III-6-1-3 Thermal diffusion

— The verification

The numerical result of thermal diffusion shows the temperature rise above ambient water temperature. According to the observed water temperature in 1981, the temperature ranged from 28°C to 28.4°C except the river mouth areas of Jurong Riv. and Pandan Riv.

In these area, the water temperature is about 0.5°C higher than ambient waters.

In the present stage, around the Jurong Stage Power Station which has the thermal discharge (5.6°C higher above ambient waters and discharge rate is 33.4 m^3/sec), the observed temperatures show from 28.1°C to 28.2°C and these values has slight difference compared with ambient water temperatures.

Fig. III-6-18 shows the distribution of computed temperature rise above ambient water temperature. The maximum temperature rise above ambient water is equal to 0.1°C around the Jurong Stage Power Station and 0.04°C around the Pasir Panjung Power Station.

This computed result indicates that thermal discharges induced from both stations have slight influence on the ambient water temperature. Since the observed data and the computed result show the smae characteristic of water temperature, that is, both results show rapid mixing of thermal discharge, it can be judged that the numerical result has good agreement compared with observed data.

— The temperature rise above ambient in the future stage

Introducing the topography change and thermal discharge of future stage, the thermal dispersion pattern is computed in the same manner.

Figs. III-6-19 and III-6-20 show the distribution of computed temperature rise above ambient water temperature and Table III-6-7 shows those values at typical points.

From these numerical results, the temperature rises above ambient in the future stage are summarized as follows:

1 As compared with the computed temperature rise above ambient water temperature in the present stage, in the future stage when the current condition is westward the water temperature is 0.1°C higher within the area surrounded by Merliman, Merbau and Seraya islands.

In any other area the change of temperature rise is limited to less than 0.05°C. Averaging the computed temperatures at 21 stations (S.1 to S.49), it is equal to 0.03°C in the present stage and is equal to 0.06°C in the future stage, consequently only the temperature rise of 0.03°C is produced by the increase of thermal discharge rate.

2 As compared with water temperature rise above ambient water temperature produced by the westward current, the eastward current produces the lower temperature distribution. The averaged one is equal to 0.06°C for the westward current and is equal to 0.03°C for the eastward current.

The maximum temperature rise above ambient water temperature shows about 0.1°C and the averaged one is limited to less than 0.05°C, so the thermal discharge of future stage has a slight effect on water temperature.

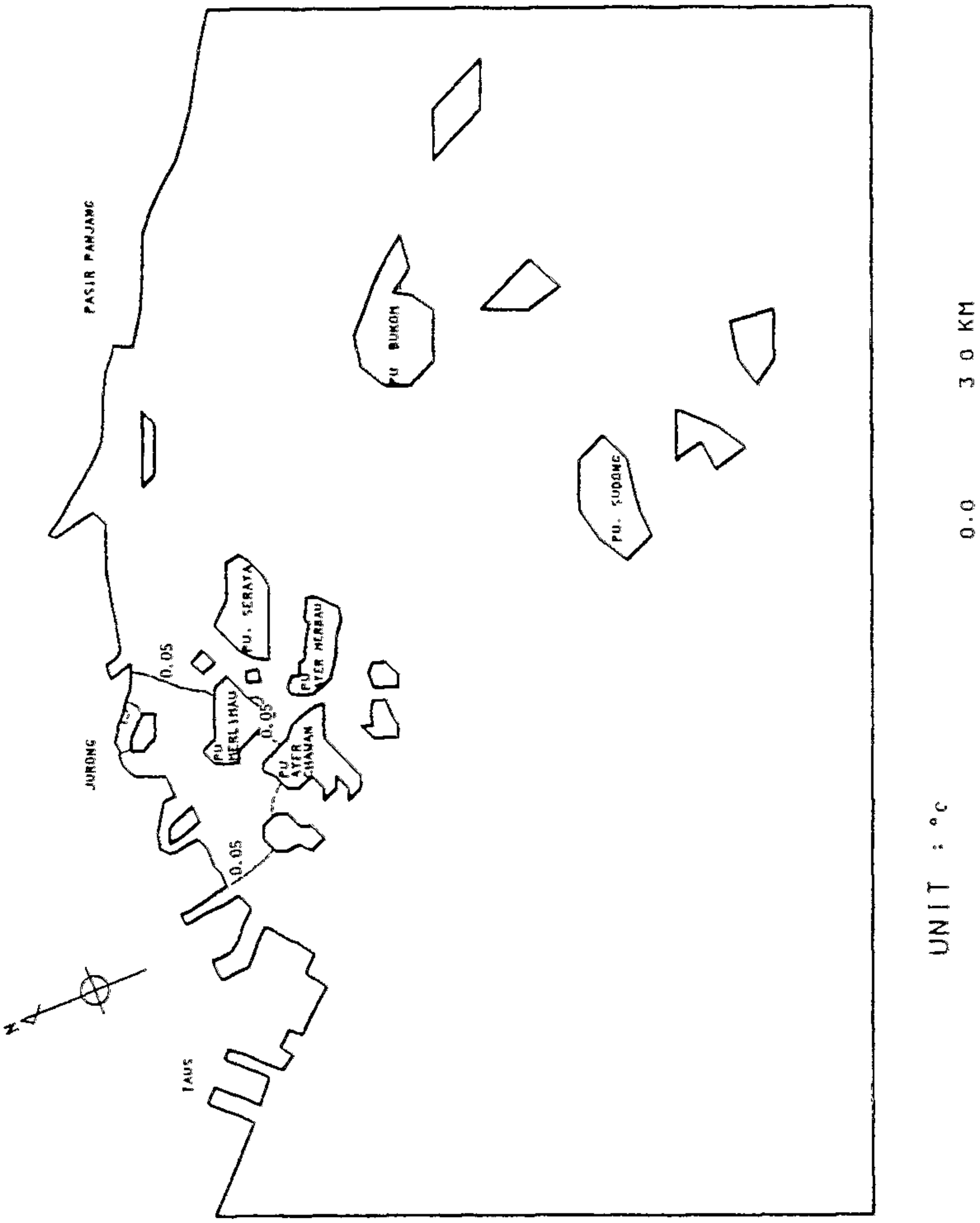


Fig. III-6-18 Computed temperature rise above ambient water temperature in present stage

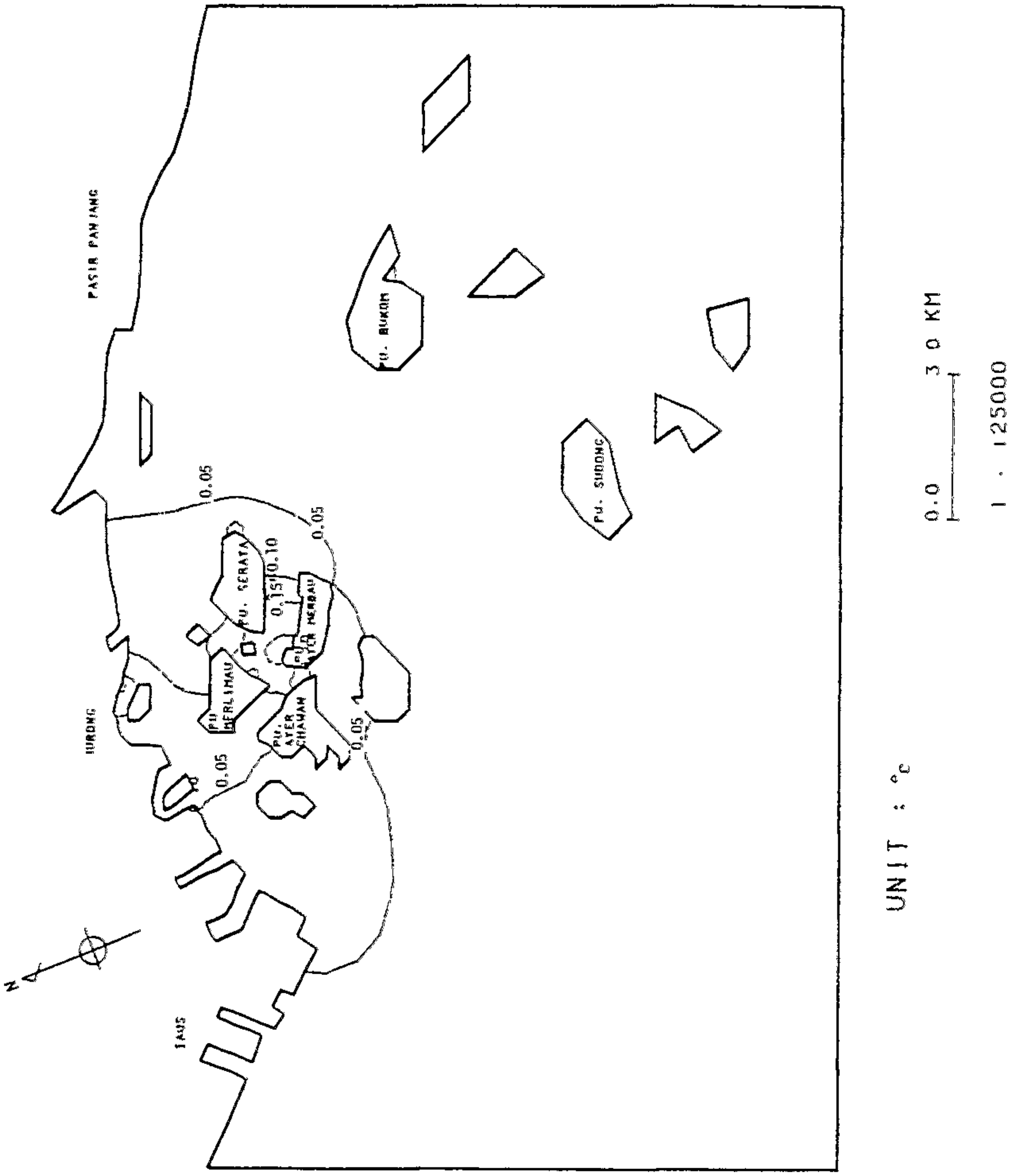


Fig. III-6-19 Computed temperature rise above ambient water temperature in future stage (westward current)

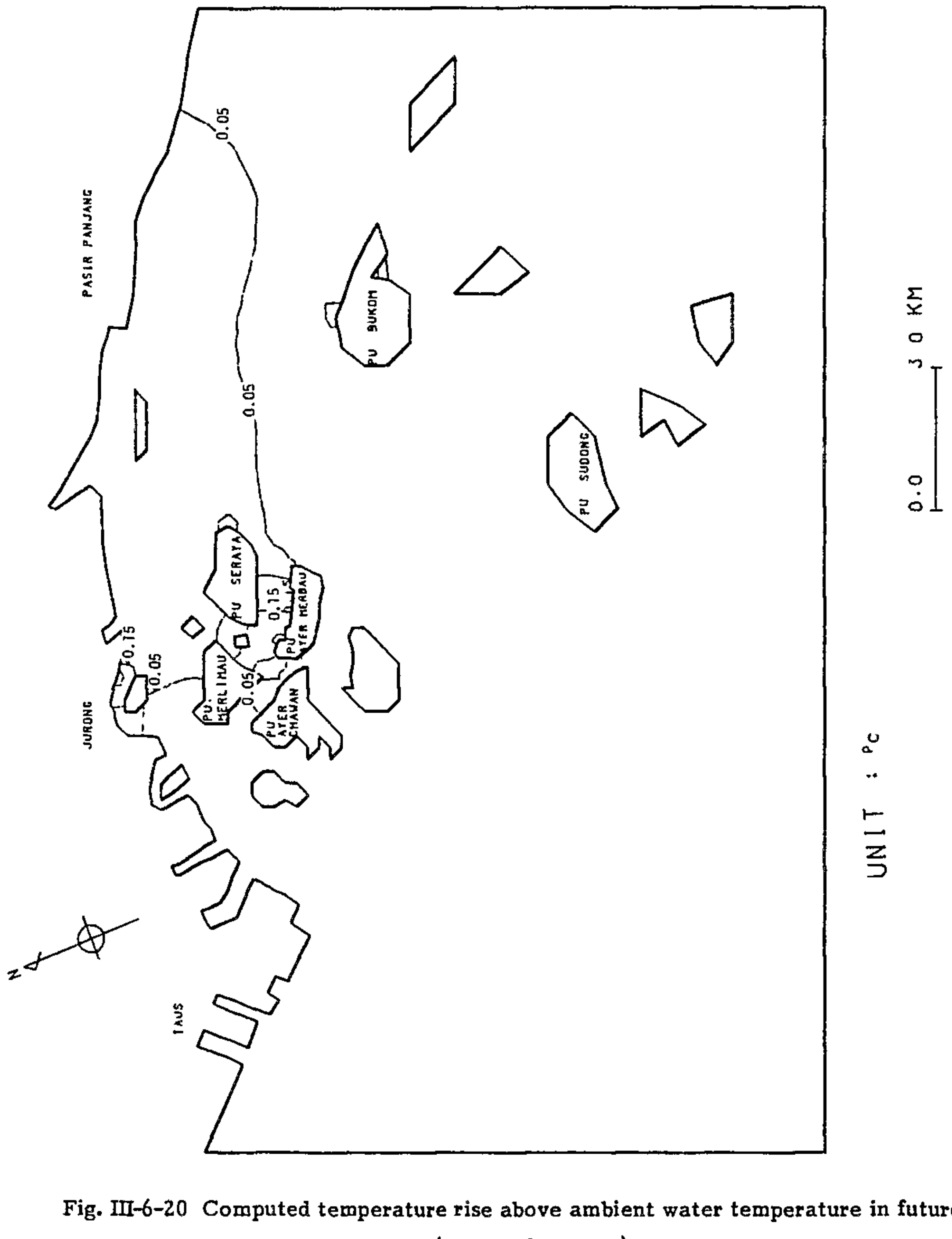


Fig. III-6-20 Computed temperature rise above ambient water temperature in future stage (eastward current)

Table III-6-7 Computed temperature rise above ambient water temperature at typical points

(UNIT : PPM)

POINT	PRESENT STAGE	FUTURE STAGE	
		E-W	W-E
S 1	0.016	0.038	0.066
S 3	0.014	0.035	0.062
S 5	0.012	0.026	0.042
S 6	0.012	0.025	0.032
S 12	0.016	0.060	0.076
S 13	0.014	0.053	0.050
S 16	0.044	0.090	0.082
S 21	0.012	0.038	0.015
S 24	0.057	0.101	0.041
S 25	0.040	0.158	0.104
S 28	0.053	0.108	0.029
S 29	0.015	0.057	0.014
S 30	0.011	0.036	0.004
S 31	0.052	0.099	0.013
S 36	0.023	0.053	0.003
S 38	0.013	0.034	0.001
S 39	0.049	0.092	0.006
S 45	0.029	0.059	0.001
S 47	0.019	0.044	0.001
S 48	0.014	0.036	0.001
S 49	0.019	0.043	0.001
A	0.012	0.018	0.053
B	0.012	0.018	0.048
C	0.006	0.011	0.027
D	0.001	0.002	0.010
E	0.029	0.068	0.073
F	0.010	0.033	0.005
G	0.006	0.019	0.001
H	0.008	0.021	0.000
I	0.014	0.032	0.000

III-6-2 Results in Tekong Area

III-6-2-1 Currents

--- The verification

The numerical result is compared with the current pattern and the verification of simulation model is performed in the same manner with the case of Seraya area.

The tidal current is computed for three tidal periods (36 hours) and the constnat current computed for 1000 time steps (4.2 hours) to obtain the sufficiently stable results.

As for the verification, the computed current ellipses and constant current vectors are compared with observed data. Table III-6-8 and Fig. III-6-21 show the comparison of current ellipses. Further, Table III-6-9 shows the comparison of constant current vectors. From tables and figure, following verifications are summarized.

(1) Comparing the numerical result with observed data about the current ellipse, the differences are shown approximately from -5 cm/sec to -0.2 cm/sec on the length of major axis.

At st.T2, st.TC3 and st.TC4, the differences are from -1.4 cm/sec to -0.2 cm/sec and the good agreements are obtained, but relatively large difference as -5 cm/sec is shown at st.TC1.

From the view point of maximum velocity, the averaged ratio of maximum velocity between computed result and observed data is 1.0506 (at st.TC1 as 1.1603, at st.TC2 as 1.0044, at st.TC3 as 1.0329 and at st.TC4 as 1.0050) and the computed result is slightly larger than the observed data, but the good agreement can be obtained.

As for the directions of major axis which indicate the current direcions of maximum velocities, the differences between the computed reuslts and observed data are shown approximately from -16° to 1°, so that the computed current directons represent the observed one. The computed current ellipses have the flat shapes similar with the observed data and obvious oscillating currents on straight line are simulated.

(2) As for the constant current velocity, the differences between observed data and computed results are in the range from -0.6 cm/sec to 2.6 cm/sec.

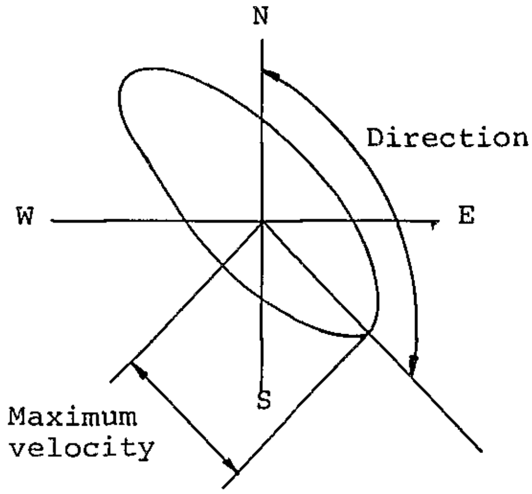
At st.TC1 and st.TC4 the differences are included within 1 cm/sec, but at st.TC3 the differences shows 2.6 cm/sec. In the channel east to Tekong island, observed data show the southward current at st.TC2, and the northward current at st.TC3 since it is considered that these currents produce the current-trip in this channel. As it is quite difficult to compute such a current-trip in the narrow channel, the data at st.TC3 is omitted to compare with the numerical result.

Averaged ratio of current velocity between computed one and observed one excluding that of st.TC3 is equal to 1.0027 and the difference of current direction is obtained as from 10° to 68°. Comparatively large difference of current direction is shown at st.TC1 and st.TC2 but the computed current pattern agrees with observed one.

From these considerations, the computed results prove the observed physical processes about the tidal current and constant current. These verified numerical results are shown in Fig. III-6-22 as constant current and in Fig. III-6-23 as the every one hour current patterns in which the constant current and the tidal current are superposed each other.

Table III-6-8 Comparison between the observed and the computed tidal ellipses

Point		Maximum velocity (cm/s) a OBS.	b CALC.	c = a - b Difference	d = b/a ratio	Direction (°) e OBS.	f CALC.	g = e - f Difference
1981	TC 1	31.20	36.20	-5.00	1.1603	155	139	16
	TC 2	43.41	43.60	-0.19	1.0044	115	116	-1
	TC 3	41.05	42.40	-1.35	1.0329	178	175	3
	TC 4	42.41	42.62	-0.21	1.0050	134	139	-5



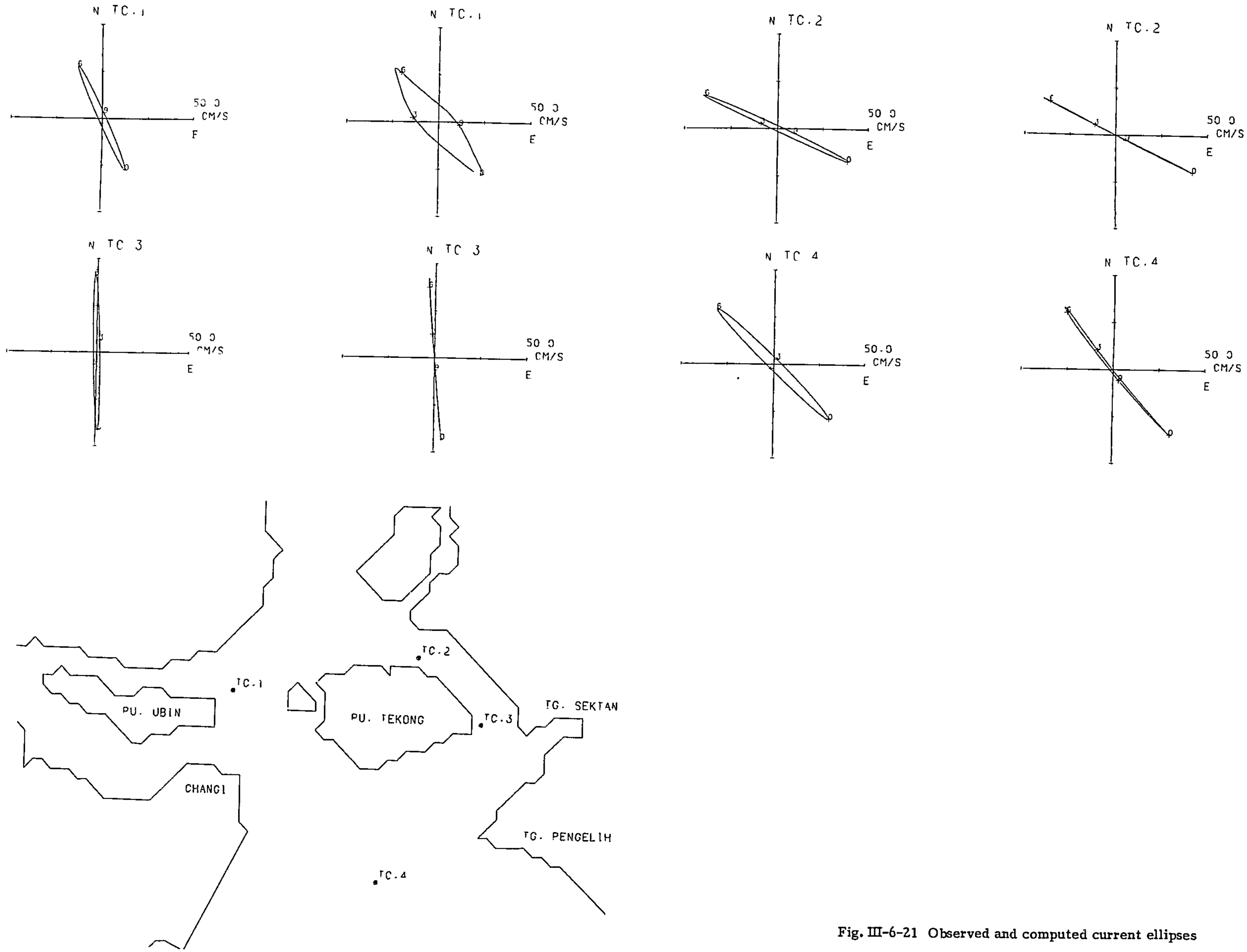


Fig. III-6-21 Observed and computed current ellipses

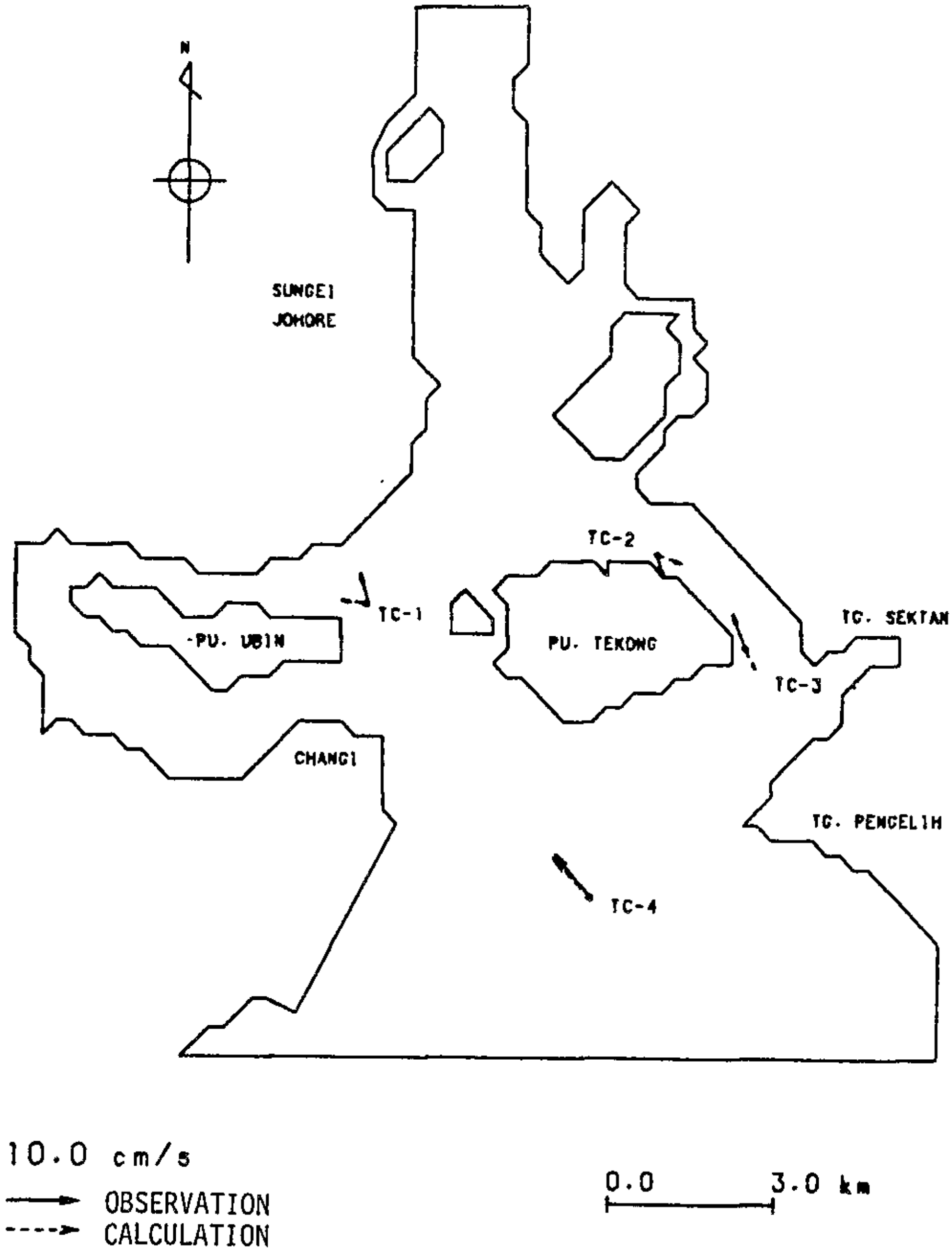


Table III-6-9 Comparison of the constant current vector

POINT	OBSERVATION		CALCULATION		DIFFERENCE		
	a VELOCITY (cm/s)	b DIRECTION (°)	c VELOCITY (cm/s)	d DIRECTION (°)	e=a-c VELOCITY (cm/s)	f=b-d DIRECTION (°)	g=c/a VELOCITY RATIO
TC-1	4.47	336.66	4.85	275.64	-0.38	61.04	1.0851
TC-2	3.24	160.69	2.83	114.31	0.41	46.38	0.8729
TC-3	5.17	339.25	2.62	170.28	2.55	168.97	0.5062
TC-4	7.66	319.92	7.65	309.90	0.00	10.02	0.9994
					N S DIRECTION		

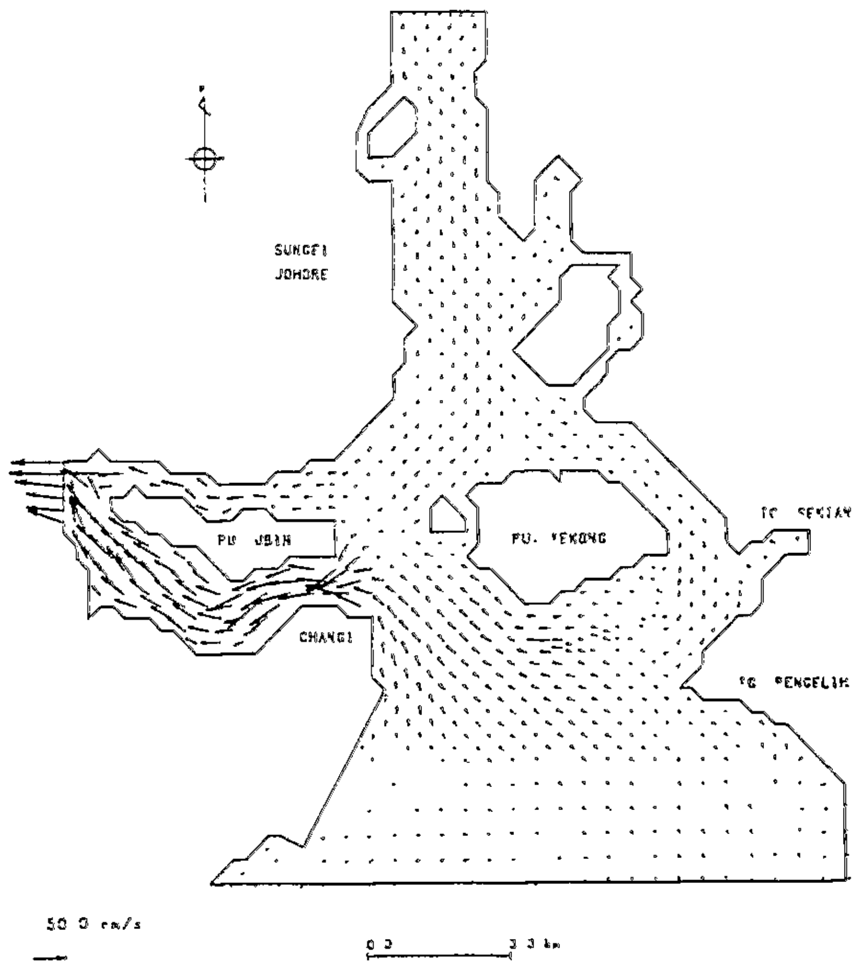


Fig. III-6-22 Constant current in present stage

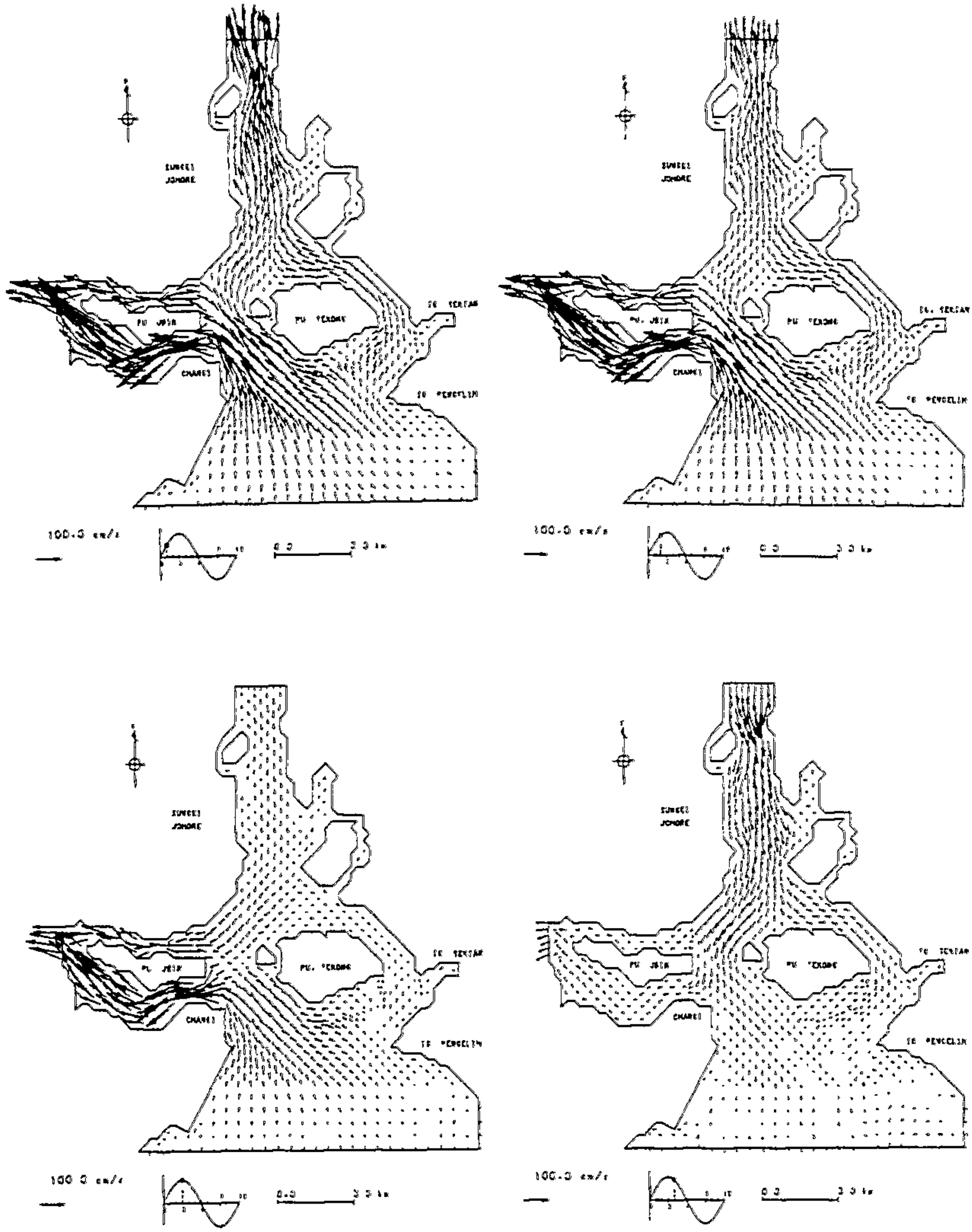


Fig. III-6-23-(1) Current patterns in present stage

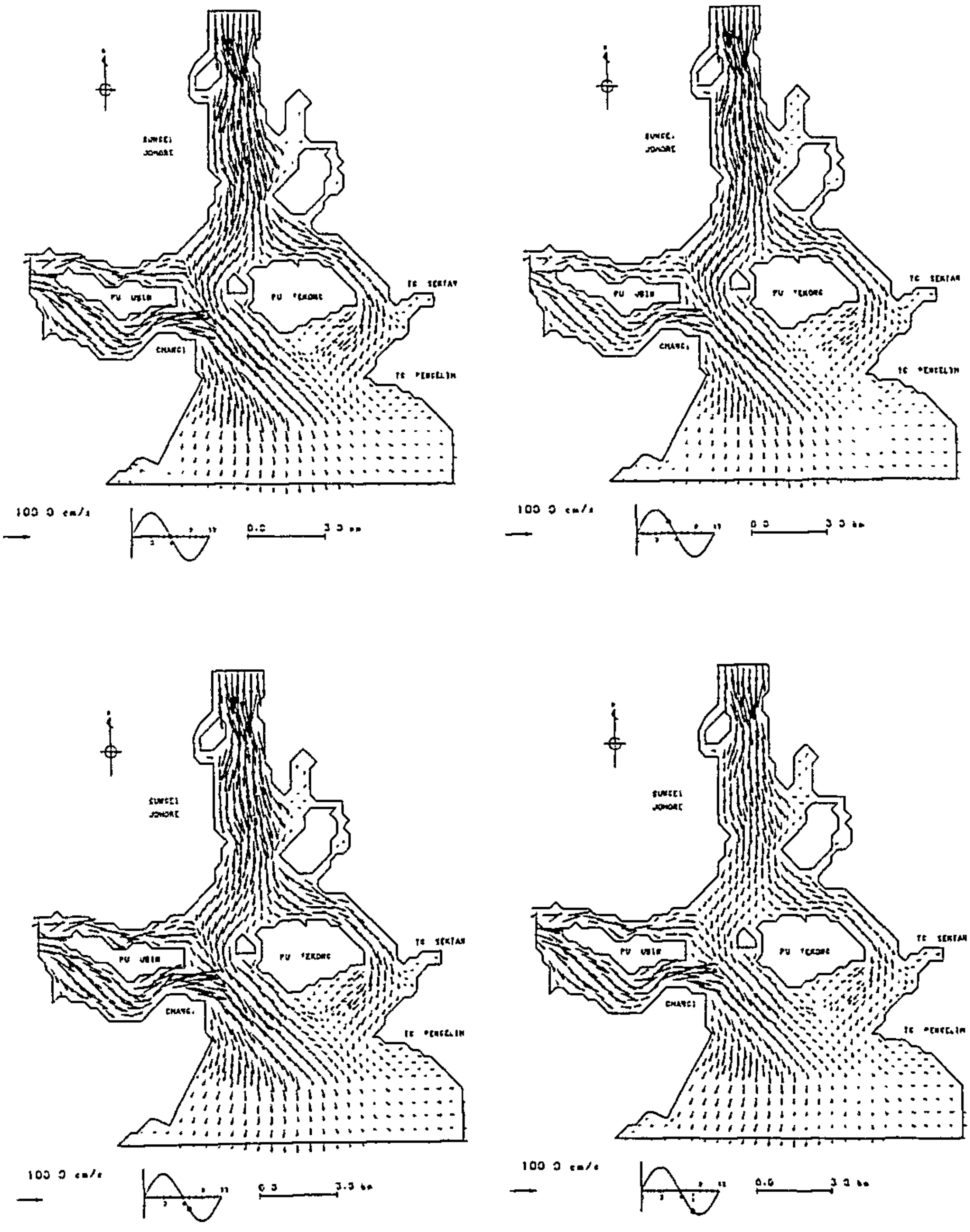


Fig. III-6-23-(2) Current patterns in present stage

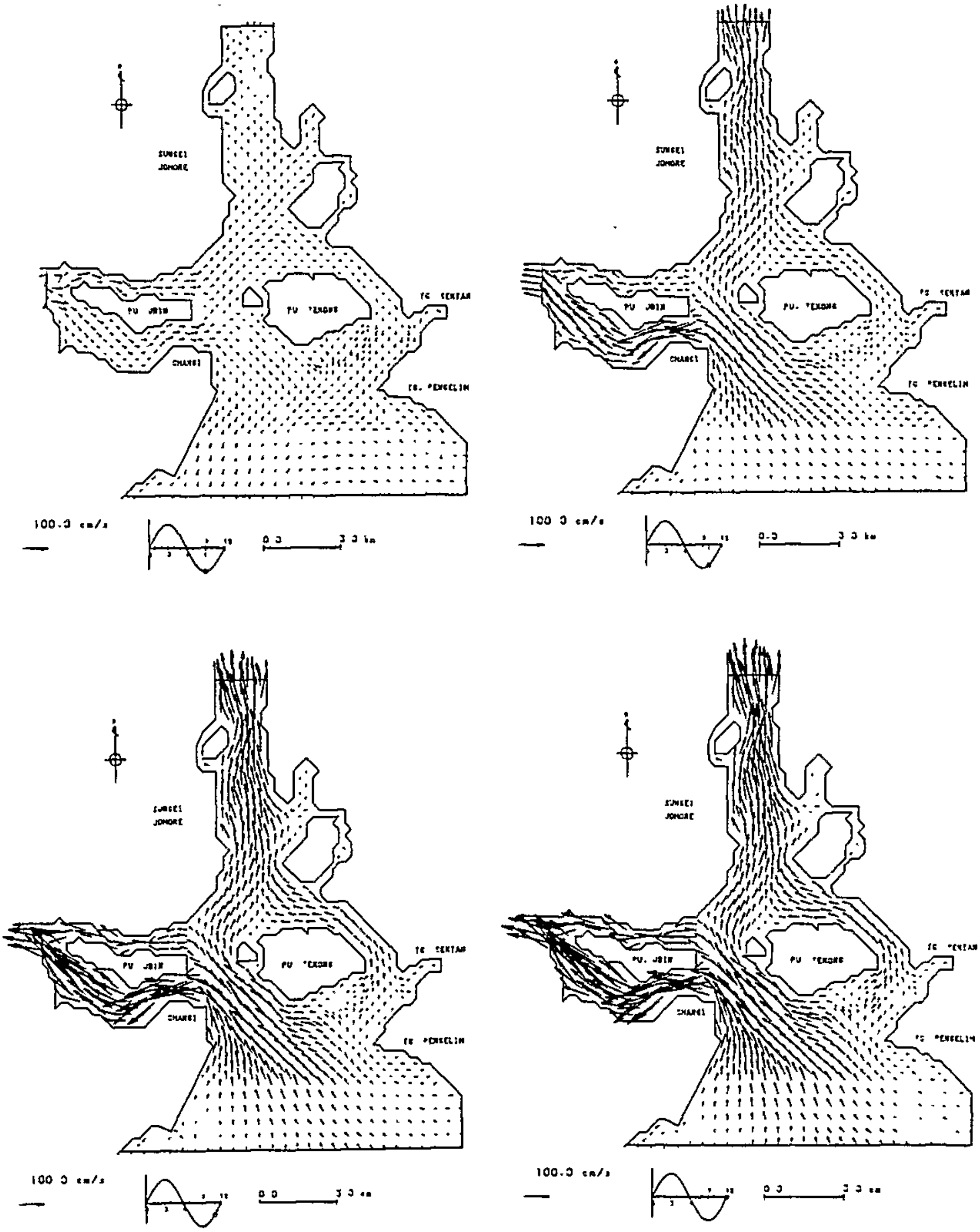


Fig. III-6-23-(3) Current patterns in present stage

— Current in the future stage

Altering the topography and the inflow rate, the current computation of future stage is carried out. Fig. III-6-26 shows the computed current when the coal firing power station is constructed and Fig. III-6-26 shows the current when the coal firing power station and the integrated steel mill are constructed. In these figures the constant current is coupled with the tidal current.

The current difference of these two cases is produced by discharge at integrated steel mill (9300 m/day), so only the slight change is shown around the discharging point (v. Figs. III-6-24 and III-6-25).

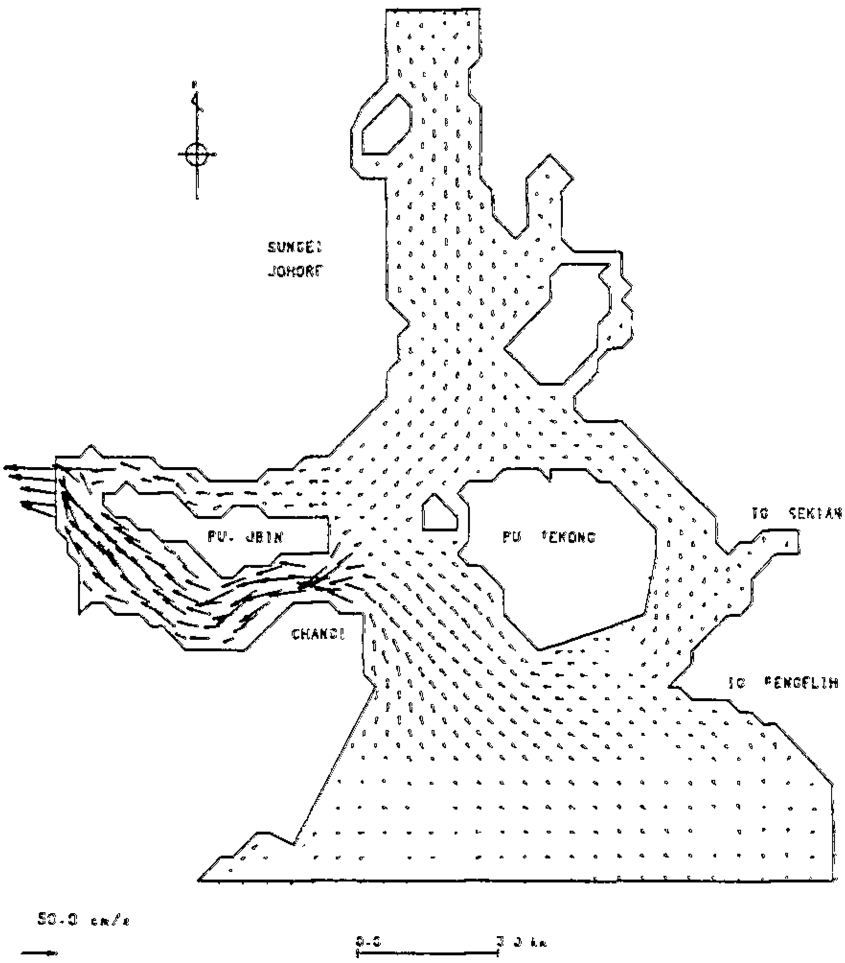


Fig. III-6-24 Constant current in future stage (Coal firing power station constructed)

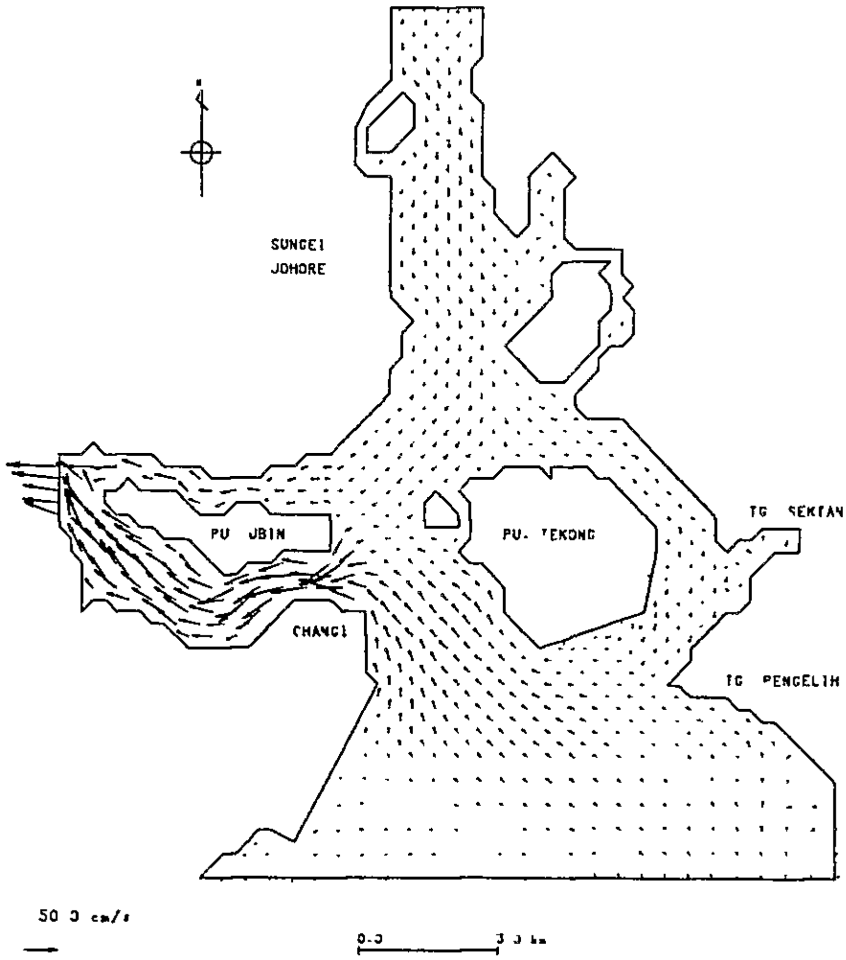


Fig. III-6-25 Constant current in future stage (Coal firing power station and integrated steel mill constructed)

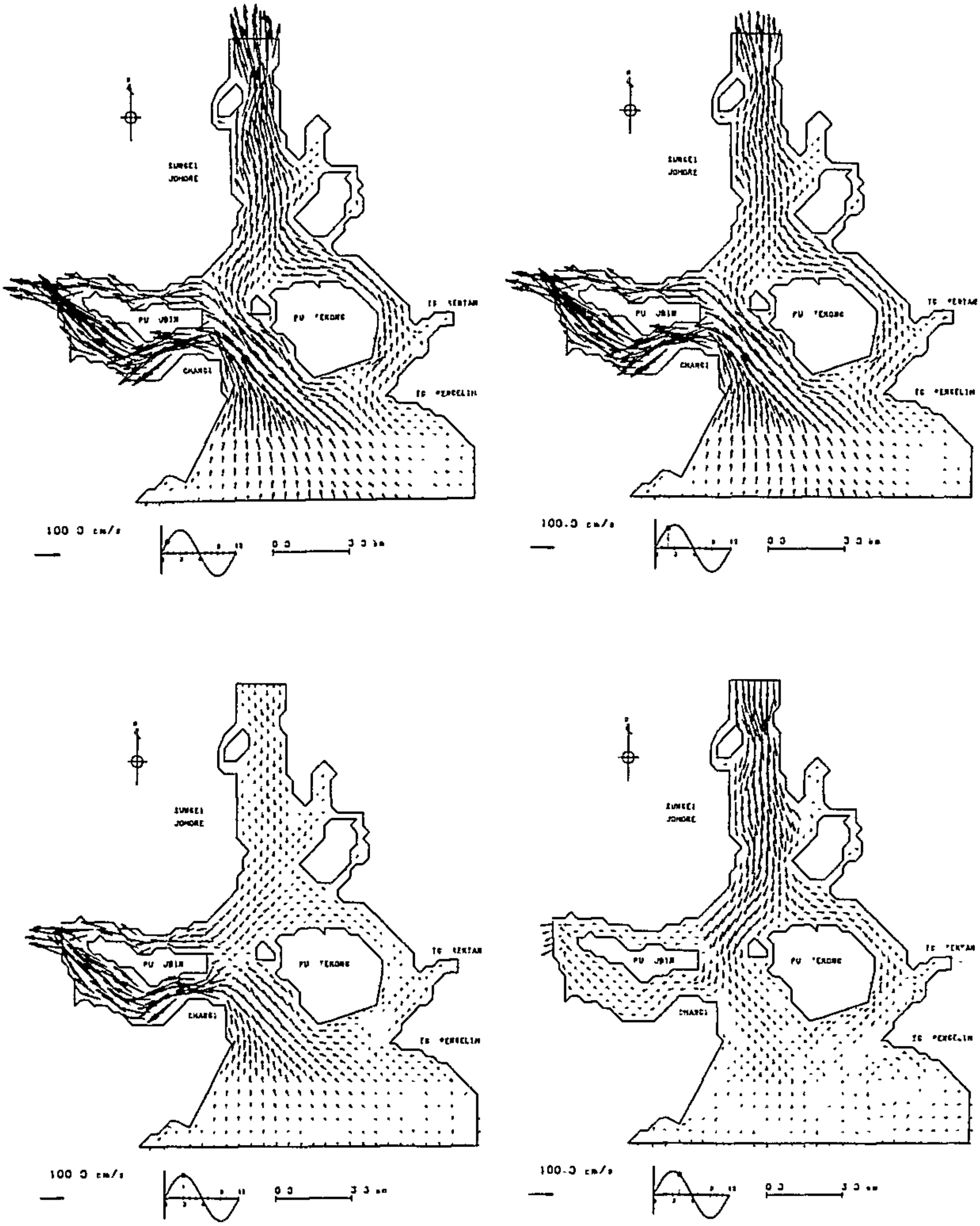


Fig. III-6-26-(1) Current patterns in future stage (Coal firing power station constructed)

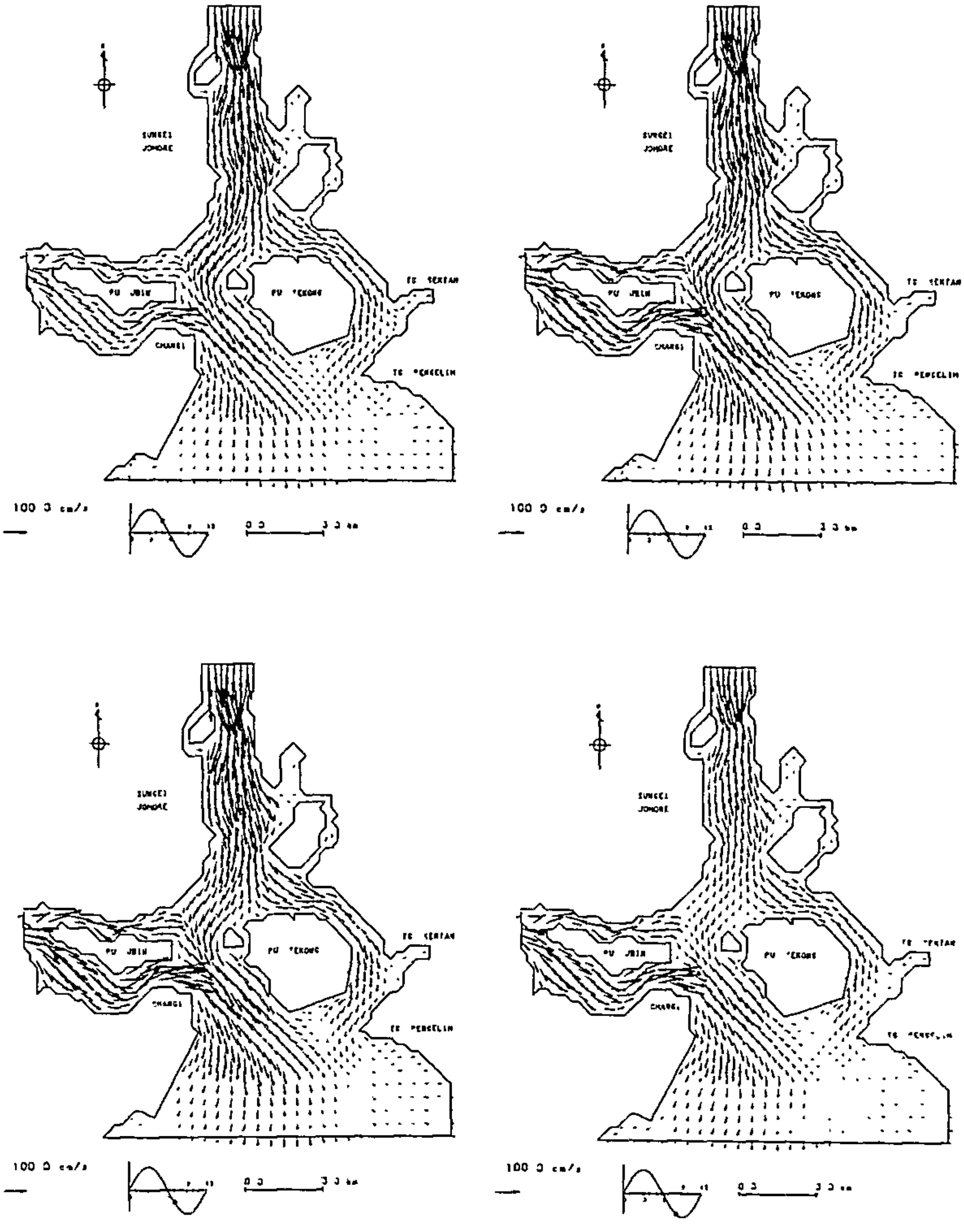


Fig. III-6-26-(2) Current patterns in future stage (Coal firing power station constructed)

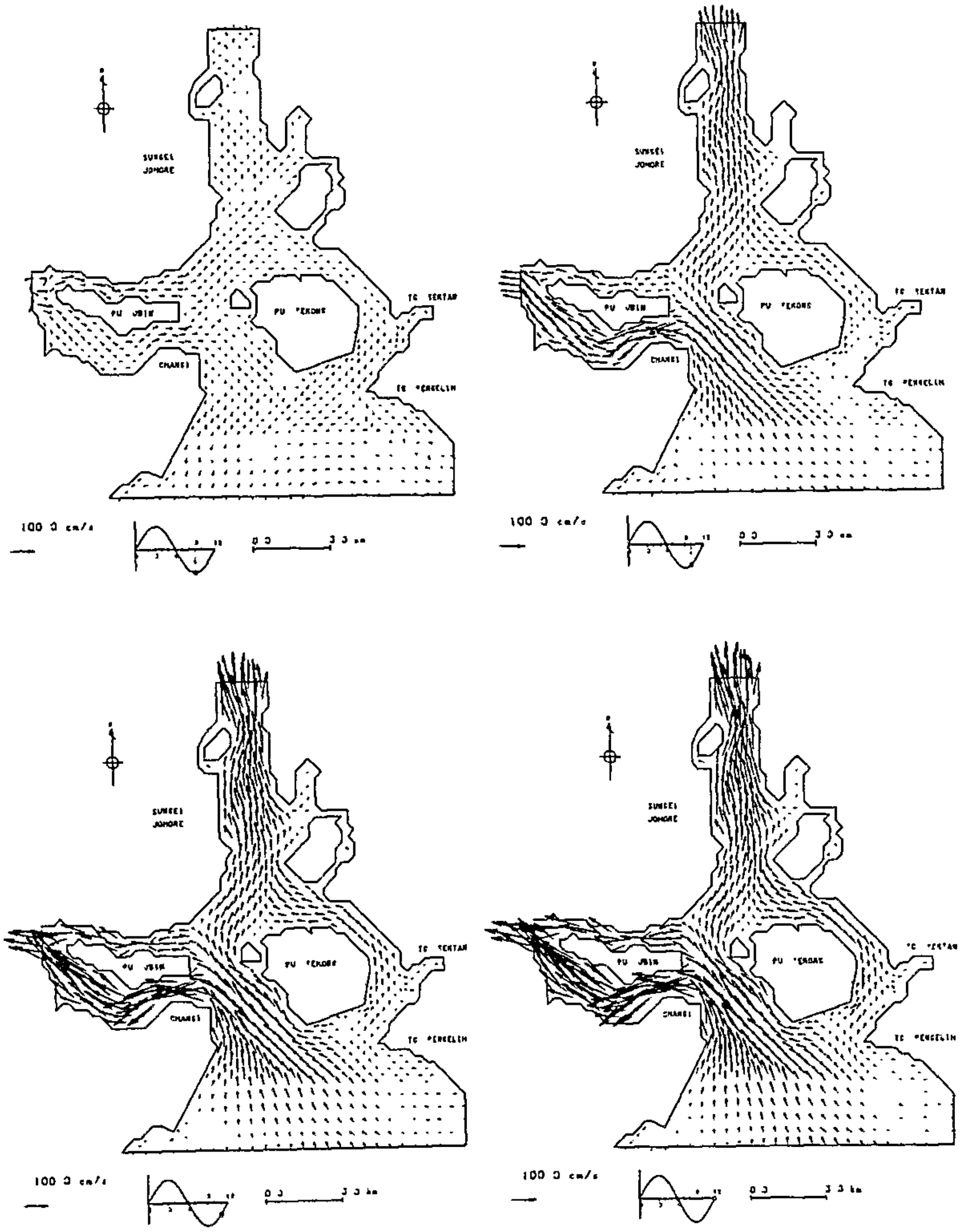


Fig. III-6-26-(3) Current patterns in future stage (Coal firing power station constructed)

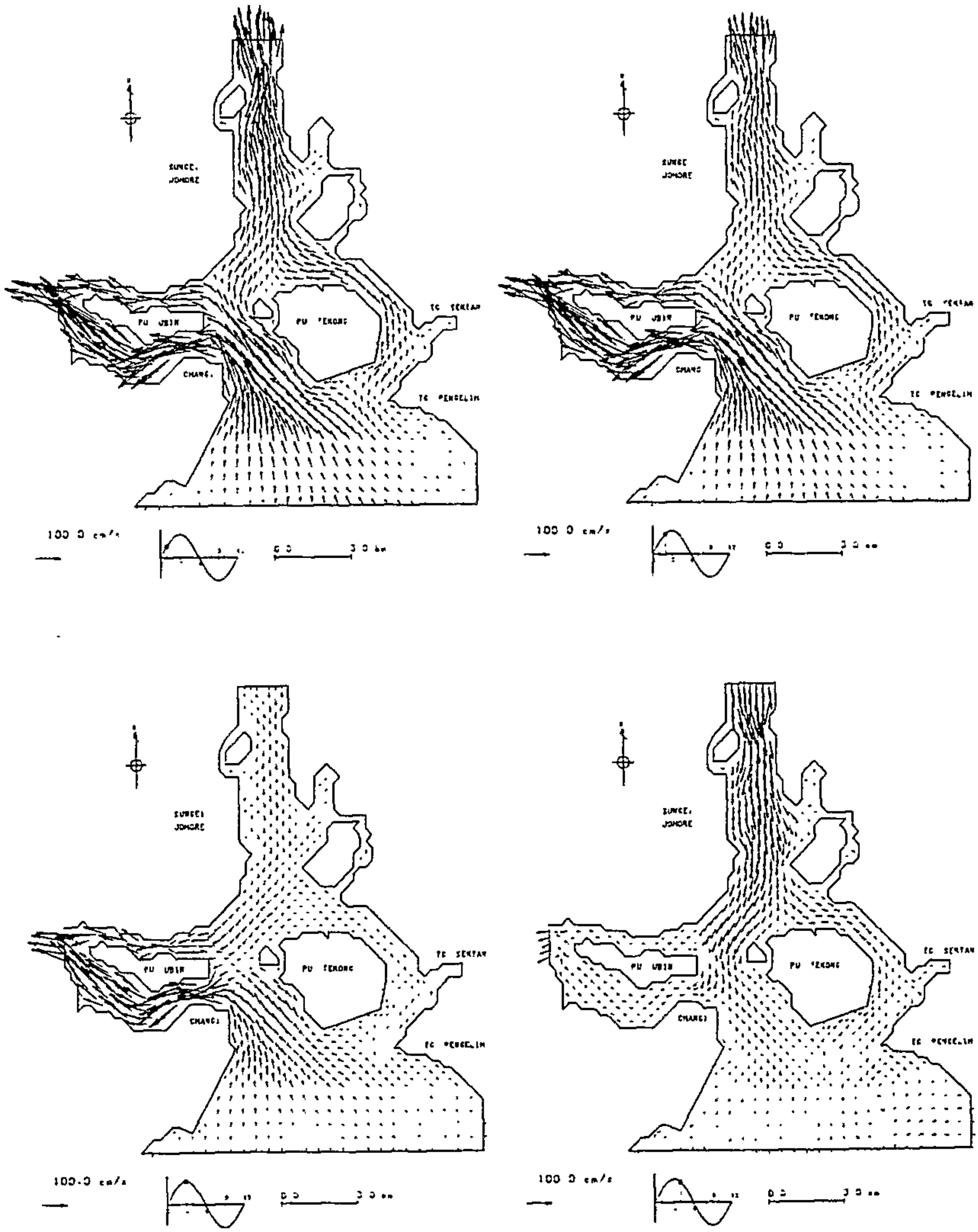


Fig. III-6-27-(1) Current patterns in future stage (Coal firing power station and integrated steel mill constructed)

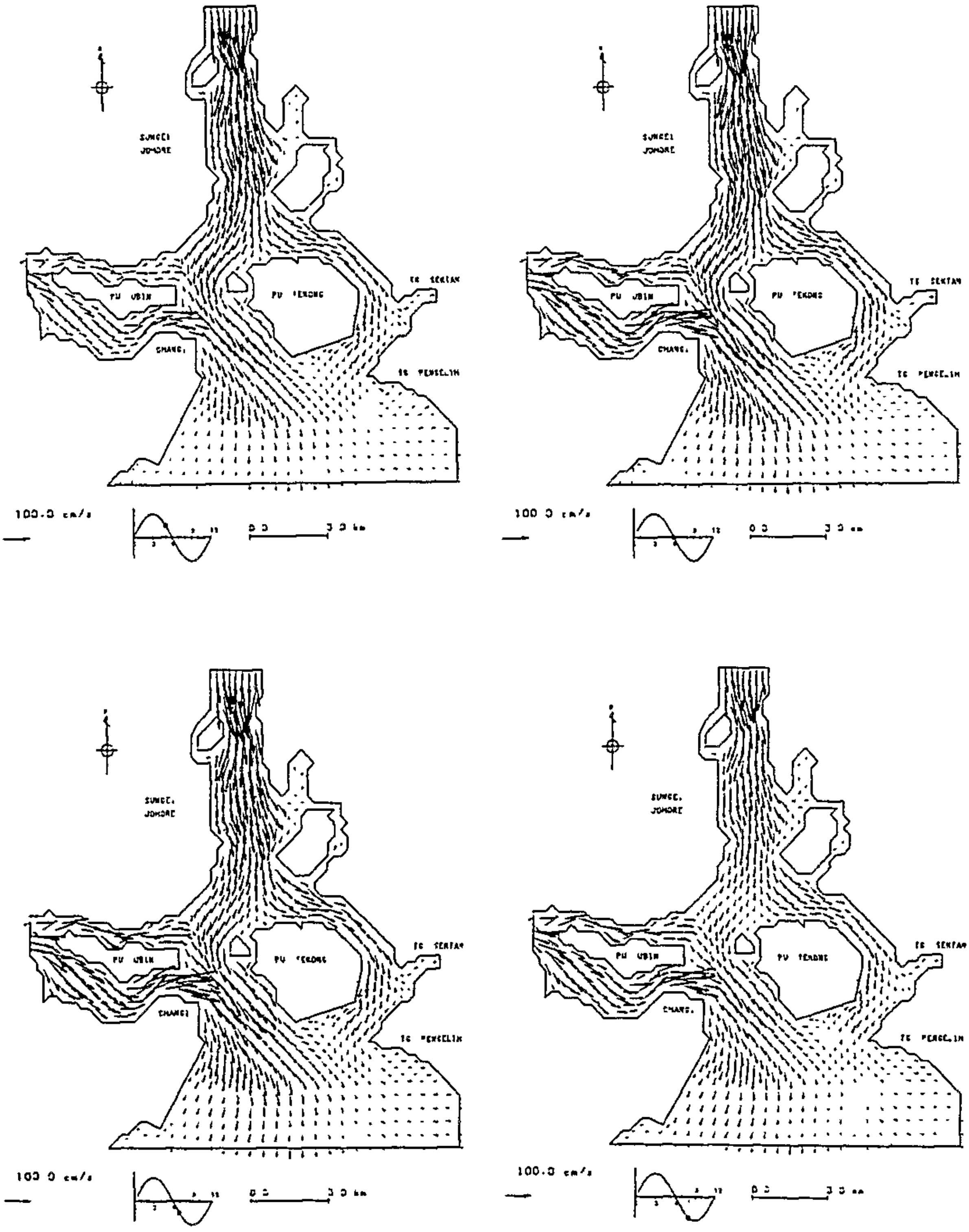


Fig. III-6-27-(2) Current patterns in future stage (Coal firing power station and integrated steel mill constructed)

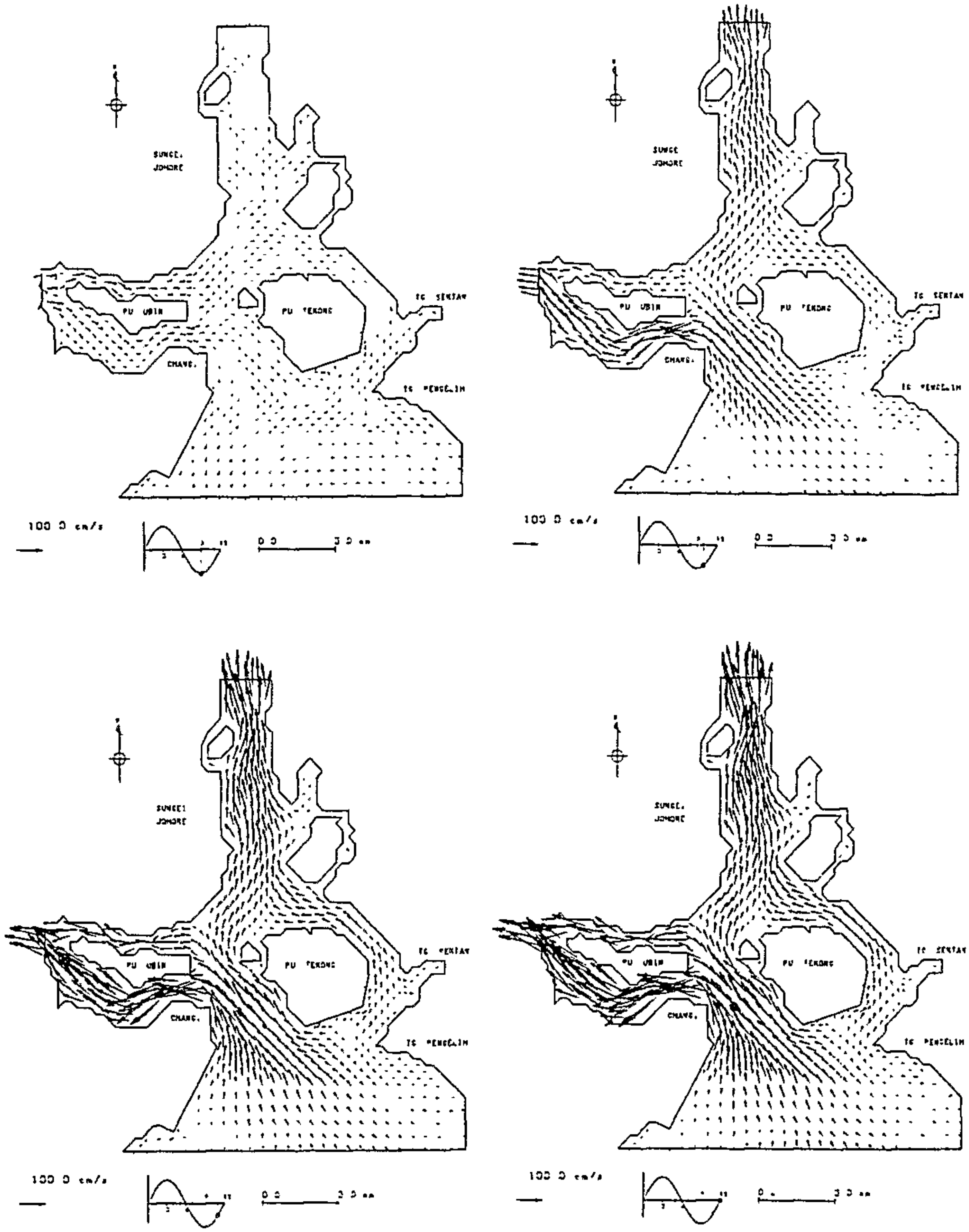


Fig. III-6-27-(3) Current patterns in future stage (Coal firing power station and integrated steel mill constructed)

— The change of current

The numerical results of two cases in future stage show an inconsiderable difference, therefore, the comparison of numerical result is performed between the present stage and the future stage when the coal firing power station and the integrated steel mill are constructed.

Fig. III-6-28 shows the changes of velocity and current direction for every one hour at the representative points.

Fig. III-6-29 shows the distributions of velocity change at ebb tide and flood tide.

From these figures, the change of current in the future stage can be summarized as follows (the comment about the tidal time is equal to that of west coast in Tekong island):

(1) At high water, the small magnitude current pattern from the open sea to Johore channel remains. The difference of velocity between the present and the future is larger than 1 cm/sec at point E (1.4 cm/sec) locating south to Tekong island but at any other point the difference is less than 1 cm/sec.

    The maximum difference of current direction is shown in the channel between southward of the reclaimed land and Tg.Pengelish as 14^{o}.

(2) After 3 hours from the high water, the tidal current velocity from Johore channel to the open sea raises to fast, but this current cancells with the constant current and the velocity is smaller than that of flood tide. The difference of velocity between the present and the future is more than 1 cm/sec at point H southeast to Changi, TC-3 east to the reclaimed land, point D and point E south to the reclaimed land.

    Fig. III-6-29 shows that the velocity is increasing within about 8 cm/sec in the channel between the reclaimed land and Tg. Pengelish (1 km x 3 km) and the velocity is decreasing within about 8 cm/sec in the area south to the reclaimed land.

    The maximum difference of current direction is equal to 5^{o} in the channel between the reclaimed land and Tg. Pengelish.

(3) At the low water, the tidal current cancells with the constant current and the current velocity is smallest through a tidal period. At every point, the change of velocity is less than 1 cm/sec. The change of current direction is shown in the channel between the reclaimed land and Tg. Pengelish as 10^o.

(4) After 3 hours from the low water, the tidal current and the constant current have the same current direction as from the open sea to Johore channel, and the strongest current is shown. In the area between Tekong island and Changi, the velocity is shown as from 50 cm/sec to 70 cm/sec. The difference of velocity between the pesent and the future is more than 1 cm/sec at st.TC-3, point C, D, E, G and H.

Fig. III-6-29 shows the difference of velocity as follows:

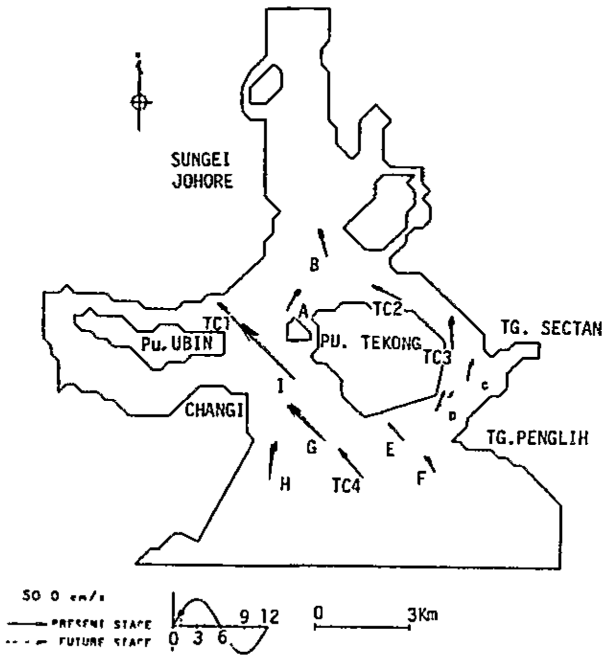
— In the area (2 km x 3 km) belonging to the channel between the reclaimed land and Tg.Pengelish the velocity is increasing within 6 cm/sec.

— In the area (2 km x 2 km) south to the reclaimed land the velocity is increasing within about 8 cm/sec.

— In the area (3 km x 3 km) southeast to Changi the velocity is increasing within about 4 cm/sec.

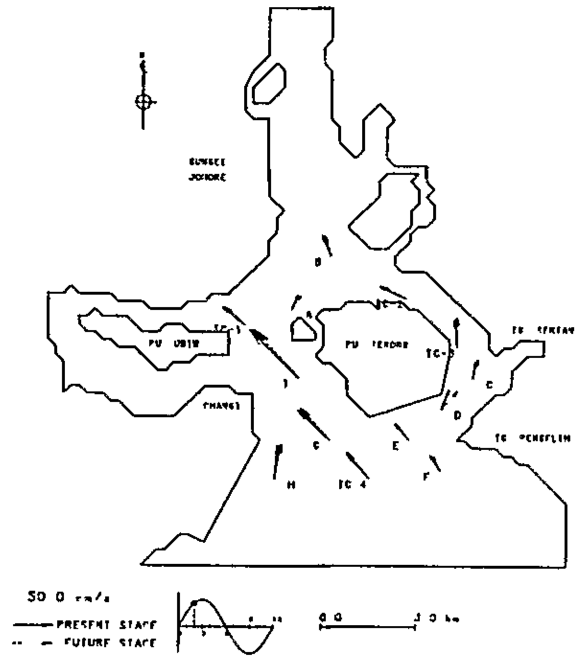
The maximum difference of current direction is about 10^o in the above channel.

From these points of view, the change of current is shown in the considerably wide area at flood tide or ebb tide. In these conditions of tide the velocity is comparatively large.



POINT	PRESENT STAGE a VELOCITY (cm/s)	b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	d DIRECTION (°)	DIFFERENCE e=a-c VELOCITY (cm/s)	f=b-d DIRECTION (°)	g=c/a VELOCITY RATIO
TC-1	34.78	318.51	34.59	318.32	0.19	0.18	0.9944
TC-2	40.17	295.41	40.72	295.41	-0.55	0.00	1.0138
TC-3	38.42	355.29	42.00	354.15	-3.58	1.14	1.0932
TC-4	36.13	323.30	37.11	321.83	-0.98	1.47	1.0273
A	31.45	27.91	31.04	27.66	0.41	0.25	0.9871
B	38.08	342.83	38.20	342.34	-0.11	0.49	1.0030
C	22.75	8.72	25.53	5.02	-2.77	3.70	1.1219
D	25.55	25.00	29.16	35.74	-3.61	10.74	1.1411
E	21.29	327.55	17.34	325.88	3.96	1.67	0.8142
F	16.33	332.60	15.99	333.60	0.33	1.00	0.9795
G	49.49	313.66	51.16	315.13	-1.67	1.46	1.0338
H	39.27	10.24	41.05	10.31	-1.78	0.07	1.0453
I	78.63	314.79	78.49	315.52	0.15	0.73	0.9981

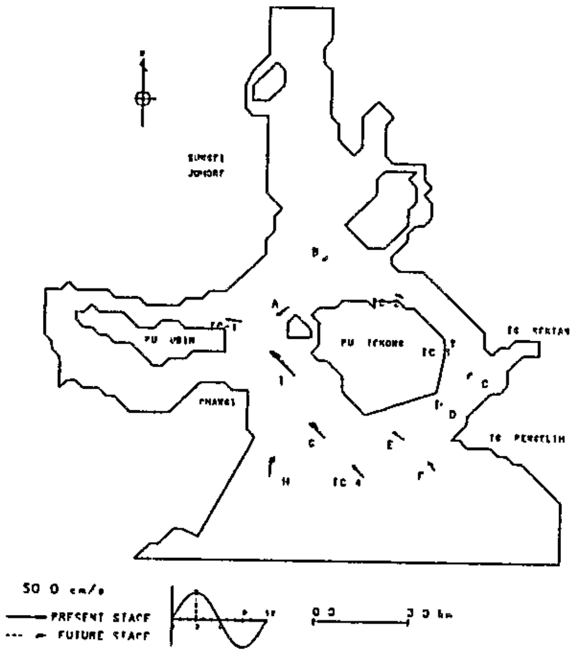
N S DIRECTION



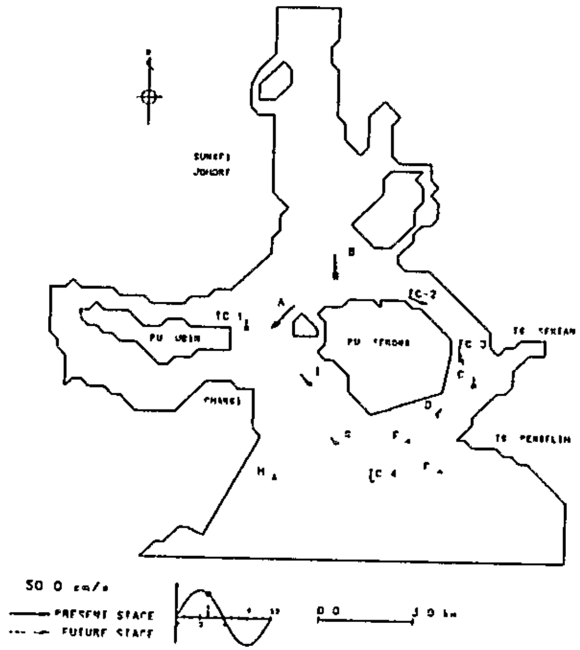
POINT	PRESENT STAGE a VELOCITY (cm/s)	b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	d DIRECTION (°)	DIFFERENCE e=a-c VELOCITY (cm/s)	f=b-d DIRECTION (°)	g=c/a VELOCITY RATIO
TC-1	29.24	312.40	29.05	312.17	0.19	0.23	0.9935
TC-2	35.40	295.22	35.66	295.22	-0.26	0.00	1.0073
TC-3	34.83	355.38	37.64	354.05	-2.81	1.33	1.0807
TC-4	30.06	324.32	30.90	322.53	-0.83	1.79	1.0277
A	21.55	26.89	21.18	26.61	0.37	0.29	0.9828
B	29.61	338.25	29.59	337.81	0.01	0.43	0.9995
C	21.35	10.70	23.75	6.89	2.40	3.81	1.1125
D	25.06	24.16	27.85	35.21	-2.79	11.05	1.1114
E	19.39	330.37	15.42	328.29	3.97	2.08	0.7952
F	16.01	333.22	15.47	333.68	0.54	0.47	0.9663
G	41.37	314.63	42.87	315.97	-1.50	1.34	1.0363
H	37.55	11.12	38.93	11.05	-1.38	0.06	1.0366
I	67.74	315.03	67.30	315.87	0.45	0.84	0.9934

N S DIRECTION

Fig. III-6-28-(1) Change of velocity and current direction

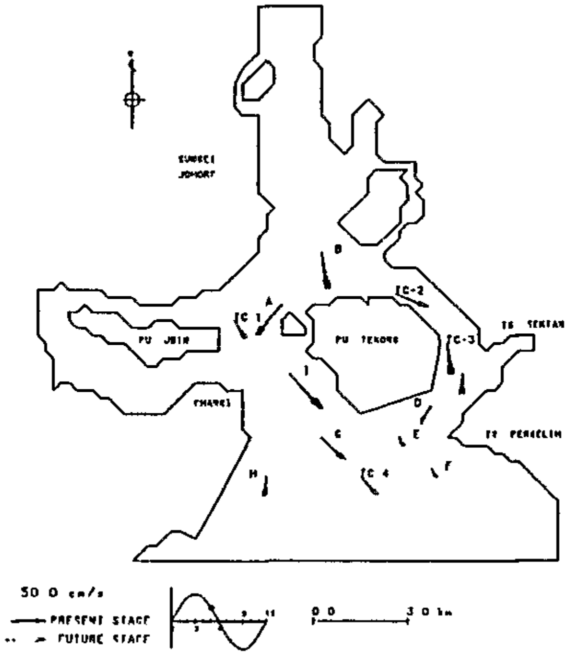


POINT	PRESENT STAGE a VELOCITY (cm/s)	PRESENT STAGE b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	FUTURE STAGE d DIRECTION (°)	DIFFERENCE e=a-c VELOCITY (cm/s)	DIFFERENCE f=b-d DIRECTION (°)	g=c/a VELOCITY RATIO
TC-1	13.12	270.48	13.06	270.12	0.05	0.36	0.9958
TC-2	8.45	295.45	8.40	295.46	0.05	0.01	0.9944
TC-3	8.64	355.26	8.82	353.51	-0.18	1.75	1.0212
TC-4	7.44	331.64	8.04	326.78	-0.60	4.85	1.0813
A	16.48	231.37	16.67	231.26	-0.18	0.11	1.0111
B	9.55	229.19	9.63	228.74	-0.09	0.45	1.0090
C	5.24	12.60	5.76	9.62	0.52	2.99	1.0984
D	7.85	14.73	6.91	28.40	0.93	13.67	0.8812
E	7.02	318.74	5.61	305.97	1.40	12.77	0.8001
F	6.13	334.45	5.55	330.98	0.58	3.47	0.9050
G	11.98	317.28	12.74	318.45	0.76	1.17	1.0637
H	18.85	16.91	19.22	16.41	-0.37	0.50	1.0198
I	23.09	313.78	22.58	315.30	0.51	1.52	0.9779

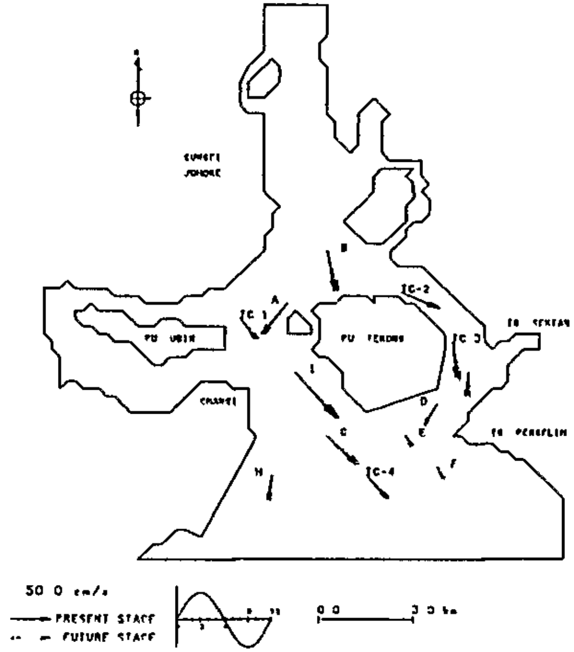


POINT	PRESENT STAGE a VELOCITY (cm/s)	PRESENT STAGE b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	FUTURE STAGE d DIRECTION (°)	DIFFERENCE e=a-c VELOCITY (cm/s)	DIFFERENCE f=b-d DIRECTION (°)	g=c/a VELOCITY RATIO
TC 1	17.00	164.42	16.94	164.39	0.06	0.03	0.9967
TC 2	22.34	114.73	22.66	114.73	-0.33	0.00	1.0146
TC 3	20.83	174.48	23.03	174.24	-2.20	0.24	1.1057
TC 4	22.84	135.85	22.73	135.92	0.11	0.06	0.9950
A	39.63	222.52	39.47	222.47	0.16	0.05	0.9960
B	33.40	178.57	33.44	178.31	-0.04	0.25	1.0011
C	14.10	189.14	14.69	186.06	-0.59	3.08	1.0418
D	12.98	214.90	16.62	218.45	3.64	3.55	1.2803
E	9.39	152.20	8.07	158.07	1.31	5.87	0.8601
F	8.83	146.27	9.09	151.15	-0.26	4.88	1.0293
G	27.07	133.97	27.25	134.64	-0.18	0.67	1.0067
H	12.72	173.10	13.32	174.53	0.59	1.43	1.0467
I	39.19	137.39	39.01	137.77	0.19	0.38	0.9952

Fig. III-6-28-(2) Change of velocity and current direction

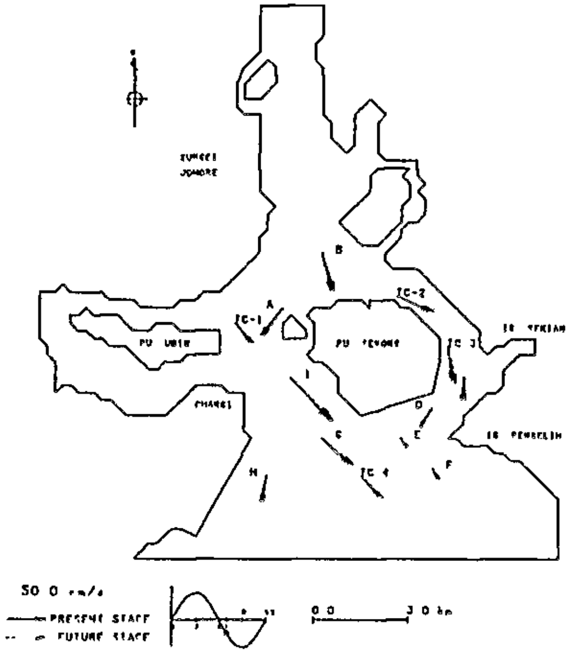


POINT	PRESENT STAGE a VELOCITY (cm/s)	PRESENT STAGE b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	FUTURE STAGE d DIRECTION (°)	DIFFERENCE e=a-c VELOCITY (cm/s)	DIFFERENCE f=b-d DIRECTION (°)	g=c/a VELOCITY RATIO
TC-1	31.52	146.25	31.39	146.20	0.13	0.05	0.9959
TC-2	42.07	115.01	42.44	115.01	-0.37	0.00	1.0088
TC-3	39.34	174.30	42.37	174.07	-3.03	0.23	1.0770
TC-4	43.16	136.50	43.54	136.34	-0.38	0.16	1.0088
A	50.21	220.10	49.88	220.02	0.32	0.08	0.9936
B	49.35	171.95	49.34	171.72	0.02	0.22	0.9997
C	25.99	188.46	26.86	185.97	-0.87	2.49	1.0335
D	24.92	211.51	29.99	216.53	-5.07	5.03	1.2034
E	18.73	143.97	15.87	145.32	2.86	1.35	0.8472
F	18.57	147.06	18.77	149.87	-0.21	2.82	1.0111
G	53.49	134.01	54.17	134.55	-0.69	0.54	1.0128
H	30.10	181.92	31.09	182.35	0.99	0.42	1.0329
I	79.81	137.28	79.23	137.81	0.58	0.52	0.9927

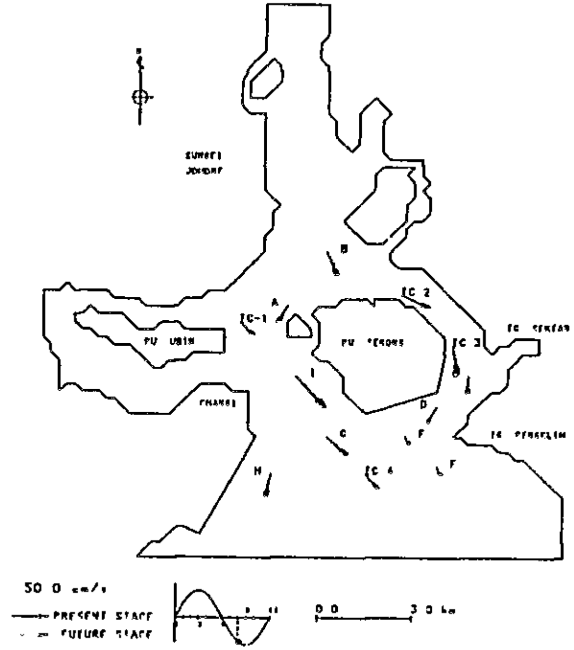


POINT	PRESENT STAGE a VELOCITY (cm/s)	PRESENT STAGE b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	FUTURE STAGE d DIRECTION (°)	DIFFERENCE e=a-c VELOCITY (cm/s)	DIFFERENCE f=b-d DIRECTION (°)	g=c/a VELOCITY RATIO
TC-1	38.49	141.20	38.34	141.14	0.15	0.06	0.9961
TC-2	50.34	115.25	50.70	115.24	-0.36	0.00	1.0072
TC-3	47.36	174.24	50.51	174.07	-3.15	0.17	1.0665
TC-4	52.86	136.38	53.51	136.25	-0.66	0.13	1.0124
A	51.52	218.67	51.13	218.57	0.39	0.10	0.9924
B	54.64	169.22	54.60	168.99	0.04	0.23	0.9992
C	30.95	187.82	31.80	185.64	-0.85	2.18	1.0275
D	30.24	210.56	35.43	215.68	-5.19	5.12	1.1715
E	22.99	139.36	19.64	139.43	3.35	0.07	0.8543
F	23.19	147.00	23.31	149.20	-0.12	2.20	1.0050
G	66.48	133.73	67.31	134.21	-0.83	0.48	1.0125
H	38.34	183.98	39.43	184.22	-1.08	0.25	1.0283
I	99.07	137.36	98.36	137.85	0.70	0.48	0.9929

Fig. III-6-28-(3) Change of velocity and current direction

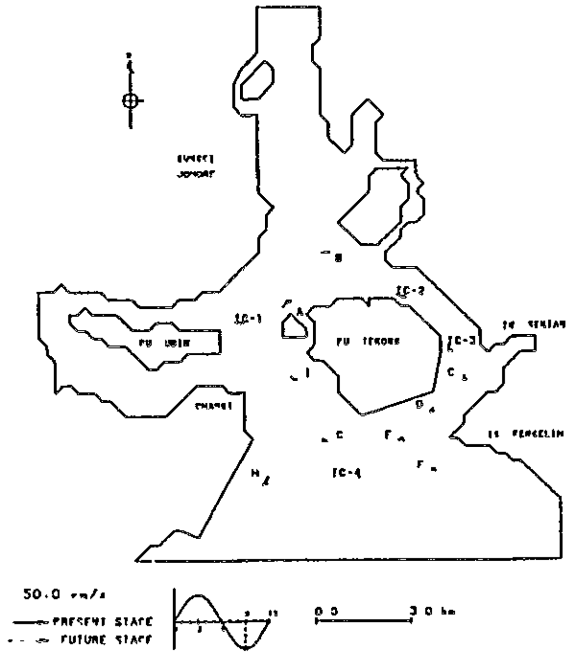


POINT	PRESENT STAGE a VELOCITY (cm/s)	PRESENT STAGE b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	FUTURE STAGE d DIRECTION (°)	DIFFERENCE e=a-c VELOCITY (cm/s)	DIFFERENCE f=b-d DIRECTION (°)	g=c/a VELOCITY RATIO
TC-1	37.64	138.31	37.48	138.23	0.15	0.08	0.9959
TC 2	48.23	115.50	48.59	115.49	0.37	0.00	1.0076
TC 3	45.83	174.25	48.77	174.13	-2.94	0.12	1.0641
TC 4	51.45	136.53	52.22	136.43	-0.77	0.10	1.0150
A	43.50	216.70	43.09	216.55	0.41	0.14	0.9905
B	49.20	166.78	49.17	166.51	0.03	0.27	0.9994
C	29.87	187.49	30.58	185.47	-0.72	2.02	1.0240
D	30.13	209.62	34.38	214.98	-4.25	5.36	1.1410
E	23.27	136.07	19.87	135.53	3.39	0.54	0.8542
F	23.20	147.30	23.07	149.00	0.13	1.70	0.9942
G	65.63	133.47	66.36	133.97	-0.74	0.50	1.0112
H	39.98	185.85	41.02	186.03	-1.04	0.18	1.0259
I	98.30	137.46	97.62	137.89	0.68	0.43	0.9931

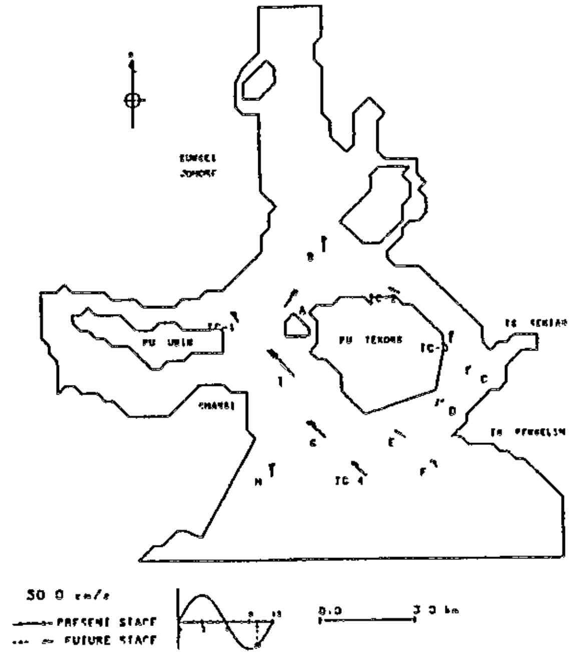


POINT	PRESENT STAGE a VELOCITY (cm/s)	PRESENT STAGE b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	FUTURE STAGE d DIRECTION (°)	DIFFERENCE e=a-c VELOCITY (cm/s)	DIFFERENCE f=b-d DIRECTION (°)	g=c/a VELOCITY RATIO
TC 1	28.78	133.57	28.65	133.44	0.13	0.13	0.9954
TC-2	36.81	115.69	37.06	115.68	-0.26	0.00	1.0070
TC 3	36.00	174.37	38.32	174.19	-2.32	0.18	1.0645
TC-4	38.15	137.60	38.92	137.23	-0.77	0.37	1.0203
A	23.77	211.45	23.40	211.20	0.37	0.24	0.9845
B	31.79	159.74	31.76	159.37	0.03	0.37	0.9990
C	23.62	188.40	24.31	186.28	-0.69	2.11	1.0294
D	25.72	207.76	28.22	214.18	2.50	6.42	1.0973
E	19.65	135.87	16.47	134.30	3.18	1.57	0.8382
F	19.20	148.21	18.79	149.10	0.41	0.89	0.9786
G	49.58	133.46	50.20	134.13	-0.61	0.67	1.0124
H	35.88	188.53	36.76	188.64	-0.88	0.11	1.0244
I	76.34	137.39	75.79	137.80	0.55	0.41	0.9928

Fig. III-6-28-(4) Change of velocity and current direction

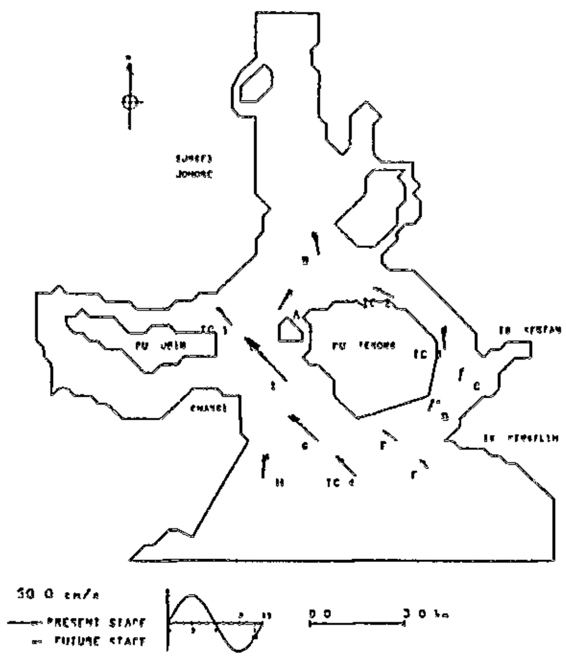


POINT	PRESENT STAGE a VELOCITY (cm/s)	PRESENT STAGE b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	FUTURE STAGE d DIRECTION (°)	DIFFERENCE e=a-c VELOCITY (cm/s)	DIFFERENCE f=b-d DIRECTION (°)	g=c/a VELOCITY RATIO
TC-1	12.84	107.56	12.79	107.36	0.05	0.20	0.9960
TC-2	10.23	115.91	10.21	115.92	0.03	0.01	0.9975
TC-3	10.56	174.65	11.03	174.01	-0.47	0.64	1.0442
TC-4	12.83	138.69	13.34	136.84	-0.52	1.85	1.0403
A	12.37	46.84	12.50	46.75	-0.14	0.08	1.0109
B	7.50	80.35	7.52	79.82	-0.03	0.53	1.0036
C	6.90	191.43	7.22	188.90	-0.31	2.53	1.0453
D	9.27	200.81	8.89	209.91	0.38	9.10	0.9594
E	8.88	129.11	7.91	120.56	0.97	8.55	0.8907
F	8.49	146.11	8.24	144.66	0.25	1.45	0.9704
G	16.97	133.88	17.46	134.51	-0.48	0.63	1.0285
H	18.27	190.61	18.47	190.30	-0.20	0.31	1.0108
I	27.77	135.26	27.41	135.97	0.36	0.71	0.9870



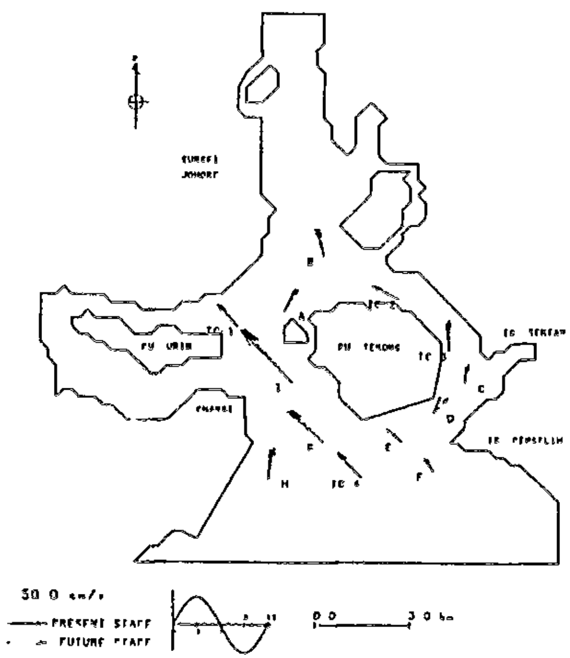
POINT	PRESENT STAGE a VELOCITY (cm/s)	PRESENT STAGE b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	FUTURE STAGE d DIRECTION (°)	DIFFERENCE e=a-c VELOCITY (cm/s)	DIFFERENCE f=b-d DIRECTION (°)	g=c/a VELOCITY RATIO
TC-1	10.22	343.76	10.17	343.66	0.05	0.10	0.9947
TC-2	13.35	295.78	13.74	295.78	-0.39	0.00	1.0290
TC-3	12.23	354.85	13.83	354.64	-1.60	0.21	1.1312
TC-4	12.15	320.69	12.43	320.35	-0.27	0.34	1.0225
A	24.84	35.46	24.66	35.38	0.18	0.08	0.9929
B	19.62	357.68	19.70	357.06	0.08	0.62	1.0039
C	7.21	3.76	7.80	0.74	-0.59	3.02	1.0820
D	6.55	32.13	8.33	38.05	-1.78	5.92	1.2711
E	5.43	322.95	4.26	331.18	1.17	8.24	0.7842
F	3.32	335.59	3.30	341.12	0.02	5.53	0.9929
G	16.51	312.82	16.67	314.74	-0.17	1.92	1.0101
H	10.37	10.27	11.22	11.19	0.85	0.92	1.0817
I	25.28	316.17	25.42	316.31	-0.14	0.14	1.0054

Fig. III-6-28-(5) Change of velocity and current direction



POINT	PRESENT STAGE a VELOCITY (cm/s)	PRESENT STAGE b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	FUTURE STAGE d DIRECTION (°)	DIFFERENCE a-c VELOCITY (cm/s)	DIFFERENCE b-d DIRECTION (°)	c/a VELOCITY RATIO
TC-1	22.48	323.97	22.37	323.82	0.11	0.15	0.9950
TC-2	26.87	295.82	27.39	295.82	0.52	0.00	1.0192
TC 3	24.67	354.96	27.27	354.40	2.60	0.56	1.1056
TC-4	25.27	321.11	26.01	320.18	-0.74	0.93	1.0291
A	29.07	31.17	28.77	31.01	0.30	0.16	0.9897
B	30.19	347.62	30.32	347.07	-0.12	0.55	1.0040
C	14.26	4.83	15.62	1.81	-1.36	3.01	1.0957
D	14.26	27.44	16.88	36.02	-2.61	8.59	1.1831
E	13.03	318.84	10.77	318.75	2.26	0.10	0.8263
F	9.19	331.13	9.10	333.19	0.09	2.06	0.9907
G	34.76	312.83	35.52	314.44	-0.76	1.61	1.0218
H	24.97	10.70	26.31	11.04	-1.34	0.34	1.0537
I	54.04	315.28	54.14	315.67	-0.10	0.39	1.0019

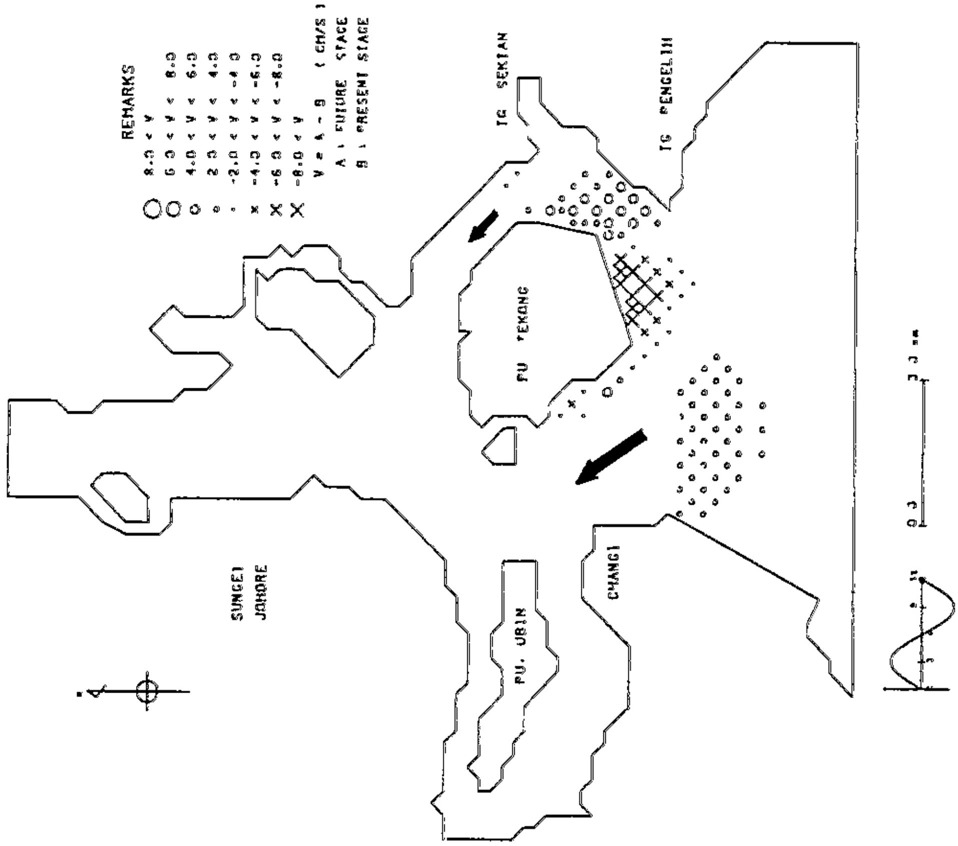
DIRECTION (N, S)



POINT	PRESENT STAGE a VELOCITY (cm/s)	PRESENT STAGE b DIRECTION (°)	FUTURE STAGE c VELOCITY (cm/s)	FUTURE STAGE d DIRECTION (°)	DIFFERENCE a-c VELOCITY (cm/s)	DIFFERENCE b-d DIRECTION (°)	c/a VELOCITY RATIO
TC 1	30.88	320.43	30.72	320.26	0.16	0.17	0.9949
TC-2	35.86	295.63	36.44	295.63	-0.58	0.00	1.0162
TC 3	33.51	355.13	36.80	354.26	3.29	0.86	1.0982
TC 4	33.09	322.19	34.04	320.96	0.96	1.22	1.0290
A	31.80	29.03	31.44	28.81	0.37	0.21	0.9884
B	36.59	344.51	36.73	344.00	0.14	0.51	1.0037
C	19.48	6.67	21.66	3.35	-2.18	3.32	1.1119
D	20.75	25.92	24.03	35.80	-3.28	9.88	1.1579
E	18.21	323.03	15.35	321.66	3.16	1.37	0.8263
F	13.41	331.70	13.23	333.08	0.17	1.37	0.9871
G	45.51	313.15	46.82	314.68	-1.31	1.53	1.0288
H	34.13	10.40	35.80	10.58	-1.68	0.18	1.0491
I	71.39	314.92	71.42	315.48	0.03	0.57	1.0005

DIRECTION (N, S)

Fig. III-6-28-(6) Change of velocity and current direction



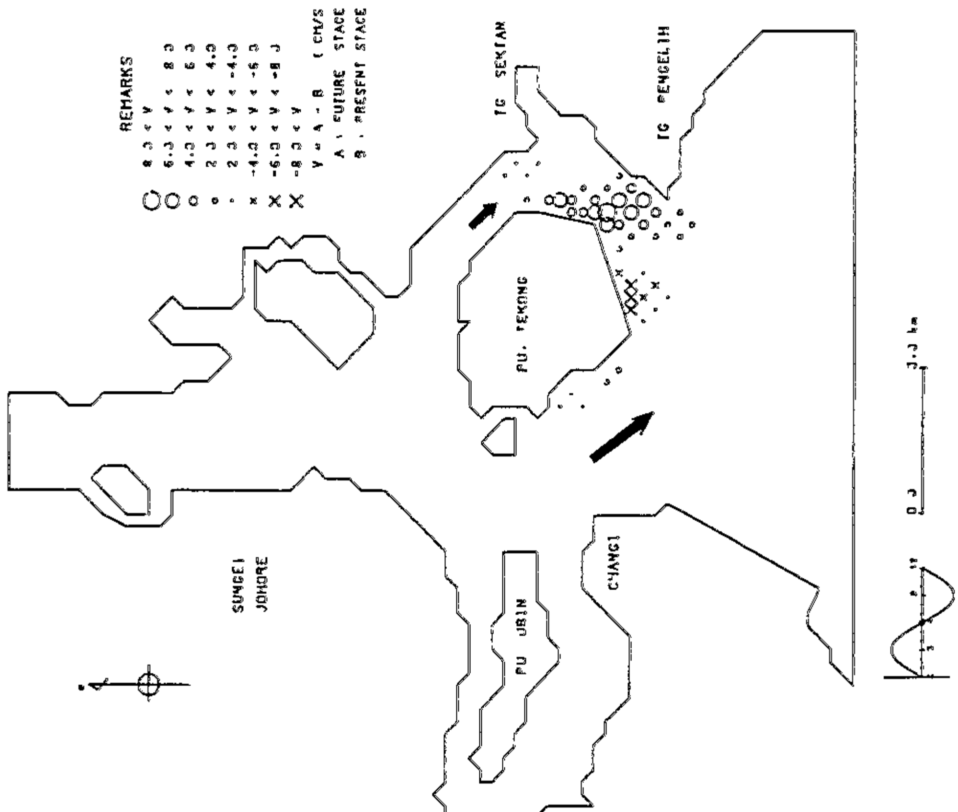


Fig. III-6-29 Distribution of velocity change

III-6-2-2 COD dispersion

— The verification

Computing the distribution of COD concentration, the numerical results are compared with the observed COD concentrations and the verification of simulation model is carried out.

In Tekong area, since the water quality was observed at the feeble current condition, the averaged water quality is computed using the steady state simulation model.

Fig. III-6-30 shows the computed distribution of COD concentration and the comparison between the observed data and the computed result is shown in Fig. III-6-31 and Table III-6-10.

Further, Fig. III-6-32 shows the comparison between observed and computed at the typical sections.

Summarizing the verification from these figures and table as follows:

(1) The computed distribution of COD concentration shows that the concentration is high in the area north to Tekong island and low in the area south to the island, and these charactersistics are same with distribution of concentration obtained by the observation.

(2) When the computed result is compared with the observed data at the stations amount to 11 points (T1 to T32), the maximum difference is equal to 1.1 ppm. Averaging the concentrations at these stations, the observed one is equal to 1.56 ppm and the computed one is equal to 1.49 ppm, which means only the slight difference is shown.

(3) The following corelation obtained between observed data and the computed result are given as follows:

Corelation coefficient 0.71

Linear regression $y = 0.722x + 0.481$

where y represents the observed value and x, the computed value. Excluding the data at st.T32 which shows the large difference, following relation is obtained.

Corelation coefficient 0.85

Linear regression $y = 0.712x + 0.393$

From these considerations it can be obtained that the computed result has good agreement with observed data.

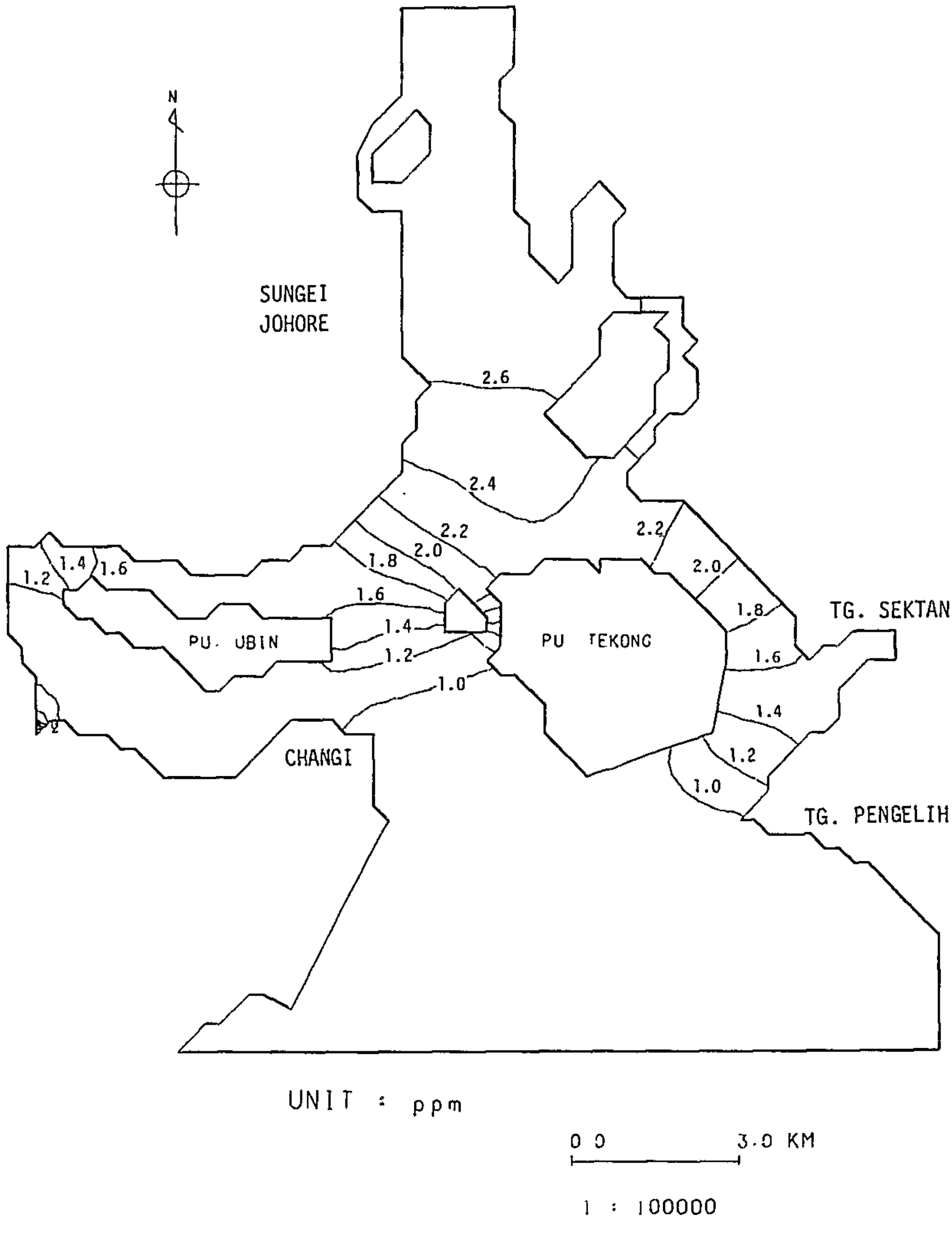
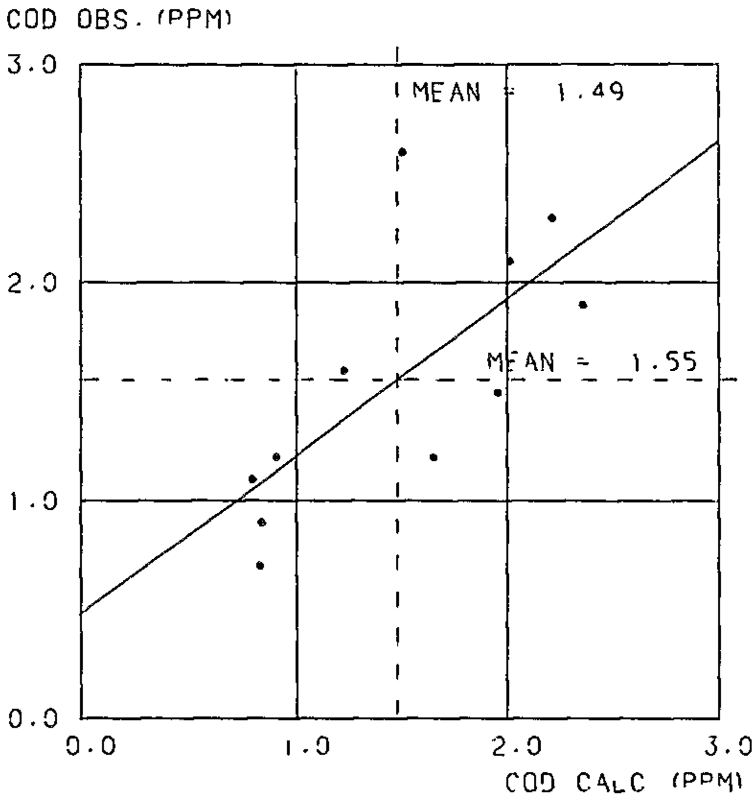


Fig. III-6-30 Computed distribution of COD in present stage

Table III-6-10 Comparison between observed and computed

(UNIT : PPM)

POINT	OBS	CALC.
T 1	1.20	1.66
T 3	1.50	1.96
T 4	1.60	1.24
T 9	2.30	2.22
T 13	0.70	0.83
T 15	1.10	0.80
T 16	1.90	2.36
T 21	0.90	0.84
T 27	2.10	2.02
T 28	1.20	0.91
T 32	2.60	1.52
MEAN	1.56	1.49



$Y = 0.72X + 0.48$ R = 0.71 (t Test: $t_R > t\ 0.05$; $2.67 > 1.83$)

Fig. III-6-31 Corelation between observed and computed

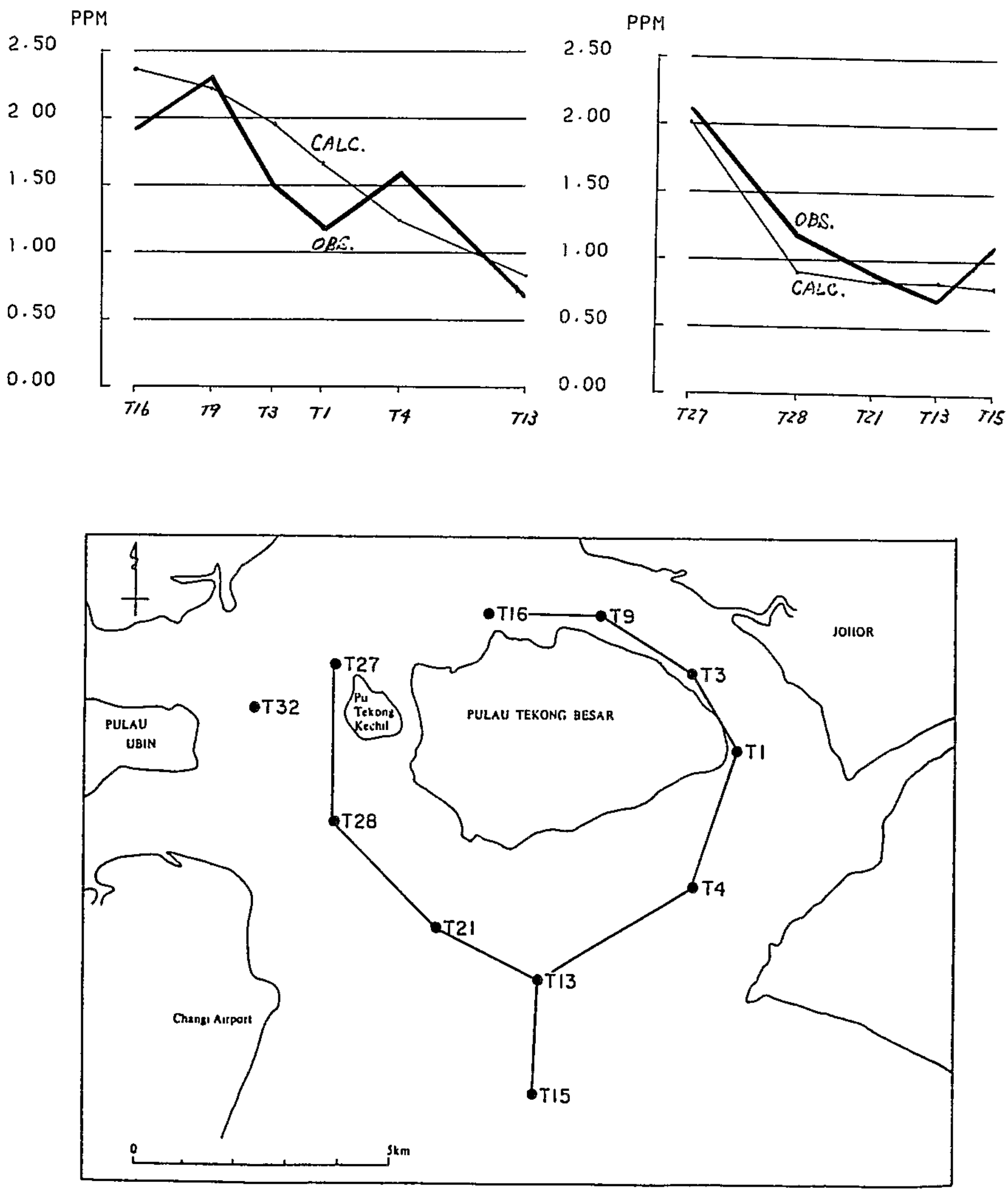


Fig. III-6-32 COD concentrations at typical sections

— The water quality in the future stage

Changing the data on topography and pollutant flux correspond to the future stage, the computation is performed in the same manner with that of present stage. Figs. III-6-33 and Fig. III-6-34 show the distribution of COD concentrations, Table III-6-11, the concentrarions at the representative points and Fig. III-6-36, the COD concentrations on the typical sections. From these figures and table, summarizong the water quality in the future stage as follows:

1 Comparing the water quality between the stages of present and future (the case when the coal firing power station and integrated steel mill are both constructed), the difference of concentration remains within 0.03 ppm. The averaged concentration through 11 points (T1 to T32) is equal to 1.50 ppm in the future stage and only 0.01 ppm as the rise of concentration is shown when it is compared with that of the present stage.

2 In the future stage, the difference of concentration is within 0.01 ppm between the two cases, one the case when coal firing power station is constructed and the other the case when coal firing power station and integrated steel mill are constructed.

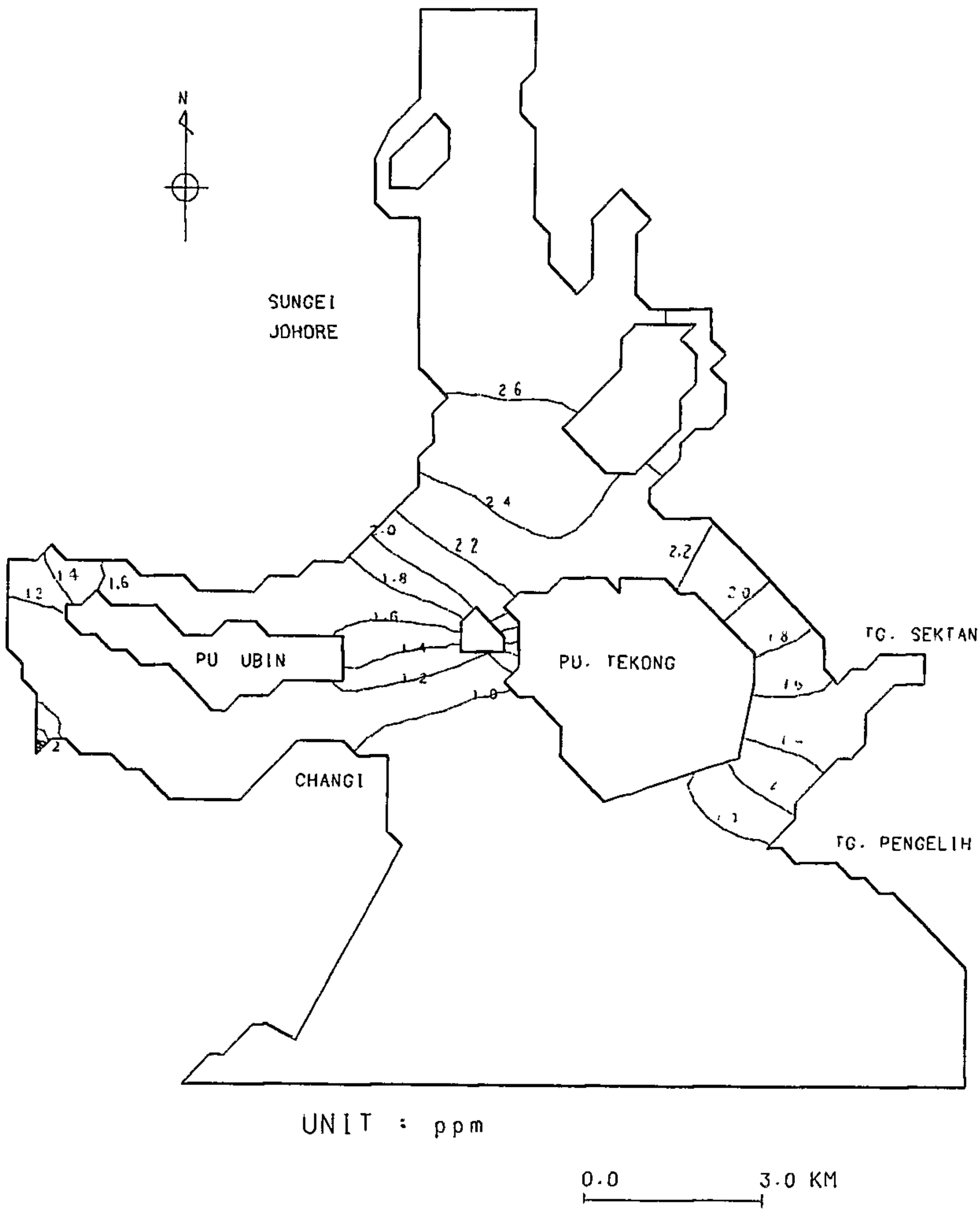


Fig. III-6-33 COD distribution in future stage (Coal firing power station constructed)

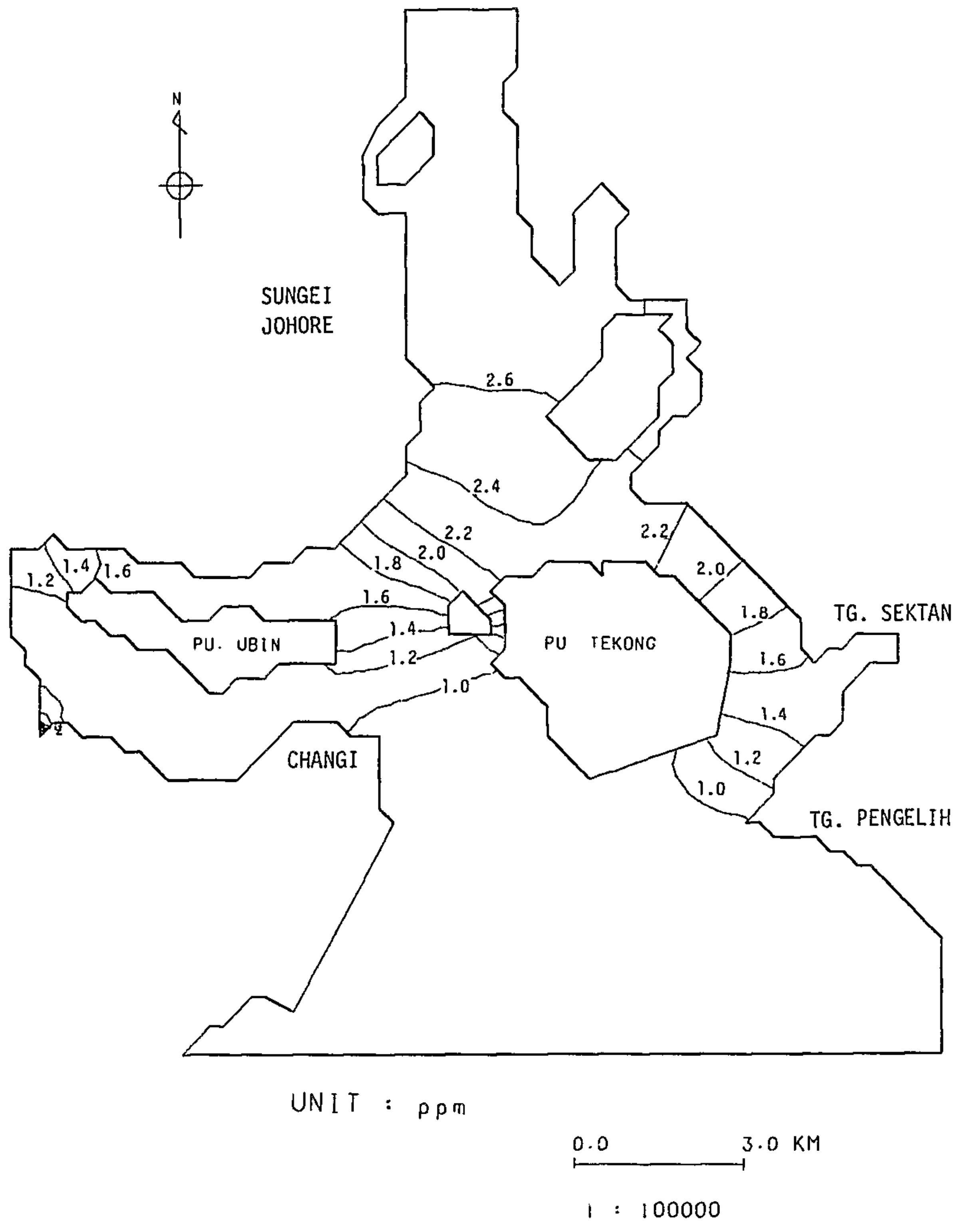


Fig. III-6-34 COD distribution in future stage (Coal firing power station and integrated steel mill constructed)

Table III-6-11 Concentrations at the representative points

(UNIT : PPM)

POINT	PRESENT STAGE	FUTURE STAGE	
		P.S.	P.S. & ST.MIL
T 1	1.662	1.722	1.711
T 3	1.963	1.997	1.987
T 4	1.239	1.272	1.265
T 9	2.219	2.235	2.230
T 13	0.831	0.829	0.826
T 15	0.795	0.798	0.798
T 16	2.363	2.370	2.370
T 21	0.838	0.822	0.820
T 27	2.021	2.022	2.028
T 28	0.910	0.893	0.892
T 32	1.518	1.514	1.519
A	2.738	2.739	2.739
B	2.685	2.686	2.687
C	2.484	2.487	2.490
D	1.089	1.063	1.056
E	0.933	0.894	0.885
F	0.948	0.942	0.938
G	0.792	0.798	0.800
H	0.790	0.786	0.785
I	0.831	0.819	0.816
J	1.640	1.637	1.643
K	1.102	1.091	1.092
L	1.102	1.091	1.092
M	1.620	1.617	1.622
N	1.113	1.102	1.104

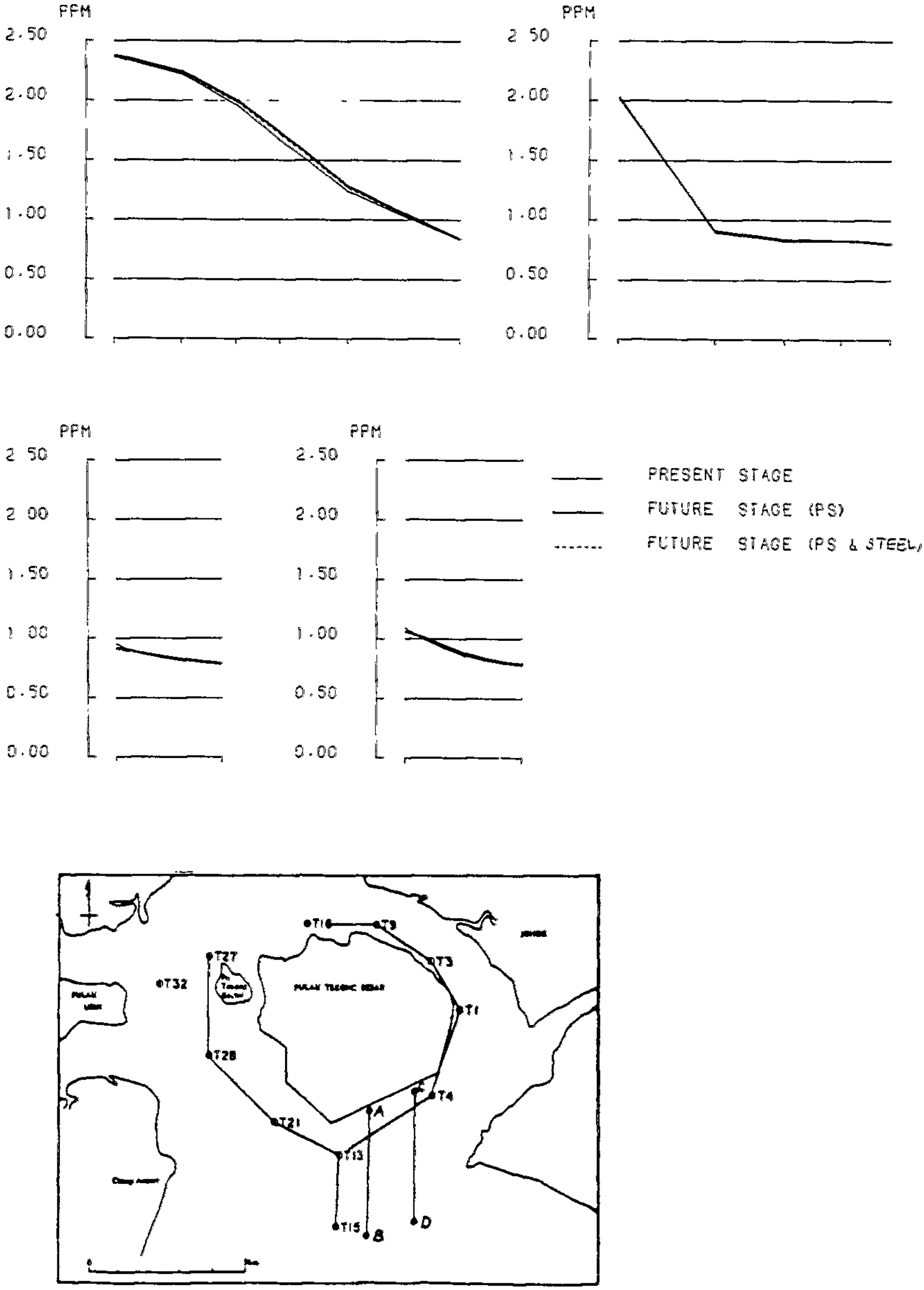


Fig. III-6-35 COD concentrations at the typical sections

III-6-2-3 Thermal diffusion

In the present stage, as the Tekong area has no thermal discharge, the verification is not performed.

The numerical result of thermal diffusion in future stage is shown in Fig. III-6-36 as the distribution of temperature rise above ambient water temperature and in Table III-6-12 as the temperatures rise above ambient water temperature at representative points.

The thermal discharge (5.6°C higher above ambient water temperature and discharge rate is 27.8 m^3/sec) is produced at the coal firing power station. The maximum temperature rise above ambient water temperature is equal to 0.5°C around the discharging point.

In the area surrounded by the reclaimed land, Tg.Sektan and Tg.Pengelish (3km x 3 km), the temperature rise is shown as 0.1°C above ambient water temperature.

The maximum computed temperature rise above ambient water temperature (0.5°C) is less than the maximum difference obtained by observed data (0.6°C).

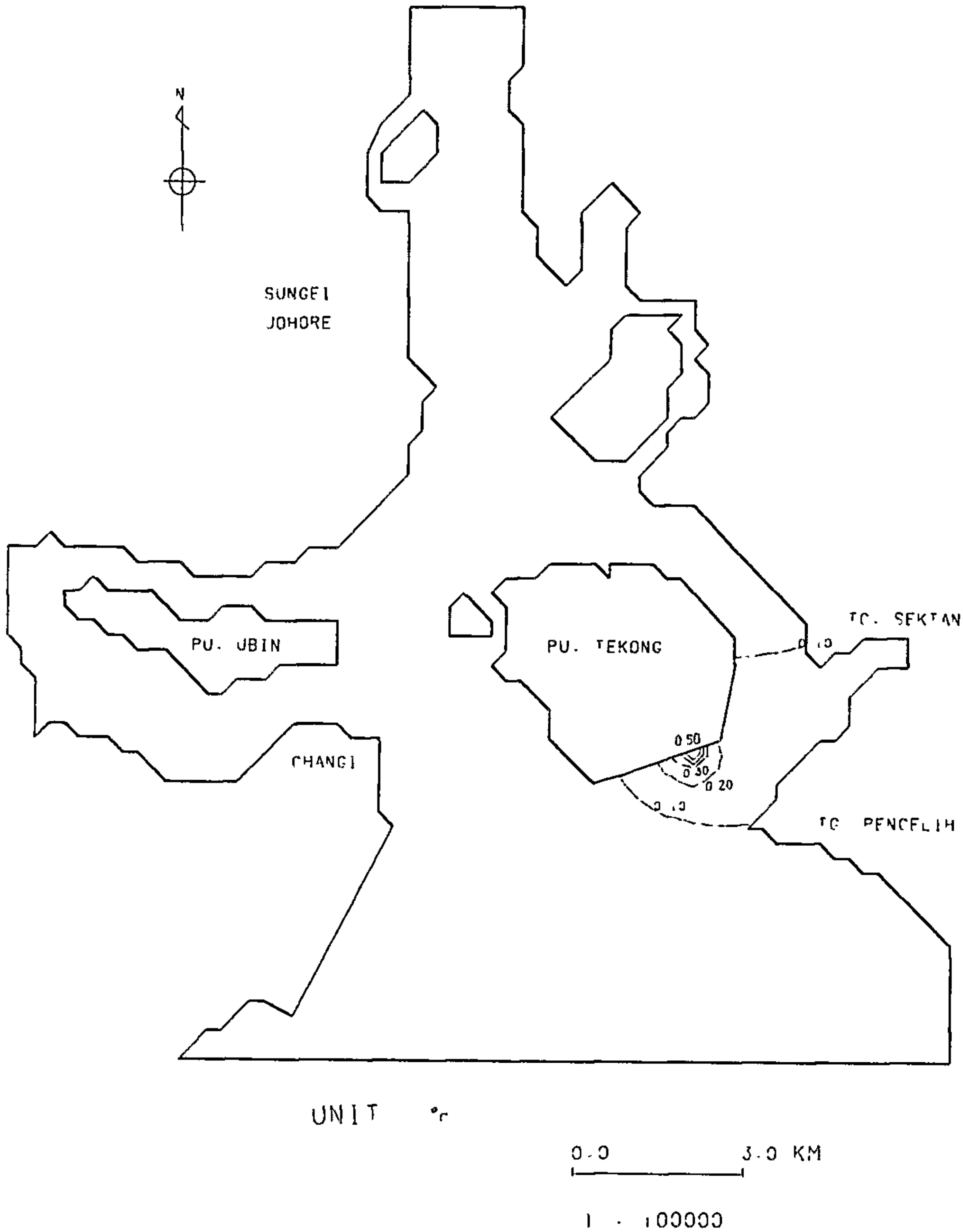


Fig. III-6-36 Computed temperature rise above ambient water temperature in future stage

Table III-6-12 Computed temperature rise above ambient water temperature at typical points

POINT	:	T (°C)
T 1	:	0.098
T 3	:	0.062
T 4	:	0.169
T 9	:	0.033
T 13	:	0.042
T 15	:	0.024
T 16	:	0.015
T 21	:	0.035
T 27	:	0.014
T 28	:	0.030
T 32	:	0.021
A	:	0.000
B	:	0.002
C	:	0.006
D	:	0.281
E	:	0.098
F	:	0.127
G	:	0.022
H	:	0.018
I	:	0.029
J	:	0.019
K	:	0.026
L	:	0.026
M	:	0.018
N	:	0.026

SCOPE OF WORK

FOR

THE STUDY OF ENVIRONMENTAL EFFECTS

OF COAL FIRING POWER STATIONS

AND INTEGRATED STEEL MILL

DECEMBER 1980

This Scope of Work is agreed by the following two authorities concerned;

The Jurong Town Corporation,
Government of the Republic of Singapore.

Japan International Cooperation Agency,
the Official Agency responsible for the implementation
of technical cooperation programmes of
the Government of Japan.

To confirm the aforementioned, the Scope of Work is herewith attached and signed by the responsible personnel of the said authorities concerned.

Date: 19th December 1980
Issued at: Singapore

For the Jurong Town Corporation,
Government of the Republic of
Singapore.

YING YAK HANG
PRINCIPAL DIRECTOR (TECHNICAL)
JURONG TOWN CORPORATION
GOVERNMENT OF THE REPUBLIC OF
SINGAPORE

For Japan International
Cooperation Agency,
the Government of Japan.

菊島一郎

ICHIRO KIKUSHIMA
LEADER OF THE JAPANESE
PRELIMINARY SURVEY TEAM
DEPUTY DIRECTOR
ENVIRONMENTAL PROTECTION GUIDANCE
DIVISION
INDUSTRIAL LOCATION & ENVIRONMENTAL
PROTECTION BUREAU
MINISTRY OF INTERNATIONAL TRADE AND
INDUSTRY

IN THE PRESENCE OF:-

LIM SAK LAN
SENIOR DIRECTOR, ENGINEERING
JURONG TOWN CORPORATION

御手洗章弘

AKIHIRO MITARI
HEAD, INDUSTRY DIVISION
MINING & INDUSTRIAL PLANNING
AND SURVEY DEPARTMENT
JAPAN INTERNATIONAL COOPERATION
AGENCY

1. Introduction

In response to the request of the Government of the Republic of Singapore, the Government of Japan has agreed to extend the technical assistance to conduct the study on the environmental effects of coal firing power stations and the integrated steel mill which will be sited in the new industrial estates of the Republic of Singapore, which assistance is given in accordance with the laws and regulations in force in Japan.

The study will be carried out through The Japan International Cooperation Agency (hereinafter referred to as JICA), which is the official agency responsible for the implementation of technical cooperation programmes of the Government of Japan, in close cooperation with the Government of the Republic of Singapore and authorities concerned.

2. Objectives

The objectives of the study are:-

(1) To conduct the field survey in terms of air and water qualities within and at surrounding areas of Pulau Seraya, Jurong, Pulau Tekong, where the proposed coal firing power stations and the integrated steel mill are to be sited.

(2) To conduct the simulation study by computers based on the data obtained from the above said field survey and to assess the estimated pollution loads when these plants are in operation.

3. Scope of the study

3-1 Survey Areas

(A) Pulau Seraya, the proposed site of the coal firing power station and its surrounding areas.

(B) Pulau Tekong, the proposed site of the coal firing power station and the integrated steel mill, and its surrounding areas.

(C) Other areas mutually agreed to be surveyed.

3-2 Survey Plan

(A) Air Quality Survey

i) Long Term Measurement

a) Sulphur dioxide (SO_2) concentration

b) Wind directions and velocity at ground surface

c) Net radiation

d) Temperature

Notes: Period of measurement - 1 year

ii) Short Term Measurement

a) Vertical profile of wind directions and velocity

Notes: Period of measurement - two days each at two stations.

iii) Simulation - Simulation of sulfur dioxide (SO_2)

(B) Water Quality Survey

i) Measurement

a) Current directions and velocity

b) Chemical Oxygen Demand (COD)

c) Water temperature and salinity

Notes: Period of measurement - 2 weeks per measuring point for the above (a), once per measuring point for the above (b) and (c), and 1.5 months in total including preparation works.

ii) Simulation - Simulation of COD and temperature

4. Time Schedule

As shown in ANNEX I (Subject to change)

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5. <u>Report</u>

5-1 Interim Report

i) 30 copies

ii) The interim report will be submitted in English to the Government of the Republic of Singapore within 5 months after the completion of the simulation for water quality survey.

iii) The interim report will contain the results of the water quality survey and refer to the progress of air quality survey.

iv) The Government of the Republic of Singapore will provide the comments to JICA through the Embassy of Japan within 1 month after receipt of the interim report.

5-2 Draft Final Report

i) 30 copies

ii) The draft final report will be submitted in English within 4 months after the completion of the simulation for air quality survey.

iii) The Government of the Republic of Singapore will provide the comments to JICA through the Embassy of Japan within 1 month after receipt of the draft final report.

5-3 Final Report

i) 50 copies together with 50 copies of abstracts.

ii) The final report will be submitted in English within 2 months after receipt of the comments of the draft final report.

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6. <u>Contribution of the Government of the Republic of Singapore</u>

1. The Government of the Repûblic of Singapore will assign a qualified counterpart to be responsible for liaison and cooperation with the team conducting the survey. (hereinafter referred to as Survey Team)
2. The Government of the Republic of Singapore will provide the Survey Team with the necessary and available information and data.
3. The Government of the Republic of Singapore will make arrangements for the Survey Team to visit the authorities concerned.
4 The Government of the Republic of Singapore will provide the Survey Team with an office, sites for monitoring stations, laboratory testing facilities, storage space, temporary site office, transportation and boats as are necessary for the survey (ANNEX II)
5. The Government of the Republic of Singapore will exempt the Survey Team from taxes and duties on machinery, equipments and materials brought in Singapore by the Survey Team.
6. The Government of the Republic of Singapore will exempt the members of the Survèy Team from any tax, including import and export duties imposed on the members' personal effects.
7. The Government of the Republic of Singapore will make an effort to ensure the securities of machinery, equipments and materials brought in Singapore by the Survey Team.

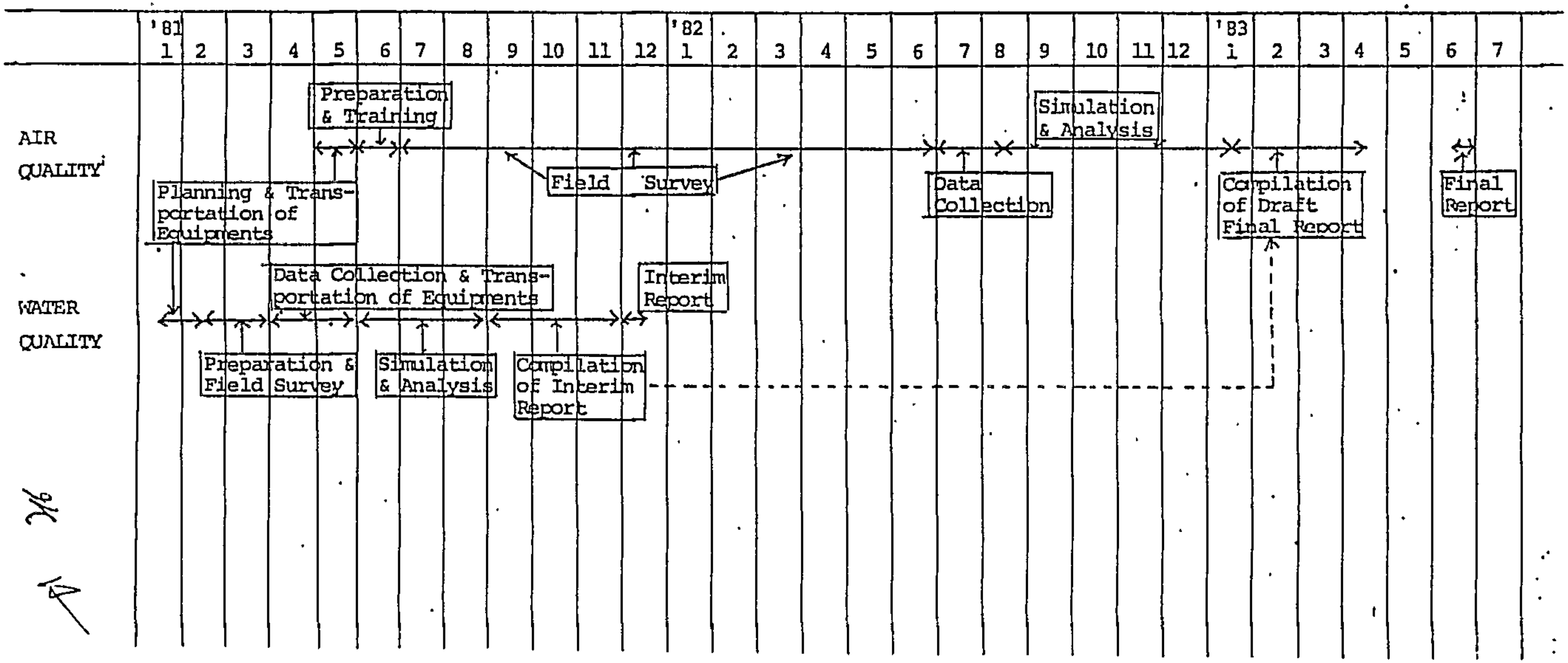
7. Contribution of the Government of Japan

1. The Government of Japan, through JICA, will provide a Survey Team who will conduct the field survey and simulation according to the Time Schedule (ANNEX I)

2. The Government of Japan will conduct during the stay of the Survey Team in the Republic of Singapore the training course for the Singapore counterparts to further their skills in operating and maintaining the necessary measuring machinery and equipments for the period of the field survey.

ANNEX I

TIME SCHEDULE FOR THE STUDY OF ENVIRONMENTAL EFFECTS OF COAL FIRING POWER STATION AND INTEGRATED STEEL MILL IN THE REPUBLIC OF SINGAPORE



The Detailed Information on Provision of Facilities by the Government of The Republic of Singapore

[1] Air Quality Survey

1. Monitoring Stations
   About 7 monitoring stations are to be established in the surrounding areas of the proposed sites. The land or places for these monitoring stations should be provided.
2. Electricity Supply
   The electricity connection and supply for monitoring stations at mutually agreed sites should be provided by the Government of the Republic of Singapore.
3. The Facilities to Accomodate the Chemical Reagents
   The facilities for storage, preparation of chemical reagents and distilled water should be provided at Jurong Town Corporation's Laboratory or National University of Singapore's Laboratory.
4. The Government of the Republic of Singapore will provide necessary personnel for the daily operation and maintenance of the monitoring stations.

[2] Water Quality Survey

1. The Laboratory Testing Facilities for Chemical Analysis
   The laboratory testing facilities for chemical analysis of aqueous samples shall be provided at Jurong Town Corporation's Laboratory or National University of Singapore's Laboratory.
2. The Storage Space for the Measuring Equipments and Materials
   The storage space to be provided for the measuring equipments and materials shall be big enough for opening of the packages and adjusting the equipments.
3. The Small Boats for Survey
   The Survey Team will require 3 small boats for about 20 days in total. The Government of the Republic of Singapore will provide the Survey Team with such number of boats as are necessary for the survey.

[3] Handling of Measuring Equipments

All the measuring equipments necessary to conduct the field survey will be, in principle, brought in and out by the Survey Team. The Government of the Republic of Singapore is requested to provide facilities and arrangement on the followings:-

(a) Custom clearance including loading and unloading

(b) Inland transportation

(c) Packing and unpacking

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MINUTES OF MEETINGS

FOR

THE STUDY OF ENVIRONMENTAL EFFECTS

OF COAL FIRING POWER STATIONS

AND INTEGRATED STEEL MILL

DECEMBER 1980

MINUTES OF MEETINGS

FOR

THE STUDY OF ENVIRONMENTAL EFFECTS

OF COAL FIRING POWER STATIONS

AND INTEGRATED STEEL MILL

19TH DECEMBER 1980

CONFIRMED BY:

YING YOK HANG
PRINCIPAL DIRECTOR (TECHNICAL)
JURONG TOWN CORPORATION
GOVERNMENT OF THE REPUBLIC OF
SINGAPORE

菊島一郎
ICHIRO KIKUSHIMA
LEADER OF THE JAPANESE
PRELIMINARY SURVEY TEAM
DEPUTY DIRECTOR
ENVIRONMENTAL PROTECTION
GUIDANCE DIVISION
INDUSTRIAL LOCATION & ENVIRONMENTAL
PROTECTION BUREAU
MINISTRY OF INTERNATIONAL TRADE AND
INDUSTRY

MINUTES OF MEETINGS

The Japanese Preliminary Survey Team and the Singapore Counterpart had discussion on the Environment Effects of the Coal Firing Power Stations and Integrated Steel Mill and the following were mutually agreed upon.

Data of the Proposed Coal Firing Power Stations and the Integrated Steel Mill

(A) Coal Firing Power Station

i) The Japanese side requested for information on the proposed coal firing power station.

ii) After discussion with the Singapore side which included P.U.B., the assumptions given in Appendix A were agreed upon.

iii) It was indicated that one coal firing power station will be on Pulau Seraya and one on Pulau Tekong. (See Appendix D)

(B) Integrated Steel Mill

i) The Singapore side indicated that the proposed steel mill will use about eight million tons of iron ore per year and producing about one million tons of steel product by the direct reduction process using coal.

ii) The Japanese side requested for technical information similar to those in Appendix A.

iii) The Singapore side replied that it is not in a position to provide, except that the location will be in Pulau Tekong (See Appendix D). However, it will try to obtain the information requested by the Japanese side at the earliest possible date.

iv) It was mutually agreed that this matter will be further discussed and resolved when the next water quality survey team visits Singapore.

(C) Data on Emission Sources (Present & Future 1990)

(a) Air Quality

i) The Japanese side requested for emission data both present and future and suggested that if such data is not available then a survey be carried out to obtain the same.

ii) The Singapore side agreed to carry out such survey.

iii) The Japanese side indicated that these data should be made available by June 1982.

iv) The Singapore side agreed to the above.

(b) Water Quality

i) The Japanese side requested for effluent data present and future including industries located on the southern islands and suggested if such data is not available then a survey be carried out to obtain the same.

ii) The Singapore side agreed to carry out such survey.

iii) The Japanese side indicated that these data should be made available by May 1981.

iv) The Singapore side agreed to the above.

(c) Malaysian Development Plan (North of Straits of Johore)

i) The Japanese side requested information regarding industrial development plan immediately north of the Straits of Johore.

ii) The Singapore side replied that it is not in a position to do so.

iii) It was mutually agreed that effects of the Malaysian developments shall not be considered.

(D) Monitoring Points

Based on survey carried out by Japanese Preliminary Survey Team, the following monitoring points were agreed upon.

(a) Air Quality

i) SO_2, wind direction, wind velocity - 7 points

ii) Net radiation - 1 point

iii) Vertical distribution of temperature - 1 point

iv) Pilot balloon observation - 2 points

(b) Water Quality

i) Current direction, current velocity - 10 points (around the two proposed sites

ii) Water temperature, salinity, COD observation. - 30 points (around the two proposed sites

(c) Clearance from Competent Authorities

The Singapore side will arrange and obtain necessary clearance from the competent authorities to conduct the above surveys.

(E) Simulation Methods

i) The Japanese side stated that for SO_2 diffusion calculation, Plume Puff model will be adopted and predict a yearly concentration of SO_2.

ii) As for water temperature and COD diffusion calculation, FEM (Finite Element Method) will be adopted.

iii) The Singapore side agreed to the above methods.

(F) Evaluation on the Environmental Effects and Impacts

i) The Japanese side enquired about the environmental ambient standards of SO_2 and COD.

ii) The Singapore side replied that it has only the emission standard but not the ambient standard.

iii) The Japanese side stated that it will predict the levels of SO_2 and COD from the coal firing power stations and integrated steel mill.

iv) The Japanese side stated that it will also be able to predict the total levels of SO_2 and COD in the year 1990 if adequate datas on the emission are collected from the survey referred in para C.

v) It was mutually agreed that if no ambient standard is indicated by the Singapore side, the Japanese side will not be in a position to comment on the levels of SO_2 and COD and in any case further evaluation will have to be carried by the Singapore side.

(G) Maintenance of monitoring stations

i) The Japanese side requested the Singapore side to provide the necessary personnel for the daily operation and maintenance of the monitoring stations as indicated in Appendix 'B'.

ii) Singapore side agreed to provide the personnel required.

(H) Survey Schedule

i) The Japanese side mentioned that the schedule may need to be altered. Such alteration will be mutually discussed and agreed upon.

ii) The Singapore side agreed to the above.

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5(I) Contributions

i) The Japanese side requested that land and sea transport for future survey team and equipments and their local counterparts be provided in accordance with schedule in Appendix 'C'.

ii) The Singapore side agreed to provide the same.

iii) At the commencement of the survey, the Japanese side will arrange for all the equipments to be delivered to Jurong Town Hall. The Singapore side will arrange for the transportation of the equipments from the Jurong Town Hall to the various monitoring stations and will be responsible for the setting up of the stations.

iv) On completion of survey, the Singapore side will arrange for transportation of all equipments from the monitoring stations back to Jurong Town Hall and the Japanese side will arrange to collect the same from Jurong Town Hall.

(J) Datas/Reports

i) The Singapore side requested that information supplied to the Japanese side shall be treated as confidential materials. Similarly the results and report of the study are to be treated also as confidential.

ii) The Japanese side agreed to the above.

Assumption on Coal Firing Power Station

Generated Output	350 MW x 2
Fuel	Coal Calorific Value 7,000 Kcal/kg Sulphur 1% (wt%) Consumption 154×10^4 t/year (operation rate 70%)
Stack	Gas Volume 182×10^4 Nm^3/h Gas Temperature 150°C (without desulfurization of flue gas) Gas Discharge Velocity 30 m/s Height 200m
Cooling Sea Water	Amount 29.4 m^3/s Temperature difference 7°C
Effulent	Volume 1,200 m^3/d COD 160 mg/l

NOTE:

The sites of stacks and outlets are as shown in Appendix D

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ON THE MAINTENANCE OF MONITORING STATIONS

	Qualified Persons	Regular Persons
1 SO_2 Monitor	Once every 20 days:- a Absorption solution and chart sheet, ink should be refilled or replaced b Calibration of monitor should be conducted c Chart data for last 20 days should be sent to Japan through JICA, Singapore	Once per everyday he should check the monitoring station whether it is operating properly without any trouble or not
2 Wind Speed Meter	Same as above but no calibration required	Same as above
3 Net Solar Radiation Flux Meter and Air Thermometer	Same as No (2) above	Same as No (1) and (2) above

APPENDIX C

TIME SCHEDULE FOR FIELD SURVEY IN SINGAPORE (AIR QUALITY)

Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	.		388		390		392		394	395		.	
Travel & Official Visits																																								
Number of Persons	4	4																																						
1. Site Selection,																																								
N.of Person			4	4	4	4	4	4	4	4																														
2. To set equipments & Training																																								
N.of Person											4	4	4	4	4	4	4	4	4	4	4	4																		
3. Surveillance & Pilot Balloon																																								
N.of Person																							4	4	4	4														
4. Observation																										(365)														
N.of Person																							(1)						(1)											
5. Travel to Japan																																								
N.of Person																											4													
6. Travel to S'pore																																								
N.of Person																													2											
7. Withdrawal of Equipments																																								
N.of Person																														2	2	2	2	2	2					
8. Travel to Japan																																								
N.of Person																																				2	2			

TENTATIVE TIME SCHEDULE FOR FIELD SURVEY IN SINGAPORE (WATER QUALITY)

Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Travel & Official Visits																																								
Number of Persons	2	2																																						
1. Site Selection Jurong Area																																								
N. of person			2	2	2	2																																		
N.of ships				1																																				
2. Site Selection Tekong Area																																								
N.of person							2	2	2	2																														
N.of ships								1																																
3. Travel of Survey Team																																								
N.of person										6																														
4. Preparation																																								
N.of person											8	8	8	8	8																									
5. Setting of Equipments																																								
a) Jurong N.of person																8																								
N.of ships																2																								
b) Tekong N.of person																	8																							
N.of ships																	2																							
6. Observation & Withdrawal																		Observation														Withdrawal & Reserve								
N.of person																		8	8	8	8	8	8	4	4	4	4	4	4	4	4	4	4	4	4					
Local Employ																		(1)		(1)		(1)	(1)									(2)	(2)	(2)	(2)					
N.of ships																		3	2	3	2	(3)	(3)	2	2			2	2			2	2	(2)	(2)					
7. Travel to Japan																																								
N.of person																							4																	

(2)

TENTATIVE TIME SCHEDULE FOR FIELD SURVEY IN SINGAPORE (WATER QUALITY)

Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
8. Packing of Equipments																																								
N.of person																																				4	4	4	4	
9. Travel to Japan																																								
N.of person																																								4

MINUTES OF MEETINGS

FOR

THE STUDY OF ENVIRONMENTAL EFFECTS

OF COAL FIRING POWER STATIONS

AND INTEGRATED STEEL MILL

FEBRUARY 1981

MINUTES OF MEETINGS

FOR

THE STUDY OF ENVIRONMENTAL EFFECTS

OF COAL FIRING POWER STATIONS

AND INTEGRATED STEEL MILL

21ST FEBRUARY 1981

Confirmed by:

YING YOK HANG PRINCIPAL DIRECTOR (TECHNICAL) JURONG TOWN CORPORATION GOVERNMENT OF THE REPULIC OF SINGAPORE	友田正敏 MASATOSHI TOMODA ENVIRONMENTAL PROTECTION GUIDANCE DIVISION INDUSTRIAL LOCATION & ENVIRONMENTAL PROTECTION BUREAU MINISTRY OF INTERNATIONAL TRADE AND INDUSTRY FOR JAPAN INTERNATIONAL COOPERATION AGENCY

Minutes of Meeting

The Japanese Survey Team and the Singapore Counterpart had discussion on the Environmental Effect of the Coal Firing Power Stations and Integrated Steel Mill and the following were mutually agreed upon.

Data of the Proposed Coal Firing Power Stations and the Integrated Steel Mill

(A) Coal Firing Power Station

(i) The Japanese Side worked out a revised set of assumptions on the proposed coal firing power stations.

(ii) After discussion with the Singapore Side which included the P.U.B., the assumptions given in Appendix 'A' were agreed upon.

(iii) These assumptions will supertede those contained in Appendix 'A' of Minutes of Meetings dated 19th December 1980.

(B) Intergrated Steel Mill

(i) The Japanese Side showed a set of draft assumptions on the proposed integrated steel mill, studied and calculated based on the data provided by the Singapore side.

(ii) After discussion with the Singapore Side, which included E.D.B., the assumptions given in Appendix 'B' were agreed upon.

(iii) These assumptions will be adopted for the purpose of the study.

(iv) The location of the stacks and effluent points are as indicated on the plan (Appendix 'C') attached.

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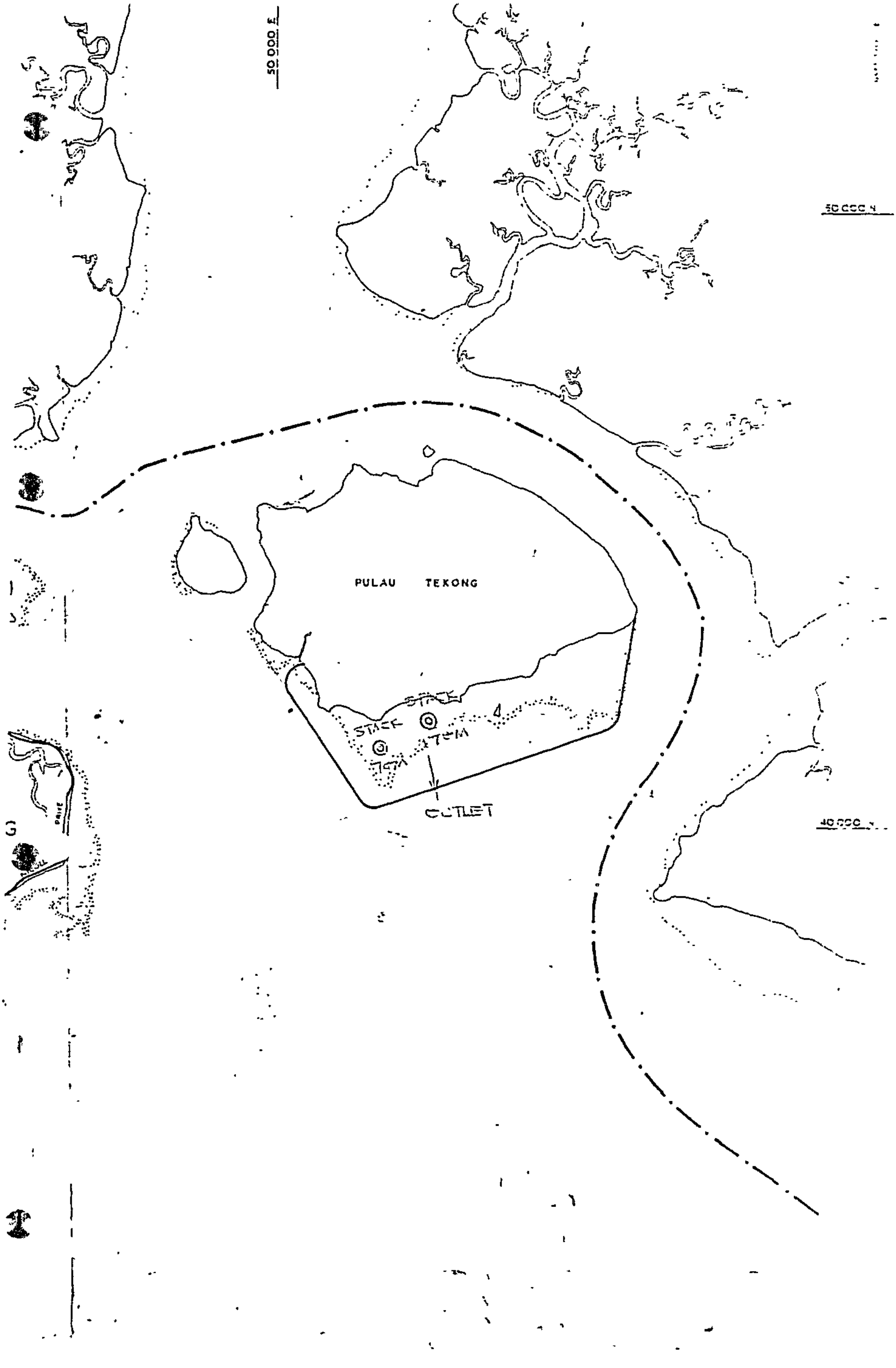
Assumption on Coal Firing Power Stations

Location	P. Seraya	P. Tekong
General Capacity	750 MW (250 MW x 3)	700 MW (350 MW x 2)
Fuel Calorific value Sulfur Consumption	Coal 27 MJ/kg 1% (wt) 1.7 Mt/year	Coal 27 MJ/kg 1% (wt) 1.6 Mt/year
Stack Height Gas Temperature Gas Volume Gas Discharge Velocity	183 m 150°c 2,650,000 Nm^3/h 25 m/s (without flue gas desulfurization)	183 m 150 °c 2,470,000 Nm^3/h 25 m/s (without flue gas desulfurization)
Cooling Sea Water Volume Temperature Difference	110,000 m^3/h 8.3°c	100,000 m^3/h 8.3°c
Effluent Volume (COD) Mn	1,500 m^3/d 50 mg/l	1,500 m^3/d 50 mg/l
	(Boiler air heater washing effluent, after neutralisation & mixing with water treatment plant effluent)	

Assumption on Integrated Steel Mill

Location	Pulau Tekong
Production Process	Grate Kiln and Electric Arc Furnace Steelmaking
Ore Feed	Lump Ore (Fe 62.6%, S 0.018%) 800 x 10^4t/year
Product	Bar and Wire Rod 100 x 10^4t/year Balance (reduced iron) for Export
Reductant	Coal (S 1%wt) Calorific Value 30 MJ/kg Consumption 336 x 10^4t/year (Operation rate 83%)
Fuel	Heavy Oil (S 3%wt) Consumption 431 x 10^3kl/year(Grate Kiln) 357 x 10^2kl/year(Reheating Furnace)
Stack	Grate Kiln Process Gas Volume 5 x 10^6 Nm^3/h Gas Temperature 100°c (without desulfurization of flue gas) SO_2 Volume 3,500 Nm^3/h Gas Discharge Velocity 30 m/s Height 170 m Reheating Furnace Gas Volume 6.3 x 10^4 Nm^3/h Gas Temperature 500°c SO_2 Volume 100 Nm^3/h Gas Discharge Velocity 30 m/s Height 70 m
Effluent	Volume 9,300 m^3/day (10% of total used water) (COD) Mn 7 ppm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PULAU TEKONG
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OUTLET
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THE STUDY OF ENVIRONMENTAL EFFECTS
OF COAL FIRING POWER STATIONS
AND INTEGRATED STEEL MILL

MINUTES OF MEETING

OF

THE PRESENTATION OF DRAFT REPORT

VOLUME 1 - WATER QUALITY

FEBRUARY 1982

MINUTES OF MEETING

The Japanese study team for the Water Quality Survey of the Study of Environmental Effects of Coal Firing Power Stations and Integrated Steel Mill in the Republic of Singapore (Hereinafter referred to as "The Team"), sent by the Japan International Cooperation Agency (Hereinafter referred to as "JICA"), presented to the Singapore authorities a report entitled "DRAFT REPORT ON ENVIRONMENTAL EFFECTS OF COAL FIRING POWER STATIONS AND INTEGRATED STEEL MILL IN THE REPUBLIC OF SINGAPORE VOLUME 1 - WATER QUALITY".

The following is a summary of the meetings and discussions:

1 Schedule of Meetings and Participants

The schedule of meetings and participants are listed in Annexes 1 & 2.

2 Presentation of the Draft Report

2.1 The Team presented the Draft Report which has been prepared based on the objectives, the scope of work, and information described in the following record of discussions:

- Scope of Work dated 19 December 1980
- Minutes of Meeting dated 21 February 1981

The presentation was made by highlighting the features of the study and results.

2.2 The Singapore authorities and the Team exchanged views on the Draft Report.

1 The Singapore authorities expressed satisfaction and appreciation for the dedication, efforts and hard work put in to complete the study.

2 A preliminary review of the Draft Report indicates that the contents of the Report are objective.

4 The Singapore authorities expressed the intention of making questions in order to clarify the contents of the Draft Report, if necessary

- The Team replied to the Singapore authorities that such questions should be made to JICA's office in Singapore by 28 February 1982. The answers will be made in written form outside the final report.

3 Final Report of Volume 1 - Water Quality

The Draft Report of Volume 1 - Water Quality will be considered as final.

The Final Report of Volume 1 - Water Quality will be submitted to the Singapore authorities by the end of Arpil 1982.

YING YOK HANG PRINCIPAL DIRECTOR (TECHNICAL) JURONG TOWN CORPORATION FOR GOVERNMENT OF REPUBLIC OF SINGAPORE	YOICHI SUZUKI LEADER OF THE JAPANESE WATER QUALITY SURVEY TEAM FOR JAPAN INTERNATIONAL CO-OPERATION AGENCY

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ENVIRONMENTAL STUDY
WATER QUALITY SURVEY

Technical Session for The Discussion on The Draft Water Quality Survey Report

Venue: Jurong Town Hall, Singapore

Time: 9.30 am - 12.00 noon

Date: 5 February 1982

Member Lists

Japanese Report Team

Mr Yoichi Suzuki	-	IPCAJ, Leader, Water Quality Survey Team
Mr Kihachi Inagaki	-	IPCAJ, Co-ordinator
Mr Kisaburo Nakata	-	MITI
Mr Masaya Konno	-	MITI

Japanese Embassy

Mr Tokio Katayama	-	1st Secretary, Commercial Attache

Singapore Team

Mr Lim Sak Lan	-	Jurong Town Corporation
Mr Tan Suan Yong	-	Jurong Town Corporation
Mr Hee Ah Mui	-	Jurong Town Corporation
Mr Ng Hwee Choon	-	Jurong Town Corporation
Mr Chiang Kok Meng	-	Ministry of the Environment
Mr Foong Chee Leong	-	Ministry of the Environment
Mr Jasbir Singh	-	Port of Singapore Authority
Mr Yang Keng Num	-	Port of Singapore Authority
Mr Wong Seng Chee	-	Port of Singapore Authority
Mr Joseph Hui	-	Anti-Pollution Unit
Dr Tay Joo Hwa	-	National University of Singapore
Dr Ng Wun Jern	-	National University of Singapore

Annex 1

ENVIRONMENTAL STUDY
WATER QUALITY SURVEY

Presentation of Draft Report

Venue: VIP Lounge, Jurong Town Hall, Singapore

Time: 9.00 am - 10.00 am

Date: 4 February 1982

Member Lists

Japanese Report Team

Mr Yoichi Suzuki	-	IPCAJ, Leader, Water Quality Survey Team
Mr Kihachi Inagaki	-	IPCAJ, Co-ordinator
Mr Kisaburo Nakata	-	MITI
Mr Masaya Konno	-	MITI

Singapore Counterpart (JTC)

Mr Tang I Fang	-	Chairman
Mr Francis Mak	-	General Manager
Mr Ying Yok Hang	-	Principal Director (Technical)
Mr Lim Sak Lan	-	Senior Director (SME)
Mr Tan Suan Yong	-	Senior Principal Civil Engineer
Mr Hee Ah Mui	-	Senior Civil Engineer

JICA