**4. TSS dispersion model**

The model had been applied to the Upper Gulf of Thailand whereas various activities took place in it. Four major rivers, Mae Klong, Tha Chin, Chao Phraya and Bangpakong discharged fine sediments and nutrients into the domain.

The seawater movement was extracted from the Hydrodynamic model. The numerical grid was fixed in the horizontal discretization; dx = dy = 1.86 km. relatively small time step was selected for the simulations (dt=600s). The parameterization of the processes affecting the transport and mixing of sediments in the marine environment applied in the mathematical model was mostly considered, covering the most important factors controlling the phenomena.

In the Upper Gulf of Thailand, the water circulation is affected by tidal current. Anongponyoskun (2004) reported that the tide in the Upper Gulf of Thailand is mixed tide with the tidal of magnitudes about 2-3 m. The velocity data showed that the main direction of flow was north-south direction. Anongponyoskun (2000) reported that the main flow at Si Chang Island during ebb tide and flood tide is about 1.0 m/sec in north-south direction.

Vito (1977) showed that the size of particle related with the settling velocity such that

$$w \propto D^2 \qquad (23)$$

where w = settling velocity

D = particle diameter

The relation showed that the velocity about 0.1 m/sec could move the particle smaller than 0.5 mm away from the seabed. So if there is movement of seawater, the particle suspension would have happened.

4.1 TSS Measurement in the field

From the 10 cruises, TSS from each station at the sea surface was measured. TSS in the middle of the Upper Gulf of Thailand was only 2-4 mg/l. The TSS increased near Si Chang Island and near Laem Phak Bia. The TSS nearshore was about 20-60 mg/l during dry season. During wet season the TSS increased to 20-200 g/l because of the loaded particle from the rivers.

Vashrangsi (1978) reported that around the eastern coast of the Gulf of Thailand from Khlong Dan to Bang Lamung, the quantity of the TSS was about 8-226±164 mg/l. Doydee and Anongponyoskun (2004) found that the TSS was abundance near the river mouth and coastal area. It decreased in offshore area. The averaged TSS nearshore was about 19-106 mg/l.

Kovantanakul (1986) showed that the concentration of suspended sediment in water samples had a relatively low variability with the range from 0.6-35.6 mg/l, the average concentration ranged from 3.1-18.3 mg/l. Sediment concentrations near the river mouth were generally high and substantially decreased to the low values of less then 5 mg/l towards the sea.

4.2 TSS Determination from LANDSAT data

For satellite image data, the classification and masking technique was essential for performing the image processing over areas that interested, which in this study was the water body. The remote sensing data used in this study were the image LANDSAT 5 TM with the path/raw 129/51 and acquisition date of 5$^{th}$ December 2003, 20$^{th}$ October 2004, 21$^{st}$ November 2004, 8$^{th}$ January 2005, 13$^{th}$ March 2005 and 19$^{th}$ July 2005. TSS coincided with the digital value of band 1, 2 and 3 were suitable for creating the simple chart of the TSS.

LANDSAT digital data were represented by dimensionless digital numbers ranging from 0-255 levels in each channel. They were quantitatively related to the intensity of reflected radiant energy with a linear relation. The relationship between the ratio of reflectance values and sum of reflectance values to TSS were determined.

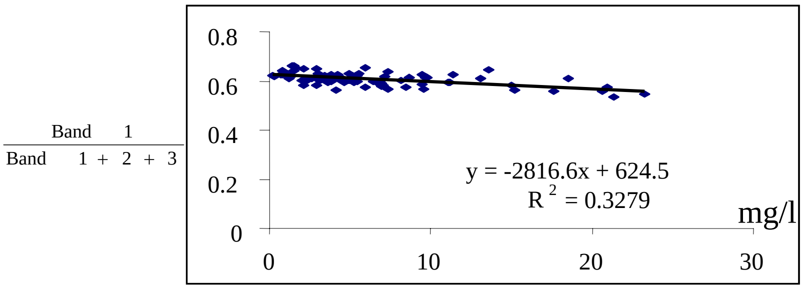



**Figure 22** The relation of TSS and ratio of reflectance band 1, 2 and 3, respectively

The relationships of these values had relatively medium correlation coefficients of 0.3279 as shown in Figure 22. The TSS was computed by using the formulas of reflectance ratio of band 1, 2 and 3 which related to TSS by application program. By empirical, the TSS distribution patterns of band 1/ band (1+2+3) seem to be closer than the others. The relation formulas of the TSS and reflectance ratio could be written as:

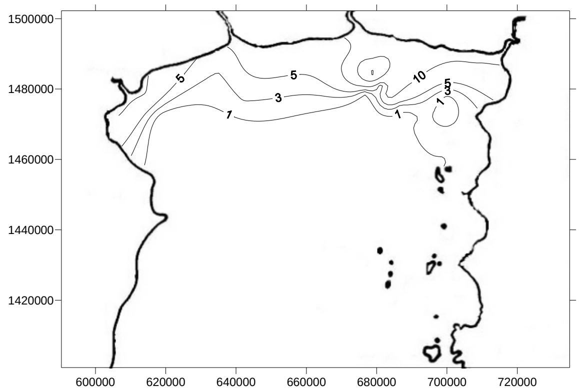
$$y = -2816.6x + 624.5 \qquad (24)$$

$$R^2 = 0.3279$$

where $y = \dfrac{\text{Band } 1}{\text{Band } 1 + 2 + 3}$

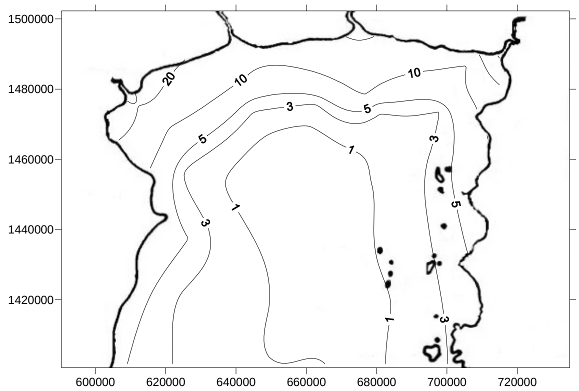
x = TSS concentration

The computed results were represented by using the application software to determine the TSS around the Gulf. The comparison between the satellite images with the computed distribution TSS by band 1/ band (1+2+3) were shown in the Figure 23.



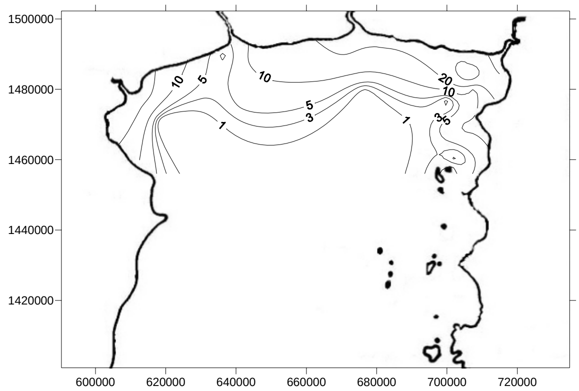

5th December 2003

$$\frac{\text{Band } 1}{\text{Band } 1+2+3}$$




20th October 2004

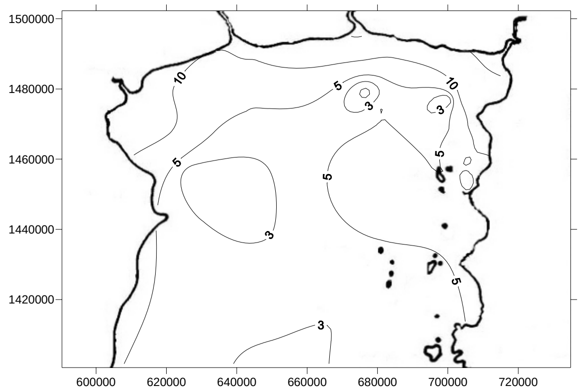
$$\frac{\text{Band } 1}{\text{Band } 1+2+3}$$




21st November 2004

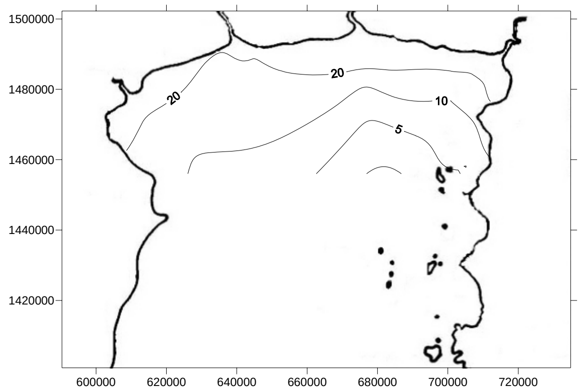
$$\frac{\text{Band } 1}{\text{Band } 1+2+3}$$

**Figure 23** The comparison of the TSS (mg/l) distribution of band 1/band(1+2+3) with LANDSAT images



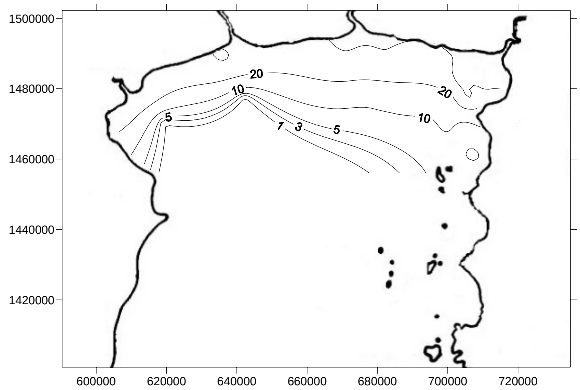

8th January 2005

$$\frac{\text{Band} \quad 1}{\text{Band} \quad 1 + 2 + 3}$$




13th March 2005

$$\frac{\text{Band} \quad 1}{\text{Band} \quad 1 + 2 + 3}$$




19th July 2005

$$\frac{\text{Band} \quad 1}{\text{Band} \quad 1 + 2 + 3}$$

**Figure 23** (Continued)

4.3 Model verification

Comparisons of computed value with actual observation values were necessary for checking the results of TSS dispersion model. The variations of observed TSS at near Ko Phai and near Chao Phraya River mouth for 2 days were shown in Figure 24. The observed TSS near Ko Phai and Chao Phraya River mouth showed that the averaged magnitudes of the TSS near the coast or the river were 4.5 mg/l and 7.1 mg/l, respectively.

The selected points for checking TSS were at Chao Phraya River mouth. The variations of the predicted TSS at Chao Phraya River mouth for 200 days were shown in Figure 25. The magnitudes of observed value are close to the predicted value which range cover in the red box. The variations of TSS were in the range about 4-10 mg/l near Chao Phraya River mouth.

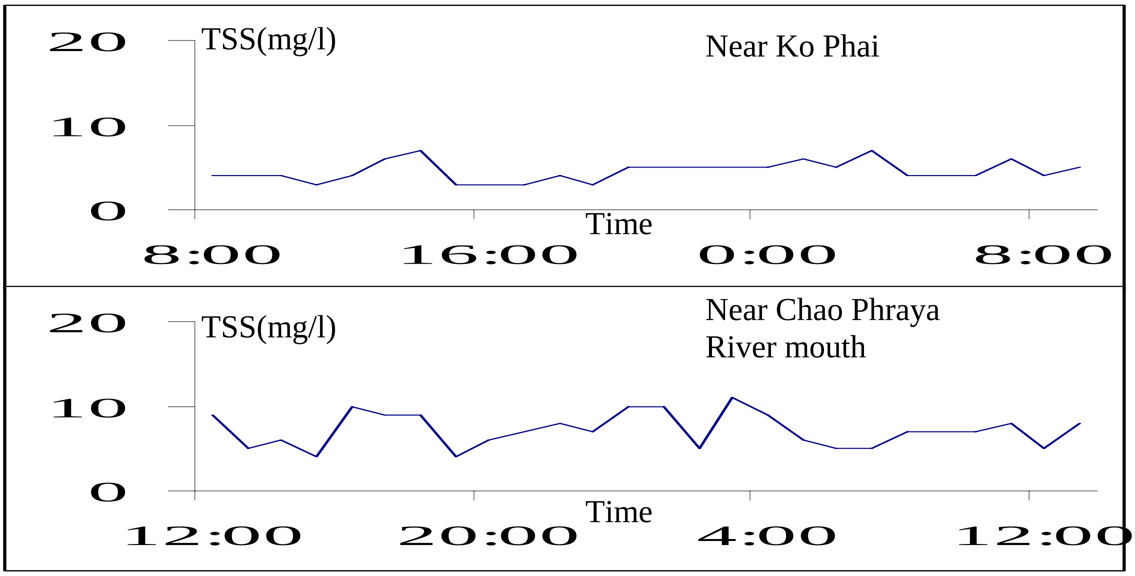



**Figure 24** The variations of TSS (mg/l) near Ko Phai and Chao Phraya River mouth by on 26th -27th January and 27th -28th January 2005, respectively

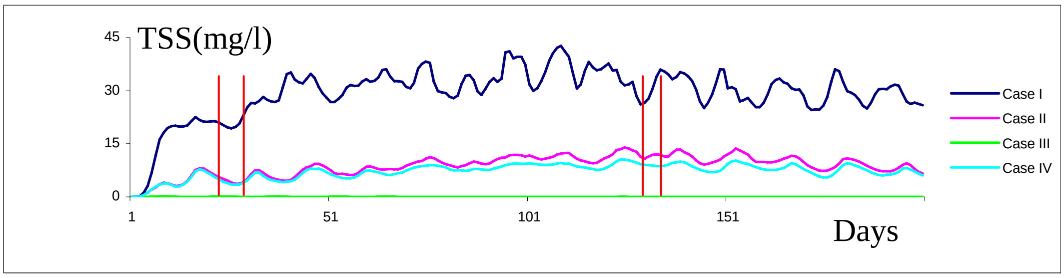



**Figure 25** The variation of TSS at 35,15 (near Chao Phraya River mouth) for 200 days by TSS dispersion model

The patterns of TSS dispersions by the model were verified by comparing the computed diffusion pattern to the Satellite imagery of suspended sediment in the Upper Gulf of Thailand. When river inflow was introduced into the model, it was found that river affected the circulation pattern only around river mouths in the Upper Gulf of Thailand. The patterns of TSS dispersion would be simulated by 4 cases as:

Case I. The high TSS concentrations and high discharge with K ~ $10^3$ $cm^2$/sec.

Case II. The high TSS concentrations and high discharge with K ~ $10^4$ $cm^2$/sec.

Case III. The high TSS concentrations and high discharge with K ~ $10^3$ $cm^5$/sec.

Case IV. The low TSS concentrations and low discharge with K ~ $10^4$ $cm^2$/sec.

The patterns of TSS dispersion for 4 cases could be shown as Figure 26a-26h. The TSS distribution concentration of Case I had the wide high TSS concentration. The quantity of TSS concentration was slow decreasing far from the river mouths. The rapidly decreasing TSS concentration was case III. The high TSS concentration was near the shore. The verification pattern of dispersion case II and case IV was done by comparing the predicted diffusion patterns with the satellite image showed similar trend in the diffusion pattern between observed and simulated results. It confirmed this research that the suitable condition for the diffusion coefficient cases should be K ~ $10^4$ $cm^2$/sec. The pattern of case II and case IV were similar to the observation pattern.