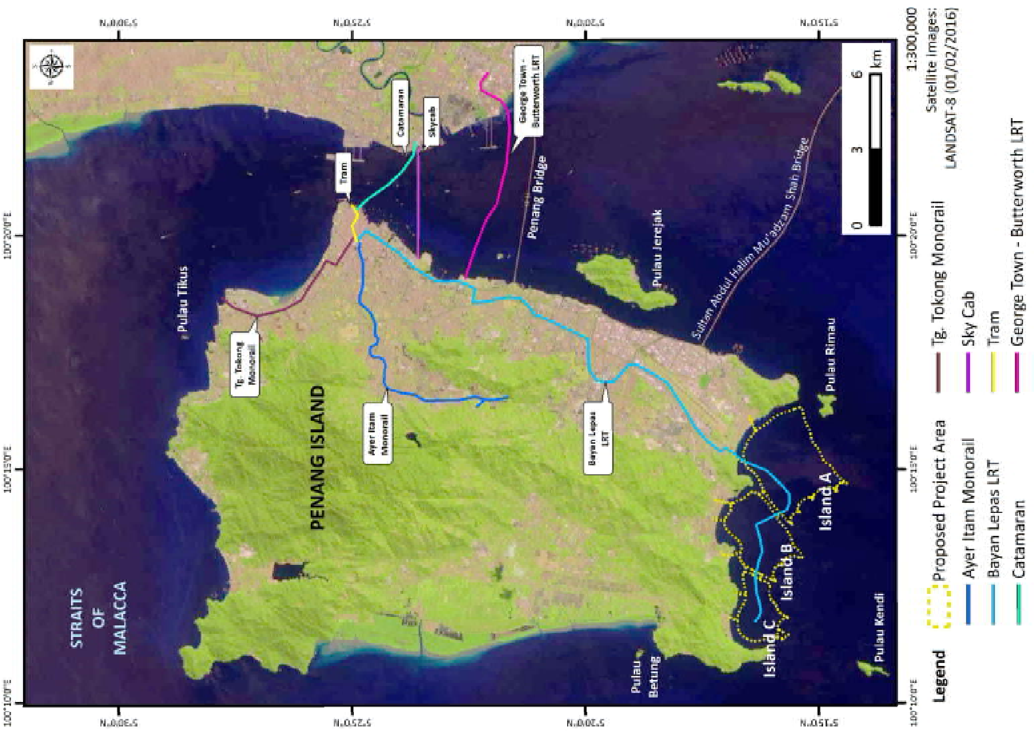
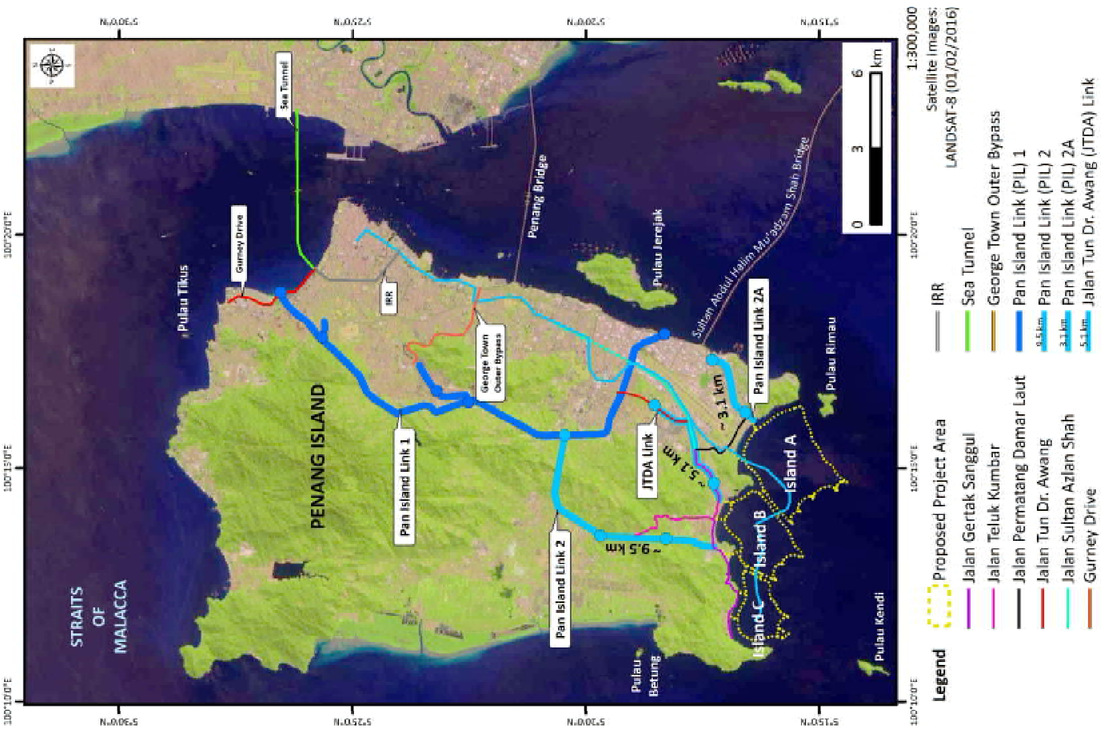
F7.84 Proposed transportation network for PSR





T7.53 Estimated trip generation (PCUs/hour)

Peak Period	Island	Car	Motorcycle	Truck	Bus	Total
AM	A	18,931	4,007	6,295	2,154	31,387
	B	20,653	2,672	4,061	662	28,049
	C	7,649	1,156	2,053	374	11,232
	Total	**47,234**	**7,837**	**12,408**	**3,189**	**70,669**
PM	A	16,452	3,066	5,482	1,768	26,768
	B	23,109	2,729	4,057	387	30,282
	C	8,716	1,315	1,836	191	12,057
	Total	**48,276**	**7,109**	**11,376**	**2,346**	**69,107**

The surrounding developments are also predicted to have their contributions towards the trips generated and attracted to the development site. This is known as background growth and the growth rate for said background growth has been identified and included in the assessment.

7.9.2.4 Scenario Definitions of TIA

The following scenarios have been assessed for the traffic impact assessment which are explained as follows:

a) *Without Development* - This scenario includes all proposed external transport infrastructure outlined in T7.54, other key developments within the study area without the proposed PSR development
b) *With Development* - This scenario includes all proposed internal and external transport infrastructure outlined in T7.54 including PIL and the connections between PIL and the proposed PSR development. Mitigation measures proposed to alleviate the traffic impacts generated by the proposed development is also incorporated.

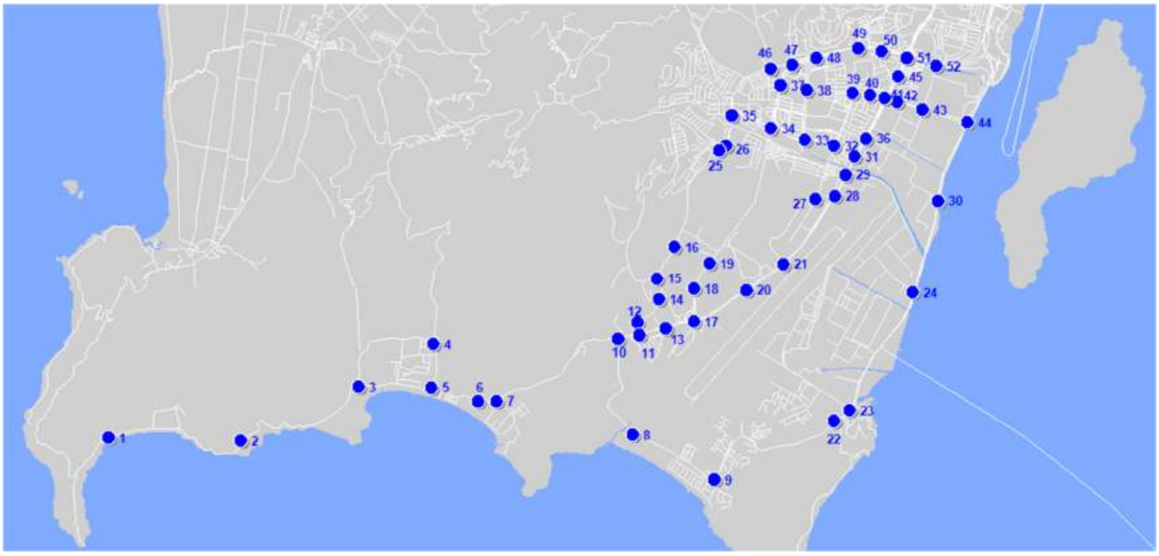
T7.54 Proposed external transport infrastructure

Projects		Without Development	With Development
Rail	LRT Bayan Lepas	✓	✓
	LRT Bayan Lepas (extension to PSR)		✓
	Monorail AI+TB	✓	✓
	BRT	✓	✓
	Crossing LRT	✓	✓
	Mainland monorail	✓	✓
	Georgetown tram	✓	✓
Bus	Rationalisation of bus routes at rail corridor	✓	✓
	Feeder bus system	✓	✓
PSR Highway	PIL1	✓	✓
	PIL2		✓
	PIL2A		✓
	Jalan Tun Dr. Awang (JTDA) elevated road		✓
Other public transportation	Sky Cab	✓	✓
Policy	Increased private vehicle charging - existing areas	✓	✓
	Increased private vehicle charging - PSR		✓
	Fuel price	✓	✓
PSR	PSR Development traffic		✓
Government committed highways	Penang Third Crossing - Sea Tunnel	✓	✓
	Georgetown Inner Ring Road (IRR)	✓	✓
	Georgetown Outer Bypass (GTOB)	✓	✓
	North Coast Pair Road (NCPR) (Zenith Section)	✓	✓
	North Coast Pair Road (NPCR) (SRSC Section)	✓	✓
	Gurney Expressway	✓	✓
	Connecting road between NCPR and Gurney Expressway	✓	✓
	Ayer Itam Pair Road (at Bukit Kukus)	✓	✓
	Tun Dr. Lim Chong Eu Elevated Expressway	✓	✓
	General road widening in Teluk Kumbar	✓	✓
	Batu Maung flyover	✓	✓
	Macallum U-turn and road improvement	✓	✓
	The Lights - Connector roads and internal roads	✓	✓
	Jalan Pisang/Jalan Zoo road improvement	✓	✓
	Jalan Bukit Gambir/Jalan Tun Dr. Awang junction improvement	✓	✓
	FIZ contraflow system at Hilir Sungai Kluang 4	✓	✓
	Jalan Bayan Lepas/Jalan Teluk Kumbar/Jalan Permatang Damar Laut junction improvement	✓	✓
	Jalan Sultan Azlan Shah road improvement	✓	✓
	Jalan Kampung Batak road improvement	✓	✓
	Jalan Sultan Azlan Shah improvement at Batu Uban	✓	✓
	NSE link road	✓	✓

7.9.2.5 Traffic Performance

The road network within the study area is characterised by a dense road network and junctions. These junctions are either signalised or unsignalised and are pinch points that are the controlling factor in determining effective traffic throughput and ultimately the capacity of the road network. As such, the impact assessment will look into the performance of the junctions.

The junctions envisaged to be impacted by the proposed PSR development, shown in F7.85 and T7.55, were assessed using the SIDRA 6.1 junction analysis software. The program assesses the operational performance of the junctions based on inputs relating to the layout and geometry of the junction and the observed traffic volumes. The key performance indicator for junction is the controlled delay(s). For both signalised and unsignalised junctions, the Level of Service (LoS) relates to the delay experienced by traffic at the junctions (T6.26 in *Chapter 6: Existing Environment* shows the relationship between delay and the LoS).



F7.85 Locations of junctions simulated in the study

T7.55 Details of junctions simulated in the study

Junction	Description
1	From PSR Island C to Jalan Gertak Sanggul
2	From PSR Island C to Jalan Gertak Sanggul
3	Jalan Gertak Sanggul - P235
4	Jalan Teluk Kumbar - P235
5	Jalan Teluk Kumbar - Jalan Gertak Sanggul
6	From PSR Island B to Jalan Teluk Kumbar
7	Jalan Teluk Kumbar - Jalan Sungai Batu
8	From PSR Island A to Jalan Permatang Damar Laut (at western airport boundary)
9	From PSR Island A to Jalan Permatang Damar Laut (at Lorong Permatang Damar Laut)
10	Jalan Permatang Damar Laut - Jalan Teluk Kumbar
11	Jalan Bayan Lepas - Jalan Dato' Ismail Hashim

T7.55 Details of junctions simulated in the study (cont'd)

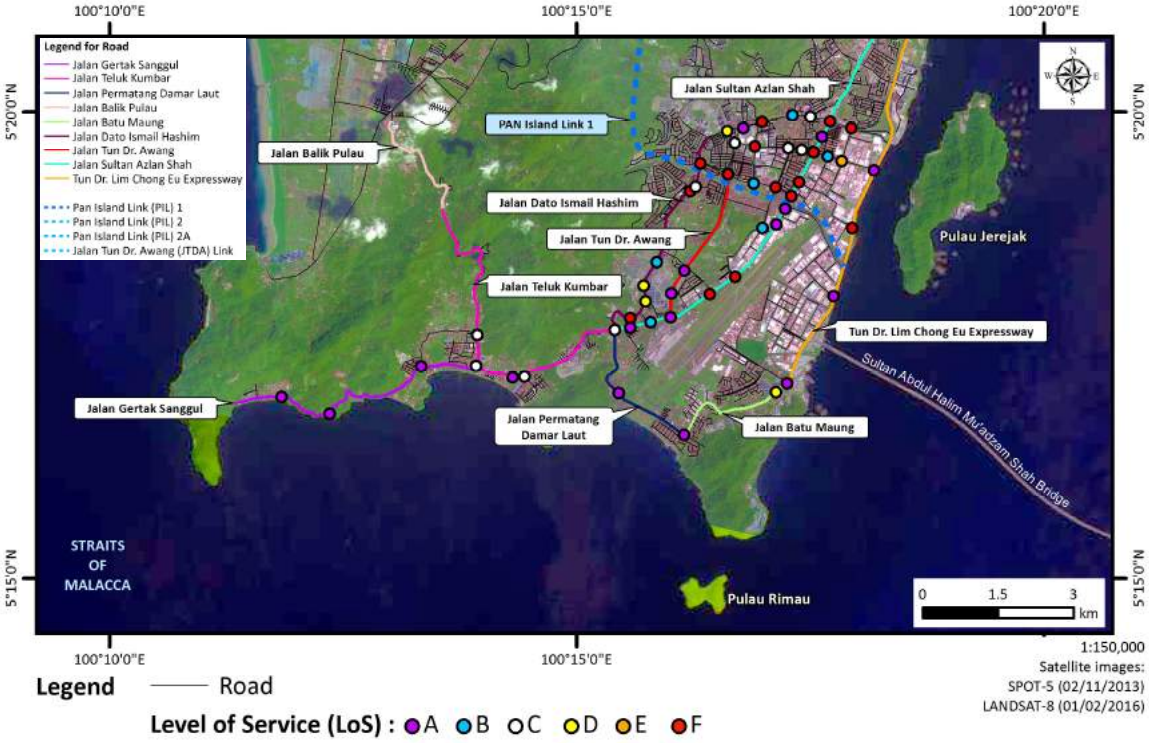
Junction	Description
12	Jalan Dato Ismail Hashim -Jalan Dato' Ismail Hashim
13	Jalan Bayan Lepas - Jalan Garuda
14	Jalan Mahkamah - Jalan Dato' Ismail Hashim
15	Persiaran Kelicap - Jalan Dato' Ismail Hashim
16	Pintasan Kelicap 1 - Jalan Rajawali and Jalan Dato Ismail Hashim
17	Jalan Sultan Azlan Shah - Jalan Tun Dr. Awang
18	Jalan Tun Dr. Awang - Persiaran Rajawali
19	Jalan Tun Dr. Awang Double U-turn
20	Jalan Sungai Tiram 1 and Jalan Sultan Azlan Shah
21	Jalan Sultan Azlan Shah/Lorong Sungai Tiram 1
22	Jalan Permatang Damar Laut - Jalan Teluk Tempoyak
23	Jalan Permatang Damar Laut - Jalan Batu Maung
24	Tun Dr. Lim Chong Eu Highway -Hilir Sungai Kluang 1
25	Jalan Kenari - Jalan Dato' Ismail Hashim
26	Lebuh Sungai Ara 1 - Jalan Dato' Ismail Hashim
27	Jalan Mayang Pasir - Lebuh Sungai Tiram 1
28	Jalan Tokong Ular - Jalan Sultan Azlan Shah
29	Jalan Sultan Azlan Shah - Jalan Tokong Ular
30	Kampung Jawa Highway - Tun Dr. Lim Chong Eu Highway
31	Jalan Tengah - Jalan Sultan Azlan Shah
32	Jalan Tengah - Jalan Mayang Pasir
33	Jalan Tengah - Persiaran Mahsuri
34	Jalan Tun Dr Awang - Jalan Bayan-Jalan Tengah
35	Jalan Dato' Ismail Hashim - Jalan Bayan
36	Kampung Jawa Highway - Jalan Sultan Azlan Shah
37	Jalan Tun Dr. Awang - Jalan Mahsuri
38	Jalan Mahsuri - Persiaran Mahsuri
39	Jalan Mayang Pasir - Jalan Mahsuri
40	Jalan Mahsuri - Jalan Nibung
41	Jalan Mahsuri – Jalan Kampung Jawa and Jalan Sultan Azlan Shah
42	Jalan Kampung Jawa - Lorong Kampung Jawa
43	Jalan Kampung Jawa - Lebuh Kampung Jawa
44	Jalan Kampung Jawa - Tun Dr. Lim Chong Eu Highway
45	Jalan Bahagia - Jalan Sultan Azlan Shah
46	Jalan Dato Ismail Hashim - Jalan Paya Terubong
47	Jalan Tun Dr Awang - Jalan Dato' Ismail Hashim
48	Persiaran Bukit Jambul - Jalan Tun Dr. Awang
49	Jalan Bukit Gambir - Jalan Tun Dr. Awang
50	Jalan Tun Dr Awang - Jalan Kampung Relau
51	Jalan Tun Dr Awang – Sungai Nibong Highway - Jalan Sultan Azlan Shah
52	Sungai Nibong Highway - Lebuh Kampung Jawa

7.9.3 Overall Findings for Traffic

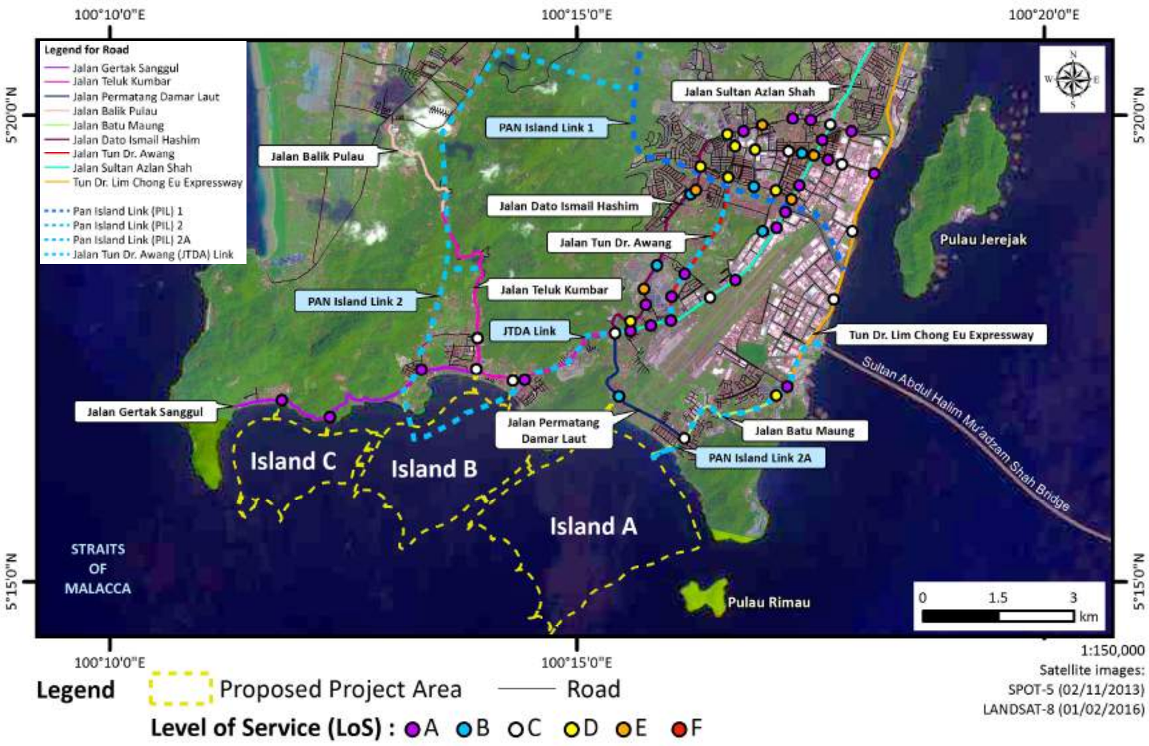
F7.86 and F7.87 shows the comparison of junction performance between the Without and With Development scenario while T7.56 summarised the junction counts according to the LoS. Details on the performance for each junctions simulated in the study is given in T7.57. The results shown that With Development scenario, which includes the Bayan Lepas LRT extension to PSR, PIL2, PIL2A and JTDA, bring about a sharp reduction (100%) in the number of junctions operating at LoS F. There are also increase in number of junctions performing at LoS A, B and C. Thus, in general, it can be deduced that there is an improvement in traffic condition as the proposed development also include a number of new external connection as well as upgrading of the existing roads at Jalan Teluk Kumbar, Jalan Permatang Damar Laut and Jalan Gertak Sanggul.

T7.56 Junction counts according to the LoS

Level of Service (LoS)	Junction Count			
	AM		PM	
	Without Development	With Development	Without Development	With Development
A	17	22	15	20
B	6	6	5	7
C	9	11	8	8
D	4	8	4	10
E	1	5	3	7
F	15	0	17	0

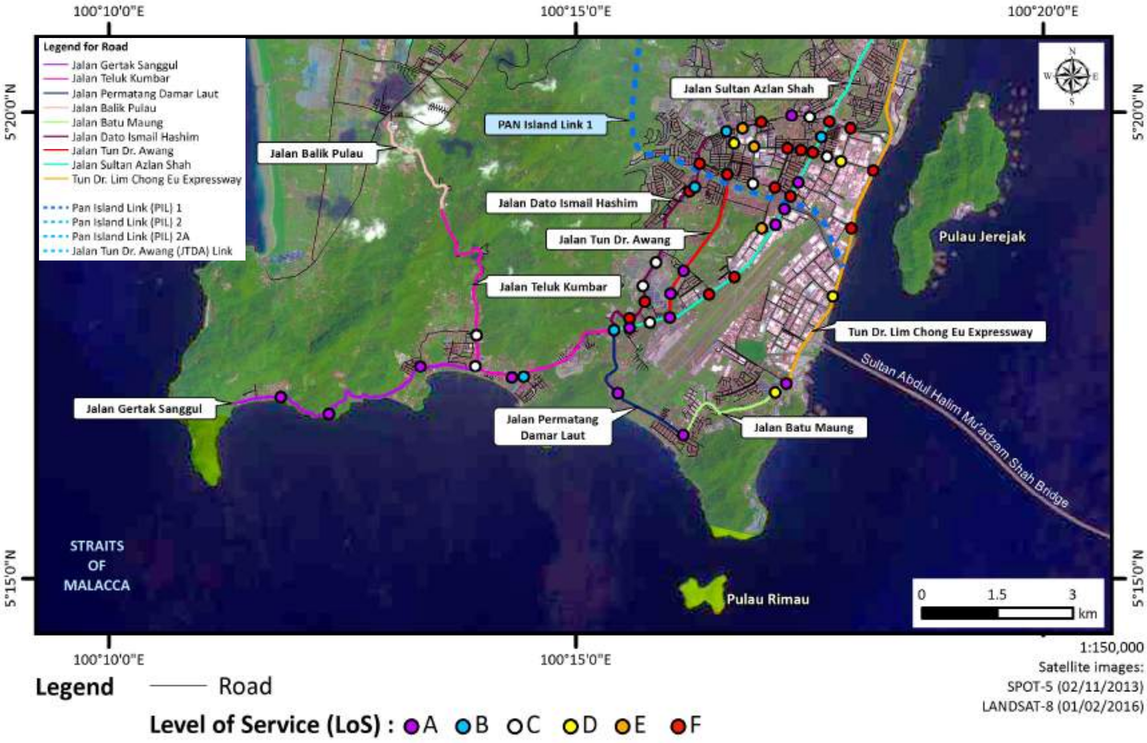


a) Without development

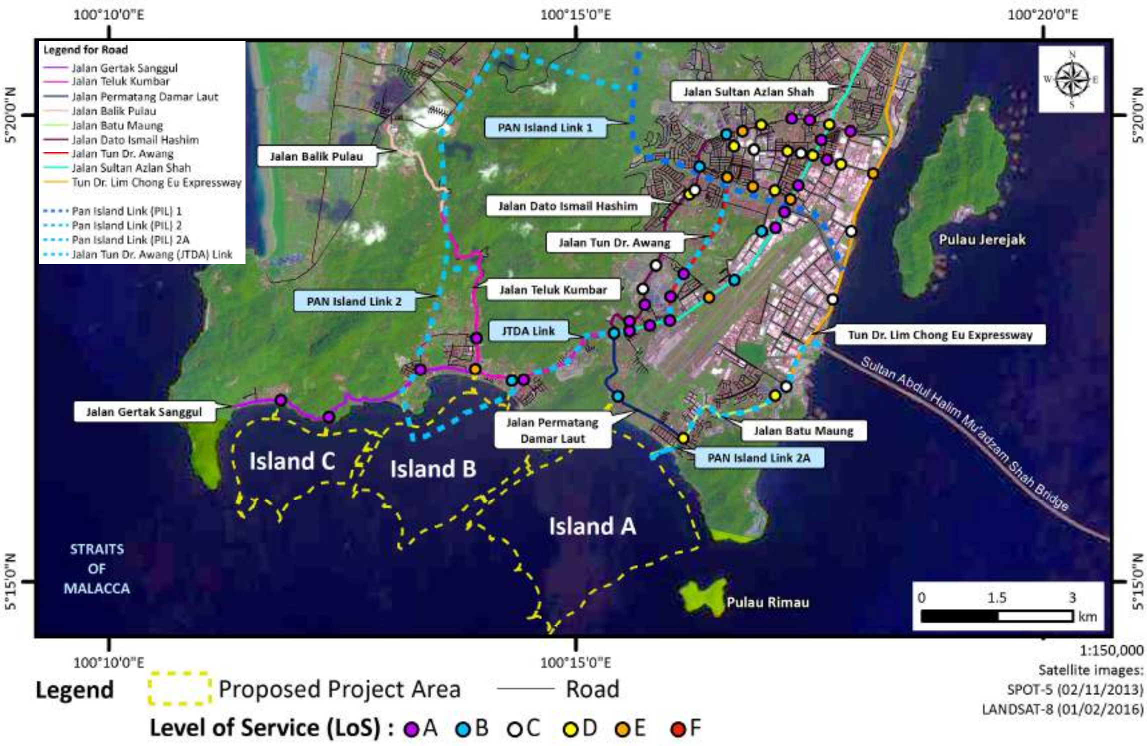


b) With development

F7.86 Junction performance comparison for AM traffic: Without vs. With development



a) Without development



b) With development

F7.87 Junction performance comparison for PM traffic: Without vs. With development

T7.57 Performance of simulated junctions

Junction	Description	AM		PM	
		Without Development	With Development	Without Development	With Development
1	From PSR Island C to Jalan Gertak Sanggul	A	A	A	A
2	From PSR Island C to Jalan Gertak Sanggul	A	A	A	A
3	Jalan Gertak Sanggul - P235	A	A	A	A
4	Jalan Teluk Kumbar - P235	C	C	C	A
5	Jalan Teluk Kumbar - Jalan Gertak Sanggul	C	C	C	E
6	From PSR Island B to Jalan Teluk Kumbar	A	C	A	B
7	Jalan Teluk Kumbar - Jalan Sungai Batu	C	A	B	A
8	From PSR Island A to Jalan Permatang Damar Laut (at western airport boundary)	A	B	A	B
9	From PSR Island A to Jalan Permatang Damar Laut (at Lorong Permatang Damar Laut)	A	C	A	D
10	Jalan Permatang Damar Laut - Jalan Teluk Kumbar	C	C	B	B
11	Jalan Bayan Lepas - Jalan Dato' Ismail Hashim	A	A	A	A
12	Jalan Dato Ismail Hashim -Jalan Dato' Ismail Hashim	F	D	F	A
13	Jalan Bayan Lepas - Jalan Garuda	B	A	C	A
14	Jalan Mahkamah - Jalan Dato' Ismail Hashim	D	A	F	A
15	Persiaran Kelicap - Jalan Dato' Ismail Hashim	D	E	C	C
16	Pintasan Kelicap 1 - Jalan Rajawali and Jalan Dato' Ismail Hashim	B	B	C	C
17	Jalan Sultan Azlan Shah - Jalan Tun Dr. Awang	A	A	A	A
18	Jalan Tun Dr. Awang - Persiaran Rajawali	A	A	A	A
19	Jalan Tun Dr. Awang Double U-turn	A	A	A	A
20	Jalan Sungai Tiram 1 and Jalan Sultan Azlan Shah	F	C	F	E
21	Jalan Sultan Azlan Shah/Lorong Sungai Tiram 1	F	A	F	B
22	Jalan Permatang Damar Laut - Jalan Teluk Tempoyak	D	D	D	D
23	Jalan Permatang Damar Laut - Jalan Batu Maung	A	A	A	C
24	Tun Dr. Lim Chong Eu Highway -Hilir Sungai Kluang 1	A	C	D	C
25	Jalan Kenari - Jalan Dato' Ismail Hashim	F	B	F	D
26	Lebuh Sungai Ara 1 - Jalan Dato' Ismail Hashim	C	E	B	C
27	Jalan Mayang Pasir - Lebuh Sungai Tiram 1	B	B	E	B
28	Jalan Tokong Ular - Jalan Sultan Azlan Shah	A	A	A	A
29	Jalan Sultan Azlan Shah - Jalan Tokong Ular	A	A	A	A
30	Kampung Jawa Highway - Tun Dr. Lim Chong Eu Highway	F	C	F	C

T7.57 Performance of simulated junctions (cont'd)

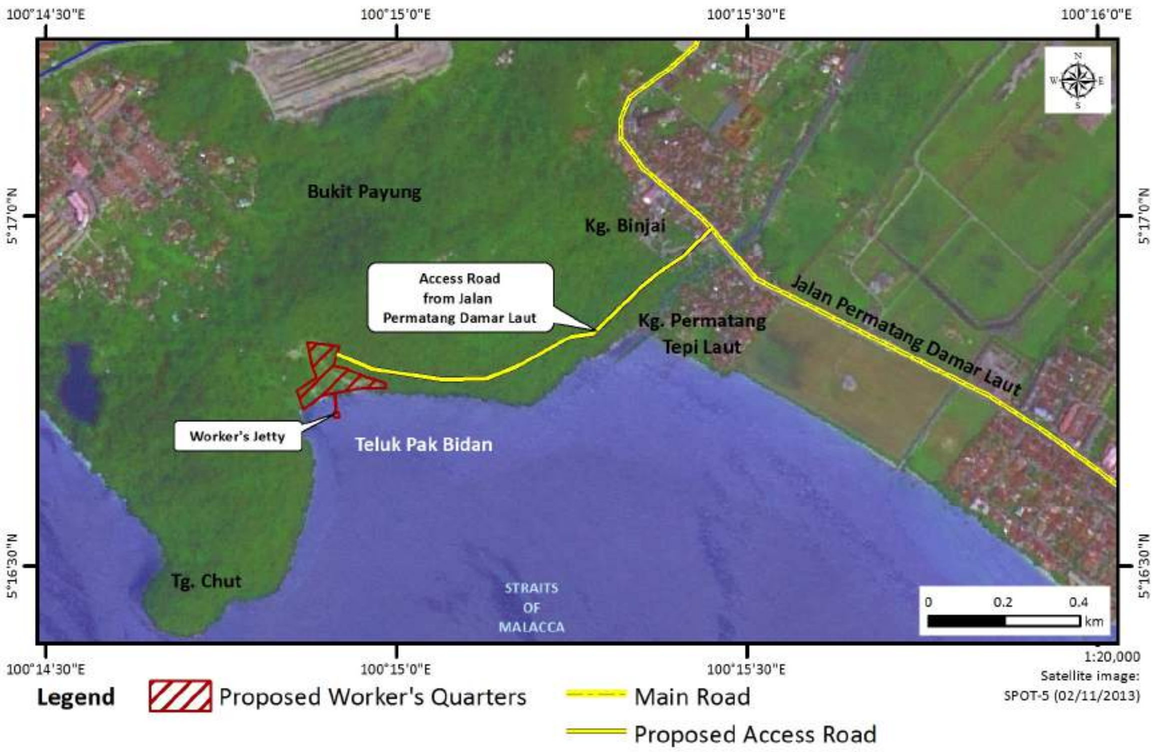
Junction	Description	AM		PM	
		Without Development	With Development	Without Development	With Development
31	Jalan Tengah - Jalan Sultan Azlan Shah	F	E	F	E
32	Jalan Tengah - Jalan Mayang Pasir	F	D	F	D
33	Jalan Tengah - Persiaran Mahsuri	B	B	C	E
34	Jalan Tun Dr Awang - Jalan Bayan-Jalan Tengah	F	D	F	E
35	Jalan Dato' Ismail Hashim - Jalan Bayan	F	D	F	B
36	Kampung Jawa Highway - Jalan Sultan Azlan Shah	F	A	A	A
37	Jalan Tun Dr. Awang - Jalan Mahsuri	C	D	D	D
38	Jalan Mahsuri - Persiaran Mahsuri	F	D	E	C
39	Jalan Mayang Pasir - Jalan Mahsuri	C	C	F	D
40	Jalan Mahsuri - Jalan Nibung	C	B	F	C
41	Jalan Mahsuri – Jalan Kampung Jawa and Jalan Sultan Azlan Shah	F	E	F	D
42	Jalan Kampung Jawa - Lorong Kampung Jawa	B	A	C	A
43	Jalan Kampung Jawa - Lebuh Kampung Jawa	E	C	D	D
44	Jalan Kampung Jawa - Tun Dr. Lim Chong Eu Highway	A	A	F	E
45	Jalan Bahagia - Jalan Sultan Azlan Shah	A	A	B	A
46	Jalan Dato Ismail Hashim - Jalan Paya Terubong	D	D	B	B
47	Jalan Tun Dr Awang - Jalan Dato' Ismail Hashim	A	A	E	E
48	Persiaran Bukit Jambul - Jalan Tun Dr. Awang	F	E	F	D
49	Jalan Bukit Gambir - Jalan Tun Dr. Awang	B	A	A	A
50	Jalan Tun Dr Awang - Jalan Kampung Relau	C	A	C	A
51	Jalan Tun Dr Awang – Sungai Nibong Highway - Jalan Sultan Azlan Shah	F	C	F	D
52	Sungai Nibong Highway - Lebuh Kampung Jawa	F	A	F	A

7.10 Noise

Noise pollution will be temporary impacts as it will only be generated during the Project implementation stages. After all work is completed (post-reclamation), the impact of noise pollution will cease. Among all activities that will be carried out over the course of Project implementation, the construction of workers' quarters (Pre-dredging Phase) and rock perimeter bund are expected to emit a significant level of noise. Impact of noise pollution is also related with the working hours of the proposed Project. Noise emitted from the work will be more noticeable at night because of the quieter background.

7.10.3.1 Pre-dredging

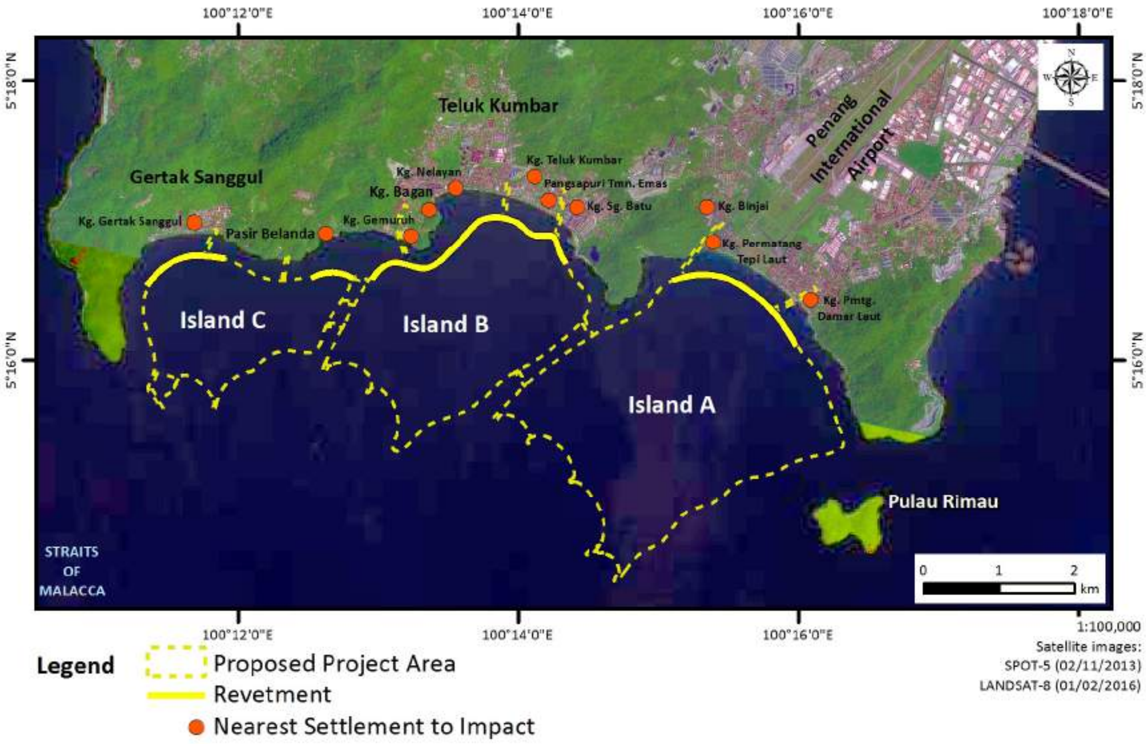
The construction of workers' quarters during this phase will involve heavy machineries and lorries movement that usually emit a high level of noise. However, the noise impact from this activity is projected to be insignificant as the construction site is located away from residential areas (approximately 400 m) and the area is surrounded by hilly terrain and lush vegetation which will act as an effective sound buffer, as shown in F7.88. In addition, it is expected that the construction activities will only be conducted during day time; thus the impact of noise during this phase is manageable and will not cause significant impact.



F7.88 Proposed location of workers' quarters

7.10.3.2 Land Reclamation

Normally, dredging operations emit minimal noise so the impact on noise pollution from dredging is expected to be insignificant. However, certain land reclamation activities, such as rock bund and rock revetment construction, will produce noticeable levels of noise caused by the movement of excavators on the rock barge, transferring the rocks from barge to lorry and rock-laying activities. These may become a problem during the construction of the rock bund nearest to the residential area, as shown in F7.89. The issue of noise pollution from rock bund construction is expected to be apparent if the activity is carried out at night. Even though the residential area is separated approximately by 40 to 250 m to the rock bund alignment, noise from rock bund construction may still be perceivable at night time because of the lower background noise, thus becoming a source of nuisance.



F7.89 Section of revetment nearby residential areas

7.11 Air Quality

Impacts on air quality related to the proposed development will primarily come from dust generation and exhaust emission from vessels, generator set, machineries and equipment. It should be noted that the impacts on air quality are rather concentrated and short-termed, depending on the direction and velocity of the existing wind along with the magnitude of work. It is projected that only land-based activities will produce a significant amount and meriting proper management in order to alleviate this particular impact.

7.11.1 Pre-dredging

This activity involves land-clearing works as well as working on exposed topsoil. If unmitigated, the construction activities will churn up significant amounts of dust, especially during dry season, which will cause deterioration in air quality. Although the dust generation may be significant, the impact is expected to be naturally alleviated by the lush vegetation that surrounds the site location. Furthermore, the site location is located away from any sensitive receptor. However, vehicles travelling through the access road may cause dust to scatter to the surrounding area, especially at the entry point connecting the access road and the existing main road. If left unmitigated, residents nearby the entry point and along the main road used by the lorries will be affected.

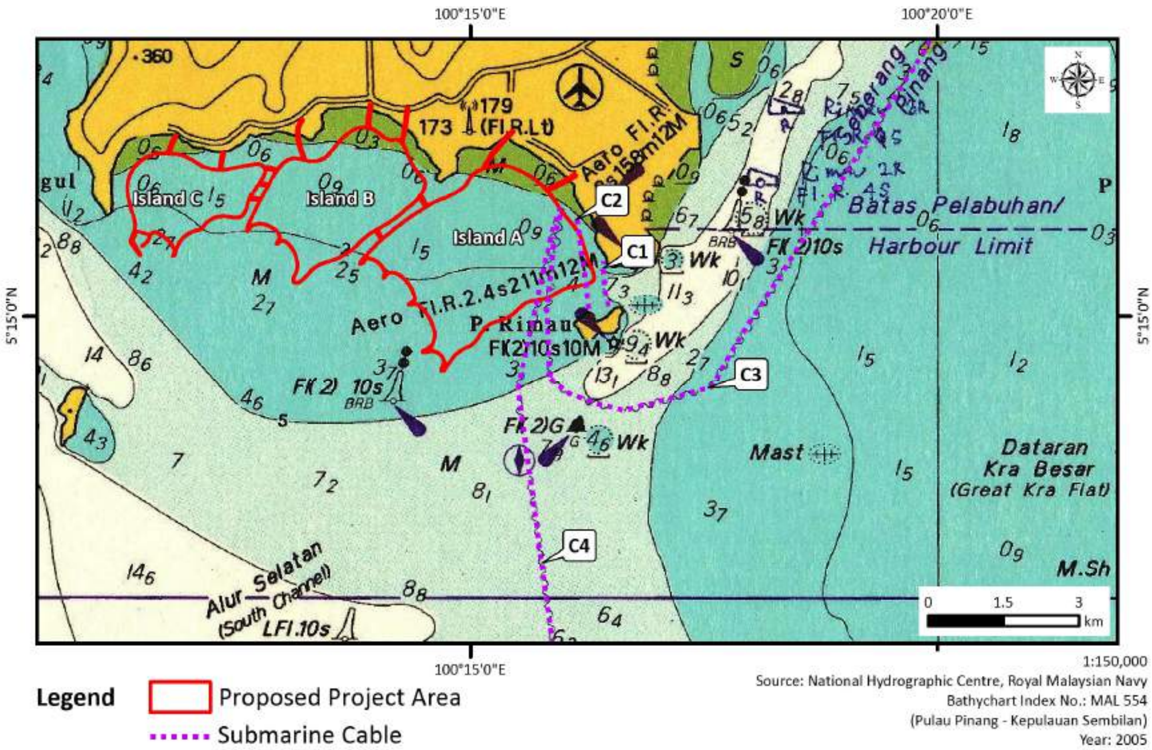
7.11.2 Land Reclamation and Dredging

The nature of land reclamation and dredging activities does not involve working with material containing dry fine material that can be dispersed by wind. Thus dust generation can be considered as insignificant. While vessels and machineries deployed will produce emission from their exhaust, the location where they operate (at sea, away from residential areas) will significantly reduce the impact on air quality.

7.12 Submarine Cables

Four submarine cables were identified to be located within the proposed Project area, as illustrated in F7.90. Details for each cables are presented in T7.58.

Inevitably, these submarine cables shall be removed as they are situated within the Project's footprint. The relocation works are expected to commence once the Project has entered Phase B.



F7.90 Submarine cables within the Project site

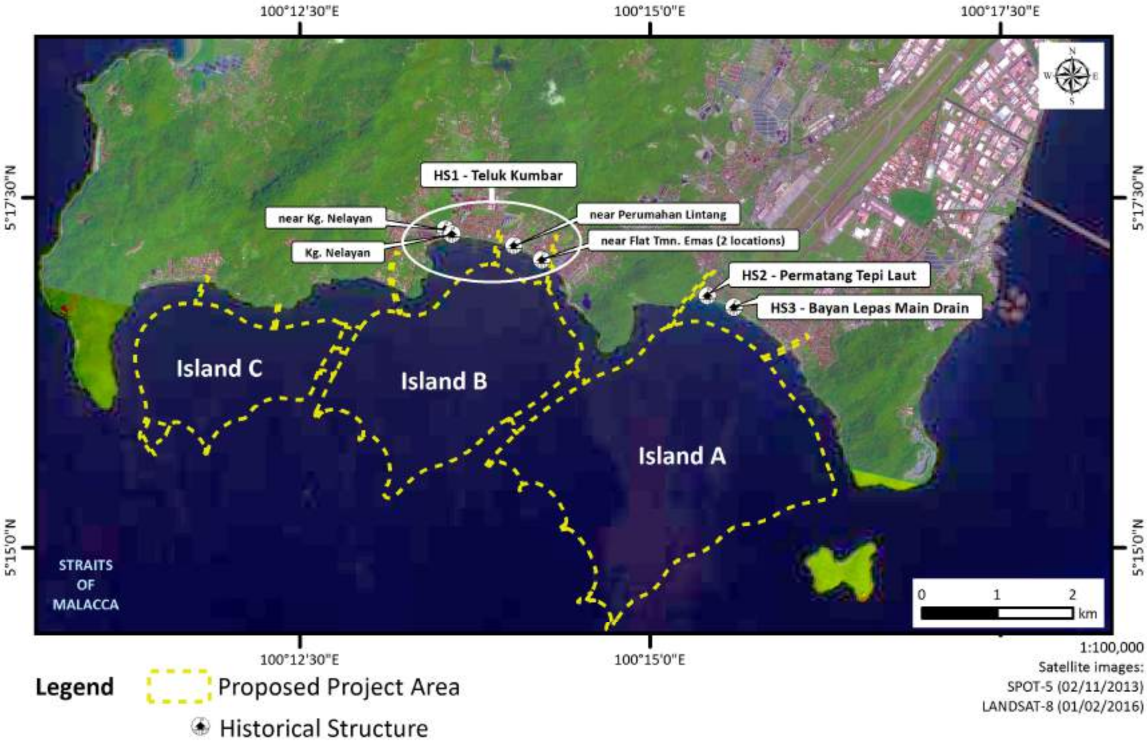
T7.58 Details of submarine cables within the Project site

No.	Cable Type	Cable Owner	Cable Connection
C2	Submarine electric cable	Unknown*	Penang Island - Pulau Rimau
C3	Submarine fibre optic cable	TIME dotCom Berhad	Permatang Damar Laut - Prai
C4	Submarine fibre optic cable	TIME dotCom Berhad	Permatang Damar Laut - Kuala Kurau

Note: Owner of C1 and C2 cables cannot be identified at the time of this study. It is believed that these cables are used by the lighthouse at Pulau Rimau, pending confirmation by the Marine Department.

7.13 Historical Structures

Several historical structures, namely World War II pillboxes, can be found scattered along Penang's southern coastline, as shown in F7.91. Currently, all pillboxes are neglected and in a state of disrepair. For pillboxes located at Teluk Kumbar, they are found to be located inland from the shore, thus shielding them from the hydraulic impact caused by the proposed Project. As such, it is expected that these pillboxes will be unaffected by the proposed Project.



F7.91 Locations of historical structures (WWII pillbox)

Meanwhile, the pillboxes located at Permatang Tepi Laut and near Bayan Lepas Main Drain are situated on the shoreline and thus considered vulnerable to the impact. Nevertheless, findings from the hydraulic simulation has shown that the location of these two pillboxes will not receive any significant changes brought about by the proposed Project and thus can be considered as being unaffected.

7.14 Tsunami Impact Assessment

Earthquake-generated tsunami waves evolve from generation followed by propagation, run-up and ends with inundation. Tsunami hazards are generally concentrated along exposed coastlines. Tsunami primarily affects low-lying coastal area as the advancing tsunami waves propagate inland. The resultant inundation can cause damage and loss of properties as well as human lives.

7.14.1 Tsunami Incident on 26th December 2004

Penang Island was hit by tsunami waves following the devastating earthquake that occurred off the coast of northern Sumatra on 26th December 2004. The strength of the earthquake was measured to 9.0 on the Richter scale. The area east of Pantai Sungai Batu at Teluk Kumbar did not experience serious inundation. The nearby road was inundated about 50 m inland. Slight movement of rocks occurred along the nearby river training structure (DID, 2005).

7.14.2 Tsunami Simulation

It is noted that the probability of a tsunami coinciding with HAT is extremely low. The return period of HAT is approximately 18.3 years. In comparison, the percentage of time that water levels exceed the MHWS level and MSL are about 4 and 50%, respectively. The percentage exceedance of the actual tidal level at the time of arrival of the historical tsunami at Penang Island is 22% of the time. For the purpose of assessment, the plots of the tsunami event of 2004 simulated at MHWS level are presented in this report. However, the analysis is done for results from simulations for all four tidal levels, which is referred to as Cases 1 to 4 as shown in T7.59. The difference in maximum water levels between existing and post-reclamation condition were derived. The impact also depends on the floodability of the coastal hinterland and in particular, the topographic settings.

T7.59 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

Although the probability of another tsunami with magnitude high enough to impact the south coast of Penang is judged to be low, the assessment has not quantified the risk associated with tsunami events as it requires detailed knowledge of the following elements:

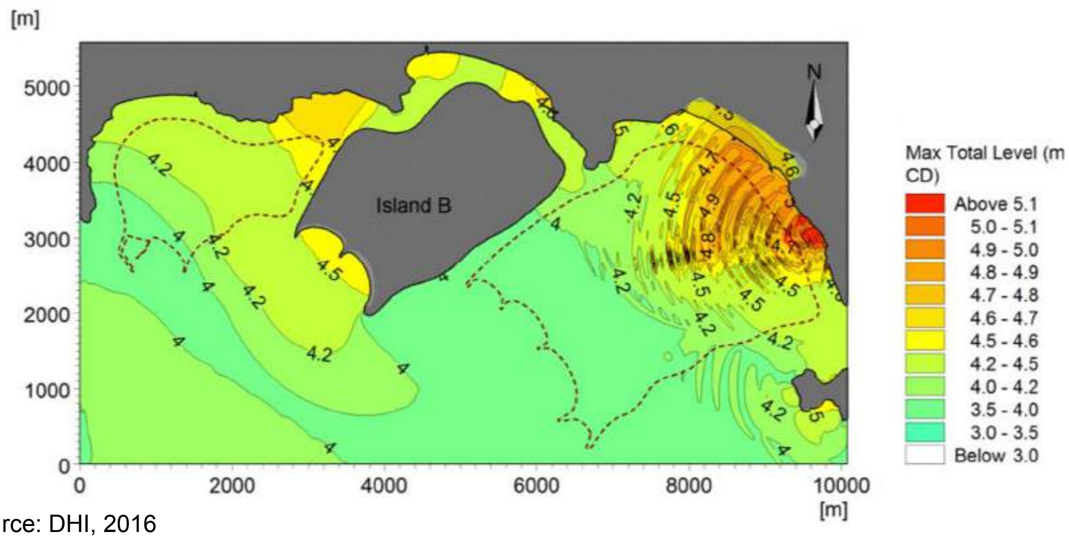
a) Cause to trigger a tsunami in this region particularly the tsunami hazards occurring around Sumatra-Andaman area;
b) Probability of a destructive tsunami, i.e. the probability of an earthquake of a given magnitude occurring along a given fault-line at a given time, which is extremely difficult to quantify; and
c) The associated water level at the time of occurrence of the tsunami as this could occur during mean, low and high water levels. An analysis of water levels shows that it is unlikely that a tsunami will occur during high water levels, particularly during HAT condition as the HAT return period (without storm surge levels) is about 18.3 years.

The potential inundation in inland areas has also been analysed as an uncertainty in the tsunami assessment since topographic data is limited around the nearshore region. The results show that increased inland storage reduced water levels.

7.14.3 Impact Assessment

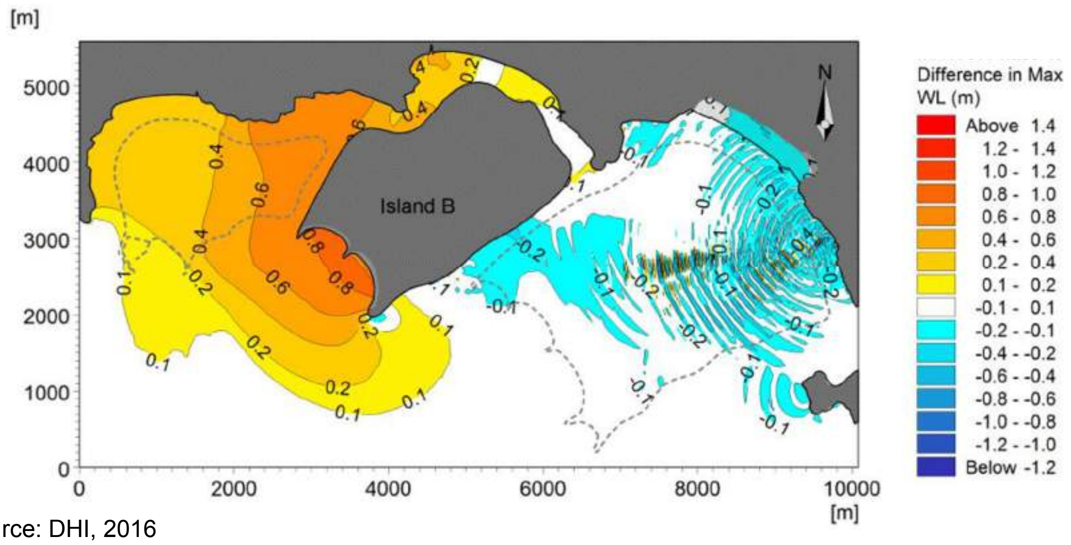
a) Scenario 2

The maximum absolute water level and the difference plots are presented in F7.92 and F7.93 respectively. The results show that the proposed Island B induces an increase in water levels of up to 0.8 m within the waters sandwiched by the reclamation and Tanjung Gertak Sanggul. A reduction in water levels of up to about 0.2 m with respect to the existing condition occurs east of the Island B. A water level increase of about 0.8 m is experienced between the artificial headlands of Island B. The furthest extent of 0.1 m increase in water level is predicted at an offshore area about 4 km from the existing the coastline.



Source: DHI, 2016

F7.92 Maximum water levels during the impact of tsunami waves with a tidal level corresponding to MHWS level for Scenario 2

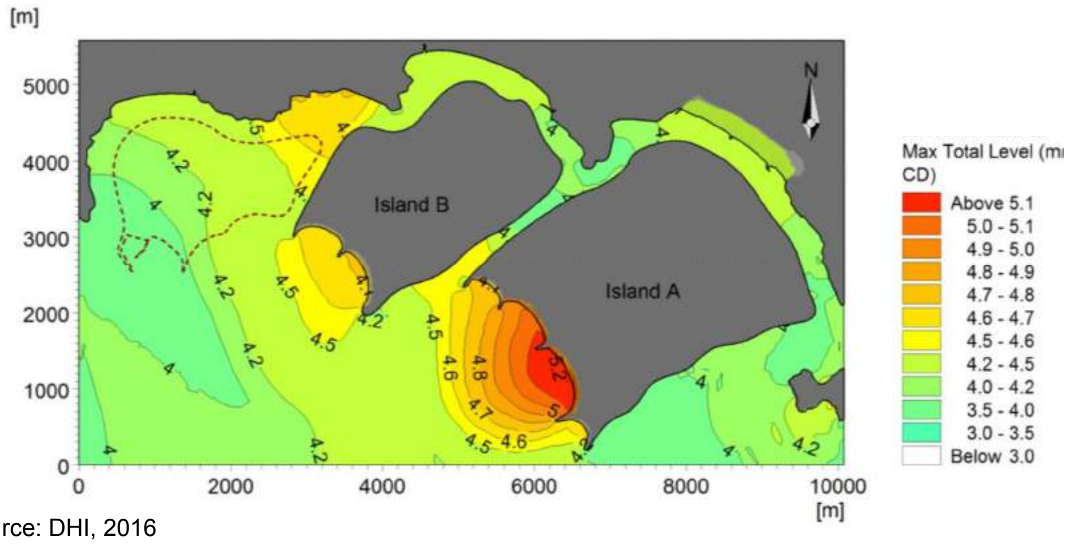


Source: DHI, 2016

F7.93 Difference in maximum water levels during the impact of tsunami waves with a tidal level corresponding to MHWS level for Scenario 2 compared with the existing condition

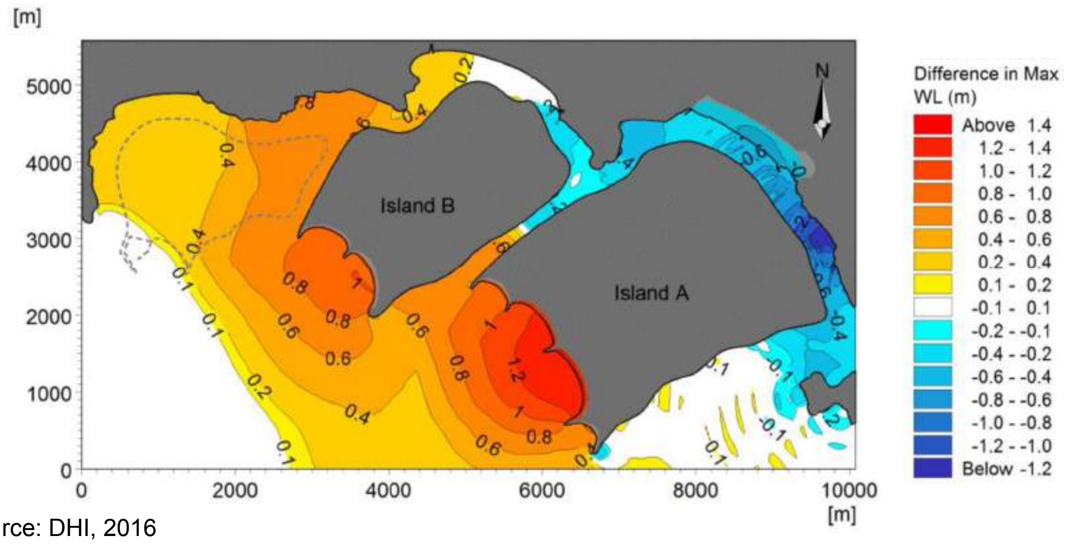
b) Scenario 3

The maximum absolute water level and the difference plots are shown in F7.94 and F7.95 respectively. The water body east of the reclamation and within the channels benefits from the sheltering effect of the islands that results in a maximum water level reduction of up to 0.6 m. The proposed islands will induce an increase in water level within the area extending from the seaward-facing edge of Island A towards Tanjung Gertak Sanggul. The magnitude of the increase is up to 0.6 m at the existing coastline and up to 1.2 m at the seaward-facing edge of Island A. The furthest extent of 0.1 m increase in water level is up to about 5 km eastwards and 8 km southwards from the existing coastline.



Source: DHI, 2016

F7.94 Maximum water levels during the impact of tsunami waves with a tidal level corresponding to MHWS level for Scenario 3

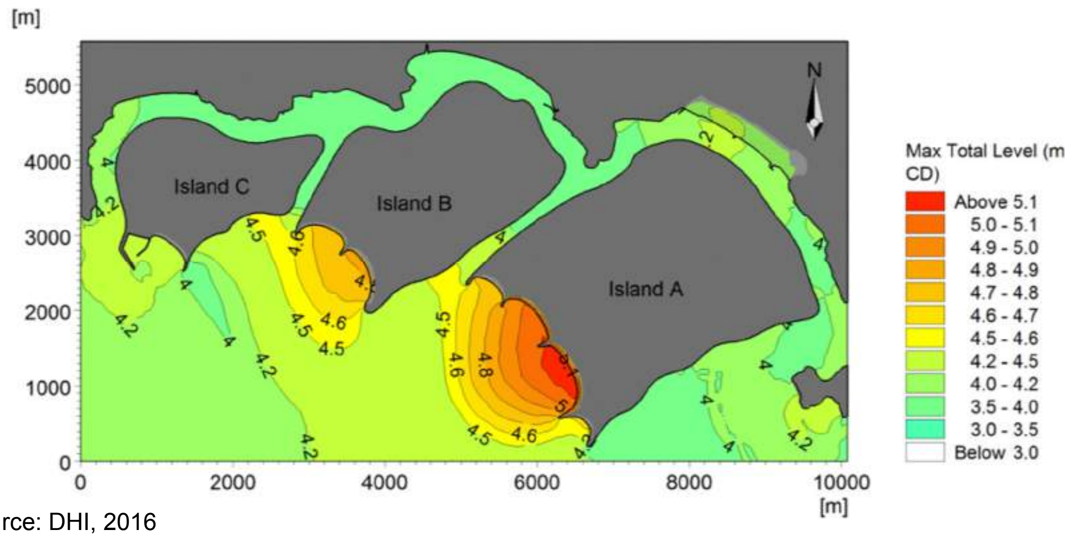


Source: DHI, 2016

F7.95 Difference in maximum water levels during the impact of tsunami waves with a tidal level corresponding to MHWS level for Scenario 3 compared with the existing condition

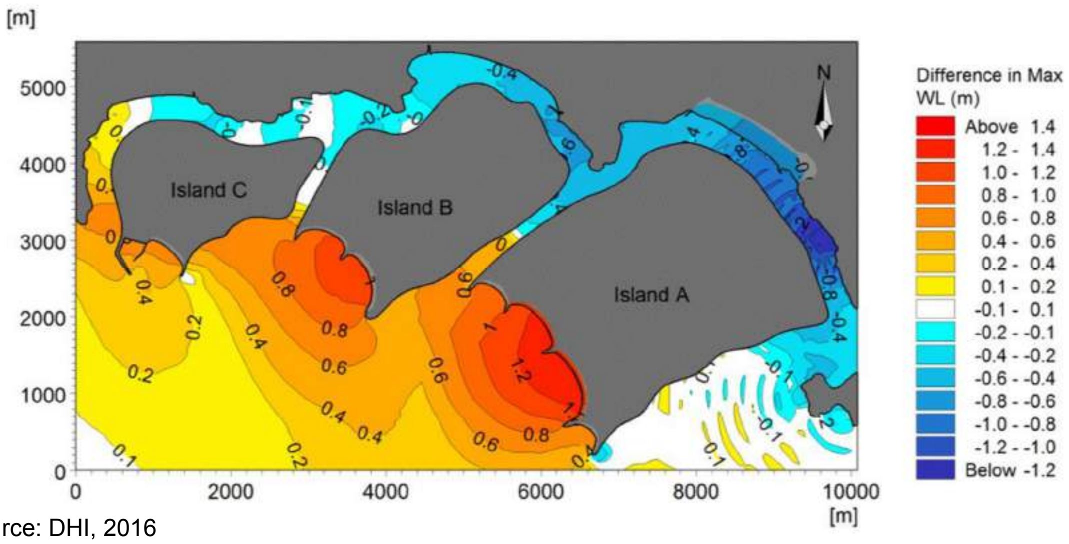
c) Scenario 4

The maximum absolute water level and the difference plots are presented in F7.96 and F7.97 respectively. From the simulation results, it can be observed that the islands will induce a reduction in maximum water levels by up to 1 m between Tanjung Teluk Tempoyak extending within the channels until Island C. This is due to the sheltering afforded by the presence of the islands seawards of the existing coastline. The furthest extent of 0.1 m increase in water level occurs about 8.5 km eastwards and 8.5 km southwards from the existing coastline. Increase in water levels extending from the seaward face of Island A towards Tanjung Gertak Sanggul are up 1.2 m occurring at Island A.



Source: DHI, 2016

F7.96 Maximum water levels during the impact of tsunami waves with a tidal level corresponding to MHWS level for Scenario 4



Source: DHI, 2016

F7.97 Difference in maximum water levels during the impact of tsunami waves with a tidal level corresponding to MHWS level for Scenario 4 compared with the existing condition

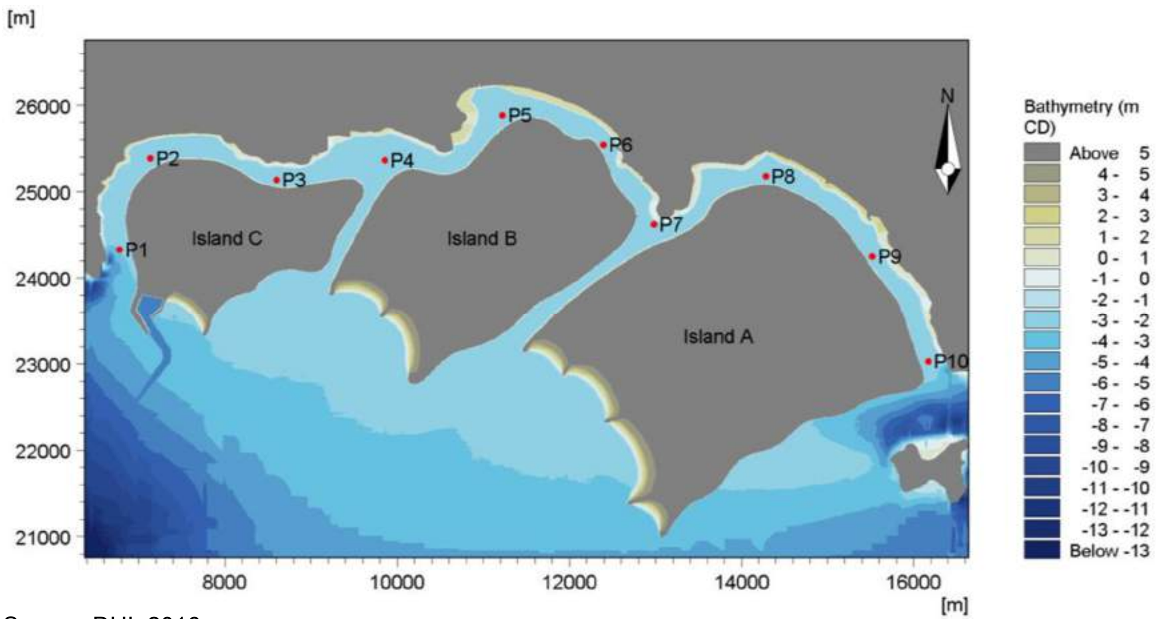
7.14.4 Overall Findings for Tsunami

The differences in maximum water levels in the vicinity of the existing coastline are presented at 10 locations as shown in F7.98 and summarised in T7.60. It can be inferred from the modelling results that the predicted differences of maximum water levels between "with Project" and the existing conditions are significantly influenced by the sheltering effects provided by the reclaimed islands. It is predicted that the impact of the tsunami on the existing shoreline will mainly reduce after the development is fully completed. However, impacts are different for the different phases of the Project as follows:

a) *Scenario 2* – A decrease in maximum water levels is observed along the frontage of Permatang Damar Laut. The reduction is found to be about 0.1 m at P9. The proposed reclamation will induce an increase in water levels along the west/southwest frontage of Island B and along the frontage of Gertak Sanggul. The increase in maximum water levels is predicted at P4 which would experience an increase of 0.8 m;

b) *Scenario 3* – Island A and B will provide protection to the coastal waters behind the development resulting in a water level reduction of up to 0.7 m (P9) compared with the existing conditions. Water levels are found to increase by up to 0.8 m at P4, which is relatively similar to Scenario 2 along the western and southwestern frontage of Island B as well as the existing Penang southern coastline; and

c) *Scenario 4* – The existing coastline behind the proposed reclamations becomes well-protected due to the sheltering offered by the reclaimed islands. A reduction in water levels of up to 0.9 m is predicted particularly along the inner channel that separates the proposed reclamation islands from the existing coastline. Increase in water levels extending from the seaward face of Island A towards Tanjung Gertak Sanggul are up 1.2 m occurring at Island A.



Source: DHI, 2016

F7.98 Location of predicted differences of maximum water level extraction in the vicinity of the existing southern Penang coastline

T7.60

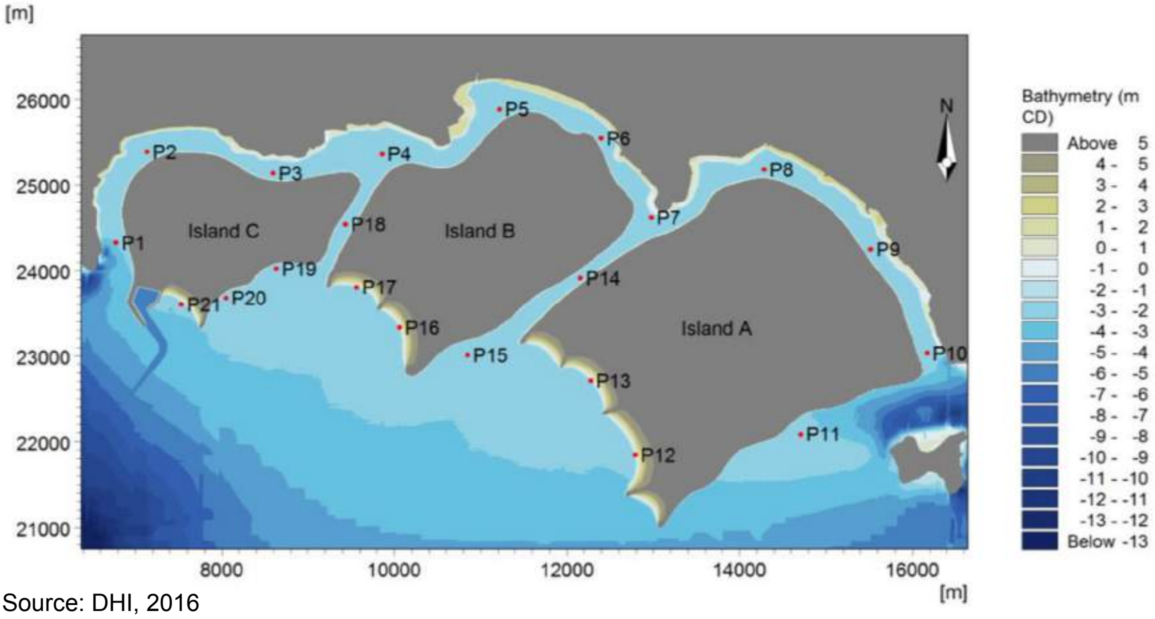
Summary of predicted difference in maximum total water levels in the vicinity of the existing southern Penang coastline during the impact of tsunami waves for Case 1 (MSL), Case 2 (actual tidal level), Case 3 (MHWS) and Case 4 (HAT) for all development phasing

Phase	Points	Difference in Maximum Water Level (m)			
		Case 1	Case 2	Case 3	Case 4
Scenario 2 (Island B)	P1	+0.1	+0.2	+0.3	+0.3
	P2	+0.4	+0.4	+0.4	+0.3
	P3	+0.5	+0.5	+0.6	+0.6
	P4	+0.7	+0.8	+0.7	+0.7
	P5	*	+0.2	+0.3	+0.4
	P6	*	*	+0.1	+0.2
	P7	*	+0.1	+0.1	+0.1
	P8	-0.1	-0.1	*	*
	P9	-0.3	-0.1	-0.2	-0.1
	P10	*	*	-0.1	-0.1
Scenario 3 (Islands A and B)	P1	+0.1	+0.1	+0.3	+0.3
	P2	+0.3	+0.3	+0.3	+0.3
	P3	+0.5	+0.6	+0.6	+0.7
	P4	+0.7	+0.8	+0.7	+0.7
	P5	*	+0.2	+0.3	+0.3
	P6	-0.2	-0.2	-0.1	*
	P7	-0.2	-0.2	-0.2	-0.1
	P8	-0.2	-0.2	-0.3	-0.2
	P9	-0.7	-0.7	-0.7	-0.5
	P10	-0.3	-0.4	-0.5	-0.6
Scenario 4 (All Islands)	P1	+0.6	+0.6	+0.6	+0.5
	P2	+0.1	+0.1	+0.1	+0.1
	P3	-0.2	-0.1	-0.1	*
	P4	-0.2	-0.1	-0.1	-0.1
	P5	-0.6	-0.4	-0.3	-0.3
	P6	-0.7	-0.7	-0.6	-0.5
	P7	-0.5	-0.6	-0.5	-0.5
	P8	-0.5	-0.4	-0.5	-0.4
	P9	-0.8	-0.9	-1.0	-0.8
	P10	-0.3	-0.4	-0.5	-0.6

Note: * - changes are between -0.1 to +0.1 m
Source: DHI (2016)

The southern coast of Penang Island has limited exposure to tsunami effects from the Indian Ocean compared to the western and northern coasts. The simulation results have demonstrated that the proposed reclaimed islands could provide sheltering to the coastline behind it for the simulated 2004 tsunami event.

The predicted maximum tsunami-induced water levels for each modelling scenario and phasing have also been extracted at 21 locations as shown in F7.99 and summarised in T7.61. This was done to assess the maximum water levels that can occur within the direct vicinity of the Project site as a result of the tsunami event.



Source: DHI, 2016

F7.99 Location of predicted differences of maximum water level extraction for tsunami waves' propagation around the proposed Project site

T7.61 Summary of predicted maximum tsunami-induced water levels during the impact of tsunami waves for Case 1 (MSL), Case 2 (actual tidal level), Case 3 (MHWS) and Case 4 (HAT) for all development phasing

Phase	Points	Maximum Water Level (m CD)			
		Case 1	Case 2	Case 3	Case 4
Scenario 2 (Island B)	P1	2.77	3.28	3.87	4.29
	P2	3.27	3.76	4.30	4.70
	P3	3.36	3.81	4.38	4.79
	P4	3.60	4.08	4.63	5.05
	P5	3.23	3.84	4.48	4.94
	P6	3.36	3.87	4.52	5.00
	P7	2.98	3.57	4.22	4.68
	P8	3.44	3.91	4.63	4.93
	P9	3.57	4.21	4.82	5.21
	P10	3.26	3.81	4.42	4.89
	P11	2.91	3.37	4.00	4.44
	P12	2.85	3.29	3.81	4.21
	P13	2.76	3.21	3.73	4.16
	P14	2.68	3.12	3.80	4.27
	P15	2.93	3.36	3.86	4.26
	P16	3.56	4.00	4.54	4.92
	P17	3.56	4.04	4.55	4.93
	P18	3.52	3.98	4.51	4.91
	P19	3.35	3.84	4.36	4.75
	P20	3.06	3.56	4.11	4.52
	P21	2.88	3.33	3.86	4.26

T7.61
Summary of predicted maximum tsunami-induced water levels during the impact of tsunami waves for Case 1 (MSL), Case 2 (actual tidal level), Case 3 (MHWS) and Case 4 (HAT) for all development phasing (cont'd)

Phase	Points	Maximum Water Level (m CD)			
		Case 1	Case 2	Case 3	Case 4
Scenario 3 (Islands A and B)	P1	2.72	3.23	3.82	4.25
	P2	3.22	3.70	4.25	4.65
	P3	3.35	3.83	4.43	4.85
	P4	3.59	4.09	4.65	5.09
	P5	3.17	3.76	4.40	4.87
	P6	3.07	3.64	4.30	4.80
	P7	2.74	3.31	3.99	4.49
	P8	3.29	3.75	4.31	4.74
	P9	3.13	3.67	4.35	4.85
	P10	2.91	3.41	3.98	4.33
	P11	3.13	3.55	4.03	4.42
	P12	4.32	4.73	5.18	5.52
	P13	4.12	4.53	5.02	5.39
	P14	2.91	3.43	4.00	4.44
	P15	3.48	3.94	4.48	4.87
	P16	3.64	4.13	4.70	5.09
	P17	3.60	4.11	4.67	5.07
	P18	3.50	3.97	4.53	4.94
	P19	3.35	3.86	4.41	4.82
	P20	3.06	3.58	4.16	4.59
	P21	2.85	3.29	3.82	4.26
Scenario 4 (All Islands)	P1	3.21	3.64	4.15	4.53
	P2	3.03	3.48	4.01	4.41
	P3	2.64	3.14	3.72	4.13
	P4	2.70	3.22	3.82	4.28
	P5	2.62	3.16	3.81	4.28
	P6	2.64	3.19	3.86	4.34
	P7	2.46	2.92	3.61	4.10
	P8	3.06	3.57	4.15	4.59
	P9	2.99	3.49	4.04	4.53
	P10	2.94	3.43	4.00	4.35
	P11	3.09	3.48	4.06	4.43
	P12	4.32	4.71	5.13	5.45
	P13	4.15	4.55	5.03	5.38
	P14	2.86	3.28	3.83	4.29
	P15	3.45	3.90	4.42	4.82
	P16	3.74	4.23	4.80	5.20
	P17	3.65	4.14	4.72	5.14
	P18	2.77	3.28	3.87	4.31
	P19	3.40	3.90	4.50	4.93
	P20	3.13	3.66	4.28	4.72
	P21	3.38	3.82	4.34	4.71

It can be concluded from the results presented in T7.57 that:

a) The predicted maximum total water levels generally increase with an increase in tidal datum. The tsunami-induced excess water levels do not alter significantly for HAT, MHWS and MSL levels. The tsunami-induced water level does not increase with an increase in tidal datum;

b) Upon development, the highest increase in water levels around Island A predicted off the seaward-facing island's edge, i.e. proposed beach area are represented by the following points:

   i) P12 (5.5 m CD for HAT, 5.2 m CD for MHWS, 4.3 m CD for MSL); and
   ii) P13 (5.4 m CD for HAT, 5.0 m CD for MHWS, 4.2 m CD for MSL).

c) The highest total water levels around Island B predicted off the proposed beach area are represented by the following points:

   i) P16 (5.2 m CD for HAT, 4.8 m CD for MHWS, 3.7 m CD for MSL); and
   ii) P17 (5.1 m CD for HAT, 4.7 m CD for MHWS, 3.7 m CD for MSL).

d) The highest total water levels around Island C predicted off the proposed beach area are represented by the following points:

   i) P19 (4.9 m CD for HAT, 4.5 m CD for MHWS, 3.4 m CD for MSL);
   ii) P20 (4.7 m CD for HAT, 4.3 m CD for MHWS, 3.1 m CD for MSL); and
   iii) P21 (4.7 m CD for HAT, 4.3 m CD for MHWS, 3.4 m CD for MSL).

e) The seaward-facing edge of the reclaimed islands experience relatively high water levels during the tsunami event. The water levels as high as about 1.2, 1.0 and 0.6 m could occur along the beach fronts of Islands A, B and C respectively; and

f) It is considered reasonable to base the design of the reclamations' platform levels on the prediction for the final phasing and disregard the other interim phases as the construction of the interim phases are of relatively short duration compared with the full Project phasing. However, if there is a large uncertainty in the duration of the construction of the different Project phasing then a conservative estimate (i.e. the largest value for the different phases) should be considered to avoid potential risks.

7.15 Human Environment and Socio-economy

Social impacts are the outcome of the reactions between the activities of a Project and the components of the host social environment. As a host society, the communities surrounding the Project area would be affected from the changes introduced to the area, either directly or indirectly and either positively or negatively (if any). Socio-economically, such changes could be seen outright. But more often than not, these are less discernible, especially when they involve perceived notions, feelings and sentiment. The latter could only be seen and felt when they become manifested into other forms.

For this component, the impacts will be discussed according to the Project implementation activities listed as follows:

a) Pre-dredging;
b) Land reclamation and dredging; and
c) Post-reclamation and operation.

The activities during the reclamation or construction phase and that of the operational phase would normally trigger different changes and reactions from their implementation. The socio-economic components that are predicted to be impacted during construction are labour, livelihood, health and safety, tranquility and aesthetics as well as psychological well-being. Those that may be impacted during post reclamation shall pertain to employment, income and revenue, wider multiplier impacts, impacts on demography, socio-cultural impacts and aesthetics.

7.15.1 Pre-dredging

Construction workers are normally housed in base or workers' camps. Some of the workers will also be living in work vessels (e.g. TSHD). This is often a potential source of health and safety hazards and are also not without their socio-cultural implications.

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

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

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

Accommodating and putting foreign workers or workers from other states of Malaysia together under the same roof or within the same workers' camp complex may have their repercussions. The presence of foreign workers, probably numbering up to several hundreds and co-existing alongside the locals, could disrupt the cultural and racial balance of the area, thus transforming the social makeup of the area into a more cosmopolitan entity. Physical conflict could easily develop as a result of the differences in culture and subculture, values, attitude and tolerance level among the different ethnics and races.

This is understandable as the different cultures, values, attitude and tolerance level of the locals and aliens coexisting alongside each other, could and have been proven volatile, to erupt even with slight friction.

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

The influx of young male workers would not change the population age and sex structures of the study area but would accentuate them. The current young age structure may be even younger when the presence of the young in-migrant workers would cause a slight decrease in the percentage of the mature-matured and old age groups.

With the current sex ratio of the study area being already imbalanced with 111 M per 100 F, the presence of excessive young male workers would put the sex ratio of the area in the near future to being highly skewed with an excess of males. Such an imbalanced sex structure may cause social repercussions and abnormal sexual behaviour.

7.15.2 Land Reclamation and Dredging

7.15.2.1 Labour

Reclamation would require a large number of workers as the nature of work requires both in-shore and overland construction activities. As the reclamation is to be carried out in phases, the manpower requirements for reclamation in the first phase will be in the range of 500 workers during the peak of the reclamation works, although not as many during dredging activities.

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

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

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

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

7.15.2.2 Livelihood

The main socio-economic issue in the development of the proposed Project pertains to the economic pursuits of the locals, particularly the fishing communities numbering approximately 866 fishermen from Kampung Permatang Damar Laut, Kampung Permatang Tepi Laut, Kampung Sungai Batu, Kampung Teluk Kumbar and Kampung Gertak Sanggul. Although the setting up of the Project would entail the creation of numerous economic opportunities, be they in new economic ventures or employment opportunities, it would also pose inconveniences to the local fishermen. This is especially so to the inshore fishermen toiling in the Zone A area, in disrupting their activities, affecting local marine life (although temporarily) and most importantly covering their current fishing ground. As such, the fishermen were of the opinion that they should be compensated for the inconveniences that they would likely be facing when the Project is under construction or what they would face when the particular fishing ground would be lost forever and become a trade-off to the Project.

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

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

7.15.2.3 Tranquillity and Aesthetics

Reclamation activities shall create a scene of bustling activities and constant humming of machineries. To those staying near and regulars who ply the area would often find the area disturbing and no longer tranquil.

The natural panorama of the sea view fronting the stretch from Tanjung Teluk Tempoyak in the east and Tanjung Gemuruh in the west would be lost forever. But in its stead, three islands would be put in place together with the transport, industrial, housing and mixed development in the near future. These new structures may have their own charms and the aesthetic value of the sea front would be in the eyes of the beholders. Their presence may actually help to attract different types of visitors or tourists who have a preference for coastal structures. However, it must also be acknowledged that the creation of the three islands would change the configuration of the map of the southern coast of Pulau Pinang altogether.

7.15.2.4 Psychological Well-being

Since knowing the sea fronting their settlements is to be reclaimed, the fishermen of the fishing settlements who would be directly affected, especially the inshore fishermen, have been worrying over their fate. They fear the reclamation that would totally eliminate the fishing ground, which is said to be rich in prawns and fish. This would shrink and limit their fishing area, resulting in reduced catch and landing and consequently their livelihood and income.

Going further out to open sea does not only mean going for longer distances but also at higher cost due to higher petrol consumption. Furthermore, prawns are not available in deeper waters. Also, the fishermen of Kampung Permatang Tepi Laut had been worrying over the status of their settlement and that they would be dislocated. Constant worry of an uncertain future may lead to stress and consequently affecting the psychological well-being of the fishermen.

7.15.3 Post-reclamation and Operational Phases

7.15.3.1 Employment

An industrial development, housing and mixed development ventures would undoubtedly generate direct employment opportunities for the different levels of skills required i.e. from skilled, semi-skilled to unskilled job opportunities in the various sectors of the development, be they in industrial, commercial or services sectors. At the peak of the development of the newly-reclaimed land, a labour force of 1,100 is expected to be employed. By year 2050, during the operational phase, an estimated 300,000 new employment opportunities will be created primarily in the manufacturing and services sector.

The impact on employment could be significant, depending on the ratio of labour recruited from the local area or from an external area, with benefits accrued to the former if some are employed from within. The latter would be most beneficial if recruited from among the trained but unemployed or those looking for a job for the first time. The impact would be long-term in nature.

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

7.15.3.2 Income and Revenue

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

Workers who commute from the surrounding urban areas such as Bayan Lepas, Jelutong, Georgetown or even Seberang Perai would make little economic contribution to the local economy. So too would those moving in without their family. If the trend persists, i.e. not many moving into the locality, benefits to the local economy would not be significant. However, should the trend reverse, i.e. more moving into the local area and with their family which would be most probable when accommodation and other facilities, amenities and services are available and provided, the local area would tend to benefit from it most significantly. The latter is expected as low-cost and affordable housing are to be built in the newly created land area providing dormitory function to the accommodation needs of the labour force.

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

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

In addition to the direct local and/or regional employment effects, a mega project such as the proposed Project has a range of secondary or indirect impacts. The workforce, which may be substantial (and well paid), can generate considerable retail expenditure in the locality, on a whole range of goods and services. This may be a considerable boost for the local retail economy.

The proposed Project itself requires supplies ranging from components to be supplied by local engineering firms, to provisions for the canteen and homes. These can also boost the local economy. Such demands create employment, additional to that directly created by the proposed Project. The additional workforce may demand other services locally such as health, education, and housing which may generate additional construction. These demands will create additional employment.

Also, the existing coastal area may undergo further development, upgrading or renewal as being feared by the affected fishing communities of Kampung Permatang Tepi Laut as the majority of them are lodgers on the land where their houses were built. Overall, the net effect may be considerably larger than the original direct injection of jobs and income into the locality or southern Penang Island. Such wider economic impacts are considered as beneficial and long-term in nature.

7.15.3.3 Demography, Housing and Other Services

The workforce involved in the operation of the proposed Project is likely to be drawn partly from local sources (within daily commuting distance of the Project site) and partly from farther afield or from an external source. Those employees recruited from beyond daily commuting distance can be expected to move into the development area permanently during operation. Some of these employees will bring their families into the area. In-migrant workers and their families will have several effects on the locality, namely:

a) They will result in an increase in the population of the area and possibly changing the age and sex structure of the nearby local population;
b) They will require accommodation in the area or housing within reasonable commuting distance of the proposed Project site;
c) They will place additional demands on a range of local services, including schools, health and recreational facilities, police and emergency services; and
d) They will have financial implications for the local authorities in the area, with additional costs of service provision set against an increase in revenues.

7.15.3.4 Socio-cultural

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

a) Changes in the occupational and socio-economic mix of the area's population and the potential ensuing impacts of conflict – ethnic, social or cultural;
b) Problems of integration among the incoming house buyers and workforce and families in the Project area and probably into the local community and community activities; and
c) There may be a clash of lifestyle and expectations between incomers and the local community of Southern Penang Island insofar where culture is concerned.

With a new population size living in the area, the magnitude of the social impacts could be enormous. Those (including foreigners) who may be of multiple social, economic and cultural background would be staying and living alongside each other as well as the host society. Social and cultural conflicts and frictions may evolve if measures for cordial and harmonious living are not promoted.

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

7.15.3.5 Aesthetics

The natural panorama of the sea view fronting the traditional fishing settlements of South Pulau Pinang from Kampung Permatang Damar Laut to Kampung Gertak Sanggul would be lost forever. But in its stead, a massive land area with industrial, commercial and housing structures would be put in place in the near future. These may have their own charms although they may also be offensive to nature lovers. The aesthetic value of the sea front would stand to be relative depending on the onlookers. As mentioned earlier, these structures may in fact attract different type of visitors or tourists too.

Overland, the traditional fishing villages too have their own uniqueness and charm. This too would have to be considered. The fishing communities' plea for relocation in one place only saw the manifestation of their awareness to preserve their way of life and heritage. However, in the era of infrastructure development and high urbanisation, their preservation only calls for rebuilding them with a provision of better infrastructure and facilities whilst preserving their cultural life intact.

7.16 Viewshed Analysis

The viewshed analysis function determines visibility on a surface from one point to another along a line of sight or across the entire surface by assigning code 1 for areas which are in view and code 0 for areas which are not (Bratt, 2004, Longley *et al.*, 2005, O'Sullivan *et al.*, 2003). Viewshed is useful in assessing how visible certain objects might be.

7.16.1 Methodology

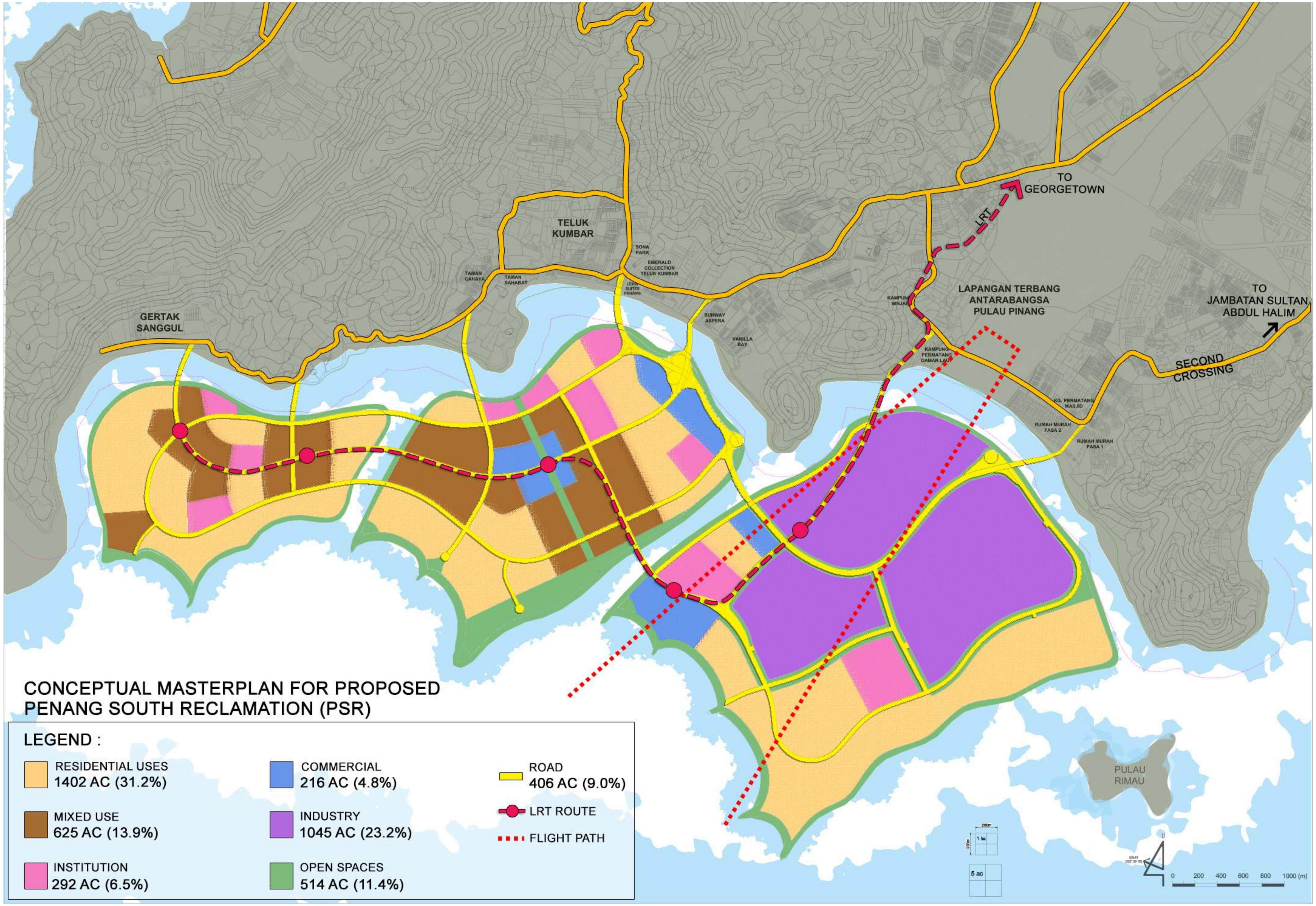
For this assessment, the viewshed from an observation tower is identified. The elevation raster displays the height of the land (darker locations represent lower elevations), and the observation tower is marked as a green triangle. Cells in green are visible from the observation tower, and cells in pink are not.

Factors involved in the viewshed analysis are as view location, topography and features that prevent building from being seen. High rise and impacted location in the surroundings of the study area are shown in T7.62.

T7.62 High rise and impacted location (within 5-km circumference)

Location	Height of Sight from Mean Sea Level (m)	Distance from Proposed Site (m)	Type
Gertak Sanggul	5	400	Beach
Lexis Suites Hotel	5 (ground floor) and 100 (top floor)	500	Hotel
Permatang Damar Laut	5	550	Beach

F7.100 shows the proposed layout of the proposed development. The proposed tallest building for residential is 20 levels (66 m) and for commercial are 15 levels (55 m). The locations where the analysis is conducted can be identified as Lexis Suites Hotel at Teluk Kumbar (F7.101), Gertak Sanggul (F7.102) and Permatang Damar Laut (F7.103).



F7.100 Proposed topside development at PSR

F7.101 Lexis Suites Hotel at Teluk Kumbar

F7.102
View from Gertak Sanggul

F7.103
Permatang Damar Laut

7.16.2 Findings for Viewshed Analysis

7.16.2.1 Gertak Sanggul

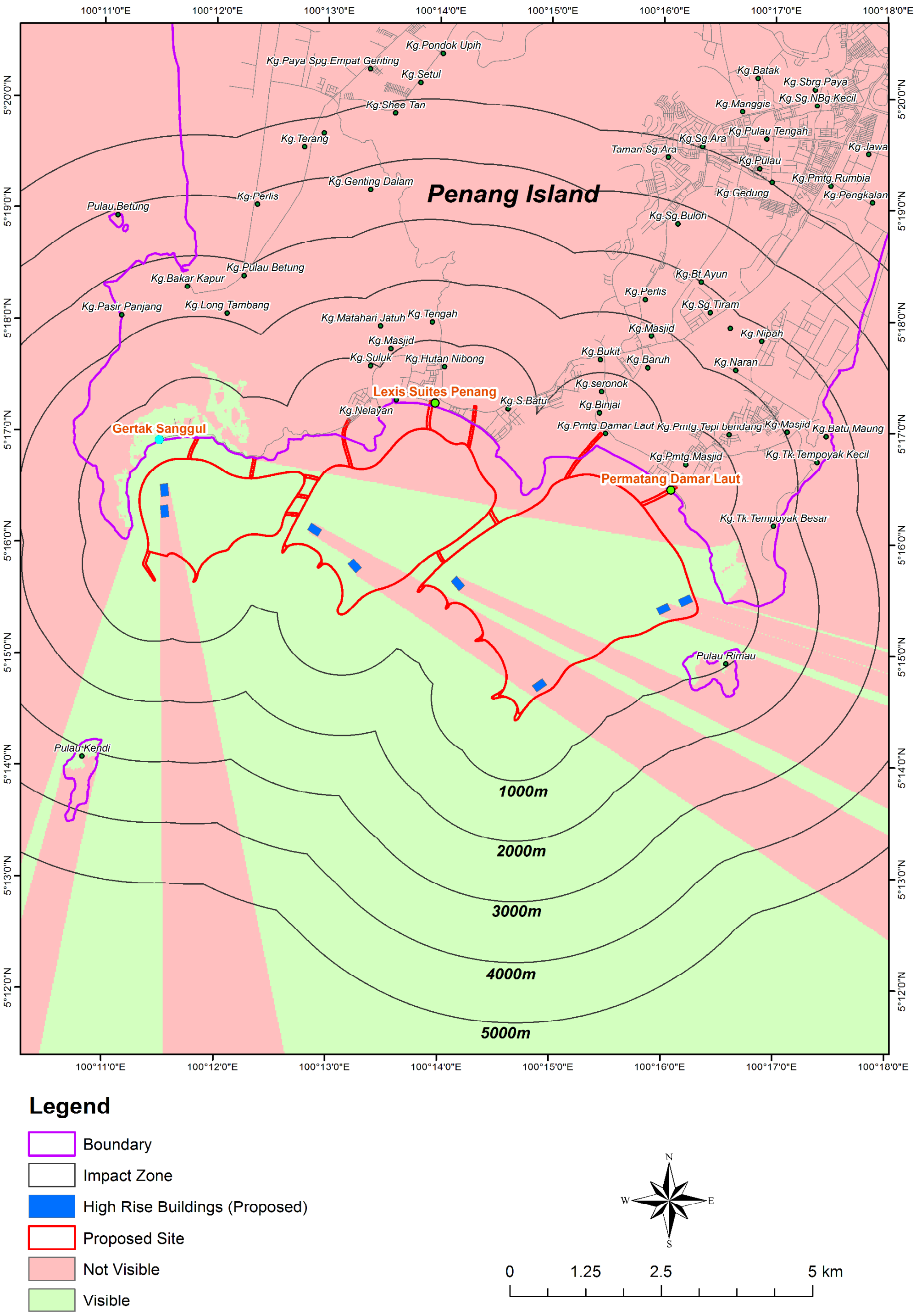
The distance from Gertak Sanggul's view point on the beach to the proposed development is approximately 400 m. F7.104 shows a map view from Gertak Sanggul.

7.16.2.2 Lexis Suites Hotel

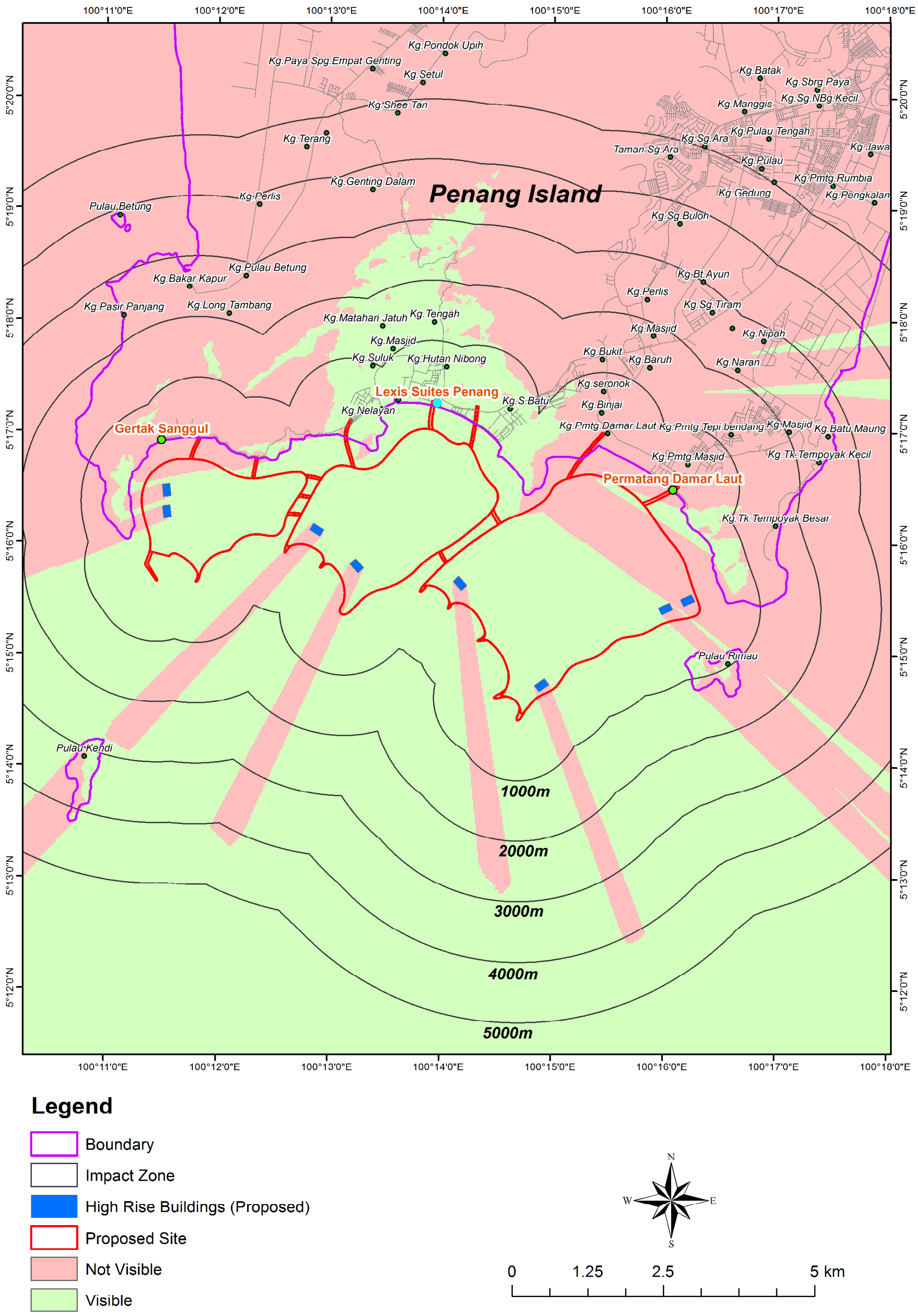
Lexis Suites Hotel is situated at the southern part of Penang Island. With accommodations of 222 rooms and 26 floors, the Lexis Suites Hotel is among the tallest high rise building in Teluk Kumbar. The analysis consists of two parts which are from the top floor and ground level (beach). The top floor and ground floor map view from Lexis Suites Hotel are shown in F7.105 and F7.106 respectively.

7.16.2.3 Permatang Damar Laut

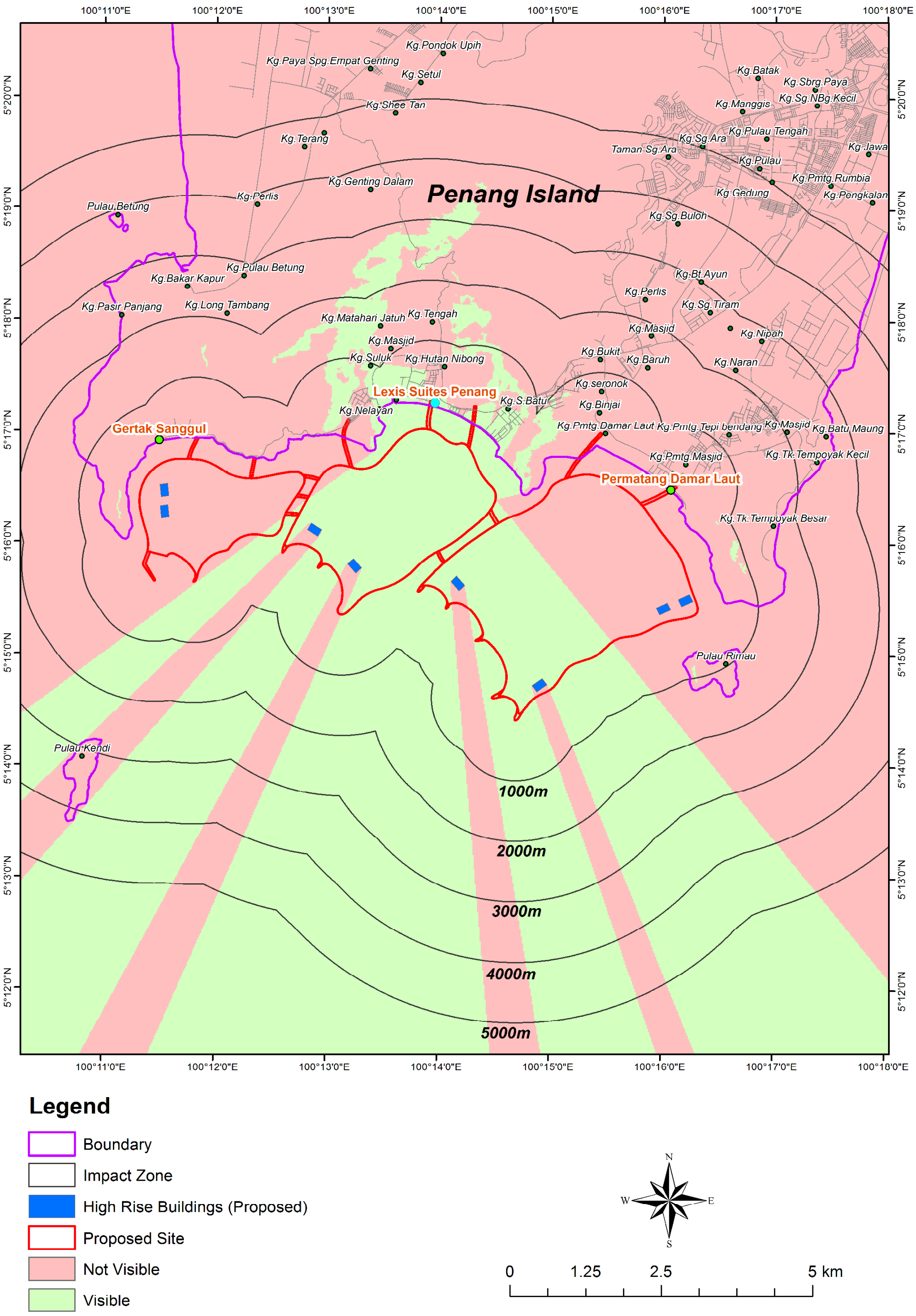
The distance from Permatang Damar Laut's view point on the beach to the proposed development is approximately 550 m. F7.107 shows the map view from Permatang Damar Laut.



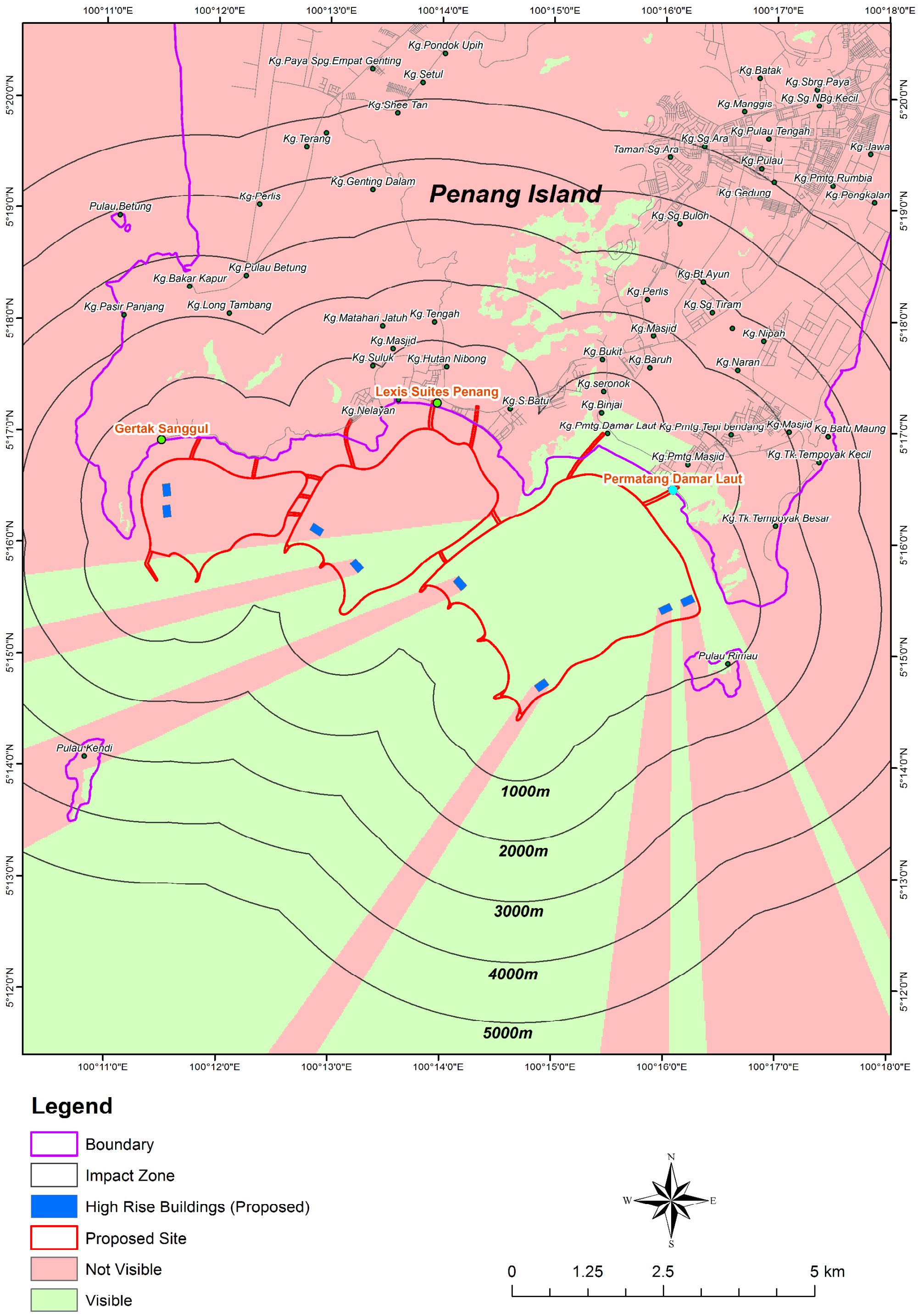
F7.104 Viewshed from Gertak Sanggul



F7.105 Viewshed from Lexis Suites Hotel (top floor)



F7.106 Viewshed from Lexis Suites Hotel (ground floor)



F7.107 Viewshed from Permatang Damar Laut

7.17 Economic Valuation of Environmental Impact

Due to the substantial capital investment and subsequent operation, the proposed Project is expected to provide a boost to the local economy. However, the land reclamation and dredging activities as well as the operation of the proposed Project are also likely to cause some negative environmental impacts that must be mitigated.

Contained in this section are commitments of the Project Proponent to mitigate many of the expected environmental impacts, as detailed in *Chapter 8: Pollution Prevention and Mitigation Measures (P2M2)*. As is common for any proposed development of this nature, some of the negative impacts cannot be completely mitigated, thus justifying the need to quantify, and to the extent possible in monetary terms, the degradation in services obtainable from the disturbed natural environment. Such valuation serves to demonstrate the significance of the environmental values of the services and thus providing some measure of trade-off that will be incurred if the Project were to be implemented. The flows of environmental services that will be foregone following Project implementation are real economic loss to different stakeholders and hence, must be quantified so that informed decisions can be made. The valuation process is facilitated by recent progress in the methods and protocol of environmental resources evaluation that allows for the computation of reliable monetary estimates of the value of losses in environmental services.

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

7.17.1 Objective

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

7.17.2 Methodology

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

"… a key issue is to identify and quantify the changes in the flow of goods and services produced by the environment which are impacted by a development project, and then to monetise these changes into costs or benefits".
The valuation process can be divided into nine steps, as follows:

a) *Step 1: Identify the project stakeholders.*

The stakeholders are determined by establishing clear links between the degradation in environmental services to the impacted parties.

b) *Step 2: Define the "with project" and "without project" scenarios.*

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

c) *Step 3: Describe the physical impacts.*

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

d) *Step 4: Quantify the impacts on the environment over the duration of the project.*

The physical impacts of the project on the environment are explained and quantified via scientific assessments of the study team that include among others marine biologists, air and water quality specialists, and hydraulic specialist.

e) *Step 5: Monetise the impacts.*

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

f) *Step 6: Discounting.*

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

g) *Step 7: Determine the Net Present Value.*

The net present value is computed in this step by adding up the discounted values of the losses and gains in environmental services.

h) *Step 8: Perform sensitivity analysis.*

Sensitivity test is conducted for different discount rates to demonstrate the impact of variation in discount rates on the net present value of the environmental costs and benefits.

i) *Step 9: Make a recommendation.*

An overall assessment is made based on the magnitude of Net Present Values at different levels of discount rates

7.17.3 Identification of Changes in Environmental Services

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

Based on discussions with other (consultants) team members responsible to assess the impacts of the Project on all environmental components as well as reports prepared by them, T7.56 shows the environmental services that may change as a result of Project implementation. The table describes the kind and spatial extent of the impacts as well as their respective locations. From among these potential impacts, mitigation measures are considered, and only those that remain to be significant are evaluated in this study.

7.17.4 Valuation of Significant Change in Environmental Services

Eight environmental services (T7.63) can potentially change as a result of Project implementation. These are: loss of mudflat due to reclamation, loss of mudflat due to capital and maintenance dredging, potential impact on mangrove area, potential impact on coral area, loss of fishing ground and access to sea (higher cost of fishing effort), reduction in water quality due to increase in suspended sediment, erosion and accretion, and change in area's aesthetic. Of the eight potential changes in environmental services, four are considered to be significant enough for evaluation. These are:

a) Loss of mudflat or muddy seabed due to reclamation,
b) Loss of mudflat or muddy seabed due to capital and maintenance dredging,
c) Reduction in coral area productivity, and
d) Loss of fishing ground access to sea (higher cost of fishing effort).

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

7.17.4.1 Loss of Mudflat or Muddy Seabed Due to Reclamation

Reclamation will result in permanent loss of the mudflat or muddy seabed. The loss of mudflat or muddy seabed will result in some reduction in the amount of resources important to support marine lives. The total area that will be affected is 1,800 hectares (4,500 acres).

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

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

T7.63 Valuation of Significant Change in Environmental Services

Environmental Service	Location and Impacted Individuals/ Communities	Spatial Extent	Remarks
Coastal Morphology - **Erosion** and **accretion** due to the introduction of reclaimed land to the existing coastal area.	Hydraulic modelling results show that erosion and sedimentation impact occur after the reclamation is completed. It is projected that sedimentation will occur at Tanjung Gertak Sanggul and within the dredged channel. Meanwhile, erosion is expected to occur offshore of Island C, Tanjung Teluk Tempoyak and Pulau Rimau.	The bed level changes induced by the various development scenarios are expected to result in erosion rates of up to +- 0.2 m/year at Tanjung Teluk Tempoyak and Pulau Rimau	Pulau Rimau is uninhabited while Tanjung Teluk Tempoyak consists of rocky headlands as well as being uninhabited. No economic loss of significance is expected so no valuation is therefore necessary.
Marine Biology - Loss of **mudflat and muddy seabed** due to **reclamation**. Permanent loss is expected for the entire mudflat and muddy seabed making up the footprint of the reclamation site. This area serves as crustacean feeding ground and macrobenthos habitat. This activity will result in some loss in the amount of resources important to support marine life since such area serves as habitat for benthos	The exact location of the reclamation site is given in the *Project Description* chapter of this EIA report. Fishermen and local communities deriving benefits from the marine resources.	A total of 1,800 hectares (4,500 acres) will be reclaimed. (See also Item 2 for loss of mudflat/ muddy seabed due to dredging)	Total loss of mudflat or muddy seabed. The productivity loss method is used to evaluate the loss in environmental services and functions. Reclamation is expected to begin in 2018 for Island B (560 hectares), then in 2020 for Island A (920 hectares), and in 2024 for Island C (320 hectares).
Marine Biology - Loss of **mudflat or muddy seabed** due to **capital and periodic dredging**. Temporary loss is expected for the entire would-be-dredged area. This mudflat serves as crustacean feeding ground and macrobenthos habitat. This activity will result in some loss in the amount of resources important to support marine life since such area serves as habitat for benthos and feeding ground for fishes.	The exact location of the reclamation site is given in the *Project Description* chapter of this EIA report. Generally, it is located in the navigation and access channels and marina basin. Fishermen and local communities deriving benefits from the marine resources.	A total of 345.5 hectares (863.75 acres) will be dredged mostly for the navigation and access channels between the reclaimed islands, and between the reclaimed islands and Penang Island	Initial loss of mudflat habitat during dredging work. Dredging will be conducted in four phases: Phase 1 (115 hectares) in 2017, Phase 2 (110 hectares) in 2021, Phase 3 (80 hectares) in 2025 and Phase 4 (40 hectares) in 2028. The frequency of maintenance dredging required is about once every 5 years. Further, a 5-year full-recovery period for marine organisms is assumed, suggesting an average productivity of about one-fifth for the year following dredging work. Marine organisms are expected to just about fully recover during the intervening period in between dredging works. The productivity loss method is used to evaluate the loss in environmental services and functions.

T7.63 Valuation of Significant Change in Environmental Services (cont'd)

Environmental Service	Location and Impacted Individuals/Communities	Spatial Extent	Remarks
Marine Biology – Potential reduction in environmental services obtainable from **coral** area due to increase in total suspended sediment, sedimentation and erosion, thus resulting in some loss in the amount of resources important to support marine life. Coral areas provide a range of valuable ecosystem services including sheltering habitat essential to a variety of marine species. In addition, the biodiversity of coral reefs provides scientific, pharmaceutical (discovered or yet-to-be discovered), and educational value. Moreover, many coral areas also attract tourists, and protect coastal developments from shoreline erosion. The productivity of corals in delivering these services will be impacted by water quality degradation and sedimentation.	Pulau Rimau (0.5 km from Project location) and Pulau Kendi (5 km from Project location). Fishermen and local communities deriving benefits from marine resources.	The size of the Pulau Rimau coral area on the western side of the island is approximately 0.918 hectare	Sediment spill dispersion modelling results indicate that the suspended sediment concentrations due to dredging works for the access channels as well as the reclamation works would not be significant for the coral area of Pulau Rimau (no impact is expected at Pulau Kendi). However, to be conservative, this study assumes that environmental services obtainable from the coral area will be reduced by 50% during the construction period and thereafter for the Pulau Rimau coral.
Terrestrial Biology – Potential reduction in environmental services obtainable from **mangrove** area due to sedimentation and erosion, thus resulting in some loss in the amount of resources important to support marine life. Mangrove areas are known to provide environmental services including (a) Production of charcoal and poles, (b) Provision of feeding and breeding grounds for shrimp, fish, crab and mollusc, (c) Provision of traditional goods (d) Carbon sequestration function, (e) Shoreline protection, and (f) Option, existence and biodiversity value.	Mangroves of Teluk Tempoyak Kecil, Teluk Tempoyak Besar, Permatang Tepi Laut, Kampung Binjai, Bayan Lepas Main Drain, Sungai Batu, Teluk Kumbar and Gertak Sanggul. Fishermen and local communities deriving benefits from the marine resources as well as the general population that benefit from carbon sequestration function.	Results of hydraulic modelling show that the impact due to sedimentation and erosion is negligible	Since no impact is expected, no valuation is necessary.
Aesthetic - Change in the form of **intrusion** of man-made structures into the **view scape** following Project completion.	Areas surrounding the reclaimed land. Coastal villagers and visitors to where the newly reclaimed land is visible.	The shore area where the reclaimed land plus built structures are visible	The direction of impact of the Project on aesthetic is uncertain since it is hard to argue with certainty that the Project will give rise to negative impact on the general aesthetics of the area. Furthermore, even if the Project is perceived (by the current residents and visitors) to cause some negative impacts on aesthetics, it may well be argued that this will be compensated by the gain in sea view scape of future residents and visitors of the reclaimed islands.

T7.63 Valuation of Significant Change in Environmental Services (cont'd)

Environmental Service	Location and Impacted Individuals/ Communities	Spatial Extent	Remarks
Socio-economy – Loss of **fishing ground** and hindrance of access to the sea. Reduction in the size of fishing ground because part of the sea will be reclaimed. The reclamation will force the fishermen to find alternative fishing ground/s, potentially increasing their operational cost. The reclaimed land mass and terminal will also hinder direct movements of costal fishing vessels. Thus, some fishermen will incur additional cost of going to and back from the fishing ground.	The reclaimed area as given in the Project Description section of this DEIA report. The directly affected stakeholders are the coastal (Zone A) fishermen operating from four landing sites identified in the study area namely, Kampung Permatang Damar Laut (85 vessels), Kampung Sungai Batu (105 vessels), Kampung Teluk Kumbar (131 vessels), and Kampung Gertak Sanggul (77 vessels).	All of the reclaimed area	Fishermen who routinely fish in the affected area will have to find other locations. The additional cost of fishing involves the increase in cost of travelling to and back from the alternative fishing ground. They may have to travel farther because conflict may arise as they encroach into traditional fishing grounds of existing fishermen.
Water Quality – Increase in suspended TSS during reclamation and dredging work that reduces the quality and therefore productivity of marine habitat. Furthermore, any degradation of water quality at the water abstraction points of the hatcheries near Kampung Permatang Damar Laut, Kampung Teluk Kumbar, Pulau Betung, and Kampung Gertak Sanggul will adversely affect their operations and output.	Coastal waters around reclaimed land and the dredging work area. Of significance are the aquaculture sites near Pulau Betung and Kampung Teluk Tempoyak Kecil; and hatcheries near Kampung Permatang Damar Laut, Kampung Teluk Kumbar, Pulau Betung, and Kampung Gertak Sanggul.	With the installation of perimeter bund and silt curtain during reclamation and dredging, the extent of impact is predicted by the hydraulic modelling to be much reduced, especially at the environmental sensitive areas. In the case of the aquaculture sites, the predicted concentration is well below the tolerable limits of 80 mg/L [Water Quality Standards for Aquaculture in Malaysia (Liong, P.C., 1984)]. However, the hydraulic modelling results indicate that the water abstraction points of the hatcheries near Kampung Permatang Damar Laut and Kampung Teluk Kumbar will be temporarily impacted during reclamation. This impact will be mitigated by an upgrade to the filtration systems of the hatcheries as well as relocation of pipes for water abstraction as proposed in the	Mitigating measures through the installation of perimeter bund and silt curtain during reclamation and dredging work will render the impact insignificant. No valuation is necessary. However, also see the impact on dredging work and reclamation on marine biology.

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

Total size of mudflats in Peninsular Malaysia is estimated at 35,064 hectares. Dividing the estimates on the annual value of the production of cockles, bivalves, gastropods/snails, shrimps and fish by the total size of mudflats, the estimated environmental service of mudflats in the form of direct use value (adjusted for price increase at the rate of 4% per year) is provided in T7.64. The direct use value for mudflat is therefore estimated at RM6,981.24/hectare/year.

T7.64
Estimated average loss in environmental services (per hectare per year) from mudflat by service type

	Environmental Services (Production)	Unit Value (RM per hectare per year)
Direct Use Value	Cockles	3,954.90
	Bi valves	2,645.54
	Gastropods/snails	25.86
	Shrimps	217.46
	Fish	137.48
Total		**6,981.24**

Confirmatory site visit indicates that not all components of valuation presented in T7.60 are relevant to the site. In particular, gastropods/snails are minimal at the proposed site. Hence, the relevant components of valuation are cockles, bivalves, shrimps and fish. The adjusted loss in environmental services from mudflat is therefore RM6,955.38/hectare/year.

The annual value of environmental services forgone from the loss of mudflat is obtained by multiplying the size of the affected area by the estimated value of environmental services loss per hectare of reclaimed area (i.e. RM6,955.38/hectare/year). The loss is expected to build up as reclamation will begin in 2018 for Island B (560 hectares), then in 2021 for Island A (920 hectares), and in 2025 for Island C (320 hectares).

7.17.4.2 Loss of Mudflat or Muddy Seabed Due to Capital and Maintenance Dredging

Loss of mudflat due to dredging works (capital and maintenance dredging) will take place at the navigation and access channels between the reclaimed islands, and between the reclaimed islands and Penang Island. The estimated size of mudflat or muddy seabed affected is 345.5 hectares (863.75 acres). Periodic maintenance dredging is expected to be conducted on average about once every 5 years.

The benthic communities are known to recover after dredging work. A 5-year impact period on the benthic communities is typically assumed for each dredging exercise, which is the time required for the seabed life to recover. Hence, one possible way of computing the loss is by assuming that the benthic communities recover at a constant rate throughout each dredging cycle. A 5-year full-recovery period implies an average productivity of about one-fifth for the year following dredging work.

The frequency of maintenance dredging required is about once every 5 years, so a 5-year frequency is used as the basis of computation. Further, a 5-year full-recovery period for marine organisms is assumed, suggesting an average productivity of about one fifth for the year following dredging work. Marine organisms are expected to just about fully recover during the intervening period in between dredging works.

The projected loss in environmental services is computed by multiplying the size of the affected area by the estimated value of environmental services loss per hectare of reclaimed area (i.e. RM6,955.38/hectare/year). The size of impacted area will increase over time in tandem with the four dredging phases. The size and timing of area to be dredged are as follows: Phase 1 (115 hectares) in 2017, Phase 2 (110 hectares) in 2021, Phase 3 (80 hectares) in 2025 and Phase 4 (40 hectares) in 2028.

The estimation of the environmental services lost due to dredging work follows the method used in determining the loss of mudflat or muddy seabed due to reclamation. After adjusting for general increase in price level the value of cockle, bivalves, shrimp and fish production of mudflats is estimated at RM6,955.38/hectare/year. Since some recovery can be expected within dredging cycles, total loss is expected following any dredging work and will gradually fall up to the fifth year. Thereafter, the cycle is repeated when the area is re-dredged. This method implies that the loss of RM6,955.38/hectare in the first year of dredging and gradually falls up to the fifth year in a linear fashion.

7.17.4.3 Loss of Coral Area Productivity

Corals are found in the oceans all over the world, from the coast of Alaska to the warm tropical waters of Southeast Asia and the Caribbean. The bigger coral reefs that grow quickly are found in the shallow ocean waters of the tropics. Within 5 km of the Project site, there are two coral areas of significance, namely at Pulau Rimau and Pulau Kendi. Based on locational proximity of the coral area of Pulau Rimau (about 0.5 km away from Project site), it may be affected by reclamation activities. However, results of the hydraulic modelling show that with strict mitigation measures (e.g. installation of perimeter bund and silt curtain), the impact of sediment plume at Pulau Rimau coral is not expected to be significant. (No impact is expected for Pulau Kendi). However, to be conservative, this study assumes that environmental services obtainable from the coral area will be reduced by 50% during the construction period and thereafter. The size of the Pulau Rimau coral is approximately 0.918 hectare.

Reclamation and dredging work may cause sediment plume to reach the coral area thus reducing its productivity and health. However, as mentioned earlier, this is not expected to be significant if mitigation measures are put in place before reclamation work begins. Coral areas provide a range of valuable ecosystem services. First, they provide sheltering habitat essential to a variety of marine species. In the Philippines, for example, coral areas supply between 11 and 29% of the total fisheries production (Burke *et. al.*, 2002). In addition, the biodiversity of coral reefs provides scientific, pharmaceutical (discovered or yet-to-be discovered), and educational value. Moreover, many coral areas also attract tourist, and protect coastal developments from shoreline erosion. Corals are also thought to facilitate the growth of mangroves and seagrasses. The productivity of corals in delivering these services will be impacted by water quality degradation and sedimentation.

No valuation study has been conducted for the value of environmental services provided by coral areas of Malaysia. Internationally, although not as abundant as valuation studies on mangrove, several published studies on the value of environmental services provided by coral areas are available. Unit values from these studies were converted to the current 2016 price to determine the respective values of environmental services.

■ Economic Value of Coral Area

The Millennium Ecosystem Assessment (MEA) provides a framework to define and assess the global status of the ecosystem goods and services. The framework identifies four categories of services provided by ecosystems: provisioning services, regulating services, cultural services and supporting services (T7.65). It is within this framework that the services provided by the coral area found at Pulau Rimau and Pulau Kendi.

T7.65

Ecosystem services provided by coral area

Provisioning Services *Products obtained from ecosystems*	■ Food (fish and shellfish) ■ Genetic resources ■ Natural medicines and pharmaceuticals ■ Ornamental resources ■ Building materials
Regulating Services *Benefits obtained from regulation of ecosystem processes*	■ Erosion control ■ Storm protection ■ Climate regulation
Cultural Services *Non-material benefits obtained from ecosystem*	■ Spiritual and religious values ■ Knowledge systems/educational values ■ Inspiration ■ Aesthetic values ■ Social traditions ■ Sense of place ■ Recreation and ecotourism
Supporting Services *Natural processes that maintain the other services*	■ Sand formation ■ Primary production

Source: Adapted from Millennium Ecosystem Assessment (MEA), 2003, "Ecosystems and Human Well-being: A Framework for Assessment." Washington DC: Island Press.

Past valuation studies have tended to report average ecosystem service productivity as a basis for valuing the loss of environmental services produced by coral sites. This study

adopts these average values but updates them to the present to take care of general price inflation. As most of the values are reported in USD, this study also adjusts the values to reflect the current exchange rate.

In a seminal paper published in the prestigious Journal of Nature, Constanza *et. al.* (1997) classifies ecosystem services produced by coral areas into eight categories namely:

a) *Disturbance regulation* - Capacitance, damping and integrity of ecosystem response to environmental fluctuations;
b) *Waste treatment* - Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds;
c) *Biological control* - Trophic-dynamic regulations of populations;
d) *Habitat/Refugia* - Habitat for resident and transient populations;
e) *Food production* - That portion of gross primary production extractable as food;
f) *Raw materials* - That portion of gross primary production extractable as raw materials;
g) *Recreation* - Providing opportunities for recreational activities; and
h) *Cultural* - Providing opportunities for non-commercial uses.

The values are reproduced in T7.66. They ranged from a low of USD1 for cultural service per hectare per year to a high of USD3,008 for recreation. The total value of ecosystem services is USD6,075/hectare/year. These values are converted to 2016 by assuming a 3% inflation rate and an exchange rate of USD1 = RM4.20.

T7.66 Estimated environmental services value (per hectare per year) of Pulau Rimau corals by service type

Services	Constanza *et. al.* (1997) USD/ha/year	Hoisington and Eadie (2012) AUD/ha/year	Burke *et. al* (2002) USD/ha/year (Mid Value/ Range)	Average Values (2016) (RM)
Provisioning Services *(Products obtained from ecosystems)*				
■ Food (fish and shellfish) ■ Genetic resources ■ Natural medicines and pharmaceuticals ■ Ornamental resources ■ Building materials	247	140	277.50/ 145-410	1,367.33
Regulating Services *(Benefits obtained from regulation of ecosystem processes)*				
■ Erosion control ■ Storm protection ■ Climate regulation	2,813	79	577.50/ 55-1,100	8,226.39
Cultural Services *Non-material benefits obtained from ecosystem*				
■ Spiritual and religious values ■ Knowledge systems/ educational values ■ Inspiration ■ Aesthetic values ■ Social traditions ■ Sense of place ■ Recreation and	3,009	9	553.50/ 7-1,100	8,570.07
Supporting Services (*Natural processes that maintain the other services)*				
■ Sand formation ■ Primary production	7	134	52/ 24-80	293.20
Total	**6,076**	**362**	**1,460.50**	**18,456.99**

In another study, Hoisington and Eadie (2012) set out to estimate the economic value of ecosystem services for the proposed Commonwealth Marine Reserves Network in Australia. The study identifies five ecosystem services produced by coral areas. The researchers explicitly state that they have been conservative in their estimation and have not included existence and non-use values. The five services are:

a) food production;
b) raw materials;
c) climate regulation;
d) habitat services – lifecycle maintenance; and
e) recreation and tourism.

Consistent with their conservative approach, the estimated values start from a low of AUD1 for raw materials per hectare per year to a high of AUD134 for lifecycle maintenance. These values are converted to 2016 by assuming a 3% inflation rate and an exchange rate of AUD1 = RM3.30. The values are reproduced in T7.66.

Closer to home, Burke *et. al* (2002) produces a range of estimates for ecosystem services produced by coral areas in South East Asia. The study listed five broad categories of services namely:

a) sustainable fisheries (local consumption);
b) sustainable fisheries (live fish export);
c) coastal protection (erosion prevention);
d) tourism and recreation; and
e) aesthetic/Biodiversity value.

Instead of providing point estimates, the study provides a range of values for each category. This is mainly because the proposed values are sourced from several other studies [i.e. White *et. al.* (2000), White and Cruz-Trinidad (1998), and Cesar (1996)]. The values (also reproduced in T7.66) are within expected bound for some but tend to have a wide range for others. For example, sustainable fisheries for local consumption is valued at the USD120-USD360 range, while those for tourism and recreation at the USD7-USD1,110 range.

The last column of T7.66 provides the average value of ecosystem service by type as well as the total economic value. The average values in RM are established by first updating all figures to 2016 prices assuming an inflation rate of 3%, and subsequently converting them into RM using current exchange rates. The three estimates of value of each service type are them summed and divided by three to produce the average values in RM for 2016. The total economic value of ecosystem services produced by corals amounts to RM18,456.99/ hectare/year.

Because of the mitigation measures that will be implemented (e.g. perimeter bund and silt curtain), the impact of sediment plume is not expected to be very significant. However, in order to be conservative in approach, this study assumes that services obtainable from the coral area of Pulau Rimau will be reduced by 50% during the construction period and thereafter. The reduction in ecosystem services produced by the coral area of Pulau Rimau is therefore estimated at RM8,472 per year.

7.17.4.4 Loss in Fishing Ground and Increase in Fuel Cost for Fishermen

The directly-affected fishermen are the coastal (Zone A) fishermen operating from four landing sites identified in the study area namely, Kampung Permatang Damar Laut, Kampung Sungai Batu, Kampung Teluk Kumbar, and Kampung Gertak Sanggul. The area to be reclaimed is part of the fishing ground as well as used as direct routes to fishing ground by local fishermen.

A total of 398 fishing boats operate regularly within the area to be reclaimed, based on data provided by local leaders of the fishermen communities. By landing sites, the number of vessels are as follows:

a) Kampung Permatang Damar Laut (85 vessels);
b) Kampung Sungai Batu (105 vessels);
c) Kampung Teluk Kumbar (131 vessels); and
d) Kampung Gertak Sanggul (77 vessels).

Fishing takes place by day and by night, and at various stages of the tide. The fishermen will be directly impacted because the would-be reclaimed area is their regular fishing ground or used as direct routes to fishing ground, and they will have to travel longer distances to alternative fishing grounds. They can only do so at a higher cost since they will have to travel further to these areas, with added difficulty of encroaching into traditional fishing grounds of existing fishermen.

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

By consulting several representatives of the fishermen community, it is determined that the fishermen generally use outboard engines ranging from 30 to 115 horsepower. The most popular engines are the 30, 60 and 115 horsepower while a significantly smaller proportion of fishermen use bigger horsepower engines. The corresponding estimated fuel usage per day are 30 to 115 litres per trip depending on engine horsepower. A litre of subsidised petrol costs the fishermen RM1. However, for economic valuation, the true resource cost as reflected by unsubsidised market price should be used. For this study a market price of RM2.00 per litre is applied to determine fuel cost.

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

a) The average number of fishing days is 20 trips in a month. This figure is derived from the survey conducted on the fishermen;
b) The proportion of boats belonging to the 30, 60 and 115 horsepower categories is approximately 32.5, 59.9 and 7.6% respectively. This is based on information gathered from the fishermen; and
c) The additional fuel cost for trips to alternative fishing grounds is assumed 25% higher than the current cost.

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

Fuel in litres/trip x RM2/litre x 20 trips x 25%

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

7.17.5 Overall Findings for Economic Valuation of Environmental Impact

T7.67 to T7.69 show the streams of discounted loss of environmental services over a period of 50 years that can be attributed to the proposed Project. The 8% rate is chosen to reflect the market rate of interest conventionally use for Project evaluation while 6 and 4% are more appropriate rates for social evaluation.

T7.67 Estimates of the discounted environmental loss (discount rate = 8%)

Year	Loss of Mudflat (Reclamation)	Loss of Mudflat (Dredging)	Reduction in Coral Productivity	Loss of Fishing Ground - Additional Fuel Cost	Discounted Loss
0	3,895,013	799,869	8,472	2,592,000	7,295,353
1	3,606,493	592,495	7,844	2,400,000	6,606,833
2	8,825,413	411,455	7,263	2,222,222	11,466,354
3	8,171,679	253,985	6,725	2,057,613	10,490,002
4	7,566,369	1,150,293	6,227	1,905,197	10,628,086
5	7,005,898	852,069	5,766	1,764,072	9,627,804
6	7,889,524	591,714	5,339	1,633,400	10,119,977
7	7,305,115	365,256	4,943	1,512,407	9,187,721
8	6,763,995	1,146,121	4,577	1,400,377	9,315,071
9	6,262,959	848,979	4,238	1,296,645	8,412,821
10	5,799,036	589,569	3,924	1,200,598	7,593,126
11	5,369,478	483,253	3,633	1,111,664	6,968,028
12	4,971,739	930,820	3,364	1,029,319	6,935,242
13	4,603,462	685,404	3,115	953,073	6,245,054
14	4,262,465	471,239	2,884	882,475	5,619,063
15	3,946,726	355,205	2,671	817,106	5,121,709
16	3,654,376	684,180	2,473	756,580	5,097,610
17	3,383,682	503,793	2,290	700,537	4,590,301
18	3,133,039	346,375	2,120	648,645	4,130,179
19	2,900,962	261,087	1,963	600,598	3,764,609
20	2,686,076	502,893	1,818	556,109	3,746,895
21	2,487,107	370,303	1,683	514,916	3,374,008
22	2,302,877	254,596	1,558	476,774	3,035,805
23	2,132,293	191,906	1,443	441,457	2,767,100
24	1,974,346	369,641	1,336	408,757	2,754,080
25	1,828,098	272,183	1,237	378,478	2,479,997
26	1,692,683	187,136	1,145	350,443	2,231,407
27	1,567,299	141,057	1,061	324,484	2,033,901
28	1,451,203	271,697	982	300,448	2,024,331
29	1,343,707	200,063	909	278,193	1,822,872
30	1,244,173	137,550	842	257,586	1,640,151
31	1,152,012	103,681	780	238,506	1,494,978
32	1,066,678	199,706	722	220,839	1,487,944
33	987,664	147,052	668	204,480	1,339,865
34	914,504	101,104	619	189,333	1,205,560
35	846,763	76,209	573	175,309	1,098,853
36	784,040	146,790	531	162,323	1,093,683
37	725,963	108,088	491	150,299	984,841
38	672,188	74,314	455	139,166	886,123
39	622,396	56,016	421	128,857	807,690
40	576,293	107,895	390	119,312	803,890
41	533,604	79,448	361	110,474	723,887
42	494,078	54,623	334	102,291	651,326
43	457,480	41,173	310	94,714	593,676
44	423,592	79,306	287	87,698	590,883
45	392,215	58,396	265	81,202	532,079
46	363,162	40,150	246	75,187	478,744
47	336,261	30,264	228	69,618	436,370
48	311,353	58,292	211	64,461	434,317
49	288,290	42,923	195	59,686	391,094
Total	**141,975,821**	**16,827,614**	**111,930**	**34,245,928**	**193,161,293**

T7.68 Estimates of the discounted environmental loss (discount rate = 6%)

Year	Loss of Mudflat (Reclamation)	Loss of Mudflat (Dredging)	Reduction in Coral Productivity	Loss of Fishing Ground - Additional Fuel Cost	Discounted Loss
0	3,895,013	799,869	8,472	2,592,000	7,295,353
1	3,674,540	603,674	7,992	2,445,283	6,731,490
2	9,161,590	427,128	7,540	2,306,871	11,903,128
3	8,643,009	268,634	7,113	2,176,293	11,095,049
4	8,153,782	1,239,595	6,710	2,053,107	11,453,195
5	7,692,247	935,544	6,331	1,936,893	10,571,015
6	8,825,883	661,941	5,972	1,827,258	11,321,054
7	8,326,305	416,315	5,634	1,723,828	10,472,082
8	7,855,004	1,330,987	5,315	1,626,253	10,817,559
9	7,410,381	1,004,518	5,014	1,534,201	9,954,115
10	6,990,926	710,744	4,731	1,447,359	9,153,760
11	6,595,213	593,569	4,463	1,365,433	8,558,678
12	6,221,899	1,164,878	4,210	1,288,145	8,679,132
13	5,869,716	873,936	3,972	1,215,231	7,962,854
14	5,537,468	612,198	3,747	1,146,444	7,299,857
15	5,224,027	470,162	3,535	1,081,551	6,779,275
16	4,928,327	922,692	3,335	1,020,331	6,874,685
17	4,649,365	692,239	3,146	962,577	6,307,326
18	4,386,193	484,918	2,968	908,091	5,782,171
19	4,137,918	372,413	2,800	856,690	5,369,821
20	3,903,697	730,859	2,642	808,198	5,445,395
21	3,682,733	548,318	2,492	762,451	4,995,993
22	3,474,276	384,101	2,351	719,293	4,580,021
23	3,277,619	294,986	2,218	678,579	4,253,401
24	3,092,093	578,909	2,092	640,168	4,313,263
25	2,917,069	434,319	1,974	603,932	3,957,295
26	2,751,952	304,244	1,862	569,748	3,627,805
27	2,596,181	233,656	1,757	537,498	3,369,092
28	2,449,227	458,550	1,657	507,073	3,416,508
29	2,310,592	344,021	1,564	478,371	3,134,548
30	2,179,804	240,989	1,475	451,293	2,873,562
31	2,056,419	185,078	1,392	425,749	2,668,636
32	1,940,018	363,214	1,313	401,650	2,706,194
33	1,830,205	272,497	1,238	378,915	2,482,856
34	1,726,609	190,886	1,168	357,467	2,276,130
35	1,628,876	146,599	1,102	337,233	2,113,810
36	1,536,676	287,700	1,040	318,144	2,143,559
37	1,449,694	215,843	981	300,136	1,966,654
38	1,367,636	151,200	925	283,147	1,802,908
39	1,290,222	116,120	873	267,120	1,674,335
40	1,217,191	227,885	824	252,000	1,697,900
41	1,148,293	170,968	777	237,736	1,557,774
42	1,083,296	119,764	733	224,279	1,428,072
43	1,021,977	91,978	692	211,584	1,326,231
44	964,129	180,506	652	199,608	1,344,896
45	909,556	135,423	615	188,309	1,233,903
46	858,072	94,865	581	177,650	1,131,167
47	809,502	72,855	548	167,594	1,050,499
48	763,681	142,978	517	158,108	1,065,283
49	720,453	107,268	488	149,158	977,367
Total	**185,136,554**	**22,412,533**	**141,543**	**43,306,027**	**250,996,657**

T7.69 Estimates of the discounted environmental loss (discount rate = 4%)

Year	Loss of Mudflat (Reclamation)	Loss of Mudflat (Dredging)	Reduction in Coral Productivity	Loss of Fishing Ground - Additional Fuel Cost	Discounted Loss
0	3,895,013	799,869	8,472	2,592,000	7,295,353
1	3,745,204	615,284	8,146	2,492,308	6,860,942
2	9,517,347	443,714	7,833	2,396,450	12,365,343
3	9,151,295	284,432	7,531	2,304,279	11,747,537
4	8,799,322	1,337,735	7,242	2,215,652	12,359,951
5	8,460,886	1,029,027	6,963	2,130,435	11,627,311
6	9,894,488	742,087	6,695	2,048,495	12,691,765
7	9,513,931	475,697	6,438	1,969,707	11,965,772
8	9,148,010	1,550,080	6,190	1,893,949	12,598,229
9	8,796,164	1,192,369	5,952	1,821,105	11,815,589
10	8,457,850	859,881	5,723	1,751,062	11,074,517
11	8,132,548	731,929	5,503	1,683,714	10,553,694
12	7,819,757	1,464,032	5,291	1,618,956	10,908,037
13	7,518,998	1,119,495	5,088	1,556,688	10,200,269
14	7,229,805	799,295	4,892	1,496,815	9,530,808
15	6,951,736	625,656	4,704	1,439,246	9,021,342
16	6,684,361	1,251,461	4,523	1,383,890	9,324,236
17	6,427,271	956,949	4,349	1,330,663	8,719,232
18	6,180,068	683,241	4,182	1,279,484	8,146,975
19	5,942,373	534,814	4,021	1,230,273	7,711,481
20	5,713,820	1,069,754	3,866	1,182,955	7,970,396
21	5,494,058	818,004	3,718	1,137,457	7,453,236
22	5,282,748	584,037	3,575	1,093,708	6,964,068
23	5,079,565	457,161	3,437	1,051,643	6,591,806
24	4,884,197	914,430	3,305	1,011,195	6,813,128
25	4,696,344	699,233	3,178	972,303	6,371,058
26	4,515,715	499,237	3,056	934,906	5,952,915
27	4,342,034	390,783	2,938	898,949	5,634,703
28	4,175,032	781,659	2,825	864,374	5,823,890
29	4,014,454	597,708	2,716	831,128	5,446,007
30	3,860,052	426,750	2,612	799,162	5,088,576
31	3,711,589	334,043	2,512	768,425	4,816,568
32	3,568,835	668,165	2,415	738,870	4,978,286
33	3,431,572	510,923	2,322	710,452	4,655,269
34	3,299,589	364,788	2,233	683,127	4,349,736
35	3,172,682	285,541	2,147	656,853	4,117,223
36	3,050,655	571,150	2,064	631,589	4,255,459
37	2,933,322	436,739	1,985	607,297	3,979,344
38	2,820,502	311,822	1,909	583,940	3,718,173
39	2,712,021	244,082	1,835	561,481	3,519,419
40	2,607,713	488,222	1,765	539,885	3,637,585
41	2,507,416	373,326	1,697	519,120	3,401,560
42	2,410,977	266,547	1,631	499,154	3,178,310
43	2,318,247	208,642	1,569	479,956	3,008,414
44	2,229,084	417,334	1,508	461,496	3,109,422
45	2,143,350	319,121	1,450	443,746	2,907,668
46	2,060,913	227,845	1,395	426,679	2,716,833
47	1,981,648	178,348	1,341	410,268	2,571,605
48	1,905,430	356,739	1,289	394,489	2,657,947
49	1,832,145	272,786	1,240	379,316	2,485,486
Total	**255,022,137**	**31,571,968**	**189,272**	**57,909,095**	**344,692,472**

When discounted at the rate of 8%, the total present value of the stream of annual loss amounts to RM193.2 million over a period of 50 years. The corresponding values for 6 and 4% discounts rates are RM251.0 million and RM344.7 million respectively. This study notes that the sum should not be construed as indicating Project feasibility. Rather, they provide some indication of the magnitude, in monetary terms, of the reduction in the flow of environmental services as a result of the implementation of the Project over the evaluation period.

In view of the expected loss in the value of environmental services it is recommended that the Project Proponent initiate offsetting programmes to enhance some environmental services such as construction of artificial reef, replanting of mangroves and fish stocking.

While the economic gain from the Project outweighs this loss of environmental services, the parties affected by this loss, especially the fishermen community, must be supported so that their livelihood is not adversely affected by the Project. The support can be in the form of *ex-gratia*/compensation, training and employment scheme, improved facilities and others measures as discussion in *Chapter 8: Pollution Prevention and Mitigation Measures (P2M2)*.