5 Existing Environment

This section provides background information on the existing physical-chemical, biological and human environment for the Project area and the assessment zones. The key sensitive environmental receptors are identified and described. The information is based on baseline surveys and secondary information from literature and other reports for the area.

The spatial areas of focus or extent around the Project site are variable, depending on the environmental component in question, and has been based on the anticipated zone of impacts identified during the scoping phase and outlined in the approved TOR. As mentioned in Chapter 1, the following principle distances are being applied:

- Marine physical and biological environment – 10 km radius from the project boundary;
- Terrestrial physical environment – 5 km radius from the project boundary; and
- Socioeconomics and Public health – 5 km radius.

Details of the methods and results of the baseline surveys are given in the appendices.

5.1 Physical-Chemical Environment

5.1.1 Data Collection and Sources

The existing physical-chemical environment for the project area is described within a radius of between 5 km and 10 km from the boundary of the project footprint depending on the relevant component.

The description of the physical-chemical environment is based on primary data supported by available published secondary data as detailed in Table 5.1.

Table 5.1 Details of data collection for physical-chemical environment

Component	Type of Data	Source	Date of Collection
Topography and bathymetry	Primary	Ground survey	2012
Geology	Secondary	Geological map by JUPEM	Map dated 1985
Marine sediment	Primary	Transect line for 60 stations	2013
Meteorology	Secondary	• Meteorological Department • DHI Internal Data	2010 – 2012
Hydrographic conditions	Primary	Hydrographic survey	2013
Hydrology and drainage	Secondary	Mapping using satellite image and verified by site observations	2013
Coastal morphology	• Primary • Secondary	• Ground survey • Literature	• 2013

Component	Type of Data	Source	Date of Collection
Marine and rivermouth water quality	Primary	Ground survey	• NE monsoon: 31 January – 1 February 2013 • Intermonsoon: 21 – 23 May 2013 • SW monsoon: 20 – 22 August 2013
Air quality	Primary	Ground survey	28 February – 2 March 2014
Ambient noise	Primary	Ground survey	28 February – 2 March 2014
Vibration	Primary	Ground survey	16 – 19 June 2014

5.1.2 Topography and Bathymetry

5.1.2.1 Topography

The project area is located at south-east coastal waters of Pontian district and the topography of this area is mainly made up of flat or slightly undulating land of less than 5 – 10 m elevation where palm oil tree and rubber tree plantations dominate. Low land comprised of mudflat areas are found along the shoreline where mangrove trees can be seen.

5.1.2.2 Bathymetry

The proposed reclamation area is located in the shallow tidal flats between Tg. Bin and Tg. Piai. The bathymetry of the area is based on recent topographic and bathymetric surveys of the area and sea chart information. Details of the survey data are given in Appendix C. The compiled bathymetry at a regional scale is shown in Figure 5.1 and for the project area Figure 5.2. Key characteristic features of the area include:

- The areas off Tg. Piai are quite shallow and wide sub-tidal mudflats extend from the shore 4 km towards the navigation channel and 5.7 km in the north to south direction;
- A navigation channel to the east of the Project site has been dredged to -17.5 m CD to allow access of large vessels into the Port of Tg. Pelepas (PTP) area, the Tg Bin oil storage facilities and the Tg. Bin power plant. The channel curves smoothly into Sg. Pulai just east of the abandoned APH (Asian Petroleum Hub) reclamation south of Tg. Bin.
- The area to the east of the navigation channel is also quite shallow with maximum depths of approximately -5 m CD. The deepest natural depth areas to access the Straits of Johor occur next to the Singapore coastline. It should be mentioned that the international border between Malaysia and Singapore is placed along the deepest natural point;
- Approximately 1 km south of Tg. Piai there is sudden increase in water depths. Over a distance of less than 100m, water depths decrease from -1 m CD to -30 m CD;
- West of Tg. Piai there are extensive shallow mudflat areas that extend up to Pulau Kukup and beyond. The 0 m CD contour (marking the boundary of the intertidal area) is located a few hundred meters from the shoreline; and
- The Sg. Pulai area has a large and complex channel system through mangroves which has a significant exchange of water during the tidal cycle.

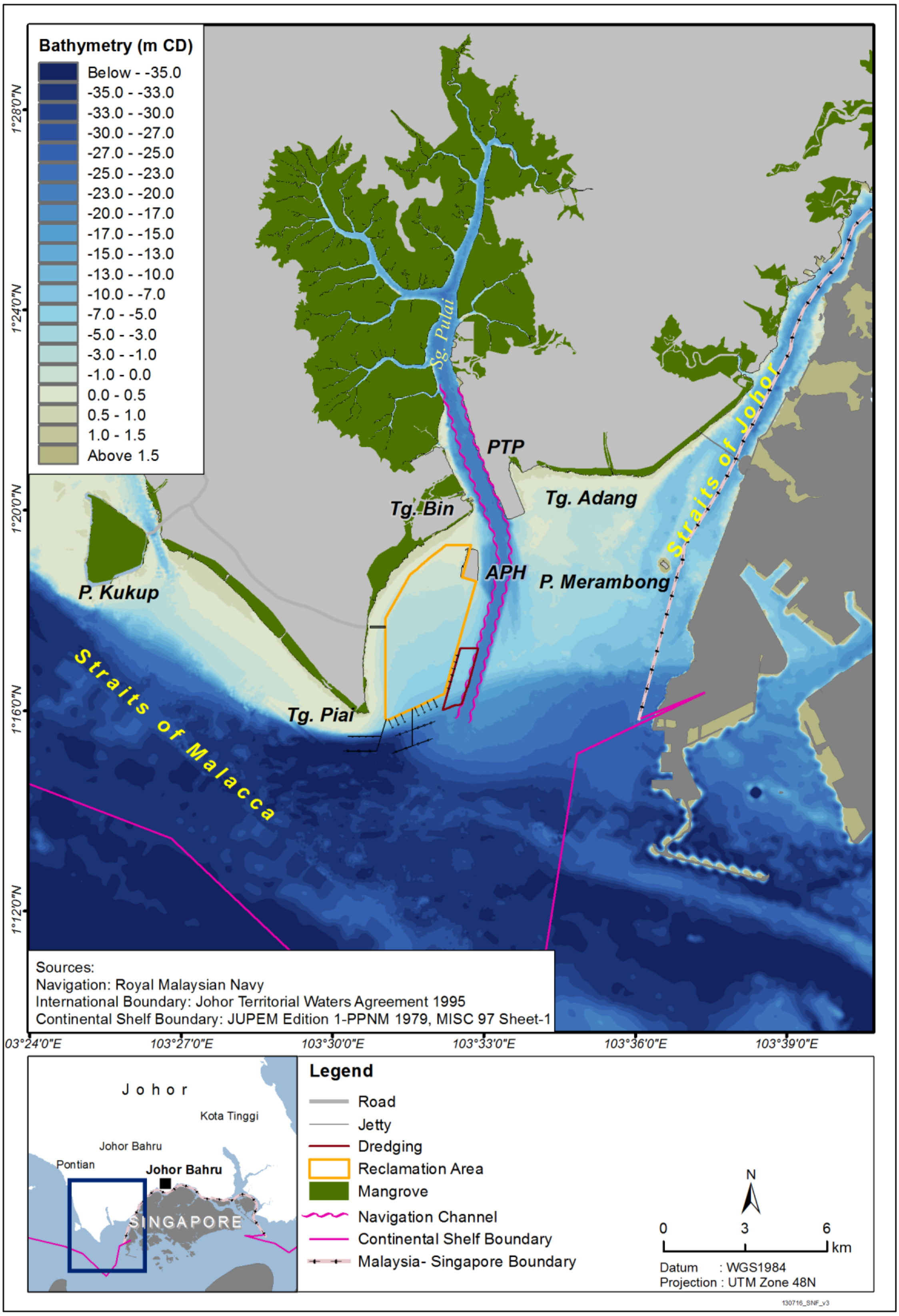

Figure 5.1 Bathymetry and project area with reclamation outlined in orange.

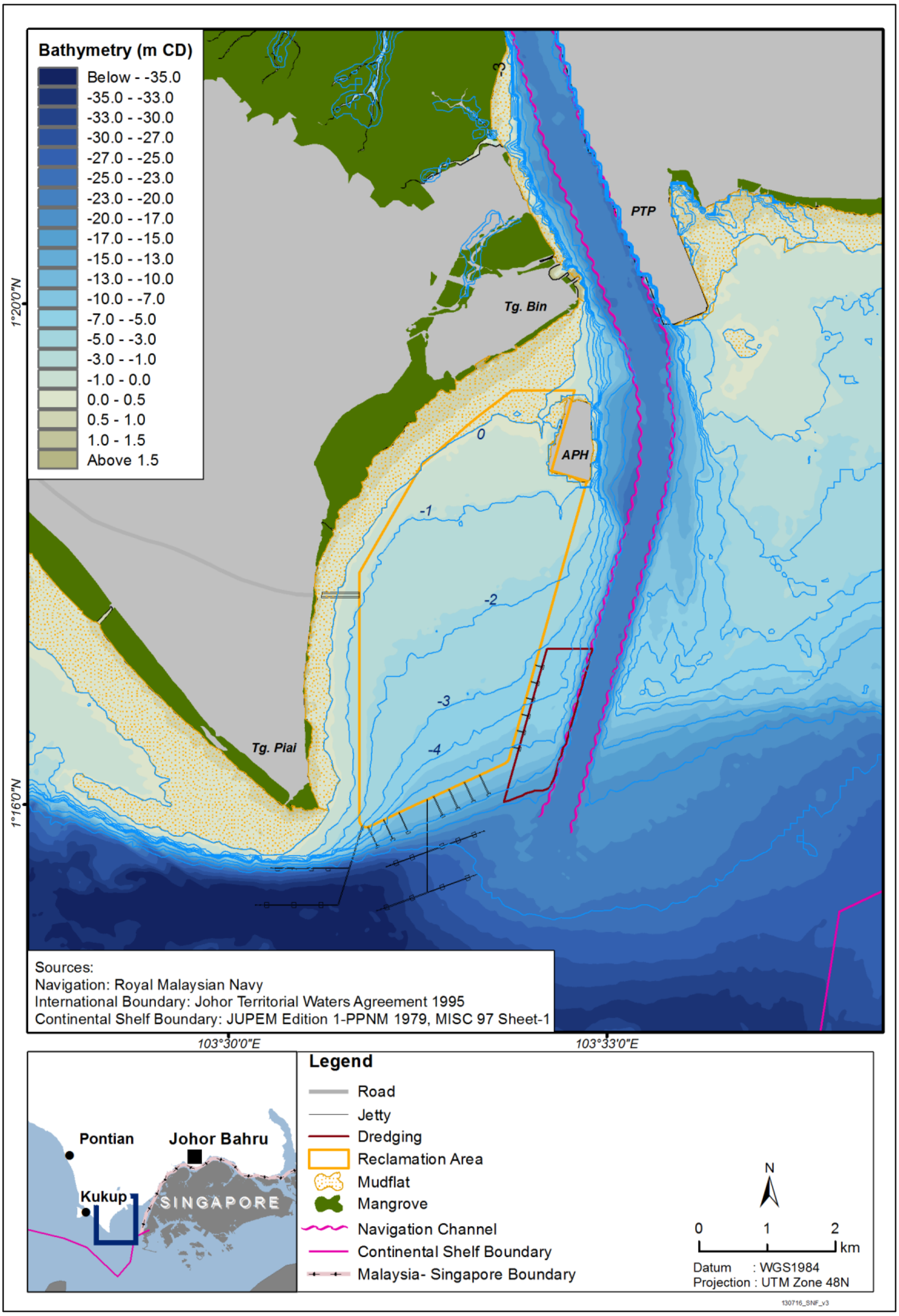

Figure 5.2 Detail of the bathymetry and proposed project area outlined with reclamation delineated in orange and dredging basin in burgundy

5.1.3 Geology

The underlying geological formation within 5 km radius from the project area occurred in the Quaternary period. The bedrock of this area is similar to basaltic rocks found in Kuantan area, which was formed during early Pleistocene age. Basalt is a type of igneous rock, which undergoes rapid weathering process to form brown or rust-red materials.

In general, marine and continental deposits consisting of clay, silt, peat with minor gravels are found in this area. Clay and silt deposits cover approximately 70% of the area and is concentrated along the coast. Dark deposits of peat, humic clay and silt combination are found in the interior part of the study area which covers approximately 30% of this area. The geology of the study area is shown in Figure 5.3.

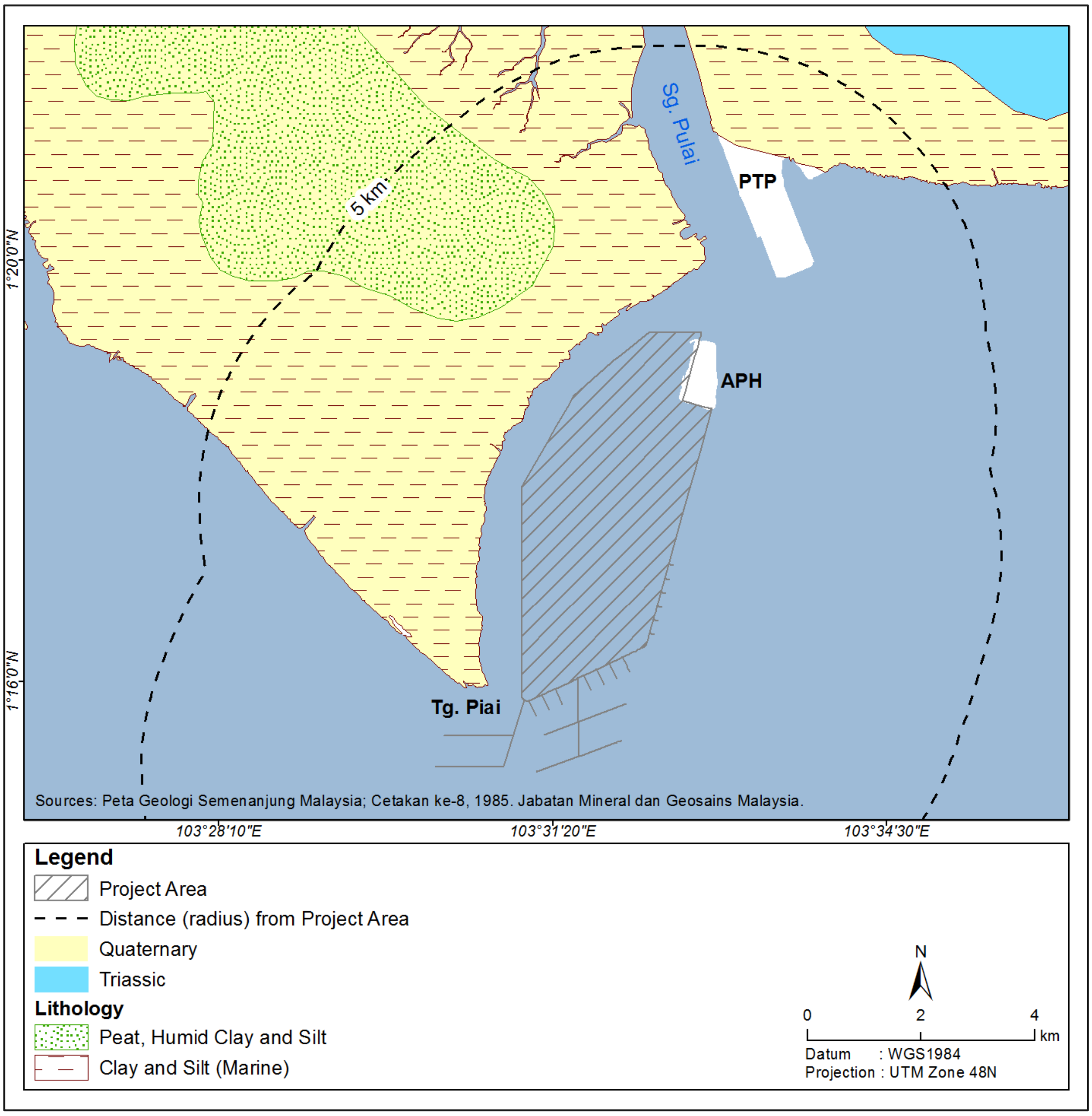

Figure 5.3 Geology of the study area

5.1.4 Marine Sediments

The type and nature of the marine sediments in the area reflect their origin, being both marine and terrestrial, as well as their topographic location and the degree of exposure to energy regimes that can lead to deposition and / or resorting and suspension as a result of waves and currents. Terrestrial origins can be local (from within the region) such as silt and sands carried out by riverine outflow or from sources farther afield and transported over geological time scales. Marine derived sediments are usually the result of biogeochemical processes associated with the deposition of calcium from the remnants of both pelagic and benthic organisms.

To obtain an understanding of the range of sediment types within the project area, surface sediment samples were collected from 85 sites across a range of water depths and analysed for texture (grain size) and chemistry.

5.1.4.1 Sediment Grain Size

Grain size analysis for sediment samples within the project area are shown in Figure 5.4. A high percentage of silt was noted for sediments collected north of P. Kukup and along the coastline south of Kukup town in Malacca Strait. Silt content exceeded the 50 percentile for the sediments samples obtained in this section.

Samples collected southwest of Tg. Piai and across the project area up to Tg. Bin showed a high percentage of silt followed by sand and clay. In contrast, samples collected south of Tg. Adang showed a high percentage of sand, increasing with depth.

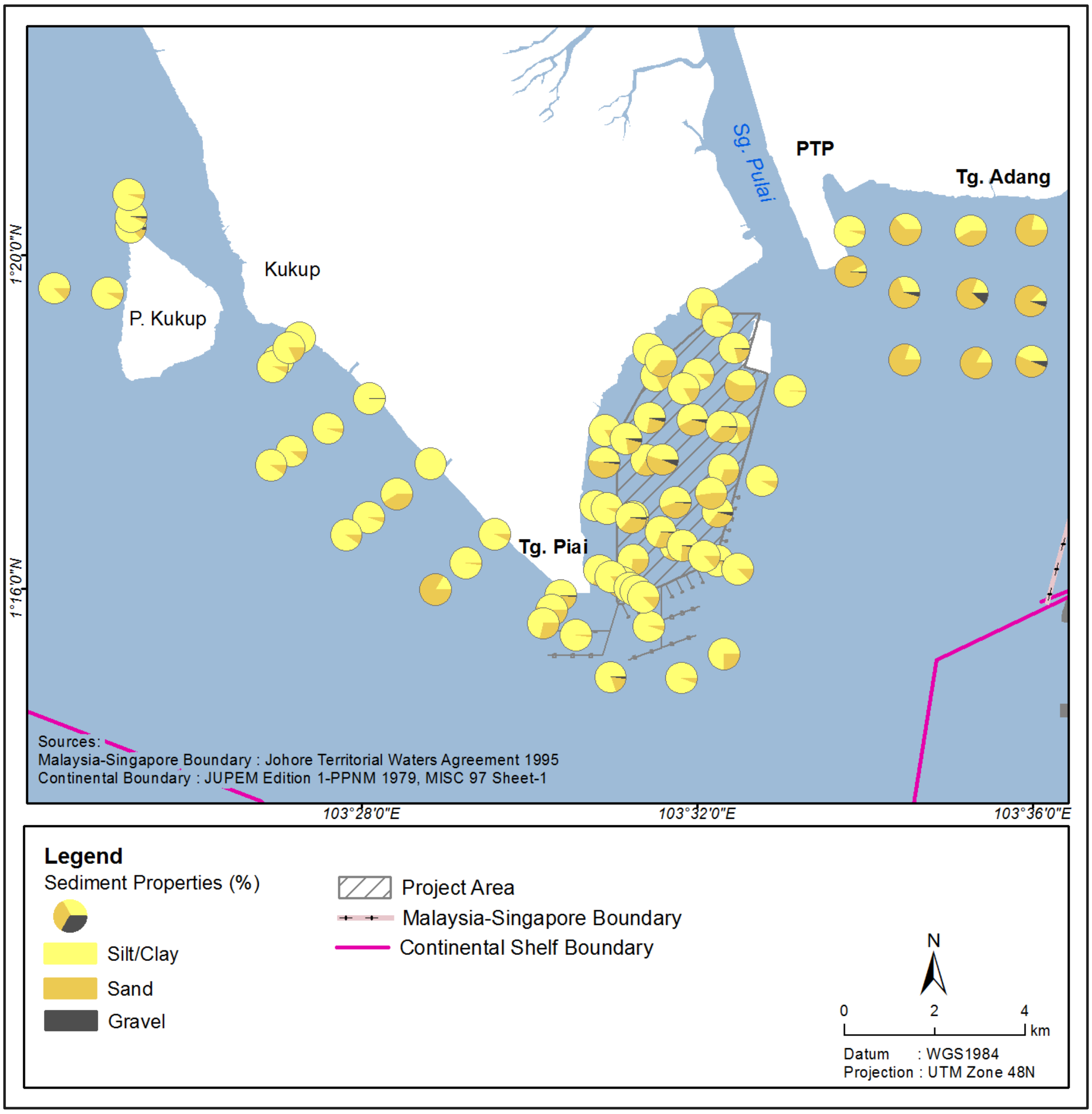

Figure 5.4 Sediment grain size properties for surface marine sediments samples collected within and around the proximity of the proposed development

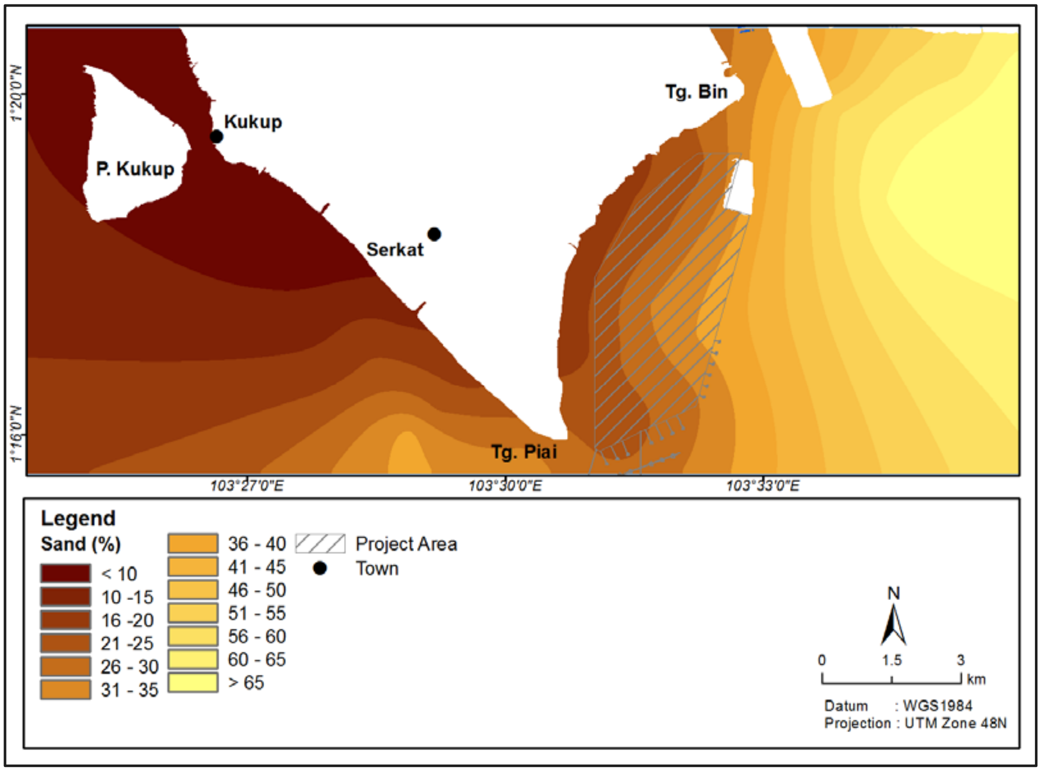

Figure 5.5 Sediment (% Sand).

5.1.4.2 Sediment Chemistry

Chemical Analysis

Samples from five (5) stations within the proposed dredging area were analysed for metals, Total Petroleum Hydrocarbons (TPH) and organic composition. The result are presented in Table 5.2 as are Reference Values and Target Values obtained from the Netherlands Standards /1/. Reference Value is the reference level indicating whether dredging spoil is still fit for discharge in surface water, under certain conditions, or should be treated otherwise. It indicates the maximum allowable level above which the risks for the environment are unacceptable. Target Value indicates the level below which risks to the environment are considered to be negligible, at the present state of knowledge.

It can be seen that the only metals that occurred in measureable concentrations were copper, lead, zinc and nickel. The occurrence of these metals can be a result of both geochemical and anthropromorphic sources, however, none were at concentrations that exceeded the reference values. There were no measureable concentrations of TPHs.

All of the samples had extremely high percentages of organics which most likely reflects the input of material from the adjacent mangrove systems as well as from the high phytoplankton concentrations that occur in the West Johor Strait.

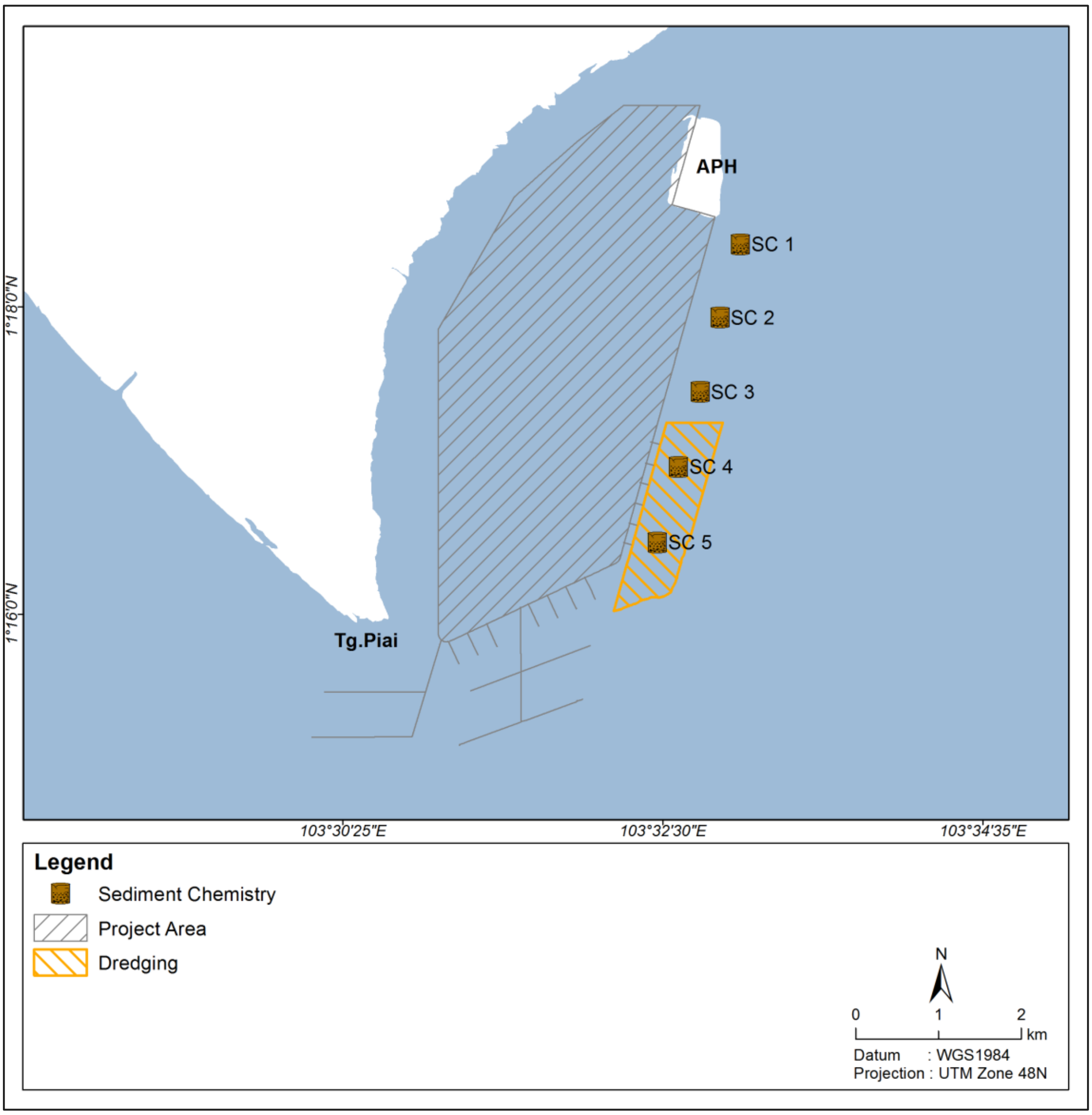

Figure 5.6 Sampling sites for the collection of surface marine sediments for chemical analysis.

Table 5.2 Laboratory results for marine sediment chemistry sampling.

Test Parameter (unit in mg/kg unless otherwise stated)	SC1	SC2	SC3	SC4	SC5	Target Value	Reference Value
Mercury (Hg)	<0.001	<0.001	<0.001	<0.001	<0.001	0.3	1.6
Cadmium (Cd)	<0.001	<0.001	<0.001	<0.001	<0.001	0.8	7.5
Chromium (Cr)	<0.03	<0.03	<0.03	<0.03	<0.03	100	380
Copper (Cu)	5.94	4.37	5.12	4.45	3.49	35	90
Arsenic (As)	<0.001	<0.001	<0.001	<0.001	<0.001	29	55
Lead (Pb)	1.18	3.54	4.21	4.1	5.05	85	530
Zinc (Zn)	15.8	19.5	17.6	17.5	14.9	140	720
Nickel (Ni)	0.46	0.48	0.14	0.65	0.66	35	45
Fluoride (F)	90.2	111	83.4	116	120	-	-
Ammoniacal Nitrogen (N)	63.3	96.8	50.9	116	113	-	-
Mineral Oil	<0.1	0.2	0.2	<0.1	0.2	50	3000
Cyanide (CN)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Organic Matter (%)	66.9	49.8	58.2	55.1	52.9	-	-
Total Petroleum Hydrocarbon (TPH) (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	-	-

Chlorophyll-a

Chlorophyll-a analysis, reflecting the amount of microphytobenthos (MPB) in the surface sediments, was also carried out on all marine sediment samples (Figure 5.7) and showed concentrations ranging between 1 – 3 µg/kg. Higher concentrations were noted in samples collected closest to the coastline, most likely reflecting a higher incidence of light reaching the sediment surface. MPBs can make a significant contribution to the overall productivity of this sort of ecosystem being an important food source for benthic grazing animals as well as having a strong influence on the availability of nutrients through nutrient transfomations in surface sediments and fluxes between the water column and the sediments.

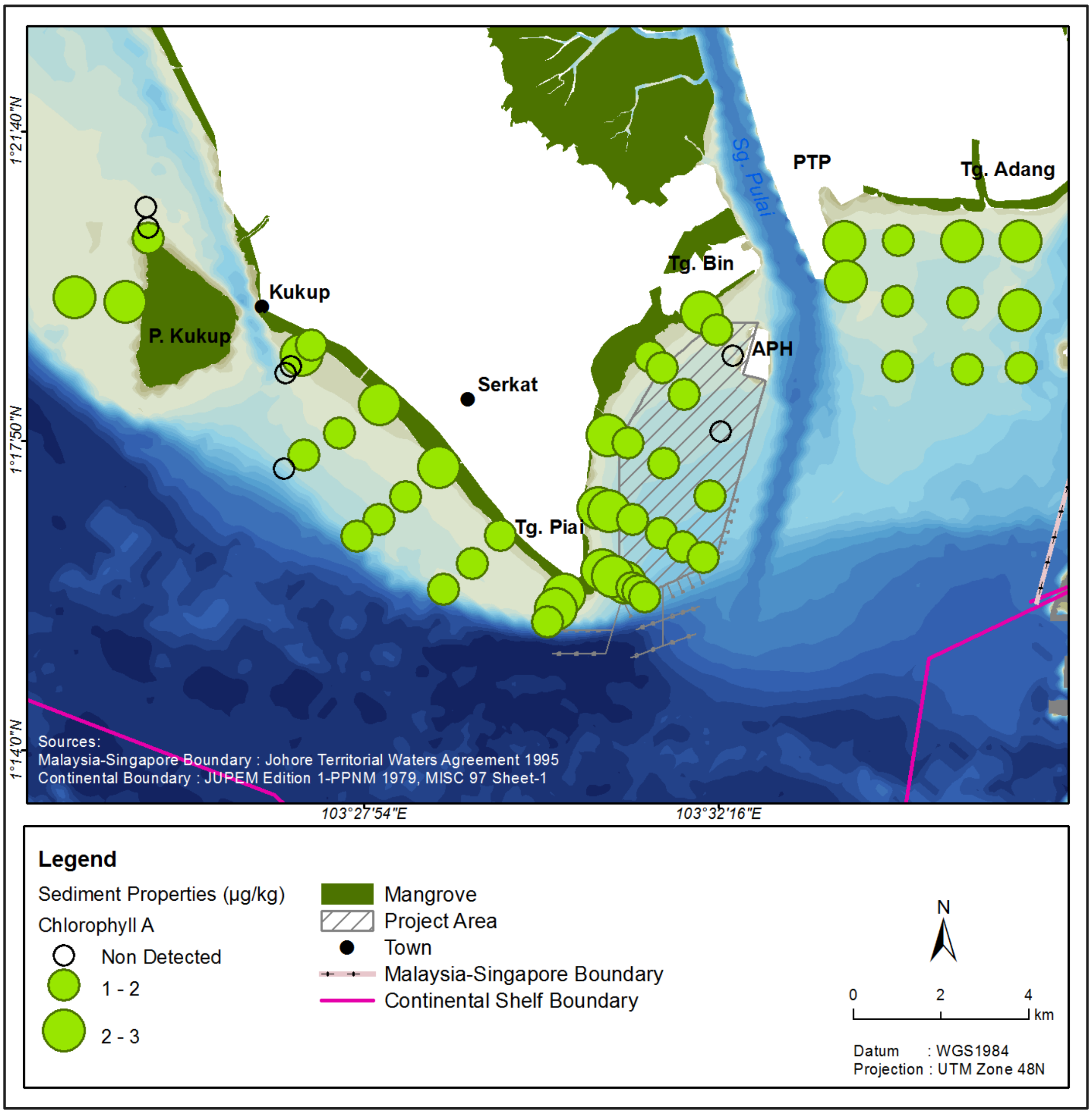

Figure 5.7 Chlorophyll-a presence in surface marine sediments samples

5.1.5 Meteorology

5.1.5.1 Wind

There are no wind records within reasonable proximity of the site. Three (3) sets of wind measurements were obtained from the following stations as shown in Figure 5.8:

- Senai Airport;
- Jurong Flatted Factory (JFF);
- Semakau.

The Senai airport data record, while it provides long-term information on wind speed and direction, is located greater than 20 km inland and is not considered to accurately describe winds over the open sea.

While records at Jurong Flatted Factory (JFF) and Semakau cover a short period, the Jurong Flatted Factory (JFF) meteorological station (operated by Singapore Metrological Services Division) is located inland, approximately 20 km from Tg. Piai. The Semakau station is located on a small island in the Singapore Straits and is also approximately 25 km from Tg

Piai. The Semakau wind station data has been used in this report as it is considered to give the most representative wind data to reflect conditions at the site.

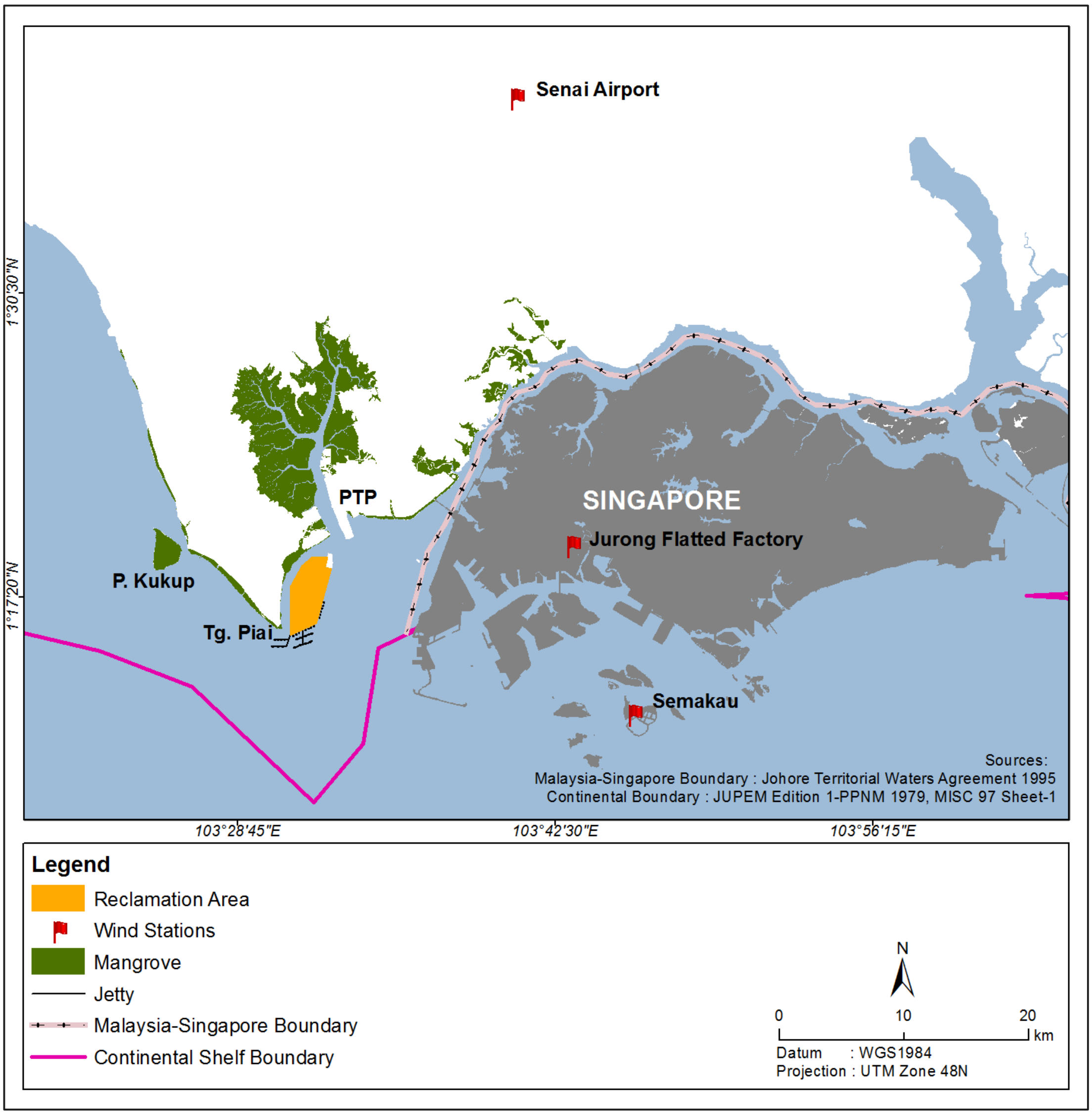

Figure 5.8 Location of meteorological stations (Senai Airport, Jurong Flatted Factory and Semakau) considered for use in this assessment.

A wind rose of the measured wind is presented in Figure 5.9. As it can be observed, predominant winds travel from the north and south directions.

The wind conditions are dominated by the monsoon conditions. The NE monsoon occurs between late October and early March, during this period winds are predominantly from the north. The SW monsoon occurs between May and early September, during this period winds are predominantly from the south. The transition periods between the monsoons is known as the inter-monsoon. Wind roses in Figure 5.10 illustrate wind conditions for the different climatic periods.

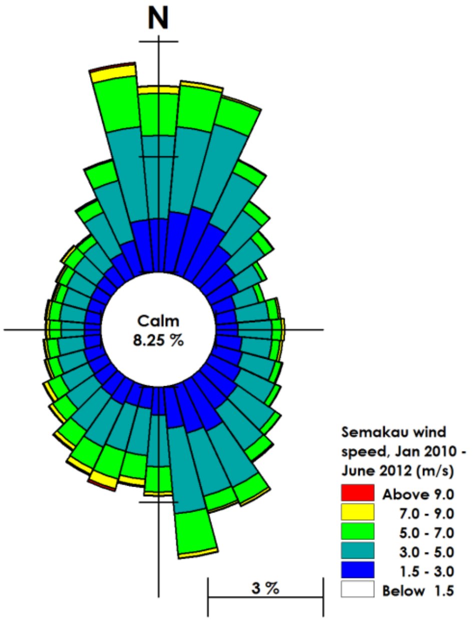

Figure 5.9 Annual wind rose based on Semakau wind measurements for the period January 2010 – June 2012.

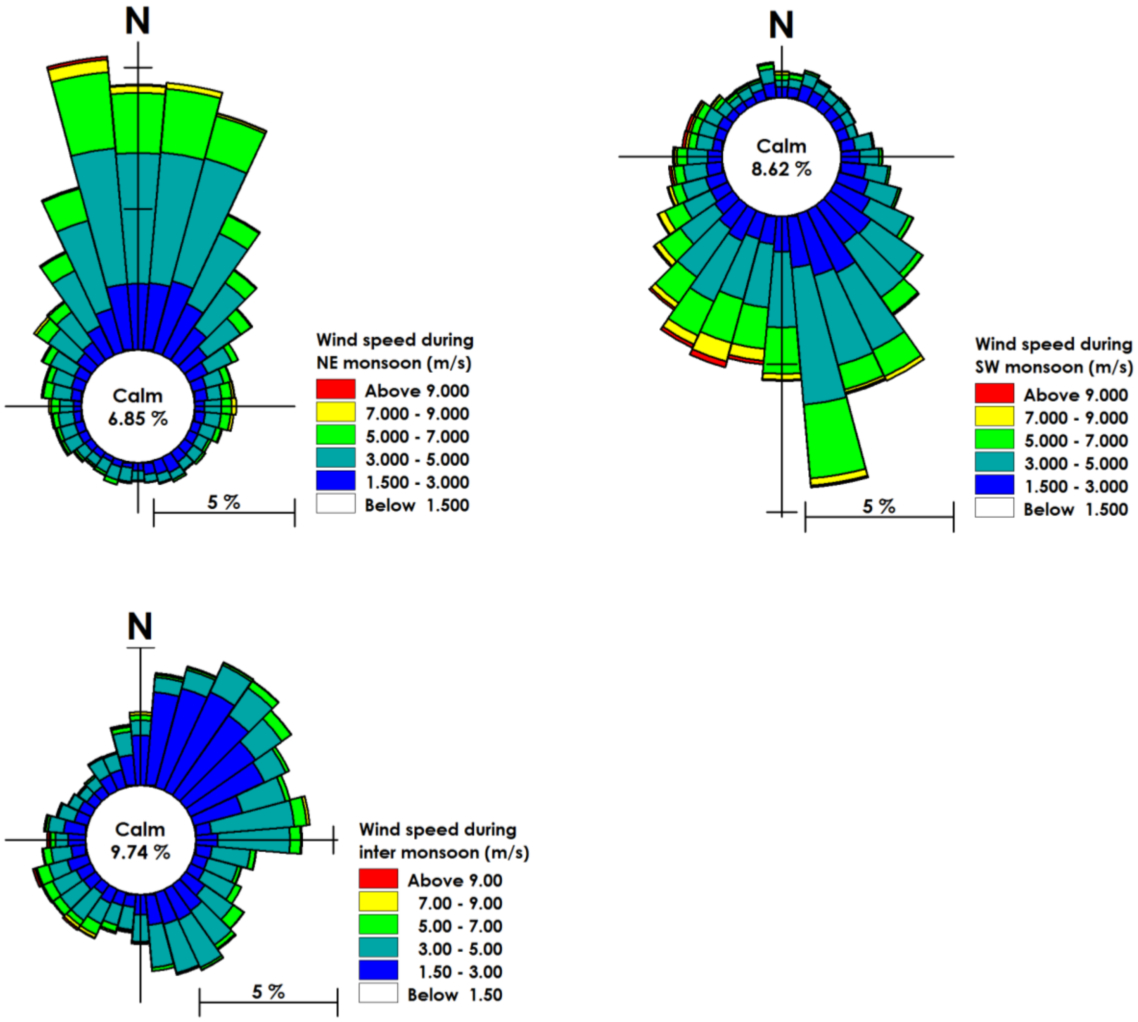

Figure 5.10 Wind roses of Semakau wind for different climatic conditions from January 2010 to June 2012.

Sumatra Squalls

Sumatra squalls are high intensity, short duration winds that occur in the region (and in the study area). They are eastward-moving systems of thunderstorms that develop at night over Sumatra or the Malacca Strait, and migrate across the west coast of Peninsular Malaysia during the SW monsoon period. The Sumatra Squalls can be recognised by their strong local gusty surface winds. These winds are accompanied by heavy rain lasting 1 to 2 hours.

The Semakau wind measurements has a 10 minute recording interval is, allowing the data to enable resolving the short-term, Sumartra squall wind phenomenon, and its variations in time. The records reveal that winds can exceed 20 m/s during these events, Figure 5.11 presents a recorded squall type event at Semakau.

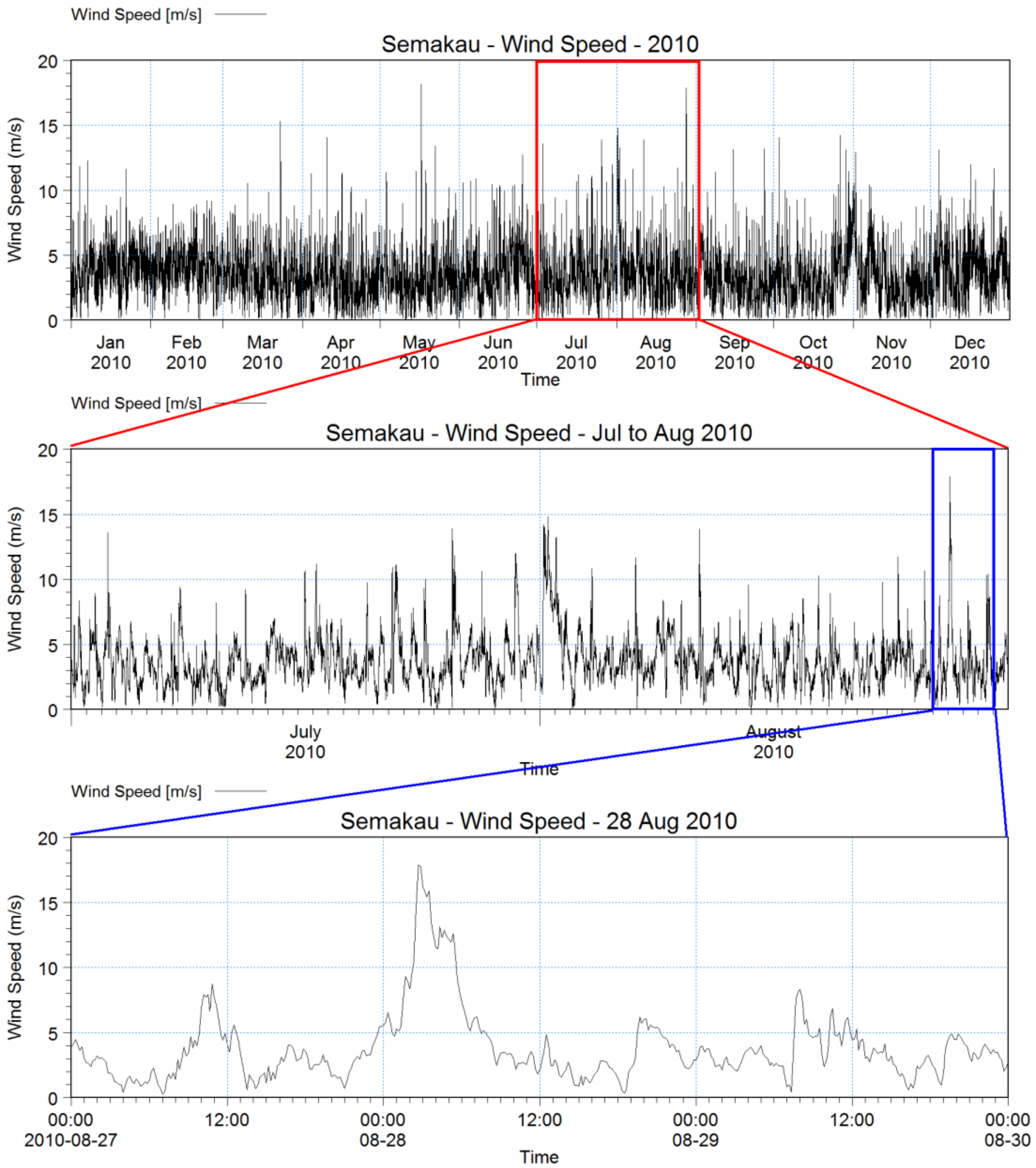

Figure 5.11 Example - Wind measurements during a Sumatra Squall on 28 Aug 2010 from Semakau station.

5.1.5.2 Rainfall

The rainfall data was obtained from two meteorological stations which located approximately 28 km (Pontian Hospital) and 71 km (Senai district of Johor) from the assessment site. Average monthly rainfall data recorded in year 2008 – 2012 at Pontian Hospital and Senai metrological station are shown below in Figure 5.12. The highest amount of rainfall recorded at Pontian was in April 2009 with 411.6 mm/month while March 2008 documented the highest amount of rainfall at Senai with 521.8 mm/month. The lowest amount of rainfall was recorded in February 2008 and January 2009 at Pontian Hospital and Senai meteorological stations with 65.8 mm/month and 44.2 mm/month respectively.

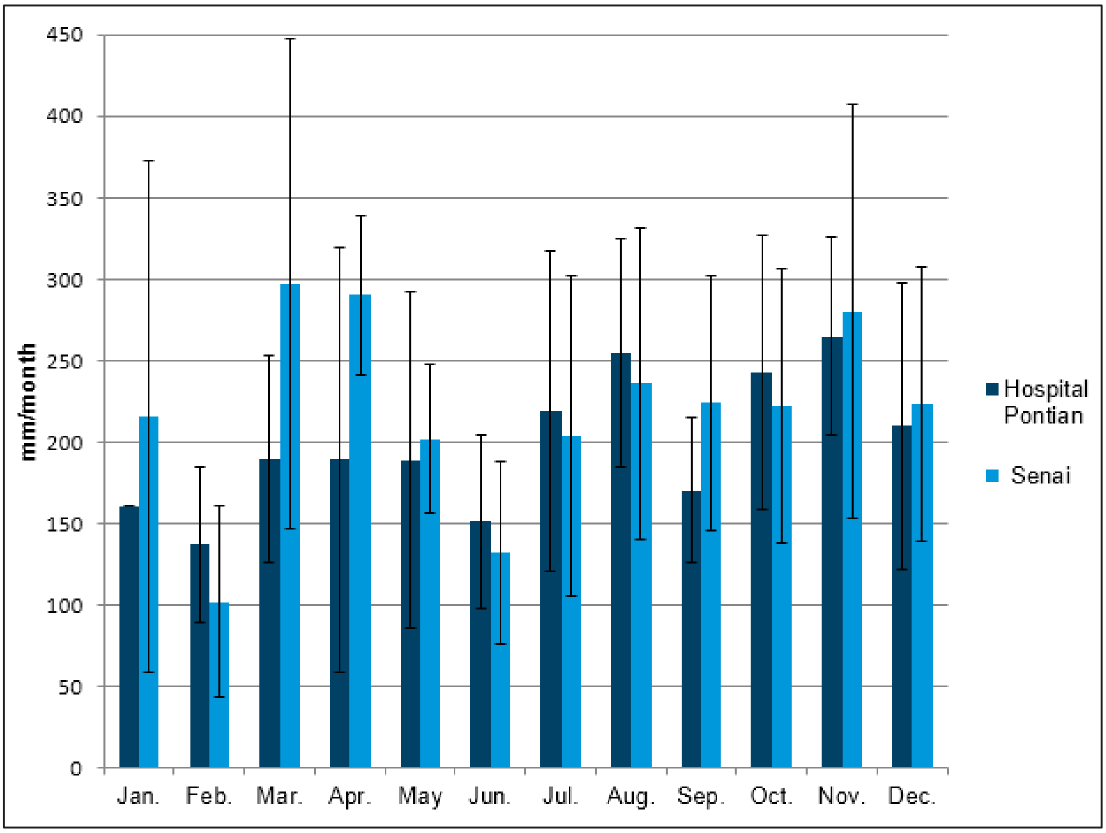

Figure 5.12 Average monthly rainfall for Pontian and Senai, 2008 -2012 (Source: *Meteorological Department Johor*). Bards indicate maximum and minimum monthly rainfall over the record period.

5.1.6 Hydrographic Conditions

This section describes the hydrographic conditions in the area including:

- Current flows;
- Water levels; and
- Wave conditions.

5.1.6.1 Current Flows

Flow conditions in the study area are primarily driven by tidal forcing but other drivers such as wind and atmospheric pressure fields can also influence current flows. Typical instantaneous current flows in the study area are presented in Figure 5.13 during flood and ebb conditions and typical predicted mean and maximum currents in Figure 5.14: The model results show that:

- Along the shallow areas east of Tg. Piai (where the development is proposed) currents are quite uniform and weak. Predicted mean current speeds in this area are below 0.2-0.3 m/s. The strength of the current speed increases from the shallow side (west) to the deeper areas towards the eastern side.
- Strong currents are predicted along the navigation channel and Sg. Pulai. Direction of the flows is aligned to Sg. Pulai and the navigation channel. The stronger current speeds are predicted around the PTP area with maximum current speeds between 1 m/s to 1.5 m/s and mean current speed is less than 0.5 m/s
- Current flows during ebb tide conditions are slightly stronger than during flood tides.
- Currents south of Tg. Piai show a significant spatial variation during low tidal levels. While currents are weak or non-existent along the tidal mudflats the currents increase rapidly as depths increase. This sudden change in current speed is predicted just 1km south of Tg. Piai
- Along the entrance of the Straits of Johor towards the second link the largest currents are predicted along the international border line and close to Singapore, this is in the deeper areas of the channel.

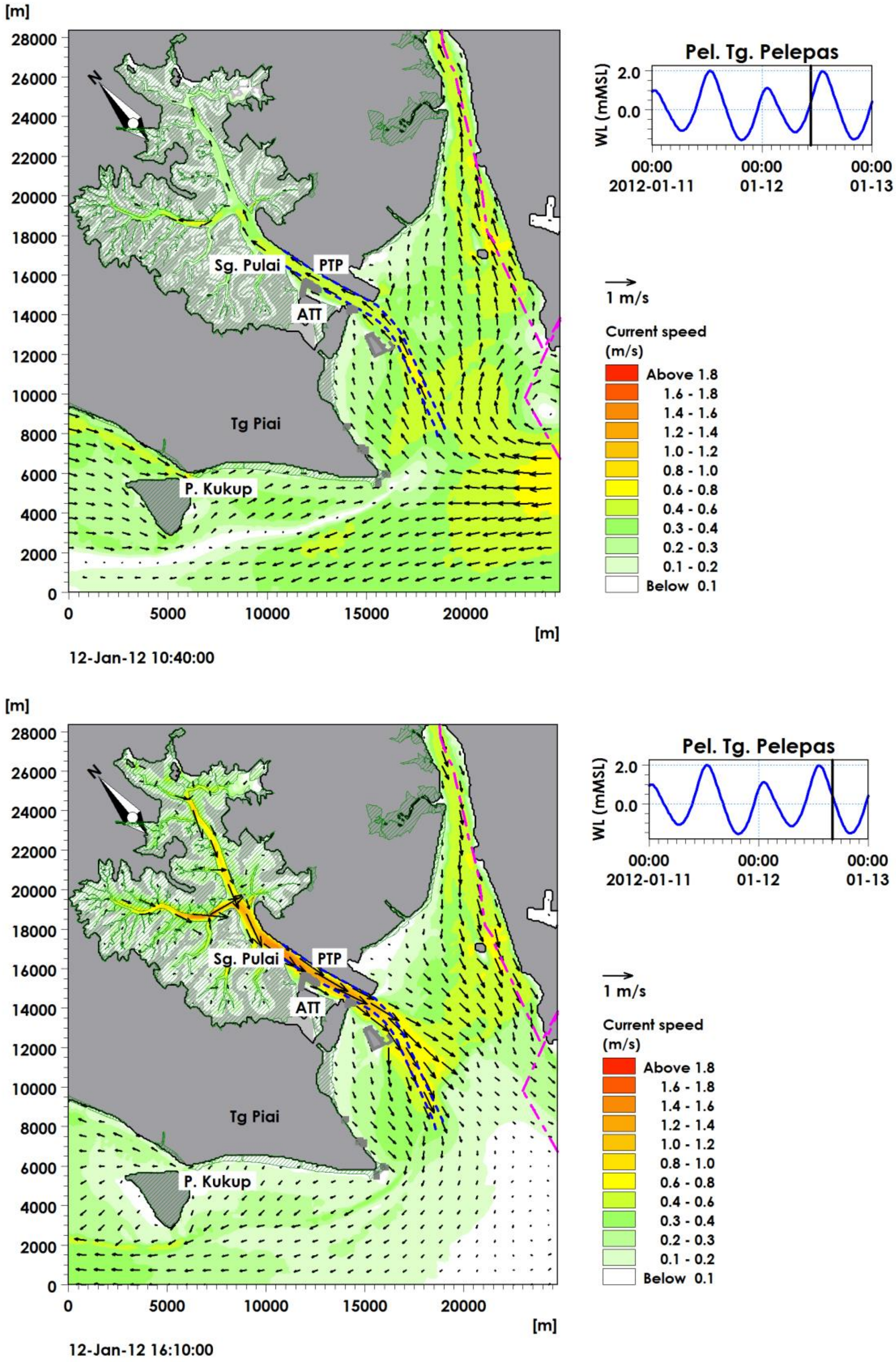

Figure 5.13 Representative spring tide current speed and direction during flood (above) and ebb (below) tide.

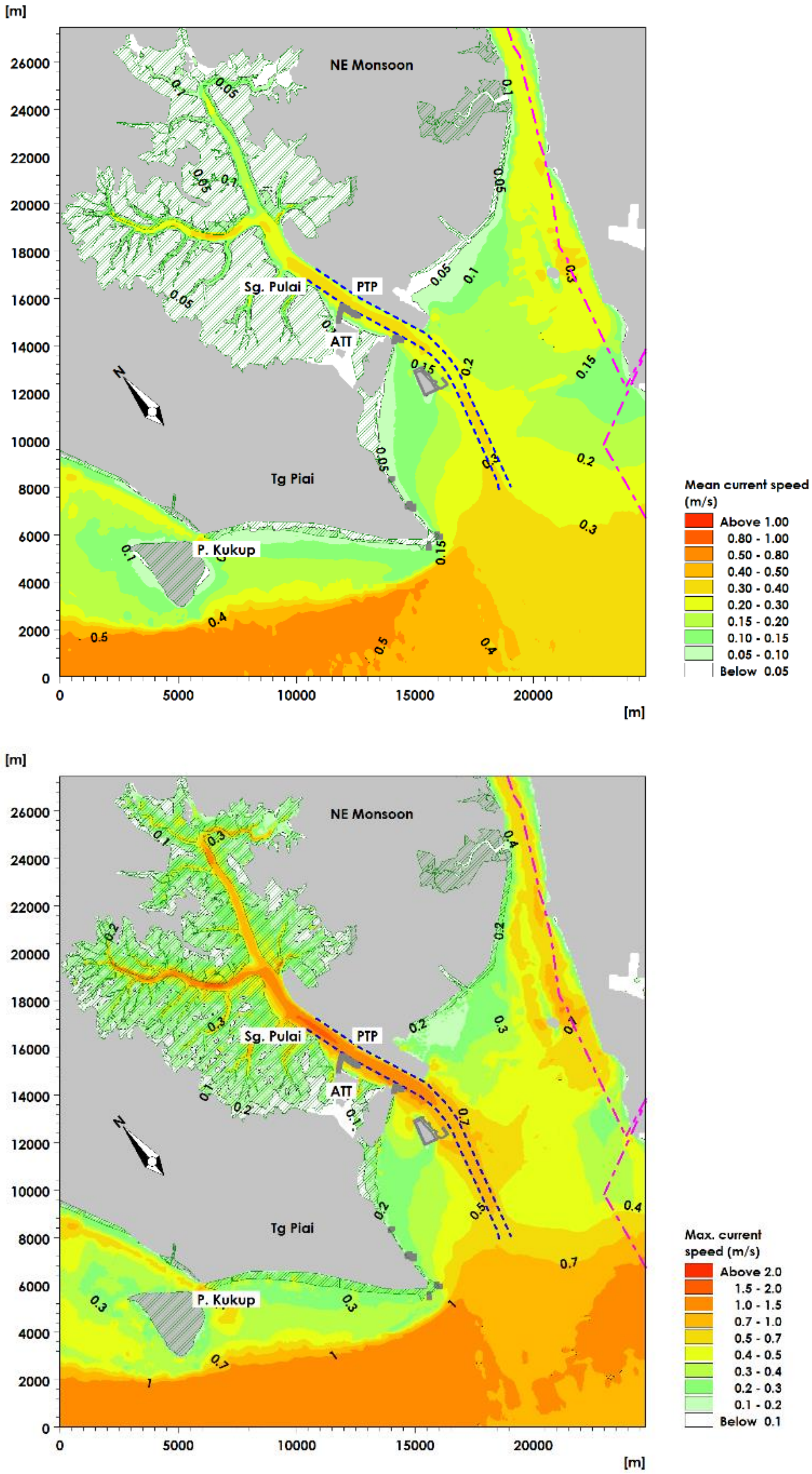

Figure 5.14 Typical predicted mean and maximum current speed in the study area.

Net or residual currents are the residual recirculation currents induced by the asymmetry of the current flows during the different tidal cycles. Usually, net currents are induced by atmospheric conditions and play a relevant role on the transport of sediments and other suspended matter in suspension as they can be transported long distances. In the study area net currents are related to the climatic conditions associated with NE, SW and inter-monsoon conditions. An example of predicted currents in the study area during NE monsoon are presented in Figure 5.15 that shows net currents travelling from east to west along the Singapore Straits and northwest to the Straits of Malacca. During the SW monsoon the currents tend to become eastward along the Straits of Singapore, but the Strait of Malacca NW current remain though of significantly less intensity and during inter-monsoon conditions net current intensity and direction tends to be more diffuse, however the pattern along the Straits of Malacca remains somewhat similar.

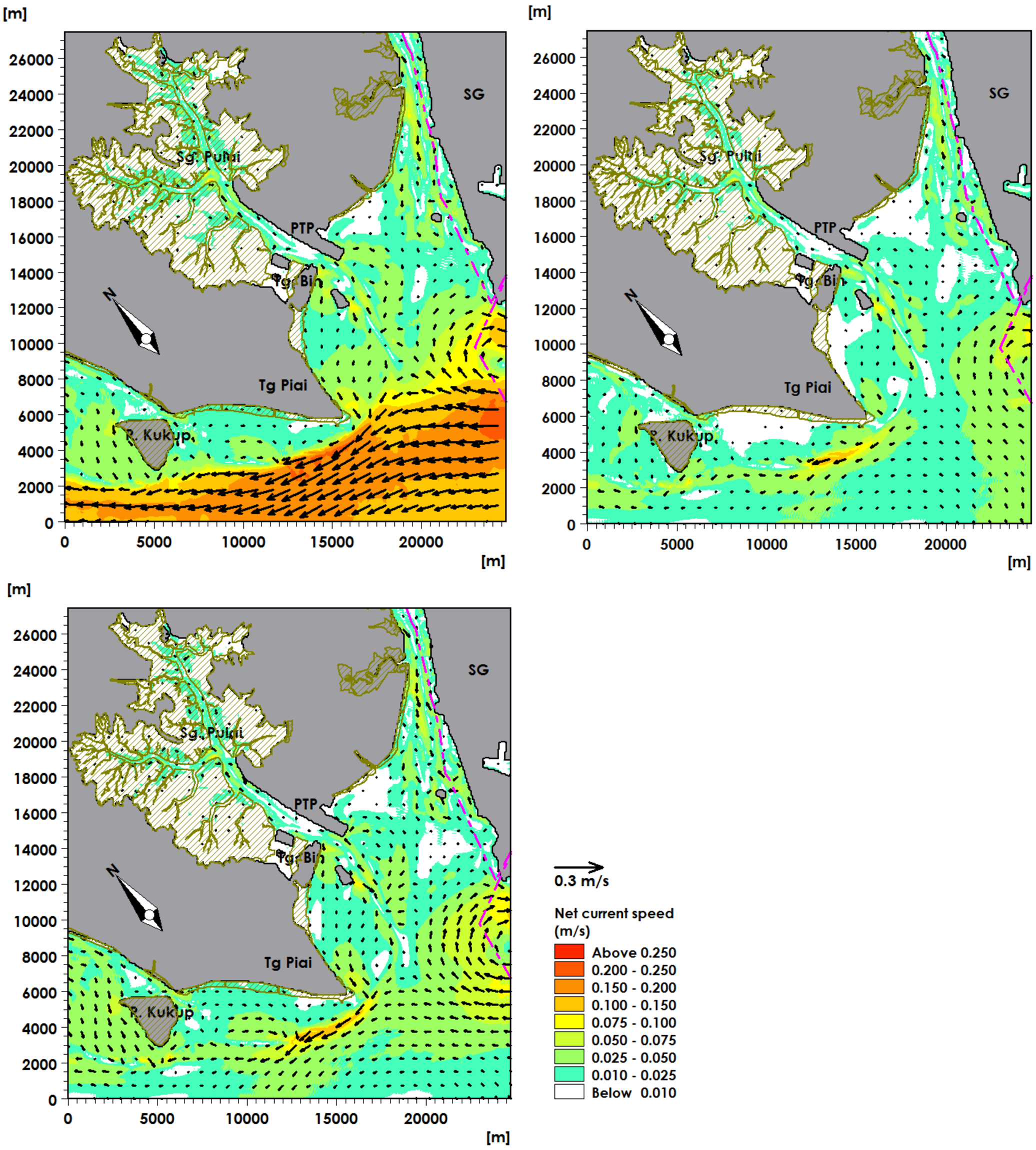

Figure 5.15 Net or residual currents computed over 15 day period. NE monsoon (left), SW monsoon (right) and inter monsoon (bottom).

5.1.6.2 Water Levels

Characteristic water levels in the study area are presented in Table 5.3, which shows that the typical tidal range is just above 3 m whereas HAT is approximately 3.75 m CD.

Table 5.3 Tidal Levels at standard ports Tanjung Pelepas and Kukup.

Levels		Tanjung Pelepas (m CD)	Kukup (m CD)
Highest Astronomical Tide	HAT	3.75	3.68
Mean High Water Spring	MHWS	3.03	3.04
Mean High Water Neap	MHWN	2.16	2.20
Mean Sea Level	MSL	1.67	1.70
Mean Low Water Neap	MLWN	1.17	1.21
Mean Low Water Spring	MLWS	0.30	0.37
Lowest Astronomical Tide / Chart Datum	LAT/CD	0.00	0.00

The tidal levels are mixed but predominantly semidiurnal tidal conditions. An illustration of measured water levels in the study area are presented in Figure 5.16.

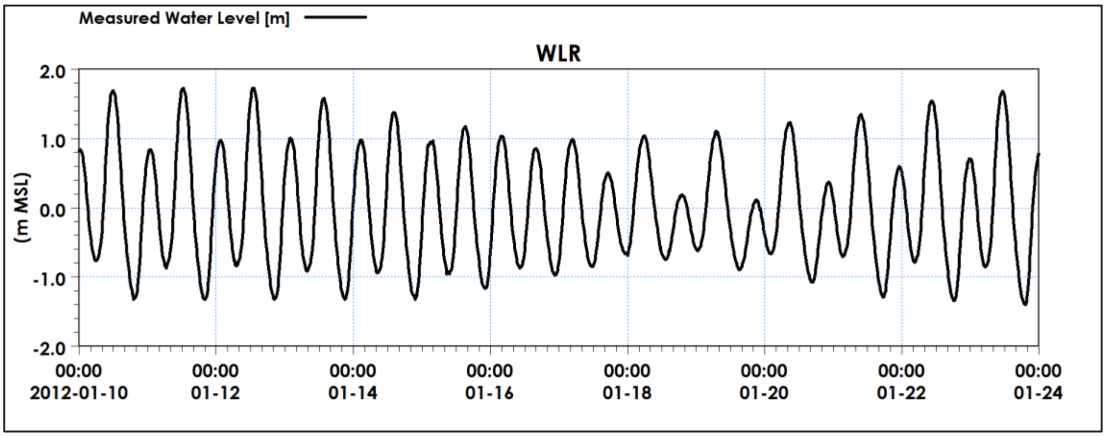

Figure 5.16 Measured water levels in the study area.

5.1.6.3 Wave Condition

The wave conditions at Tg. Piai are primarily governed by wind waves (locally generated sea waves). Due to the enclosed nature of the area, swell waves (waves propagating from long distances) are minimal. The marine traffic and the presence of a large vessels anchored in these waters also play a role on the sea state, partly due to ship wakes (waves generated by the moving vessels) and partly due to the blocking of the ambient waves by the large numbers of anchored vessels to the south east.

Wave data was collected in the Tg. Piai area and wave modelling was carried out to produce long term representative wave conditions in the area. Computed wave fields during NE and SW conditions are presented in Figure 5.17. As it can be observed wave action is limited due to the limited water fetch that allows the generation of wind–generated, short-crested sea waves with associated short periods.

Wave roses have been produced for the period Jan 2010 to May 2012 as shown in Figure 5.18. The results show that the largest waves are generated during the SW monsoon when high-intensity, short-term duration events usually described as “Sumatra” squalls occur. During these events waves can easily exceed 1 m significant wave height[1].

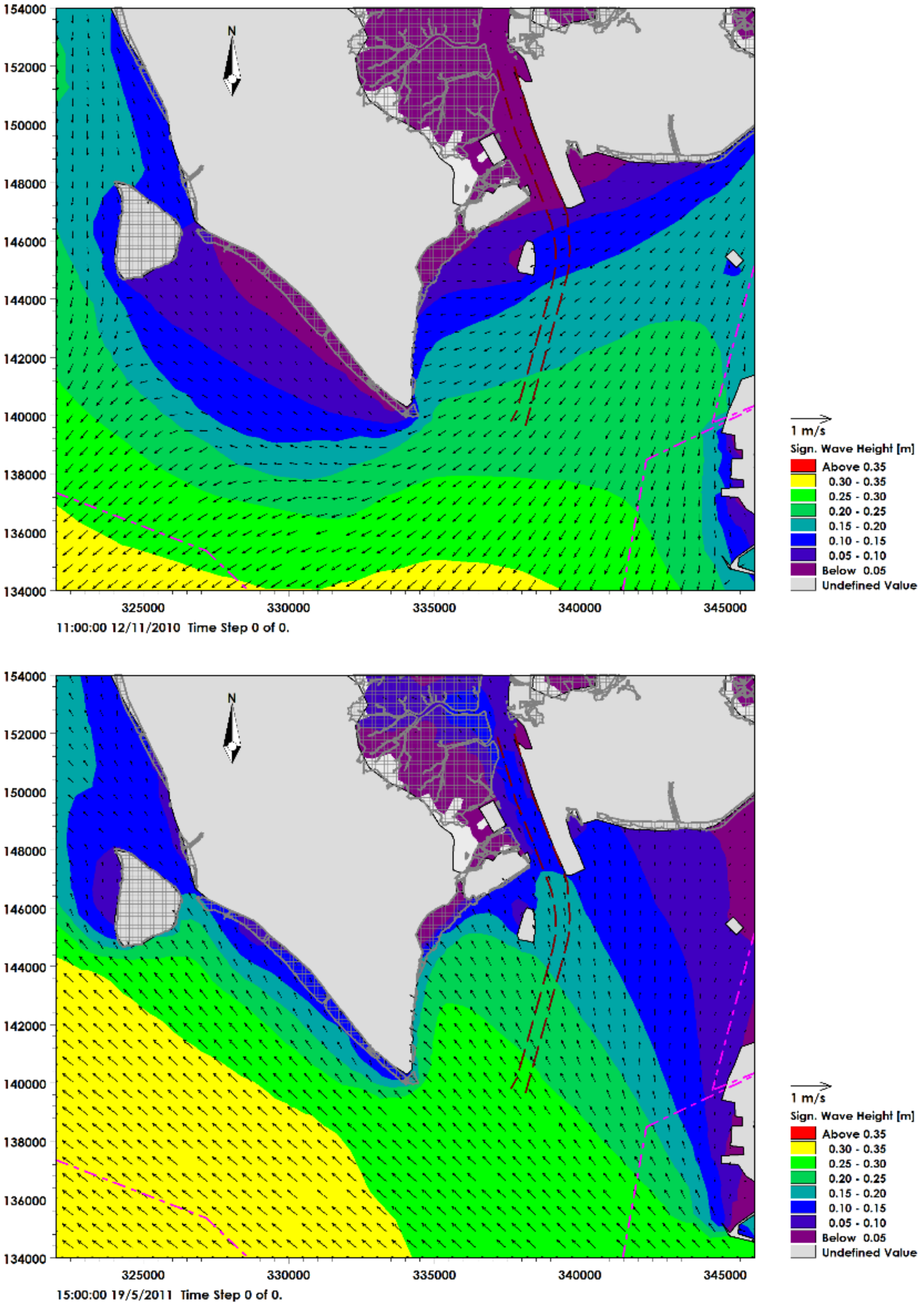

Figure 5.17 Predicted wave conditions (significant wave height) in the study area during NE Monsoon (top) and SW monsoon (bottom).

[1] the significant wave height is defined traditionally as the average wave height (trough to crest) of the highest third of the waves (H1/3).

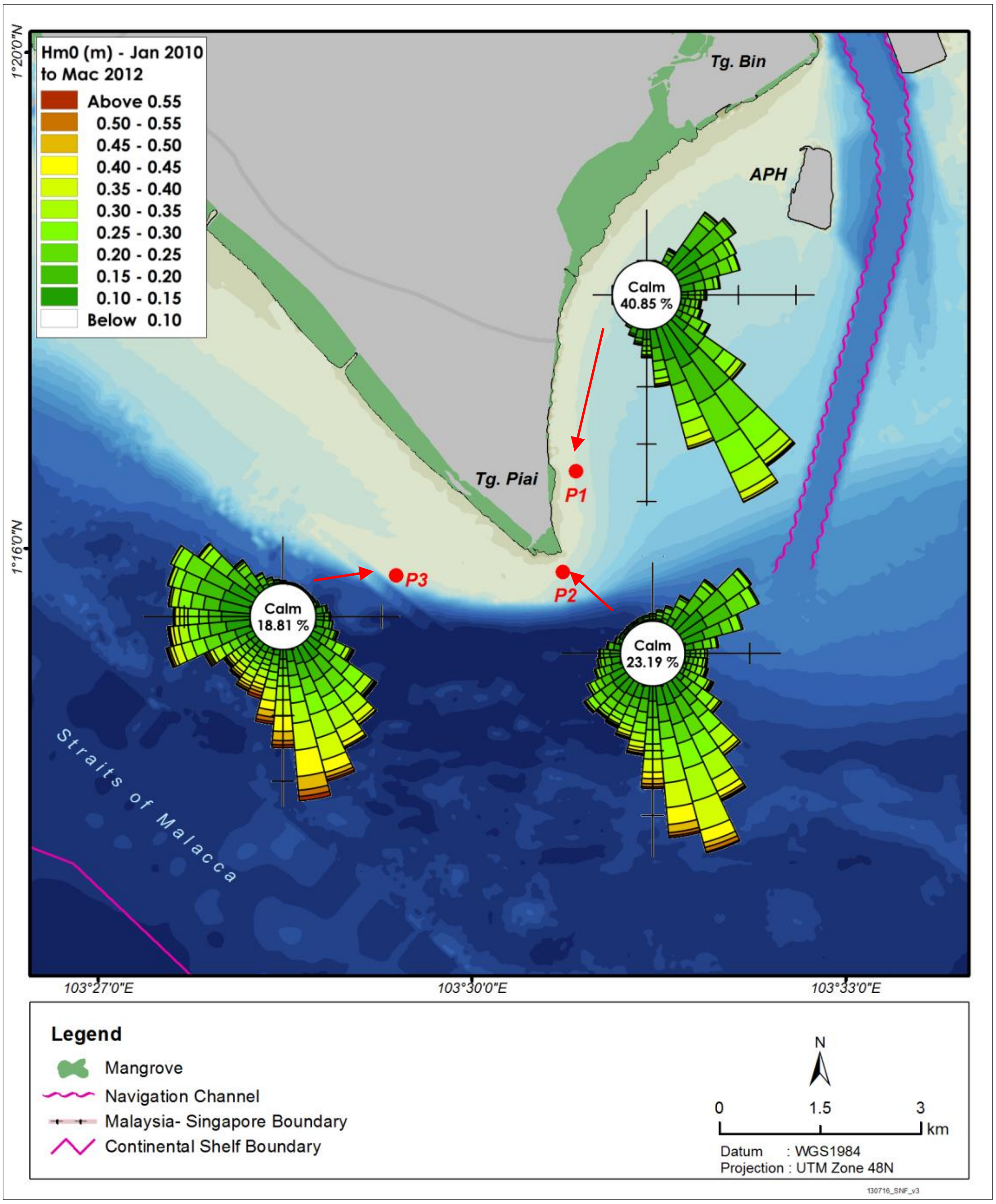

Figure 5.18 Significant wave heights at three locations over the period from Jan 2010 to May 2012.

Blocking Effect of Anchored Ships on Waves

Large numbers of ships are anchored in the Strait of Singapore to the south and south east of the site. The congestion of ships can be appreciated in satellite images as shown in Figure 5.19. Due to the extensive presence of ships the propagation of the waves through these waters, and in particular onto the Tg. Piai coastlines, is partially blocked. These waves, as they pass a vessel, will be partially reflected by the hull and the remaining will be transmitted underneath the ship hull. Simulations were carried out to evaluate the impact of anchored vessels on the wave climate in Tg Piai and the results show that the large numbers of ships affects the ambient wave field in terms of both wave heights and period (time between two wave crest), resulting in shorter wave periods and wave heights.

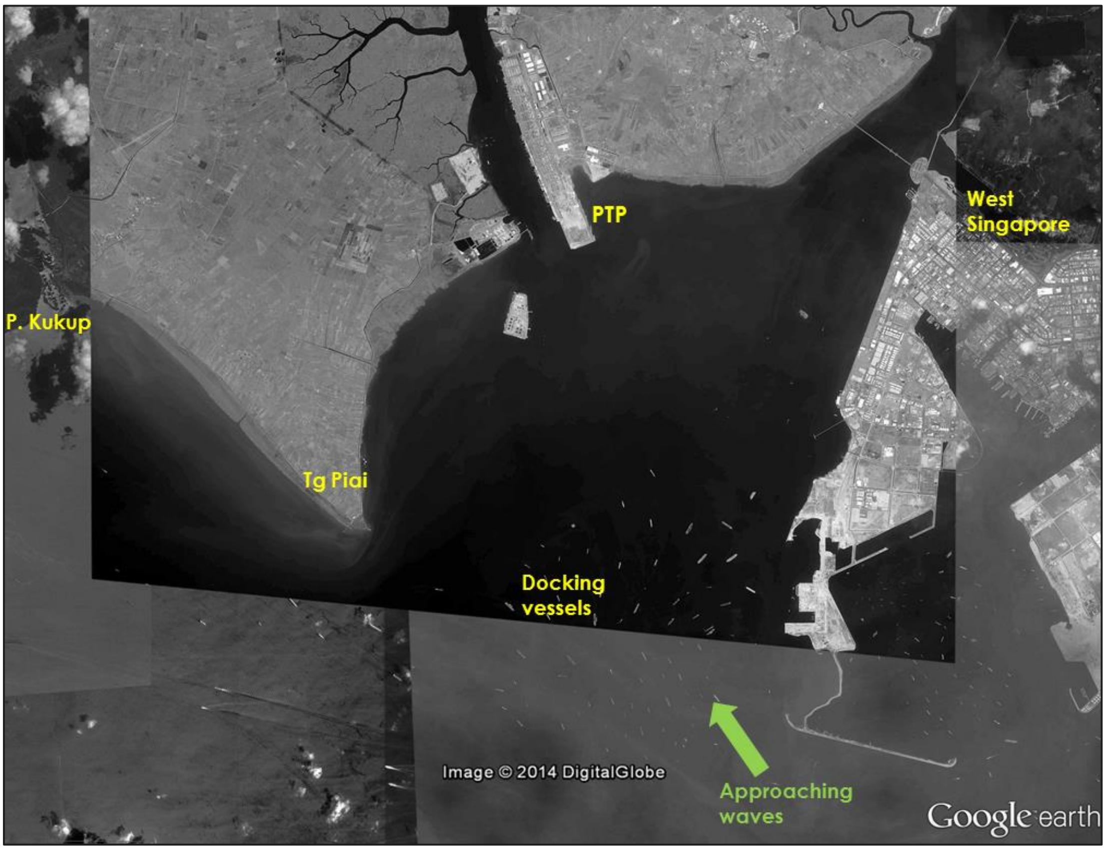

Figure 5.19 Aerial view of docking ships offshore of Tuas. (Source: Google Earth Pro, image dated June 14, 2012)

Ship Wakes

The area is heavily trafficked by a variety of large and small vessels. When a ship travels through open waters, a system of waves will typically be generated from the ship's stern and bow. Wake waves arise as a consequence of pressure differences along the ship's hull; this wave type is typically described as Kelvin waves/wakes. Typical ship wakes have been modelled for large ships arriving at and departing from PTP. Plots of the waves generated by an inbound and outbound vessel are shown in Figure 5.20. As it can observed wakes induced by inbound vessels tend to propagate further inshore into the nearshore areas, with some wave focussing in the Tg Piai area that is presently experiencing erosion.

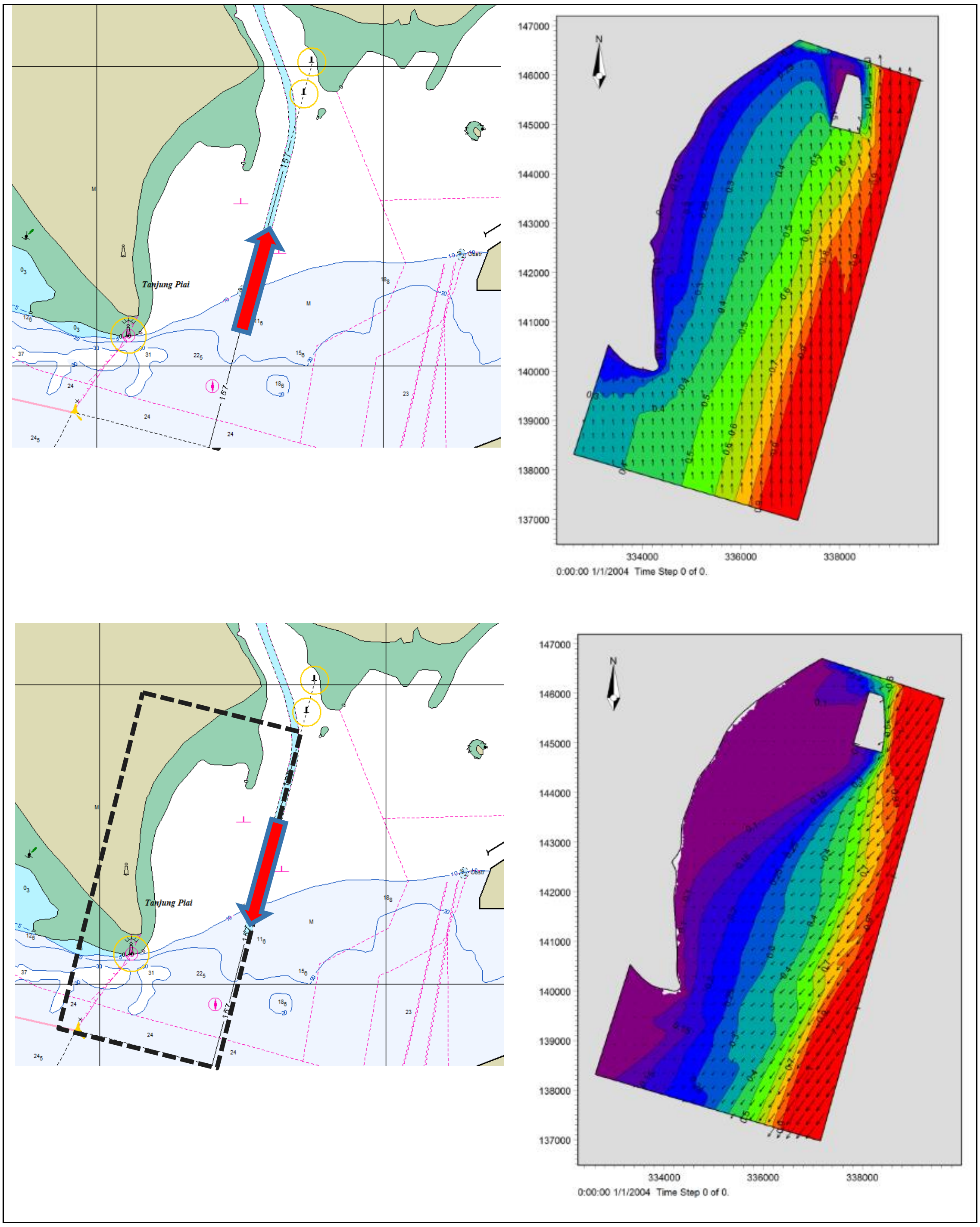

Figure 5.20 Modelled ship wakes for an inbound (above) outbound vessel (bottom).

Waves and Erosion in the Tg Piai Area

In nearshore areas the wave climate represents the main forcing - the shoreline is shaped by this forcing and also modified when changes to this forcing occur. The reshaping can be due to natural annual variations in wave climate (and the coastal system may experience inter-seasonal modulations), or it can be related to changes over longer time-scales (which often is recognized as permanent erosion/accretion). It is not possible to conclude that changes in the wave climate, the ship wakes or the ship blocking effects alone produce the erosion patterns observed. The partial blocking of wave energy from the ship hulls is, however, shown to have significant impacts on the wave field east of Tg. Piai (as compared to the situation with no ships); particularly by decreasing the wave period.

5.1.7 Hydrology and Drainage

The main river within the study area is Sg. Pulai, located approximately 1.5 km northeast of the project site. Approximately 14 km long, Sg. Pulai is a significant source of sediment supply to the project area. There are seven rivers/ streams on the western side of the project area between Tg. Bin and Tg. Piai according to the latest topography map (1996) acquired from Malaysian Surveys and Mapping Department. These rivers are Sg. Belukang, Sg. Perpat Punggor, Sg. Perpat Pasir, Sg. Chokoh Besar, Sg. Nibong, Sg. Chokoh Kecil and Sg. Sam. However verification based on recent satellite image (SPOT 10 m resolution, dated April 2013) and site surveys revealed that two (2) river outlets have been closed namely Sg. Perpat Pasir and Sg. Chokoh Kecil. The remaining five (5) rivers / streams that drain into the study area shown in Figure 5.21.

The drainage system in the area reflects the present agricultural land-use. A review of the flood maps drawn by the Department of Irrigation and Drainage Johor reveals that there have been no serious flooding incidences reported in the study area for the past 10 years.

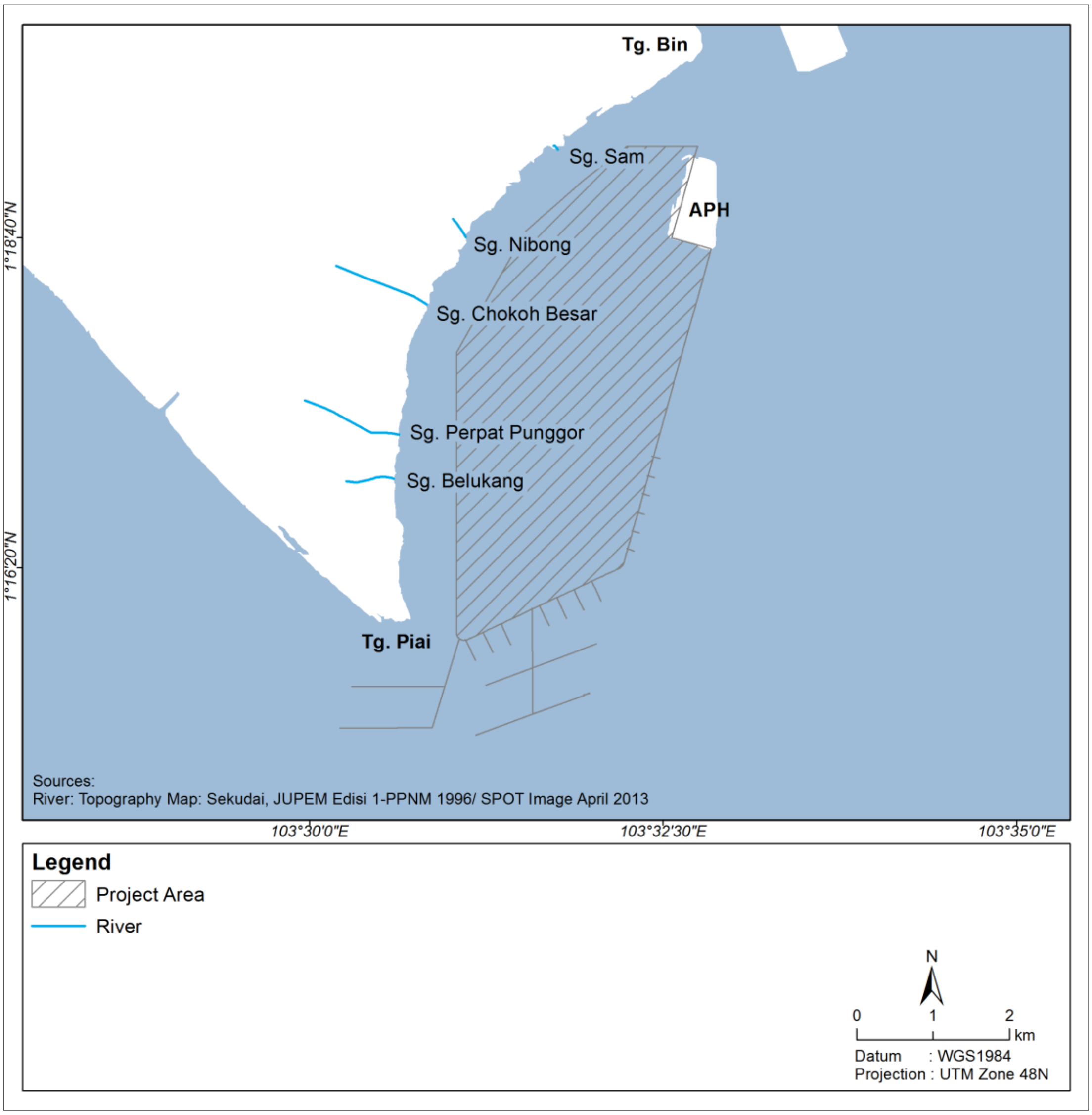

Figure 5.21 Rivers discharging into the project area.

5.1.7.1 Assessment of River Flows

Hydrological models have been applied to generate series of runoff from a range of catchment areas in southern Johor, details of this modelling is given in Appendix E. The catchment runoff is simulated on daily basis. The long time series is averaged to represent mean annual runoff throughout the simulation year 2012 for the Sg. Pulai catchment as shown in Figure 5.22. It is observed that the peak runoff tends to occur from November to March which is matching with the north-east monsoon season.

The runoff from streams and rivers along the coastline has been assessed on this basis to provide time series of flow to the sea at the locations shown in Figure 5.23 for both normal and wet climatic scenarios. The statistics of the time series are given in Table 5.4.

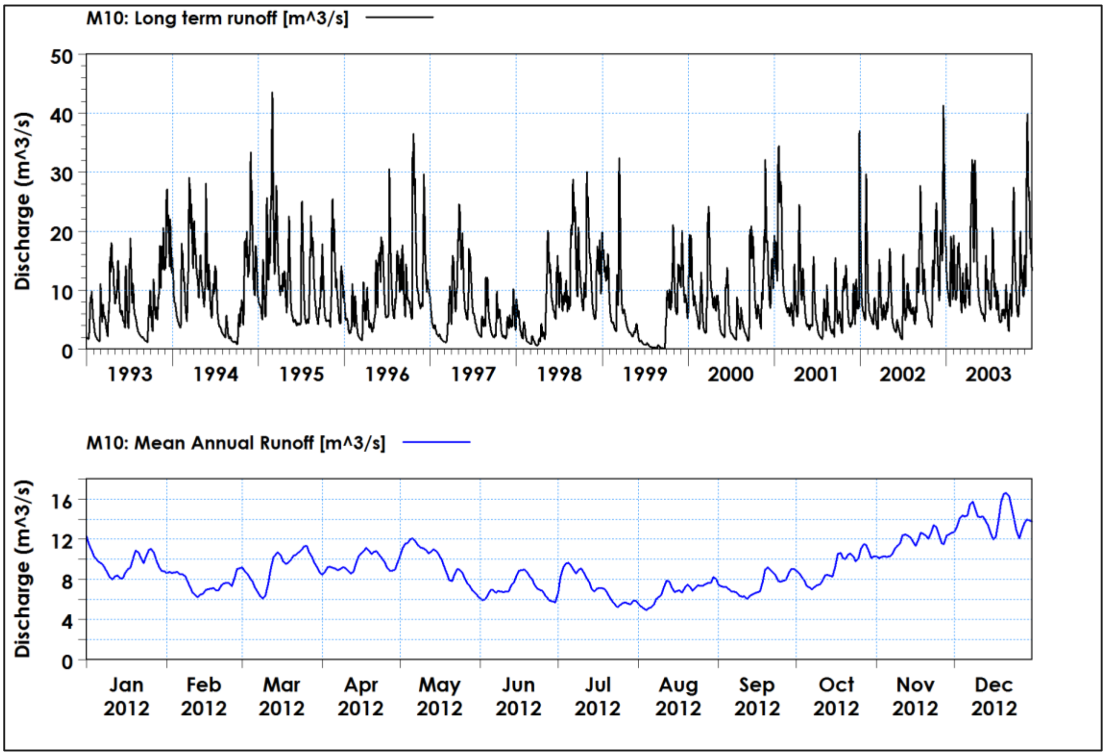

Figure 5.22 Estimated discharge from catchment M10 for long term period (top) and averaged to represent mean runoff over a year

Table 5.4 Runoff characteristics of the catchments (based on 11 years of simulated runoff).

Catchment	Outlet Point	Mean Discharge (m^3/s)	Max. Discharge (m^3/s)	Design Discharge 50yr return period (m^3/s)
M4	21	12.6	64.8	61.5
	22	0.7	3.6	3.4
	23	0.4	2.2	2.0
	24	0.3	1.4	1.4
M9	1	0.1	0.5	0.6
	2	0.3	1.8	2.3
	3	0.3	1.8	2.3
	4	0.3	1.8	2.3
	5	0.3	1.8	2.3
M10	6	0.9	4.4	5.7
	7	2.3	10.9	14.3
	8	0.9	4.4	5.7
	9	2.3	10.9	14.3
	10	0.9	4.4	5.7
	11	1.8	8.7	11.4
M11	12	0.5	2.1	2.5
	13	0.9	4.2	5.1
	14	0.2	1.1	1.3
	15	0.2	1.1	1.3
S1	16	0.1	0.7	0.7
	17	0.2	1.7	1.6
S2	18	0.1	0.3	0.3
	19	0.1	0.7	0.8
S3	20	0.2	1.1	1.3
	27	0.2	1.1	1.3
	28	0.4	2.1	2.6
S4	29	1.4	8.5	10.5
S5	30	1.0	6.7	8.5
	31	0.4	2.9	3.6
S6	32	0.2	1.2	1.5

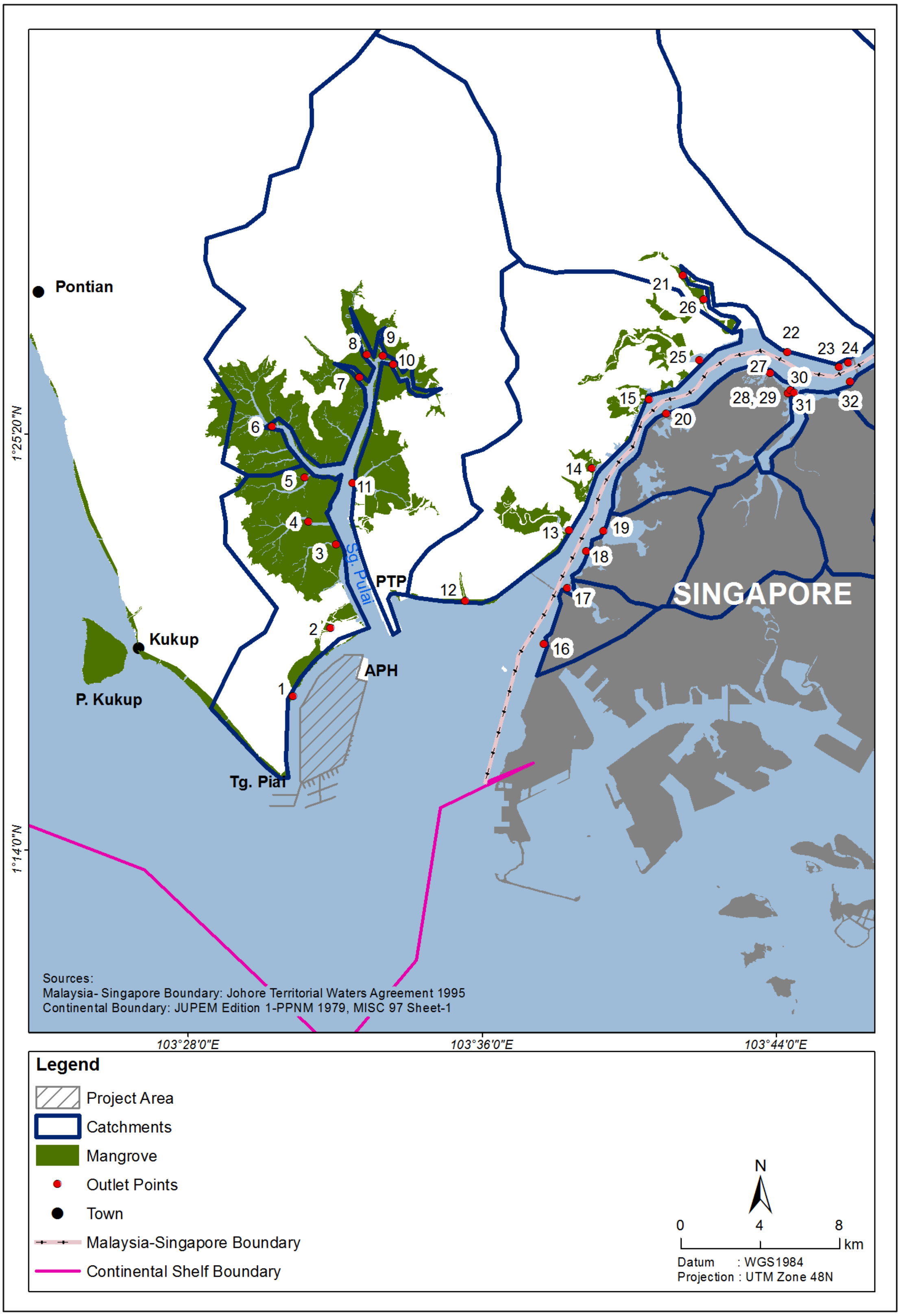

Figure 5.23 Location of outlet points used in the model.

In this regional catchment model, the flows from the five streams discharging along the eastern shoreline of Tg. Piai are grouped as Point 1. In addition to this regional modelling a local model has been used to assess the flows in these five streams. This has been carried out based on a statistical basis including storm durations between 5 minutes a 3 hours. The

100 year return period peak and average river discharges based on this assessment are set out in Table 5.5.

Table 5.5 Design Stream Flows on east coast of Tg. Piai

Catchment	Area (km^2)	Average runoff (m^3/sec)	Maximum runoff (m^3/sec)
Sg. Sam	2.5	0.15	147.5
Sg. Nibong	3.5	0.20	123.3
Sg. Chokoh Besar	4.5	0.26	147.5
Sg. Perpat Punggor	3	0.17	105.7
Sg. Belukang	2.7	0.16	95.1

5.1.8 Coastal Geomorphology

Morphological conditions in the Johor Straits area are characterised by tidal flats, shallow waters and fringing mangrove forests. The morphology is a result of the relatively benign wave and current climate in the bay, and the excess amount of fine sediments present in the Malacca Strait from reworking of Holocene deposits and the recent deposits from land based sources.

The shallow bay morphology is scoured in the western side of the bay by the Sg. Pulai river flow and ebb/flood tidal flows. These natural channels have in recent time been artificially straightened, deepened and merged into one main channel which accommodates navigation mainly up to the Port of Tanjung Pelepas (PTP). An eastern channel located closer to the Singapore waters connects the Straits of Johor to the outer areas in the Straits of Singapore.

5.1.8.1 Coastal Setting

While the western side of Tg. Piai shows an accreting coastline with a stable mangrove forest fringe (as illustrated in Photo 5.1), the eastern coastline is experiencing erosion. as shown in Photo 5.2 to Photo 5.5. Erosion is particularly pronounced northeast of the National Park monument area.

Photo 5.1 Stable mangrove coastline along the western coast of Tg. Piai National Park.

Photo 5.2 Eroding mangrove coastline along the northeast coast of Tg. Piai National Park. South view towards the monument area.

To mitigate the severe coastal erosion taking place at the tip and along the coast northeast of Tg. Piai, a semi-rigid coastal protection scheme has been implemented. The protection scheme includes loose sandbags placed side-by-side on the foreshore in a single-row arrangement. This scheme is implemented along most of the eroding parts of the coast. The sandbags are exposed at low tide (see Photo 5.3), and fully submerged at high tide.

Based on site observations, the sandbag arrangement along certain sections has been damaged by wave action (see Photo 5.3) and has not been effective in combatting erosion. In fact, at sections where waves have been able to displace the sand-bags, erosion appears to have been aggravated.

Photo 5.3 The semi-rigid protection scheme comprising loose sandbags placed on the foreshore in a side-by-side arrangement for the purpose of combating coastal erosion east of the monument area. Note the open section, which is caused by waves dislocating the sandbags.

Additional coastal protection has been constructed north of the Tg. Piai National Park. Here, rubble mounded seawalls have been constructed (see Photo 5.4). In this area the mangrove forest has disappeared, indicating that this structure has not solved the erosion problem.

Further north, a number of sandbag structures have been constructed offshore to reduce wave actions. These structures appear to have been successful in arresting the erosion. An overview of this protected area is presented in Photo 5.5.

Photo 5.4 View of the site to the north of the Tg. Piai National Park, nearby Tanjung Piai Resort. A seawall has been constructed for protection, no mangrove forest remains there.

Photo 5.5 Aerial view of the sand bag protection in the area north of the Tg Piai National Park.

An overview of the shoreline condition and the location of coastal protection structures is shown in Figure 5.24.

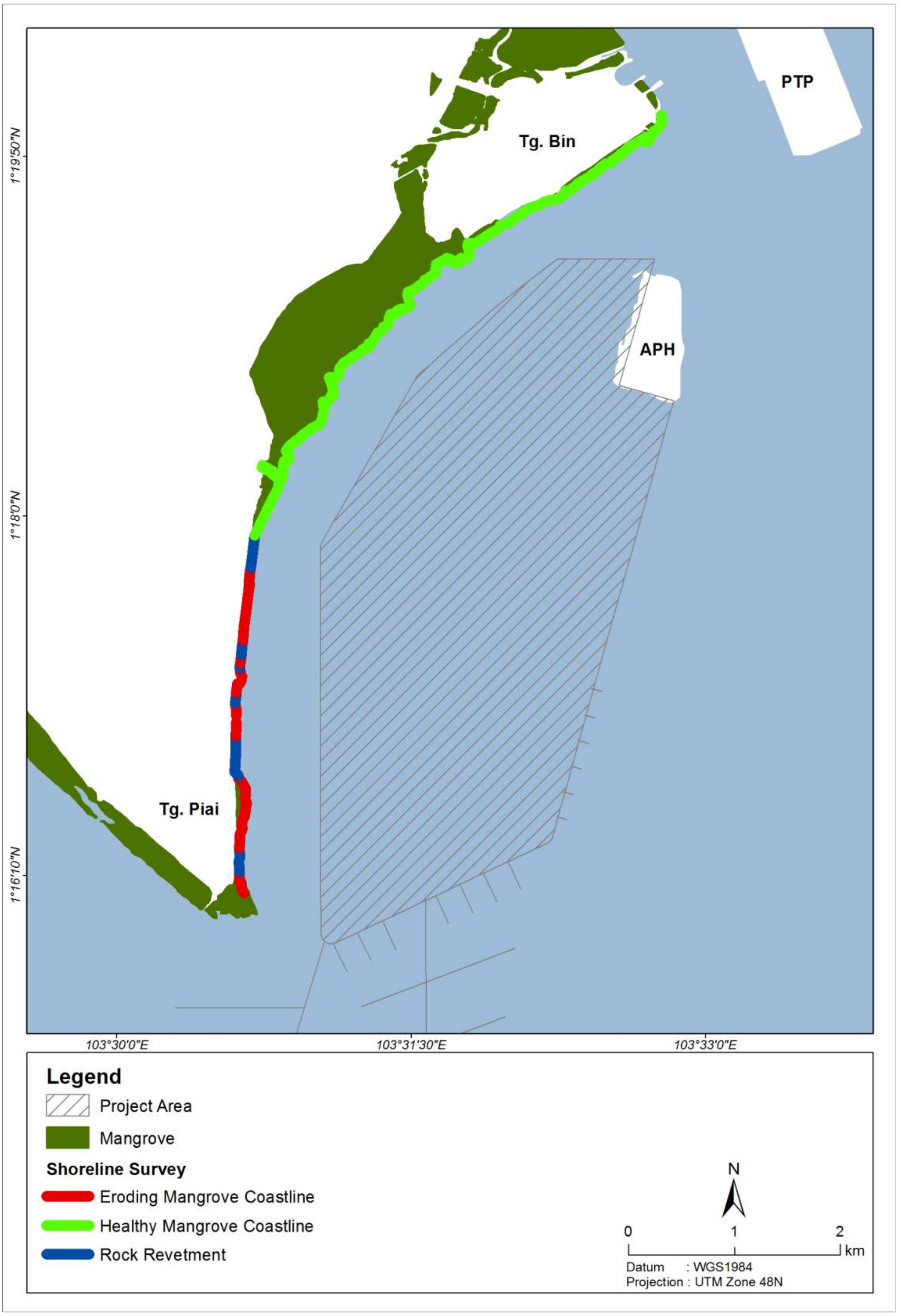

Figure 5.24 Overview of shoreline condition and coastal protection

5.1.8.2 Possible Causes of Erosion

As set out in Section 5.1.8.1 some erosion is occurring on the eastern side of Tanjung Piai. This has had a negative impact on the mangroves in this area.

The causes of this erosion have been considered in detail in the Hydraulic Study (Appendix E). Mud flat areas are highly sensitive to wave action and a change in wave conditions related to ship wakes and the blocking effect of anchored vessels is believed to have induced a shift in the equilibrium of the coastal profile. A contributing factor is the extensive presence of ships in the Strait of Singapore which has influenced the wave climate and the wave energy reaching the shoreline. The presence of vessels induce shorter period waves that tend to produce a more aggressive effect on the shore. It is considered unlikely that other hydrodynamic effects generate the observed localised erosion at Tg. Piai as changes in currents and water level induced by the Project do not impact the nearshore areas around Tg Piai.

5.1.9 Water Quality

The description of the existing water quality is based on sampling and analysis for marine and estuarine waters at 18 stations within more than 10 km radius from the project area. As shown in Figure 5.25, 14 marine water quality stations and five rivermouth/estuarine water quality stations were established. In order to assess the seasonal variations, water quality survey campaigns were carried out during three (3) different monsoonal seasons, namely northeast (NE) monsoon (November to March), intermonsoon (IM) (April) and southwest (SW) monsoon (May to September).

Water quality samples were collected at three (3) depths (i.e. surface, middle and bottom) for the marine stations while samples for the estuarine water were only collected at mid-depth. Twenty-four (24) parameters were analysed, consisting of physical, anions, heavy metals, organic and microbial concentrations and petroleum compounds (Table 5.6). The full methodology is described in Appendix B.

The water quality status was assessed against the following guidelines, as follows:

- Malaysia Marine Water Quality Criteria and Standard (MMWQCS);
- National Water Quality Standards for Malaysia (NWQS); and
- ASEAN Marine Water Quality Criteria (AMWQC).

The MMWQCS are based on four classes of beneficial use with Class 2 being adopted for the marine waters and Class E for the Rivermouth/Estuarine waters:

- Class 1 – Preservation, marine protected areas, marine parks
- Class 2 – Marine life, fisheries, coral reefs, recreational and Mariculture
- Class 3 – Ports, Oil & Gas fields
- Class E – Mangroves, estuarine and river-mouth waters.

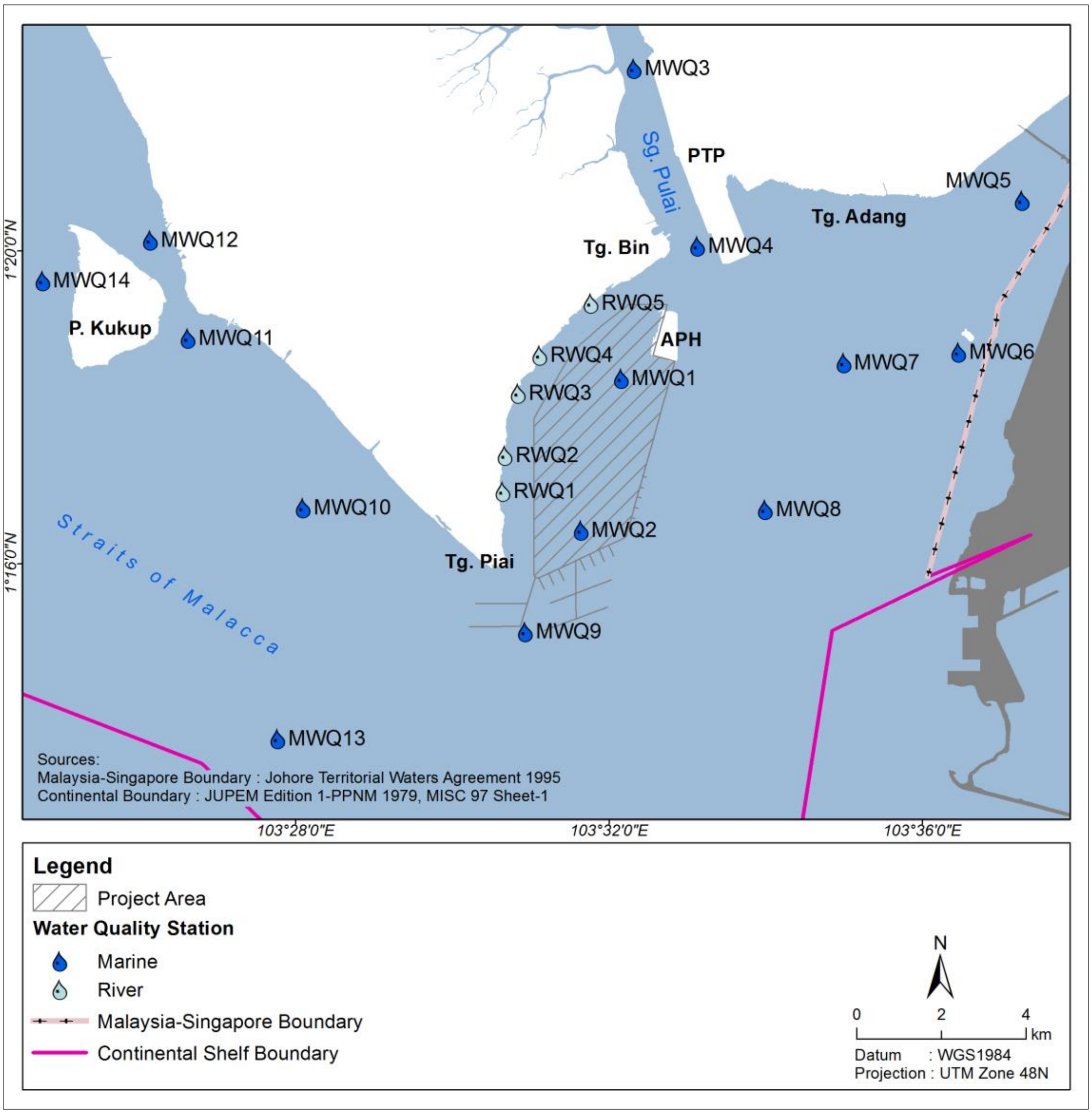

Figure 5.25 Location of water quality sampling stations

Table 5.6 Water quality parameters

Parameters	Parameters
Temperature	Chromium
pH Value	Cadmium
Dissolved Oxygen	Copper
Salinity	Nickel
Conductivity	Iron
Turbidity	Lead
Total Suspended Solids	Manganese
Ammoniacal nitrogen	Arsenic
Phosphate	Mercury
Nitrate	Total Petroleum Hydrocarbons
Biological Oxygen Demand	Benzene, Toluene, Ethylbenzene, Xylene
Loss on Ignition (LOI)	Total Volatile Organic Compounds
Oil and Grease	
Faecal Coliform	
Chlorophyll-a	

5.1.9.1 Water Quality Status

The marine water quality data have been assessed against the two MMWQCS classes - Class 2 and Class E - as shown in Figure 5.26.

In the main, almost all results were below the relevant standards where these could be applied and for many of the parameters sampled for there was a large number of results below the limits of analytical detection.

Seasonal or temporal variability was frequently greater than spatial variation and this has been illustrated for several parameters as shown below. Note that all the results shown here are an average value for the three depths. All the data collected are available in Appendix B.

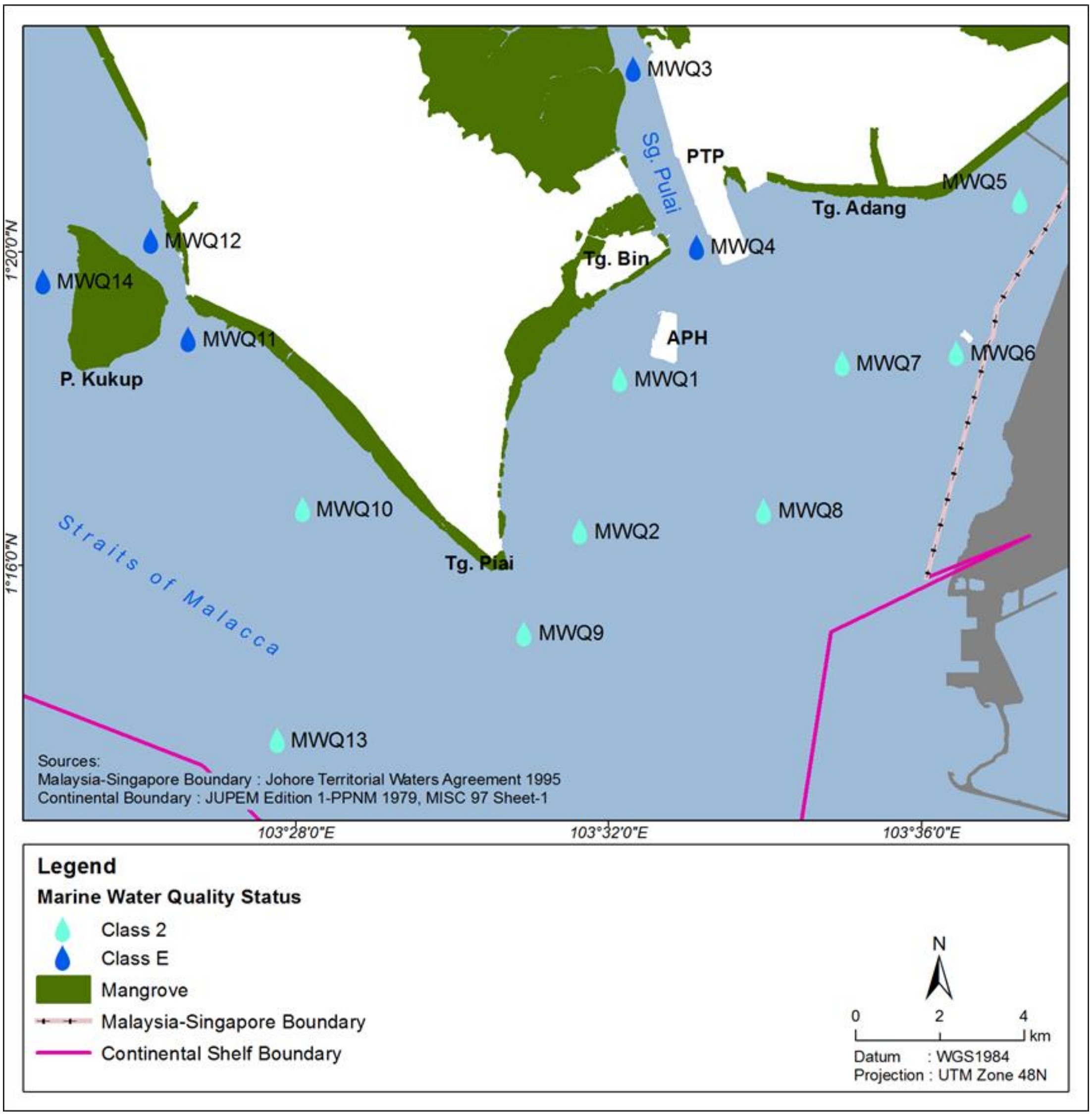

Figure 5.26 Water quality status for the marine stations

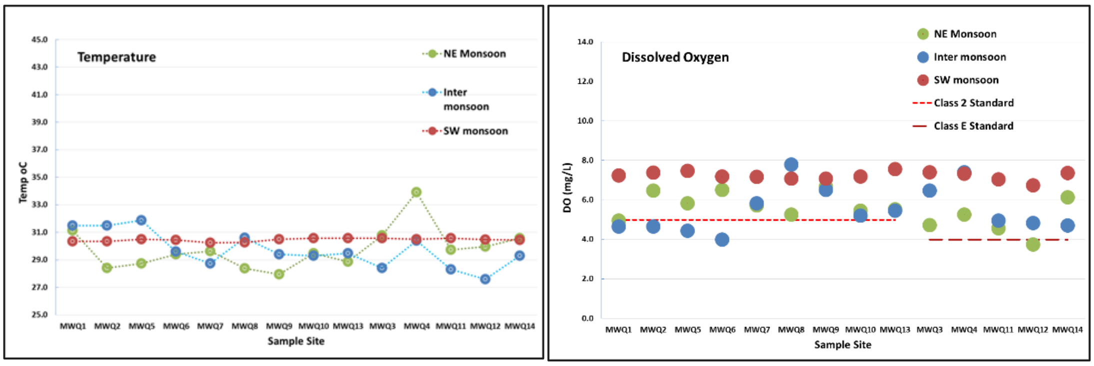

Figure 5.27 Depth averaged temperature (left) and dissolved oxygen (right) measurements at each of the marine stations for the three different seasons. The dissolved oxygen Class 2 and Class E standards below which DO should not fall are shown as the 2 different dashed lines.

Temperatures (Figure 5.27) are seen to be more variably seasonally than spatially for the South West monsoon sample set, but not during the other two seasons. Implicit in this observation is the need for a seasonal baseline with good spatial coverage to be established as part of the EMP as the Standard requires temperatures to not exceed greater than 2 oC.

The dissolved oxygen (DO) levels for all the Class 2 stations during all seasons were above the 5 mg/l Standard, with the exception of 4 sites during the inter-monsoon. Several other sites were very close to the 5 mg/L limit, as was at least one of the Class E sites where the limit is 4 mg/L (Figure 5.27). These low oxygen concentrations are a result of the West Johor Strait being subjected to high organic and nutrient loads from urban storm water and agricultural inputs from the rivers. When this high oxygen demand is coupled with the relatively low energy conditions of an inter-monsoon period low dissolved oxygen concentrations are a result. It can be seen that there is spatial variability in DO values as well. Implicit in this is the need for a well-established base line data set as part of the EMP.

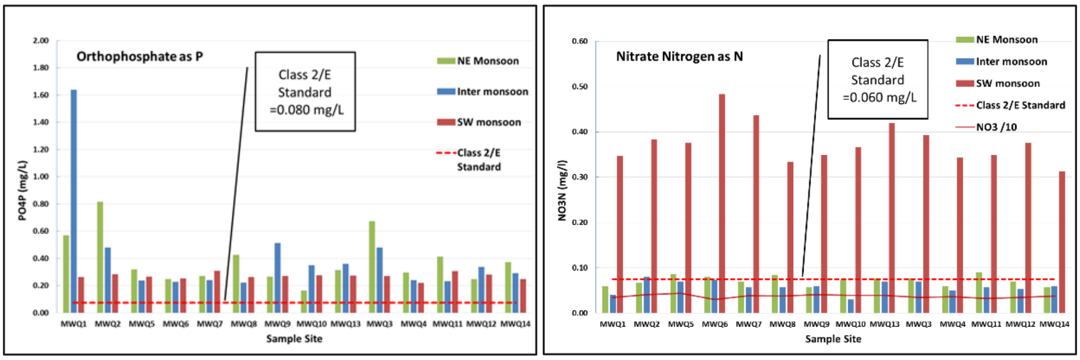

Figure 5.28 Depth averaged orthophosphate phosphorus (left) and nitrate nitrogen (right) measurements at each of the marine stations for the three different seasons. The dissolved oxygen Class 2 and Class E standards which the nutrients should not exceed are shown as the 2 different dashed lines.

The key nutrients released from agricultural and urban waste water are orthophosphate (PO_4P) and nitrate nitrogen (NO_3N). These nutrients are as also naturally occuring, critical to phytoplankton and other algae and plant growth, and are recycled throgh the sediments and water column. The net concentrations in the waters at the study site reflects all of these processses. It can be seen that at all sites both PO_4P and NO_3N exceed the Standards (Figure 5.28). They are also highly variable seasonly. The SW monsoon $N0_3N$ data are exceptionally high and it is not clear if this is an analytical calculation error by the Lab (see possible corrected values presented as line in the Figure 5.28) or an actual change in conditions. In either case the ambient values are high overall, and again a comprehensive baseline needs to be established.

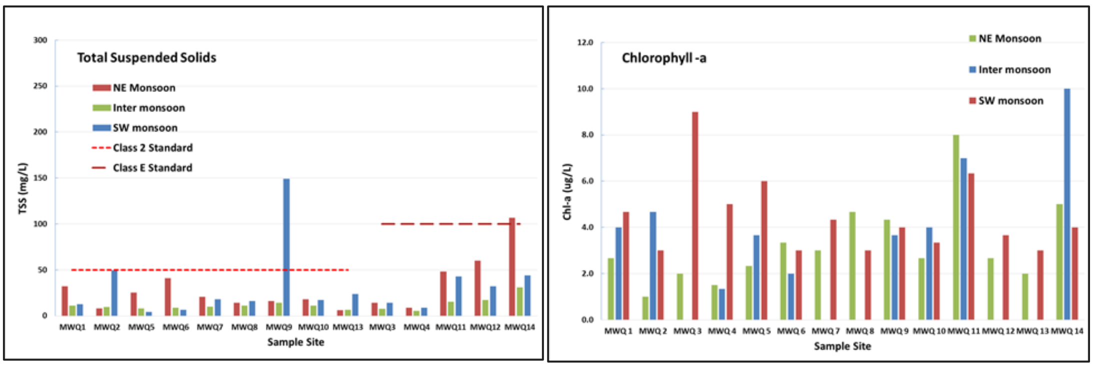

Figure 5.29 Depth averaged Total Suspended Solids (TSS - left) and Chlorophyll-a (right) measurements at each of the marine stations for the three different seasons. The Class 2 and Class E standards which TSS should not exceed are shown as the two different dashed lines.

TSS values are well below the required standards, with the exception of very high values at several points. Although most of the TSS levels for the marine stations were well within Class 2 and Class E limits of the MMWQCS of 50 mg/l and 100 mg/l respectively (Figure 5.29), high TSS levels can be observed during the NE and SW monsoons at the bottom depth level for some stations. Although high, these level are considered normal as these stations were located near mudflat areas where sediment within the water column is due to the re-suspension of the bed sediment by bottom currents. In particular on the western side of the headland the suspended sediments are mainly induced by the strong spring-tidal currents and the long period waves. The forces exerted by the longer waves and the tidal flows on the seabed (that increase with depth) induce re-suspension of sediments, and a maximum in sediment suspension is observed at some distance away from the mangrove fringe.

Chlorophyll-a concentrations are a measure phytoplankton abundance and it can be seen that these vary considerably both spatially and seasonally (Figure 5.29). This normal for a nutrient rich estuary and coastal environment such as the study area /2/.

5.1.9.2 River Water Quality Status

The sample sites for riverine wate quality sampling are shown in Figure 5.30. Note that all the results shown here are a mid depth value. All the data collected are available in Appendix B.

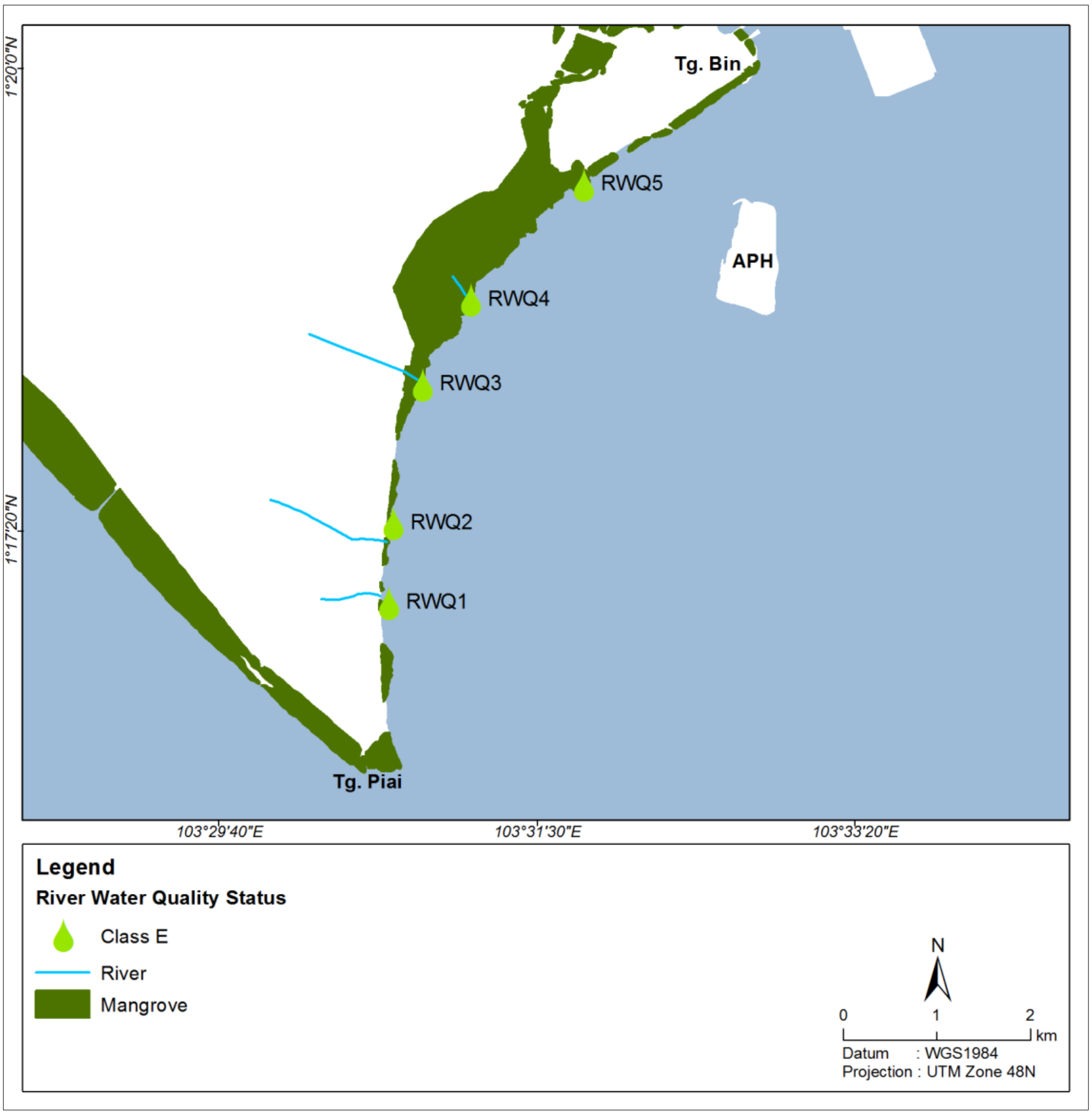

Figure 5.30 Location of riverine stations for water quality, all of which are classified as Class E waters.

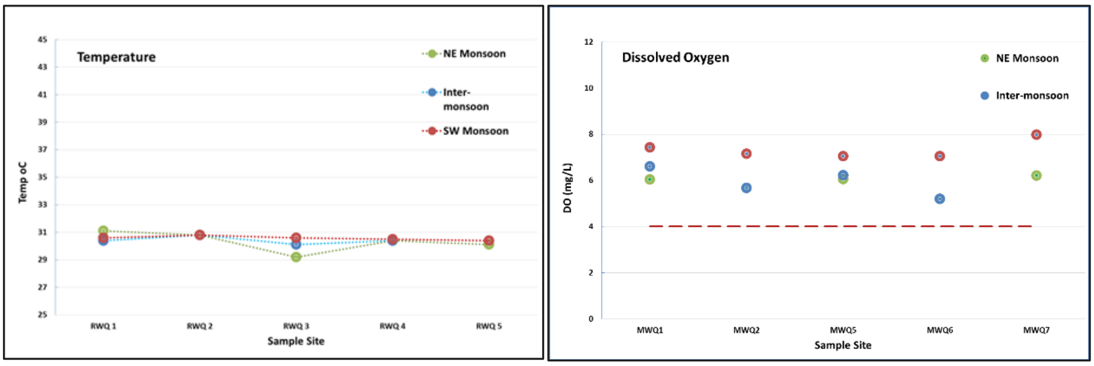

Figure 5.31 Mid depth temperature (left) and dissolved oxygen (right) measurements at each of the riverine stations for the three different seasons. The dissolved oxygen Class 2 and Class E standards below which DO should not fall are shown as the 2 different dashed lines.

Temperatures are much more uniform at the riverine sites than the marine sites, as are dissolved oxygen concentrations (Figure 5.31). The dissolved oxygen (DO) levels for all the stations during all seasons were above the Class E 4 mg/l Standard of 4 mg/L.

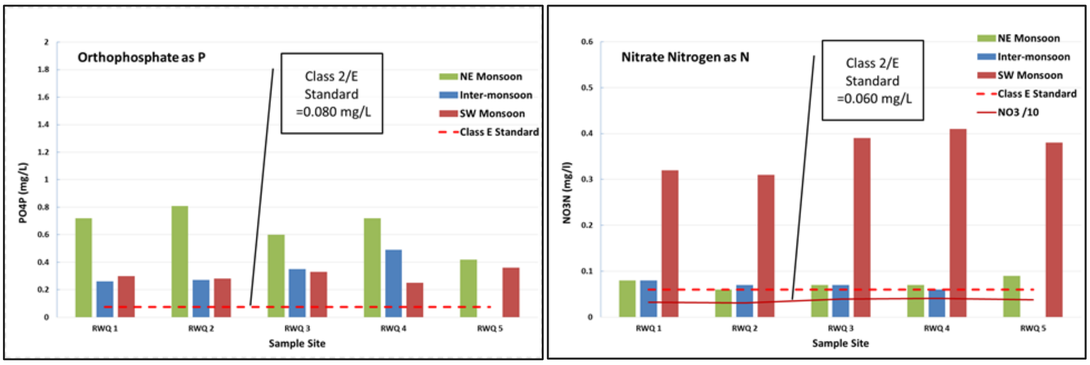

Figure 5.32 Mid depth orthophosphate phosphorus (left) and nitrate nitrogen (right) measurements at each of the riverine stations for the three different seasons. The dissolved oxygen Class 2 and Class E standards which the nutrients should not exceed are shown as the 2 different dashed lines.

The nutrient status of the riverine sites are similar to the marine sites and exceed the Standards set (Figure 5.32). These background levels are to be expected and will continue to vary depending on local conditions in the catchment from which the water is derived.

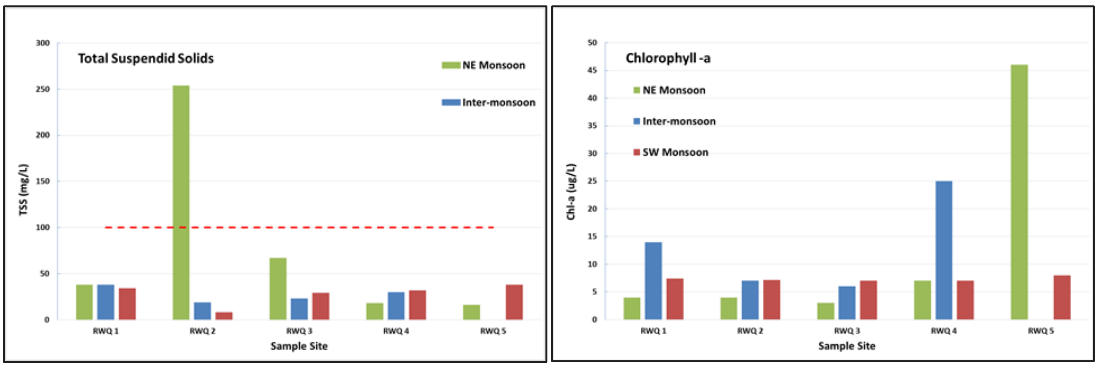

Figure 5.33 Mid depth Total Suspended Solids (TSS - left) and Chlorophyll-a (right) measurements at each of the riverine stations for the three different seasons. The Class E standards which TSS should not exceed are shown as the dashed line.

With the exception of one sample during the NE monsoon TSS values at the riverine sites were all well below the Standard of 100mg/L (Figure 5.33). This one sample is most likely a result of a rainfall-runoff event occurring as the same time as the sampling took place.

Chlorophyll-a values are not as variable as at the marine sites, but again the variation that does occur is reflective of natural changes in phytoplankton populations in such nutrient rich waters.

All other water quality parameters were below the required Standards and many were less than the analytical detection limit.

5.1.10 Air Quality

Ambient air quality survey was carried out from February 28, to March 2, 2014 at four (4) stations as shown in Figure 5.34 using sampling pumps, calibrators and connectors as detailed in Appendix B. The sampling stations were selected to represent sensitive areas which are likely to be affected by the proposed project. Sensitive areas identified around the proposed project area include schools, low density residential areas, environmentally sensitive areas and recreational areas. Parameters measured were total suspended particulates (TSP), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter smaller than 10 micron (PM_{10}), volatile organic compounds (VOC), mercury (Hg), carbon dioxide (CO_2) and carbon monoxide (CO).

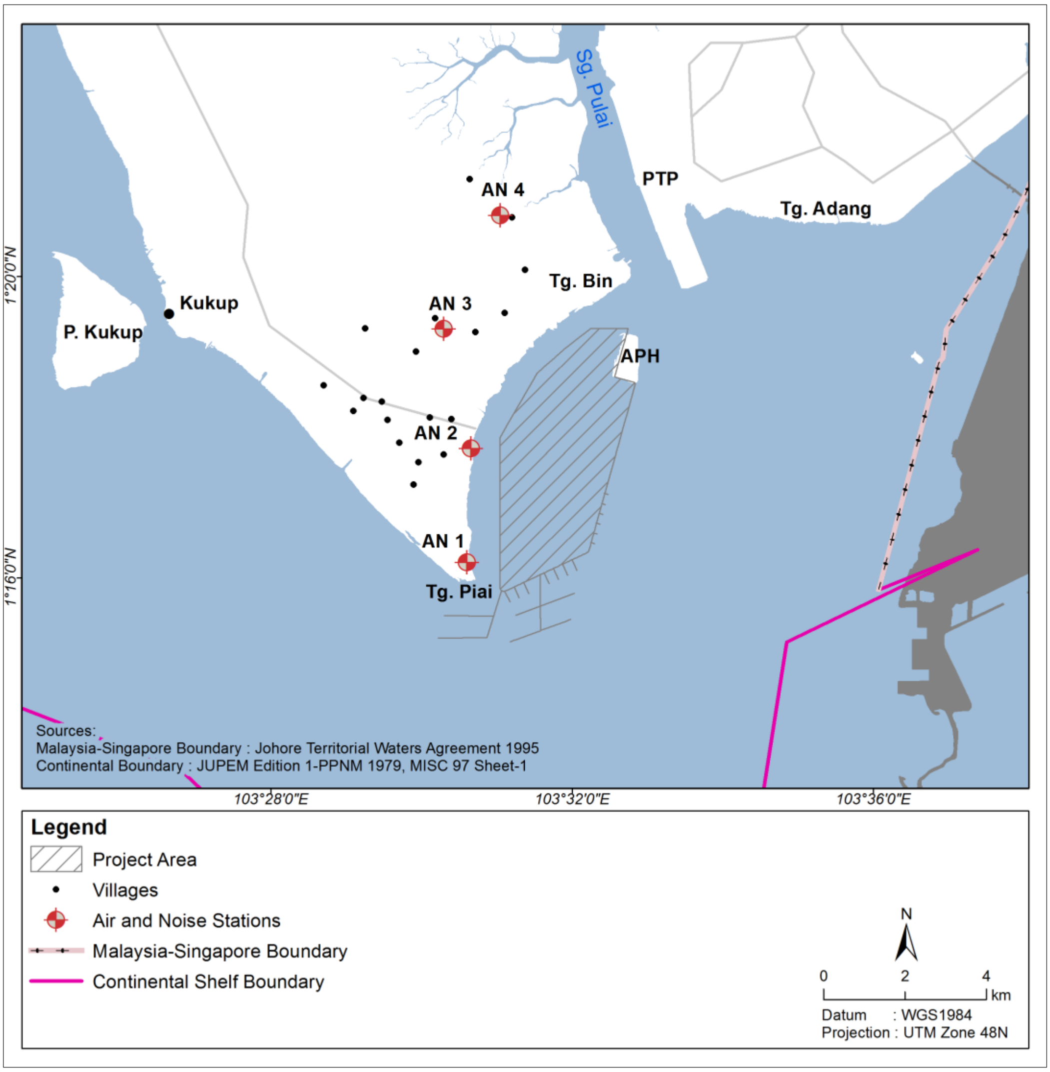

Figure 5.34 Location of air sampling, and noise and vibration monitoring stations

The air quality results were compared against the Malaysian Recommended Air Quality Standards Guideline. All the sampled parameters listed under this guideline including TSP, PM_{10}, SO_2, CO and NO_2 were well within the stipulated limit. Carbon monoxide (CO) was not detected at any of the sampling stations. The limit for VOC was compared against threshold limit values (TLV) recommended under the American Conference of Governmental Industrial Hygienists (ACGIH) where it is well below the stipulated limit. Both mercury and carbon dioxide were not listed in any specific guidelines referred under this reporting.

In general, air quality at Station AN4 was the poorest compared to other stations as all the measured parameters except carbon dioxide were highest at this station. This might be influenced by wind driven air pollutants originating from the nearby industrial areas including Tg. Bin power plant and Port Tanjung Pelepas (PTP). However it should be noted that all pollutant levels were non-hazardous to human health as they were well below the recommended limits of the respective guidelines.

5.1.11 Ambient Noise

Ambient noise level sampling was carried out from February 28 to March 1, 2014 at the same stations as the air quality survey. The results were compared against the maximum permissible sound level for Suburban Residential Areas, Public Spaces, Parks and Recreational Areas specified under Schedule 1 of the Guidelines for Environmental Noise Limits and Control /3/, where the permissible sound level is 55 dB(A) for day time and 45 dB(A) for night time. Detailed explanation of the methods and results is provided in Appendix B.

The ambient noise levels during day time were relatively high, exceeding the limit at stations AN1 (at Tg. Piai Ramsar Centre) and AN4 (Kg. Sg. Chengkeh) and just under the limit at the other two stations (Table 5.7). The predominant noise sources at all stations was road traffic.

Table 5.7 Sound levels (LAeq) recorded at the sensitive receptors during the surveys in February and March 2014.

Period	**Sound Level Equivalent (LAeq), dB(A)**				**Guidelines Schedule 1 for Suburban Residential (dB(A))**
	AN1	**AN2**	**AN3**	**AN4**	
Day time	69.7	51.3	54.1	59.1	55
Night time	66	55	53	62	45

5.1.12 Vibration

An ambient vibration survey was carried out from June 16 to 19, 2014 at the same stations as the air and noise surveys. This survey was performed in accordance to Annex B; Procedures for the Measurement of Vibration in the Environment to *The Planning Guidelines for Vibration Limits and Control in the Environment Second Edition* /3/. Based on this, a ground level seismic vibration survey was conducted using a Vibrock V901 seismograph to measure the continuous steady state vibration during day time (7 a.m. to 10 p.m.) and night time (10 p.m. to 7 a.m.). Detailed explanation of the methods and results can be referred to in Appendix B.

In general ambient vibration is within the recommended limit at all stations except for Station AN4 north of Tg. Bin and adjacent to the Vitol /ATT facility. The vibration level during day time and night time at station AN 1 and during night time at Station AN2 were well below

Curve 1[2] where vibration cannot be felt by humans. The vibration limit at Station AN2 during day time and Stations AN3 were well within the respective limit. The main vibration source at Stations AN2 and AN3 was vehicle movements and human activities.

Two (2) factors were identified to be the reason for the elevated vibration levels at Station AN4, namely the vibration source and the vibration path referring to the medium of propagation. The vibration source from the unloading activity of the building materials for house renovation works ongoing at the time of the survey approximately 5 m from the sampling station resulted in vibration spikes. However, it should be noted that such spikes are considered outliers as it is deemed a disturbance to the ambient steady state vibration. In addition, the vibration path at Station AN4 which was peaty soil generated high vibration levels in the horizontal axis.

5.2 Biological Environment

5.2.1 Data Collection and Sources

The existing biological environment consists of both terrestrial and marine environments encompassing different types of habitats. In order to capture the diversity of habitats and to also ensure their adequate representation, the biological environment is described within the following boundaries:

- Marine ecology – encompassing an area covering more than 10 km radius from the project boundary. This area includes the entire Sg. Pulai and Tg. Piai mangroves, extending to Pulau Kukup and its intertidal mudflat. It also extends until Pulau Merambong, east of the project area. Note that avifauna have been included in the marine ecology section.
- Terrestrial ecology – 5 km from the project boundary.

Table 5.8 details the data collection activities and sources for the biological environment.

Table 5.8 Details of data collection for biological environment

Component	Type of Data	Source	Date of Collection
Terrestrial vegetation	Secondary	Satellite mapping	• 2013
Terrestrial fauna	Primary	• Mist nets • Cage trappings	• 2013
Avifauna	Primary	• Point count survey • Transect line survey	• Northward migratory season (February – March 2013) • Non-migratory season (May 2013) • Southward migratory season (August – November 2013)
Mangrove	Primary	Transect	• 18-21 March 2014
Seagrass	Primary	Transect	• 3 – 4 April 2014

[2] The limits in terms of curves refers to the human vibration perception threshold where Curve 1 is the minimum threshold level which enables a human to feel the vibration. The subsequent curves are relatively the multiplier from this base curve.

Component	Type of Data	Source	Date of Collection
			• 19 – 21 May 2014
Coral	Primary	Transect	12 – 13 April 2014
Marine megafauna	Secondary	Various publications	-
Fish fauna	Primary		30 January – 6 February 2013
Plankton	Primary	16 sampling stations	• NE monsoon: 30 January – 6 February 2013 • SW monsoon: 5 – 13 June 2013 • Intermonsoon: 9 – 19 September 2013
Benthos	Primary	Transect line, totalling 60 stations	• NE monsoon: 30 January – 6 February 2013 • SW monsoon: 5 – 13 June 2013 • Intermonsoon: 9 – 19 September 2013

Due to the extensive coverage of the baseline surveys and assessment, the study area is divided into the three to four main areas for the purposes of discussion for most components. These are:

- Piai west coast – Tg. Piai up to P. Kukup;
- Piai east coast – Tg. Piai up to Tg. Bin;
- Sg. Pulai – encompassing the mangrove and riverine habitats of Sg. Pulai
- Tg. Adang-Merambong.

5.2.2 Terrestrial Ecology

5.2.2.1 Vegetation

Terrestrial flora found along the coastline around Tanjung Piai are predominantly mangroves and mixed vegetation while further inland is dominated by plantations such as coconut, palm oil and rubber as shown in Figure 5.35. Mangroves along the east coast of Tg. Piai are within the Ramsar boundary which has gained international importance (refer to section 5.2.4.1 for mangrove description). Photo 5.6 to Photo 5.9 shows some examples of terrestrial flora along the coastline.

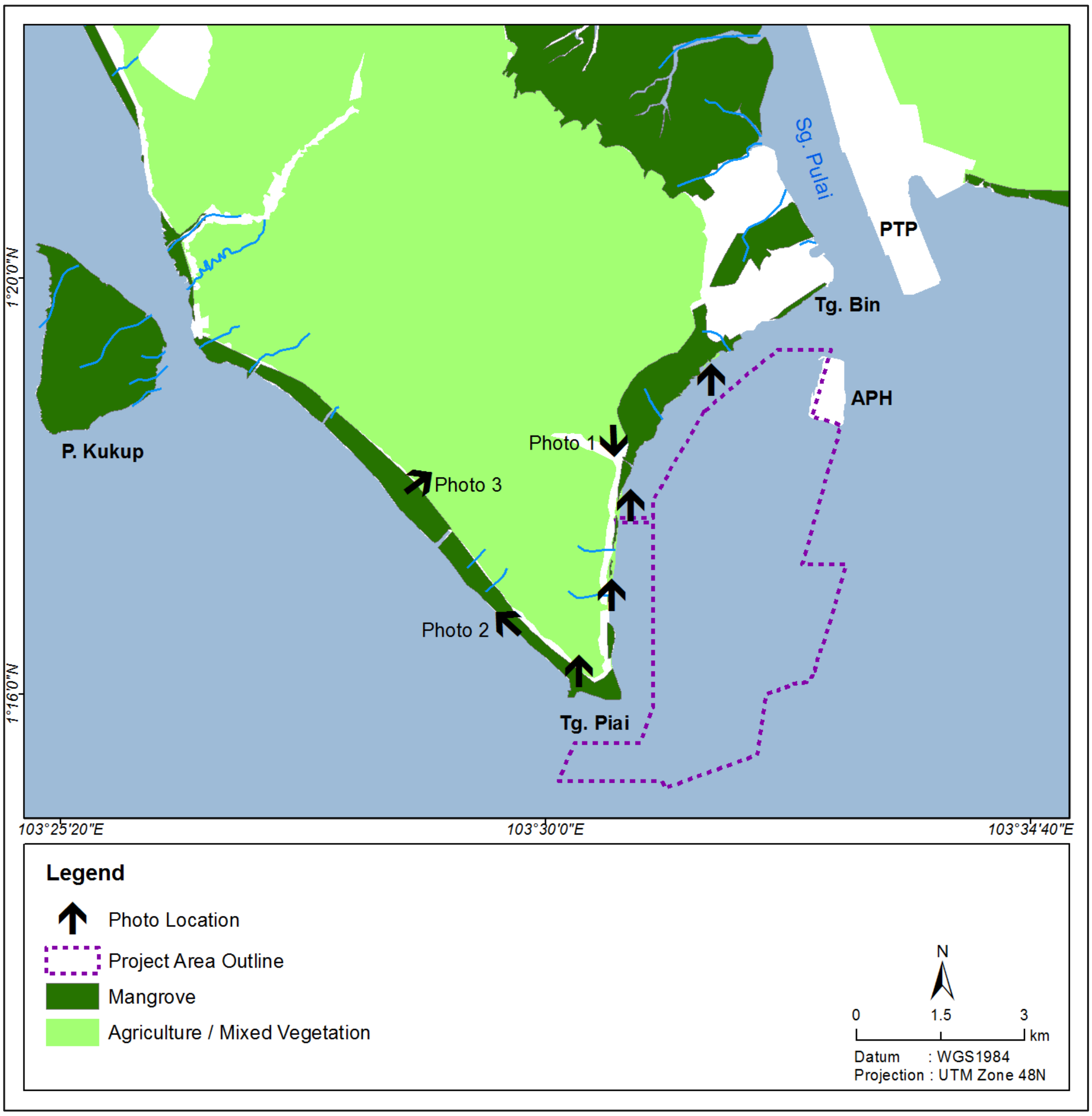

Figure 5.35 Vegetation type within the vicinity of the project area

Photo 5.6 Vegetation along the shoreline from Tg. Piai to Tg. Bin (Photo 1)

Photo 5.7 Vegetation along the shoreline from Tg. Piai to P. Kukup (Photo 2)

Photo 5.8 Mixed vegetation of Tanjung Piai

Photo 5.9 Coconut and oil palm plantation in the study area (Photo 3)

5.2.2.2 Fauna

On P. Kukup, a total of 12 species of mammals were recorded comprising two species of carnivores (civet and otter), four species of chiropterans (bats), three species of primates (monkeys), two species of rodentia (rats), and one species of ungulate (pig). On the mainland from Kukup to Tg. Piai, and Tg. Piai to Tg. Bin, a total of 18 species of mammals were recorded including three species of carnivores (civet and otters), five species of chiropterans (bats), two species of primates (monkeys), six species of rodentia (rats), one species of pholidota (pangolin) and one ungulate (pig).

A total of 28 species of mammals were recorded inhabiting Sungai Pulai mangrove, represented by six species of carnivores (cats, civets and otters), seven species of chiropterans (bats), four species of primates (monkeys), nine species of rodentia (rats), one species of pholidota (pangolin), and one ungulate (pig).

Mammals are categorised as *Totally Protected, Protected* and *Not Protected* according to the Wildlife Act 2010. Out of 29 species of mammals documented (in all locations), the Slow loris (*Nycticebus coucang*), which is only recorded in Kukup, is listed as *Totally Protected*.

Twelve species are listed as *Protected* (for example, Leopard cat *Prionailurus bengalensis* and Dusky leaf monkey *Trahypithecus obscurus*) and sixteen are listed as *Not Protected* (for example, Pangolin *Manis javanica* and Common treeshew *Tupaia glis*).

Among bat species, the Common Long-tongued Fruit Bat (*Macroglossus minimus*) is the dominant and most common fruit-eating (frugivorous) bat in the mangrove forests and coastal area. Other frugivorous bats recorded are the Horsfield's Bat (*Cynopterus horsfieldi*) and Cave Nectar Bat (*Eonycteris spelaean*). The insectivorous bats (Microchiroptera), however are less commonly encountered. An individual Trefoil Horseshoe Bat (*Rhinolophus trifoliatus*) and Pouched Tomb Bat (*Tophozous saccolaimus*) were also recorded.

The shrews were represented by the Common Treeshew (*Tupaia glis*). This species is known to be widespread on the mainland in all types of forest habitats extending from the lowlands to higher elevations up to 1,500 m. The squirrel was represented by two species, one of which is the Plantain squirrel (*Callosciurus notatus*). Members of this arboreal species are commonly found in scrubs, gardens, orchards, and smallholdings, where they range freely into the adjoining forest including the mangrove, inland primary and secondary forests.

Smooth otters (*Lutra perspicillata*) were commonly sighted in Sungai Pulai and Tanjung Piai. The mangrove waterways and creeks in the area support a viable population of this species.

The most abundant primate in the area is the Long-tailed Macaque (*Macaca fascicularis*). This species is ubiquitous throughout the mainland, occurring abundantly from the coastal zone (including mangroves), to primary and secondary forests, orchards, plantations, and forest fringes. In fact, this species has even colonised settlement areas and has learnt to co-exist successfully with humans to the extent that the monkeys have become a pest and nuisance. The other common species is the Silvered Leaf Monkey (*Trahypithecus cristatus*). This species is restricted to the west coast of Peninsular Malaysia, inhabiting mangroves, riparian and freshwater swamp forest and adjacent plantations up to 40km inland.

The most prevalent large mammal in the survey areas is the wild boar (*Sus scrofa*). This species is well-known to occupy all types of habitats including mangroves, scrub, forest fringes, and plantation areas. The wild boar, pangolin, and primates are all protected under the Wildlife Protection Act 2010.

Photo 5.10 Monkeys in Tanjung Piai National Park (left) /4/ and in P. Kukup taken during survey (right).

Photo 5.11 Example of protected wildlife: wild boar (left) and pangolin (right) /5, 6/.

5.2.3 Avifauna

Avifauna assessment was carried out using two (2) main methods, namely point count survey and line transect. Surveys were carried out in the following areas (Figure 5.36):

- Area 1: Kukup to Tg. Piai;
- Area 2: Tg. Piai to Tg. Bin (including Tg. Piai Ramsar Site);
- Area 3: Pulau Kukup Ramsar Site;
- Area 4: Pulau Merambong; and
- Area 5: Sg. Pulai Ramsar Site.

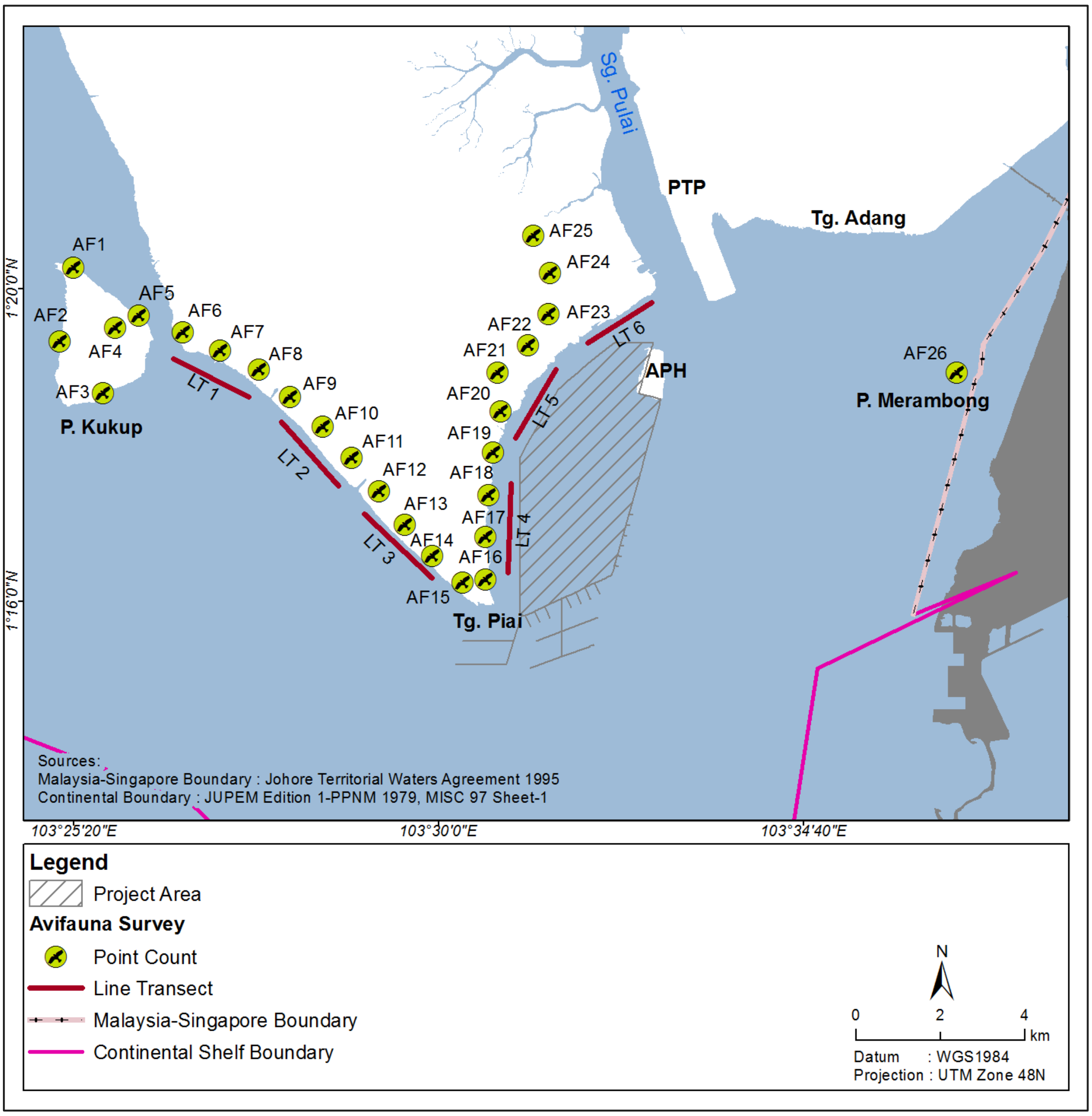

Figure 5.36 Avifauna survey stations.

Point counts were mainly carried out for inland and mangrove birds (i.e. Areas 1, 2, 3 and 4), while line transects targeted waders (i.e. Areas 1, 2 and 5). Assessment was carried out for the northern migration season (February to March 2013), non-migration season (April to May 2013) and southern migration season (August to November 2013).

5.2.3.1 Species Diversity

A total of 116 bird species, representing 48 families was recorded throughout the one-year assessment. Most of the birds are classified as residents (66 species - 57%), followed by migrant birds (35 species - 30%). Twelve of the recorded species are resident and migrant (10%), and three (3) species were introduced species (3%) as shown in Figure 5.37.

The highest number of inland and mangrove bird species was recorded in the zone from Kukup to Tg. Piai, followed by Tg. Piai east (Tg. Piai to Tg. Bin), see Figure 5.38. For waders, the highest number of species found was at Sg. Pulai, followed by the western coastline of Tg. Piai (Kukup to Piai) (Figure 5.39).

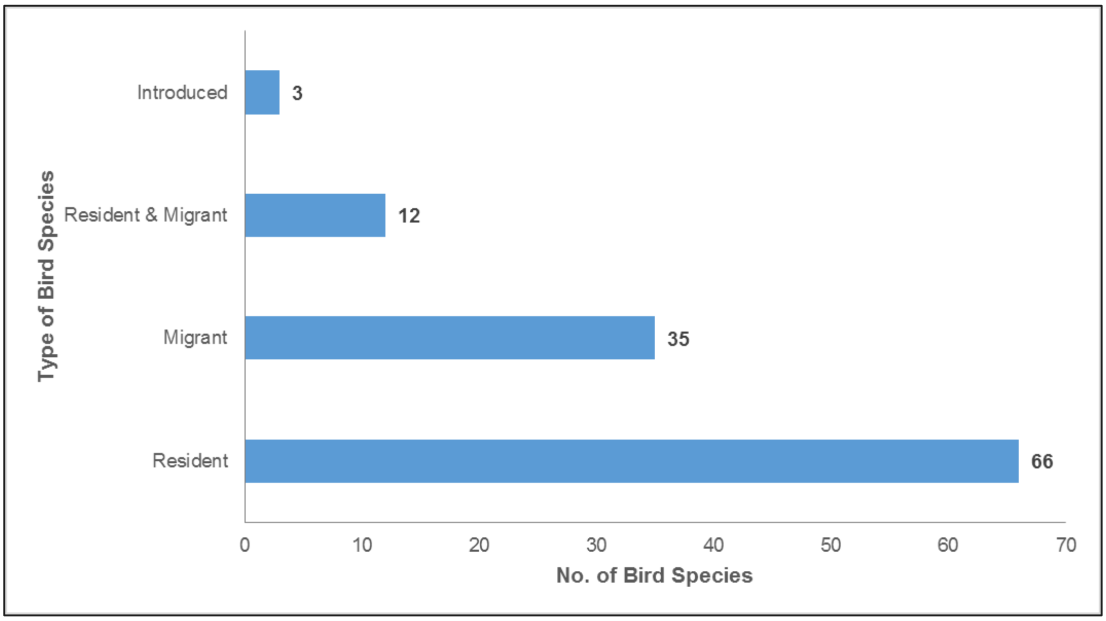

Figure 5.37 Overall bird species richness

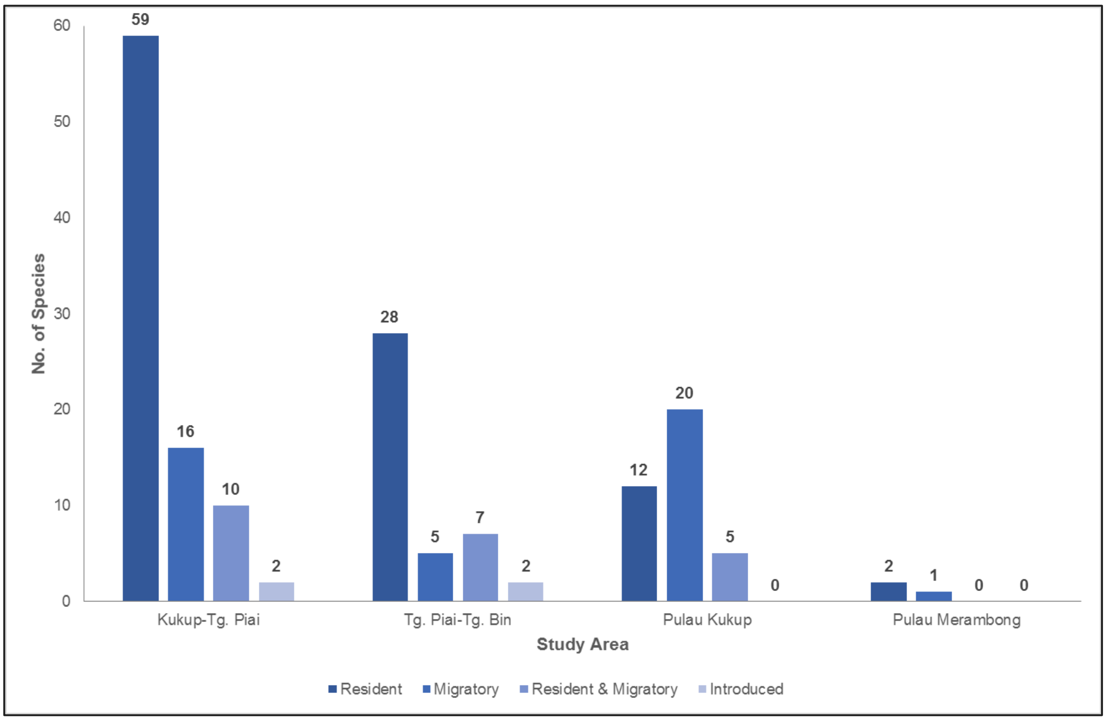

Figure 5.38 Types of inland and mangrove bird species found in the study area

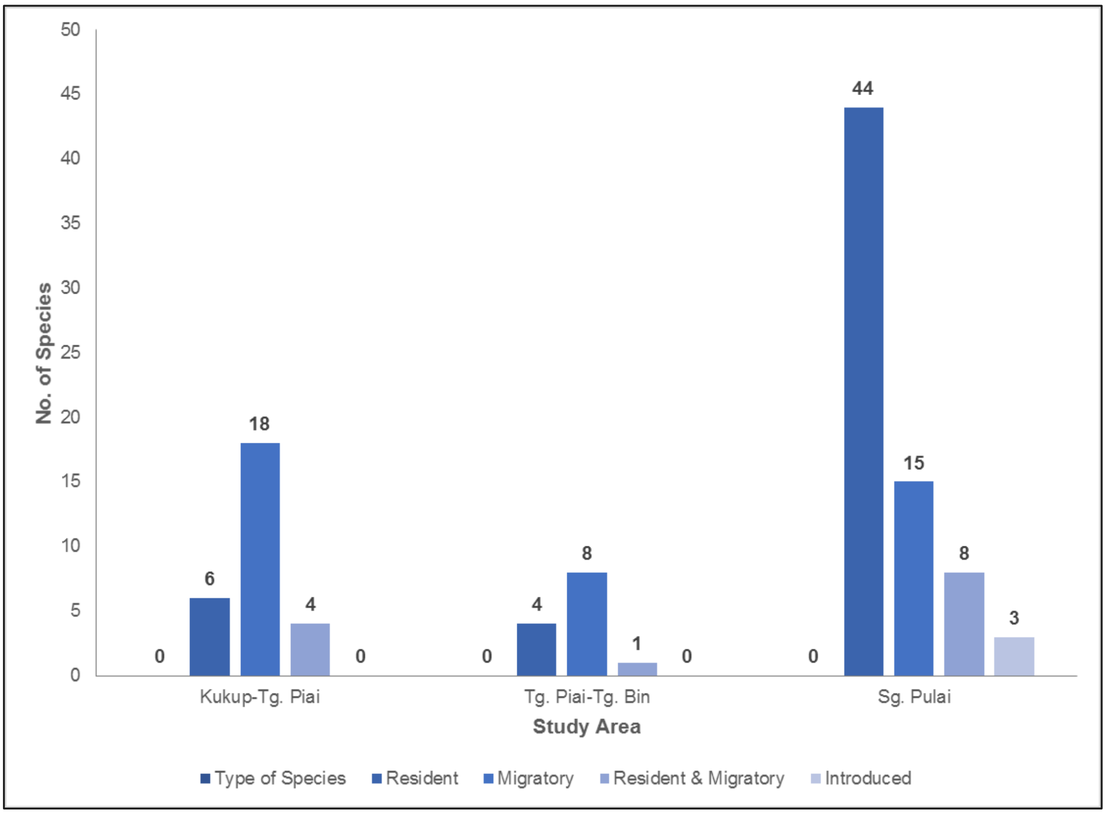

Figure 5.39 Types of waders species found in the study area

5.2.3.2 Conservation Status

Out of the 116 bird species found within the study area, 83 species are classified as 'Totally Protected' under the Protection of Wildlife Act 1972 (Figure 5.40). Examples include *Butorides striata* Little Heron, *Leptoptilos javanicus* Lesser adjutant, *Sterna hirundo* Common Tern, and *Spizaetus cirrhatus* Changeable Hawk-eagle). Under the same legislation, three (3) species (i.e. *Chalcophaps indica* Emerald Dove, *Gracula religiosa* Common Hill Myna, and *Zosterops palpebrosus* Oriental White-eye) are listed as 'Other Protected Bird Species' and 16 species (e.g. *Actitis hypoleucos* Common Sandpiper, *Xenus cinereus* Terek Sandpiper, and *Charadrius leschenaultia* Greater Sand-plover) are 'Game Bird'. The remaining 14 species are not protected under the legislation.

As shown in Figure 5.41 and Figure 5.42, the highest number of totally protected bird species was recorded on the western coast of Tg. Piai (Kukup to Tg. Piai).

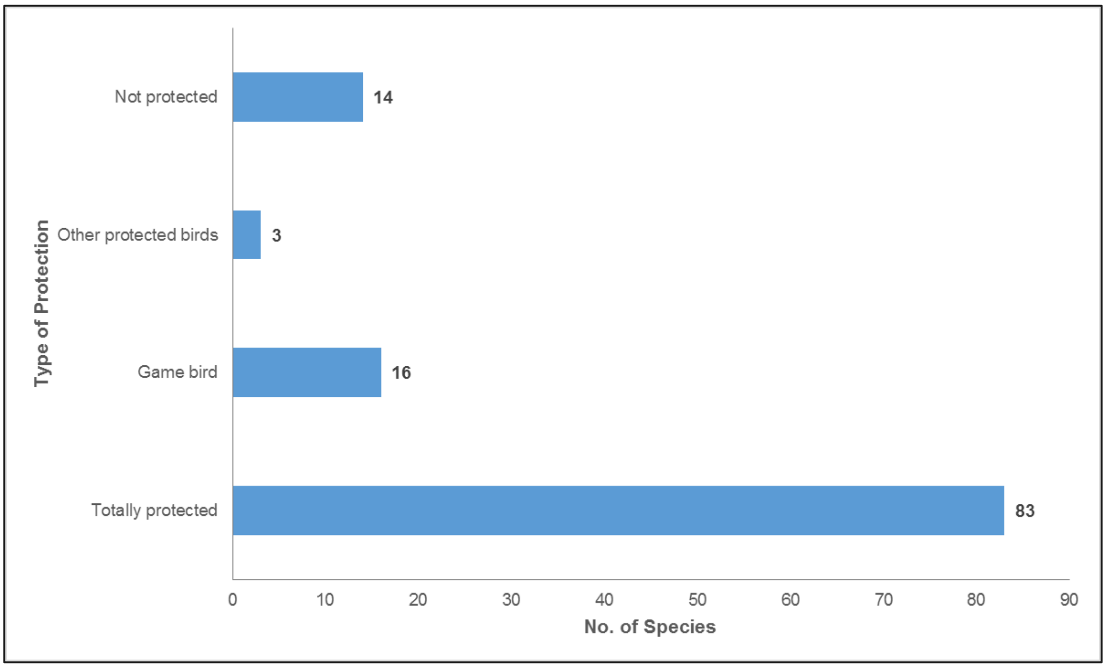

Figure 5.40 Conservation status of bird species found within study area as categorised by the Protection of Wildlife Act 1972

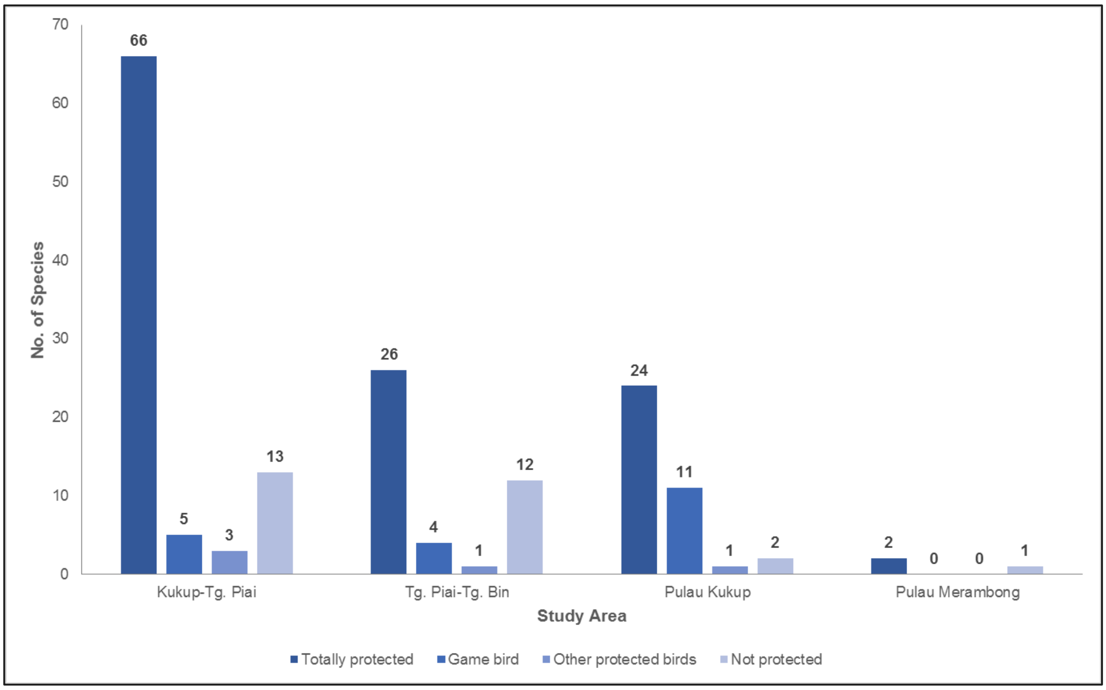

Figure 5.41 Number of inland and mangrove bird species protected under the Protection of Wildlife Act 1972

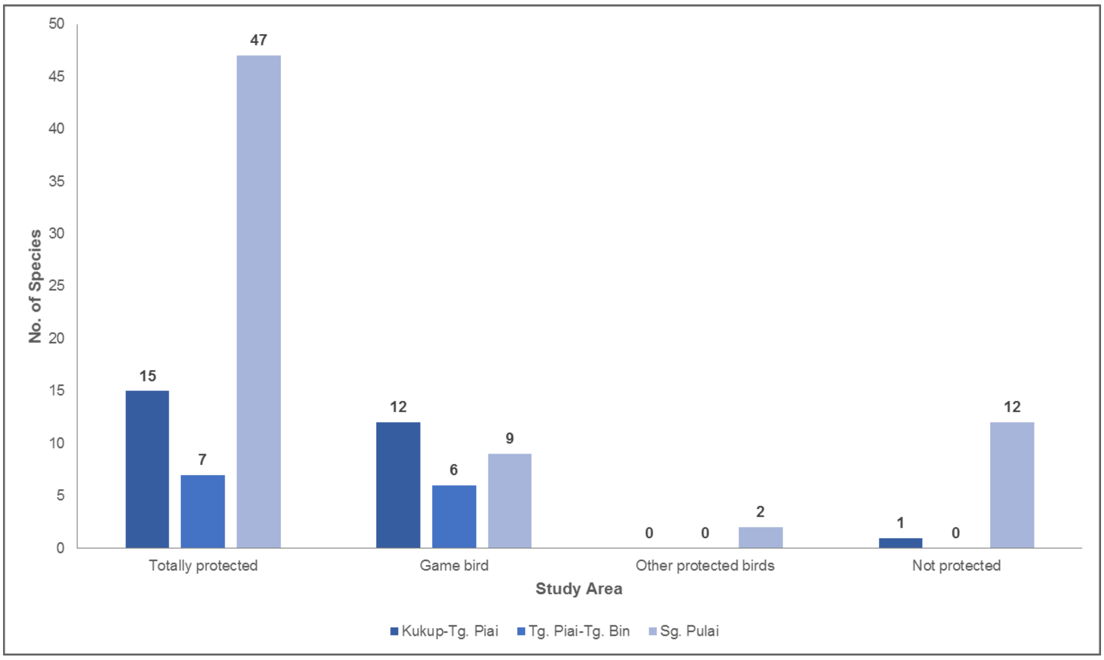

Figure 5.42 Number of waders bird species protected under the Protection of Wildlife Act 1972

Photo 5.12 Lesser adjutant

Photo 5.13 Common sandpiper

5.2.3.3 Summary

Bird distribution is generally influenced by habitat range and type. The total number of species in various habitat types such as mangroves, agricultural land, and mudflats varies according to food availability, shelter, feeding and nesting habits, biotic and abiotic factors, with a key driver being food availability.

Shorebirds and waterbirds in particular are very much dependent on the intertidal mudflats and associated mangrove areas as they support a rich benthic fauna.

High numbers of birds were recorded at P. Kukup and the west coast of Tg. Piai, while less birds were observed along the east coast from Tg. Piai to Tg. Bin. In particular, the west coast supports the highest number of species of mangrove and inland birds throughout the study area, while the highest number of wader species was found at Sg. Pulai.

5.2.4 Marine Ecology

5.2.4.1 Mangrove

In Johor, the total mangrove forest is 18,373 ha, where the larger mangrove areas were located in Sg. Pulai Forest Reserve, with an area of 8,353 ha. The list of mangrove sites in South Johor is presented in Table 5.9.

Table 5.9 Mangrove sites in South Johor /7, 8/.

Location	Area (ha)	Current Status
Pulau Kukup	99.8	National Park
Kukup – Tg. Piai	185.3	State land
Tanjung Piai	476.3	National Park
Sg. Pulai	8,353.2	Forest Reserves
Pulau Merambong	2.8	State land
Sg. Pendas	13.3	Forest Reserves
Sg. Kemudi - Sg. Bahan	155.81	Forest Reserves
Sg. Perepat - Sg. Melayu	240	Forest Reserves
Sg. Kim Kim, Sg. Laloh, Sg. Chupak	608.4	State land
Sg. Johor	3,919.3	Forest Reserves

A total of 28 species of mangroves belonging to nine (9) families were recorded within study area of P. Kukup, the mangroves between P. Kukup and Tg. Piai and from Tg. Piai to Sg. Pulai / Sg. Chengkeh. Family *Rhizophoraceae* is the most dominant family at the study area /69, 9/. The Diameter Breast Height (DBH) and heights of mangrove trees ranged from 2 – 200 cm and 4 – 90 m respectively. As for mangrove saplings, the DBH ranged from 1 – 30 cm with heights from 0.5 – 3.0 m. Based on assessment, an estimated 1,367 ha of mangrove forest between Sg. Pulai and Kukup (including Pulau Kukup) could comprise a total of more than 8,000,000 mangrove trees and saplings.

Piai

The Tg. Piai mangrove can be found along the eastern shoreline from Tg. Piai up to Tg. Bin especially around Sg. Nibong tributaries with approximate width up to 790 m from the coastline to the landward area. On the west coast from Tg. Piai to Kukup Town the approximate width of the mangrove fringe is up to 50 m. The mangrove along this shoreline is severely eroding while the mangrove along the western shoreline is relatively stable.

The mangroves along the eastern shoreline are largely within the Ramsar Sites and the National Parks (Figure 5.43).

The mangrove along the shoreline of the Project site are mixed stands of *Avicennia officinalis, Sonneratia alba* and *Rhizhophora apiculata.* Landward mangroves consist of *Bruguiera cylindrica* with *Rhiziphora apiculata* dominating the seafront. *A. alba* and *A. marina* are also present in some areas. Typically, there is an *Avicennia-Sonneratia* community on the seaward sediments where there is soft, deep mud while the *Rhizophora-Bruguiera* forest is often the more dominant as the soil becomes firmer. In total, 21 ‘true’ mangrove species and nine (9) mangrove associated species are found along the shoreline.

The highest tree density value is recorded in Tg. Piai National Park, with a total value of 4,013 trees/ha, followed by Tg. Bin – Tg. Piai (1,498 trees/ha), Sg. Pulai – Tg. Bin (1,215 trees/ha) and Tg. Piai – Kukup (808 trees/ha). Out of seven (7) taxa recorded, *Rhizophora* is the most abundant taxa at all mangrove areas, where the highest tree density was 2,528 trees/ha, recorded in Tg. Piai National Park. This was followed by Sg. Pulai to Tg. Bin (1,130 trees/ha), Tg. Bin to Tg. Piai (1,083 trees/ha) and Tg. Piai to Kukup (463 trees/ha). Photo 5.14 to Photo 5.17 shows some photos of mangroves along the coastline.

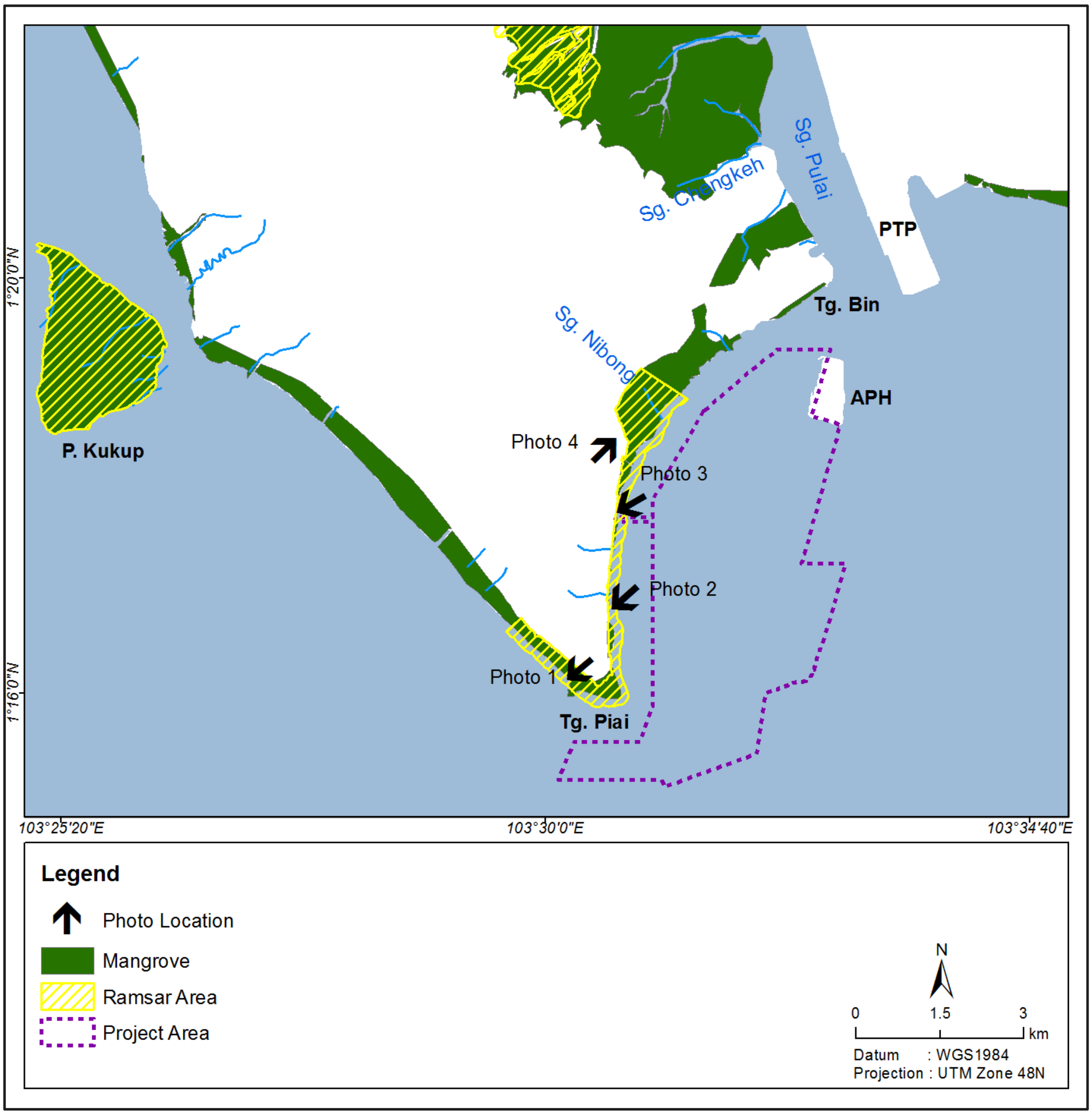

Figure 5.43 Mangroves within the vicinity of the project area. "Photo location" indicates the locations of Photo 5.14 to Photo 5.17 below.

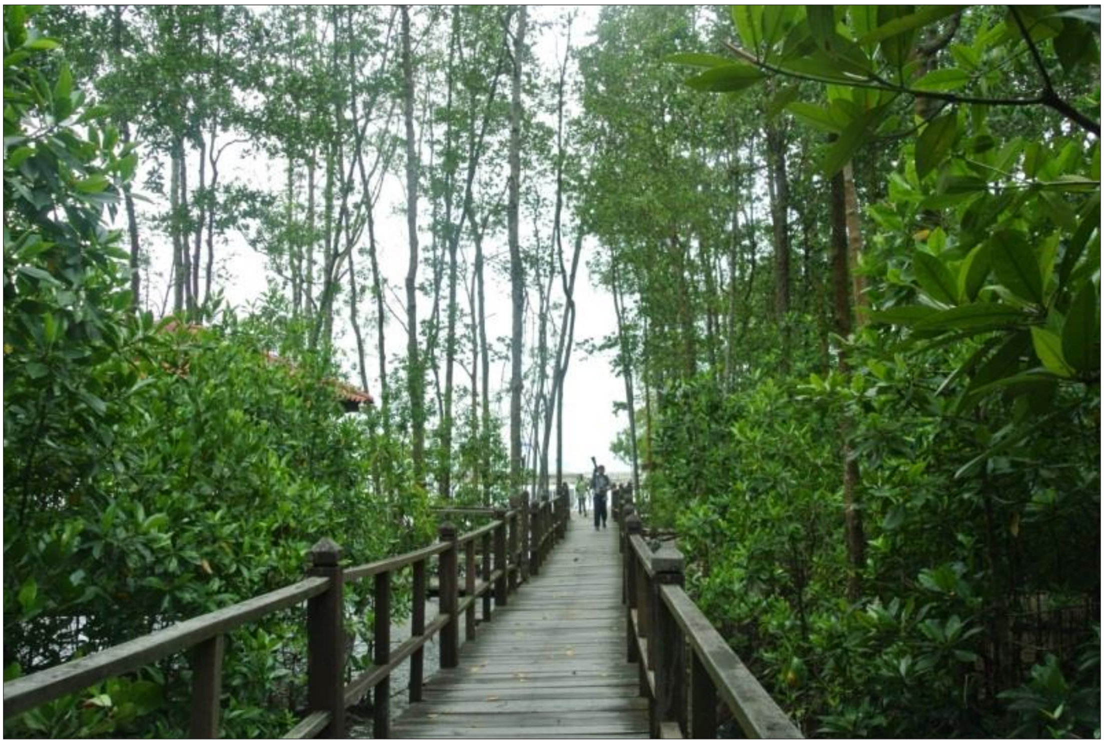

Photo 5.14 Mangrove of Tanjung Piai (Photo 1)

Photo 5.15 Mudflats of Tanjung Piai (Photo 2). Note the effect of the ongoing shore line erosion leading to the loss of mature trees.

Photo 5.16 Mudflats of Tanjung Piai-Tanjung Bin (Photo 3)

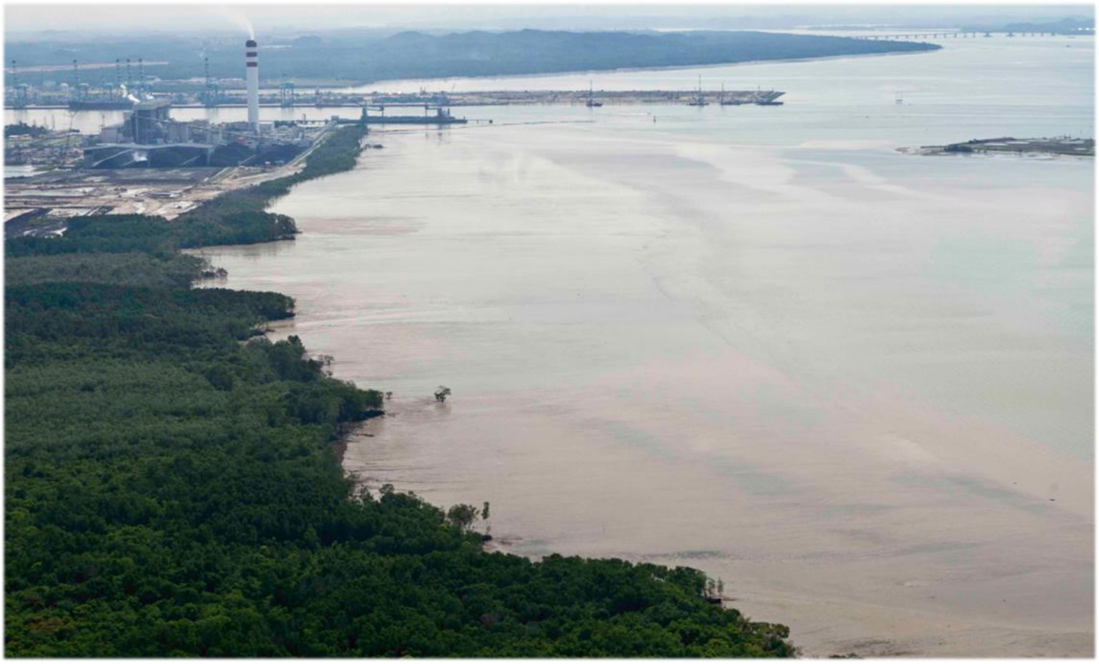

Photo 5.17 Mangrove of Tanjung Piai-Tanjung Bin (Photo 4)

The erosion along the east coast as discussed in Section 5.1.8 affects most parts of the national park, and could be related to the disappearance of common mangrove species of the seaward zone such as *Avicennia* and *Sonneratia*. However, there were erosion control bags that have been placed in the affected area for the purpose of reducing erosion (Photo 5.18).

Photo 5.18 Eroded Coastline in Tg. Piai National Park; Bottom photo: Erosion Control Bag Placed in the Eroded Area

Pulau Kukup

The major species found in the seaward zone at P. Kukup were *Avicennia alba* and *Sonneratia alba*. In the middle of Pulau Kukup, species such as *Ceriops tagal, Bruguiera gymnorrhiza, Xylocarpus granatum, Aegiceras corniculatum* and *Lumnitzera littorea* were recorded. Species from Family Rhizophoraceae, particularly *Rhizophora apiculata* and *Bruguiera cylindrica* were widely distributed at most part of the island. Photo 5.19 to Photo 5.22 show the Pulau Kukup mangrove.

There are also signs of erosion around P. Kukup (Photo 5.21 and Photo 5.22), possibly due to ship wakes. In contrast, the mainland mangrove on the west coast show signs of accretion.

Photo 5.19 Aerial view of P. Kukup mangroves looking north-west

Photo 5.20 Mangrove of Pulau Kukup.

Photo 5.21 Eroding mangrove on the northwestern side of P. Kukup.

Photo 5.22 Mangrove of Pulau Kukup. Note undercutting of mature trees, commonly a result of boat wake.

Sg. Pulai

The Sg. Pulai mangrove is both protected as a Ramsar Site and a Forest Reserve. Between Sg. Pulai and Tg. Bin where the surveys were focused, the dominant mangroves found were *Rhizophora*. Together with *Rhizophora, Avicennia* and *Sonneratia* were recorded, particularly towards the sea. The species distribution within the Sg. Pulai mangrove comprises of 24 true mangrove species and 21 mangrove associated species/10/. These true mangrove species are from the following families:

- *Rhizophoraceae;*
- *Avicenniaceae;*
- *Sonneratiaceae;*
- *Meliaseae;*
- *Rubiaceae;*
- *Combretaceae;*
- *Euphoribiaceae;*
- *Sterculiceae;*
- *Meliaceae; and*
- *Plypodiaceae*.

Photo 5.23 Aerial view of Sungai Pulai mangroves

Photo 5.24 Tributaries of Sungai Pulai: Sungai Tiram

In terms of number of mangroves, high density of trees recorded near to the shoreline compared to the landward zone, which could be related to the felling activities (Photo 5.25). However, recolonization of *Rhizophora* saplings were also observed within these clearings.

Photo 5.25 Felling observed near Sg. Chengkeh

Summary

Table below shows the summary of the mangrove condition within the study area (Table 5.10).

Table 5.10 Summary of mangrove species and density within study area.

Location	Dominant Species	Average Density (trees/ha)	Other species	Observed human pressure
Tg. Piai National Park	*Rhyzophora apiculata, Bruguiera cylindrica*	4,013	BP, RM, CT, XG, AO	Erosion
Tg.Piai to Tg. Bin	*Rhizophora* spp.	1,498	AO, BC, BG, RA, RM, CT	
Tg. Piai to Kukup	*Avicennia alba, Rhizophora apiculata, Sonneratia* spp.	808	*Avicennia* spp., *Rhizophora* spp., *Sonneratia* spp., *Ceriops* spp., Bruguiera spp.	
Sg. Pulai	*Rhizophora* spp.	1,215	*Sonneratia* spp., *Avicennia* spp., AA, AO, RA, RM, BP, BC, CT.	Clearing
P. Kukup	*Rhizophora apiculata, Bruguiera cylindrica*	n/a	AA, SA, CT, BG, XG, LI	

BP: Bruguiera parviflora; RM: Rhizophora mucronata, CT: Ceriops tagal, XG: Xylocarpus granatum, AO: Avicennia officinalis, BC: Bruguiera cylindrical, BG: Bruguiera gymnorrhiza, RA: Rhizophora apiculata, AA: Avicennia alba, SA: Sonneratia alba, LI: Lumnitzera littorea.

5.2.4.2 Seagrass Habitat

In Malaysia, fifteen (15) species of seagrasses belonging to eight (8) genera and three (3) families have been reported /11/. The west coast of Peninsular Malaysia also contain several localities along the Straits of Malacca which support well-developed seagrass communities that constitute a large portion (40.0% - 85.7%) of all known seagrass species in Malaysia, whereby the central and southern regions of the Straits have a greater diversity of seagrass species compared to the northern reaches /12/.

Distribution, abundance & health

Seagrass beds can be found in the estuary of Sungai Pulai, Merambong Shoals and Tanjung Adang Shoals, as shown in Figure 5.44 and Table 5.11 /36/. These beds are of multi-species beds, as described below, with no distinct zonation.