07 EVALUATION OF IMPACTS

7.1 Introduction

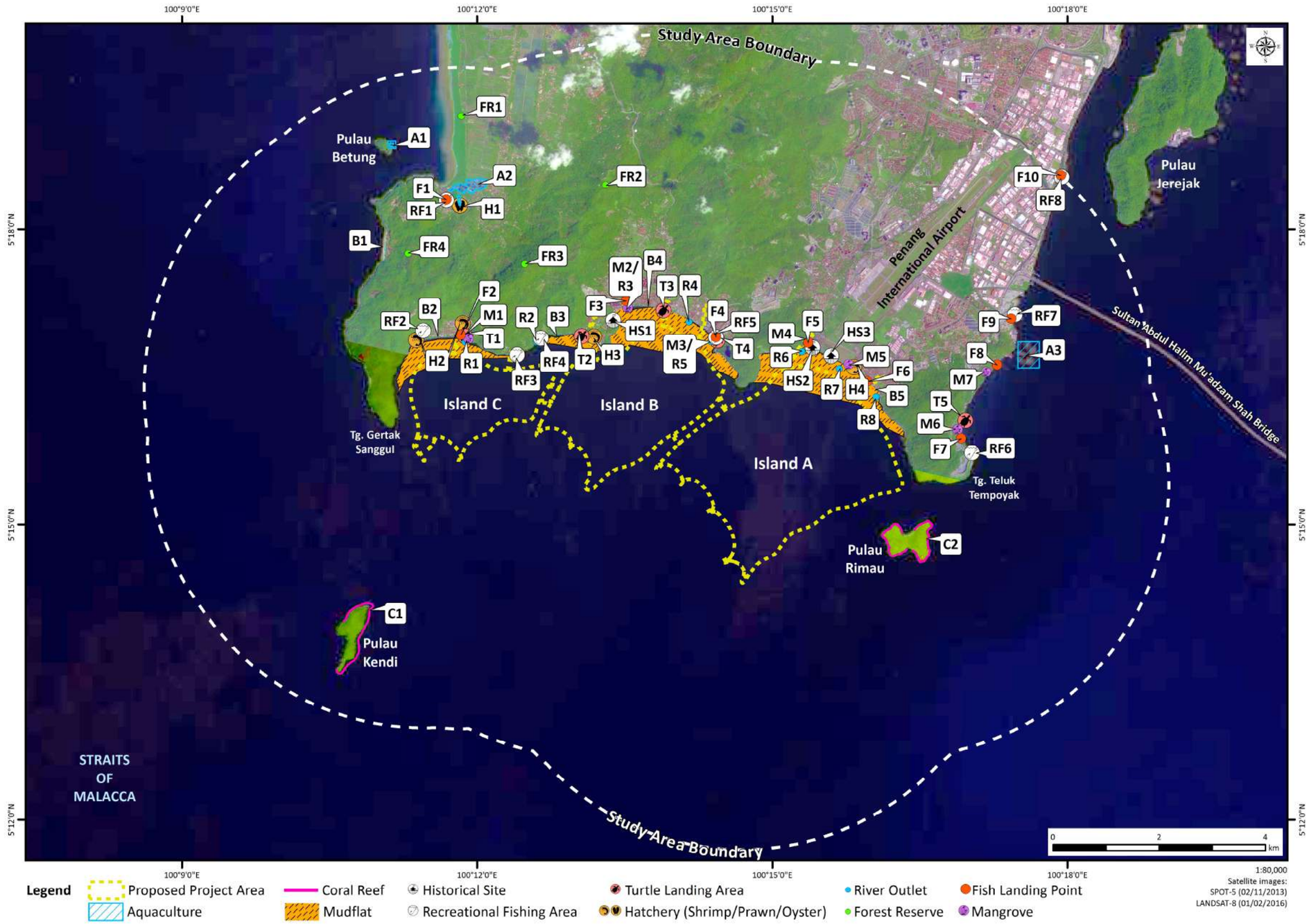
The implementation of the Project will go through several different development scenarios. Each of the scenarios will present varying degrees of environmental impacts whereby some of these may be immediate while others might be manifested over a longer period. This chapter will address key environmental issues related to the Project, particularly the impacts on various ESAs located within the 5-km zone of impact. The ESAs considered in this impact assessment exercise are similar as to those identified and explained in *Chapter 6: Existing Environment*. However, it should be noted that not all ESAs will be impacted as the proposed land reclamation and dredging will not affect the ESAs located inland. As such, these ESAs can be grouped based on whether they will be hydraulically affected by the Proposed Project activities. The list of ESAs and their locations are shown in T7.1 and F7.1 respectively.

T7.1
Summary of ESAs within the study area

Type of ESA		Label	Location
Hydraulically affected ESA	River Outlet	R1	Sungai Gertak Sanggul
		R2	Sungai Gemuruh
		R3	Sungai Teluk Kumbar
		R4	Sungai Mati
		R5	Sungai Batu
		R6	Sungai Bayan Lepas
		R7	Bayan Lepas Main Drain
		R8	Sungai Ikan Mati
	Hatcheries	H1	Near Sungai Pulau Betung
		H2	Gertak Sanggul
		H3	Teluk Kumbar
		H4	Permatang Damar Laut
	Corals	C1	Pulau Kendi
		C2	Pulau Rimau
	Mangrove	M1	Sungai Gertak Sanggul
		M2	Sungai Teluk Kumbar
		M3	Sungai Batu
		M4	Sungai Bayan Lepas
		M5	Bayan Lepas Main Drain
		M6	Teluk Tempoyak Besar
		M7	Teluk Tempoyak Kecil

T7.1
Summary of ESAs within the study area (cont'd)

Type of ESA		Label	Location
Hydraulically affected ESA (cont'd)	Aquaculture	A1	Pulau Betung
		A2	Sungai Pulau Betung
		A3	Batu Maung
	Recreational Beach	B1	Pantai Pasir Panjang
		B2	Pantai Gertak Sanggul
		B3	Pantai Tanjung Asam
		B4	Pantai Nelayan
		B5	Pantai Bakar Kapor
	Recreational Fishing Staging Area	RF1	Sungai Pulau Betung
		RF2	Gertak Sanggul
		RF3	Tanjung Karang
		RF4	Pasir Belanda
		RF5	Sungai Batu
		RF6	Teluk Tempoyak Besar
		RF7	Batu Maung
		RF8	Pantai Sri Jerjak
	Fish Landing Point	F1	Sungai Pulau Betung
		F2	Gertak Sanggul
		F3	Teluk Kumbar
		F4	Sungai Batu
		F5	Permatang Damar Laut
		F6	Permatang Tepi Laut
		F7	Teluk Tempoyak Besar
		F8	Teluk Tempoyak Kecil
		F9	Batu Maung
		F10	Sri Jerjak
	Turtle Landing Area	T1	Gertak Sanggul
		T2	Pasir Belanda
		T3	Teluk Kumbar
		T4	Sungai Batu
		T5	Teluk Tempoyak Besar
	Island	-	Pulau Betung
		-	Pulau Kendi
		-	Pulau Rimau
	Mudflat	Nearshore of Permatang Damar Laut, Teluk Kumbar and Gertak Sanggul	
Inland ESA (not affected hydraulically)	Historical Site	HS1	Teluk Kumbar
		HS2	Permatang Tepi Laut
		HS3	Bayan Lepas Main Drain
	Forest Reserve	FR1	Hutan Simpan Balik Pulau
		FR2	Hutan Simpan Bukit Genting
		FR3	Hutan Simpan Bukit Gemuruh



F7.1 ESAs within the study area

7.2 Definition and Discussion of Impacts

Impact can be defined as effects or changes to the status quo brought by the proposed development to the surrounding environment and can be characterized from several aspects such as magnitude, extent, duration and significance. The basis of the impact assessment exercise was centred on the changes in the environmental features, such as current speed, water quality and erosion, in relation to the receiving sensitive receptors. Some of the changes can be mitigated through appropriate measures, thus alleviating the impact. On the other hand, certain receptors are deemed to receive substantial transformation of the status quo which is consequently considered as total loss or a trade-off. Trade-offs are present if components of a system (in this case environmental and economics) are competing with or exclusive of each other. In NPP3, it is stated that:

"sebarang aktiviti penambakan dan tebus guna tanah tidak dibenarkan, kecuali di mana:

a. Keperluan serta manfaat aktiviti tersebut dapat dibuktikan dengan jelas dalam memberi sumbangan sosioekonomi yang signifikan pada peringkat negeri dan negara (seperti pembangunan infrastruktur);"

An overview on the impact assessment basis is presented in T7.2.

The discussion on impacts for each environmental component will be divided according to the development scenarios. These development scenarios were established as per the Project phases and its related activities, as detailed in T7.3.

The assessment of impacts presented herein can be described generally under several categories which are defined in T7.4.

T7.2 Overview of the impact assessment basis

ESAs / Receptors	Location	Point	Environmental Impact									
			Current Speed	Water Level	Wave Heights	Bed Level Changes	Sediment Spill Dispersion	Water Quality	Footprint	Noise	Air Quality	Aesthetics
River Outlet	Sungai Gertak Sanggul	R1	✓		✓	✓ (Sedimentation)		✓				✓
	Sungai Gemuruh	R2	✓		✓			✓				
	Sungai Teluk Kumbar	R3	✓		✓			✓				
	Sungai Mati	R4	✓		✓			✓				
	Sungai Batu	R5	✓		✓	✓ (Sedimentation)		✓				
	Sungai Bayan Lepas	R6	✓		✓	✓ (Erosion)		✓				✓
	Bayan Lepas Main Drain	R7	✓		✓	✓ (Erosion)		✓				✓
	Sungai Ikan Mati	R8	✓					✓				✓
Hatcheries	Near Sungai Pulau Betung	H1										
	Gertak Sanggul	H2					✓	✓	✓			
	Teluk Kumbar	H3					✓	✓	✓			
	Permatang Damar Laut	H4					✓	✓				
Corals	Pulau Kendi	C1										
	Pulau Rimau	C2	✓		✓		✓					
Turtle Landing Area	Gertak Sanggul	T1	Total loss (trade-off)									
	Pasir Belanda	T2										
	Teluk Kumbar	T3										
	Sungai Batu	T4										
	Teluk Tempoyak Besar	T5										
Islands	Pulau Betung	I1										
	Pulau Kendi	I2										
	Pulau Rimau	I3										

(✓) indicates 'has impact'

T7.2 Overview of the impact assessment basis (cont'd)

ESAs / Receptors	Location	Point	Environmental Impact									
			Current Speed	Water Level	Wave Heights	Bed Level Changes	Sediment Spill Dispersion	Water Quality	Footprint	Noise	Air Quality	Aesthetics
Recreational Beach	Pantai Pasir Pantai	B1								✓		✓
	Pantai Gertak Sanggul	B2								✓		✓
	Pantai Tanjung Asam	B3								✓		✓
	Pantai Nelayan	B4								✓		✓
	Pantai Bakar Kapor	B5								✓		✓
Recreational Fishing Staging Area	Sungai Pulau Betung	RF1										✓
	Gertak Sanggul	RF2										✓
	Tanjung Karang	RF3										✓
	Pasir Belanda	RF4										✓
	Sungai Batu	RF5										✓
	Teluk Tempoyak Besar	RF6										✓
	Batu Maung	RF7										✓
	Pantai Sri Jerjak	RF8										✓
Fish Landing Point	Sungai Pulau Betung	F1										
	Gertak Sanggul	F2	✓			✓ (Sedimentation)			✓			✓
	Teluk Kumbar	F3	✓		✓				✓			
	Sungai Batu	F4	✓		✓	✓ (Sedimentation)			✓			
	Permatang Damar Laut	F5							✓			
	Permatang Tepi Laut	F6	✓		✓				✓			✓
	Teluk Tempoyak Besar	F7										
	Teluk Tempoyak Kecil	F8										
	Batu Maung	F9										
	Sri Jerjak	F10										

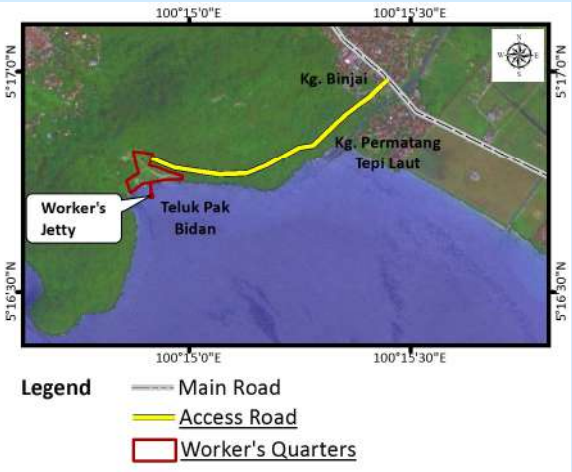
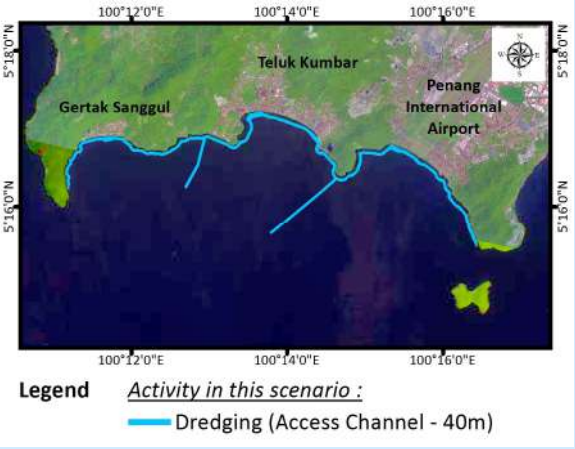
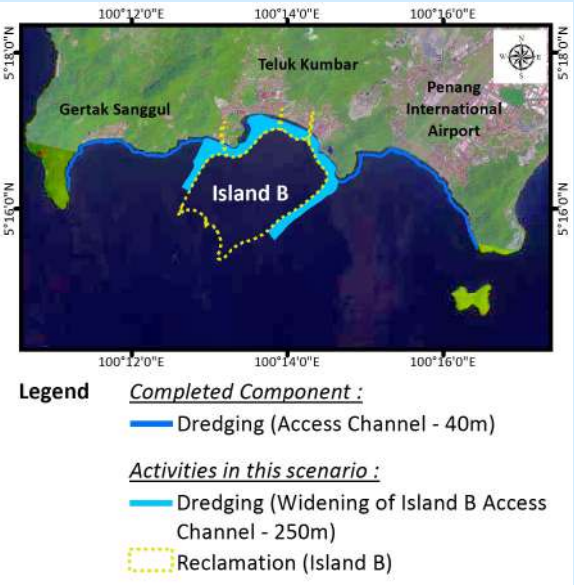
(✓) indicates 'has impact'

T7.2 Overview of the impact assessment basis (cont'd)

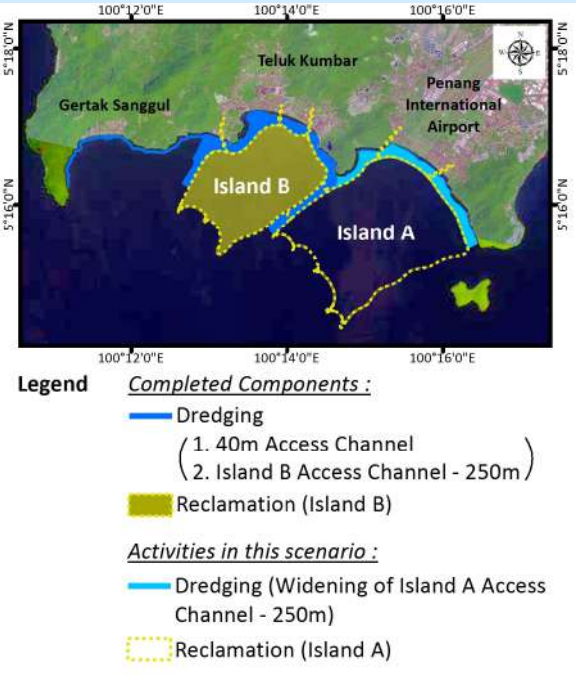
ESAs / Receptors	Location	Point	Environmental Impact									
			Current Speed	Water Level	Wave Heights	Bed Level Changes	Sediment Spill Dispersion	Water Quality	Footprint	Noise	Air Quality	Aesthetics
Aquaculture	Pulau Betung	A1										
	Sungai Pulau Betung	A2										
	Batu Maung	A3										
Mangrove	Sungai Gertak Sanggul	M1										
	Sungai Teluk Kumbar	M2										
	Sungai Batu	M3										
	Sungai Bayan Lepas	M4										
	Bayan Lepas Main Drain	M5										
	Teluk Tempoyak Besar	M6										
	Teluk Tempoyak Kecil	M7					✓		✓			
Marine Biology	Mudflat		Total loss (trade-off)									
	Plankton											
	Macrobenthos		Total loss (trade-off)									
	Fish Fauna						✓	✓	✓			
Human	Fishermen		✓				✓	✓	✓			
	Local Community									✓	✓	✓
	Business Operators									✓	✓	✓

(✓) indicates 'has impact'

T7.3 Project development phases and activities

Phase	Description	
Phase A (Pre-dredging Stage)		a) Land clearing; biomass removal and disposal b) Construction of access road ■ Length: Approximately 1 km c) Construction of temporary workers' jetty ■ Length: 50 m d) Construction of workers' quarters ■ Area: 4 acres
Phase B (Dredging to Create Access Channel Stage) Duration: 1 year		a) Dredging details: ■ Bottom width: 40 m ■ Length: 17.8 km ■ Depth: -2 m CD b) Dredging volume: 2.3 million m^3 c) Offshore disposal ground - Off Pulau Kendi
Phase C (Reclamation and Widening of the Access Channel) Duration: 7 years		a) Reclamation of Island B ■ Size: 1,400 acres ■ Total reclamation volume: 58 million m^3 b) Widening of the dredged channel around Island B ■ Width: 250 m ■ Length: 8.1 km ■ Depth: -2 m CD ■ Dredging volume: 2.2 million m^3 c) Construction of bridge piers

T7.3 Project development phases and activities

Phase	Description	
Phase D (Reclamation and Widening of the Access Channel) Duration: 8 years		a) Reclamation of Island A ■ Size: 2,300 acres ■ Total reclamation volume: 93.8 million m^3 b) Widening of the dredged channel between Island A and Penang Island ■ Width: 250 m ■ Length: 5.2 km ■ Depth: -2 m CD ■ Dredging volume: 1.6 million m^3 c) Construction of bridge piers
Phase E (Reclamation and Widening of the Access Channel) Duration: 7 years		a) Reclamation of Island C ■ Size: 800 acres ■ Total reclamation volume: 37.3 million m^3 b) Widening of the dredged channel between Island C and Penang Island ■ Width: 250 m ■ Length: 5.5 km ■ Depth: -2 m CD c) A marina and dredging of associated access channel at south-western corner of Island C d) Total dredging volume: 800,000 m^3 e) Construction of bridge piers

T7.4 Categories of impacts

Impacts	Description
Short-term Impact	This refers to impacts that are temporary in nature which primarily occur during the construction phase, relating to the reclamation and dredging activities as well as land-based development discussed in *Chapter 5 – Project Description*.
Long-term Impact	The potential long-term impacts are those related to the more permanent changes potentially induced by the proposed Project once it is constructed. These permanent changes are related to physical modification of existing environment due to water levels, current flow conditions, wave conditions, water quality and sedimentation/erosion patterns.

7.3 Impacts on Hydraulic and Hydrology

The proposed development will alter the bathymetry of the site, which then leads to changes in the hydrographic condition. In order to assess the impact caused by the changes, simulation studies were conducted according to the projected development scenarios. Different modelling methodologies were used for different hydraulic components, encompassing various factors and conditions that currently exist on site or may be present in the future (T7.5).

T7.5 Modules used for hydraulic assessments

Component	Software/Module	Parameter(s) Assessed
Hydrodynamics	MIKE 21 HD	Currents and water levels
Waves	MIKE 21 SW	Nearshore waves
Sediment transport	MIKE 21 MT	Non-cohesive sediment transport
Suspended sediment dispersion	MIKE 21 MT	Suspended sediment dispersion due to filling and dredging activities
Water quality	MIKE 21 AD	Flushing

7.3.1 Model Layout

The simulations were conducted according to the Project phases so that the results obtained will be more comprehensive and thorough. For simulation and impact assessment purposes, each model layout will be called “Scenario” that represents activities that will be carried out according to the respective development phases. However, one of the Project phases, namely Pre-dredging, will not present any impact hydraulically as it is conducted on the existing land. Thus, the Pre-dredging phase was not included as one of the scenarios in the hydraulic simulation. T7.6 details the model layout used in this study.

Model Layout	Impact Assessment Scenario
 **Legend** *Activity in this scenario :* Dredging (Access Channel - 40m)	Phase B as **Scenario 1**
 **Legend** *Completed Component :* Dredging (Access Channel - 40m) *Activities in this scenario :* Dredging (Widening of Island B Access Channel - 250m) Reclamation (Island B)	Phase C as **Scenario 2**
 **Legend** *Completed Components :* Dredging (1. 40m Access Channel 2. Island B Access Channel - 250m) Reclamation (Island B) *Activities in this scenario :* Dredging (Widening of Island A Access Channel - 250m) Reclamation (Island A)	Phase D as **Scenario 3**

T7.6
Model layouts used for hydraulic study

Model Layout	Impact Assessment Scenario
 **Legend** *Completed Components :* Dredging (1. 40m Access Channel 2. Island B Access Channel - 250m 3. Island A Access Channel - 250m) Reclamation (1. Island B 2. Island A) *Activities in this scenario :* Dredging (1. Widening of Island C Access Channel - 250m 2. Marina on Island C) Reclamation (Island C)	Phase E as **Scenario 4**

T7.6 Model layouts used for hydraulic study (cont'd)

7.3.2 Climatic Conditions

Climatic conditions are among the important parameters that have been incorporated in the simulations. Three climate seasons have been defined for the study which can be listed as follows:

a) Pure tide;
b) Northeast Monsoon; and
c) Southwest Monsoon.

The Northeast and Southwest monsoonal conditions are represented by representative wind conditions, as shown in T7.7.

Climatic Condition	Wind Direction (°N)	Wind Speed (m/s)
Pure tide	-	-
Northeast Monsoon	50	4.3
Southwest Monsoon	200	3.7

T7.7 Climatic conditions

7.3.3 Hydraulic and Hydrology Impact Assessment

The assessment of the potential impact associated with the Project on the coastal hydraulic conditions was undertaken by means of a numerical modelling approach. Hydraulic components that are assessed in this study include:

a) Current flow;
b) Water level;
c) Wave conditions;
d) Sedimentation and erosion;
e) Sediment spill dispersion; and
f) Flushing capacity (water quality).

7.3.4 Hydraulic Data Extraction at Sensitive Receptors

For the purpose of quantitative impact assessment, simulation data at several locations identified as sensitive receptors were extracted. These sensitive receptors were identified based on the general ESAs found within the 5-km zone of impact listed earlier, but focusing only at locations where the hydraulic and hydrological impacts are relevant. Several ESAs are deemed to be irrelevant for hydraulic data extraction and thus were discounted from the quantitative impact assessment, as detailed in T7.8.

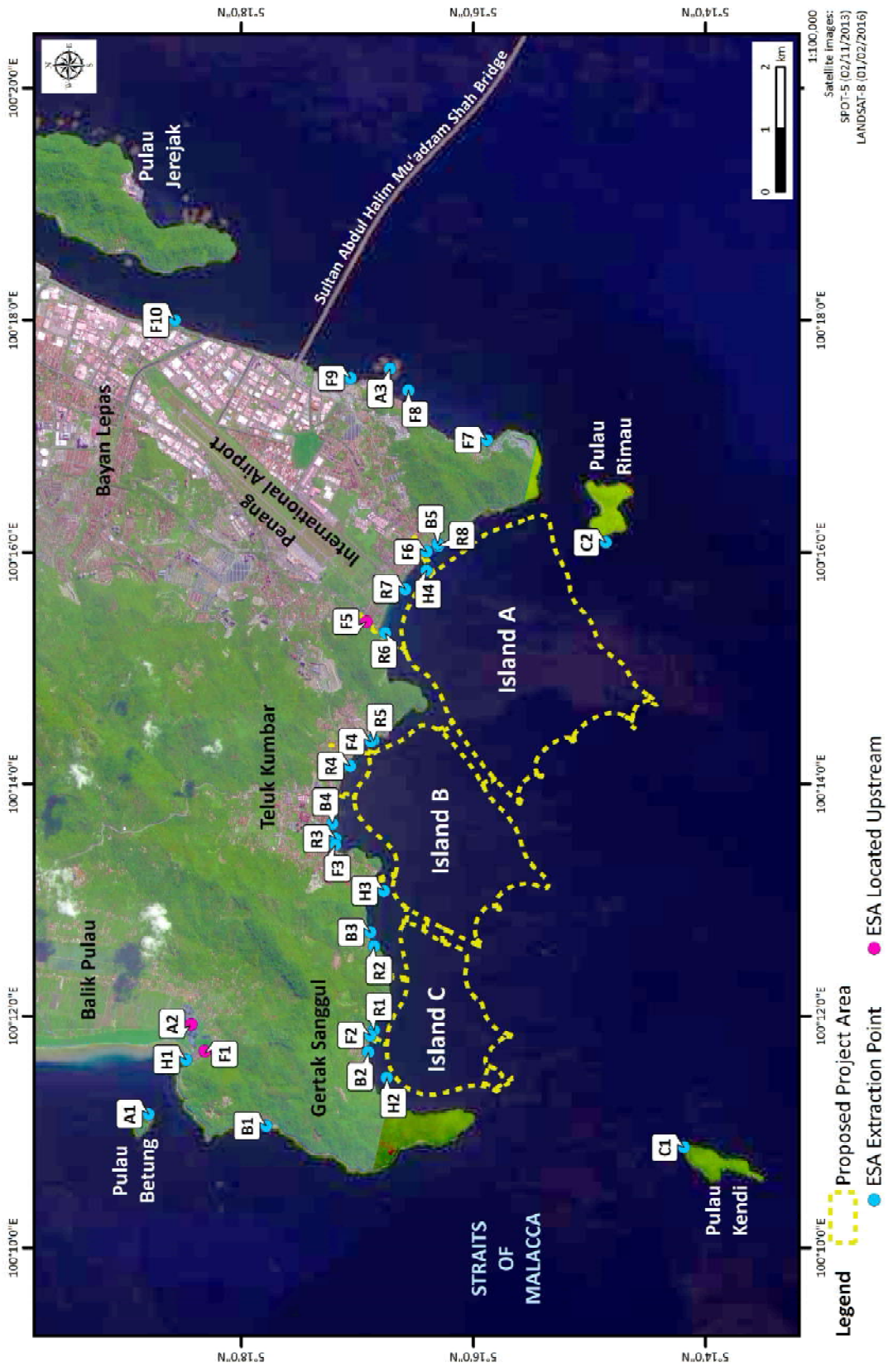
T7.8 ESAs discounted from the quantitative impact assessment

Type of ESA	Remark
Turtle landing site	Impact is not directly related to hydraulic, but more on the Project's activities and footprint
Mangrove	Mangroves observed within the study area are mostly small patches located along a river
Recreational fishing staging area	Impact is not directly related to hydraulic, but more on the Project's activities and footprint
Islands	Impact for Pulau Kendi and Pulau Rimau is represented by coral reefs (C1 and C2) situated at these islands. As for Pulau Betung, the impact is represented by the aquaculture situated nearby the island (A1)
Forest reserve	Hydraulically unaffected because of the inland location
Historical structure (WW2 pillbox)	Hydraulically unaffected because of the inland location

The sensitive receptors' extraction points are illustrated in F7.2 and also listed in T7.9. It should be noted that data extraction for Recreational Beach is done for the Sedimentation and Erosion component only, which is discussed in *Section 7.3.8*. This is because this ESA is not affected physically by other hydraulic impacts.

7.3.5 Currents

Current flow conditions are one of the main driving mechanisms of the coastal processes at the Project site. The current flow model constitutes the basis of this coastal hydraulic study, providing the hydrodynamic basis for other modelling simulations including sediment transport, water quality and sediment dispersion.



F7.2 Hydraulic simulation data extraction points for ESAs

Type of ESA	Point	Location
River Outlet	R1	Sungai Gertak Sanggul
	R2	Sungai Gemuruh
	R3	Sungai Teluk Kumbar
	R4	Sungai Mati
	R5	Sungai Batu
	R6	Sungai Bayan Lepas
	R7	Bayan Lepas Main Drain
	R8	Sungai Ikan Mati
Hatchery	H1	Near Sungai Pulau Betung
	H2	Gertak Sanggul
	H3	Teluk Kumbar
	H4	Permatang Damar Laut
Coral	C1	Pulau Kendi
	C2	Pulau Rimau
Aquaculture	A1	Pulau Betung
	A2	Sungai Pulau Betung
	A3	Batu Maung
Fish Landing Point	F1	Sungai Pulau Betung
	F2	Gertak Sanggul
	F3	Teluk Kumbar
	F4	Sungai Batu
	F5	Permatang Damar Laut
	F6	Permatang Tepi Laut
	F7	Teluk Tempoyak Besar
	F8	Teluk Tempoyak Kecil
	F9	Batu Maung
	F10	Sri Jerjak
Recreational Beach*	B1	Pantai Pasir Panjang
	B2	Pantai Gertak Sanggul
	B3	Pantai Tanjung Asam
	B4	Pantai Nelayan
	B5	Pantai Bakar Kapor

T7.9
List of hydraulic simulation data extraction points

*Note: Extraction data for recreational beach is done for sedimentation and erosion components only.

7.3.5.1 Simulation Model

For this study, the MIKE 21 Hydrodynamic (HD) module has been used to establish a current flow model that is calibrated and validated using measured current flow and water level data. The calibrated and validated current flow model is then used to simulate the existing and "with Project" conditions.

MIKE 21 HD is the basic module of the MIKE 21 system. It provides the hydrodynamic basis for computations performed in most of the other modules. It simulates water level fluctuations and flows in response to a variety of forcing functions in lakes, estuaries, bays and coastal areas. The water levels and flows are resolved on a rectangular grid covering the area of interest when provided with bathymetry, bed resistance coefficients, wind and wave fields and boundary conditions.

The model is simulated for a 14-day simulation period, covering a full spring and neap tides cycle. This model is calibrated using measured water levels and current flow conditions at site in accordance with DID guidelines.

7.3.5.2 Impact Assessment

Impacts due to the Project are predicted by assessing changes that occur with respect to the baseline condition. This is done by analysing the mean and maximum current speeds occurring during the modelled spring period. As expected, the proposed Project creates local changes to current flow patterns. However, changes in the current conditions are mostly within the Project site, apart from Pulau Rimau in Scenarios 3 and 4.

a) Scenario 1

The conditions at and around the Project site in Scenario 1 during spring and neap periods for all climatic conditions are shown in F7.3 to F7.5.

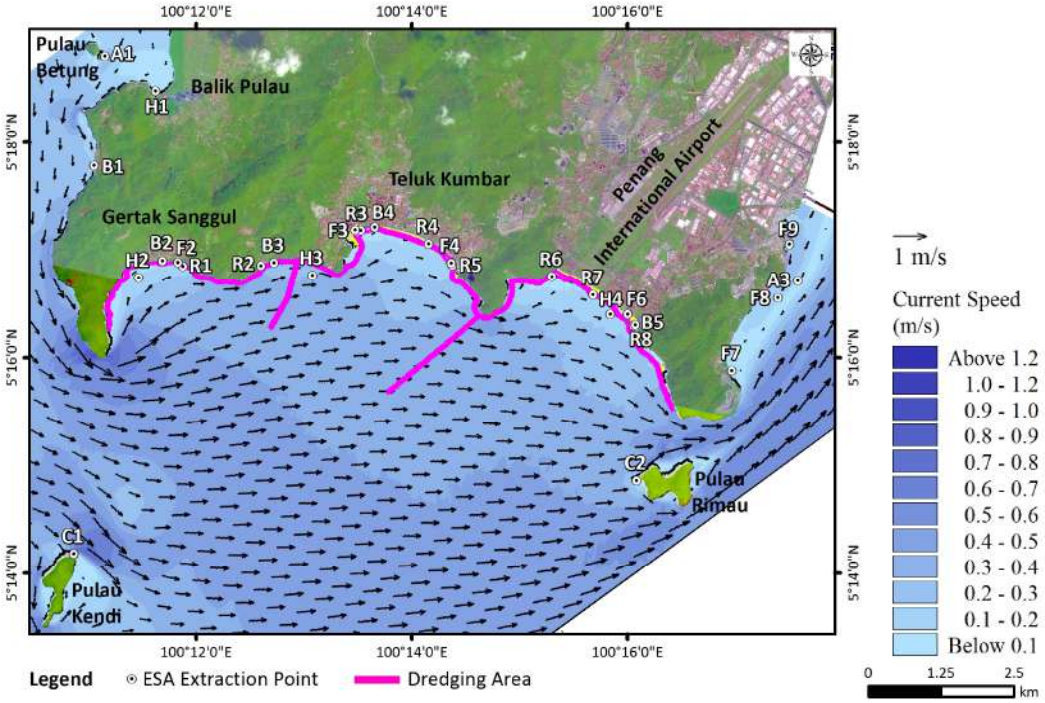
The mean and maximum current speeds for all climatic conditions are shown in F7.6. The figure shows that the mean and maximum current speeds at the Project site are very similar to those of the existing conditions, which are up to about 0.2 and 0.7 m/s respectively.

F7.7 to F7.9 show the changes in mean current speed between Scenario 1 and the existing conditions. In the pure tide and Southwest Monsoon conditions, there are increases in the mean current speed by up to 0.05 m/s in the dredged channel along the coastline of Gertak Sanggul and reduction in the mean current speed by up to 0.05 m/s along the foreshores where beach enhancement works are proposed. It is considered that such reduction is due to the higher foreshore levels.

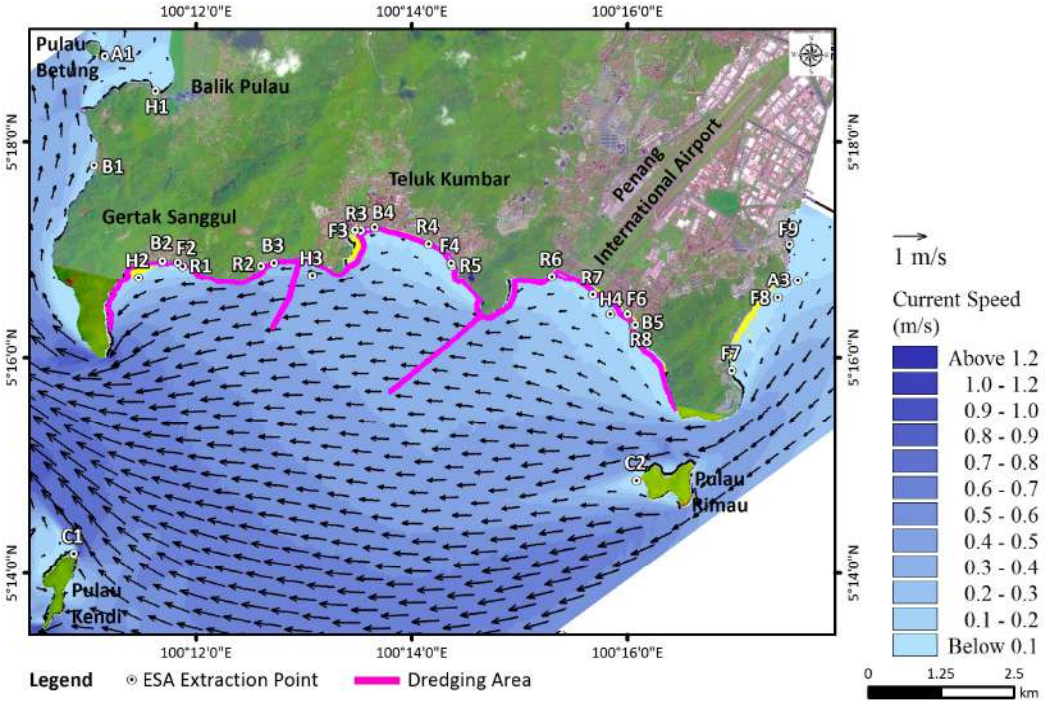
In the Northeast Monsoon condition, there is no increase in the mean current speed in the dredge channel along the foreshore of Gertak Sanggul. There is a higher reduction in the mean current speed by up to 0.1 m/s at the foreshore of Teluk Kumbar.

The changes in maximum current speed between Scenario 1 and the existing conditions are shown in F7.10 to F7.12. There are isolated spot changes in the foreshore area, mostly reductions in the maximum current speeds. These changes are negligible.

Comparisons of the mean and maximum current speed changes between the baseline and Scenario 1 at identified sensitive receptors are tabulated in T7.10.

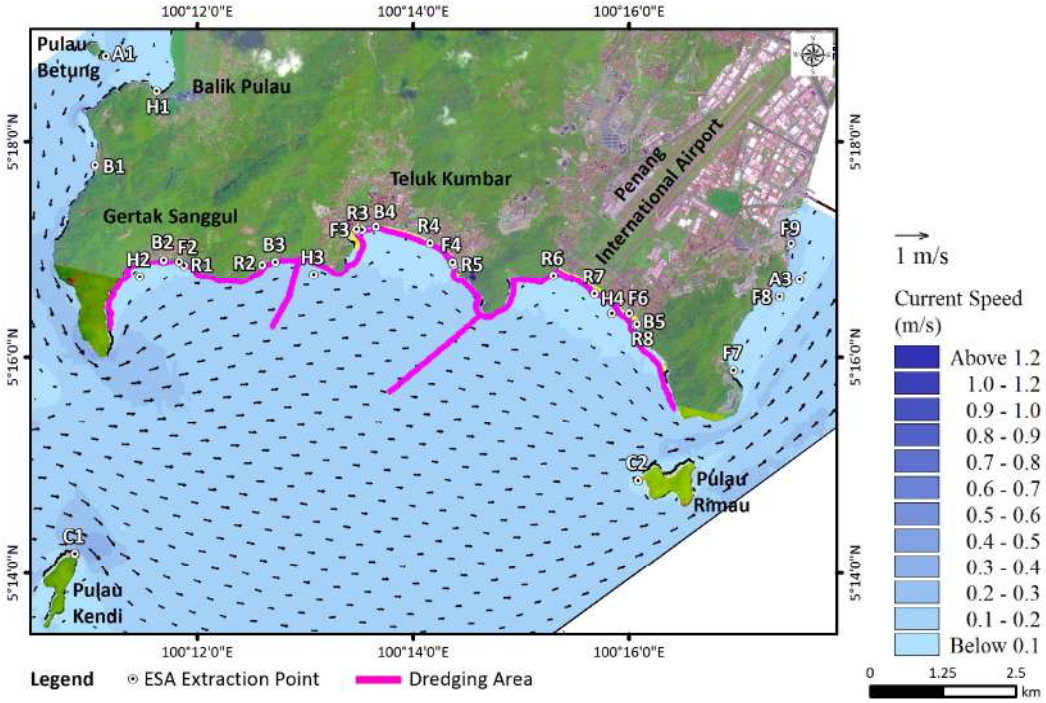


a) Spring period: Flood flow

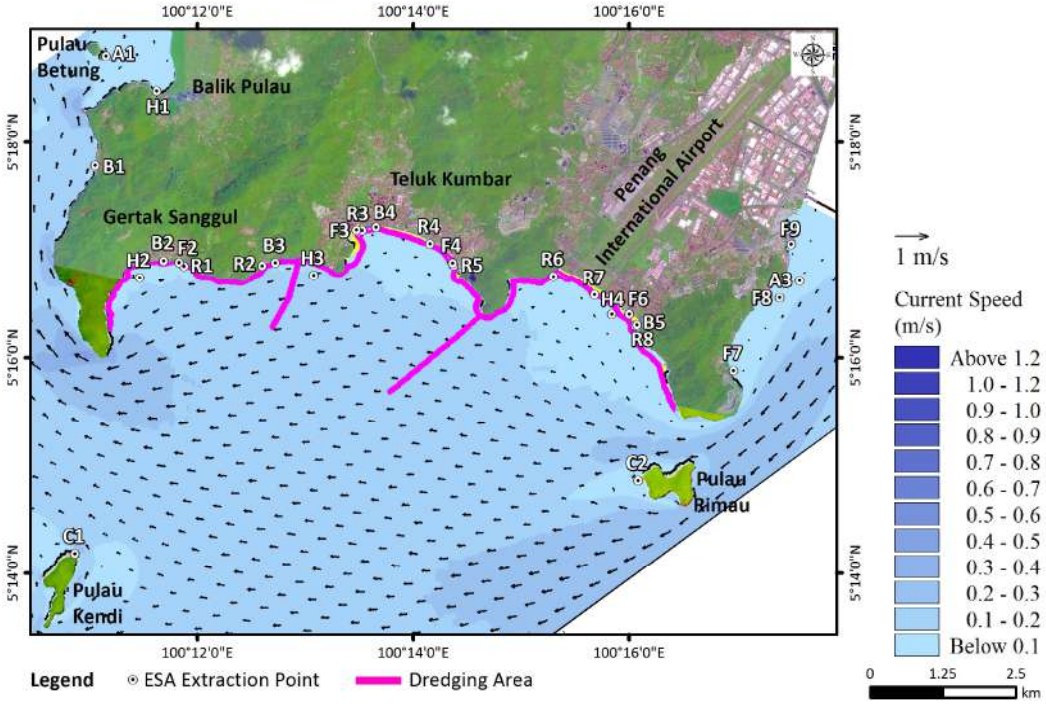


b) Spring period: Ebb flow

F7.3 Flow pattern during spring and neap periods for Scenario 1 condition (pure tide condition)

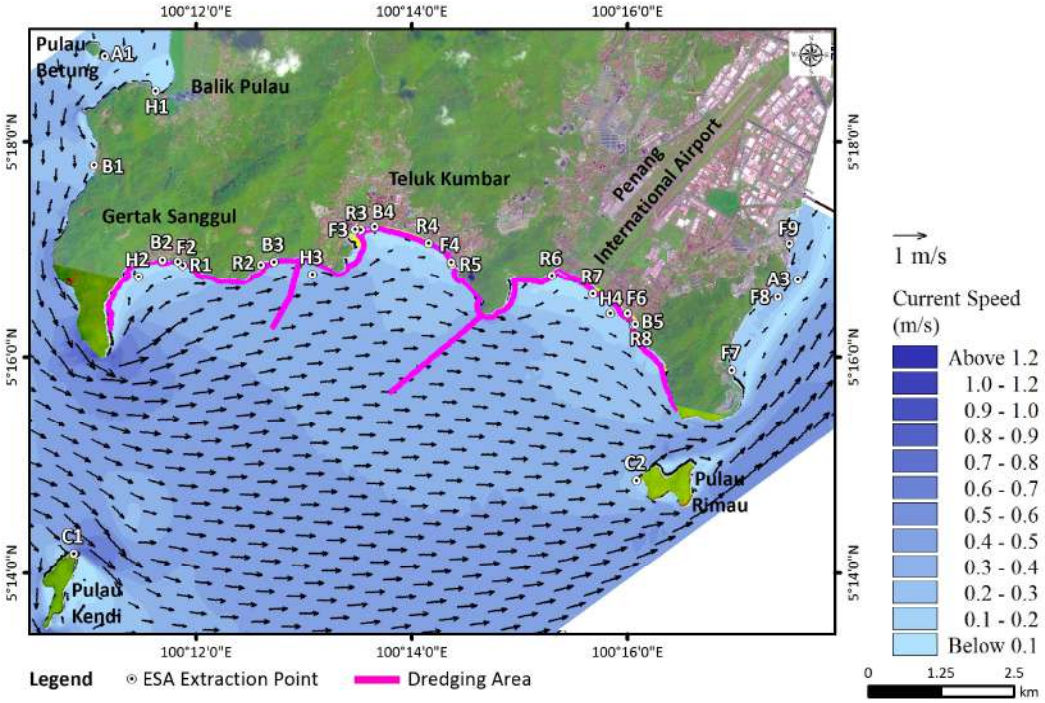


c) Neap period: Flood flow

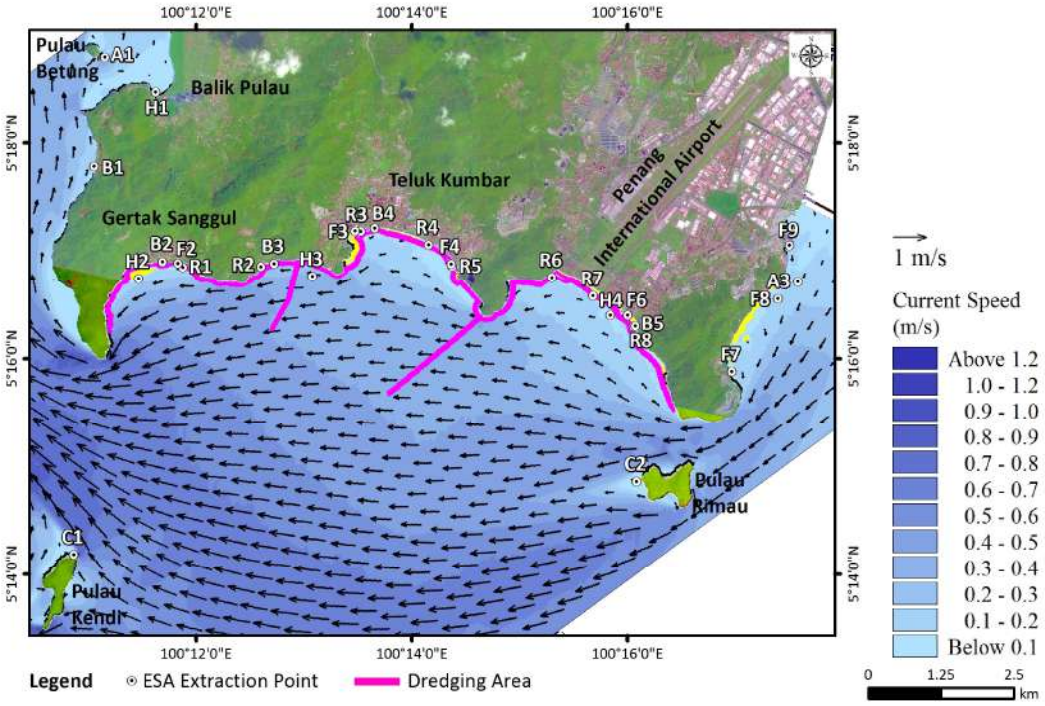


d) Neap period: Ebb flow

F7.3 Flow pattern during spring and neap periods for Scenario 1 condition (pure tide condition) (cont'd)

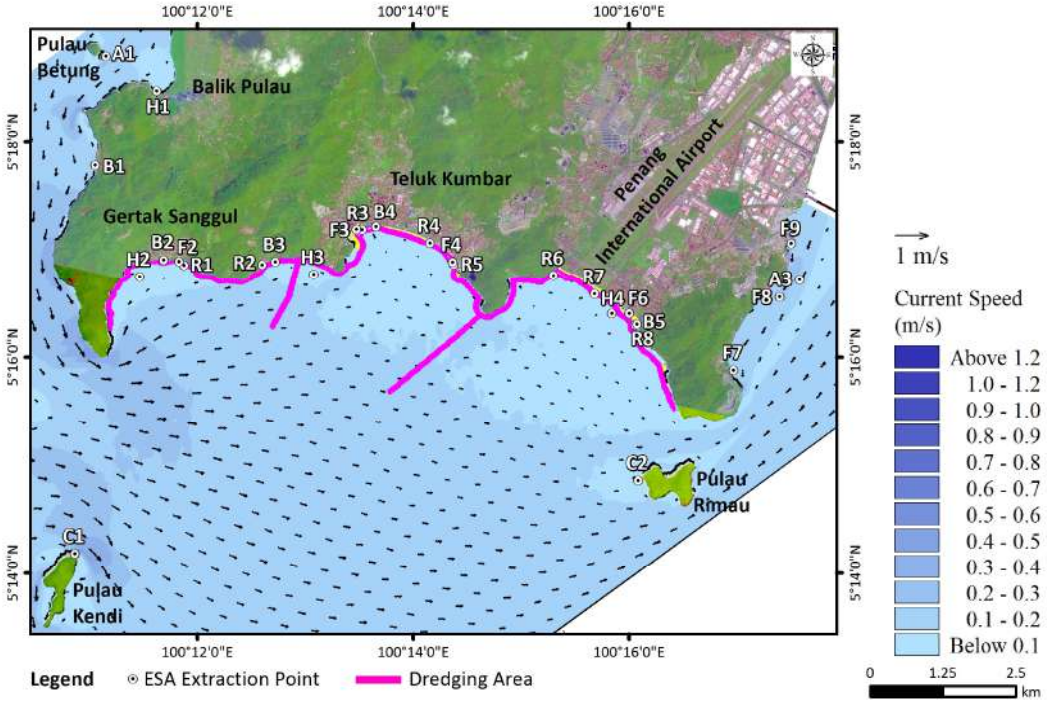


a) Spring period: Flood flow

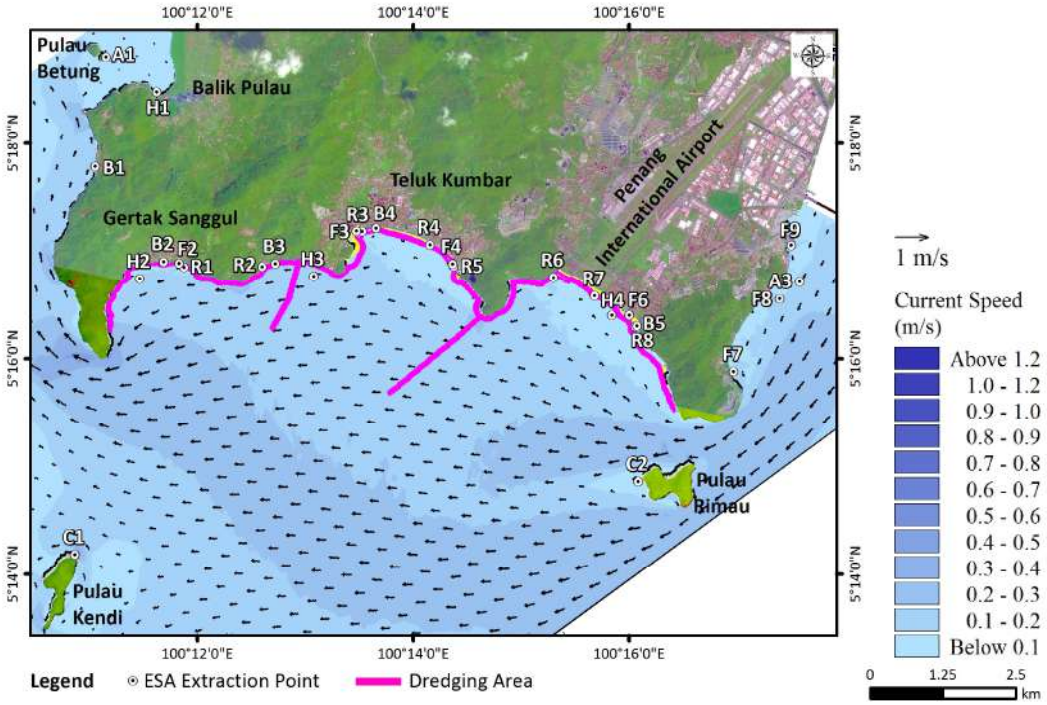


b) Spring period: Ebb flow

F7.4 Flow pattern during spring and neap periods for Scenario 1 condition (Northeast Monsoon condition)

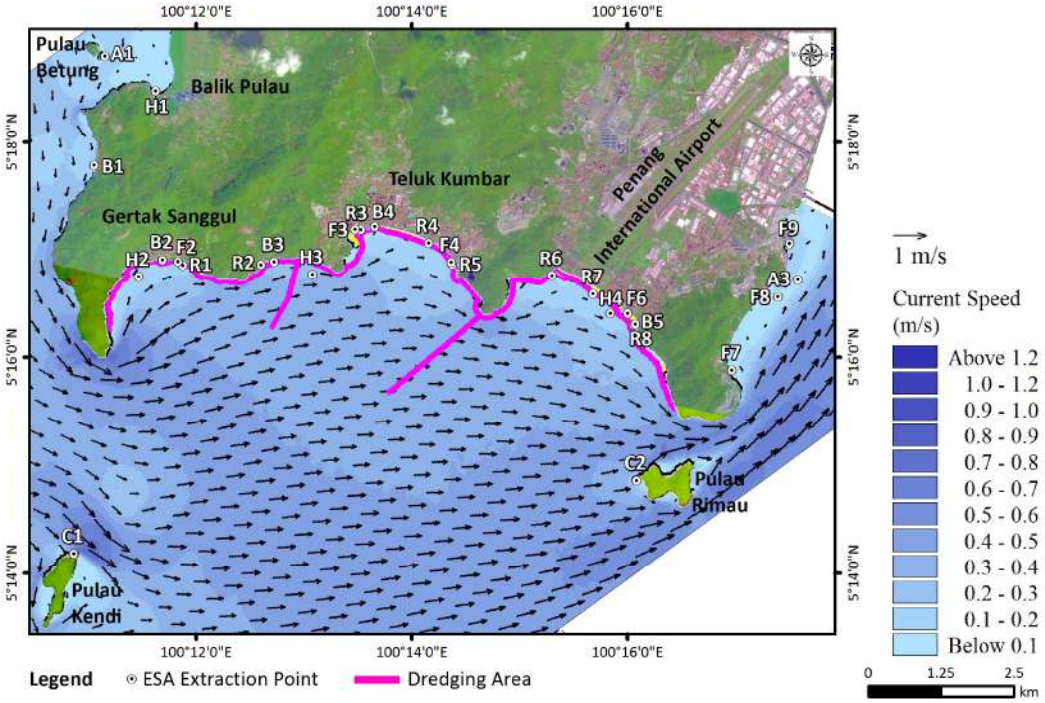


c) Neap period: Flood flow

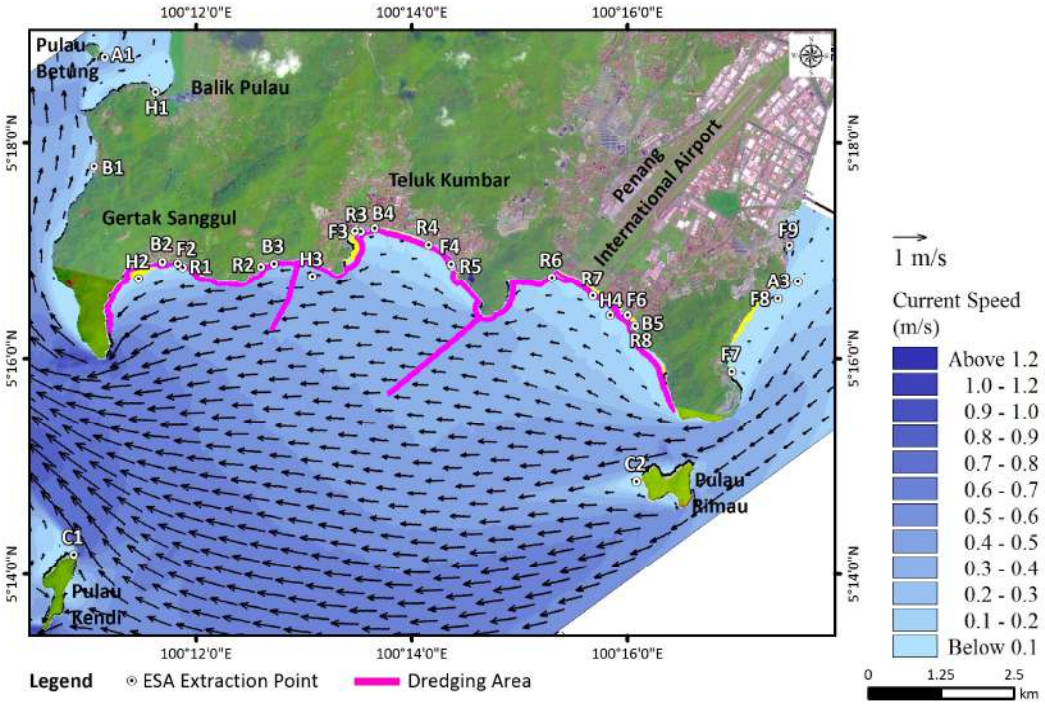


d) Neap period: Ebb flow

F7.4 Flow pattern during spring and neap periods for Scenario 1 condition (Northeast Monsoon condition) (cont'd)

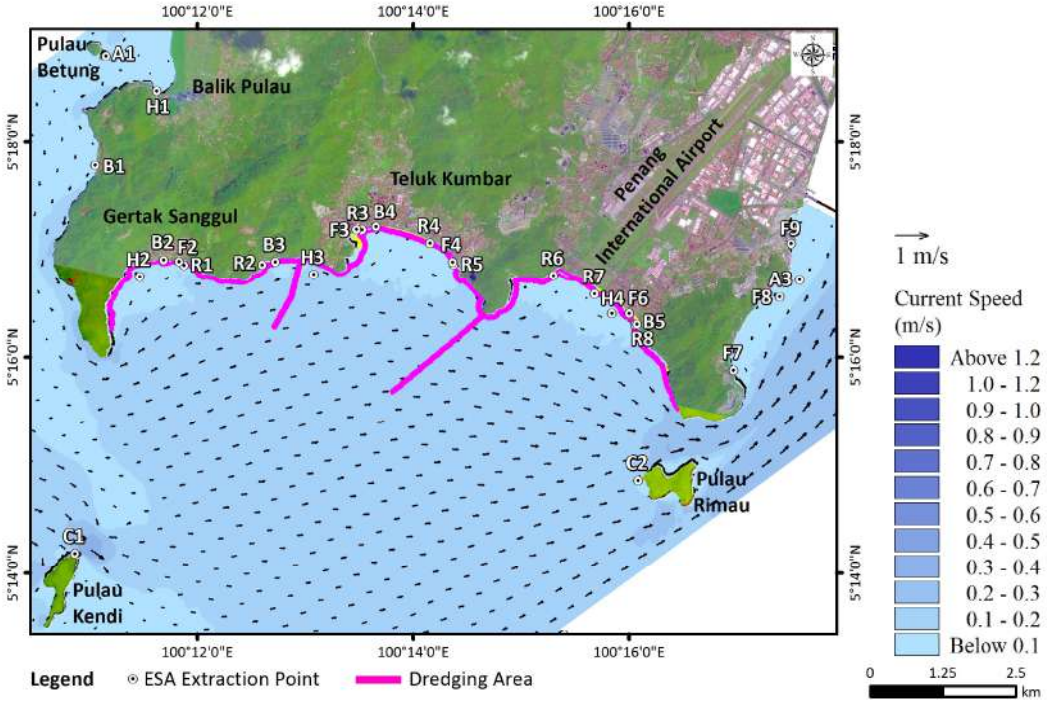


a) Spring period: Flood flow

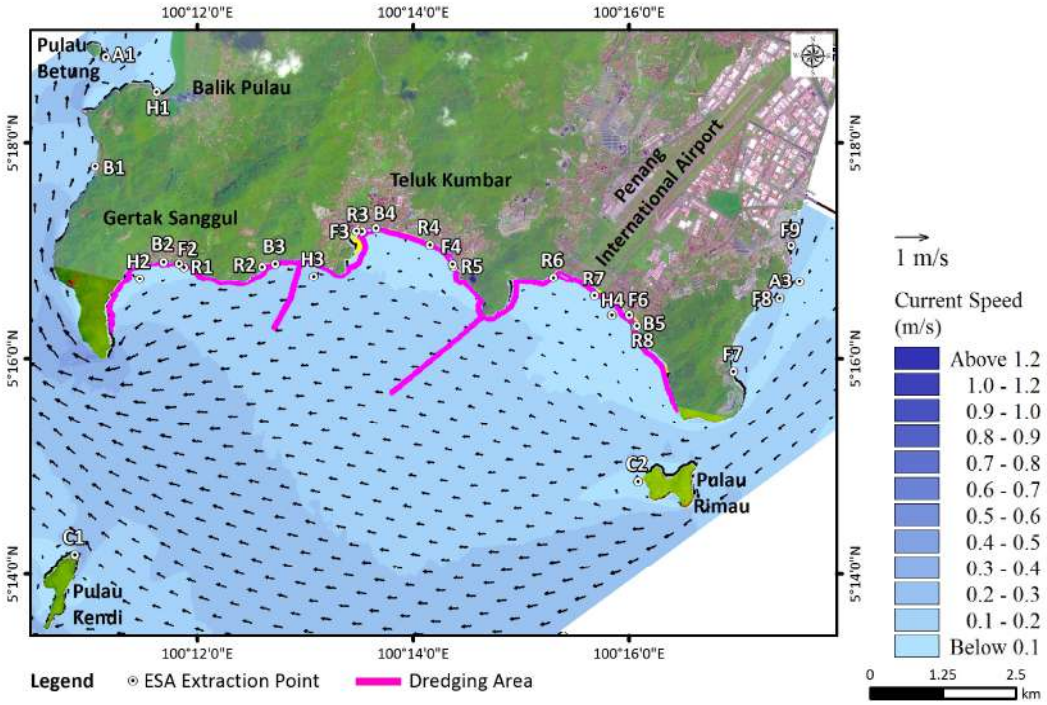


b) Spring period: Ebb flow

F7.5 Flow pattern during spring and neap periods for Scenario 1 condition (Southwest Monsoon condition)

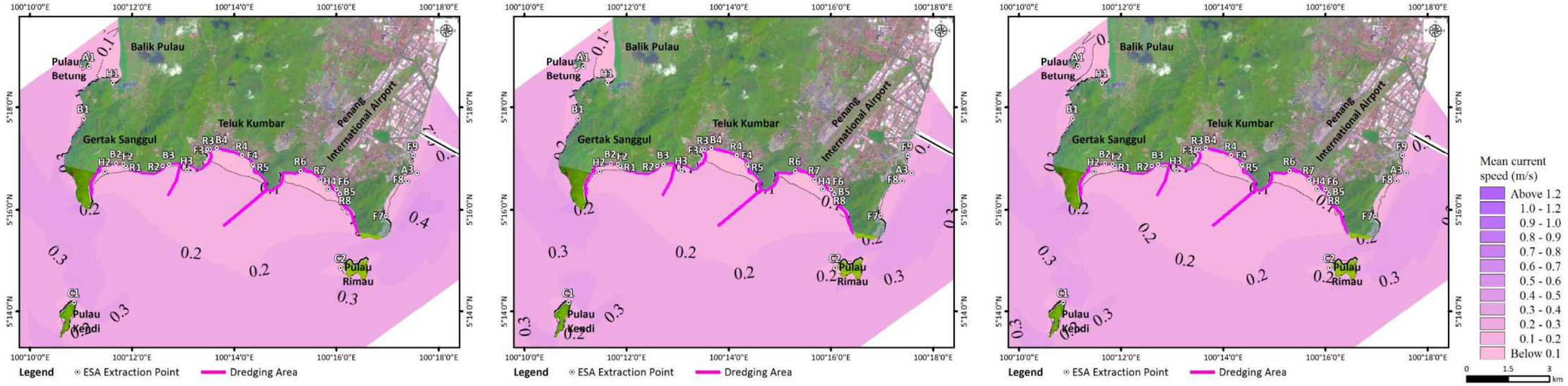


c) Neap period: Flood flow



d) Neap period: Ebb flow

F7.5 Flow pattern during spring and neap periods for Scenario 1 condition (Southwest Monsoon condition) (cont'd)



a) Mean current speed: Pure tide

c) Mean current speed: Northeast Monsoon

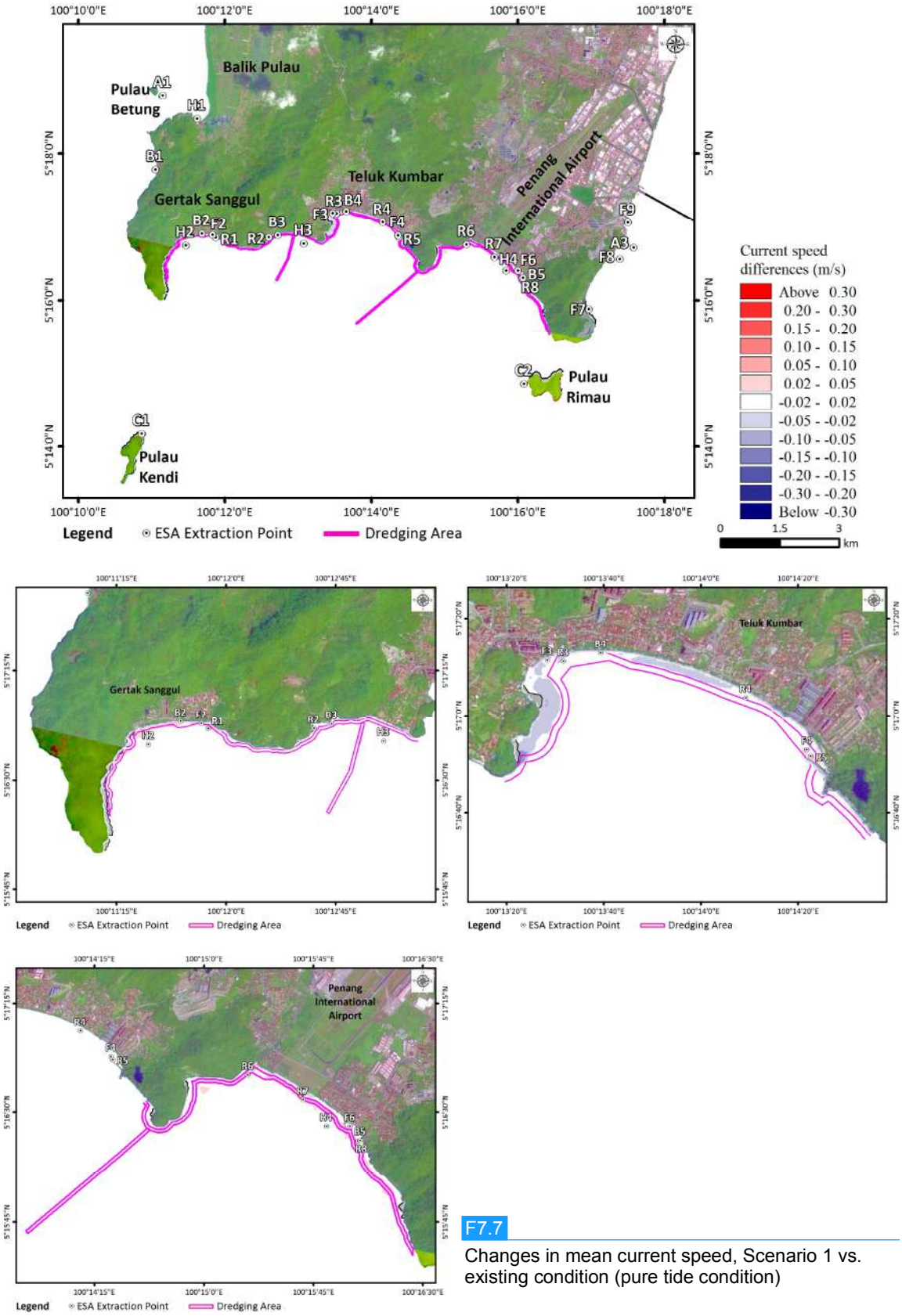
e) Mean current speed: Southwest Monsoon

b) Maximum current speed: Pure tide

d) Maximum current speed: Northeast Monsoon

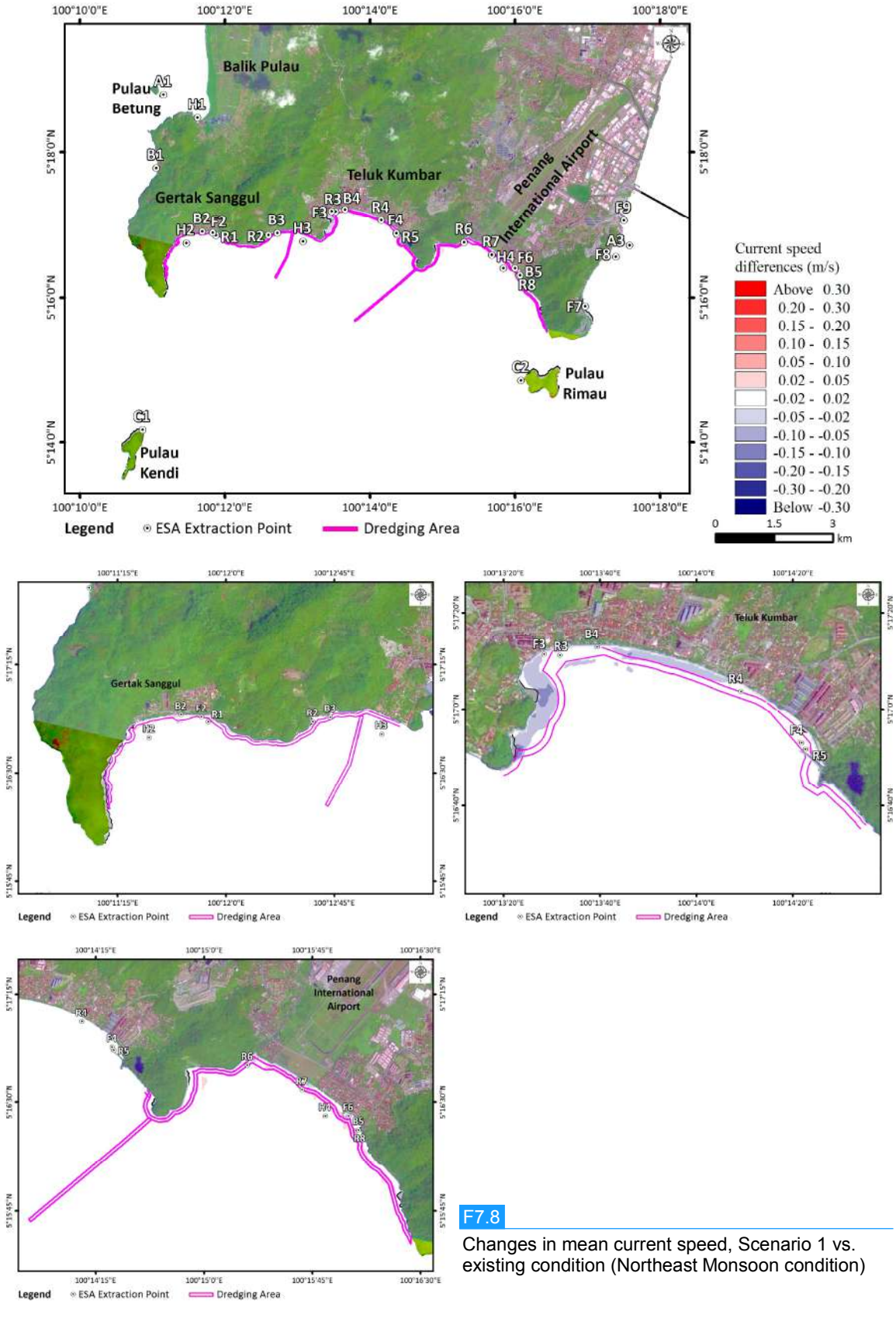
f) Maximum current speed: Southwest Monsoon

F7.6 Mean and maximum current speed plots for Scenario 1 condition



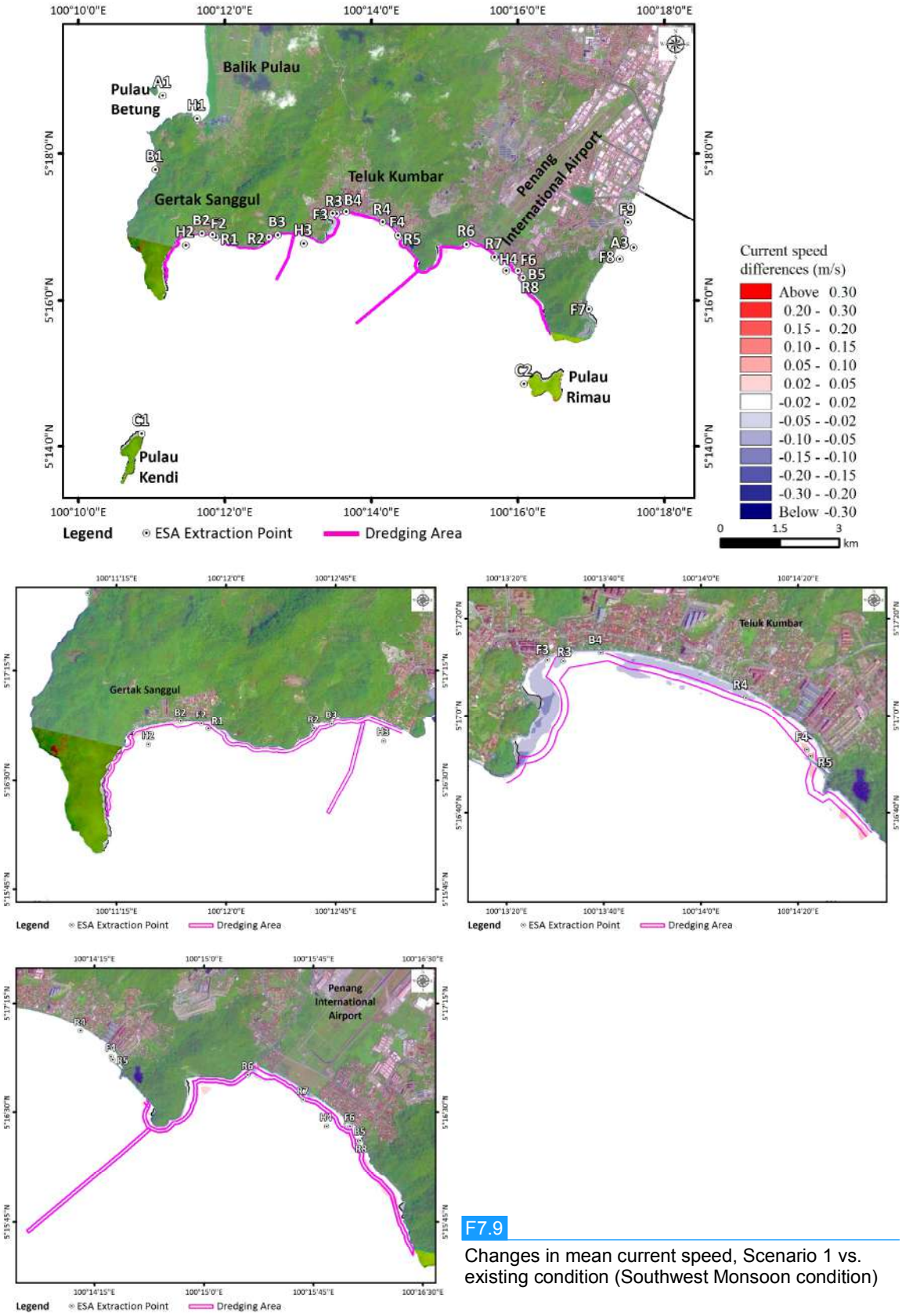
F7.7

Changes in mean current speed, Scenario 1 vs. existing condition (pure tide condition)



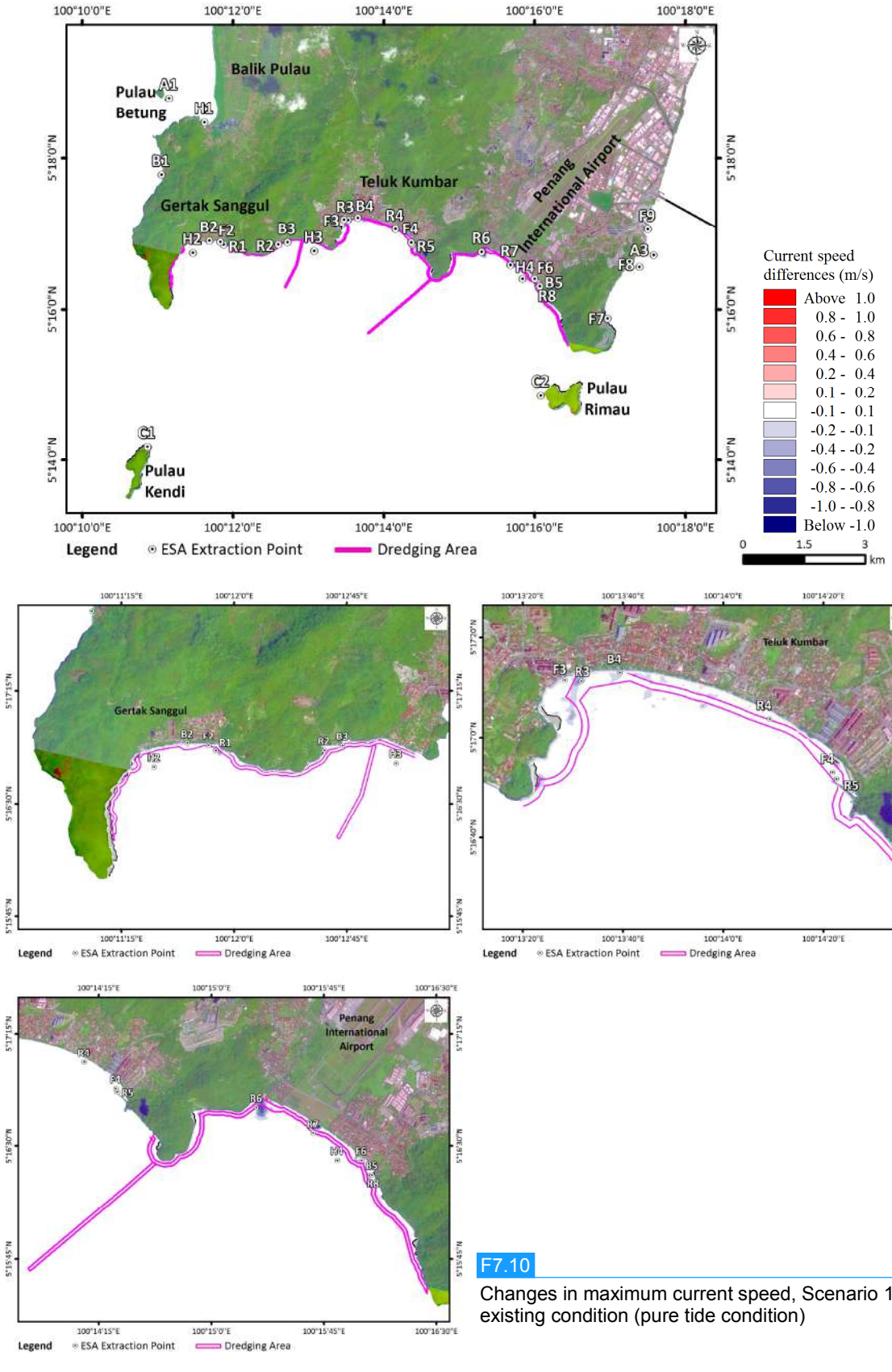
F7.8

Changes in mean current speed, Scenario 1 vs. existing condition (Northeast Monsoon condition)



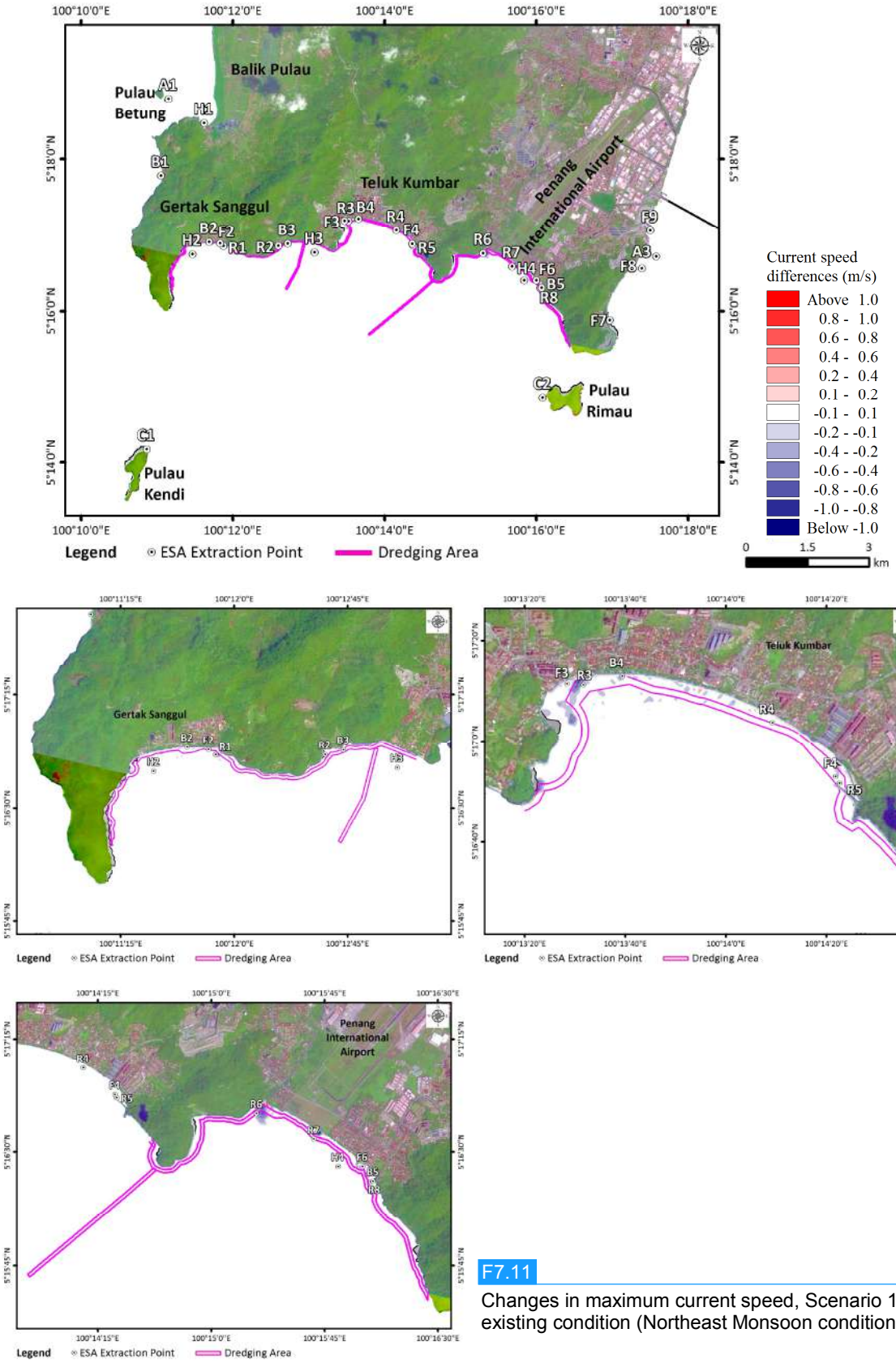
F7.9

Changes in mean current speed, Scenario 1 vs. existing condition (Southwest Monsoon condition)



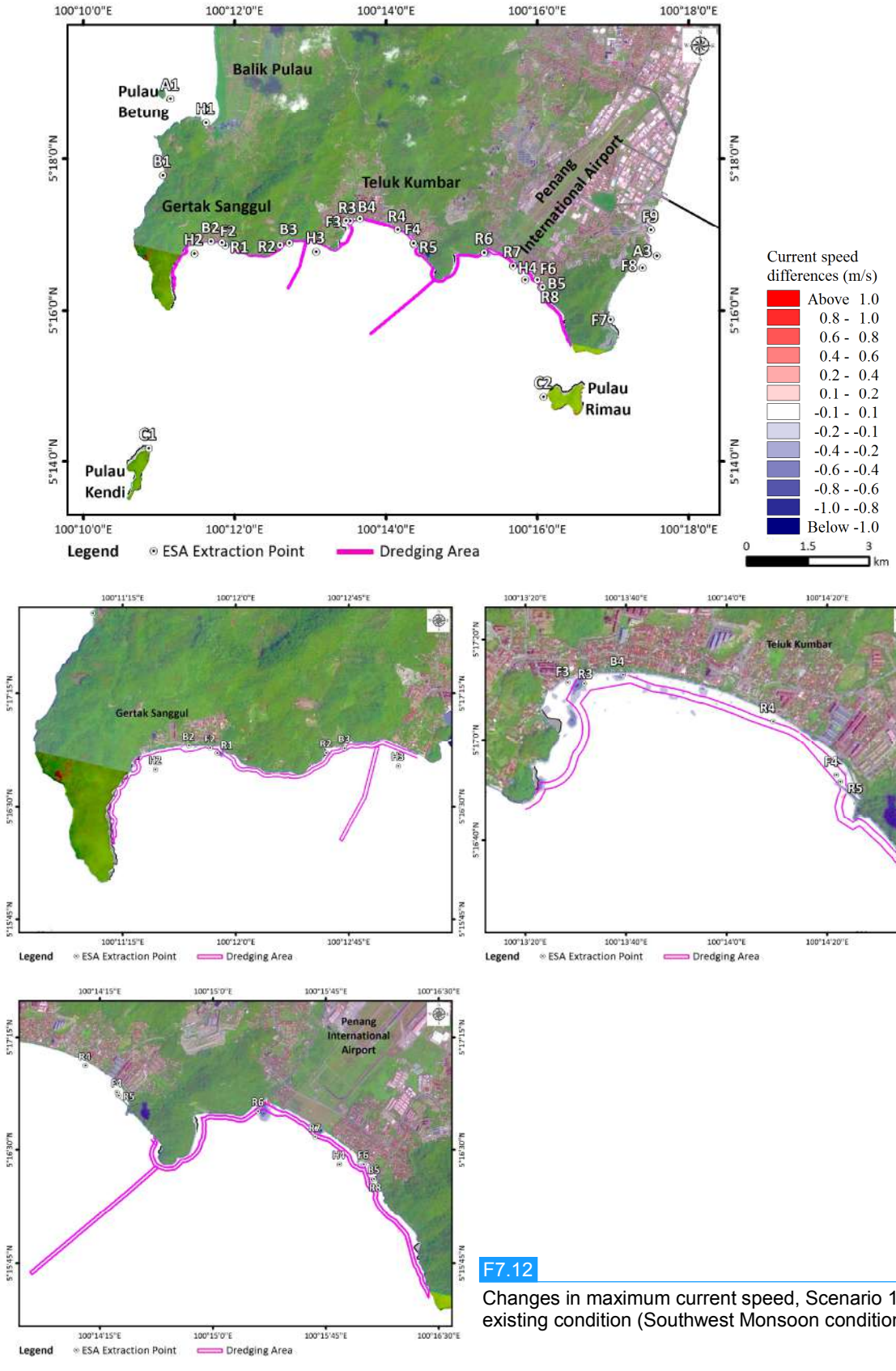
F7.10

Changes in maximum current speed, Scenario 1 vs. existing condition (pure tide condition)



F7.11

Changes in maximum current speed, Scenario 1 vs. existing condition (Northeast Monsoon condition)



F7.12

Changes in maximum current speed, Scenario 1 vs. existing condition (Southwest Monsoon condition)

T7.10 Comparison of mean and maximum current speed at the ESAs between baseline condition and Scenario 1

Point	Location	Baseline Condition		Scenario 1						Remarks
				Mean			Maximum			
		Mean Speed (m/s)	Maximum Speed (m/s)	Speed (m/s)	Difference (m/s)	Difference (%)	Speed (m/s)	Difference (m/s)	Difference (%)	
R1	Sungai Gertak Sanggul	0.08	0.21	0.08	0.00	0	0.20	-0.01	-5	Insignificant impact
R2	Sungai Gemuruh	0.10	0.25	0.10	0.00	0	0.26	0.01	4	Insignificant impact
R3	Sungai Teluk Kumbar	0.06	0.13	0.06	0.00	0	0.14	0.01	8	Insignificant impact
R4	Sungai Mati	0.03	0.07	0.02	-0.01	-33	0.09	0.02	29	Decrease in current speed may induce sluggishness
R5	Sungai Batu	0.03	0.15	0.06	0.03	100	0.17	0.02	13	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R6	Sungai Bayan Lepas	0.05	0.12	0.05	0.00	0	0.14	0.02	17	Insignificant impact
R7	Bayan Lepas Main Drain	0.06	0.16	0.08	0.02	33	0.22	0.06	38	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R8	Sungai Ikan Mati	0.05	0.15	0.08	0.03	60	0.22	0.07	47	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
C1	Pulau Kendi	0.25	0.99	0.25	0.00	0	0.99	0.00	0	Insignificant impact
C2	Pulau Rimau	0.14	0.42	0.14	0.00	0	0.42	0.00	0	Insignificant impact
H1	Sungai Pulau Betung	0.01	0.03	0.01	0.00	0	0.03	0.00	0	Insignificant impact
H2	Gertak Sanggul	0.06	0.24	0.07	0.01	17	0.17	-0.07	-29	Insignificant impact
H3	Teluk Kumbar	0.12	0.31	0.13	0.01	8	0.33	0.02	6	Insignificant impact
H4	Permatang Damar Laut	0.06	0.15	0.07	0.01	17	0.16	0.01	7	Insignificant impact

T7.10 Comparison of mean and maximum current speed at the ESAs between baseline condition and Scenario 1 (cont'd)

Point	Location	Baseline Condition		Scenario 1						Remarks
				Mean			Maximum			
		Mean Speed (m/s)	Maximum Speed (m/s)	Speed (m/s)	Difference (m/s)	Difference (%)	Speed (m/s)	Difference (m/s)	Difference (%)	
A1	Pulau Betung	0.16	0.47	0.16	0.00	0	0.47	0.00	0	Insignificant impact
A2	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data
A3	Batu Maung	0.22	0.56	0.22	0.00	0	0.55	-0.01	-2	Insignificant impact
F1	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
F2	Gertak Sanggul	0.04	0.04	0.03	-0.01	-25	0.03	-0.01	-25	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
F3	Teluk Kumbar	0.03	0.03	0.02	-0.01	-33	0.02	-0.01	-33	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
F4	Sungai Batu	0.04	0.04	0.04	0.00	0	0.04	0.00	0	Insignificant impact
F5	Permatang Tepi Laut	-	-	-	-	-	-	-	-	No data (upstream location)
F6	Permatang Damar Laut	0.06	0.06	0.07	0.01	17	0.07	0.01	17	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
F7	Teluk Tempoyak Besar	0.08	0.08	0.08	0.00	0	0.08	0.00	0	Insignificant impact
F8	Teluk Tempoyak Kecil	0.19	0.19	0.19	0.00	0	0.19	0.00	0	Insignificant impact
F9	Batu Maung	0.16	0.16	0.16	0.00	0	0.16	0.00	0	Insignificant impact

b) Scenario 2

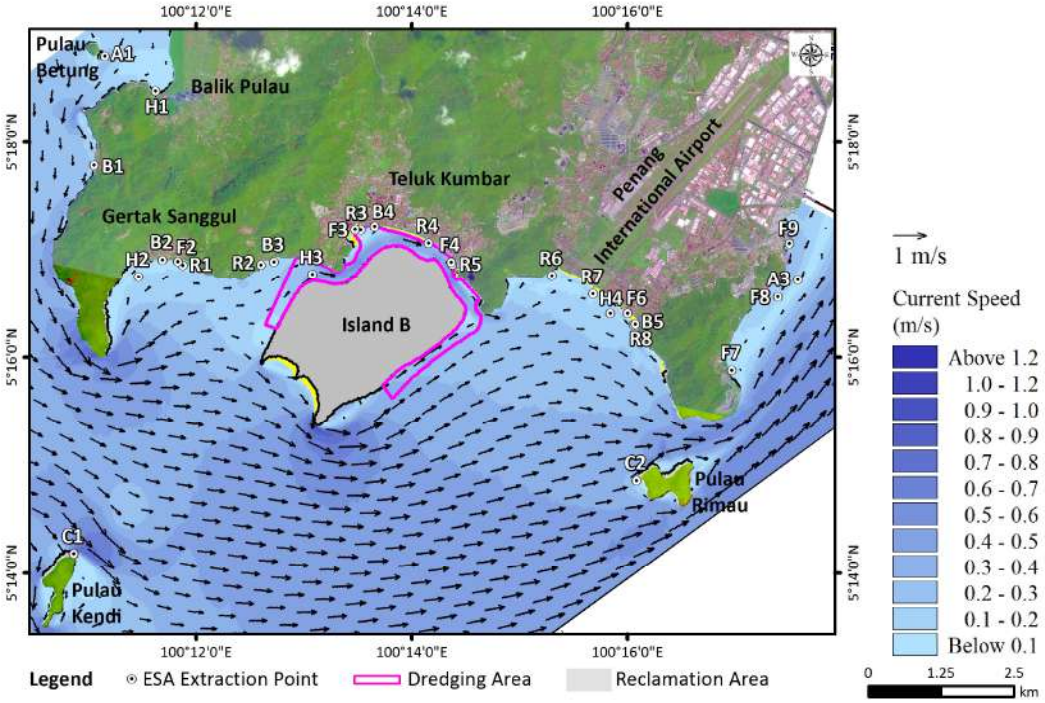
Currents flow conditions around the Project site after the implementation of Scenario 2 for the pure tide, Northeast Monsoon and Southwest Monsoon conditions are shown in F7.13 to F7.15 respectively. F7.16 shows the mean and maximum current speeds for all climatic conditions.

The changes in the mean current speeds between Scenario 2 and the existing conditions are shown in F7.17. The mean current speeds in the dredged channel between Island B and the foreshore of Teluk Kumbar are increased by up to 0.2 m/s. Such increases are expected in the dredged channels given that the current speeds at their locations in the existing inter-tidal mud flat areas are very low; generally less than 0.1 m/s. The presence of Island B appears to reduce the mean current speeds between Island B and Tanjung Gertak Sanggul and, to a lesser extent, between Island B and Tanjung Teluk Tempoyak, by up to 0.15 m/s.

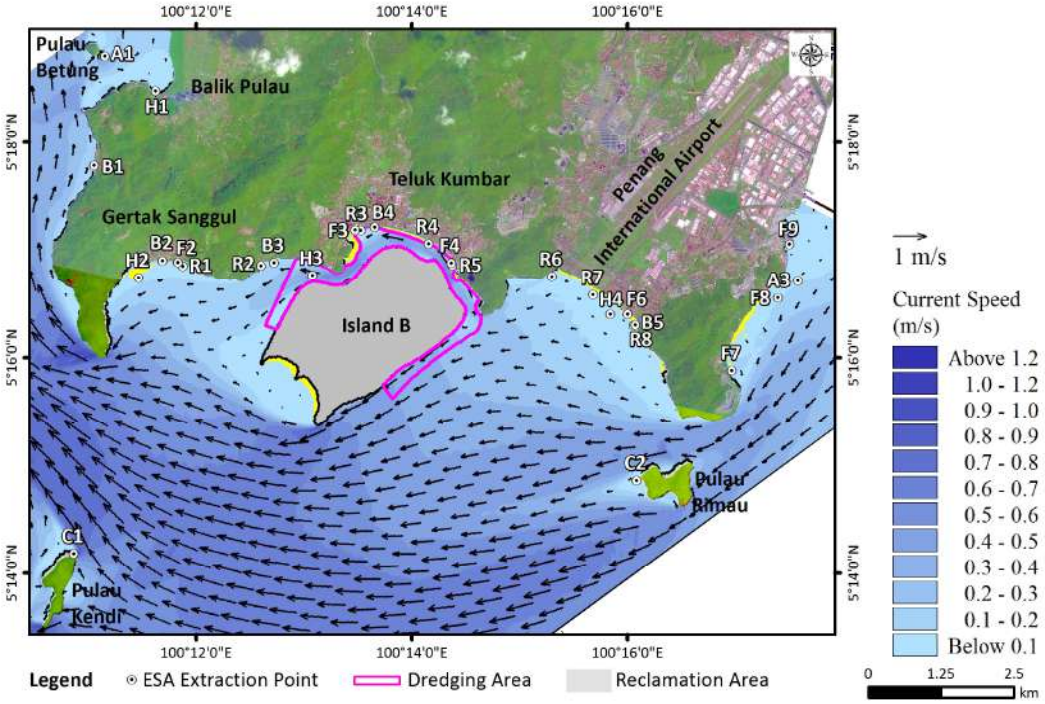
F7.18 shows the changes in maximum current speeds between Scenario 2 and the existing conditions. The figure shows that, in the dredged channel between Island B and the foreshore of Teluk Kumbar, the maximum current speeds are increased by up to 0.4 m/s. The reduction in maximum current speeds is up to 0.4 m/s between Island B and Tanjung Gertak Sanggul as well as near Tanjung Chut.

The southern-most headland of Island B appears to induce localised increases in the mean and maximum current speeds by up to 0.15 and 0.6 m/s respectively.

Comparison of the mean and maximum current speeds between the baseline and Scenario 2 are tabulated in T7.11.

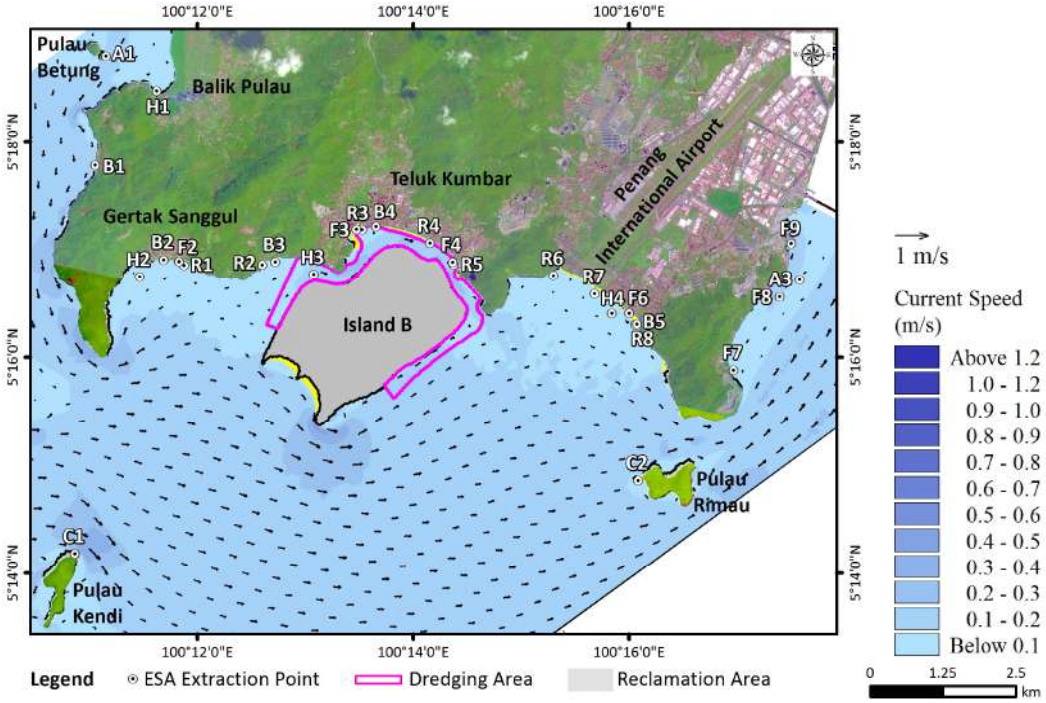


a) Spring period: Flood flow

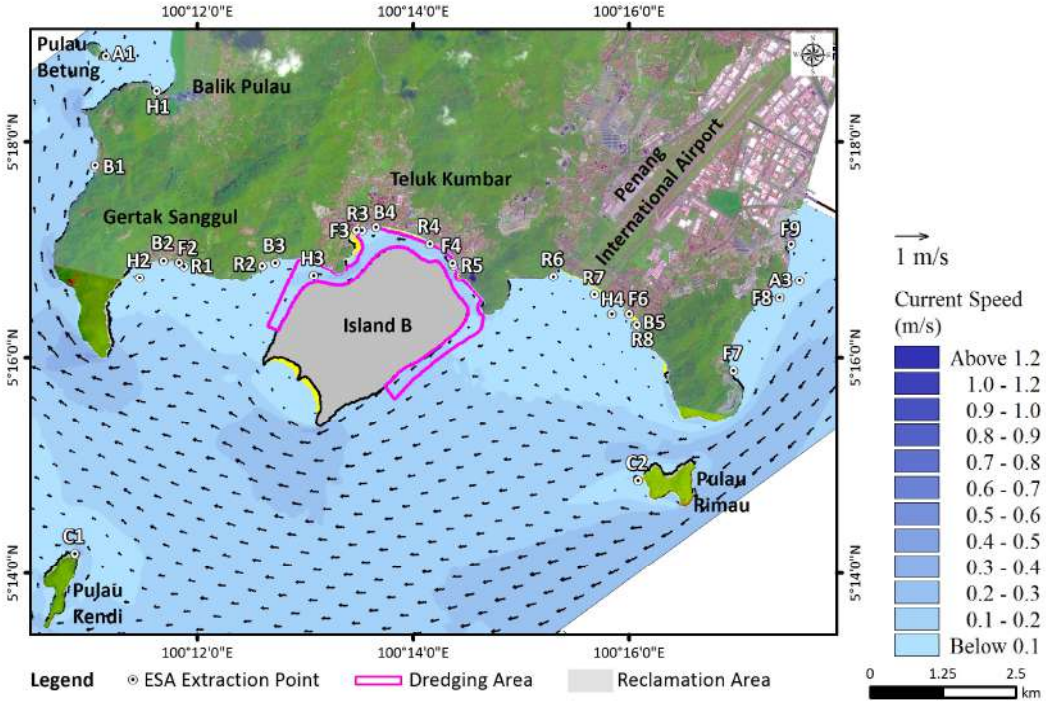


b) Spring period: Ebb flow

F7.13 Flow pattern during spring and neap periods for Scenario 2 condition (pure tide condition)

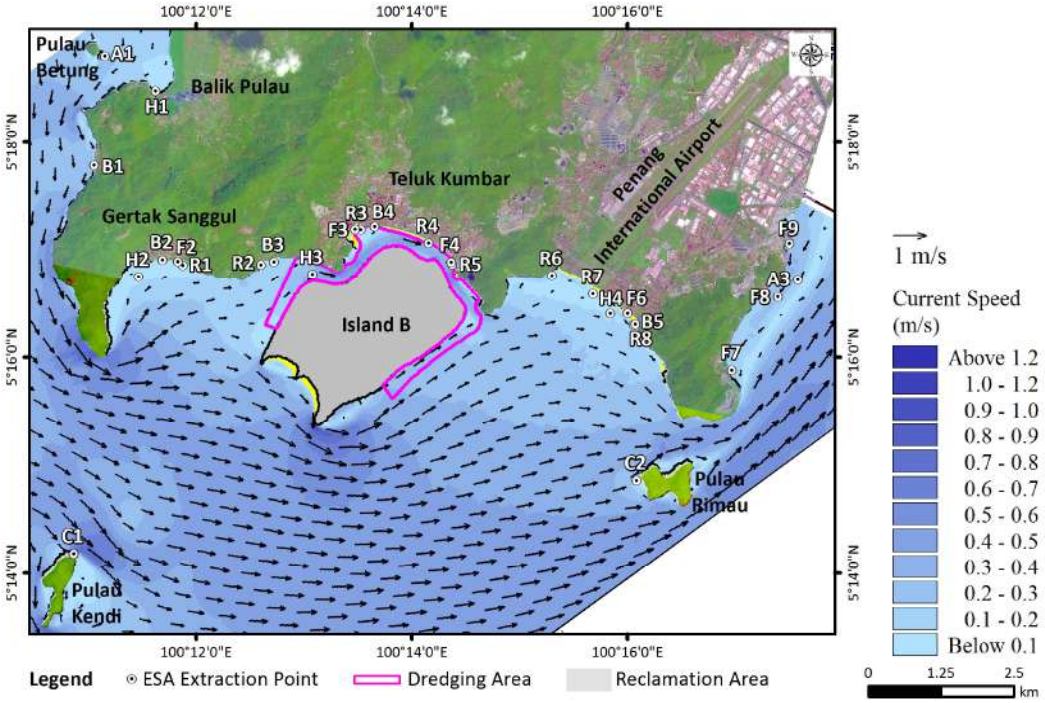


c) Neap period: Flood flow

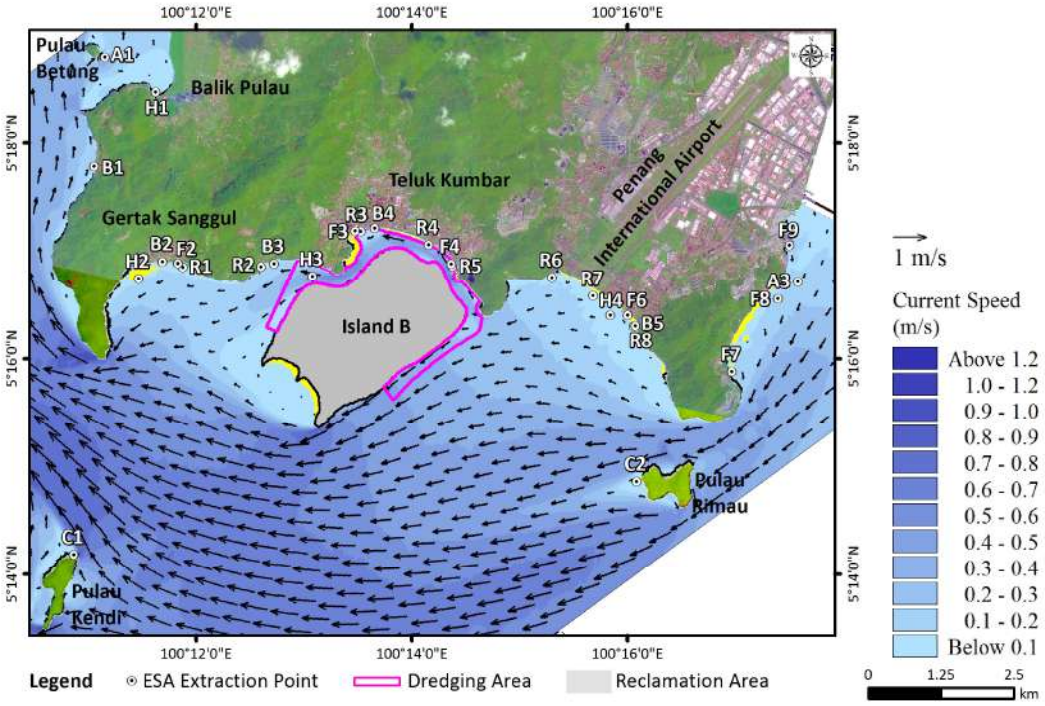


d) Neap period: Ebb flow

F7.13 Flow pattern during spring and neap periods for Scenario 2 condition (pure tide condition) (cont'd)

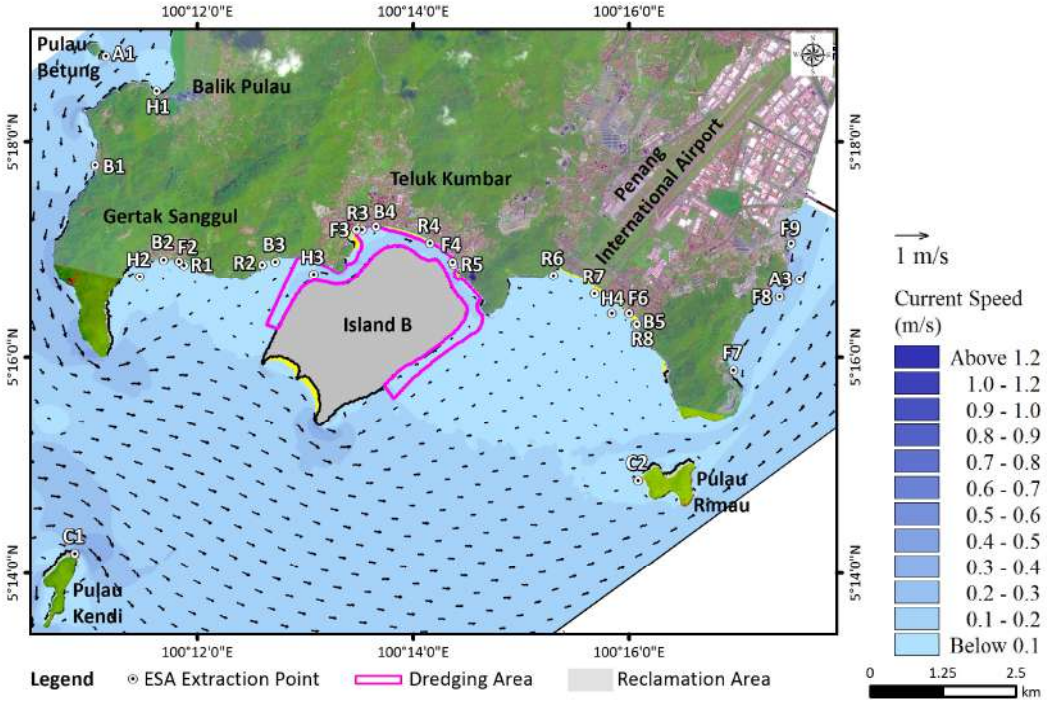


a) Spring period: Flood flow

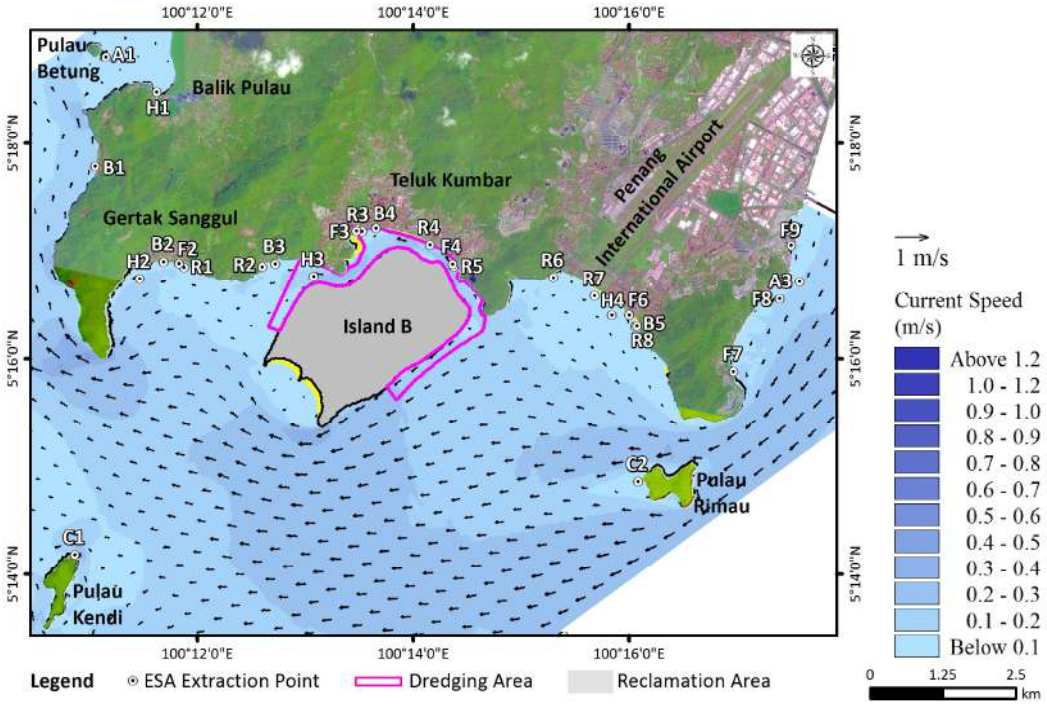


b) Spring period: Ebb flow

F7.14 Flow pattern during spring and neap periods for Scenario 2 condition (Northeast Monsoon condition)

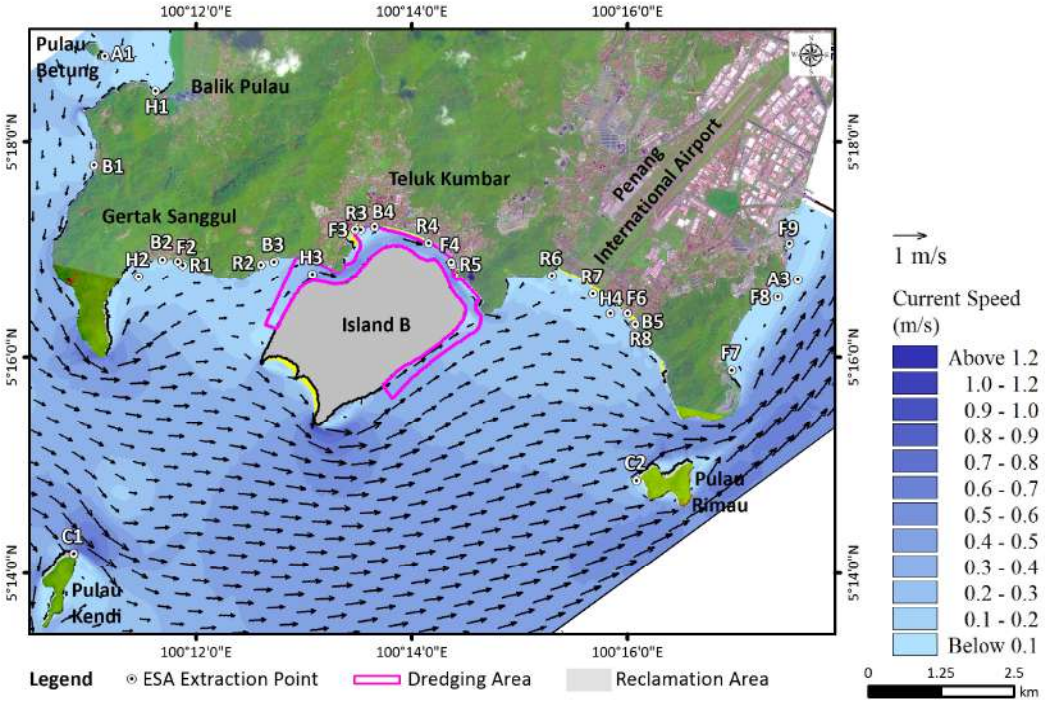


c) Neap period: Flood flow

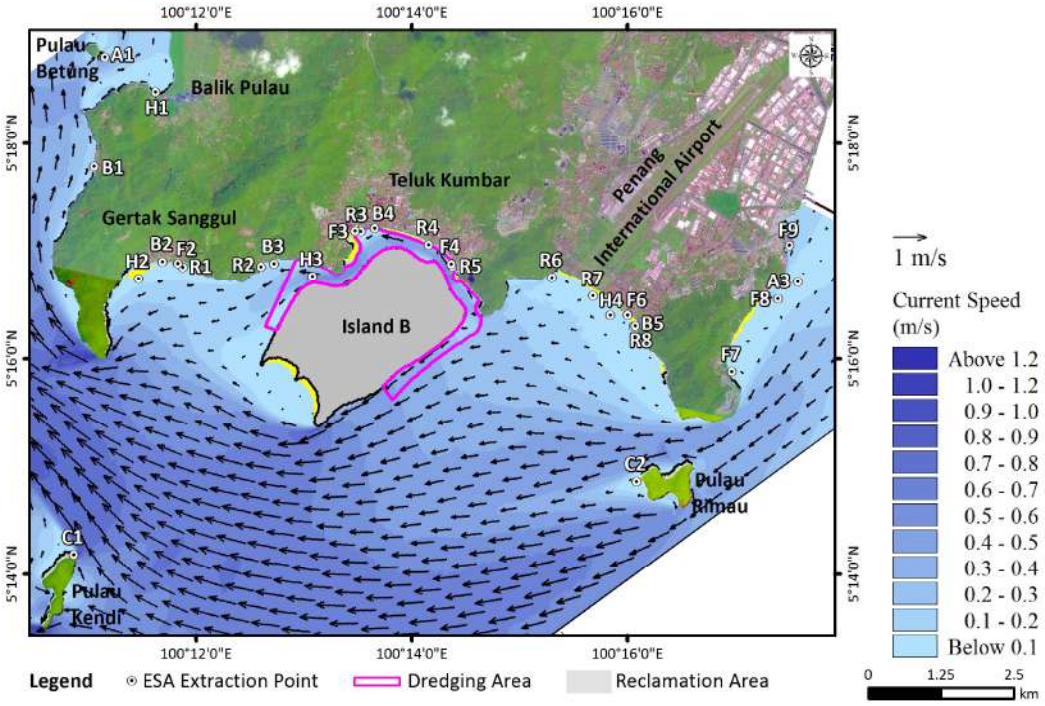


d) Neap period: Ebb flow

F7.14 Flow pattern during spring and neap periods for Scenario 2 condition (Northeast Monsoon condition) (cont'd)

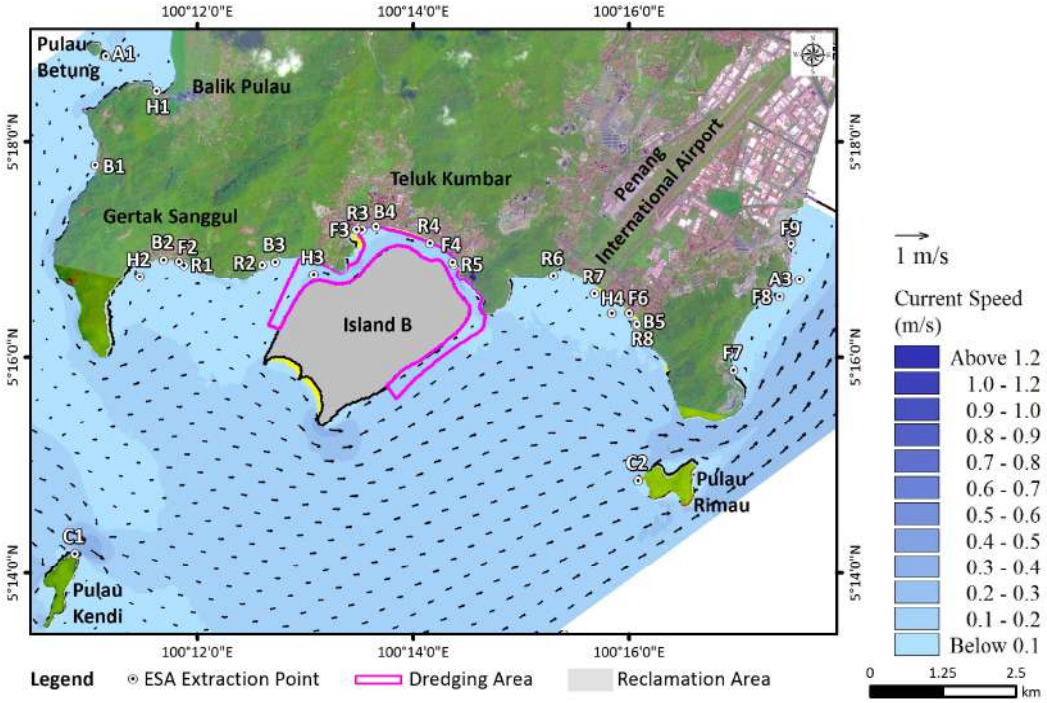


a) Spring period: Flood flow

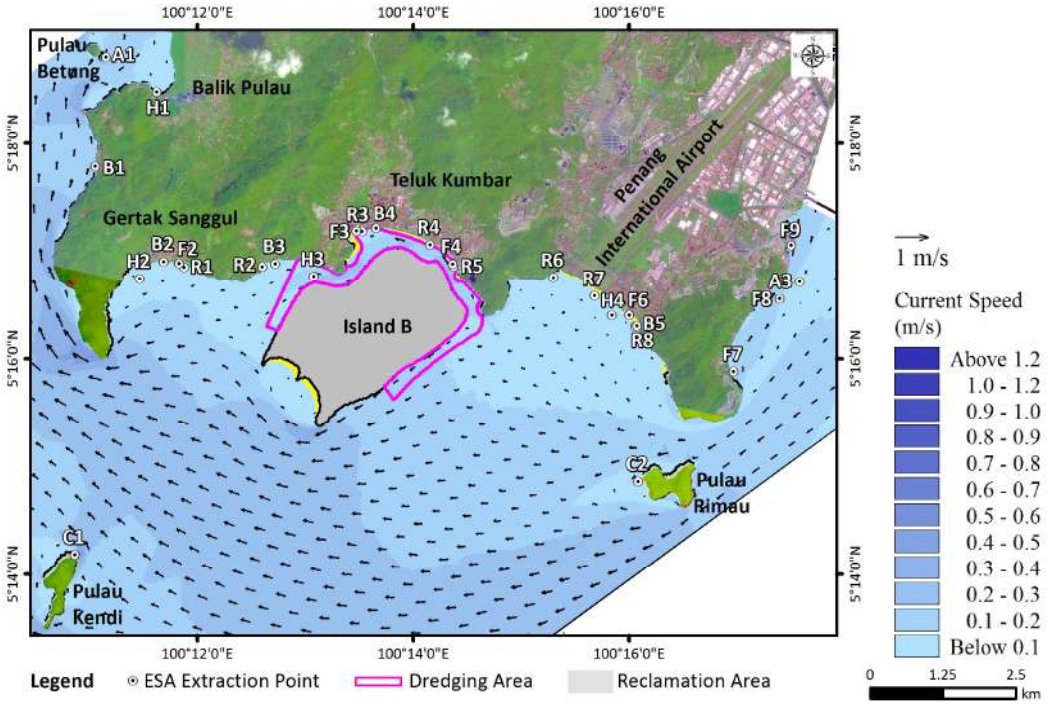


b) Spring period: Ebb flow

F7.15 Flow pattern during spring and neap periods for Scenario 2 condition (Southwest Monsoon condition)

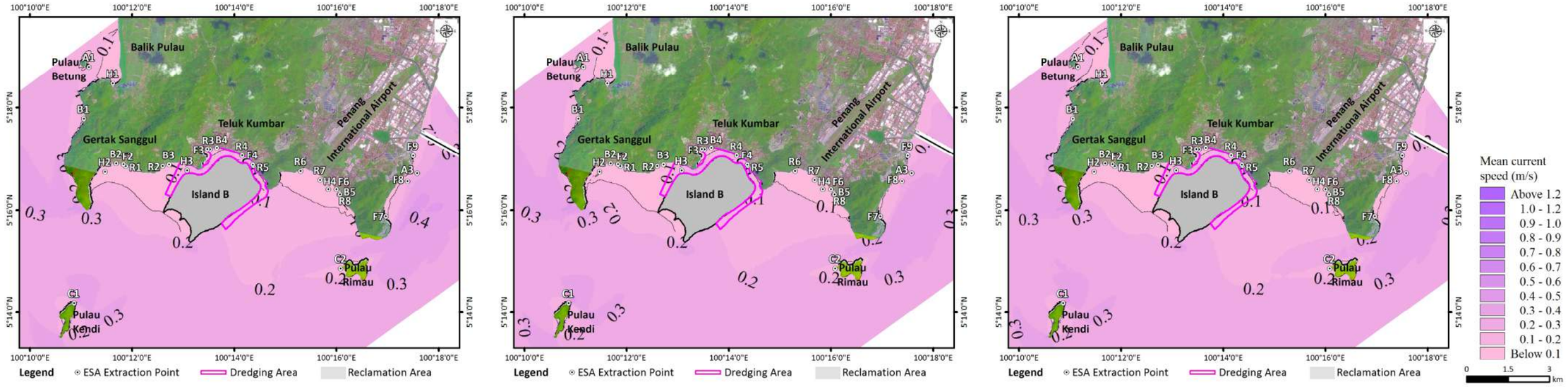


c) Neap period: Flood flow



d) Neap period: Ebb flow

F7.15 Flow pattern during spring and neap periods for Scenario 2 condition (Southwest Monsoon condition) (cont'd)



a) Mean current speed: Pure tide

c) Mean current speed: Northeast Monsoon

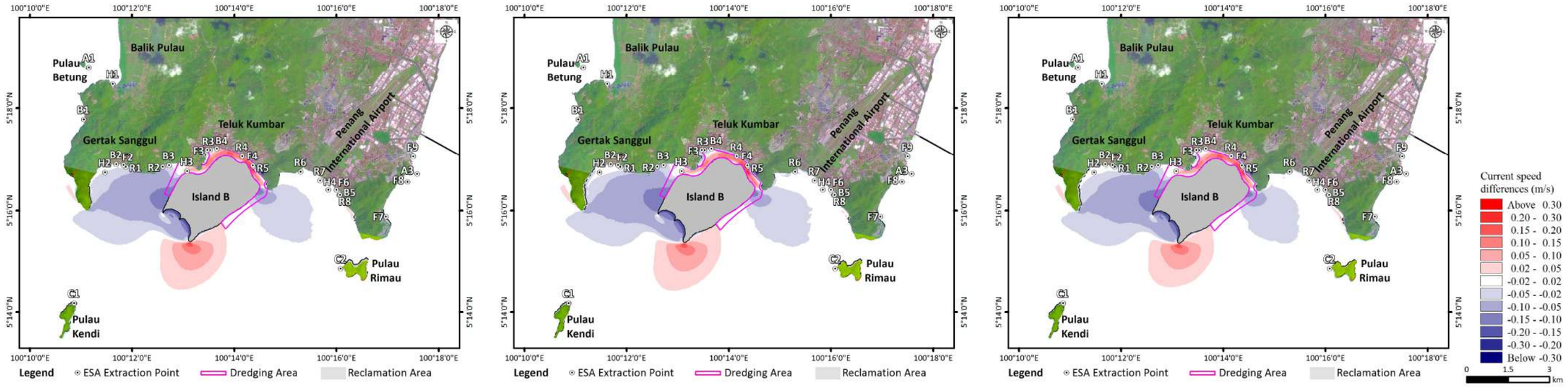
e) Mean current speed: Southwest Monsoon

b) Maximum current speed: Pure tide

d) Maximum current speed: Northeast Monsoon

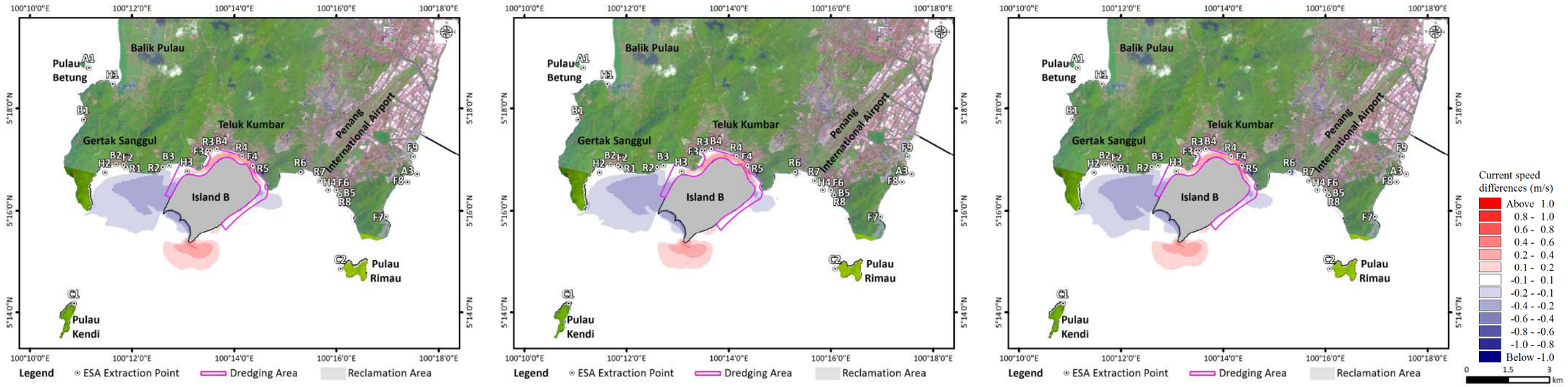
f) Maximum current speed: Southwest Monsoon

F7.16 Mean and maximum current speed plots for Scenario 2 condition



a) Pure tide condition b) Northeast Monsoon condition c) Southwest Monsoon condition

F7.17 Changes in mean current speed, Scenario 2 vs. existing condition



a) Pure tide condition b) Northeast Monsoon condition c) Southwest Monsoon condition

F7.18 Changes in maximum current speed, Scenario 2 vs. existing condition

T7.11 Comparison of mean and maximum current speed at the ESAs between baseline condition and Scenario 2

Point	Location	Baseline Condition		Scenario 1						Remarks
				Mean			Maximum			
		Mean Speed (m/s)	Maximum Speed (m/s)	Speed (m/s)	Difference (m/s)	Difference (%)	Speed (m/s)	Difference (m/s)	Difference (%)	
R1	Sungai Gertak Sanggul	0.08	0.21	0.05	-0.03	-38	0.13	-0.08	-38	Decrease in current speed may induce sluggishness
R2	Sungai Gemuruh	0.10	0.25	0.09	-0.01	-10	0.21	-0.04	-16	Decrease in current speed may induce sluggishness
R3	Sungai Teluk Kumbar	0.06	0.13	0.16	0.10	167	0.43	0.30	231	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R4	Sungai Mati	0.03	0.07	0.03	0.00	0	0.13	0.06	86	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R5	Sungai Batu	0.03	0.15	0.08	0.05	167	0.27	0.12	80	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R6	Sungai Bayan Lepas	0.05	0.12	0.04	-0.01	-20	0.12	0.00	0	Insignificant Impact
R7	Bayan Lepas Main Drain	0.06	0.16	0.07	0.01	17	0.21	0.05	31	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R8	Sungai Ikan Mati	0.05	0.15	0.07	0.02	40	0.21	0.06	40	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
C1	Pulau Kendi	0.25	0.99	0.24	-0.01	-4	0.99	0.00	0	Insignificant impact
C2	Pulau Rimau	0.14	0.42	0.14	0.00	0	0.42	0.00	0	Insignificant impact
H1	Sungai Pulau Betung	0.01	0.03	0.01	0.00	0	0.02	-0.01	-33	Insignificant impact
H2	Gertak Sanggul	0.06	0.24	0.05	-0.01	-17	0.26	0.02	8	Insignificant impact
H3	Teluk Kumbar	0.12	0.31	0.16	0.04	33	0.45	0.14	45	Insignificant impact
H4	Permatang Damar Laut	0.06	0.15	0.06	0.00	0	0.16	0.01	7	Insignificant impact

T7.11 Comparison of mean and maximum current speed at the ESAs between baseline condition and Scenario 2 (cont'd)

Point	Location	Baseline Condition		Scenario 1						Remarks
				Mean			Maximum			
		Mean Speed (m/s)	Maximum Speed (m/s)	Speed (m/s)	Difference (m/s)	Difference (%)	Speed (m/s)	Difference (m/s)	Difference (%)	
A1	Pulau Betung	0.16	0.47	0.16	0.00	0	0.46	-0.01	-2	Insignificant impact
A2	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
A3	Batu Maung	0.22	0.56	0.22	0.00	0	0.55	-0.01	-2	Insignificant impact
F1	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
F2	Gertak Sanggul	0.04	0.04	0.02	-0.02	-50	0.08	-0.09	-53	Decrease in current speed may induce sedimentation. Refer to *Section 7.3.8*.
F3	Teluk Kumbar	0.03	0.03	0.02	-0.01	-33	0.08	-0.19	-70	Decrease in current speed may induce sedimentation. Refer to *Section 7.3.8*.
F4	Sungai Batu	0.04	0.04	0.15	0.11	275	0.38	0.23	153	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
F5	Permatang Tepi Laut	-	-	-	-	-	-	-	-	No data (upstream location)
F6	Permatang Damar Laut	0.06	0.06	0.06	0.00	0	0.17	0.00	0	Insignificant impact
F7	Teluk Tempoyak Besar	0.08	0.08	0.08	0.00	0	0.25	-0.01	-4	Insignificant impact
F8	Teluk Tempoyak Kecil	0.19	0.19	0.19	0.00	0	0.54	0.01	2	Insignificant impact
F9	Batu Maung	0.16	0.16	0.16	0.00	0	0.43	0.00	0	Insignificant impact

c) Scenario 3

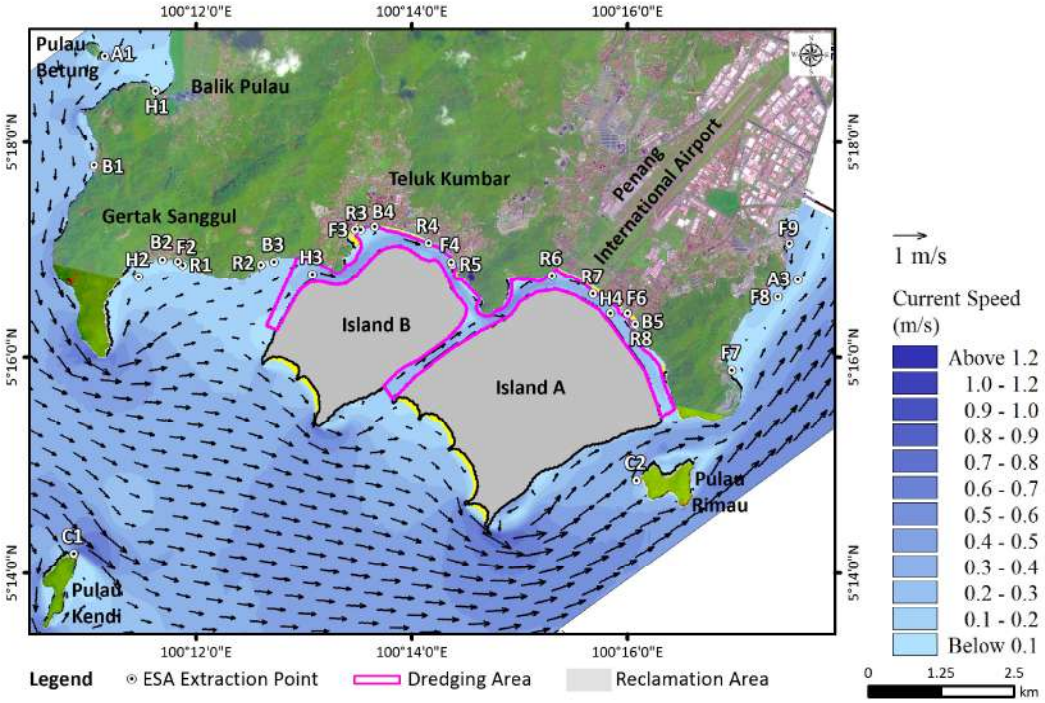
F7.19 to F7.21 show the current flow conditions around the Project site after the implementation of Scenario 3 during spring and neap periods for all climatic conditions. The mean and maximum current speeds for climatic conditions are shown in F7.22.

The changes in mean and maximum current speeds between Scenario 3 and the existing conditions are illustrated in F7.23 and F7.24 respectively. It is observed from these figures that the increase in the mean and maximum current speeds in the channel between Island B and the foreshore of Teluk Kumbar is slightly reduced to 0.1 and 0.2 m/s in respect to the observations in Scenario 2. The mean and maximum current speeds in the channel between Island A and the coastline of Permatang Damar Laut is predicted to increase by 0.1 and 0.2 m/s respectively.

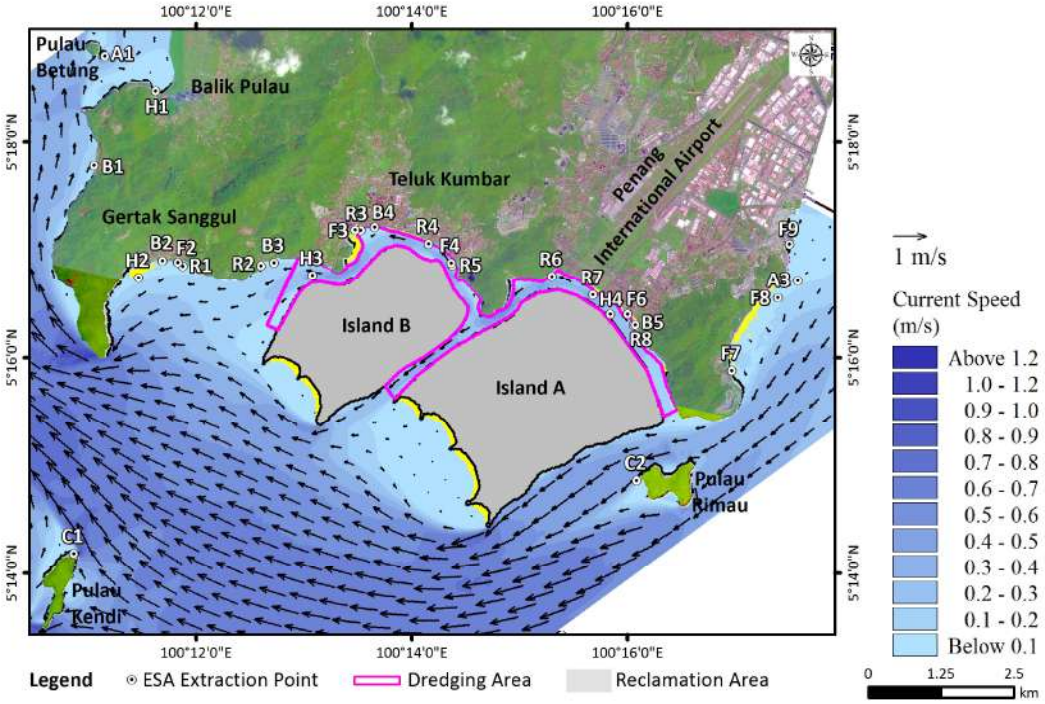
The mean and maximum currents off the southern coastline of both reclaimed islands are expected to reduce by 0.15 and 0.4 m/s respectively, mainly due to the headlands. There is a localised increase in current speed near the southern-most headland of Island A by up to 0.15 and 0.4 m/s in the mean and maximum values respectively. With the presence of Island A, the increase in the mean current speed at the southern-most headland of Island B is reduced to 0.1 m/s.

Changes in current speeds are observed around Pulau Rimau. The mean current speed is reduced by 0.1 m/s to the north and south of the island; increased by 0.15 m/s to the west of the island; and increased by 0.05 m/s to the east of the Pulau Rimau. The maximum current speed is reduced by up to 0.2 m/s to the north of the island and increased by 0.4 m/s to the west of the island.

The comparisons of the mean and maximum current speeds between the baseline and Scenario 3 are tabulated in T7.12.

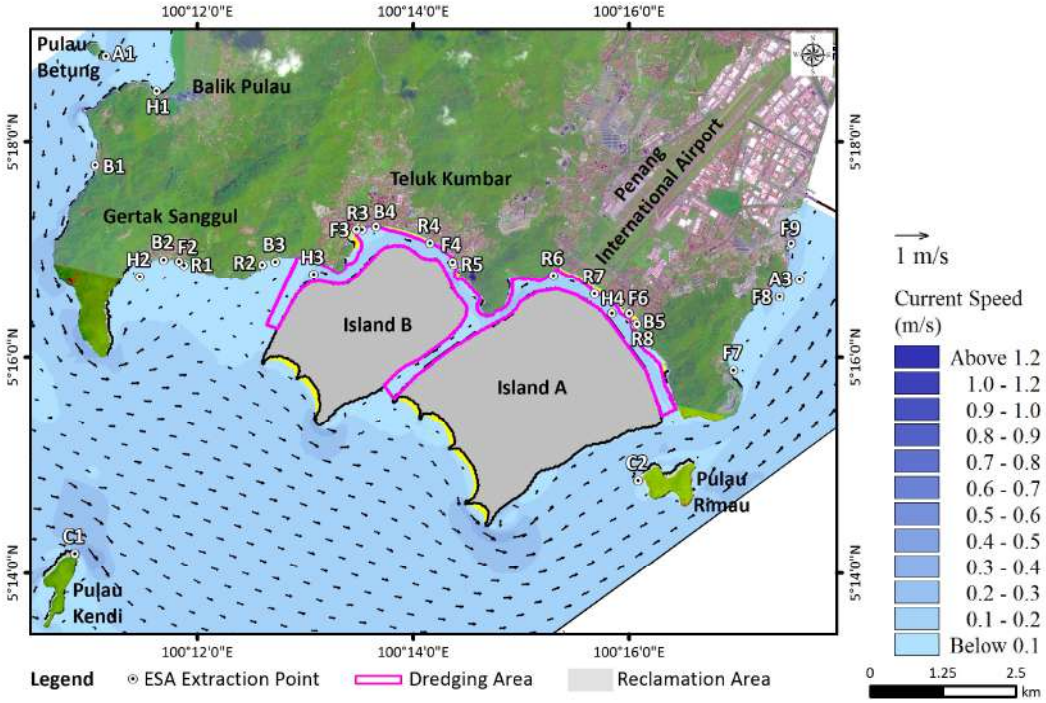


a) Spring period: Flood flow

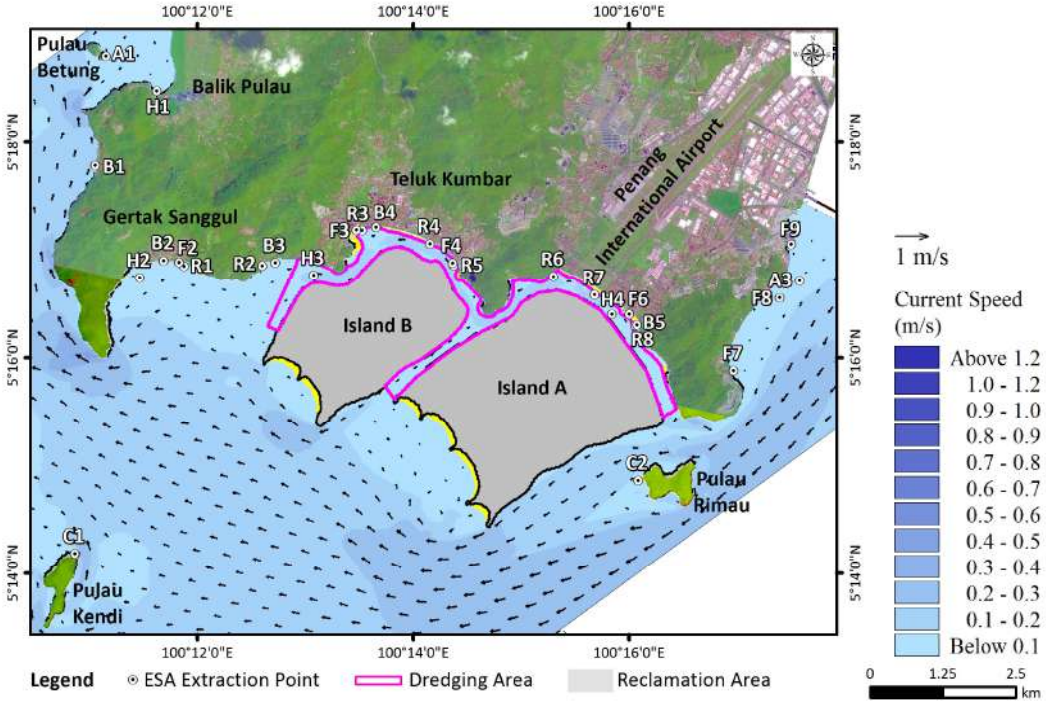


b) Spring period: Ebb flow

F7.19 Flow pattern during spring and neap periods for Scenario 3 condition (pure tide condition)

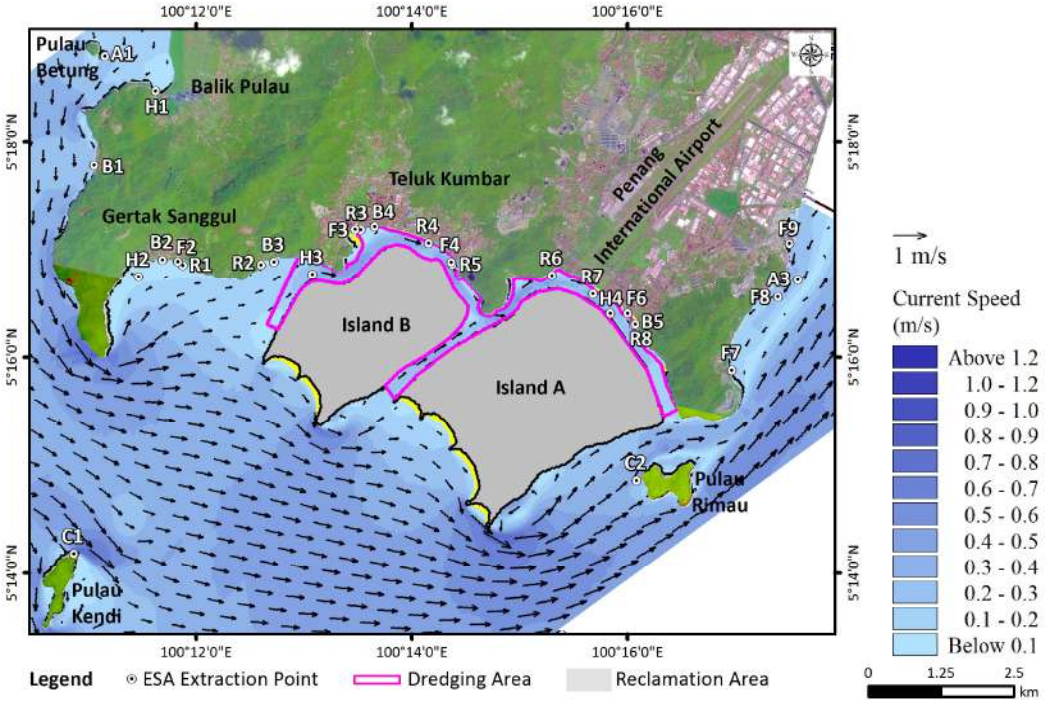


c) Neap period: Flood flow

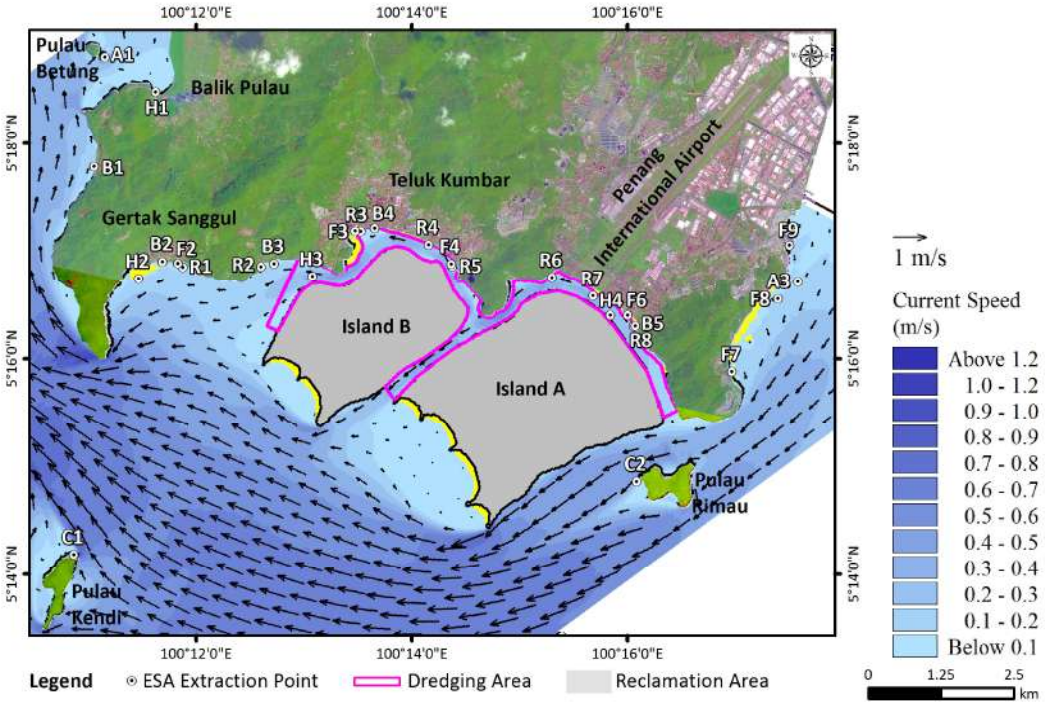


d) Neap period: Ebb flow

F7.19 Flow pattern during spring and neap periods for Scenario 3 condition (pure tide condition) (cont'd)

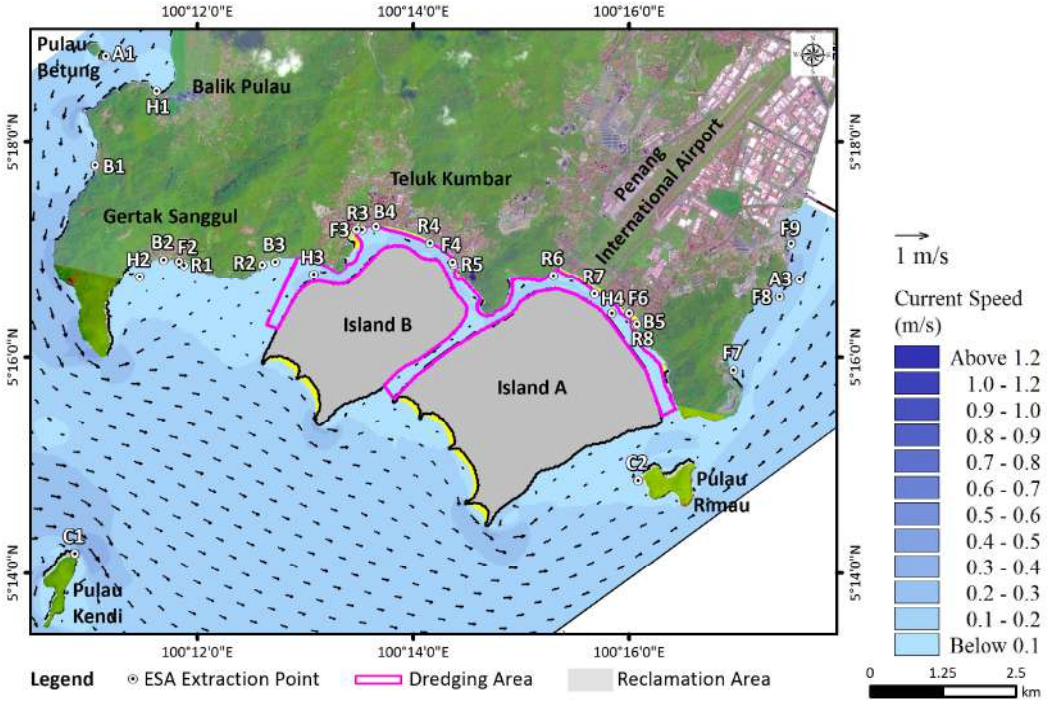


a) Spring period: Flood flow

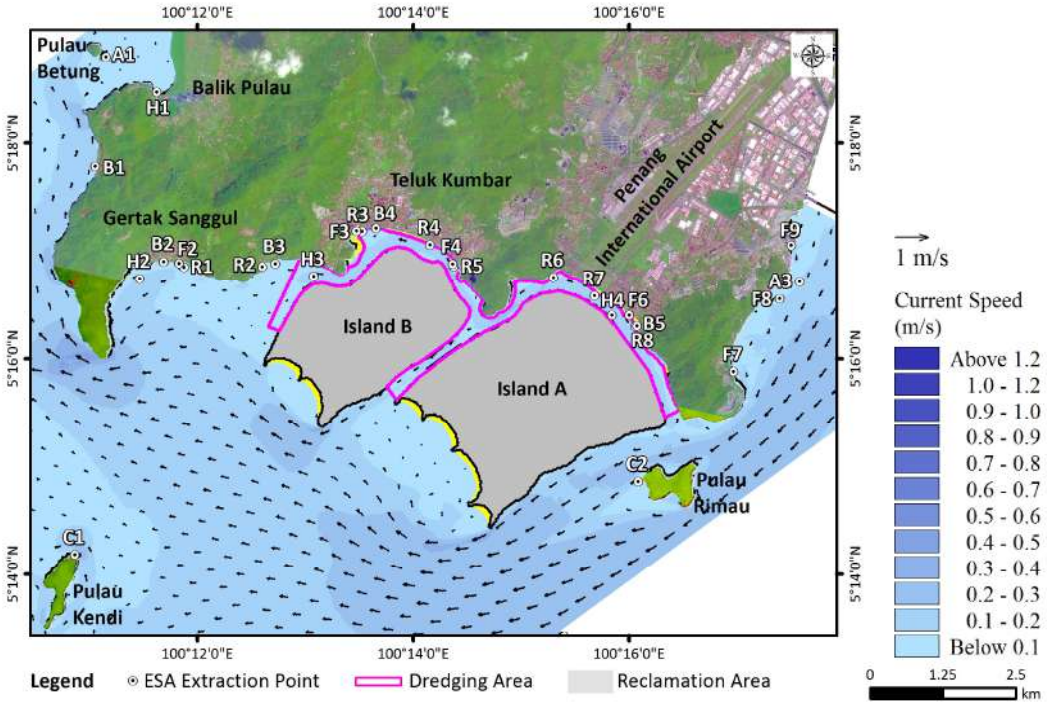


b) Spring period: Ebb flow

F7.20 Flow pattern during spring and neap periods for Scenario 3 condition (Northeast Monsoon condition)

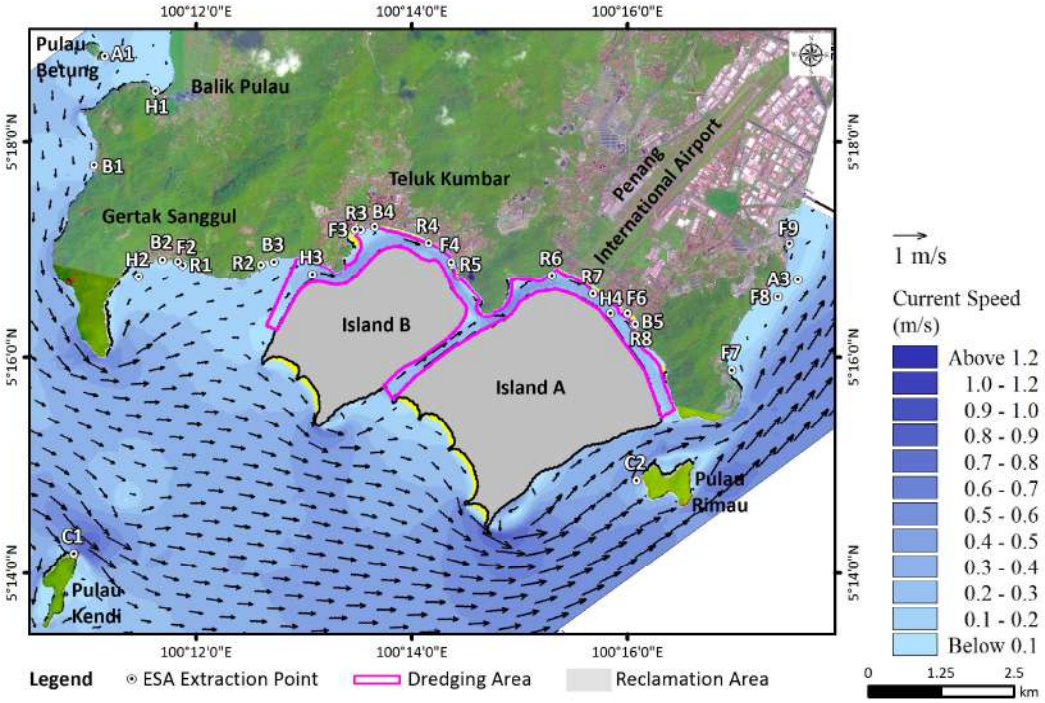


c) Neap period: Flood flow

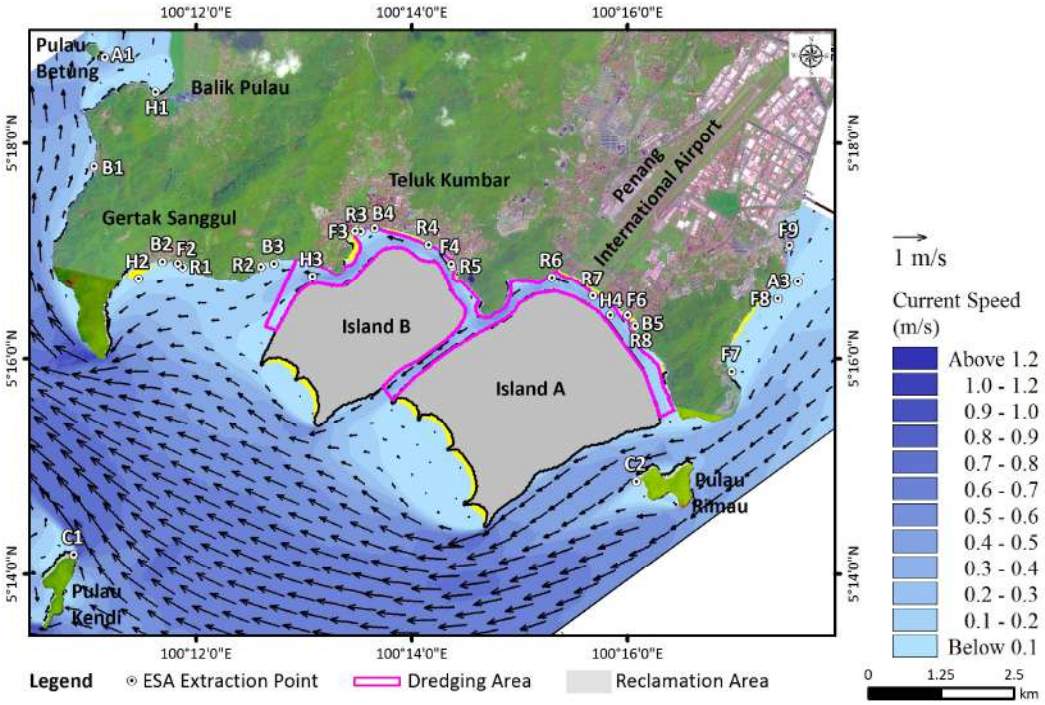


d) Neap period: Ebb flow

F7.20 Flow pattern during spring and neap periods for Scenario 3 condition (Northeast Monsoon condition) (cont'd)

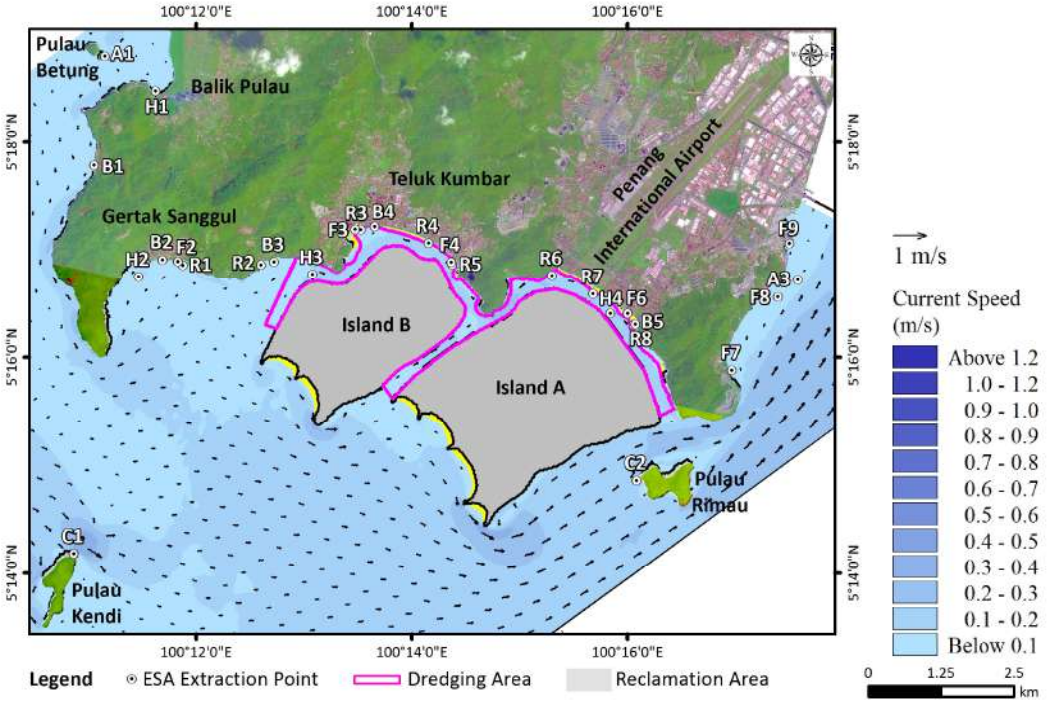


a) Spring period: Flood flow

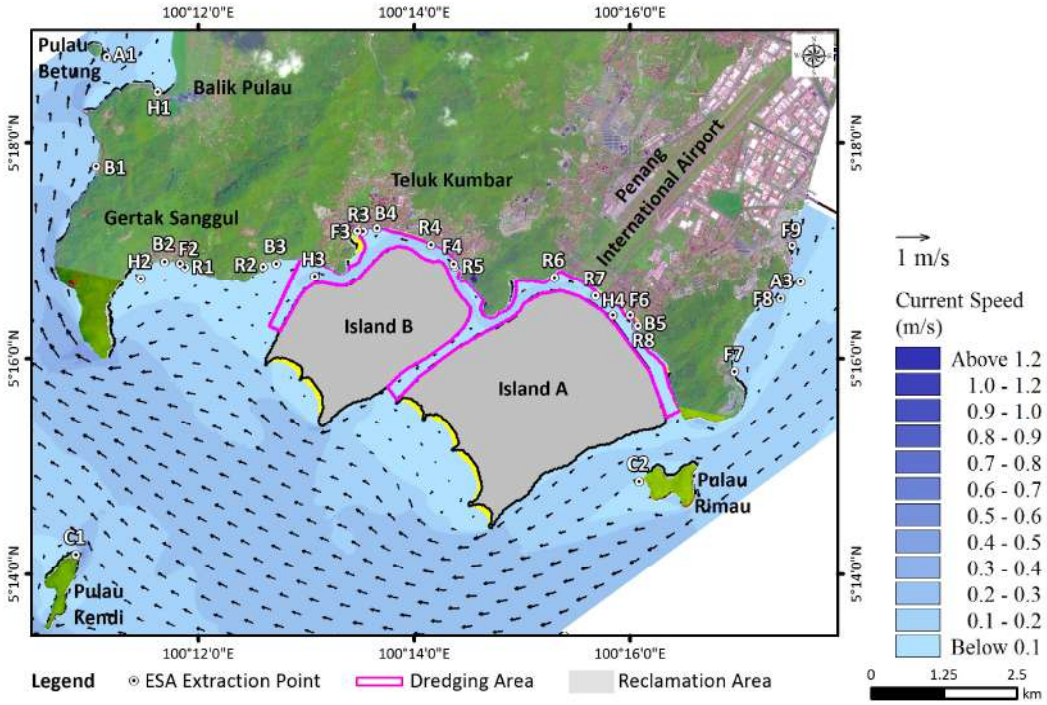


b) Spring period: Ebb flow

F7.21 Flow pattern during spring and neap periods for Scenario 3 condition (Southwest Monsoon condition)

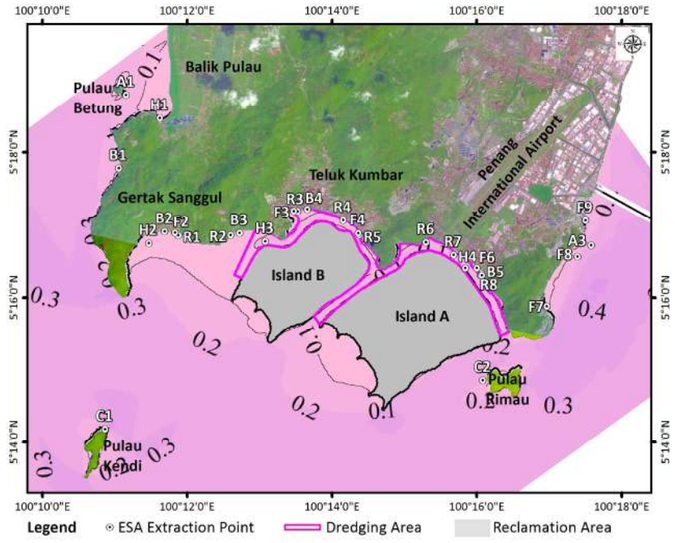


c) Neap period: Flood flow

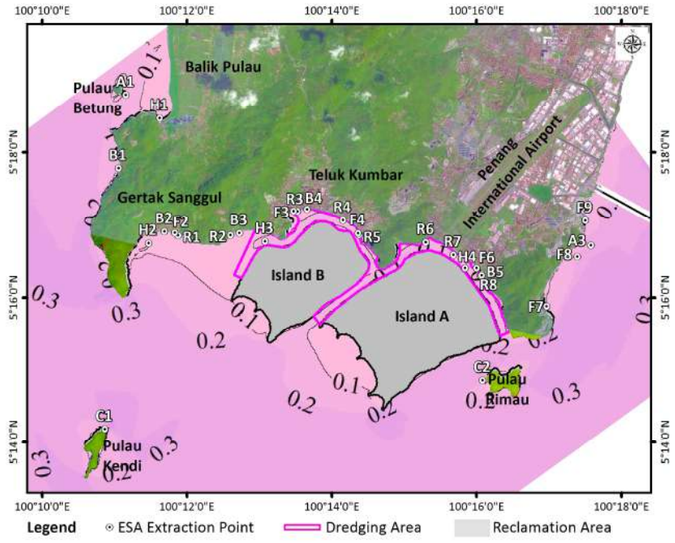


d) Neap period: Ebb flow

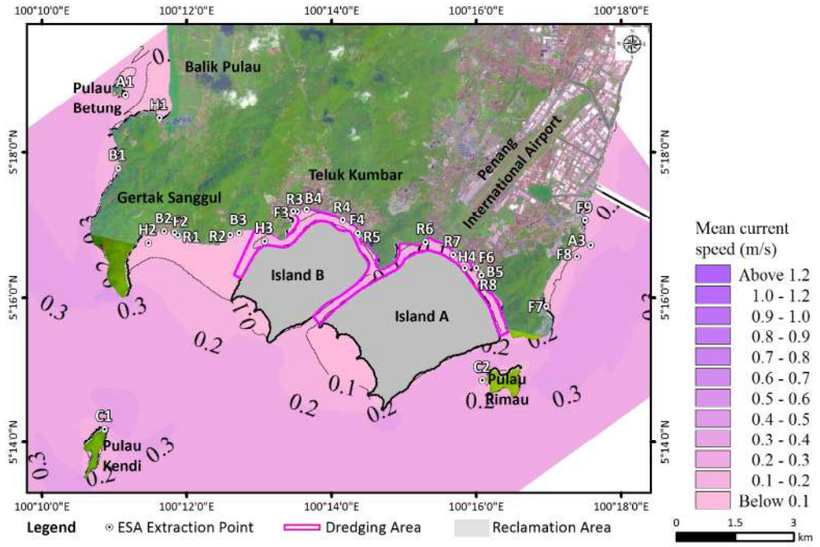
F7.21 Flow pattern during spring and neap periods for Scenario 3 condition (Southwest Monsoon condition) (cont'd)



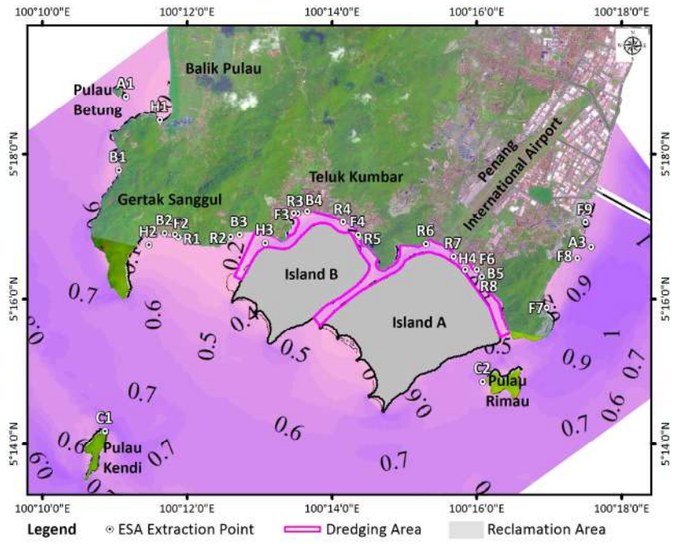
a) Mean current speed: Pure tide



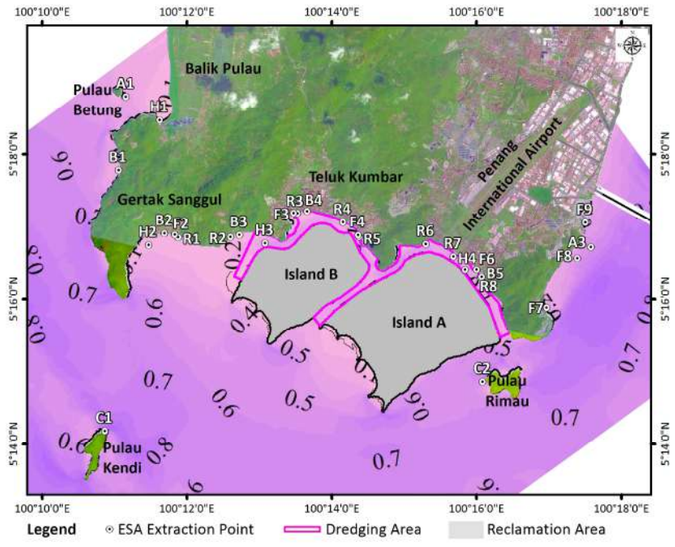
c) Mean current speed: Northeast Monsoon



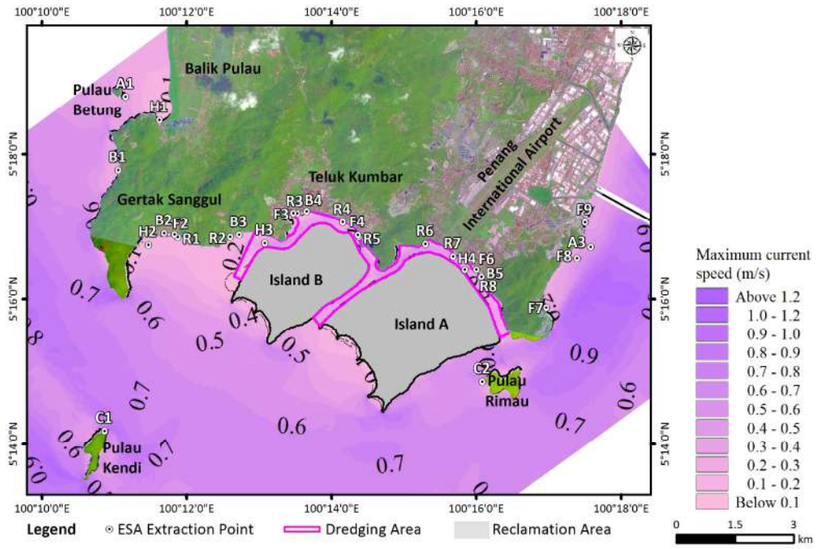
e) Mean current speed: Southwest Monsoon



b) Maximum current speed: Pure tide

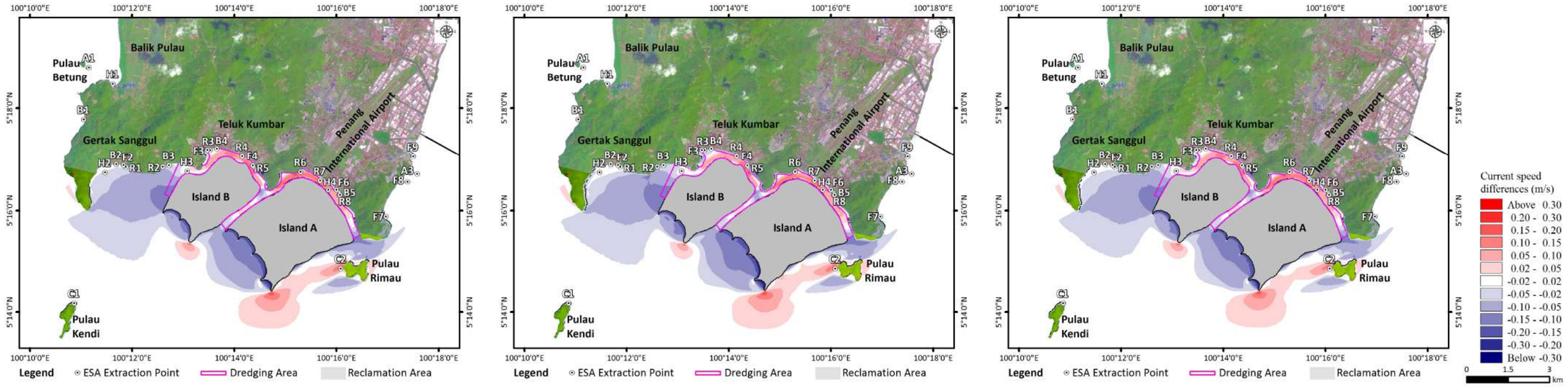


d) Maximum current speed: Northeast Monsoon



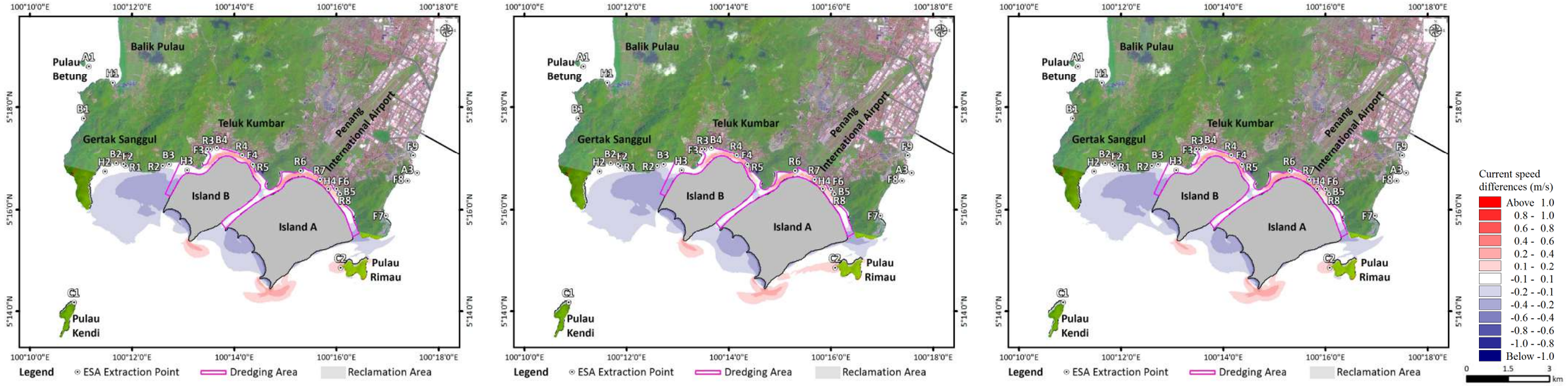
f) Maximum current speed: Southwest Monsoon

F7.22 Mean and maximum current speed plots for Scenario 3 condition



a) Pure tide condition b) Northeast Monsoon condition c) Southwest Monsoon condition

F7.23 Changes in mean current speed, Scenario 3 vs. existing condition



a) Pure tide condition b) Northeast Monsoon condition c) Southwest Monsoon condition

F7.24 Changes in maximum current speed, Scenario 3 vs. existing condition

T7.12 Comparison of mean and maximum current speed at the ESAs between baseline condition and Scenario 3

Point	Location	Baseline Condition		Scenario 1						Remarks
				Mean			Maximum			
		Mean Speed (m/s)	Maximum Speed (m/s)	Speed (m/s)	Difference (m/s)	Difference (%)	Speed (m/s)	Difference (m/s)	Difference (%)	
R1	Sungai Gertak Sanggul	0.08	0.21	0.05	-0.03	-38	0.11	-0.10	-48	Decrease in current speed may induce sluggishness
R2	Sungai Gemuruh	0.10	0.25	0.08	-0.02	-20	0.19	-0.06	-24	Decrease in current speed may induce sluggishness
R3	Sungai Teluk Kumbar	0.06	0.13	0.14	0.08	133	0.39	0.26	200	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R4	Sungai Mati	0.03	0.07	0.03	0.00	0	0.11	0.04	57	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R5	Sungai Batu	0.03	0.15	0.07	0.04	133	0.23	0.08	53	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R6	Sungai Bayan Lepas	0.05	0.12	0.18	0.13	260	0.42	0.30	250	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R7	Bayan Lepas Main Drain	0.06	0.16	0.20	0.14	233	0.45	0.29	181	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R8	Sungai Ikan Mati	0.05	0.15	0.09	0.04	80	0.23	0.08	53	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
C1	Pulau Kendi	0.25	0.99	0.24	-0.01	-4	0.97	-0.02	-2	Insignificant impact
C2	Pulau Rimau	0.14	0.42	0.23	0.09	64	0.64	0.22	52	Insignificant impact
H1	Sungai Pulau Betung	0.01	0.03	0.01	0.00	0	0.02	-0.01	-33	Insignificant impact
H2	Gertak Sanggul	0.06	0.24	0.05	-0.01	-17	0.18	-0.06	-25	Insignificant impact
H3	Teluk Kumbar	0.12	0.31	0.13	0.01	8	0.37	0.06	19	Insignificant impact

T7.12 Comparison of mean and maximum current speed at the ESAs between baseline condition and Scenario 3 (cont'd)

Point	Location	Baseline Condition		Scenario 1						Remarks
				Mean			Maximum			
		Mean Speed (m/s)	Maximum Speed (m/s)	Speed (m/s)	Difference (m/s)	Difference (%)	Speed (m/s)	Difference (m/s)	Difference (%)	
H4	Permatang Damar Laut	0.06	0.15	0.16	0.10	167	0.39	0.24	160	Insignificant impact
A1	Pulau Betung	0.16	0.47	0.16	0.00	0	0.46	-0.01	-2	Insignificant impact
A2	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
A3	Batu Maung	0.22	0.56	0.22	0.00	0	0.55	-0.01	-2	Insignificant impact
F1	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
F2	Gertak Sanggul	0.04	0.04	0.02	-0.02	-50	0.07	-0.10	-59	Decrease in current speed may induce sedimentation. Refer to *Section 7.3.8*.
F3	Teluk Kumbar	0.03	0.03	0.02	-0.01	-33	0.07	-0.20	-74	Decrease in current speed may induce sedimentation. Refer to *Section 7.3.8*.
F4	Sungai Batu	0.04	0.04	0.12	0.08	200	0.35	0.20	133	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
F5	Permatang Tepi Laut	-	-	-	-	-	-	-	-	No data (upstream location)
F6	Permatang Damar Laut	0.06	0.06	0.13	0.07	117	0.31	0.14	82	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
F7	Teluk Tempoyak Besar	0.08	0.08	0.08	0.00	0	0.25	-0.01	-4	Insignificant impact
F8	Teluk Tempoyak Kecil	0.19	0.19	0.19	0.00	0	0.53	0.00	0	Insignificant impact
F9	Batu Maung	0.16	0.16	0.16	0.00	0	0.43	0.00	0	Insignificant impact

d) Scenario 4

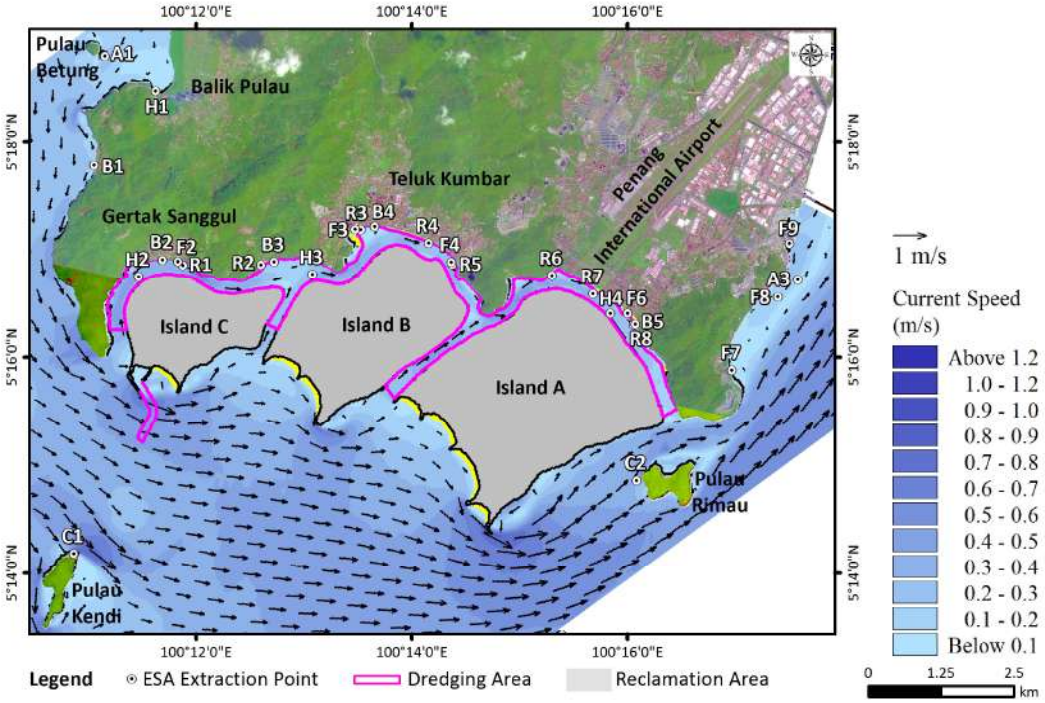
Current flow conditions in Scenario 4 for the pure tide, Northeast Monsoon and Southwest Monsoon conditions are shown in F7.25 to F7.27. The mean and maximum current speeds for all climatic conditions are shown in F7.28.

The changes in mean and maximum current speeds between Scenario 4 and the existing conditions are shown in F7.29 and F7.30 respectively. From these figures, there is a localised increase in the mean and maximum current speeds near the marina breakwater of Island C by 0.1 and 0.2 m/s. As it protrudes further into the faster current flow path as compared to the headland of Tanjung Gertak Sanggul, there is a reduction in current speed near Tanjung Gertak Sanggul up to 0.15 and 0.6 m/s in the mean and maximum values respectively.

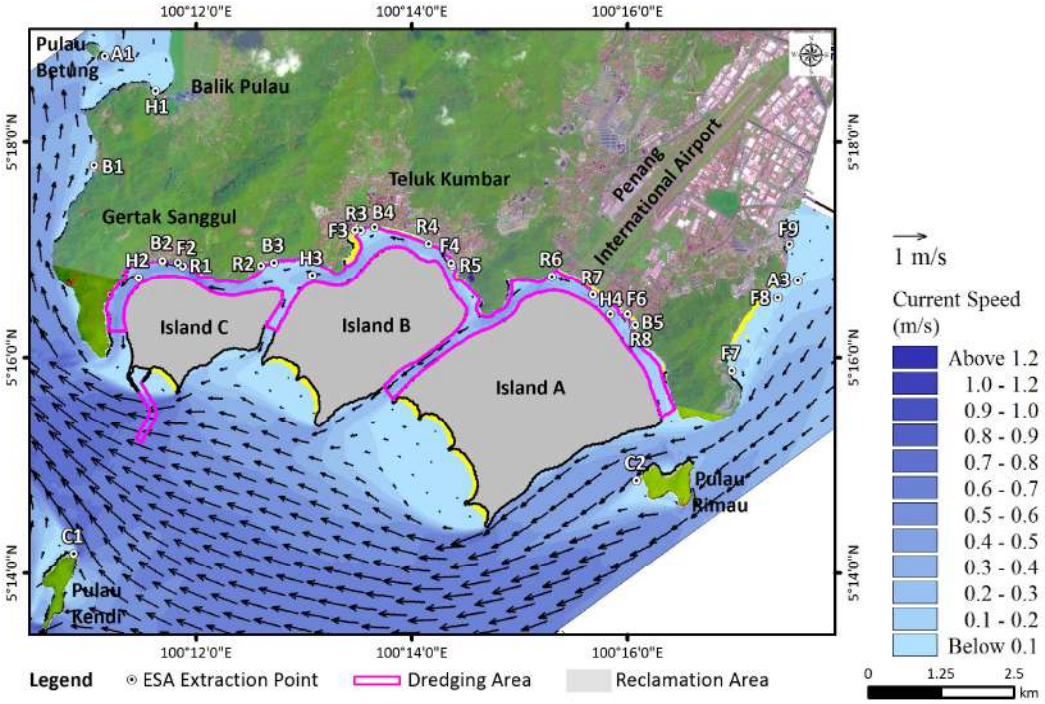
The dredged channel between the coastline of Gertak Sanggul and Island C is predicted to experience an increase in the mean current and maximum current speeds by up to 0.15 and 0.4 m/s respectively.

The changes in current speeds along the southeastern edge of Island A and Pulau Rimau are very similar to those in Scenario 3, given that the Island C is distant from these islands to induce any changes around them.

The comparison of the mean and maximum current speeds between the baseline and Scenario 4 is tabulated in T7.13.

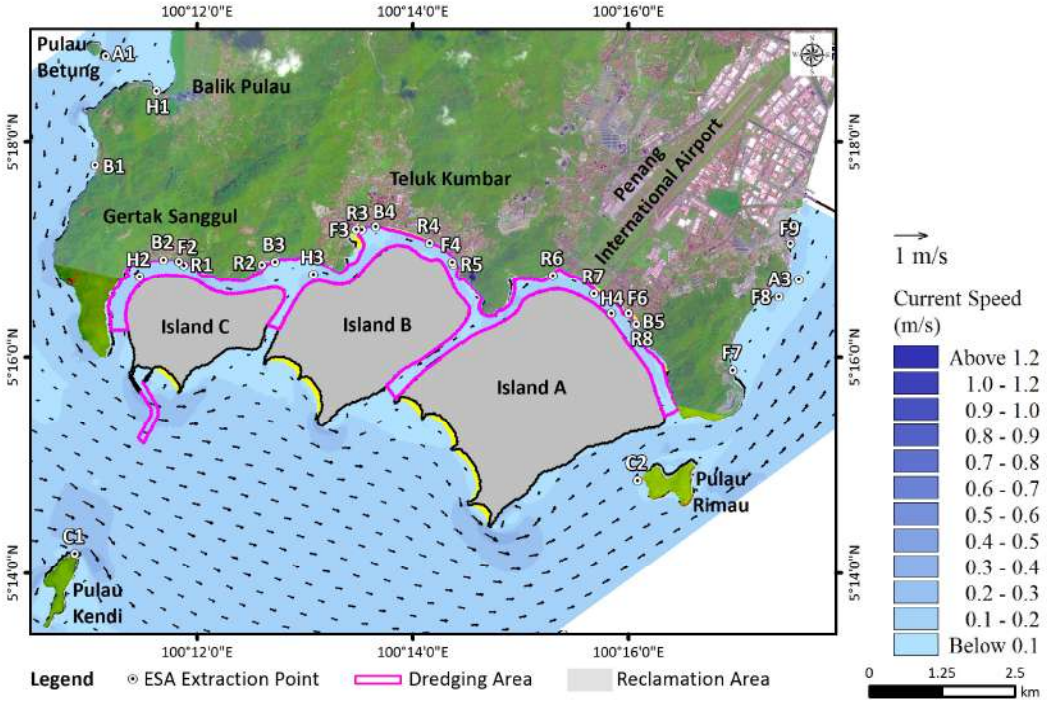


a) Spring period: Flood flow

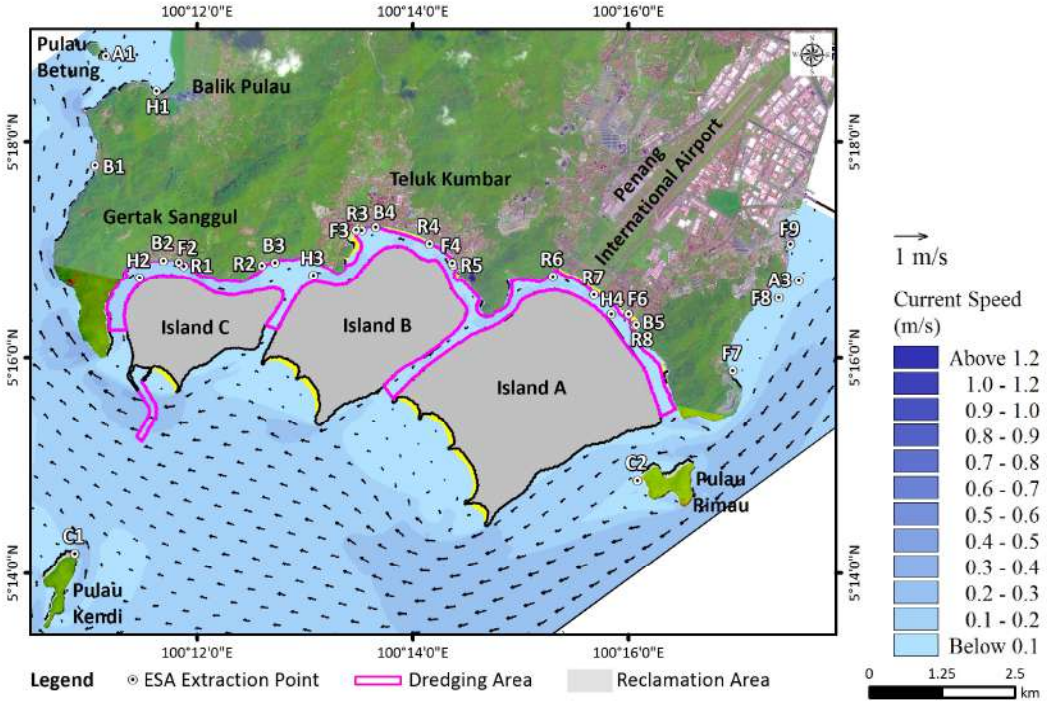


b) Spring period: Ebb flow

F7.25 Flow pattern during spring and neap periods for Scenario 4 condition (pure tide condition)

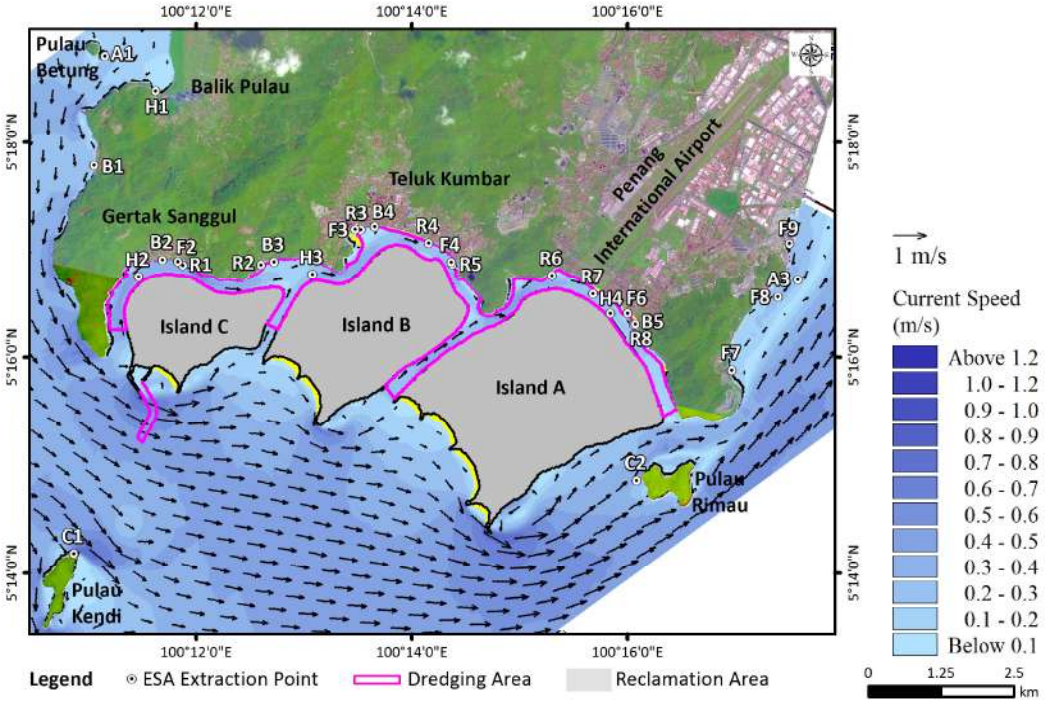


c) Neap period: Flood flow

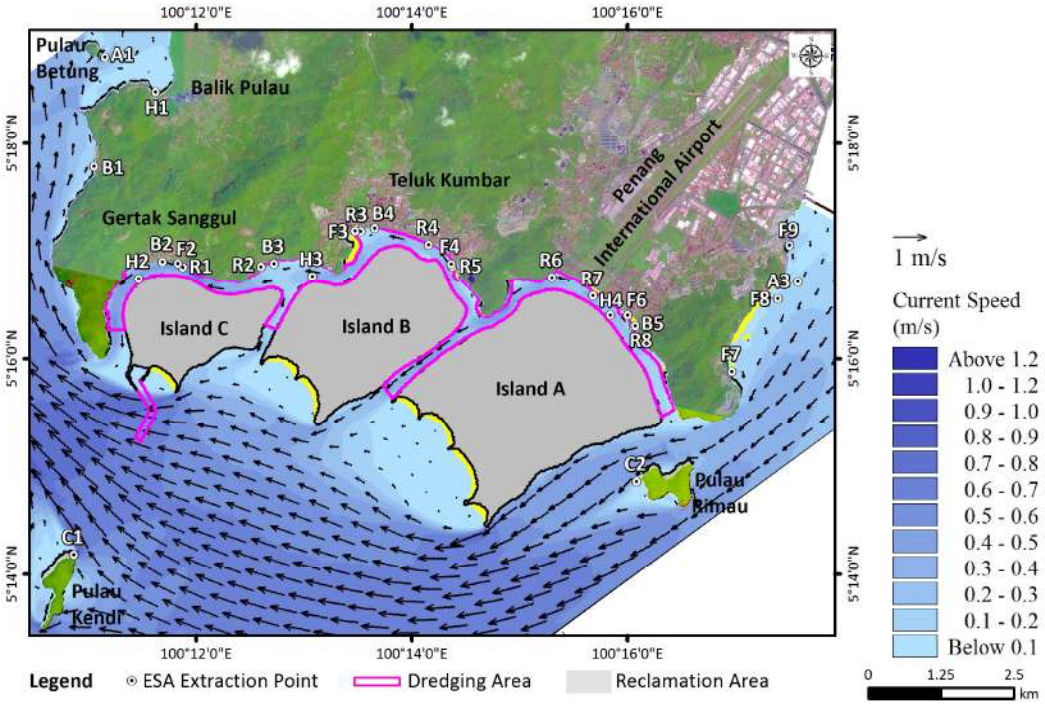


d) Neap period: Ebb flow

F7.25 Flow pattern during spring and neap periods for Scenario 4 condition (pure tide condition) (cont'd)

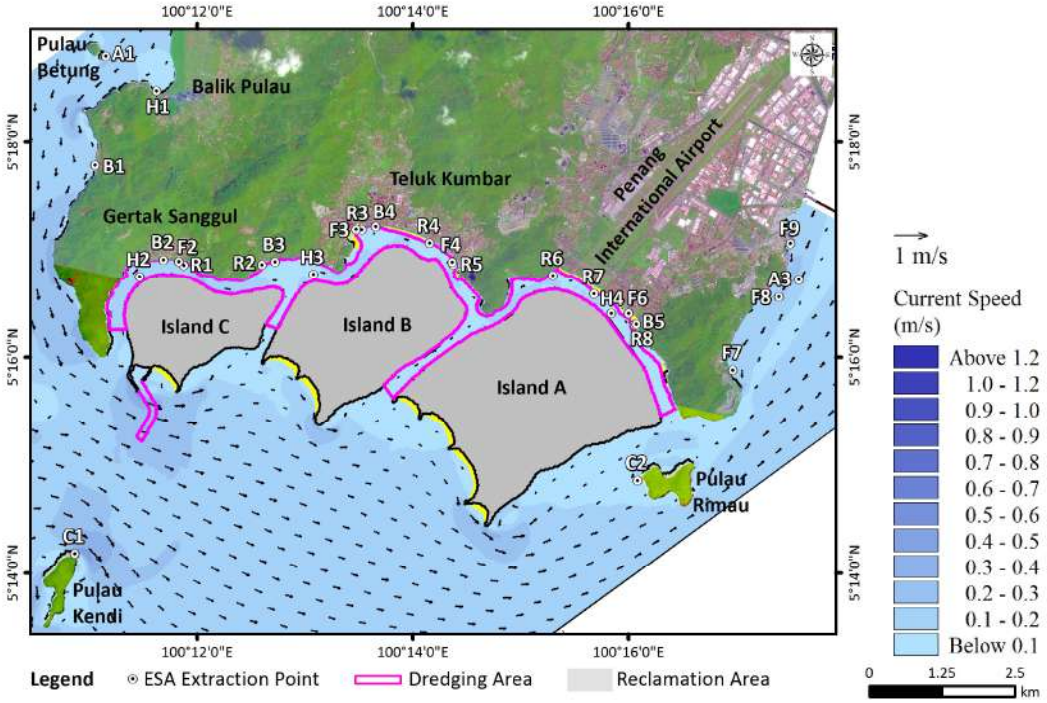


a) Spring period: Flood flow

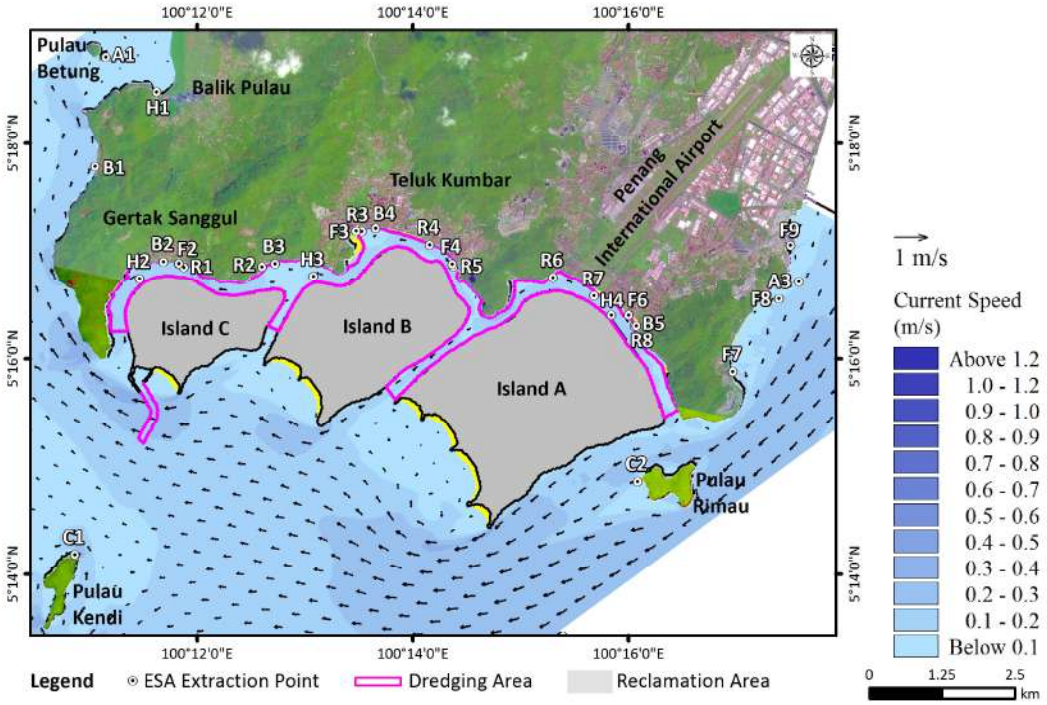


b) Spring period: Ebb flow

F7.26 Flow pattern during spring and neap periods for Scenario 4 condition (Northeast Monsoon condition)

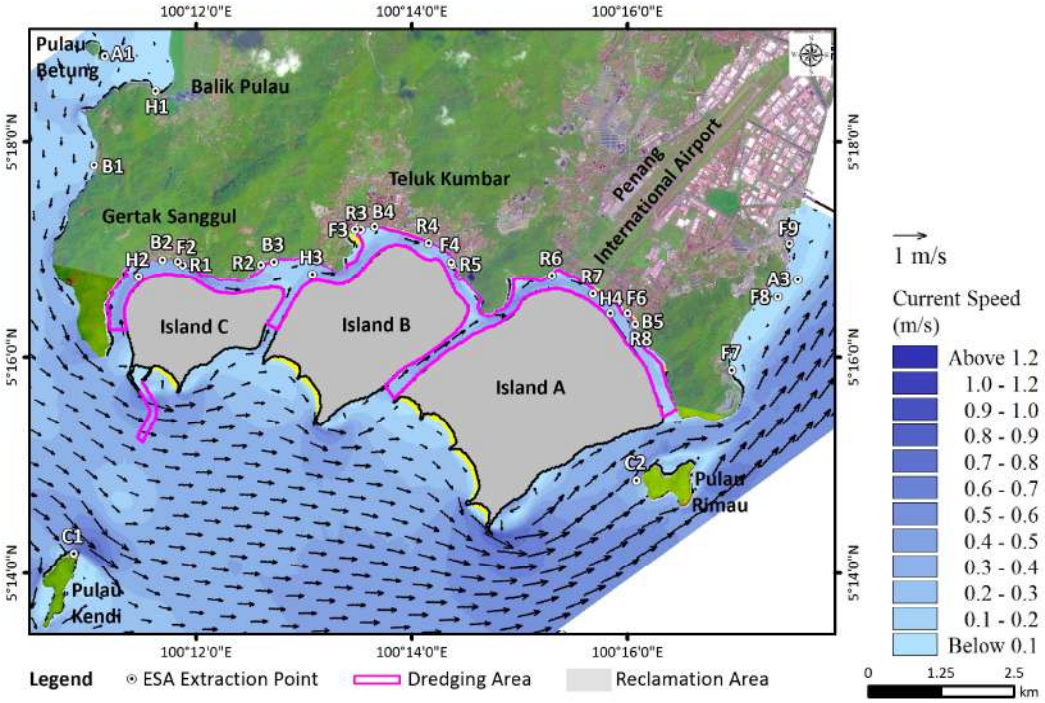


c) Neap period: Flood flow

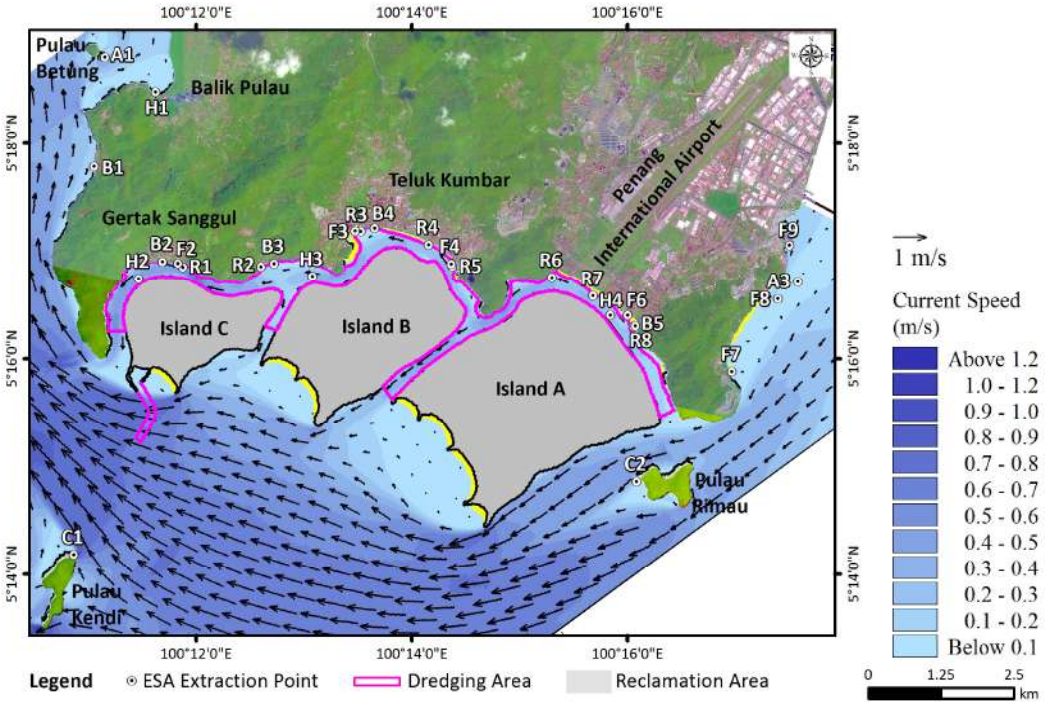


d) Neap period: Ebb flow

F7.26 Flow pattern during spring and neap periods for Scenario 4 condition (Northeast Monsoon condition) (cont'd)

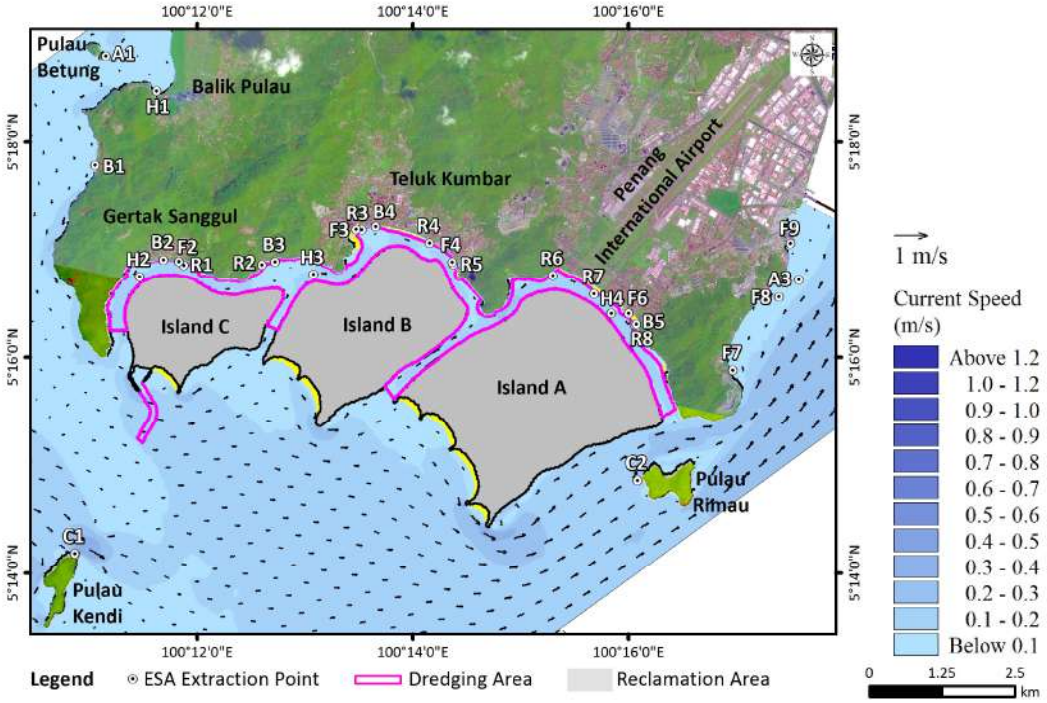


a) Spring period: Flood flow

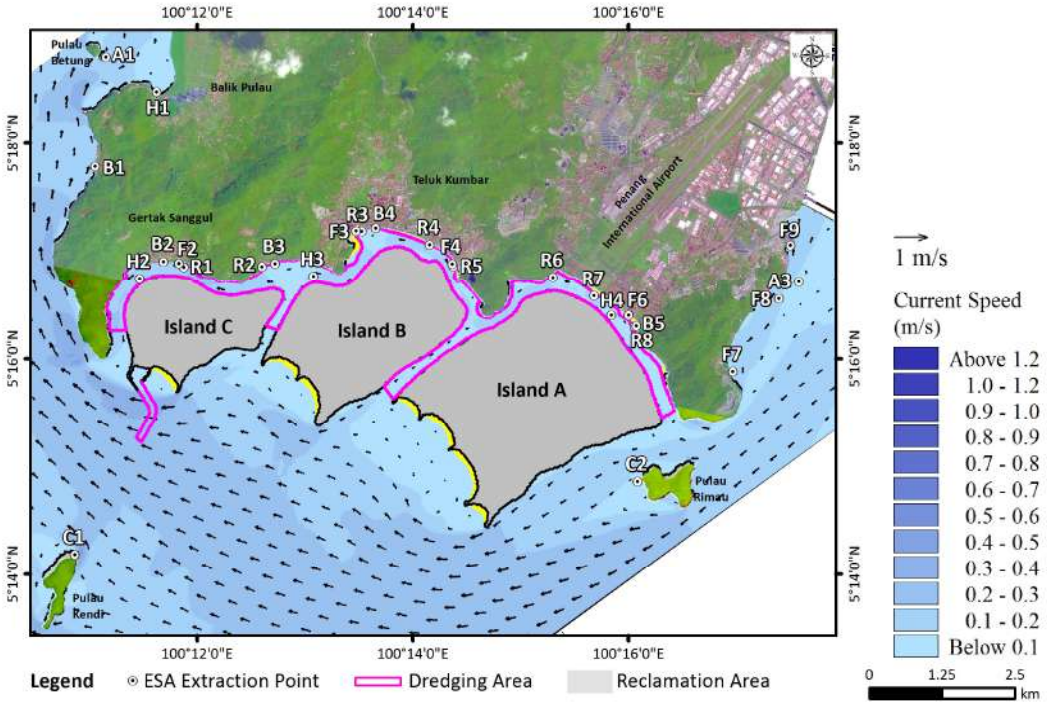


b) Spring period: Ebb flow

F7.27 Flow pattern during spring and neap periods for Scenario 4 condition (Southwest Monsoon condition)

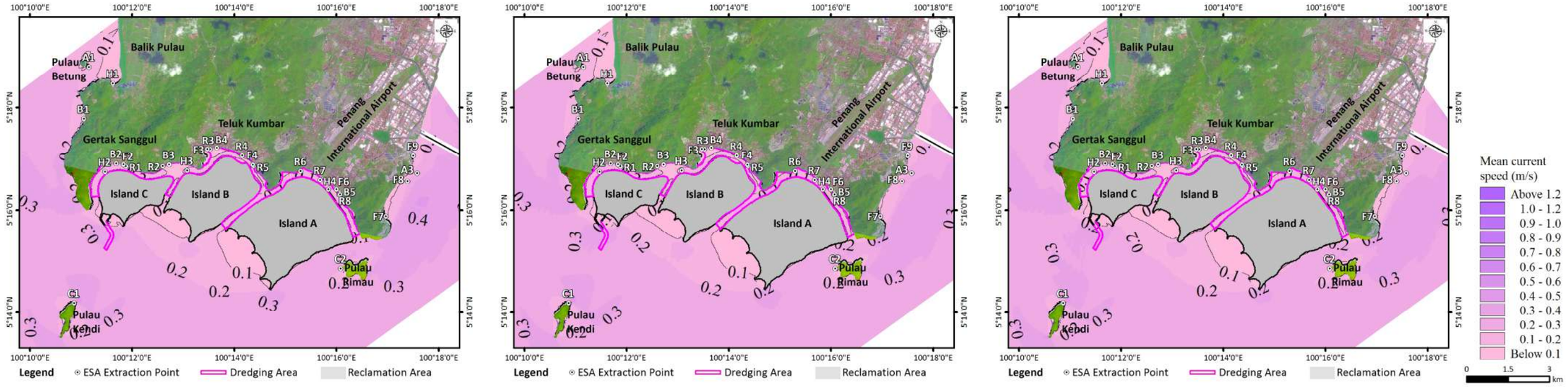


c) Neap period: Flood flow



d) Neap period: Ebb flow

F7.27 Flow pattern during spring and neap periods for Scenario 4 condition (Southwest Monsoon condition) (cont'd)



a) Mean current speed: Pure tide

b) Maximum current speed: Pure tide

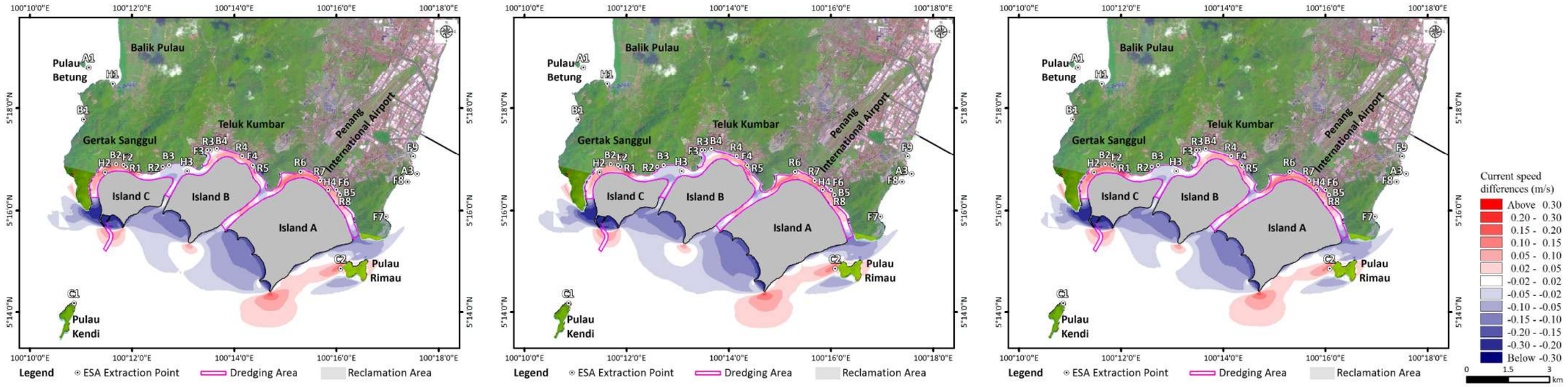
c) Mean current speed: Northeast Monsoon

d) Maximum current speed: Northeast Monsoon

e) Mean current speed: Southwest Monsoon

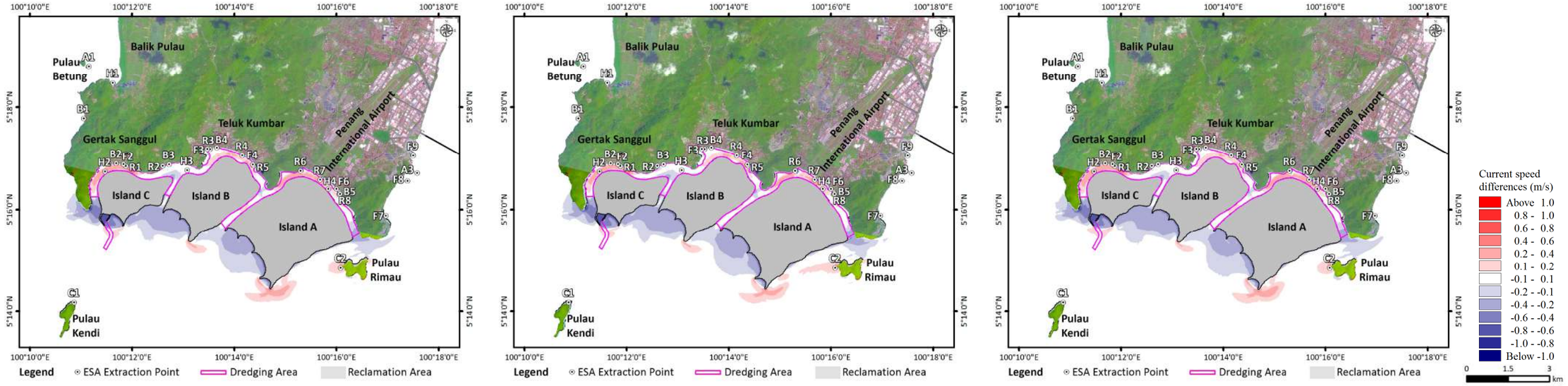
f) Maximum current speed: Southwest Monsoon

F7.28 Mean and maximum current speed plots for Scenario 4 condition



a) Pure tide condition b) Northeast Monsoon condition c) Southwest Monsoon condition

F7.29 Changes in mean current speed, Scenario 4 vs. existing condition



a) Pure tide condition b) Northeast Monsoon condition c) Southwest Monsoon condition

F7.30 Changes in maximum current speed, Scenario 4 vs. existing condition

T7.13 Comparison of mean and maximum current speed at the ESAs between baseline condition and Scenario 4

Point	Location	Baseline Condition		Scenario 1						Remarks
				Mean			Maximum			
		Mean Speed (m/s)	Maximum Speed (m/s)	Speed (m/s)	Difference (m/s)	Difference (%)	Speed (m/s)	Difference (m/s)	Difference (%)	
R1	Sungai Gertak Sanggul	0.08	0.21	0.25	0.17	213	0.68	0.47	224	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R2	Sungai Gemuruh	0.10	0.25	0.07	-0.03	-30	0.20	-0.05	-20	Decrease in current speed may induce sluggishness
R3	Sungai Teluk Kumbar	0.06	0.13	0.11	0.05	83	0.33	0.20	154	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R4	Sungai Mati	0.03	0.07	0.03	0.00	0	0.17	0.10	143	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R5	Sungai Batu	0.03	0.15	0.06	0.03	100	0.28	0.13	87	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R6	Sungai Bayan Lepas	0.05	0.12	0.17	0.12	240	0.39	0.27	225	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R7	Bayan Lepas Main Drain	0.06	0.16	0.19	0.13	217	0.42	0.26	163	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
R8	Sungai Ikan Mati	0.05	0.15	0.09	0.04	80	0.22	0.07	47	Increase in current speed may induce erosion. Refer to *Section 7.3.8*.
C1	Pulau Kendi	0.25	0.99	0.24	-0.01	-4	0.96	-0.03	-3	Insignificant impact
C2	Pulau Rimau	0.14	0.42	0.23	0.09	64	0.64	0.22	52	Insignificant impact
H1	Sungai Pulau Betung	0.01	0.03	0.01	0.00	0	0.02	-0.01	-33	Insignificant impact
H2	Gertak Sanggul	0.06	0.24	0.14	0.08	133	0.37	0.13	54	Insignificant impact
H3	Teluk Kumbar	0.12	0.31	0.12	0.00	0	0.32	0.01	3	Insignificant impact

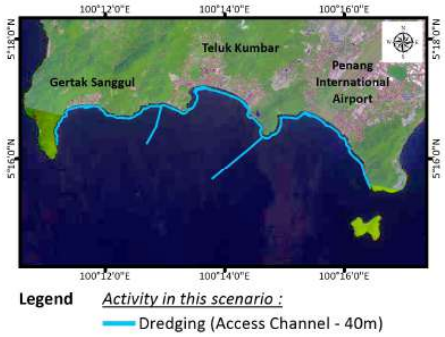
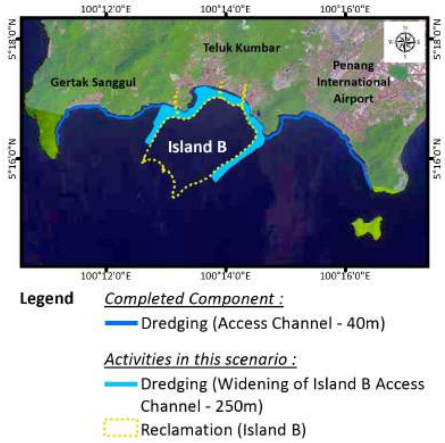
T7.13 Comparison of mean and maximum current speed at the ESAs between baseline condition and Scenario 4 (cont'd)

Point	Location	Baseline Condition		Scenario 1						Remarks
				Mean			Maximum			
		Mean Speed (m/s)	Maximum Speed (m/s)	Speed (m/s)	Difference (m/s)	Difference (%)	Speed (m/s)	Difference (m/s)	Difference (%)	
H4	Permatang Damar Laut	0.06	0.15	0.16	0.10	167	0.35	0.20	133	Insignificant impact
A1	Pulau Betung	0.16	0.47	0.16	0.00	0	0.46	-0.01	-2	Insignificant impact
A2	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
A3	Batu Maung	0.22	0.56	0.22	0.00	0	0.55	-0.01	-2	Insignificant impact
F1	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
F2	Gertak Sanggul	0.04	0.04	0.04	0.00	0	0.14	-0.03	-18	Decrease in current speed may induce sedimentation. Refer to *Section 7.3.8.*
F3	Teluk Kumbar	0.03	0.03	0.02	-0.01	-33	0.07	-0.20	-74	Decrease in current speed may induce sedimentation. Refer to *Section 7.3.8.*
F4	Sungai Batu	0.04	0.04	0.10	0.06	150	0.28	0.13	87	Increase in current speed may induce erosion. Refer to *Section 7.3.8.*
F5	Permatang Tepi Laut	-	-	-	-	-	-	-	-	No data (upstream location)
F6	Permatang Damar Laut	0.06	0.06	0.12	0.06	100	0.30	0.13	76	Increase in current speed may induce erosion. Refer to *Section 7.3.8.*
F7	Teluk Tempoyak Besar	0.08	0.08	0.08	0.00	0	0.25	-0.01	-4	Insignificant impact
F8	Teluk Tempoyak Kecil	0.19	0.19	0.19	0.00	0	0.53	0.00	0	Insignificant impact
F9	Batu Maung	0.16	0.16	0.16	0.00	0	0.42	-0.01	-2	Insignificant impact

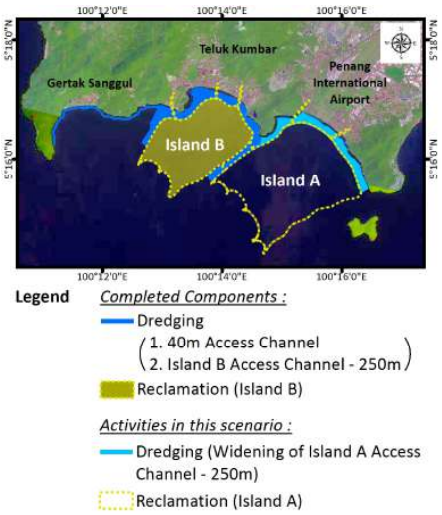
7.3.5.3 Overall Findings for Currents

Changes in the current conditions are mostly within the Project site, apart from Pulau Rimau in Scenarios 3 and 4. Changes in current speed will ultimately alter the existing sedimentation and erosion rate, thus affecting the bed level changes surrounding the Project site that may cause negative impact on the sensitive receptors. These changes in sedimentation and erosion patterns and the subsequent impacts on the sensitive receptors will be discussed in detail in the following sub-sections. As for current speed, the summaries on the potential impacts in each of the development scenarios are as follows (T7.14):

T7.14 Summary of potential impacts on currents for all scenarios

Scenario	Findings
Scenario 1 	There are insignificant and localised changes in the mean and maximum current speeds, as compared to the existing condition. The changes are mainly localised reductions in current speeds along the foreshore where beach enhancement works are proposed and in the dredged channels. Such reductions would ease navigation in the dredged channels. These reductions may result in sedimentation and reduction in flushing capacity.
Scenario 2 	The presence of Island B results in changes in current speeds within the Project site: a) Reduced current speed between Island B and Tanjung Gertak Sanggul and, to a lesser extent, between Island B and Tanjung Teluk Tempoyak by up to 0.15 m/s in the mean current speed and 0.4 m/s in the maximum current speed; b) Increased mean and maximum current speeds by up to 0.15 and 0.6 m/s respectively at the southern-most headland of Island B; and c) Increased mean and maximum currents speeds by up to 0.2 and 0.4 m/s respectively in the dredged channel between Island B and the foreshore of Teluk Kumbar. The increased current speeds in the dredged channels of up to 0.5 m/s are not expected to affect the safe navigation and berthing of the fishing boats in the dredged channel. It is expected that the higher current speeds will improve the flushing capacity in the dredged channels that is affected by Island B. The maximum current speeds at the proposed jetties locations are less than 0.4 m/s, which is acceptable for berthing. The changes in current speeds may result in sedimentation or erosion. The increased maximum current speed induced by the southern-most artificial headland of Island B is up to 1 m/s within its immediate vicinity. Although such current speeds are considered manageable for fishing boats, the rocky headland is a hazard to navigation. The increases in current speed induced by the southern-most headland of Island B are expected to reduce over time, as the seabed will re-adjust in response to the changes.

T7.14 Summary of potential impacts on currents for all scenarios (cont'd)

Scenario	Findings
Scenario 3  	With the addition of Island A, the following changes are predicted: a) Increased mean and maximum current speeds in the dredged channel between the reclaimed Islands A and B as well as the existing coastline of Permatang Damar Laut and Teluk Kumbar by up to 0.15 and 0.4 m/s respectively; b) Reduced mean and maximum current speeds off the southern coastlines of both reclaimed Islands A and B by 0.15 and 0.4 m/s respectively; c) Localised increased current speeds near the southern-most headland of Island A by up to 0.15 and 0.4 m/s respectively. d) Reduced mean and maximum current speeds to the north and south of Pulau Rimau by 0.10 and 0.2 m/s respectively; e) Increased mean and maximum current speeds to the west of Pulau Rimau by 0.15 and 0.4 m/s respectively; and f) Increased mean and maximum current speeds to the east of Pulau Rimau by 0.05 and 0.5 m/s respectively. Changes in the current speeds may result in sedimentation and erosion. The increased current speeds in the dredged channels are expected to enhance their flushing capacities that are affected by the reclaimed Islands A and B. The increased current speeds in the dredged channels of up to 0.4 m/s are not expected to affect the safe navigation of the fishing boats in the dredged channel. The maximum current speeds of up to 0.4 m/s at the proposed jetties are considered acceptable for berthing of fishing boats. The increased maximum current speeds at the southern-most headland of Islands A and B are up to 1 m/s within their immediate vicinity.
Scenario 4  	The changes in current flow conditions are largely similar to those in Scenario 3, apart from the area near Gertak Sanggul and Tanjung Gertak Sanggul. These changes are: a) Localised increased mean and maximum current speeds near the marina breakwater of Island C by 0.1 and 0.2 m/s; b) Reduced current speed near Tanjung Gertak Sanggul by up to 0.15 and 0.6 m/s in the mean and maximum values respectively, due to the marina breakwater protruding further into the current flow path as compared to the headland of Tanjung Gertak Sanggul; and c) Increased mean current and maximum current speeds in the dredged channel between the coastline of Gertak Sanggul and Island C are predicted to be up to 0.15 and 0.4 m/s respectively. The increased current speeds in the dredged channels of up to 0.4 m/s are not expected to affect the safe navigation of the fishing boats in the dredged channel. The maximum current speeds of up to 0.4 m/s at the proposed jetties are considered acceptable for berthing of fishing boats. The maximum current speed exceeds 1.1 m/s, which is considered manageable for fishing boats.

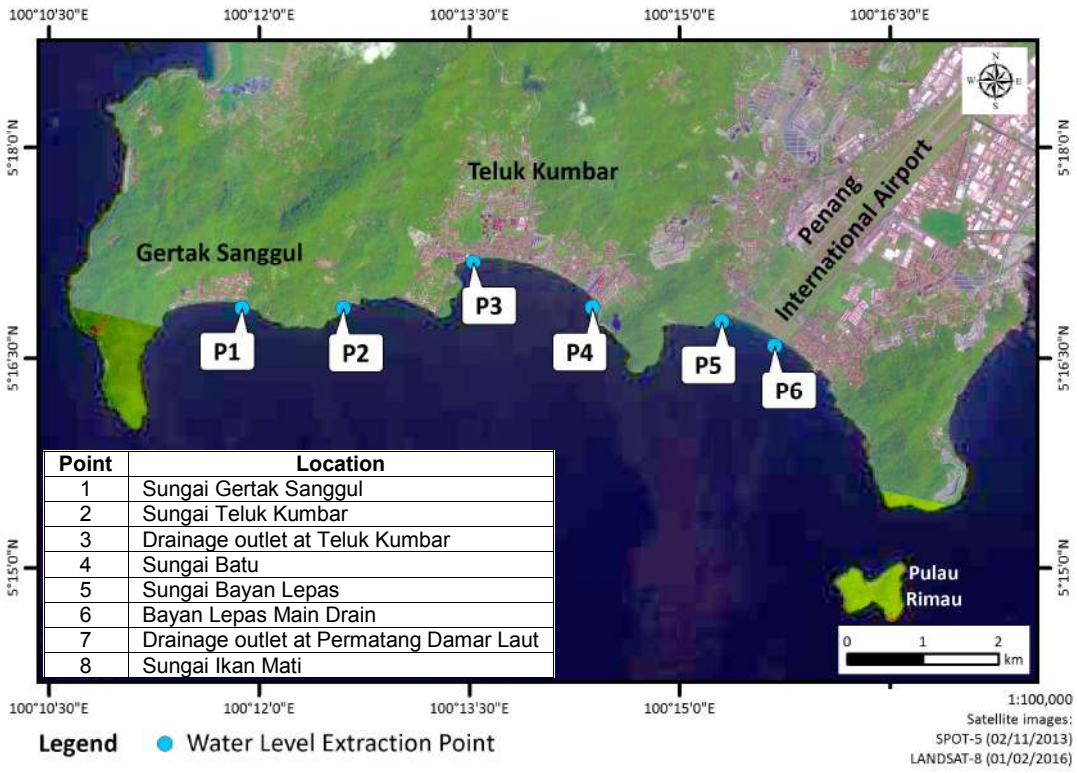
7.3.6 Water Levels

Increased water levels at the river mouths and drainage outlets near the Project site can potentially increase the flood risk upstream. For this reason, the potential changes in water levels at these locations between the existing and the four scenarios are assessed.

Peak discharge rates of two extreme return period events, namely the 1 in 1 year (Q_1) and 1 in 100 years (Q_{100}), have been incorporated in the current flow model as a constant value over the simulation period as the worst-case condition.

The drainage system on the south coast of Penang Island that discharges into the Project site is divided into six catchment areas based on the available topography map. Water levels at the mouths of the rivers and outlets of the main drains near the Project site are extracted and compared. It should be noted that this impact is mainly related to the upstream flood risk of the rivers. Thus the extraction points will only cover the river outlets. The locations of extraction points are shown in F7.31. It is noted that Sungai Ikan Mati and Sungai Mati are not included in the hydrological analysis given the very small catchment areas

The maximum high water level over the 14-day spring and neap period at each extraction point in each scenario is tabulated in T7.15 for the 1 in 1 year and 1 in 100 years peak discharge event respectively. The differences in the maximum high water level between the existing and all scenarios are also included in these tables.



Point	Location
1	Sungai Gertak Sanggul
2	Sungai Teluk Kumbar
3	Drainage outlet at Teluk Kumbar
4	Sungai Batu
5	Sungai Bayan Lepas
6	Bayan Lepas Main Drain
7	Drainage outlet at Permatang Damar Laut
8	Sungai Ikan Mati

F7.31 Locations of water level extraction points

T7.15 Comparisons of high water levels at river mouths and Bayan Lepas Main Drain outlet

Point	Location	Existing Water Level (m MSL)	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Remarks
			Water Level (m MSL)	Difference (%)	Water Level (m MSL)	Difference (%)	Water Level (m MSL)	Difference (%)	Water Level (m MSL)	Difference (%)	
1 in 1 year Peak Discharge Event											
P1	Sungai Gertak Sanggul	1.13	1.13	0	1.13	0	1.13	0	1.14	1	Highest water level increase is only 1%, thus the impact on upstream flood risk is insignificant
P2	Sungai Gemuruh	1.15	1.15	0	1.14	-1	1.13	-2	1.13	-2	
P3	Sungai Teluk Kumbar	1.15	1.14	-1	1.15	0	1.14	-1	1.16	1	
P4	Sungai Batu	1.15	1.15	0	1.16	1	1.15	0	1.16	1	
P5	Sungai Bayan Lepas	1.18	1.18	0	1.17	-1	1.17	-1	1.17	-1	
P6	Bayan Lepas Main Drain	1.18	1.18	0	1.17	-1	1.18	0	1.18	0	
1 in 100 year Peak Discharge Event											
P1	Sungai Gertak Sanggul	1.13	1.13	0	1.13	0	1.13	0	1.14	1	Highest water level increase is only 1%, thus the impact on upstream flood risk is insignificant
P2	Sungai Gemuruh	1.15	1.15	0	1.14	-1	1.13	-2	1.13	-1	
P3	Sungai Teluk Kumbar	1.15	1.14	-1	1.15	0	1.14	-1	1.16	1	
P4	Sungai Batu	1.15	1.15	0	1.16	1	1.15	0	1.16	1	
P5	Sungai Bayan Lepas	1.18	1.18	0	1.17	-1	1.17	-1	1.17	-1	
P6	Bayan Lepas Main Drain	1.18	1.18	0	1.17	-1	1.18	0	1.18	0	

7.3.6.1 Overall Findings for Water Levels

The comparisons of water levels between the existing and all scenarios show that there are:

a) 1 to 2% reductions in water levels at Sungai Gemuruh, Sungai Teluk Kumbar and Bayan Lepas Main Drain in both 1 in 1 year and 1 in 100 years peak discharge events; and
b) 1% (0.01 m) increase in water levels at Sungai Gertak Sanggul, Sungai Batu and Sungai Bayan Lepas in both events.

With such insignificant increase in water levels, it is unlikely that the upstream flood risks will be increased in Sungai Gertak Sanggul, Sungai Batu and Sungai Bayan Lepas with the implementation of the Project.

7.3.7 Waves

Results for wave simulations in the vicinity of the Project site for all "with Project" scenarios are presented below. The assessment of wave conditions was undertaken using the MIKE 21 Spectral Wave (SW) module.

7.3.7.1 Simulation Model

MIKE 21 SW is a fully spectral wave model based on an unstructured mesh. The model solves spectral wave action balance equation formulated in either Cartesian or Spherical coordinates. Effects of wave generation, dissipation and non-linear wave-wave interactions are described by state-of-the-art source functions. The numerical representation of the geographical domain is obtained using an unstructured mesh composed of triangular elements and an efficient cell-centred finite volume method.

In assessing the potential impact on wave conditions, the 16-year offshore wave dataset extracted from the WaveWatch III global wave hindcast model has been used. Extreme value analysis is undertaken using this offshore wave data to obtain extreme wave conditions that are later used as boundary conditions of the local wave model. Changes in the extreme wave conditions between the existing and "with Project" conditions are determined in the local wave model.

An extreme value analysis is carried out using the MIKE 21 EVA module for extreme wave conditions to be used as boundary conditions of the local wave model. The analysis is based on the 16-year wave data extracted offshore of the Project site. The Project site is exposed to westerly and southerly waves only, due to sheltering provided by Peninsular Malaysia and Penang Island. As such, waves coming from 180, 210, 240 and 270^{o}N have been used for extreme value analysis. Among these directions, the predominant waves are propagating from 270^{o}N based on the frequency of occurrence of 41.3%, compared with 180, 210 and 240^{o}N that have a frequency of occurrence of 5.5, 6.1 and 8.2% respectively.

The best distribution is used to estimate the extreme values corresponding to 1 in 1 year and 1 in 60 years return period events. These events are chosen to determine the changes in a typical design return period event. T7.16 shows the offshore wave condition from the EVA analysis for wave propagating from mean wave direction (MWD) of 180, 210, 240 and 270^{o}N in these return period events.

7.3.7.2 Impact Assessment

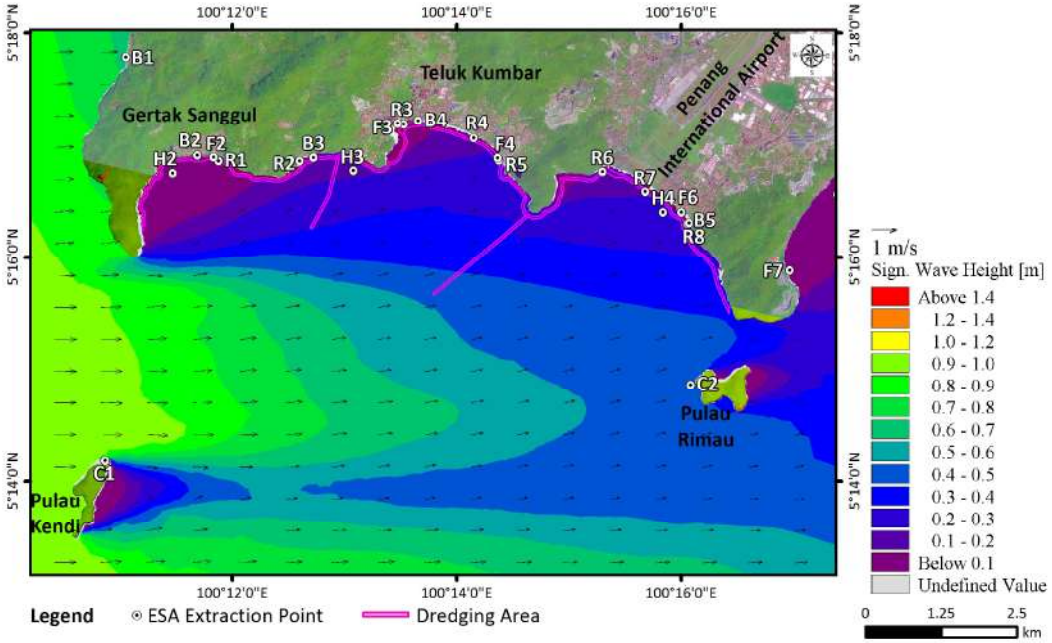
Among the MWD, the highest wave frequency that occurred at the Project site are from waves propagating from 270°N, with a frequency of occurrence at 41.5%, as shown in T7.16. As such, the discussion on impacts related to the wave modelling results will focus on waves propagating from 270°N as the predominant wave direction. Results for wave simulations in the vicinity of the Project site according to the defined scenarios are presented below.

Mean Wave Direction (°N)	Frequency of Occurrence (%)	Return Period Event			
		1 in 1 year		1 in 60 years	
		H_{m0} (m)	T_p (s)	H_{m0} (m)	T_p (s)
180	5.5	1.0	5.0	1.4	5.5
210	6.1	0.9	5.0	1.2	5.5
240	8.2	0.8	5.0	1.2	6.5
270	41.3	1.0	5.5	1.5	6.0

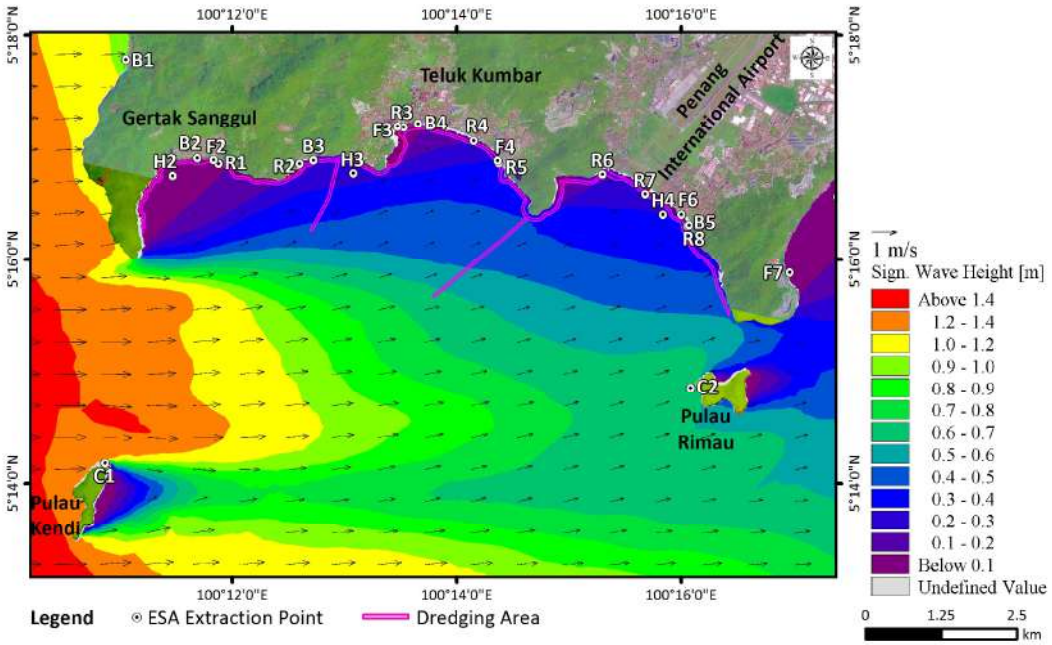
T7.16
Wave conditions corresponding to return period events of 1 in 1 year and 1 in 60 years used as local wave model boundary conditions

a) Scenario 1

The modelling results of the 1 in 1 year and 1 in 60 years return period events under Scenario 1 for the dominant wave direction are shown in F7.32. Meanwhile, the differences in wave heights for the predominant waves, as compared to those in the existing condition, are shown in F7.33. Comparisons of the predominant wave heights at the ESAs between baseline and Scenario 1 are tabulated in T7.17.



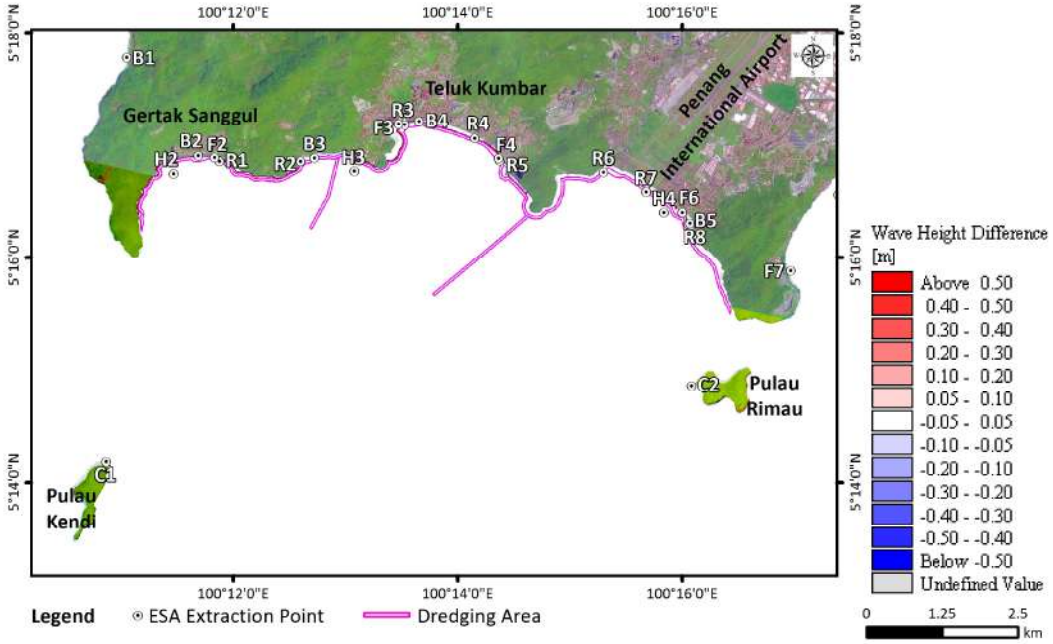
a) 1 in 1 year return period event: H_{m0} = 1.0 m, T_p = 5.5 s



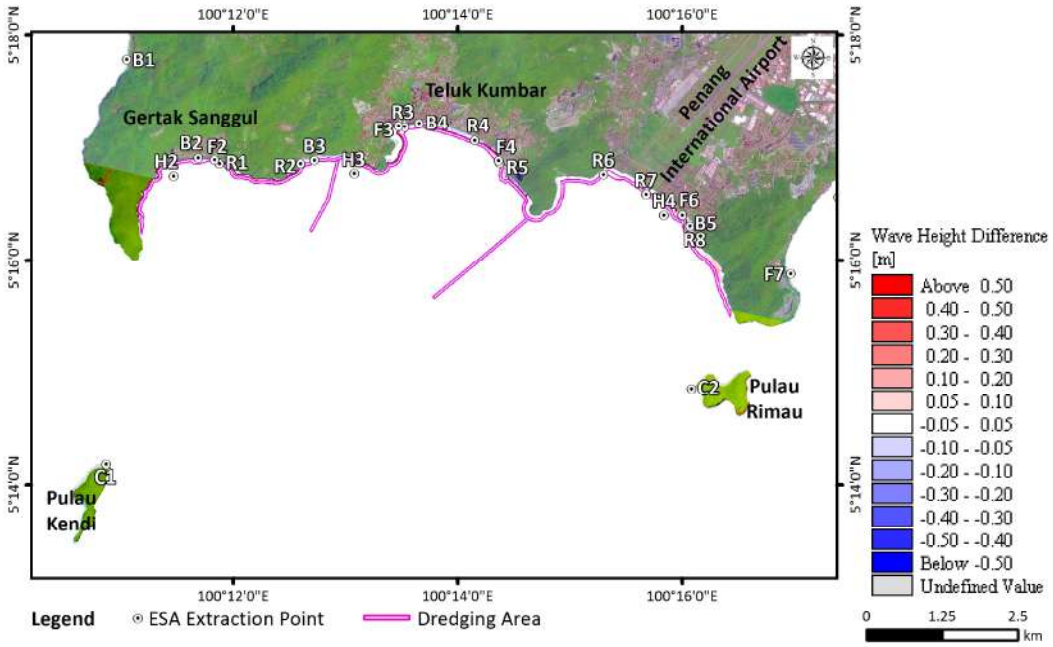
b) 1 in 60 year return period event: H_{m0} = 1.5 m, T_p = 6.0 s

Note: Frequency of occurrence = 41.3%

F7.32 Significant wave heights; Scenario 1 condition; MWD = 270°N



a) 1 in 1 year return period event: H_{m0} = 1.0 m, T_p = 5.5 s



b) 1 in 60 year return period event: H_{m0} = 1.5 m, T_p = 6.0 s

Note: Frequency of occurrence = 41.3%

F7.33 Wave height difference; Scenario 1 vs. existing condition; MWD = 270°N

T7.17 Comparison of the predominant wave heights at the ESAs between baseline condition and Scenario 1

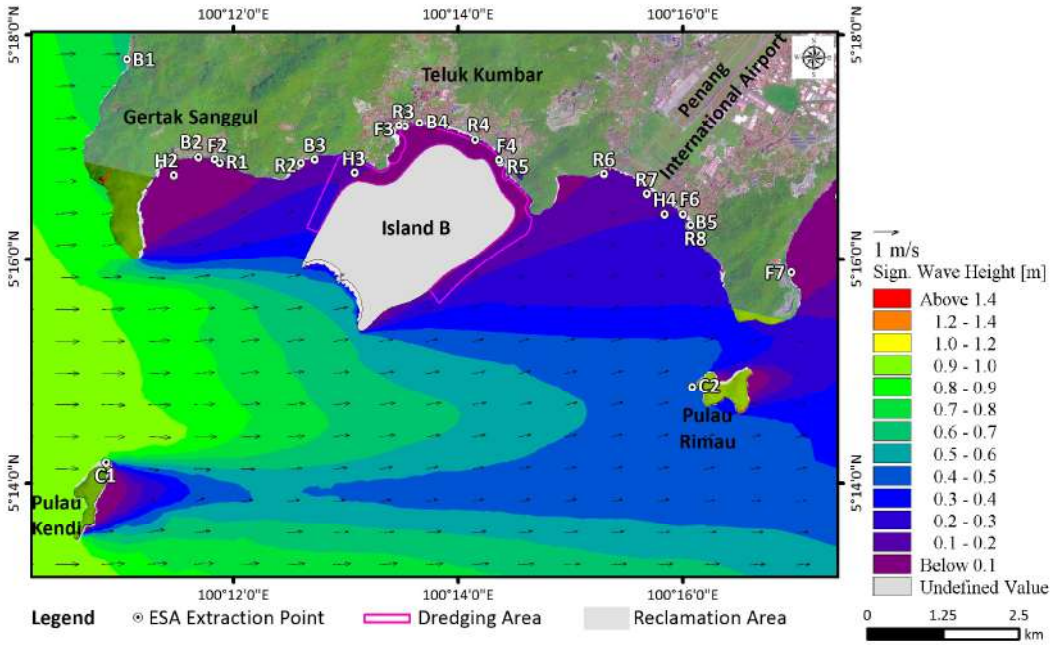
Point	Location	Baseline Condition		Scenario 1						Remarks
				1 in 1 year			1 in 60 year			
		1 in 1 year (m)	1 in 60 year (m)	Value (m)	Difference (m)	Difference (%)	Value (m)	Difference (m)	Difference (%)	
R1	Sungai Gertak Sanggul	0.05	0.07	0.06	0.01	20	0.08	0.01	14	Insignificant impact
R2	Sungai Gemuruh	0.13	0.18	0.12	-0.01	-8	0.18	0.00	0	Insignificant impact
R3	Sungai Teluk Kumbar	0.04	0.05	0.01	-0.03	-75	0.02	-0.03	-60	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8*.
R4	Sungai Mati	0.13	0.18	0.12	-0.01	-8	0.16	-0.02	-11	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8*.
R5	Sungai Batu	0.15	0.19	0.22	0.07	47	0.30	0.11	58	Insignificant impact
R6	Sungai Bayan Lepas	0.11	0.14	0.11	0.00	0	0.16	0.02	14	Insignificant impact
R7	Bayan Lepas Main Drain	0.16	0.21	0.17	0.01	6	0.22	0.01	5	Insignificant impact
R8	Sungai Ikan Mati	0.13	0.15	0.12	-0.01	-8	0.14	-0.01	-7	Insignificant impact
C1	Pulau Kendi	0.78	1.15	0.78	0.00	0	1.15	0.00	0	Insignificant impact
C2	Pulau Rimau	0.47	0.63	0.47	0.00	0	0.63	0.00	0	Insignificant impact
H1	Sungai Pulau Betung	0.17	0.22	0.17	0.00	0	0.22	0.00	0	Insignificant impact
H2	Gertak Sanggul	0.03	0.04	0.03	0.00	0	0.05	0.01	25	Insignificant impact
H3	Teluk Kumbar	0.18	0.25	0.19	0.01	6	0.26	0.01	4	Insignificant impact
H4	Permatang Damar Laut	0.22	0.28	0.23	0.01	5	0.30	0.02	7	Insignificant impact

T7.17 Comparison of the predominant wave heights at the ESAs between baseline condition and Scenario 1 (cont'd)

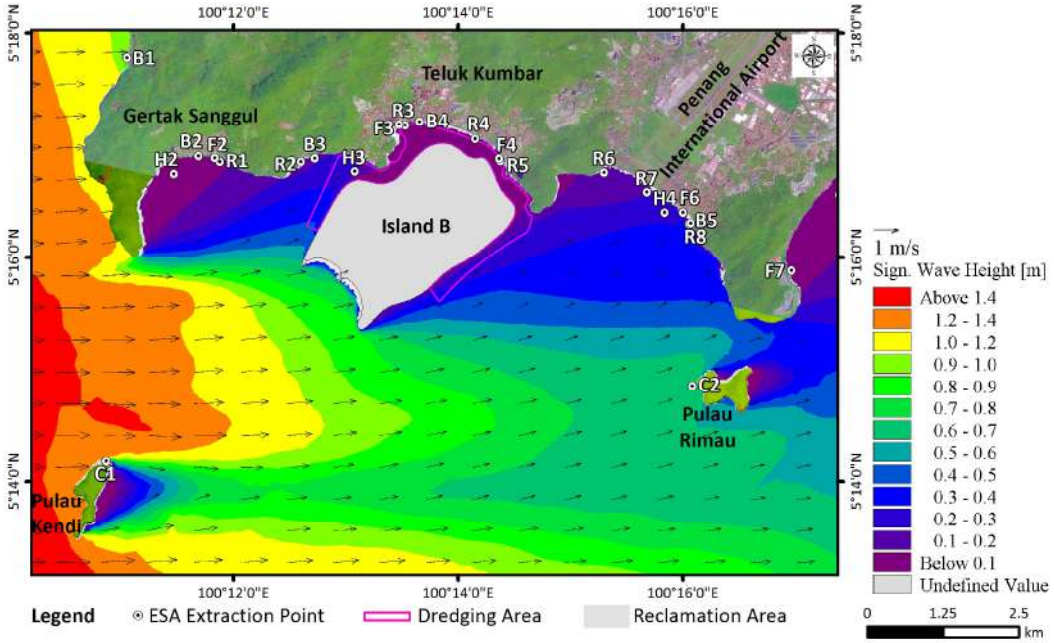
Point	Location	Baseline Condition		Scenario 1						Remarks
				1 in 1 year			1 in 60 year			
		1 in 1 year (m)	1 in 60 year (m)	Value (m)	Difference (m)	Difference (%)	Value (m)	Difference (m)	Difference (%)	
A1	Pulau Betung	0.58	0.80	0.58	0.00	0	0.80	0.00	0	Insignificant impact
A2	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
A3	Batu Maung	0.02	0.03	0.02	0.00	0	0.03	0.00	0	Insignificant impact
F1	Sungai Pulau Betung	-	-	-	-	-	-	-	-	Insignificant impact
F2	Gertak Sanggul	0.05	0.06	0.05	0.00	0	0.07	0.01	17	Insignificant impact
F3	Teluk Kumbar	0.02	0.02	0.00	-0.02	-100	0.00	-0.02	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8*.
F4	Sungai Batu	0.19	0.26	0.12	-0.07	-37	0.16	-0.10	-38	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8*.
F5	Permatang Tepi Laut	-	-	-	-	-	-	-	-	No data (upstream location)
F6	Permatang Damar Laut	0.11	0.13	0.13	0.02	18	0.16	0.03	23	Insignificant impact
F7	Teluk Tempoyak Besar	0.03	0.04	0.03	0.00	0	0.04	0.00	0	Insignificant impact
F8	Teluk Tempoyak Kecil	0.02	0.03	0.02	0.00	0	0.03	0.00	0	Insignificant impact
F9	Batu Maung	0.02	0.02	0.02	0.00	0	0.02	0.00	0	Insignificant impact
F10	Sri Jerjak	0.01	0.02	0.01	0.00	0	0.02	0.00	0	Insignificant impact

b) Scenario 2

The modelling results of the 1 in 1 year and 1 in 60 years return period events under Scenario 2 for the dominant wave direction are shown in F7.34. Meanwhile, the differences in wave heights for the dominant waves, as compared to those in the existing condition, are shown in F7.35. Comparisons of the predominant wave heights at the ESAs between baseline and Scenario 2 are tabulated in T7.18.

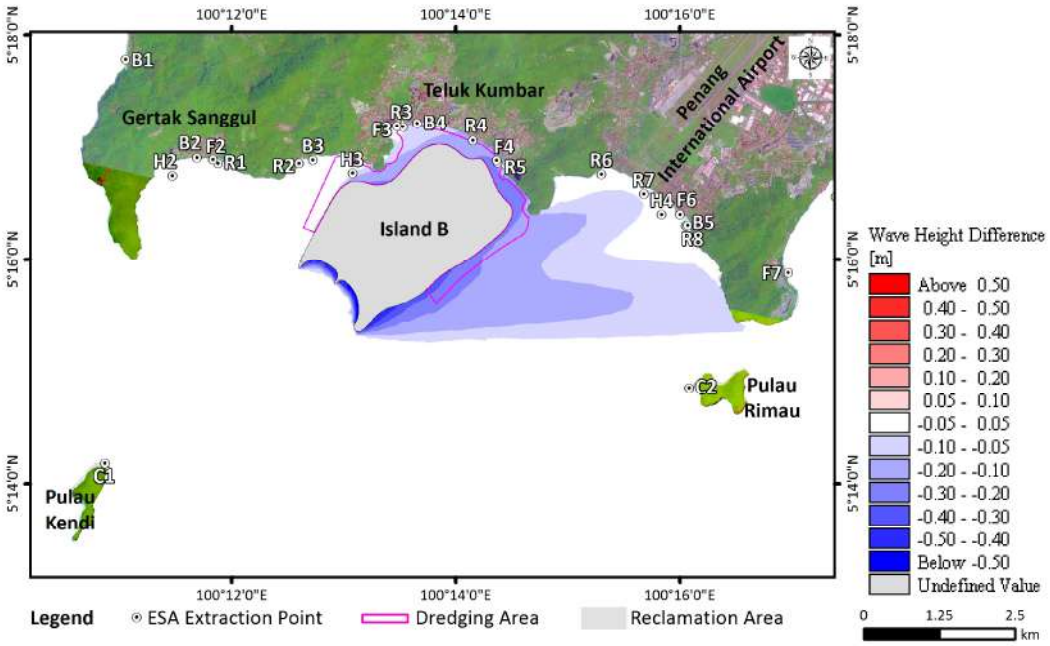


a) 1 in 1 year return period event: H_{m0} = 1.0 m, T_p = 5.5 s

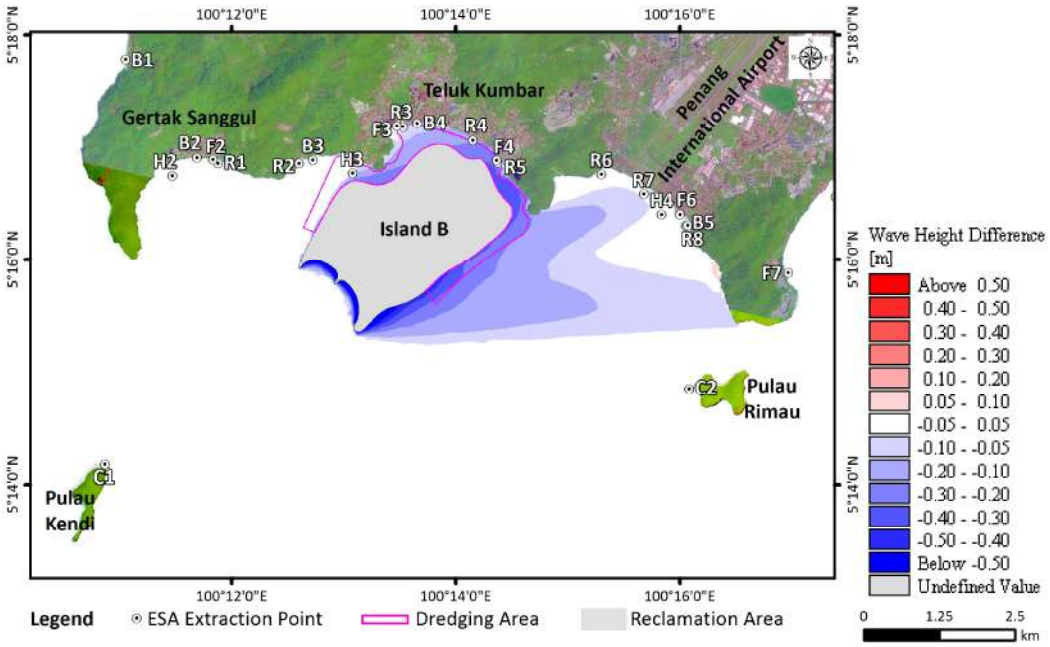


b) 1 in 60 year return period event: H_{m0} = 1.5 m, T_p = 6.0 s

F7.34 Significant wave heights; Scenario 2 condition; MWD = 270°N



a) 1 in 1 year return period event: H_{m0} = 1.0 m, T_p = 5.5 s



b) 1 in 60 year return period event: H_{m0} = 1.5 m, T_p = 6.0 s

F7.35 Wave height difference; Scenario 2 vs. existing condition; MWD = 270°N

T7.18 Comparison of the predominant wave heights at the ESAs between baseline condition and Scenario 2

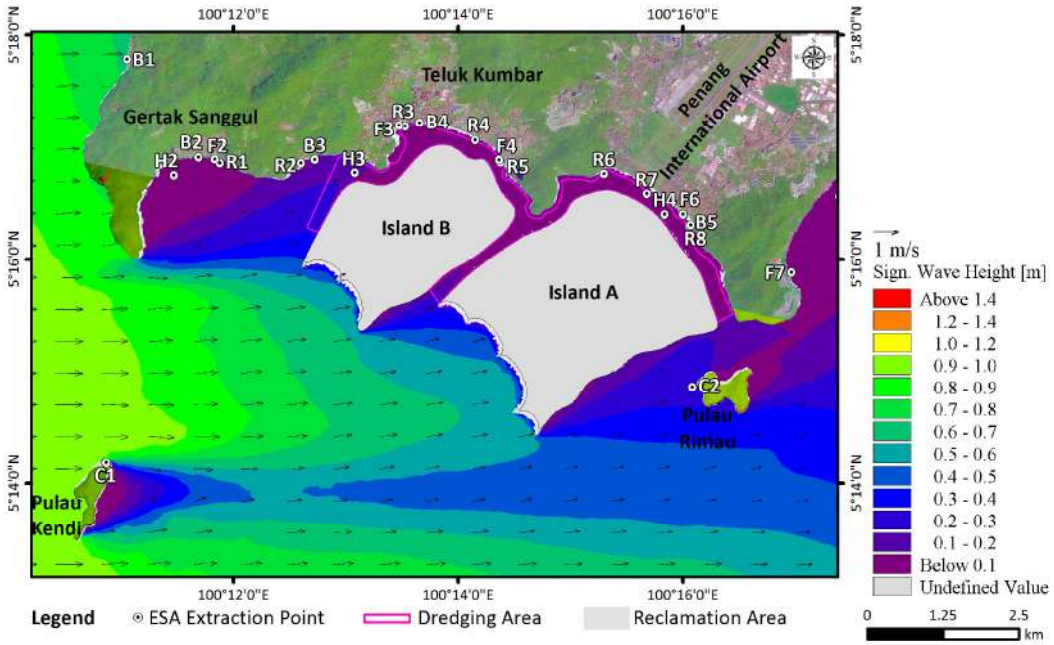
Point	Location	Baseline Condition		Scenario 1						Remarks
				1 in 1 year			1 in 60 year			
		1 in 1 year (m)	1 in 60 year (m)	Value (m)	Difference (m)	Difference (%)	Value (m)	Difference (m)	Difference (%)	
R1	Sungai Gertak Sanggul	0.05	0.07	0.06	0.01	20	0.08	0.01	14	Insignificant impact
R2	Sungai Gemuruh	0.13	0.18	0.12	-0.01	-8	0.18	0.00	0	Insignificant impact
R3	Sungai Teluk Kumbar	0.04	0.05	0.00	-0.04	-100	0.00	-0.05	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8.*
R4	Sungai Mati	0.13	0.18	0.00	-0.13	-100	0.00	-0.18	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8.*
R5	Sungai Batu	0.15	0.19	0.00	-0.15	-100	0.00	-0.19	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8.*
R6	Sungai Bayan Lepas	0.11	0.14	0.09	-0.02	-18	0.13	-0.01	-7	Insignificant impact
R7	Bayan Lepas Main Drain	0.16	0.21	0.13	-0.03	-19	0.17	-0.04	-19	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8.*
R8	Sungai Ikan Mati	0.13	0.15	0.11	-0.02	-15	0.14	-0.01	-7	Insignificant impact
C1	Pulau Kendi	0.78	1.15	0.78	0.00	0	1.15	0.00	0	Insignificant impact
C2	Pulau Rimau	0.47	0.63	0.47	0.00	0	0.63	0.00	0	Insignificant impact
H1	Sungai Pulau Betung	0.17	0.22	0.17	0.00	0	0.22	0.00	0	Insignificant impact
H2	Gertak Sanggul	0.03	0.04	0.03	0.00	0	0.05	0.01	25	Insignificant impact
H3	Teluk Kumbar	0.18	0.25	0.15	-0.03	-17	0.21	-0.04	-16	Insignificant impact
H4	Permatang Damar Laut	0.22	0.28	0.19	-0.03	-14	0.26	-0.02	-7	Insignificant impact

T7.18 Comparison of the predominant wave heights at the ESAs between baseline condition and Scenario 2 (cont'd)

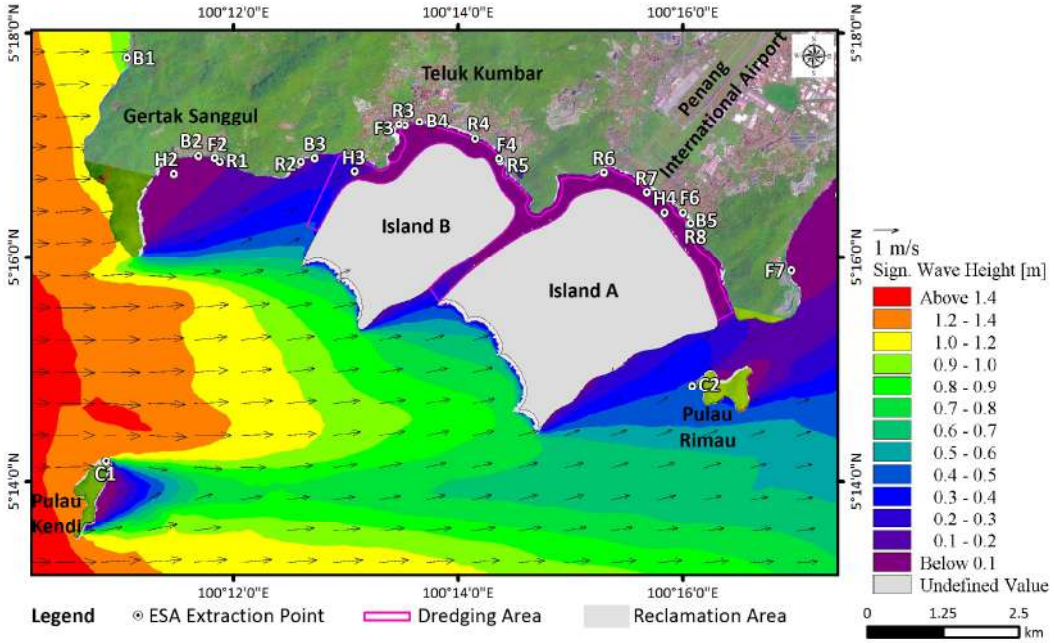
Point	Location	Baseline Condition		Scenario 1						Remarks
				1 in 1 year			1 in 60 year			
		1 in 1 year (m)	1 in 60 year (m)	Value (m)	Difference (m)	Difference (%)	Value (m)	Difference (m)	Difference (%)	
A1	Pulau Betung	0.58	0.80	0.58	0.00	0	0.80	0.00	0	Insignificant impact
A2	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
A3	Batu Maung	0.02	0.03	0.02	0.00	0	0.03	0.00	0	Insignificant impact
F1	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
F2	Gertak Sanggul	0.05	0.06	0.05	0.00	0	0.07	0.01	17	Insignificant impact
F3	Teluk Kumbar	0.02	0.02	0.00	-0.02	-100	0.00	-0.02	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8*.
F4	Sungai Batu	0.19	0.26	0.00	-0.19	-100	0.00	-0.26	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8*.
F5	Permatang Tepi Laut	-	-	-	-	-	-	-	-	No data (upstream location)
F6	Permatang Damar Laut	0.11	0.13	0.12	0.01	9	0.15	0.02	15	Insignificant impact
F7	Teluk Tempoyak Besar	0.03	0.04	0.03	0.00	0	0.04	0.00	0	Insignificant impact
F8	Teluk Tempoyak Kecil	0.02	0.03	0.02	0.00	0	0.03	0.00	0	Insignificant impact
F9	Batu Maung	0.02	0.02	0.02	0.00	0	0.02	0.00	0	Insignificant impact
F10	Sri Jerjak	0.01	0.02	0.01	0.00	0	0.02	0.00	0	Insignificant impact

c) Scenario 3

The modelling results of the 1 in 1 year and 1 in 60 years return period events under Scenario 3 for the dominant wave direction are shown in F7.36. Meanwhile, the differences in wave heights for the dominant waves, as compared to those in the existing condition, are shown in F7.37. Comparisons of the predominant wave heights at the ESAs between baseline and Scenario 3 are tabulated in T7.19.

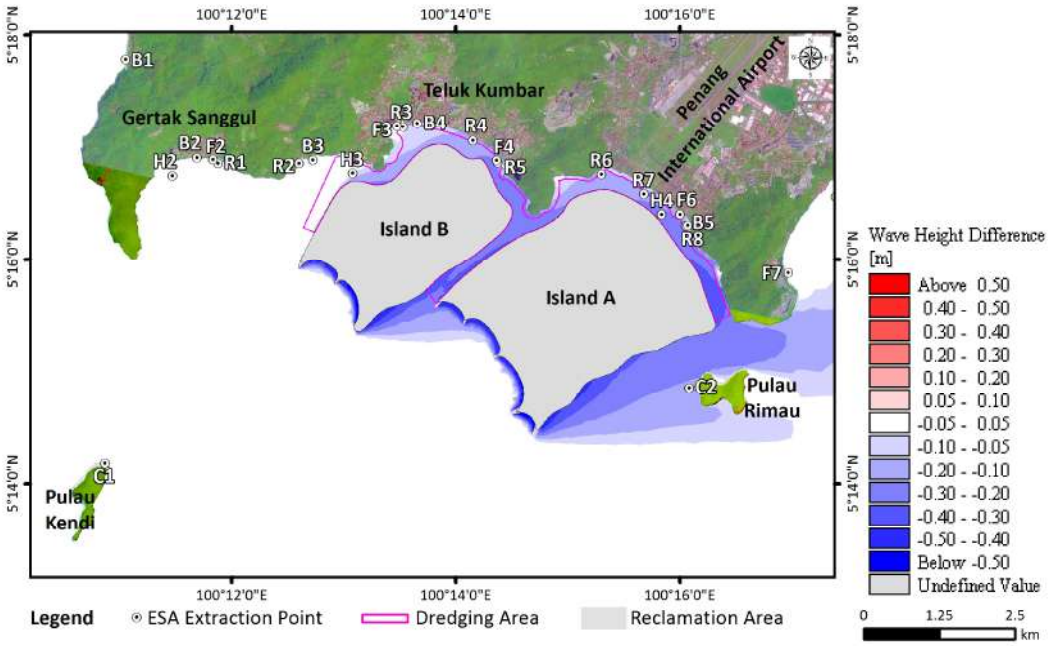


a) 1 in 1 year return period event: H_{m0} = 1.0 m, T_p = 5.5 s

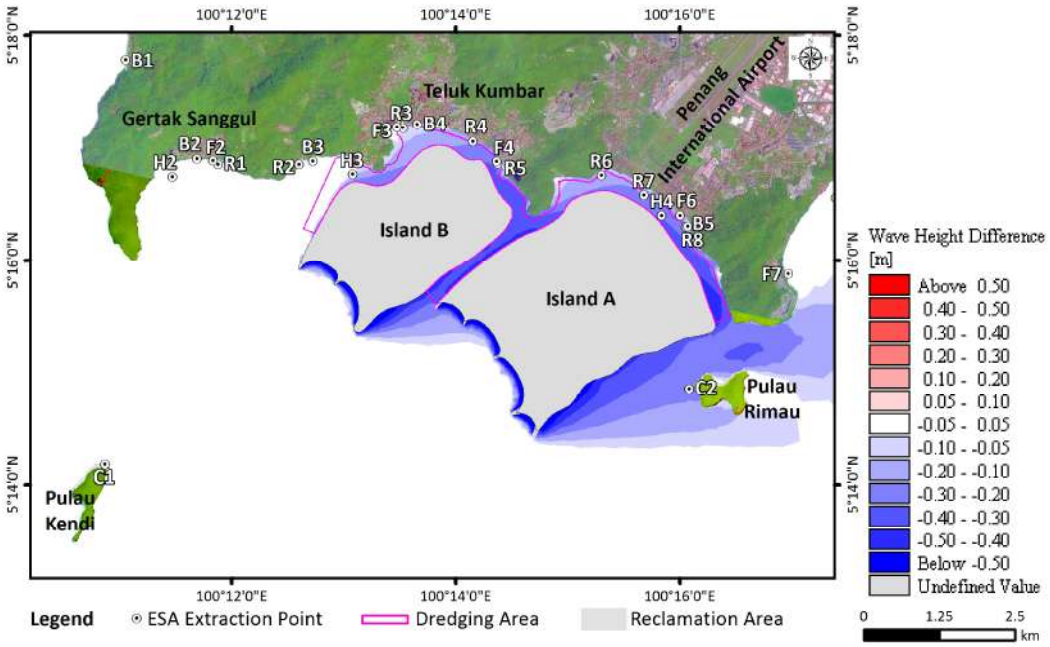


b) 1 in 60 year return period event: H_{m0} = 1.5 m, T_p = 6.0 s

F7.36 Significant wave heights; Scenario 3 condition; MWD = 270°N



a) 1 in 1 year return period event: H_{m0} = 1.0 m, T_p = 5.5 s



b) 1 in 60 year return period event: H_{m0} = 1.5 m, T_p = 6.0 s

F7.37 Wave height difference; Scenario 3 vs. existing condition; MWD = 270°N

T7.19 Comparison of the predominant wave heights at the ESAs between baseline condition and Scenario 3

Point	Location	Baseline Condition		Scenario 1						Remarks
				1 in 1 year			1 in 60 year			
		1 in 1 year (m)	1 in 60 year (m)	Value (m)	Difference (m)	Difference (%)	Value (m)	Difference (m)	Difference (%)	
R1	Sungai Gertak Sanggul	0.05	0.07	0.06	0.01	20	0.08	0.01	14	Insignificant impact
R2	Sungai Gemuruh	0.13	0.18	0.12	-0.01	-8	0.18	0.00	0	Insignificant impact
R3	Sungai Teluk Kumbar	0.04	0.05	0.00	-0.04	-100	0.00	-0.05	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8.*
R4	Sungai Mati	0.13	0.18	0.00	-0.13	-100	0.00	-0.18	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8.*
R5	Sungai Batu	0.15	0.19	0.00	-0.15	-100	0.00	-0.19	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8.*
R6	Sungai Bayan Lepas	0.11	0.14	0.00	-0.11	-100	0.00	-0.14	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8.*
R7	Bayan Lepas Main Drain	0.16	0.21	0.00	-0.16	-100	0.00	-0.21	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8.*
R8	Sungai Ikan Mati	0.13	0.15	0.00	-0.13	-100	0.00	-0.15	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8.*
C1	Pulau Kendi	0.78	1.15	0.78	0.00	0	1.15	0.00	0	Insignificant impact
C2	Pulau Rimau	0.47	0.63	0.29	-0.18	-38	0.41	-0.22	-35	Decrease in wave height may cause detrimental impact to corals. Refer to *Section 7.5.1.*

T7.19 Comparison of the predominant wave heights at the ESAs between baseline condition and Scenario 3 (cont'd)

Point	Location	Baseline Condition		Scenario 1						Remarks
				1 in 1 year			1 in 60 year			
		1 in 1 year (m)	1 in 60 year (m)	Value (m)	Difference (m)	Difference (%)	Value (m)	Difference (m)	Difference (%)	
H1	Sungai Pulau Betung	0.17	0.22	0.17	0.00	0	0.22	0.00	0	Insignificant impact
H2	Gertak Sanggul	0.03	0.04	0.03	0.00	0	0.05	0.01	25	Insignificant impact
H3	Teluk Kumbar	0.18	0.25	0.15	-0.03	-17	0.21	-0.04	-16	Insignificant impact
H4	Permatang Damar Laut	0.22	0.28	0.00	-0.22	-100	0.00	-0.28	-100	Insignificant impact
A1	Pulau Betung	0.58	0.80	0.58	0.00	0	0.80	0.00	0	Insignificant impact
A2	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
A3	Batu Maung	0.02	0.03	0.02	0.00	0	0.03	0.00	0	Insignificant impact
F1	Sungai Pulau Betung	-	-	-	-	-	-	-	-	No data (upstream location)
F2	Gertak Sanggul	0.05	0.06	0.05	0.00	0	0.07	0.01	17	Insignificant impact
F3	Teluk Kumbar	0.02	0.02	0.00	-0.02	-100	0.00	-0.02	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8*.
F4	Sungai Batu	0.19	0.26	0.00	-0.19	-100	0.00	-0.26	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8*.
F5	Permatang Tepi Laut	-	-	-	-	-	-	-	-	No data (upstream location)
F6	Permatang Damar Laut	0.11	0.13	0.00	-0.11	-100	0.00	-0.13	-100	Decrease in wave height may induce sedimentation. Refer to *Section 7.3.8*.
F7	Teluk Tempoyak Besar	0.03	0.04	0.02	-0.01	-33	0.04	0.00	0	Insignificant impact
F8	Teluk Tempoyak Kecil	0.02	0.03	0.02	0.00	0	0.03	0.00	0	Insignificant impact
F9	Batu Maung	0.02	0.02	0.01	-0.01	-50	0.02	0.00	0	Insignificant impact
F10	Sri Jerjak	0.01	0.02	0.01	0.00	0	0.02	0.00	0	Insignificant impact