13.3 Analysis on Sedimentation

13.3.1 Preparation of Sedimentation Data for the Numerical Simulations

In order to assess quantitatively sedimentation in the channels that are to be planned in Ganh Rai Bay, the following data are prepared and input the numerical simulation model:

1) Bathymetric geography based on the survey by the Study Team and navigation charts,
2) Distribution of sediments in the area of the simulations based on the results of surveys by the Study Team,
3) Boundary conditions on the coast and open sea area,
4) Tidal level and distribution of tidal currents in the area in the rainy and dry seasons based on the surveys by the Study Team,
5) Distribution of daily waves (eventually wave-induced currents) in the area in the rainy and dry seasons based on the analysis of daily waves for five years done by the Study Team,
6) Discharges of water and suspended solids (SS) from the rivers flowing in Ganh Rai Bay, which are measured by the Study Team in the rainy and dry seasons, which is explained in the following section, and
7) Others.

Among the above items, Item 5) Daily wave conditions by season have already been discussed above 13.2. The most imperative data to be prepared at this stage are Item 5) River Discharge of Water and Suspended Solid in the rainy and dry seasons.

(1) River Discharge of Water and Sediment

There are three major rivers that flow in Ganh Rai Bay and most influential to morphology of the area, i.e. the Thi Vai River, the Long Tau River (Saigon River), and the Dinh River.

Surveys on the current (or water discharge), suspended solids (SS), and sediment are carried out at the mouth of these three rivers and two more cross sections in the Thi Vai River in October 2001 representing the rainy season, and December 2001, representing the dry season. The locations of the cross sections are shown in Figure 13.3.1-1. The cross section of a river is divided into 15 segments, in principle, 3 layers vertically and 5 columns horizontally, an example of the division is shown in Figure 13.3.1-2. The results are summarized in Table 13.3.1-1 and illustrated in Figure 13.3.1-3 (1) and (2).

There are important characteristics found from the results:

1) In the rainy season, the largest volume of SS is transported at the Long Tau River, next at the Thi Vai River, and the last at the Dinh River. In the dry season, the order is the Thi Vai River, the Long Tau River and the Dinh River.

2) In the rainy season, the SS is 1.5 to 2.7 times larger than that in the dry season, except the flood tide in the Long Tau River and Thi Vai River, when the rates are 5 at R2 (Cai Mep) and 12 at R4 (Long Tau River mouth).

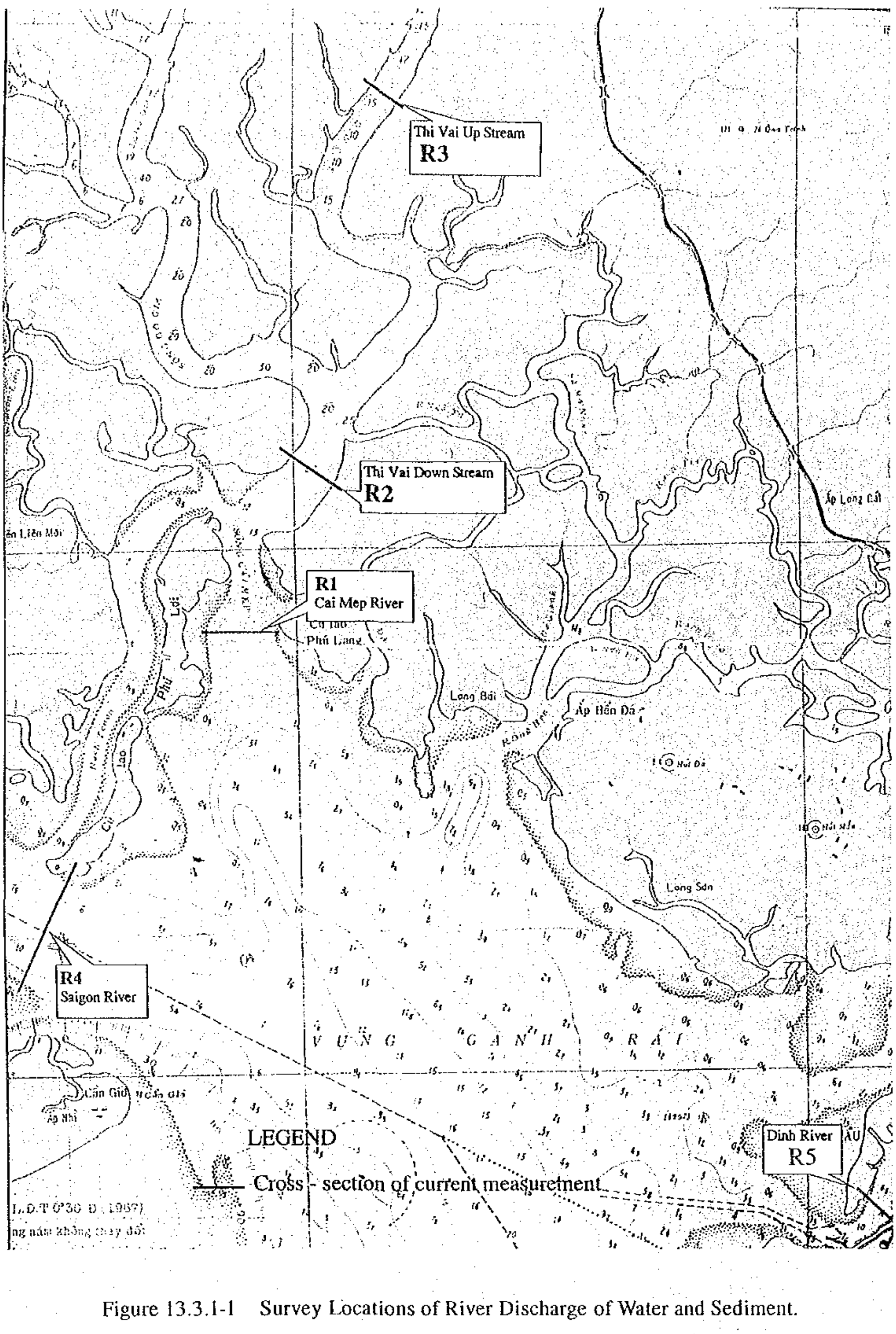
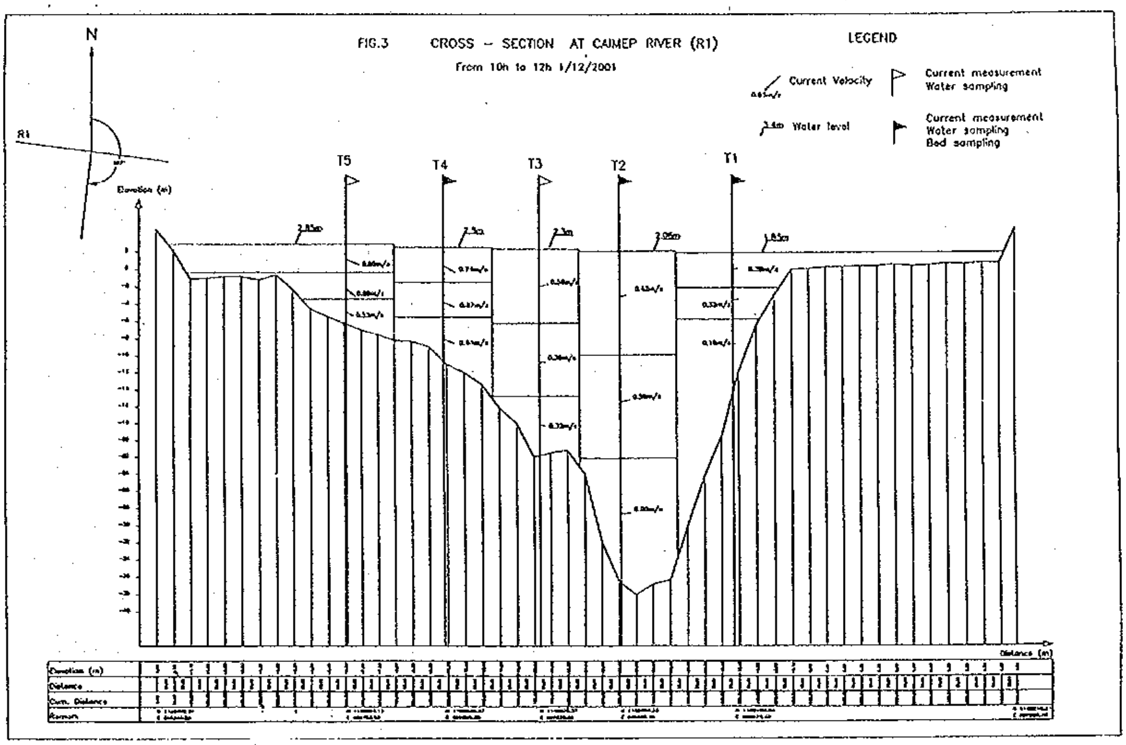
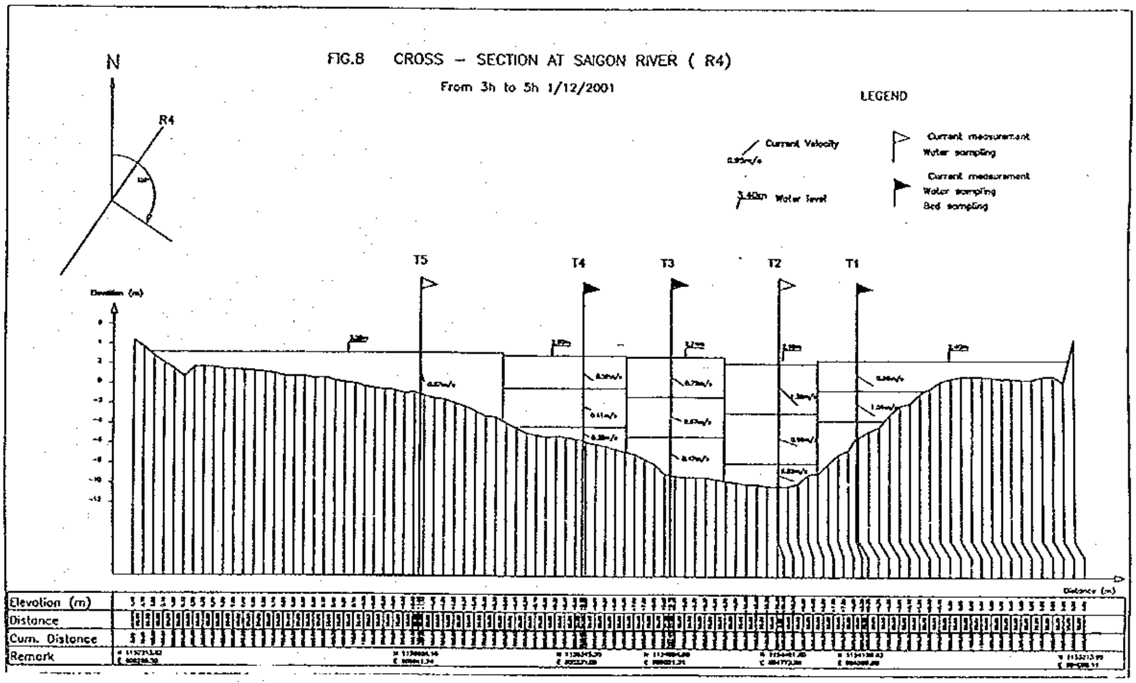


Figure 13.3.1-1 Survey Locations of River Discharge of Water and Sediment.



(1) Thi Vai River, Section R1



(2) Long Tau River, Section R4

Figure 13.3.1-2 Example of Segment Division of River Cross Section .

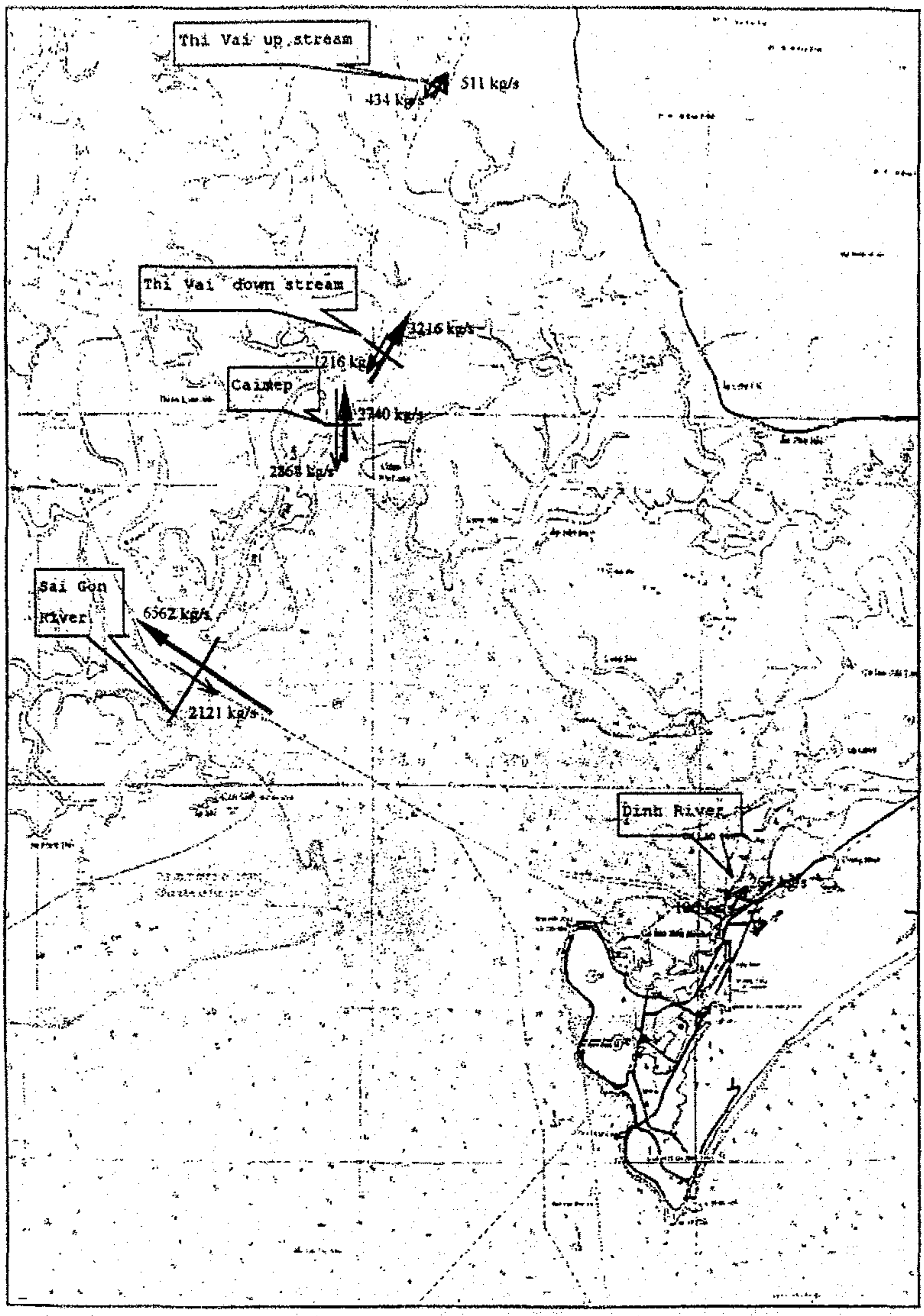


Figure 13.3.1-3 (1) Volume of Suspended Solids Transported at Ebb Tide and Flood Tide (Measured during spring tide on 19/10/2001)

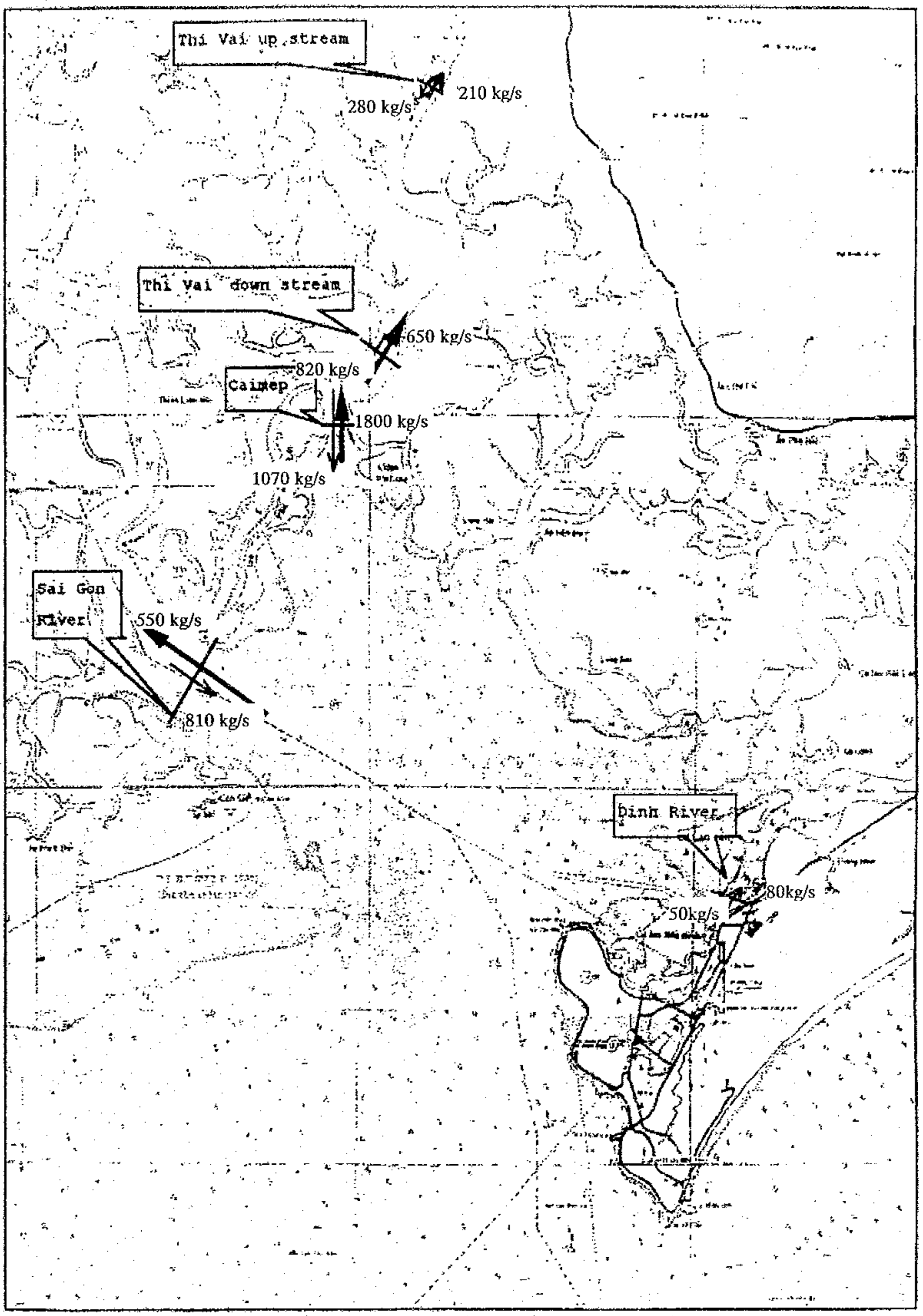


Figure 13.3.1-3 (2) Volume of Suspended Solids Transported at Ebb Tide and Flood Tide (Measured during spring tide on 1/12/2001)

Table 13.3.1-1 Measured Amount of River-Transported Sediment

(1) Rainy Season (Date of survey: 19/10/2001)

Name of river	Cross section No.	Sediment transport (kg/sec) and Direction (deg. N)			
		Ebb tide		Flood tide	
		Amount	Direction	Amount	Direction
Thi Vai River	R1 (River mouth)	2,870	187	2,740	7
	R2 (Cai Mep)	1,220	231	3,220	51
	R3 (Thi Vai)	430	216	510	36
Long Tau River	R4 (River mouth)	2,120	118	6,560	298
Dinh River	R5 (River mouth)	110	237	270	57

(2) Dry Season (Date of survey: 01/12//2001)

Name of river	Cross section No.	Sediment transport (kg/sec) and Direction (deg. N)			
		Ebb tide		Flood tide	
		Amount	Direction	Amount	Direction
Thi Vai River	R1 (River mouth)	1,070	187	1,800	7
	R2 (Cai Mep)	820	231	650	51
	R3 (Thi Vai)	280	216	210	36
Long Tau River	R4 (River mouth)	810	118	550	298
Dinh River	R5 (River mouth)	50	237	80	57

Source: Study Team

3) Generally speaking for the rainy season, the SS that flows out (ebb tide) and in (Flood tide) is almost balanced at the Thi Vai River mouth. On the other hand, the movement of SS into a river (upstream movement) exceeds outward flow (downstream movement) for about 2.5 to 3.1 times at the Long Tau River and the Dinh River. In the dry season, the difference becomes smaller to be 0.7 to 1.7.

4) High density SS is commonly measured at the bottom layers.

(2) Seabed Material

The distribution of the seabed material in terms of the median diameter, d_{50}, is already shown in Figure 3.2.3 (1) and (2).

The bottom materials change from place to place, ranging from clay to sand, in the Thi Vai River; commonly sandy in deeper depth than 20 m and silty in the shallower depth. It is silty at the Long Tau River mouth, and sandy at Dinh River mouth.

The reason why the median diameter is quite larger at the midstream than that at the sides is apparently due to strong current at the midstream.

13.3.2 Records of Maintenance Dredging

The record of regular bathymetric survey and maintenance dredging at any portion of the channels in Ganh Rai Bay can be the only proof of sedimentation, and can be used as the approximate data of sedimentation to calibrate the Simulation Model.

There are three places where bathymetric surveys were carried out for checking water depth of the channel and/or management of channel dredging:

1) Long Tau River Approach Channel for maintenance dredging
2) Dinh River Channel for maintenance dredging, and
3) Thi Vai River Approach Channel for checking the channel depth.

(1) Maintenance Dredging at Long Tau River Approach Channel

VMS has been carried out maintenance dredging of the channel at the exit of the Long Tau River (P5-P9; Length: 2.2 km, Width: 150m) every year since 1997. The planned maintenance depth is CDL -8.5m, and the side slope is 1:5.

The dredged records are summarized in Table13.3.2-1. The average volume dredged annually was 26,000m^3/year from 1998 to 2000. It is characteristic that the dredged area is along the southern edge of the channel, which suggests the sedimentation is dominated from that direction at this portion of the channel.

Table 13.3.2-1 Record of Maintenance Dredging of the Channel in Ganh Rai Bay
(Location: P5 – P9 on Long Tau River Approach Channel)

Year	Dredged volume (m^3)	Dredging period		Dredger employed		Budget ($\times 10^6$ VND)
		From	To	Type	Capacity	
1996	Not done					
1997	134,000	29/7	5/9	Hopper**	5,000 m^3	2,051
1998	21,000	25/6	5/7	Hopper**	5,000 m^3	351
1999	35,000	24/6	11/7	Hopper**	5,000 m^3	500
	*882,000**	*19/1*	*02/7*	*Bucket*	*500 m^3/h*	*21,000*
2000	22,000	25/6	28/6	Hopper**	5,000 m^3	439

Source: VMS

Notes: * This is the capital dredging at the sharp bend near Go Dau in the Thi Vai River by bucket dredger TC 81, TC82 and TC 91. The dumping site was the Ba Hao River.

** Hopper suction dredger "Long Chau" and "Tran Hung Dao"

It is noted that the dumping site of the dredged material is within a radius of 500m, centering at:

Longitude: 106 degrees 59' 12" East, and
Latitude: 10 degrees 20' 48" North,

which is about 4.5km off the eastern tip of the Can Gio coast to the south-east direction. The water depth is about CDL-3m. This dumping site is located at 6.4km to the west of the Vung Tau Approach Channel. Vung Tau Port Authority might designate this place, as the volume of dumping was quite limited. It is noted that, in a case where the dumping volume becomes large, the location should be selected further offshore so that the dumped materials will not affect sedimentation of the channel.

(2) Maintenance Dredging at Dinh River Channel

Presently the Dinh River Channel consists of about 2.7km long natural channel and about 3km long artificially maintained channel to reach the berths and basins of Vung Tau Petroleum Technical Service Company (PTSC) and, then, of Viet-So Petroleum JV (Vietsopetro). They own and manage the cannel and basins. The regulation of the Vung Tau Port Authority defines the size of the Channel to be CDL-7.0m in depth and 150m in width.

PTSC's Wharf has a length of 450m planned for the ship of 10,000 DWT, which has been operational since 1993. The latter channel presently has the shallowest depth of 6.5m and the narrowest width of 100m between the depth contours of 6m. PTSC and Vietsopetro maintain these channels and basins by themselves.

According to PTSC, the channel is scheduled to dredge once three years, or already dredged twice in the past in 1996 and 1999. The Maritime Dredging Company No. 2 (MADRECO) has the records of its dredging works as shown in Table 13.3.2-2.

Table 13.3.2-2 MADRECO's Records of Dredging Works in the Study Area

Year	Location	Project Owner	Remarks
1996	PTSC Port – Vung Tau*	PTSC	*PTSC Basin
1997	PTSC Port – Vung Tau Tan Thuan Port – HCM City Saigon Channel – Vung Tau	PTSC Tan Thuan Port VMS	
1998	Ben Nghe Port –HCM City PTSC Port – Vung Tau*	Ben Nghe Port PTSC	 *PTSC Basin
1999	Go Dau – Thi Vai River Saigon Channel – Vung Tau PTSC Port – Vung Tau*	VMS VMS PTSC	Capital Dredging *PTSC Basin
2000	Vietsopetro Port – Vung Tau** Saigon Channel – Vung Tau	Viet-So Petroleum JV VMS	**Dinh River Channel

Source: Maritime Dredging Company No.2 (Brochure, 2001). Note: Remarks are by the Study Team

It is to be noted that the dumping site is the shallow water to the north of the channel.

(3) Sounding Records at Thi Vai River Approach Channel

Thi Vai River Approach Channel and the channel in the river from the corner of Buy No. 5 to Thi Vai (Cross Sections No. 10 to No. 17) have been surveyed every year from 1997 to 2000.

13.3.3 Qualitative Assessment of Sedimentation in the Channel

In view of necessity of dredging and maintenance of the channel in the Mater Plan with the planned depth of CDL -14m and -16m, the coastal process shall be discussed to assess the possible sedimentation volume. The analysis shall consist of two steps. The first step is to establish understanding of the phenomena occurring at the site based on the relevant available data and qualitative assessment of them. The second step is to prepare suitable simulation models reflecting the phenomena and carry out numerical simulations of possible sedimentation quantitatively. Hereinafter, perspectives of the phenomenon are described briefly and qualitatively.

In Ganh Rai Bay there are following four portions of the navigation channels where attention should be paid in view of anticipated sedimentation and maintenance dredging in the planned deep channel.

(1) Vung Tau Approach Channel

The entrance portion of Vung Tau Approach Channel from Buoy No.0 to No.5 has not been dredged in the past. This is because the actual water depth in this portion is from 10.3m to 24m, which can mostly clear the presently regulated depth of CDL -12.0m with a width of 200m.

In between and around the Buoy No. 0 and No.5 (or No. K) for about 3km in length, there are infiltrations of shallow contours less than 14m from the both sides of the channel. Among them the area at the corner of Buoy No. 3, shallow water extends from the head of the Vung Tau Cape. The bottom material in this area is fine sand.

This phenomenon could be discussed in three ways. The first is coastal process of the Vung Tau Beach under the action of the northeast monsoon. The area of interest corresponds to the shade of the headland of Vung Tau. The second is much wider scale phenomenon, covering the Vung Tau Cape and the Soai Lap River Mouth, where large-scale movement of the seabed materials might reach the Vung Tau Approach Cannel. The third is a flush effect by the tidal currents, which possibly contributes as a major factor to the maintenance of the depth of the present channel.

In any event, the present natural seabed could be more or less in a state of dynamic equilibrium in the long run, judging from the fact that maintenance dredging has not been carried out.

It is noted that there is a survey subject yet to be preferably conducted in advance of feasibility study, which is a geological investigation of the soil layer beneath the seabed to confirm non-existence of hard rock. This is because no one can assure that there is no rock within a few-meter depth below the seabed surface, which definitely affects the cost and the feasibility of the Project.

(2) Dinh River Channel

Judging from the past records of maintenance dredging, the basin and the channel at the mouth of the Dinh River needs to be dredged rather regularly to allow large ships to enter their ports. The echo sounding records kept by the appraisal organization of dredging works and the Study Team show a considerable degree of sedimentation in the channel, i.e. an order of 1 m at the mouth of the channel in the past one year, as shown in Figure A13.3.3-1.

From technical point of view, it shall be noted that the area at the mouth of the Dinh River is the place where the Study Team confirmed the existence of "fluid mud" in front of PTSC Basin. On the other hand, the river discharge of water and SS is quite small in quantity compared with those at the mouths of the Long Tau River and the Thi Vai River.

Paying attention to a fact that the channel runs through very shallow water with fine seabed materials consisting of clayey silt, the combined effect of tidal current and wave-induced current on agitation and transport of bed materials from the surrounding seabed is possibly the major cause of siltation and sedimentation in the channel.

In addition, it is reminded that the dumping site of the dredged material is the shallow water to the north of the channel, which could have a possibility of returning the dumped soils back into the channel.

It could be judged that maintenance dredging of a certain volume could be unavoidable unless drastic countermeasures would be taken such as, subject to confirmation of the effect by hydraulic model tests, construction of a parallel training wall along the channel.

(3) Thi Vai River Approach Channel

For the large ships calling at the ports in the Thi Vai River, the shallow portion of the Thi Vai River Approach Channel can be a bottleneck of navigation. The portion where the water depth is less than 16m, measuring from CDL, lies from Buoy No.5 to No.10 with a total length of about 9 km. This portion of the Channel is regulated by the Vung Tau Port Authority to have CDL –9.50m in depth and 150m in width.

The portion of the Channel has not dredged in the past, or no maintenance dredging has been required under the present conditions of the operations of existing ports in the river. On top of this fact, bathymetric maps prepared in the past a few years indicate no significant change in the depth and seabed configuration as shown in the cross sections of Figure A13.3.3-2. The degree of sedimentation and erosion is minimal along the center of the channel as shown in Figure 13.3.3-1 except the exit of the Thi Vai River where the depth is as deep as 60m.

They imply that the seabed in this portion could be in a rather stable state of dynamic equilibrium despite of actions of relatively strong current under the present hydraulic circumstances.

The dominant phenomenon in this area is spreading and dispersion of the water and sediments from the Thi Vai River after passing the narrow mouth of the river at Cai Mep due to funnel-shaped geography. It results in decrease of current speed compared with that in the river, wherein the water loses the sustaining power of suspended solids proportional to the decrease in the flow speed.

On the other hand, when the tidal current is to upstream direction during flood tide, agitation of the seabed materials possibly occurs to bring re-suspended solids, judging from the result of the River Discharge Survey. In addition, sand drift by the action of waves might be accompanied when the sea is rough, causing movement of sediments along the shoreline, or lateral to the channel.

Under a new condition where a deep artificial channel will be exploited, all of the above effects could be the factors of sedimentation in the channel. It is noted, however, that the tidal current flows almost parallel to the alignment of the planned channel, minimizing the effect of the current crossing the channel, and maintaining the effect of flushing of seabed, which can be a favorable condition in this channel development plan. Still, it should be anticipated that a certain amount of maintenance dredging could be required in the planned channel.

(4) Long Tau River Approach Channel

This portion of the channel is not the route to the Thi Vai River. Still, the past dredging records are good reference in evaluating the stability of the artificial channel.

Figure A13.3.3-3 is an example of cross sectional change after dredging. It is judged that, due to strong current, the channel bed is always agitated and sometimes the current crosses the channel, and thus the leveling effect dominates the area. As the result, the deeper parts in the channel are buried and shallower parts are eroded quickly, resulting in rather stable water depth.

In this context, it is anticipated that maintenance dredging in this part of the channel is inevitable for the designated channel depth of CDL –8.5m.

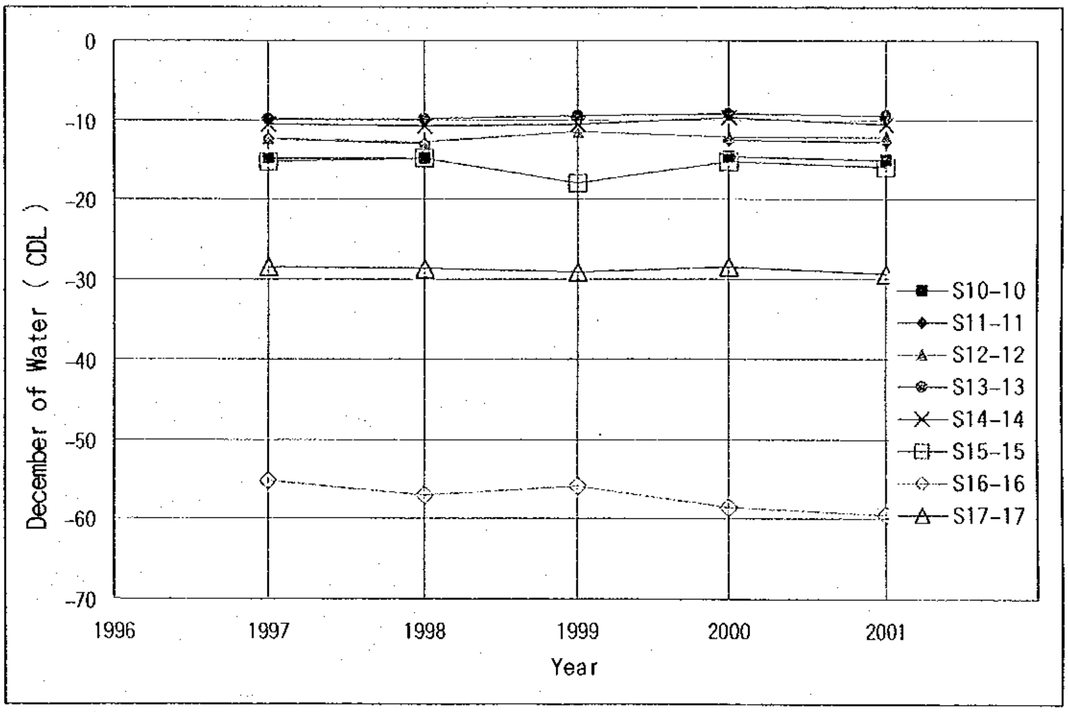


Figure 13.3.3.1 Change of Water Depth at Thi Vai River Approach Channel
Source: Study Team.

13.3.4 Numerical Simulation of Sedimentation in the Channel

(1) Method of Sedimentation Analysis

The flow of analysis of sedimentation is presented in Table 13.3.4-1. The analysis is divided into seven steps as shown in this Table.

The step 1 is the study of the present conditions as summarized in Chapter 3. The step 2 is the understanding of the phenomena and characteristics as discussed in Chapter 13. The step 3 is identification of the planned channels. Then, modeling of Simulation Calculations, which is described below. The next step is verification and modification of the model by means of measured values. The step 6 is, after calibration of the model for the present conditions, forecast of sedimentation is carried out for the planned channels. Lastly, evaluation and application are made on the result of the forecast of sedimentation, including improvement of channel alignment from the sedimentological viewpoint.

(2) Model Structure

The numerical model employed is "PHRI-JPC Model" which account for three dimensional siltation caused by tidal currents and wave-induced currents in estuaries, and water discharge and sediment supply from rivers. The program of tidal currents and diffusion on the shore consists of ①continuity equation, ②equations of motion, and ③mass conservation equations of salinity and suspended solids.

The model is mainly divided into three parts:

1) The tidal current module is a three-dimensional level model. It consists of nested grids as shown in Figure 13.3.4-1. The vertical partition selected is of three horizontal layers as shown in Figure 13.3.4-2,
2) The wave deformation module includes the wave refraction, diffraction, shearing and the interaction between surface waves and the mud bed, and
3) The total amount of deposition within each mesh is estimated from calculated results of erosion and deposition.

The grid consists of square meshes with a length of 100m. The mesh map is shown in Figure 13.3.4-3(1).

In case of the channel depth of –14m, the mesh is zoomed up to 50 m intervals along the channel as shown in Figure 13.3.4-3(2), in order to reproduce the phenomena more precisely.

Numerical constants introduced in the simulations are as follows:

1) Horizontal eddy viscosity (A_x and A_y) and diffusion coefficients (K_x and K_y):
   x-direction = 100,000 cm^2/sec, y-direction = 100,000 cm^2/sec

2) Vertical diffusion coefficient (K_z)
   z-direction = 1. 0 cm^2/sec

3) Friction coefficient

Middle layer (γi^2) = 0.001, Bottom layer (γb^2) = $gn^2 / h^{1/3}$

4) Manning's roughness coefficient

N = 0.025 (MKS unit)

5) Time step

Δt = 2.0 sec for current calculation

Δt = 20 sec for diffusion calculation

6) Settling velocity

Mud: Function of concentration, C

$Ws = A \times C^B$ for $C \leqq Ch$

$= 2.6 \times 10^{-1}$ cm/sec for $C > Ch$

where $Ch = 4.3$ kg/cm^3, $A = 0.6 \times 10^{-3}$ m^4/kg/sec, and B = 1.

Sand: Rubey's Formula: 2.5 cm/sec

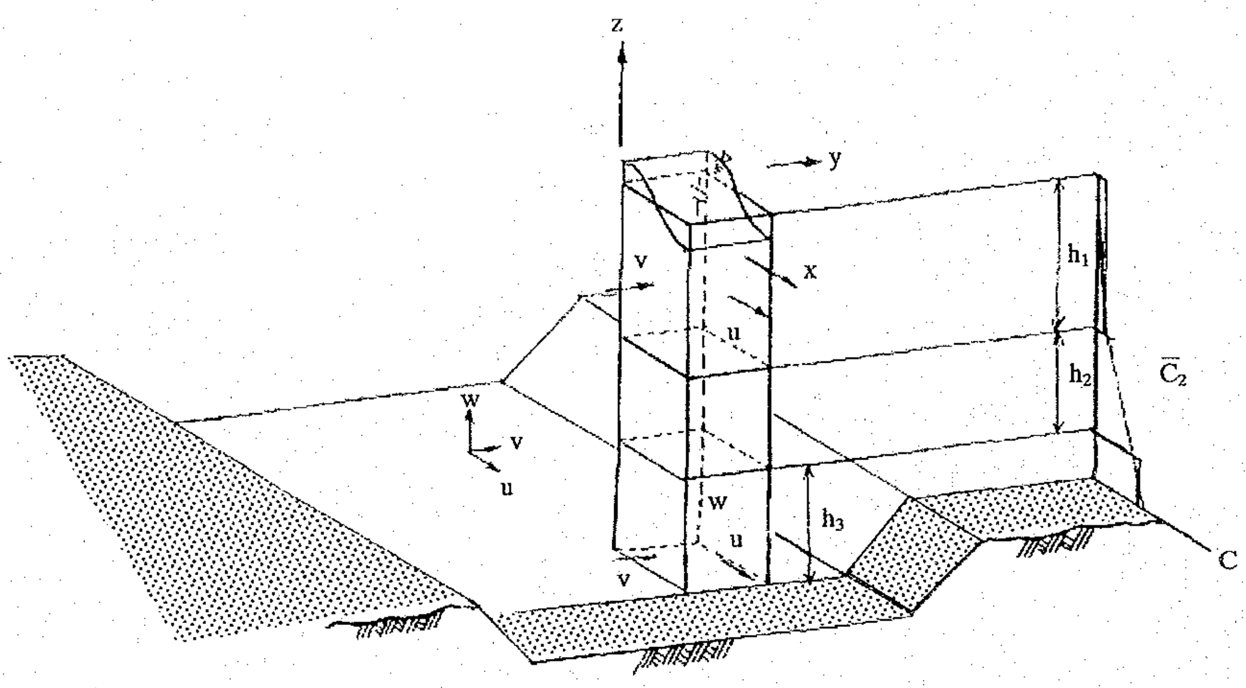


Figure 13.3.4-1 Three-dimensional Level Model

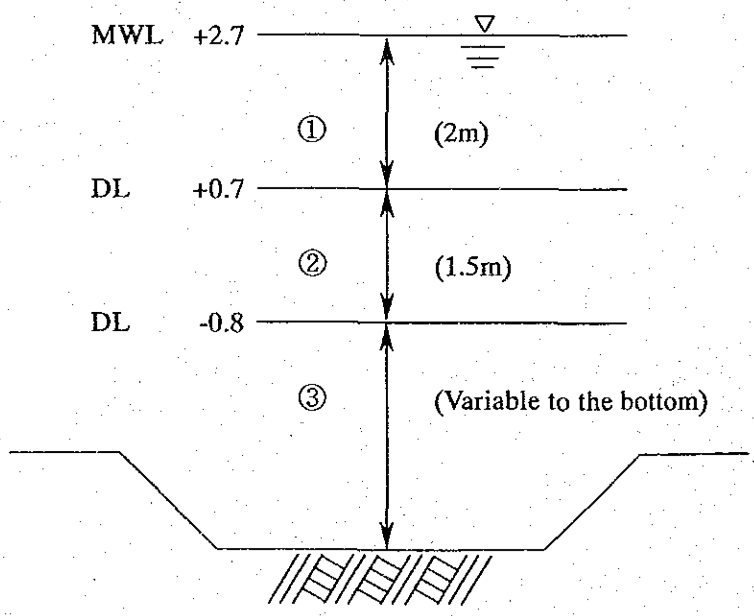


Figure 13.3.4-2 Vertical Partition of Horizontal Layers

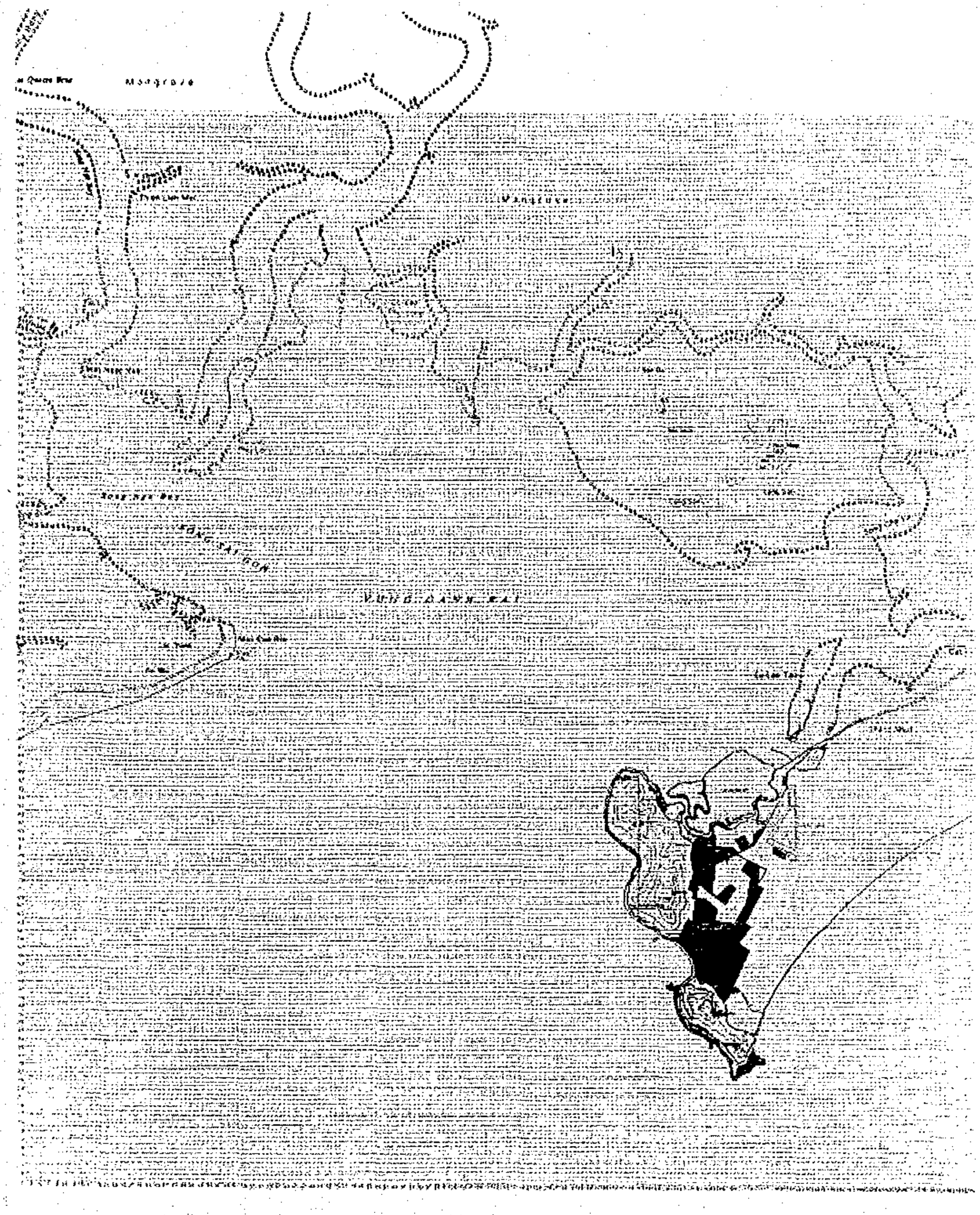


Figure 13.3.4-3 (1) Mesh Map of Numerical Simulation

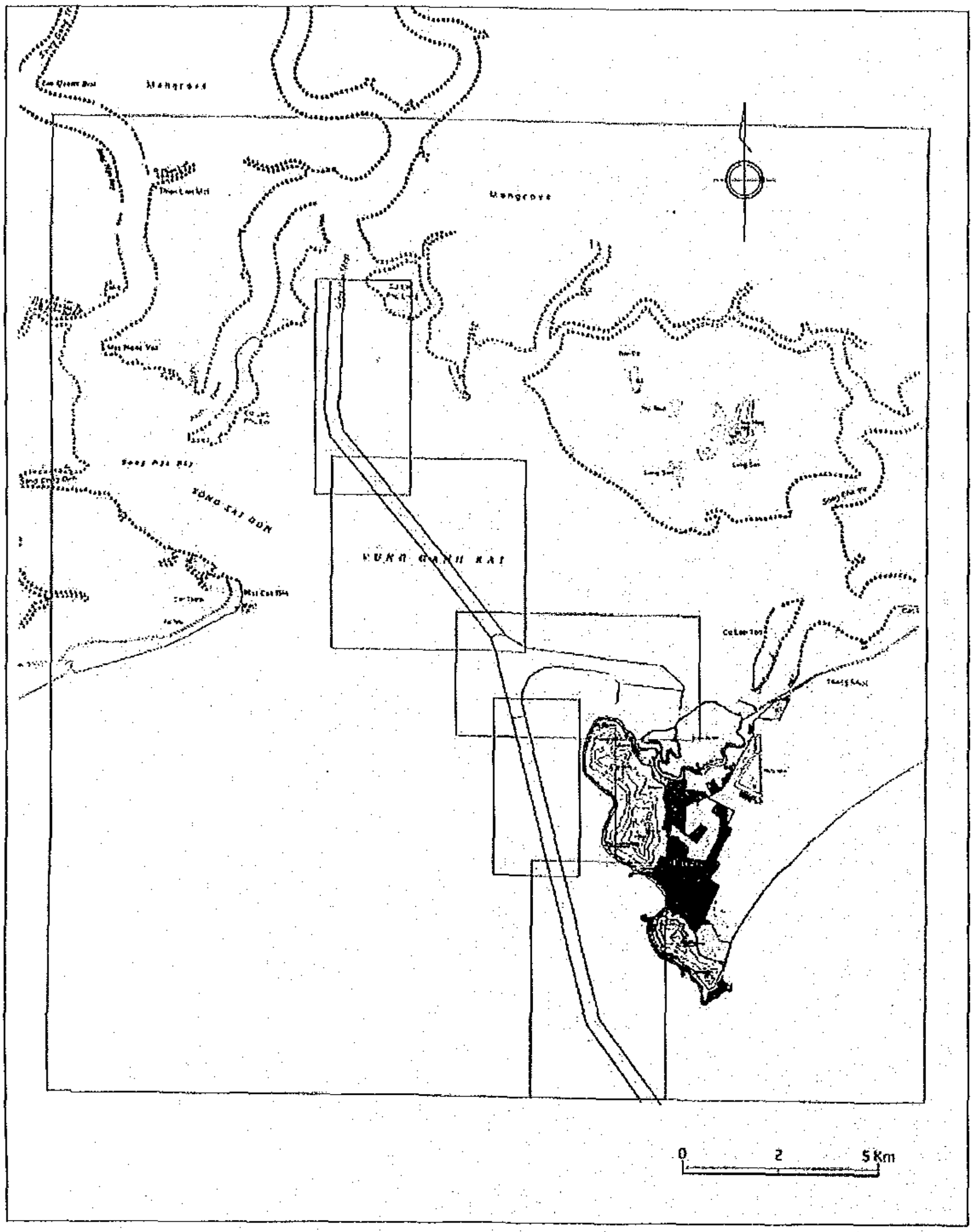


Figure 13.3.4-3(2) Zoomed-up Mesh along The Channel

(3) Reproduction of the Present Condition

1) Harmonic Constants and Tidal Ellipses of Currents

The input data related to the natural conditions for the numerical simulation are summarized in Table 13.3.4-2. The wave and wind conditions are divided into the dry and rainy seasons. Tidal data are given at the outer boundaries of offshore and rivers as spring tide conditions (M2 and S2 components).

Table 13.3.4-2 Input Data for Numerical Simulations (Natural Conditions)

Component		Condition	
		Dry Season (Nov.toApr.)	Rainy Season (May to Oct.)
Waves (Energy average)	Height Period Direction	H=2.0m T=5.3sec 139°	H=0.9m T=4.1m 209°
Winds	Speed Direction	U=5.0m/sec E	U=2.5m/sec SW
Tide	Amplitude Period	$\Delta\eta$=1.2m T=12hours	
Water Level	Mean Sea Level	ODL=+2.7m	
Sediment	Density	ρ s=2.65t/m3	
	Mud:Water content	Mud:w=200%(Silt+Clay:80%,Sand:20%) Where w is variable depend on density.	
	Sand:Void ratio	Sand:n=0.4(Silt+Clay:20%,Sand:80%)	

The observed tidal currents in Ganh Rai Bay are of a typical diurnal type. An example of the result of the analysis of harmonic constants is presented in Table A13.3.4-1. The dominant components are M2, S2, K1, O1 and N2. The tidal current ellipses are shown in Figure A13.3.4-1 for the same case of Station V1. It confirms the nature of very sharp reversing currents.

Examples of the frequency distribution of the currents are illustrated in Figure 13.3.4-4 (1) and (2) for bottom current in June and December 2001, respectively. The patterns and current directions are mostly same between the two seasons except those at V4. The dominant direction at the bottom of V4 is NNE in June and NW in December, which could be an effect of monsoon wind.

2) Flow Pattern for the Present Conditions

The result of current calculation is shown in Figure 13.3.4-5(1) for the present hydraulic and morphological conditions, which represent the annual average conditions of tidal and wave-induced currents. The distribution of current vectors can be understood that the reproduction of currents in the numerical model is pretty well in terms of the average speed and directions of the observed currents.

The comparison of the tidal ellipses for spring tide (M2 and S2 components) between observed and calculated ellipses are demonstrated in Figure 13.3.4-5(2). They coincide each other very well, which proves that the model is well in accord with the actual conditions of tidal current.

3) Trend of Siltation/Sedimentation

The simulated current obtained above is applied to the siltation module. An example of the result of simulations is shown in Figure 13.3.4-6(1) for the present conditions. Change in depth between measurement and simulation along the Thi Vai River Approach Channel is as shown in Table 13.3.4-3 below, where the places of the Section Nos. are shown in Figure 13.3.4-6 (2). . It is understood that the local characteristics of siltation/sedimentation explained qualitatively in **13.3.3** above, are reproduced pretty well in this simulation result.

(4) Result of Simulation of Tidal Current

An example of the result of simulations of tidal current with/without planned channels is shown in Figure 13.3.4.-7(1). The figure shows the results for 1) Existing Conditions, 2) With Planned Channels, and their differences in percentage.

The most significant characteristics of the current are:

a. The strongest ebb current occurs at the center of the Bay, the direction of which is the southeast.
b. The strongest flood current occurs along the east side of the Bay toward the north.

The difference of current speed between with and without channel cases is within ±2% in the Bay, and ±10% near the Ben Dinh area.

(5) Assessment of Siltation/Sedimentation in the Planned Channel

It is necessary to define the "sedimentation, or accumulation" and "erosion" in a channel. Referring to Figure 13.3.4-7(2), the sedimentation/erosion is defined by the accumulation/erosion above/below the channel bottom to be dredged. The areas below the channel profile are all disregarded.

It is noted that there could be twice to five times larger volume of "accumulation below channel bottom" in the channels than that of "accumulation above the channel bottom." This is because some parts in the channels have deeper natural depth than the planned depth.

The above model is applied to the new configurations of the planned channel with the following three dimensions:

Case 1) Depth of the channel: h = CDL –16m with a bottom width of the channel: b = 500m,
Case 2) Depth of the channel: h = CDL –14m with a bottom width of the channel: b = 350m, and
Case 3) Depth of the channel: h = CDL –12m with a bottom width of the channel: b = 150m.

The side slope is assumed to be 1/5 for the all cases.

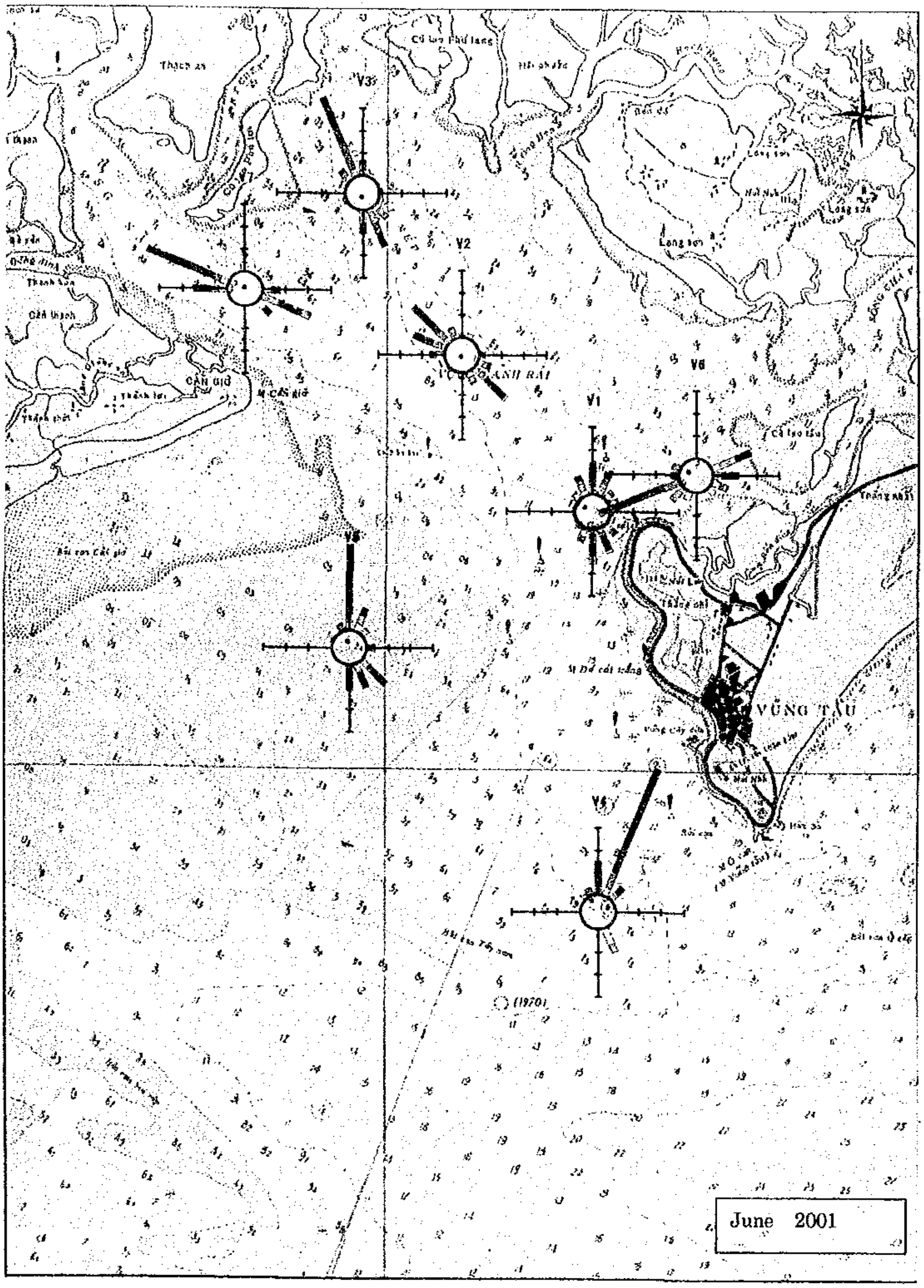


Figure 13.3.4-4 (1) Frequency Distribution of Bottom Current (June 2001)
Source: Study Team

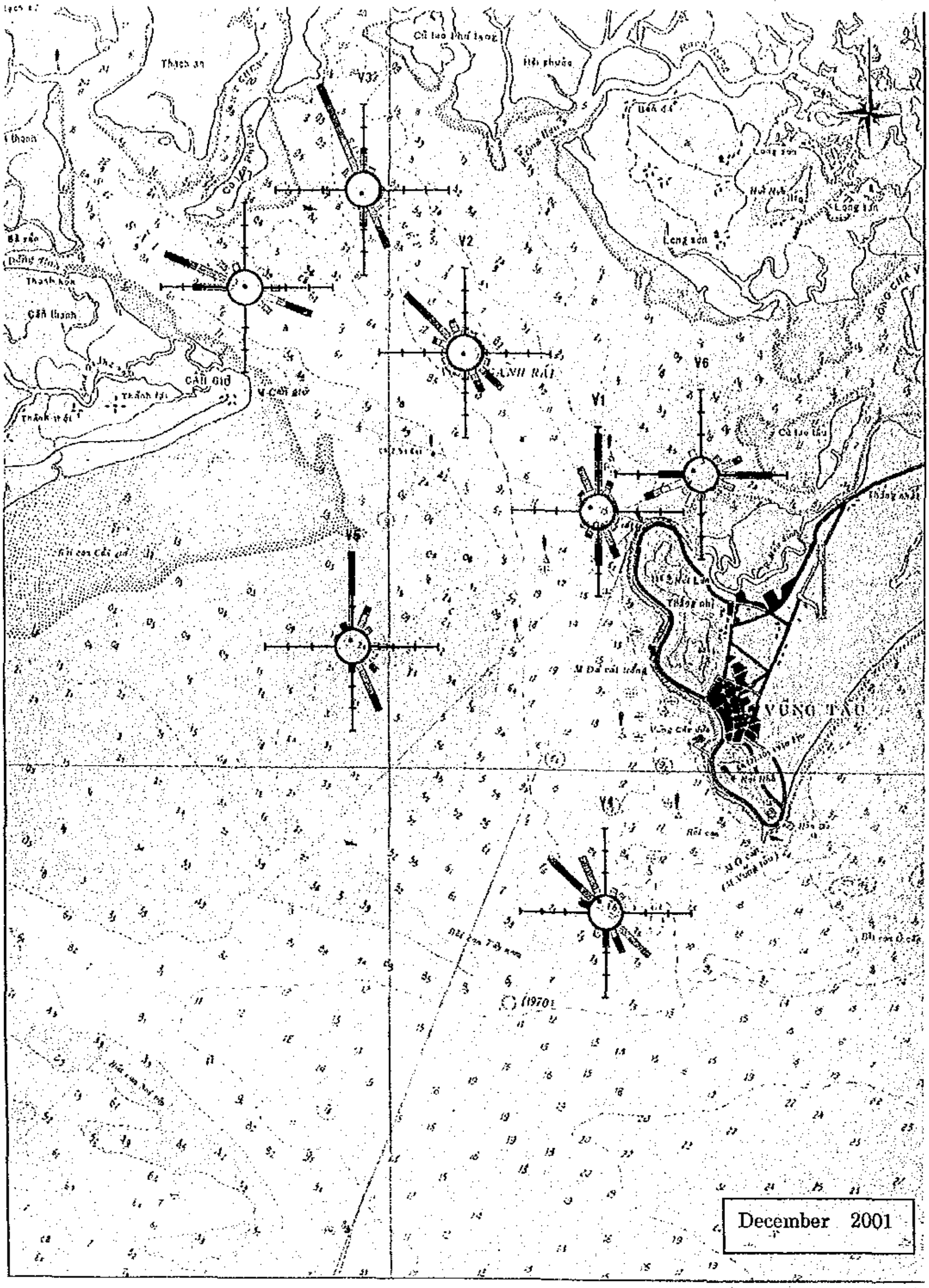


Figure 13.3.4-4 (2) Frequency Distribution of Bottom Current (December 2001)
Source: Study Team

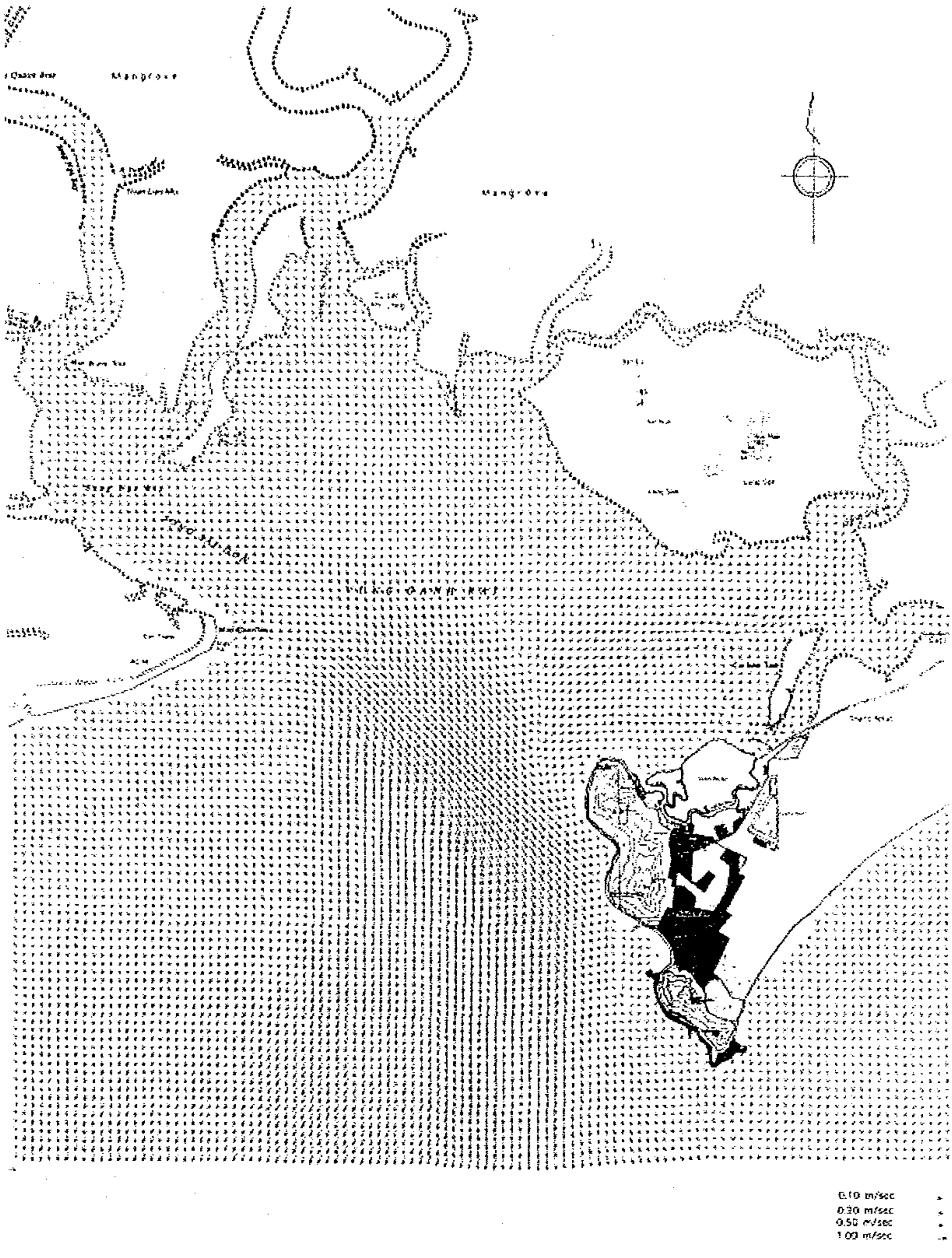


Figure 13.3.4-5(1) Reproduced Flow Pattern
Source: Study Team

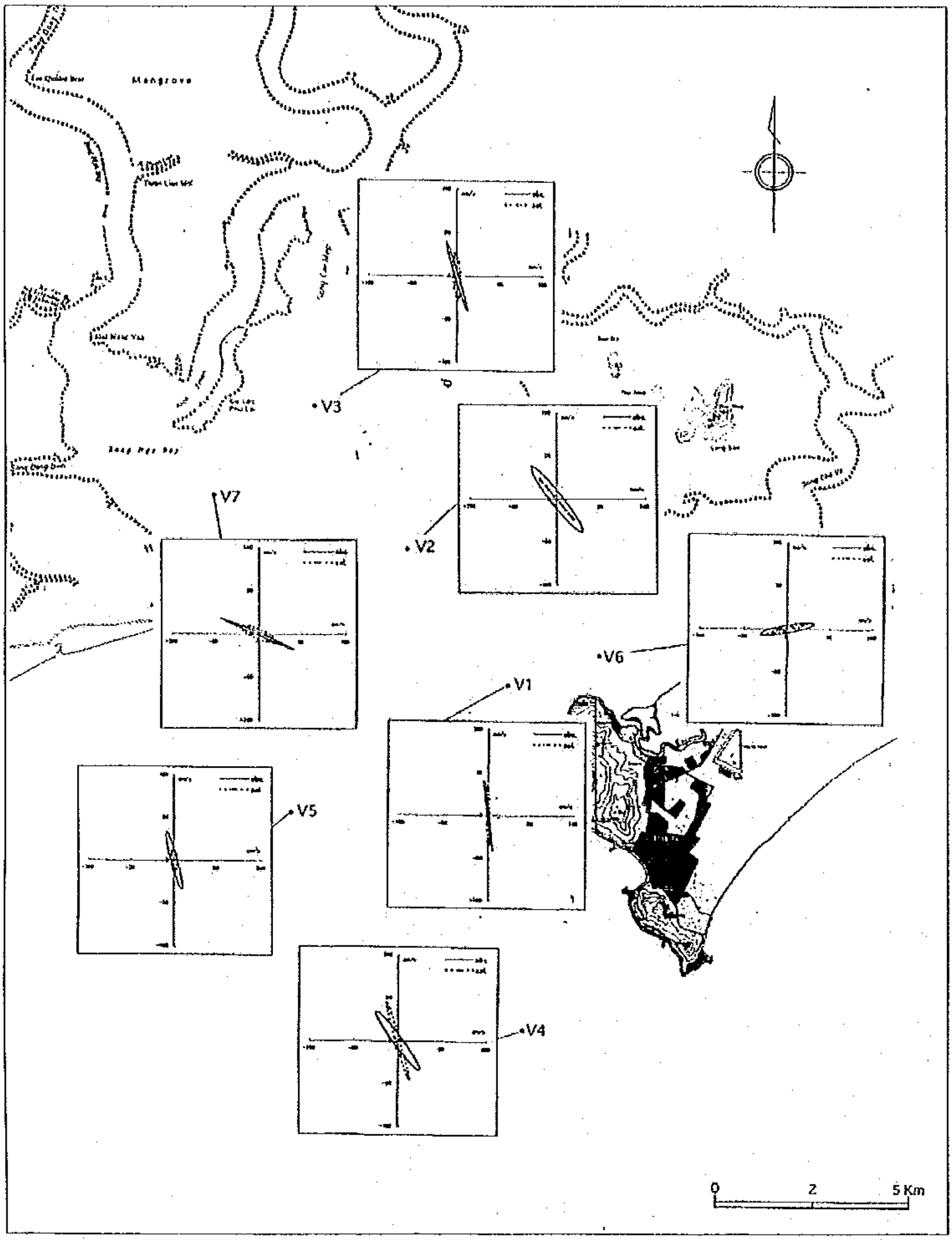


Figure 13.3.4-5(2) Comparison of the Tidal Ellipses between Observed and Calculated Ellipses (Spring Tide)

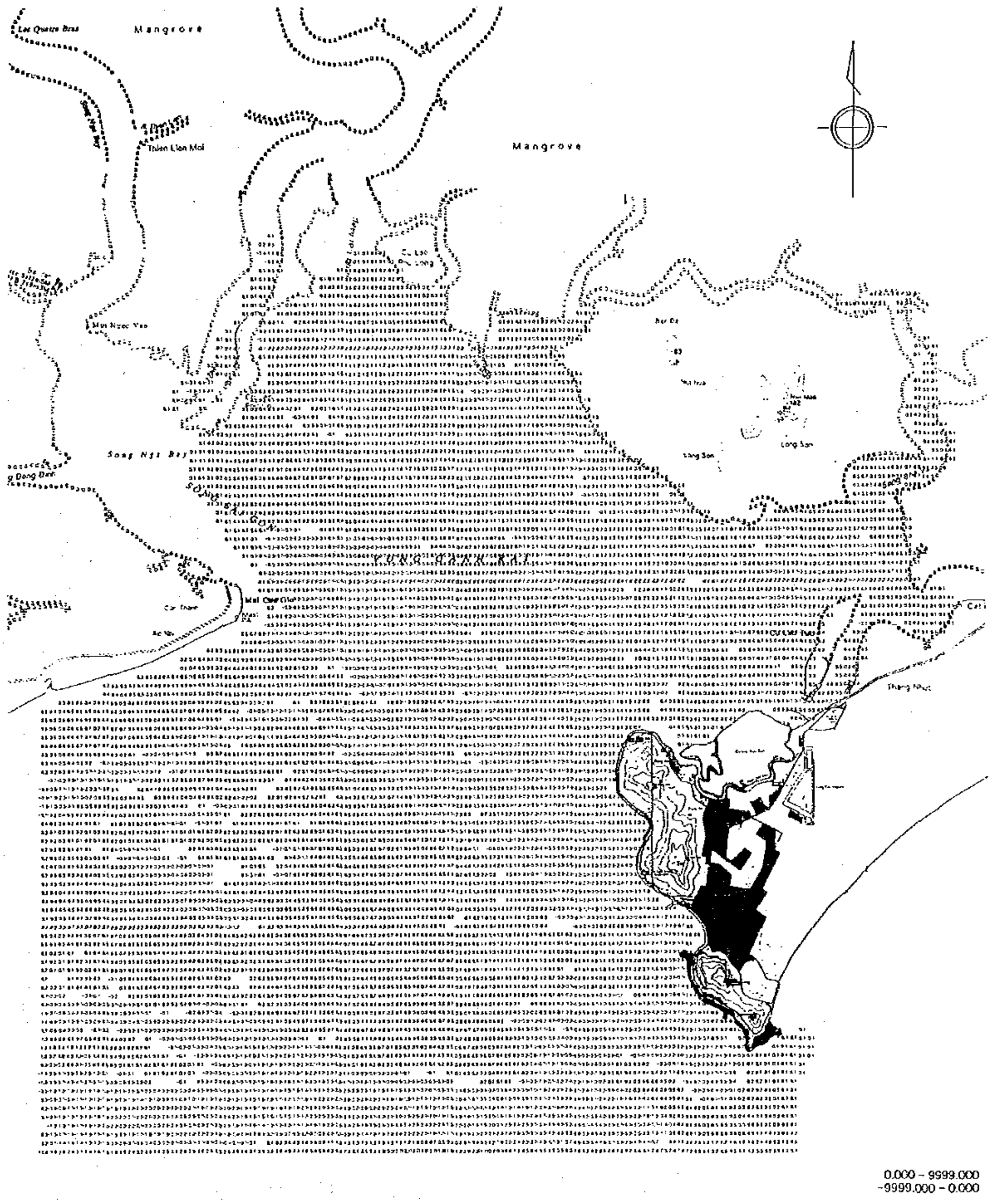


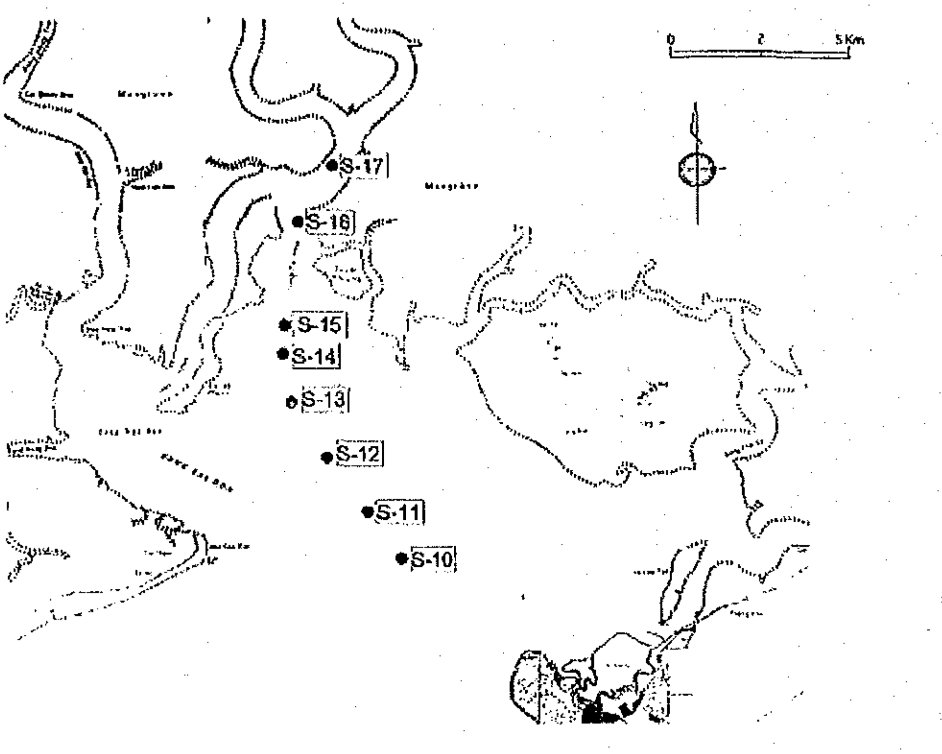
Figure 13.3.4-6(1) Result of Simulation of Siltation in the Present Conditions

Source: Study Team

Table 13.3.4-3 Comparison of Change in Depth(m) between Measurement and Simulation under the Present Condition

Section No.	Measurement (*)	Simulation
S-10	0.0	0.0
S-11	-0.2	0.0
S-12	0.0	0.1
S-13	0.1	0.1
S-14	0.0	0.1
S-15	-0.2	0.1
S-16	-1.0	-1.2
S-17	-0.2	-0.3

(*)Average annual change from 1997 to 2001



-The applicability of the simulation model of sedimentation is examined by the measured data at 8 sections along the Thi Vai Approach Channel. The accuracy is proved to be enough.

Figure 13.3.4-6(2) Places of the Section Nos.

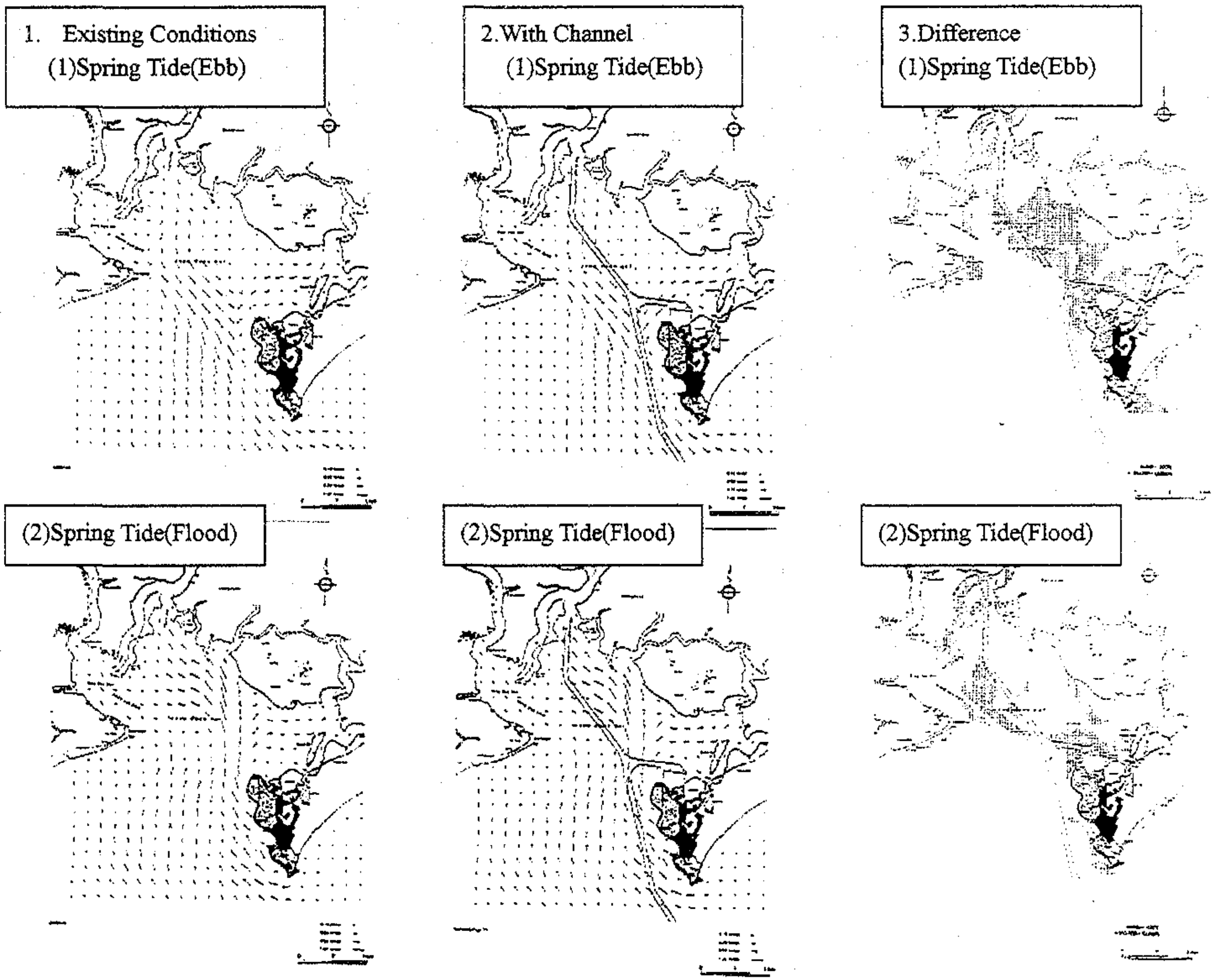


Figure 13.3.4-7(1) Results of Simulation of Tidal Current with/without Channel (Depth=CDL-16m, Width=500m)

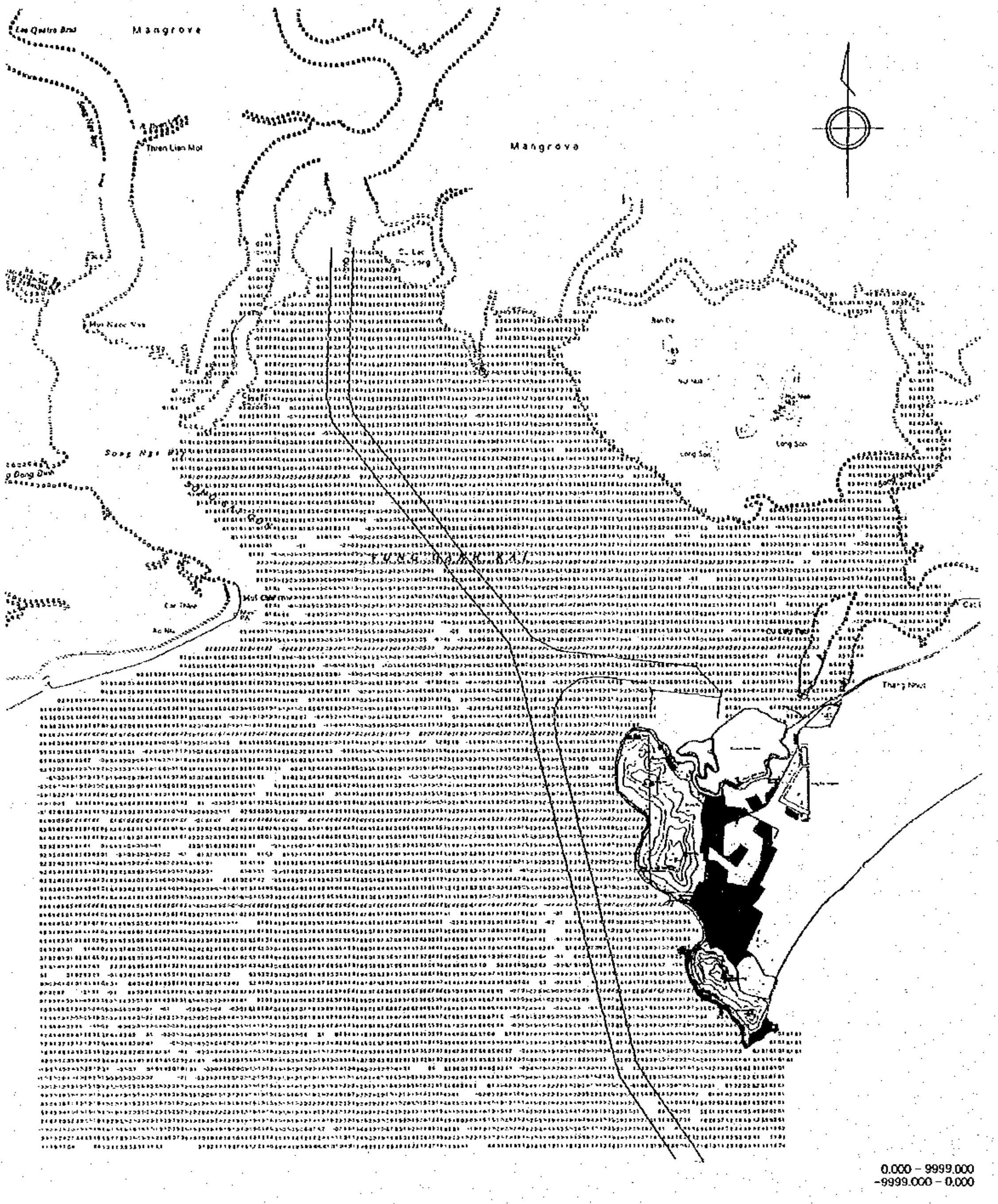


Figure 13.3.4-7(2) Result of Simulation of Siltation in Planned Channel

Source: Study Team

An example of the results of simulations of sedimentation is introduced in Figure 13.3.4-8 for Channel depth -14m. In this Figure, (1) is the planned channel and (2) is the changed alignment, considering the current directions, or reducing the strong cross-currents.

There are six areas where considerable sedimentation occurs in the channels, or from offshore, 1) Entrance and 2) Center of the Vung Tau Approach Channel, 3) Around the buoy No. 5, 4) Lower stream of the Corner of the Thi Vai Approach Channel, 5) Out of the mouth of the Thi Vai River, and 6) At the middle of the Dinh River Channel.

It is noted that the above simulation is for the average conditions for dry and rainy seasons. It is necessary to take account the unusual weather such as typhoons. It could be a few times larger than the average one, if the variation of the past dredged volume is considered such as those in the Long Tau River Approach Channel.

There is another factor to modify the results of simulations, because of the inability of the model at the mesh boundaries, where horizontal movement of the bottom profile cannot be calculated. It can be the direct effect of the wave action on the shallow shoulder and slope of a channel. Such example is the case of the Ben Dinh-Sao Mai Channel, where the effect of waves can be assessed from the records of dredging in 2000 and 2001. Its erosion at the shoulder and slope was about 100 thousand m^3/year and sedimentation on the immediate bottom was an order of 150 thousand m^3/year.

In consideration of these factors, the estimated annual volume of sedimentation is summarized in Table 13.3.4-4 for each channel.

Table 13.3.4-4 Estimated Volume of Sedimentation in Planned Channels

Case No. (Depth x Width)	Channels	Estimated Volume of Sedimentation (Thousand m^3/year)
Case 1 (-16 m x 500m)	Vung Tau Approach Channel	60~200
	Thi Vai River Approach Channel	190~600
	Dinh River Channel	80~400
Case 2 (-14 m x 350m)	Vung Tau Approach Channel	20~100
	Thi Vai River Approach Channel	140~400
	Dinh River Channel	70~300
Case 3 (-12 m x 150m)	Vung Tau Approach Channel	10~50
	Thi Vai River Approach Channel	80~250
	Dinh River Channel	40~250

Source: Study Team

It is noted that the re-aligned channel shown in Figure 13.3.4-8 has a reduction of sedimentation volume of about 30 %. It is, however, not always applicable in execution, if the increase in capital dredging of the Thi Vai River Channel which, in this alignment, runs through relatively shallow water .

It should also be noted that the above figures are indices of the degree of siltation/sedimentation simulated by the numerical model, which can roughly represent average situation of the site, and can be used to evaluate the order of the phenomenon for the planning purposes only. To finalize the estimate of siltation/sedimentation, it is imperative to make detailed analyses including introduction of hydraulic model tests, and field monitoring or follow-up surveys of siltation/sedimentation by means of test pits, or temporary dredging at the site.

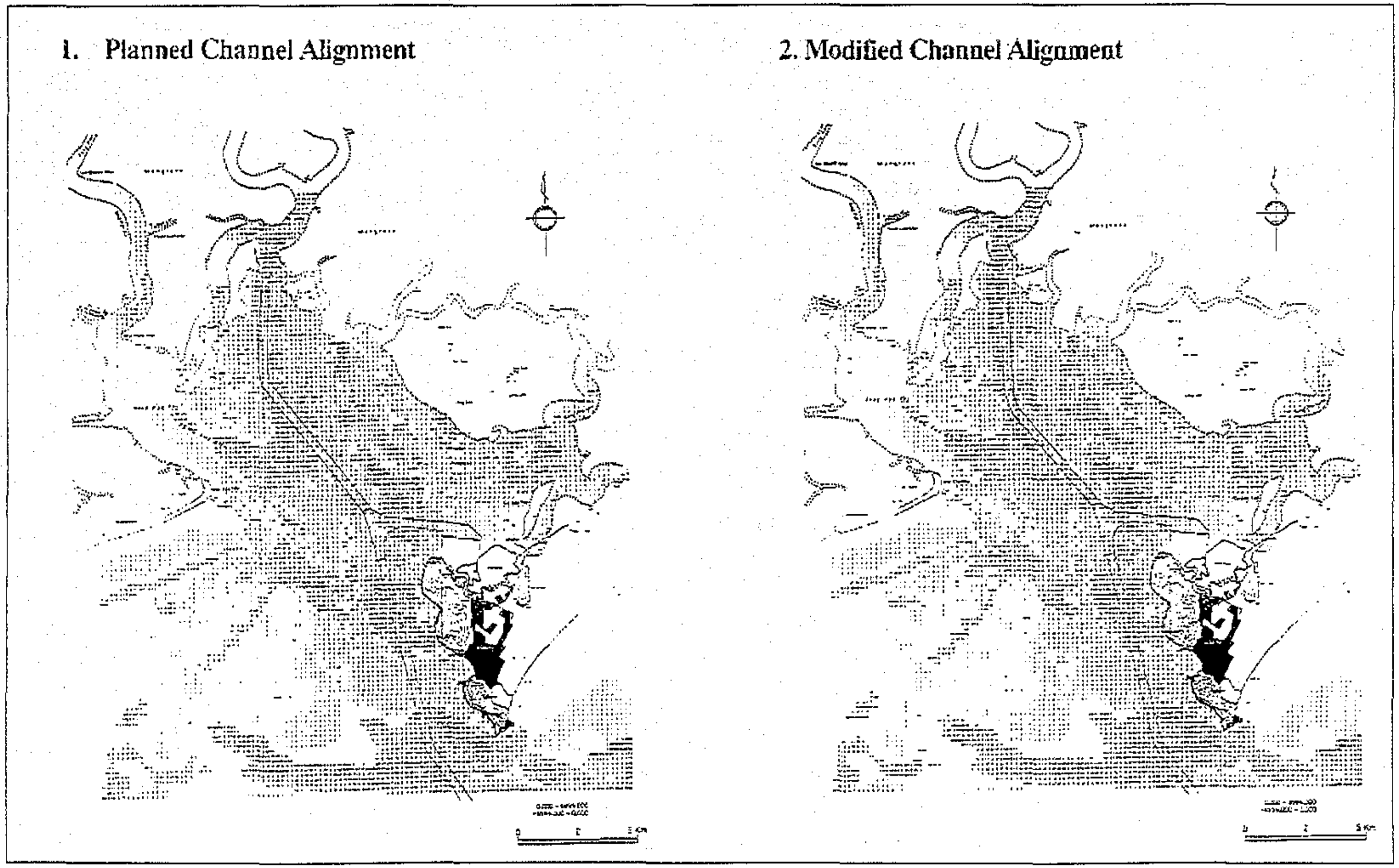


Figure 13.3.4-8 Result of Simulation/Sedimentation for Planned and Modified Channels (Depth=CDL-14m, Width=350m)

13.3.5 Numerical Simulation of Change in Coastlines

(1) Method and Model of Simulation

Change of coastlines is assessed based on so-called "One-line Theory," which takes account the movement of seabed material by longshore current due to radiation stress of waves. The effect of waves is evaluated by the average energy of waves by the seasons.

The simulation was applied to the Vung Tau Coast and Can Gio Coast.

The boundary conditions of waves are given similar to the Sedimentation Model explained above. They are separated into the dry and wet seasons. The source of wave data is the usual waves assessed for the past five years.

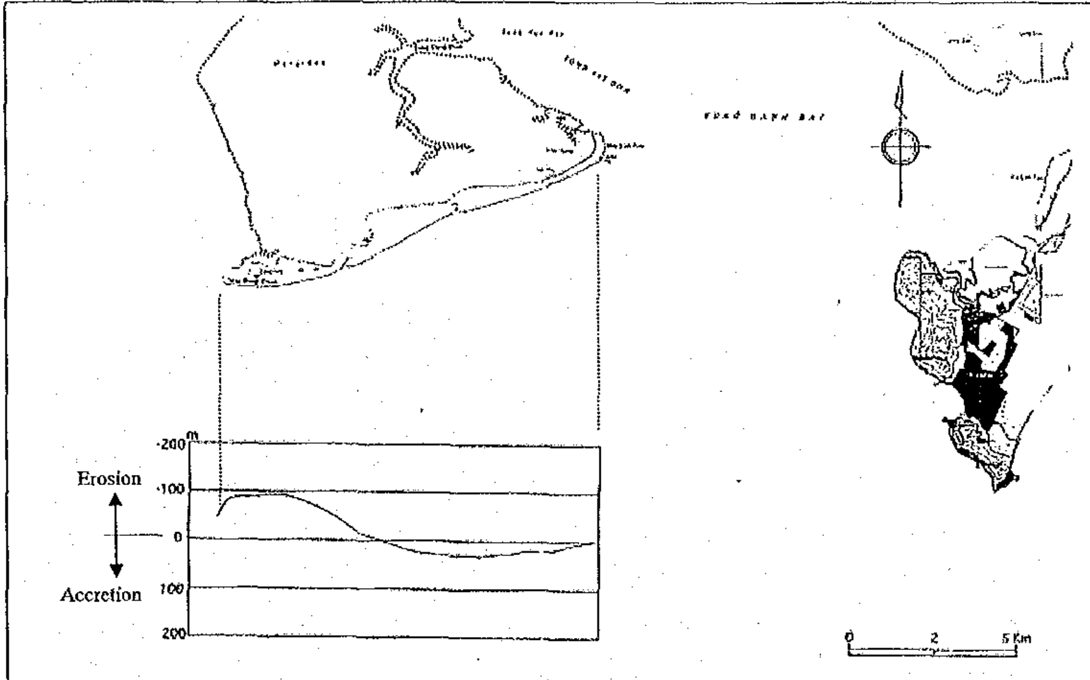
(2) Results of Simulations

The results of simulations are shown in Figure 13.3.5-1.

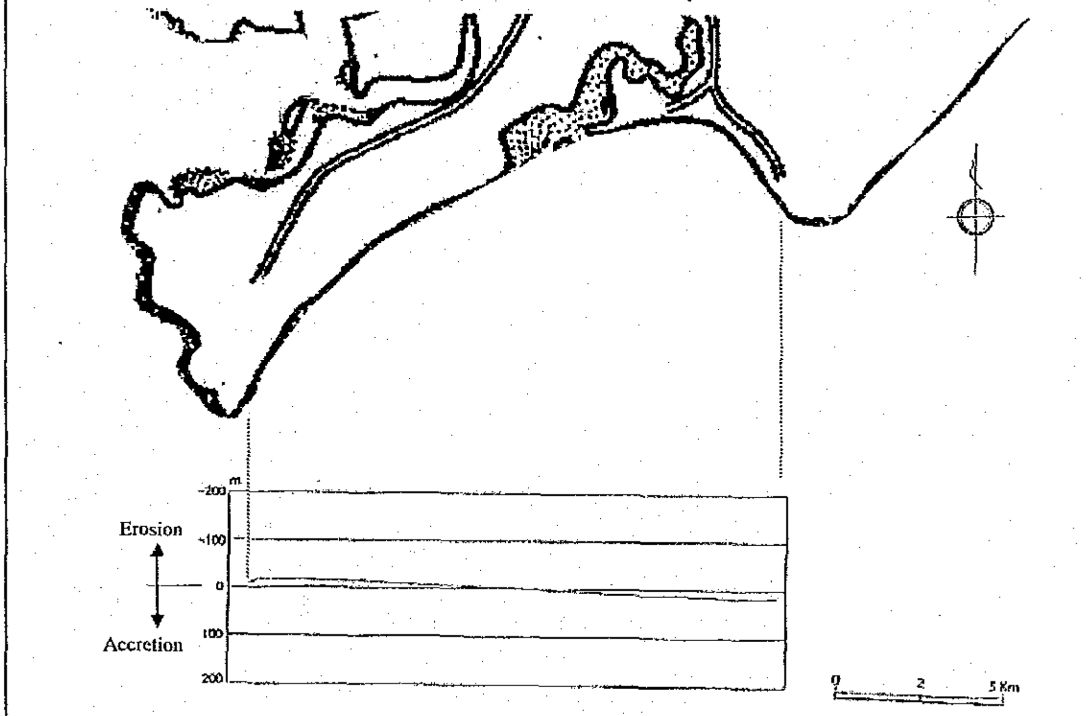
It is proved that the shoreline of Vung Tau is quite stable. The shoreline is a kind of "pocket beach " between the hard headland of Vung Tau.

On the other hand, the shoreline of Can Gio advances at the eastern part and retreat at the western part. This is because of soft bottom materials and free boundaries to the longshore directions.

These above trends agree the result of analysis of the past photographs very well.



(1) Coasts in Ganh Rai Bay



(2) Coast in Front of Vung Tau

Figure 13.3.5-1 Expected Change in Coastlines by means of One-line Theory Analysis