FEATURE

# Sediment Transport : Study Evaluation of Proposed Causeway in Tanjung Manis Port, Sarawak, for Industrial and Aquaculture Development


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**The Sarawak Government has proposed Tanjung Manis Halal Hub (TMHH) as the largest integrated halal hub in the State. It covers 77,000 ha of agriculture land, stretching from Pulau Bruit in the north to Sarikei Town in the south. In line with the Government's aspirations under the New Economic Model (NEM), TMHH is planned to attract investors with high value projects and transform the region into a high-income generator zone.**

Through the Sarawak Timber Industry Development Corporation (STIDC), the Sarawak Government is currently looking at ways to expand the economic activities in the vicinity of existing waterways, from the current aquaculture industry to other activities such as refineries, oil & gas onshore facilities and ship building.

The area of study is located in deltas and estuaries of several major rivers, including Batang Rajang. The near-pristine environment includes mangroves and coastal peat forests, which are ideal for agriculture. The proposed area is located at the meandering channel in a coastal wetland that is subject to diurnal tides. It is approximately 8-10km from the river mouth and near Belawai Island. An approximate location of the study area is shown in Figure 1.

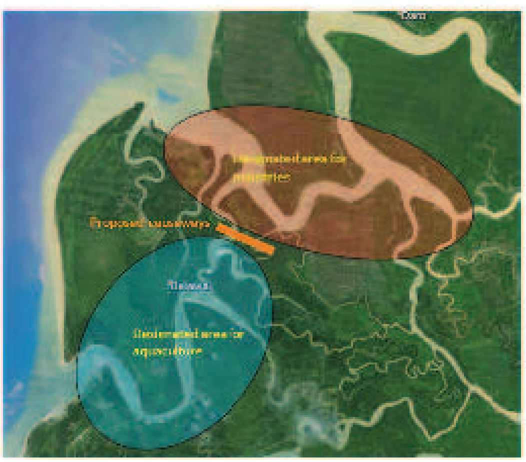


*Figure 1: Proposed development at Tanjung Manis port*

## NUMERICAL SIMULATION CONDITION

Numerical models were established to assess environmental impacts which might be caused by the waterway separation. Numerical models were established to simulate the complex coastal response to the proposed engineering works. Delft3D was used as the numerical modelling tool to investigate hydrodynamics, sediment transport and morphology, water quality for fluvial, estuarine and coastal environments.

The coastal hydraulic model consisted of hydrodynamic, sediment transport and pollution tracer dispersion modelling. Hydrodynamic modelling was carried out to simulate the water level variations and current velocities induced by a variety of force functions, such as tides. This model formed the basis for carrying out the subsequent coastal processes.

At this stage, the effluent characteristics from industrial works were not known. Therefore, tracer dispersion would be modelled to assess

*Figure 2: Selected outfall locations for simulations*

the dilution and spreading of possible pollutions in the delta area. As the ship building area will extend about 10km along the riverbanks, three typical locations have been selected to represent the discharge points upstream, downstream and midway of the project site (Figure 2).

## HYDRODYNAMIC RESULTS

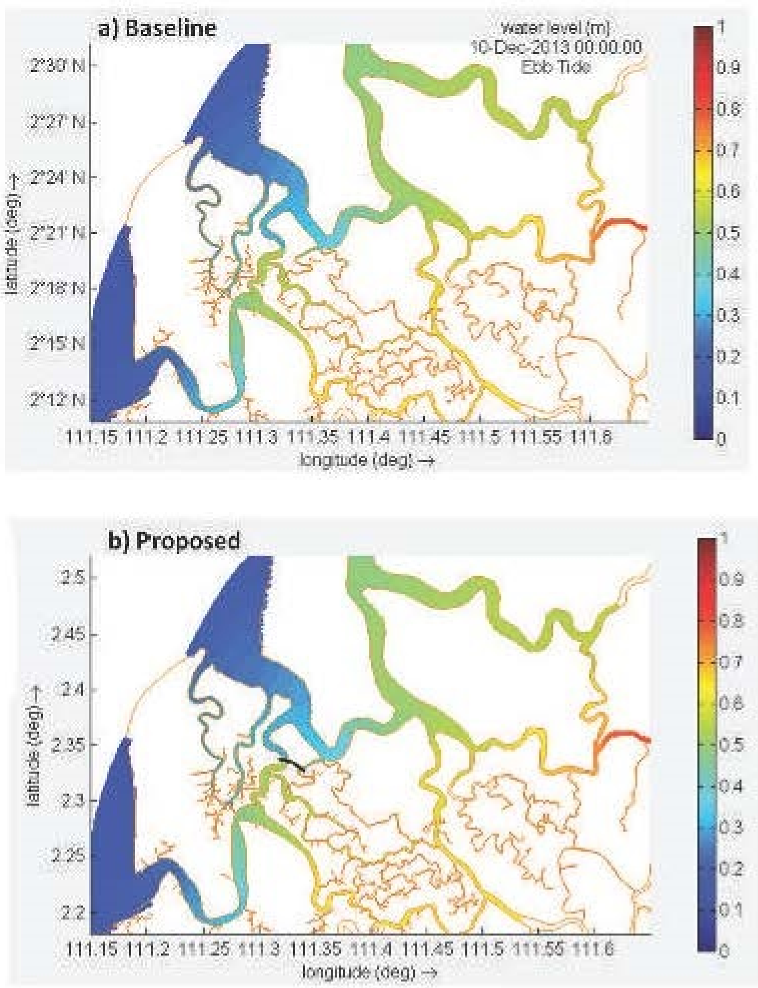
### *TIDE AND CURRENT*

Hydrodynamic modelling was carried out to simulate the water level variations and current velocities induced by tides and river flows under existing condition and the proposed option.

Water level and current plots for the exit conditions and with the proposed causeways during the typical tide stages, are shown in Figures 3 and 4 respectively. The results show that the current flow at the project site is dominated by the tidal variations.

Hydrodynamic impacts can be assessed by comparing the flow conditions between existing conditions and the proposed causeways. Based on the results, it is possible to conclude that:

1. The proposed causeways block the flow in the two waterways, LobaBuan and LobaPaloh. The flow field in the vicinity of causeways is nearly stagnant.
2. Water level difference before and after the construction of the causeways is in the order of 0.1 m in the blocked waterways.
3. The maximum current speed difference is in the order of 1.0 m/s in the blocked waterways.



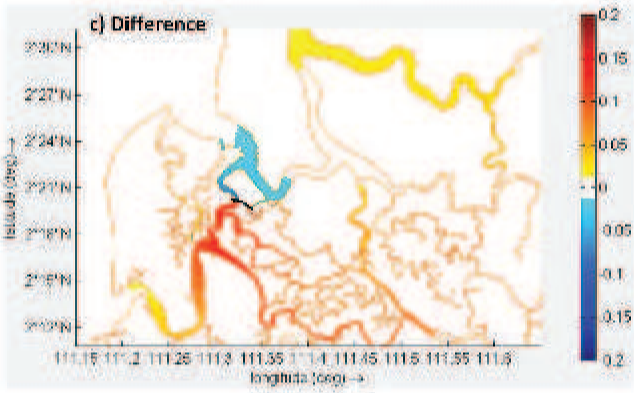



*Figure 3 (a): Typical water level at ebb tide for a) baseline; b) with proposed cause way, and c) the difference*

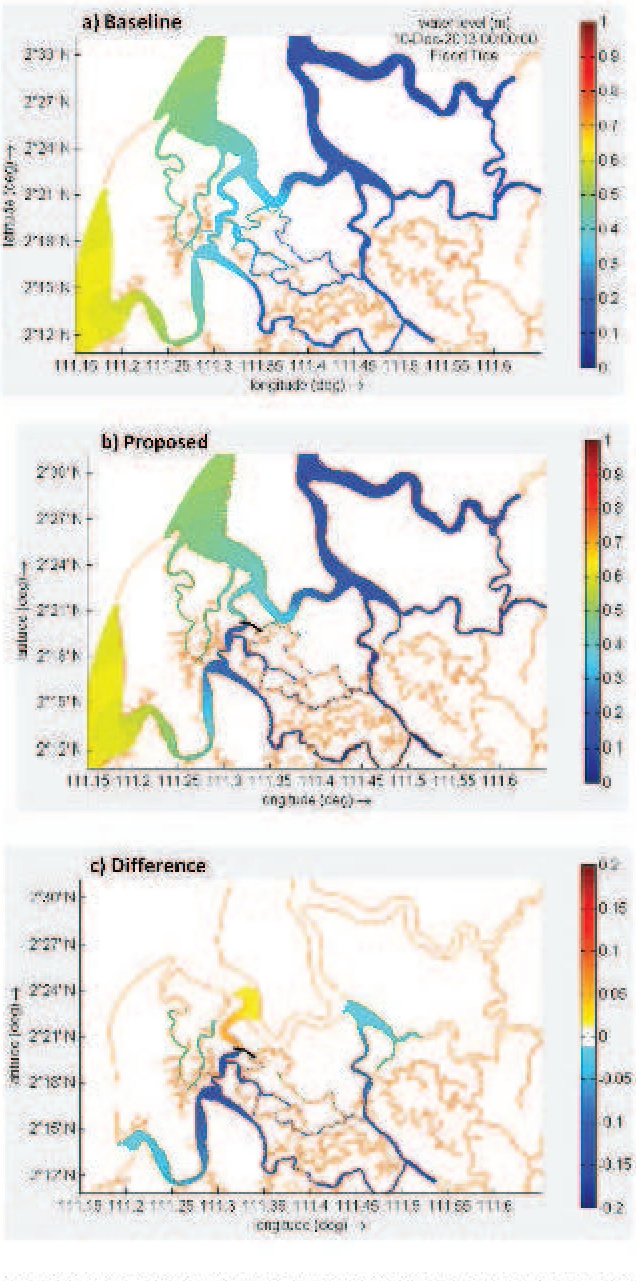



*Figure 3 (b): Typical water level at flood tide for a) baseline; b) with proposed cause way, and c) the difference*

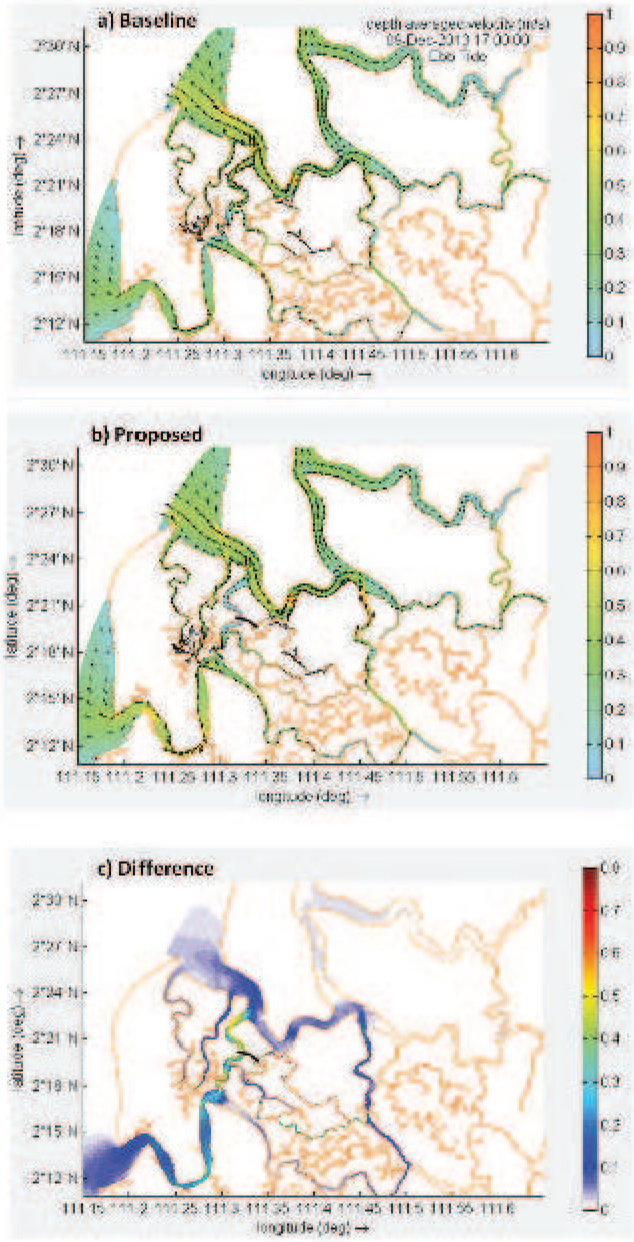
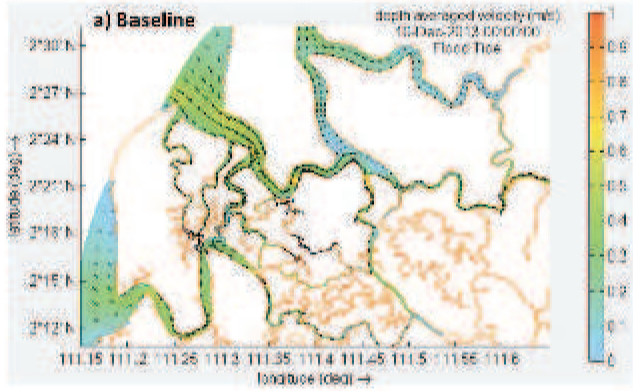
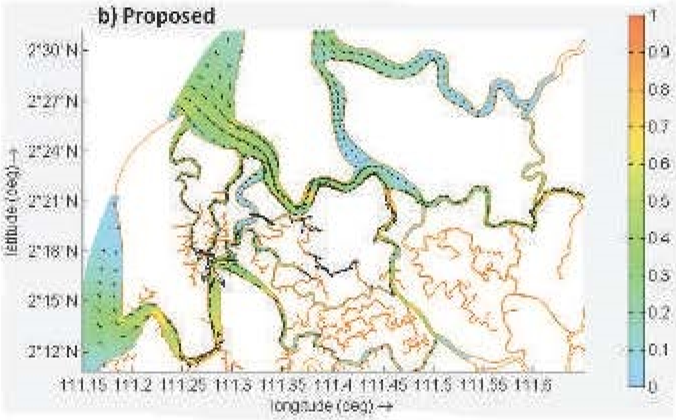



*Figure 4 (a): Typical tide current at ebb tide for a) baseline; b) with proposed causeway, and c) the difference*





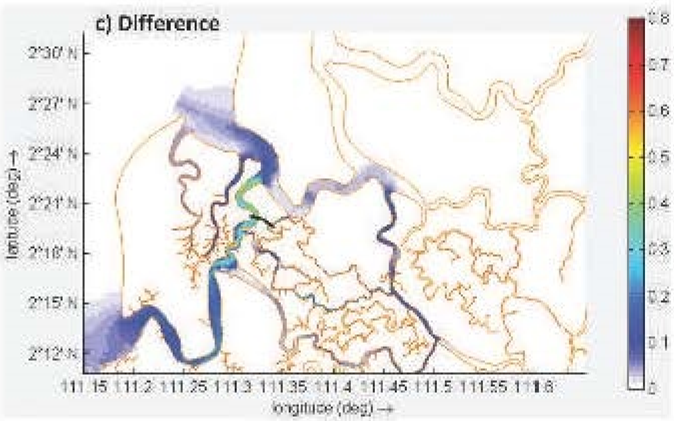




*Figure 4 (b): Typical tide current at flood tide for a) base line; b) with proposed causeway, and c) the difference*

### SEDIMENTATION AND COASTAL MORPHOLOGY

The sediment transport pattern can be affected by the proposed development works when the local flow field is modified. Siltation and erosion processes will cause the local morphology changes. The simulation was carried out to assess the sediment transport before and after the development works and the impact on the local morphology variations. The mean sediment transport rate and accumulated erosion or siltation under normal flow conditions are shown in Figures 5.1 and 5.2, respectively.

The impacts on sediment transport can be assessed by comparing the typical sediment transport rate between the existing conditions and with the proposed causeways. Based on the results it is possible to conclude that:

1. Sediment transport patterns in the waterways of LobaBuan and LobaPaloh and adjacent river reaches are different if the flow is blocked by the causeways.
2. The sediment transported into LobaBuan and LobaPaloh can be trapped in the outer reaches of the long waterways. *See* Figure 5.2 (b). The maximum accretion rate under normal flow condition is in the order of 1 m/year.
3. However, further inside the waterways to the causeways, siltation or erosion is less as the flow is smaller and sediment transport rate is much lower in the inner reaches. *See* Figure 5.2 (b).

### POLLUTANT DISPERSION

The dispersion pattern of pollutants discharged from three different outfall locations along the river is shown in Figure 2. For analysis purposes, it is assumed that the discharge is 10 m3/s with the initial concentration of 100 ppm (or 0.1 kg/m3), which is continuously discharged from each outfall. This assumption is conservative for common applications of pollutant discharge from plants.

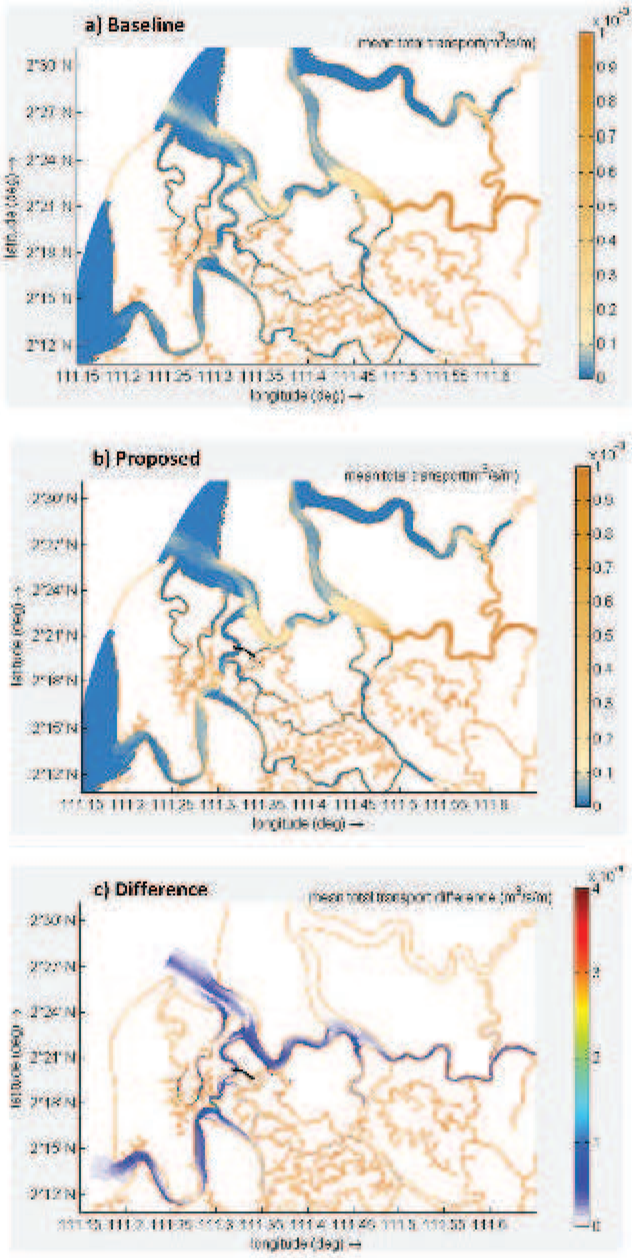
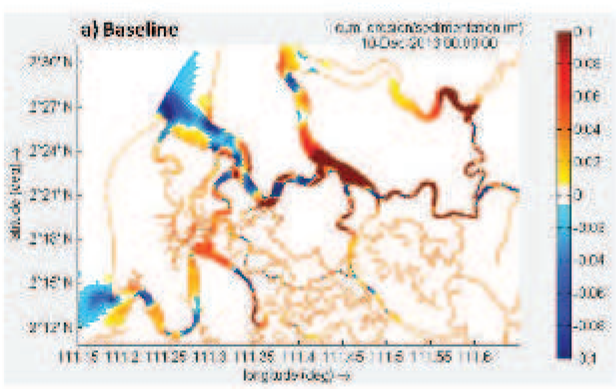



*Figure 5.1: Mean sediment transport rate under normal flow condition over the simulation period for a) baseline; b) with proposed causeway, and c) the difference*



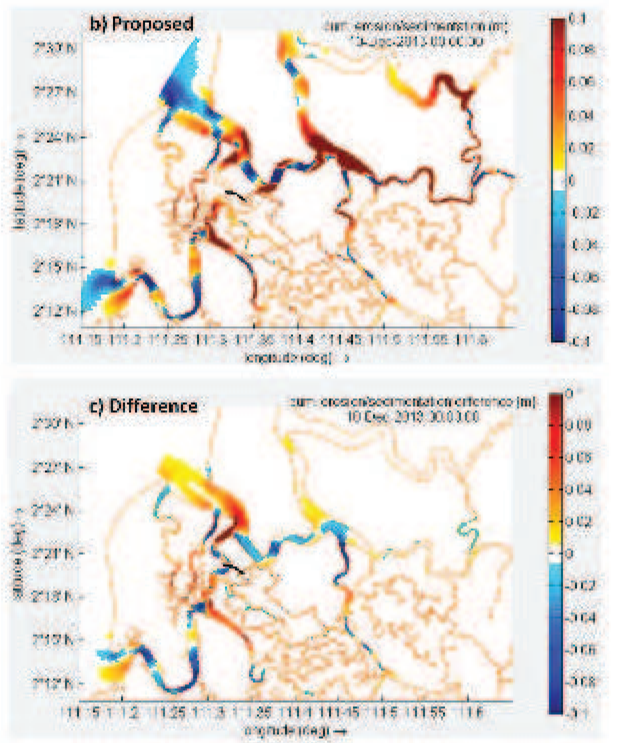




*Figure 5.2: Mean erosion/sediment rate under normal flow condition over the simulation period for a) baseline; b) with proposed causeway, and c) the difference*

The typical dispersion patterns are plotted in Figures 6.1 to 6.3 for different discharge points, respectively. The pollutant plume can reach the designated aquaculture regions through LobaBuan and LobaPaloh and other waterways. The concentration, however, is very low at this region. For example, at the point located in the northern part of aquaculture area, the concentration is 1.5x10-3kg/m3, i.e. only 0.15% of the assumed initial value. With the causeways, no discharge plume is dispersed through LobaBuan and LobaPaloh. However, trace pollutant is still observed in the aquaculture area as this can be dispersed via other waterways. The concentration is further decreased to 2x10-4 kg/m3. The time series of pollutant concentration during simulation period are shown in Figure 6.4.

Based on the results it is possible to conclude that:

1. The pollutant dispersion pattern and concentration distribution in the waterways of LobaBuan and LobaPaloh are different for the three outfall points.
2. Most of the pollutant load is diluted in the main river of Btg. Paloh as the outfalls are located along the river. The pollutant plume is also dispersed into the neighbouring tributaries and waterways.
3. The pollutant plume can reach the designated aquaculture regions through LobaBuan and LobaPaloh and other waterways. However, the concentration is very low in the region. With a soluble pollutant loading of 100 ppm at 10 m3/s flow rate, the concentration is decreased to less than 0.02 ppm.
4. For some special cases when the pollutant matter is insoluble and transported in the form of small particles or patches, the concentration may occasionally reach up to 1 ppm.

5. The causeways can block the dispersion through LobaBuan and LobaPaloh and the concentration is substantially decreased behind the causeways. The concentration is decreased to below 0.002 ppm.

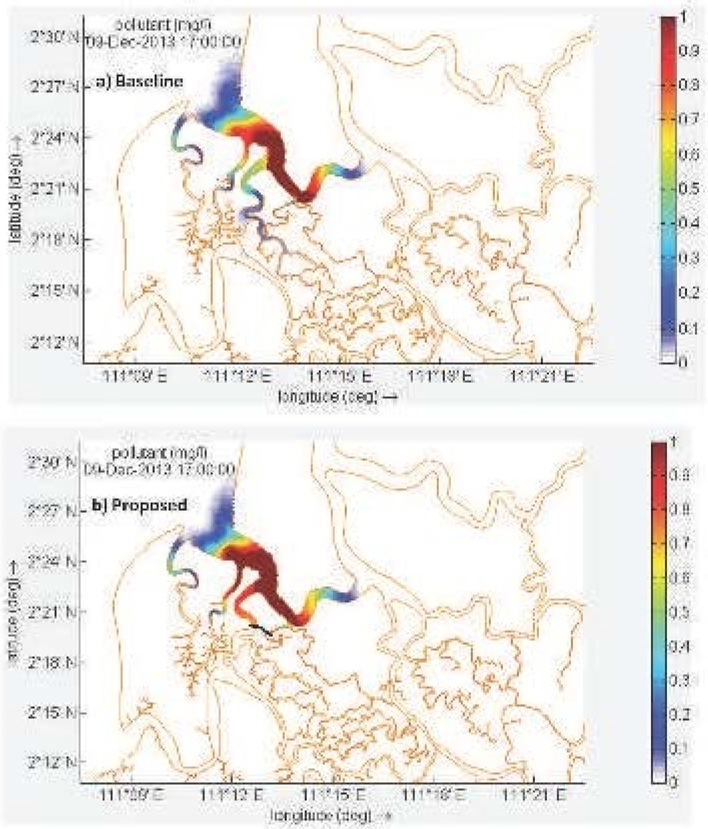



*Figure 6.1: Typical dispersion pattern (mg/l)from discharge outfall-1 a) baseline; b) with proposed causeway*

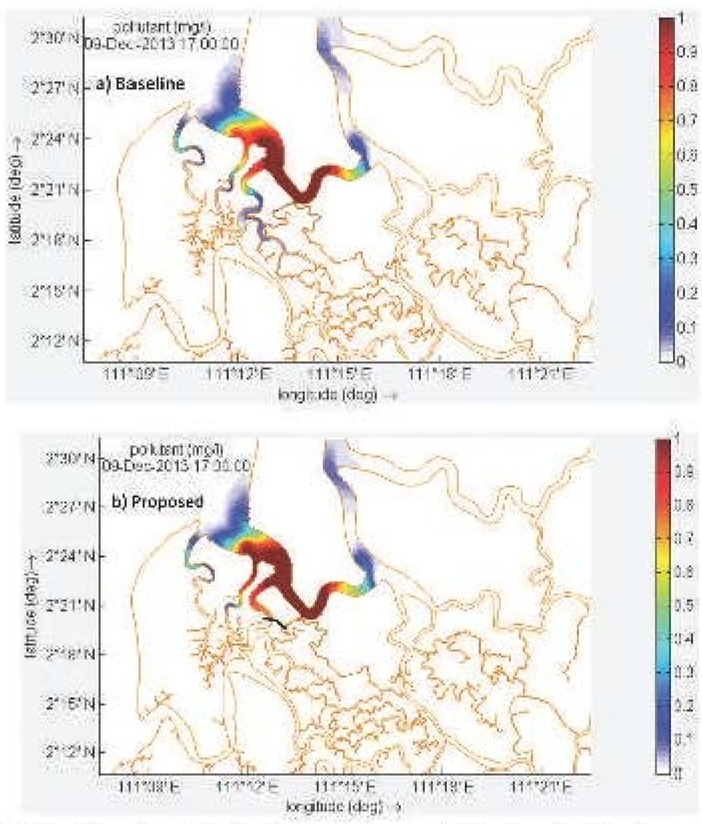



*Figure 6.2: Typical dispersion pattern (mg/l) from discharge outfall-2 a) baseline; b) with proposed causeway*

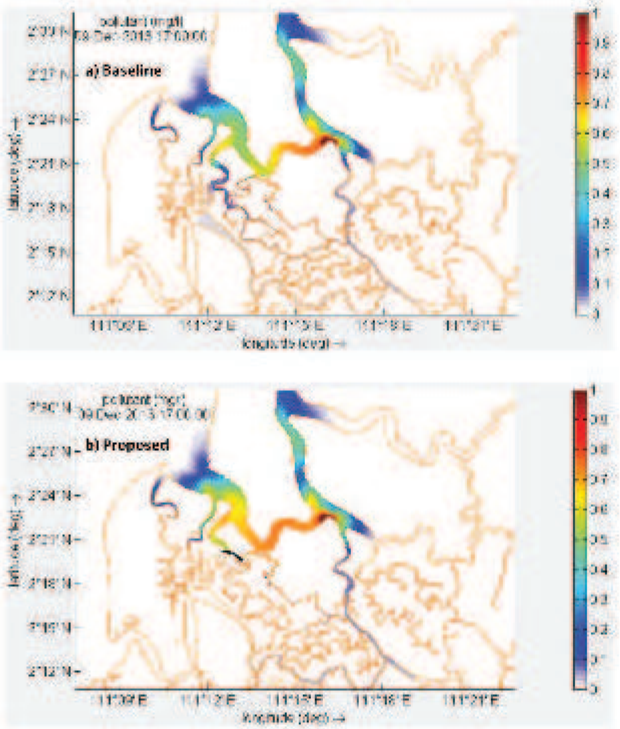



*Figure 6.3: Typical dispersion pattern (mg/l) from discharge outfall-3 a) baseline ; b) with proposed causeway*

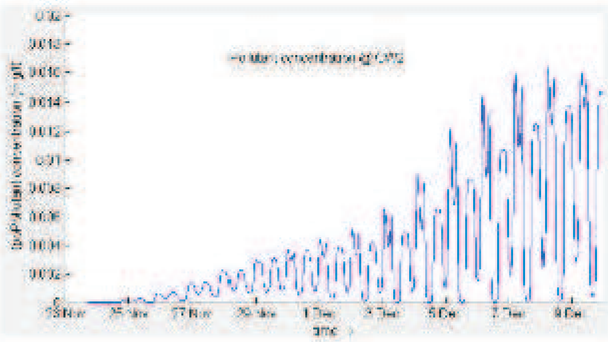


*Figure 6.4 (a): Time series of concentration without separator, which is located in the northern part of aquaculture area*

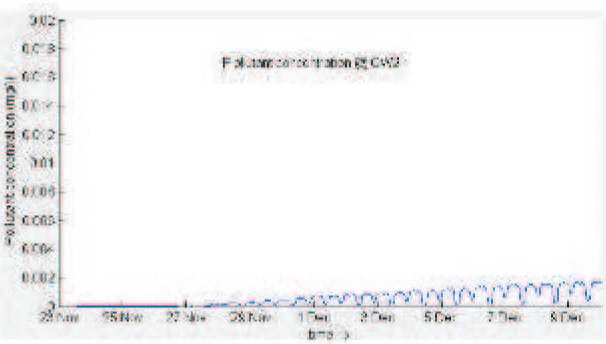


*Figure 6.4 (b): Time series of concentration with separator*

## CONCLUSION

This coastal hydraulic study investigates the impact of the proposed causeways in term of hydrodynamic, sediment transport, sediment and pollutant dispersion. Based on the results, it can be concluded that:

1. The proposed causeways block the flows in the two waterways, LobaBuan and LobaPaloh. The flow field in the vicinity of the causeways is nearly stagnant.
2. Water level difference before and after construction of causeways is in the order of 0.1 m in the blocked waterways.
3. Current speed difference is in the order of 1.0 m/s in the blocked waterways.
4. Sediment transport patterns in the waterways of LobaBuan and LobaPaloh and adjacent river reaches are different if the flow is blocked by the causeways.
5. The sediment transported into LobaBuan and LobaPaloh can be trapped in the outer reaches of the long waterways. The maximum accretion rate under normal flow condition is in the order of 1 m/year.
6. Further inside the waterways to the causeways, siltation or erosion becomes milder as the flow is smaller and sediment transport rate is much lower in the inner reaches.
7. The pollutant dispersion pattern and concentration distribution in the waterways of LobaBuan and LobaPaloh are different for the three outfall points.
8. Most pollutant load is diluted in the main river of Btg. Paloh as the outfalls are located along the river. The pollutant plume is also dispersed into the neighbouring tributaries and waterways.
9. The pollutant plume can reach the designated aquaculture regions through LobaBuan and LobaPaloh and other waterways. However, the concentration becomes very low in the region. With a soluble pollutant loading of 100 ppm at 10 m3/s flow rate, the concentration decreases to less than 0.02 ppm.
10. The causeways can block the dispersion through LobaBuan and LobaPaloh and the concentration is substantially decreased behind the causeways. The concentration is decreased to below 0.002 ppm.
11. For special cases when the pollutant matter is insoluble and transported in the form of small particles or patches, the concentration may occasionally reach up to 1 ppm. ■

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