KURSUS PERMODELAN
HIDRAULIK (TAHAP 1)

Pemahaman & Interpretasi Asas Daripada Laporan Kajian Hidraulik (termasuk kajian kes)

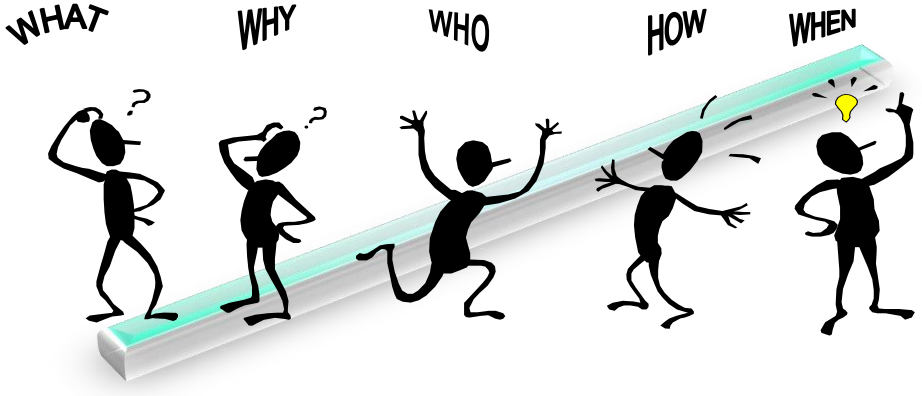
Pembentang: Ir. Iwan Tan Sofian Tan

DR. NIK & ASSOCIATES SDN. BHD.
No. 22 & 24, Jalan Wangsa Delima 6, Seksyen 5, Pusat Bandar Wangsa Maju (KLSC), 53300 Kuala Lumpur. Tel: 03-41458866 Fax: 03-41458877

Pengenalan

Kajian Hidraulik

- **Keperluan kajian**
- **Tujuan kajian**
- **Perlaksanaan kajian**
- **Hasil kajian**



Keperluan Kajian

- Surat Pekeliling Am Bil. 5 Tahun 1987. **Peraturan Meluluskan dan/atau Melaksanakan Projek Pembangunan di Kawasan Pantai Negara**. Jabatan Perdana Menteri Malaysia

- Jabatan Pengairan & Saliran Malaysia. 1997. **Garispanduan JPS 1/97: Guidelines on Erosion Control for Development Projects in the Coastal Zone**. Kuala Lumpur: JPS

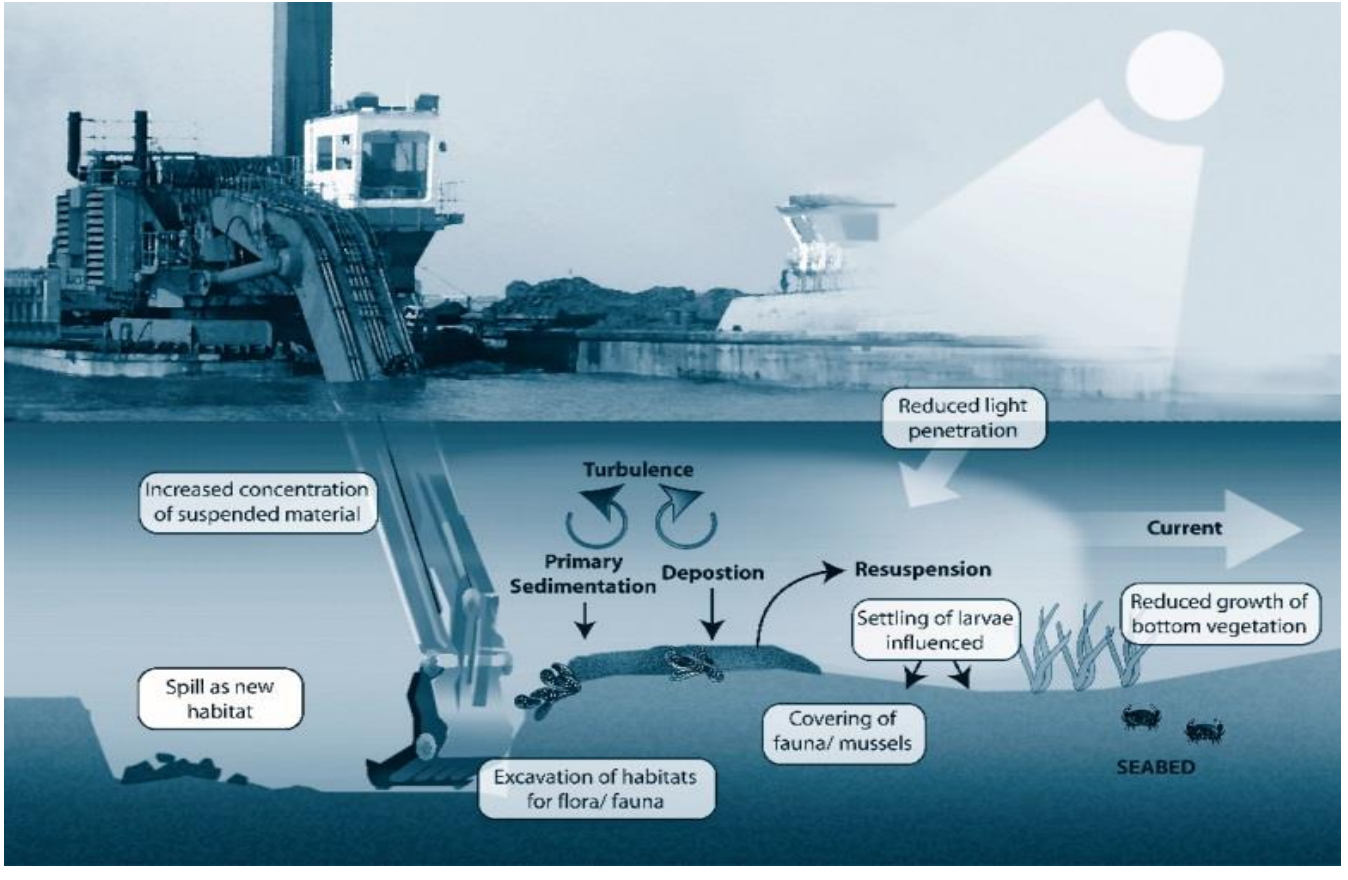
- Jabatan Pengairan & Saliran Malaysia. 2001. **Guidelines for Preparation of Coastal Engineering Hydraulic Study and Impact Evaluation (for Hydraulic Studies using Numerical Models)**. Fifth Edition. Kuala Lumpur: JPS

- Jabatan Pengairan & Saliran Malaysia. **Keperluan Tambahan Bagi Permodelan Hidrodinamik Untuk Permohonan Pembangunan Di Hadapan Garis Pantai**. Surat Bernombor Rujukan (45) dlm PPS.14/2/23 Jld.2 (11 Jun 2013)

Tujuan Kajian

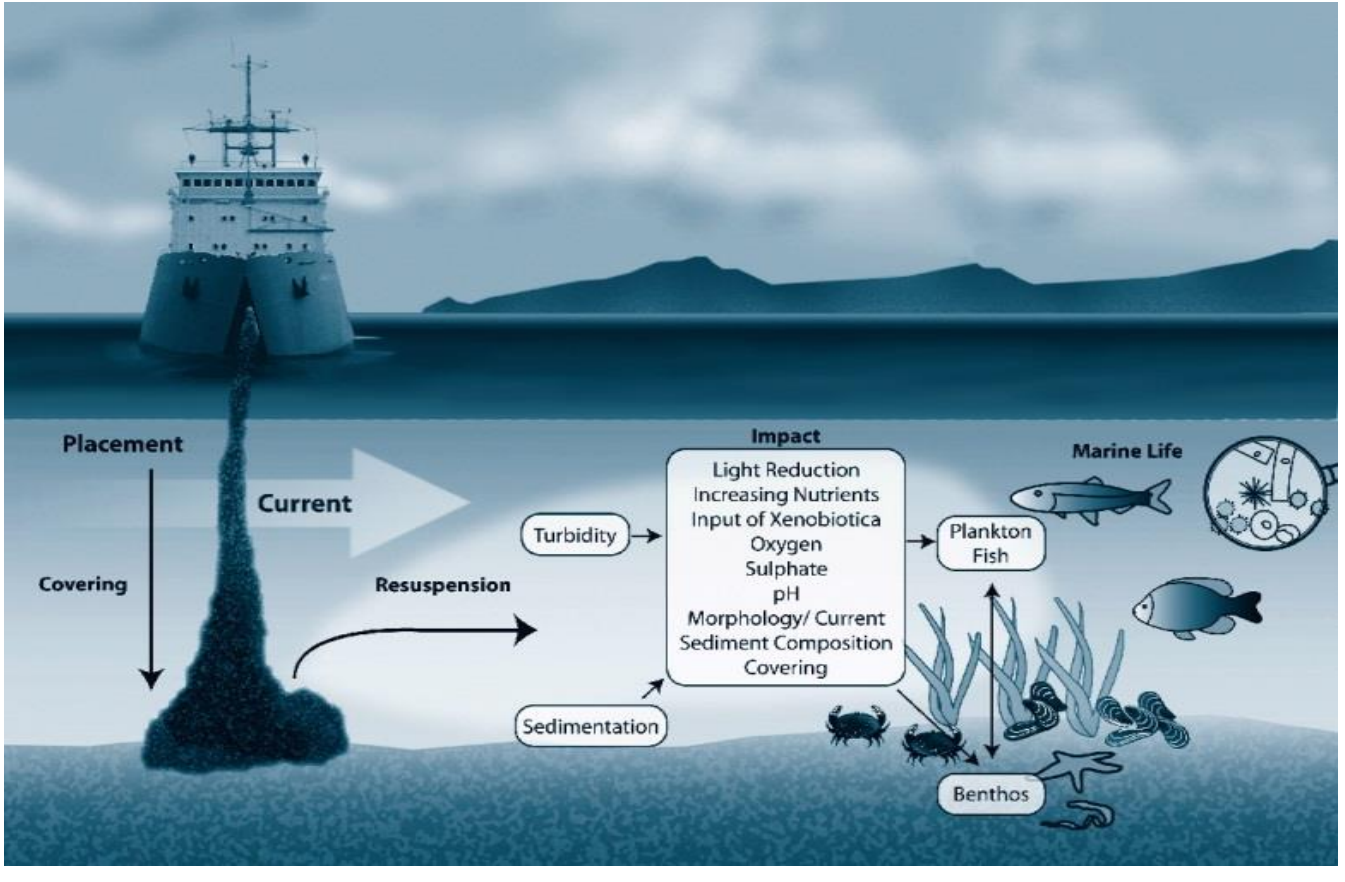
- Memahami keadaan terkini tapak & kawasan persekitaran
- Mengenalpasti kesan kepada proses pantai akibat pembangunan yang dicadangkan
- Mengoptimumkan cadangan pembangunan
- Menentukan kaedah/langkah mitigasi

Kajian: Kaeadah Pembinaan



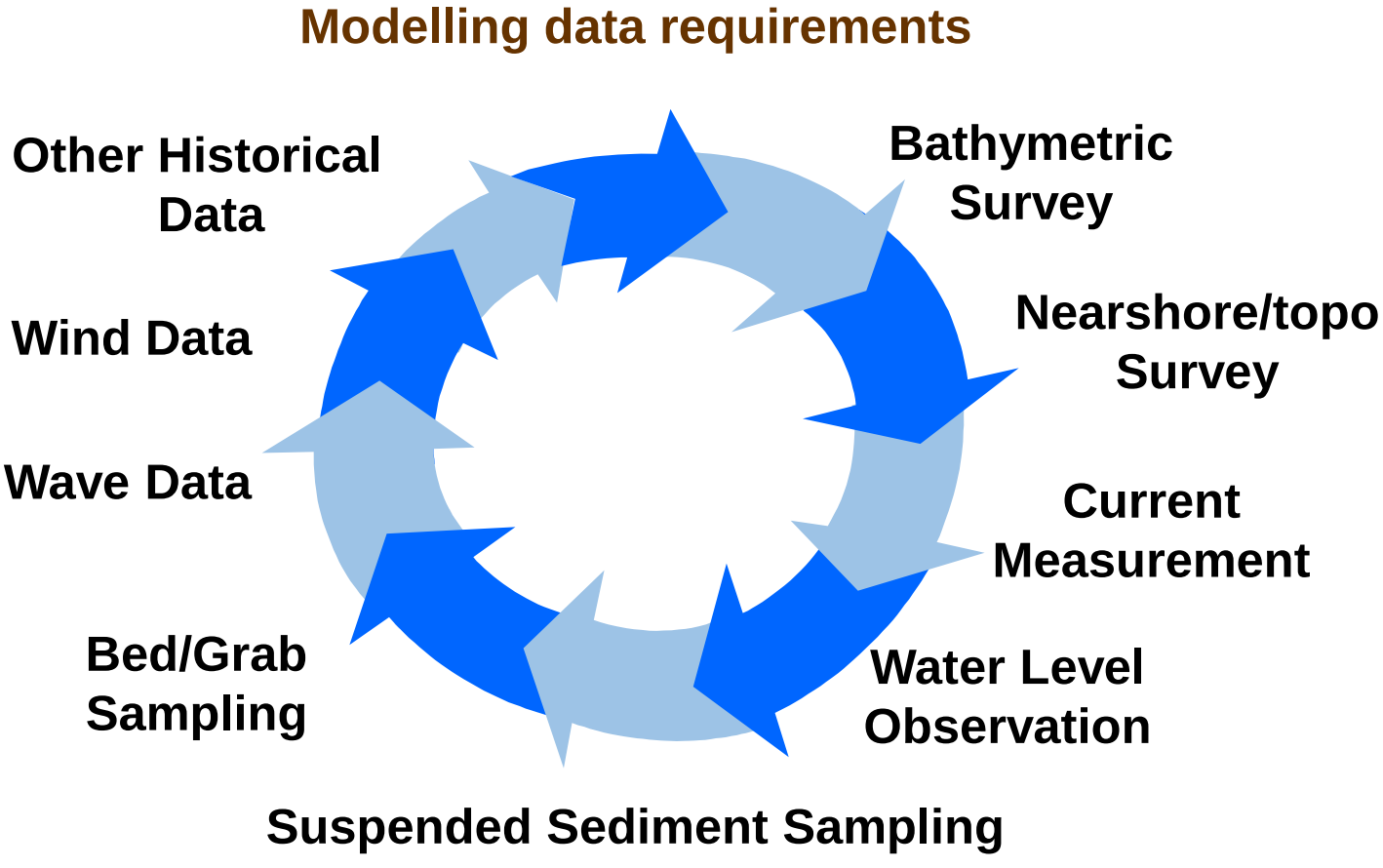
Pengerukan

Kajian: Kaeadah Pembinaan



Penambakan

Permodelan Numerik



Penghayatan Tapak

Penghayatan Tapak: Projek STP2, Penang


Southern end of STP1 abutting Gurney Drive


Oriental Seafood Restaurant


Drain near Oriental Seafood Restaurant


Exposed mudflat at Gurney Drive during low water

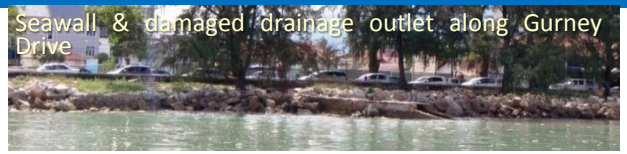

Rock revetment along Gurney Drive fronting Gurney Plaza & G Hotel


Seawall along Gurney Drive


Damaged & unmaintained drainage outlet near G Hotel


Pantai Gurney Drive, a short narrow beach with a damaged drainage outlet


Drainage outlet located next to Pantai Gurney Drive during low water


Seawall & damaged drainage outlet along Gurney Drive


Damaged drainage outlet near Bali Hai Restaurant


Damaged drainage outlet along Gurney Drive

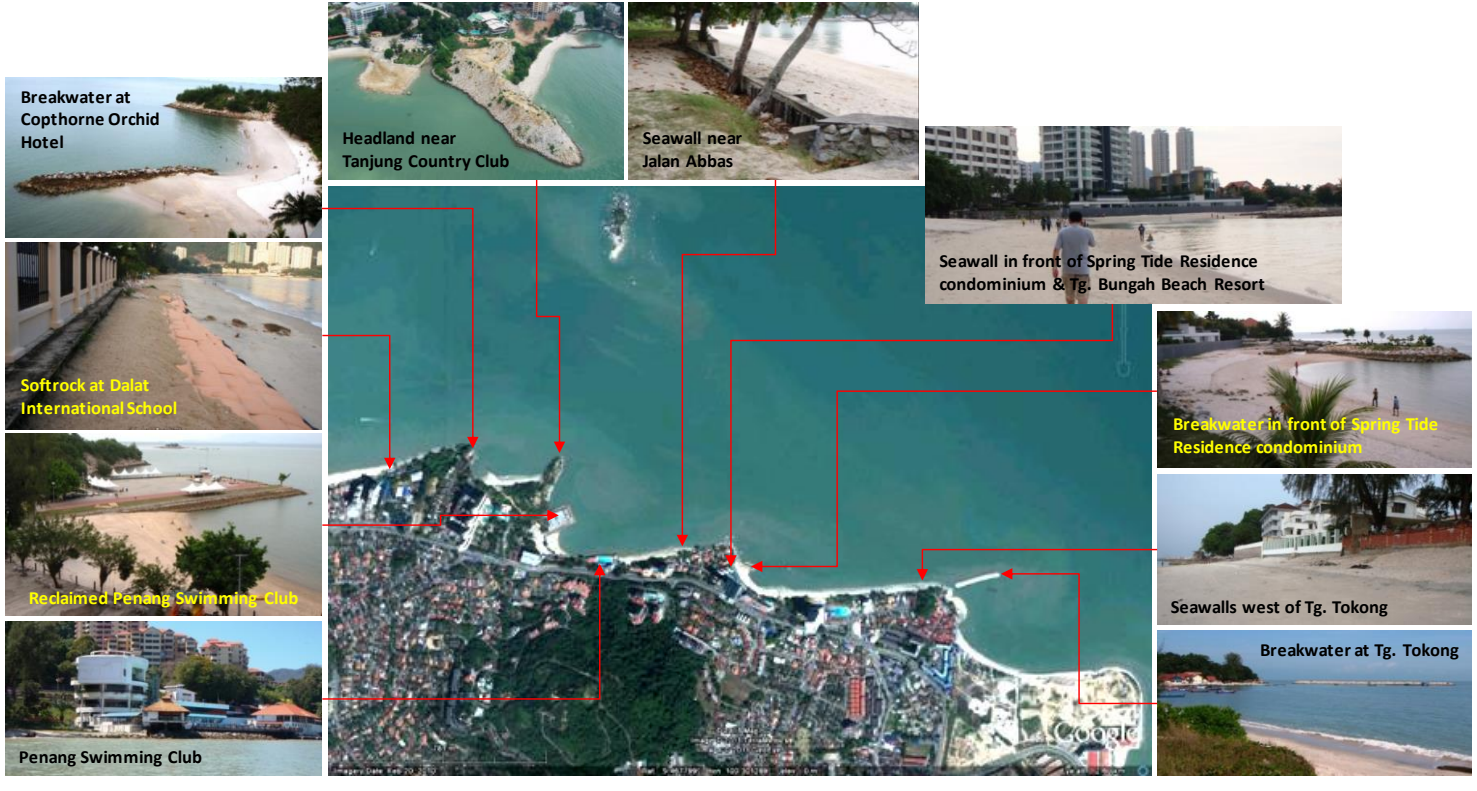

Rock revetment in front of Evergreen Laurel Hotel along Gurney Drive


Drainage outlet near Evergreen Laurel Hotel


Pantai Gurney Drive Hujung

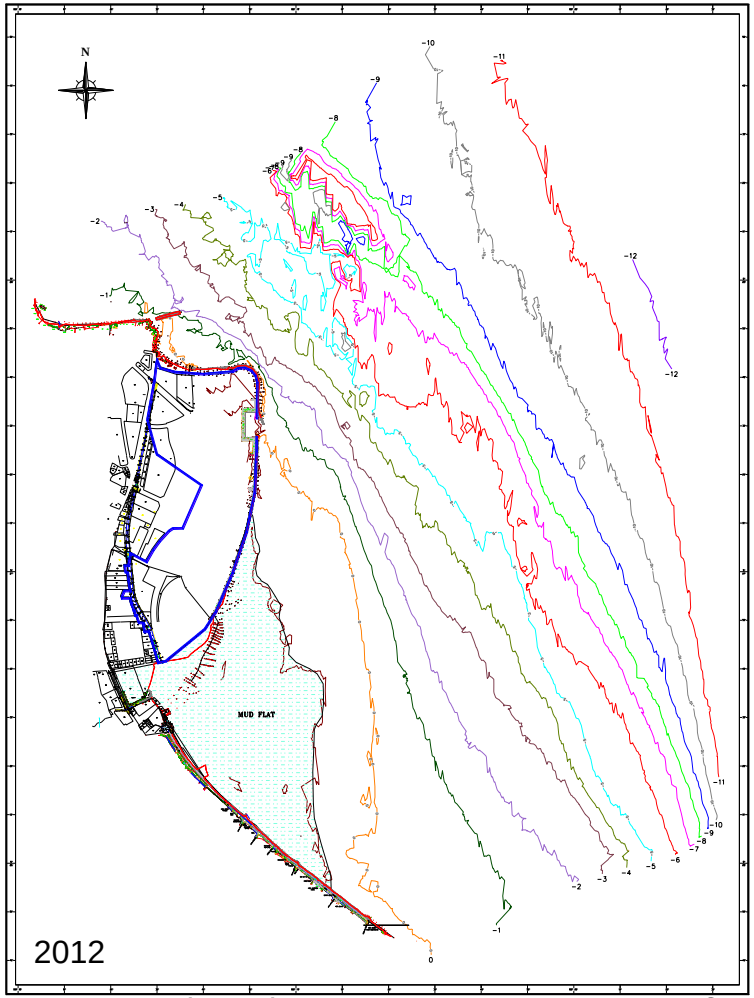

Damaged seawall fronting Northam Beach Cafe

Penghayatan Tapak: Projek STP2, Penang (2013)



Struktur-struktur yang dibina antara
Tg. Bungah & Tg. Tokong

Penghayatan Tapak: Projek STP2, Penang



Kerja ukur batimetri & topografi

Nearshore turbid water from Tg. Huma to Tg. Tokong (2007)

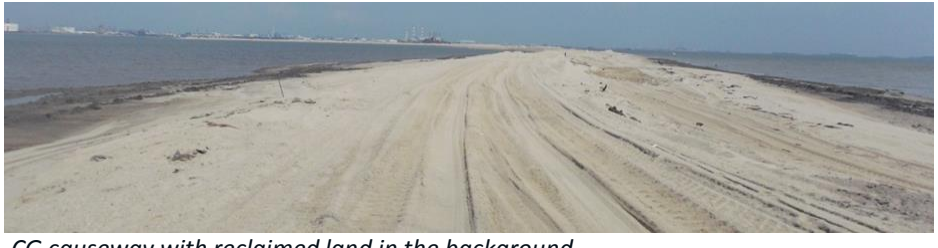
Turbid nature of nearshore waters around Tg. Tokong & Bagan Jermal (1996)

Nearshore turbid water around Tg. Tokong (2011)

Penghayatan Tapak: Forest City, Johor (2014)

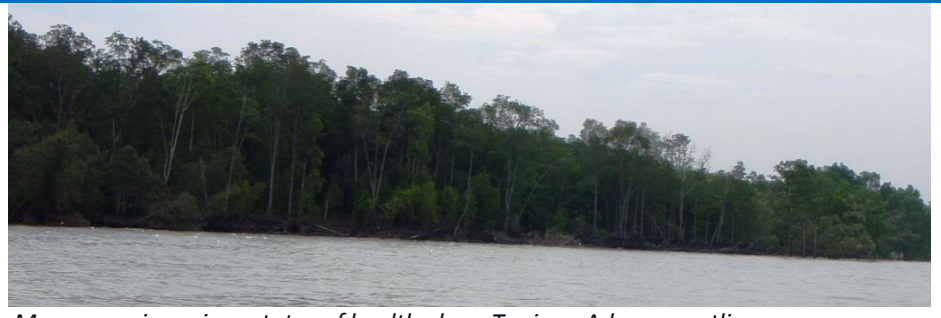
A line of mangroves along Tanjung Adang's coastline near PTP

PTP coastline facing Tanjung Adang



CG causeway with reclaimed land in the background

Reclaimed land located within Western Johor Straits



Mangroves in various states of health along Tanjung Adang coastline

Damaged vertical wall at Puteri Harbour

Sungai Pok Besar outlet (facing upstream)

Penghayatan Tapak: Forest City, Johor

Tanjung Piai's eastern coastline protected by sand-filled geotextile bags

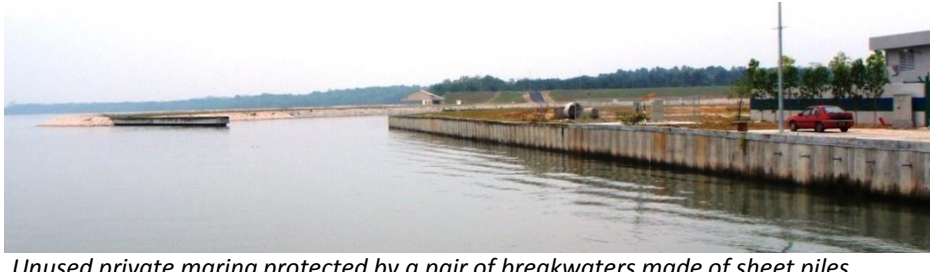
Tanjung Piai's eroding western coastline

Rock revetment protects coastline at Tanjung Piai Resort near Tanjung Piai radar tower

Tanjung Bin power plant's coastline facing Western Johor Straits

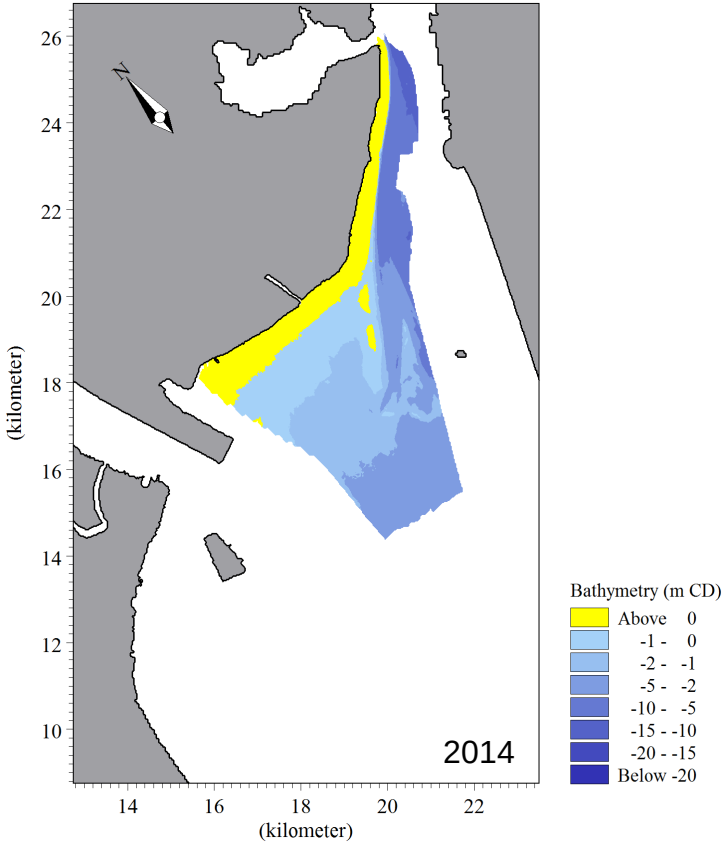
Cleared mangroves north of Sungai Pendas river mouth

Cage culture situated northeast of Second Link Bridge

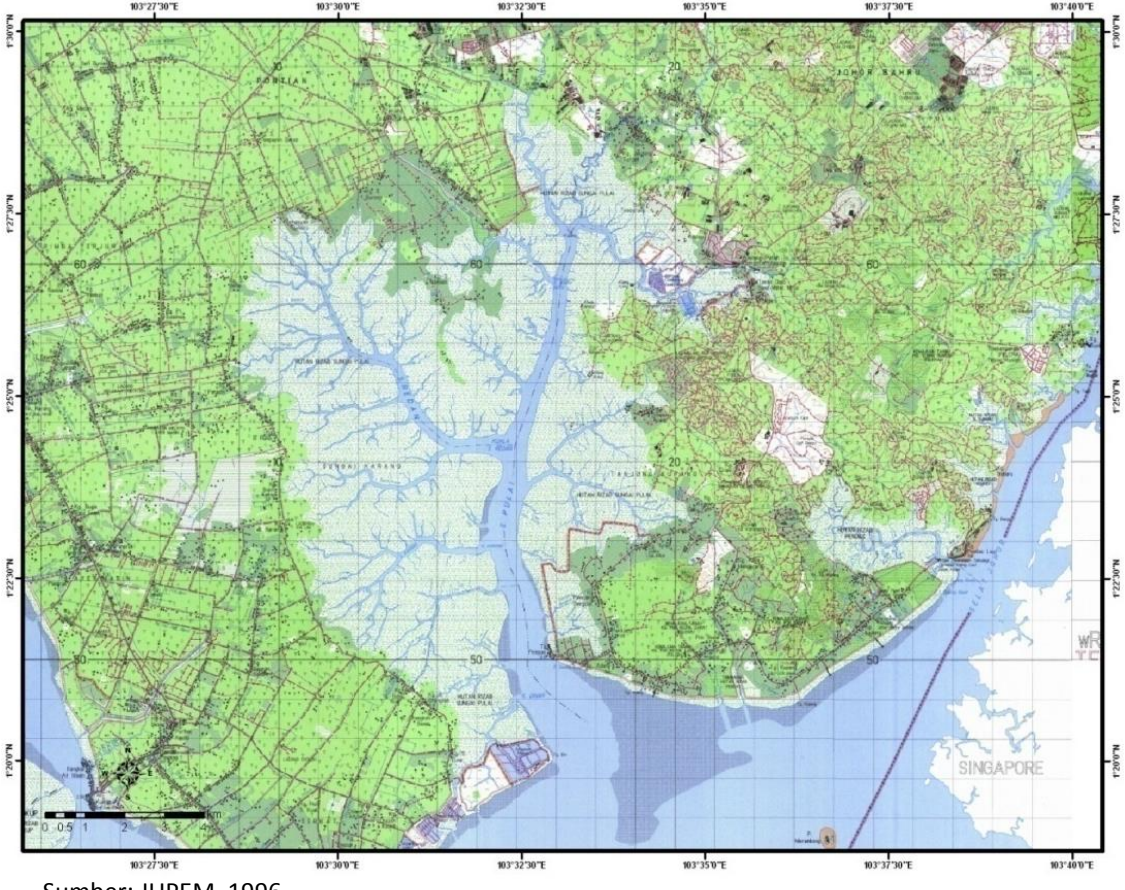


Unused private marina protected by a pair of breakwaters made of sheet piles adjacent to ferry terminal

Penghayatan Tapak: Forest City, Johor



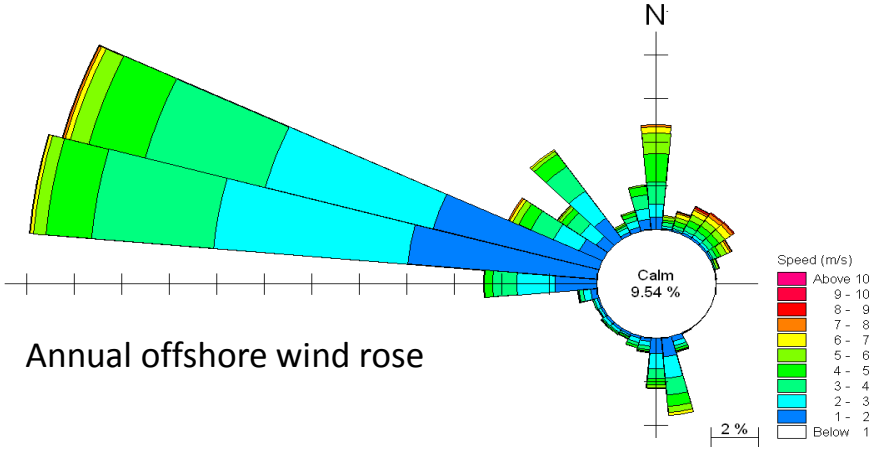
Kerja ukur batimetri & topografi



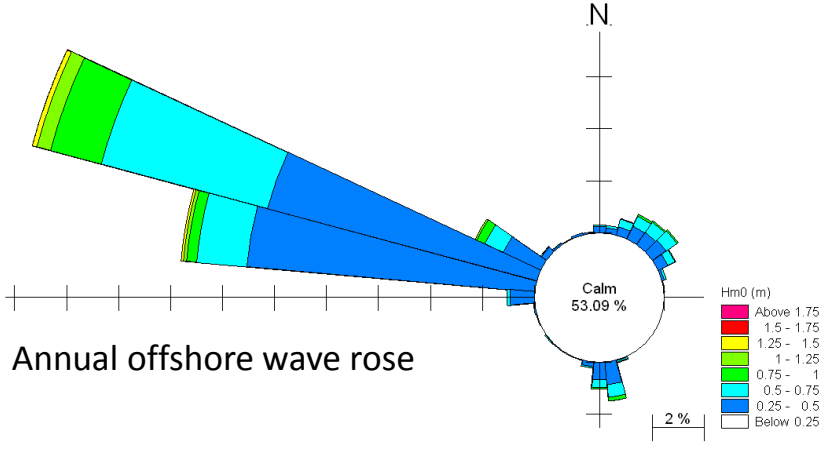
Sumber: JUPEM, 1996

Peta topografi bagi lembangan Sungai Pulai

Pengumpulan Data di Tapak: STP2, Penang



Annual offshore wind rose



Annual offshore wave rose

Locations of onshore & offshore wind data extraction points

Tidal datum levels for Kedah Pier & Tg. Tokong, Pulau Pinang

Tidal Levels	Elevation (m)	
	Kedah Pier	Tanjung Tokong
Highest Astronomical Tide (HAT)	3.09	3.07
Mean High Water Spring (MHWS)	2.69	2.60
Mean High Water Neap (MHWN)	1.96	1.90
Mean Sea Level (MSL)	1.71	1.63
Mean Low Water Neap (MLWN)	1.45	1.37
Mean Low Water Spring (MLWS)	0.72	0.67
Lowest Astronomical Tide (LAT)	0.00	0.00

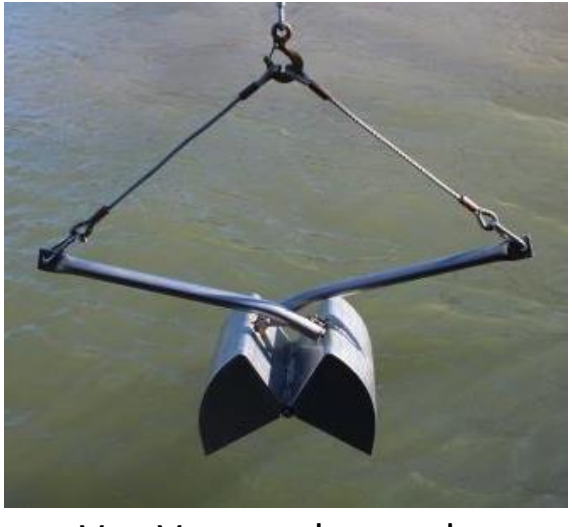
Pengumpulan Data di Tapak: Peralatan

Tide gauge

Acoustic doppler current profiler (ADCP)

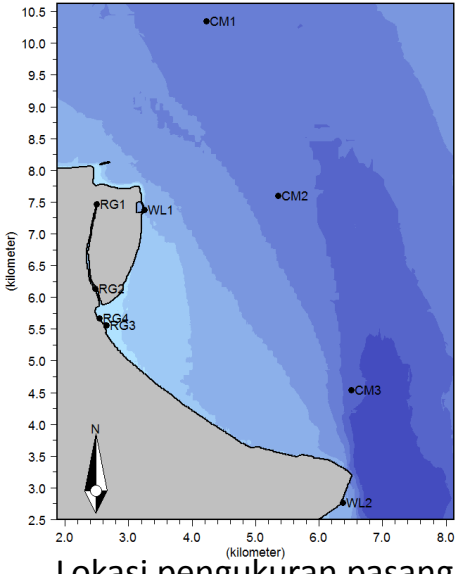
Current meter

Van Dorn sampler



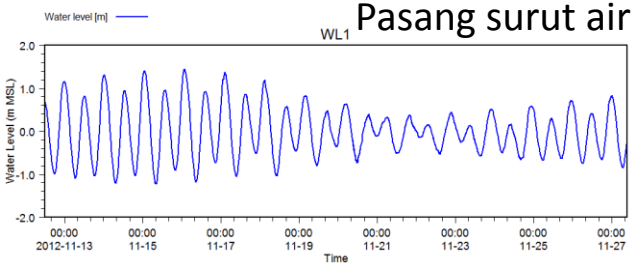
Van Veen grab sampler

Pengumpulan Data di Tapak: STP2, Penang

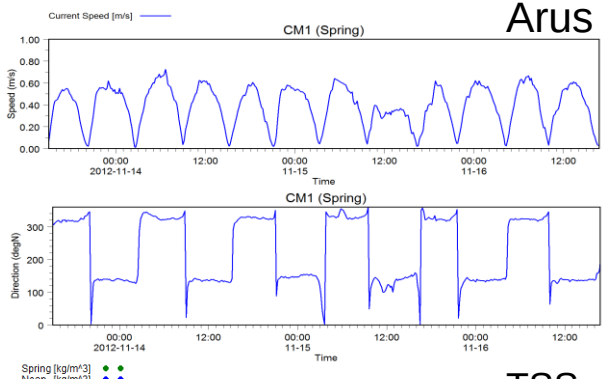


Lokasi pengukuran pasang surut air, arus & *river gauging*

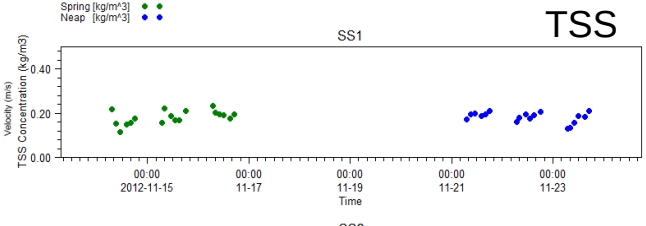
Pasang surut air



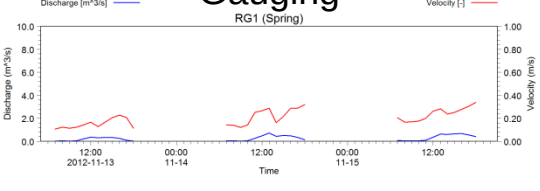
Arus

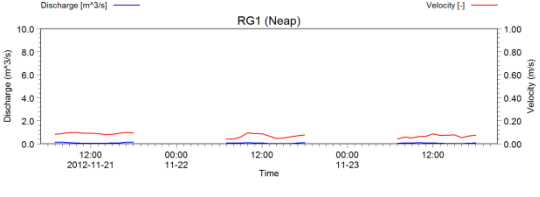


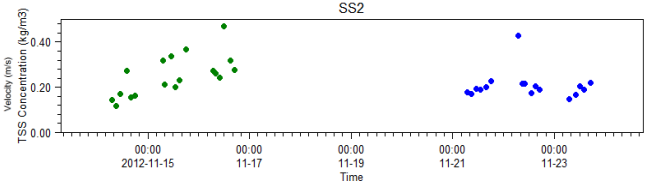
TSS

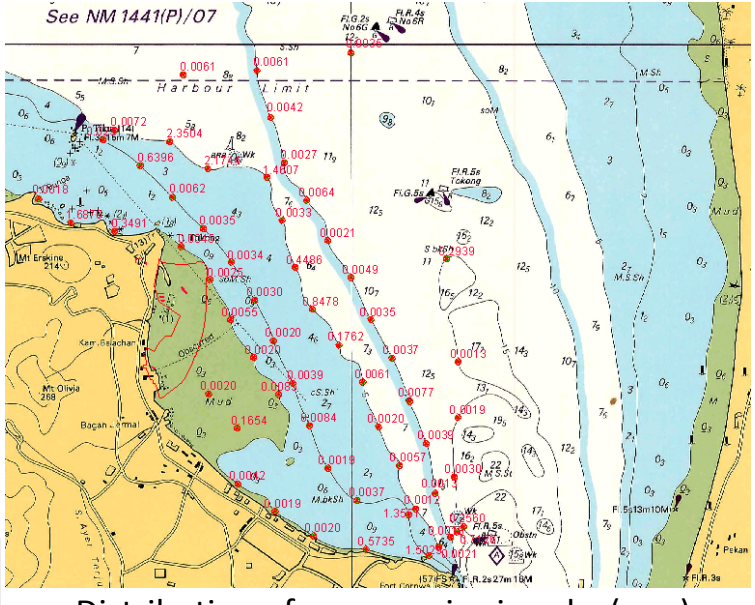


Gauging





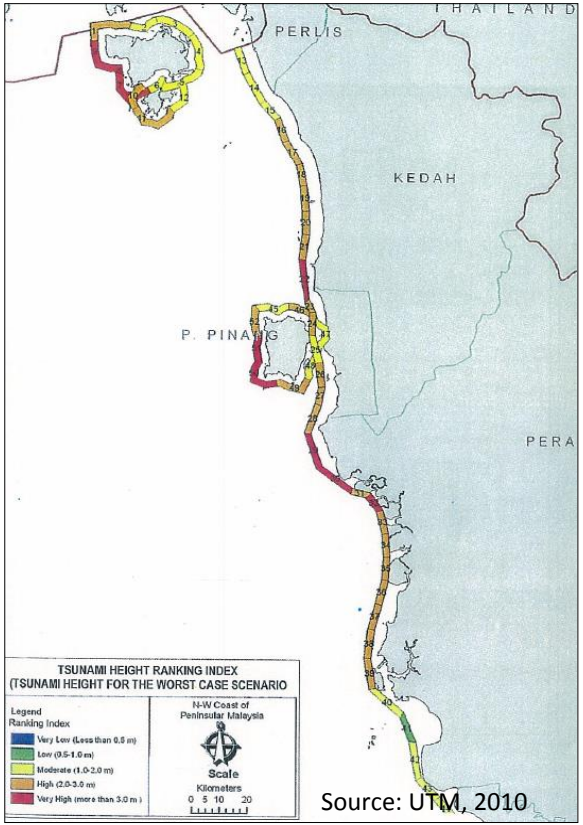




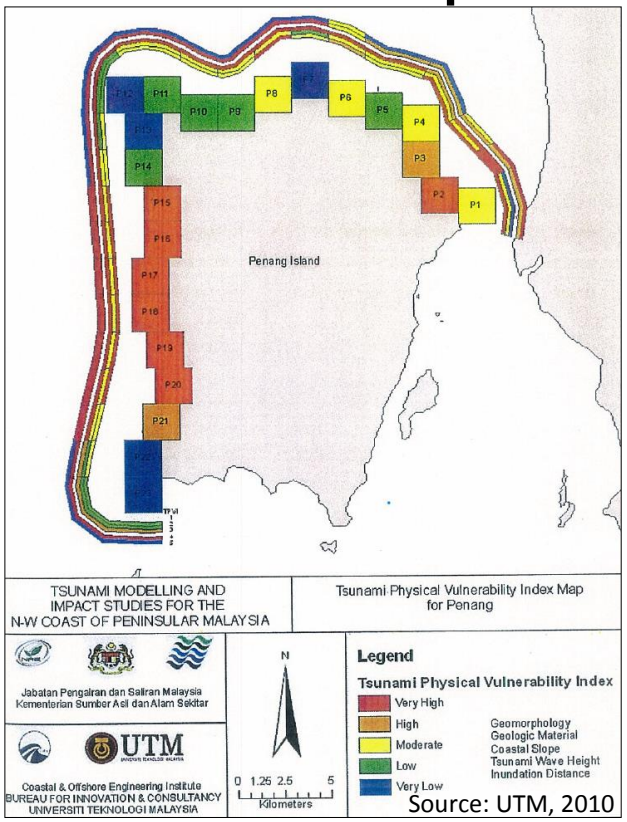
Distribution of mean grain size, d_{50} (mm) based on collected bed samples

Maklumat Lain: STP2, Penang

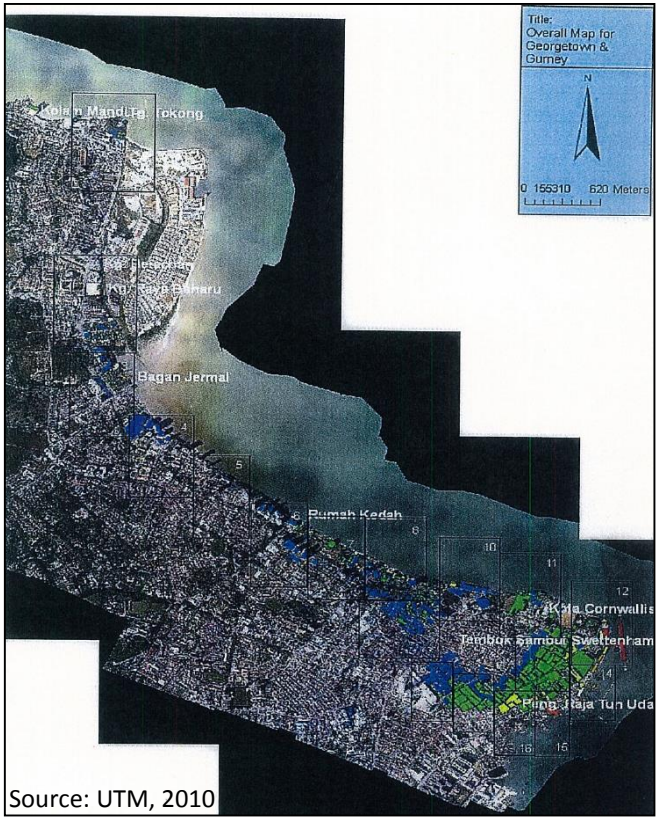
Tsunami Impact



Maximum tsunami height ranking index along the northwestern coast of Peninsular Malaysia

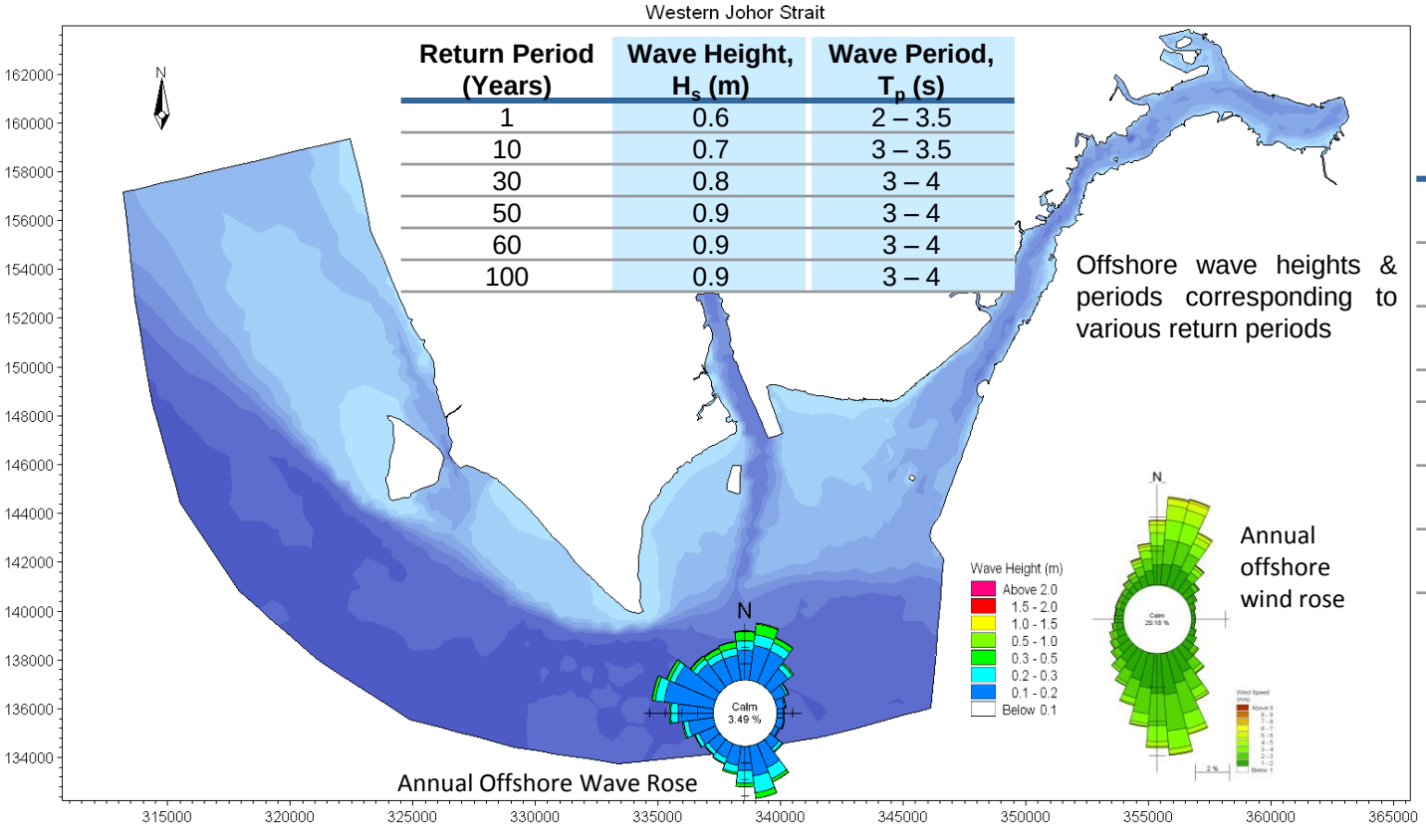


Tsunami Physical Vulnerability Index (TPVI) map for Penang



Extent of inundation along coastline extending from Tg. Tokong until Pengkalan Feri Raja Tun Uda based on tsunami worst-case scenario (inundated areas shaded in blue)

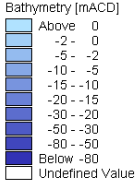
Pengumpulan Data di Tapak: Forest City, Johor



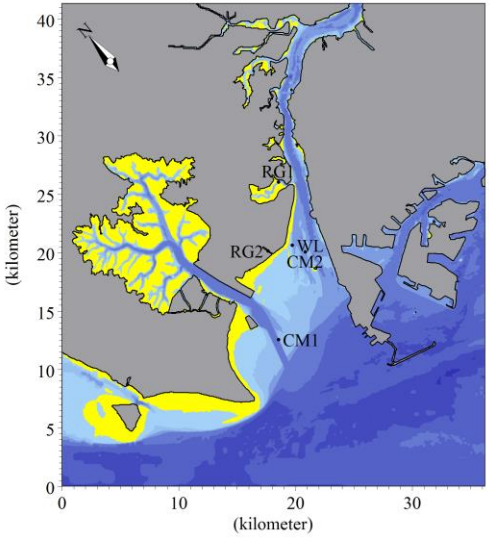
Return Period (Years)	Wave Height, H_s (m)	Wave Period, T_p (s)
1	0.6	2 – 3.5
10	0.7	3 – 3.5
30	0.8	3 – 4
50	0.9	3 – 4
60	0.9	3 – 4
100	0.9	3 – 4

Tidal datum levels for Tanjung Pelepas Port, Johor

Tidal Levels	m CD
Highest Astronomical Tide (HAT)	3.75
Mean High Water Spring (MHWS)	3.03
Mean High Water Neap (MHWN)	2.16
Mean Sea Level (MSL)	1.66
Mean Low Water Neap (MLWN)	1.17
Mean Low Water Spring (MLWS)	0.30
Lowest Astronomical Tide (LAT)	0.00

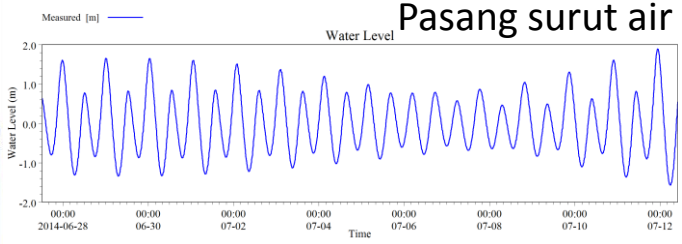


Pengumpulan Data di Tapak: Forest City, Johor

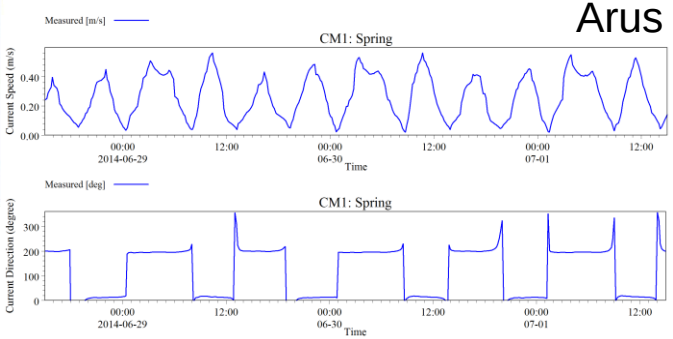


Lokasi pengukuran pasang surut air, arus & *river gauging*

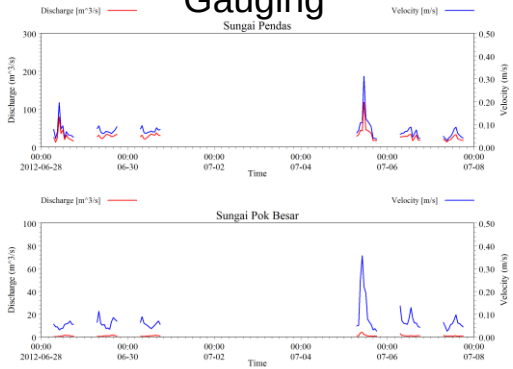
Pasang surut air



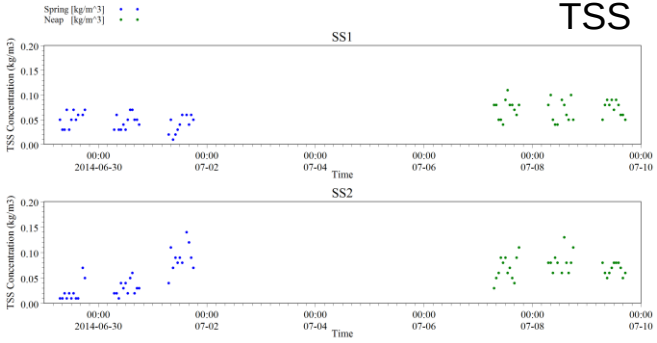
Arus

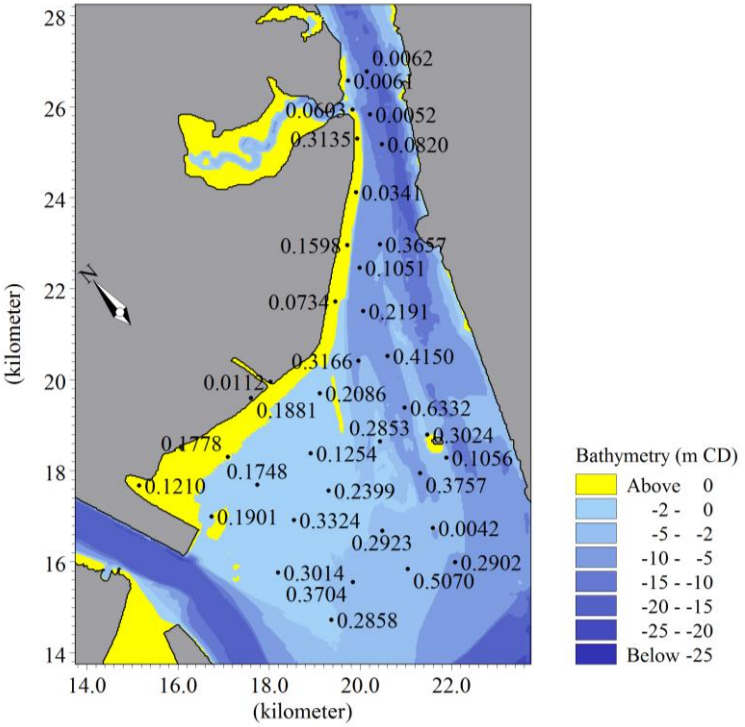


Gauging



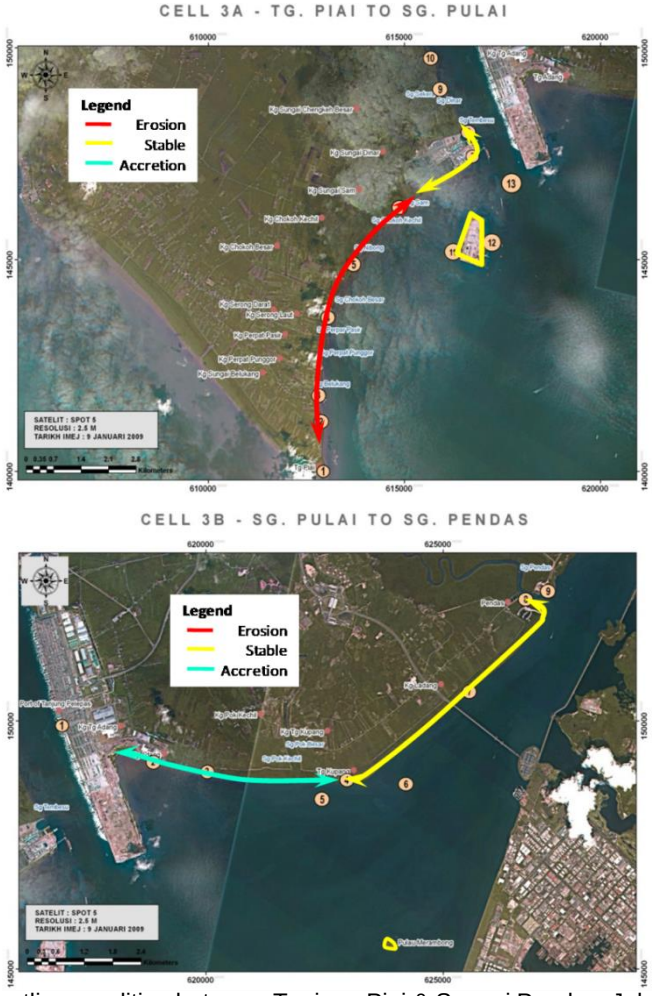
TSS





Distribution of mean grain size, d_{50} (mm) based on collected bed samples

Maklumat Lain: Forest City, Johor



Coastline condition between Tanjung Piai & Sungai Pendas, Johor (ISMP Iskandar Malaysia: UKM *et al.*, 2010)

Sea level change based on data from tide gauge stations between 1993 & 2008 in Malaysia

Coastline	Stations	NAHRIM (2010)		Din *et al.* (2012)	
		Analysis Period	SLR (mm/yr)	Analysis Period	SLR (mm/yr)
Peninsular Malaysia: West Coast	Pulau Langkawi	12/01/85-08/25/09	1.9		1.2
	Pulau Pinang	12/01/84-08/25/09	2.3		1.8
	Lumut	01/01/85-01/12/09	2.1		2.3
	Port Klang	01/01/84-12/02/07	1.3	1993-2008	2.3
	Tanjung Keling	12/01/84-08/18/09	1.3		1.4
	Kukup	01/01/96-12/31/08	3.0		3.0
	Johor Bahru	01/01/84-01/17/09	2.3		2.2
Peninsular Malaysia: East Coast	Tanjung Sedili	11/01/86-08/18/09	1.2		1.8
	Pulau Tioman	12/03/85-08/17/09	1.8		2.4
	Tanjung Gelang	01/01/84-08/17/09	2.6	1993-2008	2.6
	Chendering	11/01/84-12/11/08	2.2		3.2
	Geting	11/01/86-08/18/09	1.3		1.7
Sabah	Kota Kinabalu	07/01/87-01/01/05	4.4	1993-2008	2.4
	Sandakan	08/20/93-01/16/09	4.1	1993-2008	3.5
	Lahad Datu	01/01/96-01/17/09	3.6	1996-2008	0.2
	Tawau	07/01/87-01/18/09	3.5	1993-2008	2.8
	Kudat	01/01/96-01/01/09	3.0	1996-2008	0.6
	Labuan	01/01/96-03/13/08	0.7	1996-2008	0.9
Sarawak	Bintulu	04/30/92-11/29/09	0.2		0.1

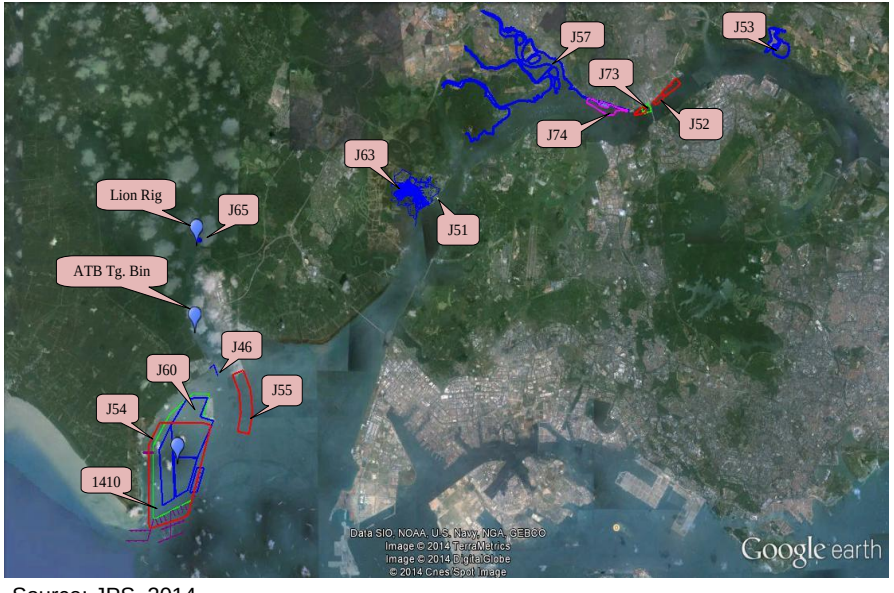
A mean sea level rise of about 1.25 mm/year was inferred at Tanjung Piai based on tidal data recorded from 1986 to 2006 (NAHRIM, 2010)

Maklumat Lain: Forest City, Johor

Committed Developments

Label	Project Title
J46	Proposed Tanjung Bin Power Plant Expansion
J51	Permohonan Lesen Pendudukan Sementara Bagi Tujuan Tapak Jeti & Lesen Air Di Perairan Selat Johor, Mukim Pulai, Daerah Johor Bahru Oleh Tetuan UEM Land Bhd
J52	Tanjung Puteri
J53	Permohonan Tanah Kerajaan bagi Tujuan Pembinaan Jeti Persendirian di atas Plot 1 Persisiran Sg. Lunchoo, Plot 1 Bersebelahan PTD 204706, Plot 3 Bersebelahan PTD 119776 (Plot B) di Teluk Senibong, Mukim Plentong, Daerah Johor Bahru oleh Front Concept Sdn. Bhd.
J54	Proposed Reclamation Works, Construction & Operation of Terminal Facilities & the Petroleum Storage, Construction of Marines Facilities Including Jetties in Tanjung Piai, Johor oleh Spektrum Kukuh
J55	Phase III Dredging & Reclamation Works at Pelabuhan Tanjung Pelepas
J57	Pembangunan Perdagangan Perumahan di atas Lot PTD 153805, PTD 71924, PTD 71925, PTD 136980, PTD 72272 – 72277, Mukim Pulai
J60	Tanjung Piai Tentatif

Label	Project Title
J63	Hydraulic Consultancy Services for the Proposed Development of Residential South, Puteri Harbour, Nusajaya
J65	EIA Study for the Proposed Jetty Construction of Mukim Tanjung Kupang
J73	Coastal Hydraulic Study for Proposed Reclamation 15.322 ha for Mixed Development, Mukim Dewan Bandar Johor Bahru, Johor for Johor Lagoon Park (JLP) Project
J74	Kajian Hidraulik bagi Tujuan Susunatur Perdagangan Bercampur di atas Lot PTB 22821-22828, Jalan Persiaran Abu Bakar Sultan, Johor Bahru untuk Tetuan Lido Waterfront Boulevard
Lion Rig	Hydraulic Study for Lion Rig Builder Jetty, Johor

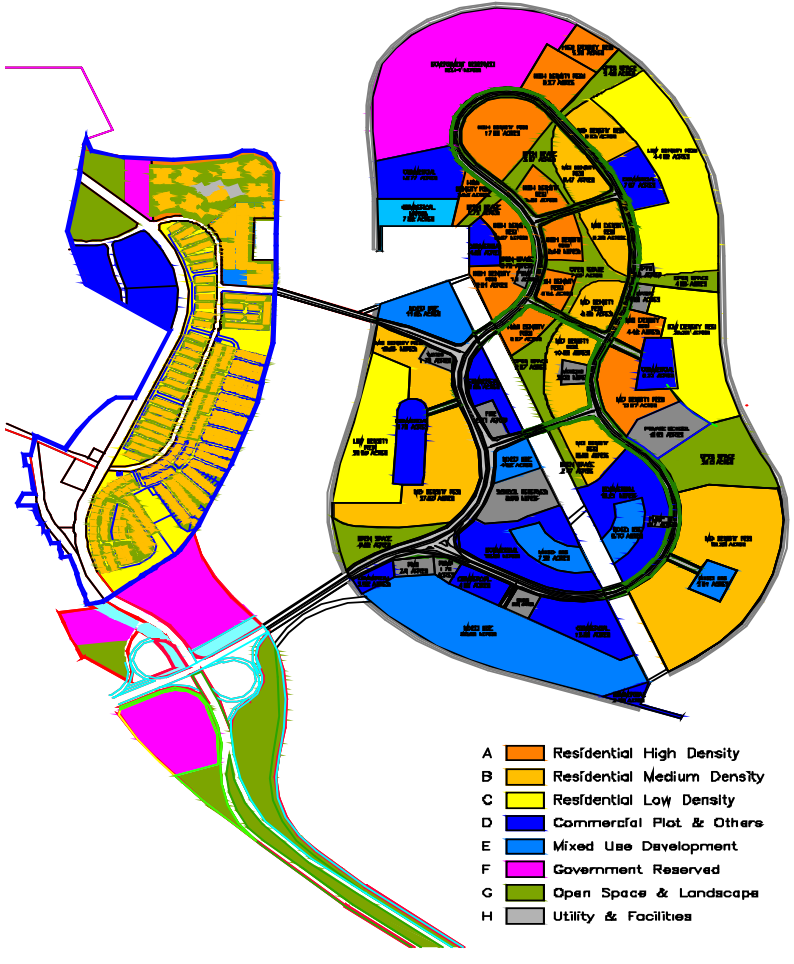


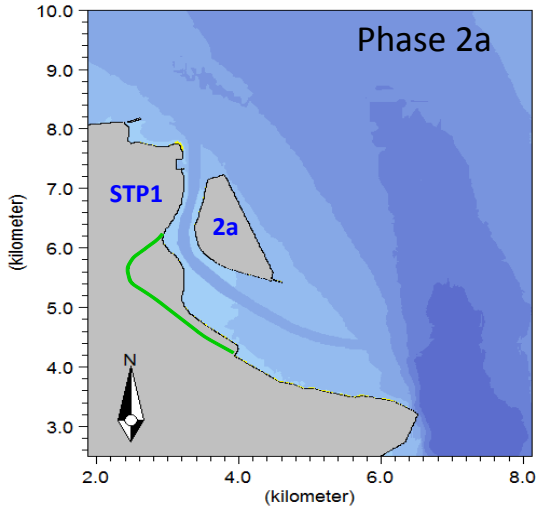
Source: JPS, 2014

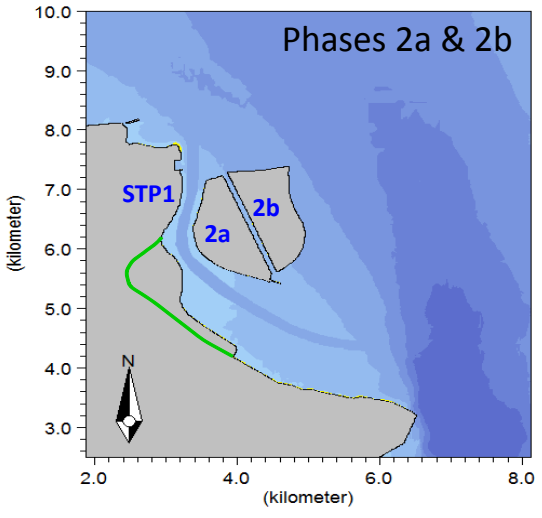
Locations of committed development along Johor Straits

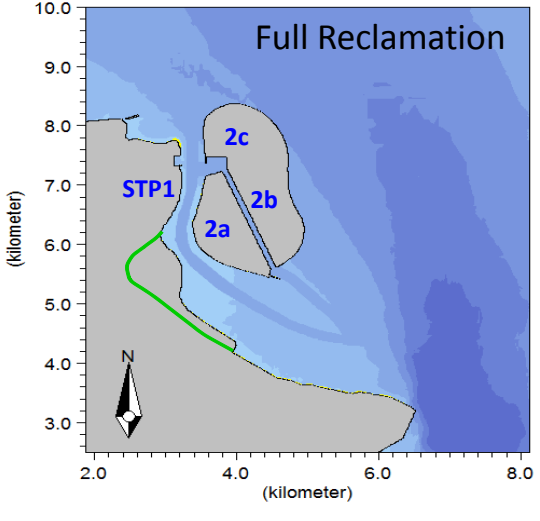
Cadangan Pembangunan

Cadangan Pembangunan: STP2, Penang









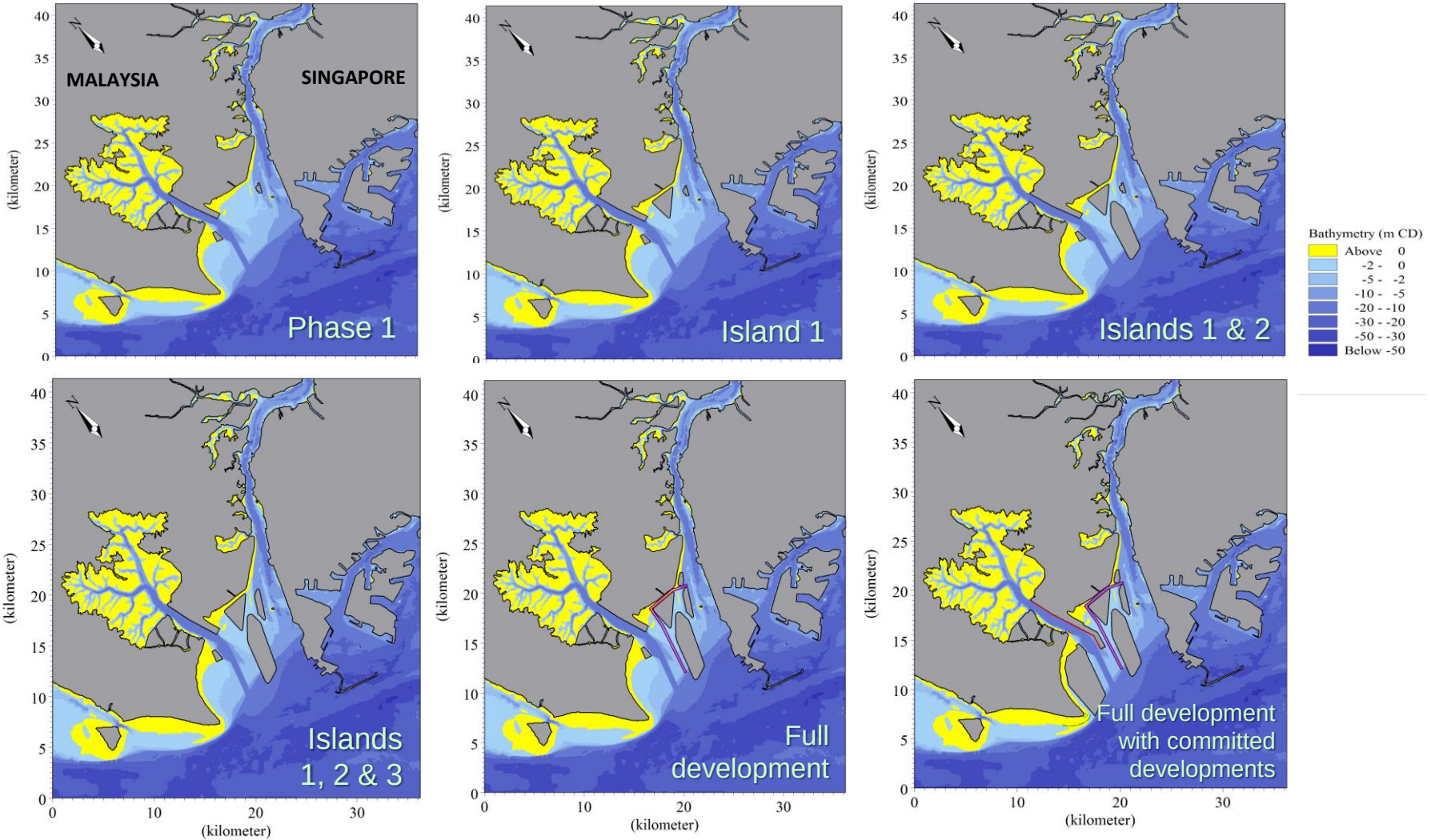
Existing Coastline

Bathymetry (m MSL)

Above	0
-2 -	0
-5 -	-2
-10 -	-5
-15 -	-10
-20 -	-15
-30 -	-20
-40 -	-30
-50 -	-40
Below	-50

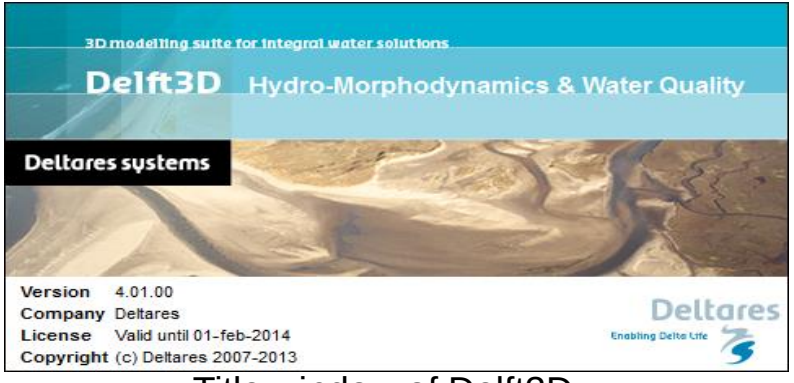
Project phasing

Cadangan Pembangunan: Forest City, Johor

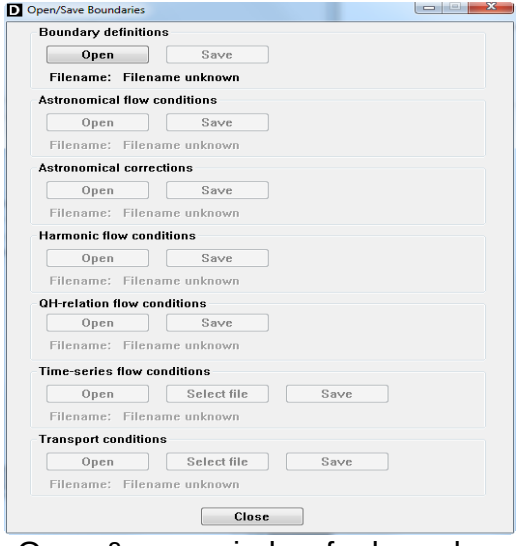


Permodelan Numerik

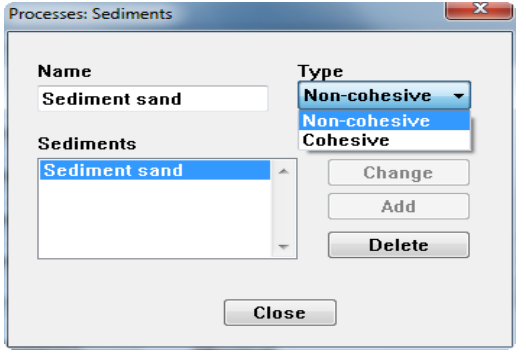
Delft3D



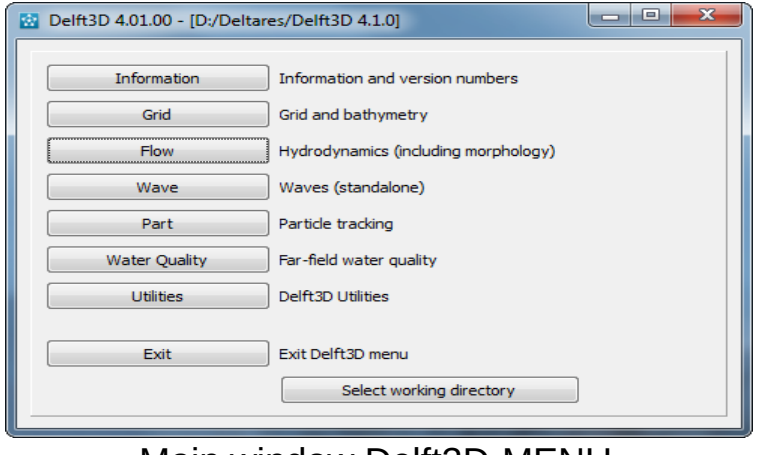
Title window of Delft3D



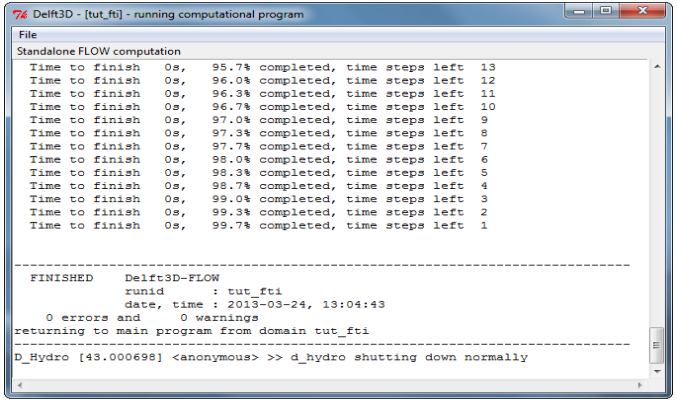
Open & save window for boundary locations & conditions



Sediment definition window

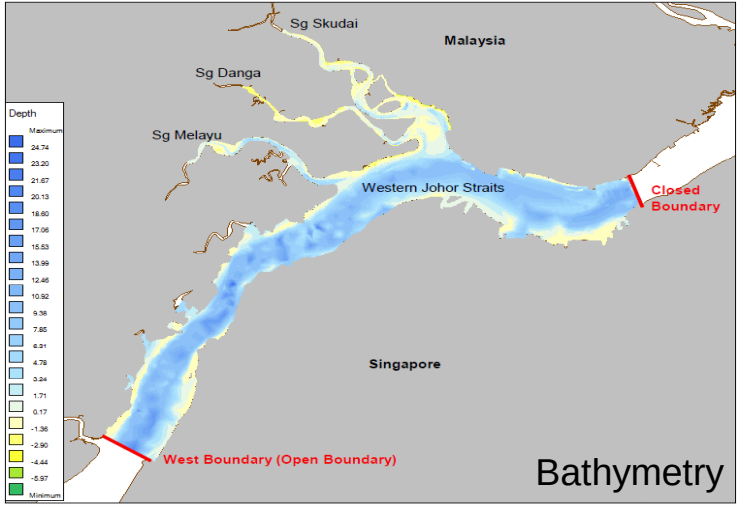


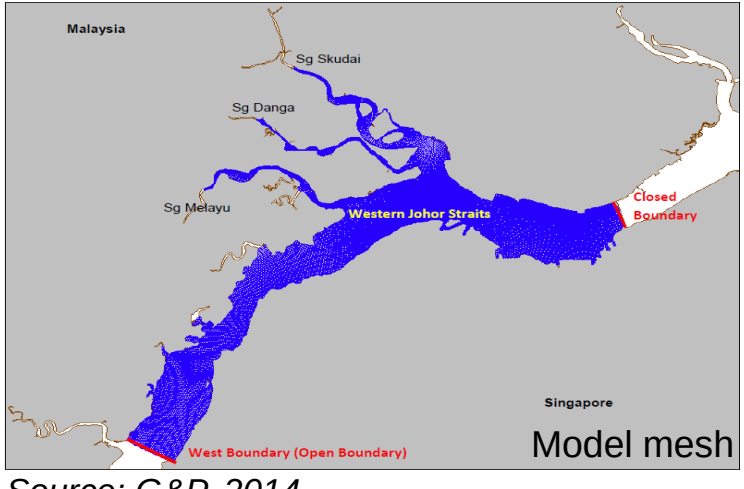
Main window Delft3D-MENU

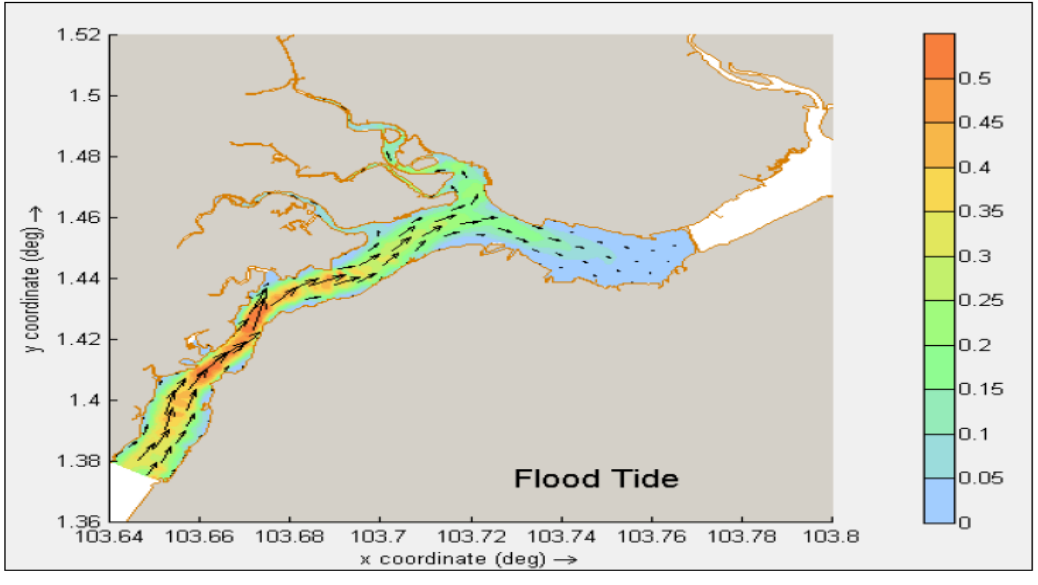


Part of the report to the output window

Delft3D





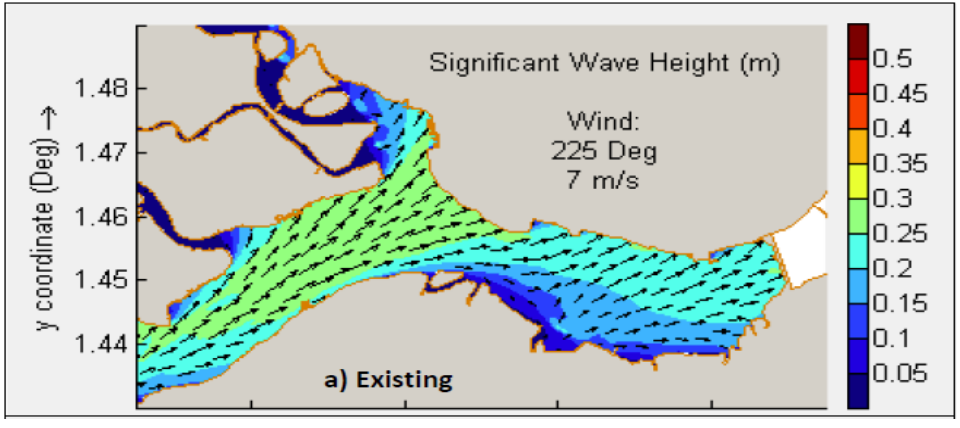


Current flow

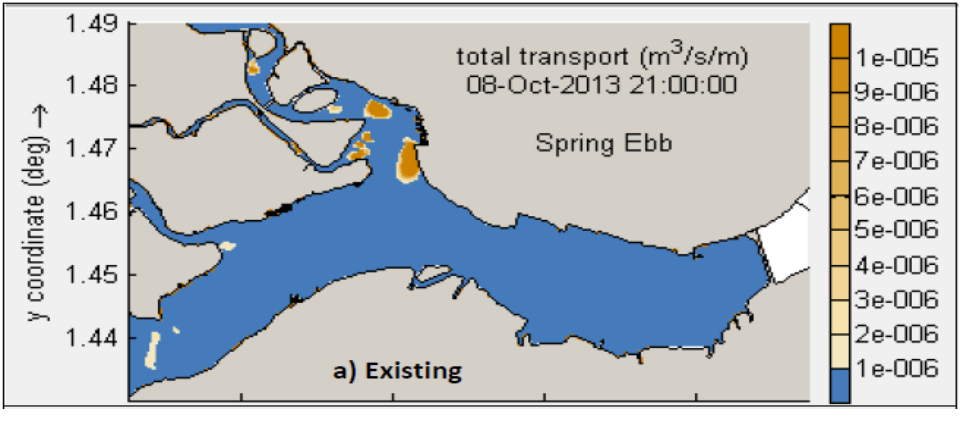
Pantai Lido, Johor

Source: G&P, 2014

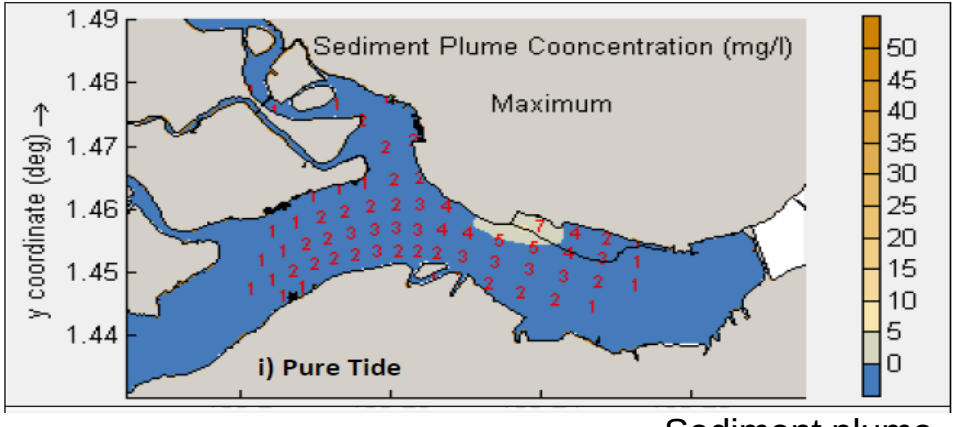
Delft3D



Waves



Sediment transport

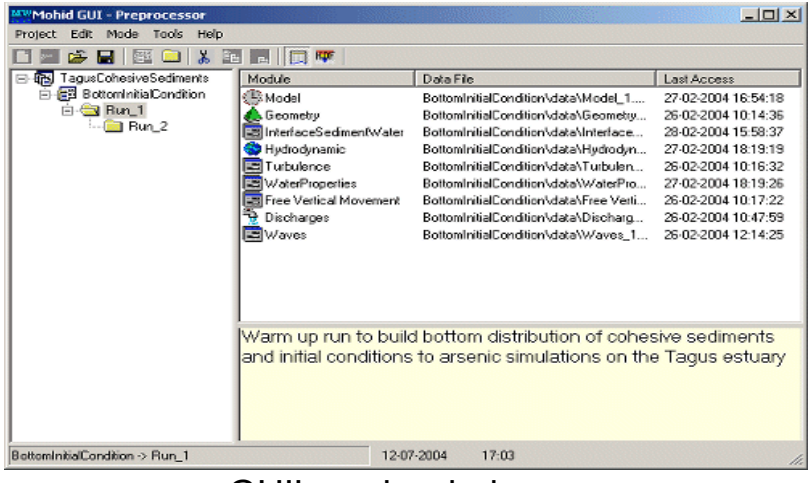


Sediment plume

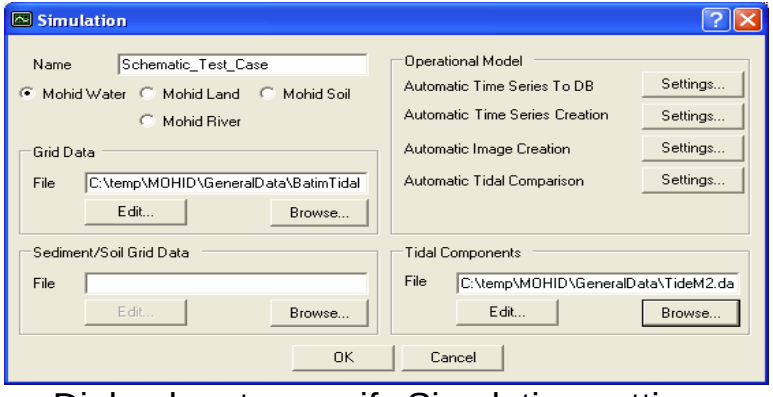
Pantai Lido, Johor

Source: G&P, 2014

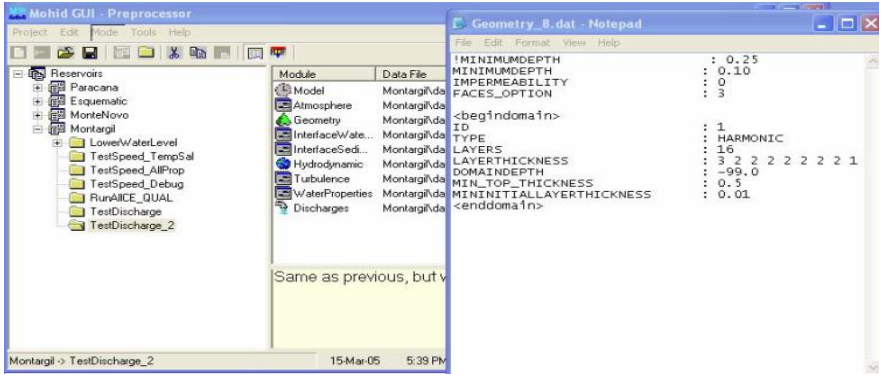
MOHID Water



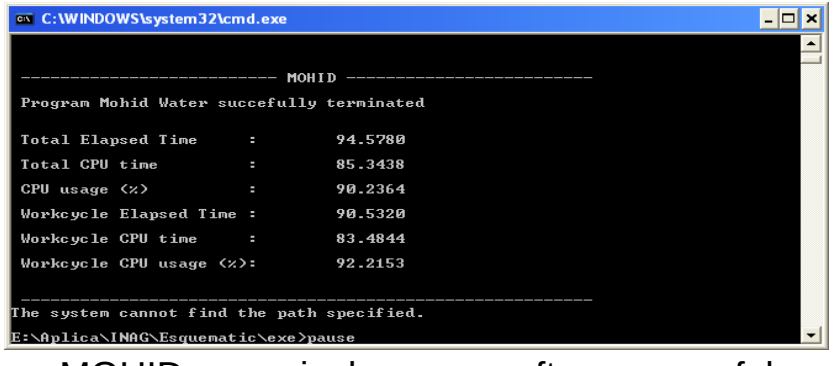
GUI's main window



Dialog box to specify Simulation settings

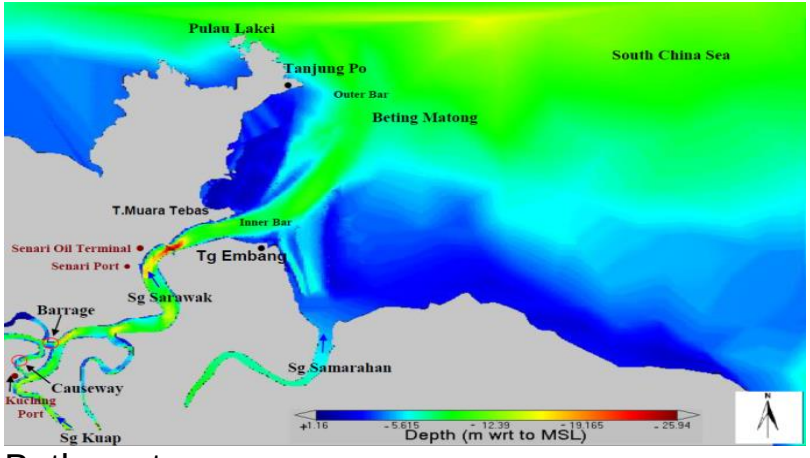


User desktop after opening a module data file



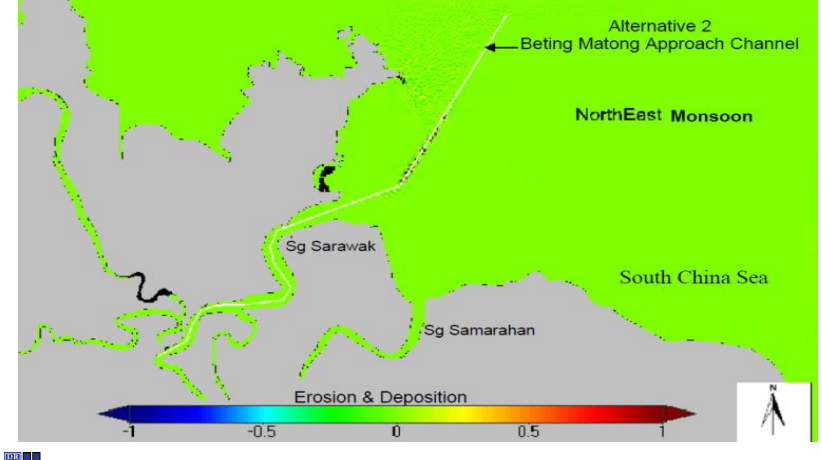
MOHID numerical program after successful execution

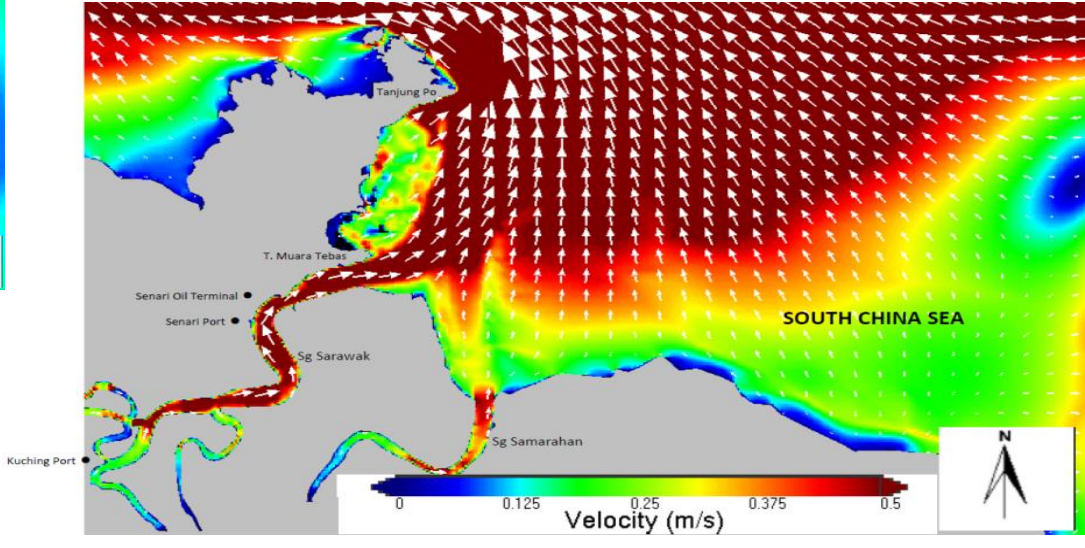
MOHID Water



Bathymetry

Dz Diagram showing erosion & deposition



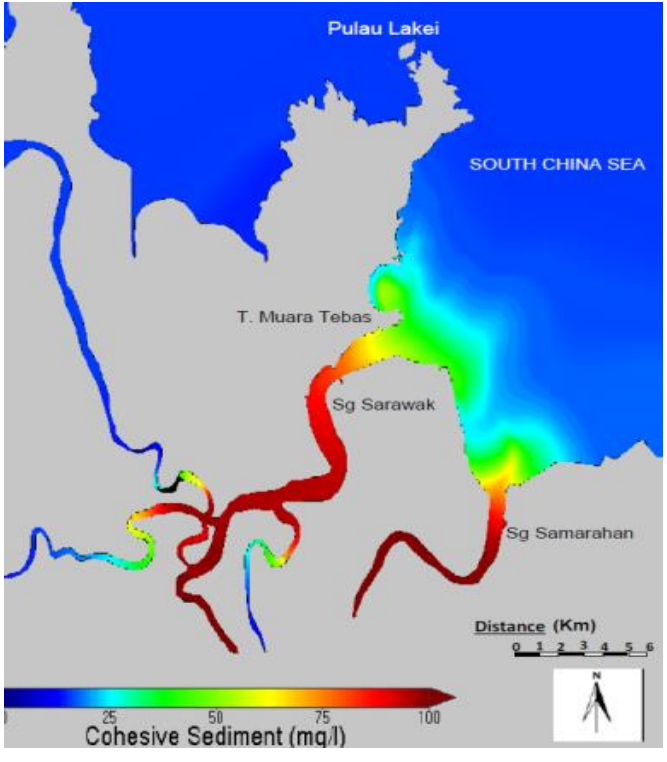


Source: Perunding MSA, 2010

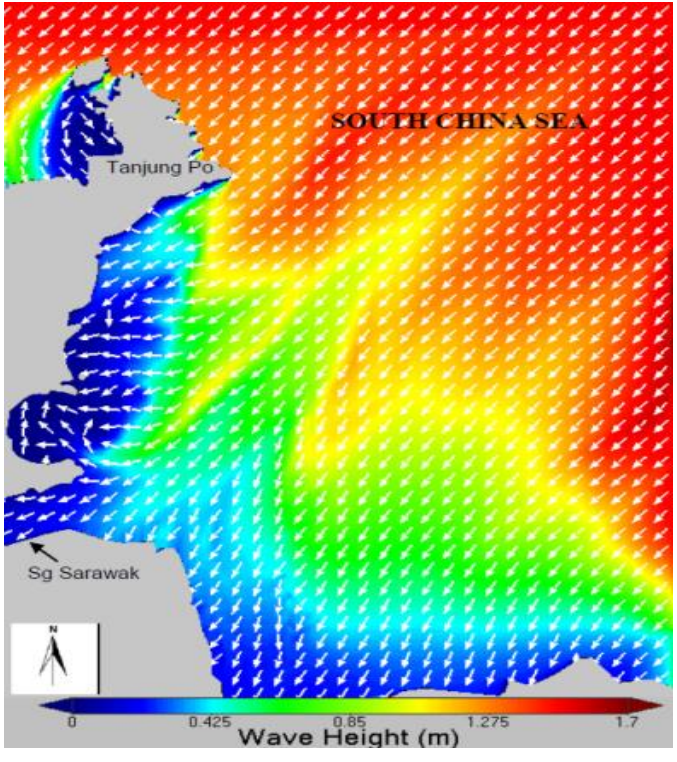
Current flow

Sungai Sarawak, Sarawak

MOHID Water



Suspended sediment dispersion

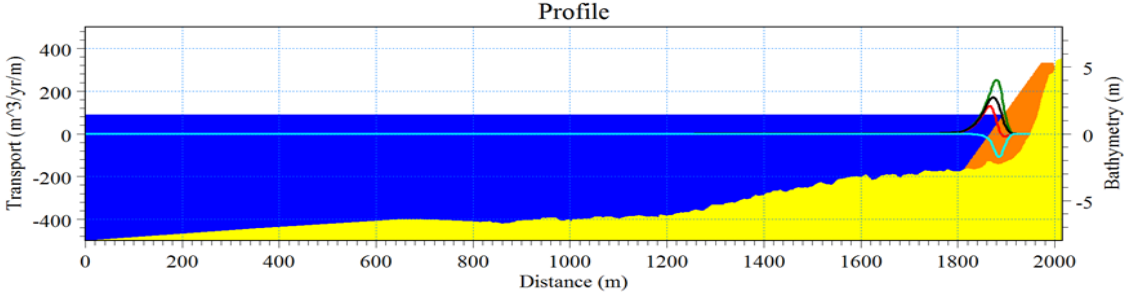


Waves

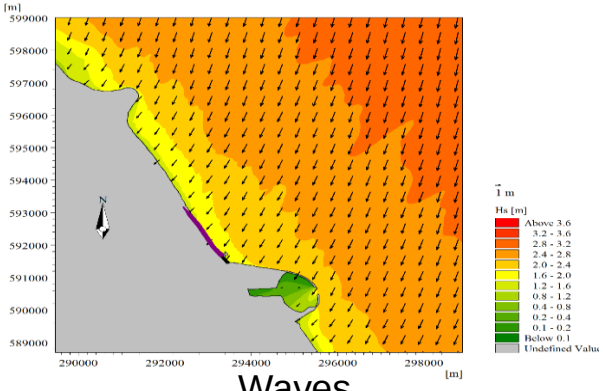
Source: Perunding MSA, 2010

Sungai Sarawak, Sarawak

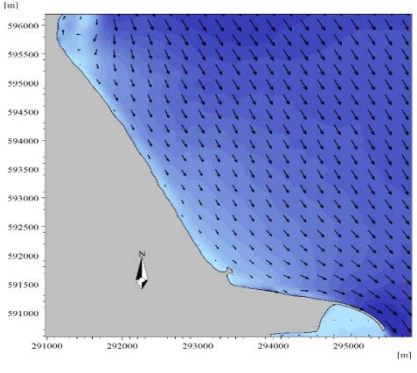
MIKE & Litpack



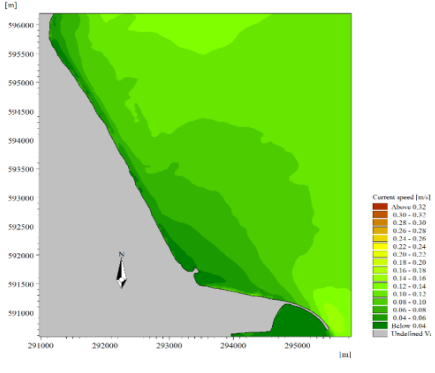
Littoral transport



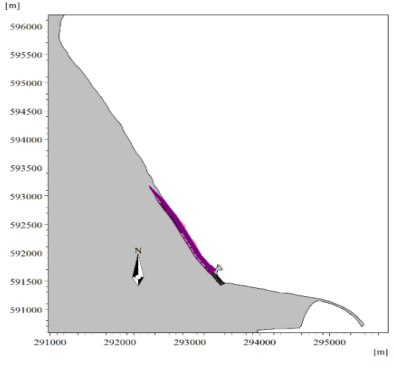
Waves



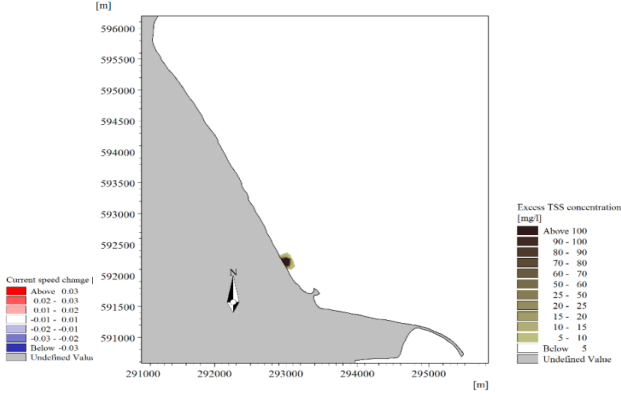
Hydrodynamic



Mean current speed



Mean current speed change

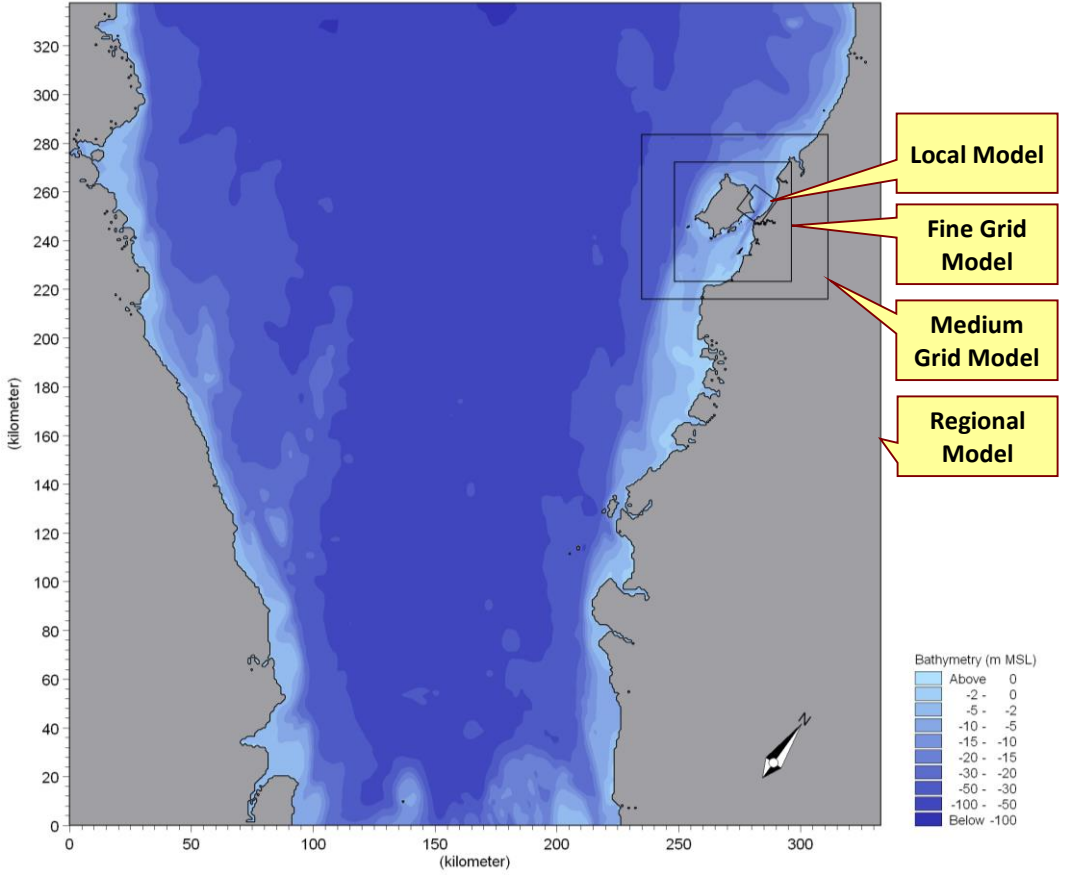


Suspended sediment dispersion

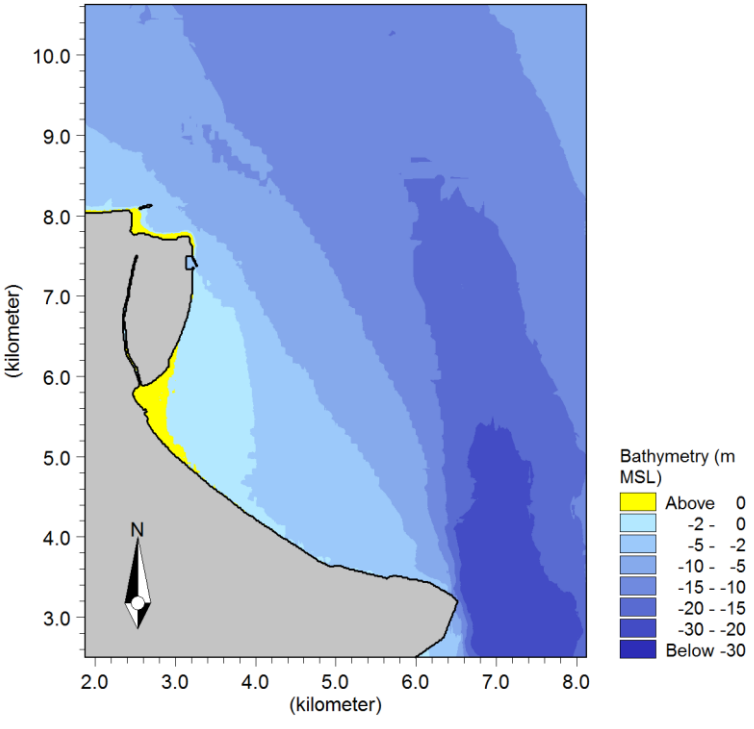
Seberang Takir, Terengganu

Permodelan Numerik: Hidrodinamik

Model: STP2, Penang

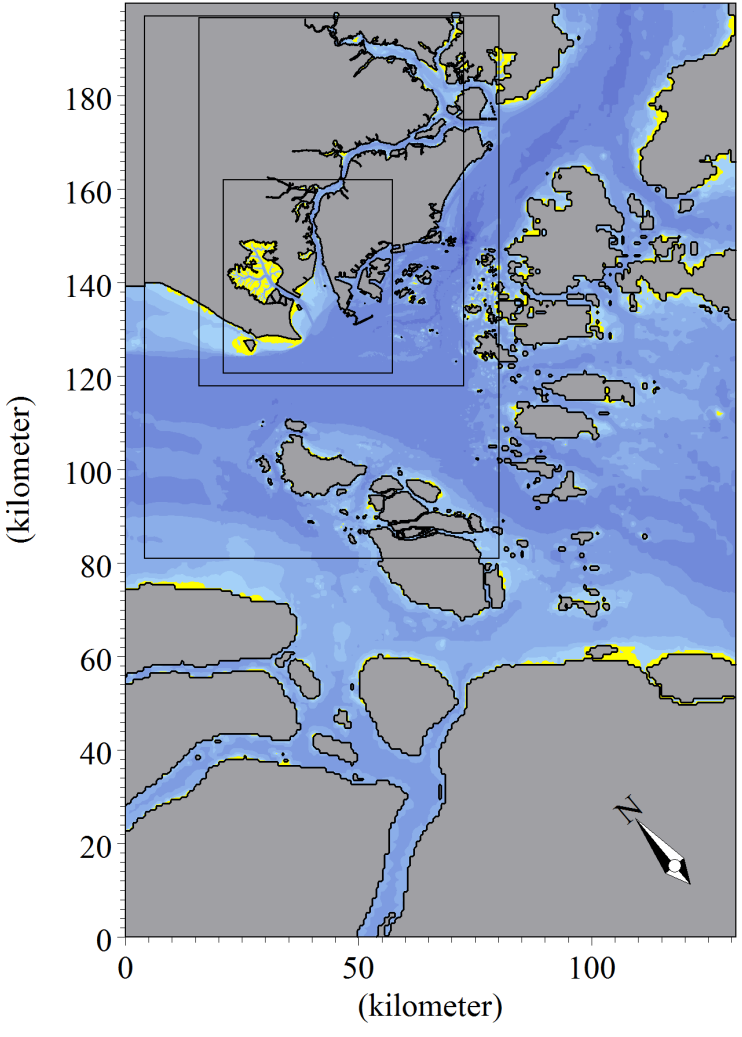


Model bathymetries



Local model: Existing Condition

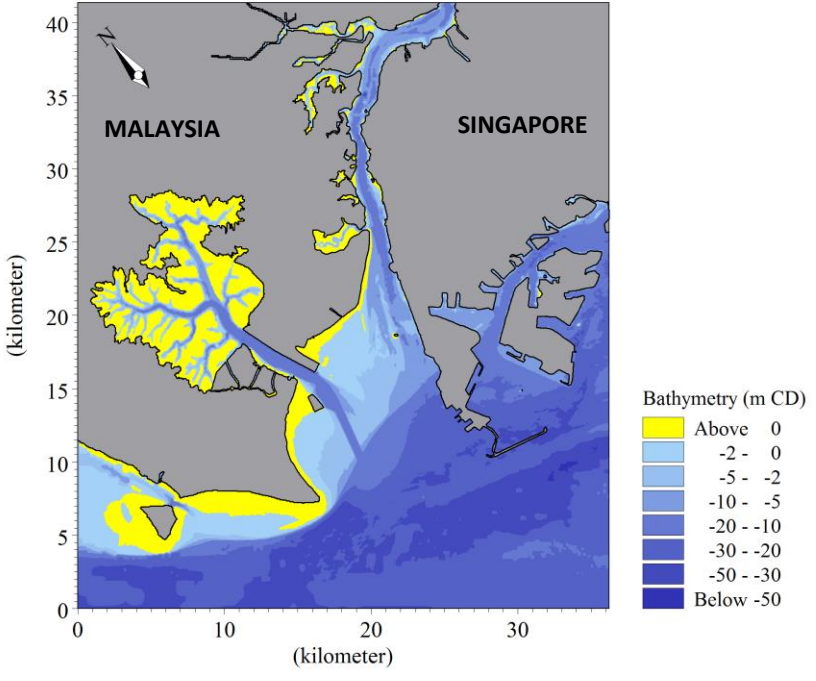
Model: STP2, Forest City, Johor



Nested model bathymetries

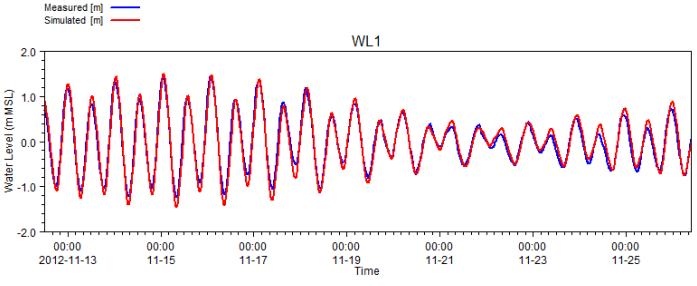
Bathymetry (m CD)

Above	0
-2 -	0
-5 -	-2
-10 -	-5
-20 -	-10
-50 -	-20
-80 -	-50
-100 -	-80
-120 -	-100
-150 -	-120
Below	-150

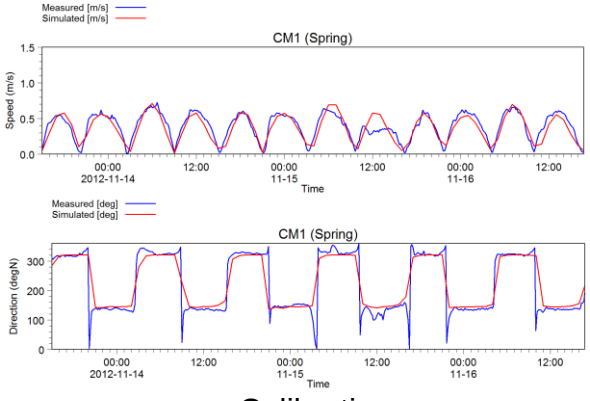


Model bathymetry: Local model (pre-reclamation condition)

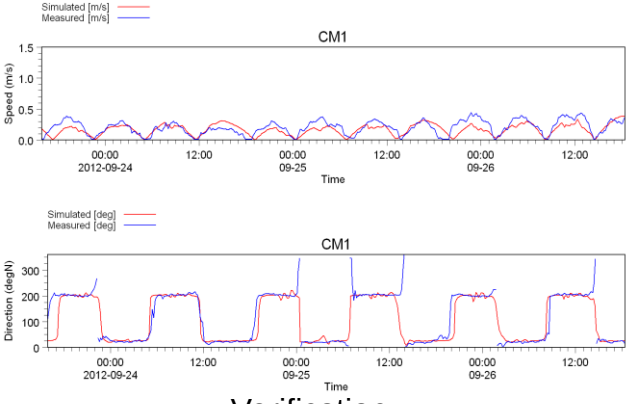
Kalibrasi & verifikasi: STP2, Penang



Water levels



Calibration



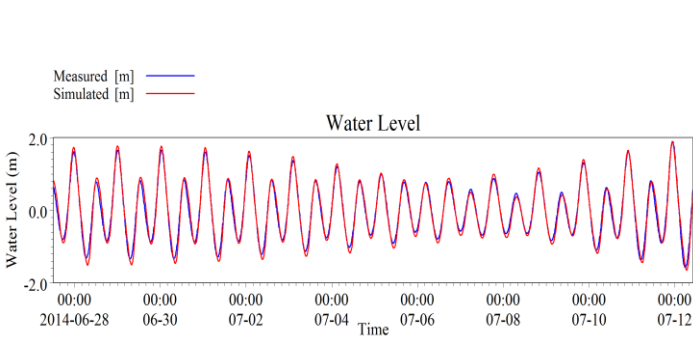
Verification

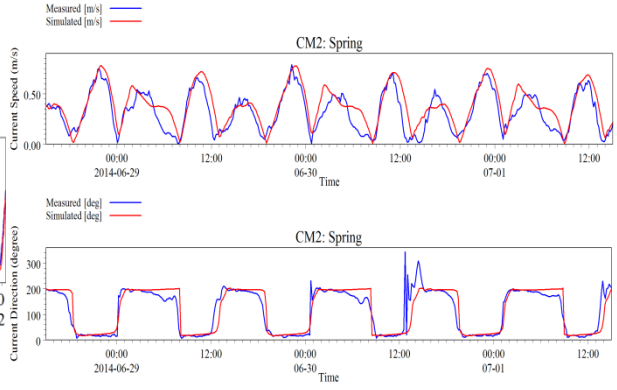
Currents

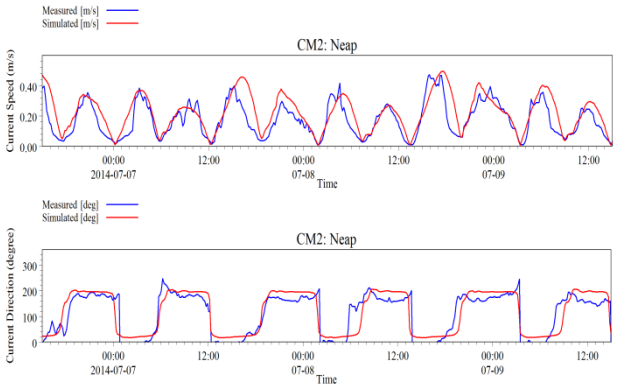
Parameters	Water Level	Current Speed	Current Direction
Tolerence	≤10%	≤20%	≤20°

JPS modelling guidelines' required performance for model calibration & verification (2013)

Kalibrasi & verifikasi: Forest City, Johor







Calibration

Verification

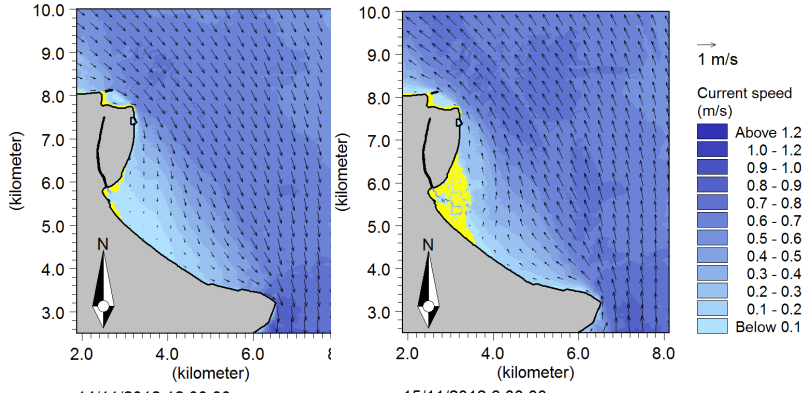
Water levels

Currents

Parameters	Water Level	Current Speed	Current Direction
Tolerence	≤10%	≤20%	≤20°

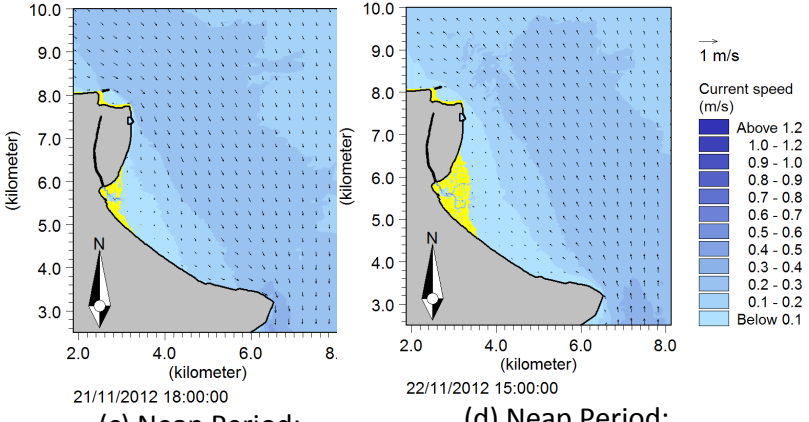
JPS modelling guidelines' required performance for model calibration & verification (2013)

Keadaan Sedia Ada: STP2, Penang



Spring Period: Flood Flow

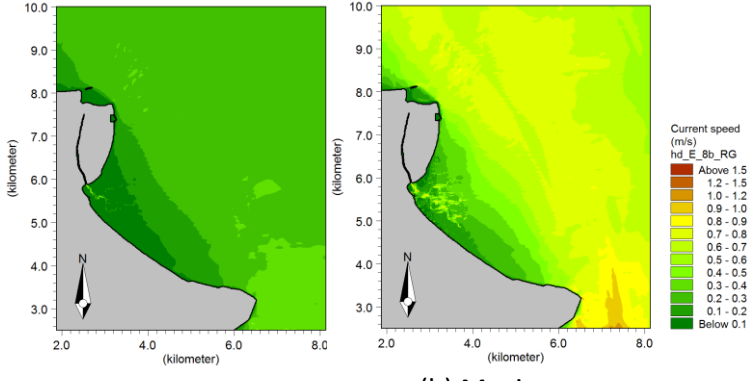
(b) Spring Period: Ebb Flow



(c) Neap Period: Flood Flow

(d) Neap Period: Ebb Flow

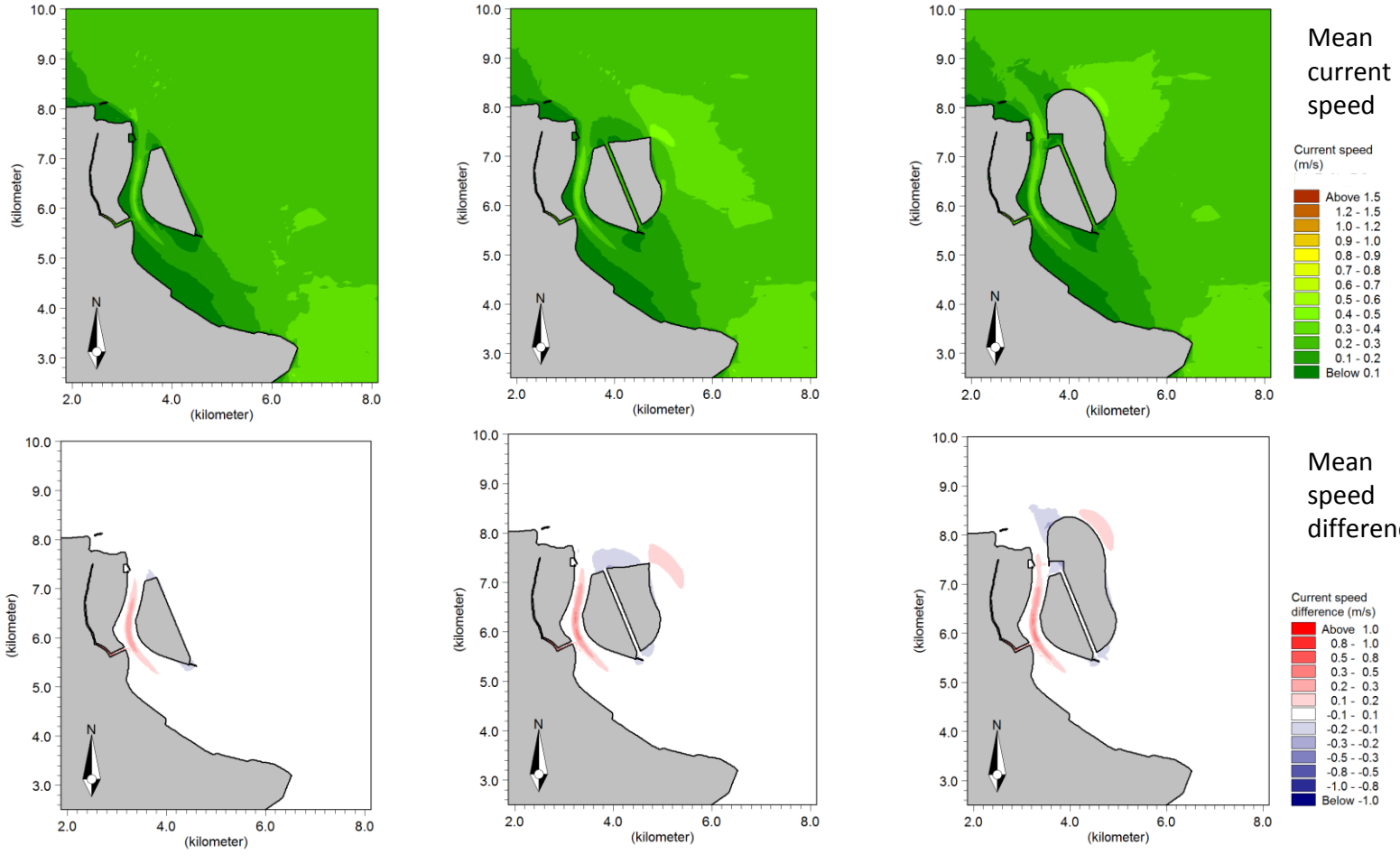
Mean & maximum current



(a) Mean

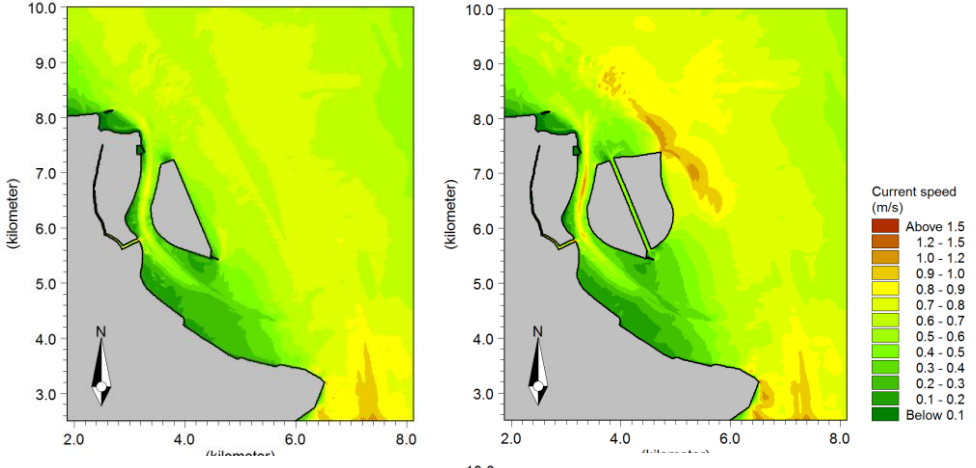
(b) Maximum

Dengan Pembangunan: STP2, Penang

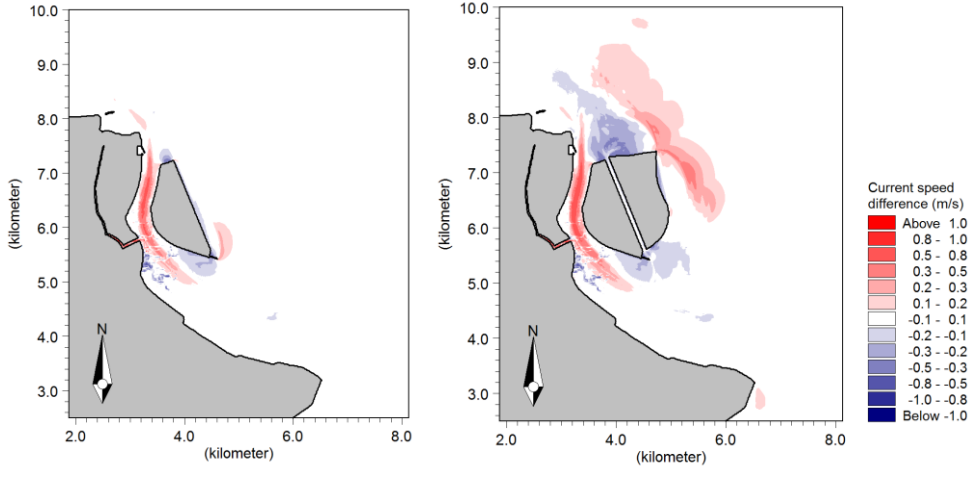


Phase 2a | Phases 2a & 2b | Full reclamation

Dengan Pembangunan: STP2, Penang



Maximum current speed



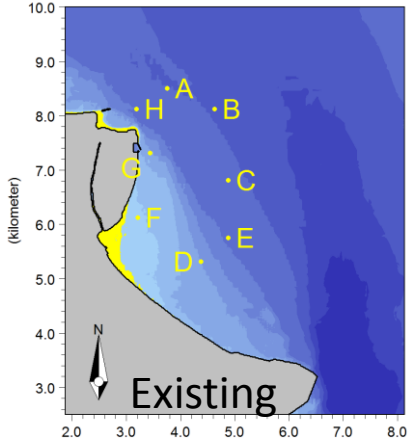
Maximum speed difference

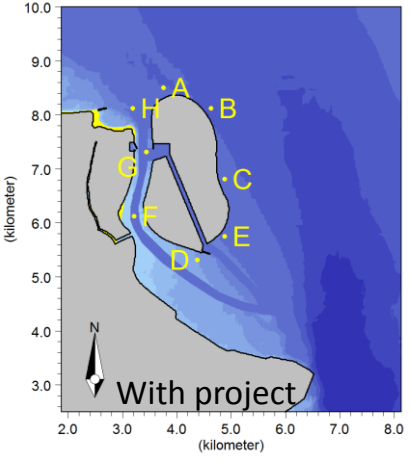
Phase 2a

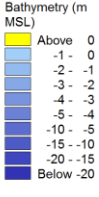
Phases 2a & 2b

Full reclamation

Perbandingan: STP2, Penang







Extraction points

Mean current speed comparison

Point	Existing (m/s)	Full Reclamation	
		Speed (m/s)	Difference (%)
A	0.31	0.22	-29
B	0.28	0.43	56
C	0.28	0.23	-20
D	0.17	0.07	-57
E	0.24	0.16	-34
F	0.58	0.34	-40
G	0.21	0.24	16
H	0.26	0.25	-5

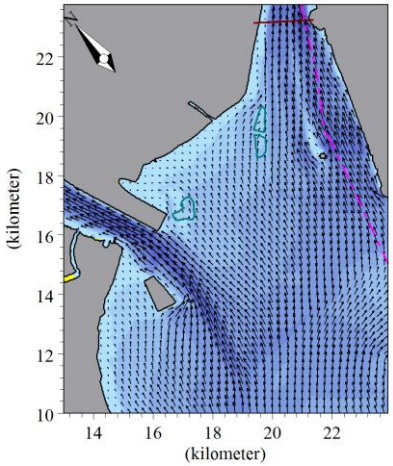
Maximum current speed comparison

Point	Existing (m/s)	Full Reclamation	
		Speed (m/s)	Difference (%)
A	0.80	0.74	-8
B	0.70	1.01	44
C	0.69	0.63	-9
D	0.44	0.22	-51
E	0.54	0.46	-14
F	1.41	0.83	-42
G	0.58	0.64	9
H	0.68	0.76	13

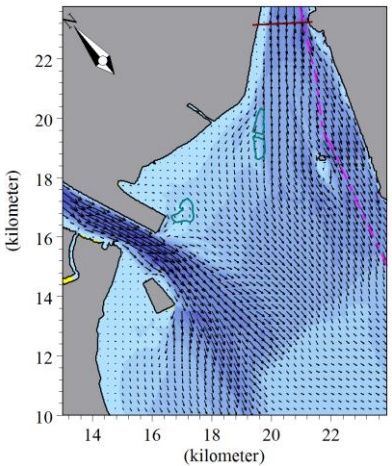
Maximum high water level comparison

Point	Existing (m)	Full Reclamation	
		High Water Level (m)	Difference (%)
A	1.47	1.48	1
B	1.47	1.45	-1
C	1.47	1.45	-1
D	1.47	1.46	0
E	1.46	1.46	0
F	1.47	1.47	0
G	1.47	1.47	0
H	1.47	1.48	1

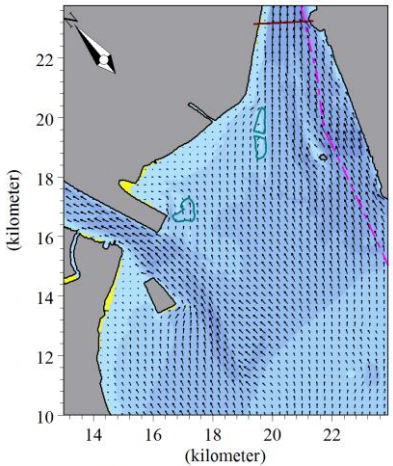
Keadaan Sebelum Penambakan: Forest City, Johor



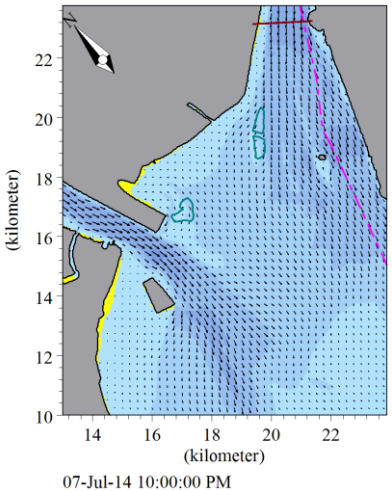
Spring period: Flood flow



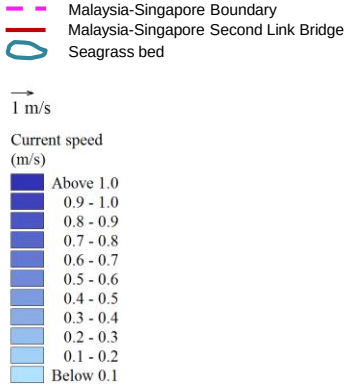
Spring period: Ebb flow

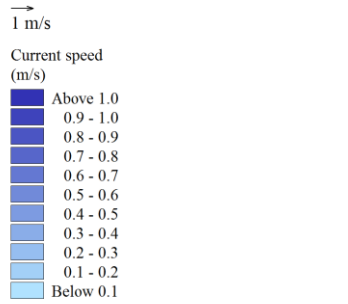


Neap period: Flood flow

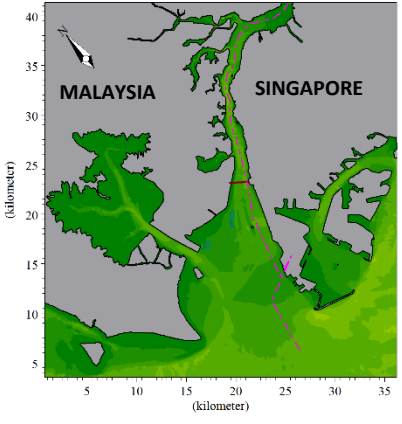


Neap period: Ebb flow

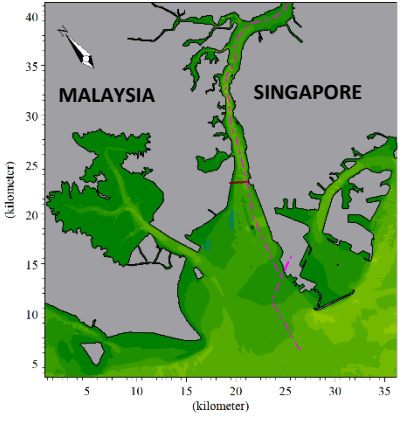




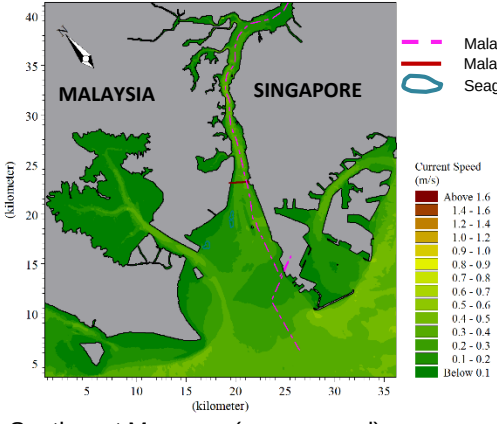
Keadaan Sebelum Penambakan: Forest City, Johor



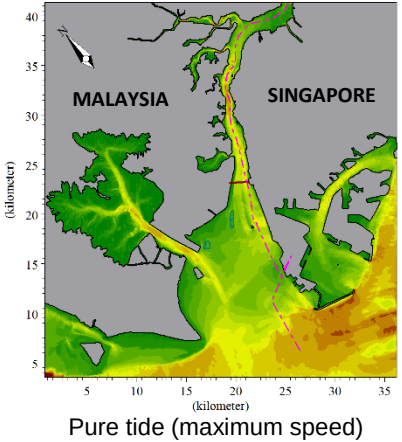
Pure tide (mean speed)



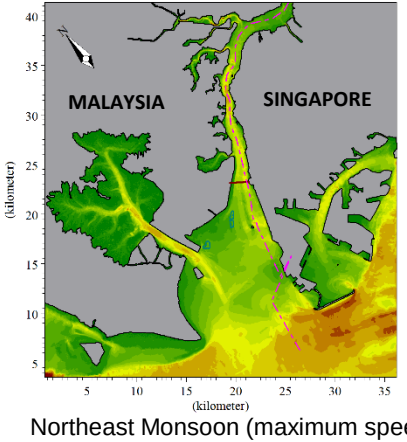
Northeast Monsoon (mean speed)



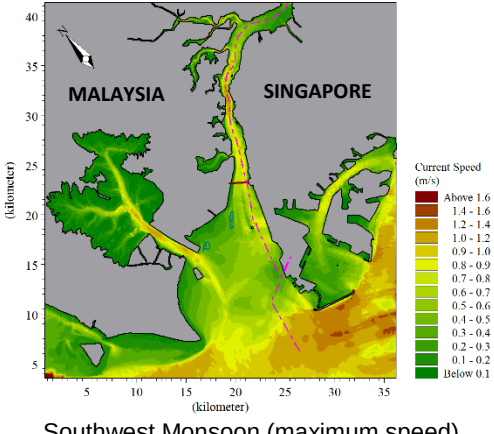
Southwest Monsoon (mean speed)



Pure tide (maximum speed)

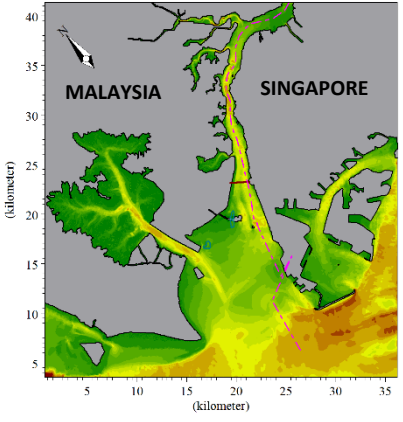


Northeast Monsoon (maximum speed)

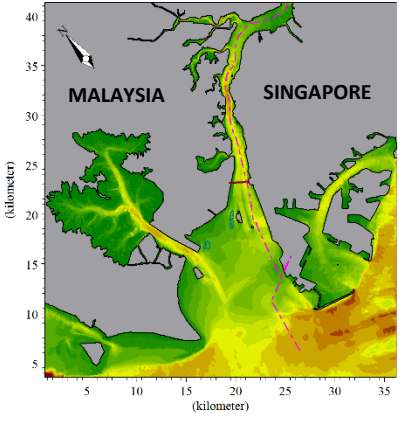


Southwest Monsoon (maximum speed)

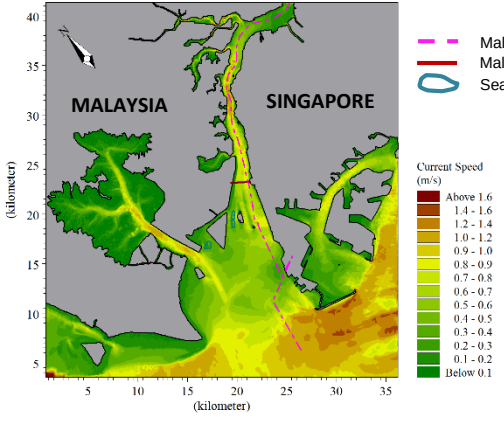
Dengan Pembangunan: Forest City, Johor



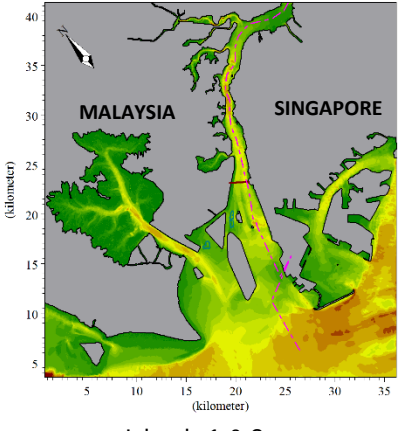
Existing condition



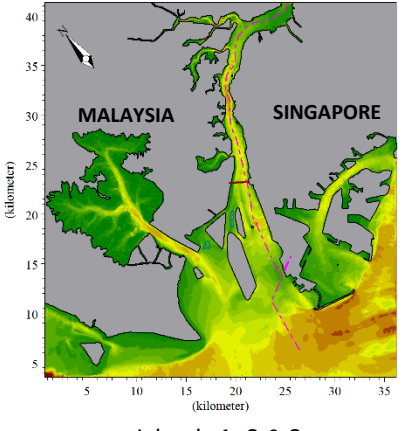
Phase 1



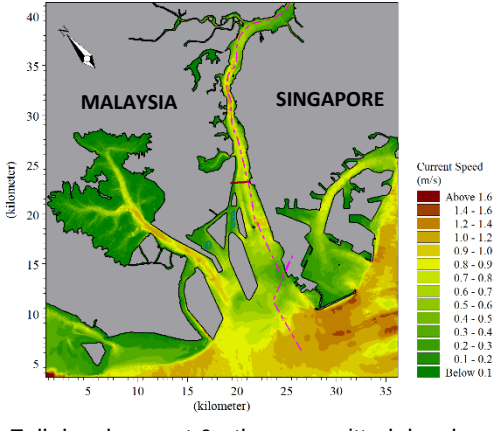
Island 1



Islands 1 & 2

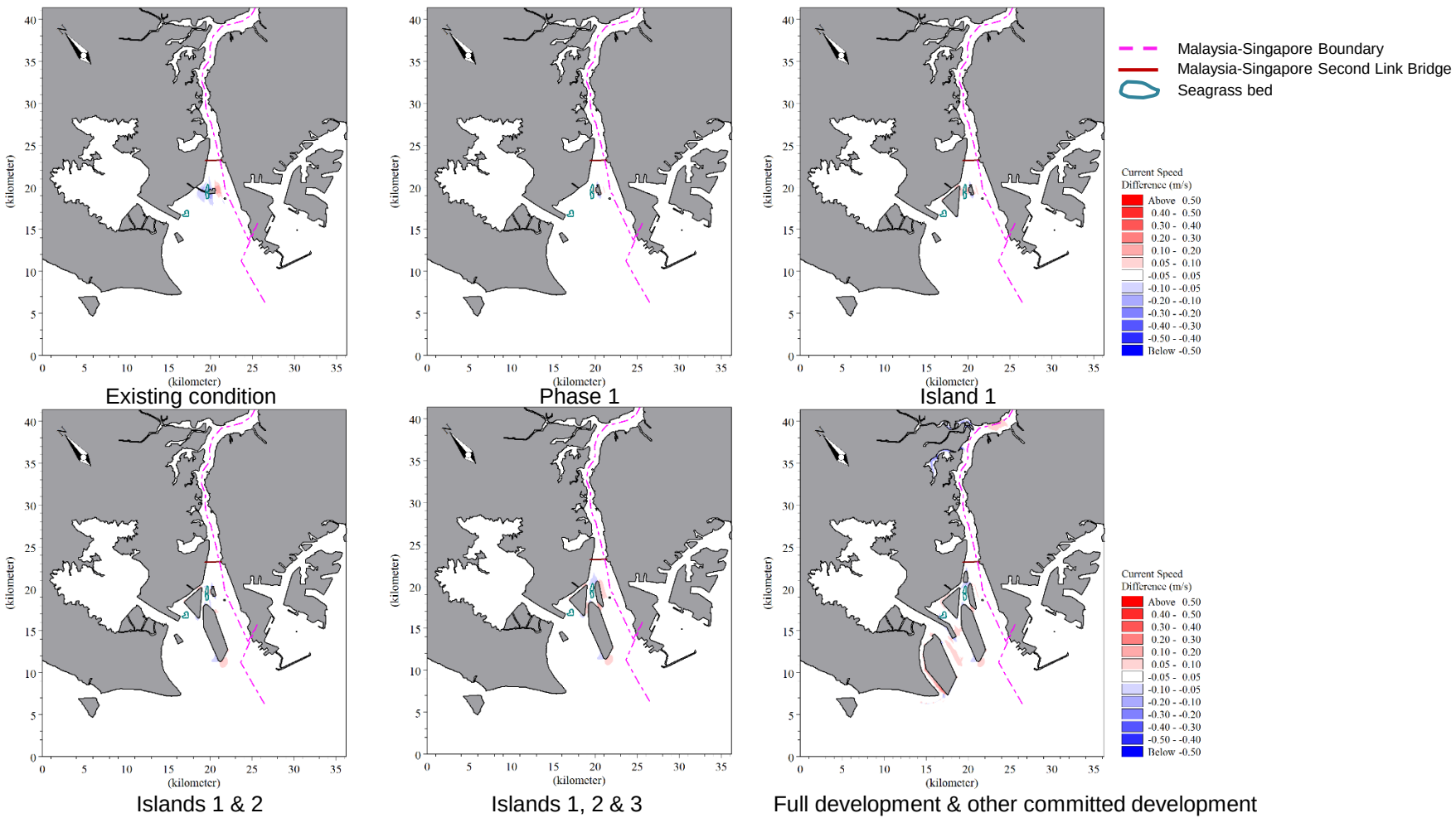


Islands 1, 2 & 3



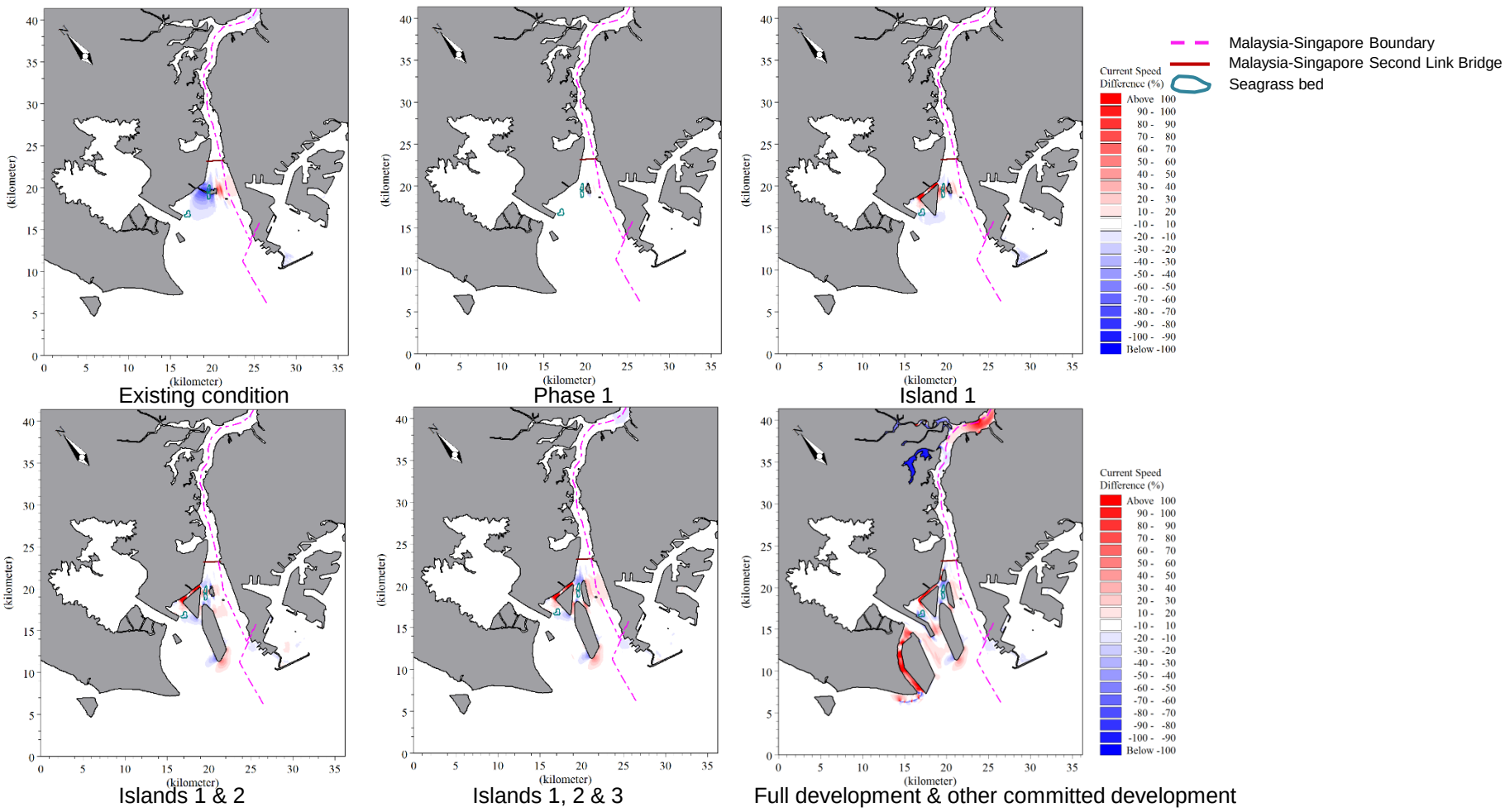
Full development & other committed development

Dengan Pembangunan: Forest City, Johor



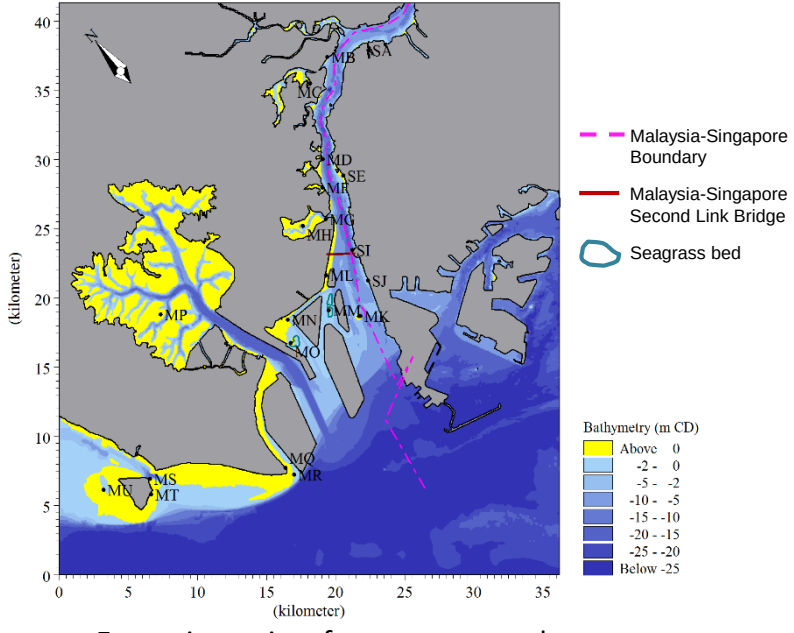
Mean current speed change: Existing vs. 'with Project' condition

Dengan Pembangunan: Forest City, Johor



Mean current speed change (in percentage): Existing vs. 'with Project' condition

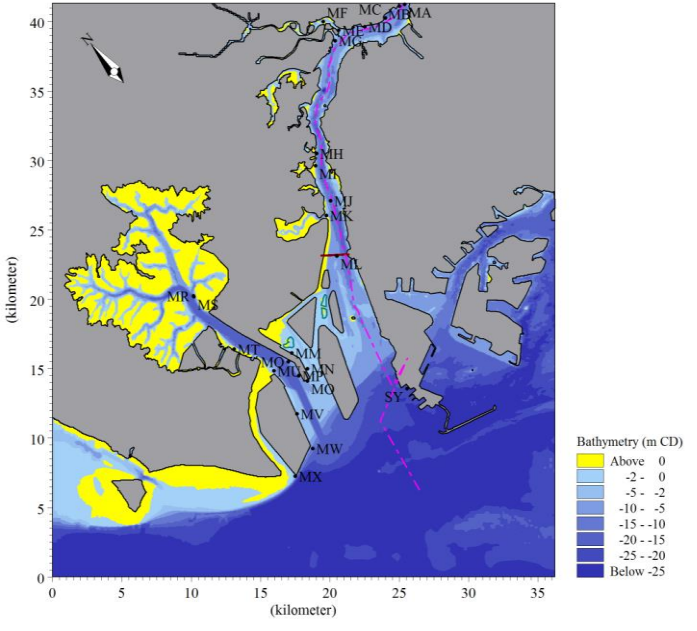
Dengan Pembangunan: Forest City, Johor



Extraction points for current speed at Environmentally Sensitive Areas (ESAs)

Legend:

SA	Sungei Buloh Wetland
MB	Aquaculture at Sungai Melayu
MC	Mangroves at Sungai Melayu
MD	Mangroves at Sungai Bahan
SE	Mangroves at Pergam
MF	Mangroves at Sungai Kemudi
MG	Aquaculture at Sungai Pendas
MH	Mangroves at Sungai Pendas
SI	Tuas Checkpoint
SJ	Merawang Beacon
MK	Pulau Merambong
ML	Mangroves along Tanjung Kupang
MM	Merambong Shoal
MN	Tanjung Adang
MO	Tanjung Adang Shoal
MP	Sungai Pulai Ramsar site
MQ	Tanjung Piai bird habitat
MR	Tanjung Piai Ramsar site
MS	Aquaculture at Kukup
MT	Pulau Kukup Ramsar site
MU	Pulau Kukup mudflat



Extraction points for current speed near committed development areas

Legend:

MA	Johor-Singapore Causeway
MB	R&F project site
MC	Lido Waterfront: East
MD	Lido Waterfront: West
ME	Sungai Skudai river mouth
MF	Sungai Skudai
MG	Sungai Danga river mouth
MH	CIQ Jetty
MI	Residential South
MJ	Medini outfall
MK	Sungai Pendas river mouth
ML	Malaysia-Singapore Second Link Bridge
MM	PTP Phase 3A: East
MN	PTP Phase 3B: East
MO	PTP Phase 3B: Seaward
MP	PTP Phase 3B: Berths
MQ	PTP Phase 3A: Berths
MR	Dyna Mac jetty
MS	Lion Rig jetty
MT	ATB Oil Terminal
MU	Tanjung Bin power plant outfall
MV	Spektrum Kukuh Petroleum Hub: East
MW	Spektrum Kukuh Petroleum Hub: Southeast
MX	Spektrum Kukuh Petroleum Hub: Southwest
SY	Tuas Expansion

Perbandingan: Forest City, Johor

Mean & maximum current speed comparison at extraction points for Environmentally Sensitive Areas (ESAs)

Point	Location	Existing		Full Development						Committed Development					
				Mean			Maximum			Mean			Maximum		
		Mean Speed (m/s)	Maximum Speed (m/s)	Speed (m/s)	Diff. (m)	Diff. (%)	Speed (m/s)	Diff. (m)	Diff. (%)	Speed (m/s)	Diff. (m)	Diff. (%)	Speed (m/s)	Diff. (m)	Diff. (%)
SA	Sungei Buloh Wetland	0.01	0.04	0.01	0.00	10	0.04	0.01	25	0.01	0.00	14	0.05	0.01	36
MB	Aquaculture at Sungai Melayu	0.67	1.12	0.66	0.00	-1	1.12	0.00	0	1.41	0.75	112	2.41	1.30	116
MC	Mangroves at Sungai Melayu	1.36	1.41	1.36	0.00	0	1.41	0.00	0	1.41	0.05	4	2.41	1.00	71
MD	Mangroves at Sungai Bahan	0.32	0.86	0.31	-0.01	-3	0.84	-0.02	-2	0.29	-0.03	-8	0.81	-0.06	-6
SE	Mangroves at Pergam	0.50	1.41	0.50	0.00	1	1.41	0.00	0	0.50	0.00	0	1.41	0.00	0
MF	Mangroves at Sungai Kemudi	0.06	0.23	0.06	0.00	2	0.24	0.01	6	0.06	0.00	4	0.25	0.02	9
MG	Aquaculture at Sungai Pendas	0.03	0.15	0.03	0.00	-2	0.16	0.01	8	0.03	0.00	-1	0.16	0.01	6
MH	Mangroves at Sungai Pendas	0.03	0.08	0.03	0.00	-1	0.07	-0.01	-10	0.03	0.00	1	0.08	0.00	-3
SI	Tuas Checkpoint	0.23	0.59	0.23	0.00	-1	0.57	-0.02	-3	0.22	-0.01	-4	0.55	-0.04	-7
SJ	Merawang Beacon	0.16	1.41	0.17	0.01	6	1.41	0.00	0	0.17	0.01	4	1.41	0.00	0
MK	Pulau Merambong	0.12	0.34	0.14	0.01	12	0.39	0.05	13	0.13	0.01	9	0.37	0.03	7
ML	Mangroves along Tanjung Kupang	0.42	1.41	0.42	0.00	1	1.41	0.00	0	0.42	0.00	1	1.41	0.00	0
MM	Merambong Shoal	0.09	0.30	0.09	0.00	-2	0.26	-0.04	-13	0.07	-0.02	-17	0.25	-0.05	-17
MN	Tanjung Adang	0.46	1.41	0.48	0.02	5	1.41	0.00	0	0.48	0.02	3	1.41	0.00	0
MO	Tanjung Adang Shoal	0.09	1.41	0.09	0.00	3	1.41	0.00	0	0.08	-0.01	-9	1.41	0.00	0
MP	Sungai Pulai Ramsar site	1.38	1.41	1.38	0.00	0	1.41	0.00	0	1.38	0.00	0	1.41	0.00	0
MQ	Tanjung Piai bird habitat	0.77	1.41	0.77	0.00	0	1.41	0.00	0	0.79	0.01	2	1.41	0.00	0
MR	Tanjung Piai Ramsar site	0.15	0.45	0.15	0.00	0	0.43	-0.02	-5	0.08	-0.07	-45	0.37	-0.08	-17
MS	Aquaculture at Kukup	0.07	0.30	0.07	0.00	0	0.30	0.00	0	0.07	0.00	0	0.30	0.00	0
MT	Pulau Kukup Ramsar site	0.17	1.12	0.17	0.00	0	1.12	0.00	0	0.17	0.00	0	1.12	0.00	0
MU	Pulau Kukup mudflat	0.06	0.18	0.06	0.00	0	0.18	0.00	0	0.06	0.00	0	0.18	0.00	-1

Note: Diff. denotes 'difference'

0.1 m/s = 0.36 km/hr
0.5 m/s = 1.8 km/hr
1.0 m/s = 3.6 km/hr

Perbandingan: Forest City, Johor

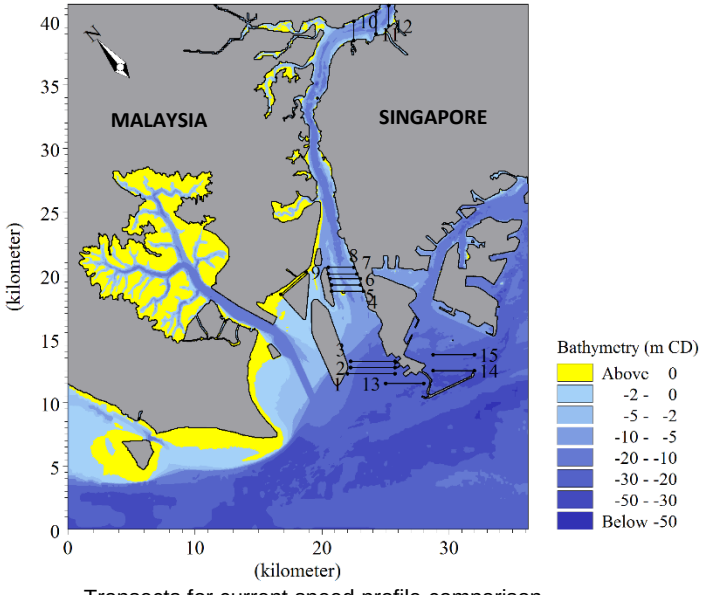
Maximum high water level comparison at extraction points for Environmentally Sensitive Areas (ESAs)

Point	Location	Existing	Full Development			Committed Development		
		Level (m)	Level (m)	Diff. (m)	Diff. (%)	Level (m)	Diff. (m)	Diff. (%)
SA	Sungei Buloh Wetland	2.24	2.25	0.01	0	2.22	-0.02	-1
MB	Aquaculture at Sungai Melayu	1.88	1.86	-0.01	-1	1.00	-0.88	-47
MC	Mangroves at Sungai Melayu	0.40	0.42	0.01	4	1.00	0.60	147
MD	Mangroves at Sungai Bahan	2.08	2.10	0.02	1	2.08	0.00	0
SE	Mangroves at Pergam	2.01	2.03	0.01	1	2.01	0.00	0
MF	Mangroves at Sungai Kemudi	2.01	2.03	0.02	1	2.02	0.00	0
MG	Aquaculture at Sungai Pendas	2.04	2.04	0.00	0	2.04	0.00	0
MH	Mangroves at Sungai Pendas	2.04	2.05	0.01	1	2.05	0.01	1
SI	Tuas Checkpoint	2.02	2.01	0.00	0	2.01	-0.01	0
SJ	Merawang Beacon	1.98	1.97	0.00	0	1.97	0.00	0
MK	Pulau Merambong	1.96	1.95	-0.01	0	1.95	-0.01	-1
ML	Mangroves along Tanjung Kupang	1.96	1.97	0.01	0	1.97	0.01	1
MM	Merambong Shoal	1.97	1.97	0.00	0	1.97	0.00	0
MN	Tanjung Adang	1.91	1.93	0.02	1	1.91	0.00	0
MO	Tanjung Adang Shoal	1.95	1.96	0.01	1	1.95	0.01	1
MP	Sungai Pulai Ramsar site	0.59	0.60	0.01	2	0.63	0.04	7
MQ	Tanjung Piai bird habitat	1.65	1.65	0.00	0	1.65	0.00	0
MR	Tanjung Piai Ramsar site	1.88	1.88	0.00	0	1.89	0.01	1
MS	Aquaculture at Kukup	1.88	1.88	0.00	0	1.88	0.00	0
MT	Pulau Kukup Ramsar site	1.87	1.87	0.00	0	1.87	0.00	0
MU	Pulau Kukup mudflat	1.87	1.87	0.00	0	1.87	0.00	0

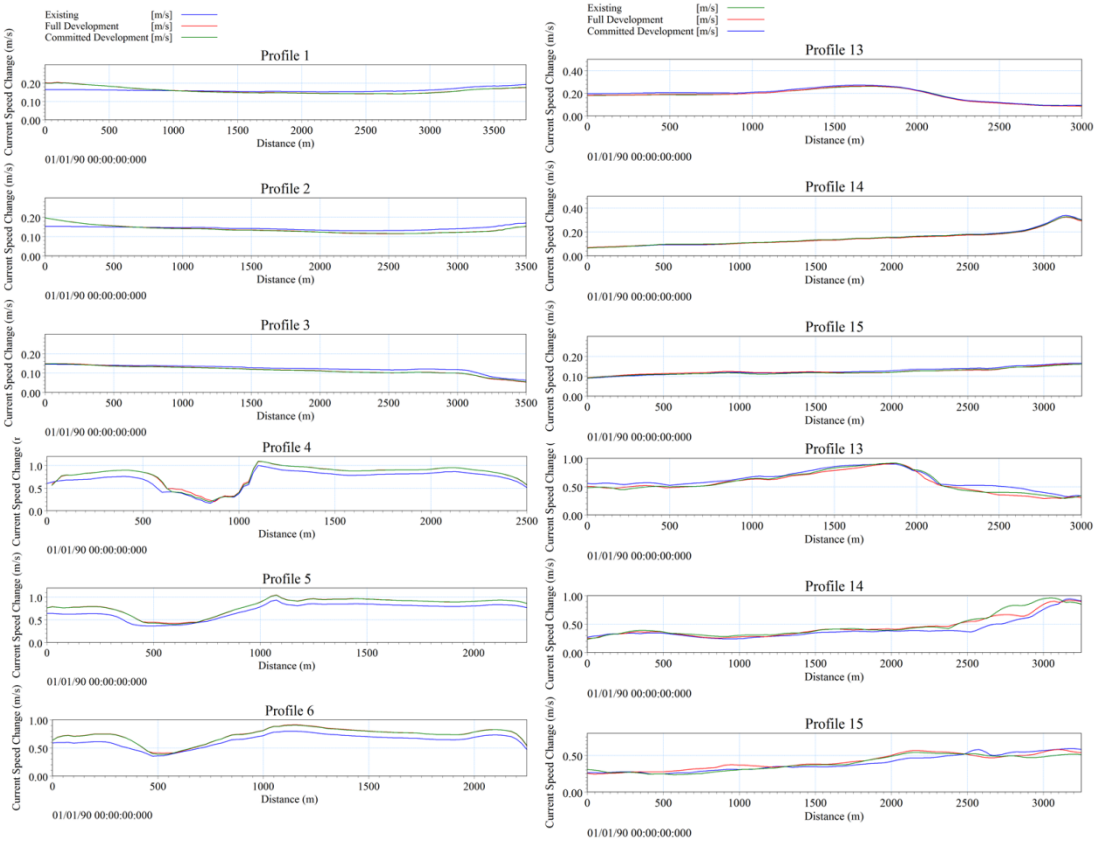
Maximum high water level comparison at extraction points around committed development areas

Point	Location	Existing	Full Development			Committed Development		
		Level (m)	Level (m)	Diff. (m)	Diff. (%)	Level (m)	Diff. (m)	Diff. (%)
MA	Johor-Singapore Causeway	2.23	2.23	0.00	0.00	2.23	0	0
MB	R&F project site	2.23	2.23	0.00	0.00	2.23	0	0
MC	Lido Waterfront: East	2.23	2.23	0.00	0.00	2.23	0	0
MD	Lido Waterfront: West	2.23	2.23	0.00	-0.01	2.22	0	-1
ME	Sungai Skudai river mouth	2.23	2.22	0.00	-0.03	2.20	0	-1
MF	Sungai Skudai	2.24	2.24	0.01	-0.01	2.23	0	0
MG	Sungai Danga river mouth	2.22	2.21	-0.01	-0.03	2.19	0	-2
MH	CIQ Jetty	2.08	2.10	0.02	0.00	2.09	1	0
MI	Residential South	2.08	2.09	0.02	0.00	2.08	1	0
MJ	Medini outfall	2.05	2.06	0.01	-0.01	2.05	0	0
MK	Sungai Pendas river mouth	2.05	2.05	0.01	-0.01	2.04	0	0
ML	Malaysia-Singapore Second Link Bridge	2.01	2.01	0.00	0.00	2.01	0	0
MM	PTP Phase 3A: East	1.94	1.95	0.01	0.01	1.95	0	0
MN	PTP Phase 3B: East	1.92	1.93	0.01	0.02	1.94	1	1
MO	PTP Phase 3B: Seaward	1.92	1.93	0.01	0.00	1.92	0	0
MP	PTP Phase 3B: Berths	1.92	1.93	0.01	0.00	1.92	0	0
MQ	PTP Phase 3A: Berths	1.93	1.94	0.01	0.01	1.94	1	1
MR	Dyna Mac jetty	2.11	2.12	0.01	0.05	2.16	0	2
MS	Lion Rig jetty	2.11	2.12	0.01	0.04	2.16	0	2
MT	ATB Oil Terminal	1.97	1.97	0.00	0.04	2.01	0	2
MU	Tanjung Bin power plant outfall	1.93	1.94	0.01	0.01	1.94	1	1
MV	Spektrum Kukuh Petroleum Hub: East	1.91	1.91	0.00	0.00	1.91	0	0
MW	Spektrum Kukuh Petroleum Hub: Southeast	1.89	1.89	0.00	0.00	1.88	0	0
MX	Spektrum Kukuh Petroleum Hub:	1.88	1.88	0.00	0.00	1.88	0	0

Dengan Pembangunan: Forest City, Johor



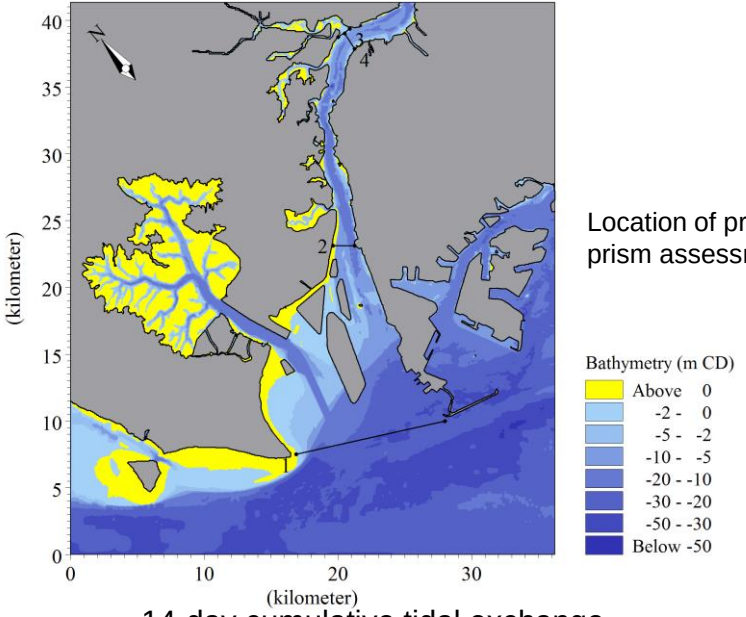
Transects for current speed profile comparison



Current speed profile comparison

Dengan Pembangunan: Forest City, Johor

Tidal Prism



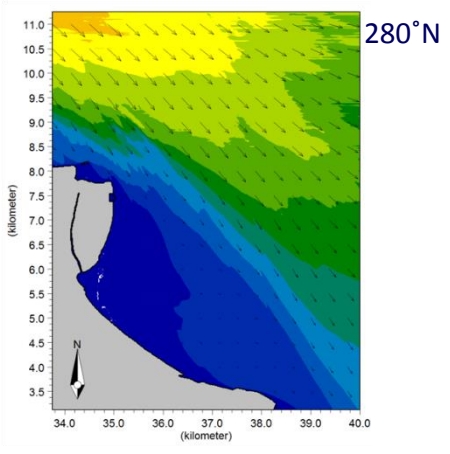
Location of profiles for tidal prism assessment

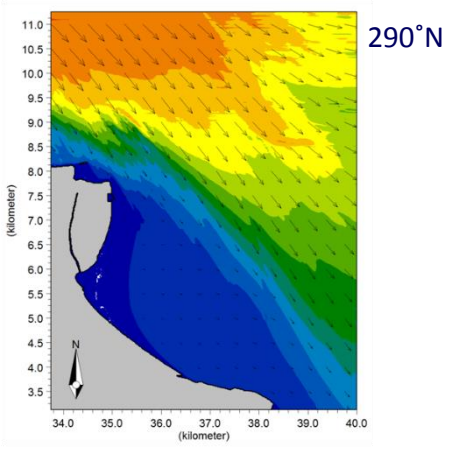
14-day cumulative tidal exchange

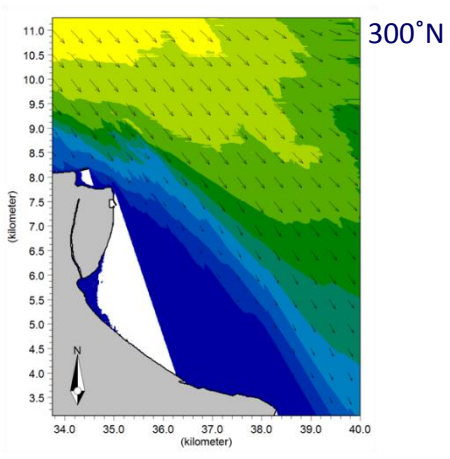
Condition	Profile 1 (Tg. Piai – Tuas)		Profile 2 (Second Link Bridge)		Profile 3 (Sg. Skudai)		Profile 4 (Sg. Skudai – Singapore)	
	Discharge (10^6 m^3)	Change (%)	Discharge (10^6 m^3)	Change (%)	Discharge (10^6 m^3)	Change (%)	Discharge (10^6 m^3)	Change (%)
Pre-reclamation	29,235	-	3,106	-	2,562	-	1,272	-
Full development	27,836	-5	3,033	-2	2,588	-1	1,201	-6
Other committed developments only	28,096	-4	2,979	-6	1,186	-53	1,450	14
Full development & other committed developments	26,988	-8	2,913	-6	1,338	-48	1,373	8

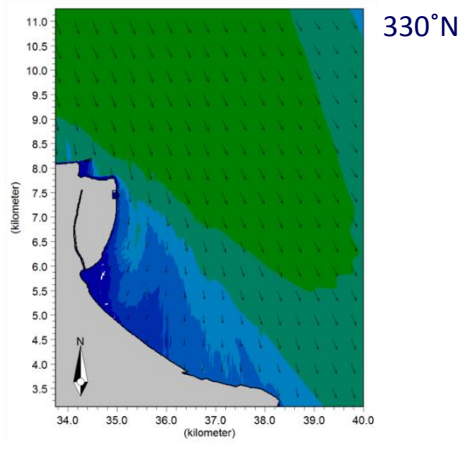
Permodelan Numerik:
Ombak

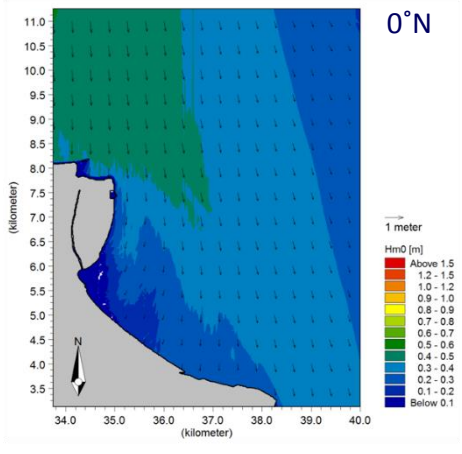
Keadaan Sedia Ada: STP2, Penang







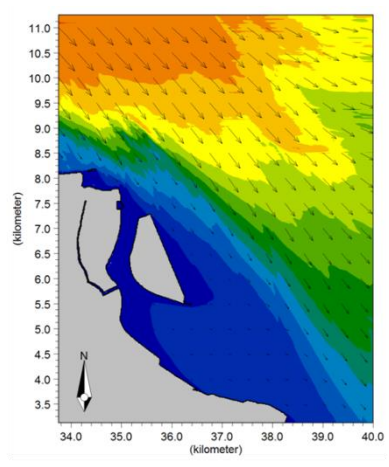


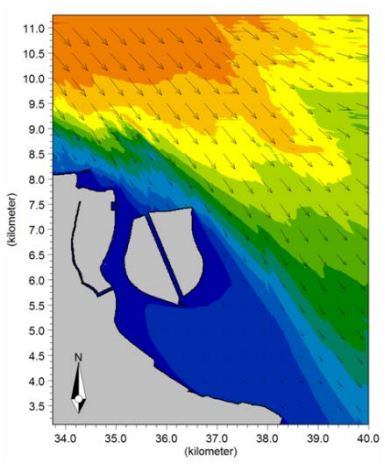


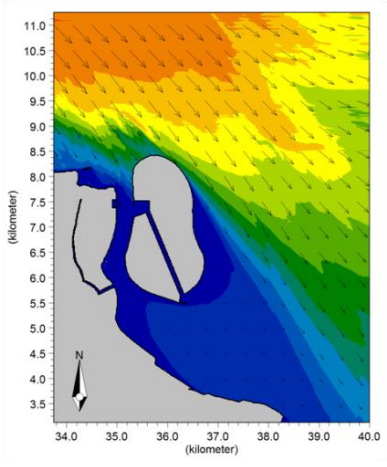
Wave boundary conditions

Direction (°N)	H_{m0} (m)	T_m (s)
280	1.4	5.1
290	1.9	5.4
300	1.1	4.9
330	0.6	2.9
0	0.6	2.5

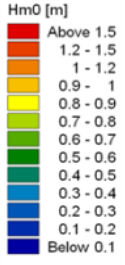
Dengan Pembangunan: STP2, Penang



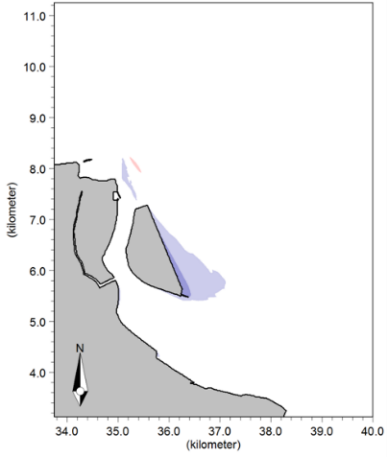


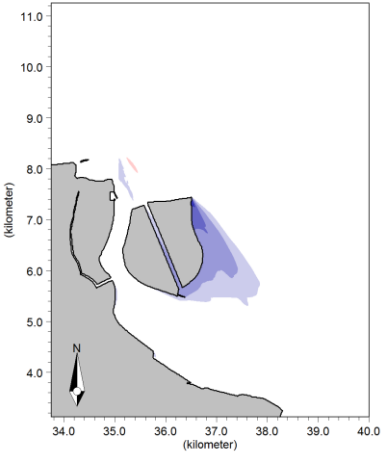


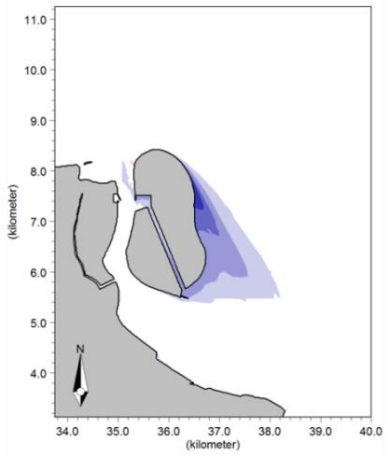
Wave height



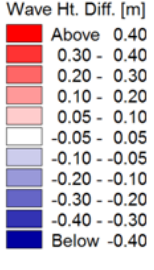
290˚N







Wave height difference

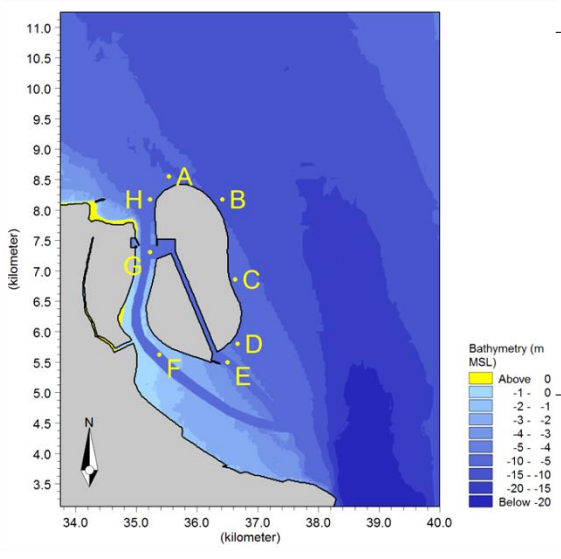


Phase 2a

Phases 2a & 2b

Full reclamation

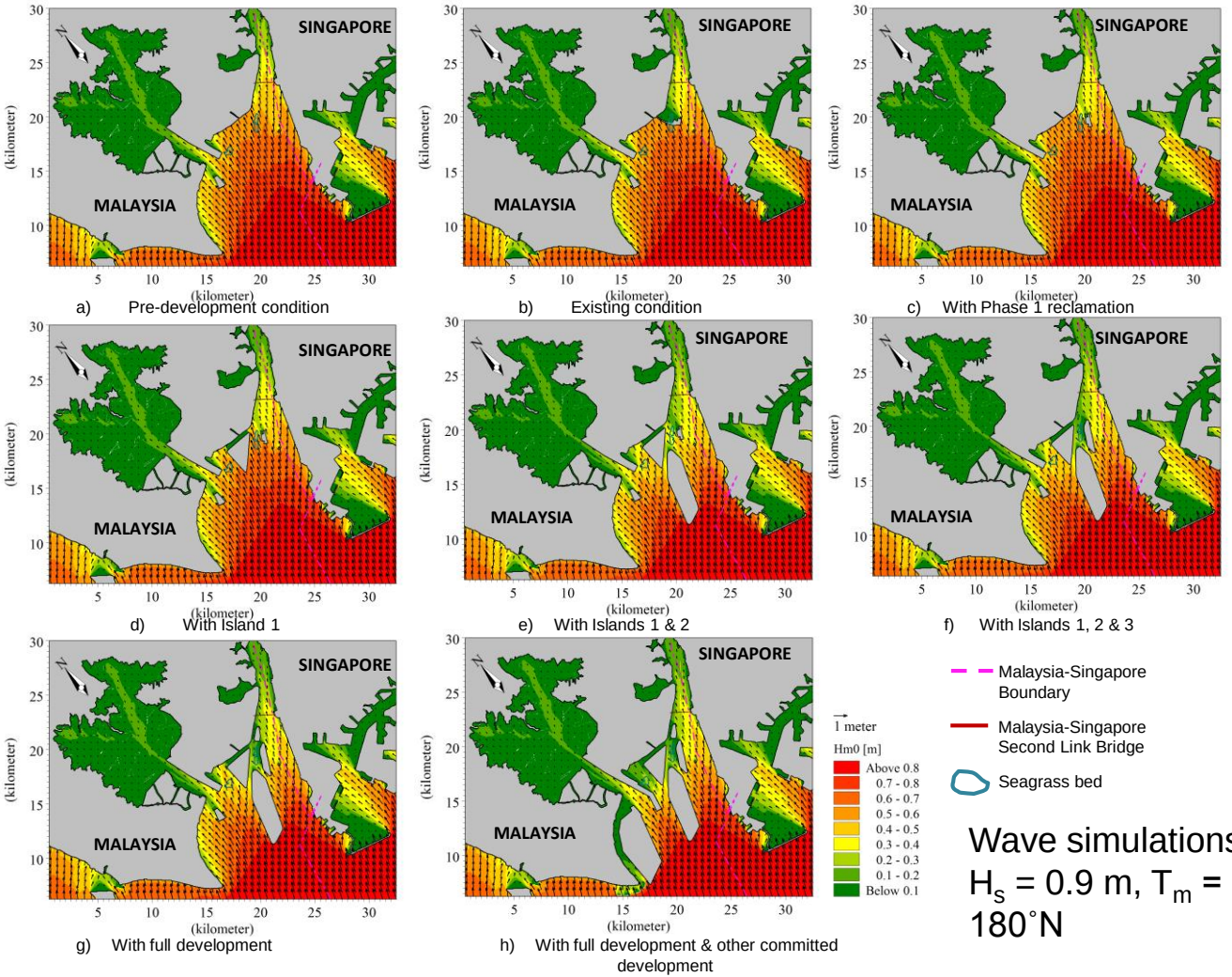
Perbandingan: STP2, Penang



Wave data extraction points

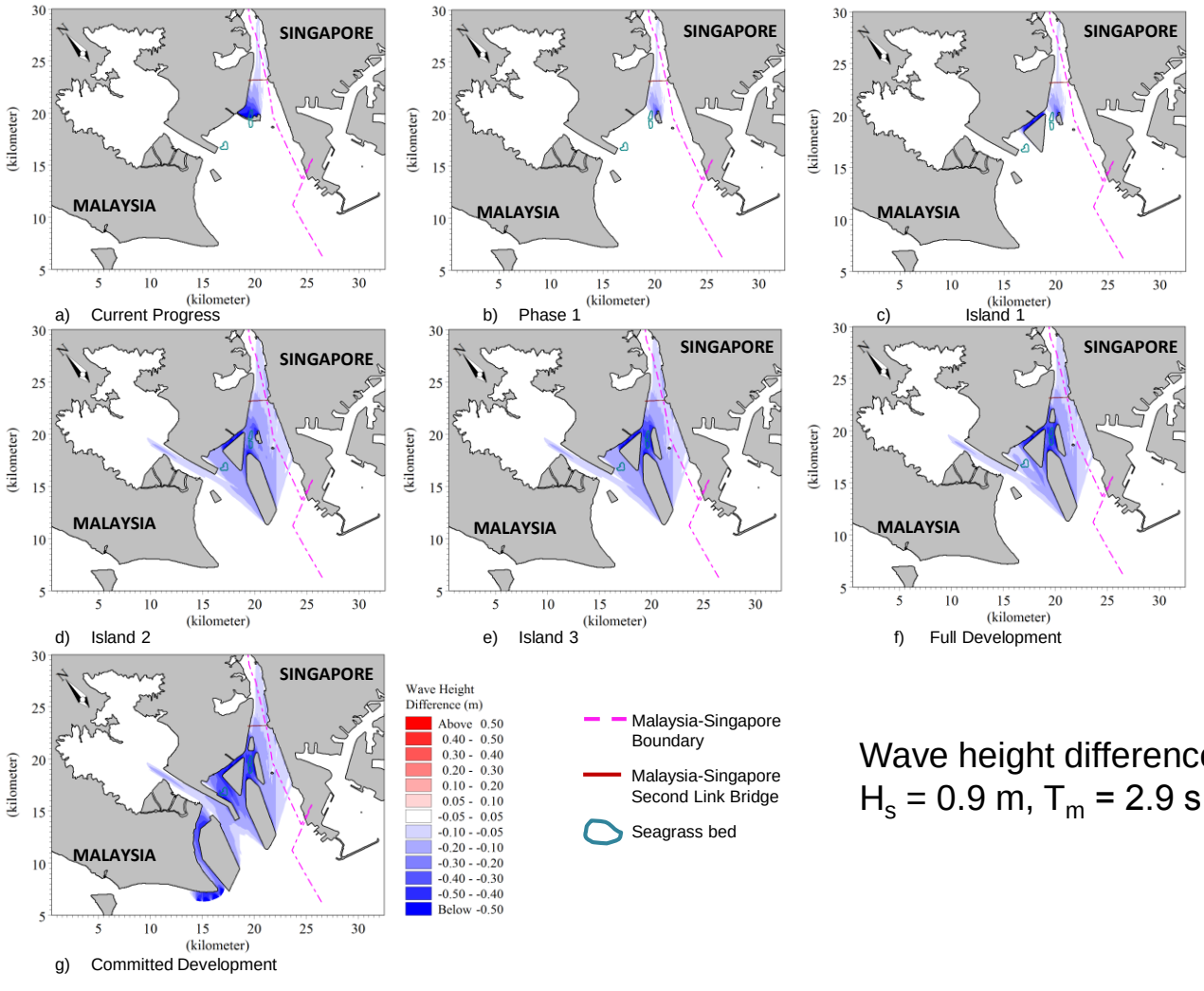
Direction (°N)	Point	Existing	Phase 2a			Full Reclamation		
		Height (m)	Height (m)	Difference		Height (m)	Difference	
				Value (m)	%		Value (m)	%
280	A	0.36	0.36	0.00	0	0.36	0.00	0
	B	0.53	0.53	0.00	0	0.51	-0.02	-4
	C	0.23	0.22	-0.01	-6	0.02	-0.21	-92
	D	0.11	0.05	-0.06	-51	0.02	-0.09	-81
	E	0.10	0.03	-0.07	-67	0.03	-0.07	-68
	F	0.07	0.05	-0.02	0	0.05	-0.02	0
	G	0.03	0.03	0.00	-3	0.03	0.00	0
	H	0.35	0.35	0.00	1	0.35	0.00	1
290	A	0.41	0.41	0.00	0	0.41	0.00	0
	B	0.65	0.65	0.00	0	0.62	-0.03	-4
	C	0.26	0.25	-0.01	-4	0.04	-0.22	-85
	D	0.16	0.09	-0.07	-44	0.04	-0.11	-72
	E	0.16	0.07	-0.09	-55	0.07	-0.09	-57
	F	0.10	0.09	-0.02	-16	0.09	-0.02	-16
	G	0.06	0.06	0.00	0	0.06	0.00	0
	H	0.43	0.44	0.01	1	0.44	0.01	1

Ombak: Forest City, Johor



Wave simulations for offshore H_s = 0.9 m, T_m = 2.9 s & θ = 180˚N

Ombak: Forest City, Johor



Wave height differences for offshore H_s = 0.9 m, T_m = 2.9 s & θ = 180˚N

Perbandingan: Forest City, Johor

Extracted wave heights near committed development sites

180° N

Point	Wave Height (m)								Wave Height Difference													
									Existing		Phase 1		Island 1		Islands 1 and 2		Islands 1, 2 and 3		Full Development		With Committed Development	
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Value (m)	Percentage (%)	Value (m)	Percentage (%)	Value (m)	Percentage (%)	Value (m)	Percentage (%)	Value (m)	Percentage (%)	Value (m)	Percentage (%)	Value (m)	Percentage (%)
MA	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
MB	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
MC	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
MD	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
ME	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	-5
MF	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.03	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	-0.05	-65
MG	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.00	0	0.00	0	0.00	0	0.00	0	0.00	-1	0.00	-1	0.00	-1
MH	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.00	-1	0.00	-1	0.00	-1	0.00	-2	0.00	-2	0.00	-2	0.00	-2
MI	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.00	0	0.00	0	0.00	0	0.00	-1	0.00	-1	0.00	-1	0.00	-1
MJ	0.21	0.21	0.21	0.21	0.18	0.18	0.18	0.18	-0.01	-3	-0.01	-4	-0.01	-4	-0.04	-18	-0.04	-18	-0.04	-18	-0.04	-18
MK	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.00	-2	0.00	-2	0.00	-2	0.00	-4	0.00	-5	0.00	-5	0.00	-5
ML	0.42	0.34	0.37	0.36	0.31	0.31	0.31	0.31	-0.07	-17	-0.05	-12	-0.05	-12	-0.11	-25	-0.11	-26	-0.11	-26	-0.11	-26
MM	0.61	0.61	0.61	0.61	0.48	0.48	0.50	0.04	0.00	0	0.00	0	0.00	0	-0.12	-20	-0.12	-20	-0.11	-18	-0.57	-93
MN	0.66	0.66	0.66	0.66	0.52	0.52	0.54	0.37	0.00	0	0.00	0	0.00	0	-0.14	-21	-0.14	-21	-0.12	-18	-0.29	-44
MO	0.65	0.65	0.65	0.65	0.57	0.57	0.57	0.51	0.00	0	0.00	0	0.00	0	-0.08	-12	-0.08	-12	-0.08	-12	-0.13	-20
MP	0.63	0.63	0.63	0.63	0.57	0.57	0.57	0.47	0.00	0	0.00	0	0.00	0	-0.06	-10	-0.06	-10	-0.06	-10	-0.16	-26
MQ	0.56	0.56	0.56	0.56	0.50	0.50	0.50	0.39	0.00	0	0.00	0	0.00	0	-0.06	-11	-0.06	-11	-0.06	-11	-0.17	-31
MR	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
MS	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
MT	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0	0.00	0	0.00	0	0.00	-1	0.00	-1	0.00	-1	0.00	-1
MU	0.28	0.28	0.28	0.28	0.24	0.24	0.24	0.23	0.00	0	0.00	0	0.00	0	-0.04	-14	-0.04	-14	-0.04	-14	-0.05	-18
MV	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.48	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	-0.18	-27
MW	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
MX	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
SY	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0

Points:

MA	Johor-Singapore Causeway
MB	R&F project site
MC	Lido Waterfront: East
MD	Lido Waterfront: West
ME	Sungai Skudai river mouth
MF	Sungai Skudai
MG	Sungai Danga river mouth
MH	CIQ Jetty
MI	Residential South
MJ	Medini outfall
MK	Sungai Pendas river mouth
ML	Malaysia-Singapore Second Link Bridge
MM	PTP Phase 3A: East
MN	PTP Phase 3B: East
MO	PTP Phase 3B: Seaward
MP	PTP Phase 3B: Berths
MQ	PTP Phase 3A: Berths
MR	Dyna Mac jetty
MS	Lion Rig jetty
MT	ATB Oil Terminal
MU	Tanjung Bin power plant outfall
MV	Spektrum Kukuh Petroleum Hub: East
MW	Spektrum Kukuh Petroleum Hub: Southeast
MX	Spektrum Kukuh Petroleum Hub: Southwest
SY	Tuas Expansion

Scenarios:

Case 1	Pre-development
Case 2	Existing
Case 3	Phase 1
Case 4	Island 1
Case 5	Islands 1 and 2
Case 6	Islands 1, 2 and 3
Case 7	Full Development
Case 8	With Committed Development

Perbandingan: Forest City, Johor

Extracted wave heights around proposed development at Environmentally Sensitive Areas

Point	Wave Height (m)								Wave Height Difference											
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Existing		Phase 1		Island 1		Islands 1 and 2		Islands 1, 2 and 3		Full Development		With Committed Development	
									Value (m)	Percentage (%)	Value (m)	Percentage (%)	Value (m)	Percentage (%)	Value (m)	Percentage (%)	Value (m)	Percentage (%)	Value (m)	Percentage (%)	Value (m)	Percentage (%)
SA	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0
MB	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.00	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	-0.08	-100
MC	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0
MD	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.00	0	0.00	-1	0.00	-1	-1	-2	0.00	-2	0.00	-2	0.00	-2
SE	0.14	0.11	0.11	0.11	0.09	0.09	0.09	0.09	-0.04	-26	-0.04	-26	-0.04	-26	-26	-38	-0.05	-38	-0.05	-38	-0.05	-38
MF	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0
MG	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0
MH	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0
SI	0.31	0.26	0.27	0.27	0.20	0.20	0.20	0.19	-0.04	-14	-0.03	-11	-0.04	-12	-12	-36	-0.11	-36	-0.11	-37	-0.11	-37
SJ	0.45	0.45	0.44	0.44	0.37	0.37	0.37	0.37	0.00	0	0.00	-1	0.00	-1	-1	-16	-0.07	-16	-0.07	-16	-0.07	-16
MK	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0
ML	0.36	0.15	0.28	0.27	0.15	0.12	0.05	0.04	-0.21	-59	-0.08	-23	-0.09	-26	-26	-57	-0.24	-66	-0.31	-87	-0.32	-88
MM	0.62	0.62	0.62	0.62	0.35	0.20	0.20	0.20	0.00	0	0.00	0	0.00	0	0	-44	-0.43	-68	-0.43	-68	-0.43	-69
MN	0.49	0.49	0.49	0.44	0.36	0.36	0.40	0.11	0.00	0	0.00	0	-0.05	-10	-10	-26	-0.13	-26	-0.09	-18	-0.38	-78
MO	0.55	0.55	0.55	0.55	0.42	0.42	0.44	0.11	0.00	0	0.00	0	0.00	0	0	-24	-0.13	-24	-0.11	-20	-0.45	-81
MP	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0
MQ	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.06	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	-0.20	-76
MR	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.04	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	-0.62	-94
MS	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0
MT	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0
MU	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.00	0	0.00	0	0.00	0	0	0	0.00	0	0.00	0	0.00	0

Points:

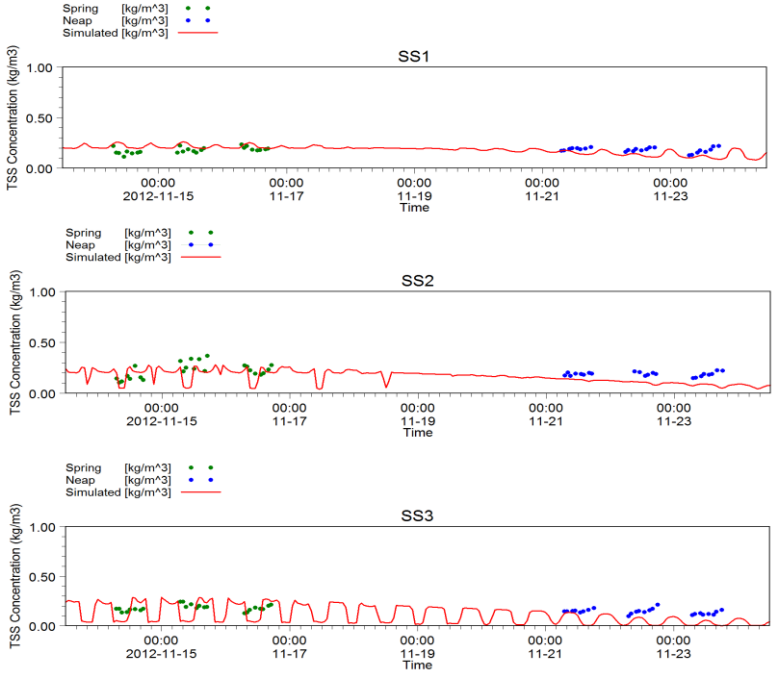
SA	Sungei Buloh Wetland
MB	Aquaculture at Sungai Melayu
MC	Mangroves at Sungai Melayu
MD	Mangroves at Sungai Bahan
SE	Mangroves at Pergam
MF	Mangroves at Sungai Kemudi
MG	Aquaculture at Sungai Pendas
MH	Mangroves at Sungai Pendas
SI	Tuas Checkpoint
SJ	Merawang Beacon
MK	Pulau Merambong
ML	Mangroves along Tanjung Kupang
MM	Merambong Shoal
MN	Tanjung Adang
MO	Tanjung Adang Shoal
MP	Sungai Pulai Ramsar site
MQ	Tanjung Piai bird habitat
MR	Tanjung Piai Ramsar site
MS	Aquaculture at Kukup
MT	Pulau Kukup Ramsar site
MU	Pulau Kukup mudflat

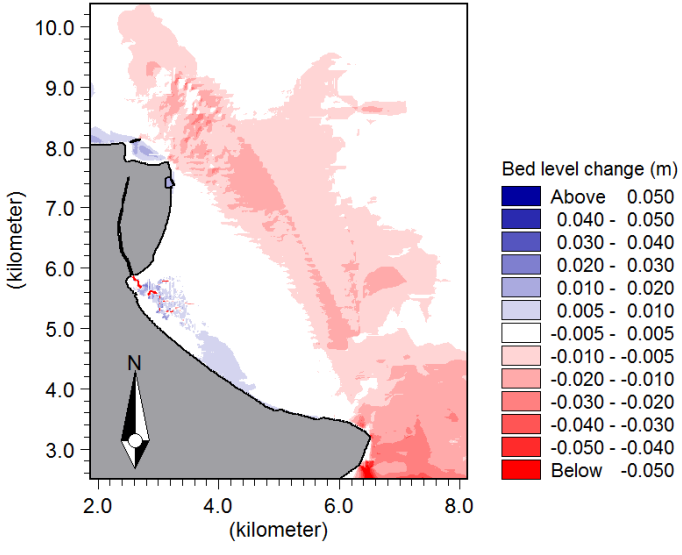
Scenarios:

Case 1	Pre-development
Case 2	Existing
Case 3	Phase 1
Case 4	Island 1
Case 5	Islands 1 and 2
Case 6	Islands 1, 2 and 3
Case 7	Full Development
Case 8	With Committed Development

Permodelan Numerik:
Angkutan Enapan

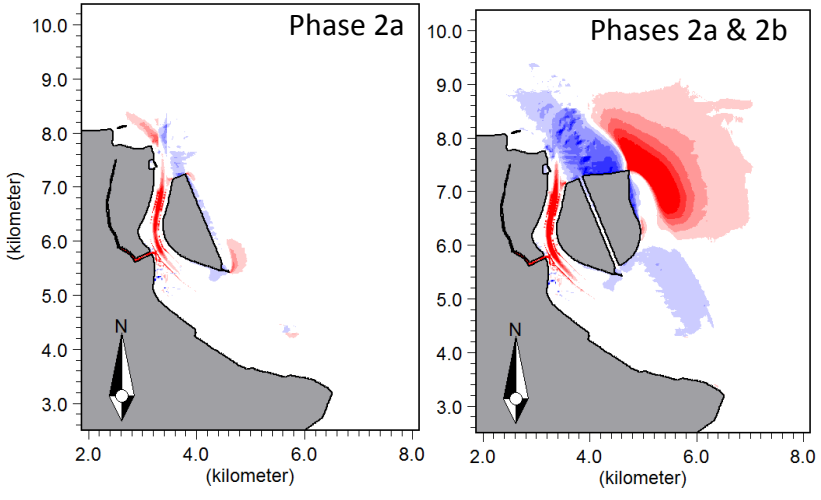
Dengan Pembangunan: STP2, Penang

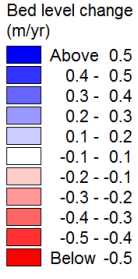


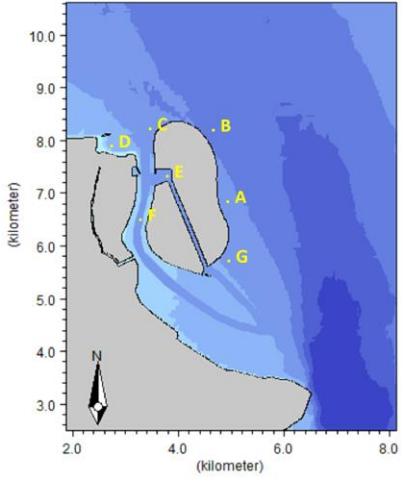


Bed level changes for existing condition

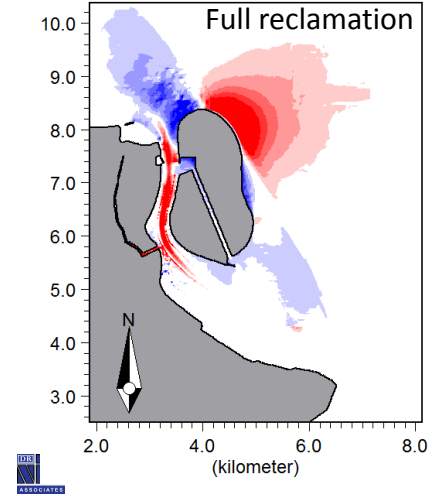
Dengan Pembangunan: STP2, Penang



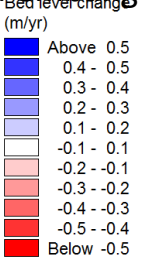




Lokasi pencerapan data enapan



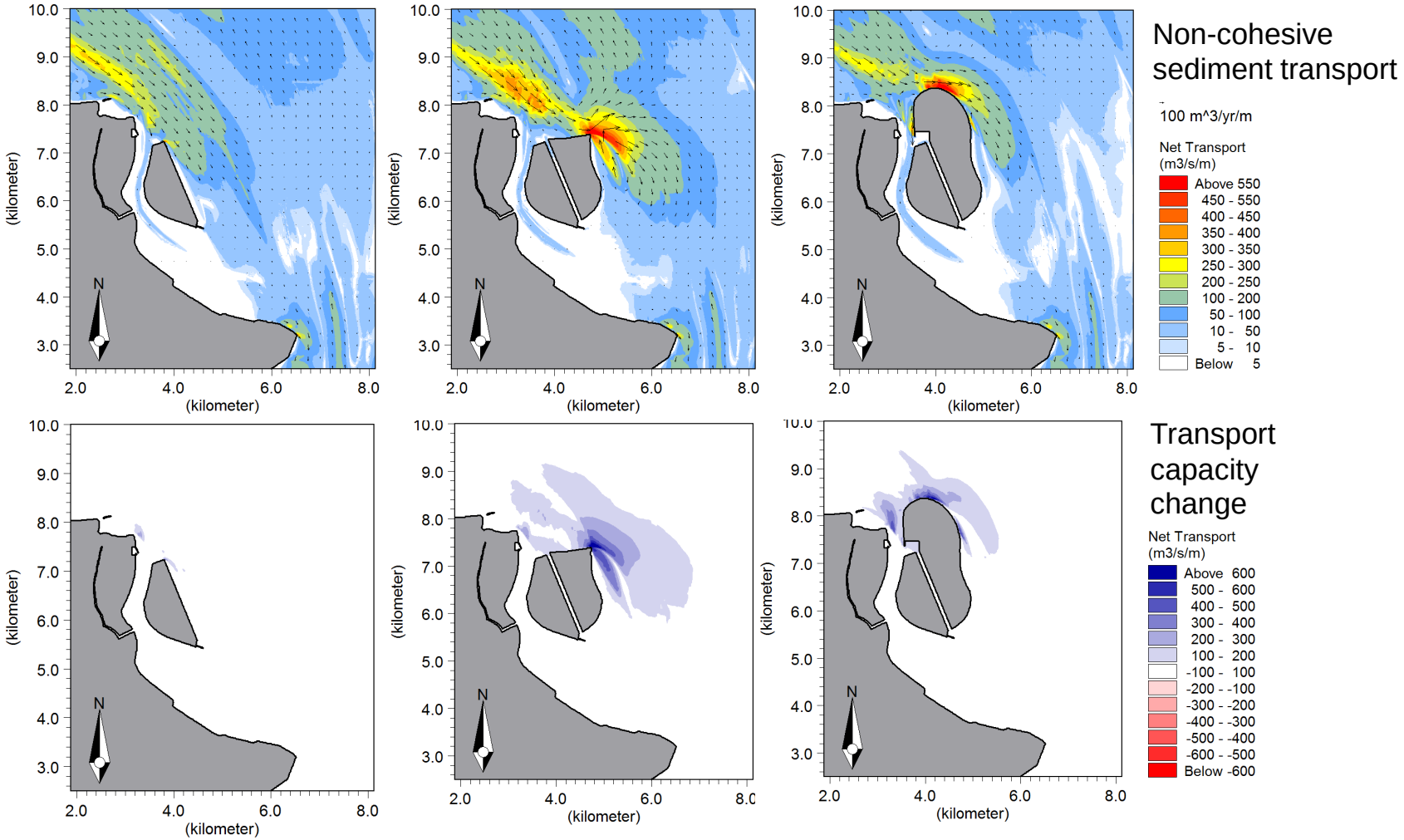
Projected annual bed level change:
Keadaan sedia ada lwn keadaan 'Dengan Pembangunan'



Kadar purata endapan

Point	Location	Kadar Purata Endapan (m/year)		
		Phase 2a	Phases 2a & 2b	Full Reclamation
A	Eastern coastline of reclamation	0.1	0.3	0.3
B	East/northeast of reclamation	-0.2	-0.3	-0.3
C	North to northwest of reclamation	0.1	0.3	0.2
D	Fishermen jetty	0.0	0.0	0.0
E	STP2 marina	0.1	0.2	0.3
F	Flushing channel	-0.4	-0.7	-0.6
G	Southeast of reclamation	-0.2	0.1	0.1

Angkutan Enapan: STP2, Penang

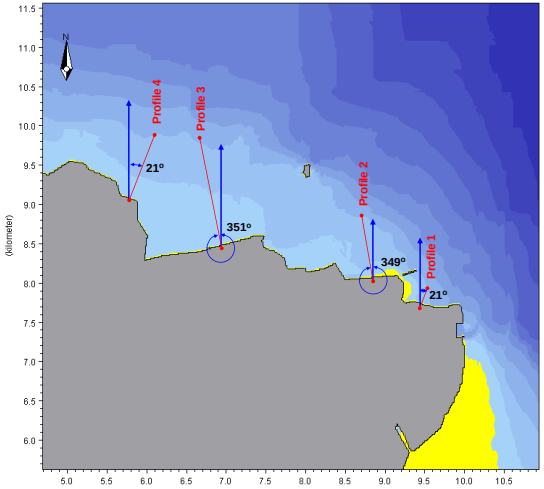


Phase 2a

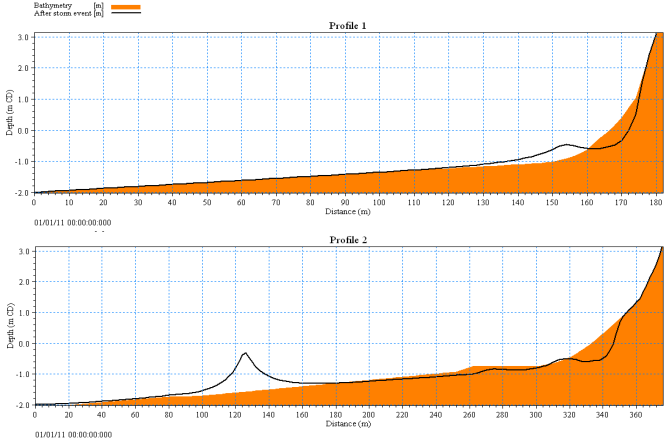
Phases 2a & 2b

Full Reclamation

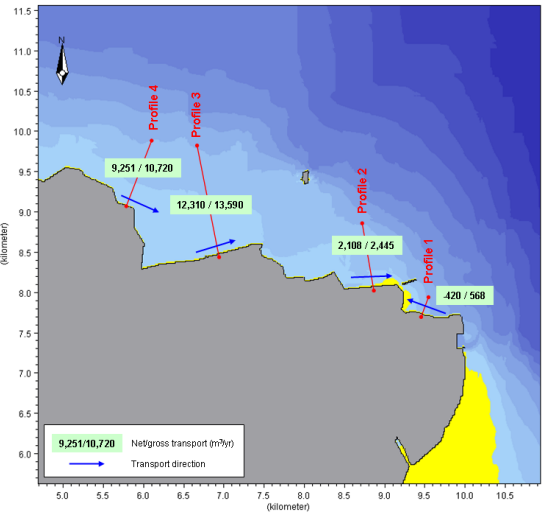
Angkutan Litoral: STP2, Penang



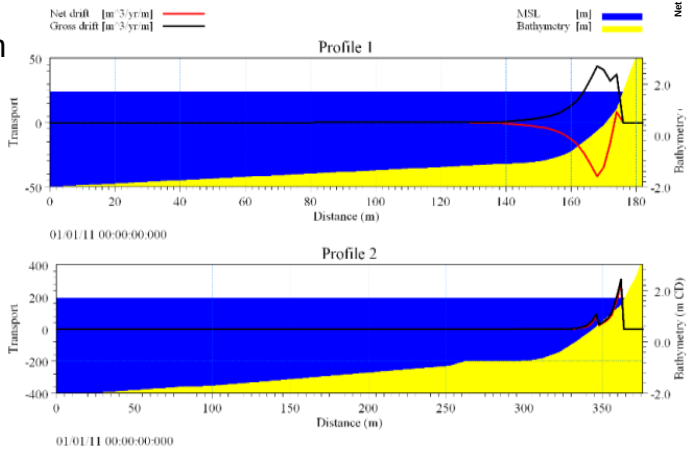
Extracted profiles



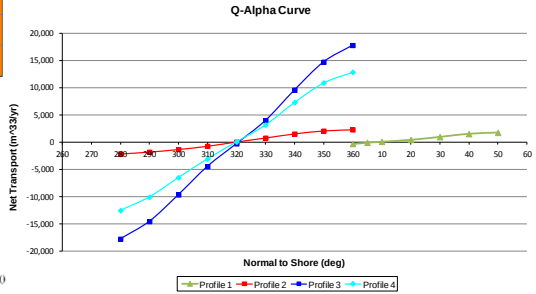
Changes after 1-year storm event



Sediment budget from Tg. Tokong to Teluk Tikus

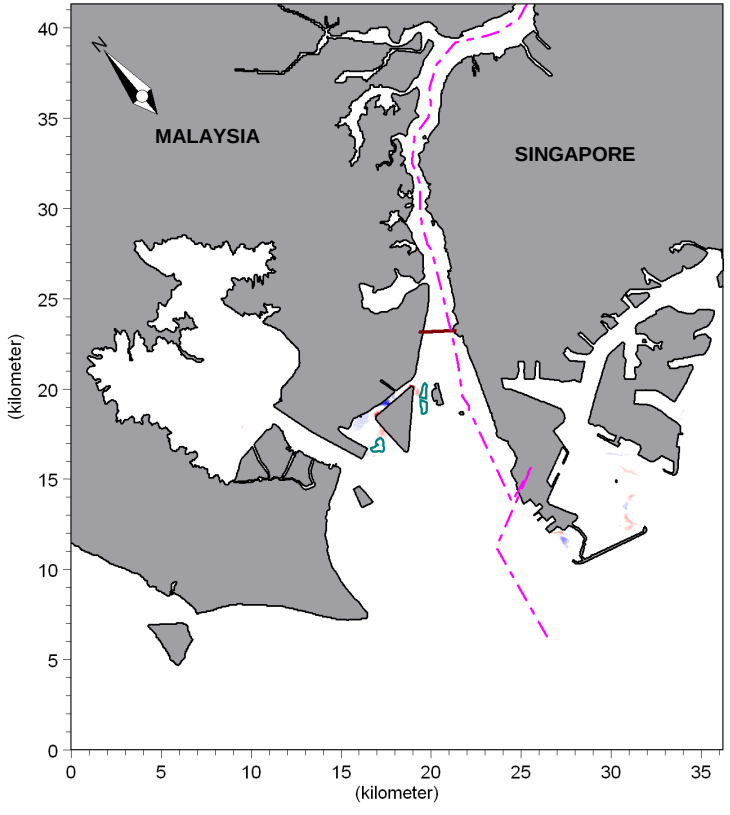


Cross-shore distribution of average annual sediment transport

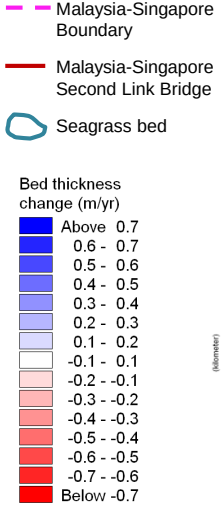


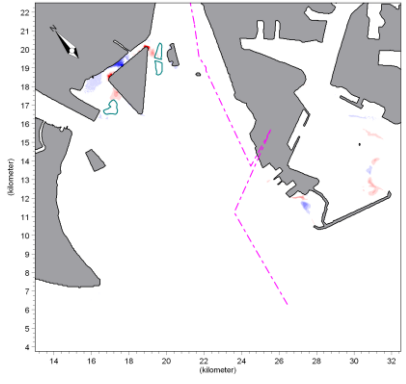
Equilibrium shoreline orientation (Q-Alpha curve)

Dengan Pembangunan: Forest City, Johor

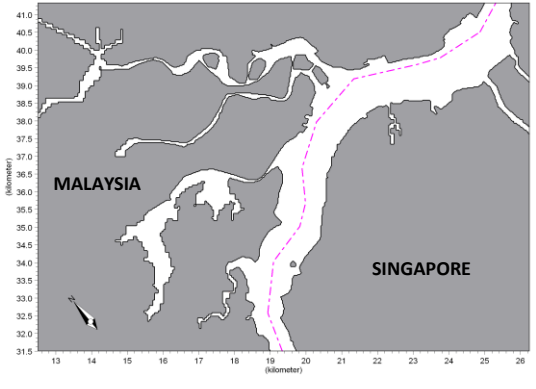


Island 1





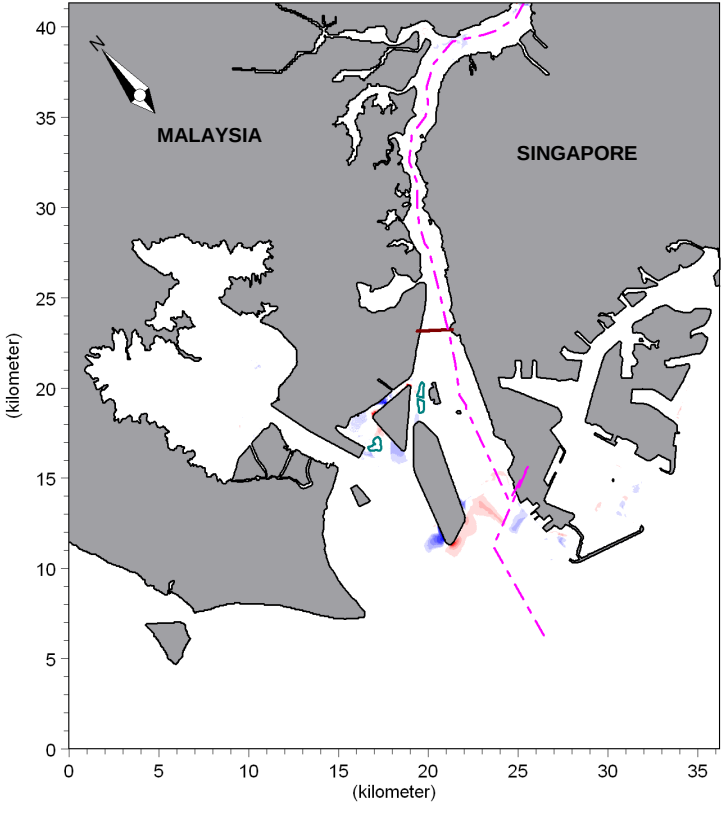
Around Project Site



Around Sungai Melayu to Causeway

Projected annual bed level change: Pre-reclamation condition vs. 'with Project' condition (Phase 1)

Dengan Pembangunan: Forest City, Johor



Islands 1 & 2

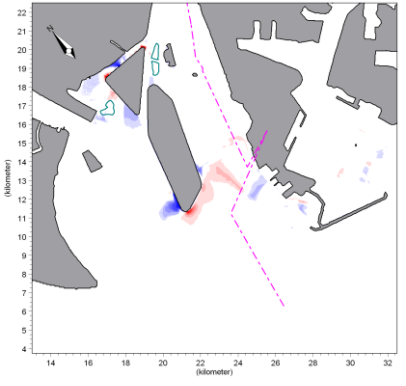
Malaysia-Singapore Boundary

Malaysia-Singapore Second Link Bridge

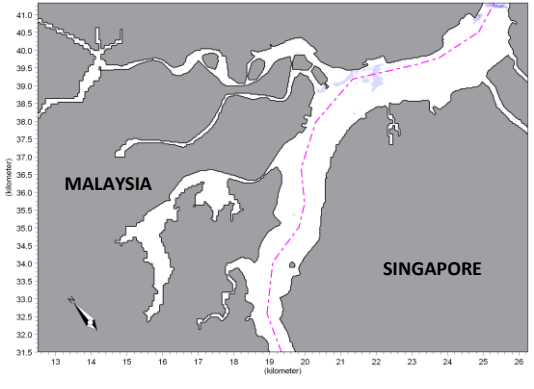
Seagrass bed

Bed thickness change (m/yr)

- Above 0.7
- 0.6 - 0.7
- 0.5 - 0.6
- 0.4 - 0.5
- 0.3 - 0.4
- 0.2 - 0.3
- 0.1 - 0.2
- -0.1 - 0.1
- -0.2 - -0.1
- -0.3 - -0.2
- -0.4 - -0.3
- -0.5 - -0.4
- -0.6 - -0.5
- -0.7 - -0.6
- Below -0.7



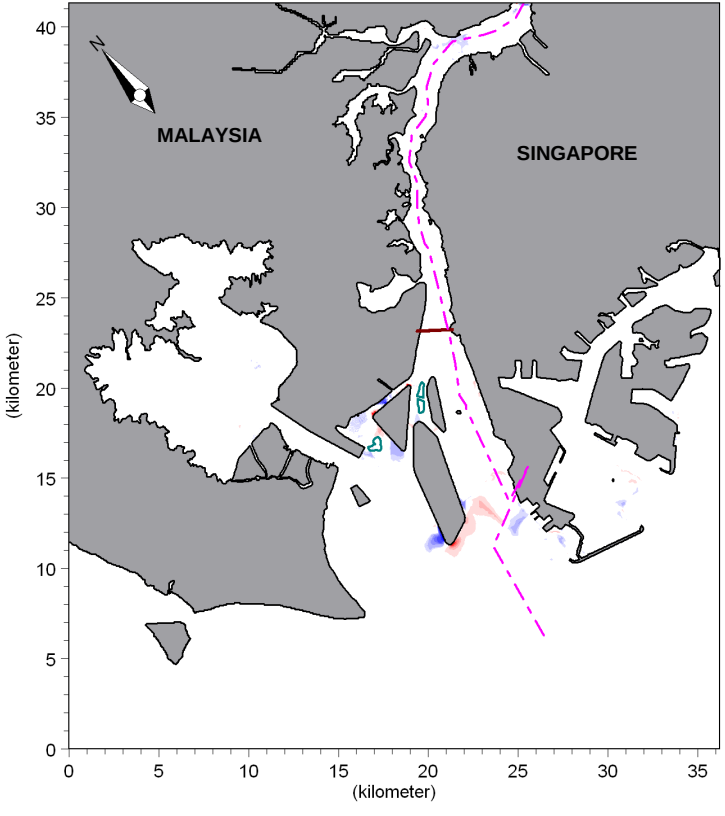
Around Project Site



Around Sungai Melayu to Causeway

Projected annual bed level change: Pre-reclamation condition vs. 'with Project' condition (Islands 1 & 2)

Dengan Pembangunan: Forest City, Johor



Islands 1, 2 & 3

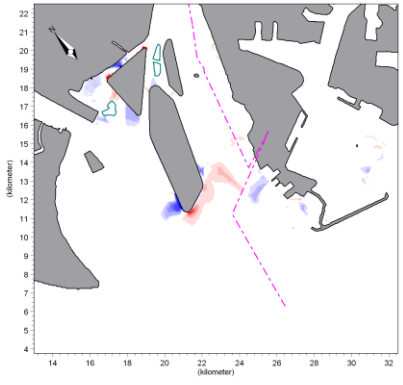
Malaysia-Singapore Boundary

Malaysia-Singapore Second Link Bridge

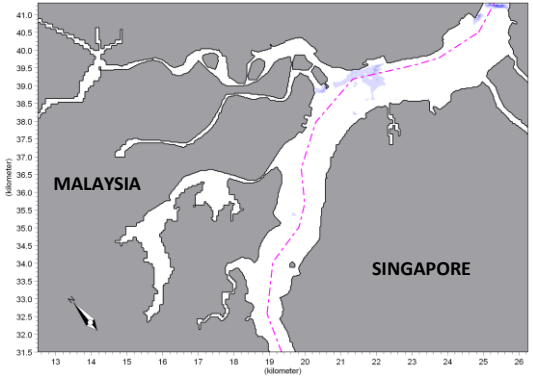
Seagrass bed

Bed thickness change (m/yr)

- Above 0.7
- 0.6 - 0.7
- 0.5 - 0.6
- 0.4 - 0.5
- 0.3 - 0.4
- 0.2 - 0.3
- 0.1 - 0.2
- -0.1 - 0.1
- -0.2 - -0.1
- -0.3 - -0.2
- -0.4 - -0.3
- -0.5 - -0.4
- -0.6 - -0.5
- -0.7 - -0.6
- Below -0.7



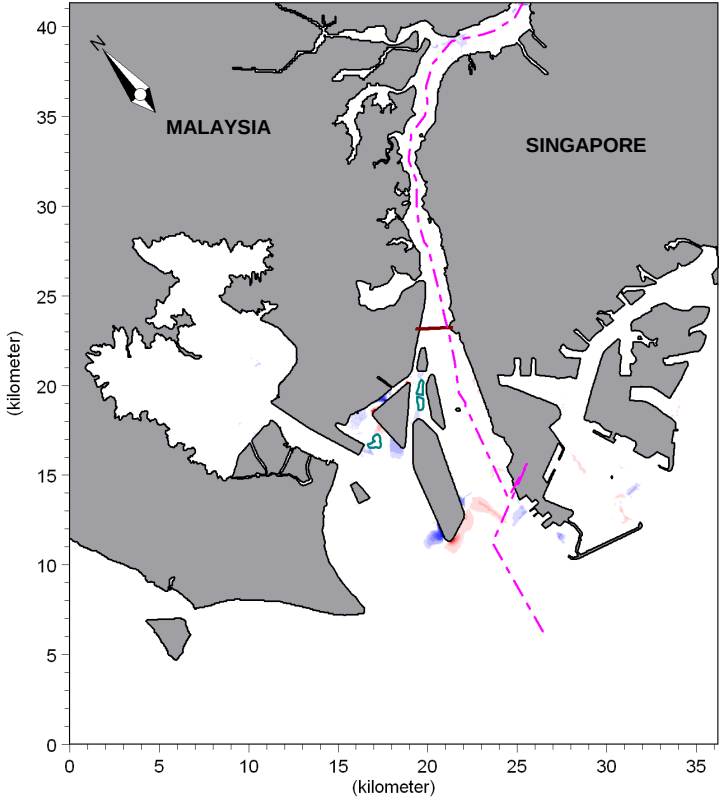
Around Project Site



Around Sungai Melayu to Causeway

Projected annual bed level change: Pre-reclamation condition vs. 'with Project' condition (Islands 1, 2 & 3)

Dengan Pembangunan: Forest City, Johor



Full Development

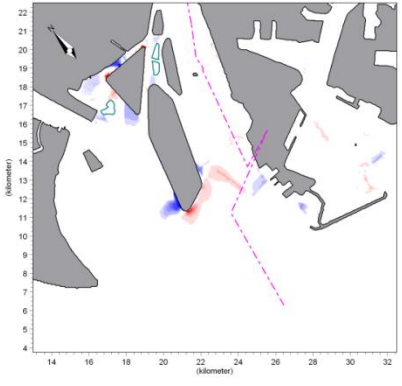
Malaysia-Singapore Boundary

Malaysia-Singapore Second Link Bridge

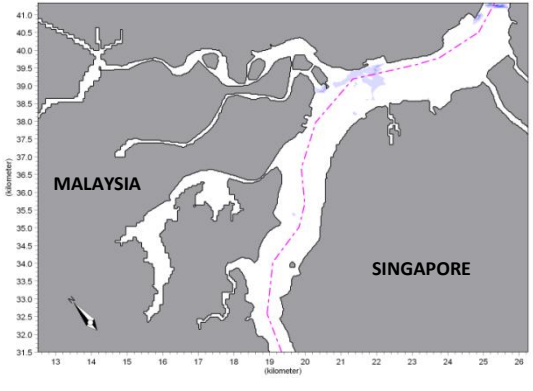
Seagrass bed

Bed thickness change (m/yr)

- Above 0.7
- 0.6 - 0.7
- 0.5 - 0.6
- 0.4 - 0.5
- 0.3 - 0.4
- 0.2 - 0.3
- 0.1 - 0.2
- -0.1 - 0.1
- -0.2 - -0.1
- -0.3 - -0.2
- -0.4 - -0.3
- -0.5 - -0.4
- -0.6 - -0.5
- -0.7 - -0.6
- Below -0.7



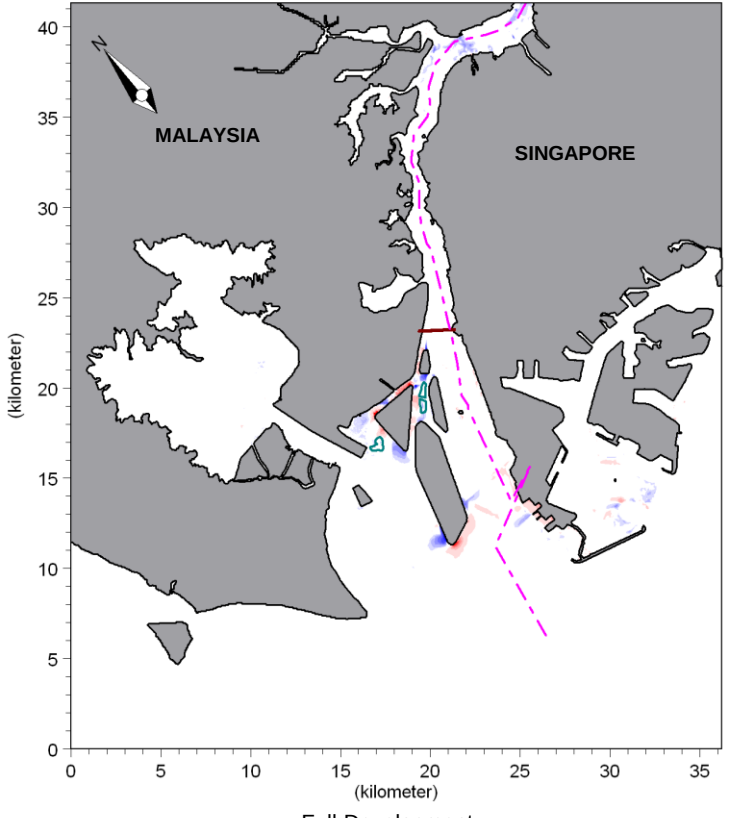
Around Project Site



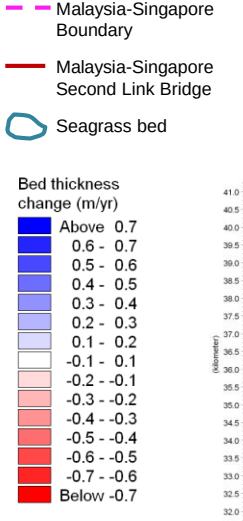
Around Sungai Melayu to Causeway

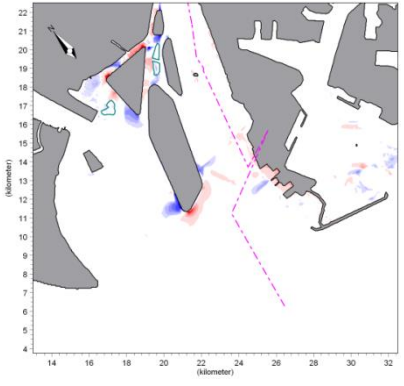
Projected annual bed level change: Pre-reclamation condition vs. Full Development condition (pure tide condition)

Dengan Pembangunan: Forest City, Johor

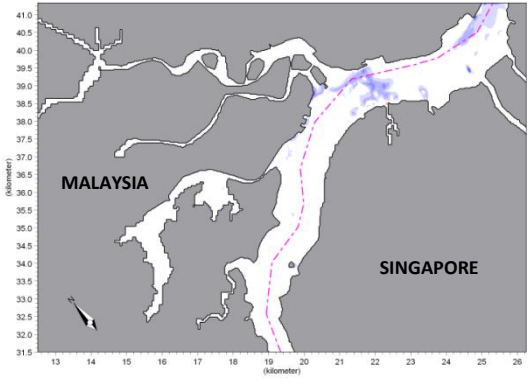


Full Development





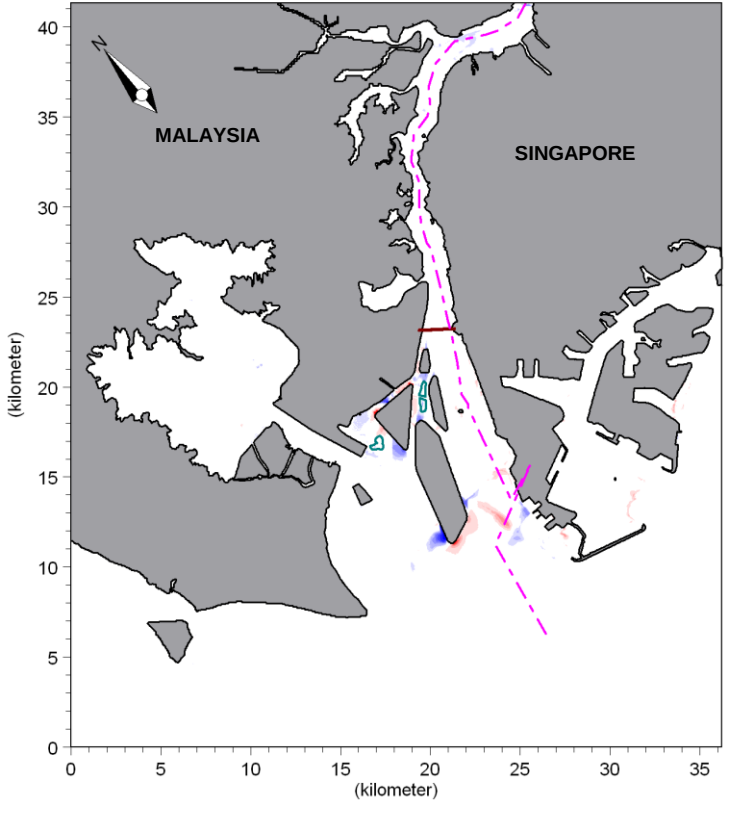
Around Project Site



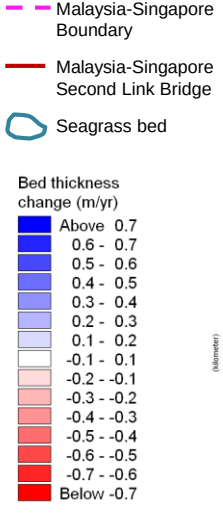
Around Sungai Melayu to Causeway

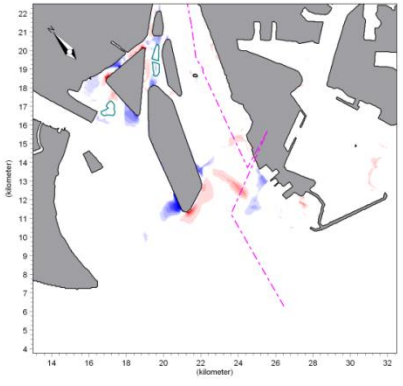
Projected annual bed level change: Pre-reclamation condition vs. Full Development condition

Dengan Pembangunan: Forest City, Johor

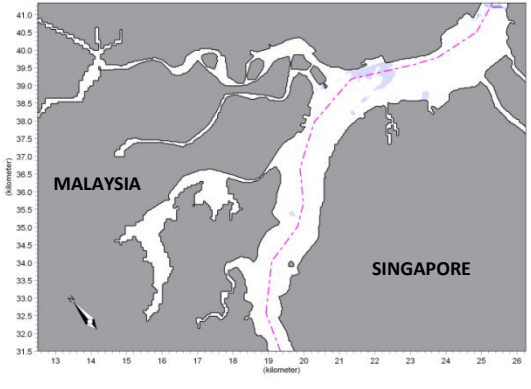


Full Development





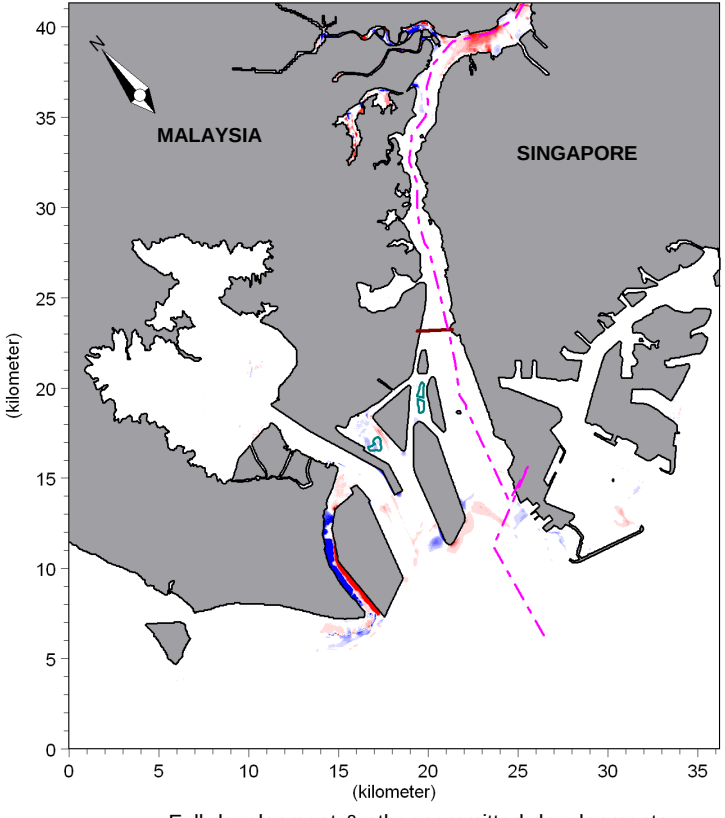
Around Project Site



Around Sungai Melayu to Causeway

Projected annual bed level change: Pre-reclamation condition vs. Full Development condition (Southwest Monsoon condition)

Dengan Pembangunan: Forest City, Johor



Full development & other committed developments

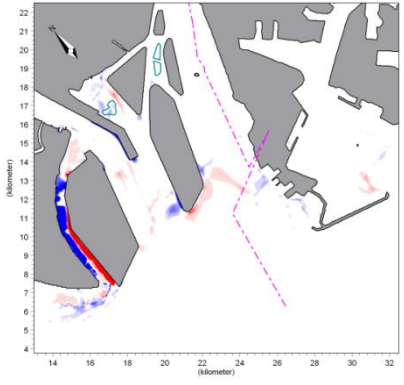
Malaysia-Singapore Boundary

Malaysia-Singapore Second Link Bridge

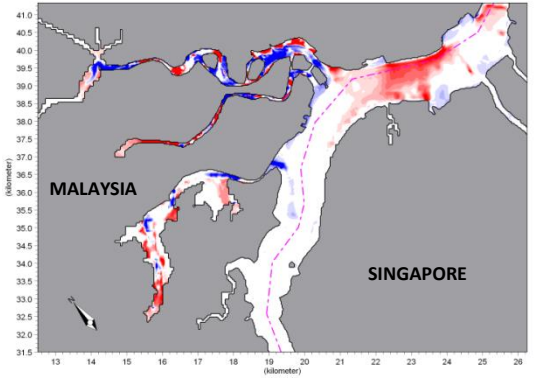
Seagrass bed

Bed thickness change (m/yr)

- Above 0.7
- 0.6 - 0.7
- 0.5 - 0.6
- 0.4 - 0.5
- 0.3 - 0.4
- 0.2 - 0.3
- 0.1 - 0.2
- -0.1 - 0.1
- -0.2 - -0.1
- -0.3 - -0.2
- -0.4 - -0.3
- -0.5 - -0.4
- -0.6 - -0.5
- -0.7 - -0.6
- Below -0.7



Around Project Site



Around Sungai Melayu to Causeway

Projected annual bed level change: Pre-reclamation condition vs. Full Development & other committed developments

Perbandingan: Forest City, Johor

Average sedimentation rates at committed development areas

Point	Average sedimentation rate (m/yr)						
	Existing Condition	Phase 1	Island 1	Islands 1 and 2	Islands 1, 2 and 3	Full Development	Full Development with Committed Development
MA	0.4	0.0	0.05	0.5	0.7	0.7	-0.3
MB	0.0	0.0	0.0	0.05	0.05	0.05	-0.3
MC	-0.05	0.0	0.0	-0.05	-0.05	-0.05	0.1
MD	0.0	0.0	0.0	0.0	0.0	0.00	-0.5
ME	0.0	0.0	0.0	0.0	0.0	0.0	0.05
MF	0.0	0.0	0.0	0.05	0.0	0.0	1.1
MG	0.0	0.0	0.0	0.0	0.0	0.0	0.1
MH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MI	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MK	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MM	0.0	0.0	0.0	0.0	0.0	0.0	0.1
MN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MO	0.0	0.0	0.0	0.0	0.0	0.0	0.7
MP	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MU	0.0	0.0	0.0	0.0	0.0	0.0	-0.0
MV	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MW	0.0	0.0	0.0	0.0	0.05	0.05	-0.1
MX	0.0	0.0	0.0	0.0	0.0	0.0	0.05
SY	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Average sedimentation rates at Environmentally Sensitive Areas (ESA)

Point	Average sedimentation rate (m/yr)						
	Existing Condition	Phase 1	Island 1	Islands 1 and 2	Islands 1, 2 and 3	Full Development	Full Development with Committed Development
SA	0.0	0.0	0.0	0.0	0.0	0.0	0.1
MB	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MF	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MG	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SI	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MK	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MN	0.0	0.0	0.0	0.1	0.1	0.1	0.0
MO	0.0	0.0	0.0	0.1	0.1	0.1	0.1
MP	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MU	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: Negative values indicate erosion

Permodelan Numerik:
Serakan Pepejal Terampai

Jenis-jenis *Dredger*

Clam shell dredger

Cutter suction dredger (CSD)

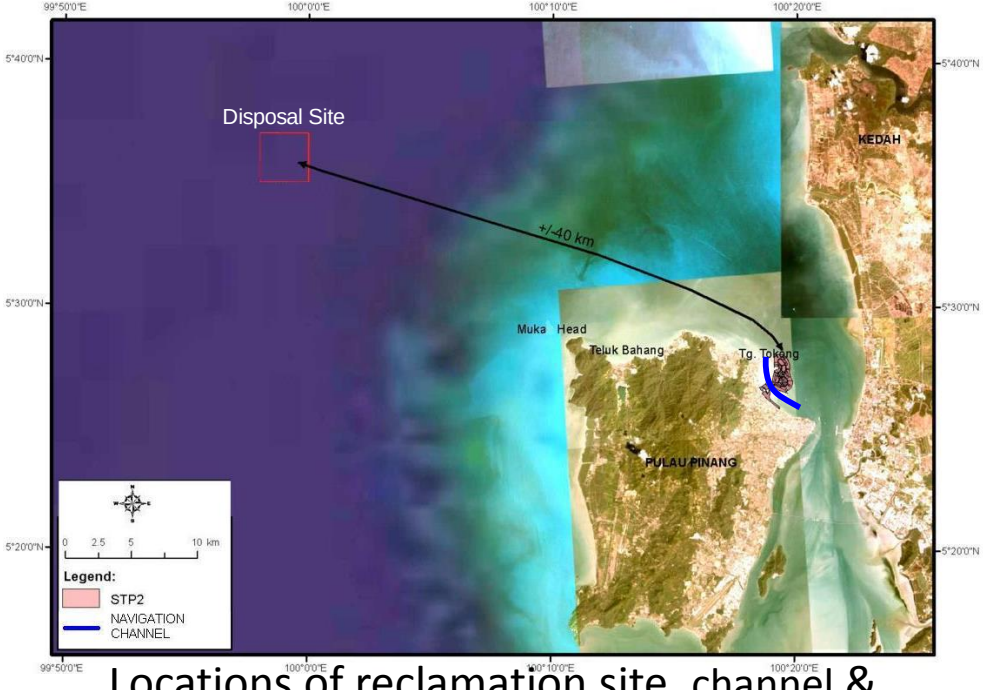
Trailing suction hopper dredger (TSHD)

Operasi *Dredger*

- Dredging conducted by a Cutter Suction Dredger (CSD)
- Dredger commences dredging from offshore towards land
- Dredged material transferred to temporary offshore disposal area via pipeline
- Dredging simulated for 12 hours operation (7.00 a.m. – 7.00 p.m.)

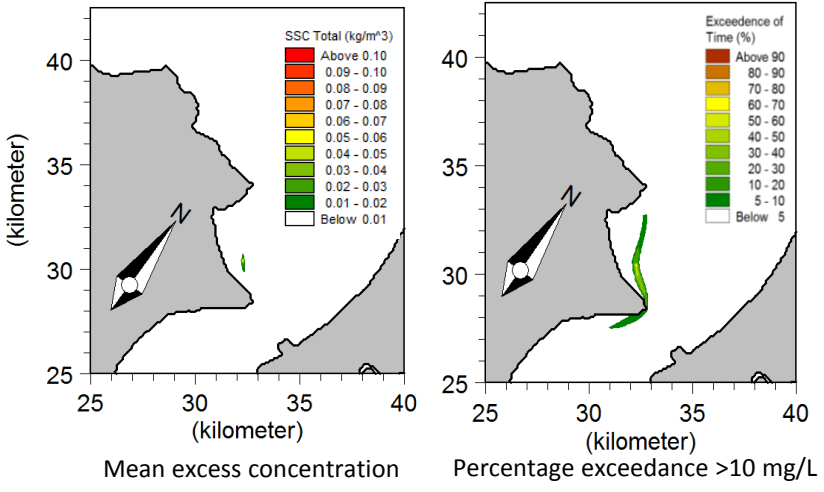
Description	Value	Source
Volume to be excavated (m^3)	250,000	Contractor
Sediment density (kg/m^3)	1,540	Analysis of seabed samples
Percentage of fines (%)	60	Analysis of seabed samples
Percentage of spill from drag head (%)	2	DID guidelines (2001)
Percentage of spill during disposal (%)	20	DID guidelines (2001)
Dredging production rate (m^3/hour)	500	Contractor
Disposal rate (m^3/hour)	200	Contractor
Daily spilled volume (tonnes)	444	Calculation

Serakan Pepejal Terampai: STP2, Penang



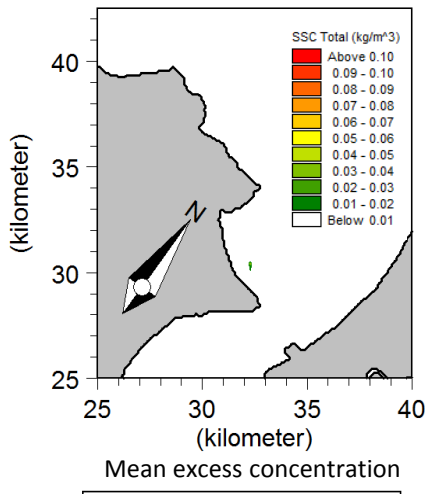
Locations of reclamation site, channel & disposal area

Serakan Pepejal Terampai: STP2, Penang

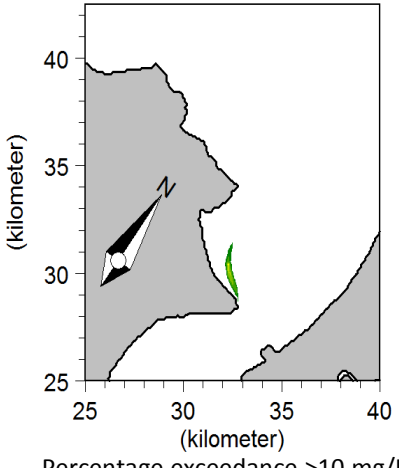


Mean excess concentration

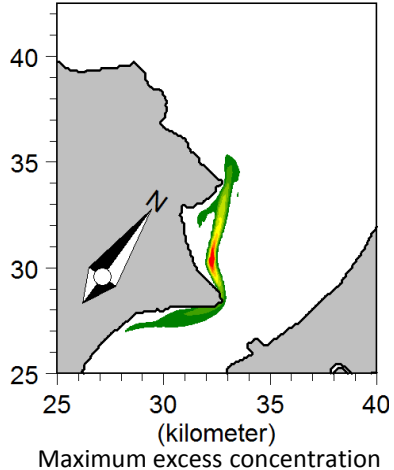
Percentage exceedance >10 mg/L



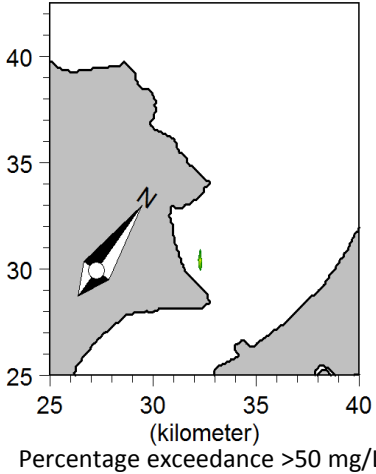
Mean excess concentration



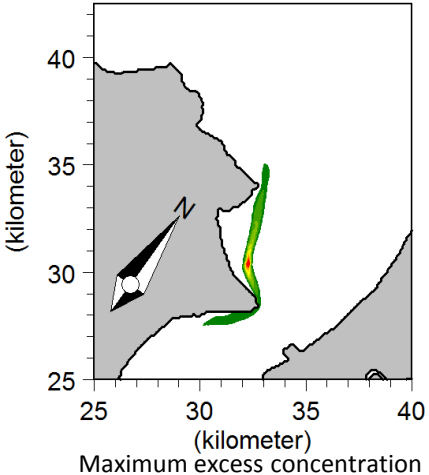
Percentage exceedance >10 mg/L



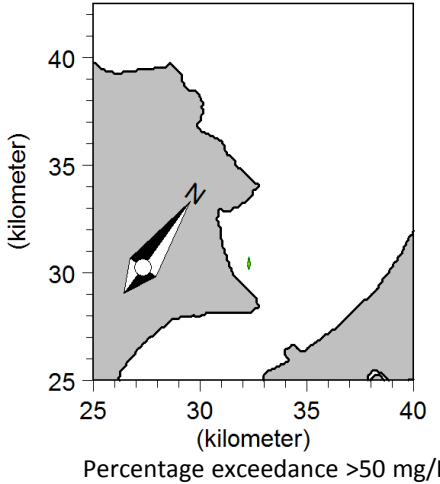
Maximum excess concentration



Percentage exceedance >50 mg/L



Maximum excess concentration

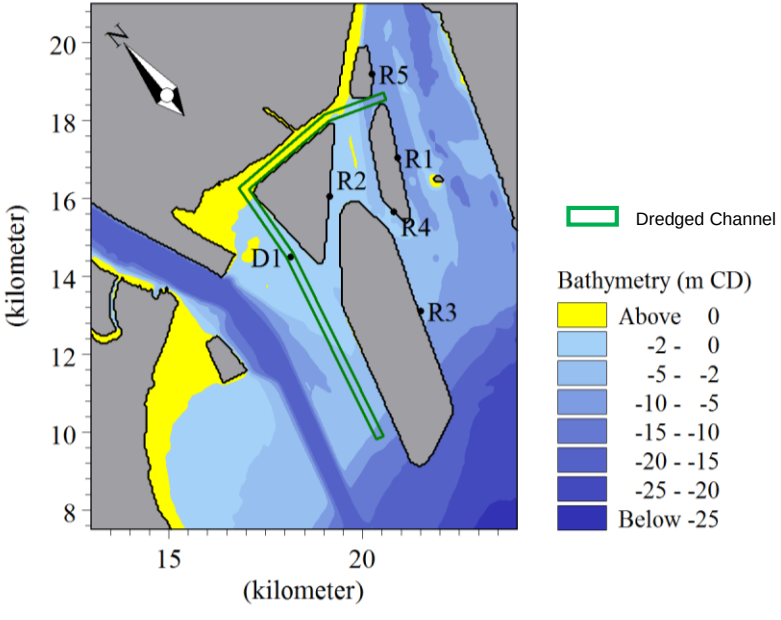


Percentage exceedance >50 mg/L

Uncontained condition

With silt curtain

Serakan Pepejal Terampai: Forest City, Johor

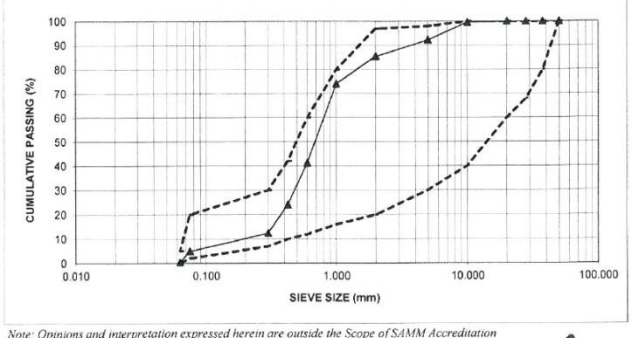


Location of source points for reclamation (R) & dredging (D) used in the sediment spill modelling

MATERIAL : B)SAND SOURCE : HH 199 (D/S : 1/6/14)

Table 2 : Particle Size Distribution (BS 812 : Part 103 : 1985)

SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	CUM. PASSING	Spec. by Customer
mm	(g)	(g)	%	%
50.000	0.0	1137.8	100	100 - 100
37.500	0.0	1137.8	100	80 - 100
28.000	0.0	1137.8	100	68 - 100
20.000	0.0	1137.8	100	60 - 100
10.000	4.3	1133.5	100	40 - 100
5.000	83.2	1050.3	92	30 - 98
2.000	76.8	973.5	86	20 - 97
1.000	129.8	843.7	74	16 - 80
0.600	374.2	469.5	41	12 - 60
0.425	195.2	274.3	24	10 - 42
0.300	132.9	141.4	12	7 - 30
0.075	84.9	56.5	5	2 - 20
0.063	52.3	4.2	0	0 - 5
PAN	4.2	0		
TOTAL	1137.8			

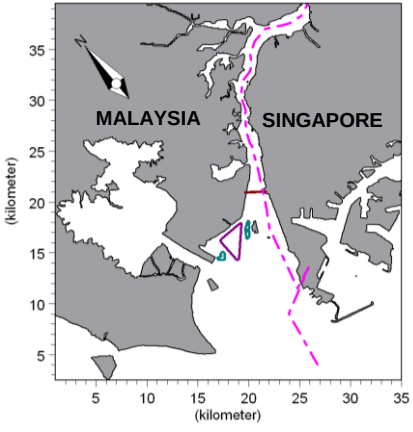


Note: Opinions and interpretation expressed herein are outside the Scope of SAMM Accreditation

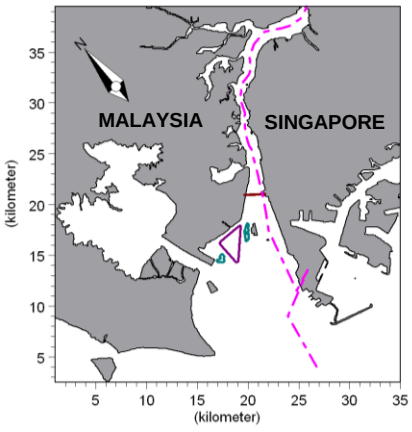
MOHD SULAIMAN BIN OMAR
GEOLAB (M) SDN BHD (210351-V)
Head of Section, Civil Lab

Particle size distribution (PSD) of fill material for proposed development

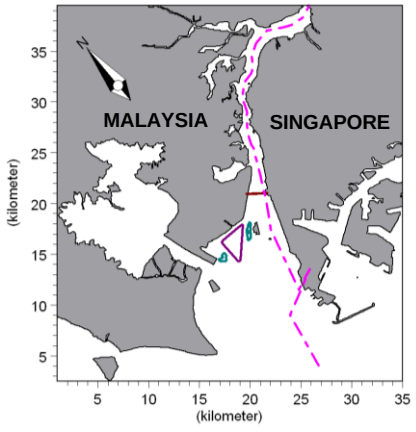
Serakan Pepejal Terampai: Forest City, Johor



Pure tide condition

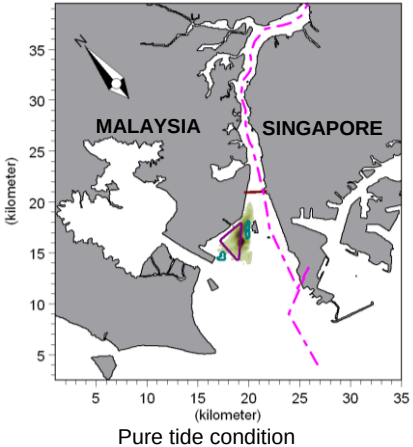


Northeast Monsoon Condition

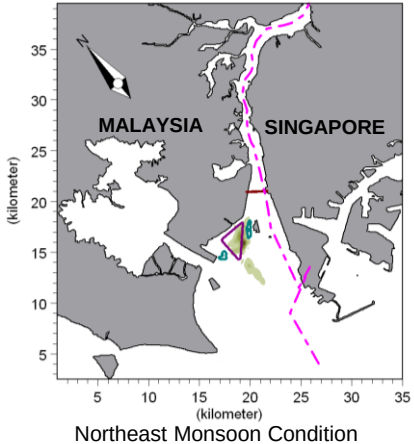


Southwest Monsoon Condition

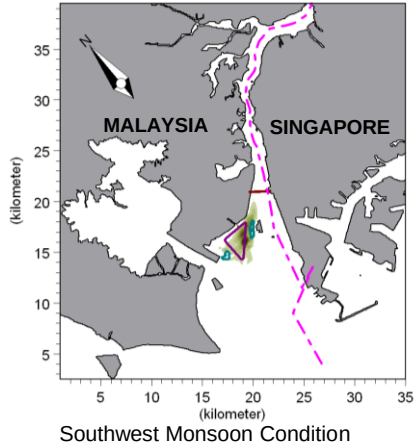
Mean excess suspended sediment concentration due to reclamation works for Island 1: Uncontained condition



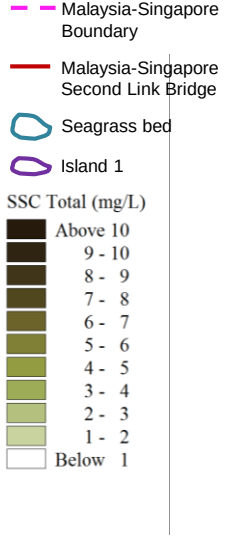
Pure tide condition



Northeast Monsoon Condition

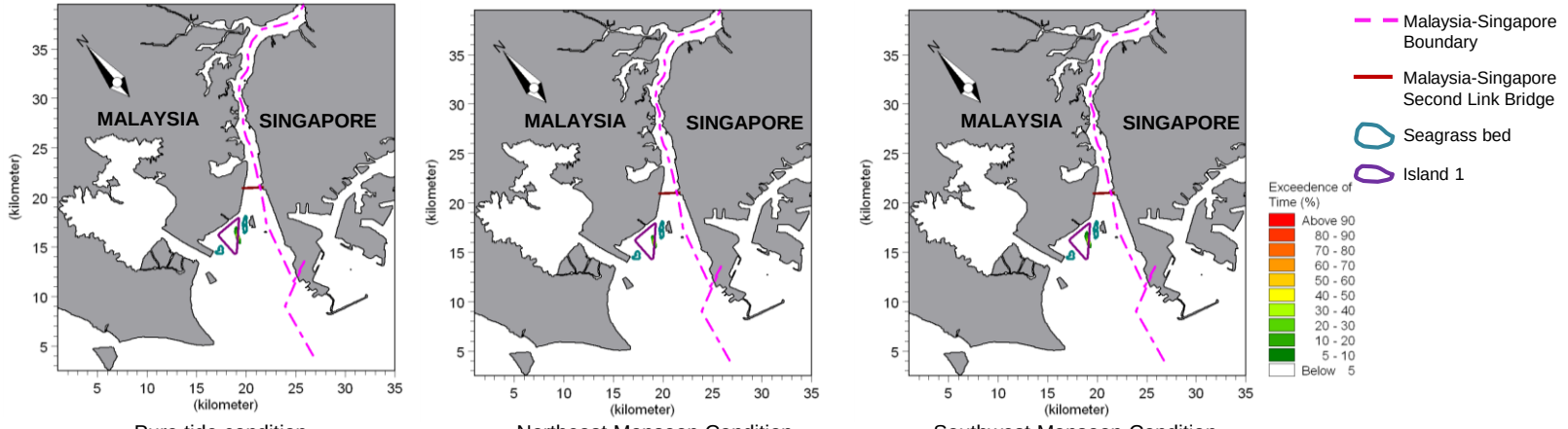


Southwest Monsoon Condition



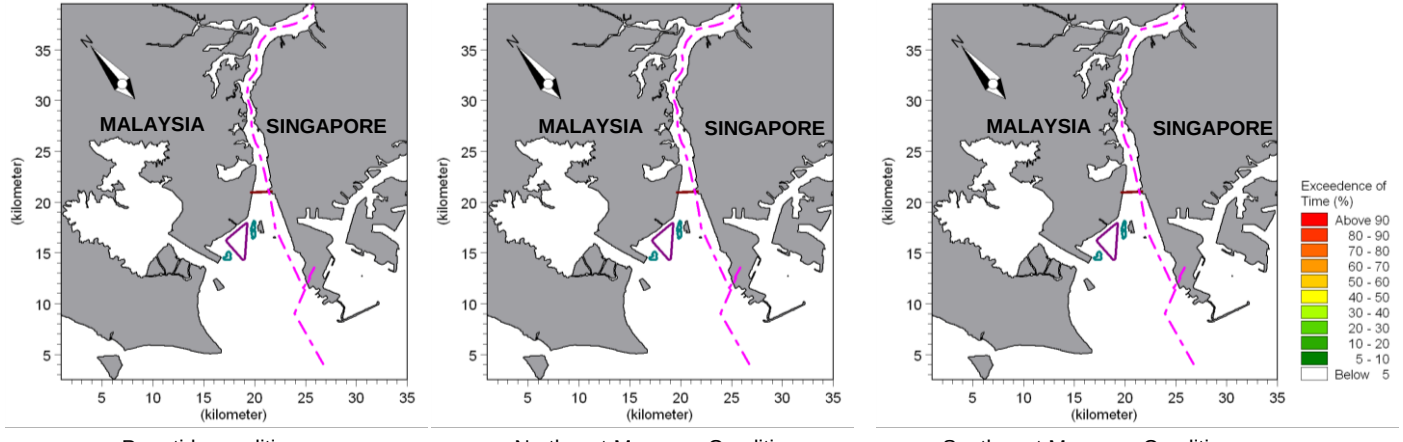
Maximum excess suspended sediment concentration due to reclamation works for Island 1: Uncontained condition

Serakan Pepejal Terampai: Forest City, Johor



Pure tide condition | Northeast Monsoon Condition | Southwest Monsoon Condition

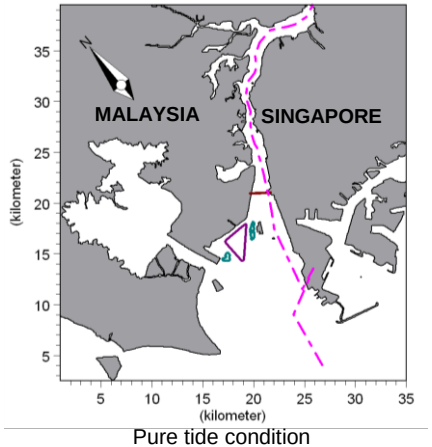
Percentage of exceedance of suspended sediment concentration above 1 mg/L due to reclamation works for Island 1: Uncontained condition



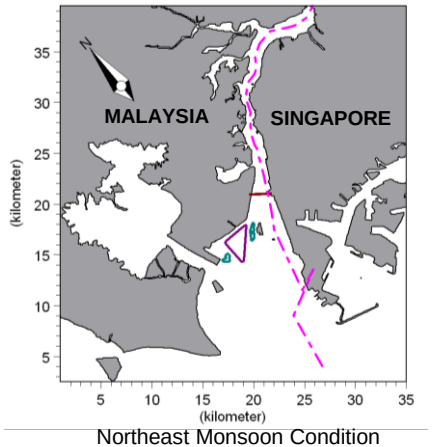
Pure tide condition | Northeast Monsoon Condition | Southwest Monsoon Condition

Percentage of exceedance of suspended sediment concentration above 5 mg/L due to reclamation works for Island 1: Uncontained condition

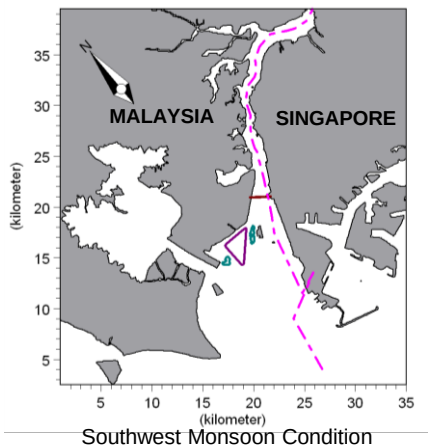
Serakan Pepejal Terampai: Forest City, Johor



Pure tide condition

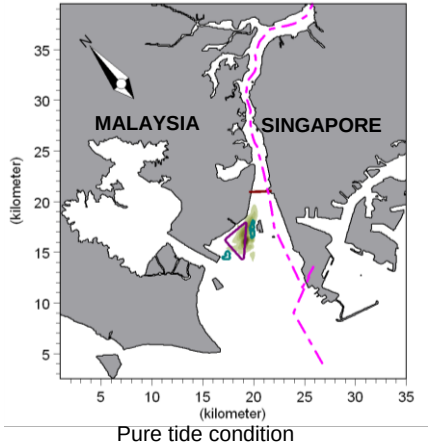


Northeast Monsoon Condition

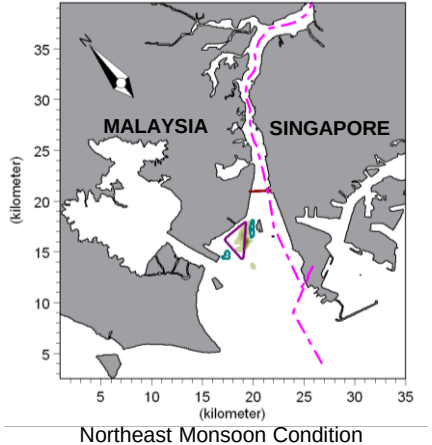


Southwest Monsoon Condition

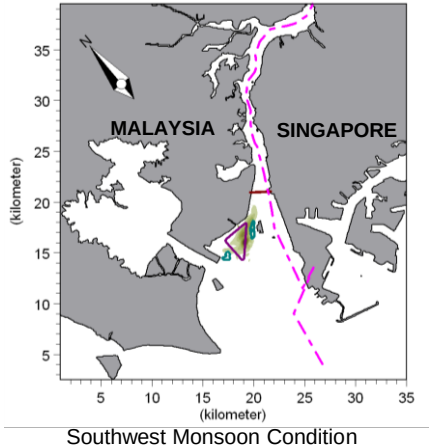
Mean excess suspended sediment concentration due to reclamation works for Island 1: With silt curtain



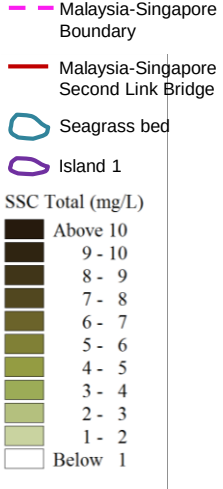
Pure tide condition



Northeast Monsoon Condition

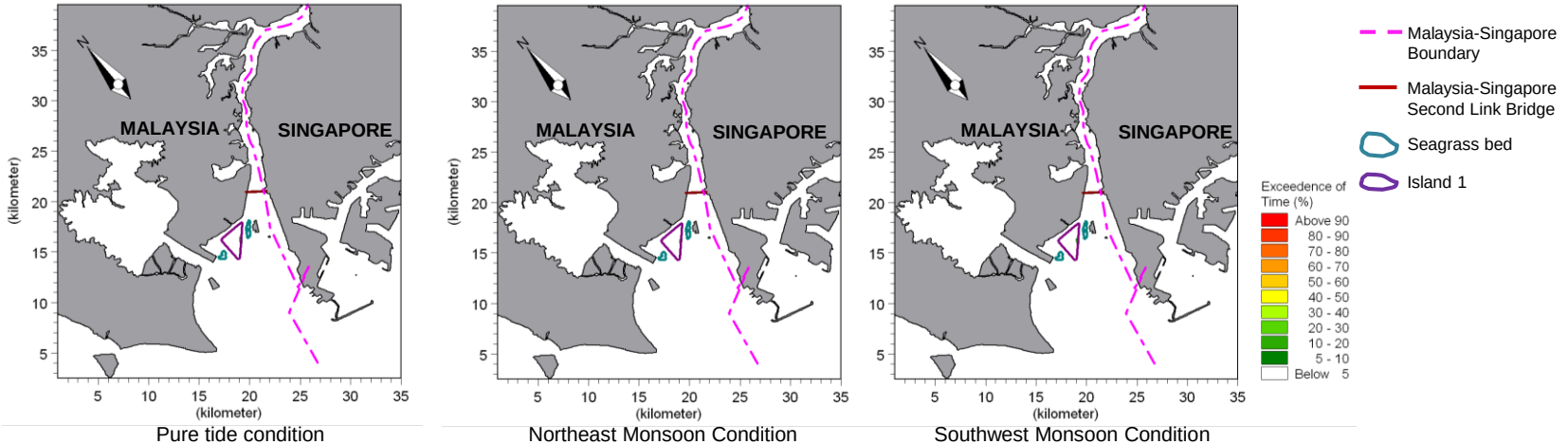


Southwest Monsoon Condition



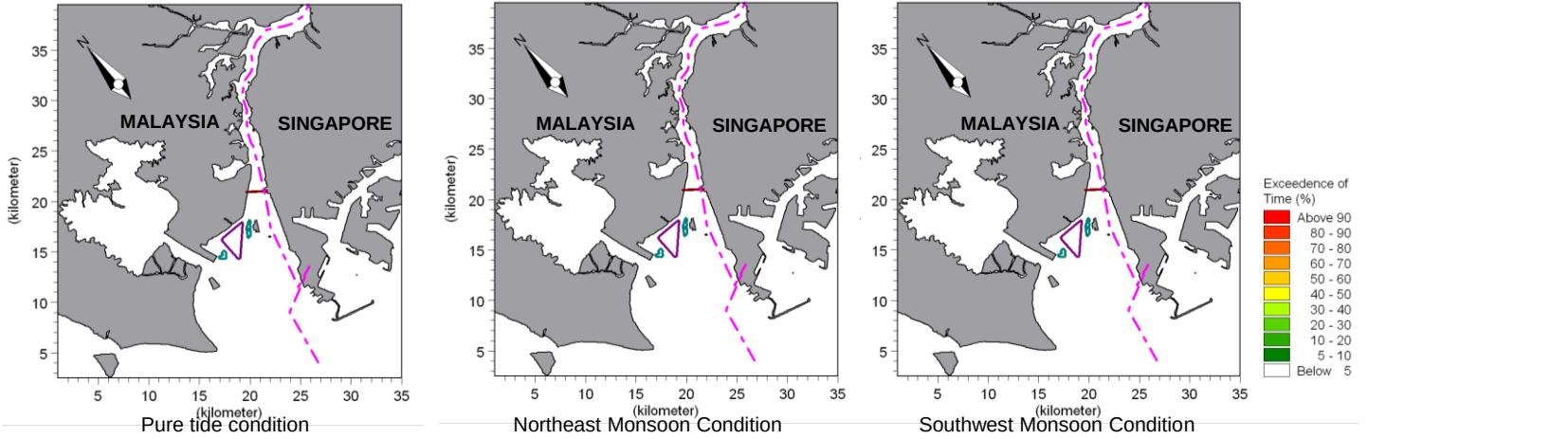
Maximum excess suspended sediment concentration due to reclamation works for Island 1: With silt curtain

Serakan Pepejal Terampai: Forest City, Johor



Pure tide condition | Northeast Monsoon Condition | Southwest Monsoon Condition

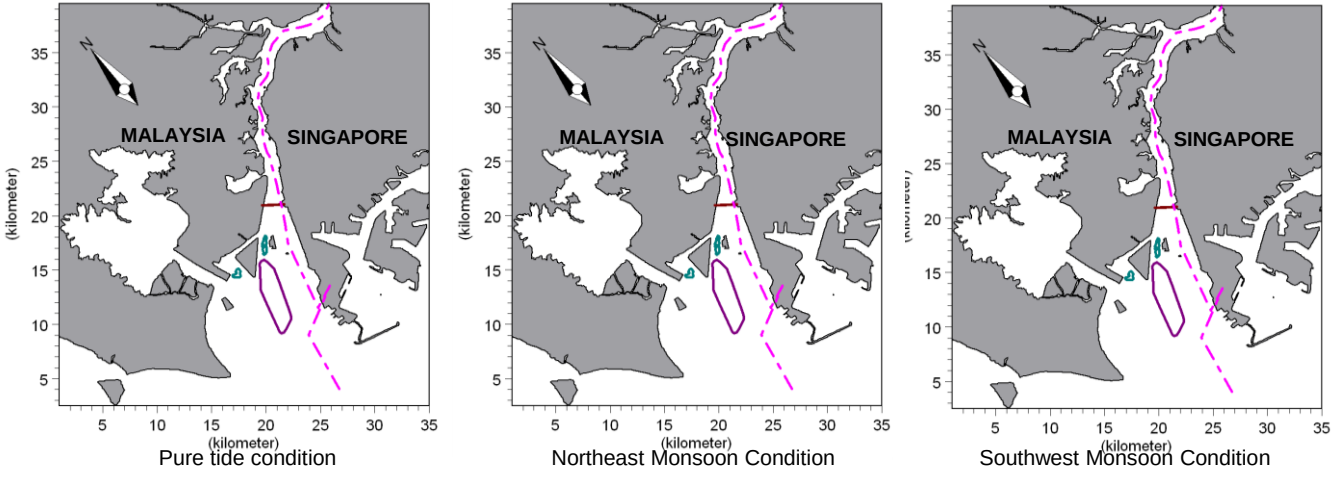
Percentage of exceedance of suspended sediment concentration above 1 mg/L due to reclamation works for Island 1: With silt curtain



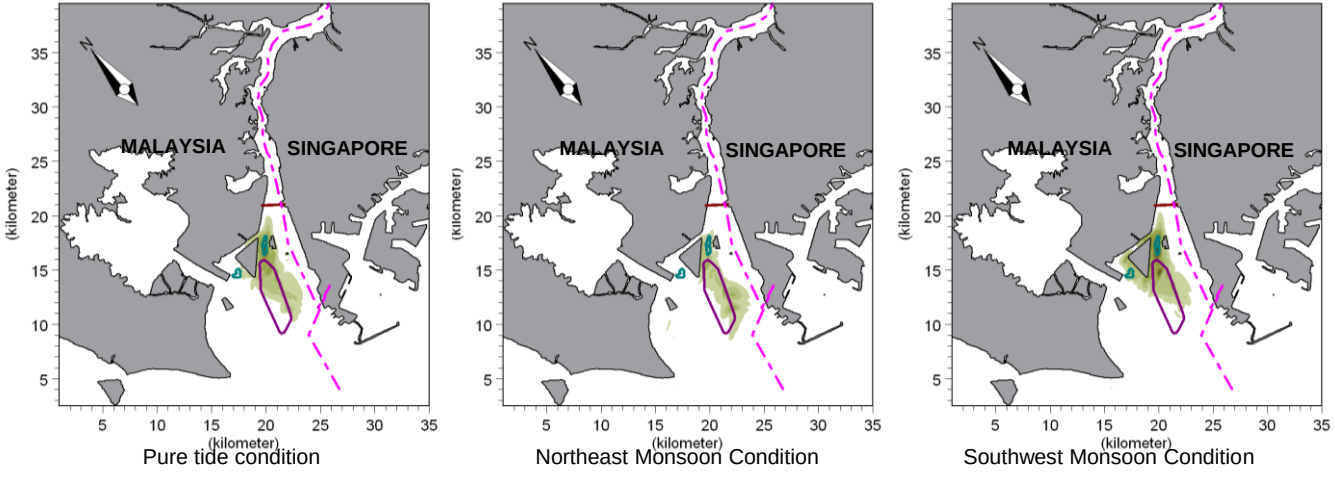
Pure tide condition | Northeast Monsoon Condition | Southwest Monsoon Condition

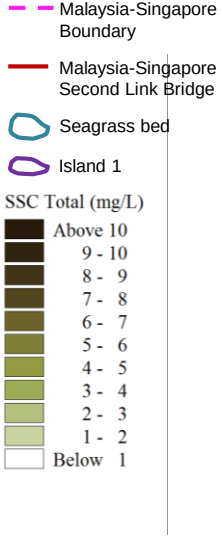
Percentage of exceedance of suspended sediment concentration above 5 mg/L due to reclamation works for Island 1: With silt curtain

Serakan Pepejal Terampai: Forest City, Johor



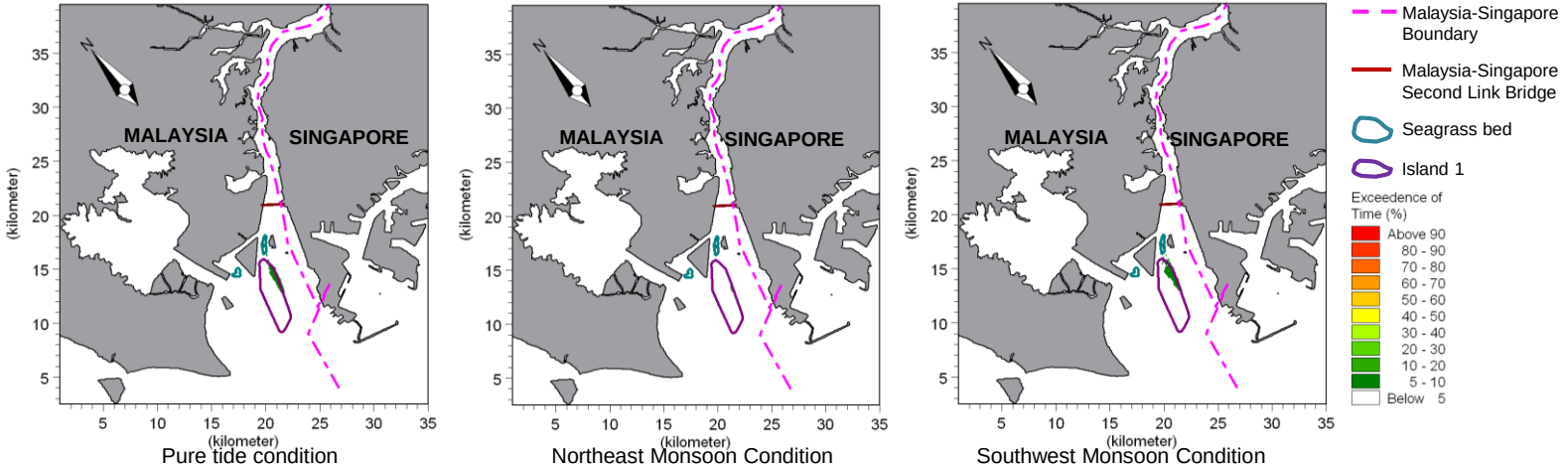
Mean excess suspended sediment concentration due to reclamation works for Island 2: Uncontained condition





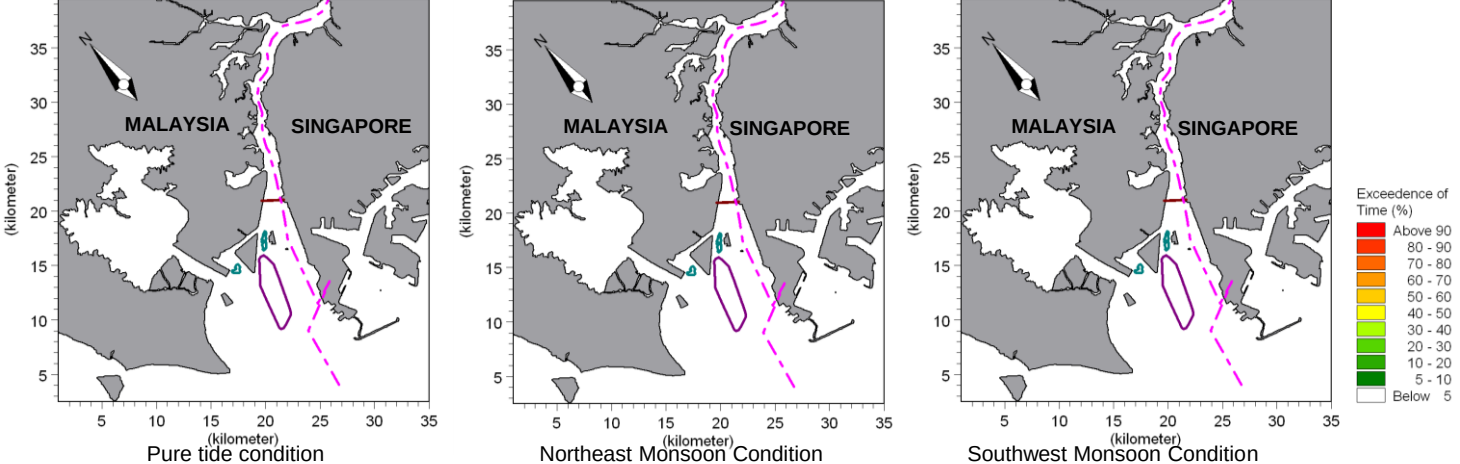
Maximum excess suspended sediment concentration due to reclamation works for Island 2: Uncontained condition

Serakan Pepejal Terampai: Forest City, Johor



Pure tide condition | Northeast Monsoon Condition | Southwest Monsoon Condition

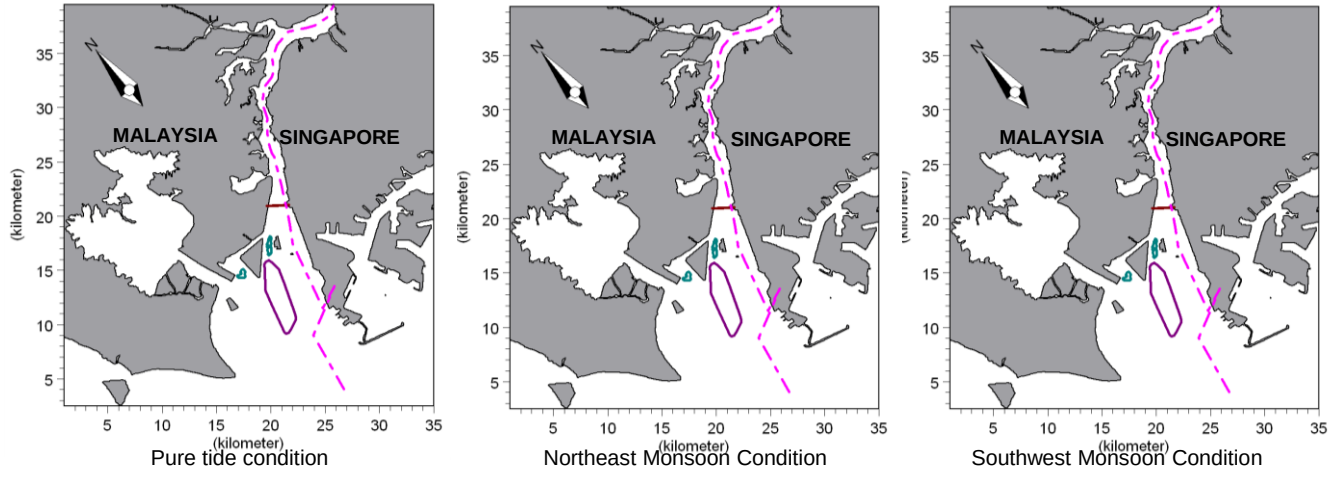
Percentage of exceedance of suspended sediment concentration above 1 mg/L due to reclamation works for Island 2: Uncontained condition



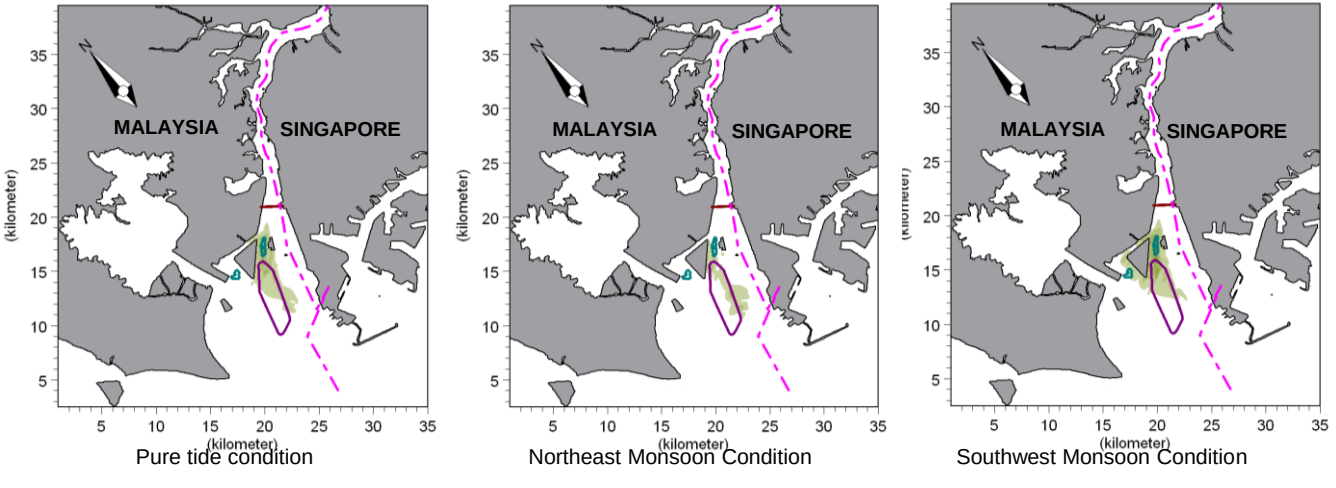
Pure tide condition | Northeast Monsoon Condition | Southwest Monsoon Condition

Percentage of exceedance of suspended sediment concentration above 5 mg/L due to reclamation works for Island 2: Uncontained condition

Serakan Pepejal Terampai: Forest City, Johor

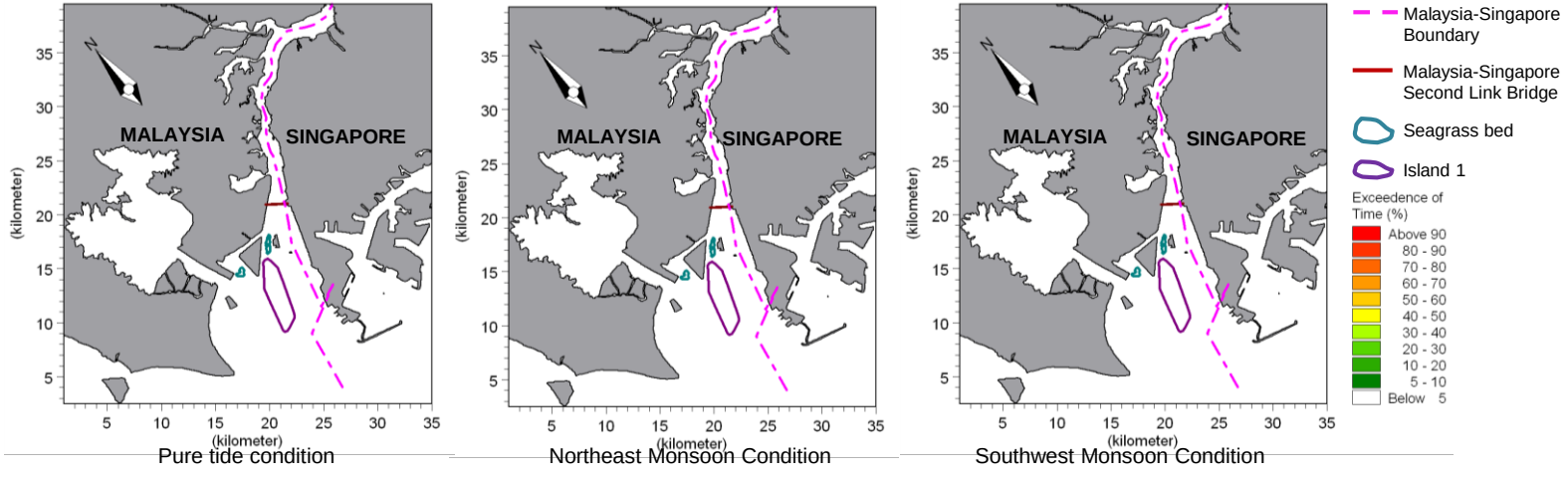


Mean excess suspended sediment concentration due to reclamation works for Island 2: With silt curtain



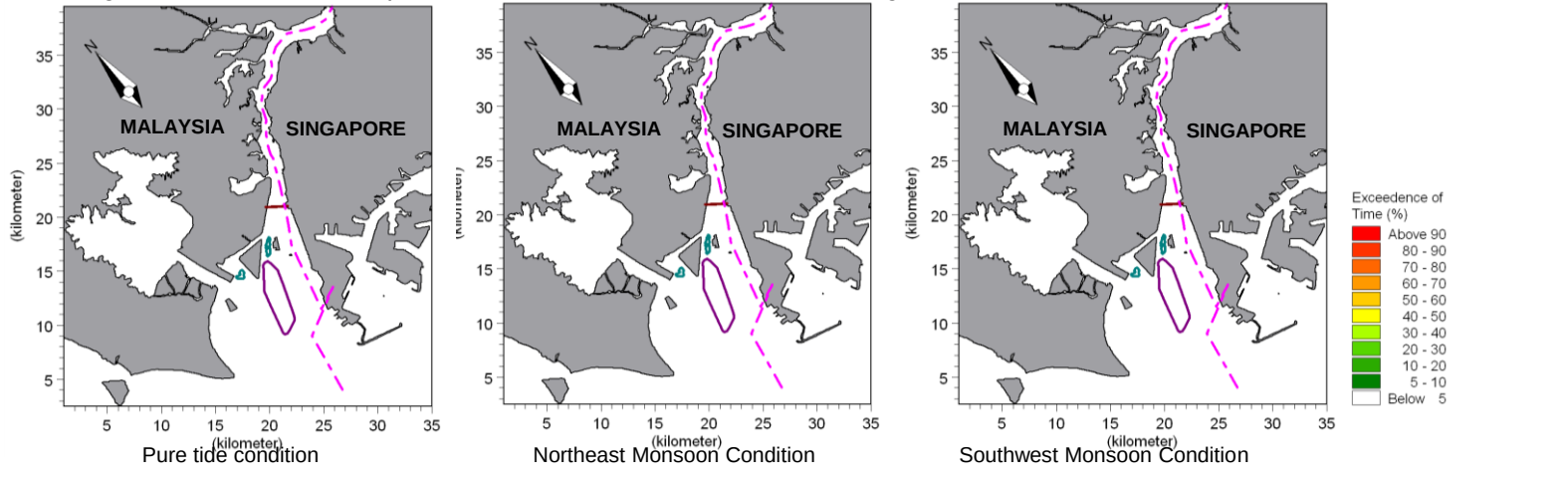
Maximum excess suspended sediment concentration due to reclamation works for Island 2: With silt curtain

Serakan Pepejal Terampai: Forest City, Johor



Pure tide condition | Northeast Monsoon Condition | Southwest Monsoon Condition

Percentage of exceedance of suspended sediment concentration above 1 mg/L due to reclamation works for Island 2: With silt curtain



Pure tide condition | Northeast Monsoon Condition | Southwest Monsoon Condition

Percentage of exceedance of suspended sediment concentration above 5 mg/L due to reclamation works for Island 2: With silt curtain

Serakan Pepejal Terampai: Forest City, Johor

Mean excess suspended sediment concentrations at Environmentally Sensitive Areas (uncontained condition)

Point	Location	Excess Concentration (mg/L)				
		Phase 1	Island 1	Island 2	Island 3	Full Development
SA	Sungei Buloh Wetland	0	0	0	0	0
MB	Aquaculture at Sungai Melayu	0	0	0	0	0
MC	Mangroves at Sungai Melayu	0	0	0	0	0
MD	Mangroves at Sungai Bahan	0	0	0	0	0
SE	Mangroves at Pergam	0	0	0	0	0
MF	Mangroves at Sungai Kemudi	0	0	0	0	0
MG	Aquaculture at Sungai Pendas	0	0	0	0	0
MH	Mangroves at Sungai Pendas	0	0	0	0	0
SI	Tuas Checkpoint	0	0	0	0	0
SJ	Merawang Beacon	0	0	0	0	0
MK	Pulau Merambong	0	0	0	0	0
ML	Mangroves along Tanjung Kupang	0	0	0	0	0
MM	Merambong Shoal	0	0	0	0	0
MN	Tanjung Adang	0	0	0	0	0
MO	Tanjung Adang Shoal	0	0	0	0	0
MP	Sungai Pulai Ramsar site	0	0	0	0	0
MQ	Tanjung Piai bird habitat	0	0	0	0	0
MR	Tanjung Piai Ramsar site	0	0	0	0	0
MS	Aquaculture at Kukup	0	0	0	0	0
MT	Pulau Kukup Ramsar site	0	0	0	0	0
MU	Pulau Kukup mudflat	0	0	0	0	0

Mean excess suspended sediment concentrations at Environmentally Sensitive Areas (with sit curtain)

Point	Location	Excess Concentration (mg/L)				
		Phase 1	Island 1	Island 2	Island 3	Full Development
SA	Sungei Buloh Wetland	0	0	0	0	0
MB	Aquaculture at Sungai Melayu	0	0	0	0	0
MC	Mangroves at Sungai Melayu	0	0	0	0	0
MD	Mangroves at Sungai Bahan	0	0	0	0	0
SE	Mangroves at Pergam	0	0	0	0	0
MF	Mangroves at Sungai Kemudi	0	0	0	0	0
MG	Aquaculture at Sungai Pendas	0	0	0	0	0
MH	Mangroves at Sungai Pendas	0	0	0	0	0
SI	Tuas Checkpoint	0	0	0	0	0
SJ	Merawang Beacon	0	0	0	0	0
MK	Pulau Merambong	0	0	0	0	0
ML	Mangroves along Tanjung Kupang	0	0	0	0	0
MM	Merambong Shoal	0	0	0	0	0
MN	Tanjung Adang	0	0	0	0	0
MO	Tanjung Adang Shoal	0	0	0	0	0
MP	Sungai Pulai Ramsar site	0	0	0	0	0
MQ	Tanjung Piai bird habitat	0	0	0	0	0
MR	Tanjung Piai Ramsar site	0	0	0	0	0
MS	Aquaculture at Kukup	0	0	0	0	0
MT	Pulau Kukup Ramsar site	0	0	0	0	0
MU	Pulau Kukup mudflat	0	0	0	0	0

Serakan Pepejal Terampai: Forest City, Johor

Maximum excess suspended sediment concentrations at Environmentally Sensitive Areas (uncontained condition)

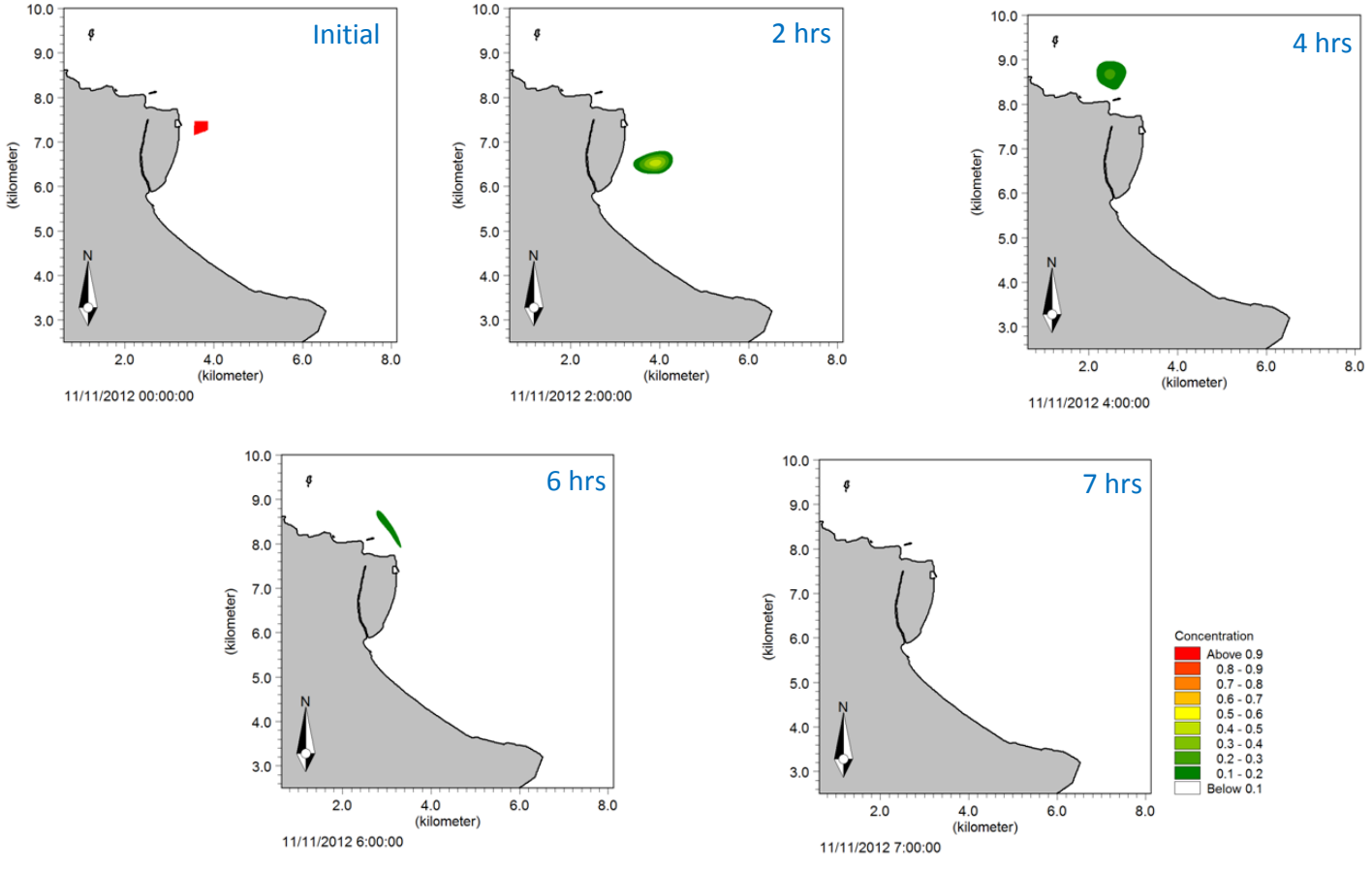
Point	Location	Excess Concentration (mg/L)				
		Phase 1	Island 1	Island 2	Island 3	Full Development
SA	Sungei Buloh Wetland	1	1	1	1	1
MB	Aquaculture at Sungai Melayu	1	1	1	1	1
MC	Mangroves at Sungai Melayu	1	1	1	1	1
MD	Mangroves at Sungai Bahan	1	1	1	1	1
SE	Mangroves at Pergam	1	1	1	1	1
MF	Mangroves at Sungai Kemudi	1	1	1	1	1
MG	Aquaculture at Sungai Pendas	1	1	1	1	1
MH	Mangroves at Sungai Pendas	1	1	1	1	1
SI	Tuas Checkpoint	1	1	1	1	1
SJ	Merawang Beacon	1	1	1	1	1
MK	Pulau Merambong	1	1	1	1	1
ML	Mangroves along Tanjung Kupang	1	1	1	1	1
MM	Merambong Shoal	1	1	1	1	1
MN	Tanjung Adang	1	1	1	1	1
MO	Tanjung Adang Shoal	1	1	1	1	1
MP	Sungai Pulai Ramsar site	1	1	1	1	1
MQ	Tanjung Piai bird habitat	1	1	1	1	1
MR	Tanjung Piai Ramsar site	1	1	1	1	1
MS	Aquaculture at Kukup	1	1	1	1	1
MT	Pulau Kukup Ramsar site	1	1	1	1	1
MU	Pulau Kukup mudflat	1	1	1	1	1

Maximum excess suspended sediment concentrations at Environmentally Sensitive Areas (with sit curtain)

Point	Location	Excess Concentration (mg/L)				
		Phase 1	Island 1	Island 2	Island 3	Full Development
SA	Sungei Buloh Wetland	1	1	1	1	1
MB	Aquaculture at Sungai Melayu	1	1	1	1	1
MC	Mangroves at Sungai Melayu	1	1	1	1	1
MD	Mangroves at Sungai Bahan	1	1	1	1	1
SE	Mangroves at Pergam	1	1	1	1	1
MF	Mangroves at Sungai Kemudi	1	1	1	1	1
MG	Aquaculture at Sungai Pendas	1	1	1	1	1
MH	Mangroves at Sungai Pendas	1	1	1	1	1
SI	Tuas Checkpoint	1	1	1	1	1
SJ	Merawang Beacon	1	1	1	1	1
MK	Pulau Merambong	1	1	1	1	1
ML	Mangroves along Tanjung Kupang	1	1	1	1	1
MM	Merambong Shoal	1	1	1	1	1
MN	Tanjung Adang	1	1	1	1	1
MO	Tanjung Adang Shoal	1	1	1	1	1
MP	Sungai Pulai Ramsar site	1	1	1	1	1
MQ	Tanjung Piai bird habitat	1	1	1	1	1
MR	Tanjung Piai Ramsar site	1	1	1	1	1
MS	Aquaculture at Kukup	1	1	1	1	1
MT	Pulau Kukup Ramsar site	1	1	1	1	1
MU	Pulau Kukup mudflat	1	1	1	1	1

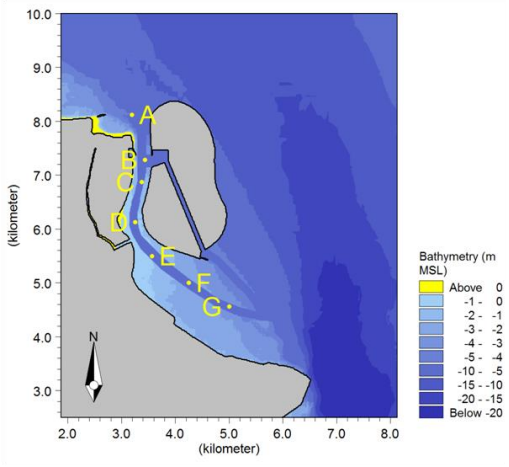
Permodelan Numerik: *Flushing*

Flushing (advection-dispersion): STP2, Penang

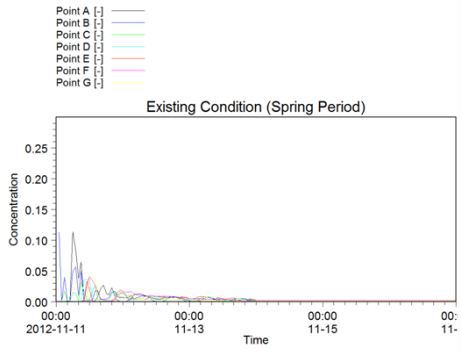


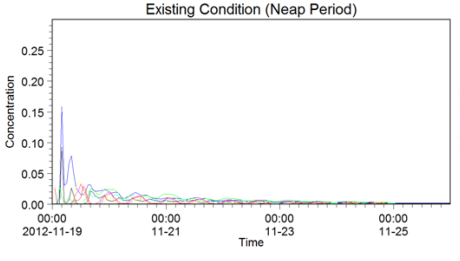
Concentration of tracer during spring period (existing condition)

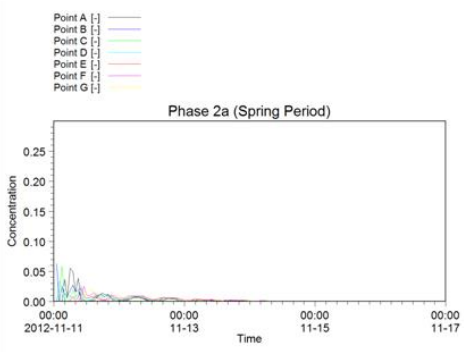
Flushing (advection-dispersion): STP2, Penang

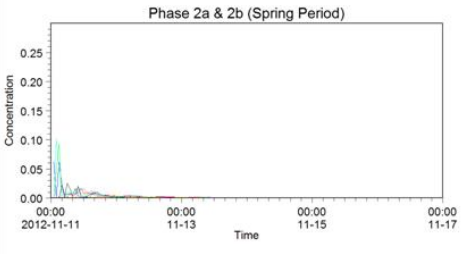


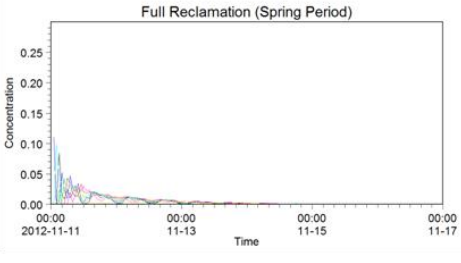
Location of extraction points for flushing assessment

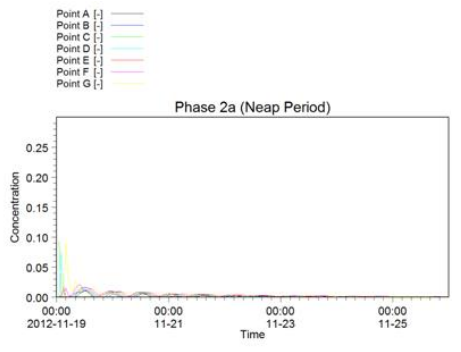


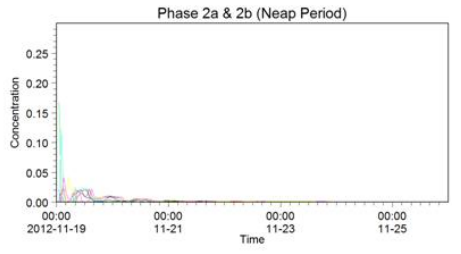


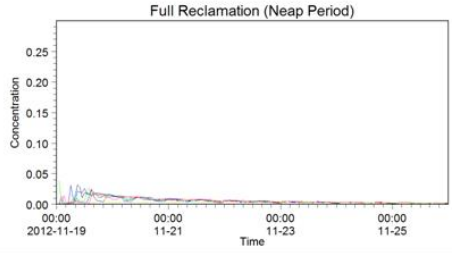






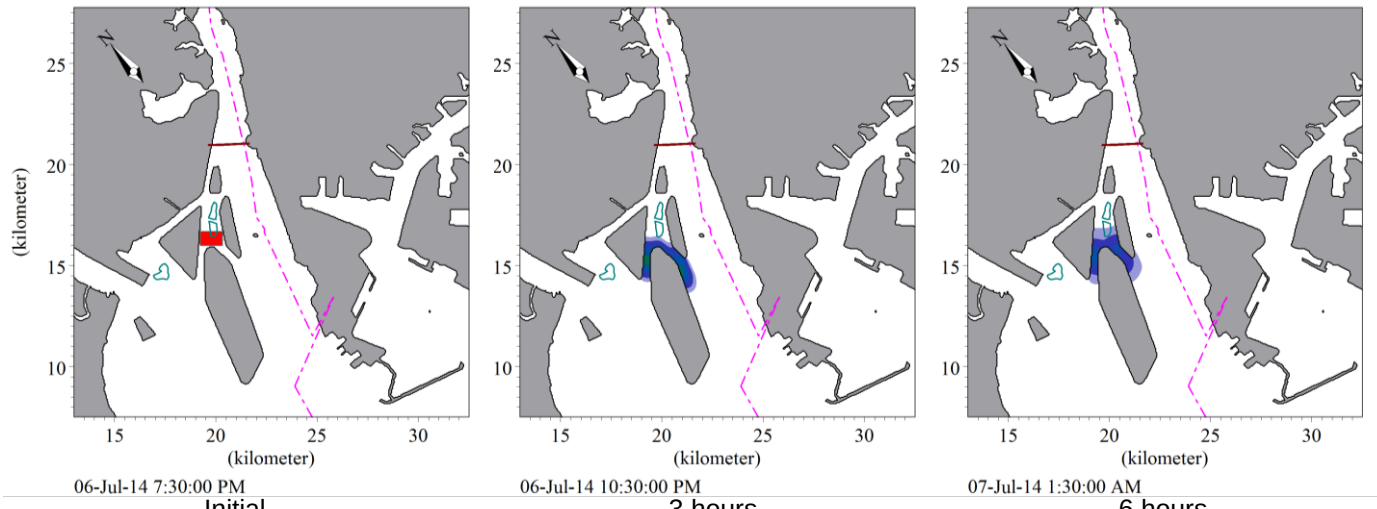




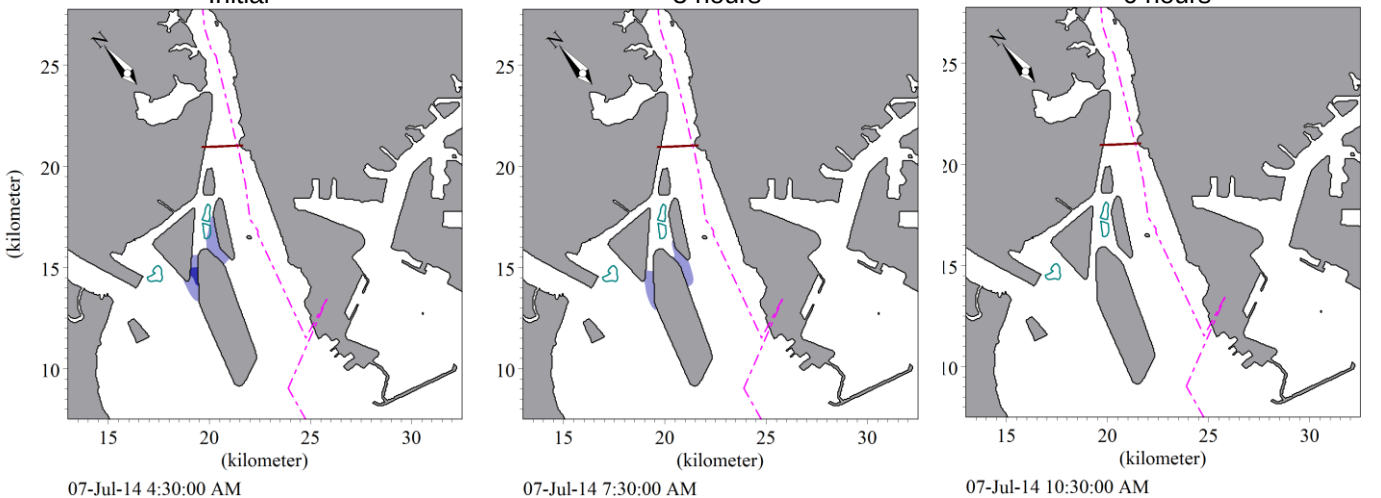


Residual concentration proportional to initial concentration

Flushing (advection-dispersion): Forest City, Johor



Concentration of tracer during neap period for full development (Northeast Monsoon condition)

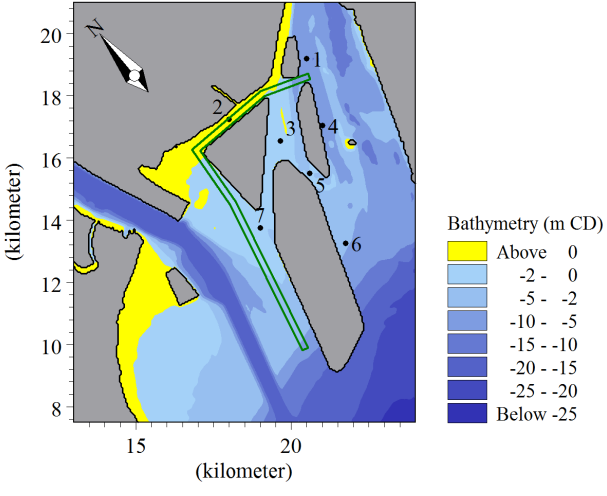


Malaysia-Singapore Boundary

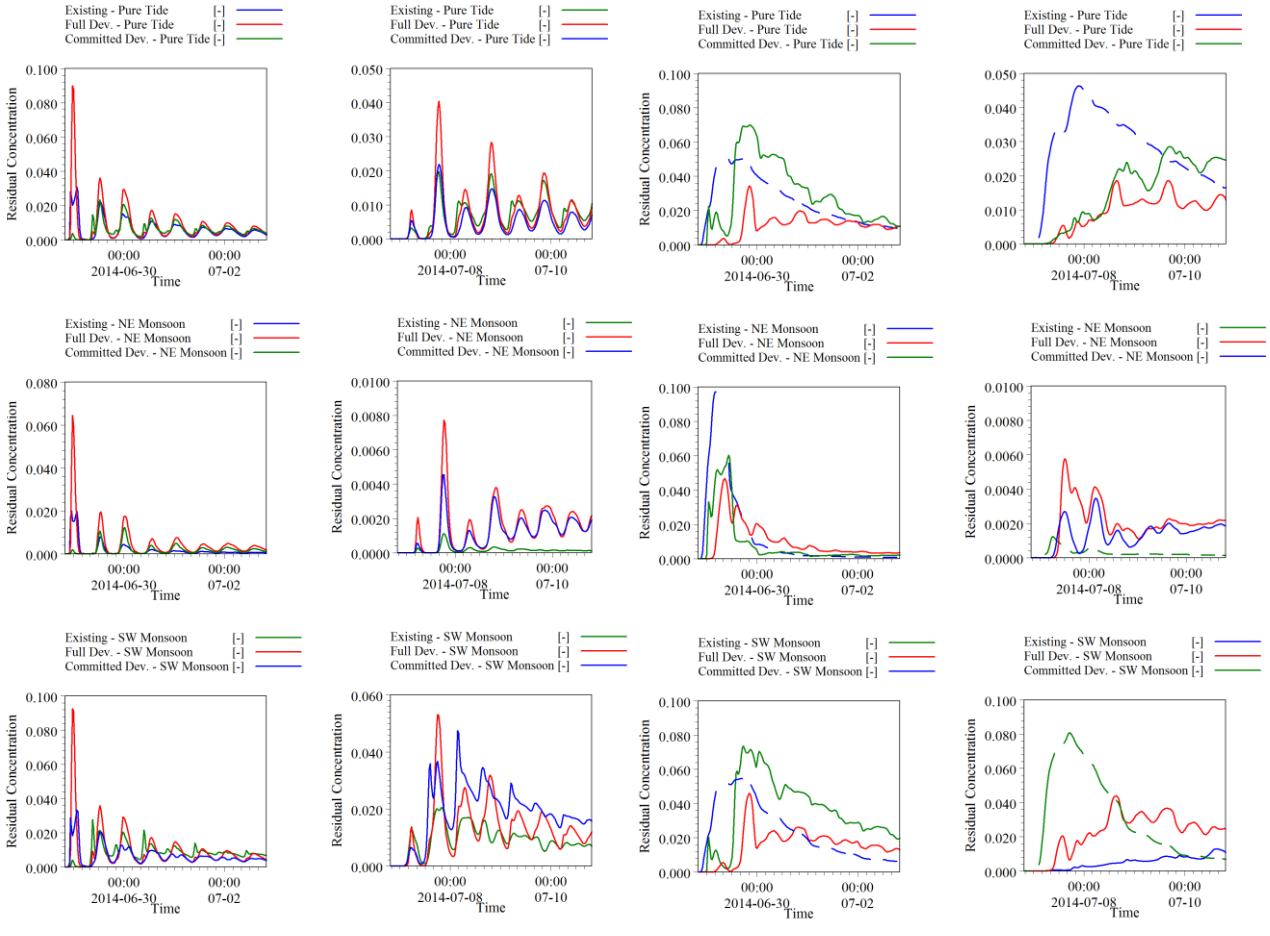
Malaysia-Singapore Second Link Bridge

Seagrass bed

Flushing (advection-dispersion): Forest City, Johor



Locations of extraction points for tracer concentration comparison



Residual concentration proportional to initial concentration at location Point 1

Residual concentration proportional to initial concentration at location Point 2

Flushing (advection-dispersion): Forest City, Johor

Full tracer dispersal duration during spring & neap periods

Condition	Spring Period		Neap Period	
	Duration (hrs)	Change (%)	Duration (hrs)	Change (%)
Pre-reclamation	9	-	15	-
Existing	9	0	15	0
Phase 1	9	0	18	20
Island 1	12	33	24	60
Islands 1 & 2	15	67	24	60
Islands 1, 2 & 3	18	100	30	100
Full development	18	100	30	100
Full development & other committed developments	21	133	39	160

1. *The residual tracer concentration reduces to 50% within 6 hrs*
2. *The percentage change is calculated with respect to the pre-reclamation condition*

Langkah Mitigasi

Langkah Mitigasi

- **Tirai kelodak**: Menghalang/melencongkan serakan pepejal terampai
- **Jenis *dredger***: Jumlah bahan yang hilang/terampai boleh dikurangkan dengan melakukan pengendalian & penyelengaraan peralatan yang cermat
- **Pengendalian/operasi terkawal**: Kerja diberhentikan semasa tempoh arus berkelajuan tinggi
- ***Flushing*:** Mengurangkan pelepasan enap cemar ke dalam perairan terbuka
- **Hakisan**: Struktur kawalan yang direkabentuk dengan baik dipasang di kawasan terhakis; pemantauan disyorkan bag memastikan kerja-kerja tebatan dilakukan dengan cepat

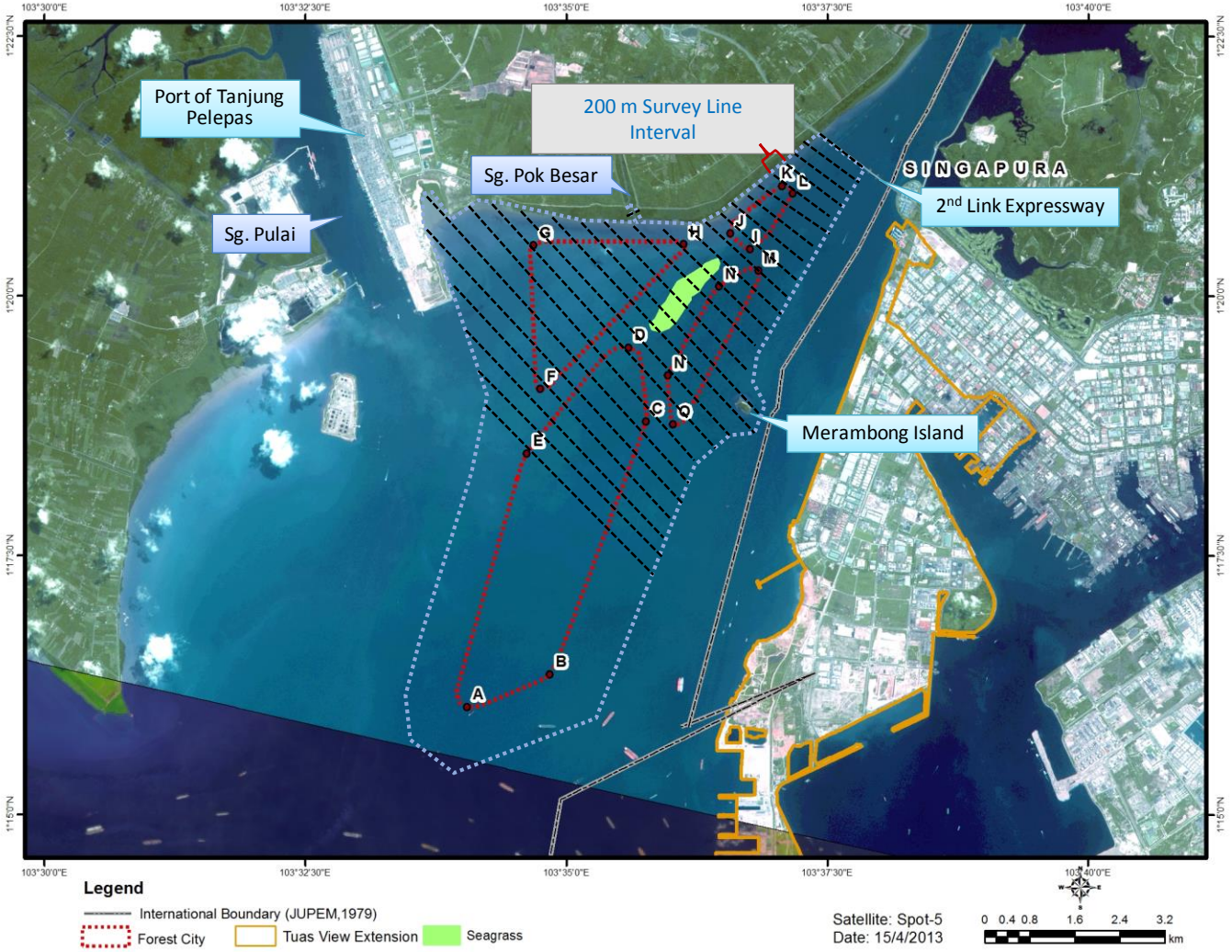
Langkah Mitigasi

- **Pemendapan:** Pantai rekreasi boleh dibentuk di kawasan yang berpotensi mengalami pemendapan. Kajian & rekabentuk yang wajar perlu dilakukan terdahulu; pengerukan berkala perlu dilaksanakan di kawasan perairan seperti pelabuhan & marina

- **Longkang/saluran:** Pengawalan pelepasan enap cemar, sedimen & larian banjir di hulu kawasan tadahan bagi memastikan sistem saliran berfungsi menyalurkan discas rekabentuk banjir & meningkatkan mutu air

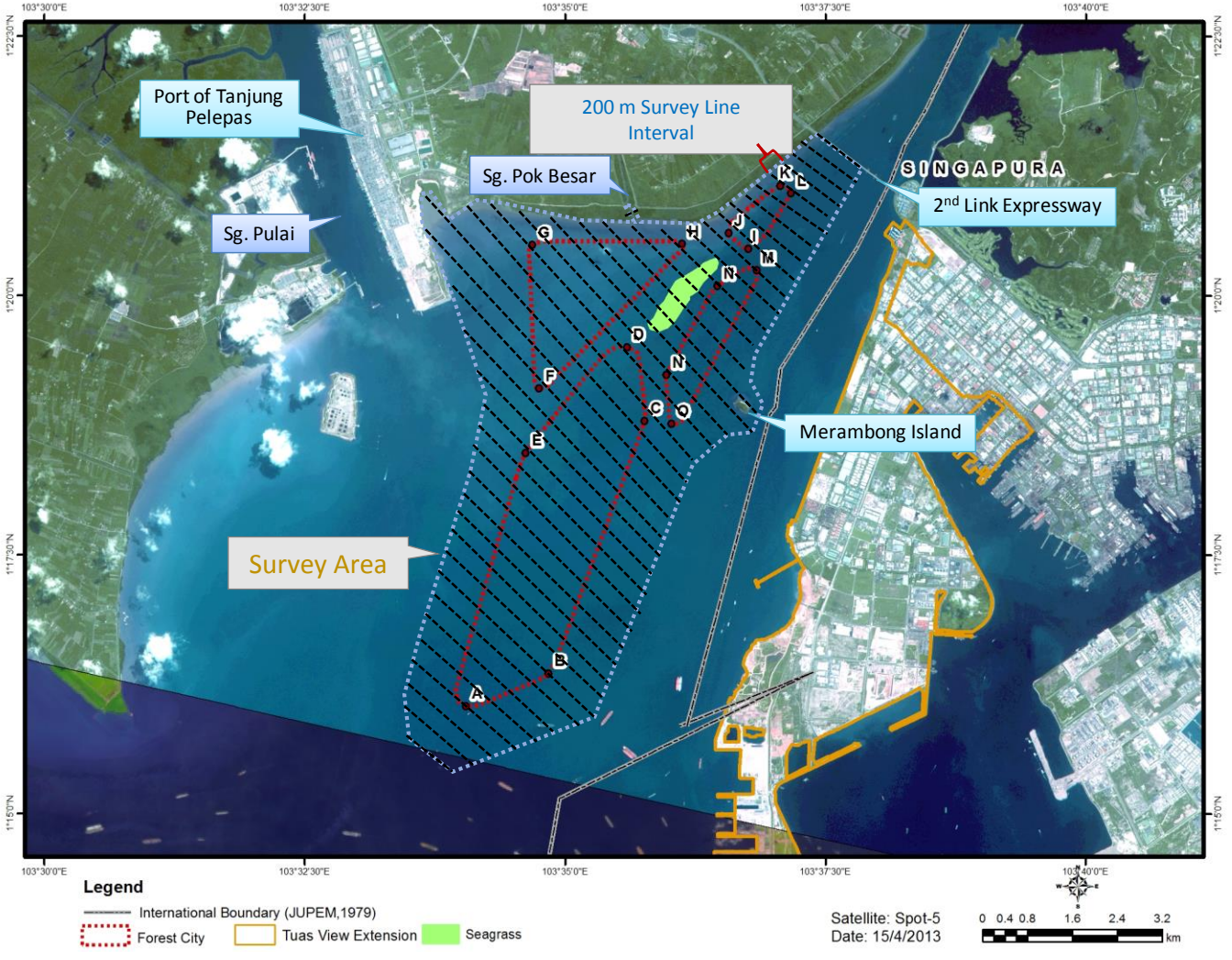
- **Pemantauan:** Kerja ukur berkala bagi meaksir perubahan aras pantai & dasar laut semasa & selepas pembangunan; kerja ukur dilakukan dengan julat 100 m mengunjur 1 km be kiri & kanan tapak pembangunan serta 1 km ke arah laut & 50 m ke arah darat

Langkah Mitigasi: Kerja ukur pemantauan



Island 1

Langkah Mitigasi: Kerja ukur pemantauan



Q&A