06 EXISTING ENVIRONMENT

6.1 Introduction

The existing environment of the Project site shall be described according to four (4) sub-chapters which are:

a) existing Physical Environment;
b) existing Biological Environment;
c) existing Human Environment; and
d) environmentally Sensitive Areas (ESAs).

6.2 Existing Physical Environment

The existing physical environment of the whole Project area located within a 5-km radius from the Project boundary will be described into different sections as the following:

a) land use;
b) hydraulic components;
c) climate and meteorology;
d) tsunami
e) hydrology and drainage;
f) geology and geotechnical;
g) water quality;
h) sediment quality;
i) air quality;
j) noise;
k) marine traffic and navigation; and
l) land traffic.

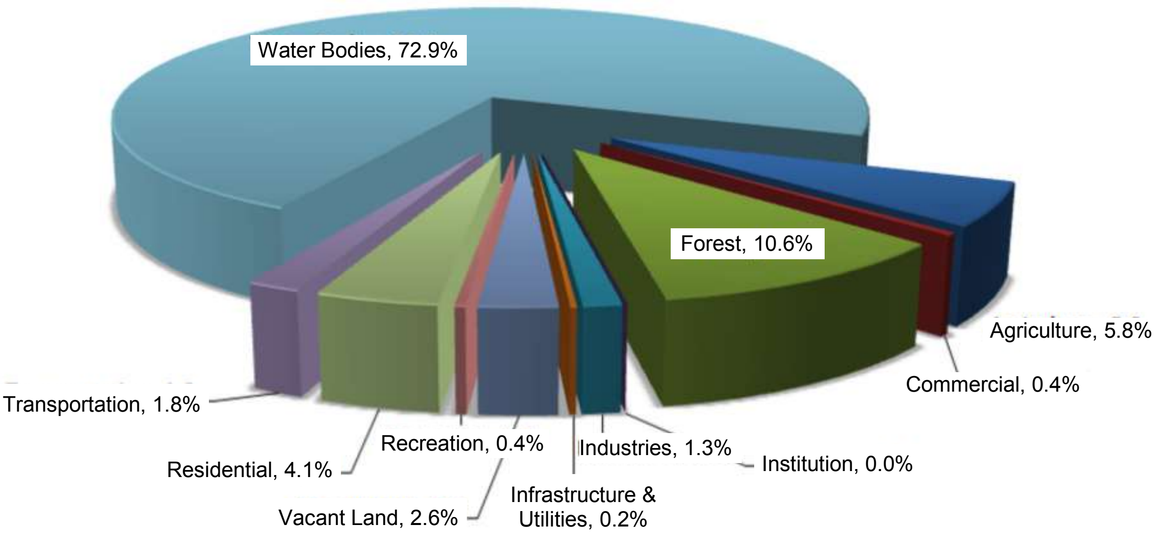
6.2.1 Land Use

This section describes the land use of the study area which refers to the area of 22,545.78 hectares within a 5-km radius from the proposed Project boundary. A major portion or three-quarters of the study area comprise the surrounding waters of the South Channel while the remaining is land-based. The study area includes the entire Mukim 6, 7, 8, 9, 10, 11, 12, I and J of Southwest District. The proposed Project area falls under the jurisdiction of the City Council of Penang Island.

Based on the land use map by the Department of Town and Country Planning (JPBD), the area surrounding the proposed Project site displays a coherent land use pattern. The main land use pattern within the study area consists of Forest, Water Bodies and Agriculture (F6.1 and T6.1). The existing land uses of the study area with 250 m intervals of the 5-km radius are shown in F6.2. The category of Water Bodies covers 72.86% of the existing land use, followed by Forest and Agricultural at 10.64% and 5.77% respectively.

The development patterns of land use at the Southwest District show that the residential development is concentrated around Teluk Kumbar, Bayan Lepas and Batu Maung while industrial activities are concentrated at the Bayan Lepas FIZ. The descriptions of land use are also based on several other sources as listed below:

a) Satellite image (SPOT-5, 20 February 2013);
b) Satellite image (Google Earth); and
c) Field observation and verification on 28 to 31 August 2016.



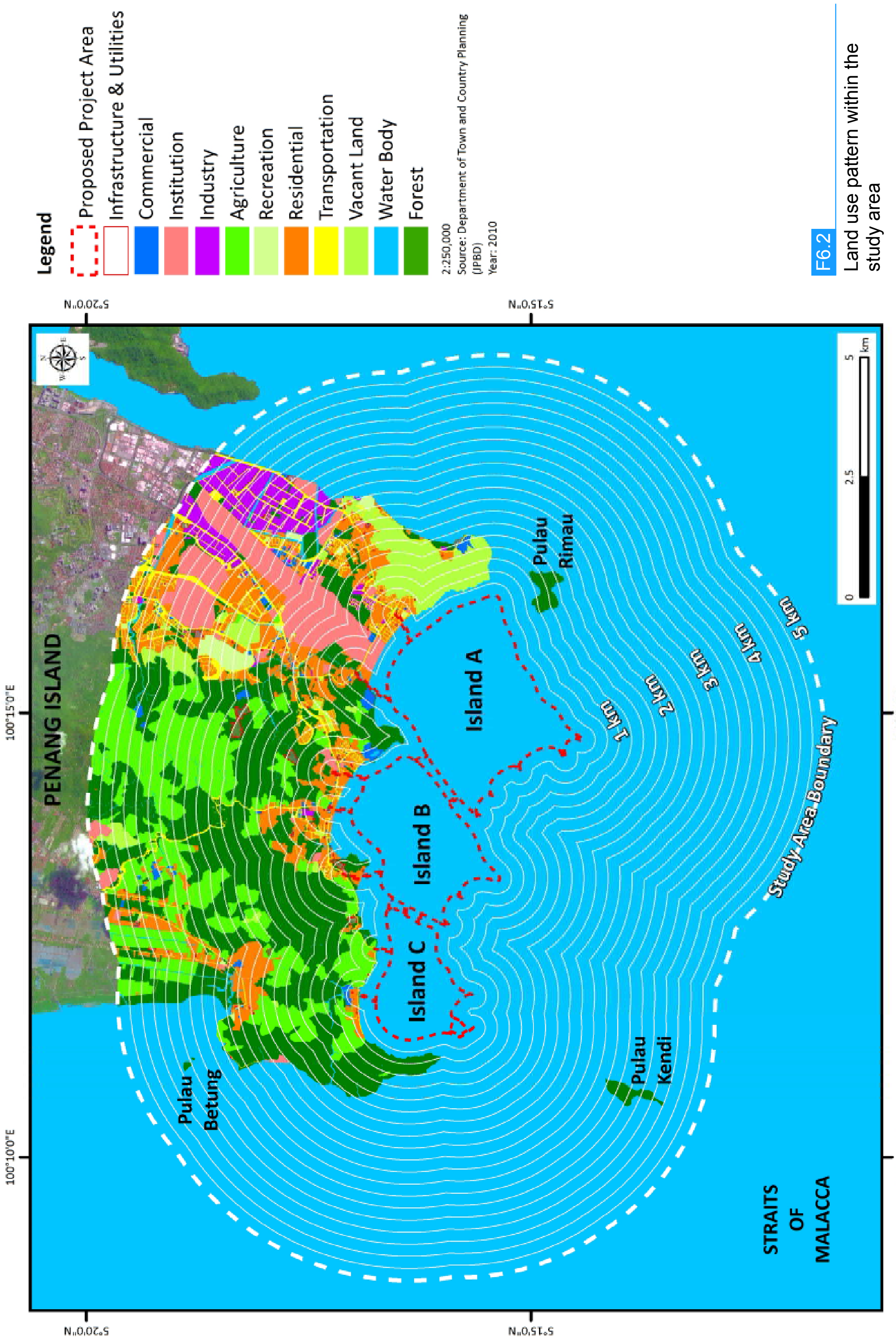
Source: JPBD (2010)

F6.1 Percentage of the current land use within the study area

T6.1 Current land use distribution within the study area

Category	Area (hectare)	Percentage (%)
Agriculture	1,300.28	5.77
Commercial	89.72	0.40
Forest	2,399.51	10.64
Institution	0.00	0.00
Industries	289.87	1.29
Infrastructure & Utilities	49.43	0.22
Vacant Land	591.77	2.62
Recreation	80.06	0.36
Residential	916.10	4.06
Transportation	403.01	1.79
Water Bodies	16,426.02	72.86
TOTAL	**22,545.78**	**100.00**

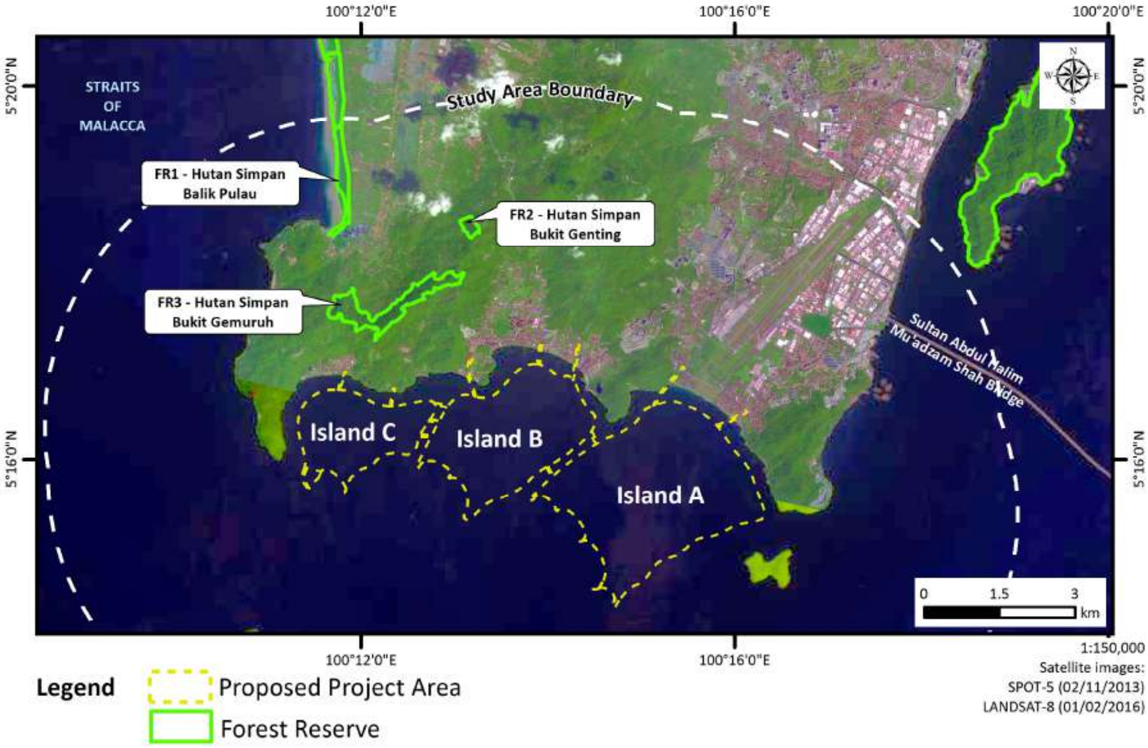
Source: JPBD (2010)



F6.2 Land use pattern within the study area

6.2.2.1 Forest Area

Forest Area is the second largest land use in the proposed Project site and covers 10.64% of the total land use. The major forest reserves in the proposed Project site are Bukit Gemuruh Forest Reserve, Bukit Genting Forest Reserve and Balik Pulau Forest Reserve. The total area of the forest reserve in the study area is 126.96 hectares. The nearest forest reserve is Bukit Gemuruh Forest Reserve which is less than 2 km from the Project site. F6.3 shows the forest reserve area within the proposed Project site.



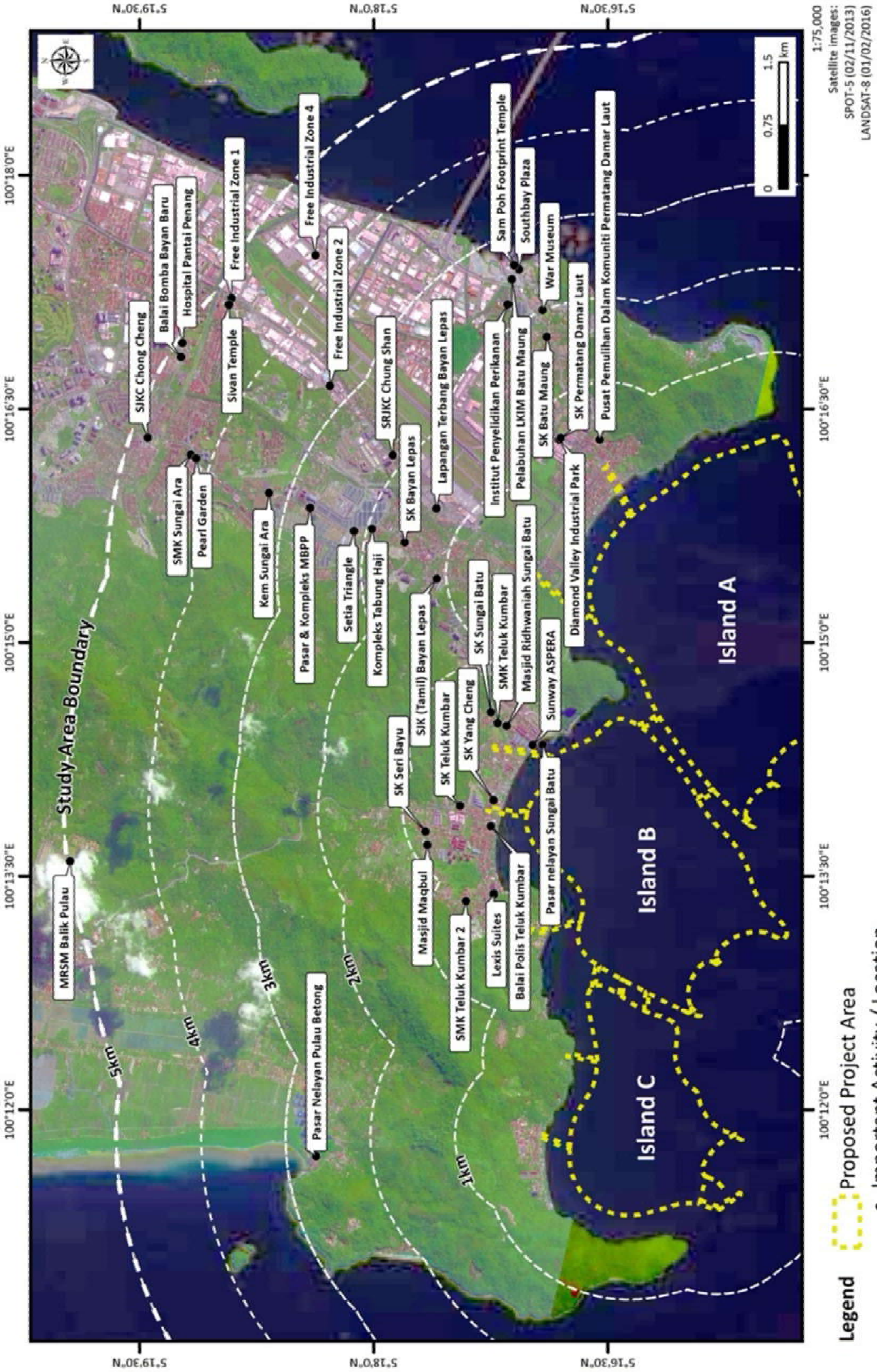
F6.3 Forest area within the study area

6.2.2.2 Other Land Use Activities

In the study area, there are important places and activities carried out by the local residents. There are many public facilities within the study area such as mosques, town halls, tourist attractions and Government buildings. Several education centres in the form of schools and colleges are also present within these corridors. T6.2, F6.4 and F6.5 show the important locations and land use activities in the study area.

T6.2 Current active and important activities/ locations

Place	Radius	Latitude	Longitude
1. Free Industrial Zone 1	5 km	5.31520°N	100.28680°E
2. Free Industrial Zone 2	4 km	5.30467°N	100.27747°E
3. Free Industrial Zone 4	5 km	5.30622°N	100.29144°E
4. SMK Teluk Kumbar 2	1 km	5.29014°N	100.22231°E
5. Masjid Maqbul	1 km	5.29428°N	100.22831°E
6. SK Seri Bayu	1 km	5.29446°N	100.22977°E
7. Balai Polis Teluk Kumbar	1 km	5.28747°N	100.23034°E
8. SK Teluk Kumbar	1 km	5.29078°N	100.23250°E
9. Lexis Suites	1 km	5.28718°N	100.22309°E
10. SK Yang Cheng	1 km	5.28720°N	100.23312°E
11. Sunway ASPERA	1 km	5.28303°N	100.23902°E
12. Pasar nelayan Sungai Batu	1 km	5.28196°N	100.23902°E
13. Masjid Ridhwaniah Sungai Batu	1 km	5.28581°N	100.24106°E
14. SMK Teluk Kumbar	1 km	5.28675°N	100.24136°E
15. SK Sungai Batu	1 km	5.28750°N	100.24252°E
16. SJK (C) Chong Cheng	5 km	5.32413°N	100.27191°E
17. SMK Sungai Ara	5 km	5.31954°N	100.27008°E
18. Pearl Garden	5 km	5.31895°N	100.26969°E
19. Kem Sungai Ara	4 km	5.31120°N	100.26600°E
20. SRJK (C) Chung Shan	3 km	5.29795°N	100.27001°E
21. Sivan Temple	5 km	5.31548°N	100.28613°E
22. Setia Triangle	3 km	5.30212°N	100.26190°E
23. Kompleks Tabung Haji	3 km	5.30020°N	100.26216°E
24. SK Bayan Lepas	2 km	5.29671°N	100.26071°E
25. Lapangan Terbang Bayan Lepas	2 km	5.29331°N	100.26434°E
26. Hospital Pantai Penang	5 km	5.32043°N	100.28206°E
27. Balai Bomba Bayan Baru	5 km	5.32057°N	100.28055°E
28. MRSM Balik Pulau	5 km	5.33243°N	100.22659°E
29. Pasar Nelayan Pulau Betung	3 km	5.30615°N	100.19503°E
30. Pasar & Kompleks MBPP	3 km	5.30681°N	100.26440°E
31. SJK (Tamil) Bayan Lepas	2 km	5.29329°N	100.25682°E
32. Diamond Valley Industrial Park	1 km	5.28024°N	100.27172°E
33. SK Permatang Damar Laut	1 km	5.28007°N	100.27189°E
34. Pusat Pemulihan Dalam Komuniti Permatang Damar Laut	1 km	5.27588°N	100.27172°E
35. SK Batu Maung	2 km	5.28154°N	100.28271°E
36. War Museum	2 km	5.28196°N	100.28559°E
37. Southbay Plaza	3 km	5.28446°N	100.28994°E
38. Sam Poh Footprint Temple	3 km	5.28501°N	100.29037°E
39. Pelabuhan LKIM Batu Maung	3 km	5.28525°N	100.28887°E
40. Institut Penyelidikan Perikanan	3 km	5.28571°N	100.28615°E



F6.4 Existing land use activities and important locations

1. Free Industrial Zone 1

2. Free Industrial Zone 2

3. Free Industrial Zone 4

4. SMK Teluk Kumbar 2

5. Masjid Maqbul

6. SK Seri Bayu

7. Balai Polis Teluk Kumbar

8. SK Teluk Kumbar

9. Lexis Suites

10. SK Yang Cheng

11. Sunway ASPERA

12. Pasar Nelayan Sungai Batu

13. Masjid Ridhwaniah Sungai Batu

14. SMK Teluk Kumbar

15. SK Sungai Batu

16. SJK (C) Chong Cheng

17. SMK Sungai Ara

18. Pearl Garden

F6.5 Important places and associated activities


19. Kem Sungai Ara

20. SRJK (C) Chung Shan


21. Sivan Temple


22. Setia Triangle


23. Kompleks Tabung Haji

24. SK Bayan Lepas


25. Lapangan Terbang Bayan Lepas

26. Hospital Pantai Penang


27. Balai Bomba Bayan Baru


28. MRSM Balik Pulau


29. Pasar Nelayan Pulau Betung

30. Pasar dan Kompleks MBPP


31. SJK (Tamil) Bayan Lepas


32. Diamond Valley Industrial Park

33. SK Permatang Damar Laut


34. Pusat Pemulihan Dalam Komuniti Permatang Damar Laut


35. SK Batu Maung

36. War Museum

F6.5 Important places and associated activities (cont'd)

37. Southbay Plaza

38. Sam Poh Footprint Temple

39. Pelabuhan LKIM Batu Maung

40. Institut Penyelidikan Perikanan

F6.5 Important places and associated activities (cont'd)

6.2.2 Hydraulic Components

The existing hydraulic components of the study area will be explained by the following:

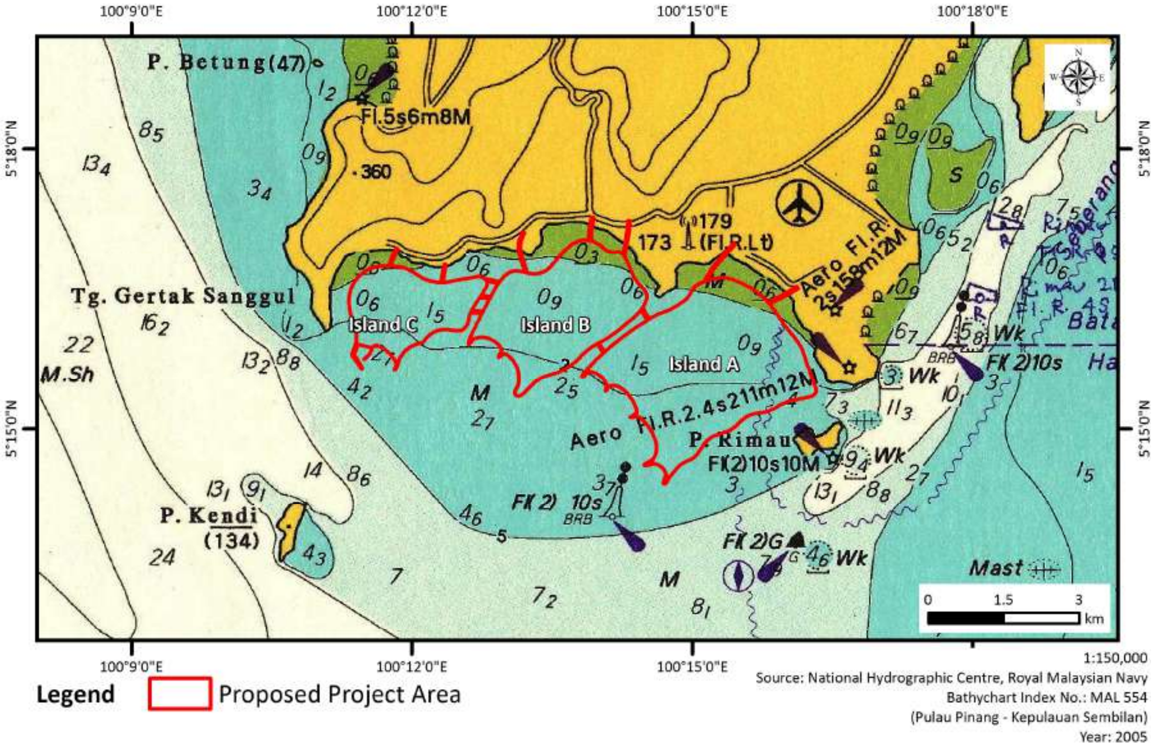
a) bathymetry;
b) water levels;
c) currents; and
d) wave.

6.2.2.1 Bathymetry

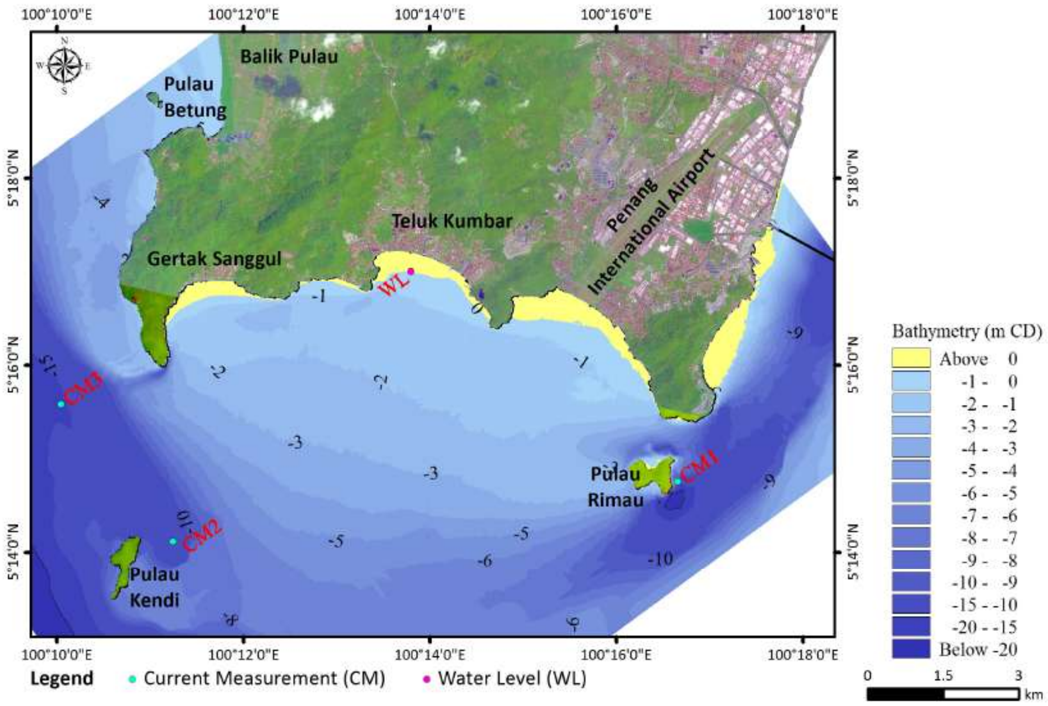
F6.6 shows the Project site overlain on the bathymetry chart (No. MAL554). A bathymetric survey was conducted from August to October 2015 by Jurukur Perunding Services to ascertain the existing bed and nearshore levels within and in the immediate vicinity of the Project site. The Project site is generally shallow, with a sea bed level of about –0.3 to –4 m CD. There are natural deep channels near the headlands of Tanjung Gertak Sanggul and Tanjung Teluk Tempoyak, indicating relatively fast currents in these areas.

6.2.2.2 Water Levels

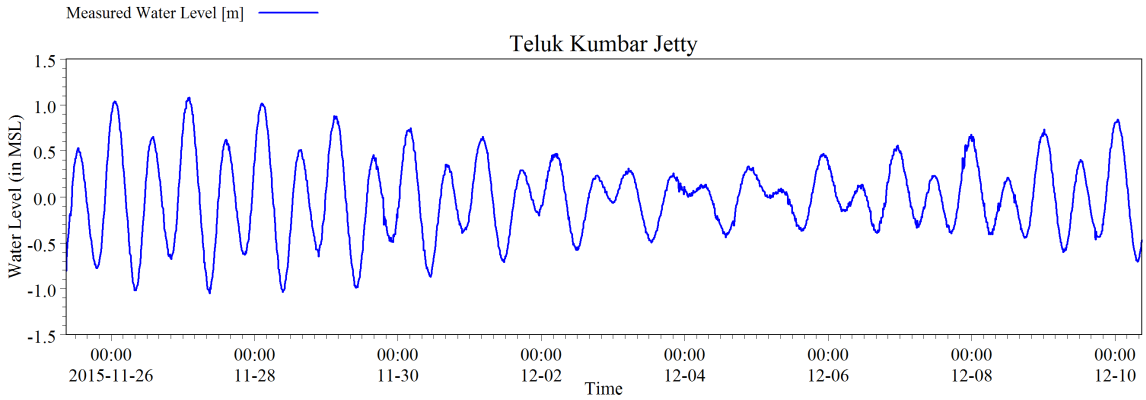
In situ water levels were measured by an automatic water level recorder, Valeport 740 installed at Teluk Kumbar Jetty (100° 13.796'E, 5° 16.998'N). Its location is indicated in F6.7. The measurement period was between 25 November and 10 December 2015. Time-series records of the measured water levels are shown in F6.8.



F6.6 Project site overlain on the bathymetry chart



F6.7 Location of water level measurement

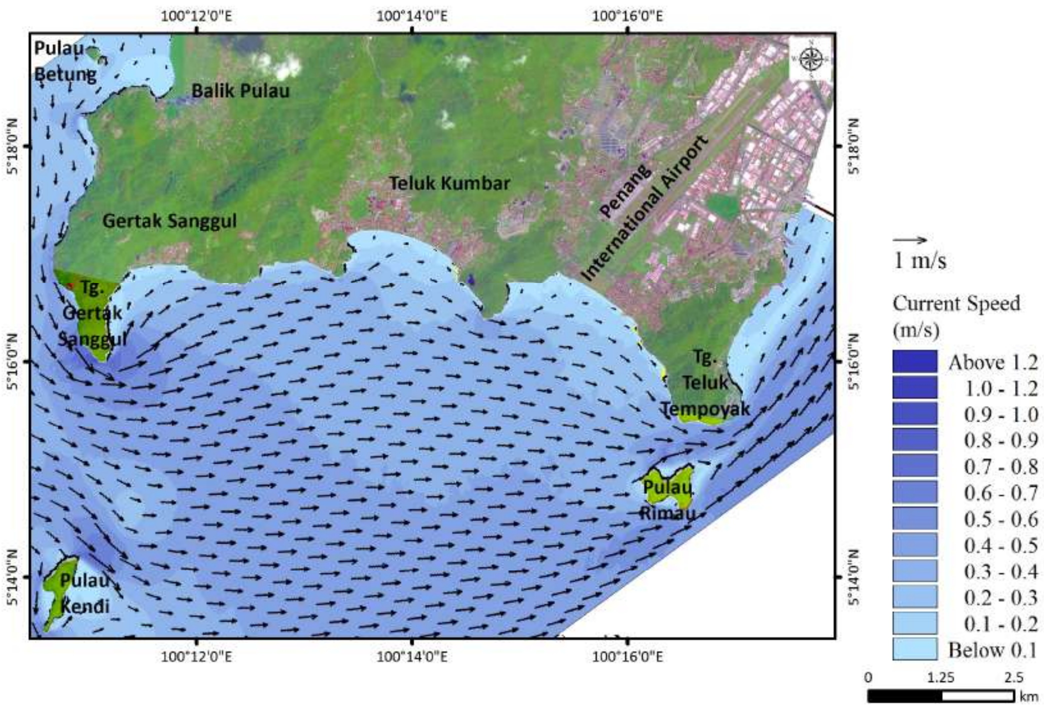


F6.8 Measured water levels

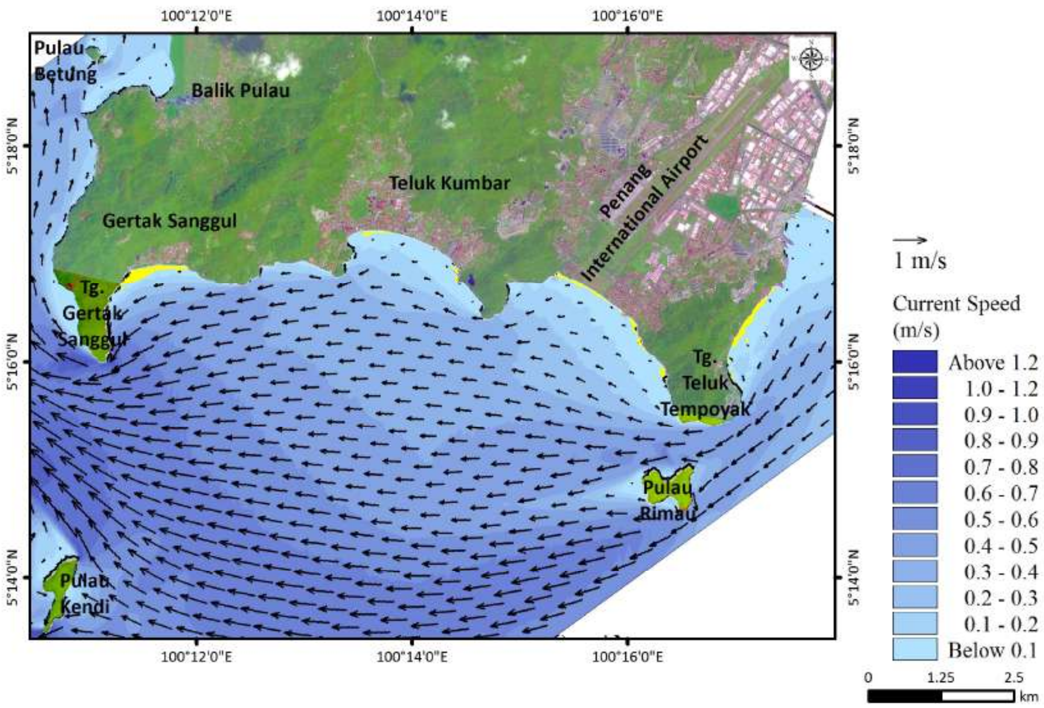
6.2.2.3 Currents

Currents around the Project site for flood and ebb flows during spring and neap periods for pure tide and seasonal conditions are shown in F6.9 to F6.11 respectively. Currents within the Straits of Malacca flow into Penang Straits during flood flow. Water flows out from Penang Straits during ebb flow. The mudflats and mangroves within the Project area are exposed at various stages of low water events.

Mean and maximum current speed plots for seasonal conditions are shown in F6.12 and F6.13. It can be inferred from the results that mean and maximum current speeds of up to about 0.2 and 0.8 m/s respectively can occur in the vicinity of the Project site for all seasonal conditions. On average, the current is of moderate speed while maximum current speed occurs at Pulau Kendi, Tanjung Teluk Tempoyak and Tanjung Gertak Sanggul.

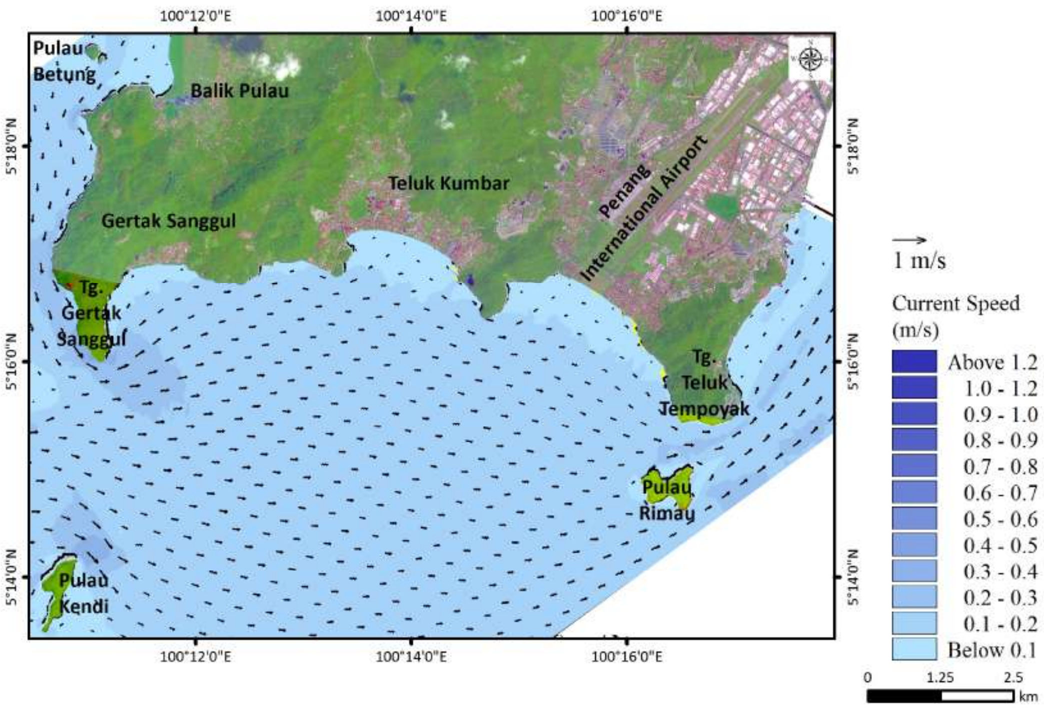


a) Spring period: Flood flow

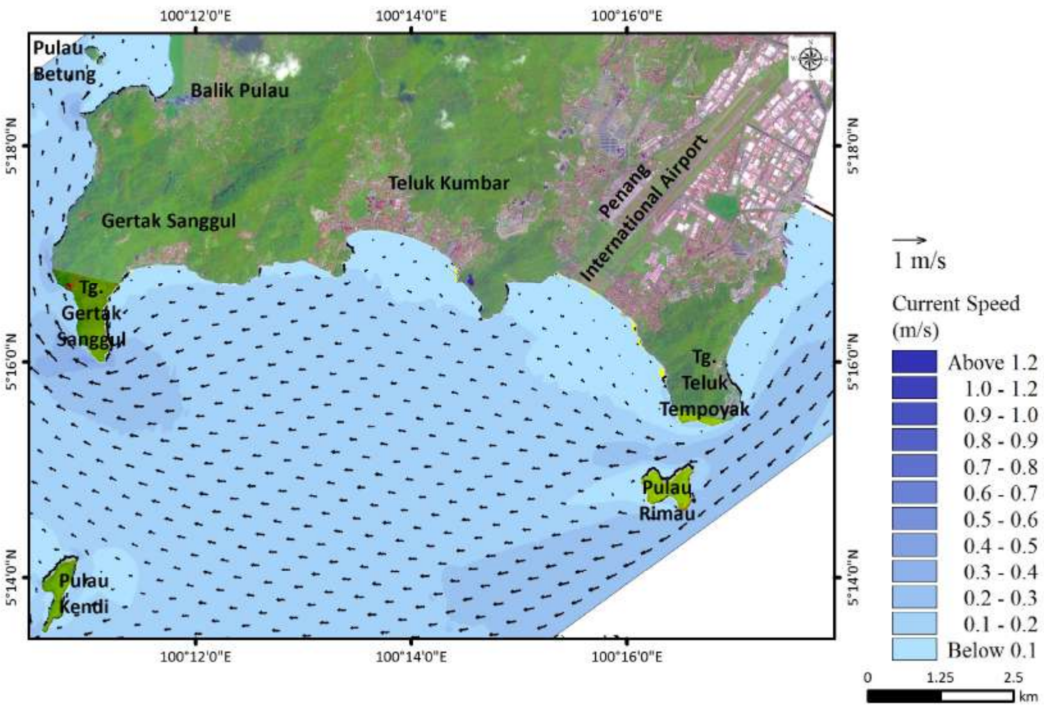


b) Spring period: Ebb flow

F6.9 Flow pattern during spring and neap periods for existing conditions (pure tide condition)

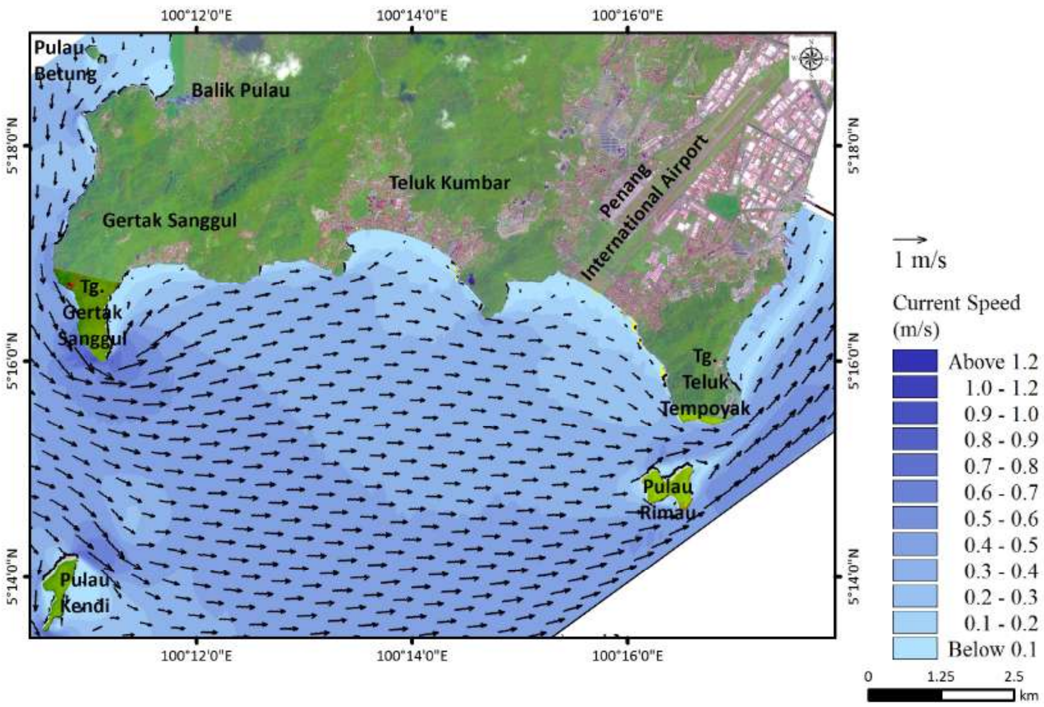


c) Neap period: Flood flow

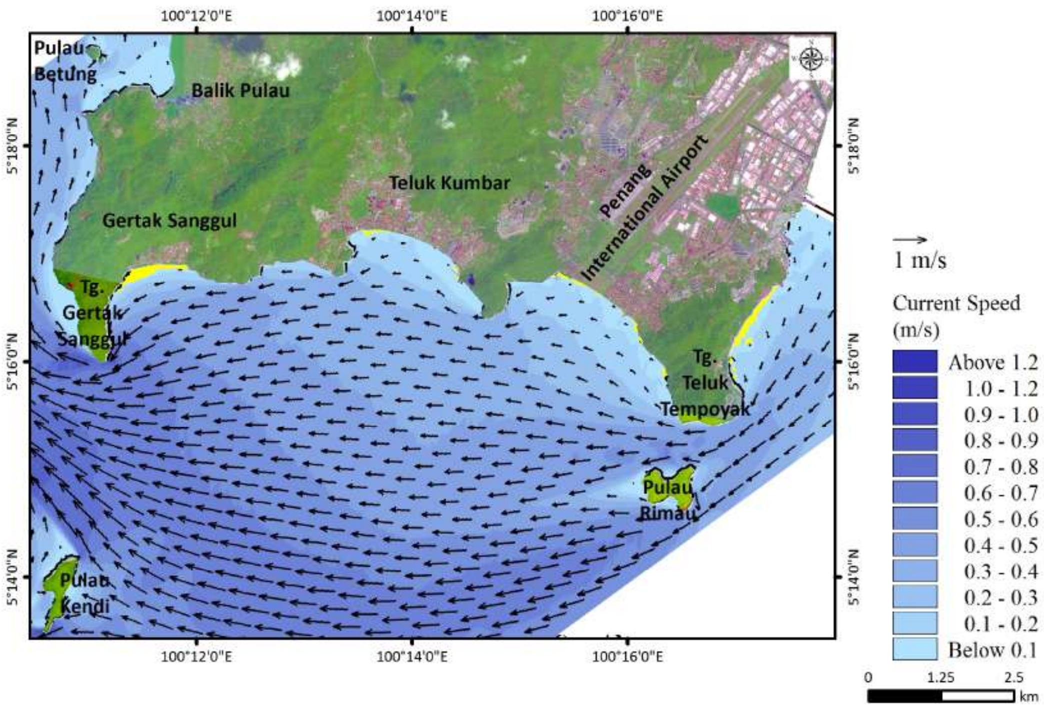


d) Neap period: Ebb flow

F6.9 Flow pattern during spring and neap periods for existing conditions (pure tide condition) (cont'd)

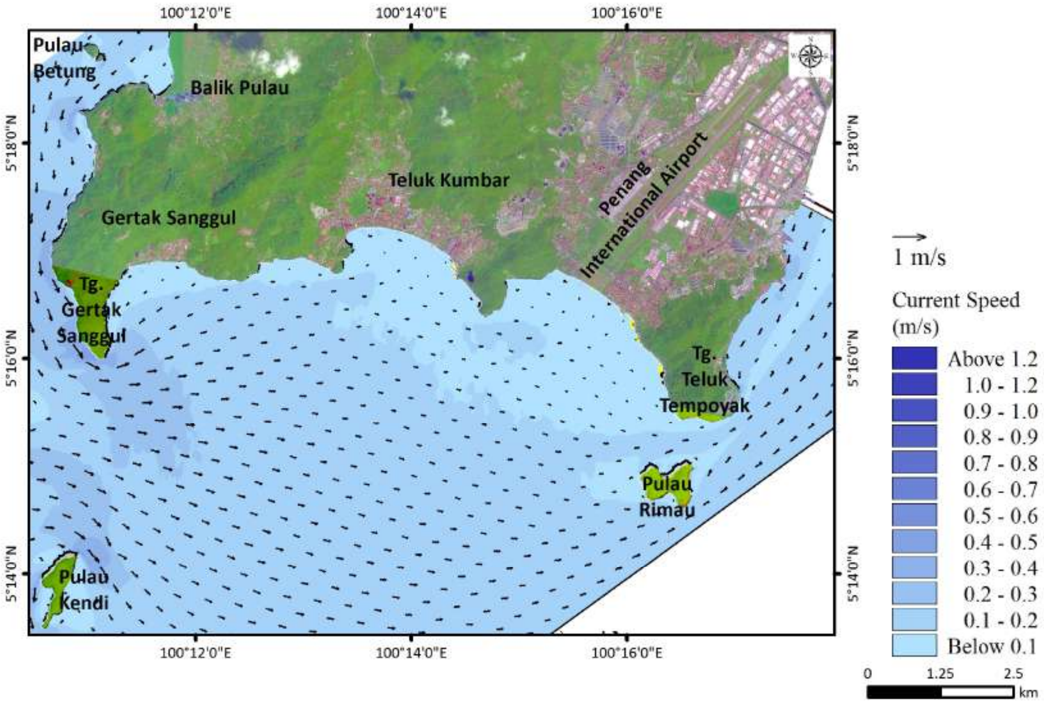


a) Spring period: Flood flow

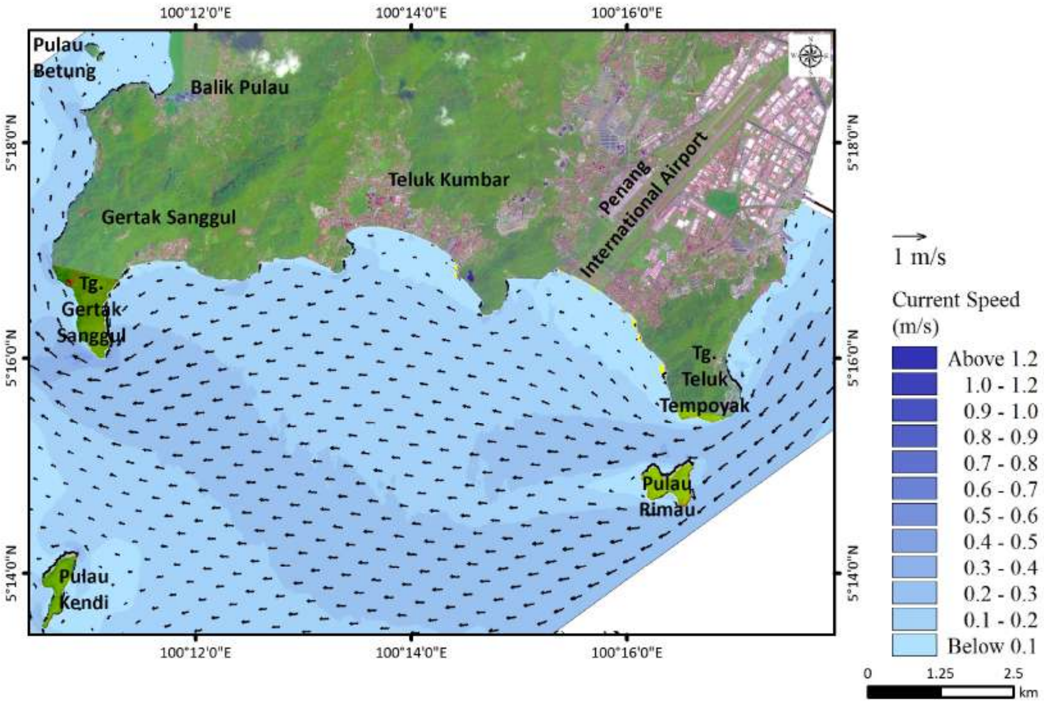


b) Spring period: Ebb flow

F6.10 Flow pattern during spring and neap periods for existing conditions (Northeast Monsoon condition)

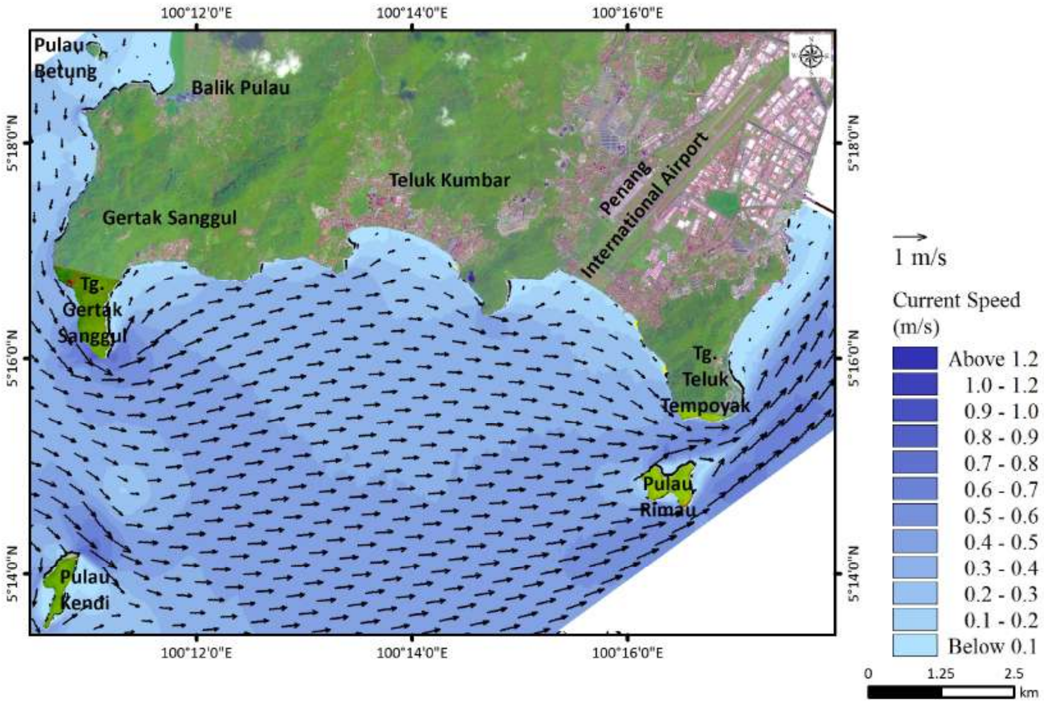


c) Neap period: Flood flow

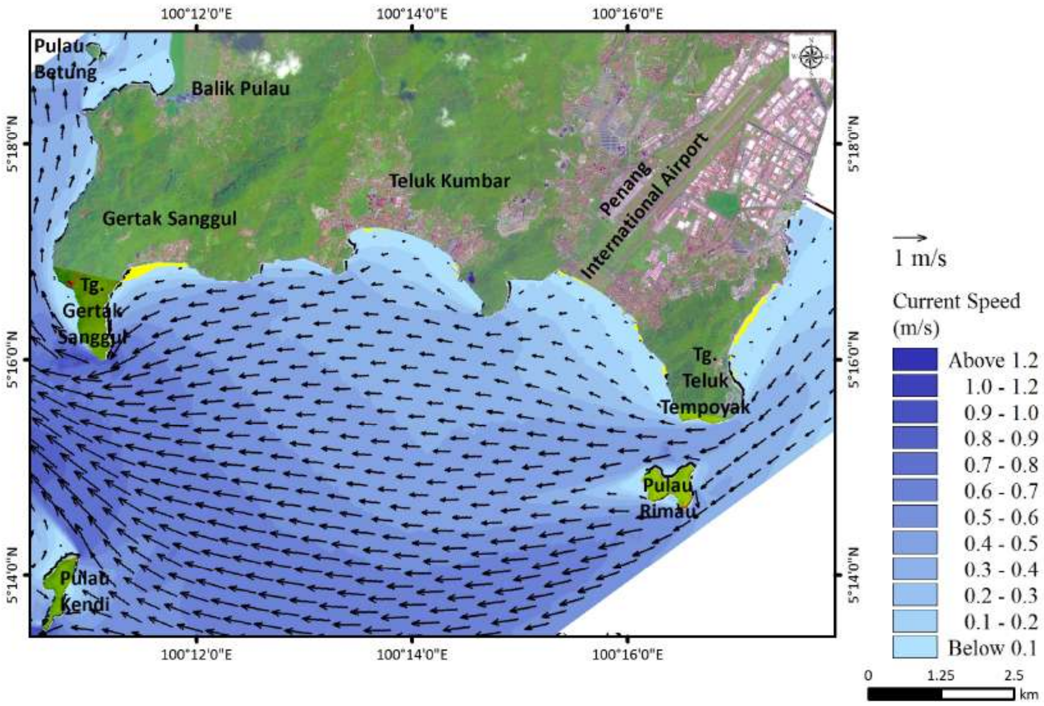


d) Neap period: Ebb flow

F6.10 Flow pattern during spring and neap periods for existing conditions (Northeast Monsoon condition) (cont'd)

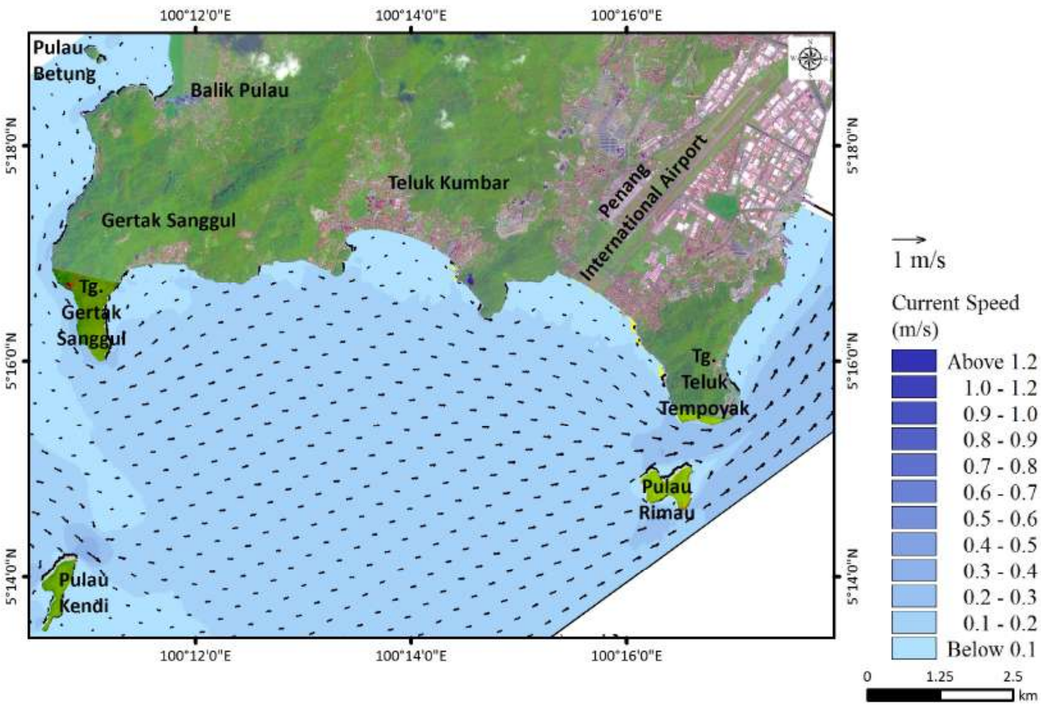


a) Spring period: Flood flow

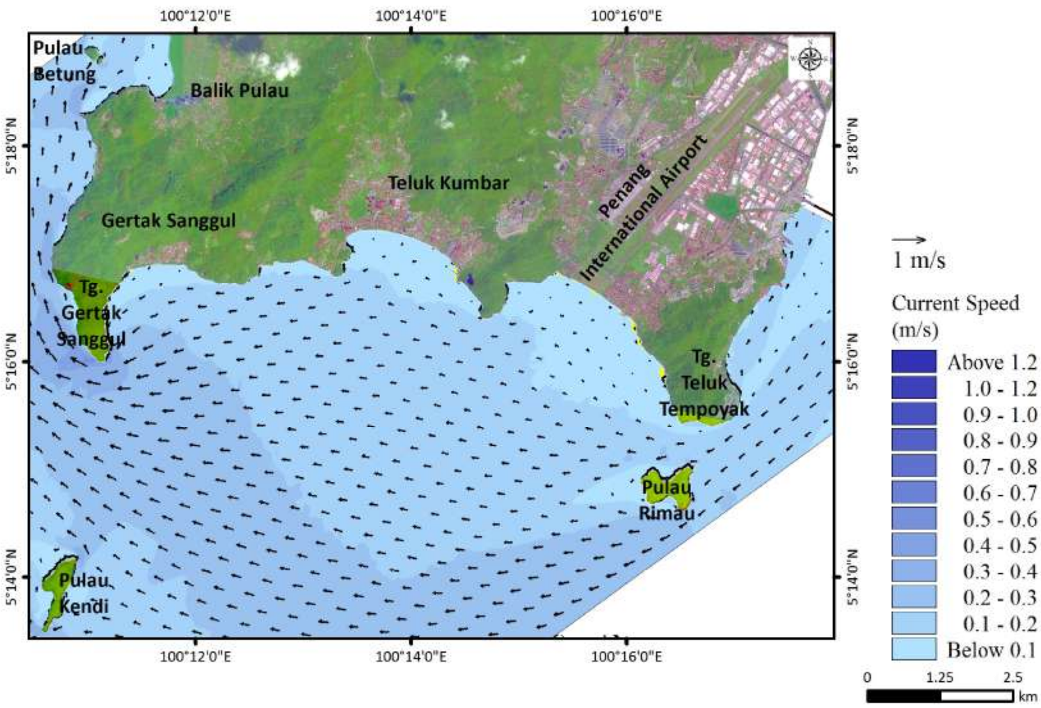


b) Spring period: Ebb flow

F6.11 Flow pattern during spring and neap periods for existing conditions (Southwest Monsoon condition)

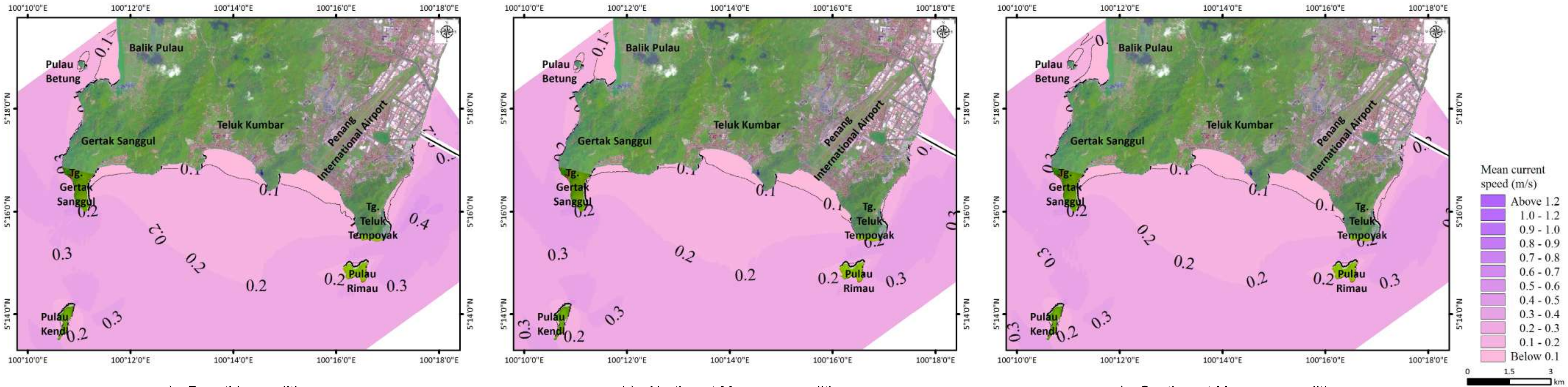


c) Neap period: Flood flow



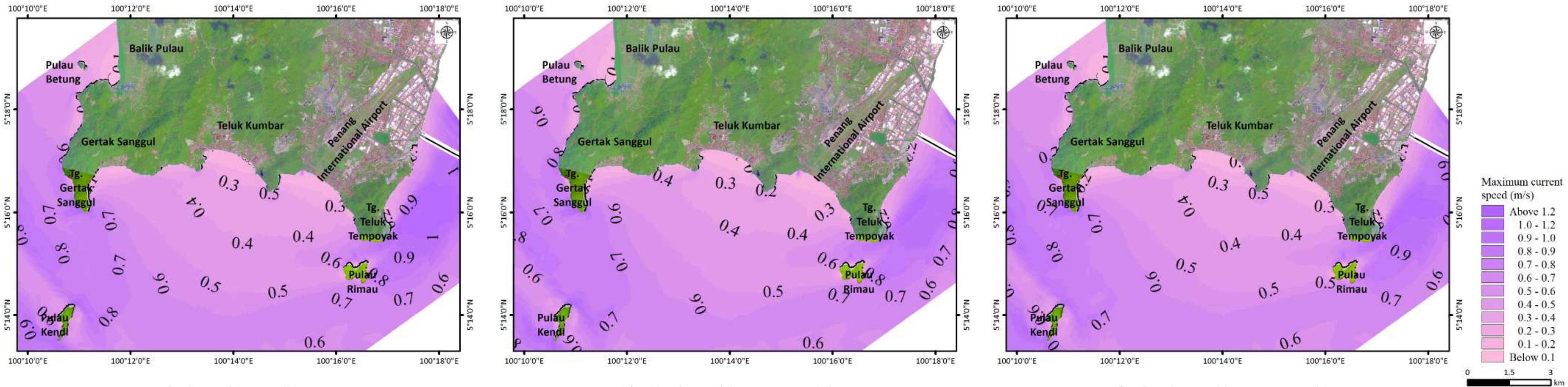
d) Neap period: Ebb flow

F6.11 Flow pattern during spring and neap periods for existing conditions (Southwest Monsoon condition) (cont'd)



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

F6.12 Mean current speed plots for baseline condition

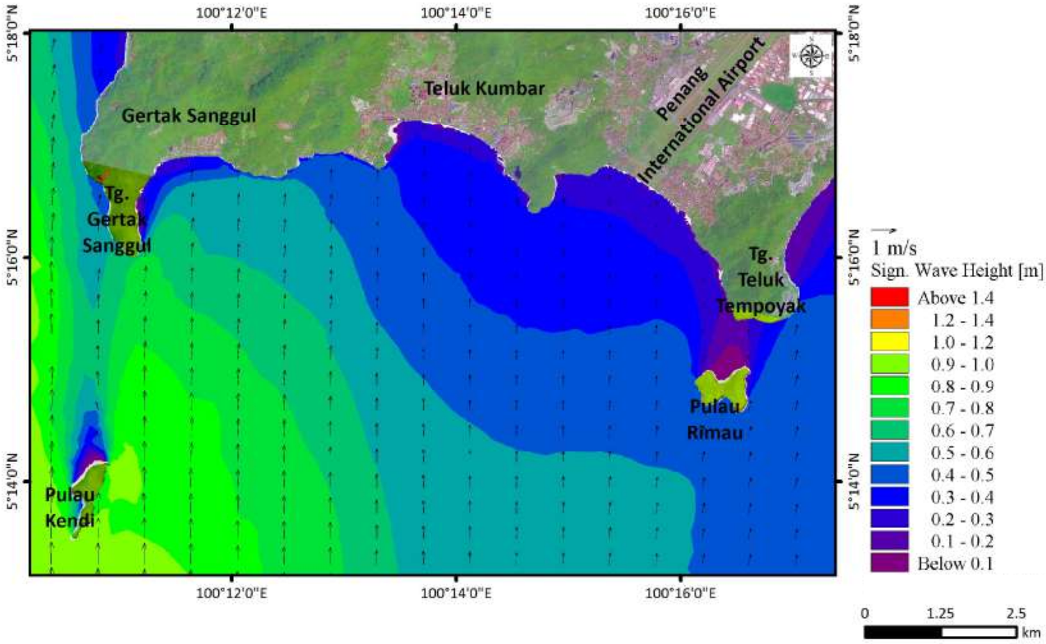


a) Pure tide condition
b) Northeast Monsoon condition
c) Southwest Monsoon condition

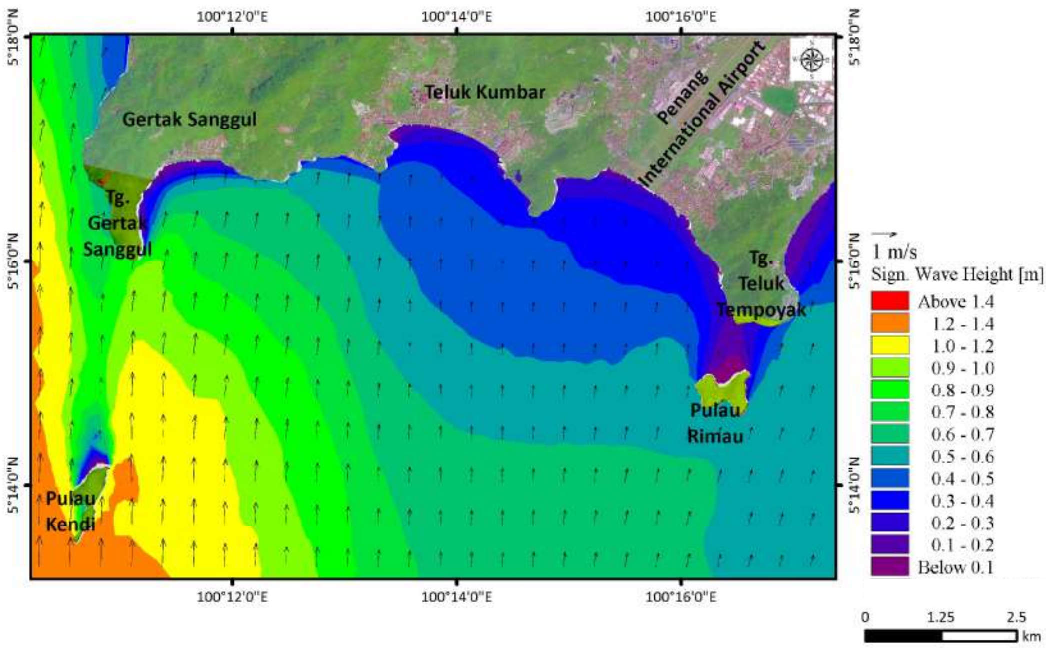
F6.13 Maximum current speed plots for baseline condition

6.2.2.4 Waves

The wave modelling results of the 1 in 1 year and 1 in 60 years return period events under the baseline condition are shown in F6.14 to F6.17 for waves propagating from the 180, 210, 240 and 270°N respectively.

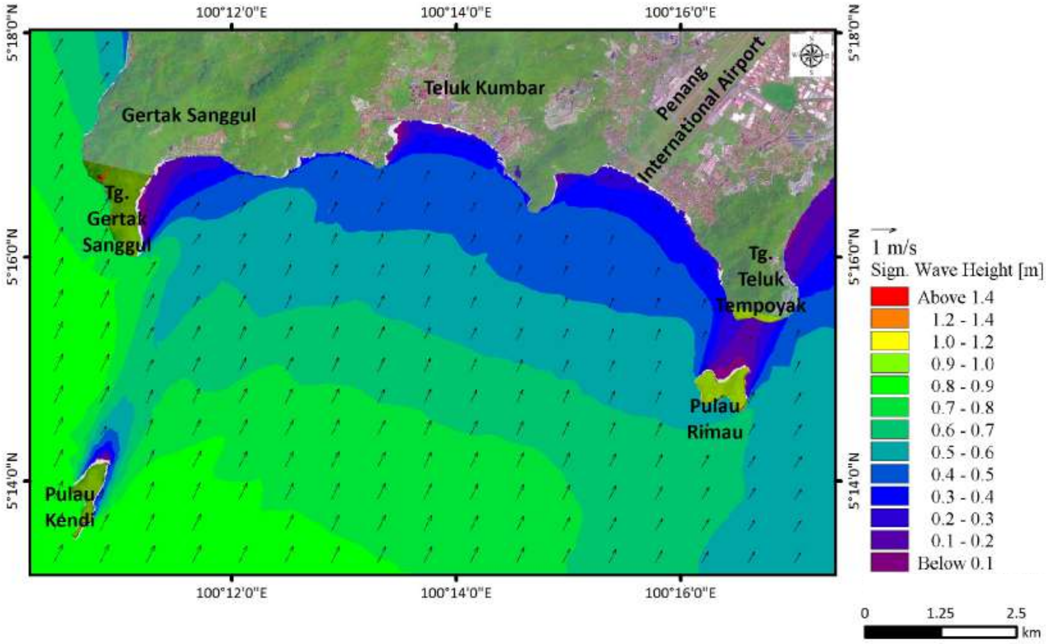


a) 1 in 1 year return period event: H_{m0} = 1.0 m, T_p = 5.0 s

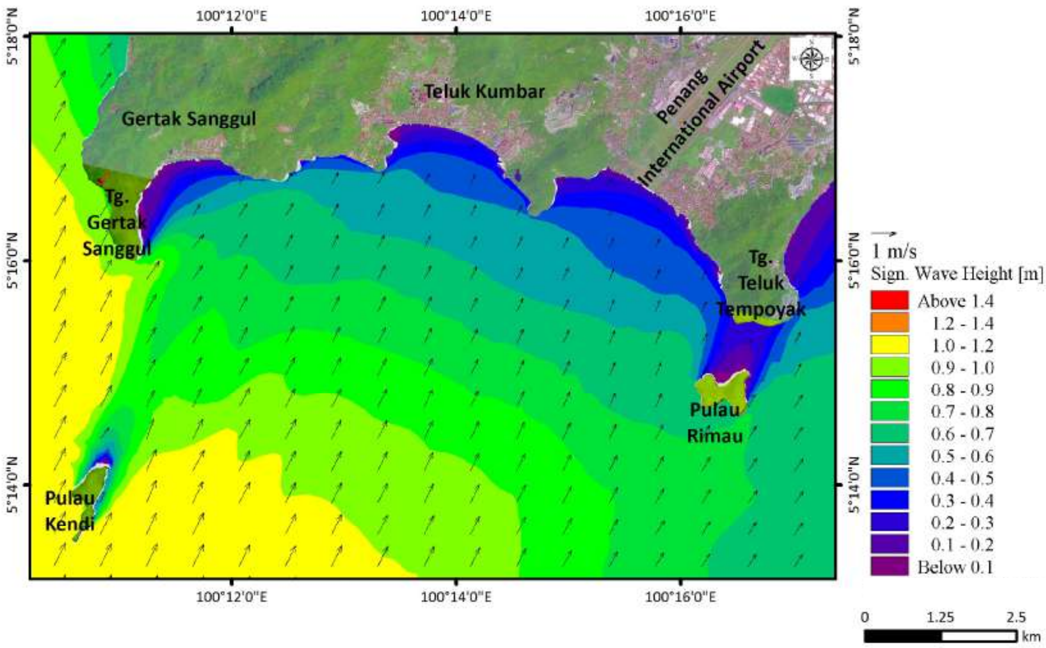


b) 1 in 60 year return period event: H_{m0} = 1.4 m, T_p = 5.5 s

F6.14 Significant wave heights (H_{m0}); baseline condition; Mean Wave Direction = 180°N

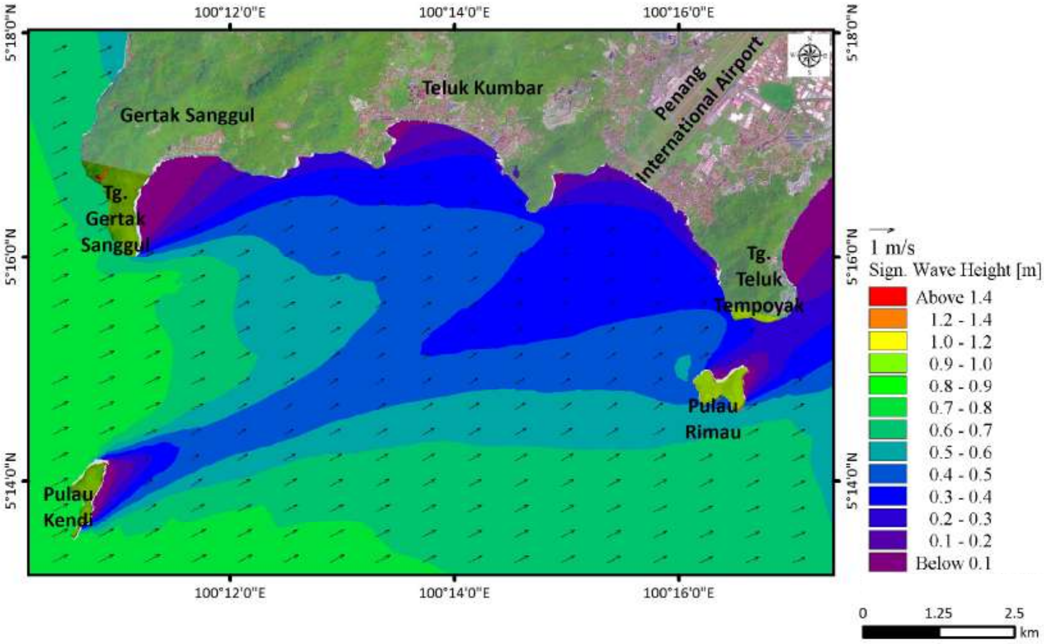


a) 1 in 1 year return period event: H_{m0} = 0.9 m, T_p = 5.0 s

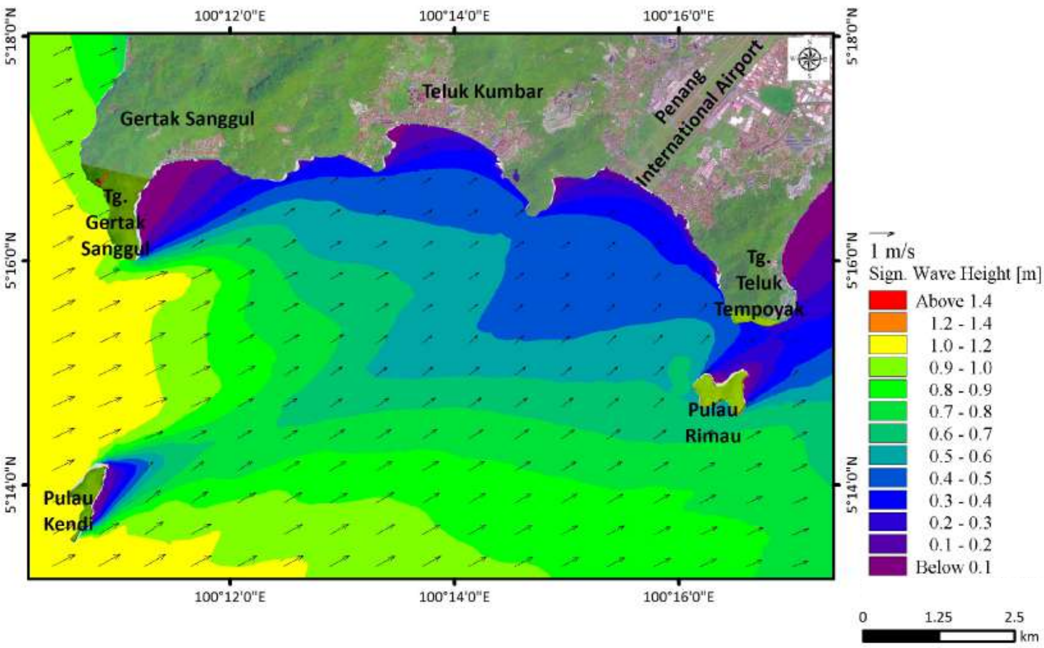


b) 1 in 60 year return period event: H_{m0} = 1.2 m, T_p = 5.5 s

F6.15 Significant wave heights (H_{m0}); baseline condition; Mean Wave Direction = 210°N

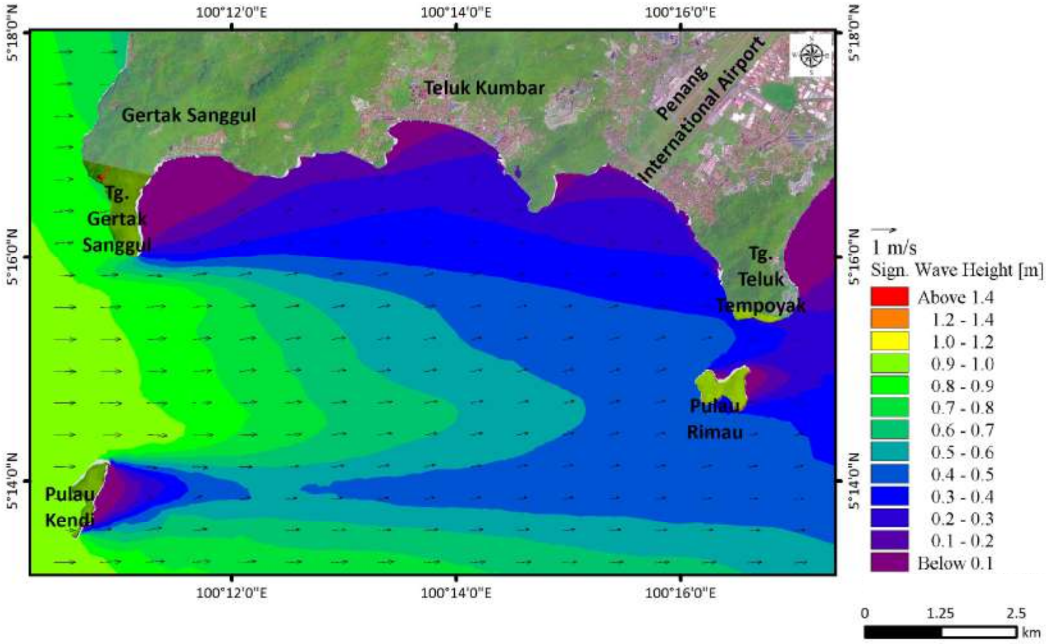


a) 1 in 1 year return period event: H_{m0} = 0.8 m, T_p = 5.0 s

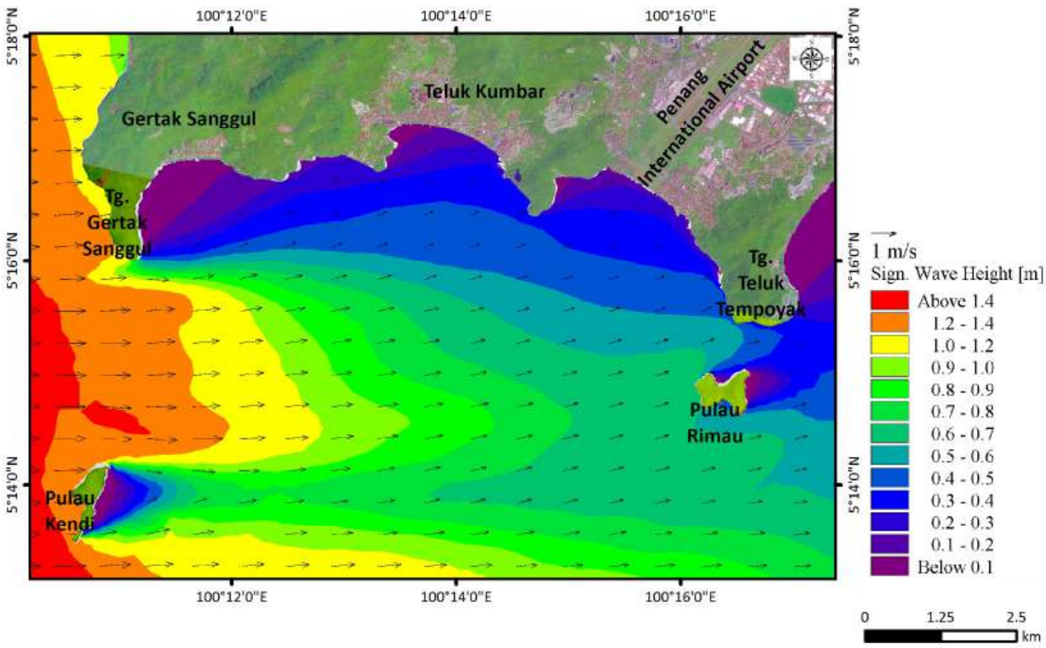


b) 1 in 60 year return period event: H_{m0} = 1.2 m, T_p = 6.5 s

F6.16 Significant wave heights (H_{m0}); baseline condition; Mean Wave Direction = 240°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

F6.17 Significant wave heights (H_{m0}); baseline condition; Mean Wave Direction = 270°N

6.2.3 Climate and Meteorology

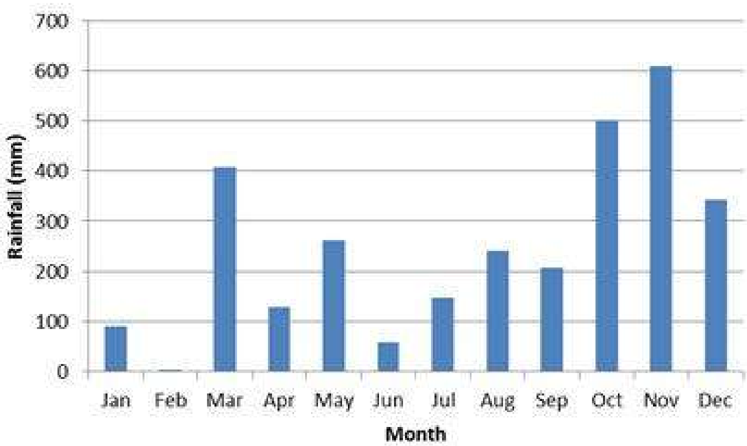
The climate of the Project study area reflects an equatorial climate, which is generally hot and wet throughout the year with little variation. Four rainfall regimes are inherent here, which are:

a) Northeast Monsoon from December to March;
b) Inter-monsoon period from April to May;
c) Southwest Monsoon from June to September; and
d) Inter-monsoon period from October to November.

The distribution of annual rainfall for the Bayan Lepas main drain, Sungai Bayan Lepas, Sungai Batu, Sungai Teluk Kumbar, Sungai Gemuruh and Sungai Gertak Sanggul basin does not vary much throughout the year. The study area experiences an average of 3,000 mm of rainfall annually. Temperature throughout the year is quite constant with an average of 28°C. The temperature usually peaks in the afternoon with an average of 32°C and falling to its lowest during the evening with an average of 24°C. The relative humidity similarly shows very little variation throughout the year with an average of 80%.

6.2.3.1 Monthly Rainfall

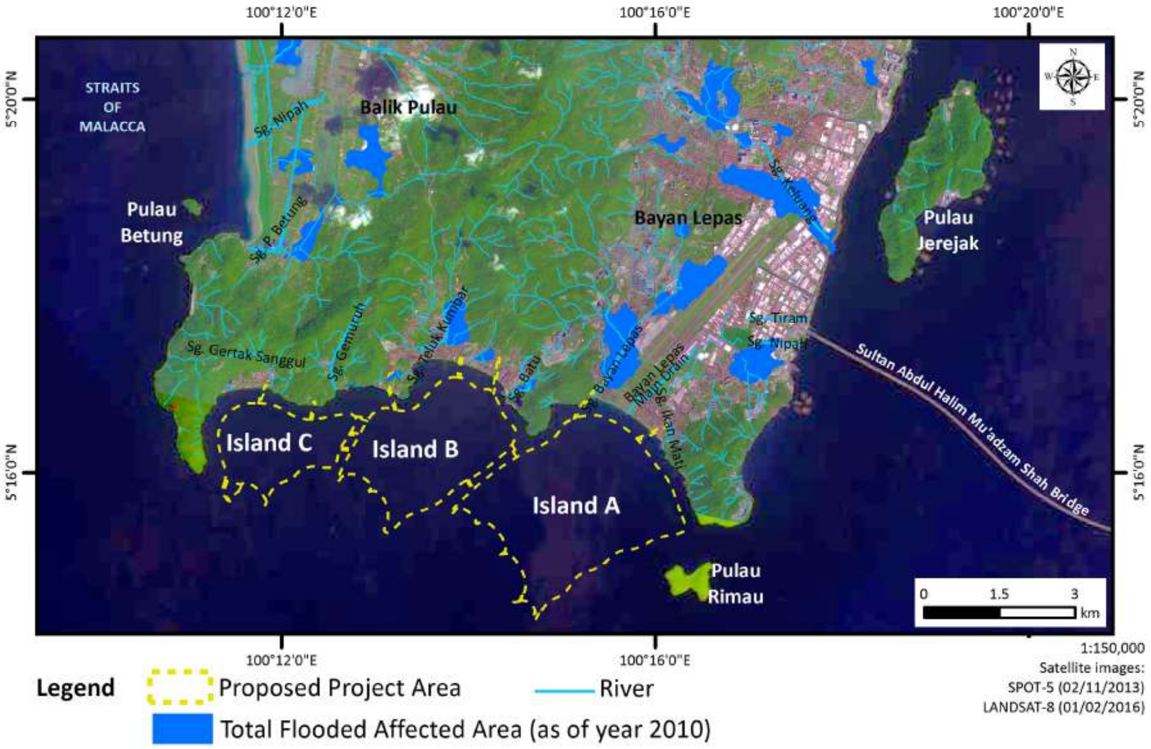
In general, the highest and lowest mean rainfall normally occurs in November and February respectively. Based on observations from the nearest rainfall station, the maximum minimum and rainfall recorded in November and February are about 610 and 3 mm respectively (F6.18).



F6.18
Monthly rainfall recorded at station Pintu Air Bagan, Air Itam, Penang

6.2.3.2 Flooding Condition

It is very likely that the larger river catchments have been subjected to flooding on various occasions. This is possibly true for Sungai Teluk Kumbar where a tidal gate and storm pump have been installed. River flooding is caused by incidence of heavy rainfall (monsoon or convective) and the resultant large concentration of runoff that exceeded river capacity. This is further compounded by the low-lying and flat terrain at the lower catchment where the Project site is situated. The flood events are also aggravated by high tide levels that can increase the downstream boundary levels which result in higher flood levels. From the flood event map as shown in F6.19, Sungai Bayan Lepas and Sungai Teluk Kumbar were recorded to be prone to flooding.



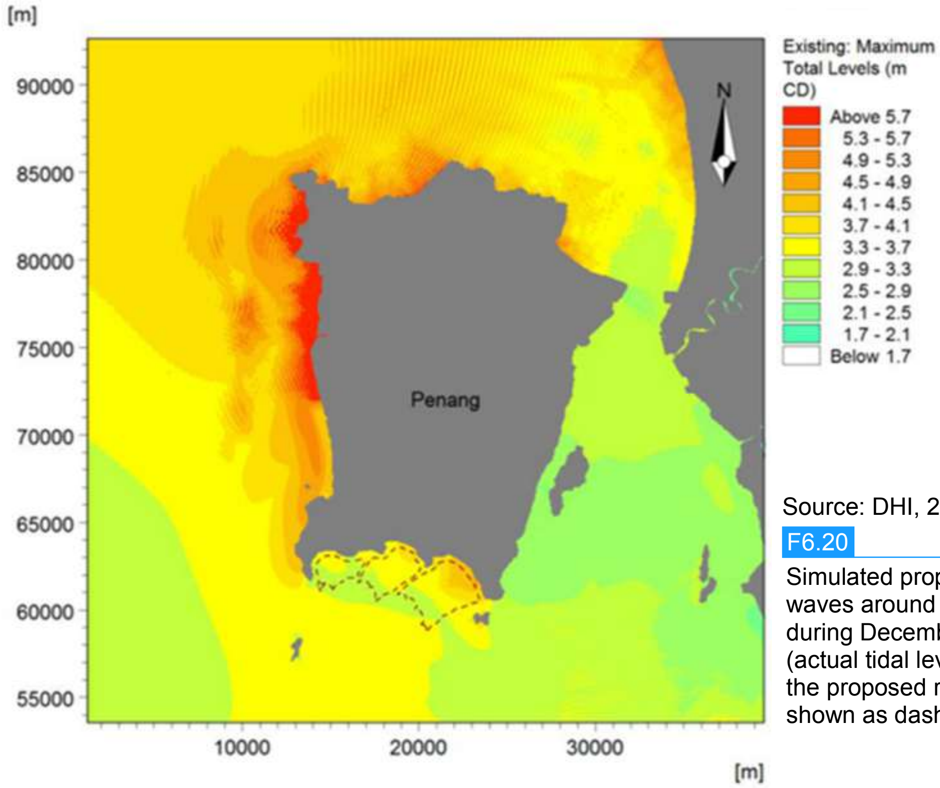
F6.19 Recorded flood extent of the rivers at south of Penang Island (as of year 2010)

It is envisaged that in circumstances where no rainfall occurs, tidal intrusion may inundate the low-lying areas up to about 2.69 m deep during Mean High Water Spring (MHWS) condition. It might reach up to 3.09 m deep during Highest Astronomical Tide (HAT) condition.

6.2.4 Tsunami

Tsunami can generally occur anytime and anywhere subject to the factors of tsunami generation. Earthquakes are the most common contributors to a tsunami. However, accurate prediction of earthquakes is extremely difficult. Predicting when and where the next tsunami will strike is currently not feasible. Once a tsunami is generated, forecasting tsunami arrival and impact is possible via modelling and measurement techniques.

An assessment of combined tidal and tsunami-induced water levels has been carried out using a detailed two-dimensional hydraulic model (MIKE 21 HD model) to assess the impact of the tsunami waves in the waters of southern Penang Island. The proposed development phases were evaluated separately. The simulation results show that the southern and eastern coasts of Penang Island have limited exposure to tsunami effects from the Indian Ocean compared to the western and northern coasts of Penang Island (F6.20) due to the relatively-sheltered location of this coastal stretch.



Source: DHI, 2016

F6.20 Simulated propagation of tsunami waves around Penang Island during December 2004 event (actual tidal level); the outlines of the proposed reclamations are shown as dashed red lines

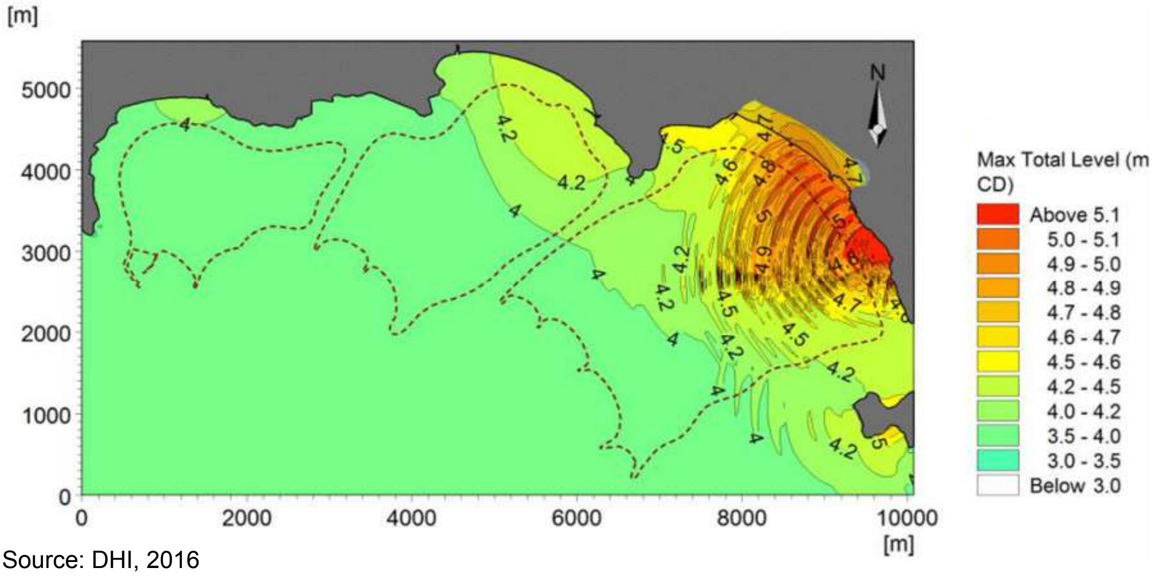
The simulations were conducted based on the December 2004 tsunami event at four tidal levels. The tidal levels are important for the water level assessment as the water depth, which the tsunami propagates influences the propagation speed, wave attenuation and shoaling of tsunami wave transformation. For design purpose, a relatively conservative tidal datum could be selected based on the tidal characteristics of the nearest tidal station, i.e. Kedah Pier, Penang. As earthquake events and tidal conditions are uncorrelated, the tsunami event of 2004 has been simulated for tidal levels as elaborated in T6.3.

T6.3 Tidal characteristics at Kedah Pier tidal station, Penang

Level	Simulation Case	Value (m CD)	Exceedence in Percentage of Time (%)
Mean Sea Level (MSL)	1	1.71	50
Actual water level (1300 hrs, 26th December 2004)	2	2.16	22
Mean High Water Spring (MHWS)	3	2.69	4
Highest Astronomical Tide (HAT)	4	3.09	*

Note: The probability of a tsunami coinciding with HAT is extremely low, as the return period is about 18.3 years

The predicted maximum water level map for a simulation carried out for the existing condition is shown in F6.21. The maximum water level is higher at the frontage of Permatang Damar Laut but reduces progressively westwards towards Gertak Sanggul.



Source: DHI, 2016

F6.21 Maximum water levels during the impact of tsunami waves with a tidal level corresponding to MHWS level for the existing condition

6.2.5 Hydrology and Drainage

The river catchments within the Project study area are shown in F6.22. There are eight rivers present along the south of Penang Island's coastline. However, only five main catchments were studied namely Sungai Gertak Sanggul, Sungai Teluk Kumbar, Sungai Batu, Sungai Bayan Lepas and Bayan Lepas Main Drain. The other three rivers (Sungai Mati, Sungai Gemuruh and Sungai Ikan Mati) contribute insignificant pollutants downstream, making them negligible. All river catchments are mapped out as shown in F6.22 while the area and dimensions for the five main rivers are tabulated in T6.4 and T6.5 respectively.

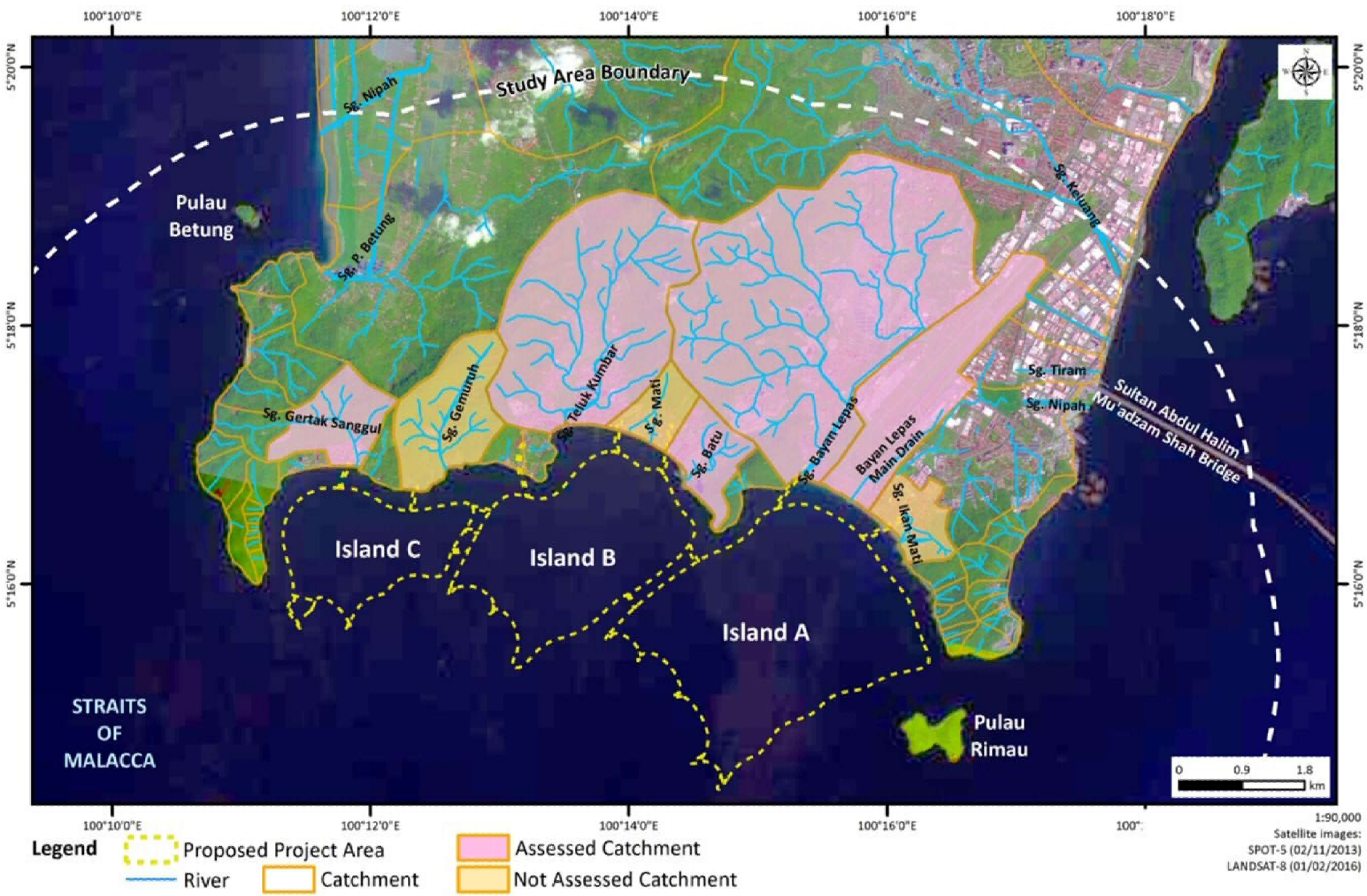
T6.4 Area of main river catchment

Rivers	Catchment Area (km^2)
Bayan Lepas Main Drain	2.98
Sungai Bayan Lepas	7.43
Sungai Batu	1.22
Sungai Teluk Kumbar	7.05
Sungai Gertak Sanggul	1.34

Source: Southern Penang Rivers - Water Quality Study (2016)

T6.5 Dimensions of the rivers along the south coast of Penang Island

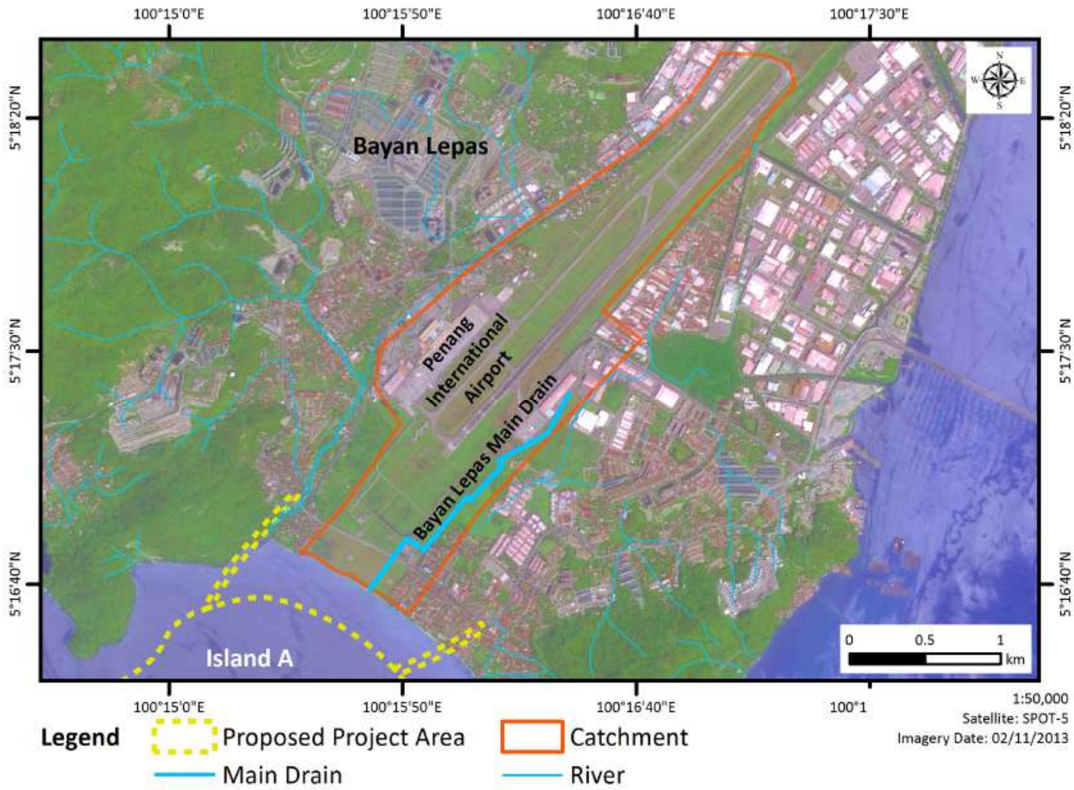
River Name	River Width (m)	River depth (m)	Base Flow (m^3/s)
Bayan Lepas Main Drain	2.0	2.0	0.028
Sungai Bayan Lepas	2.0	3.6	0.16
Sungai Batu	2.5	2.1	0.07
Sungai Teluk Kumbar	5.0	0.25	0.37
Sungai Gertak Sanggul	2.0	2.7	0.04



F6.22 River catchments within the Project study area

6.2.5.1 Bayan Lepas Main Drain

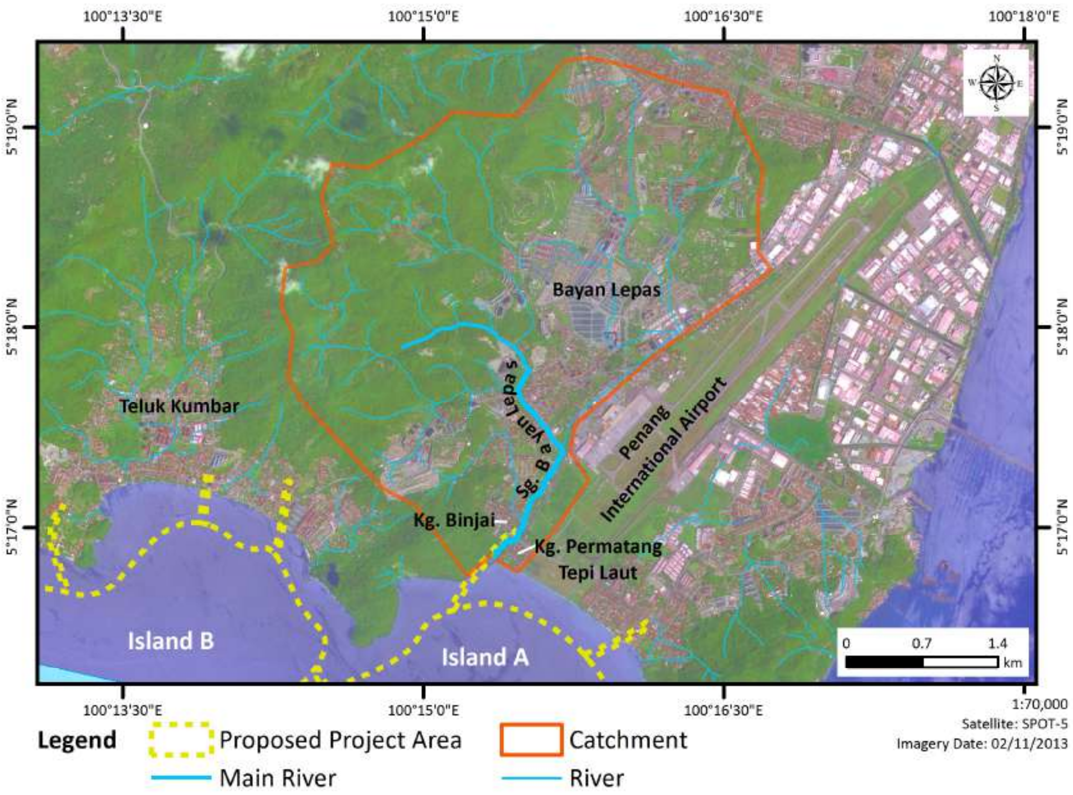
The Bayan Lepas Main Drain has a width and depth of 2.0 m with a catchment area of 2.98 km^2. It caters for flows from Penang International Airport and the surrounding development area in Bayan Lepas. It discharges into the sea at the southern part of the airport runway. F6.23 indicates the location of the Bayan Lepas Main Drain catchment. The Bayan Lepas Main Drain's primary purpose is to facilitate transfer flow from the urban discharges away from the development area. It is not a river but it does contribute a significant amount of flow to the coastal area during a storm event.



F6.23 Bayan Lepas Main Drain catchment

6.2.5.2 Sungai Bayan Lepas

Sungai Bayan Lepas has a width of 2.0 m and depth of 3.6 m. The catchment area is the biggest among all rivers at south Penang Island at 7.43 km^2. It originates from the area of Bukit Gambir, flowing through the village of Bayan Lepas and joins the sea just south of Penang International Airport. The river flows through a residential (high-rise) as well as some shophouses area before flowing into the sea. F6.24 indicates the location of the Sungai Bayan Lepas catchment.



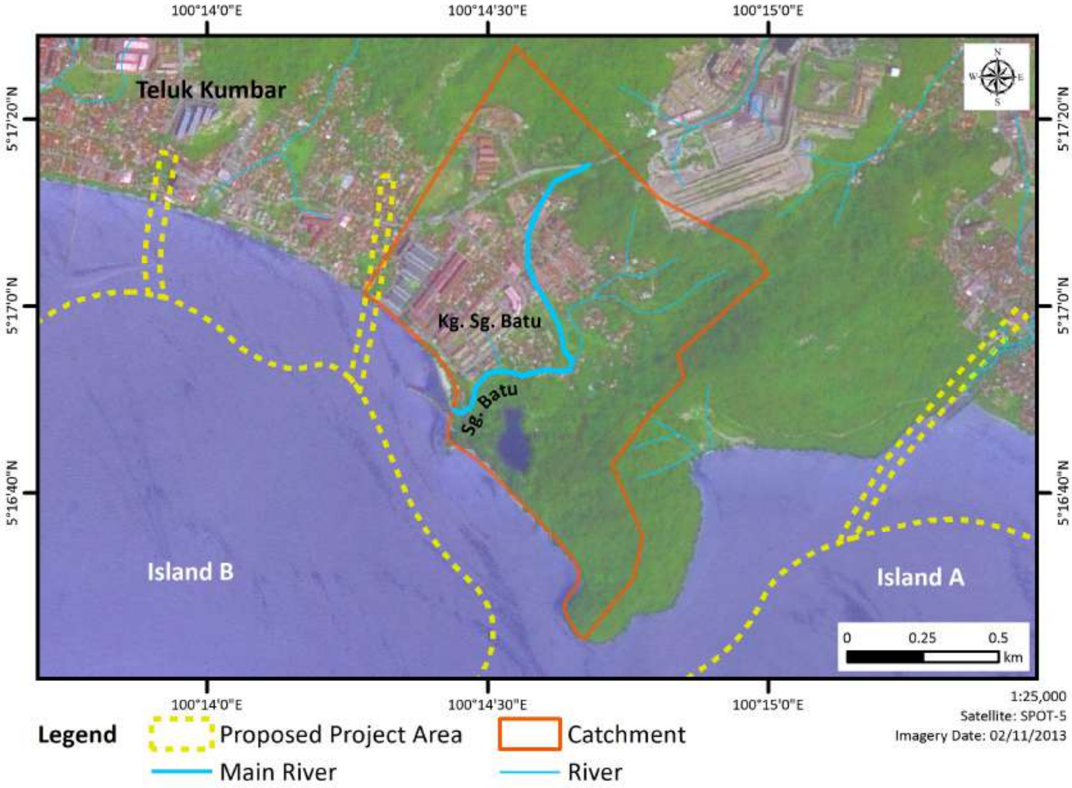
F6.24 Sungai Bayan Lepas catchment

6.2.5.3 Sungai Batu

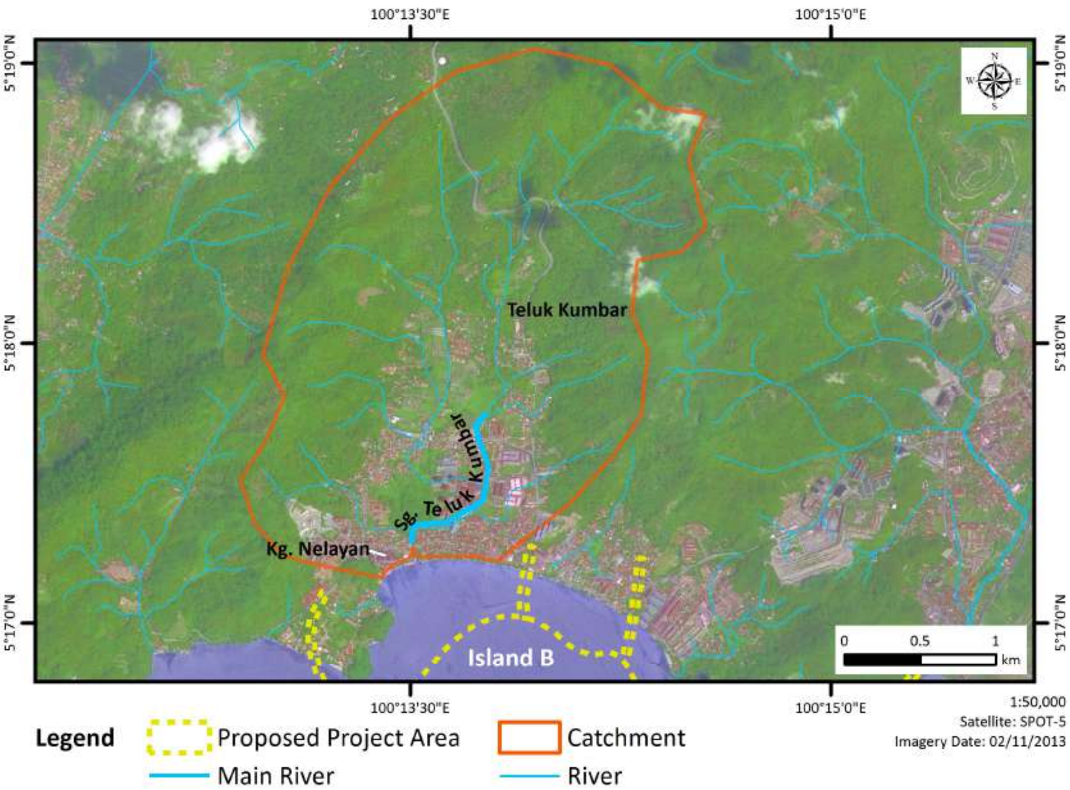
The width and depth of Sungai Batu are 2.5 and 2.1 m respectively. The catchment area is also the smallest at 1.22 km^2 in size. Sungai Batu originates from Kampung Sungai Batu, flowing through the residential area and joins the coast after flowing through a lake at a public beach area. Water flow is relatively slow with numerous locations where stagnant water can accumulate. F6.25 below indicates the location of the Sungai Batu catchment.

6.2.5.4 Sungai Teluk Kumbar

Sungai Teluk Kumbar is the widest at 5 m in width, but the shallowest at only 0.25 m in depth. The catchment area is the second largest after Sungai Bayan Lepas at 7.05 km^2. Sungai Teluk Kumbar originates from Bukit Papan, flowing through Kampung Tengah and joins the river at Kampung Teluk Kumbar. Sungai Teluk Kumbar passes through a relatively dense residential area, areas of mixed development and some small fishing villages. A tidal gate and pump operated by DID is present at this river. F6.26 indicates the location of the Sungai Teluk Kumbar catchment.



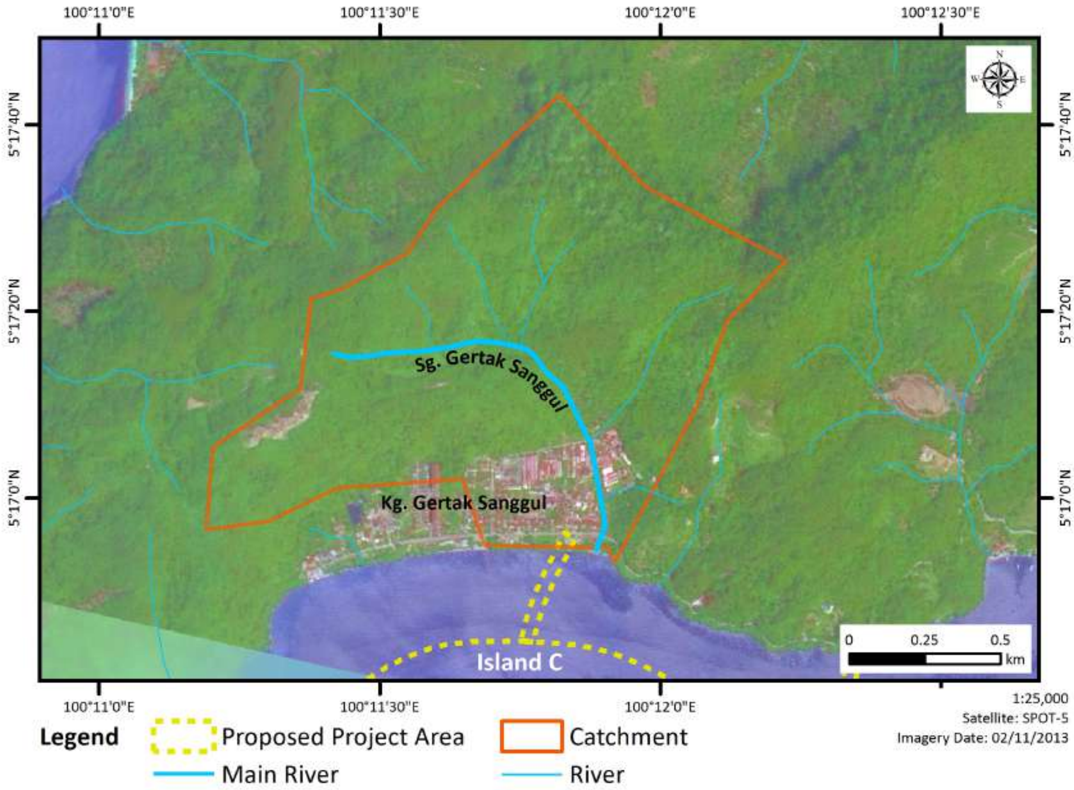
F6.25 Sungai Batu catchment



F6.26 Sungai Teluk Kumbar catchment

6.2.5.5 Sungai Gertak Sanggul

Sungai Gertak Sanggul has a width of 2.0 m and depth of 2.7 m. The catchment area is 1.34 km^2. Sungai Gertak Sanggul flows through Kampung Gertak Sanggul. The upstream area can be characterised as a combination of mainly residential area and undeveloped upstream areas. The river also flows through a cottage industry facility (pig farm). F6.27 shows the location of the Sungai Gertak Sanggul catchment.



F6.27 Sungai Gertak Sanggul catchment

6.2.6 Geology and Geotechnical

A geology and geotechnical study was conducted to assess the subsurface condition at the Project area. The reclamation site is located within the tidal range of about 2 m and water depth of –0.3 to –4.0 m CD.

6.2.6.1 Methodology

The methodology in conducting the studies comprises the following:

a) Geological assessment;
b) Geotechnical assessment study; and
c) Reclamation embankment stability analyses.

a) Geological Assessment

The geological assessment is carried out by reviewing available secondary data which are previous works and geological maps. The maps referred to are the Geological Map of Pulau Pinang from New Series L7010, Part of Sheet 28 published in 1994 by the Director-General of Geological Survey, Malaysia and the map published in 2012 by the Director-General of Minerals and Geoscience Malaysia.

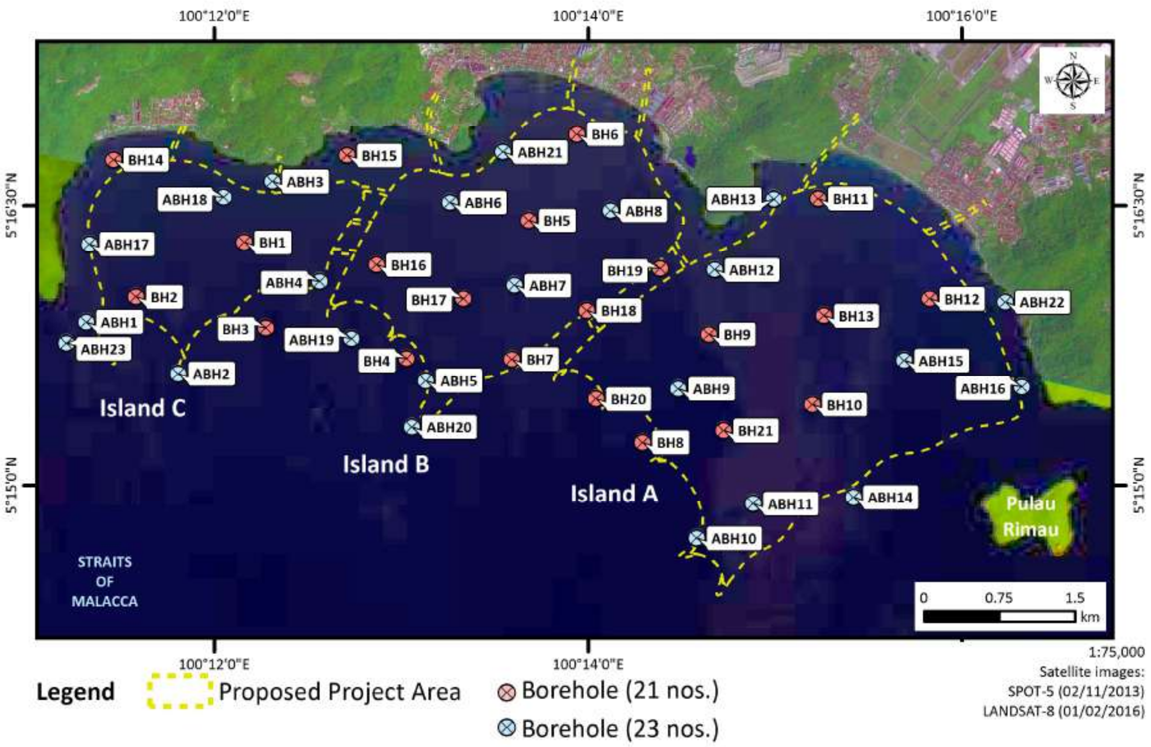
b) Geotechnical Assessment Study

The geotechnical assessment study is based on the Preliminary Geotechnical Design Report produced by G&P Professionals Sdn. Bhd. The report interprets the soil investigation (SI) works done at the proposed Project site. The SI works were first conducted by Geolab (M) Sdn. Bhd. and Strata Drill Sdn. Bhd. in July 2014 followed by a second round of SI works by Geolab (M) Sdn. Bhd. and Test Sdn. Bhd. in September 2015. A total number of 44 boreholes were sunk to obtain the subsoil information (F6.28).

c) Reclamation Embankment Stability Analyses

The stability of the reclamation embankment was analyzed to determine the safe fill slopes and the required ground treatment during construction. The embankment stability is assessed using a limit equilibrium analysis by Slope/W. The external stability is checked against circular slip surface by Modified Bishop method and non-circular (wedge) slip surface by Spencer's method. The following stages were taken into consideration in the stability analyses:

i) Construction stage; and
ii) Serviceability stage.

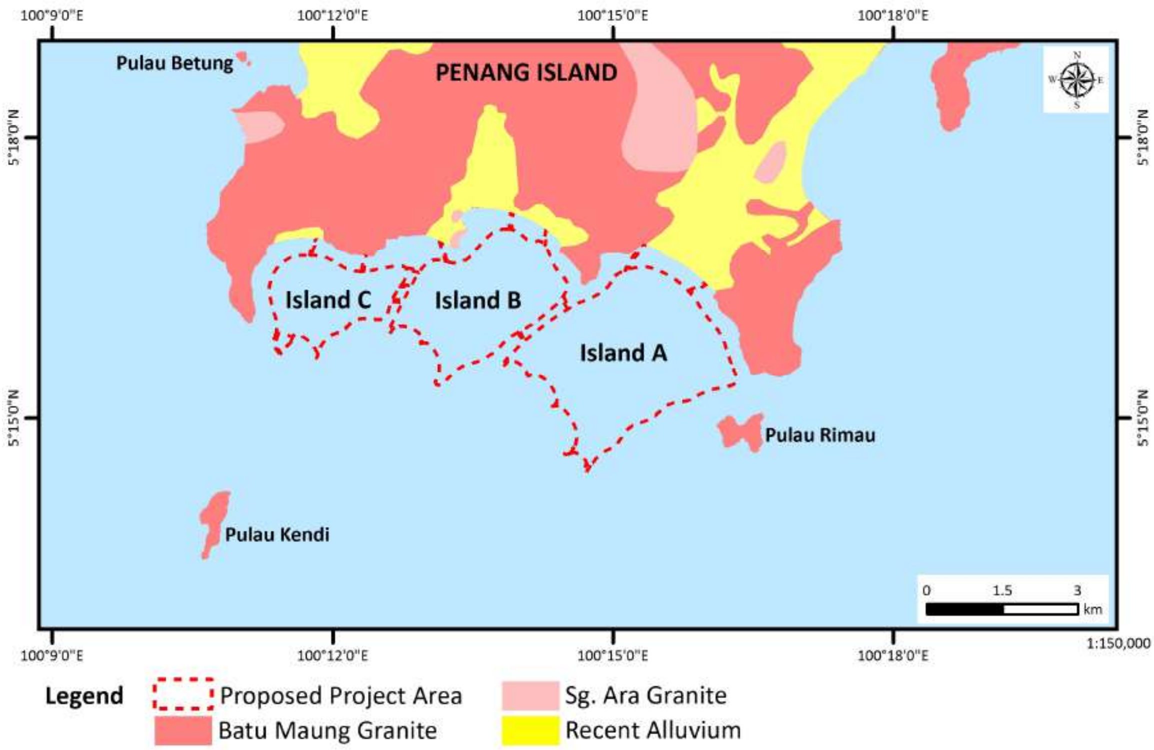


F6.28 Locations of boreholes

6.2.6.2 Geological Formation

The existing geological features of Penang Island mostly comprise igneous rocks which are intrusive rocks. It consists mainly of granite with minor granodiorite. The geological formation of south Penang Island is shown in F6.29. The south of Penang Island is underlain by Recent Alluvium over Batu Maung Granite, the latter generally consisting of medium to coarse grained biotite-muscovite granite with microcline predominates. The age of Batu Maung Granite is Early Permian to late Carboniferous. The overburden material of Batu Maung Granite generally consists of silty sand which is derived from the weathering of granite bedrock.

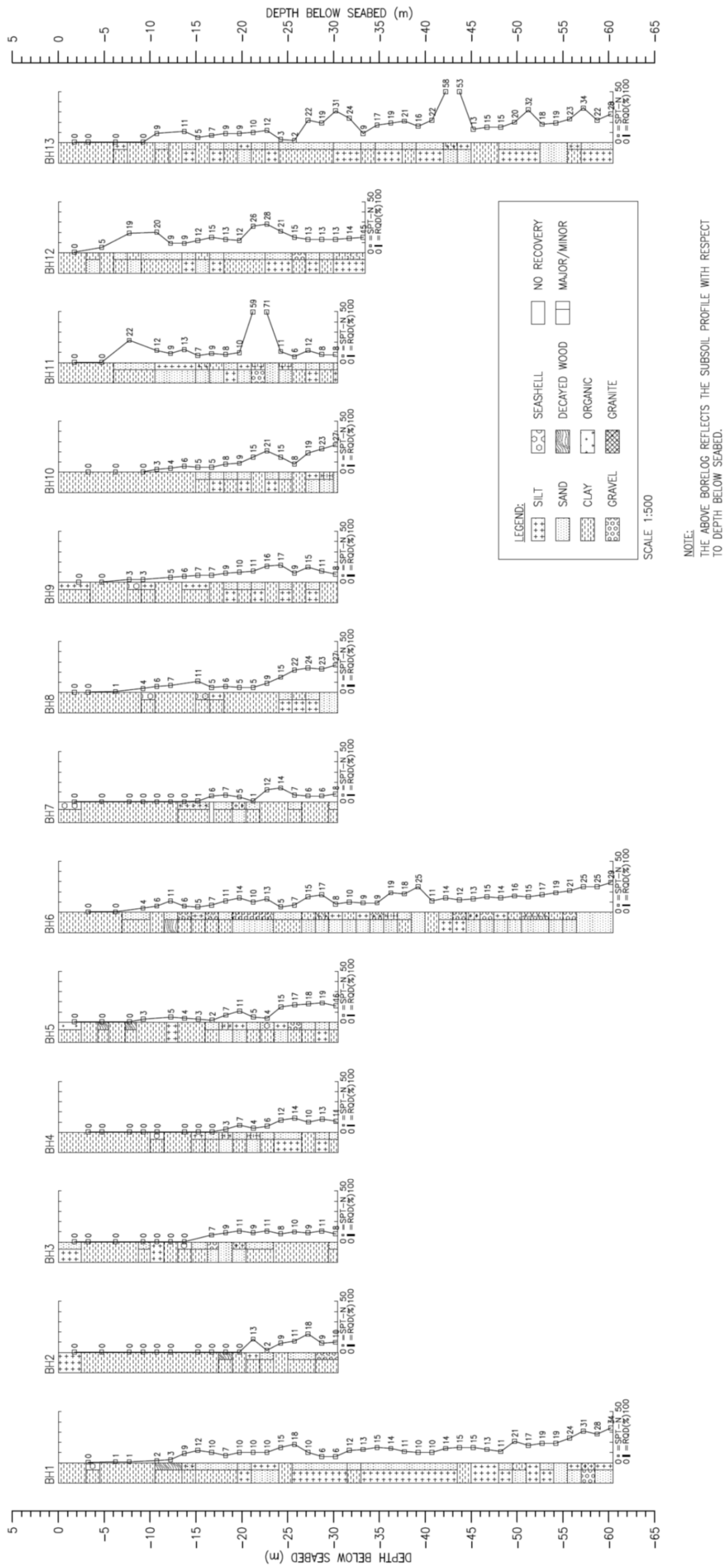
Meanwhile the Recent Alluvium is Quaternary in age, which is much younger than Batu Maung Granite and generally consists of coastal and fluviatile clay, sand and gravel and is usually a soft ground. However, geology underneath this alluvium may encounter granitic bedrock with variety of depth.



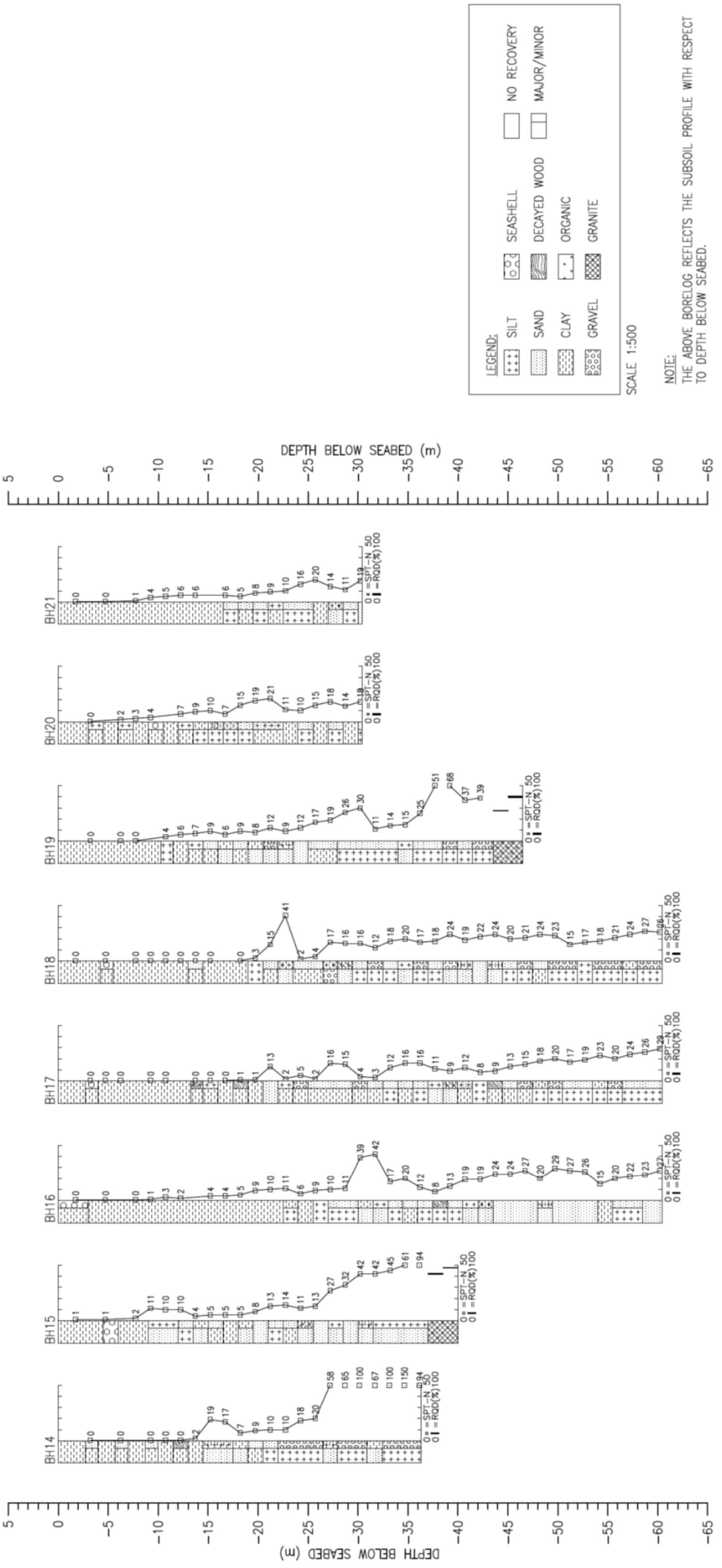
F6.29 Geological map of south Penang

6.2.6.3 Geotechnical Properties

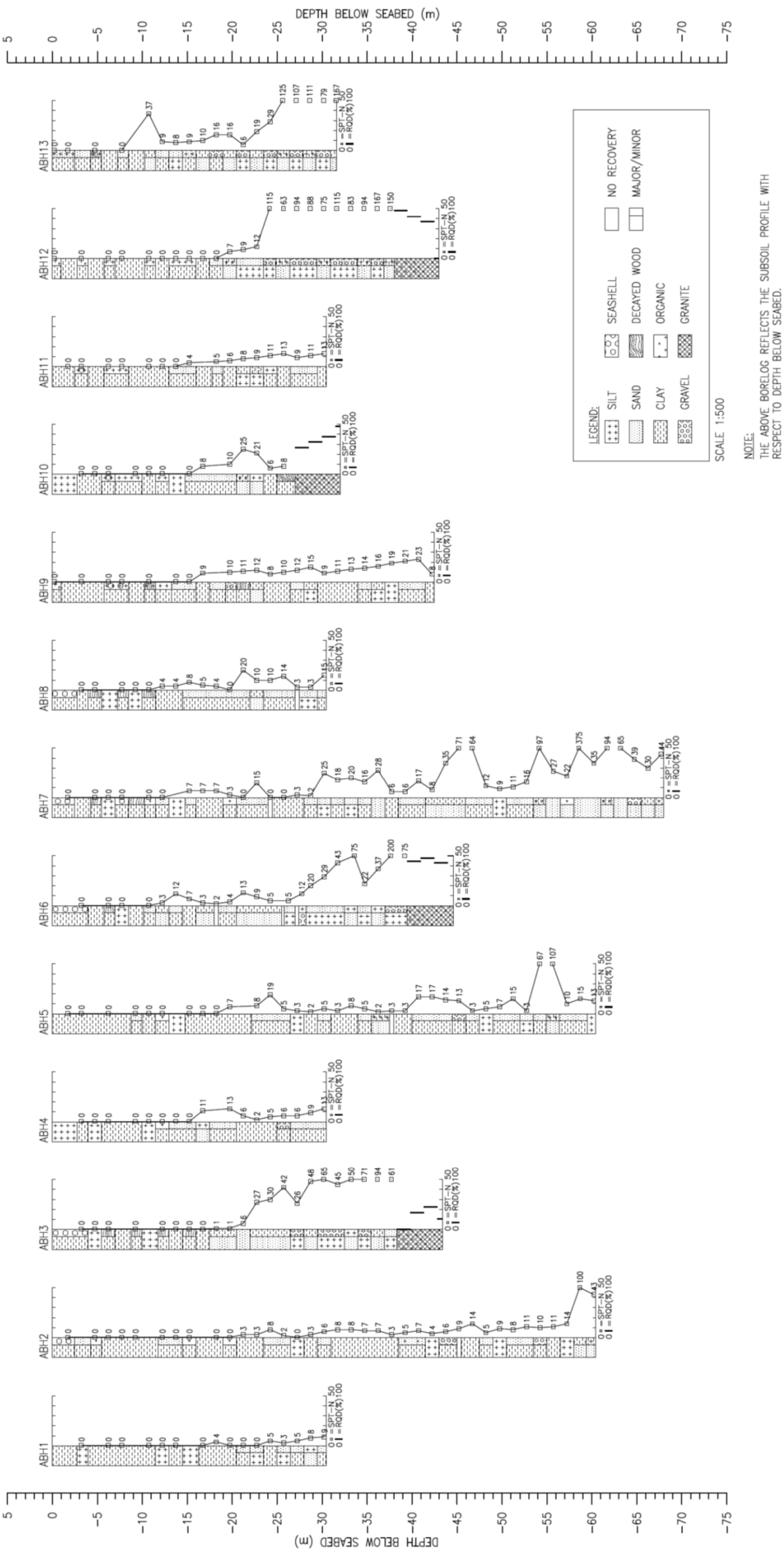
The borelog profiles (F6.30 to F6.33) show that the seabed subsoil stratum mainly consists of clay and sandy clay. BH15 and BH19 encountered granite at 37 and 43 m below the seabed respectively. ABH3, 6, 10, 16, 18 and 22 also encountered granite during the second study stage SI works at 38, 40, 27, 28, 29 and 2 m respectively. This further confirmed the geological formation of Batu Maung Granite at the proposed site.



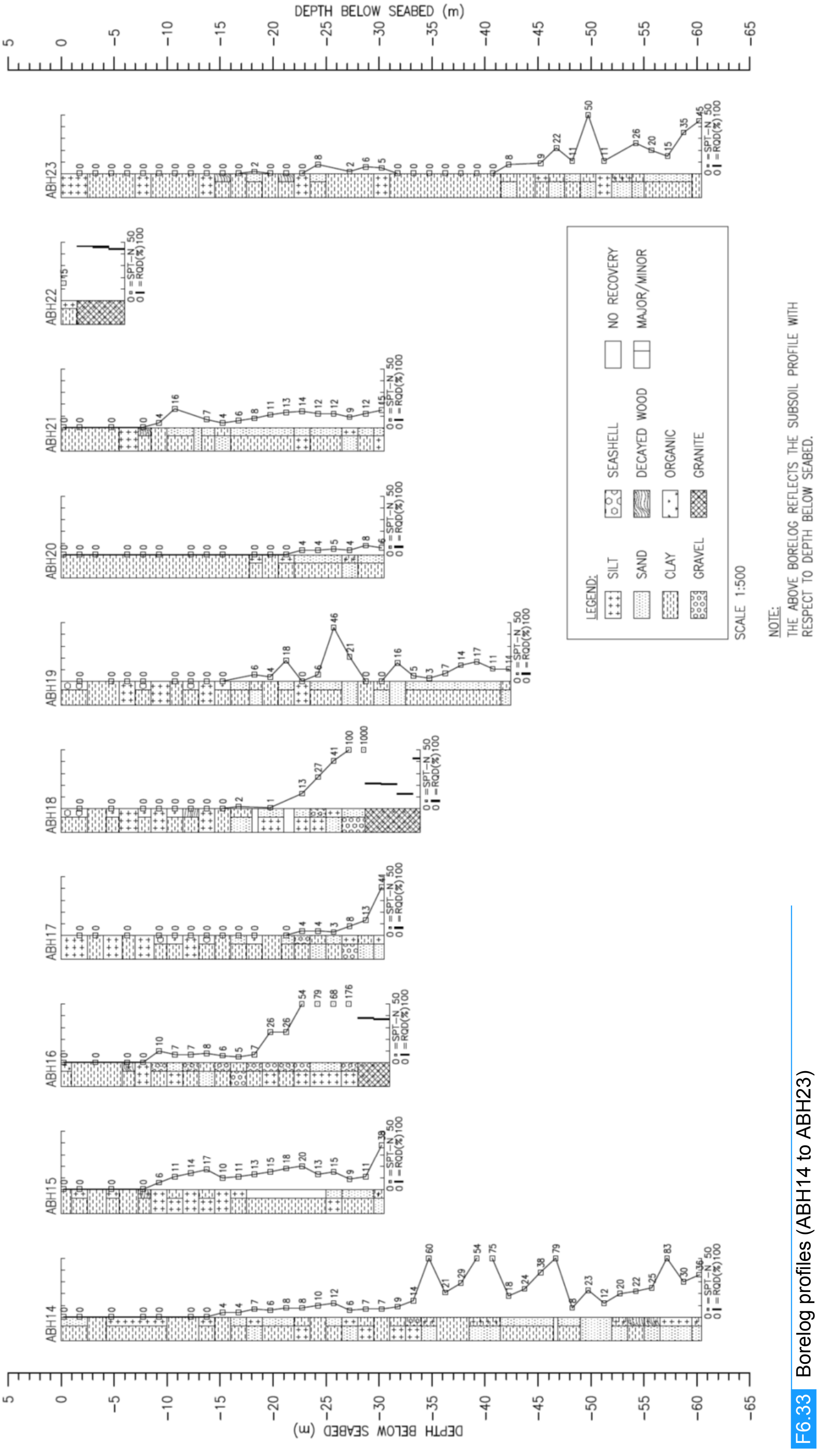
F6.30 Borelog profiles (BH1 to BH13)



F6.31 Borelog profiles (BH14 to BH21)



F6.32 Borelog profiles (ABH1 to ABH13)



F6.33 Borelog profiles (ABH14 to ABH23)

6.2.6.4 Reclamation Embankment Stability Analyses

Reclamation embankment stability analyses were conducted based on conditions as stipulated in T6.6. The result shows that the embankment is stable as shown in T6.7 and T6.8.

T6.6 Factors of Safety (FoS) for each stage

Stage	Condition	Sea Water Condition	FOS
Construction Stage	Undrained (Total Stress Parameters)	Normal – MLWS	1.2
	Undrained (Total Stress Parameters)	Rapid - MHWS[a] - MSL[b]	1.1
Serviceability Stage	Drained (Effective Stress Parameters)	Normal – MLHW	1.4
	Drained (Effective Stress Parameters)	Rapid - MHWS[a] - MSL[b]	1.2

Notes:
i) Normal – Groundwater level and sea level are at the same level
ii) Rapid - Groundwater level and sea level are not at the same level
iii) [a] – Groundwater level
iv) [b] – Sea level

T6.7 Stability analyses summary for sand bund

Filling Stage	Factor of Safety (Fos)						Remark
	Normal			Rapid Drawdown			
	Circular	Wedge	Min FoS	Circular	Wedge	Min FoS	
Construction							
Sand containment bund	1.4	1.8	1.2	1.6	1.7	1.1	Achieved minimum safety factor
Fill 0.5 m above MHWS with PVD installation and 0.5 m thick surcharge	1.2	1.3	1.2	1.2	1.3	1.1	Achieved minimum safety factor
Fill to designed surcharge level	1.3	1.5	1.2	1.4	1.5	1.1	Achieved minimum safety factor
Serviceability							
Trim to final platform level	1.5	1.6	1.4	1.5	1.5	1.2	Achieved minimum safety factor

T6.8 Stability analyses summary for rock bund

Filling Stage	Factor of Safety (Fos)				Remark
	Normal		Rapid Drawdown		
	Circular	Min FoS	Circular	Min FoS	
Construction					
Rock containment bund	1.33 (R to L) 1.20 (L to R)	1.20	-	1.10	Achieved minimum safety factor
Fill 0.5 m above MHWS with PVD installation and 0.5 m thick surcharge	1.22	1.20	-	1.10	Achieved minimum safety factor
Fill to designed surcharge level	1.23	1.20	1.20	1.10	Achieved minimum safety factor
Serviceability					
Trim to final platform level	2.07	1.40	1.95	1.20	Achieved minimum safety factor

6.2.7 Water Quality

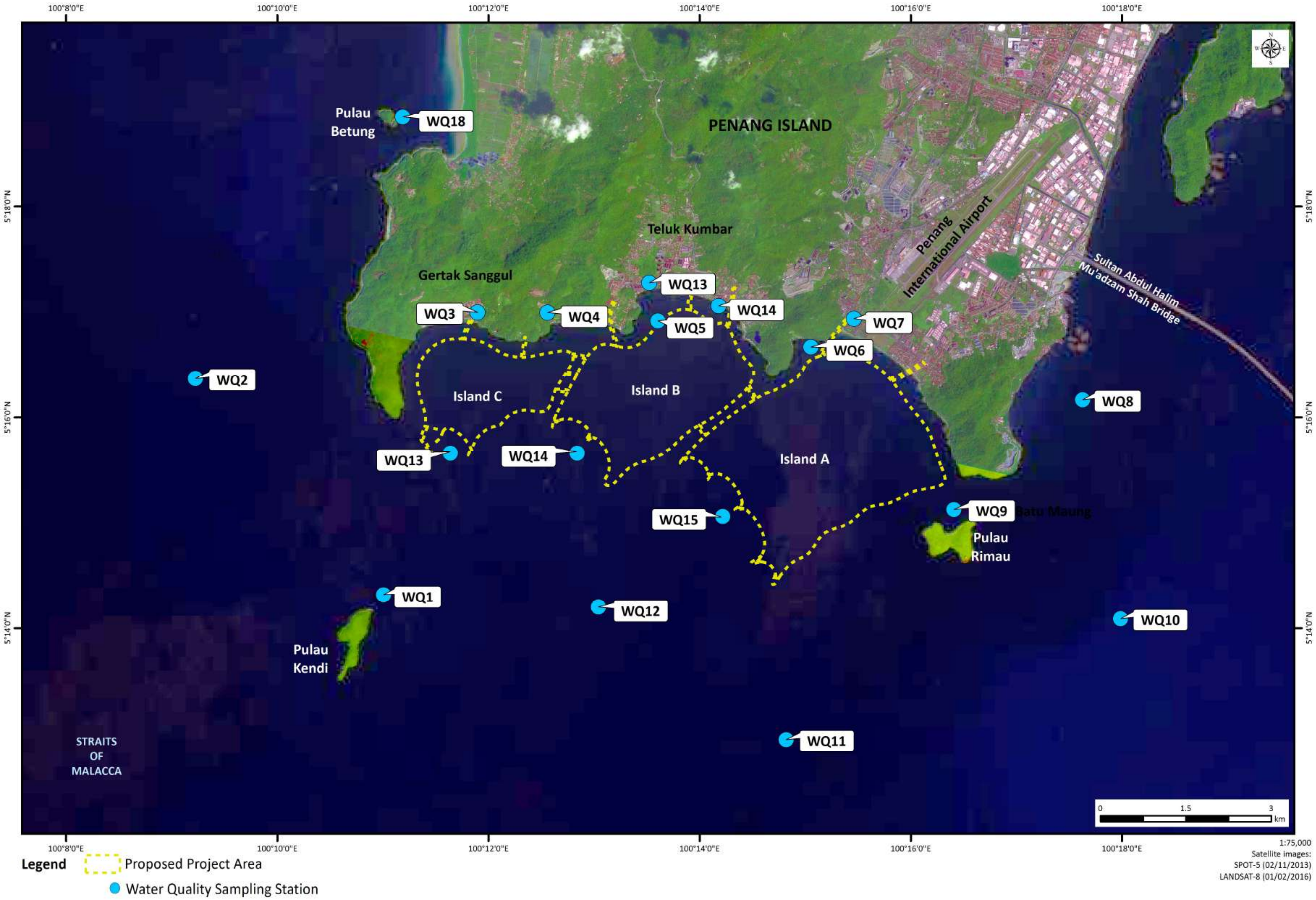
18 water quality sampling stations were identified within the Project area as shown in T6.9 and F6.34. Water samples at stations WQ1 to WQ13 were taken on 9 January 2016 for spring tide, both during flooding and ebbing; and on 5 February 2016 for neap tide. Additional sampling stations WQ14 to WQ17 were selected later on to include an additional discharge outlet from Penang Island as well as consideration of beaches on the man-made islands. The samplings for stations WQ14 to WQ17 were conducted on 4 March 2016 for flooding and ebbing. The last sampling exercise at Pulau Betung (WQ18) was the final addition as per TOR review panel's comments. It was completed on 25 May 2016 and 2 June 2016 for neap and spring tides, respectively. It is to be noted that the weather was fine during all sampling sessions.

T6.9 Coordinates of the water quality sampling stations

Station	Coordinates	Type of Water	Description
WQ1	5° 14' 19.01" N, 100° 11' 0.34" E	Marine	North of Pulau Kendi 
WQ2	5° 16' 22.154" N, 100° 9' 13.46" E	Marine	About 3 km to the west of Tanjung Gertak Sanggul 
WQ3	5° 16' 59.78" N, 100° 11' 53.75" E	River	River mouth of Sungai Gertak Sanggul 
WQ4	5° 16' 59.7" N, 100° 12' 33.5" E	River	River mouth of Sungai Gemuruh 
WQ5	5° 16' 54.96" N, 100° 13' 36.24" E	Marine	Proposed flushing channel between Tanjung Bongkok and the proposed Island B
WQ6	5° 16' 40.04" N, 100° 15' 3.19" E	Marine	Proposed flushing channel between Tanjung Chut and the proposed Island A
WQ7	5° 16' 56.26" N, 100° 15' 27.6" E	River	River mouth of Sungai Bayan Lepas 
WQ8	5° 16' 10.062" N, 100° 17' 37.68" E	Marine	About 1.5 km to the east of Kampung Teluk Tempoyak 
WQ9	5° 15' 7.52" N, 100° 16' 24.54" E	Marine	North of Pulau Rimau 
WQ10	5° 14' 5.429" N, 100° 17' 59.24" E	Marine	About 3 km to the south east of Pulau Rimau 

T6.9 Coordinates of the water quality sampling stations

Station	Coordinates	Type of Water	Description	
WQ11	5° 12' 56.51" N, 100° 14' 49.159" E	Marine	About 3 km to the south of the proposed Island A	
WQ12	5° 14' 12.098" N, 100° 13' 2.447" E	Marine	About 2 km to the south of the proposed Island B	
WQ13	5° 17' 16.7" N, 100° 13' 31.4" E	River	River mouth of Sungai Teluk Kumbar	
WQ14	5° 17' 3.49" N, 100° 14' 10.87" E	River	In front of two main discharge outlets from Teluk Kumbar	
WQ15	5° 15' 39.6" N, 100° 11' 38.4" E	Marine	In front of the proposed beach at Island C	
WQ16	5° 15' 39.6" N, 100° 12' 50.4" E	Marine	In front of the proposed beach at Island B	
WQ17	5° 15' 3.6" N, 100° 14' 13.2" E	Marine	In front of the proposed beach at Island A	
WQ18	5°18'51.1" N, 100°11'11.3" E	Marine	Near aquaculture at Pulau Betung	



F6.34 Water quality sampling stations

6.2.7.1 Methodology

Marine water samples were taken at three depths (surface, middle and bottom) at stations with water depths of more than 5 m. Two-depth sampling was applied for water depths ranging from 3 to 5 m while only one depth sampling was done at those of less than 3 m. The sampling details are listed in T6.10. The samples were analyzed by an accredited laboratory [ALS Technichem (M) Sdn. Bhd.]. *In-situ* analyses were also made using portable analytical meters which comply with the standard methods as specified by the APHA procedures.

T6.10
Water quality sampling details

Items	Details
Physical	Temperature, salinity, pH, conductivity, turbidity, dissolved oxygen (DO), total suspended solids (TSS)
Anions	Ammoniacal nitrogen, phosphate, nitrate, sulphate
Cations/Heavy Metals	Cr, Cd, Cu, Ni, Fe, Pb, Mn, As, Hg
Organics	BOD, Total Organic Carbon (TOC), oil and grease
Microbial	Fecal coliform, *E. Coli*
Number of stations	18
Depths	3 depths (surface, middle, bottom)
Tides	Spring and neap (flooding and ebbing)

6.2.7.2 Results

The results for all water quality sampling sessions are tabulated in T6.11 and T6.12. The results obtained for marine water are compared with the Malaysian Marine Water Quality Criteria and Standard (MWQCS) (T6.13).

T6.11 Baseline water quality results (spring tide)

Parameter	Unit	WQ1 (Marine)						WQ2 (Marine)					
		Ebbing (27.0 m)			Flooding (27.2 m)			Ebbing (18.6 m)			Flooding (19.0 m)		
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
pH		8.41	8.36	8.3	8.18	8.33	8.28	8.44	8.41	8.34	8.43	8.34	8.39
Temperature	^{o}C	30.3	29.8	29.6	30.2	29.8	29.6	30	29.6	29.4	30	29.4	29.5
DO	mg/L	4.7	3.8	4.4	5.2	4.9	4.5	5.5	4.3	3.8	4.7	4.1	3.9
Salinity	ppt	9.91	9.97	9.92	29.96	9.81	30.58	30.11	30.52	30.59	30.11	30.57	30.53
Conductivity	uS/cm	17,036	16,900	16,932	46,395	16,790	47,190	46,596	47,131	47,228	46,587	47,230	47,152
Turbidity	NTU	7	7	5	7	5	6	5	8	8	8	5	6
TSS	mg/L	15	18	13	15	10	14	17	19	16	17	12	19
COD		16	18	20	10	11	12	19	19	15	15	16	17
BOD		5	6	7	3	3	5	8	9	5	4	5	5
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TOC		0.5	0.4	0.5	0.1	0.4	0.3	0.8	0.4	0.4	0.3	0.5	0.4
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3-N)		0.34	0.04	0.01	0.05	0.35	0.08	0.03	0.01	0.01	0.15	0.06	0.03
Nitrate		0.96	1.35	0.14	0.59	0.16	0.33	1.03	1.40	1.45	0.47	0.39	0.32
Phosphate		0.23	0.35	0.37	0.16	0.36	0.13	0.26	0.32	0.42	0.25	0.08	0.35
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Arsenic (As*)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (Pb)		0.003	0.028	0.026	0.003	0.006	0.130	0.003	0.016	0.028	0.009	0.019	<0.001
Copper (Cu)		<0.001	<0.001	0.003	0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001
Manganese (Mn)		0.002	0.006	0.008	0.002	0.002	0.005	0.002	0.003	0.022	0.003	0.004	<0.001
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)		0.05	0.14	0.16	0.01	0.03	0.10	0.4	0.06	0.42	0.04	0.18	0.18
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		660,000	44,000	<1	21,100	71,000	53,000	56,000	5,000	1,000	103,000	11,400	13,300

Note: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.11 Baseline water quality results (spring tide) (cont'd)

Parameter	Unit	WQ5 (Marine)		WQ6 (Marine)		WQ8 (Marine)					
		Ebbing (1.6 m)	Flooding (2.1 m)	Ebbing (1.1 m)	Flooding (1.6 m)	Ebbing (7.1 m)			Flooding (7.0 m)		
		Surface	Surface	Surface	Surface	Surface	Middle	Bottom	Surface	Middle	Bottom
pH		8.21	8.44	8.49	8.52	8.51	8.51	8.48	8.22	8.08	8.16
Temperature	°C	32.4	31.1	32.1	31.3	30.4	30.2	29.9	29.8	29.8	29.5
DO	mg/L	4.6	5.2	7.20	5.2	6.3	5.9	5.2	5.3	4.8	4.6
Salinity	ppt	29.56	29.79	29.46	29.52	29.91	29.49	29.61	29.94	29.85	29.87
Conductivity	uS/cm	46,587	46,198	45,704	45,859	45,915	45,504	45,907	46,203	46,173	46,237
Turbidity	NTU	5	9	8	7	6	8	7	3	5	5
TSS	mg/L	13	18	19	16	12	16	14	15	13	10
COD		16	14	18	19	15	19	15	18	16	9
BOD		5	5	7	6	5	6	5	7	5	6
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TOC		1.2	0.6	1.5	0.7	0.7	0.6	0.5	1.0	0.2	0.3
Chlorophyll-A		<0.5	0.5	<0.5	0.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3-N)		0.13	0.10	0.07	0.52	0.02	0.07	0.12	0.42	0.04	0.08
Nitrate		0.64	0.21	2.19	0.41	2.30	2.55	2.22	0.08	0.06	0.07
Phosphate		0.23	0.05	0.43	0.27	0.43	0.44	0.43	0.07	0.15	0.37
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (Pb)		<0.001	<0.001	0.003	<0.001	0.001	0.005	0.019	0.001	0.064	0.024
Copper (Cu)		<0.001	<0.001	0.002	<0.001	0.001	0.002	0.002	<0.001	0.004	0.004
Manganese (Mn)		0.018	0.012	0.011	0.014	0.012	0.004	0.013	0.009	0.014	0.015
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)		0.10	0.04	0.19	0.08	0.11	0.06	0.16	0.06	0.06	0.03
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		2,500	700	6,300	2,300	100	2,300	31,000	<1	44,000	<1

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.11 Baseline water quality results (spring tide)

Parameter	Unit	WQ9 (Marine)						WQ10 (Marine)		
		Ebbing (9.6 m)			Flooding (10.0 m)			Ebbing (3.0 m)	Flooding (4.1 m)	
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Surface	Bottom
pH		8.27	8.42	8.46	8.26	8.32	8.36	8.44	8.41	8.43
Temperature	°C	30.4	30	30.1	28.7	29.6	29.7	31.1	30.1	30.3
DO	mg/L	6.9	5.7	5.5	4.5	4.2	4.8	5.6	4.6	4.8
Salinity	ppt	29.63	29.66	29.64	9.87	9.81	29.92	29.84	29.57	29.6
Conductivity	uS/cm	45,955	45,933	45,977	16,955	17,090	46,321	45,989	45,858	45,876
Turbidity	NTU	7	7	5	5	7	5	8	6	6
TSS	mg/L	14	14	10	10	14	10	12	13	14
COD		20	18	18	12	13	18	16	17	16
BOD		7	6	6	4	6	6	5	6	6
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1	<1
TOC		0.8	0.6	0.6	0.3	0.5	0.5	0.6	0.2	0.8
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3-N)		0.06	0.01	0.14	0.04	0.20	0.04	0.03	0.36	0.08
Nitrate		3.17	3.67	1.94	0.02	0.07	0.49	3.17	0.04	0.05
Phosphate		0.52	0.56	0.43	0.16	0.35	0.12	0.16	0.44	0.15
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (Pb)		<0.001	0.023	0.007	0.002	0.022	0.020	0.001	0.002	0.020
Copper (Cu)		0.002	<0.001	0.002	<0.001	0.001	0.004	0.001	0.001	0.002
Manganese (Mn)		0.010	0.010	0.012	0.001	0.004	0.011	0.005	0.016	0.025
Nickel (Ni)		<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)		0.08	0.12	0.19	0.11	0.19	0.20	0.09	0.30	0.49
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		40,000	1,700	4,000	6,000	<1	900	<1	2,700	1,000

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.11 Baseline water quality results (spring tide) (cont'd)

Parameter	Unit	WQ3 (Estuarine)		WQ4 (Estuarine)	WQ7 (Marine)		WQ13 (Marine)	
		Ebbing	Flooding	Flooding	Ebbing	Flooding	Ebbing	Flooding
		Surface	Surface	Surface	Surface	Surface	Surface	Surface
pH		7.86	7.57	8.72	8	7.79	8.02	7.9
Temperature	°C	29.2	28.9	27.3	30.6	29.2	30.2	28.8
DO	mg/L	1.6	1.4	5.4	2.8	1.4	1.4	1.1
Salinity	ppt	1.84	15.06	0.04	4.48	4.25	1.88	2.96
Conductivity	uS/cm	3,808	24,906	81.6	8,152	7,753	3,598	551
Turbidity	NTU	6	6	4	4	6	5	6
TSS	mg/L	17	19	6	13	14	10	15
COD		20	14	15	18	19	18	13
BOD		7	5	5	7	7	6	6
Oil & Grease		<1	<1	<1	<1	<1	<1	<1
TOC		2.5	0.7	0.8	2.8	2.7	0.7	0.4
Chlorophyll-A		<0.5	0.7	<0.5	<0.5	<0.5	<0.5	0.6
Ammoniacal Nitrogen (NH_3-N)		0.01	0.05	0.33	0.03	0.23	0.05	0.11
Nitrate		0.91	0.22	0.27	2.86	0.17	2.43	0.46
Phosphate		0.27	0.34	9.29	0.43	0.04	0.48	0.33
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002
Arsenic (As*)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (Pb)		<0.001	<0.001	<0.001	0.002	0.001	<0.001	<0.001
Copper (Cu)		<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001
Manganese (Mn)		0.022	0.030	0.005	0.103	0.138	0.076	0.047
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010
Iron (Fe)		0.26	0.17	0.12	1.04	0.66	0.58	0.71
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		1,700	7,200	6,100	79,000	900	69,000	135,000

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide)

Parameter	Unit	WQ1 (Marine)						WQ2 (Marine)					
		Ebbing (27.0 m)			Flooding (25.9 m)			Ebbing (19.0 m)			Flooding (19.1 m)		
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
pH		8.57	8.52	8.47	8.60	8.55	8.55	8.52	8.55	8.53	8.53	8.47	8.51
Temperature	^{o}C	30.0	29.7	29.7	30.0	29.7	29.6	30.2	29.6	29.6	30.0	29.3	29.5
DO	mg/L	4.71	5.01	4.41	5.11	5.02	4.70	4.91	5.28	5.61	5.27	4.44	5.15
Salinity	ppt	31.92	32.03	32.05	31.93	31.97	32.06	31.94	31.90	32.02	31.92	32.25	31.91
Conductivity	uS/cm	49,087	49,216	49,248	49,103	49,124	49,255	49,110	49,044	49,179	49,083	49,505	49,036
Turbidity	NTU	1	4	8	1	1	11	<1	<1	<1	<1	<1	5
TSS	mg/L	10	12	16	8	10	20	7	6	6	9	7	15
COD		16	18	20	18	17	16	19	19	15	15	16	17
BOD		4	6	8	5	4	4	8	7	4	4	4	5
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TOC		0.4	0.3	0.4	0.1	0.5	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3-N)		0.08	0.10	0.36	0.08	0.12	0.09	0.08	0.09	0.10	0.20	0.07	0.11
Nitrate		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
Phosphate		<0.01	0.02	0.022	<0.01	0.01	0.02	0.12	0.02	0.02	0.01	0.02	0.02
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.003	0.002	0.003	0.002	0.001	0.001	0.003	0.001	0.001	0.002	0.001	0.002
Lead (Pb)		<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.015	<0.001
Manganese (Mn)		0.001	0.004	0.019	<0.001	0.002	0.013	<0.001	<0.001	<0.001	<0.001	0.002	0.011
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)		0.03	0.16	0.30	0.16	0.15	0.33	0.09	0.07	0.03	0.14	0.11	0.22
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		<1	2,000	400	500	74,000	1,100	<1	4,500	700	<1	<1	200

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ5 (Marine)		WQ6 (Marine)		WQ8 (Marine)					
		Ebbing (1.8 m)	Flooding (1.6 m)	Ebbing (1.2 m)	Flooding (0.9 m)	Ebbing (7.2 m)			Flooding (7.0 m)		
		Surface	Surface	Surface	Surface	Surface	Middle	Bottom	Surface	Middle	Bottom
pH		8.61	8.72	8.86	8.56	8.69	8.65	8.64	8.07	8.34	8.31
Temperature	°C	31.3	29.7	32.0	29.4	30.5	30.1	30.0	29.4	29.6	29.7
DO	mg/L	6.63	5.62	8.90	5.55	6.94	6.32	6.11	5.28	4.70	5.11
Salinity	ppt	31.25	31.26	30.11	28.53	31.36	31.56	31.61	30.86	31.05	31.08
Conductivity	uS/cm	48,221	48,207	46,691	44,380	48,346	48,595	48,639	47,592	47,868	47,916
Turbidity	NTU	1	1	4	23	<1	4	1	2	2	1
TSS	mg/L	8	9	13	11	5	14	9	10	11	10
COD		16	14	18	16	15	16	15	18	16	17
BOD		4	4	4	5	7	7	8	8	7	7
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TOC		0.9	1.0	1.5	1.2	0.7	0.7	1.0	0.9	1.1	1.2
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3-N)		0.15	0.10	0.33	0.34	0.12	0.09	0.14	0.14	0.47	0.39
Nitrate		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.001	<0.01	<0.01	<0.01
Phosphate		0.04	0.03	0.06	0.08	0.02	0.03	0.02	0.05	0.03	0.03
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.003	0.001	<0.001	0.002	0.002	0.002	0.001	0.002	0.001	0.002
Lead (Pb)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
Manganese (Mn)		0.007	0.007	0.005	0.017	0.003	0.003	0.017	0.006	0.009	0.007
Nickel (Ni)		0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Iron (Fe)		0.08	0.03	0.10	0.25	0.03	0.08	0.17	0.07	0.06	0.08
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		4,600	62,00	100	2,600	3,400	3,600	600	70	1,000	57,000

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ9 (Marine)						WQ10 (Marine)	
		Ebbing (10.2 m)			Flooding (11.0 m)			Ebbing (3.5 m)	Flooding (3.6 m)
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Surface
pH		8.57	8.55	8.58	8.44	8.54	8.49	8.73	8.53
Temperature	^{o}C	29.6	29.6	29.7	29.6	29.7	29.6	30.8	29.6
DO	mg/L	5.65	5.61	5.57	5.10	5.22	5.10	6.56	4.58
Salinity	ppt	31.22	31.21	31.22	31.22	31.23	31.22	31.44	31.26
Conductivity	uS/cm	48,090	48,088	48,110	48,095	48,121	48,100	48,474	48,164
Turbidity	NTU	1	<1	<1	<1	2	2	1	3
TSS	mg/L	7	5	7	8	10	9	8	11
COD		20	18	18	12	14	13	16	17
BOD		7	7	7	4	5	4	4	4
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1
TOC		0.4	0.5	1.0	0.3	0.7	0.3	0.5	0.4
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3-N)		0.08	0.13	0.14	0.09	0.18	0.09	0.13	0.31
Nitrate		<0.01	<0.01	<0.01	0.08	<0.01	<0.01	<0.01	<0.01
Phosphate		0.01	0.01	0.03	0.03	0.01	0.01	0.02	0.02
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Lead (Pb)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese (Mn)		0.002	0.003	0.003	<0.001	0.004	0.005	0.003	0.008
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)		0.07	0.07	0.10	0.02	0.11	0.08	0.17	0.17
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		500	<1	100	<1	3,200	400	100	300

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ11 (Marine)						WQ12 (Marine)					
		Ebbing (9.1 m)			Flooding (9.3 m)			Ebbing (6.4 m)			Flooding (5.7 m)		
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
pH		8.62	8.62	8.61	8.66	8.63	8.64	8.62	8.62	8.61	8.66	8.63	8.64
Temperature	°C	30	30.0	30.0	30.0	29.9	29.9	30	30.0	30.0	30.0	29.9	29.9
DO	mg/L	5.86	5.47	5.56	5.46	5.93	5.86	5.86	5.47	5.56	5.46	5.93	5.86
Salinity	ppt	31.77	31.74	31.78	31.75	31.77	31.82	31.77	31.74	31.78	31.75	31.77	31.82
Conductivity	uS/cm	48,875	48,828	48,887	48,851	48,881	48,936	48,875	48,828	48,887	48,851	48,881	48,936
Turbidity	NTU	<1	<1	1	1	<1	1	<1	<1	1	1	<1	1
TSS	mg/L	6	6	7	10	7	10	6	6	7	10	7	10
COD		16	15	16	16	15	14	16	15	16	16	15	14
BOD		4	4	4	4	4	4	4	4	4	4	4	4
Oil & Grease		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TOC		0.2	0.4	0.5	0.4	0.4	0.3	0.2	0.4	0.5	0.4	0.4	0.3
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3-N)		0.08	0.14	0.11	0.08	0.08	0.09	0.08	0.14	0.11	0.08	0.08	0.09
Nitrate		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate		<0.01	0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.01	<0.01	<0.01	0.02	<0.01
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.001	0.002
Lead (Pb)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese (Mn)		0.001	0.001	0.002	0.002	<0.001	0.001	0.001	0.001	0.002	0.002	<0.001	0.001
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)		0.06	0.04	0.06	0.11	0.09	0.07	0.06	0.04	0.06	0.11	0.09	0.07
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform		<1	2,200	5,900	<1	6,000	400	<1	2,200	5,900	<1	6,000	400

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ14 (Marine)		WQ15 (Marine)			
		Ebbing (0.6 m)	Flooding (1.0 m)	Ebbing (3.5 m)		Flooding (4.2 m)	
		Surface	Surface	Surface	Bottom	Surface	Bottom
pH		8.53	8.56	8.59	8.58	8.57	8.57
Temperature	°C	31.3	34.0	30.7	30.7	30.8	30.7
DO	mg/L	4.49	5.37	6.01	5.16	6.26	6.2
Salinity	ppt	28.89	30.00	30.78	30.77	30.76	30.76
Conductivity	uS/cm	45,056	46,593	47,532	45,723	47,634	47,504
Turbidity	NTU	40	40	2	3	3	3
TSS	mg/L	26	26	8	13	4	14
COD		18	20	15	16	13	16
BOD		6	7	5	5	4	5
Oil & Grease		<1	<1	<1	<1	<1	<1
TOC		0.9	0.8	0.2	0.6	0.3	0.6
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3-N)		0.51	0.60	0.25	0.23	0.48	0.48
Nitrate		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate		0.30	0.24	0.03	0.04	0.03	0.04
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.002	0.002	0.002	0.002	0.002	0.002
Lead (Pb)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese (Mn)		0.028	0.030	0.003	0.003	0.003	0.004
Nickel (Ni)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)		0.01	0.01	0.03	0.03	0.06	0.02
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1
Faecal Coliform		400	900	2,400	600	500	<1

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ16 (Marine)				WQ17 (Marine)				WQ18 (Marine)	
		Ebbing (4.2 m)		Flooding (4.0 m)		Ebbing (4.2 m)		Flooding (4.0 m)		Ebbing (3.8 m)	Flooding (3.9 m)
		Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Surface
pH		8.69	8.70	8.67	8.68	8.31	8.42	8.50	8.55	8.70	8.41
Temperature	°C	30.6	30.6	30.6	30.6	30.5	30.5	30.3	30.2	32.0	31.4
DO	mg/L	7.05	7.10	7.08	7.3	6.66	6.67	6.01	6.06	11.0	7.1
Salinity	ppt	30.56	30.56	30.50	30.58	30.58	30.62	30.61	30.65	27.54	27.68
Conductivity	uS/cm	46,763	47,237	47,540	47,235	47,288	47,312	47,915	47,862	43,112	43,274
Turbidity	NTU	3	3	3	2	3	2	3	3	12	9
TSS	mg/L	14	4	3	11	5	14	13	5	6	4
COD	mg/L	17	12	11	12	10	10	13	13	12	10
BOD	mg/L	5	4	3	4	3	3	4	4	4	3
Oil & Grease	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TOC	mg/L	0.5	1.1	0.4	0.9	0.5	0.9	0.3	0.4	1.2	0.6
Chlorophyll-A	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3-N)	mg/L	0.54	0.48	0.42	0.46	0.46	0.52	0.61	0.32	0.29	0.22
Nitrate	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate	mg/L	0.04	0.04	0.03	0.04	0.04	0.05	0.04	0.06	0.04	0.05
Cadmium (Cd)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Lead (Pb)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.004
Copper (Cu)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002
Manganese (Mn)	mg/L	0.005	0.005	0.004	0.004	0.002	0.003	0.003	0.003	0.009	0.010
Nickel (Ni)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002
Iron (Fe)	mg/L	0.04	0.02	0.02	0.02	0.02	0.06	0.05	0.04	0.15	0.21
E. coli	cfu/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Faecal Coliform	cfu/100 ml	<1	<1	<1	<1	<1	<1	700	<1	<1	<1

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.12 Baseline water quality results (neap tide) (cont'd)

Parameter	Unit	WQ3 (Estuarine)		WQ4 (Estuarine)	WQ7 (Marine)		WQ13 (Marine)	
		Ebbing	Flooding	Flooding	Ebbing	Flooding	Ebbing	Flooding
		Surface	Surface	Surface	Surface	Surface	Surface	Surface
pH		7.85	7.02	8.74	8.05	8.49	7.13	7.25
Temperature	°C	30.1	28.7	26.2	30	27.3	30.3	28.2
DO	mg/L	2.40	1.22	5.10	2.3	1.5	0.96	0.46
Salinity	ppt	1.24	20.23	0.03	0.79	0.26	5.53	7.76
Conductivity	uS/cm	2,667	32,531	74.1	1,587	549	9,908	13,518
Turbidity	NTU	37	3	2	43	43	37	4
TSS	mg/L	34	46	6	42	54	34	26
COD		14	54	64	18	18	29	34
BOD		4	18	19	9	6	9	9
Oil & Grease		<1	<1	<1	<1	<1	<1	<1
TOC		7.9	6.5	0.7	5.0	3.9	4.7	3.3
Chlorophyll-A		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ammoniacal Nitrogen (NH_3-N)		3.18	7.00	0.07	1.16	0.06	4.32	5.15
Nitrate		<0.01	<0.01	1.11	2.27	<0.01	<0.01	1.71
Phosphate		6.11	6.21	0.19	0.88	0.13	1.40	2.46
Cadmium (Cd)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As*)		0.003	0.002	<0.001	0.007	0.006	0.002	0.001
Lead (Pb)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)		0.009	0.004	<0.001	<0.001	<0.001	0.015	0.003
Manganese (Mn)		0.037	0.035	0.007	0.077	0.066	0.042	0.028
Nickel (Ni)		<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.002
Iron (Fe)		0.69	0.45	0.15	1.00	1.21	0.64	0.55
E. coli	cfu/100 ml	27,000	44,000	<1	1,100	3,300	14,900	50,000
Faecal Coliform		79,000	660,000	57,000	25,000	114,000	420,000	1,140,000

Notes: DO: Dissolved Oxygen COD: Chemical Oxygen Demand BOD: Biochemical Oxygen Demand TOC: Total Organic Carbon

T6.13 Malaysia Marine Water Quality Criteria and Standard (MWQCS)

Parameter	Class 1	Class 2	Class 3	Class E
Beneficial Uses	Preservation, marine protected areas, marine parks	Marine life, fisheries, coral reefs, recreational and mariculture	Ports, oil & gas fields	Mangroves estuarine and river-mouth water
Temperature (˚C)	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient
Dissolved Oxygen (mg/L)	>80% saturation	5	3	4
Total suspended solids (mg/L)	25 mg/L or ≤ 10% increase in seasonal average, whichever is lower	50 mg/L (25 mg/L) or ≤ 10% increase in seasonal average, whichever is lower	100 mg/L or ≤ 10% increase in seasonal average, whichever is lower	100 mg/L or ≤ 30 % increase in seasonal average, whichever is lower
Oil and grease (mg/L)	0.01	0.14	5	0.14
Mercury* (µg/L)	0.04	0.16 (0.04)	50	0.5
Cadmium (µg/L)	0.5	2 (3)	10	2
Chromium (VI) (µg/L)	5	10	48	10
Copper (µg/L)	1.3	2.9	10	2.9
Arsenic (III)* (µg/L)	3	20 (3)	50	20 (3)
Lead (µg/L)	4.4	8.5	50	8.5
Zinc (µg/L)	15	50	100	50
Cyanide (µg/L)	2	7	20	7
Ammonia (unionized) (µg/L)	35	70	320	70
Nitrite (NO_2) (µg/L)	10	55	1000	55
Nitrate (NO_3) (µg/L)	10	60	1000	60
Phosphate (µg/L)	5	75	670	75
Phenol (µg/L)	1	10	100	10
Tributyltin (TBT) (µg/L)	0.001	0.01	0.05	0.01
Fecal coliform (Human health protection for seafood consumption) – Most Probable Number (MPN)	70 fecal coliform 100mL-1	100 fecal coliform 100mL-1 and (70 fecal coliform 100mL-1)	200 fecal coliform 100mL-1	100 fecal coliform 100 mL-1 and (70 fecal coliform 100mL-1)
Polycyclic Aromatic Hydrocarbon (PAHs) ng/g	100	200	1,000	1,000

6.2.7.3 Discussions

The discussion for the water quality results shall be done according to the results and findings relating to marine water and estuarine water.

6.2.7.3.1 Marine Water

Water quality at the coastal region was moderate, but not exactly pristine. DO levels generally remain between 4 to 6 mg/L throughout. Nutrients such as ammoniacal nitrogen (NH_3-N), nitrate-nitrogen (NO_3-N) and phosphate were detected at WQ1 (near Pulau Kendi) and WQ2, albeit still at low levels and only during spring tide. NH_3-N levels were less than 0.5 mg/L, NO_3-N less than 1.5 mg/L and phosphate less than 0.5 mg/L. These imply sufficient dispersion although at these levels, the risk of algae blooms was still present. Faecal coliform here was also elevated particularly during spring tide, reaching as high as 600,000 cfu/100 mL.

Similar circumstances were also seen at WQ10, WQ11, WQ12, WQ15, WQ16 and WQ17 as NO_3-N went up to 4.76 mg/L (WQ11). Levels of NH_3-N and phosphate however were slightly lower, not exceeding 0.7 mg/L for either parameter. Fecal coliform levels also dissipated, albeit only slightly and still remained unsuitable for body contact.

The elevated NO_3-N trend was also apparent at WQ8 and WQ9, particularly during spring tide, reaching almost as high as 3.7 mg/L. Phosphate did not exceed 0.5 mg/L. During neap tide, the levels again dissipated.

Although *E. coli* was undetected, the faecal coliform count still remained in the thousands. Hence the coastal region can be deemed as unsuitable for body contact activities.

Turbidity measurements were made *in-situ*. The readings at the rest of the stations are considerably low with suspended solids values below 25 mg/L.

The oil and grease (O&G) parameter indicates the oil level present in the water body. If it is present in substantial amounts (at greater than about 10 mg/L), it will form a layer on the water surface. This may cause several impacts such as reducing the ability of oxygen dissolution into water which is harmful to aquatic life. The O&G levels recorded in the surrounding waters at the Project area showed concentrations at less than 1 mg/L at all stations. The values are all similar at all depths during spring and neap tides.

Iron has no stated limit in MWQCS. There is no particular pattern of the heavy metals concentration within the water column, signifying that the metals are of background concentrations in sea water and not due to any localized sources.

6.2.7.3.2 Estuarine Water

The water quality at the estuarine of Sungai Gertak Sanggul (WQ3) was not exactly pristine, although some local fishermen still cast their nets here to catch fish bait. While the water was clear (reflected by the low turbidity during neap and spring tides), there were instances when organic parameters such as BOD, NH3-N and phosphate increased, particularly during neap tide. BOD here went as high as 18 mg/L, whereas NH_3-N was between 3.18 to 7.00 mg/L. The elevated organics translated to low DO; of less than 2.5 mg/L during all tidal cycles. The contamination was likely due to organic (potentially sewage) contribution from surrounding sources. This was reflected by the high *E. coli* count of between 27,000 to 44,000 cfu/100 mL, which was also in tandem with high presence of faecal coliform. Such circumstances are decidedly unsuitable for body contact. There is even a pig farm in the vicinity.

It is also to be noted that most pollutants dissipated during spring tide (except faecal coliform which still remained unsuitable for body contact). The pollutants likely dispersed to the coastal region.

This may be a cause for concern, as the flushing of pollutants could be disrupted by the presence of the proposed development. There is even potential for accumulation along the strait if the water becomes stagnant (e.g. intertidal). Build-up of nutrients, such as NH_3-N, NO3-N and phosphate presents the risk of algae blooms and even eutrophication, with nitrogen species being the limiting nutrient for marine environments. This potential impact needs to be mitigated by ensuring the hydrodynamics of the region is not impeded due to the presence of the islands.

Similar observations were also apparent for Sungai Gemuruh (station WQ4) although these were not as bad as Sungai Gertak Sanggul. BOD (19 mg/L) and faecal coliform (57,000 cfu/100 mL) were high during neap tide but dissipated during spring tide. Phosphate on the other hand, increased during spring tide, being up to 9.29 mg/L. Local fishermen were also observed casting nets to catch fish bait here.

The organics at Sungai Teluk Kumbar (WQ13) was moderate, exhibiting mid-range BOD between 6 to 9 mg/L. However, NH_3-N was very elevated during spring tide, between 4.32 to 5.15 mg/L. This indicated faecal (sewage) contamination was apparent, but not prevalent; at least in terms of organics. The faecal coliform levels of up to 1,140,000 cfu/100 mL reaffirmed this. These are levels entirely not appropriate for body contact.

At Sungai Bayan Lepas (WQ7), elevation in BOD and NH_3-N was again apparent though not as prevalent as at Sungai Gertak Sanggul or Sungai Teluk Kumbar. BOD here ranged between 6 to 9 mg/L during spring tide as NH_3-N went up to 1.13 mg/L during ebbing. Poor re-aeration coupled with the organic contamination lead to low DO levels during neap and spring tides, registering about 1.4 to 2.8 mg/L. Sewage was a main suspect as faecal coliform went as high as 114,000 cfu/100 mL at this location.

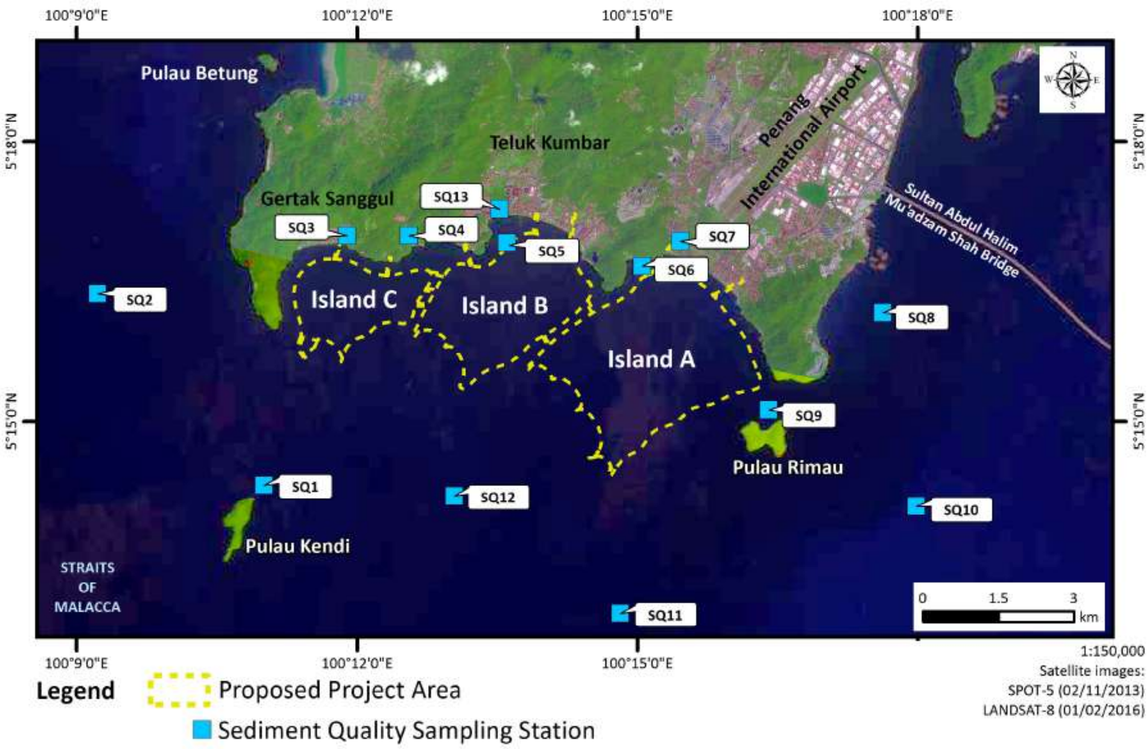
That being so, these river systems exhibited signs of faecal contamination as indicated by the occasional increase in nutrients, *E. coli* and faecal coliform.

With the exception of manganese, iron and arsenic, heavy metals remained largely undetected in most of the river systems. Arsenic could have originated from the soil, which was due to the inherent geomorphology.

TSS and turbidity levels were also low for the most part. The measured turbidity showed that the highest levels recorded were at WQ7 which is located at the outlet of Sungai Bayan Lepas with 43 NTUs for both ebbing and flooding conditions. This coincides with the suspended solids concentration recorded with 42 and 54 mg/L during ebbing and flooding respectively. The second and third highest readings recorded for turbidity and SS are WQ3 and WQ13. During flooding for both stations, the turbidity values were very low but the SS readings were the opposite. This specifies that the SS value signifies the coarser solids, which are normally measured as higher SS but low turbidity.

6.2.8 Sediment Quality

13 sediment quality stations were chosen to obtain baseline sediment samples as shown in F6.35. The coordinates of the sampling stations are tabulated in T6.14.



F6.35 Sediment quality sampling stations

T6.14 Coordinates of the sediment quality sampling stations

Station	Coordinates	Description
SQ1	5°14'19.01"N, 100°11'0.34"E	North of Pulau Kendi
SQ2	5°16'22.154"N, 100°9'13.46"E	About 3 km to the west of Tanjung Gertak Sanggul
SQ3	5°16'59.78"N, 100°11'53.75"E	River mouth of Sungai Gertak Sanggul
SQ4	5°16'59.7"N, 100°12'33.5"E	River mouth of Sungai Gemuruh
SQ5	5°16'54.96"N, 100°13'36.24"E	The proposed flushing channel between Tanjung Bongkok and the proposed Island B
SQ6	5°16'40.04"N, 100°15'3.19"E	The proposed flushing channel between Tanjung Chut and the proposed Island A
SQ7	5°16'56.26"N, 100°15'27.6"E	River mouth of Sungai Bayan Lepas
SQ8	5°16'10.062"N, 100°17'37.68"E	About 1.5 km to the east of Kampung Teluk Tempoyak
SQ9	5°15'7.52"N, 100°16'24.54"E	North of Pulau Rimau
SQ10	5°14'5.429"N, 100°17'59.24"E	About 3 km to the south east of Pulau Rimau
SQ11	5°12'56.51"N, 100°14'49.159"E	About 3 km to the south of the proposed Island A
SQ12	5°14'12.098"N, 100°13'2.447"E	About 2 km to the south of the proposed Island B
SQ13	5°17'16.7"N, 100°13'31.4"E	River mouth of Sungai Teluk Kumbar

6.2.8.1 Methodology

The sediment samples were obtained using a Van Veer Grab. The grab was lowered vertically into the river or seabed. The closure of the grab bucket was then triggered when it touched the bottom. The grab was pulled up and the sediment samples were then kept in a labelled plastic container before being sent to the laboratory for analysis.

Chemical analyses were conducted in accordance to the relevant standards which are based on the US EPA Standard (T6.15). F6.36 shows the sediment quality sampling activities.

T6.15
US EPA Standard for sediment quality

Parameter	Unit	US EPA Standard		
		Non-Polluted	Moderately Polluted	Heavily Polluted
Zinc (Zn)	mg/kg	<90	90 – 200	>200
Nickel (Ni)	mg/kg	<20	20 – 50	>50
Lead (Pb)	mg/kg	<40	40 – 60	>60
Arsenic (As)	mg/kg	<3	3 – 8	>8
Cadmium (Cd)	mg/kg	-	-	>6
Copper (Cu)	mg/kg	<25	25 – 50	>50
Chromium (Cr)	mg/kg	<25	25 – 75	>75
Nitrate	mg/kg	N/A	N/A	N/A
Total Phosphorus	mg/kg	N/A	N/A	N/A
Oil & Grease	mg/kg	<1,000	1,000-2,000	>2,000

F6.36
Sediment quality sampling activities

6.2.8.2 Results

The baseline sediment quality results are tabulated in T6.16.

T6.16 Baseline sediment quality results

Parameters	Unit	Stations						
		SQ1	SQ2	SQ3	SQ4	SQ5	SQ6	SQ7
Nitrate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Phosphorus	mg/kg	598	528	820	33	648	353	594
Oil & Grease	mg/kg	<10	<10	<10	<10	<10	<10	<10
Sulphide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Organic Matter	%	32.6	28.8	4.0	2.0	43.8	3.9	5.2
Total Organic Carbon	%	1.6	2.6	1.2	0.6	2.8	1.2	1.2
Nickel	mg/kg	10	8	4	<1	11	3	5
Copper	mg/kg	9	5	55	<1	21	6	14
Chromium	mg/kg	18	16	8	<1	20	5	9
Lead	mg/kg	14	12	10	1	15	6	16
Arsenic	mg/kg	3	5	2	<1	6	3	5
Cadmium	mg/kg	<1	<1	<1	<1	<1	<1	<1
Zinc	mg/kg	41	33	128	4	53	24	58
Manganese	mg/kg	319	327	74	13	294	144	123
Iron	mg/kg	21,700	23,000	12,200	1,030	29,000	12,100	19,100

		SQ8	SQ9	SQ10	SQ11	SQ12	SQ13
Nitrate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Phosphorus	mg/kg	740	444	669	620	648	625
Oil & Grease	mg/kg	<10	<10	<10	<10	<10	<10
Sulphide	mg/kg	<0.1	0.5	<0.1	<0.1	<0.1	<0.1
Organic Matter	%	48.9	3.1	33.5	34.0	27.4	4.0
Total Organic Carbon	%	2.3	1.3	0.9	1.7	1.4	1.8
Nickel	mg/kg	11	1	10	10	9	2
Copper	mg/kg	33	3	8	9	10	34
Chromium	mg/kg	20	2	19	18	17	5
Lead	mg/kg	16	3	16	15	14	13
Arsenic	mg/kg	7	3	7	5	6	1
Cadmium	mg/kg	<1	<1	<1	<1	<1	<1
Zinc	mg/kg	52	10	46	42	41	47
Manganese	mg/kg	406	184	362	303	361	40
Iron	mg/kg	27,900	4,820	28,500	22,400	24,400	5,350

6.2.8.3 Discussions

The results as tabulated in T6.16 show significantly high values of copper (Cu) in the sediment at station SQ3 (Sungai Gertak Sanggul) at 55 mg/kg, making it fall under the "Heavily Polluted" category. The high levels of Cu in the sediment are probably due to the accumulation of heavy metals coming from the upstream human activities of Sungai Gertak Sanggul. Zinc (Zn) concentration falls under "Moderately Polluted" for station SQ3. The same station also shows the highest values for Total Phosphorus with 820 mg/kg, indicating high level of nutrients in the sediment. The concentration of chromium (Cr) is quite high at some stations with the highest at stations SQ5 and SQ8 but still falling under "Non-Polluted". Arsenic (As) concentration too is high and falls under "Moderately Polluted" with high values at stations SQ5, SQ8 and SQ10. Organic matters are also detected at significant levels for almost all stations. It can be concluded that the sediment quality within the Project area is categorized as "Moderately Polluted" and probably caused by anthropogenic activities.

6.2.9 Noise

Ambient noise measurements were carried out to establish the existing background noise levels near the sensitive receptors. This information will be used in the noise impact assessment and/or for compliance verification during the construction stage of the Project based on the Planning Guidelines for Environmental Noise Limits Control, Second Edition (2007) published by DOE.

6.2.9.1 Methodology

The measurements were performed according to the International Electro-technical Commission (IEC) specifications. The sound level meter was placed at a height of about 1.2 m above the ground on a tripod. The guidelines specified that the monitoring time should be "continuous day-night sampling". The sound-level meter was calibrated onsite each day before the first measurement was taken and after the final measurement was completed.

The noise parameters measured were L_{eq}, L_{min}, L_{max}, L_{10} and L_{90}. The definition of the noise descriptors are indicated as follows:

a) L_{eq}: the equivalent continuous noise level in dBA, which has the same energy as the original fluctuating noise for the same given period of time;
b) L_{min}: the noise level in dBA, which is the lowest level measured for the same a) period;
c) L_{max}: the noise level in dBA, which is the highest level measured for the same period;
d) L_{10}: the noise level in dBA, which exceeds 10% of the time; and
e) L_{90}: the noise level in dBA, which exceeds 90% of the time.

Three (3) locations were identified as the noise sampling stations as tabulated in T6.17 and also illustrated in F6.37. The baseline results were compared to the following construction noise criteria given in DOE's The Planning Guidelines for Environmental Noise Limits and Control, as summarized in T6.18.

T6.17 Locations of noise sampling stations

Station	Description	Coordinates
N1	Sekolah Jenis Kebangsaan Cina Poi Eng	5° 16' 56.24" N, 100° 11' 45.44" E
N2	Sekolah Kebangsaan Teluk Kumbar	5° 17' 26.32" N, 100° 13' 58.69" E
N3	Perkarangan Masjid Al Qahhar	5° 16' 28.95" N, 100° 15' 59.58" E

Receiving Land Use Category	Day-time (0700 - 2200)	Night-time (2200 - 0700)
Noise Sensitive Areas, Low Density Residential, Institutional (School, Hospital), Worship Areas	50 dBA	40 dBA
Suburban Residential (Medium Density) Areas, Public Spaces, Parks, Recreational Areas	55 dBA	45 dBA
Urban Residential (High Density) Areas, Designated Mixed Development Areas (Residential - Commercial)	60 dBA	50 dBA
Commercial Business Zones	65 dBA	55 dBA
Designated Industrial Zones	70 dBA	60 dBA

T6.18
Maximum Permissible Sound Levels (L_{Aeq}) by Receiving Land Use for Planning and New Development (Schedule 1)

6.2.9.2 Results

The baseline noise results are tabulated in T6.19.

Station	Time Period	Noise Level (dBA)				
		L_{Aeq}	L_{min}	L_{max}	L_{10}	L_{90}
N1	Day-time (0700 – 2200)	54.2	48.6	68.2	60.3	53.7
	Night-time (2200 – 0700)	49.7	46.9	57.0	52.9	49.2
N2	Day-time (0700 – 2200)	53.1	47.4	60.2	57.9	52.2
	Night-time (2200 – 0700)	49.6	46.2	54.7	51.2	48.5
N3	Day-time (0700 – 2200)	48.3	45.5	60.3	50.2	48.0
	Night-time (2200 – 0700)	46.7	43.4	59.6	49.7	45.9

T6.19
Baseline noise results

6.2.9.3 Discussions

The results recorded were compared with the Suburban Residential Areas land use category. The results show that noise during day time is below the maximum permissible limit while for night time is slightly higher. The noise was mainly generated from human activities from the school areas and vehicles' movement on the road. Sounds from animals also added to the ambient noise recorded at the stations.

6.2.10 Air Quality

The ambient air quality sampling was conducted to determine the existing environmental air quality around the Project area. It was done from the 16 to 18 February 2016. The parameters observed were Total Suspended Particulates (TSP), Particulate Matter ($PM_{2.5}$), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2) and Ozone (O_3).

6.2.10.1 Methodology

Three (3) stations were selected for the study namely AQ1, AQ2 and AQ3. The locations of the stations are described in T6.20 and also depicted in F6.37. The ambient air is absorbed from the surrounding area using a pre-calibrated portable pump stationed at fixed points. For the TSP parameter, the High Volume sampler method was used to collect the samples. These were tested at the laboratory for the concentrations of relevant parameters. The results were then compared with the New Malaysia Ambient Air Quality Standard (DOE, 2014) (T6.21). Only TSP is compared with the Recommended Malaysian Air Quality Guidelines (RMAQG).

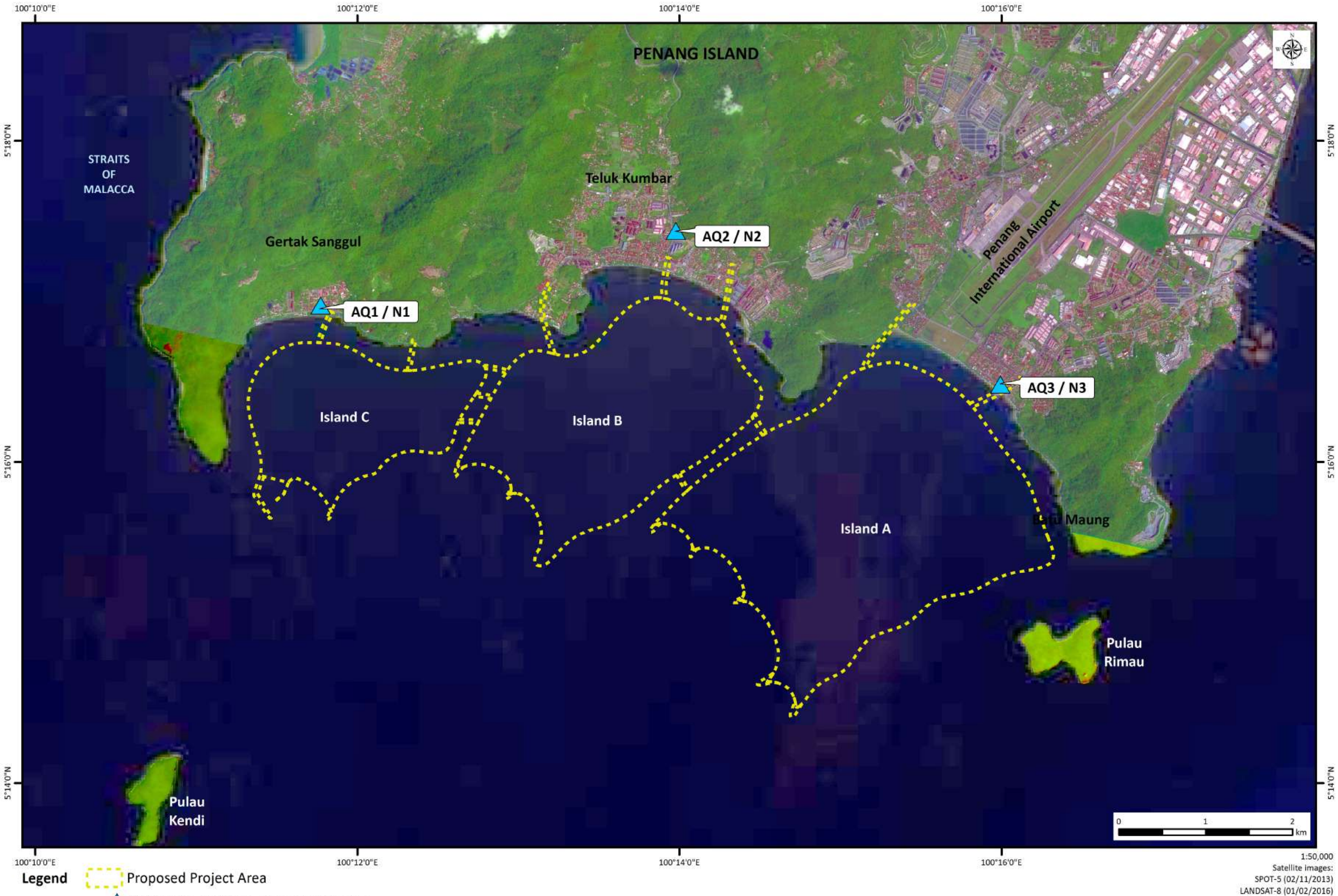
T6.20 Locations of the air quality sampling stations

Station	Description	Coordinates
AQ1	Sekolah Jenis Kebangsaan Cina Poi Eng	5° 16' 56.24" N, 100° 11' 45.44" E
AQ2	Sekolah Kebangsaan Teluk Kumbar	5° 17' 26.32" N, 100° 13' 58.69" E
AQ3	Perkarangan Masjid Al Qahhar	5° 16' 28.95" N, 100° 15' 59.58" E

T6.21 New Malaysia Ambient Air Quality Standard

Pollutants	Averaging Time	New Malaysia Ambient Air Quality Standard		
		Interim Target 1 in 2015 (IT-1) (µg/m^3)	Interim Target 2 in 2018 (IT-2) (µg/m^3)	Standard 2020 (µg/m^3)
PM_{10}	1 year	50	45	40
	24 hours	150	120	100
$PM_{2.5}$	1 year	35	25	15
	24 hours	75	50	35
SO_2	1 hour	350	300	250
	24 hours	105	90	80
NO_2	1 hour	320	300	280
	24 hours	75	75	70
O_3	1 hour	200	200	180
	8 hour	120	120	100
CO*	1 hour	35	35	30
	8 hour	10	10	10

Note: *mg/m^3
Source: DOE, 2014



Legend
Proposed Project Area
Air Quality and Noise Sampling Station

F6.37 Air quality and noise sampling stations

6.2.10.2 Results

The air quality baseline results are shown in T6.22.

T6.22
Baseline air quality results

Parameters	Duration	Results			RMAQG/Malaysia Ambient Air Quality Standard
		AQ1	AQ2	AQ3	
TSP (µg/m^3)	24 hours	42	14	111	260
$PM_{2.5}$ (µg/m^3)	24 hours	28	<1	69	75
SO_2 (µg/m^3)	1 hour	167	167	167	350
NO_2 (µg/m^3)	1 hour	<42	<42	<42	320
CO (mg/m^3)	1 hour	<0.1	<0.1	<0.1	35
O_3 (µg/m^3)	1 hour	<20	<20	<20	200

6.2.10.3 Discussion

The TSP level at station AQ3 is quite high compared to stations AQ1 and AQ2. However, the results for all parameters are below the standard. Therefore, it can be concluded that the existing air quality within the Project area is good.

6.2.11 Marine Traffic and Navigation

This section will address the environmental issues associated with the proposed development and impacts on marine traffic and navigation within the Project area. The assessment has been made based on the information received and from research specifically done on the subject matter, and has taken into account various factors regarding:

a) existing marine facilities and utilization;
b) existing condition of local climate; and
c) existing marine traffic procedures and safety rules.

A Marine Traffic Risk Assessment (MTRA) will be carried out to assess marine traffic risks caused by the Project, both during and post construction, and to develop Standard Operating Procedure to ensure safety of all boats and vessels, including fishing boats

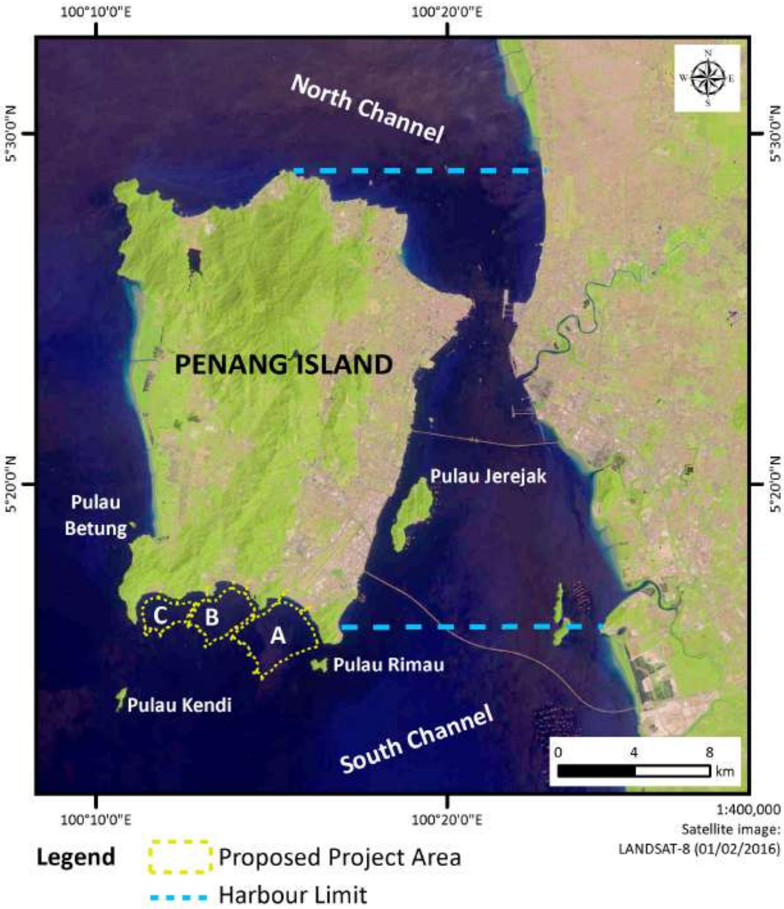
6.2.11.1 Methodology

The assessment was done using qualitative and quantitative methods including local knowledge, experience, data available from the Project Proponent, adjacent port-operating companies, government authorities and agencies, as well as interviews with the fishermen, their associations and local communities.

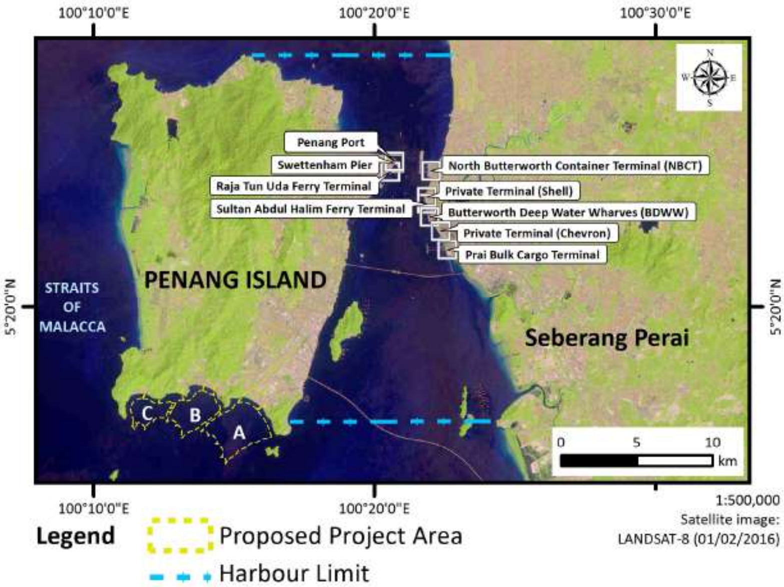
6.2.11.2 Existing Marine Facilities and Utilization

Penang Port is the oldest and longest established port in Malaysia. It is administrated by Penang Port Commission while Penang Port Sdn. Bhd. is licensed to act as its operator. Equipped with facilities to handle nearly all types of containerized and non-containerized cargo, Penang Port provides important access for shippers in the northern states of Peninsular Malaysia and also the southern provinces of Thailand.

The proposed Project site is located on the southern bay of Penang Island which is outside of the boundary of the Penang Port Limit. One of the accesses to Penang Port, called South Channel, is located adjacent to the Project site as illustrated in F6.38. F6.39 shows the main existing marine facilities located in Penang.



F6.38
North and South Channels



F6.39
Main marine facilities in Penang

i) Marine Facilities

Several marine facilities can be found within the Penang Port Limit which are as follows:

- *Swettenham Pier* - Passenger traffic for leisure cruises is handled at the Swettenham Pier Cruise Terminal located on the island of Penang.
- North Butterworth Container Terminal (NBCT) - NBCT is equipped with six berths (N1 to N6) that are 1.5 km in total length together with 13 Quay Gantry Cranes (QGCs). Out of these cranes, seven are post Panamax QGCs capable of handling vessels with 18 rows of container across. Berth capacity is currently at 2 million Twenty-foot Equivalent Units (TEU) per annum.
- *Ferry Terminal* - Penang Port provides ferry services from 5:30 am to 1:00 am linking Georgetown (Raja Tun Uda Terminal) on the island with Butterworth (Sultan Abdul Halim Terminal) on the mainland. It operates a fleet of eight ferries, namely *Pulau Pinang, Pulau Payar, Pulau Angsa, Pulau Kapas, Pulau Undan, Pulau Rawa, Pulau Talang-Talang* and *Pulau Rimau*.
- *Butterworth Deep Water Wharves (BDWW)* - Break-bulk handling is primarily undertaken at BDWW, a terminal completed in 1969. Located on the mainland, BDWW is capable of handling 2.5 million tonnes of cargo per annum. It offers a linear berth with a length of 1.05 km.
- *Prai Bulk Cargo Terminal* - This dedicated bulk cargo terminal was built to handle both dry and liquid bulk cargoes. The terminal is situated south of Perai Power Station and to the north of the Penang Bridge. It has 5 berths and measures 632 m in length. This terminal is capable of handling 3.9 million tonnes of cargo per annum whereby 500 m of berth is utilized for normal dry-bulk cargo while the remaining 132 m of berth is used for handling Dangerous Goods (DG) in either liquid or gaseous state. An inner berth measuring 154 metres in length allows for the handling of both dry and liquid bulk cargo.
- *Private Terminals* - Oil storage depots found in Butterworth were first set up more than 100 years ago. They are very near to the sea ports, industrial estate and busy shipping lane of Penang Straits. In 2013 about 2.7 million tonnes were handled at private terminals operated by companies such as Chevron, Petron and Shell who together with Petronas are the biggest players in the liquid bulk market.

T6.23 shows the number of vessel calls at Penang Port for the past few years encompassing various types of vessels.

T6.23 Number of vessel calls at Penang Port

Year	Type of Vessel							Total
	Ferry	Container	Tanker	Bulk Carrier	General Cargo	Others	Cruise Vessel	
2013	762	1,557	1,140	210	711	407	1,331	6,118
2014	1,000	1,557	1,058	193	627	428	1,201	6,064
2015	1,180	1,529	1,098	238	610	444	1,128	6,227

Source: Penang Port Sdn. Bhd.

ii) Bridges

Apart from the marine facilities, it should be noted that both of the bridges connecting Penang Island and the mainland are situated within the Penang Port Limit. The bridges are:

- *Penang Bridge* - The bridge is 13.5 km long with a span of 8.4 km over water that connects Prai on the mainland with Gelugor on the island. The iconic centre span has a height limitation of 28 m for vessels passing underneath it.
- *Sultan Abdul Halim Muadzam Shah Bridge* - Conversationally known as "The Second Bridge", it connects Bandar Cassia (Batu Kawan) in Seberang Perai with Batu Maung on Penang Island. The total length of the bridge is 24 km with length over water at 16.9 km. It too has a height limitation of 28 m for vessels passing underneath it.

iii) Fishing Vessels

Based on the location of the proposed Project site, it is expected that most of the fishermen affected are from the Southwest District of Penang. The total number of fishermen in the SW District is approximately 2,757 while the number of licensed fishing boats is about 733 boats, as shown in T6.24.

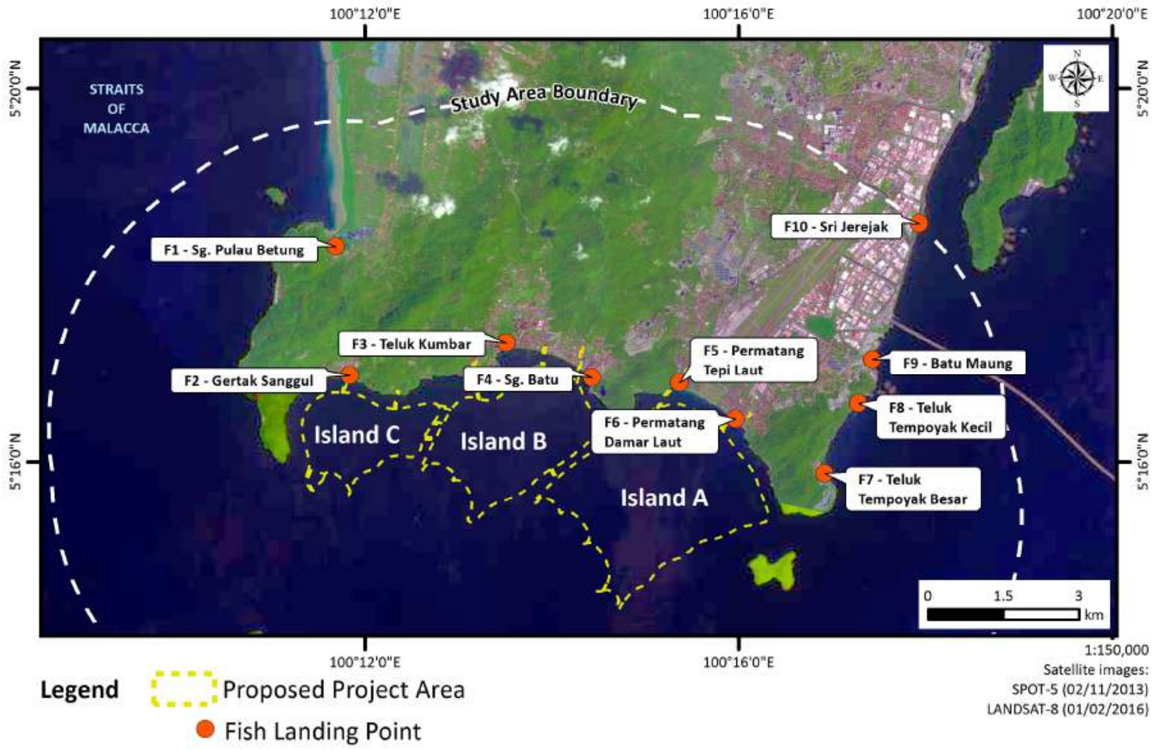
T6.24 Fish landing points and the numbers of registered fishermen and licensed boats

Fish Landing Points	No. of Fishermen	No. of Boats		
		Outboard Engine	Inboard Engine	Total
Permatang Damar Laut	185	91	1	92
Sungai Batu	180	90	0	90
Teluk Kumbar	220	129	1	130
Gertak Sanggul	106	56	4	60
Sri Jerjak	92	50	0	50
Batu Maung	1,591	40*	77	117*
Teluk Tempoyak	157	85	0	85
Pulau Betung	226	109	0	109
Total	**2,757**	**650**	**83**	**733**

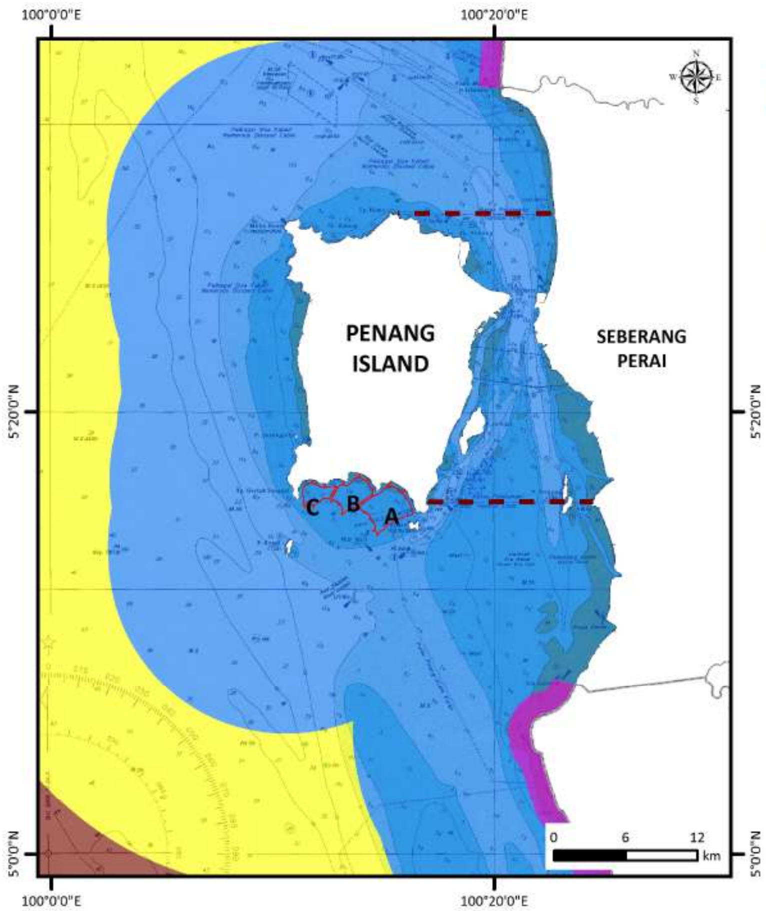
Source: Department of Fisheries, Penang (2016) - unpublished
Note: *Estimated

Focusing on the southern bay of Penang Island, there are a few fishing villages located along the shoreline adjacent to the Project site. The identified fish-landing points are shown in F6.40. Meanwhile, T6.24 listed each of the fish-landing points together with the respective numbers of registered fishermen and licensed boats.

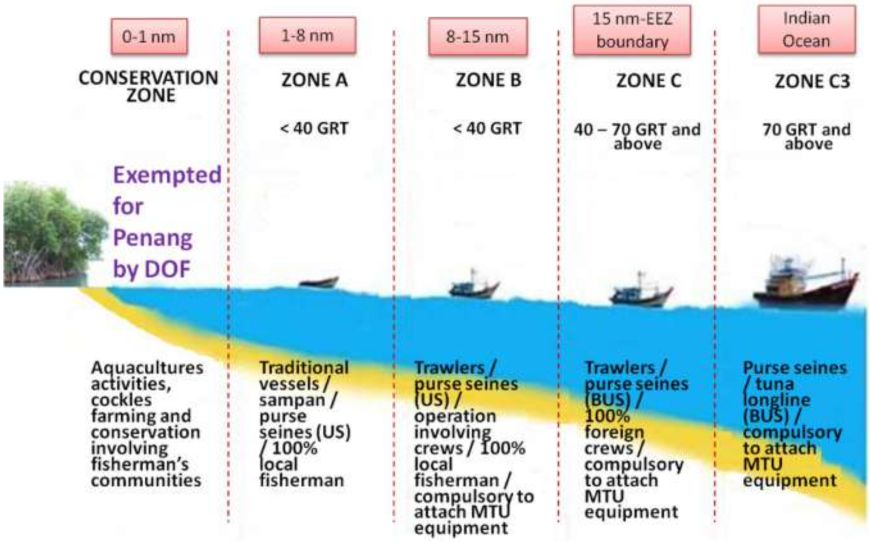
Fishing activities are carried out within the straits between the island and mainland and as far out to the Straits of Malacca. According to the prevailing regulation, no fishing is allowed within one nautical mile from the coastline as it is considered as conservation zone. However, Penang has been exempted from having a conservation zone as per the letter by the Department of Fisheries (DOF) [Ref No: Prk.ML.08/35-22(71)]. This exemption is due to complaints from local fishermen through *Persatuan Nelayan Pulau Pinang* of the shrinking fishing area caused by the presence of the conservation zone. The fishing zones are illustrated in F6.41. Details of the fishing zones are shown in F6.42. Artisanal fishing is allowed within Zone A while boats equipped with commercial fishing gears are required to operate within Zone B and beyond. Fishing boats do criss-cross the navigational channels when sailing to and from their fishing grounds.



F6.40 Fish landing points



F6.41 Fishing zones for Penang



Source: Department of Fisheries Malaysia

F6.42 Details of each fishing zone

6.2.11.3 Existing Marine Traffic Procedures and Safety Rules

a) Penang Port Control

Penang Port Control monitors and regulates marine traffic in the Port Area and the respective navigable waters within the Port Limit. The movement of all vessels within the Port Limit must obtain prior permission from the Penang Port Control.

Pilotage is mandatory for the movement of ships of 600 Gross Register Tonnage (GRT) and above within the pilotage compulsory area, as well as ships of 200 GRT and above berthing or unberthing at private jetties or the port's wharves.

b) Existing navigation

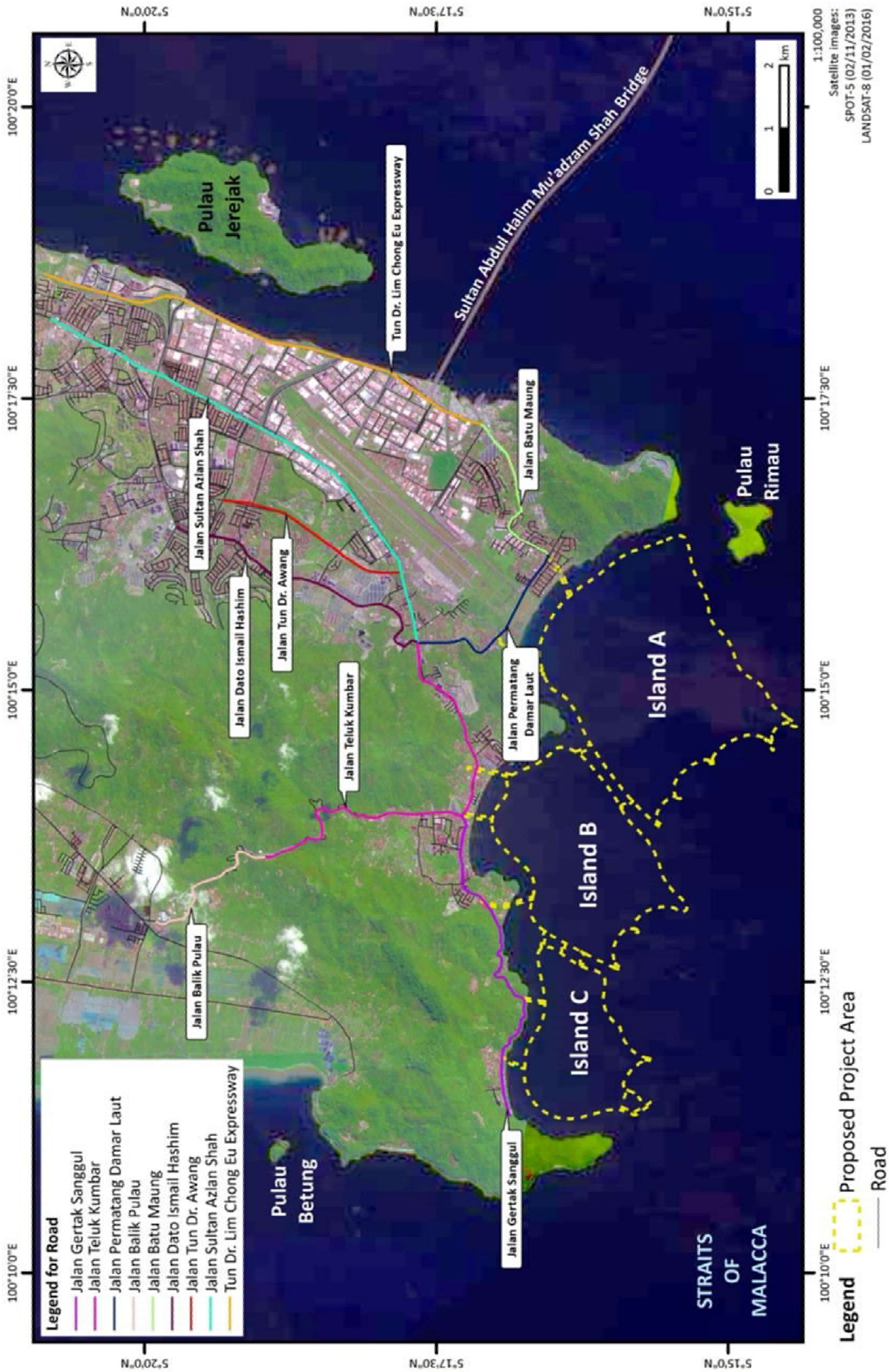
Penang Port can be approached using the North or South Channel:

i) *North Channel* - The North Channel is the primary approach to Penang Port and it is used by most vessels. The main ship channel is 10 miles in length, has a width of 183 m and a depth of at least 10.2 m. North Channel can be approached via the North Channel Light Float (5° 35.9' N, 100° 12.45' E). Vessels awaiting pilot can anchor in the pilot waiting area. Approaches to the port area are well marked by navigational aids.

ii) *South Channel* - For entry through the South Channel, a pilot will be taken on board near the Rimau Wreck Buoy located 1.6 km south of Pulau Rimau Lighthouse. The approach via this channel is restricted to vessels with water draft and air draft of 6 and 28 m respectively. The number of vessels using South Channel is very small in comparison with the total vessel calls at Penang Port.

6.2.12 Land Traffic

The study area is illustrated in F6.43. The area consists of all major road corridors and junctions likely to be affected by the traffic volumes generated by the proposed PSR development, including all site access points to Islands A, B and C, major junctions and roadway sections in proximity of the PSR development.



F6.43 Traffic study area

6.2.12.1 Methodology

Traffic counts were undertaken at major junctions during the AM and PM periods to capture typical traffic conditions during a commuter weekday. These junctions were selected due to their close proximity to the PSR islands. Vehicles entering and leaving each survey station are recorded in 15-minute intervals and classified as motorcycles, cars, light trucks, heavy trucks or buses. Video cameras were set up at the selected sites to capture the vehicle flows and turning movements. The counts are then enumerated manually for the nominated AM and PM peak hours.

6.2.12.2 Passenger Car Unit (PCU) Conversion Factors

For the purpose of assessing the capacity of the road network, each vehicle classification is converted into PCUs to reflect the amount of road capacity they use in relation to a standard car. The conversion unit from vehicles to PCUs for the observed classes of vehicles is based on the values provided by Trip Generation Manual (HPU Malaysia), 2010 as summarised below in T6.25.

T6.25
PCU conversion factors

Vehicle Classification	PCU Conversion Factor
Car/Van/4WD/MPV	1.00
Motorcycles	0.33
Light lorry	1.75
Lorry/truck/heavy vehicles	2.25
Buses/coaches	2.25

Source: Trip Generation Manual (HPU Malaysia), 2010

6.2.12.3 Definition of the Peak Periods

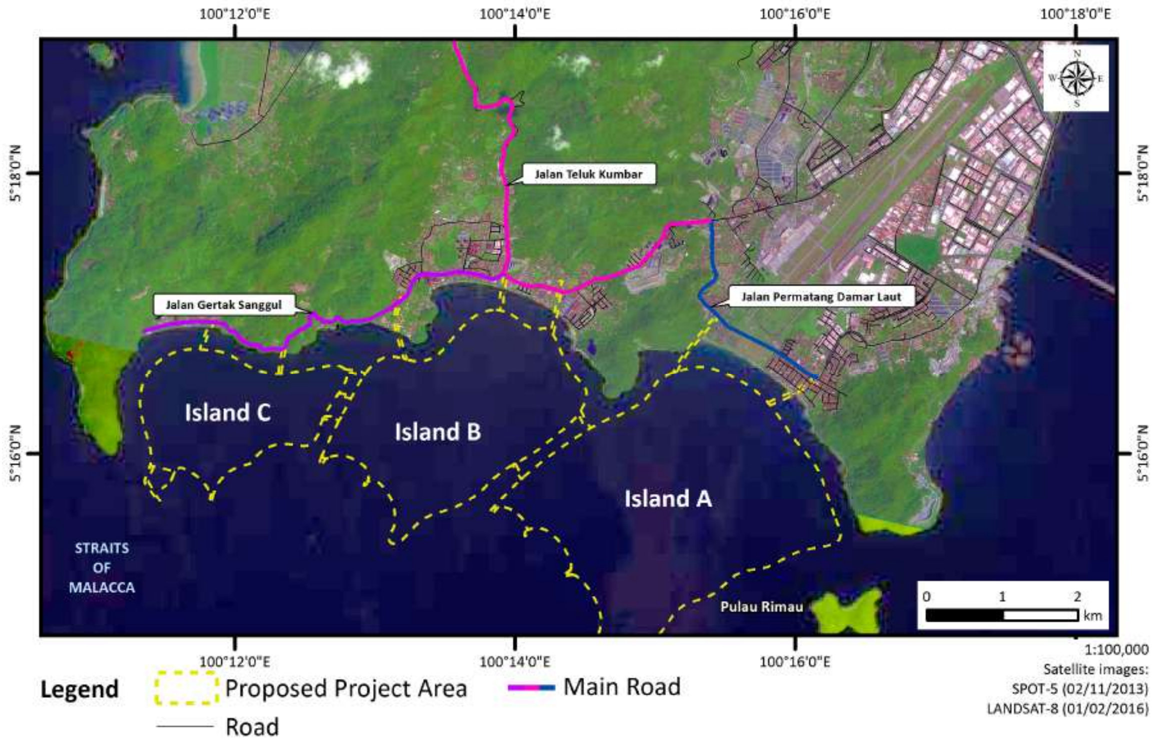
The peak hour periods were determined by analysing the hourly traffic flows at all junctions within the study area. Based on analysis of the traffic flow data collected, the peak hours are found to occur during the following periods:

a) AM peak: 0730 – 0830 hours; and
b) PM peak: 1730 – 1830 hours.

6.2.12.4 Existing Major Roads

The major roads that are included in the study area in close proximity to the proposed PSR development are (F6.44):

a) *Jalan Permatang Damar Laut* - F6.45 shows the configuration of Jalan Permatang Damar Laut which is 2-lane 2-way road. Jalan Permatang Damar Laut is a major state road (P10) functioning as a collector road from Batu Maung to Teluk Kumbar area.
b) *Jalan Teluk Kumbar* - This is one of the major federal roads (6) with the 2-lane 2-way type road that connects Jalan Permatang Damar Laut and Jalan Balik Pulau. The road condition is shown in F6.46.
c) *Jalan Gertak Sanggul* - Jalan Gertak Sanggul is a 2-lane 2-way road which is categorized as a state road that is divided into two which are P226, from Jalan Teluk Kumbar to Jalan Kampung Masjid and P224, the state road from Jalan Kampung Masjid to the Gertak Sanggul area. This road functions as the main collector road for Gertak Sanggul area as shown in F6.47.



F6.44 Existing major roads nearest to proposed PSR

F6.45 Jalan Permatang Damar Laut (towards Batu Maung)

F6.46 Jalan Teluk Kumbar (from Jalan Permatang Damar Laut)

F6.47 Jalan Gertak Sanggul (from Teluk Kumbar)

6.2.12.5 Existing Traffic Volumes

The operational conditions of the roadways are based on the “Level of Service” (LoS) concept to classify the varying conditions of traffic flow. Levels of service are designated from “A” through “F”, from best to worst, covering the entire range of traffic operating conditions. LoS “A” through “E” generally represents conditions where traffic volumes are at less than the facilities capacity, while LoS “F” represents conditions where capacity is exceeded and/or forced conditions exist. For both signalized and non-signalized junctions, the Level of Service (LoS) relates to the delay experienced by traffic at the junctions. T6.26 shows the relationship between delay and the LoS. The current junction performance for the AM and PM peak periods is tabulated in T6.27 and also illustrated in F6.48 and F6.49.

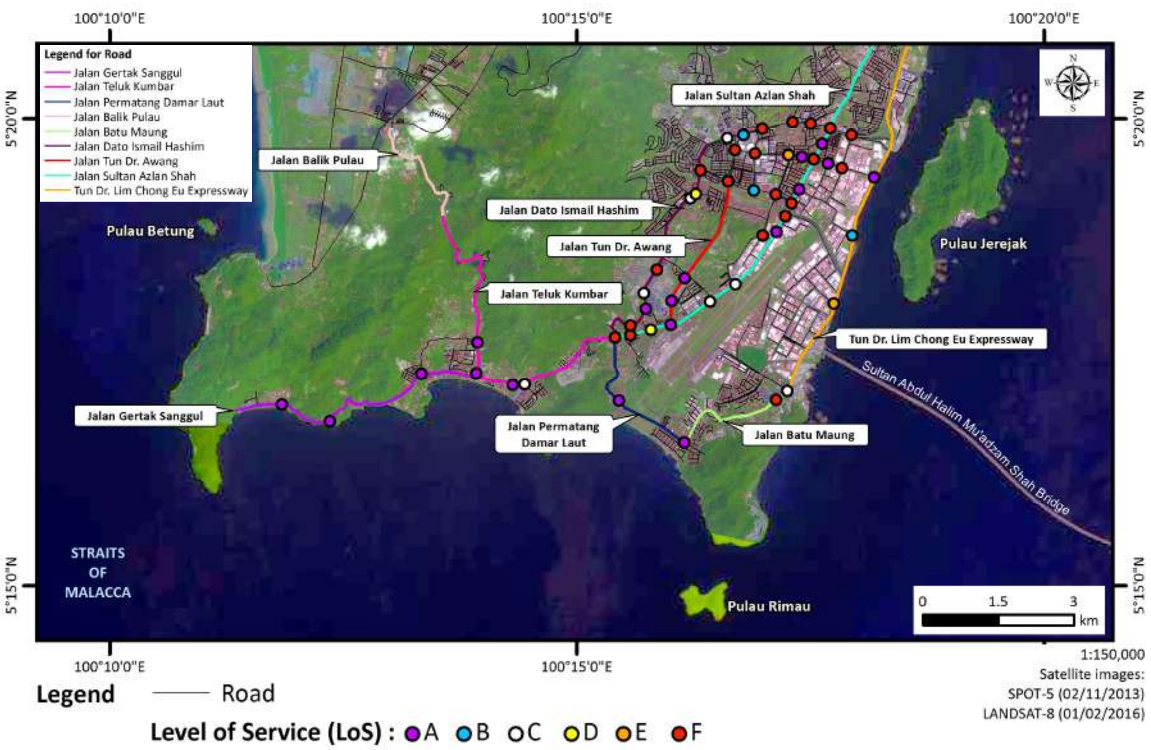
Level of Service	Controlled Delays in Seconds	
	Priority Junctions	Signalised Junctions
A	=< 10 seconds	=< 10 seconds
B	>10 -15 seconds	>10 - 20 seconds
C	>15 - 25 seconds	>20 - 35 seconds
D	>25 - 35 seconds	>35 - 55 seconds
E	>35 - 50 seconds	>55 - 80 seconds
F	> 50 seconds	> 80 seconds

T6.26 LoS for signalized and priority junctions

Source: REAM, 2002

Level of Service		A	B	C	D	E	F
Number of junctions	AM	18	3	7	2	2	20
	PM	19	3	4	5	7	14

T6.27 Existing number of junctions for each LoS (2015) (AM and PM) junction performance



F6.48 Existing AM peak hour junction performance