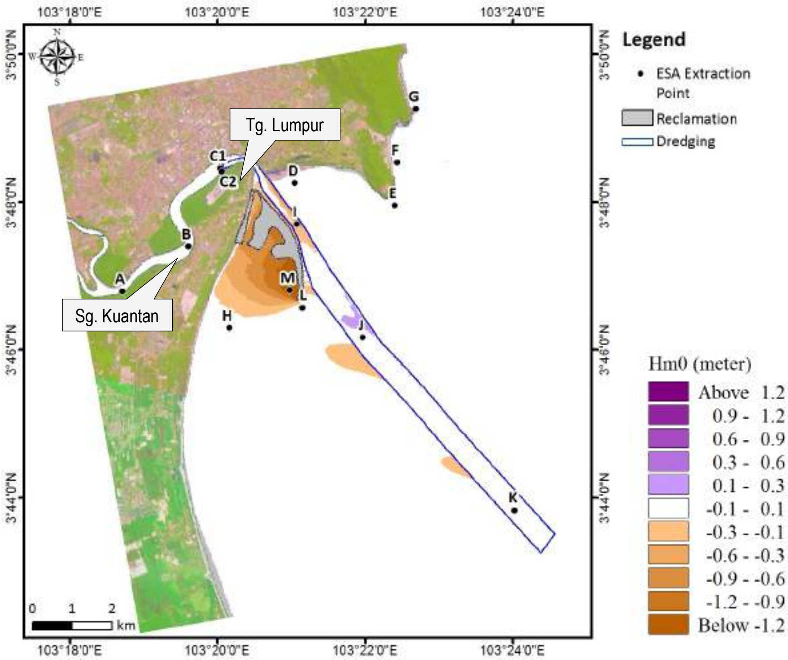
e) θ = 150°N

Figure 7.34 *(cont'd)* ► Wave Simulations for 'with Project' Condition: Phase 2a

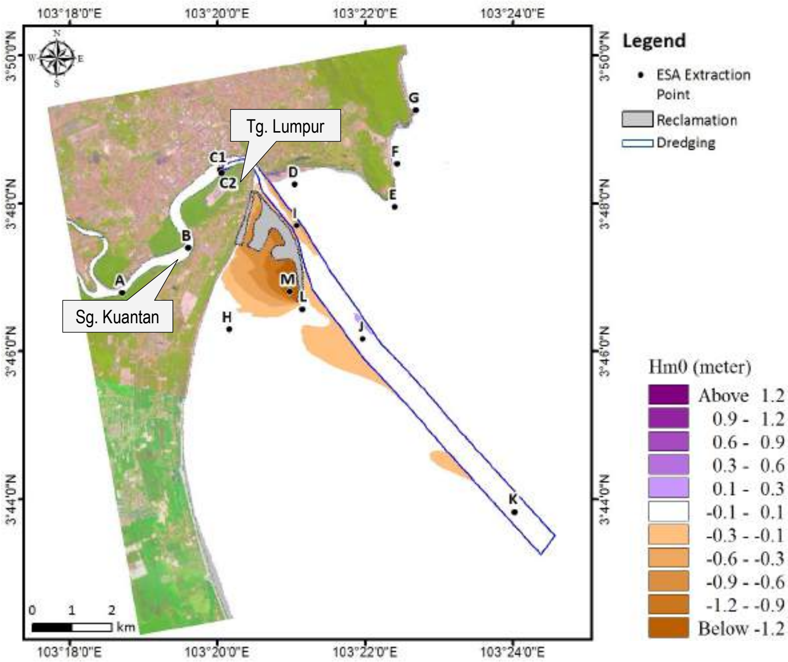


a) θ = 30°N

Figure 7.35 ► Wave Height Difference for 'with Project' Condition: Phase 2a

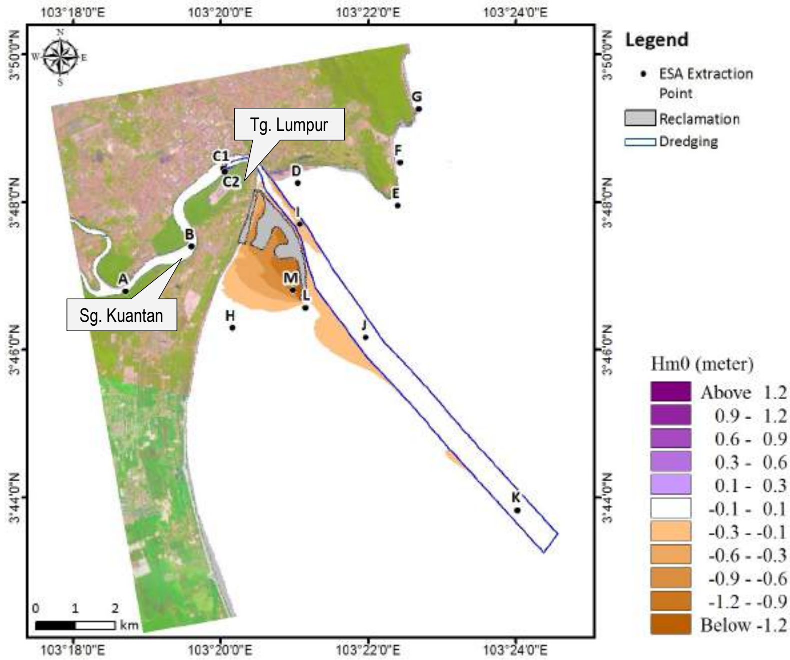


b) θ = 60°N

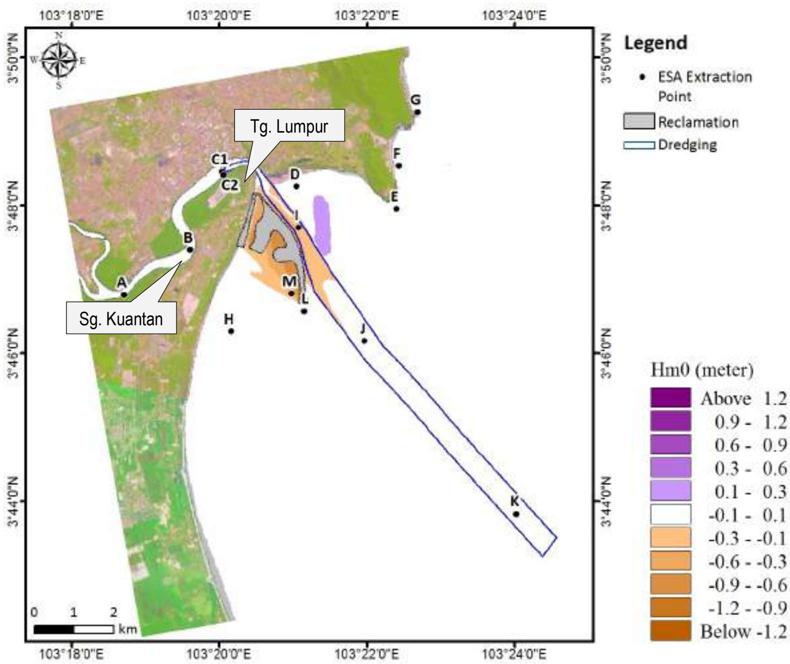


c) θ = 90°N

Figure 7.35 *(cont'd)* ► Wave Height Difference for 'with Project' Condition: Phase 2a

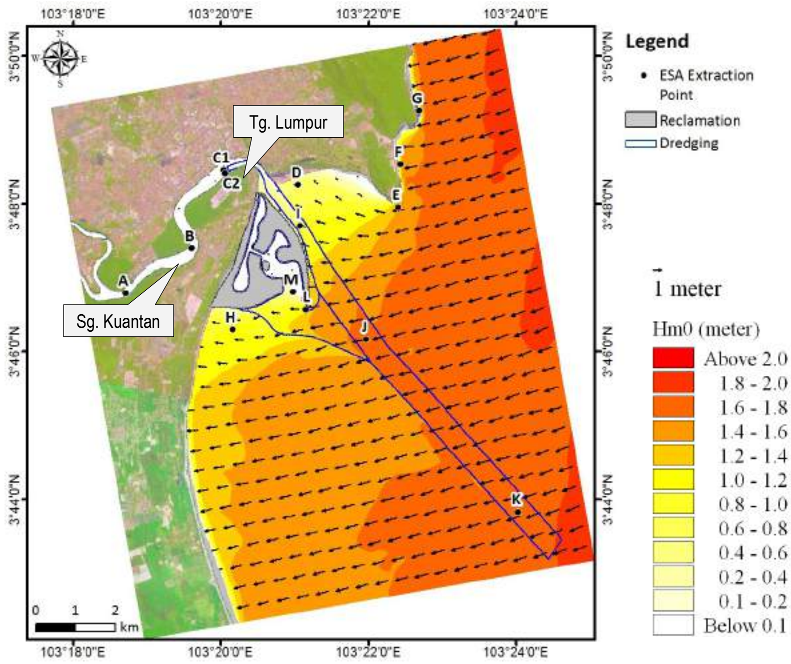


d) θ = 120°N

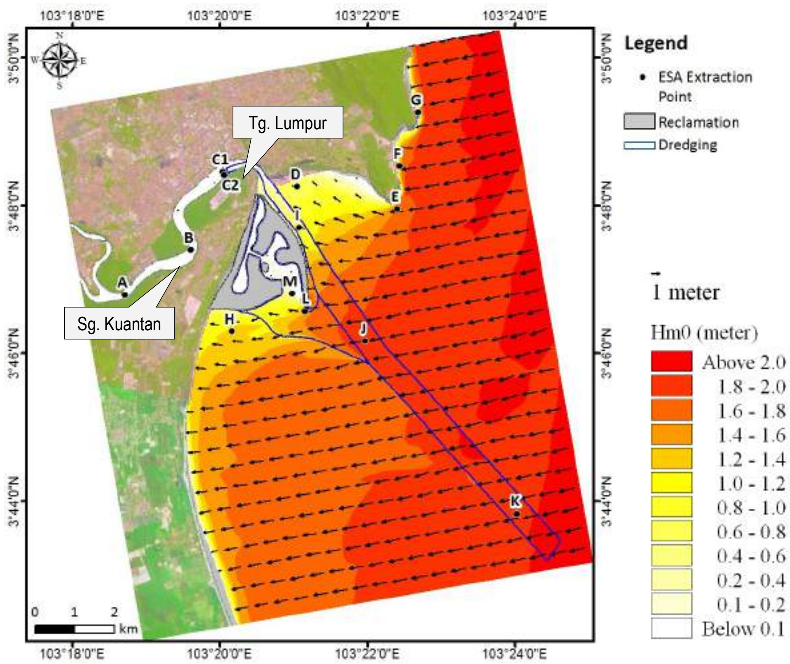


e) θ = 150°N

Figure 7.35 *(cont'd)* ► Wave Height Difference for 'with Project' Condition: Phase 2a

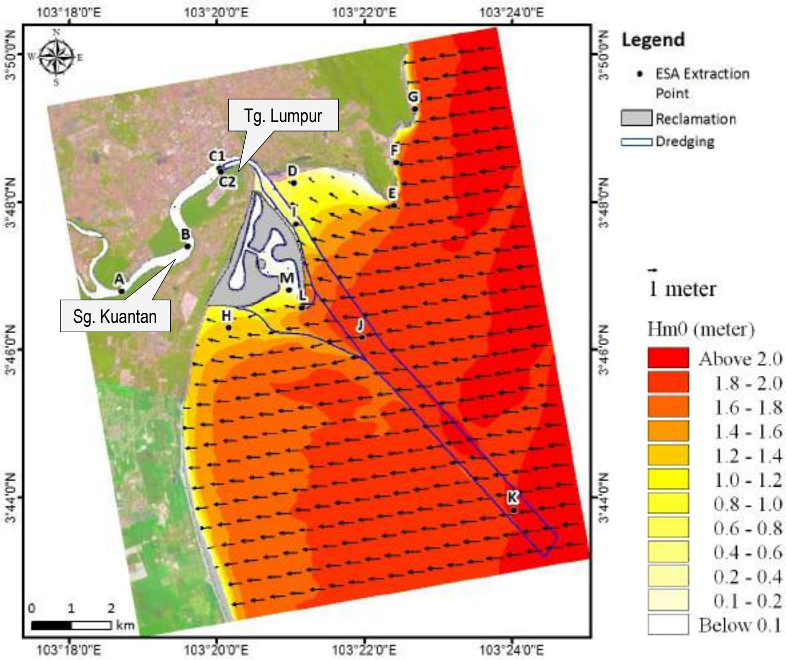


a) θ = 30°N

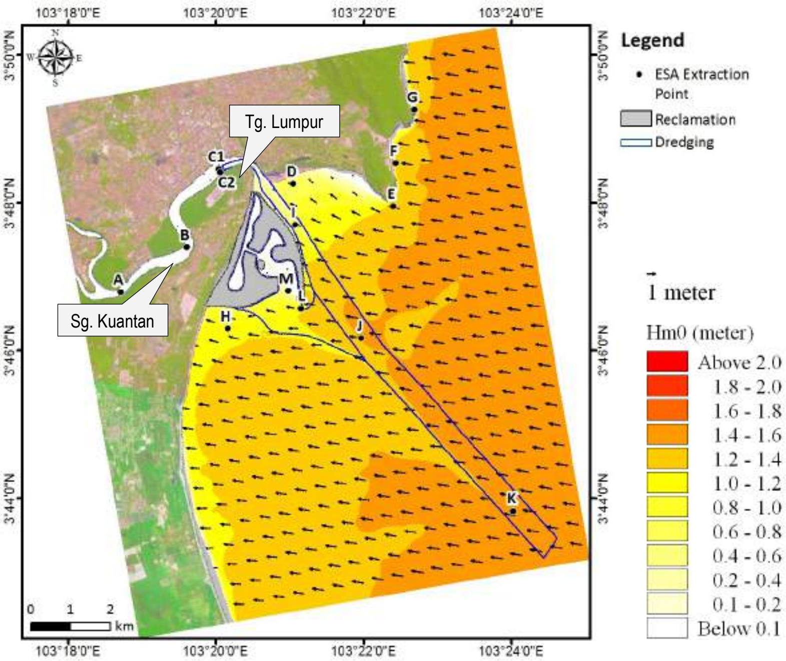


b) θ = 60°N

Figure 7.36 ► Wave Simulations for with Project' Condition: Phase 2b

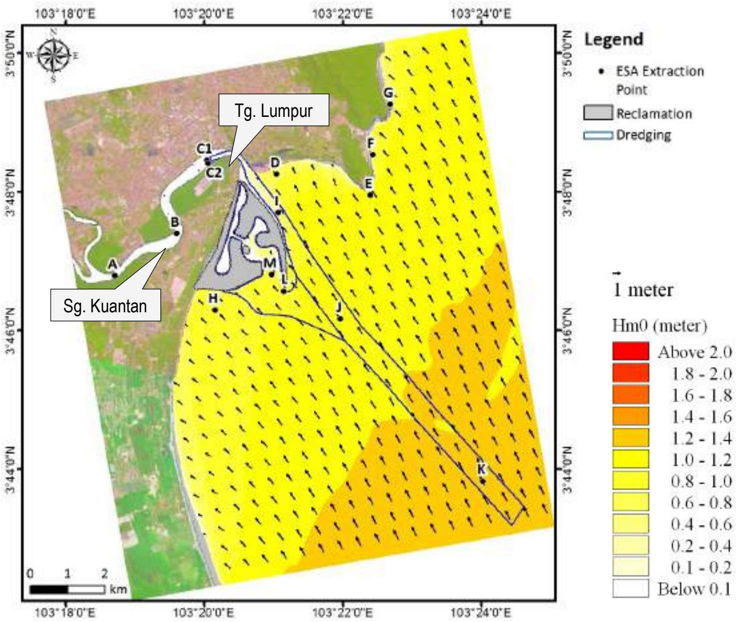


c) θ = 90°N



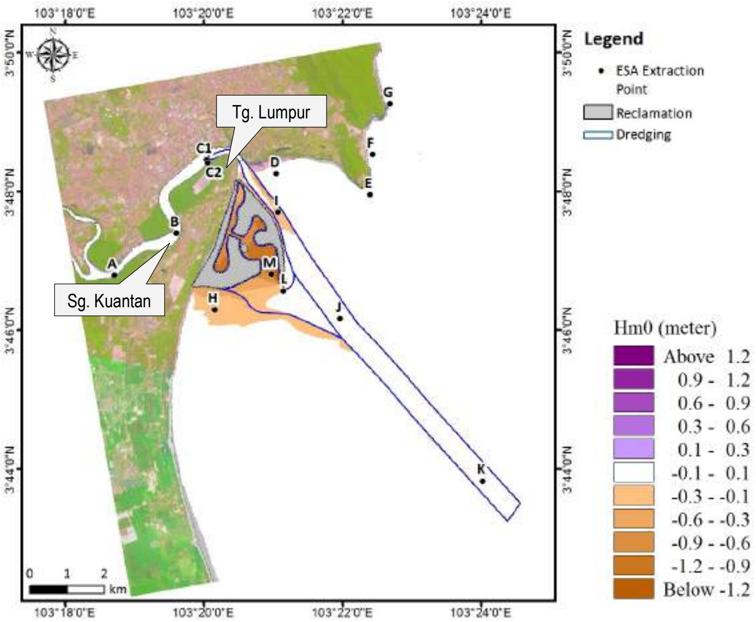
d) θ = 120°N

Figure 7.36 *(cont'd)* ► Wave Simulations for 'with Project' Condition: Phase 2b



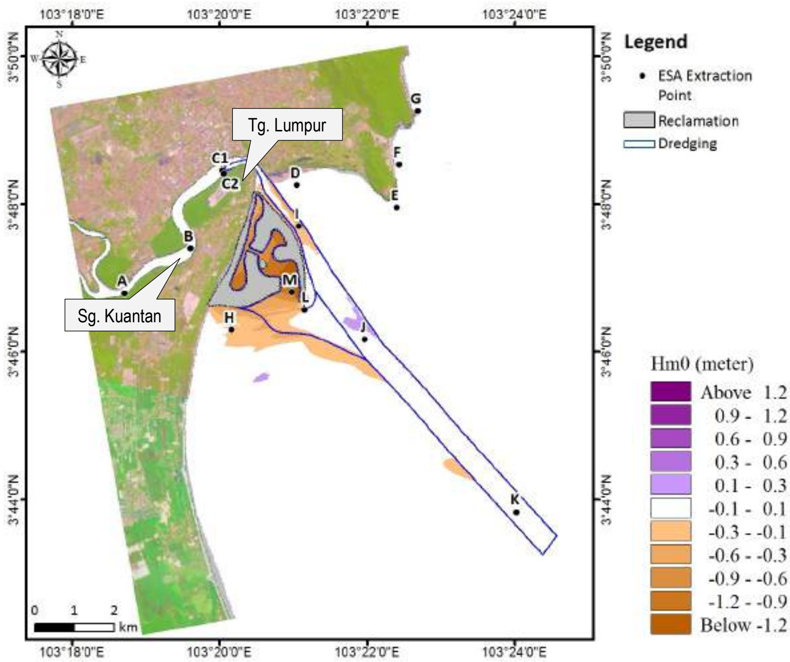
e) θ = 150°N

Figure 7.36 *(cont'd)* ► Wave Simulations for 'with Project' Condition: Phase 2b

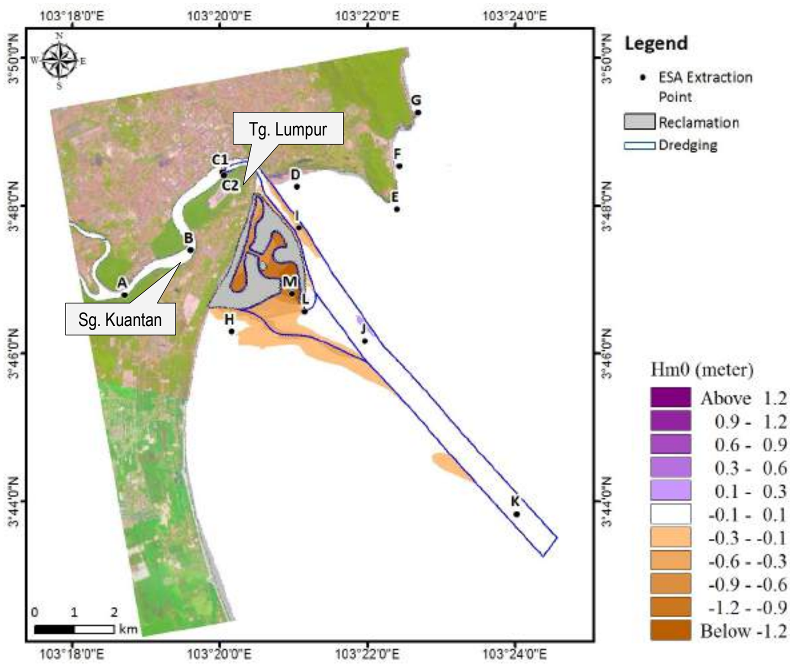


a) θ = 30°N

Figure 7.37 ► Wave Height Difference for 'with Project' Condition: Phase 2b

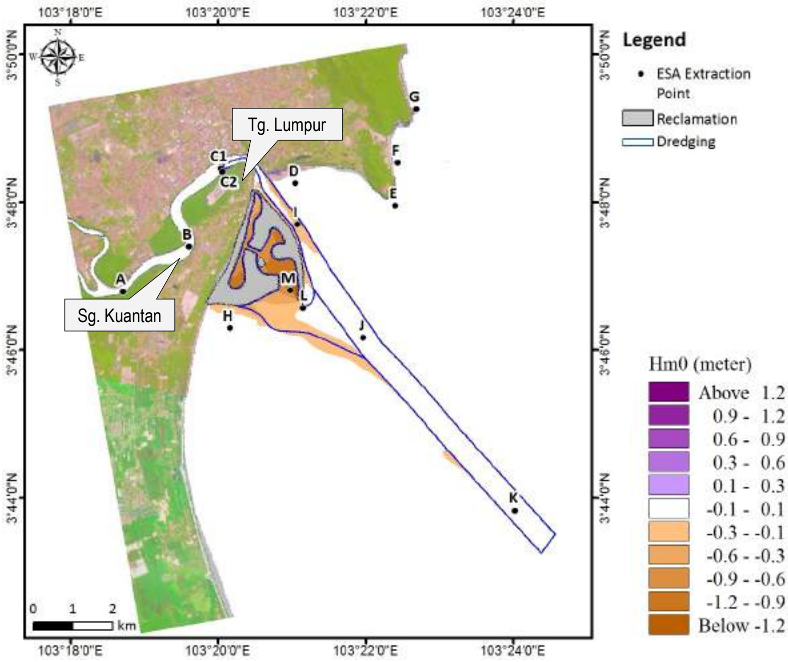


b) θ = 60°N

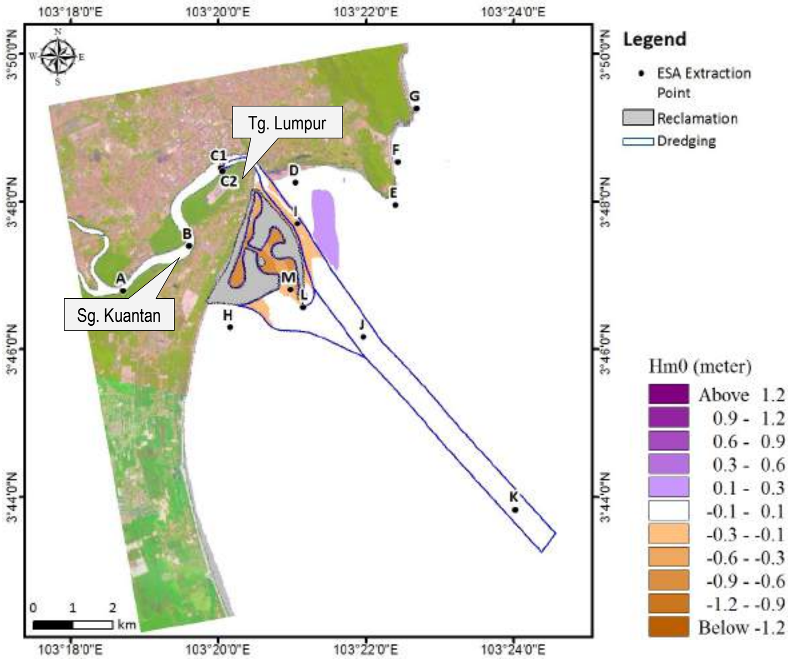


c) θ = 90°N

Figure 7.37 *(cont'd)* ► Wave Height Difference for 'with Project' Condition: Phase 2b



d) θ = 120°N



e) θ = 150°N

Figure 7.37 *(cont'd)* ► Wave Height Difference for 'with Project' Condition: Phase 2b

Impact of Waves at ESAs and Around the Project Area

Wave heights were extracted at ESAs and around the Project area to assess the changes in wave height after the Project is completed (*Figure 7.2*). Wave height change after the development is tabulated in *Table 7.11*. There is a significant reduction in wave heights within the waters of surrounding areas after development. The location of the proposed marina appears to be reasonably sheltered from offshore waves.

Observations of wave activity based on characteristic annual conditions due to 'with Project' conditions are:

i) Wave height decrease of varying degree occurs within the cruise channel, marina and south of the development for most simulated directions;
ii) The development reduces wave heights by as much as 98% for incoming waves from 30, 60, 90, and 120°N within the marina. There is relatively little impact due to waves from 150°N; and
iii) The highest wave height encountered along the development is about 1.6 m fronting the southeastern end of development. An increase in wave height will cause erosion at that area.

It can be inferred from the results that waves propagating from 90°N induce the most impact along the surrounding shoreline. This is followed by waves coming from 60, 120, 30°N. The least impact is felt for incoming waves from 150°N.

Table 7.11 ► Wave Heights at ESAs and Around the Project Area

Direction (°N)	Point	Location	Wave Height (m)			Wave Height Difference			
			Existing Condition	Phase 2a	Phase 2b	Phase 2a		Phase 2b	
						Value (m)	Percentage (%)	Value (m)	Percentage (%)
30	A	Kuantan Forest Reserve	0.062	0.062	0.062	0	0	0	0
	B	Hutan Rizab Paya Laut Kuantan	0.024	0.024	0.024	0	0	0	0
	C1	Tanjung Lumpur Bridge (northern pier)	0.045	0.045	0.045	0	0	0	0
	C2	Tanjung Lumpur Bridge (southern pier)	0.047	0.047	0.047	0	0	0	0
	D	Pantai Tanjung Sisek	0.458	0.458	0.458	0	0	0	0
	E	Kuantan Tembeling Resort	1.436	1.436	1.436	0	0	0	0
	F	Teluk Cempedak	1.511	1.511	1.511	0	0	0	0
	G	Beserah Forest Reserve	1.577	1.577	1.577	0	0	0	0
	H	Tanjung Lumpur sandflat	1.179	1.115	1.026	**-0.064**	**-5**	**-0.153**	**-13**
	I	Navigation channel (upstream)	0.885	0.577	0.577	**-0.308**	**-35**	**-0.308**	**-35**
	J	Navigation Channel (midstream)	1.61	1.688	1.688	**0.078**	**5**	**0.078**	**5**
	K	Navigation Channel (downstream)	1.699	1.747	1.747	**0.048**	**3**	**0.048**	**3**
	L	Southeastern end of development	1.318	1.287	1.273	**-0.031**	**-2**	**-0.045**	**-3**
	M	Marina entrance	1.228	0.032	0.034	**-1.196**	**-97**	**-1.194**	**-97**
60	A	Kuantan Forest Reserve	0.056	0.056	0.056	0	0	0	0
	B	Hutan Rizab Paya Laut Kuantan	0.022	0.022	0.022	0	0	0	0
	C1	Tanjung Lumpur bridge (northern pier)	0.047	0.047	0.047	0	0	0	0
	C2	Tanjung Lumpur bridge (southern pier)	0.047	0.047	0.047	0	0	0	0
	D	Pantai Tanjung Sisek	0.56	0.56	0.56	0	0	0	0
	E	Kuantan Tembeling Resort	1.673	1.673	1.673	0	0	0	0
	F	Teluk Cempedak	1.681	1.681	1.681	0	0	0	0
	G	Beserah Forest Reserve	1.724	1.724	1.724	0	0	0	0
	H	Tanjung Lumpur sandflat	1.365	1.317	1.239	**-0.049**	**-4**	**-0.126**	**-9**
	I	Navigation channel (upstream)	0.951	0.579	0.579	**-0.372**	**-39**	**-0.372**	**-39**
	J	Navigation Channel (midstream)	1.849	1.93	1.93	**0.082**	**4**	**0.082**	**4**
	K	Navigation Channel (downstream)	1.933	2.001	2.001	**0.068**	**4**	**0.068**	**4**
	L	Southeastern end of development	1.557	1.518	1.505	**-0.039**	**-2**	**-0.052**	**-3**
	M	Marina entrance	1.459	0.031	0.036	**-1.429**	**-98**	**-1.424**	**-98**

Table 7.11 *(cont'd)* ► Wave Heights at ESAs and Around the Project Area

Direction (°N)	Point	Location	Wave Height (m)			Wave Height Difference			
			Existing Condition	Phase 2a	Phase 2b	Phase 2a		Phase 2b	
						Value (m)	Percentage (%)	Value (m)	Percentage (%)
90	A	Kuantan Forest Reserve	0.039	0.039	0.039	0	0	0	0
	B	Hutan Rizab Paya Laut Kuantan	0.022	0.022	0.022	0	0	0	0
	C1	Tanjung Lumpur Bridge (northern pier)	0.049	0.049	0.049	0	0	0	0
	C2	Tanjung Lumpur Bridge (southern pier)	0.046	0.046	0.046	0	0	0	0
	D	Pantai Tanjung Sisek	0.57	0.57	0.57	0	0	0	0
	E	Kuantan Tembeling Resort	1.747	1.747	1.747	0	0	0	0
	F	Teluk Cempedak	1.709	1.709	1.709	0	0	0	0
	G	Beserah Forest Reserve	1.743	1.743	1.743	0	0	0	0
	H	Tanjung Lumpur sandflat	1.414	1.384	1.36	**-0.03**	**-2**	**-0.054**	**-4**
	I	Navigation channel (upstream)	0.956	0.539	0.539	**-0.416**	**-44**	**-0.416**	**-44**
	J	Navigation Channel (midstream)	1.894	1.947	1.947	**0.054**	**3**	**0.054**	**3**
	K	Navigation Channel (downstream)	1.969	2.029	2.029	**0.059**	**3**	**0.059**	**3**
	L	Southeastern end of development	1.654	1.571	1.567	**-0.083**	**-5**	**-0.087**	**-5**
	M	Marina entrance	1.55	0.029	0.032	**-1.521**	**-98**	**-1.518**	**-98**
120	A	Kuantan Forest Reserve	0.023	0.023	0.023	0	0	0	0
	B	Hutan Rizab Paya Laut Kuantan	0.022	0.022	0.022	0	0	0	0
	C1	Tanjung Lumpur Bridge (northern pier)	0.041	0.041	0.041	0	0	0	0
	C2	Tanjung Lumpur Bridge (southern pier)	0.038	0.038	0.038	0	0	0	0
	D	Pantai Tanjung Sisek	0.509	0.509	0.509	0	0	0	0
	E	Kuantan Tembeling Resort	1.295	1.295	1.295	0	0	0	0
	F	Teluk Cempedak	1.357	1.357	1.357	0	0	0	0
	G	Beserah Forest Reserve	1.365	1.365	1.365	0	0	0	0
	H	Tanjung Lumpur sandflat	1.186	1.16	1.184	**-0.025**	**-2**	**-0.002**	**0**
	I	Navigation channel (upstream)	0.874	0.537	0.537	**-0.337**	**-39**	**-0.337**	**-39**
	J	Navigation Channel (midstream)	1.397	1.427	1.427	**0.03**	**2**	**0.03**	**2**
	K	Navigation Channel (downstream)	1.452	1.475	1.475	**0.022**	**2**	**0.022**	**2**
	L	Southeastern end of development	1.265	1.175	1.155	**-0.09**	**-7**	**-0.11**	**-9**
	M	Marina entrance	1.216	0.031	0.031	**-1.186**	**-97**	**-1.185**	**-97**

Table 7.11 *(cont'd)* ► Wave Heights at ESAs and Around the Project Area

Direction (°N)	Point	Location	Wave Height (m)			Wave Height Difference			
			Existing Condition	Phase 2a	Phase 2b	Phase 2a		Phase 2b	
						Value (m)	Percentage (%)	Value (m)	Percentage (%)
150	A	Kuantan Forest Reserve	0.02	0.02	0.02	0	0	0	0
	B	Hutan Rizab Paya Laut Kuantan	0.036	0.036	0.036	0	0	0	0
	C1	Tanjung Lumpur Bridge (northern pier)	0.036	0.036	0.036	0	0	0	0
	C2	Tanjung Lumpur Bridge (southern pier)	0.034	0.034	0.034	0	0	0	0
	D	Pantai Tanjung Sisek	0.741	0.748	0.749	**0.007**	**1**	**0.008**	**1**
	E	Kuantan Tembeling Resort	1.038	1.049	1.05	**0.011**	**1**	**0.012**	**1**
	F	Teluk Cempedak	0.893	0.895	0.895	**0.002**	**0**	**0.003**	**0**
	G	Beserah Forest Reserve	0.781	0.784	0.784	**0.003**	**0**	**0.003**	**0**
	H	Tanjung Lumpur sandflat	0.888	0.887	0.887	**-0.001**	**0**	**-0.001**	**0**
	I	Navigation channel (upstream)	0.75	0.538	0.582	**-0.212**	**-28**	**-0.167**	**-22**
	J	Navigation Channel (midstream)	1.108	1.026	1.039	**-0.082**	**-7**	**-0.069**	**-6**
	K	Navigation Channel (downstream)	1.235	1.208	1.208	**-0.027**	**-2**	**-0.027**	**-2**
	L	Southeastern end of development	1.02	0.986	0.98	**-0.033**	**-3**	**-0.04**	**-4**
	M	Marina entrance	0.978	0.525	0.572	**-0.453**	**-46**	**-0.406**	**-42**

7.2.2.3.5 Sedimentation and Erosion (Bed Level Changes)

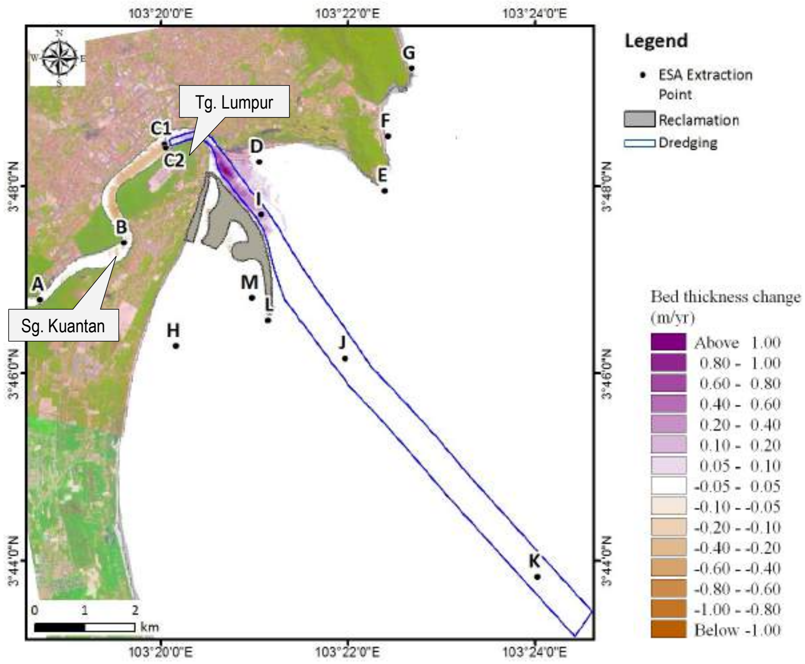
Assessment of sedimentation and erosion due to the proposed project are done by assessing the sediment transport that occur with respect to the existing condition. This is done by analysing the difference of the transport capacity occurring during the modelled period. The changes in transport capacity were used to assess the impact. A decrease and increase in transport capacity indicates likelihood for occurrence of sedimentation and erosion respectively. The proposed project creates local changes to capacity of cohesive and non-cohesive sediment transport.

A. Bed Level Changes for Cohesive Sediments (Mud)

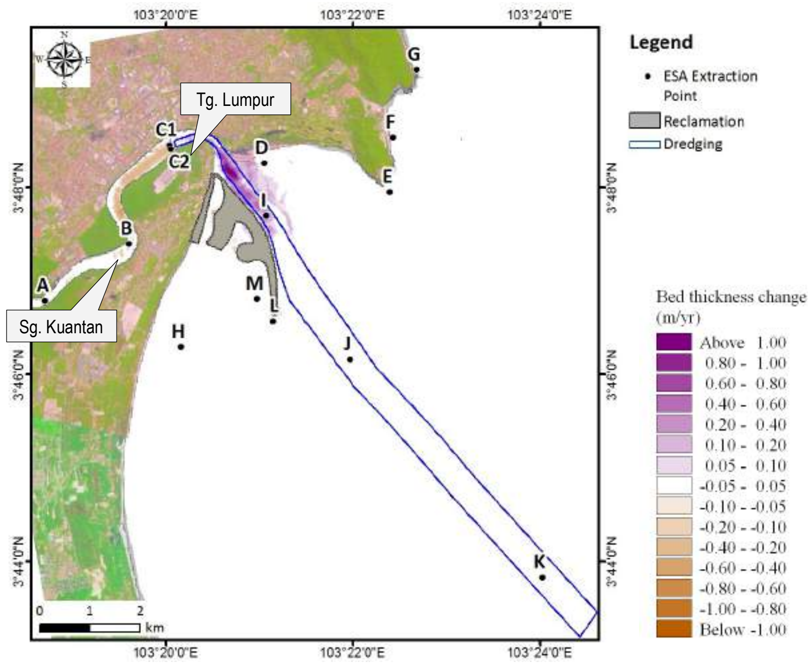
The projected annual bed level changes for the various 'with Project' scenarios with respect to the existing condition are shown in *Figures 7.38* and *7.39* for seasonal condition. The results indicate that the bed level changes induced by the development are localised within the immediate vicinity of the Project site. The changes are relatively similar for seasonal conditions.

The impacts on the cohesive sediment transport due to the development can be summarised as follows:

i) Phase 2a: Erosion was observed within the development’s lagoon and inner marina of up to about 0.6 and 0.4 m/year respectively before the dredging for full development is conducted. Sedimentation of about 0.1 m/year is predicted to occur in the development’s channel. Sedimentation of up to about 1.2 m/year can be observed immediately in front of the river mouth abutting the reclamation. Erosion is observed to extend approximately 3 km upstream of the bridge. Erosion of up to about 0.6 m/year can be observed extending about 2 km upstream of the proposed navigation channel; and
ii) Phase 2b: Sedimentation of up to about 1 m/year is predicted to occur within the developments water area. Sedimentation of about 0.6 m/year is predicted to occur at the turning basin. Sedimentation of up to about 1.2 m/year can be observed immediately in front of the river mouth for both phases. Erosion is observed to extend approximately 3 km upstream of the bridge. Erosion of up to about 0.6 m/year can be observed extending about 2 km upstream of the proposed navigation channel.

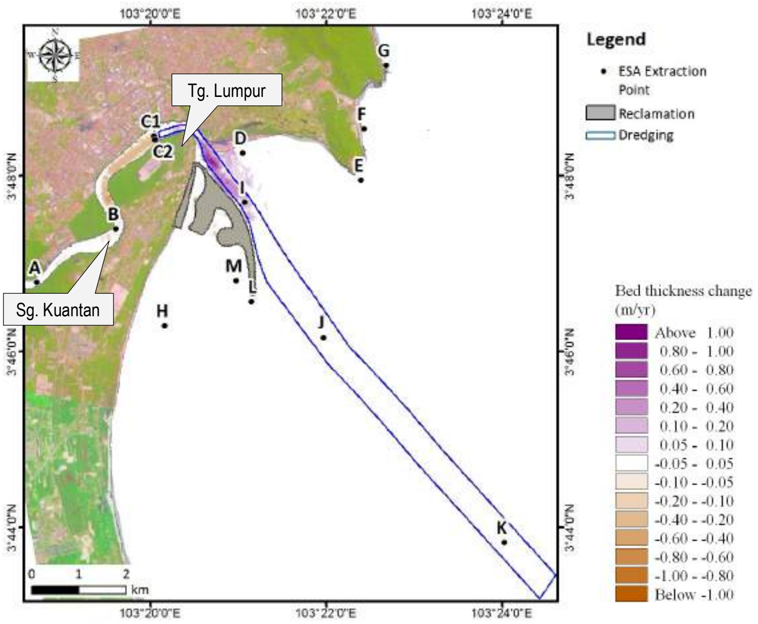


a) Pure tide condition



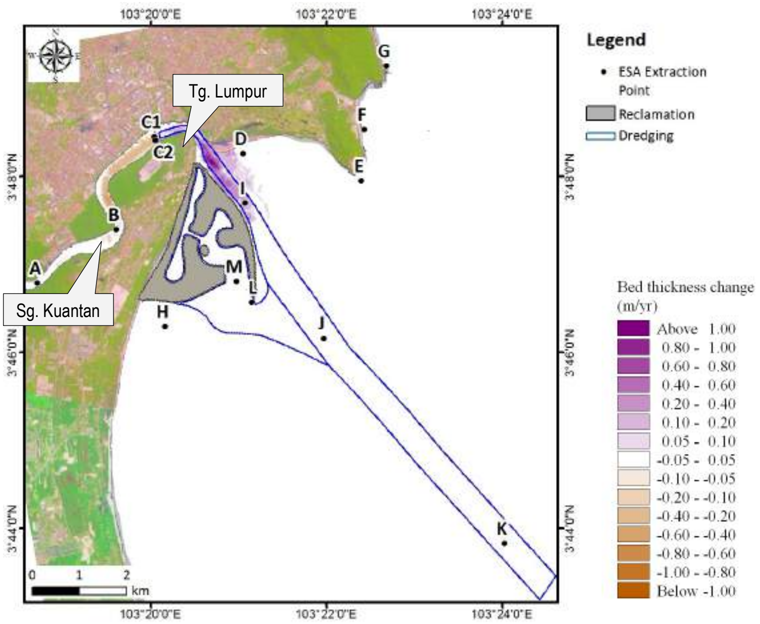
b) Northeast Monsoon condition

Figure 7.38 ► Projected Bed Level Change for Cohesive Sediments: Existing vs. Phase 2a



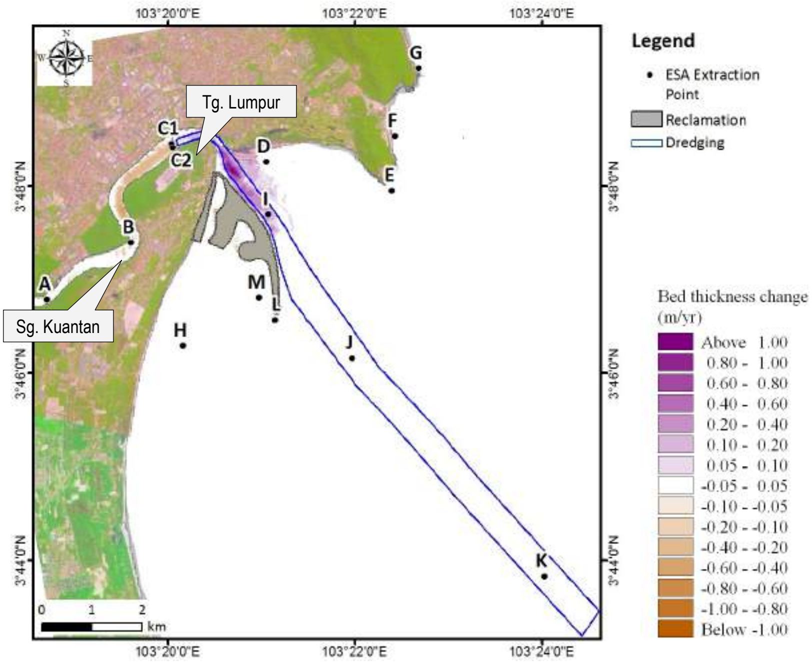
c) Southwest Monsoon condition

Figure 7.38 *(cont'd)* ► Projected Bed Level Change for Cohesive Sediments: Existing vs. Phase 2a

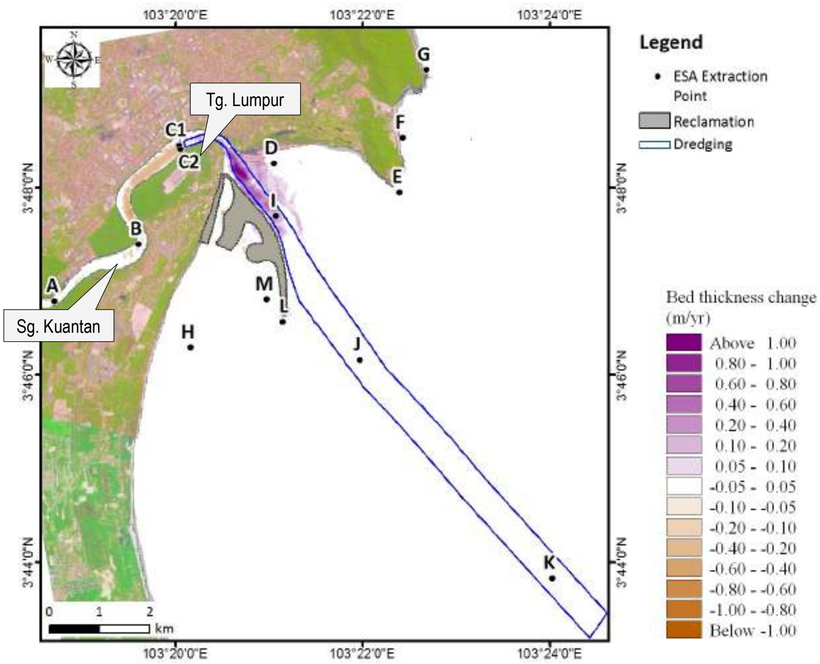


a) Pure tide condition

Figure 7.39 ► Projected Bed Level Change for Cohesive Sediments: Existing vs. Phase 2b



b) Northeast Monsoon condition



c) Southwest Monsoon condition

Figure 7.39 *(cont'd)* ► Projected Bed Level Change for Cohesive Sediments: Existing vs. Phase 2b

Impact of Sedimentation and Erosion for Cohesive Sediments at ESAs and Around the Project Area

Figure 7.40 and *Table 7.12* show the average sedimentation rate for cohesive sediments at environmentally sensitive areas (ESAs) and around the Project site. Slight erosion of up to about 0.1 m/yr was observed at the Tanjung Lumpur bridge piers and near Hutan Rizab Paya Laut Kuantan upon completion of the dredging works. Sedimentation of up to about 0.1 m/yr can occur within the navigation channel abutting the Project.

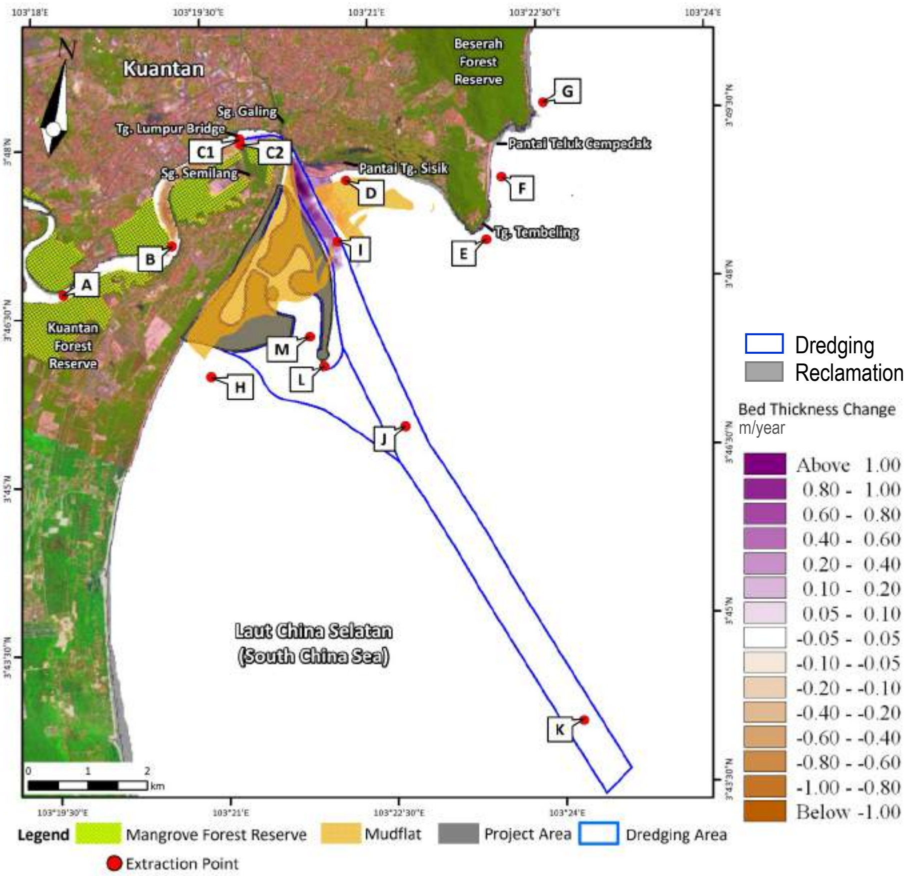


Figure 7.40 ► Average Sedimentation Rates for Cohesive Sediments at ESAs and around the Project Area

Table 7.12 ► Average Sedimentation Rates for Cohesive Sediments at ESAs and around the Project Area

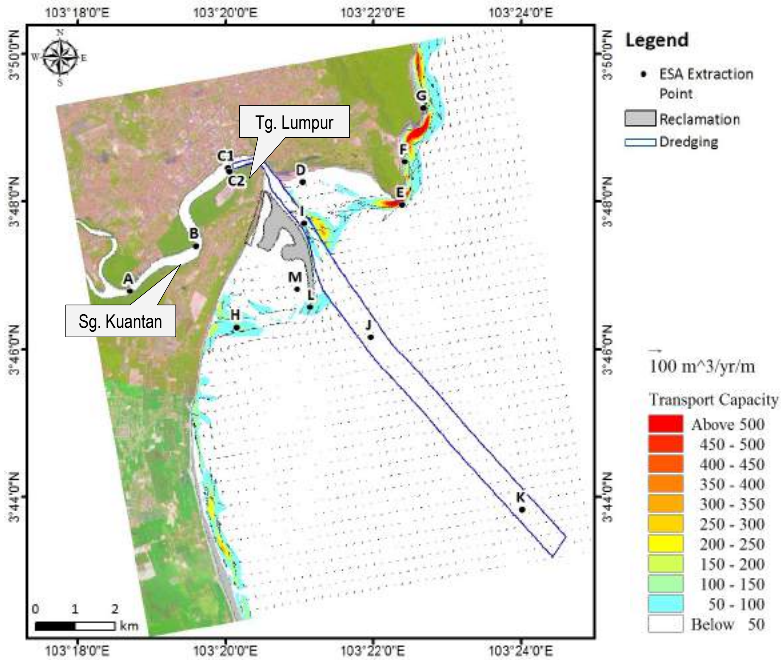
Point	Location	Average Sedimentation Rate (m/year)	
		Phase 2a	Phase 2b
A	Kuantan Forest Reserve	0.0	0.0
B	Hutan Rizab Paya Laut Kuantan	-0.1	-0.1
C1	Tanjung Lumpur Bridge (northern pier)	-0.1	-0.1
C2	Tanjung Lumpur Bridge (southern pier)	-0.1	-0.1
D	Pantai Tanjung Sisek	0.0	0.0
E	Kuantan Tembeling Resort	0.0	0.0
F	Teluk Cempedak	0.0	0.0
G	Beserah Forest Reserve	0.0	0.0
H	Tanjung Lumpur sandflat	0.0	0.0
I	Navigation channel (upstream)	0.1	0.1
J	Navigation channel (midstream)	0.0	0.0
K	Navigation channel (downstream)	0.0	0.0
L	Southeastern end of development	0.0	0.0
M	Marina entrance	0.0	0.0

Note: Negative values indicate erosion; Positive values indicate sedimentation

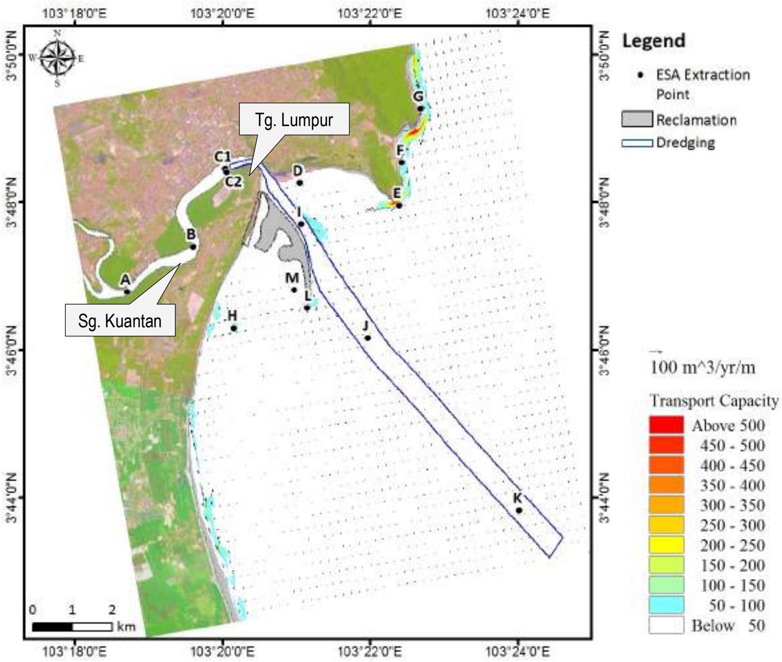
B. Bed Level Changes for Non-cohesive Sediments (Sand)

The proposed Project creates local changes to capacity of non-cohesive sediment transport. These changes are localised where increment and decrement of transport capacity occur. The changes are generally due to the proposed reclamation and capital dredging. Generally, transport capacity decrease occurs at the proposed dredged navigation channel, within reclamation area, and dredged marina channel. Meanwhile, transport capacity increase will be experience at the northeast edge of the dredged channel and concentrated at the tip of the southeastern end of the reclamation.

Results for sediment transport, transport and capacity changes for Phase 2a are shown in *Figures 7.41* and *7.42* respectively. Similar plot for Phase 2b scenario are presented in shown in *Figures 7.43* and *7.44* respectively. The most significant sediment transport change for both phases scenarios occur during the Northeast Monsoon period.

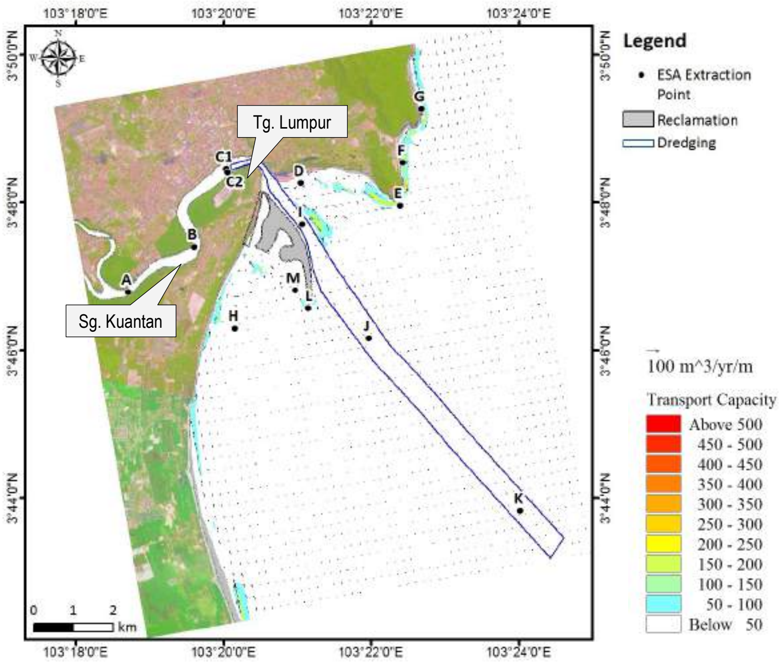


a) Northeast Monsoon

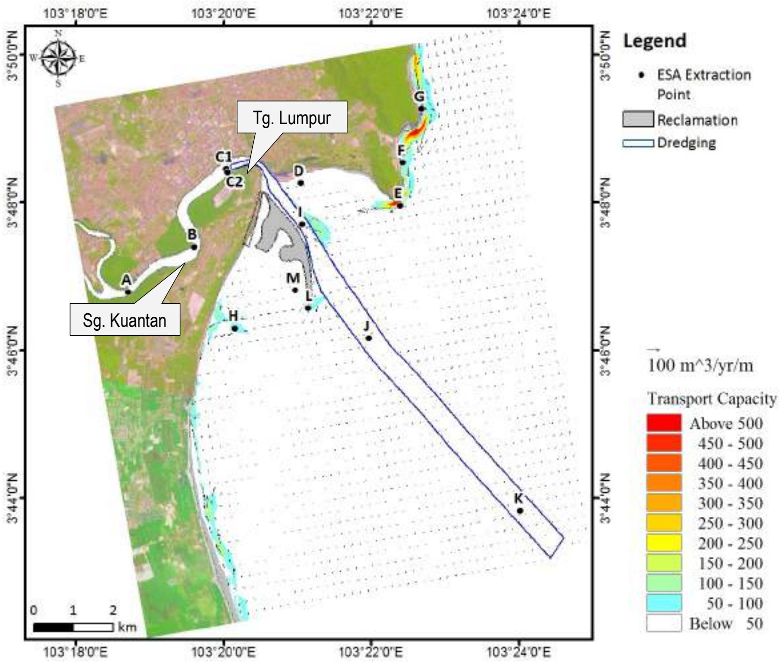


b) Inter-monsoon (April)

Figure 7.41 ► Non-cohesive Sediment Transport Pattern for Phase 2a

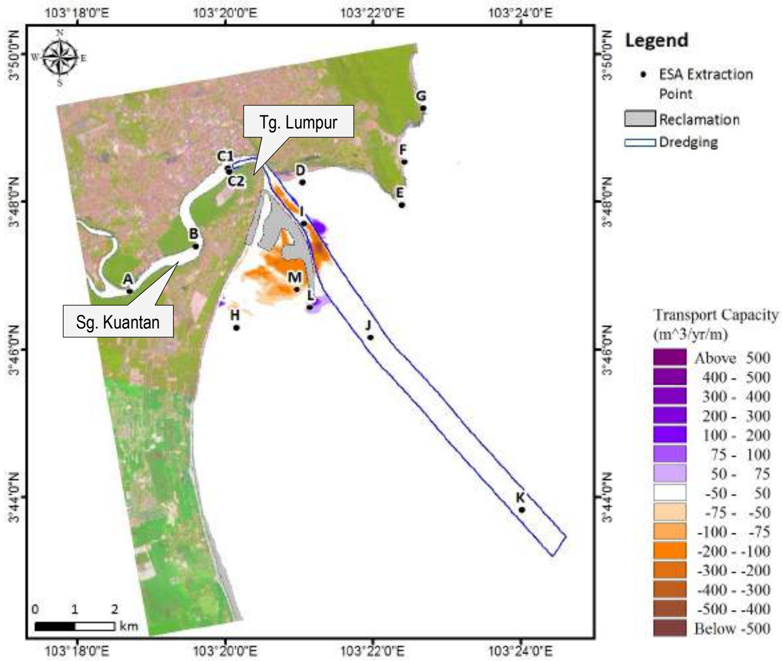


c) Southwest Monsoon

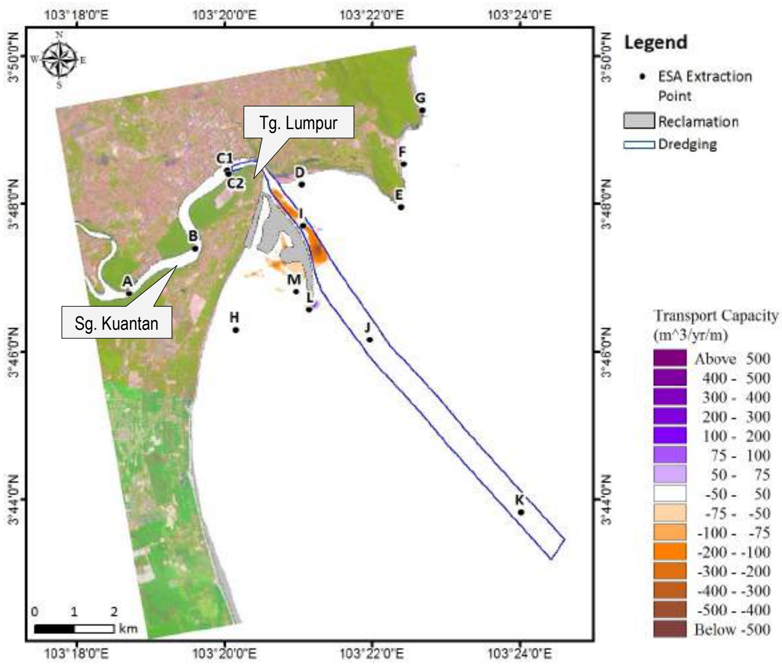


d) Inter-monsoon (October)

Figure 7.41 *(cont'd)* ► Non-cohesive Sediment Transport Pattern for Phase 2a

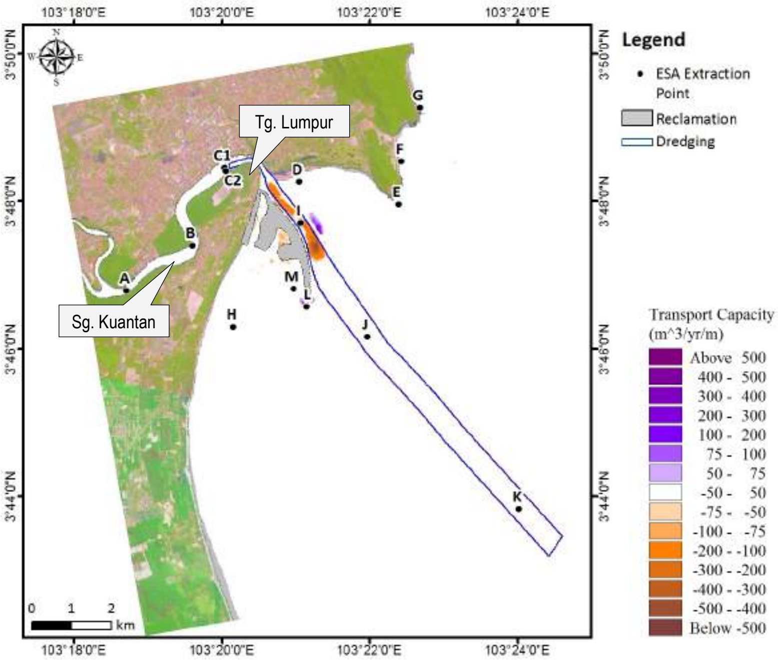


a) Northeast Monsoon

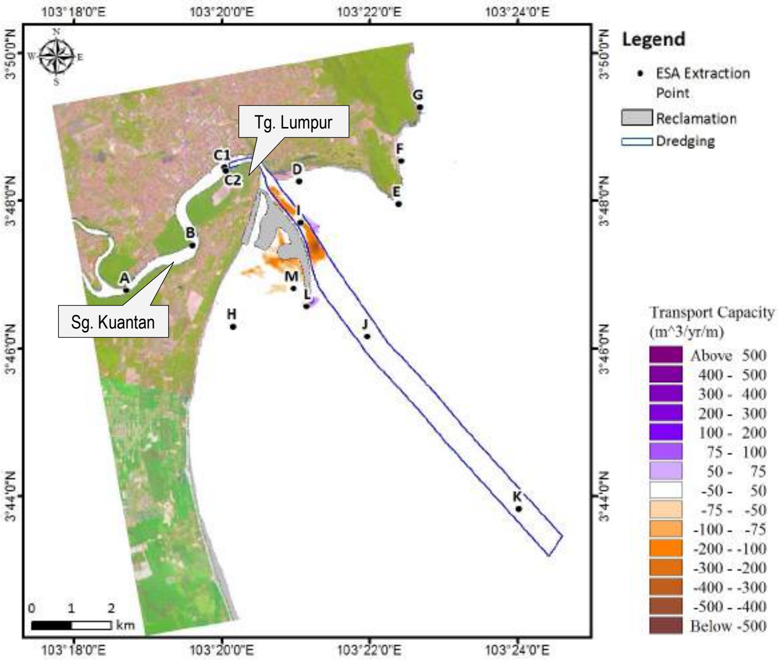


b) Inter-monsoon (April)

Figure 7.42 ► Changes in Non-cohesive Sediment Transport Capacity: Existing vs. Phase 2a

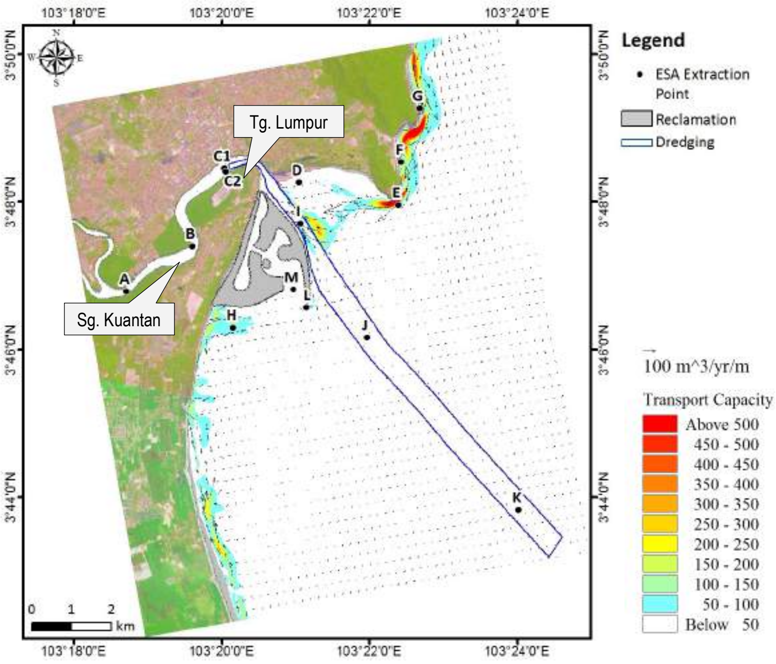


c) Southwest Monsoon

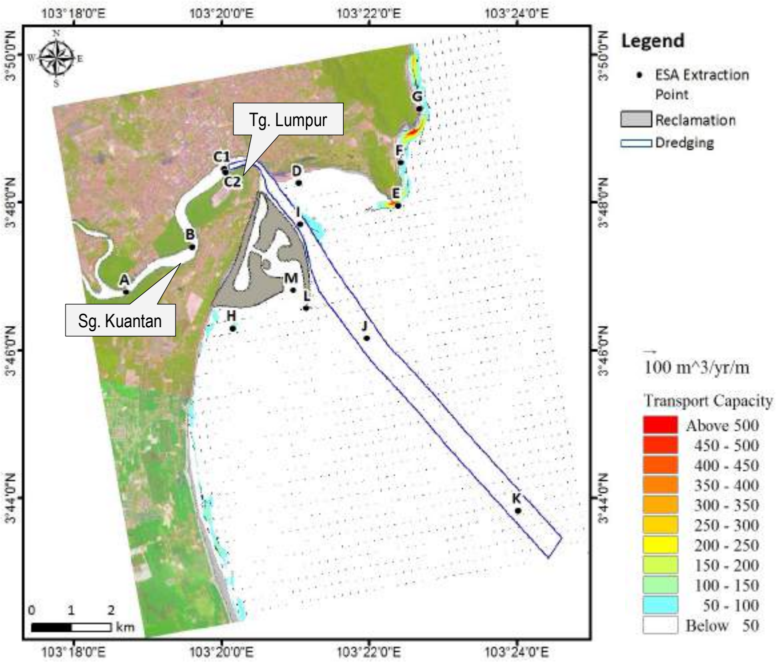


d) Inter-monsoon (October)

Figure 7.42 *(cont'd)* ► Changes in Non-cohesive Sediment Transport Capacity: Existing vs. Phase 2a

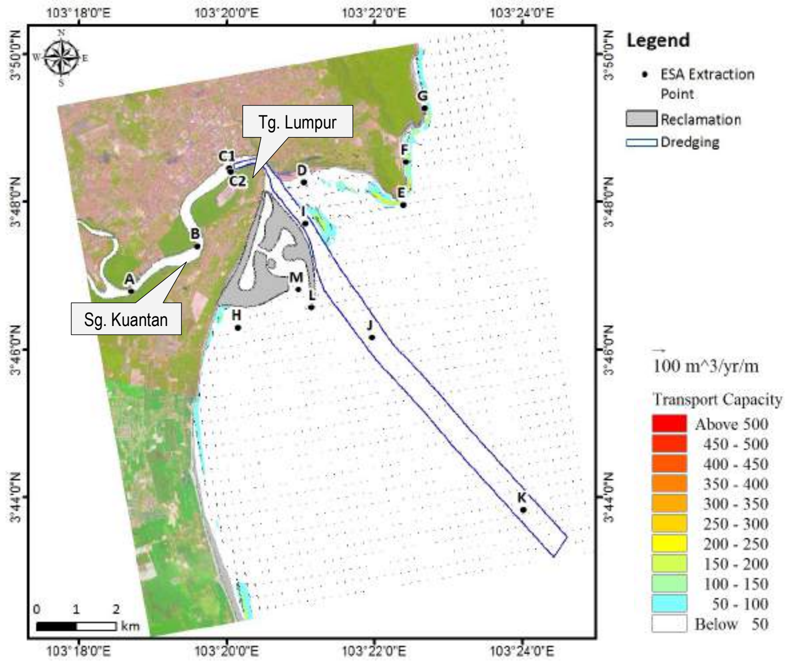


a) Northeast Monsoon

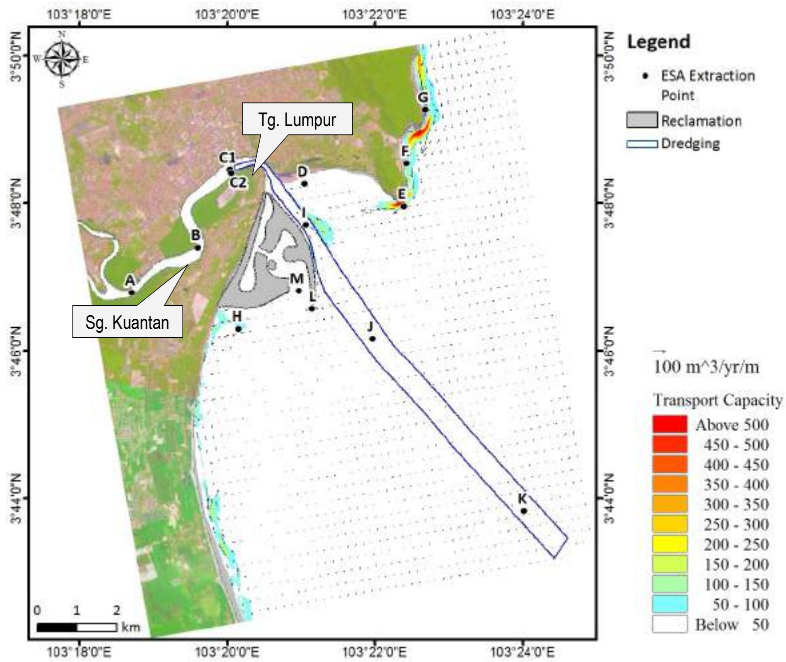


b) Inter-monsoon (April)

Figure 7.43 ► Non-cohesive Sediment Transport Pattern for Phase 2b

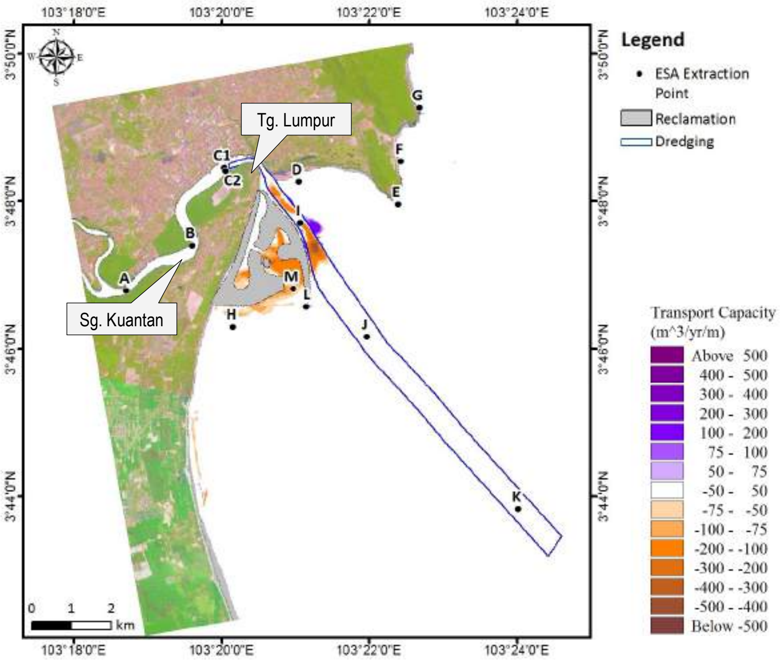


c) Southwest Monsoon

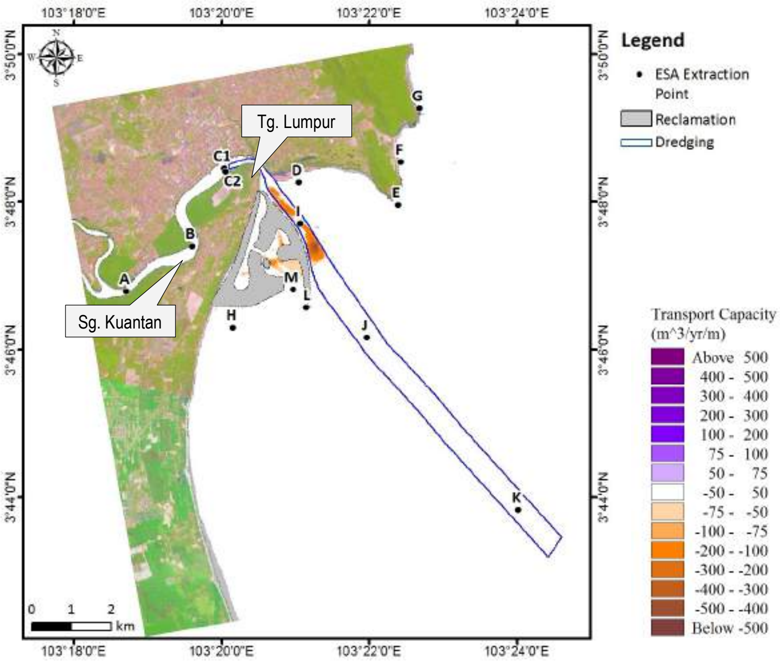


d) Inter-monsoon (October)

Figure 7.43 *(cont'd)* ► Non-cohesive Sediment Transport Pattern for Phase 2b

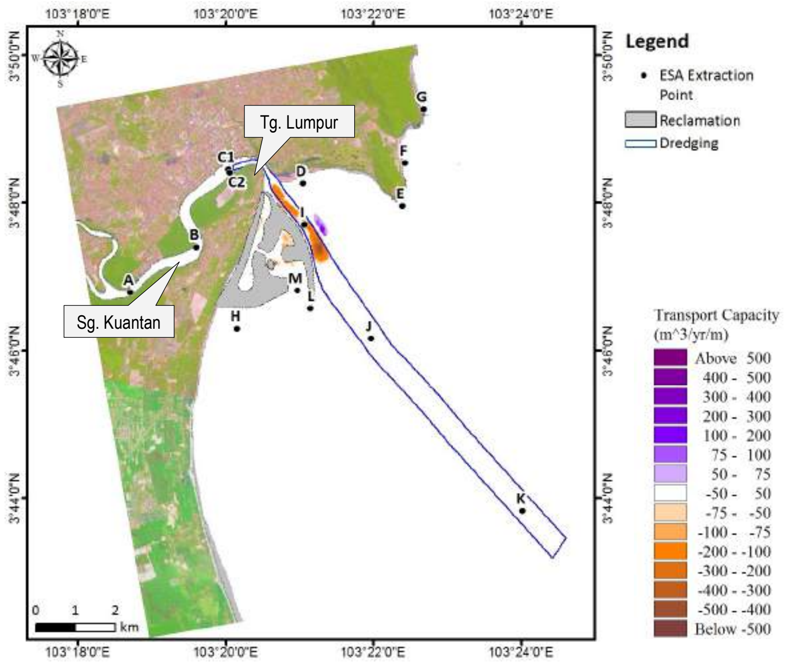


a) Northeast Monsoon

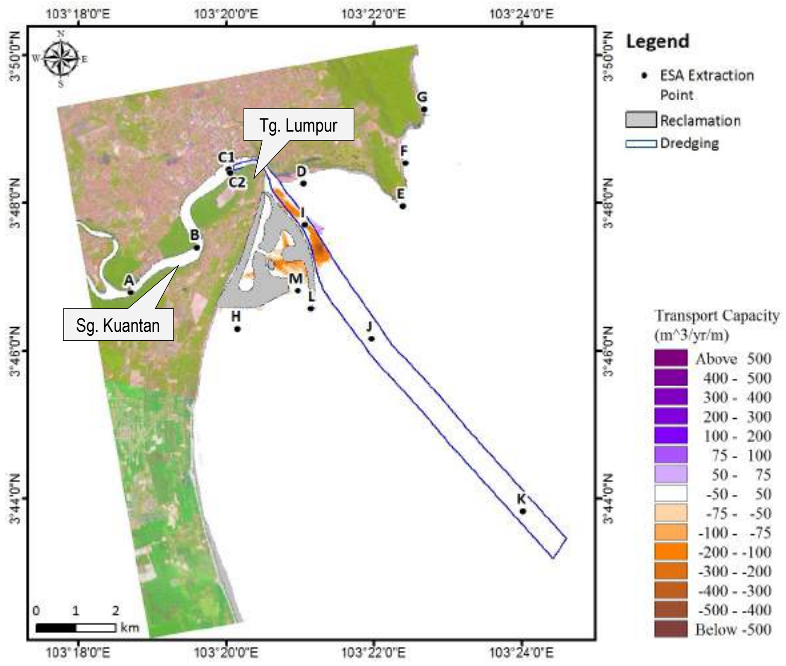


b) Inter-monsoon (April)

Figure 7.44 ► Changes in Non-cohesive Sediment Transport Capacity: Existing vs. Phase 2b



c) Southwest Monsoon



d) Inter-monsoon (October)

Figure 7.44 *(cont'd)* ► Changes in Non-cohesive Sediment Transport Capacity: Existing vs. Phase 2b

The following can be deduced from the simulation results for the non-cohesive sediment transport:

i) Phase 2a – Sediment bypassing from Tanjung Tembeling headland is partially interrupted by the reclaimed land and expect to deposit inside the dredged area. Sedimentation of up to about 1.1 m/year is predicted to occur. Decrease in sand transport capacity occurs within the development's dredged area as a result of the relatively low current speeds and wave sheltering. Sedimentation at the marina entrance is expected to be about 0.6 m/year. The coastline of about 1 km immediate south of the reclamation is expected to erode by about 0.2 m/year due to interruption of sediment bypassing originating from Tanjung Tembeling. There is slight increase in sand transport capacity at the tip of southeastern end of the reclamation and at the northeastern edge of the dredged channel where potential scour of about 0.4 m/year is estimated. These areas shall be suitably mitigated; and
ii) Phase 2b – Sediment bypassing from Tanjung Tembeling headland has been partially interrupted by the Phase 2a. The sediments deposit within the dredged area where sedimentation of up to about 1.1 m/year is expected. Sedimentation at the marina entrance is expected to be about 0.6 m/year. The coastline of about 1 km immediate south of the Project is expected to erode by about 0.1 m/year due to interruption of sediment bypassing originating from Tanjung Tembeling. There is slight increase in sand transport capacity at the tip of southeastern end of the reclamation and at the northeastern edge of the dredged channel where potential scour of about 0.5 m/year is estimated. These areas shall be suitably mitigated.

The impacts are quantified on a fixed bed. This implies that the calculated transport capacity changes cannot reduce due to morphological adaptability. The values can be considered as conservative and sufficient to identify potential areas of erosion or deposition in measuring the initial impacts.

The amount of sediments contributed by the rivers and neighbouring coastline varies from year to year not only due to natural influence but also anthropogenic causes. Shorefront and catchment development as well as erosion due to land clearing result in higher supply of sediments thereby increasing the likelihood of sedimentation. Climatic change such as floods also significantly affect the amount of sediments brought contributed to the open waters.

Impact of Sedimentation and Erosion for Non-cohesive Sediments at ESAs and Around the Project Area

Changes in sediment transport at the ESAs and around Project areas were extracted and assessed. It is expected that the changes in the sediment transport capacity are localized as shown in *Table 7.13*.There is a slight decrease in sedimentation rate at the southeastern end of the development (Point L) during Phase 2b, from –0.4 to –0.5 m/year.

Table 7.13 ► Average Sedimentation Rates for Non-cohesive Sediments at ESAs and around the Project Area

Point	Location	Average Bed Level Change (m/year)	
		Phase 2a	Phase 2b
A	Kuantan Forest Reserve	0	0
B	Hutan Rizab Paya Laut Kuantan	0	0
C1	Tanjung Lumpur Bridge (northern pier)	0	0
C2	Tanjung Lumpur Bridge (southern pier)	0	0
D	Pantai Tanjung Sisek	0	0
E	Kuantan Tembeling Resort	0	0
F	Teluk Cempedak	0	0
G	Beserah Forest Reserve	0	0
H	Tanjung Lumpur sandflat	-0.1	-0.1
I	Navigation channel (upstream)	1.1	1.1
J	Navigation channel (midstream)	0	0
K	Navigation channel (downstream)	0	0
L	Southeastern end of development	-0.4	-0.5
M	Marina entrance	0.6	0.6

Note: Negative values indicate erosion; Positive values indicate sedimentation

7.2.2.4 Water Quality

It is known that the major source of impact to water quality is sediment dispersion caused by land reclamation and dredging activities (which has been discussed in *Section 7.2.2.2.1)*. Other than that, oil and grease from dredgers and vessels employed for the Project may spill into the sea and cause contamination. Spilled oil and grease may disperse over a large area primarily on the surface layer of the marine water when moved by water currents and the wind. Depending on the spill level, oil and grease may reach the shoreline and contaminating the sediments, organisms and habitat. Improper discharge of waste from these vessels may also have negative impacts to the surrounding water.

Dredging activity will cause disturbance to the surface layer of the seabed, thus suspending solids in the water column and consequently affecting the water turbidity. These suspended solids may contain contaminants and, when dispersed, may introduce a high level of heavy metals into the water.

Some of the vessels will have toilet and kitchen facilities for the crews staying on board. Direct discharge of wastewater, greywater and other solid waste into the sea is detrimental to water quality if done in large quantity.

Ballast water and bilges generated from the vessels usually contain significant level of pollutants, in which oil being the most common contaminant. According to Environmental Quality (Scheduled Waste) Regulation 2005, a mixture of water and oil such as ballast water is classified as Scheduled Waste. These contaminants will be introduced into the environment if the ballast water and bilges is not handled correctly as per the prevailing regulations.

7.2.2.5 Marine Biological Environment

Main potential impact during transportation and placement of reclamation materials to the designated area is the degradation of water quality, which could affect marine life. During this activity, sediment dispersion may cause turbidity in the water column if it is not executed accordingly.

Dredging activity may possibly release suspended sediments into the water column. In many cases, the turbidity plumes can be visible seen trailing behind the dredger or at the down current of the dredging area (*Photo 7.1*). Increases in suspended sediments and turbidity levels may under certain conditions have adverse effects on marine faunas and floras by reducing light penetration into the water column and by physical disturbance (Anchor Environmental, 2003).

Photo 7.1 ► Example of a Dredger at Work has Caused Turbidity Plume
Source: http://resources0.news.com.au/

Increases in turbidity cause reduction in light penetration through the water column, thus reducing the photosynthetically active radiation (PAR) from reaching deeper areas or the bottom (Parr *et al.* 1998, Wellington *et al.* 2010). The primary production of the phytoplankton in the water column, and the phytobenthos on the sea bottom, as well as other aquatic plants can significantly be affected (QEA *et al.* 2001, Parr *et al.* 1998, Wallen 1951), depending on the levels of turbidity. Study by Telesnicki and Goldberg (1995) recorded significant reduction in photosynthesis ratios of zooxanthellae exposed to >28 NTU turbidity. On the contrary, high turbidity could sometimes be associated with phytoplankton bloom, which might occur if the dredging and disposal activities resulted in excessive nutrients released from the sediment (Wellington *et al.* 2010).

Reduced light penetration also has a sensory impact by preventing various organisms from seeing their food, their preys and predators, their mates and offspring. In other words, the life history strategies of certain marine species will be affected. Larval fishes for example, have UV-sensitive cone -cells that are believed to aid in detection of planktonic prey (Sandstrom, 1999). Experiments by Wellington *et al.* (2010) showed a marginally decreased zooplankton consumption by juvenile fish in turbid water conditions (>50 NTU). Consequently, the consumption rates, growth rates and ultimately recruitment rates were expected to decline with increasing turbidity (Sandstrom & Karas 2002, Wellington *et al.* 2010).

Increased suspended sediments can affect filter feeding organisms, through abrasion, clogging and damaging of their feeding and breathing equipment (Brehmer 1965; Parr *et al.* 1998). Young fish in particular, can be damaged if suspended sediments become trapped in their gills and increased fatalities of young fish have been observed in heavily turbid water (Wilbur 1971). Adult fish are likely to move away from or avoid areas of high suspended solids, at the dredging, disposal and reclaimed sites (ABP Research R701 1997). The suspended particulate matters in the water column will ultimately resettle to the bottom, and depending on the settlement amount and rates, will be detrimental for benthic organisms. The blanketing or smothering may cause stress or reduced rates of survival, growth or reproduction of the affected organisms (Bray *et al.* 1997).

7.2.2.5.1 Plankton and Benthos

The presence of the newly reclaimed land is not expected to cause any significant impact on the water quality or change in the currents so as to affect the plankton and benthic populations in the long term. Nevertheless, there would be localized changes in the accretion and scouring of seabed sediments due to hydrodynamic changes, which would then affect the benthic community through loss of suitable habitat. However, this is not ecologically significant due to the low species diversity and poor abundance.

Likewise, the presence of newly reclaimed land could also cause the composition of the mudflats to change due to sedimentation or loss of the bottom mud substrate through increased scouring. However, at the points where current speeds are relatively low, the increases are also low and considered not significant. This is unlikely to affect the benthic community of the coastal tidal mudflats as the potential increased scouring or erosion is limited to around the newly reclaimed land only. However, the impact seems to be insignificant (for both zoo- and phytoplankton) populations within the adjacent waters of the proposed Project as their dynamicity is largely influenced by daily tidal movements.

i) Phytoplankton

At the dredging site where SSC is >150 mg/L, the phytoplankton population and primary productivity will be severely affected. There will be less light penetration thus phytoplankton production will be significantly reduced. On the other hand, dredging might release nutrient from sediment, thus phytoplankton within the upper water column will be more productive. Further away in a range of 0.5 km to 2.5 km from the dredging site (SSC level between 25 to 100 mg/L), the phytoplankton will still be affected but not detrimental.

ii) Zooplankton

At the dredging site where SSC is >150 mg/L, the zooplankton will be affected. Feeding activity of the visually foraging group will be significantly reduced due to less visibility. Group that feeds on the phyto will be affected due to high total suspended solids (TSS) and reduce primary productivity. On the other hand, increased phytoplankton production due to nutrient released will be beneficial for this group. Further away in a range of 0.5 km to 3.5km from the dredging site (SSC level between 25 to 100 mg/L), the zooplankton will still be affected but not detrimental.

iii) Macrobenthos

The macrobenthos within the dredging areas will be a total loss. In areas with high SSC (>150 mg/L), the population will be severely affected due to siltation (smothered). High TSS cause impairment of filtering mechanisms, with other physical effect. Further away with a range of 0.5 km to 3.5 km from the dredging areas, the macrobenthos will be in stress and the population structure might be affected. The hardy and more tolerant species such as the Capitellidae (*Photo 7.2*) and Spionid (*Photo 7.3*) are expected to dominate.

Photo 7.2 ► Capitellidae
Source: http://www.roboastra.com/

Photo 7.3 ► Spionid
Source: http://www.pmel.noaa.gov/

7.2.2.5.2 Fisheries

Generally, it is envisaged that diversity and abundance of fish may decrease due to the increasing TSS value in the water. The occurrence might clog and cause gill and epidermis abrasion. Foraging activity for both the pelagic and demersal species will be affected due to less prey species (zooplankton, macrobenthos, smaller fish etc.) as well as reduced visibility. Nevertheless, fish are mobile nekton which could swim away from the dredging area.

Although the reclamation and dredging activities will have a temporary impact on the water quality, there is no significant fish population of economic importance within the area. However, there are some artisanal fishing activities using gill nets and seines off the Kuantan coast. Both of the Project activities could affect catch yields of the inshore fishermen by restricting areas for access and reducing fish stocks (which tend to escape and avoid the adjacent working areas).

7.2.2.6 Marine Traffic and Navigation Safety

During the reclamation and dredging period, there will be additional marine vessels, i.e. tugboats, CSD, TSHD etc. plying within the coastal water in the vicinity of the Project site. It is envisaged that during the whole Project period, there will be 3 to 4 trips/day of vessels movement to and from the designated work area. These frequent movements of large vessels may disrupt the small fishing boats mooring nearby. The existing navigation route may face interference and temporary aids for navigation purposes may need to be established. There may also be increased risk of accidents and collision with fishermen's boats during the Project period.

7.2.2.7 Air Quality

The nature of reclamation works will present an open surface with loose soil that is susceptible to wind erosion. The dust will be blown away from the working area depends on the wind direction and condition. Exhaust emissions from marine vessels and machineries i.e. excavators, trucks and bulldozers have the potential to affect the air quality. However, these impacts are relatively of short term and very localized.

7.2.2.8 Noise

Generally, there will be additional noise from the reclamation works particularly during compaction and ground improvement works. However, the noise impact is considered insignificant.

7.2.3 Impacts during Post Reclamation

Post reclamation described in this section refers to a stage when the reclamation and dredging are completed, but no topside development is undertaken yet. The existence of the newly reclaimed land will has no further impact on terrestrial flora and fauna as these have already been cleared during the land clearing and reclamation phases. However, certain commensal species such as the pigeons, pipits (*Anthus* sp.), doves, bulbuls, mynah birds, crows, etc. may still thrive in the disturbed area.

On the other hand, there would be localised changes in the accretion and scouring of seabed sediments due to hydrodynamic changes, which would then affect the benthic community through loss of suitable habitat. The tidal mudflat and marine life may recover in due time, with benthic and pelagic marine life attracted to the new coastline of the reclaimed area. The deposition sites would form mudflats that in turn, would attract benthic communities, fish and birds as well as artisanal fish to forage for food in the area.

The presence of the 273.57 hectares of a newly reclaimed land may incur additional cost and fuel to the local fishermen as they need to travel further from their usual route.

7.2.4 Impacts during Operation and Maintenance Phase

This section addressed the potential impacts that may arise once all the proposed development is completed and in operation. The new development is expected to increase the demand on infrastructures and utilities, especially on the water supply and electricity. Poor handling in wastewater discharged from the development may affect the water courses nearby. In addition to that, the increasing of marine vessels plying within the Project area may also affect the water bodies such as oil leakage and disposal of waste. In terms of traffic, both land and marine traffic are envisaged to have additional traffic volume generated from the proposed development. The scenic beauty of Tanjung Lumpur will also change due to the presence of high building development.

7.2.4.1 Water Quality

It is proposed that there will be two (2) sewage treatment plants (STPs) to be built on the reclaimed land as shown in *Chapter 5* (*Section 5.7.5.3*). With areas of 1.38 and 1.21 hectares, both STPs are expected to receive wastewater discharged from commercial and residential development respectively. The STPs for commercial and residential zones will be designed to cater up to 25,000 and 20,000 P.E. respectively. On the other hand, the proposed reclamation reduces flushing in the vicinity of the Project site. Appropriate measures need to be implemented to reduce the release of pollution load into the open waters.

7.2.4.2 Marine Traffic

Once the marina cruise terminal is operating, it is envisaged the number of yachts and cruise ships entering and docking at the facilities will increase. However, the proposed dredging works will result in varying depths, from -6 m to -12 m CD at the designated areas, and this will provide open access for marine commercial vessels to berth at the marina. In terms of marine traffic volume, the marina is located off the main marine traffic routes and it is fairly protected from waves and currents. Hence, minimal impact is expected on mooring and unmooring operation from the waves, currents and passing.

7.2.4.3 Land Traffic Dispersal

Generally, the proposed KWRC development would inevitably result in additional trips generated onto the adjacent existing road network. The following assumptions are made in order to assess the traffic generated from the proposed KWRC:

i) Project on the normal traffic growth of the surrounding road network;
ii) Evaluate the trips generated by the proposed development;
iii) Carry out a distribution and assignment of generated trips onto the surrounding road network; and
iv) Assess the traffic impact of the trips generated by the proposed development onto the surrounding road network.

Forecast of total future traffic is a combination of two traffic components:

i) Normal traffic growth: the growth of future traffic irrespective of the proposed development; and
ii) Site traffic: the traffic generated by and attracted to the KWRC proposed development.

The summation of these two traffic components will represent the forecast of total future traffic in the study area.

7.2.4.3.1 Trip Generation

Using the Trip Generation Manual 2010 published by Malaysia Highway Planning Unit, the morning and evening peak hour traffic attracted (in) and produced (out) by the proposed KWRC are computed as tabulated in *Table 7.14.*

Table 7.14 ► Trip Generation Calculation

Time	Landuse (ha)	Trip Generation (vph)		Trip (%)		Trip (vph)	
		Total	Ext (50%)	In	Out	In	Out
AM	273.57	10, 725	5, 362	49	51	2,609	2,753
PM		14, 922	7,461	47	53	3,513	3,948

7.2.4.3.2 Trip Distribution and Assignment

Trip distribution estimates the percentage of trips between one zone and another, given the previously determined number of trips between one zone and another from the traffic survey and observed traffic movements during the survey.

Trip assignment uses the “capacity restraint” approach where it is assumed that a road has finite capacity and as this limit is approached, speeds and travel time decrease and other routes become more attractive.

For this analysis, trip distribution and assignment analysis were carried out. The trips generated by the proposed development are assumed to be distributed in accordance to the current traffic pattern and it is assumed 50 % external trips.

The trend for future trip modes are considered in favour of public transportation as evidenced by the provision of adequate bus stops surrounding the proposed development located within walking distance. The following ranges of modal splits are considered:

- **40:60 ratio of public transport users as compared to private vehicle users.**
  The assumption for vehicle occupancy is listed in *Table 7.15* and *Table 7.16* tabulates the results of the 40:60 ratio. The design year selected for the traffic assessment is 2025, being assumed that the Project will be fully occupied and operated on this year.

Table 7.15 ► Vehicle Occupancy

Vehicle Class				
Car	Motorcycle	Lorries	Trucks	Buses
3	1.5	1	1	50

Table 7.16 ► Future Trips (vph) after Conversion of 40% to Public Transport

i) JCT1: Ingress and egress junction of Jalan Pantai Sepat and Federal Road 183: Jalan Tanjung Lumpur

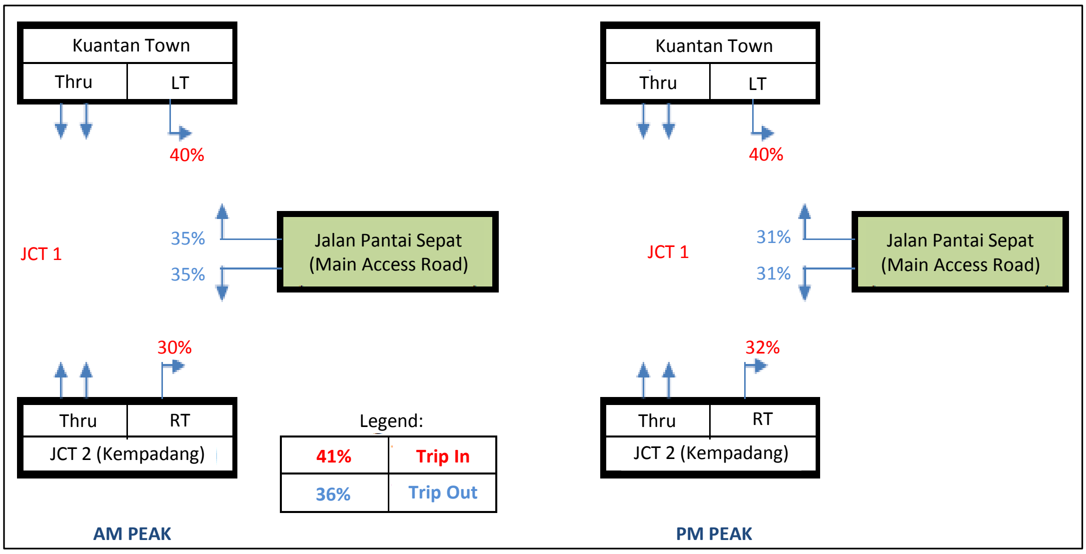
Time	Car/Van/Tax/ Utility	Medium Lorry	Heavy Lorry	Bus	Motorcycle	Total
AM	5,090	560	0	242	1,935	**7,828**
PM	6,427	559	0	325	2,637	**9,948**

ii) JCT2: T-junction of Jalan Yayasan Pahang and Federal Road 183: Jalan Tanjung Lumpur

Time	Car/Van/Tax/ Utility	Medium Lorry	Heavy Lorry	Bus	Motorcycle	Total
AM	3,620	376	0	177	1,396	**5,569**
PM	4,145	374	0	210	1,566	**6,295**

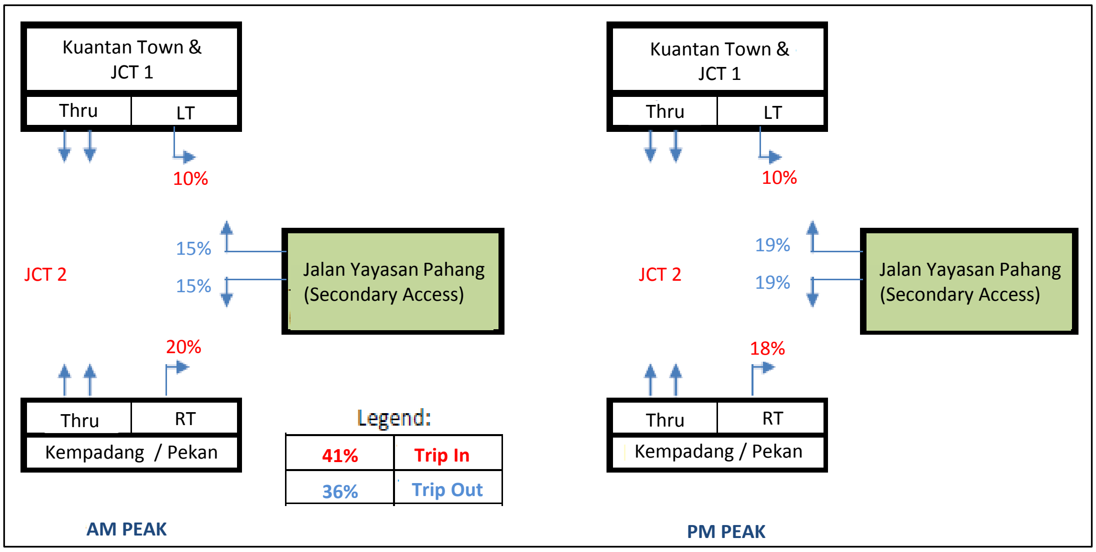
7.2.4.3.3 Traffic Distribution

Traffic distribution analysis for the proposed development were carried out to determine the percentage of traffic attracted to and from the development. From the analysis, both junctions had showed that more than 10% from the traffic will be attracted to and generated from the proposed development. The results are shown in *Figure 7.45*..



i) JCT1: Ingress and egress junction of Jalan Pantai Sepat and Federal Road 183: Jalan Tanjung Lumpur

Figure 7.45 ► Traffic Distribution Analysis



ii) JCT2: T-junction of Jalan Yayasan Pahang and Federal Road 183: Jalan Tanjung Lumpur

Figure 7.45 *(cont'd)* ► Traffic Distribution Analysis

7.2.4.4 Solid Waste Generation

Solid waste generation is expected to increase during the operational phase. The solid waste may originate from the commercial and business activities such as rubbish from packaging of materials and other wastes from daily activities. Solid waste would greatly reduce the aesthetic value of the surrounding area if not handled properly. Furthermore, dumping of wastes into the sea can pose significant risk to marine life. It also poses threats to vessels in the waterways.

7.2.4.5 Obstruction of Sea View

The sea view is a unique feature enjoyed by the locals of Tanjung Lumpur. The proposed reclamation will likely to block the panoramic existing sea view.

7.2.4.6 Infrastructure and Utilities

The newly created land will support many activities such as commercial, residential, recreational, institutional, health care and infrastructure facilities. It is anticipated that the newly created development will support approximately 25,000 people. There will be an additional demand in infrastructure and utilities as described in the following sub-sections.

7.2.4.6.1 Road

The designed shall be done according to *Arahan Teknik Jalan* (ATJ) requirements and the acquired of Road Safety Audit (RSA). The road layout design is subjected to the approval of the Pahang JKR and MPK.

7.2.4.6.2 Drainage System

The proposed drain will be designed with the consideration of the water flowing from a surface run-off into the proposed main drain. The final discharge will flow into the South China Sea through gross pollutant trap (GPT). The finalised design drawings for drainage shall be submitted to DID prior to construction.

7.2.4.6.3 Sewerage System

The sewerage system within the development is designed based on the calculated population equivalent (PE) of 25,000 and 20,000 for commercial and residential zones respectively. A total of five (5) pump stations will be allocated on the reclaimed land and two (2) STPs to fulfil the demand. The effluent discharged shall comply with Standard A discharge requirements. The finalised design drawings for sewerage shall be submitted to IWK prior to construction.

7.2.4.6.4 Water Supply

Increase in the water demand is calculated to be 4,070,900 gal/day for both commercial and residential zones. The calculation is based on assumption of a 24 hours per day supply. The design is based on Uniform Technical Guidelines for Water Reticulation and Plumbing by National Water Services Commission (SPAN). The water supply is to be approved by Pengurusan Air Pahang Berhad (PAIP).

7.2.4.6.5 Electricity

The overall development is anticipated to require 300.2 MW of additional power supply. All electricity services will be provided by Tenaga Nasional Berhad (TNB).

7.2.4.6.6 Telecommunication Services

The works for the telecommunication services shall comply with the requirements of Telekom Malaysia Berhad.

7.2.5 Abandonment Plan

Should any of the project activities be abandoned, it may cause adverse impacts particularly with regards to physical stability, hydrodynamics, public safety, ecological conditions and sustainability, aesthetics, land use, social expectations and economic conditions within the site area.

7.2.5.1 Temporary Closure

Temporary closure may be required should the reclamation and dredging related activities cease with the intent of resuming activities in the future. Temporary closures may be planned or unplanned and could arise from several conditions. These include design failures, financial challenges, political issues and extreme climatic conditions. The impermanent closure may last for weeks or could extend for years.

7.2.5.2 Permanent Closure

Permanent closure may happen when there is no intent to resume reclamation and dredging activities and the partially created land will remain as it is. The exposed landscape may induce further environmental disturbance or setbacks. For example, the aggravated wind and wave erosion, rampant weedy growth and increase in vectors and pest species.

7.3 Evaluation of Impacts on the Human Environment

Social impacts are the outcome of reactions between the activities of a project and the components of the host social environment. As a host society, the communities surrounding the project area would inevitably be affected by the changes introduced to the area; either directly or indirectly, and either positively or negatively. From the socio-economic aspect, such changes may be seen outright. But more often than not, these are less discernible, especially when they involve perceived notions, feelings and sentiments. The latter is often only seen and felt when they become manifested into other forms. The main components of this Project comprise reclamation towards creating new land of 273.57 hectares which abuts the existing coastline and dredging of the Sungai Kuantan river mouth, navigation channel and seafront area within the newly created land.

7.3.1 During Reclamation and Dredging

All the associated activities from reclamation and dredging will have the potential to create socio-economic impacts. The main socio-economic impacts during the construction activities would relate to labour, livelihood, health and safety, base camp/socio-cultural, tranquillity of the area and aesthetics.

7.3.1.1 Labour

Reclamation would require a large number of workers as the nature of work requires both in-shore and overland construction activities. As the reclamation is to be carried out in phases, the manpower requirements for reclamation in Phase 2a will be in the range of 500 workers during the peak of the reclamation works.

The workforce will comprise engineers, skilled, semi-skilled and unskilled workers. The requirement of several hundred workers will boost the local labour market and employment opportunities. This will lead to a boost in the local economy, thus improving the economic standing of the locals. Although employment of foreign workers is expected during the reclamation phase, the total engagement of only foreigners would result in this advantage and opportunity to the locals being forfeited. To be locally relevant, local labour should be given priority. This is especially so when increased employment opportunities for the local population is perceived by the majority of locals as being one of the advantages of the Project, and which is also one of the main reasons for supporting the Project.

The impact of the Project on the labour force will be significant – again, if at least 30% of the jobs generated are filled by the locals from within as well as from the surrounding study area. However, these job opportunities are temporary in nature and for a limited duration during the construction period.

The hiring of foreign workers would bring with it different kinds of impact, of both positive and negative. The main advantage would be in the fulfilment of the labour demand for the construction works. On the other hand, the negative point would be the potential social and cultural implications that may arise. These will be dealt with separately in *Section 7.3.2.5* Although these impacts could be significant, they are also short-term in nature.

The activities would also require the deployment of contractors and the mobilization of vehicles and equipment. This would again boost local participation and the economy should these activities be made to involve the locals. The impact on contracting works is also significantly high for the duration of the construction period. Again, should the contracting works come with providing the contractors' own workers, it should be stipulated that a fraction of these workers would have to be locals.

With regards to dredging, the Project is seen to be more advantageous to contracting firms which secure the jobs. The contracting firms referred here apply to firms that provide various services for the dredging works and the transportation of dredged materials to the designated fill area. This is particularly so when the number of workers to be employed for the two activities would be almost negligible; of around 15 persons or so, comprising skilled and semi-skilled dredger handlers and tugboat skippers employed by the contracting firms. As such, the locals would hardly be relevant in providing the manpower needed unless some unskilled labours are also needed as handy men to help around. However, should new workers be required, the locals should be given priority to make the Project relevant locally.

7.3.1.2 Livelihood

A direct impact of dredging is increased in turbidity due to suspended solids from the dislodged seabed materials. This would affect the waters of the surrounding areas, upstream and downstream as influenced by the direction of the sea current. As marine life has low tolerance of turbidity, most would migrate away or perish. Hence, this would affect the fishing activities of the local inshore fishermen and their landings. Dredging activities would indirectly affect the livelihood of the local inshore fishermen until the construction is completed. However, the majority would not be as affected since they go out to fish further away from the shore.

It is to be noted that the transportation of dredged materials to the designated offshore disposal area could become a potential source in damaging fishing nets and traps. This would affect and reduce the fish landings of the majority of the fishermen in the area and subsequently threaten their income.

The main socio-economic issue in the development of the proposed Project pertains to the economic pursuits of the locals, particularly the fishing communities which number approximately 1,100 people. Although the setting up of the Project would entail the creation of numerous economic opportunities, be they in new economic ventures or employment opportunities, the Project would also pose inconveniences to the local fishermen. This is especially so to the inshore fishermen toiling in the Zone A area, numbering at least 700, in disrupting their activities (access to sea and back to mooring area). Local marine life will be affected (although temporarily) and there might be possible damage to the fishermen's fishing gears. Such likely inconveniences were also expressed by the fishermen interviewed during the FGD and Public Dialogue. The resultant impacts would be the impairment of the livelihood of the local fishermen whereby there would be a reduction in the amount of fish and prawns landed, and subsequently the income earned for the day.

As such, the fishermen were of the opinion that they should be compensated for the inconveniences that they would likely be facing when the Project is under construction, or until such time when the environs are back to normal.

The deployment of 500 workers would slightly push up the current population size of the study area. Increased population size would bring about increased demand in basic goods and services. Those that would be in high demand include accommodation, prepared food services, convenient goods etc. The local business ventures in the nearby small townships such as Tanjung Lumpur, Tanjung Api and Peramu should grab this opportunity in improving their livelihood and income earned from such spin-off effect, thus making the development of the area surrounding them more relevant by indirectly taking part in its implementation.

By realizing and undertaking this source of potential spin-off benefits, the locals would stand to gain and would again be made to feel relevant in the development that is taking place around them. This is especially so for the enterprising operators in the surrounding area.

7.3.1.3 Safety

Safety is not the only consideration at the construction site but also at sea. As transportation of heavy machineries and construction materials to the site are to be done by sea, the additional marine traffic loads from the transportation of machineries and construction materials would make the marine traffic condition in the area stressful. This condition would be potentially hazardous to small boats that ply the area (such as fishing vessels for all the fishing zones from inshore to off-shore - the latter in sailing to and from their off-shore fishing grounds).

The navigation channel is also the main route taken by fishing boats to get in and out of Sungai Kuantan and the nearby Sungai Kuantan river mouth landing and berthing area. They would be faced with potential safety threats if any of the dredging activities untowardly get in their way.

7.3.1.4 Base Camp/Socio-Cultural

The 500 workers would have to be accommodated during the construction period. Assuming that local workers who would be living within commuting distance of the Project site do not stay in, and those of the managerial level and the engineers would be housed in accommodations available in nearby residential areas or the nearby Kuantan City, the majority of the workers would have to be accommodated on the landward side of the Project site. Thus, construction of the workers' camps would have to be undertaken first before construction work commences.

During occupation of the accommodation provided, crowding may occur not only on a per room basis but also in the overall arrangement of the lodging blocks which may tend to be close to one another. Such a situation may become a potential source of health, safety and fire hazards as mentioned earlier, especially when unhygienic and unsystematic living conditions are allowed to occur.

Another significant potential impact pertains to the socio-cultural makeup of the workers' racial mix. Malaysia is known to rely heavily on foreign workers in many of its economic sectors. It is not surprising if most of the employment opportunities created by the Project would rely on and be taken up by foreign workers. Again, the locals would have to be more alert and be ready to compete and fill up the opportunities created. Otherwise, they would become bystanders in the midst of the development of their area.

Accommodating and putting foreign workers or workers from other states of Malaysia together under the same roof or within the same workers' camp complex may have its repercussions. The presence of foreign workers, probably numbering up to several hundreds and coexisting alongside the locals, could disrupt the cultural and racial balance of the area, thus transforming the social makeup of the area into a more cosmopolitan entity.

Physical conflict could easily develop as a result of the differences in culture and subculture, values, attitude and tolerance level among the different ethnics and races. Putting the different cultures, values, attitude and tolerance level of the locals and aliens coexisting alongside each other, could and have been proven volatile, to erupt even with slight friction.

Other associated problems are those of social and health problems. Such view is normally based on the alleged increase in crimes and diseases unknown to the country or the reappearance of those which had long since been eradicated such as malaria and tuberculosis. Hence, care should be taken that their occurrence be avoided. Changes in the local crime rate are often associated with an influx of young male itinerant employees into the impact zone during construction.

The influx of young male workers would change the population age and sex structures of the study area. The current old age structure may be replaced with a matured one when the presence of the young in-migrant workers would cause a slight decrease in the percentage of the old age group.

With the current sex ratio of Mukim Kuala Kuantan being balanced with 105 M per 100 F, the presence of excessive young male workers would put the sex ratio of the area in the near future to being skewed with an excess of males. Such an imbalanced sex structure may cause social repercussions and abnormal sexual behaviour.

7.3.1.5 Tranquility and Aesthetics

Reclamation activities that constitute the construction of containment/revetment structures, transportation of sand from the burrow areas, placement of sand to the reclaimed area and platform stability works will create a scene of bustling activities and constant humming of machineries. Those staying nearby and also visitors would often find the area disturbing and no longer tranquil. This is especially so when there are several sensitive receptors are located nearby. They comprise a school, mosque and a rural clinic (*Photos 7.4 - 7.6*). The issues of noise pollution from the first phase of the Project currently under construction and its effect on the school and school children nearby had been raised in the recent Public Dialogue.

Photo 7.4 ►
SK Tanjung Lumpur

Photo 7.5 ►
Masjid Darul Hikmah, Tanjung Lumpur

Photo 7.6 ►
Rural Clinic, Tanjung Lumpur

Reclamation activities may also affect the aesthetics of the area, especially from fugitive dust during the dry period. Located by the coast, the dry surface would be exposed to the elements of the sea and with land breezes blowing up the surface dust. Although short-term in nature, it could be relatively serious if proper mitigation measures are not adopted. This is due to the site being located within the vicinity of existing local seafood eateries that are often frequented by locals as well as intra and inter-state tourists.

Also, dredging activities may tend to look unsightly, especially with the use of the Cutter Suction Dredger which would be floating and working at the site throughout the construction period. The surrounding waters would be murky and thus repulsive to onlookers. However, the visual impact is temporary while construction lasts.

The present natural panorama of the sea view fronting the coasts that stretch from Kampung Tanjung Lumpur where the KWRC Phase 1 is located to Kampung Anak Air where the KWRC Phase 2 ends would also be lost forever.

7.3.2 During Post-reclamation and Operational Phases

This topside development will be divided into several zones which are focused on providing facilities and services to the public. It comprises of the following components:

i) Tourism attraction and facilities;
ii) Commercial development;
iii) Residential development; and
iv) Education and health facilities.

It is envisaged that the main impacts during post-reclamation and operational phases would relate to socio-economy, safety and aesthetic.

7.3.2.1 Employment

A mixed development venture would undoubtedly generate direct employment opportunities for the different levels of skills required, i.e. from skilled to semi-skilled job opportunities in the various sectors of the development. At the peak of the development of the newly-reclaimed land, a labour force of 1,000 is expected to be employed. According to the Project Proponent, an estimated 5,000 employment opportunities are projected to be created during the operational phase.

The impact of the external labour would be different depending on the number moving or not moving into the locality and those who move with or without family. Either trend would have implications on changing population size, earnings spent in the locality and its contribution to additional local income.

7.3.2.2 Income and Revenue

Direct employment render direct income earned from the salary paid. This is a definite positive remuneration and contribution to additional local earnings and from those spent locally which would contribute to additional local income. However, the additional contribution would very much depend on the amount or proportion of earnings spent locally by the outside workers who may or may not move into the local area; either bringing in or not bringing in their family as mentioned above.

Workers who commute from the surrounding urban areas such as Kuantan would make little economic contribution to the local economy. So too would those moving in without their family. If the trend persists, i.e. not many moving into the locality, benefits to the local economy would not be significant. However, should the trend reverses, i.e. more moving into the local area and with their family which would be most probable when accommodation and other facilities, amenities and services are available and provided, the local area would tend to benefit most significantly.

Notwithstanding the above, the capital investment in the proposed Project will be significant to other related agencies. If the percentage of total expenditure on goods and services (excluding labour) that would be spent in the local area in purchasing local goods and services is significant, then the local economy would thrive.

There are also rates such as assessment rates, quit rent, fees and royalties to be paid and these would create net change in local authority receipts pointing to surpluses or higher returns. Other utilities and services providers for water supply and electricity would also tend to benefit from rates collection. Such revenues would stay for the duration of the proposed Project operation.

7.3.2.3 Demography, Housing and Other Services

The workforce involved in the operation of the proposed Project is likely to be drawn partly from local sources (within daily commuting distance of the Project site) and partly from farther afield or from an external source. In addition, the house buyers may take up residence in the area. The in-migrant workers and their families as well as the new house owners and their families will have several effects on the locality as the followings:

i) They will result in an increase in the population of the area and possibly changing the age, sex structure of the nearby local population as well as its nationality components;
ii) They will require accommodation or housing within reasonable commuting distance of the proposed Project site;
iii) They will place additional demands on a range of local services, including schools, health and recreational facilities, police and emergency services; and

iv) They will have financial implications for the local authorities in the area, with additional costs of service provision set against an increase in revenues.

7.3.2.4 Potential Socio-Cultural Impacts

In-migrant workforce and KWRC house residents and their respective families will have other social impacts which can be wide-ranging and may include:

i) Changes in the occupational and socio-economic mix of the area's population and the potential ensuing impacts of conflict relating to ethnic, social or cultural differences;
ii) Introduction of a new social group – the holiday makers;
iii) Problems of integration among the incoming house buyers and workforce and families in the Project area and into the local community and community activities; and
iv) Clash of lifestyles or expectations between incomers and with the local community/Tanjung Lumpur residents (as detailed out in *Section 7.3.2.5*).

With a new population (20,000 to 25,000 population) size living in the area, the magnitude of the social impacts could be enormous. They (including foreigners) may likely be of multiple social, economic and cultural background, staying and living alongside each other as well as the host society.

Likewise, non-participation of the host communities would tend to make them feel marginalised and alienated.

7.3.2.5 Lifestyle

The implementation and completion of the KWRC development would have a lot to offer to the population at large in terms of the generation of wide opportunities in job opportunities in commercial and services industries.

The impacts of participating and non-participating in the everyday doings and daily happenings in the area surrounding the KWRC and in the outlaying area of Tanjung Lumpur would undoubtedly affect the social life and the lifestyle of the population in both the KWRC development and the surrounding areas, which could be voluntary or otherwise. This is because the surrounding social and technical systems can constrain the lifestyle choices available to the individual and the symbols she or he is able to project to others and the self.

However, it is the consumption behaviour that becomes the cornerstone of lifestyle construction in modern living which offers the possibility to create and further individualize the self with different products or services that signal different ways of life. This would in turn relate to the social environment one is living in. The former, which includes the individual living and working conditions, educational background and income level, plays an important role in creating expectations, such as success and wanting the best, for one's self or from those around. It is how one reacts, adopts or adapts to the lifestyle choices available which determines the kind of lifestyle one is projecting.

It is envisaged that there would be a creation of a bipolar society – the well-to-dos (among the salaried workers) and the not-so-well-to-dos (generally among non-salaried workers) between the KWRC development area and the surrounding area. It is also envisaged that different lifestyles would also appear within the KWRC development area itself where development has a ready creation of a mixed development of not only physical in nature but for different social levels too. As long as the different entities of development or the outcome of development co-exist harmoniously along each other, social stability will remain.

Nevertheless, it is more often than not that life in such an environment would somehow create a lot of stress to the inhabitants, which finally depends on how well one copes with this. Those who cope well would co-exist but those who fail would tend to feel being marginalised.

7.4 Residual Impacts

Residual impacts refer to the net environmental impacts after proper mitigation measures have been implemented. All residual impacts (if any) will be notified and alternatives to manage these impacts shall also be proposed accordingly. This is to ensure maximum beneficial environmental effect and that all residual impacts are within the statutory and non-statutory permissible levels. It can be envisaged that the remaining impacts would be as follows:

i) Erosion and sedimentation;
ii) Increasing marine traffic;
iii) Increasing land traffic;
iv) Changes in viewscape; and
v) Impact on socio-economy.

7.4.1 Erosion and Sedimentation

The land reclamation and dredging activities primarily affects the area within the direct vicinity of the Project area. Erosion is predicted to occur along 3 km upstream of the river, along about 1 km of the coastline south of the Project site, bridge piers and tip of the southeastern end of the development. Sedimentation is anticipated to occur at upstream of the navigation channel and at marina entrance of the proposed KWRC for full development. The summary of the anticipated sedimentation and erosion occurring within the Project site are presented in *Table 7.17*.

Table 7.17 ► Summary of the Anticipated Sedimentation Rate around the Fully Reclaimed KWRC

Point	Location	Average Bed Level Change (m/year)
		Full Development
B	Hutan Rizab Paya Laut Kuantan	-0.1
C1	Tanjung Lumpur bridge (northern pier)	-0.1
H	Tanjung Lumpur sandflat	-0.1
I	Navigation channel (upstream)	1.2
L	Southeastern end of development	-0.5
M	Marina entrance	0.6

Notes: positive means sedimentation and negative means erosion

7.4.2 Increasing Marine Traffic

Once the cruise terminal and marina is fully operated, the facilities able to berth two (2) mega cruise concurrently. The Project also offers yacht club facilities to attract local and international mariners. This will result in an increase of marine traffic within the waters of Kuantan. Hence, there is a possible risk of marine accidents between passenger ship as well as local fishermen plying within the area. However, navigational aids will be established upon approval from relevant authorities i.e. Malaysia Marine Department and Kuantan Port Authority.

7.4.3 Increasing Land Traffic

The development of KWRC includes the improvement of land traffic facilities including upgrading the Jalan Kampung Tanjung Lumpur, widening the Jalan Yayasan Pahang, provide bus terminal and create safe and comfortable walking environment to motivate the public to walk. Nevertheless, there will still be a possibility of an increase in traffic, especially during morning and evening peak hours, due to the additional population within the area.

7.4.4 Changes in Viewscape

Seaward view facing the reclaimed land will be changed. In terms of aesthetic, the view provided by the new islands is a subjective one. However, with a well-planned and landscaped development, the land will offer a new panorama where the sea is still prominent, complementing the current viewscapes.

7.4.5 Impact on Socio-economy

As the reclamation is to be carried out in phases, the manpower requirements will be in the range of 500 workers during the peak of the reclamation works. The requirement of hundred workers will boost the local labour market or employment opportunities. This will lead to a boost in the local economy, thus improving the economic standing of the locals.

Although the setting up of the Project would entail the creation of numerous economic opportunities, it would pose inconveniences to the local fishermen. This is especially so to the inshore fishermen toiling in the Zone A area, numbering at least 700, in disrupting their activities (access to sea and back to mooring area), affecting local marine life (although temporarily) and possibly damaging their fishing gears. As such, the fishermen were of the opinion that they should be compensated for the inconveniences that they would likely be facing.

7.5 Environmental Assessment Matrix

An environmental assessment matrix of the potential impacts based on the Project activities are presented in *Table 7.18* whereas *Table 7.19* tabulates potential impacts at ESAs and around the Project area.

Table 7.18 ► Environmental Assessment Matrix for Impacts According to Project Activities

No.	Environmental Components	Possible Impacts	Project Activities												Operation and Maintenance					
			Pre-construction survey	Land clearing	Installation of boundary marker buo	Installation of silt curtains	Transportation of rock/granite	Construction of perimeter rock bund	Dredging	Transportation of fill materials	Placement of fill material	Sand levelling	Soil treatment	Construction of coastal protection structures	Wastewater treatment facilities	Solid waste generation	Obstruction of sea view	Infrastructure and utilities	Land traffic	Marine traffic
1	Physical -Chemical	Bathymetry	X	X	X	X	X	T	T	X	D	X	X	X	X	X	X	X	X	X
		Geotechnical stability	X	X	X	X	X	X	D	X	X	X	X	X	X	X	X	X	X	X
		Water quality	X	X	X	X	M	X	M	M	M	X	X	X	D	M	X	X	X	M
		Marine traffic & navigation safety	X	X	T	T	M	T	M	T	M	X	X	X	X	X	X	X	X	D
		Land traffic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	D	X
		Air quality	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	T	X
		Noise	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	T	X
2	Biological	Diversity of benthic community	X	X	X	X	X	T	T	X	T	X	X	X	X	X	X	X	X	X
		Fisheries population	X	X	X	X	X	T	T	X	T	X	X	X	X	X	X	X	X	X
		Diversity of fauna (birds)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Terrestrial fauna	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Coastal mangroves	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	Socio-economy	Labour requirements	D	D	D	D	D	D	D	D	D	D	D	D	D	X	X	X	X	X
		Livelihood (locals)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	D	X	X	X
		Livelihood (fishermen)	X	X	X	X	D	D	D	D	X	X	X	X	X	X	X	X	X	D
		Safety of fishermen	X	X	X	D	D	D	D	D	X	X	X	X	X	X	X	X	X	X
		Socio-cultural	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Tranquillity and aesthetics	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Key:

X Insignificant and excluded from matrix
T Impact that is potentially but on a temporary basis and will ensure equilibrium after certain period of time.
M Impact that is potentially significant but about which there is insufficient data to make a reliable prediction. Close monitoring and control is recommended.
D Potentially significant adverse impact for which a design solution has been identified.
R Residual and significant adverse impact
E Significant environmental enhancement

Table 7.19 ► Environmental Assessment Matrix for Impacts at ESAs and Around the Project Area

Location	Hydraulic Assessment					
	Sediment Dispersion		Current Speed	Waves	Sedimentation and Erosion	
	Option 1	Option 2			Cohesive Sediments	Non-cohesive Sediments
Kuantan Forest Reserve	T	T	X	X	X	X
Hutan Rizab Paya Laut Kuantan	T	T	X	X	X	X
Tanjung Lumpur Bridge (northern pier)	T	T	X	X	X	X
Tanjung Lumpur Bridge (southern pier)	T	T	X	X	X	X
Pantai Tanjung Sisek	T	T	X	X	X	X
Kuantan Tembeling Resort	T	T	X	X	X	X
Teluk Cempedak	T	T	X	X	X	X
Beserah Forest Reserve	T	T	X	X	X	X
Tanjung Lumpur sandflat	T	T	X	X	X	X
Navigation channel (upstream)	T	T	X	X	D	D
Navigation channel (midstream)	T	T	X	X	X	X
Navigation channel (downstream)	T	T	X	X	X	X
Southeastern end of development	T	T	X	X	X	D
Marina entrance	T	T	X	X	X	D

Key:
- X Insignificant and excluded from matrix
- T Impact that is potentially significant but on a temporary basis and will ensure equilibrium after certain period of time.
- M Impact that is potentially significant but about which there is insufficient data to make a reliable prediction. Close monitoring and control is recommended.
- D Potentially significant adverse impact for which a design solution has been identified.
- R Residual and significant adverse impact
- E Significant environmental enhancement

7.6 Economic Valuation of Environmental Impacts

It is common for any proposed development of this nature will have some of the negative impacts that cannot be completely mitigated, thus justifying the need to quantify and, to the extent possible in monetary terms, the degradation in services obtainable from the disturbed natural environment. Such valuation serves to demonstrate the significance of the environmental values of the services, thus providing some measure of trade-off that will be incurred if the Project were to be implemented. The flows of environmental services that will be foregone following project implementation are real economic loss to different stakeholders and hence must be quantified so that informed decisions can be made. The valuation process is facilitated by recent progress in the methods and protocol of environmental resources evaluation that allow for the computation of reliable monetary estimates of the value of losses in environmental services.

This section outlines the methodology and presents the results of the economic valuation of the environmental impacts of the Project. The aim is to quantify the gains and losses in environmental services that can be attributed to the Project.

7.6.1 Objective

The objective of the economic valuation is to quantify and monetize the impacts of the Project on the flow of environmental services. This requires valuation in monetary terms of the changes (both negative and positive if any) in environmental services arising from project implementation over an assessment period of 50 years.

7.6.2 Methodology

A critical step in the valuation process revolves around the need to ensure valid attribution of impacts on environmental services to the Project. In order to satisfy this requirement, physical environmental impacts that can reasonably be attributable to the Project must first be demonstrated. In other words, the approach requires the establishment of a clear link between project impacts on the physical functions of the environment and the alteration of the quality and quantity of streams of environmental goods and services. The Guidelines on the Environmental Economic Valuation Impacts for EIA projects are very clear in this regard where they specify that:

"… a key issue is to identify and quantify the changes in the flow of goods and services produced by the environment which are impacted by a development project, and then to monetize these changes into costs or benefits".[1]

[1] Guidelines on the Economic Valuation of the Environmental Impacts for EIA Projects, Department of Environment, pg. 7, 2008.

The valuation process can be divided into nine distinct steps, as follows:

- *Step 1: Identify the project stakeholders.*
  The stakeholders are determined by establishing clear links between the degradation in environmental services to the impacted parties.

- *Step 2: Define the "with Project" and "without Project" scenario.*
  A contrast is considered under the "with" and "without" Project scenarios, as opposed to "before" and "after" scenarios. It involves the conceptualization of the "with" and "without" project scenarios. For the current project under evaluation, the "with Project" scenario is defined as the situation where the project is implemented that entails reclamation works, and the construction and operation of the proposed mixed development. The "without Project" scenario is depicted as the situation in which the proposed project is not implemented, i.e. maintenance of the status quo.

- *Step 3: Describe the physical impacts.*
  A listing of potential physical impacts of the project that can be reliably attributed to the project is prepared and described by focusing on the physical extent of the impact and the link between the project and its impact on the flow of environmental services.

- *Step 4: Quantify the impacts on the environment over the duration of the project.*
  The physical impacts of the project on the environment is explained and quantified via scientific assessments of the study team that include among others marine biologists, air and water quality specialists, and hydraulic specialists.

- *Step 5: Monetize the impacts.*
  The quantified impacts produced in Step 4 are monetized using market and non-market valuation techniques. Value parameters of similar environmental services obtained in other studies are used as reference points for evaluation.

- *Step 6: Discounting.*
  Costs and benefits over time (50 years) are discounted to present values using several discount rates (4%, 6% and 8%). Fifty years are typically used as the standard period of evaluation since the present value of future benefits/costs beyond 50 years tend to become quantitatively insignificant.

- *Step 7: Determine the Net Present Value.*
  The net present value is computed in this step by adding up the discounted values of the losses and gains in environmental services.

- *Step 8: Perform sensitivity analysis.*
  Sensitivity test is conducted for different discount rates to demonstrate the impact of variation in discount rates on the net present value of the environmental costs and benefits.

- *Step 9: Make a recommendation.*
  An overall assessment is made based on the magnitude of Net Present Values at different levels of discount rates.

7.6.3 Identification of Change in Environmental Services

As indicated earlier, only marginal impacts on environmental services (losses or gains) are considered in the analysis. This is to ensure that only changes in environmental services as a result of selecting the “with Project” option, and not the “without Project” option are made part of the evaluation.

Table 7.20 shows the environmental services that may change as a result of project implementation. The table describes the kind and spatial extent of the impacts as well as their respective locations. From among these potential impacts, mitigation measures are considered, and only those that are seen to be significant are evaluated in this study.

7.6.4 Valuation of Significant Change in Environmental Services

Of the eight (8) potential changes in environmental services as listed in *Table 7.20*, three (3) are considered to be significant enough for evaluation. These are:

i) Loss of mudflat due to reclamation;
ii) Loss of mudflat due to capital and maintenance dredging; and
iii) Loss of fishing ground access to sea (higher cost of fishing effort).

The other impacts are considered minimal following the implementation of mitigation measures. The nature of losses in environmental services for each of the impact is described and evaluated in the following sub-sections.

7.6.4.1 Loss of Mudflat due to Reclamation

Reclamation will result in permanent loss of the mudflat. The loss of mudflat will result in some reduction in the amount of resources important to support marine life. The total area that will be affected (i.e. part of the reclaimed area) is 156.2 hectares.

Mudflat provides habitat for some fisheries resources like cockles, bivalves and gastropods/snails and shrimps. In addition, sediment communities play a critical role in the food chain for both marine organisms as well as shorebird populations (Chong *et al.*, 1990). Sediment communities are crucially important food source for marine fish and shorebirds (Erftemeyer *et al.*, 1989; Sasekumar, 1984; Sasekumar *et al.*, 1984).

Past valuation studies have tended to use average nationwide average productivity as a basis for valuing the loss of environmental services produced by mudflats. The use of this approach is understandable because local studies are typically non-existent. This study initially uses such an approach, but subsequently makes some adjustments to the values to better reflect local conditions.

Table 7.20 ► Environmental Services Potentially Affected by the Proposed Project

No.	Environmental Components	Environmental Services Affected	Location and Impacted Individuals/Communities	Spatial Extent	Remarks
1.	**Marine biology** - Loss of **mudflat** due to **reclamation**.	Permanent loss is expected for the entire mudflat making up the footprint of the reclamation site. This mudflat serves as crustacean feeding ground and macrobenthos habitat. This activity will result in some loss in the amount of resources important to support marine life since such area serves as habitat for benthos and feeding ground for fishes.	The exact location of the reclamation boundary is shown in *Chapter 5* (*Figure 5.5*) of this EIA report. Fishermen and local communities deriving benefits from the marine resources will likely be impacted.	A total of 273.57 hectares will be reclaimed. A significant part of this area (approximately 156.2 hectares) is mudflat that will be lost, as shown in *Figure 7.46*.	Total loss of mudflat. The productivity loss method is used to evaluate the loss in environmental services and functions.
2.	**Marine biology** - Loss of **mudflat** due to **capital and maintenance dredging**.	Temporary loss is expected for the entire would-be-dredged mudflat. This mudflat serves as crustacean feeding ground and macrobenthos habitat. The dredging activity will result in some loss in the amount of resources important to support marine life since such area serves as habitat for benthos and feeding ground for fishes.	The exact locations of the reclamation and dredging boundaries are shown in *Chapter 5* (*Figures 5.5* and *5.7* respectively) of this EIA report. Generally, the mudflat is located at the navigation channel, lagoon, canal, inner marina, outer marina, cruise terminal and turning basin. Fishermen and local communities deriving benefits from the marine resources will likely be impacted.	Although 845 hectares will be dredged, the area involving mudflat is approximately 80.8 hectares as depicted in *Figure 7.46*.	Initial loss of mudflat habitat during dredging work. The hydraulic modelling results indicate that the frequency of dredging required is about once a year. Marine organisms are not expected to recover fully during the intervening period between dredging works. A three-year full-recovery period is assumed, suggesting an average productivity of about one-sixth for the year following dredging work. However, because of the frequency of dredging and hence frequent/repeated disruptions to the mudflat habitat, the loss in environmental services is considered total and permanent. The productivity loss method is used to evaluate the loss in environmental services and functions.
3.	**Terrestrial biology** - Potential reduction in environmental services obtainable from **mangrove** area due to sedimentation and erosion.	Loss of mangrove area, thus resulting in some loss in the amount of resources important to support marine life. Mangrove areas are known to provide environmental services including: ▪ Production of charcoal and poles; ▪ Provision of feeding and breeding grounds for shrimp, fish, crab and mollusc; ▪ Provision of traditional goods; ▪ Carbon sequestration function; ▪ Shoreline protection; and ▪ Option, existence and biodiversity value.	Kuantan mangrove forest on the southern bank of Sungai Kuantan. Fishermen and local communities deriving benefits from the marine resources as well as the general population that benefit from carbon sequestration function will likely be impacted.	Results of hydraulic modelling show that the impact due to sedimentation and erosion is negligible or undetectable.	Since no impact is expected, no valuation is necessary.
4.	**Socio-economy** - Loss of **fishing ground** and hindrance of access to the sea.	Reduction in the size of fishing ground because part of the sea will be reclaimed. The reclamation will force the fishermen to find alternative fishing ground/s, potentially increasing their operational cost. The reclaimed land mass and terminal will also hinder direct movements of coastal fishing vessels. Thus some fishermen will incur additional cost when going to and coming back from the fishing ground.	The reclaimed area is as stated in the *Chapter 5* (*Section 5.3.2*) of this EIA report. The directly affected stakeholders are the coastal (Zone A) fishermen operating from six jetties identified in the study area namely, Kampung Tanjung Lumpur, Kampung Tanjung Api, Kampung Peramu, Kampung Selamat, Kampung Anak Air and Kampung Kempadang. Fishermen in these areas operate around 110 vessels.	All of the reclaimed area.	Fishermen who routinely fish in the affected area will have to find other locations. The additional cost of fishing involves the increase in cost of travelling to and from the alternative fishing ground. They may have to travel further away because conflict may arise as they are encroaching into traditional fishing grounds of existing fishermen.

Table 7.20 *(cont'd)* ► Environmental Services Potentially Affected by the Proposed Project

No.	Environmental Components	Environmental Services Affected	Location and Impacted Individuals/Communities	Spatial Extent	Remarks
5.	**Water quality**	An increase in suspended TSS during reclamation and dredging works that reduces the quality and therefore productivity of marine habitat.	Coastal waters around reclaimed land and the dredging work area.	With the installation of silt curtain during reclamation and dredging, the extent of impact is confined to the narrow strip between the silt curtain and the perimeter bund (in the case of reclamation) and the confined dredging work area that will be done in stages.	Mitigating measures through the installation of silt curtain during reclamation and dredging works will render the impact insignificant. Pelagic and demersal fish will be able to avoid unfavourable conditions. No valuation is therefore necessary. However, please refer to the impacts of dredging and reclamation works on marine biology.
6.	**Coastal morphology**	Erosion and sedimentation due to the introduction of reclaimed land to the existing coastal area.	Hydraulic modelling results show that erosion and sedimentation impacts occur mostly within the proposed project site such as the navigation channel, lagoon and marina area. Outside of the project site, sedimentation of 1.2m/year is expected in front of the river mouth of Sungai Kuantan and erosion along a 1km coastal area immediately south of the project site.	The bed level changes induced by the various development scenarios are localized in or within the immediate vicinity of the project area.	Sedimentation at the river mouth of Sungai Kuantan will be mitigated through annual maintenance dredging of the navigation channel. The expected erosion of the 1 km coastal zone will be mitigated by implementing a beach nourishment programme as proposed in *Chapter 8* (*Figure 8.24*). No valuation is therefore necessary.
7.	**Recreational services**	Impact on certain areas that reduces the value of recreational services.	Potential areas that may be impacted include Teluk Cempedak (a nationally-known recreational beach) and the lesser-known Tanjung Tembeling (where a resort is located). Visitors who benefit from the recreational services are the directly impacted stakeholders.	The beach areas of Teluk Cempedak and Tanjung Tembeling.	The hydraulic modelling results showed that the two areas will not be impacted by an increase in suspended sediment, potential erosion or accretion. No valuation is therefore necessary.
8.	**Aesthetics**	Change in the form of **intrusion** of man-made structures into the **view scape** following project completion.	Areas surrounding the reclaimed land. Coastal villagers and visitors to where the newly reclaimed land is visible will likely be impacted. As will fishermen plying close by, who will see the reclaimed land and built infrastructure.	The shore area where the reclaimed land plus built structures are visible.	The direction of impact of the project on aesthetics is uncertain since it is hard to argue with certainty that the project will give rise to negative impact on the general aesthetics of the area. It will not be surprising if some people may even consider the project, once completed, to actually enhance the aesthetic quality of the area.

Sassekumar *et al.* (1998) produced an estimate of the cockle production value for mudflats of Peninsular Malaysia in a study conducted in 1995. The said study estimated the total gross value of production at US$26.4 million. The same study also estimated the values of production for bivalves, gastropods/snails, shrimps, and fish at US$17.6 million, US$0.3 million, US$2.9 million and US$2.2 million respectively. The values were obtained by multiplying the estimated quantity of production by the unit prices of US$2,600/ton (bivalves), US$600/ton (gastropods/snails), and US$200/ton (shrimp and fish). To arrive at the net value of production the researchers then applied the net revenue factor of 60% for cockles and bivalves, 30% for gastropods/snails and shrimps, and 25% for fish.

The total size of mudflats in Peninsular Malaysia is estimated at 35,064 hectares. Dividing the estimates on the annual value of the production of cockles, bivalves, gastropods/snails, shrimps and fish by the total size of mudflats, the estimated environmental service of mudflats in the form of direct use value (adjusted for price increase at the rate of 4% per year) is as provided in *Table 7.21*. The direct use value for mudflat is therefore estimated at RM 7,260.49/hectare per year.

Table 7.21 ► Estimated Average Loss in Environmental Services (per hectare per year) from Mudflat by Service Type

	Environmental Services (Production)	Unit Value (RM per hectare per year)
Direct Use Value	Cockles	4,113.10
	Bivalves	2,751.36
	Gastropods/snails	26.90
	Shrimps	226.16
	Fish	142.98
	Total	**7,260.49**

Confirmatory site visit indicates that not all components of valuation presented in *Table 7.21* are relevant to the site. In particular, gastropods/snails are minimal at the proposed site. Hence, the relevant components of valuation are cockles, bi-valves, shrimps and fish. The adjusted loss in environmental services from mudflat is therefore RM 7,233.59/hectare/year.

The annual value of environmental services forgone from the loss of mudflat is obtained by multiplying the size of the affected area (156.2 hectares) by the estimated value of environmental service produced per hectare (i.e. RM 7,233.59/hectare/year).

7.6.4.2 Loss of Mudflat due to Capital and Maintenance Dredging

Loss of mudflat due to dredging works (capital and maintenance dredging) will take place in the navigation channel, lagoon, canal, inner marina, outer marina, cruise terminal and turning basin. The estimated size of mudflat affected is 80.8 hectares from a total of 845 hectares that will be dredged.

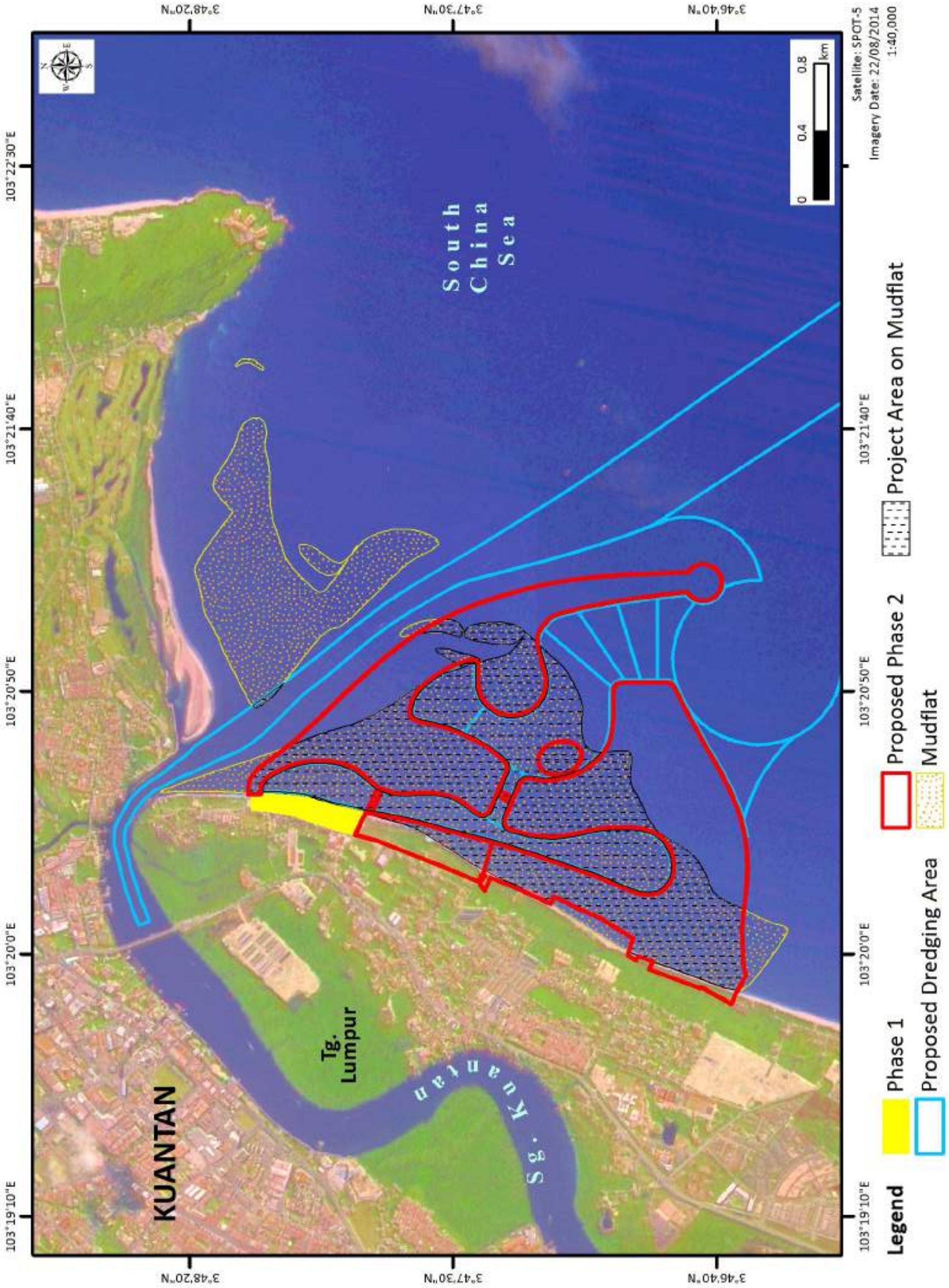


Figure 7.46 ► Project Activities Involving Mudflat Area

Because of the relatively high sedimentation rate, periodic maintenance dredging is expected to be conducted about once a year.

The benthic communities are known to recover after dredging work. A three (3)-year impact period on the benthic communities is typically assumed for each dredging exercise, which is the time required for the seabed life to recover. Hence, one possible way of computing the loss is by assuming that the benthic communities recover at a constant rate throughout each dredging cycle. A three-year full-recovery period implies an average productivity of about one-sixth for the year following dredging work since marine organisms are not expected to recover fully during the intervening period between dredging works.

However in this study, because of the frequency of dredging and hence frequent/repeated disruptions to the mudflat habitat, the loss in environmental services is considered total and permanent. The benefit from recovery is deemed minimal since the habitat will be frequently disrupted.

The estimation of the environmental services lost due to dredging work follows the method used in determining the loss of mudflat due to reclamation. After adjusting for the general increase in price level, the value of cockle, bivalves, shrimp and fish production of mudflats is estimated at RM 7,233.59/hectare per year. Although some recovery can be expected in-between the dredging cycles, the loss is considered total and permanent. This method implies that the loss of RM 7,233.59/hectare accrues annually over the evaluation period.

7.6.4.3 Loss of Fishing Ground and Increase in Fuel Cost for Fishermen

Based on *Table 7.22*, a total of 110 fibre-glass fishing boats operate regularly within the zone to be reclaimed. More specifically, the area to be reclaimed is used by local fishermen as their route to the fishing grounds. Fishing takes place by day and by night, and at various stages of the tide. The fishermen will be directly impacted because the would-be reclaimed area is part of their regular route to fishing grounds, and they will have to travel longer distances to alternative fishing grounds. They can only do so at a higher cost since they will have to travel further to these areas, with the added difficulty of encroaching into the traditional fishing grounds of existing fishermen.

This study notes that in estimating the impact of reclamation, double counting the loss in catch due to a reduction in fish feeding ground must be avoided since it is already captured in the computation of the loss of seabed habitat.

Table 7.22 ► Number of Fibre-glass Fishing Boats Operating within the Project Zone

Location	Number of Fibre-glass Fishing Boats
Tanjung Lumpur	35
Tanjung Api & Kampung Selamat	10
Kampung Peramu	10
Kampung Anak Air	15
Kampung Kempadang	40
Total	**110**

Source: Kuantan Fishermen Association, 2016

It is determined that the fishermen generally use outboard engines ranging from 15 to 60 horsepower which are the most popular. A significantly smaller proportion of fishermen use bigger-horsepower engines. The corresponding estimated fuel usage per day is 15 litres to 60 litres per trip depending on engine horsepower. A litre of subsidized petrol costs the fishermen RM 1.00. However, for economic valuation the true resource cost as reflected by unsubsidized market price should be used. For this study, a market price of RM 2.00 per litre is applied to determine the fuel cost.

In order to assess the likely increase in the cost of fuel as a result of the reclamation, the following assumptions are employed:

i) The average number of fishing days is 17 trips in a month. This figure is derived from the survey conducted of the fishermen;
ii) The proportions of boats belonging to the 15, 30 and 60 horsepower categories are approximately 20%, 30% and 50% respectively. This is based on observations made at the jetties; and
iii) The additional fuel cost for trips to alternative fishing grounds is assumed to be 25% higher than the current cost.

The additional fuel cost per month can then be computed for each engine size as:

= Fuel in litres/trip x RM 2.00/litre x 17 trips x 25%

The additional cost for each type of engine is then aggregated over all engine sizes to arrive at the total increase in fuel cost. Note that a 25% increase is assumed since the fishermen may have to increase their fishing effort substantially because of the fact that encroaching on the traditional fishing grounds of other fishermen could give rise to conflict. This situation may necessitate the affected fishermen to travel ever further.

The discounted sum of increase in fuel cost for the fishermen due to the Project over the next 50 years is provided in *Tables 7.23* to *7.25*.

Table 7.23 ► Estimates of the Discounted Environmental Loss (Discount Rate = 8%)

Year	Loss of Mudflat (Reclamation)	Loss of Mudflat (Dredging)	Loss of Fishing Ground - Additional Fuel Cost	Discounted Loss
0	1,129,888	584,474	471,240	2,185,602
1	1,046,192	541,180	436,333	2,023,706
2	968,696	501,093	404,012	1,873,801
3	896,941	463,975	374,086	1,735,001
4	830,501	429,606	346,375	1,606,483
5	768,982	397,784	320,718	1,487,484
6	712,021	368,318	296,961	1,377,300
7	659,279	341,035	274,964	1,275,278
8	610,443	315,773	254,596	1,180,813
9	565,225	292,383	235,737	1,093,345
10	523,357	270,725	218,275	1,012,357
11	484,589	250,671	202,107	937,367
12	448,694	232,103	187,136	867,933
13	415,457	214,910	173,274	803,641
14	384,683	198,991	160,439	744,112
15	356,188	184,251	148,555	688,993
16	329,803	170,603	137,550	637,956
17	305,374	157,965	127,362	590,700
18	282,753	146,264	117,927	546,945
19	261,809	135,430	109,192	506,430
20	242,415	125,398	101,104	468,917
21	224,459	116,109	93,615	434,182
22	207,832	107,509	86,680	402,021
23	192,437	99,545	80,259	372,241
24	178,183	92,171	74,314	344,668
25	164,984	85,344	68,809	319,137
26	152,763	79,022	63,712	295,497
27	141,447	73,168	58,993	273,609
28	130,969	67,749	54,623	253,341
29	121,268	62,730	50,577	234,575
30	112,285	58,084	46,831	217,199
31	103,968	53,781	43,362	201,110
32	96,266	49,797	40,150	186,213
33	89,136	46,109	37,176	172,420
34	82,533	42,693	34,422	159,648
35	76,419	39,531	31,872	147,822
36	70,759	36,602	29,511	136,872
37	65,517	33,891	27,325	126,734
38	60,664	31,381	25,301	117,346
39	56,171	29,056	23,427	108,654
40	52,010	26,904	21,692	100,605
41	48,157	24,911	20,085	93,153
42	44,590	23,066	18,597	86,253

Table 7.23 *(cont'd)* ► Estimates of the Discounted Environmental Loss (Discount Rate = 8%)

Year	Loss of Mudflat (Reclamation)	Loss of Mudflat (Dredging)	Loss of Fishing Ground - Additional Fuel Cost	Discounted Loss
43	41,287	21,357	17,220	79,864
44	38,229	19,775	15,944	73,948
45	35,397	18,310	14,763	68,470
46	32,775	16,954	13,669	63,398
47	30,347	15,698	12,657	58,702
48	28,099	14,535	11,719	54,354
49	26,018	13,459	10,851	50,328
Total	**14,928,259**	**7,722,172**	**6,226,100**	**28,876,531**

Table 7.24 ► Estimates of the Discounted Environmental Loss (Discount Rate = 6%)

Year	Loss of Mudflat (Reclamation)	Loss of Mudflat (Dredging)	Loss of Fishing Ground - Additional Fuel Cost	Discounted Loss
0	1,129,888	584,474	471,240	2,185,602
1	1,065,932	551,391	444,566	2,061,889
2	1,005,596	520,180	419,402	1,945,178
3	948,675	490,736	395,662	1,835,074
4	894,977	462,959	373,266	1,731,202
5	844,318	436,753	352,138	1,633,209
6	796,526	412,031	332,206	1,540,763
7	751,440	388,709	313,402	1,453,550
8	708,905	366,707	295,662	1,371,274
9	668,779	345,950	278,926	1,293,654
10	630,923	326,367	263,138	1,220,429
11	595,211	307,894	248,243	1,151,348
12	561,519	290,466	234,192	1,086,177
13	529,735	274,024	220,936	1,024,696
14	499,750	258,514	208,430	966,694
15	471,463	243,881	196,632	911,975
16	444,776	230,076	185,502	860,354
17	419,600	217,053	175,002	811,655
18	395,849	204,767	165,096	765,712
19	373,443	193,176	155,751	722,370
20	352,304	182,242	146,935	681,481
21	332,363	171,926	138,618	642,907
22	313,550	162,195	130,772	606,516
23	295,801	153,014	123,369	572,185
24	279,058	144,353	116,386	539,797
25	263,262	136,182	109,798	509,242
26	248,361	128,473	103,583	480,417
27	234,302	121,201	97,720	453,224
28	221,040	114,341	92,189	427,570
29	208,528	107,869	86,971	403,368

Table 7.24 *(cont'd)* ► Estimates of the Discounted Environmental Loss (Discount Rate = 6%)

Year	Loss of Mudflat (Reclamation)	Loss of Mudflat (Dredging)	Loss of Fishing Ground - Additional Fuel Cost	Discounted Loss
30	196,725	101,763	82,048	380,535
31	185,589	96,003	77,403	358,996
32	175,084	90,569	73,022	338,675
33	165,174	85,442	68,889	319,505
34	155,825	80,606	64,989	301,420
35	147,004	76,043	61,311	284,358
36	138,683	71,739	57,840	268,262
37	130,833	67,678	54,566	253,078
38	123,428	63,847	51,478	238,753
39	116,441	60,233	48,564	225,238
40	109,850	56,824	45,815	212,489
41	103,632	53,607	43,222	200,461
42	97,766	50,573	40,775	189,114
43	92,232	47,710	38,467	178,410
44	87,012	45,010	36,290	168,311
45	82,086	42,462	34,236	158,784
46	77,440	40,059	32,298	149,796
47	73,057	37,791	30,470	141,317
48	68,921	35,652	28,745	133,318
49	65,020	33,634	27,118	125,772
Total	**18,877,678**	**9,765,150**	**7,873,276**	**36,516,103**

Table 7.25 ► Estimates of the Discounted Environmental Loss (Discount Rate = 4%)

Year	Loss of Mudflat (Reclamation)	Loss of Mudflat (Dredging)	Loss of Fishing Ground - Additional Fuel Cost	Discounted Loss
0	1,129,888	584,474	471,240	2,185,602
1	1,086,430	561,995	453,115	2,101,540
2	1,044,645	540,380	435,688	2,020,712
3	1,004,466	519,596	418,931	1,942,992
4	965,833	499,611	402,818	1,868,262
5	928,685	480,395	387,325	1,796,406
6	892,967	461,919	372,428	1,727,313
7	858,622	444,153	358,104	1,660,878
8	825,598	427,070	344,330	1,596,998
9	793,844	410,644	331,087	1,535,575
10	763,312	394,850	318,353	1,476,514
11	733,953	379,663	306,109	1,419,725
12	705,724	365,061	294,335	1,365,121
13	678,581	351,020	283,015	1,312,616
14	652,482	337,519	272,129	1,262,131
15	627,386	324,538	261,663	1,213,587

Table 7.25 *(cont'd)* ► Estimates of the Discounted Environmental Loss (Discount Rate = 4%)

Year	Loss of Mudflat (Reclamation)	Loss of Mudflat (Dredging)	Loss of Fishing Ground - Additional Fuel Cost	Discounted Loss
16	603,256	312,056	251,599	1,166,911
17	580,054	300,054	241,922	1,122,030
18	557,744	288,513	232,617	1,078,875
19	536,293	277,416	223,670	1,037,379
20	515,666	266,747	215,068	997,480
21	495,833	256,487	206,796	959,116
22	476,762	246,622	198,842	922,227
23	458,425	237,137	191,194	886,756
24	440,793	228,016	183,841	852,650
25	423,840	219,246	176,770	819,856
26	407,538	210,814	169,971	788,323
27	391,864	202,705	163,434	758,003
28	376,792	194,909	157,148	728,849
29	362,300	187,413	151,104	700,816
30	348,365	180,204	145,292	673,862
31	334,967	173,273	139,704	647,944
32	322,083	166,609	134,331	623,023
33	309,696	160,201	129,164	599,061
34	297,784	154,039	124,196	576,020
35	286,331	148,115	119,420	553,865
36	275,318	142,418	114,826	532,563
37	264,729	136,941	110,410	512,080
38	254,547	131,674	106,164	492,384
39	244,757	126,609	102,080	473,446
40	235,343	121,740	98,154	455,237
41	226,292	117,057	94,379	437,728
42	217,588	112,555	90,749	420,892
43	209,219	108,226	87,259	404,704
44	201,172	104,064	83,903	389,138
45	193,435	100,061	80,676	374,172
46	185,995	96,213	77,573	359,780
47	178,841	92,512	74,589	345,943
48	171,963	88,954	71,720	332,637
49	165,349	85,533	68,962	319,843
Total	**25,243,351**	**13,058,020**	**10,528,195**	**48,829,566**

7.6.5 Overall Assessment

Tables 7.23 to *7.25* show the streams of discounted loss of environmental services over a period of 50 years that can be attributed to the Project. The 8% rate is chosen to reflect the market rate of interest conventionally used for project evaluation while 6% and 4% are the more appropriate rates for social evaluation.

When discounted at the rate of 8%, the total present value of the stream of annual loss amounts to RM28.9 million over a period of 50 years. The corresponding values for 6% and 4% discount rates are RM36.5 million and RM48.8 million respectively. This study notes that the sum should not be construed as indicating project feasibility. Rather, they provide some indication of the magnitude, in monetary terms, of the reduction in the flow of environmental services as a result of the implementation of the Project over the evaluation period.

In view of the expected loss in the value of environmental services, it is recommended for the Project Proponent to compensate the affected stakeholders directly, or initiate an offsetting programme to enhance some environmental services. In addition, the Project Proponent will continue to be in constant engagement with the local fishing association. Monetary compensation to the fishermen will be determined by State Government Authorities such as Pahang Economic Planning Unit (UPEN) on what is fair and necessary. At the same time, the Project Proponent can also offset the loss in environmental services from the mudflat by engaging in various corporate social responsibility (CSR) programmes.