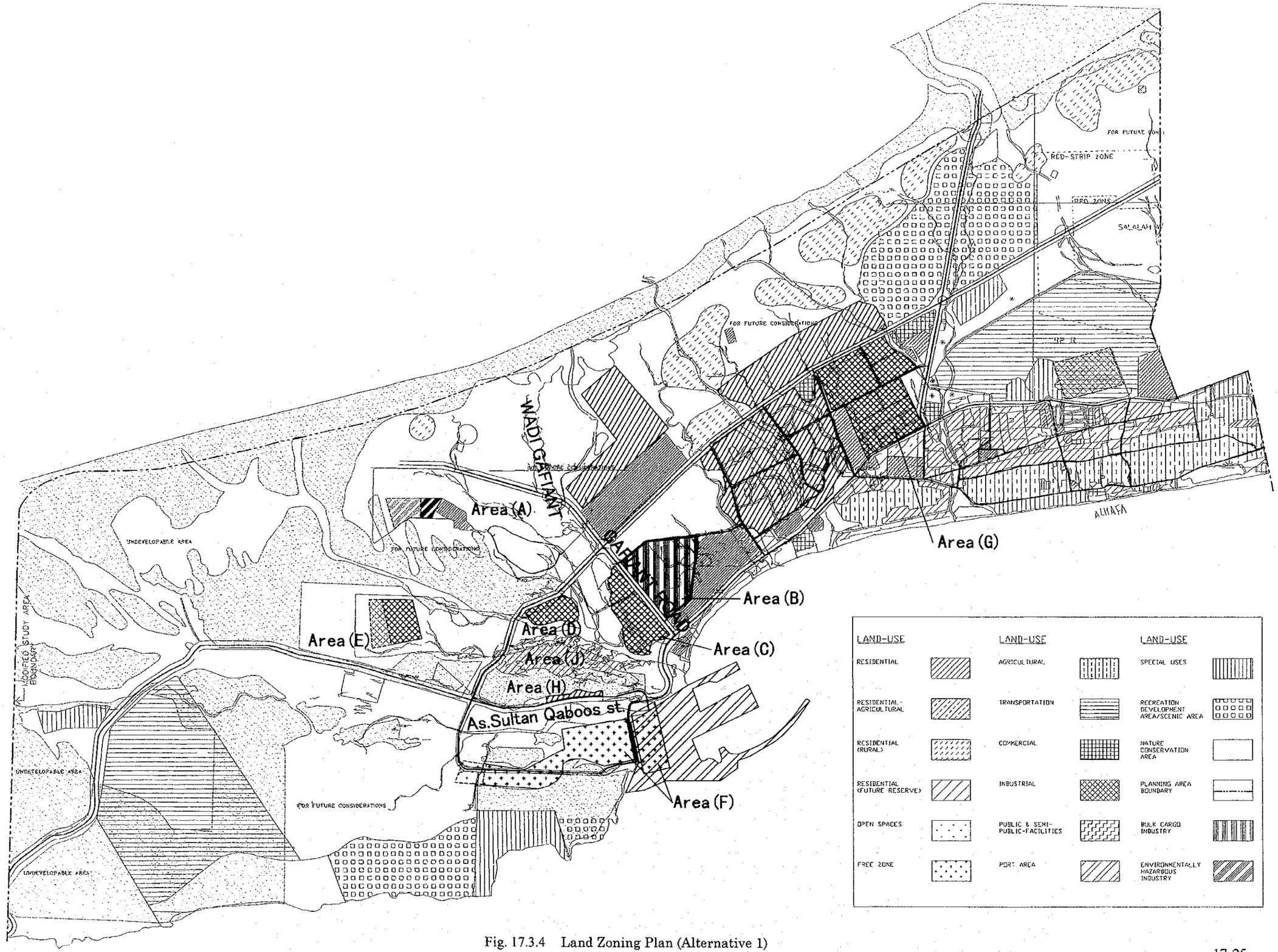


Fig. 17.3.4 Land Zoning Plan (Alternative 1)

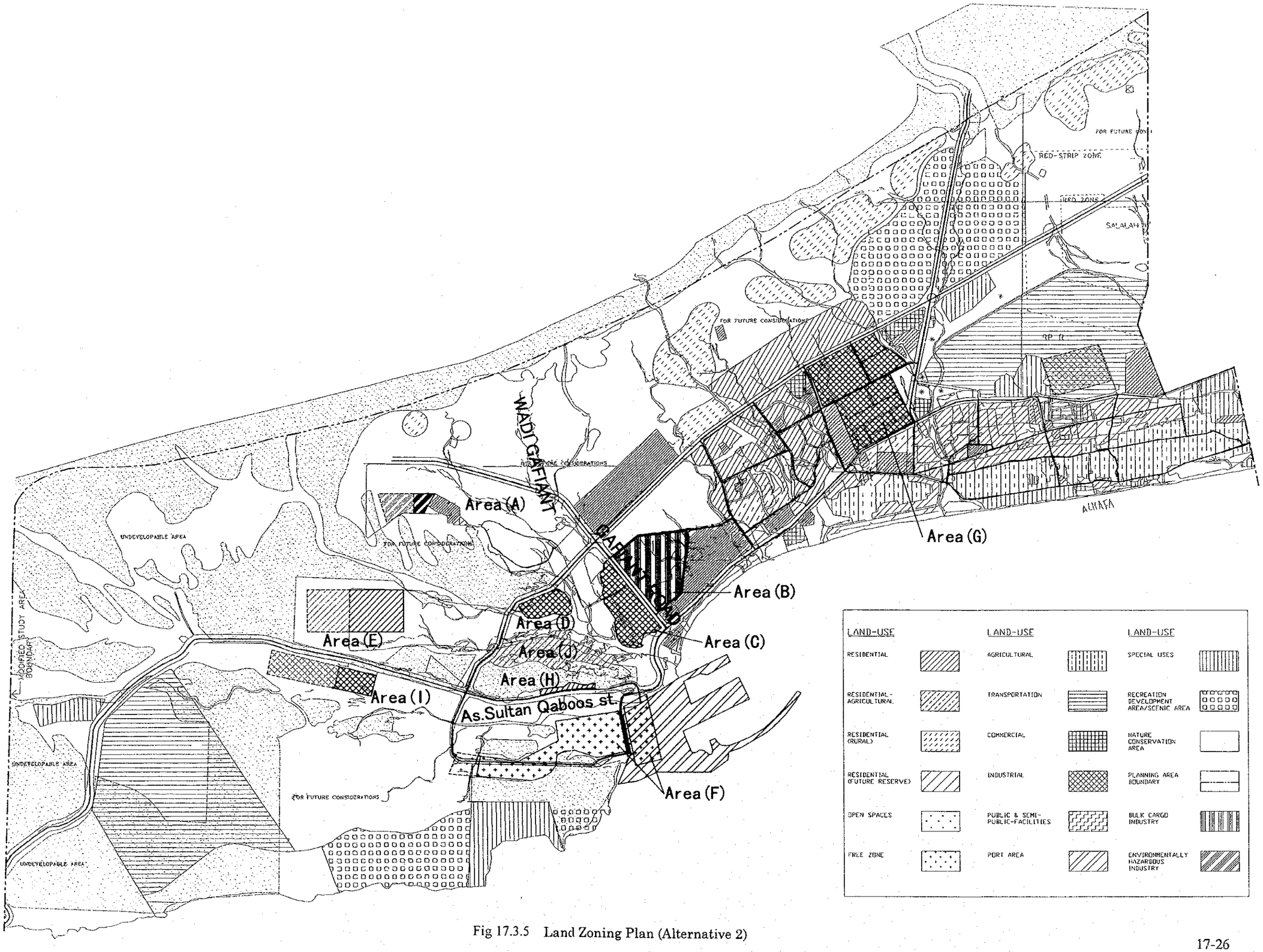
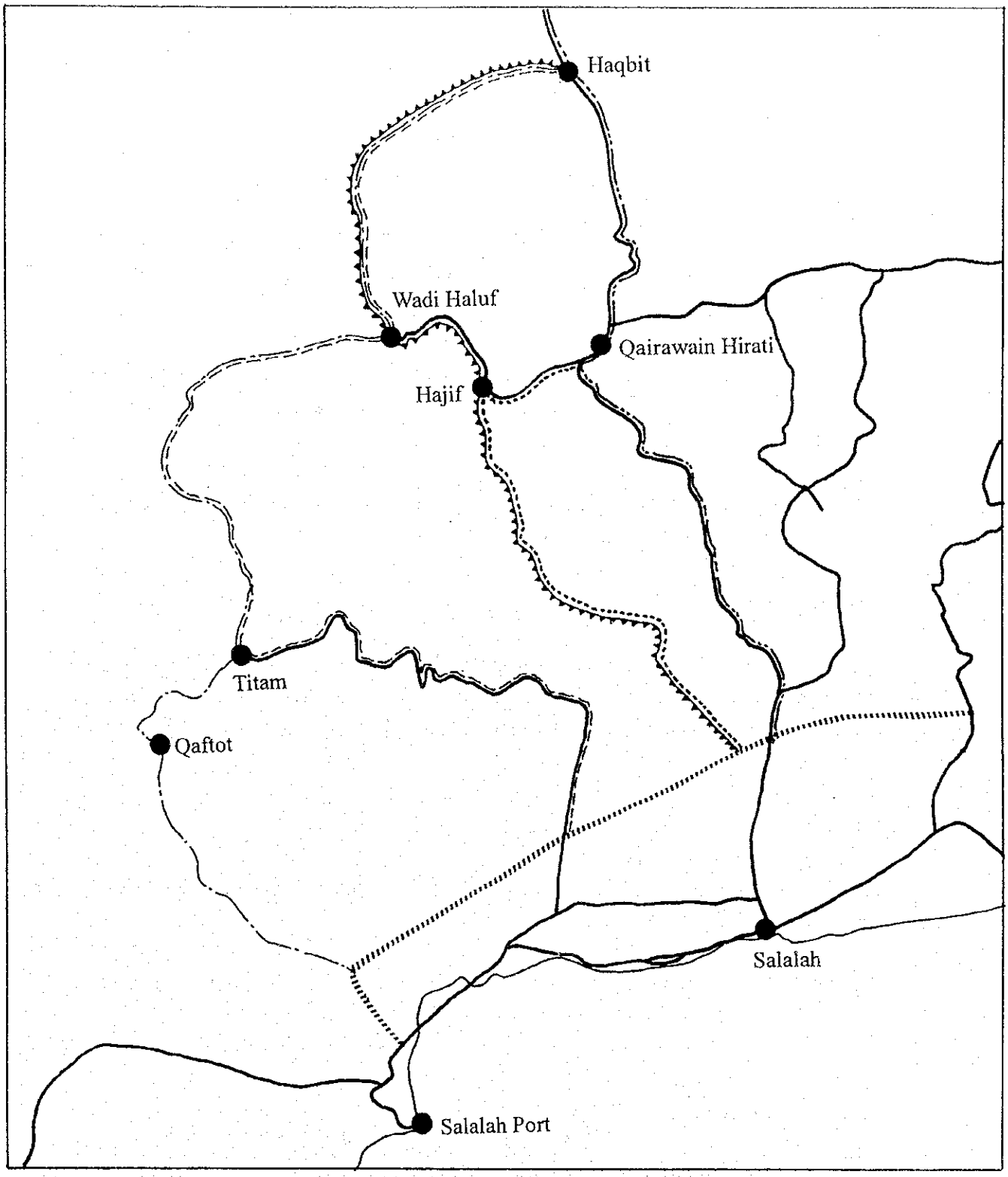


Fig 17.3.5 Land Zoning Plan (Alternative 2)



The Salalah round road with linth of 32 Km

Salalah Port / Round road / Qaftot / Titam /Haluf Masihaila / Haqbit Junction with Salalah Thumrait Rd by lenth of 78 Km.

Salalah Port / Round road / Ittin / Titam /Haluf Masihaila / Haqbit Junction with Salalah Thumrait Rd by lenth of 91.5 Km.

Salalah Port / Round road / Assir / Hajif /Haluf Masihaila / Haqbit Junction with Salalah Thumrait Rd by lenth of 81.5 Km.

Salalah Port / Round road / Assir / Hajif / Aryaff Junction (Qairawain) with Salalah Thumrait Rd by lenth of 60 Km.

Salalah Port / Round road / Salalah Thumrait Rd / Hamrir Damp / Qairawain Hirati / Thumrait by lenth of 95 Km.

Main paved roads existing in DHOFAR.

Fig 17.3.6 Road Network Plan

17.4 Expansion Needs of Industrial Infrastructure

17.4.1 Past Trend of Utility Consumption, and Infrastructure Development

This paragraph analyzes, prior to the estimate for infrastructure requirement made in 17.4.2, the past growth trend of infrastructures, basically in relation to that of GDP in Dhofar region.

In the following analysis, the growth rates of GRDP in Dhofar region in past are assumed identical to those of the national level (or "GDP"), since no reliable GRDP data are available.

Past ratios of infrastructure supplies to GDP are analyzed in 17.4.1. The analysis results are employed in the forecast made in 17.4.2.

A) Electric Power

Demand for electric power has been increased with a high correlation coefficient to GDP at 1988 constant prices. Table 17.4.1 shows growth in the power demand and GDP. It indicates that one percent growth of the GDP results in 1.24 percent increase of demand for electric power.

B) Water

Past demand for water is indicated in Table 17.4.2. The demand has increased with a high correlation to GDP.

An analysis of growth of the demand in relation to that of GDP has shown that one percent growth of GDP results in 0.932 percent increase of demand for water.

C) Telecommunications

Installed number of telephone lines in comparison to growth of GDP is indicated in Table 17.4.3. It exhibits increase of the line number with a high correlation to GDP growth.

Our analysis of it in relation to GDP growth shows that one percent growth of GDP results in 1.178 percent increase of installed telephone line quantity.

D) Natural Gas

Since there has not been consumption of natural gas in Dhofar region, it may not be reasonable to estimate future demand through the scenario on the GDP trend.

Table 17.4.4 refers to an estimated consumption of natural gas for Salalah that has been estimated by the Ministry of Oil and Gas. This report takes that as the estimate for the future demand, as the Middle Case (See paragraph 17.4.2 D).

E) Land for Industrial Use

According to the past trend of land use for industries in Oman in 1993 and 1997, one percent growth of GDP results in 1.66% increase in use of land for industries.

17.4.2 Expansion Needs Forecast

With the estimated correlations between utilities demand and GDP, as analyzed in 17.4.1, the future needs of supply capacities of utilities and land development for industrial use is forecast on the basis of the projection of local production and export in Salalah, which are shown in Tables 12.2.5 through 12.2.11.

Table 17.4.5 shows forecast demand for the infrastructures obtained in accordance with the said GRDP scenario.

A) Electric Power

Power generation capacity, as discussed in 17.4.1, has made a step-wise increase to cover the demand since 1974, in maintaining proper level of capacity for assuring stable supply/demand balance. It is evidently reasonable that this strategy of new plant installation is to be followed for the future growth of demand. The new 200 MW power plant project referred in paragraph 17.4.1 is counted in the existing generation capacity.

Forecast of the power demand to the scenarios refers to Table 17.4.6.

B) Water

With the knowledge about the recharge deficit, and subsequent declining ground water table and saline water intrusion, this report has assumed that a ten (10) percent increase from the present demand, or 269 million gallon, requires installation of water desalination plant. It is evaluated that water desalination plant should be constructed for all the "With" cases.

Forecast of the water demand to the scenarios refers to Table 17.4.7.

C) Telecommunications

Taking the condition that the Raysut Station can be extended to the three (3) times capacity or 1,870 lines, it is estimated to cover all the cases. An installation of new station is expected at some appropriate time after 2010.

D) Natural Gas

The forecast apparently includes the first largest demand for the new power station in April 2002. The said new on may be discussed upon defining the industries in the Hinterland to power station is expected to use natural gas while it replaces a part of the existing power

plants that are now using gas oil. Therefore, it is not needed to consider natural gas supply facility other than the said project.

E) Land for Industrial Use

The estimation has been made on a basis of area requirement due to estimated outputs.

The existing spare area of Raysut Industrial Estate will be used for "Without" cases. Therefore, this report evaluates that the forecast demand for the land are to be met with newly constructed estate(s).

Table 17.4.8 estimates the investment costs requirement for the industrial land preparation including public building construction and other site works.

Table 17.4.1 Electric Power Consumption in Dhofar Region for GDP

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Growth 1988/1998	Correlation coeff. with Power Consumption
GDP at 1988 Constant Prices (Million R.O.)	3,320.7	3,599.0	3,816.3	4,140.5	4,394.9	4,563.9	4,784.3	4,922.8	5,226.9	5,380.7	1.620	**0.985**
GDP Current Price (Million R.O.)	3,603.6	4,493.0	4,360.8	4,787.8	4,803.6	4,967.3	5,307.2	5,874.3	6,089.5	5,445.3	1.511	0.875
Electric Power Consumption, Dhofar (Million kWh)	334	399	412	444	494	511	547	542	608	673	2.015	
Ratio of Power Consumption to GDP at 1988 Constant Prices											**1.244**	

Source: Statistical Year Book

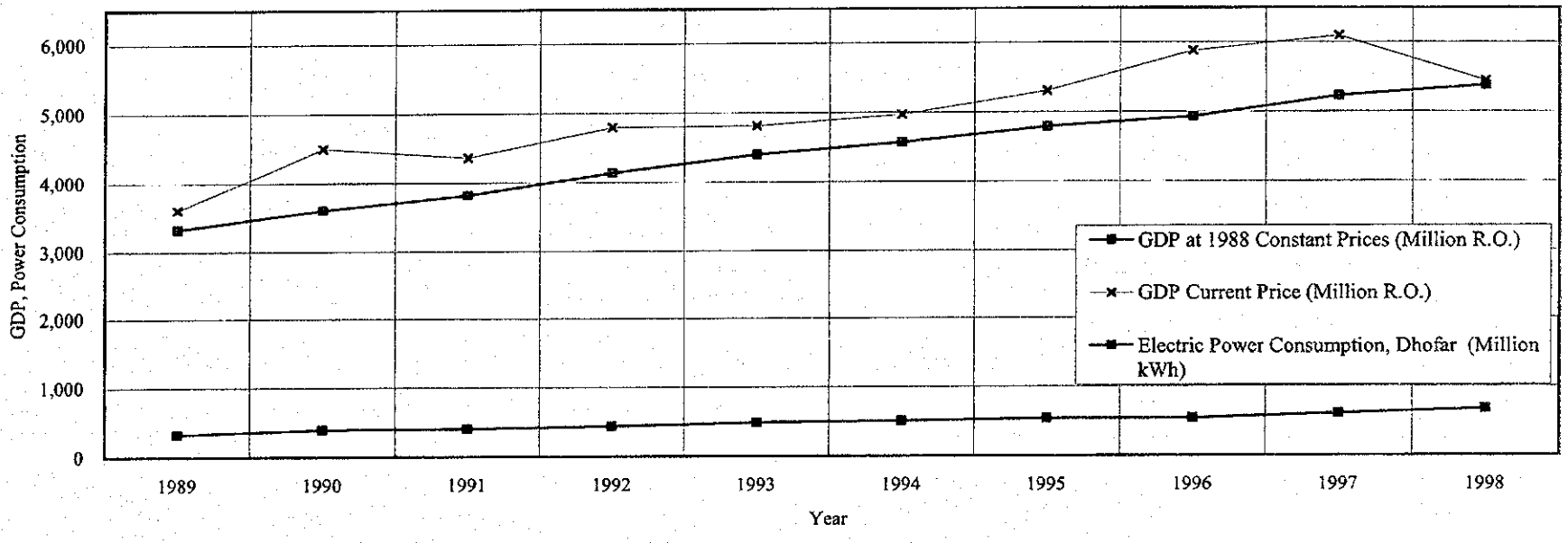


Table 17.4.2 Water Consumption in Dhofar Region for GDP

	1995	1996	1997	1998	Growth 1995/1998	Correlation coeff. with Water Consumption
GDP at 1988 Constant Prices (Million R.O.)	4,784.3	4,922.8	5,226.9	5,380.7	1.125	**0.631**
GDP Current Price (Million R.O.)	5,307.2	5,874.3	6,089.5	5,445.3	1.026	-0.519
Water Consumption (Million gallon)	2,563.3	2,563.3	2,542.1	2,687.3	1.048	
Ratio of Water Consumption to GDP at 1988 Constant Prices					**0.932**	

Source: Statistical Year Book

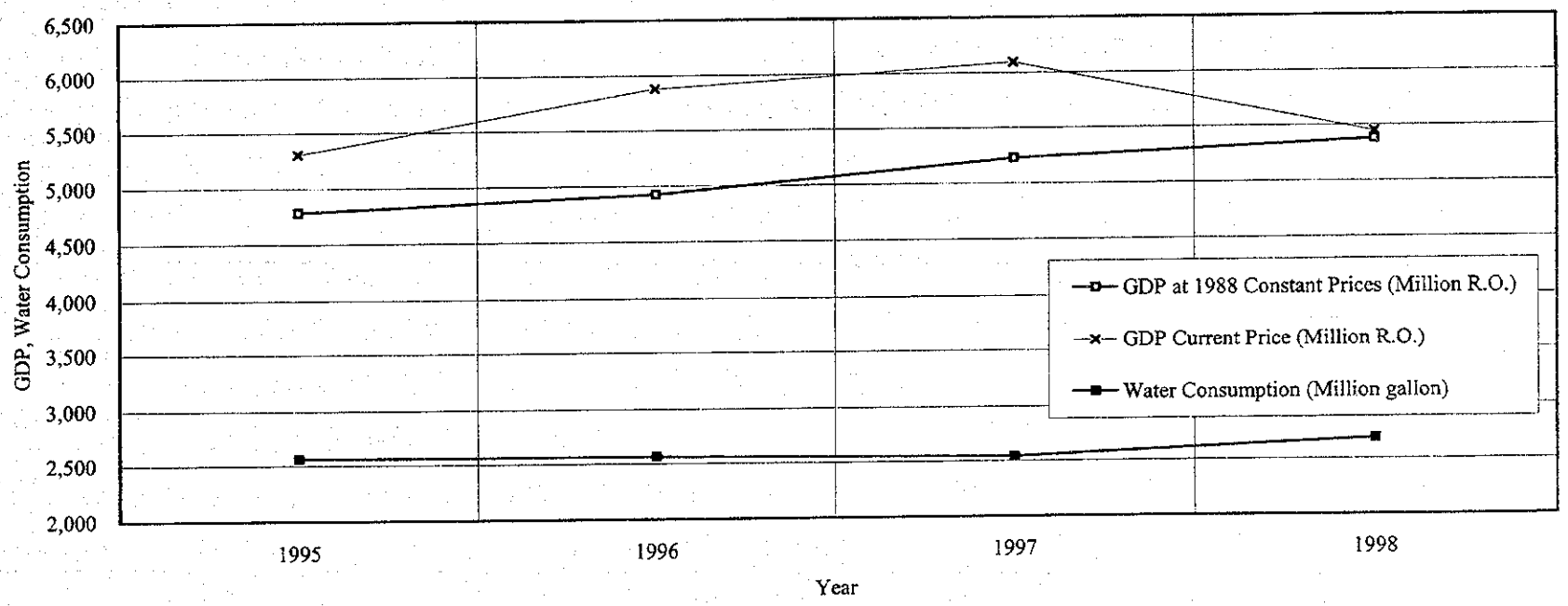


Table 17.4.3 Number of Telephone Lines in Dhofar Region for GDP

	1993	1994	1995	1996	1997	1998	Growth 1993/1998	Correlation coeff. with Tel. Lines Number
GDP at 1988 Constant Prices (Million R.O.)	4,394.9	4,563.9	4,784.3	4,922.8	5,226.9	5,380.7	1.224	**0.988**
GDP Current Price (Million R.O.)	4,803.6	4,967.3	5,307.2	5,874.3	6,089.5	5,445.3	1.134	0.715
Number of Telephone Lines (-)	12,066	12,483	13,836	14,943	15,835	17,409	1.443	
Ratio of Telephone Lines Number to GDP at 1988 Constant Prices							**1.178**	

Source: Statistical Year Book

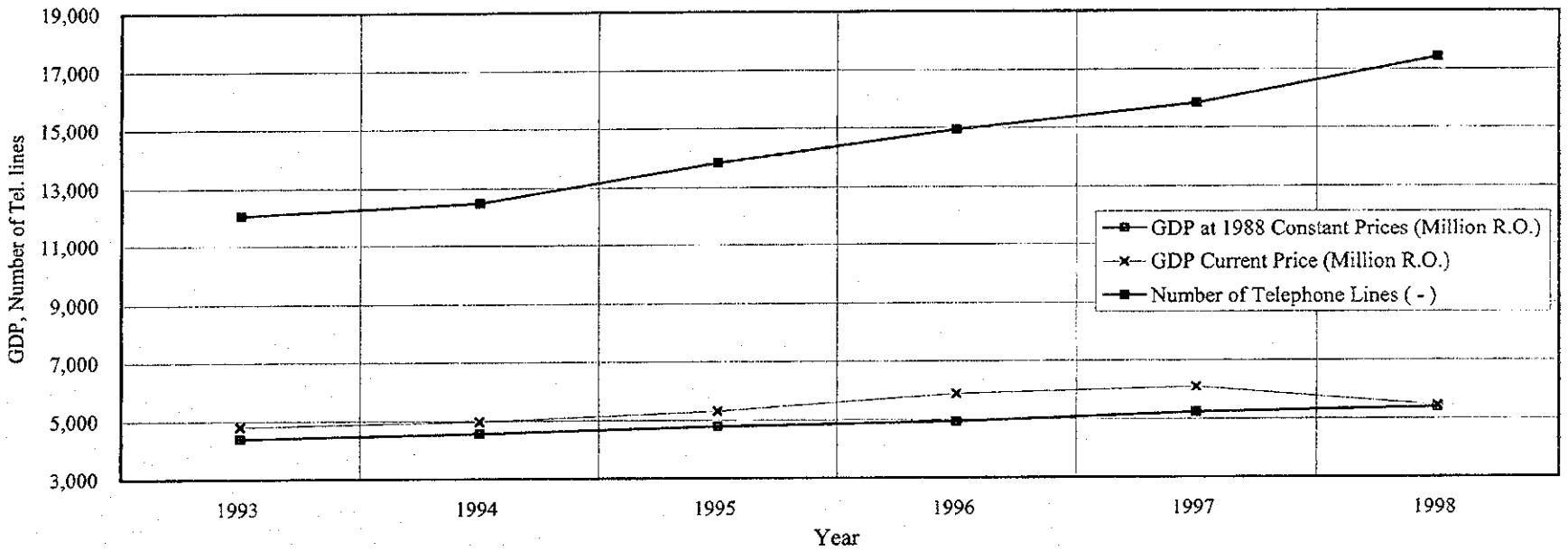


Table 17.4.4 Salalah Gas Demand Forecast (2000-2024)

(Unit: million standard cubic meter/day)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Salalah Power Station	0.000	0.000	0.940	0.980	1.030	1.070	1.115	1.170	1.229	1.278	1.329	1.381	1.438	1.494	1.539	1.586	1.633	1.682	1.733	1.784	1.838	1.899	1.961	2.026	2.093
Salalah Desalination	0.000	0.000	0.000	0.130	0.270	0.290	0.312	0.336	0.362	0.390	0.420	0.452	0.485	0.525	0.525	0.525	0.525	0.525	0.525	0.525	0.525	0.851	0.868	0.885	0.903
Raysut Cement	0.000	0.000	0.180	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360
Raysut IE	0.000	0.000	0.635	0.128	0.129	0.131	0.132	0.133	0.135	0.136	0.137	0.139	0.140	0.142	0.143	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144
Total Salalah	0.000	0.000	1.755	1.598	1.789	1.851	1.919	1.999	2.086	2.164	2.246	2.332	2.423	2.521	2.567	2.615	2.662	2.711	2.762	2.813	2.867	3.254	3.333	3.415	3.500

Source: Ministry of Oil and Gas

Table 17.4.5 Estimates for Infrastructures in Dhofar Region

Infrastructure	Case	Year	Unit	Demand in 1998	Estimated Demand	Unit	Estimated Demand as Plant	Supply Capacity in 1998	Calculated Additional Supply Capacity	Required Investment Cost (Mn. R.O.)			Maintenace Cost Mn. R.O./yr L only
										F	L	F+L	
Electric Power [1), 2)]	-	-	GWh	673.0		MW	76.8	266.0 MW	-				
1) The Supply Capacity in 1998 will be expanded to 166+20+230-150 = 266 MW in and after Apr. 2002 (ref. to para. 5.1.1). This increment is deducted at the estimation of the Additional Capacity.	With	S1	GWh[3)]		634.7	MW	72.5		149.3 MW			0	
		S2	GWh		883.4	MW	100.8		177.7 MW			0	
	Without	2003	GWh		56.8	MW	6.5		83.3 MW			0	
		2010	GWh		103.6	MW	11.8		88.7 MW			0	
2) The Estimated Additional Capacity is calculated assuming 24 hours operation for 365 days a year, in maintaining the same capacity utilization ratio as 1998 or 49.3% (ref. to Table 5.1.1). Due to the existing capacity allowance, a small addotional capacity is not counted in.		2020	GWh		162.0	MW	18.5		95.3 MW			0	
3) GWh = million kWh = thousand MWh													
Water [1)]	-	-	Mn. Gallon	2,687.3				2,740.9 Mn. Gallon	-				
1) For all of "With" cases, the estimated demand is higher than 10 % increase from the demand in 1998, 2,687.3 x 1.10 = 2,956 million gallon. Therefore, additional demand is to be supplied through desalinated water.	With	S1	Mn. Gallon		1,008.6	Mn. Gallon/d	2.8		5.5 Mn. Gallon/d	13.0	52.0	65.1	2.6
		S2	Mn. Gallon		1,398.4	Mn. Gallon/d	3.8		6.5 Mn. Gallon/d	14.7	59.0	73.7	2.9
	Without	2003	Mn. Gallon		83.6	Mn. Gallon/d	0.2		0.0 Mn. Gallon/d			0.0	
		2010	Mn. Gallon		153.5	Mn. Gallon/d	0.4		0.0 Mn. Gallon/d			0.0	
		2020	Mn. Gallon		235.8	Mn. Gallon/d	0.6		0.0 Mn. Gallon/d			0.0	

Legends L:local currency portion
F:foreign currency portion

Table 17.4.6 Electric Power Demand

	Production	Market	With, Scenario 1				With, Scenario 2			
			Output	Output	Pwr/GO	Power	Output	Output	Pwr/GO	Power
			Ton	('000RO)	(kWh/R.O.)	('000 kWh)	Ton	('000RO)	(kWh/R.O.)	('000 kWh)
Live animal & agricultural produce	NL	E	16,360	5,585	0.66	3,701	52,928	18,618	0.66	12,337
Food industry(general processing)	NL	E	52,025	17,459	0.66	11,569	191,142	57,815	0.66	38,311
Mineral products(General)	NL	E	462,654	40,028	2.01	80,472	962,445	84,509	2.01	169,898
Textiles and articles	NL	E	56,568	67,395	0.35	23,888	90,672	110,030	0.35	39,000
Textiles and articles	NL	E	6,600	26,700	0.35	9,464	6,600	26,700	0.35	9,464
Other industrial products, incl. Chemicals, plastic	NL	E	128,748	110,516	0.28	30,751	307,354	298,324	0.28	83,008
Other industrial products, incl. Chemicals, plastic	NL	E	7,200	11,800	0.28	3,283	7,200	11,800	0.28	3,283
Machinery, electrical, transp incl. Parts	NL	E	47,605	283,133	0.18	49,625	105,547	605,545	0.18	106,135
Machinery, electrical, transp incl. Parts	NL	E	12,250	33,500	0.18	5,872	12,250	33,500	0.18	5,872
Total(AA)			790,010	596,116		218,625	1,736,137	1,246,842		467,309
Food industry(general processing)	L	L	11,500	11,500	0.66	7,621	11,500	11,500	0.66	7,621
Mineral products(General)	L	L	13,000	12,100	2.01	24,326	13,000	12,100	2.01	24,326
Other industrial products, incl. Chemicals, plastic	L	L	17,800	14,800	0.28	4,118	17,800	14,800	0.28	4,118
Food industry(general processing)	L	E	5,100	5,100	0.66	3,380	5,100	5,100	0.66	3,380
Food industry(fish processing)	L	E	84,000	35,300	0.66	23,392	84,000	35,300	0.66	23,392
Mineral products(General)	L	E	32,500	30,000	2.01	60,312	32,500	30,000	2.01	60,312
Textiles and articles	L	E	25,600	77,800	0.35	27,576	25,600	77,800	0.35	27,576
Other industrial products, incl. Chemicals, plastic	L	E	18,600	18,200	0.28	5,064	18,600	18,200	0.28	5,064
Machinery, electrical, transp incl. Parts	L	E	3,550	11,000	0.18	1,928	3,550	11,000	0.18	1,928
Total(AA)			211,650	215,800		157,716	211,650	215,800		157,716
Food industry(Cereals/Oil)	L	E	667,000	171,500	0.66	113,646	667,000	171,500	0.66	113,646
Food industry(Cereals/Oil)	L	L	165,600	53,000	0.66	35,121	165,600	53,000	0.66	35,121
Total(AA)			832,600	224,500		148,767	832,600	224,500		148,767
Mineral products(Cement/Gypsum,etc)	L/OS	L	600,000	15,600	2.01	31,362	600,000	15,600	2.01	31,362
Mineral products(Cement/Gypsum,etc)	L/OS	E	1,460,000	21,000	2.01	42,218	1,460,000	21,000	2.01	42,218
Live animal & agricultural produce	L/OS	L	153,000	51,900	0.66	34,392	153,000	51,900	0.66	34,392
Live animal & agricultural produce	L/OS	E	7,100	2,400	0.66	1,590	7,100	2,400	0.66	1,590
Total (BB)			2,220,100	90,900		109,563	2,220,100	90,900		109,563
Grand Total						634,671				883,355
as 24 hrs for 365ds/yr operation					=MW	72.5			=MW	100.8

Table 17.4.7 Water Demand

	Production	Market	With, Scenario 1				With, Scenario 2			
			Output	Output	Water/GO	Water	Output	Output	Water/GO	Water
			Ton	('000RO)	(Gallon/R.O.)	('000 Gallon)	Ton	('000RO)	(Gallon/R.O.)	('000 Gallon)
Live animal & agricultural produce	NL	E	16,360	5,585	1.26	7,012	52,928	18,618	1.26	23,374
Food industry(general processing)	NL	E	52,025	17,459	1.26	21,919	191,142	57,815	1.26	72,583
Mineral products(General)	NL	E	462,654	40,028	2.27	90,664	962,445	84,509	2.27	191,417
Textiles and articles	NL	E	56,568	67,395	0.64	43,081	90,672	110,030	0.64	70,335
Textiles and articles	NL	E	6,600	26,700	0.64	17,067	6,600	26,700	0.64	17,067
Other industrial products, incl. Chemicals, plastic	NL	E	128,748	110,516	0.34	37,969	307,354	298,324	0.34	102,492
Other industrial products, incl. Chemicals, plastic	NL	E	7,200	11,800	0.34	4,054	7,200	11,800	0.34	4,054
Machinery, electrical, transp incl. Parts	NL	E	47,605	283,133	0.40	114,379	105,547	605,545	0.40	244,626
Machinery, electrical, transp incl. Parts	NL	E	12,250	33,500	0.40	13,533	12,250	33,500	0.40	13,533
Total(AA)			790,010	596,116		349,678	1,736,137	1,246,842		739,481
Food industry(general processing)	L	L	11,500	11,500	1.26	14,438	11,500	11,500	1.26	14,438
Mineral products(General)	L	L	13,000	12,100	2.27	27,407	13,000	12,100	2.27	27,407
Other industrial products, incl. Chemicals, plastic	L	L	17,800	14,800	0.34	5,085	17,800	14,800	0.34	5,085
Food industry(general processing)	L	E	5,100	5,100	1.26	6,403	5,100	5,100	1.26	6,403
Food industry(fish processing)	L	E	84,000	35,300	1.26	44,317	84,000	35,300	1.26	44,317
Mineral products(General)	L	E	32,500	30,000	2.27	67,951	32,500	30,000	2.27	67,951
Textiles and articles	L	E	25,600	77,800	0.64	49,732	25,600	77,800	0.64	49,732
Other industrial products, incl. Chemicals, plastic	L	E	18,600	18,200	0.34	6,253	18,600	18,200	0.34	6,253
Machinery, electrical, transp incl. Parts	L	E	3,550	11,000	0.40	4,444	3,550	11,000	0.40	4,444
Total(AA)			211,650	215,800		226,029	211,650	215,800		226,029
Food industry(Cereals/Oil)	L	E	667,000	171,500	1.26	215,308	667,000	171,500	1.26	215,308
Food industry(Cereals/Oil)	L	L	165,600	53,000	1.26	66,538	165,600	53,000	1.26	66,538
Total(AA)			832,600	224,500		281,846	832,600	224,500		281,846
Mineral products(Cement/Gypsum,etc)	L/OS	L	600,000	15,600	2.27	35,335	600,000	15,600	2.27	35,335
Mineral products(Cement/Gypsum,etc)	L/OS	E	1,460,000	21,000	2.27	47,566	1,460,000	21,000	2.27	47,566
Live animal & agricultural produce	L/OS	L	153,000	51,900	1.26	65,157	153,000	51,900	1.26	65,157
Live animal & agricultural produce	L/OS	E	7,100	2,400	1.26	3,013	7,100	2,400	1.26	3,013
Total (BB)			2,220,100	90,900		151,071	2,220,100	90,900		151,071
Grand Total			1,834,260			1,008,624	2,780,387			1,398,427

Table 17.4.8 Estimated Costs for Industrial Land Preparation

	Without Year 2003				Without Year 2010				Without Year 2020				With Forecasting Scenario (1) Year 2020				With Forecasting Scenario (2) Year 2020			
	Additional Area ha	Cost F+L Mn RO	Cost Foreign Mn RO	Cost Local Mn RO	Additional Area ha	Cost F+L Mn RO	Cost Foreign Mn RO	Cost Local Mn RO	Additional Area ha	Cost F+L Mn RO	Cost Foreign Mn RO	Cost Local Mn RO	Additional Area ha	Cost F+L Mn RO	Cost Foreign Mn RO	Cost Local Mn RO	Additional Area ha	Cost F+L Mn RO	Cost Foreign Mn RO	Cost Local Mn RO
Infra and Site works																				
site works	367.1	1.95	0.10	1.85	48.8	0.26	0.01	0.25	29.3	0.16	0.01	0.15	739.0	3.92	0.20	3.72	1,387.8	7.36	0.37	6.99
roads	367.1	1.95	0.00	1.95	48.8	0.26	0.00	0.26	29.3	0.16	0.00	0.16	739.0	3.92	0.00	3.92	1,387.8	7.36	0.00	7.36
water supply	367.1	0.92	0.46	0.46	48.8	0.12	0.06	0.06	29.3	0.07	0.04	0.04	739.0	1.85	0.93	0.93	1,387.8	3.48	1.74	1.74
sewages	367.1	3.19	0.64	2.55	48.8	0.42	0.08	0.34	29.3	0.25	0.05	0.20	739.0	6.41	1.28	5.13	1,387.8	12.04	2.41	9.64
storm drain	367.1	1.03	0.21	0.82	48.8	0.14	0.03	0.11	29.3	0.08	0.02	0.07	739.0	2.07	0.41	1.65	1,387.8	3.88	0.78	3.10
solid waste	367.1	0.14	0.01	0.13	48.8	0.02	0.00	0.02	29.3	0.01	0.00	0.01	739.0	0.29	0.01	0.27	1,387.8	0.54	0.03	0.51
land scaping & irrigation	367.1	0.53	0.03	0.50	48.8	0.07	0.00	0.07	29.3	0.04	0.00	0.04	739.0	1.07	0.05	1.02	1,387.8	2.01	0.10	1.91
power supply	367.1	3.65	2.73	0.91	48.8	0.48	0.36	0.12	29.3	0.29	0.22	0.07	739.0	7.34	5.51	1.84	1,387.8	13.78	10.34	3.45
telecommunications	367.1	0.35	0.26	0.09	48.8	0.05	0.03	0.01	29.3	0.03	0.02	0.01	739.0	0.70	0.52	0.17	1,387.8	1.31	0.98	0.33
Buildings																				
Administrtion	367.1	2.02	0.40	1.61	48.8	0.21	0.04	0.17	29.3	0.16	0.03	0.13	739.0	4.06	0.81	3.25	1,387.8	7.63	1.53	6.10
Advancing factory building	367.1	15.26	3.05	12.21	48.8	1.62	0.32	1.30	29.3	1.22	0.24	0.97	739.0	30.72	6.14	24.57	1,387.8	57.68	11.54	46.14
Off site works																				
roads	367.1	0.21	0.00	0.21	48.8	0.02	0.00	0.02	29.3	0.02	0.00	0.02	739.0	0.43	0.00	0.43	1,387.8	0.80	0.00	0.80
water supply	367.1	0.14	0.11	0.04	48.8	0.02	0.01	0.00	29.3	0.01	0.01	0.00	739.0	0.29	0.21	0.07	1,387.8	0.54	0.40	0.13
stormwater drainage	367.1	0.11	0.01	0.10	48.8	0.01	0.00	0.01	29.3	0.01	0.00	0.01	739.0	0.21	0.02	0.19	1,387.8	0.40	0.04	0.36
power supply	367.1	1.24	0.93	0.31	48.8	0.13	0.10	0.03	29.3	0.10	0.07	0.02	739.0	2.49	1.87	0.62	1,387.8	4.68	3.51	1.17
Total		32.66	8.93	23.74		3.84	1.07	2.77		2.60	0.71	1.89		65.76	17.98	47.79		123.60	33.76	89.74
Contingency		4.90	1.34	3.56		0.58	0.16	0.42		0.39	0.11	0.28		9.86	2.70	7.17		18.52	5.06	13.46
Total		37.56	10.27	27.30		4.41	1.23	3.19		3.00	0.82	2.18		75.63	20.67	54.96		142.02	38.82	103.20
Escalation Foreign Currency		0.00	1.54	0.00		0.00	0.18	0.00		0.00	0.12	0.00		0.00	3.10	0.00		0.00	5.82	0.00
Local Currency		0.00	0.00	0.27		0.00	0.00	0.03		0.00	0.00	0.02		0.00	0.00	0.55		0.00	0.00	1.03
Investment Cost		39.38	11.81	27.57		4.63	1.41	3.22		3.14	0.94	2.20		79.28	23.77	55.50		148.88	44.65	104.23

17.5 Economics of the Hinterland Development

17.5.1 Economic Impacts of the Hinterland Development

The detail of development is impossible to predict at present, since there is no information available about responses from potential investors on the development. Any projections can provide only outline of the possible direction with various assumptions. The economic impacts estimated in the following paragraphs are also based on assumptions that the market penetration by Salalah will be undertaken as projected with the necessary conditions being fulfilled, and that the local production will be carried out in the industrial areas as projected.

The major impacts expected from the development in view of national economy, or Dhofar economy will be:

1) Contribution to increase in GDP
2) Earning or saving of foreign exchange
3) Job creation

Table 17.5.1 summarizes the estimated economic impacts of the industrial development in the hinterland of Salalah Port, which was described in 17.1. The impacts are estimated in terms of difference in contribution compared to that of Case-without.

The contribution to GDP increase is expected to be 700 million R.O. in 2010, and 1,100 million R.O. in 2020 in the case of Projection Scenario (1). The increase accounts for 1.5 and 2.4 times of estimated GRDP in Salalah in 1998 respectively (for detail, see 4.1). The major source of increase will be trade and distribution related industries (or total of commerce, redistribution, and transportation & communication), which accounts for almost 60% of total increase. Next largest contribution comes from "other sector", which represents the infrastructure and public service sectors including electricity, construction, finance, and public administration, accounting for 34% of total in 2010, and 32% in 2020.

The contribution to job creation is also conspicuous. It will create an additional job for 21,650 persons in 2010, and 27,800 persons in 2020 (Scenario 1), compared to 52,700 persons of estimated workers in Salalah in 1995[1]. The largest contribution is expected from "other sectors", followed by the trade and distribution sector and manufacturing sector.

The contribution to foreign exchange earning will be 150million R.O. in 2010 and 250million R.O. in 2020. The largest contributing sector is the trade related sector, accounting for 62% of total in 2010, and 53% in 2020. It is followed by the manufacturing sector with contribution 33% in 2010, and 41% in 2020.

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[1] Source: Phase 5 Final Structure Plan, Revision of Salalah Structure Plan.

Tables 17.5.2 through 17.5.11 shows the detail by industry/ sector.

17.5.2 Economic Evaluation of the Impact

Following evaluates the economic impacts from the stand point of Dhofar economy, in view of cost-benefit.

The expected direct benefit from the development is the revenue from operation of relevant facilities, infrastructure, and services. However, so far no facility, infrastructure, and services has defined yet, which will be provided the locators in the hinterland. The estimates on these revenues based on various assumptions, will exceed the tolerable margin of error, resulting evaluation unreliable.

On the other hand, the costs should include the investment on infrastructure, and operation costs of the facilities, infrastructure and services. Again, particularly, the operation costs are also difficult to define at this moment.

Thus, the evaluation here compares the contribution of development to increase in GRDP, with the required investment.

Tables 17.5.12 and 17.5.13 estimate the costs and benefits related to the development. The expected benefit is not only due to the establishment of Free Zone, and provision of industrial land, but also due to development and operation of Salalah port. Thus, the costs should include a part of investment on the port development. The estimate includes a part of invested costs on port development in proportional to the cargo volume generated from the industrial development out of total cargo throughput.

The benefits are expressed in terms of value added generated from industrial sectors as well as the supporting/ relevant economic activities.

The tables also compare the costs in foreign currency portion and benefits to be transferred to foreign investors. All the benefits under the category of foreign portion will not necessarily go out of the country, to be precise. Out of the benefits, foreign portion should include those transmitted to overseas as profit (or dividend), payment for expatriate's salary and wages (of which personal consumption in Oman is necessary to be deducted), and a part of depreciation which will be invested for foreign currency portion of next investment. In the estimates, the ratio of foreign portion in the investment was applied to figure out the value added transferred to overseas.

According to the estimates, the benefit expected from the operation in one year (in 2010) is almost 7 times of that of initial investment costs in the case of Scenario 1, while it will be 6.6 times for Scenario 2. In terms of local currency portion, it will be around 5.8 times in Scenario 1, and 5.3 times for Scenario 2.

Note: The concept of return on investment should not be applied to this estimate in the same manner as ordinary investment projects. The investment in this evaluation excludes the investment to be made by the individual locators (enterprises), while the value added include all the return from these investments.

The largest source of benefits in local portion will be that of other sectors. The expected benefits from redistribution account for 6 to 8 % only. Nevertheless, it should be noted that the redistribution is still the essential part of the development scenario. It is the source of benefits to other sectors with its ripple effects. Without the development of redistribution, the benefits from "others" will not be generated significantly.

In addition to the benefits of contribution to increase in GDP, there are indirect benefits to Dhofar and Oman as a whole. These are the job creation effect and foreign exchange earning effect, as discussed in 17.5.1. The development will contribute to around 28,000 persons of job creation in the case of Scenario 1 in 2020, while it will be more than 38,000 persons in Scenario 2. However, the foreign exchange earning/ saving will not be significant, when comparing the earning with remittance to overseas as profit and expatriates' salary and wages.

Table 17.5.1 Summary of the Economic Impacts of the Salalah Port Development and Industrial Promotion in the Hinterland

Sector / Subsector — Contribution to:	Increase in GDP		Additional Job Creation		Increase in Foreign Exchange Earning / Saving	
Year:	2010	2020	2010	2020	2010	2020
Unit:	(Mn R.O.)		(Number of persons)		(Mn R.O.)	
(Scenario 1)						
Agriculture	-	-	-	-	-	-
Fishery	1.8	1.0	150	100	-	-
Mining & Quarrying	1.3	3.4	100	150	-	-
Manufacturing	49.7	100.8	4,800	8,600	51.8	102.3
Commerce	101.0	197.3	800	1,500	-	-
Redistribution	125.3	170.8	1,100	1,300	96.4	131.4
Transportation, Storage & Communication	173.4	289.8	5,000	5,900	-	-
Tourism	5.9	11.7	500	1,000	7.1	14.2
Others	237.2	360.6	9,200	9,200	-	-
Total	695.6	1,135.4	21,650	27,750	155.3	247.9
(Scenario 2)						
Agriculture	-	-	-	-	-	-
Fishery	1.8	1.0	150	100	-	-
Mining & Quarrying	1.3	3.4	100	150	-	-
Manufacturing	49.7	100.8	4,800	8,600	51.8	102.3
Commerce	101.5	197.6	800	1,500	-	-
Redistribution	254.6	366.0	2,200	2,700	195.9	281.6
Transportation, Storage & Communication	260.9	421.9	7,500	8,500	-	-
Tourism	5.9	11.7	500	1,000	7.1	14.2
Others	415.7	629.5	16,000	16,000	-	-
Total	1,091.4	1,731.9	32,050	38,550	254.8	398.1

Sources: Tables 17.5.4 through 17.5.11

Table 17.5.2 Projection of Local Production (Case-without)

Year:	Ton			Gross Output (Mn R.O.)			Assumed rates of VA/GO	Gross Value Added (Mn R.O.)				
	2003	2010	2020	2003	2010	2020		2003	2010	2020	Increase in VA (Mn RO)	AAGR
1 Food industry	207,600	293,700	406,700	125.0	139.3	164.9	0.299	37.4	41.7	49.3	11.9	1.6
2 Mineral products	749,300	953,300	1,275,500	27.9	35.5	47.8	0.523	14.6	18.6	25.0	10.4	3.2
3 Chemicals and Products	1,200	1,500	2,000	3.2	4.0	5.4	0.400	1.3	1.6	2.2	0.9	3.1
4 Plastics, rubbers	200	300	400	0.2	0.3	0.4	0.375	0.1	0.1	0.2	0.1	4.2
5 Pulp, paper and products	2,100	2,600	3,500	2.1	2.6	3.5	0.495	1.0	1.3	1.7	0.7	3.1
6 Textiles and articles	0	0	0	0.0	0.0	0.0	0.524	0.0	0.0	0.0	0.0	
7 Base metal and articles	9,500	11,700	15,700	4.3	5.3	7.2	0.526	2.3	2.8	3.8	1.5	3.1
8 Machinery, electrical equipment	0	0	0	0.0	0.0	0.0	0.263	0.0	0.0	0.0	0.0	
9 Vehicles, transportation equipment	0	0	0	0.0	0.0	0.0	0.509	0.0	0.0	0.0	0.0	
10 Other industrial products	0	0	0	0.0	0.0	0.0	0.509	0.0	0.0	0.0	0.0	
Total	969,900	1,263,100	1,703,800	162.7	187.0	229.2	0.344	56.6	66.0	82.1	25.5	2.2

Notes: VA: Value added, GO: Gross output, AAGR: Average annual growth rate

Source: Projection by the JICA Study Team

Table 17.5.3 Projection of Local Production (Case-with)

Year:	Ton			Gross Output (Mn R.O.)			Assumed rates of VA/GO	Gross Value Added (Mn R.O.)				
	2003	2010	2020	2003	2010	2020		2003	2010	2020	Increase in VA (Mn RO)	AAGR
1 Food industry	207,600	726,700	933,200	125.0	205.0	276.4	0.299	37.4	61.3	82.6	45.3	4.8
2 Mineral products	749,300	1,564,400	2,105,500	27.9	48.1	78.7	0.523	14.6	25.2	41.2	26.6	6.3
3 Chemicals and Products	1,200	2,700	5,200	3.2	7.2	13.9	0.400	1.3	2.9	5.6	4.3	9.0
4 Plastics, rubbers	200	1,400	3,200	0.2	1.4	3.2	0.375	0.1	0.5	1.2	1.1	17.7
5 Pulp, paper and products	2,100	2,900	4,300	2.1	2.9	4.3	0.495	1.0	1.4	2.1	1.1	4.3
6 Textiles and articles	0	11,500	25,600	0.0	37.4	77.8	0.524	0.0	19.6	40.8	40.8	
7 Base metal and articles	9,500	14,400	22,900	4.3	6.5	10.5	0.526	2.3	3.4	5.5	3.3	5.4
8 Machinery, electrical equipment	0	600	1,600	0.0	2.1	5.9	0.263	0.0	0.6	1.6	1.6	
9 Vehicles, transportation equipment	0	600	1,700	0.0	1.2	3.5	0.509	0.0	0.6	1.8	1.8	
10 Other industrial products	0	300	800	0.0	0.4	1.1	0.509	0.0	0.2	0.6	0.6	
Total	969,900	2,325,500	3,104,000	162.7	312.2	475.3	0.344	56.6	115.7	182.9	126.3	7.1

Notes: VA: Value added, GO: Gross output, AAGR: Average annual growth rate

Source: Projection by the JICA Study Team

Table 17.5.4 Estimated Economic Impact, Manufacturing

Contribution to:	Particular	2010	2020
GDP [1]	Gross Output (Million R.O.)		
	・ Case-with	312.2	475.3
	・ Case-without	187.0	229.2
	Difference	125.2	246.1
	Gross Value Added (Million R.O.)		
	・ Case-with	115.7	182.9
	・ Case-without	66.0	82.1
	Difference	49.7	100.8
Job creation [2]	Number of persons of job creation	4,800	8,600
Foreign exchange earning/ saving	Export (Million R.O.)		
	・ Case-with	290.7	444.3
	・ Case-without	167.7	206.2
	Difference	123.0	238.1
	Import of raw materials (Million R.O.) [3]	61.0	118.1
	Remittance of wages for expatriates [4]	5.8	9.1
	Import of plant, machinery and equipment [5]	4.4	8.6
	Net export increase	51.8	102.3

Notes: 1) See Tables 17.5.2 and 17.5.3.

2) Average gross output/person・year in 1993-1997 was 23,700 RO for the manufacturing sector, according to the Yearly Industrial Statistical Book, 1997 (MCI). It is assumed to increase by 10% by 2010, and 20% by 2020 due to increase in labor productivity.

3) Assuming that 80% of "raw materials consumed" are imported. Rate of "raw materials consumed" over "the gross output" is estimated at 62% according to the Yearly Industrial Statistical Book, 1997 (MCI).

4) Percentage for expatriate's compensation out of total is estimated at 55% in 2010 and 45% in 2020. Rate of "total compensation" over "the gross output" is estimated at 8.5%.

5) Depreciation of plant, machinery and equipment is estimated at 4% of "gross output", and 90% of them are imported.

Source: Projection by the JICA Study Team

Table 17.5.5 Estimated Economic Impact, Commerce

Contribution to:	Particular	Scenario (1)		Scenario (2)	
		2010	2020	2010	2020
GDP	Increase in gross output of manufacturing sector (Mn R.O.) (compared to the Case-without)	126.3	247.7	126.3	247.7
	Job created (person)	10,900	15,800	14,500	19,800
	Increase in expatriate population [1] (person)	6,000	7,100	8,000	8,900
	Increase in gross output of the commerce sector [2] (Mn R.O.)	123.3	240.6	123.8	241.0
	Increase in value added of the commerce sector [3] (Mn R.O.)	101.1	197.3	101.5	197.6
Job creation [4]	Increase in compensation of employees (Mn R.O.)	2.43	4.34	2.44	4.35
	Job to be created in the commerce sector (person)	800	1,500	800	1,500
Foreign exchange earning/ saving	(Included in the earning/ saving in the manufacturing sector)				

Notes:
1) Increase in jobs created by manufacturing, redistribution, and transportation & communication sectors. Increase in expatriate population is assumed at 55% and 45% of jobs created in 2010 and 2020 respectively, as the result of increase in gross output in the manufacturing sector.
2) Estimated using the following correlation equation, which is estimated on the basis of past data on the National Oman.
$Y_{com} = -337 + 0.254\ X_{pop} + 0.964\ X_{mfg}$
Where,
Y_{com} = Gross output in the commerce sector (in Mn R.O.)
X_{pop} = Population (in '000)
X_{mfg} = Gross output in the manufacturing sector (in Mn R.O.)
3) "Value added" / "Gross output" is assumed at 0.82.
4) Rate of compensation of employees out of gross output is assumed to decrease by 10% in 2010 and 20% by 2020 due to increase in labor productivity, from the current 2.64% of gross output (the average of 7 years from 1992 through 1998). Compensation is assumed to increase by 15% by 2010, and 30% by 2020 due to increase in wage rate from the current 2,500 R.O. per person (in 1997).

Source: Projection by the JICA Study Team

Table 17.5.6 Estimated Economic Impact, Redistribution

Contribution to:	Particular	Scenario (1)		Scenario (2)	
		2010	2020	2010	2020
GDP	Increase in gross output from redistribution (Mn R.O.)	417.8	569.4	848.8	1,220.1
	Increase in value added from redistribution [1] (Mn R.O.)	125.3	170.8	254.6	366.0
Job creation [2]	Increase in compensation of employees (Mn R.O.)	3.01	3.76	6.11	8.05
	Job to be created in the commerce sector (person)	1,100	1,300	2,200	2,700
Foreign exchange earning/ saving [3]		96.4	131.4	195.9	281.6

Notes: 1) "Value added" / "Gross output" is assumed at 0.3.

2) Rate of compensation of employees out of gross output is assumed to decrease by 10% in 2010 and 20% by 2020 due to increase in labor productivity, from the current 2.64% of gross output (the average of 7 years from 1992 through 1998). Compensation is assumed to increase by 15% by 2010, and 30% by 2020 due to increase in wage rate from the current 2,500 R.O. per person (in 1997).

3) Price difference between import and export is assumed 30% of import price.

Source: Projection by the JICA Study Team

Table 17.5.7 Estimated Economic Impact, Transportation Storaging and Communication

Contribution to:	Particular	Scenario (1)		Scenario (2)	
		2010	2020	2010	2020
GDP	Increase in gross output (Mn R.O.)				
	· Manufacturing sector	126.3	247.7	126.3	247.7
	· Commerce sector	123.2	243.9	123.2	243.9
	· Redistribution	417.8	569.4	848.8	1,220.1
	Transportation, storaging and communication sector [1]	247.7	414.0	372.7	602.7
	Increase in value added [2] (Mn R.O.)	173.4	289.8	260.9	421.9
Job creation [3]	Increase in compensation of employees (Mn R.O.)	14.2	19.0	21.4	27.7
	Job to be created (person)	5,000	5,900	7,500	8,500

Notes: 1) Estimated using the following correlation equation, which is estimated on the basis of past data on the National Oman.

$Y_{transp} = -229 + 0.719\ X_{mfg} + 0.290\ X_{com}$

Where,

Y_{transp} = Gross output in the transportation, storaging and communication sector (in Mn R.O.)

X_{mfg} = Gross output in the manufacturing sector (in Mn R.O.)

X_{com} = Gross output in the commerce sector and redistribution (in Mn R.O.)

2) "Value added" / "Gross output" is assumed at 0.70.

3) Rate of compensation of employees out of gross output is assumed to decrease by 400% in 2010 and 500% by 2020 due to increase in labor productivity, from the current 23.0% of gross output (the average of 7 years from 1992 through 1998). Compensation is assumed to increase by 15% by 2010, and 30% by 2020 due to increase in wage rate from the current 2,500 R.O. per person (in 1997).

Source: Projection by the JICA Study Team

Table 17.5.8 Estimated Economic Impact, Fishing

Contribution to:	Particular	2010	2020
GDP	Increase in gross output in fish processing industry (Mn R.O.)	6.3	3.4
	Increase in fish purchased [1] (Mn R.O.)	2.3	1.3
	Increase in value added [2] (Mn R.O.)	1.8	1.0
Job creation [3]	Increase in compensation of employees (Mn R.O.)	0.4	0.2
	Job to be created (person)	150	100
Foreign exchange earning/ saving	(Included in the earning/ saving in the manufacturing sector)		

Notes: 1) Raw materials consumed is assumed at 62% of gross output, and 60% of raw material costs is assumed for fish procurement.

2) Value added is estimated to account for 80% of gross output.

3) Rate of compensation of employees out of gross output is assumed to decrease by 10% in 2010 and 20% by 2020 due to increase in labor productivity, from the current 21.4% of gross output (the average of 7 years from 1992 through 1998). Compensation is assumed to increase by 15% by 2010, and 30% by 2020 due to increase in wage rate from the current 2,500 R.O. per person (in 1997).

Source: Projection by the JICA Study Team

Table 17.5.9 Estimated Economic Impact, Mining & Quarrying

Contribution to:	Particular	2010	2020
GDP	Increase in gross output [1] in other mineral product subsector (Mn R.O.)	10.2	27.7
	Increase in minerals purchased [2] (Mn R.O.)	2.5	6.7
	Increase in value added [3] (Mn R.O.)	1.3	3.4
Job creation [4]	Increase in compensation of employees (Mn R.O.)	0.3	0.5
	Job to be created (person)	100	150
Foreign exchange earning/ saving	(Included in the earning/ saving in the manufacturing sector)		

Notes:
1) For raw materials for other mineral products only. Gypsum is included in the gross output of the manufacturing sector.
2) 34.5% of gross output is the raw materials consumed, and 70% of which is assumed to be the non-metal minerals.
3) Value added is estimated to account for 50% of the gross output.
4) Rate of compensation of employees out of gross output is assumed to decrease by 250% in 2010 and 400% by 2020 due to increase in labor productivity, from the current 29% of gross output (the average of 7 years from 1992 through 1998). Compensation is assumed to increase by 15% by 2010, and 30% by 2020 due to increase in wage rate from the current 2,500 R.O. per person (in 1997).

Source: Projection by the JICA Study Team

Table 17.5.10 Estimated Economic Impact, Hotel and Restaurants

Contribution to:	Particular	2010	2020
GDP	Increase in guests attracted to Salalah [1] (person)	106,000	212,000
	Increase in expenditure by the guests [1] (Mn R.O.)	12.2	24.4
	Increase in value added [2] (Mn R.O.)	5.9	11.7
Job creation [3]	Increase in compensation of employees (Mn R.O.)	1.3	2.6
	Job to be created (person)	500	1,000
Foreign exchange earning/ saving	• Expenditure by the guests (Mn R.O.)	12.2	24.4
	• Intermediate consumption [4] (Mn R.O.)	5.1	10.2
	Net foreign exchange earning	7.1	14.2

Notes: 1) Hotel guests in Dubai was 1,790,000 in 1997. Of which 1,060,000 guests were from Asia, European, American and Australia / Nz. This figure assumes to attract 10% of these guests to Salalah in 2010, and 20% in 2020. One guest is assumed to spend 1,100 Dhs (or 115 R.O.)

2) Value added rate over the gross output is estimated at 48%.

3) Compensation rate over the gross output is estimated at 22%.

4) 52% of the gross output is consumed as the intermediate, of which 80% are imported goods.

Source: Projection by the JICA Study Team

Table 17.5.11 Estimated Economic Impact, Other Sectors

Contribution to:	Particular	Scenario (1)		Scenario (2)	
		2010	2020	2010	2020
GDP	Increase in gross output of manufacturing sector (Mn R.O.) (compared to the Case-without)	125.2	246.1	125.2	246.1
	Increase in expatriate population (person)	6,800	8,300	8,800	10,150
	Increase in gross output of the commerce sector (Mn R.O.)	123.2	243.9	123.2	243.9
	Increase in gross output from redistribution (Mn R.O.)	417.8	569.4	848.8	1,220.1
	Increase in gross output of other sectors [1] (Mn R.O.)	329.4	500.8	577.4	874.3
	Increase in value added of the other sectors [2] (Mn R.O.)	237.2	360.6	415.7	629.5
Job creation [3]	Increase in compensation of employees (Mn R.O.)	26.4	30.0	46.2	52.5
	Job to be created in the other sectors (person)	9,200	9,200	16,100	16,100

Notes: 1) Estimated using the following correlation equation, which is estimated on the basis of past data on the National Oman.

$Y_{oth} = 53.2 + 0.727\ X_{pop} + 0.572\ X_{com} + 0.120\ X_{mfg}$

Where,

Y_{oth} = Gross output in the other sectors (in Mn R.O.)

X_{pop} = Population (in '000)

X_{com} = Gross output in the commerce sector (in Mn R.O.)

X_{mfg} = Gross output in the manufacturing sector (in Mn R.O.)

2) "Value added" / "Gross output" is assumed at 0.72.

3) Rate of compensation of employees out of gross output is assumed to decrease by 300% in 2010 and 600% by 2020 due to increase in labor productivity, from the current 24.0% of gross output (the average of 7 years from 1992 through 1998). Compensation is assumed to increase by 15% by 2010, and 30% by 2020 due to increase in wage rate from the current 2,500 R.O. per person (in 1997).

Source: Projection by the JICA Study Team

Table 17.5.12 Costs and Benefits of the Hinterland Development (Scenario 1)

Costs/ Benefits (Million R.O.)				Remarks
	Foreign	Local	Total	
(1) Costs				
1) Port (*)				
2) Infrastructure				Required costs for Case-With less costs for Case-Without, including land, road, utility supply, telecom, buildings and sewages.
1 Land and site works	23.8	55.5	79.3	
2 Utilities	13.0	52.0	65.0	
Total	36.8	107.5	144.3	
(2) Benefits				
· Annual increase in GDP				Difference with Case-Without in 2010
1 Manufacturing	29.8	19.9	49.7	Assumed foreign investment 60%
2 Commerce	20.2	80.8	101.0	Assumed foreign investment 20%
3 Redistribution	100.2	25.1	125.3	Assumed foreign investment 80%
4 Transportation & communication	104.0	69.4	173.4	Assumed foreign investment 60%
5 Tourism	2.4	3.5	5.9	Assumed foreign investment 40%
6 Others	24.0	216.3	240.3	Assumed foreign investment 10%
Total	280.7	414.9	695.6	

Note: (*) R.O. 10-18 million depending on the project scope, assuming 8% of total investment costs for the port development.
The Costs refer to total investment required, while the Benefits refer to the annual benefits in 2010.

Table 17.5.13 Costs and Benefits of the Hinterland Development (Scenario 2)

Costs/ Benefits (Million R.O.)				Remarks
	Foreign	Local	Total	
(1) Costs				
1) Port (*)				
2) Infrastructure				Required costs for Case-With less costs for Case-Without, including land, road, utility supply, telecom, buildings and sewages.
1 Land and site works	44.7	104.2	148.9	
2 Utilities	14.7	59.0	73.7	
Total	59.4	163.2	222.6	
(2) Benefits				
· Annual increase in GDP				Difference with Case-Without in 2010
1 Manufacturing	29.8	19.9	49.7	Assumed foreign investment 60%
2 Commerce	20.3	81.2	101.5	Assumed foreign investment 20%
3 Redistribution	203.7	50.9	254.6	Assumed foreign investment 80%
4 Transportation & communication	156.5	104.4	260.9	Assumed foreign investment 60%
5 Tourism	2.4	3.5	5.9	Assumed foreign investment 40%
6 Others	41.9	376.9	418.8	Assumed foreign investment 10%
Total	454.6	636.8	1,091.4	

Note: (*) R.O. 10-18 million depending on the project scope, assuming 8% of total investment costs for the port development.
The Costs refer to total investment required, while the Benefits refer to the annual benefits in 2010.

Part 4 Initial Environment Impact Analysis

18. Coastal and Hinterland Features

18.1 General

Present environmental conditions and features on the Study Area are described in this Chapter. Environmental items and key factors discussed here are shown in Table 18.1.1.

These are related to oceanography, meteorology, morphology, hydrology, and human activities within the Study Area that have been identified as among the most critical in terms of potential environmental impacts.

Table 18.1.1 Discussion Items and Key Factors

Regions and Sectors		Key Factors
1	Coastal Water Region	Ocean climate / Monsoon / Morphology / Upwelling / Rich fishery and other habitats resources
2	Shore Region	Shoreline Erosion / Mangrove lagoon / Tides
3	Hinterland Region	Wadi / Flood risk / Ground water & water table
4	Social and Human Activities	Land use / Waste management (solid & water)

18.2 Coastal Water Region

(1) Ocean Climate

The coastal water region experiences two (2) monsoon seasons: the NE monsoon and SW monsoon; and the ocean climate changes drastically. The features of these monsoon seasons are as follows.

1) NE monsoon

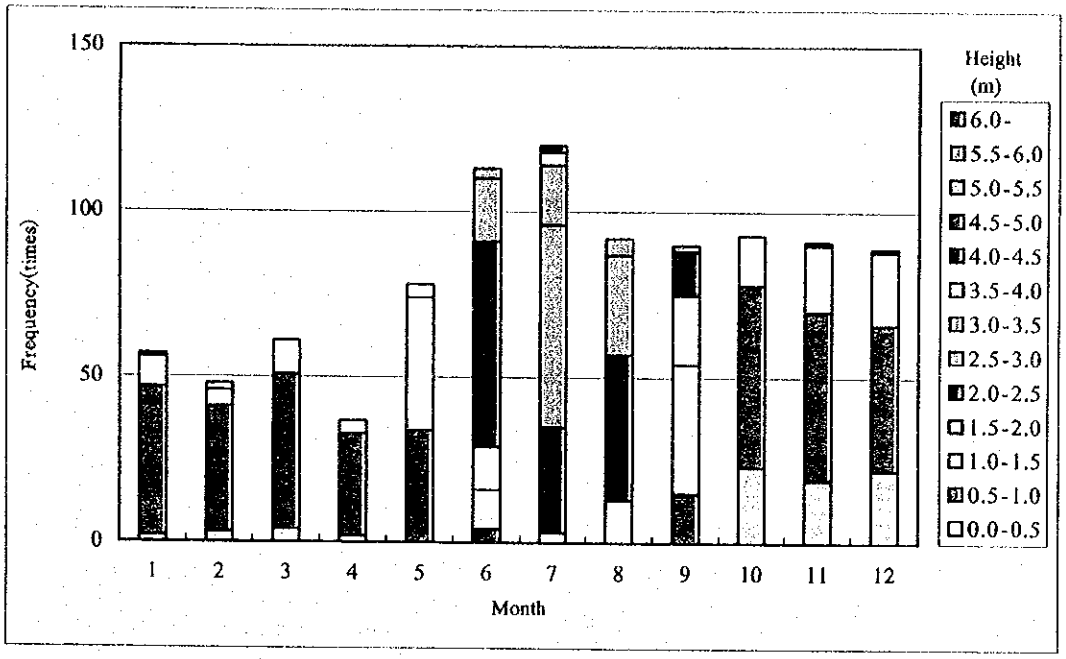
(a) Period
November through February

(b) Features
a) A dry northerly cooler wind of 7 knots to 17 knots is prevailed, and a relatively calm sea conditions with less than 1.0 m high of wave in SE is dominant based on the wave hindcast model by this Study.
b) Fine weather mostly continues, and less or almost no rain is recorded, usually.

2) SW monsoon

(a) Period
May through September

(b) Features
a) A humid southerly gentle sea breeze of 17 knots to 34 knots is prevailed, and a cloudy weather with light rain is recorded.
b) Over 1.0 m to 1.5 m high of wave in S to SSE becomes dominant in May. Wave becomes higher in July experiencing over 2.5 m, accounts for over 75% of entire wave appearance in this month.
c) A coastal upwelling is predominated, and entire surface water column is experienced relatively low temperature because of upwelling influence which brings a relatively cold deepwater.



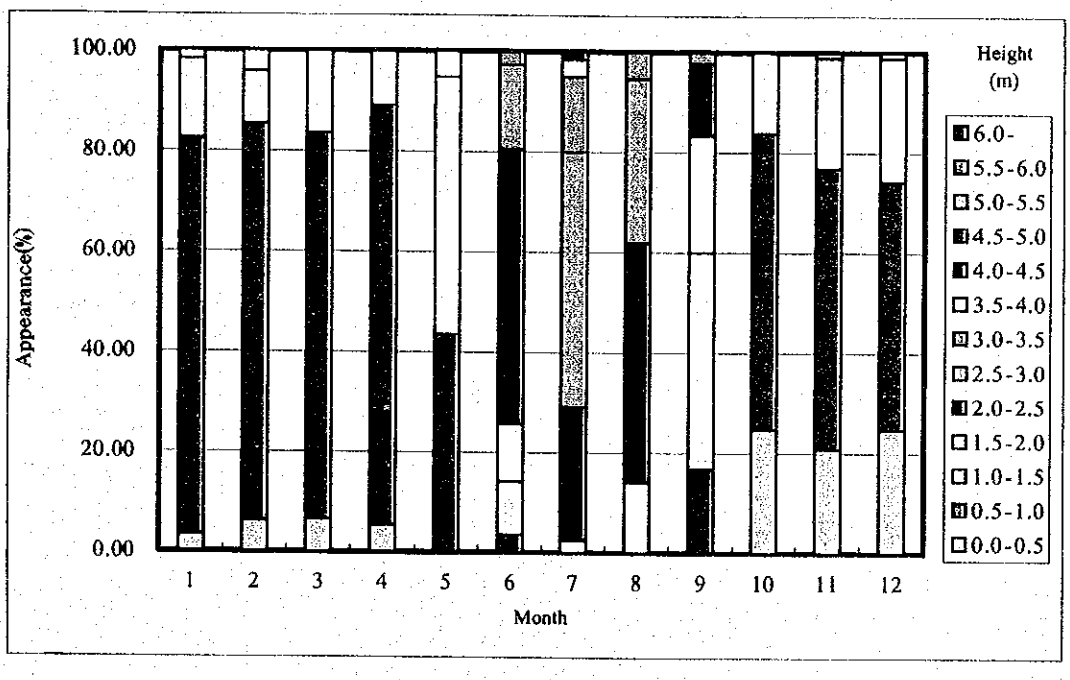
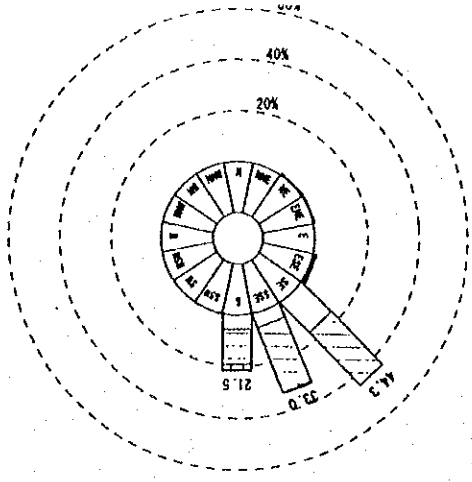
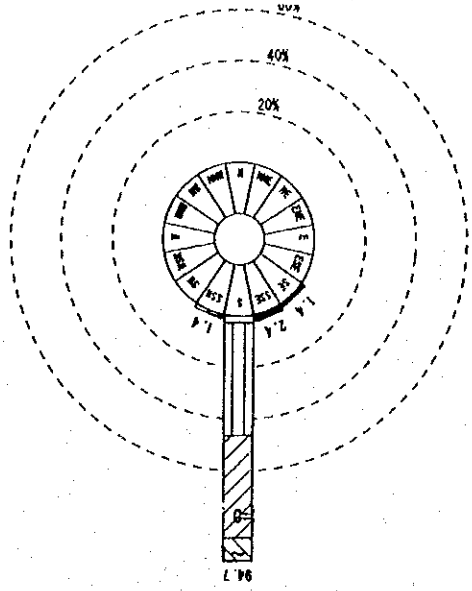


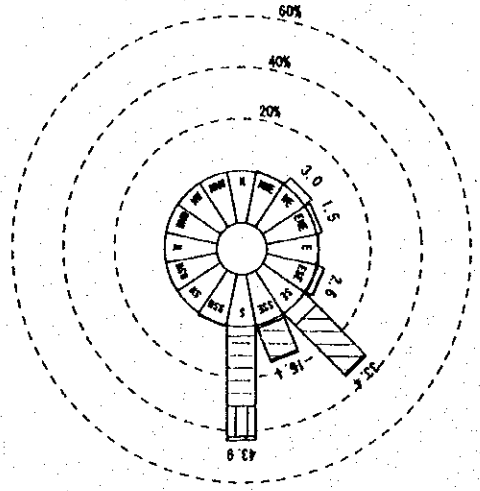
Figure 18.2.1 Monthly Appearance of wave Height by Wave Hindcast (JWA-3G: WAM model)



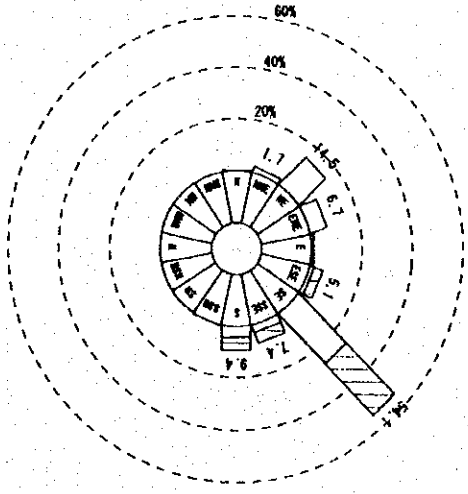
March~May



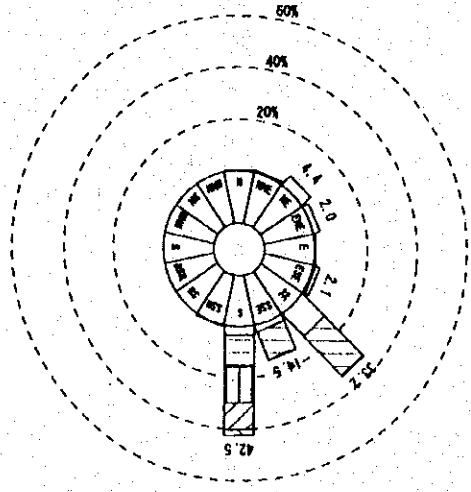
June~August



September~November



December~February



Annual

Legend

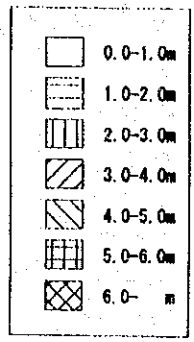


Figure 18.2.2 Wave Rose in Seasonal Variations by Wave Hindcast (JWA-3G: WAM model)

(2) Morphology and Bathymetry

1) Morphology

(a) Narrow Continental Shelf
A narrow continental shelf margin of about 20km immediately facing to the open sea, the Arabian Sea, causes the influence of deep water that has a rich nutrient.

(b) Upwelling and Rich Marine Habitats
During SW monsoon season, a coastal upwelling begins and becomes predominant in June; and this may give a rich nutrient to the coastal water to nourish fish and other marine habitats.

2) Bathymetry

(a) The seabed gradient in the area where the hydrographic survey was conducted by this Study was in 1:50 to 1:300 in easterly direction of 110° degrees.

(b) The contour line shallower than 30 m is almost parallel to the coastal line, extending to EEN with 6km of width.

(3) Current and Other Oceanographic Factors

1) Current

(a) No Existing Data Archive
There is no available data archive of current within the Study Area.

(b) Actual Observed Data by this Study
A fifteen (15) days statistics of current observation was conducted during March 26 through April 10, 2000 close to the port entrance of about 21 m water depth.

The following interpretations are based on the analysis results that represented in Fig. 18.2.3 through Fig. 18.2.9 and Table 18.2.1 through Table 18.2.4, respectively.

a) General Trends
Current oriented to offshore region is prevailed.

b) Trends of Upper Layer (2 m below sea surface)
Current speed over 0.2 m/sec in SSW, NNE, and/or S was dominant.

c) Trends of Bottom Layer (19m below sea surface)
Relatively slow in current speed compared to the upper layer; however, over 0.1 m/sec of current was prevailing in S direction.

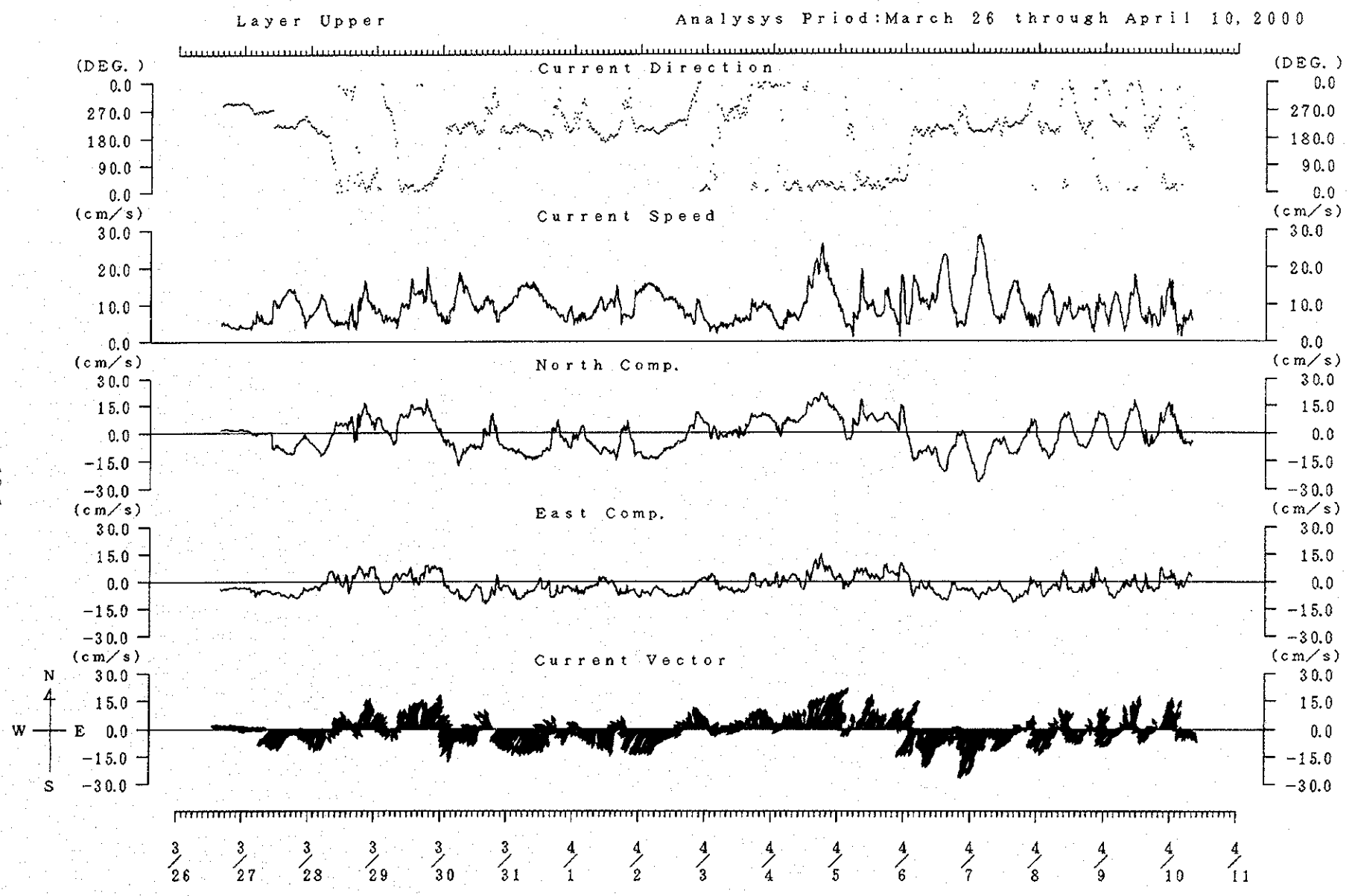


Figure 18.2.3 Observed Current OccurrenceDiagram (Upper Layer)

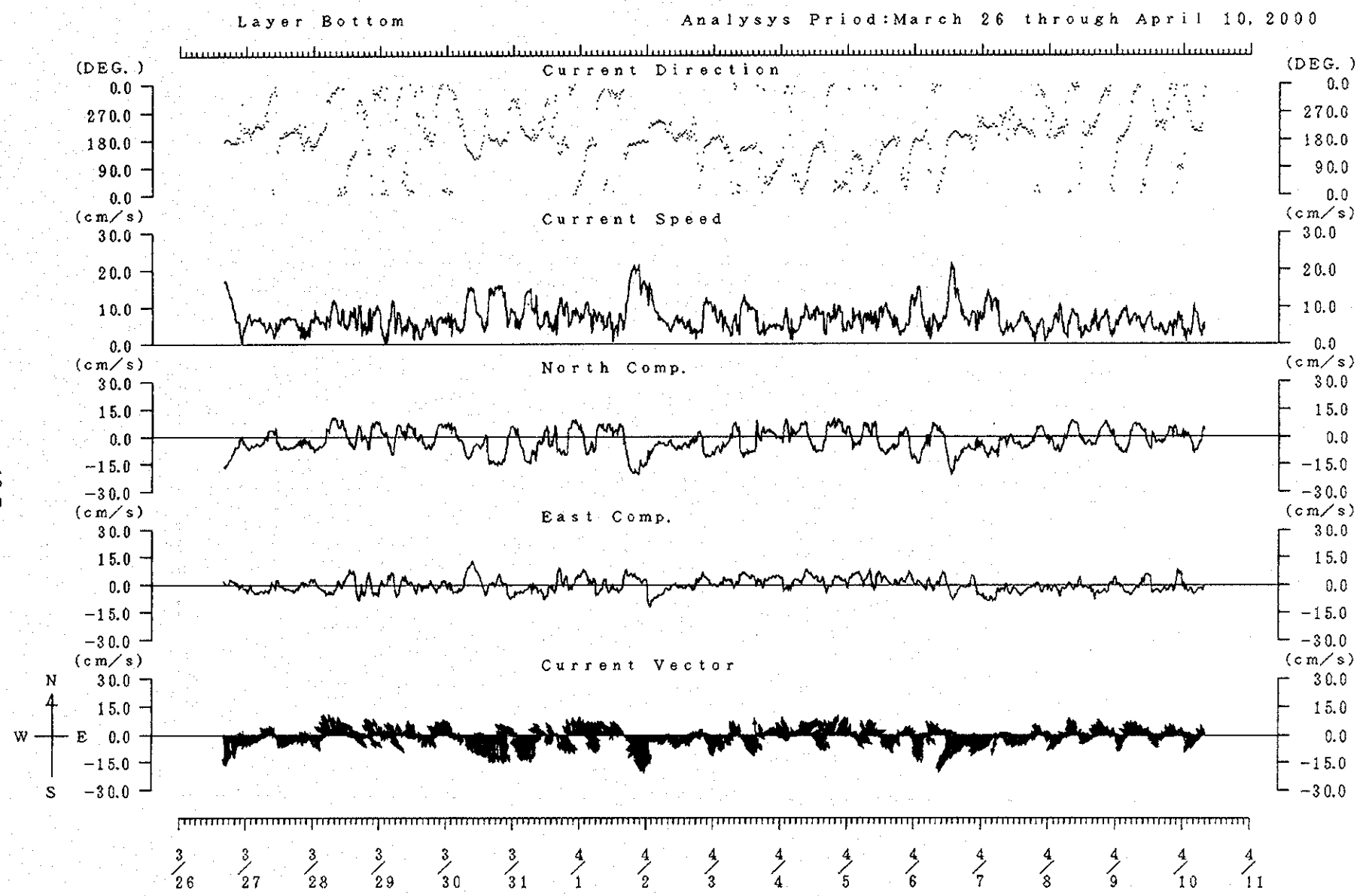


Figure 18.2.4 Observed Current OccurrenceDiagram (Bottom Layer)

Table 18.2.1 Observed Current Appearance

Analysys Period: 26-Mar-00 16:00 to 10-Apr-00 07:40 (GMT+4)

Upper

Dir. \ Cur.	0.0≤ < 5.0	5.0≤ < 10.0	10.0≤ < 15.0	15.0≤ < 20.0	20.0≤ < 25.0	25.0≤ < 30.0	30.0≤ (cm/s)	Sum	Mean
-	0 -							0 -	-
N	3 0.3	53 5.0	36 3.4	5 0.5	0 -	0 -	0 -	97 9.2	9.6
NNE	5 0.5	52 4.9	39 3.7	24 2.3	10 0.9	0 -	0 -	130 12.3	11.7
NE	5 0.5	22 2.1	17 1.6	1 0.1	0 -	1 0.1	0 -	46 4.4	9.3
ENE	7 0.7	9 0.9	0 -	0 -	0 -	0 -	0 -	16 1.5	6.3
E	3 0.3	4 0.4	0 -	0 -	0 -	0 -	0 -	7 0.7	5.7
ESE	4 0.4	4 0.4	0 -	0 -	0 -	0 -	0 -	8 0.8	5.1
SE	0 -	6 0.6	0 -	0 -	0 -	0 -	0 -	6 0.6	6.0
SSE	3 0.3	13 1.2	0 -	0 -	0 -	0 -	0 -	16 1.5	6.0
S	5 0.5	24 2.3	27 2.6	1 0.1	0 -	0 -	0 -	57 5.4	9.3
SSW	14 1.3	74 7.0	81 7.7	38 3.6	12 1.1	7 0.7	0 -	226 21.4	12.1
SW	11 1.0	66 6.3	86 8.1	9 0.9	0 -	0 -	0 -	172 16.3	10.1
WSW	13 1.2	44 4.2	4 0.4	0 -	0 -	0 -	0 -	61 5.8	6.6
W	23 2.2	49 4.6	7 0.7	0 -	0 -	0 -	0 -	79 7.5	6.2
WNW	32 3.0	29 2.7	0 -	0 -	0 -	0 -	0 -	61 5.8	5.3
NW	2 0.2	16 1.5	2 0.2	0 -	0 -	0 -	0 -	20 1.9	6.8
NNW	12 1.1	31 2.9	11 1.0	0 -	0 -	0 -	0 -	54 5.1	7.4
Sum	142 13.4	496 47.0	310 29.4	78 7.4	22 2.1	8 0.8	0 -	1056 100.0	9.4

Missing Records: 0
Percentage of Samples: 100.0%

Bottom

Dir. \ Cur.	0.0≤ < 5.0	5.0≤ < 10.0	10.0≤ < 15.0	15.0≤ < 20.0	20.0≤ < 25.0	25.0≤ < 30.0	30.0≤ (cm/s)	Sum	Mean
-	0 -							0 -	-
N	27 2.6	47 4.5	0 -	0 -	0 -	0 -	0 -	74 7.0	5.5
NNE	27 2.6	27 2.6	3 0.3	0 -	0 -	0 -	0 -	57 5.4	5.5
NE	26 2.5	5 0.5	2 0.2	0 -	0 -	0 -	0 -	33 3.1	4.6
ENE	22 2.1	10 0.9	0 -	0 -	0 -	0 -	0 -	32 3.0	4.3
E	15 1.4	13 1.2	0 -	0 -	0 -	0 -	0 -	28 2.7	5.0
ESE	7 0.7	22 2.1	2 0.2	1 0.1	0 -	0 -	0 -	32 3.0	6.9
SE	10 0.9	29 2.7	16 1.5	2 0.2	0 -	0 -	0 -	57 5.4	8.6
SSE	8 0.8	56 5.3	29 2.7	10 0.9	3 0.3	0 -	0 -	106 10.0	9.7
S	30 2.8	75 7.1	35 3.3	20 1.9	1 0.1	0 -	0 -	161 15.2	9.0
SSW	44 4.2	65 6.2	12 1.1	3 0.3	2 0.2	0 -	0 -	126 11.9	6.7
SW	38 3.6	49 4.6	18 1.7	1 0.1	0 -	0 -	0 -	106 10.0	6.5
WSW	33 3.1	14 1.3	0 -	0 -	0 -	0 -	0 -	47 4.5	4.2
W	24 2.3	6 0.6	0 -	0 -	0 -	0 -	0 -	30 2.8	3.9
WNW	17 1.6	12 1.1	0 -	0 -	0 -	0 -	0 -	29 2.7	4.6
NW	12 1.1	39 3.7	2 0.2	0 -	0 -	0 -	0 -	53 5.0	6.5
NNW	11 1.0	69 6.5	5 0.5	0 -	0 -	0 -	0 -	85 8.1	7.0
Sum	351 33.2	538 50.9	124 11.7	37 3.5	6 0.6	0 -	0 -	1056 100.0	6.9

Missing Records: 0
Percentage of Samples: 100.0%

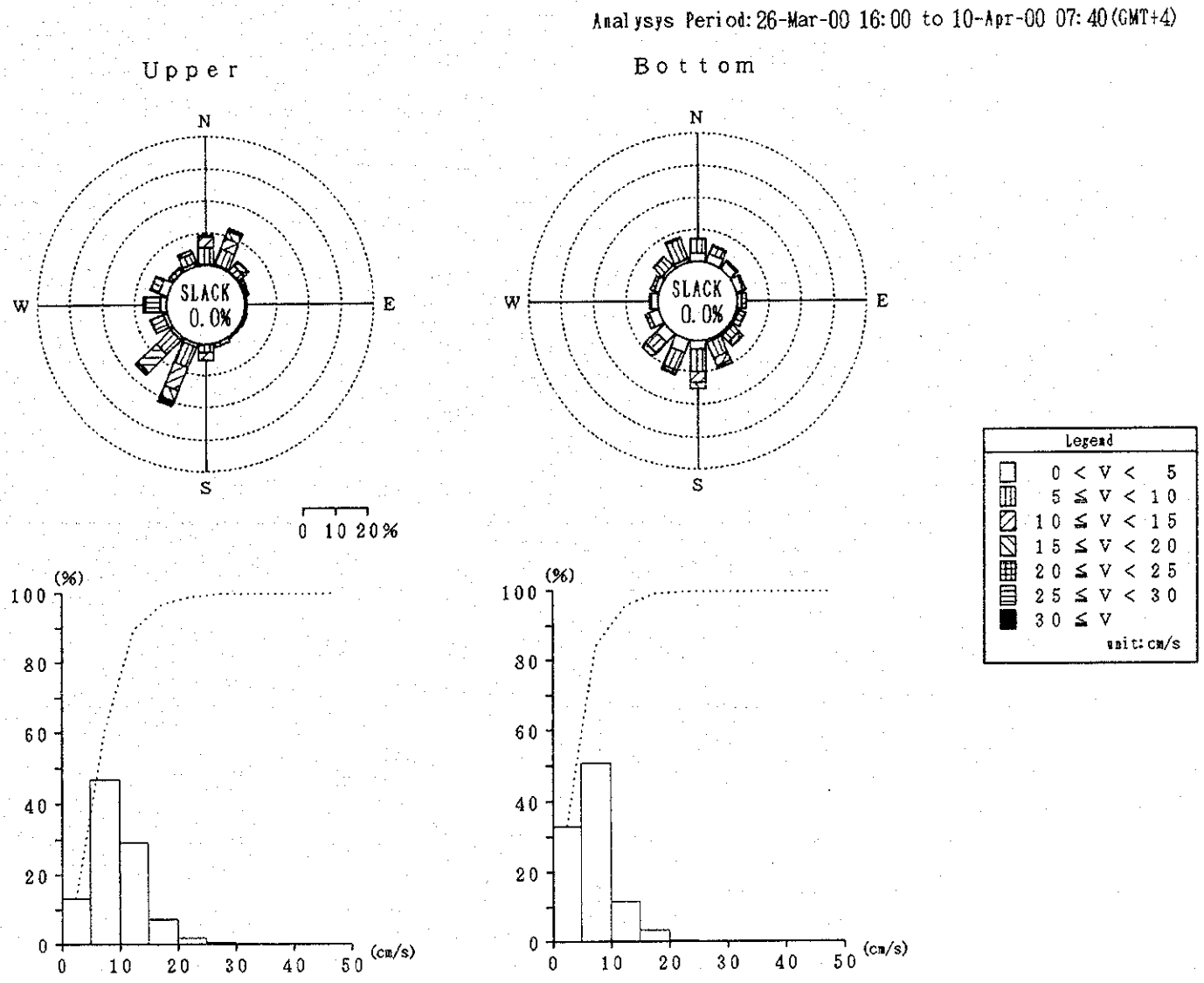


Figure 18.2.5 Current Rose

Table 18.2.2 Harmonic Tidal Analysis

Analysys Period: 26-Mar-00 16:00 to 10-Apr-00 07:40 (GMT+4)
Position: 16°56′31.8″N, 054°01′34.2″E

Upper

Constituents	N-comp.		E-comp.		Ellipse of Tidal Current				Principal Dir. 14.7°	
	Vel. (cm/s)	Lag. (°)	Vel. (cm/s)	Lag. (°)	Axis	Dir. (°)	Vel. (cm/s)	Lag. (°)	Vel. (cm/s)	Lag. (°)
K_1	5.6	12.7	1.1	48.3	L	8.8	5.7	13.6	5.7	14.3
					S	98.8	0.6	103.6		
O_1	2.6	232.1	1.1	240.2	L	24.0	2.8	233.4	2.8	232.9
					S	114.0	0.1	323.4		
P_1	1.9	12.7	0.4	48.3	L	8.8	1.9	13.6	1.9	14.3
					S	98.8	0.2	103.6		
Q_1	2.0	128.9	1.1	164.8	L	26.0	2.2	136.3	2.1	133.3
					S	116.0	0.6	226.3		
M_2	3.8	213.7	0.7	168.6	L	7.2	3.8	212.8	3.8	211.9
					S	97.2	0.5	122.8		
S_2	2.2	283.0	1.2	282.6	L	28.8	2.6	282.9	2.5	283.0
					S	118.8	0.0	192.9		
K_2	0.6	283.0	0.3	282.6	L	28.8	0.7	282.9	0.7	283.0
					S	118.8	0.0	192.9		
N_2	2.0	181.2	1.2	202.2	L	29.2	2.3	186.3	2.2	183.9
					S	119.2	0.4	276.3		
M_4	0.2	110.2	0.4	263.9	L	291.8	0.4	87.7	0.1	140.7
					S	21.8	0.1	177.7		
MS_4	0.3	283.1	0.3	188.9	L	330.4	0.3	310.7	0.3	268.8
					S	60.4	0.3	220.7		
Constant	-1.2		-2.3		243.4		2.6		-1.7	

Bottom

Constituents	N-comp.		E-comp.		Ellipse of Tidal Current				Principal Dir. 2.6°	
	Vel. (cm/s)	Lag. (°)	Vel. (cm/s)	Lag. (°)	Axis	Dir. (°)	Vel. (cm/s)	Lag. (°)	Vel. (cm/s)	Lag. (°)
K_1	2.2	184.6	1.0	331.2	L	339.1	2.3	180.0	2.2	185.2
					S	69.1	0.5	270.0		
O_1	0.4	126.3	0.3	230.5	L	341.2	0.4	113.5	0.4	128.2
					S	71.2	0.3	203.5		
P_1	0.7	184.6	0.3	331.2	L	339.1	0.8	180.0	0.7	185.2
					S	69.1	0.2	270.0		
Q_1	0.4	24.6	0.4	16.3	L	42.1	0.6	20.9	0.4	24.3
					S	132.1	0.0	290.9		
M_2	2.4	137.8	1.1	217.4	L	5.5	2.4	140.1	2.4	138.9
					S	95.5	1.0	230.1		
S_2	2.2	257.4	1.2	289.7	L	27.2	2.4	264.5	2.2	258.2
					S	117.2	0.6	354.5		
K_2	0.6	257.4	0.3	289.7	L	27.2	0.7	264.5	0.6	258.2
					S	117.2	0.2	354.5		
N_2	1.4	249.5	0.5	119.4	L	346.6	1.5	252.9	1.4	248.8
					S	76.6	0.4	162.9		
M_4	0.5	174.2	0.4	68.8	L	333.1	0.5	194.1	0.5	172.2
					S	63.1	0.3	104.1		
MS_4	0.2	67.1	0.3	243.3	L	298.5	0.4	64.1	0.2	67.5
					S	28.5	0.0	154.1		
Constant	-2.4		-0.2		185.8		2.4		-2.4	

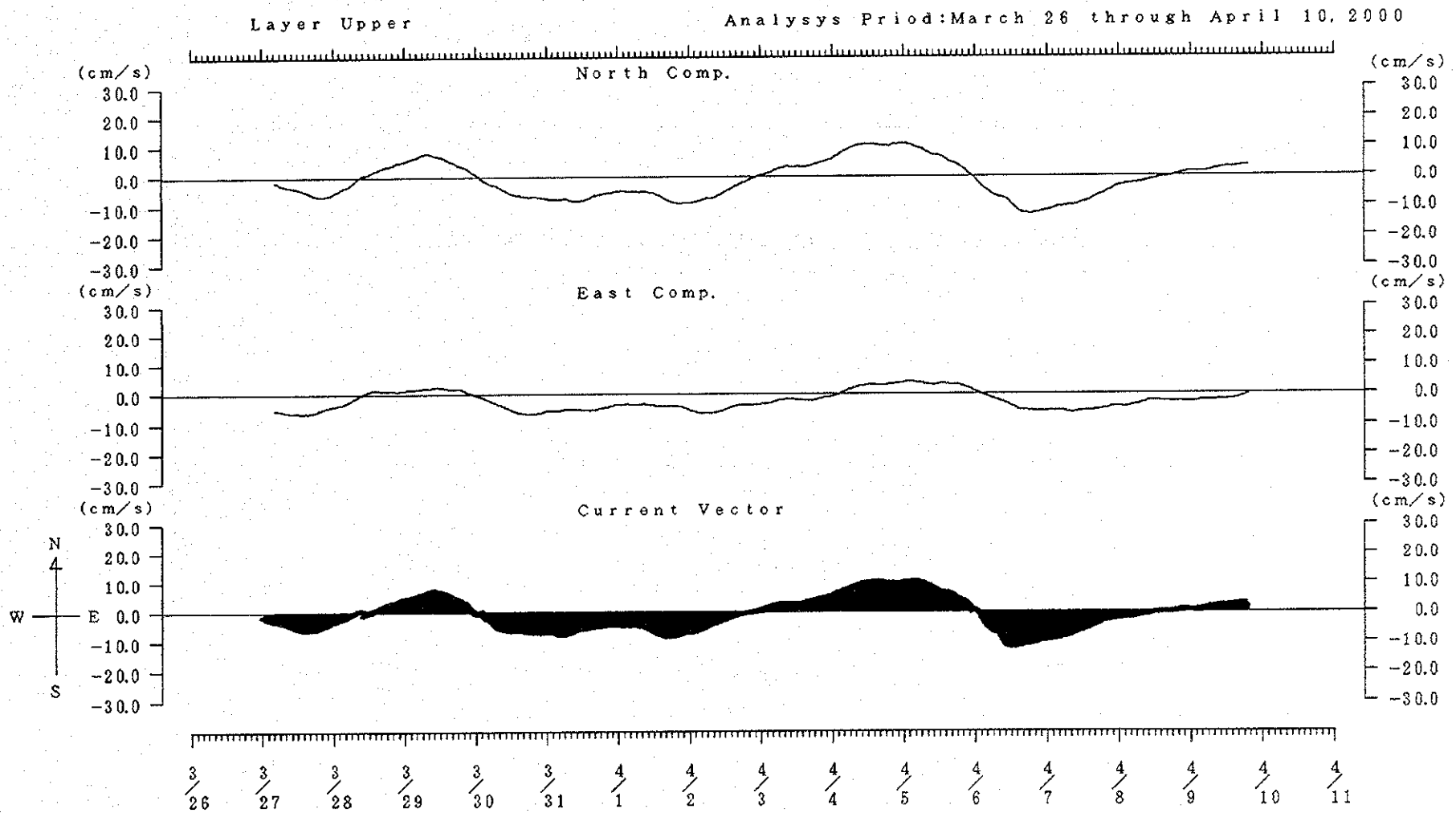


Figure 18.2.6 25 hours Running Mean Results (Upper Layer)

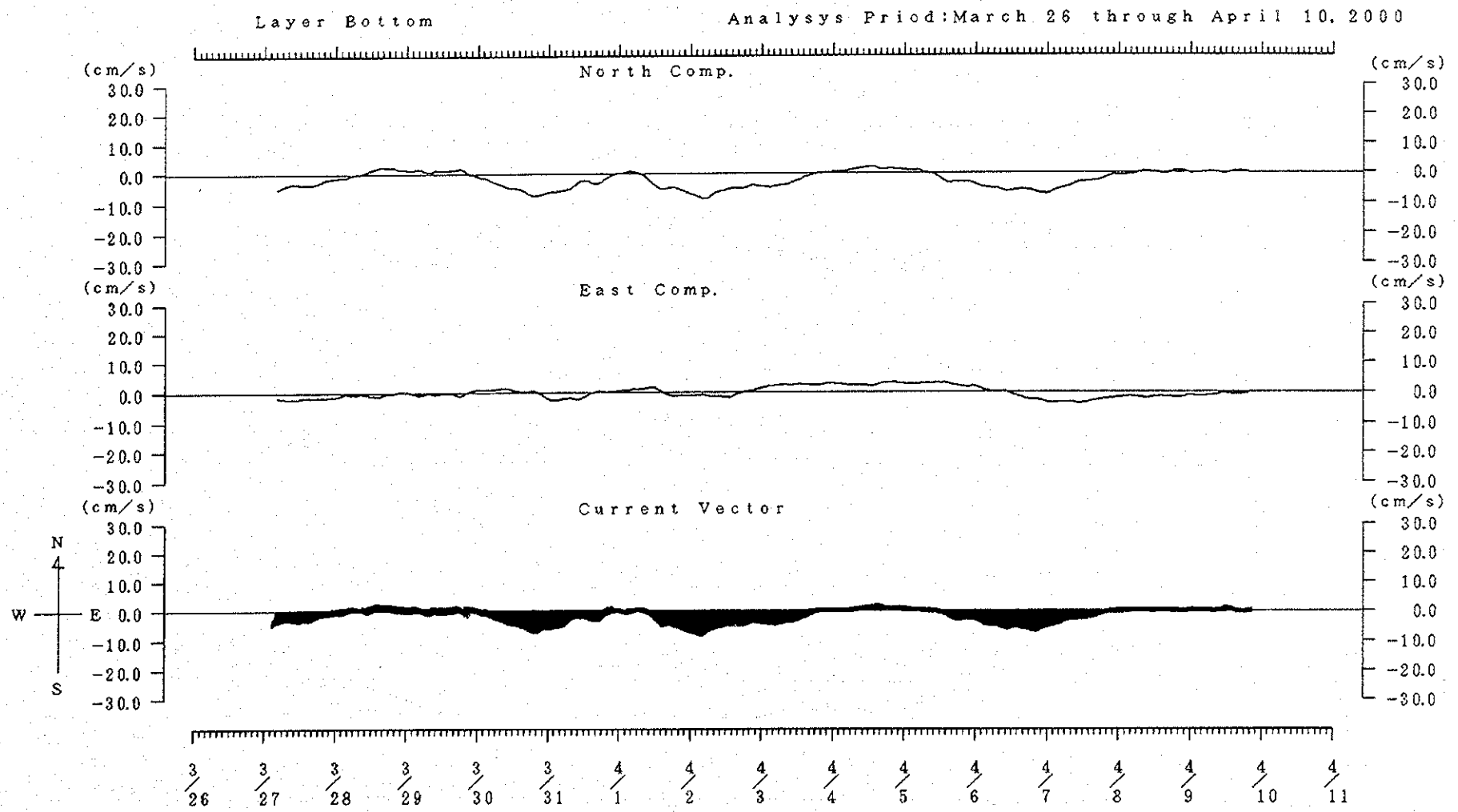


Figure 18.2.7 25 hours Running Mean Results (Bottom Layer)

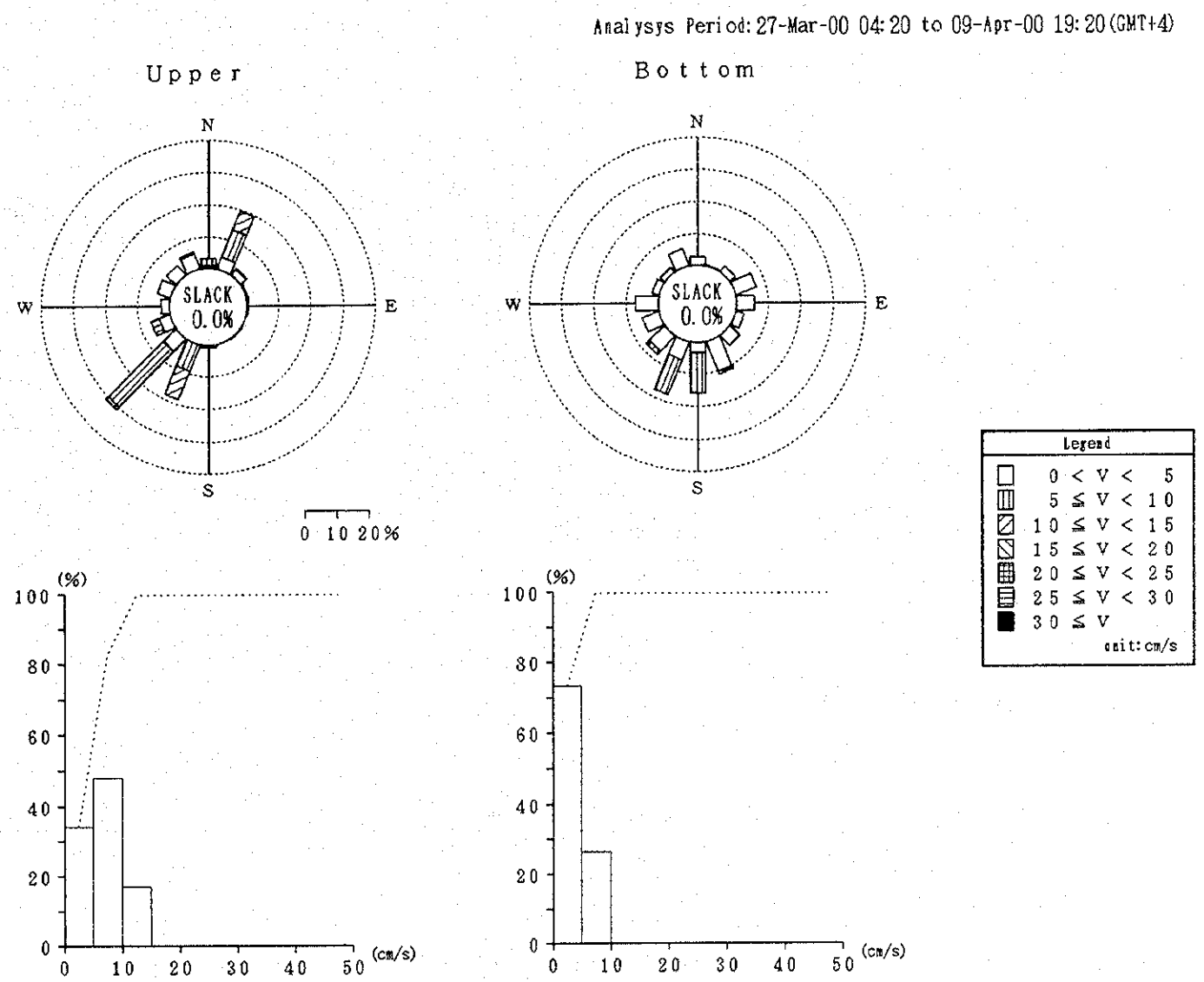


Figure 18.2.8 Current Rose (25 hours run)

Table 18.2.3 Observed Current Appearance Table (25 hours run)

Analysys Period: 27-Mar-00 04:20 to 09-Apr-00 19:20 (GMT+4)

Upper

Dir. \ Cur.	0.0≤ < 5.0	5.0≤ < 10.0	10.0≤ < 15.0	15.0≤ < 20.0	20.0≤ < 25.0	25.0≤ < 30.0	30.0≤ (cm/s)	Sum	Mean
-	0 -							0 -	-
N	8 0.8	24 2.4	0 -	0 -	0 -	0 -	0 -	32 3.3	6.5
NNE	40 4.1	88 9.0	64 6.5	0 -	0 -	0 -	0 -	192 19.6	7.6
NE	22 2.2	4 0.4	0 -	0 -	0 -	0 -	0 -	26 2.6	3.1
ENE	4 0.4	0 -	0 -	0 -	0 -	0 -	0 -	4 0.4	1.9
E	2 0.2	0 -	0 -	0 -	0 -	0 -	0 -	2 0.2	1.2
ESE	1 0.1	0 -	0 -	0 -	0 -	0 -	0 -	1 0.1	1.0
SE	2 0.2	0 -	0 -	0 -	0 -	0 -	0 -	2 0.2	1.1
SSE	2 0.2	0 -	0 -	0 -	0 -	0 -	0 -	2 0.2	1.6
S	8 0.8	0 -	0 -	0 -	0 -	0 -	0 -	8 0.8	3.4
SSW	1 0.1	86 8.8	94 9.6	0 -	0 -	0 -	0 -	181 18.4	10.1
SW	54 5.5	236 24.0	12 1.2	0 -	0 -	0 -	0 -	302 30.8	7.2
WSW	35 3.6	28 2.9	0 -	0 -	0 -	0 -	0 -	63 6.4	4.5
W	26 2.6	0 -	0 -	0 -	0 -	0 -	0 -	26 2.6	3.0
WNW	44 4.5	0 -	0 -	0 -	0 -	0 -	0 -	44 4.5	2.9
NW	40 4.1	0 -	0 -	0 -	0 -	0 -	0 -	40 4.1	3.4
NNW	49 5.0	8 0.8	0 -	0 -	0 -	0 -	0 -	57 5.8	3.8
Sum	338 34.4	474 48.3	170 17.3	0 -	0 -	0 -	0 -	982 100.0	6.7

Missing Records: 0
Percentage of Samples: 100.0%

Bottom

Dir. \ Cur.	0.0≤ < 5.0	5.0≤ < 10.0	10.0≤ < 15.0	15.0≤ < 20.0	20.0≤ < 25.0	25.0≤ < 30.0	30.0≤ (cm/s)	Sum	Mean
-	0 -							0 -	-
N	27 2.8	0 -	0 -	0 -	0 -	0 -	0 -	27 2.8	1.4
NNE	3 0.3	0 -	0 -	0 -	0 -	0 -	0 -	3 0.3	0.9
NE	22 2.2	0 -	0 -	0 -	0 -	0 -	0 -	22 2.2	2.4
ENE	67 6.8	0 -	0 -	0 -	0 -	0 -	0 -	67 6.8	2.6
E	54 5.5	0 -	0 -	0 -	0 -	0 -	0 -	54 5.5	2.2
ESE	25 2.5	0 -	0 -	0 -	0 -	0 -	0 -	25 2.5	2.3
SE	42 4.3	0 -	0 -	0 -	0 -	0 -	0 -	42 4.3	2.8
SSE	100 10.2	9 0.9	0 -	0 -	0 -	0 -	0 -	109 11.1	3.9
S	34 3.5	122 12.4	0 -	0 -	0 -	0 -	0 -	156 15.9	5.7
SSW	61 6.2	114 11.6	0 -	0 -	0 -	0 -	0 -	175 17.8	5.4
SW	64 6.5	15 1.5	0 -	0 -	0 -	0 -	0 -	79 8.0	3.4
WSW	55 5.6	0 -	0 -	0 -	0 -	0 -	0 -	55 5.6	1.5
W	70 7.1	0 -	0 -	0 -	0 -	0 -	0 -	70 7.1	1.4
WNW	23 2.3	0 -	0 -	0 -	0 -	0 -	0 -	23 2.3	1.2
NW	18 1.8	0 -	0 -	0 -	0 -	0 -	0 -	18 1.8	1.3
NNW	57 5.8	0 -	0 -	0 -	0 -	0 -	0 -	57 5.8	1.5
Sum	722 73.5	260 26.5	0 -	0 -	0 -	0 -	0 -	982 100.0	3.5

Missing Records: 0
Percentage of Samples: 100.0%

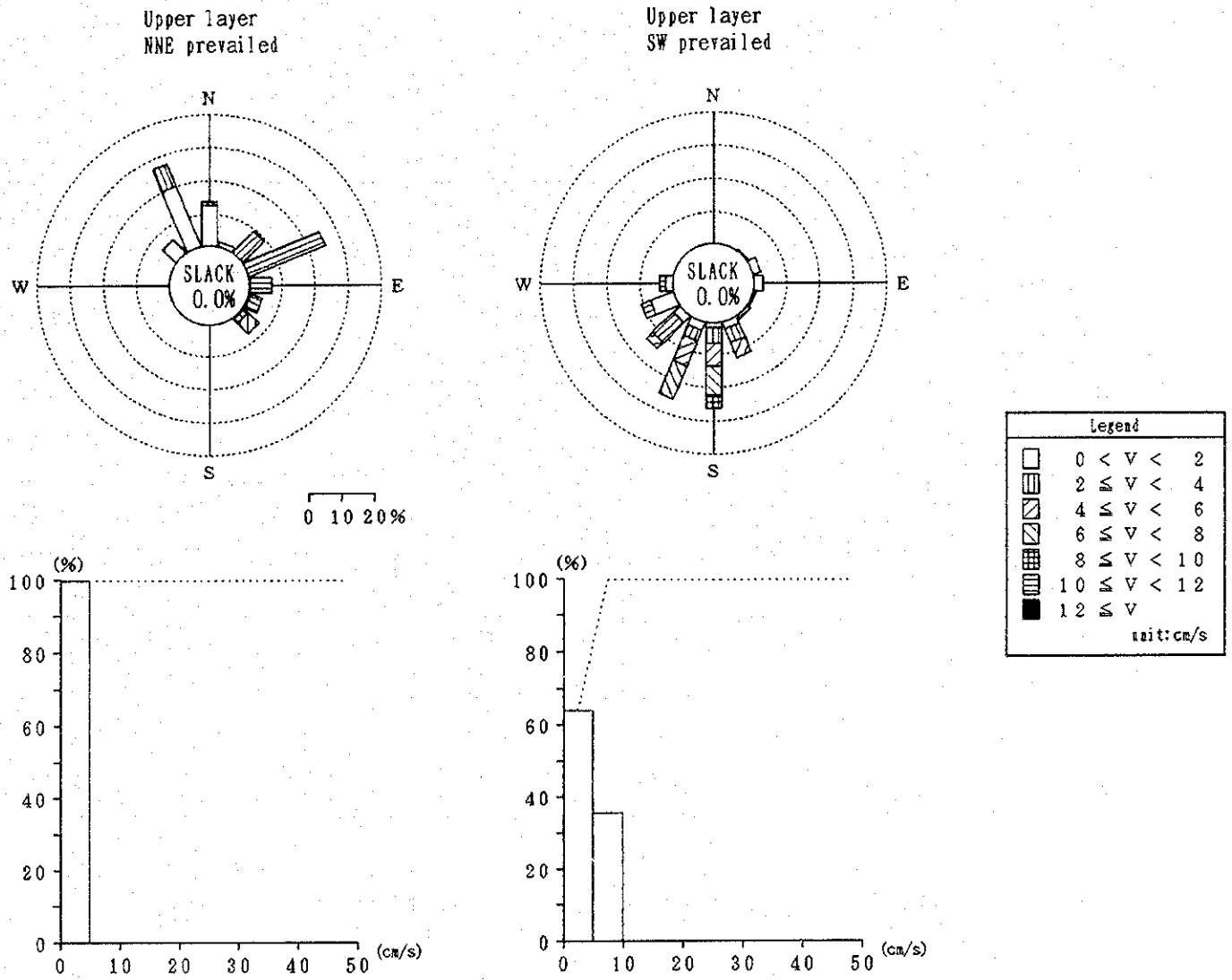


Figure 18.2.9 Current Rose (25 hours run) : NNE & SW Prevailed

Table 18.2.4 Observed Current Appearance Table (25 hours run): NNE & SW Prevailed

Upper Layer
NNE prevailed

Dir. \ Cur.	0.0≤ < 2.0	2.0≤ < 4.0	4.0≤ < 6.0	6.0≤ < 8.0	8.0≤ < 10.0	10.0≤ < 12.0	12.0≤ (cm/s)	Sum	Mean
-	0 -							0 -	-
N	24 12.5	2 1.0	0 -	0 -	0 -	0 -	0 -	26 13.5	1.4
NNE	3 1.6	0 -	0 -	0 -	0 -	0 -	0 -	3 1.6	0.9
NE	0 -	18 9.4	0 -	0 -	0 -	0 -	0 -	18 9.4	2.8
ENE	0 -	48 25.0	0 -	0 -	0 -	0 -	0 -	48 25.0	3.0
E	0 -	13 6.8	0 -	0 -	0 -	0 -	0 -	13 6.8	2.8
ESE	1 0.5	7 3.6	0 -	0 -	0 -	0 -	0 -	8 4.2	2.9
SE	1 0.5	3 1.6	9 4.7	0 -	0 -	0 -	0 -	13 6.8	3.9
SSE	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
S	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
SSW	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
SW	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
WSW	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
W	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
WNW	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
NW	11 5.7	0 -	0 -	0 -	0 -	0 -	0 -	11 5.7	1.3
NNW	38 19.8	14 7.3	0 -	0 -	0 -	0 -	0 -	52 27.1	1.5
Sum	78 40.6	105 54.7	9 4.7	0 -	0 -	0 -	0 -	192 100.0	2.2

Missing Records: 0
Percentage of Samples: 100.0%

Upper Layer
SW prevailed

Dir. \ Cur.	0.0≤ < 2.0	2.0≤ < 4.0	4.0≤ < 6.0	6.0≤ < 8.0	8.0≤ < 10.0	10.0≤ < 12.0	12.0≤ (cm/s)	Sum	Mean
-	0 -							0 -	-
N	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
NNE	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
NE	1 0.3	0 -	0 -	0 -	0 -	0 -	0 -	1 0.3	0.8
ENE	7 2.3	0 -	0 -	0 -	0 -	0 -	0 -	7 2.3	1.0
E	8 2.7	0 -	0 -	0 -	0 -	0 -	0 -	8 2.7	0.6
ESE	2 0.7	0 -	0 -	0 -	0 -	0 -	0 -	2 0.7	0.4
SE	3 1.0	1 0.3	0 -	0 -	0 -	0 -	0 -	4 1.3	1.2
SSE	7 2.3	14 4.6	15 5.0	0 -	0 -	0 -	0 -	36 11.9	3.3
S	5 1.7	15 5.0	21 7.0	26 8.6	12 4.0	0 -	0 -	79 26.2	5.7
SSW	8 2.7	11 3.6	25 8.3	33 10.9	0 -	0 -	0 -	77 25.5	5.0
SW	8 2.7	27 8.9	8 2.7	0 -	0 -	0 -	0 -	43 14.2	2.8
WSW	23 7.6	9 3.0	0 -	0 -	0 -	0 -	0 -	32 10.6	1.7
W	7 2.3	6 2.0	0 -	0 -	0 -	0 -	0 -	13 4.3	1.9
WNW	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
NW	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
NNW	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-
Sum	79 26.2	83 27.5	69 22.8	59 19.5	12 4.0	0 -	0 -	302 100.0	3.9

Missing Records: 0
Percentage of Samples: 100.0%

d) Results of Analysis

(i) Harmonic Constituents

K1 component was predominant and then M2, and O1 components were prevailed.

(ii) Harmonic Tidal Analysis

K1 component was predominant and then M2, O1, and diurnal components were prevailed.

(iii) 25 Hours Running Mean

i) Prevailing currents in NNE and SW were recognized.
- Six (6) consecutive days were NNE current, and eight (8) consecutive days were SW current.
- NNE and SW currents changed reciprocally within two (2) to four (4) days interval.

ii) Mean current speed for upper layer of these currents was 7cm/s, and it was larger than K1: a 5.7 cm/s in major axis.

iii) This current is not negligible because of its current speed as well as its pattern of appearance as stated above.

2) Other Oceanographic Factors

(a) Sea Surface Water Temperature

Except SW Monsoon season during June through September, a sea surface water temperature (SST) is relatively high ranging 25 ℃ to 28 ℃. During SW monsoon season, temperature is dropped to around 20 ℃ due to the influence of upwelling caused by SW monsoon prevailing wind.

(b) Salinities

Salinity is relatively high around 39.00‰ to 39.28‰ based on the survey results of the Study.

(4) Rich Fishery Resources and Other Habitats

Based on the interview with the concerned parties, there is no available data archive and/or writing describing fishery resources and marine mammals within the Study Area. Although there were more than thirty (30) of fish observed in the Study Area.

18.3 Shore Region

As described in the previous section, an ocean climate, especially wave climate with seasonal variations, are very important factor affecting shore region. Furthermore, an offshore-ward current was observed at the bottom layer that implies offshore ward littoral drift.

Presence of shoreline erosion and also mangrove lagoon are closely related to previously mentioned factors with tidal range level as discussed in this section.

(1) Shoreline Erosion

1) Data Archive
Some peculiarity of the beach erosion and sedimentations has already been pointed out by the coastal management study of Oman coast in early 1990's; however, a base line data such as beach profiling, sounding along the coast, and aero photo along the shore region for monitoring long-term shoreline change are insufficient.
2) Season
Coastal erosion annually starts in early May, and it develops as SW monsoon pronounced in late July.
3) Conditions
Seasonal fluctuation of up to 80 m in the shoreline position in the vicinity of Holiday Inn was recorded by beach profiling, for instance.

(2) Mangrove Lagoon

1) Present Conditions

(c) Sites
Khawr Al Qurm Kabir and its neighbor next to the Salalah Hilton Hotel which is situated about 4 km northeast of the Salalah Port north boundary.
(d) Settings to their Surroundings
a) Settings
These mangroves are cut off from the sea by sand barrier. The sand barrier of both mangroves is relatively low relief and change relief and shape seasonally: relatively low and close to strand line in SW monsoon, the high time of coastal erosion occur toward inland with landward monsoon wind and upwelling that causes sea level higher near shore line.
b) Influence of River and Surface Water
There is almost no influence of river since no river but only wadi exist, and also almost no surface water influence charging fresh water to the mangroves except meteorological events such as cyclone hit and/or flash flood that occur only few in decades in the Study Area.

c) Dominant Factor

SW monsoon wave that causes inland ward coastal erosion is a dominant factor for their settings. During SW monsoon season, they experience a fresh seawater charge directly from the sea or flash over the sand barrier at high tide that is very rare occasion during NW monsoon season, a dry and calm wave climate season.

(c) Structure and Habitats

a) Structure

A homogeneous, single species is present: *Avecennia marina.*

b) Habitats

Seasonal variations of their habitats are recognized: NE monsoon season is much diversity of habitats in birds due to a dry relative low temperature.

2) Conservation and Preservation

(a) Nation's Concern

They are protected as Nature Reserves and Scenic Reserves (SR9) by Royal Decree 49/97 and fenced off by their surroundings to protect them.

(b) Reality

Although these mangroves are well protected by fence, the following problem has been pointed out for over decades and remained unsolved.

a) Dumping construction debris and waste materials
b) Utilizing as goat and camel grazing land
c) Utilizing as recreational place such as rolling boat

(3) Tides

1) Tidal Components

Tidal components of the Salalah Port are officially released annually from the National Hydrographic Office (NHO), Royal Navy Oman (RNO) as Sultanate of Oman Tide Tables. The following Table shows the tidal components of the Salalah Port.

Table 18.3.1 Tidal Harmonic Constituents (Salalah)

Harmonic Constituent	G (degree)	H (meters)
M_2	260	0.31
S_2	288	0.12
K_1	044	0.36
O_1	043	0.18
Z_0		1.30

2) Tidal Level

Several tidal levels have been utilized for Salalah region for port construction and nautical chart production as shown in Fig. 18.3.1. Based on the vertical datum comparison of Mina Raysut during 1981 through 1997 and Salalah Port construction plan, the following tidal level is adopted for the vertical control for the Study.

M.H.H.W.	**+1.68m**
M.S.L.	**+1.30m**
M.L.L.W.	**+0.60m**

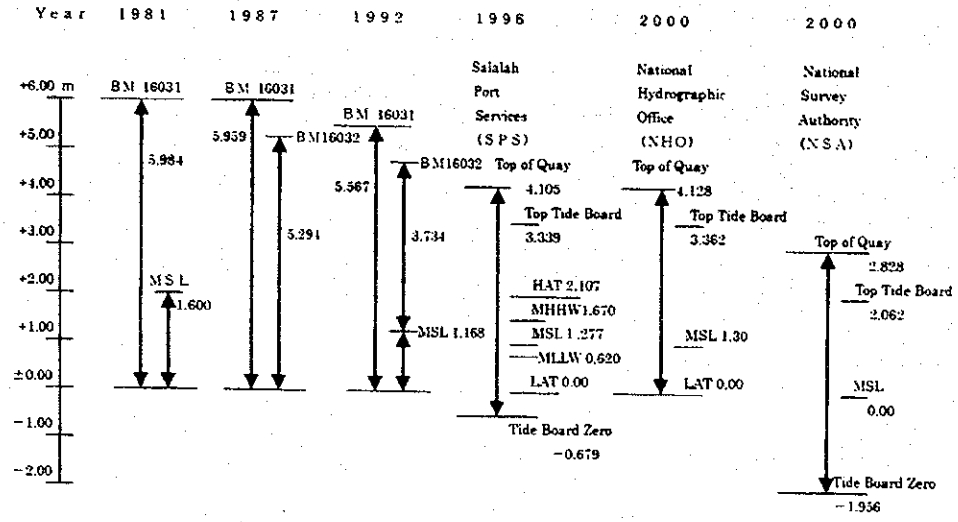


Fig. 18.3.1 Comparison of Vertical Datum
(Source: NHO, 1998 and HPA, 1996)

18.4 Hinterland Region

(1) Wadi

1) Geographical Settings

There are ten (10) major wadis located on the Salalah Plain, and six (6) of them are located on the Study Area as shown in Fig. 18.4.1. Their geographical conditions from upstream to down stream are classified and shown in the following Table.

Table 18.4.1 Geographical Classifications of Wadi in the Study Area

Classification	Geological Features	Wadi Features
Jebel Mountain Range Jebel Al Qamr & Jebel Al Qara	a) NW to NE oriented crescent shaped enclosure to the Salalah Plain b) 800 m to 1,500 m height above sea c) Southern slope is steep	**UPSTREAM** a) Narrow wadis incise deeply b) Fairly steep stream
Jerbeeb High	a) Base of Jebel connecting both mountain range and plain b) Elevations: 50m to 150m	**MIDSTREAM** a) Wider wadis incising on their course b) Relatively steep stream
Salalah Plain	a) 800 km^2 bounded to the north by the Jebel Al Qamr and to the south by the Arabian Sea. b) Almost half area: Study Area c) Elevation: less than 50 m.	**DOWN STREAM** a) Much wider streams cross the Plain to meet the sea b) Passing through residential area and/or crossing road

2) Their Role to the Environment

Except flood caused by some meteorological events such as typhoon hit and/or heavy rain recorded for the past decades in the Dhofar region (PAWR in 1983 and MWR in 1996), wadis are normally dried up, no water, except a coastal region where lagoons or tidal inlets exist; therefore, it does not transport any sediments, debris on the land, and effluent from upstream to the coastal water region which may have an potential impact to the coastal environment.

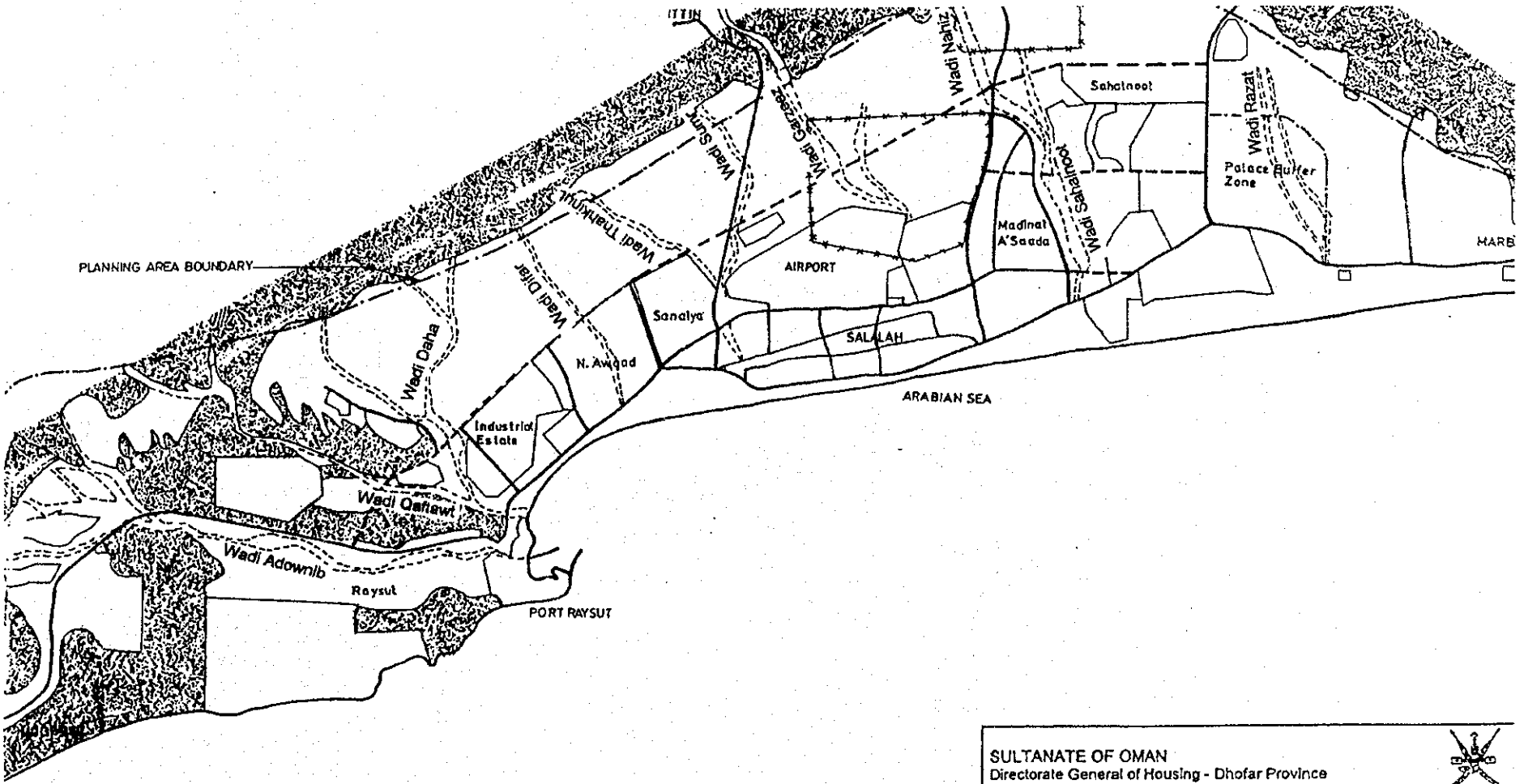


Figure 18.4.1 Major Wadis Locations

SULTANATE OF OMAN
Directorate General of Housing - Dhofar Province
Department of Planning & Survey

Project: Revision of SALALAH STRUCTURE PLAN

Figure 10-7

Title: MAJOR WADIS

NATIONAL ENGINEERING OFFICE
ARCHITECTS & CONSULTING ENGINEERS, SULTANATE OF OMAN

3) Present Conditions and Problems

Since there is no sufficient monitoring data and/or archive of wadis in the Salalah Plain at present, only reliable source is the record of some meteorological events such as flood caused by heavy rain that was recorded only few in decades for the past.

Except some meteorological events or occasion like a flood in 1983 and a cyclone hit in 1996, there is no trace of record and analysis on discharging effluent, contaminated storm runoff, and/or sediment from the land to the coastal water region.

(2) Flood Risk

1) Present Analysis

(a) Data Source and Analysis Level

Flood data are available for several MWR wadi-gauging stations in Dhofar; however, the data for Salalah region is very scarce and insufficient to predict flood frequencies and characteristics within an acceptable degree of confidence according to MWR report (1996).

(b) Available Source

Based on the most updated information provided from MWR, there are four (4) available reports and note regarding flood. These are,

a) Flood Risk Map for Salalah (1993, MWR)
b) Rainfall Intensity Frequencies (Analysis in progress, MWR)
c) Flood Alleviation after 1996 Cyclone (MWR)
d) Note on Flooding Advice for Al Wusta Highway (1999, MWR)

(c) Conditions and Interpretations

a) Flood Data and describing flood frequencies in the Study Area is scarce, almost none to describe the flood conditions. Data relevant to flooding of Salalah is only available in the eastern portion of Salalah such as Wadi Jarziz, Wadi Sahalnawt, and Wadi Arzat where a much precipitations are expected during SW monsoon season compared to the western portion of Salalah. One interesting report by MWR of Salalah describes a little or no flow occurs at west of Wadi Nahiz.

b) Rainfall intensity study of Salalah has been in progress; therefore, there is no data accumulation to provide character of the rainfall intensity at present. For southern region, no rainfall intensity charts are available; however, the Raysut Industrial Estate Project has designed their storm drainage system by using and evaluating the following Meteorological station data in Mina Raysut.

Table 18.4.2 Rainfall Intensity for Storm Water Drainage

Time of Concentration	Return Period			
	2 years		10 years	
	mm/hr	l/s/ha	mm/hr	l/s/ha
10 min.	60	165	140	385
20 min.	40	110	100	275
1 hr	20	55	60	165
2 hrs	15	40	36	100

Source: Raysut Industrial Estate Project Detail Master Plan Final Report (1989)

Remarks: Calculation was made based on a rather limited amount of existing data.

Based on this table, a 10 years one was adopted as the return period; and the time for concentration was calculated based on the Kirpich's Formula as 20 minutes for their Estate design for the storm water drainage.

c) Design floods have already been assessed for the catchments areas upstream of the Royal Properties. This assessment and the Airport Interceptor for flood protection are available design flood study so far. This maybe only a useful source that can infer the flood conditions for Salalah area; however, it is recommended to concern a local peculiarity of east and west of Salalah.

d) Flood frequency curves for Oman was developed in 1991 by MWR Surface Water Department and applied for highway culvert design and flood zoning for town planning. Some overestimated trends outcomes and revise has been made to this curve; however, MWR has applied this to Dhofar flood characteristics recently concluding inconclusive due to an insufficient data accumulation.

e) Flood Frequency for Royal Properties, Razat and Wadi Jarziz near Air Port

(i) 10 year return period: 344 / 425 (m^3/s)

(ii) 20 year return period: 500 / 621 (m^3/s)

(iii) 50year return period: 867 / 1,074 (m^3/s)

The drainage area for Razat and Wadi Jarziz are as follows.

(i) Razat: 71 (Km^2)

(ii) Wadi Jarziz: 104 (Km^2)

2) Major Concern

(a) Planning and Designing for Land Use and Construction

a) Flood Risk Maps for Salalah (1993) is useful means of flood-prone locations for allocating space of land for future planning even though the base data for analysis has mainly been used for the areas of Northern Oman and tend to overestimated flood peak and somewhat underestimated return period of flood on the map. Fig. 18.4.2 shows a part of Flood Risk Map in the Study Area.

b) Flood Alleviation after 1996 Cyclone (MWR) and Note on Flooding Advice for Al Wusta Highway are useful means to apply for a design drainage rates and flood derivation at present.

(b) Environment Impact on the Shore Region and Coastal Water Region

There is no available or sufficient data, record, and/or sources of information for describing and evaluating the impact onto the environment within the Study Area.

(3) Ground Water and Water Table

1) Present Situations

(a) Water Resources Management

a) Water Assessment Areas (WAA)

(i) For the purpose of water resources management, a five (5) Water Assessment Areas (WAA) are plotted to the Dhofar regions.

(ii) One of WAA is the Salalah, and there are eight (8) water assessment unit areas with Salalah Port and city located within the Salalah Plain West and Salalah Plain Central units.

(iii) The Study Area is located in Salalah Plain West and Central. Their location is shown in the map of Salalah WAA unit areas in Fig. 18.4.3.

b) Water Supply Well Field Protection Zone

The ground water is the only source of water supply in Salalah. The supply well filed protection zone was established and regulate the water resource development of Salalah region. Fig. 18.4.4 and Table 18.4.3 show the protection zones and their regulations.

(b) Status of Supply and Demands in Salalah WAA (Summary in 2000, MWR)

a) Water Supply

(i) The primary source of recharge to groundwater within the WAA is from rainfall, mostly during the annual monsoon and by occasional cyclonic fronts.

(ii) Mean annual precipitation ranges from less than 100 to more than 300mm on the Plain and Jebal respectively.

r Salalah Port (1993)

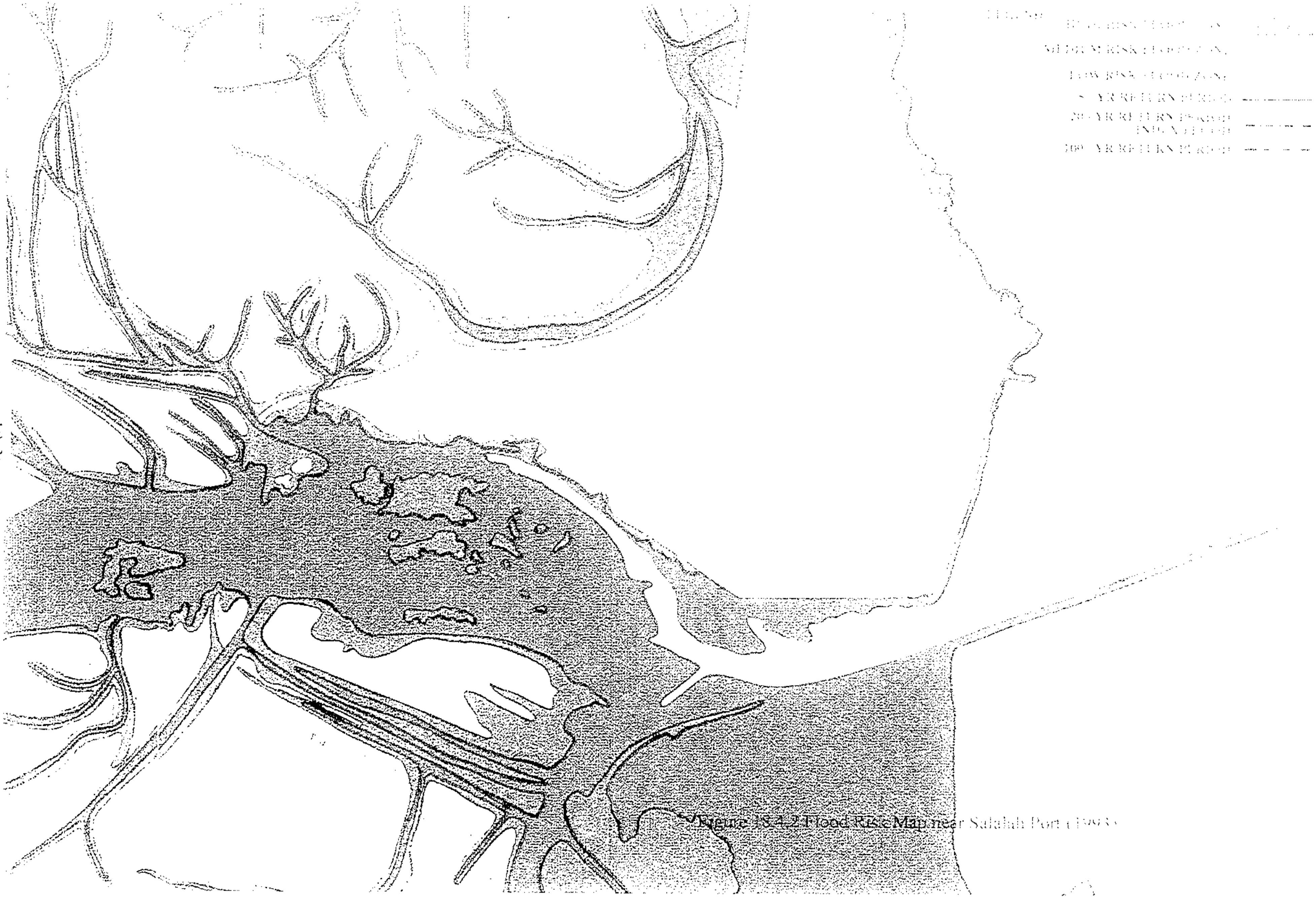


Figure 18.4.2 Flood Risk Map near Salalah Port ([illegible])

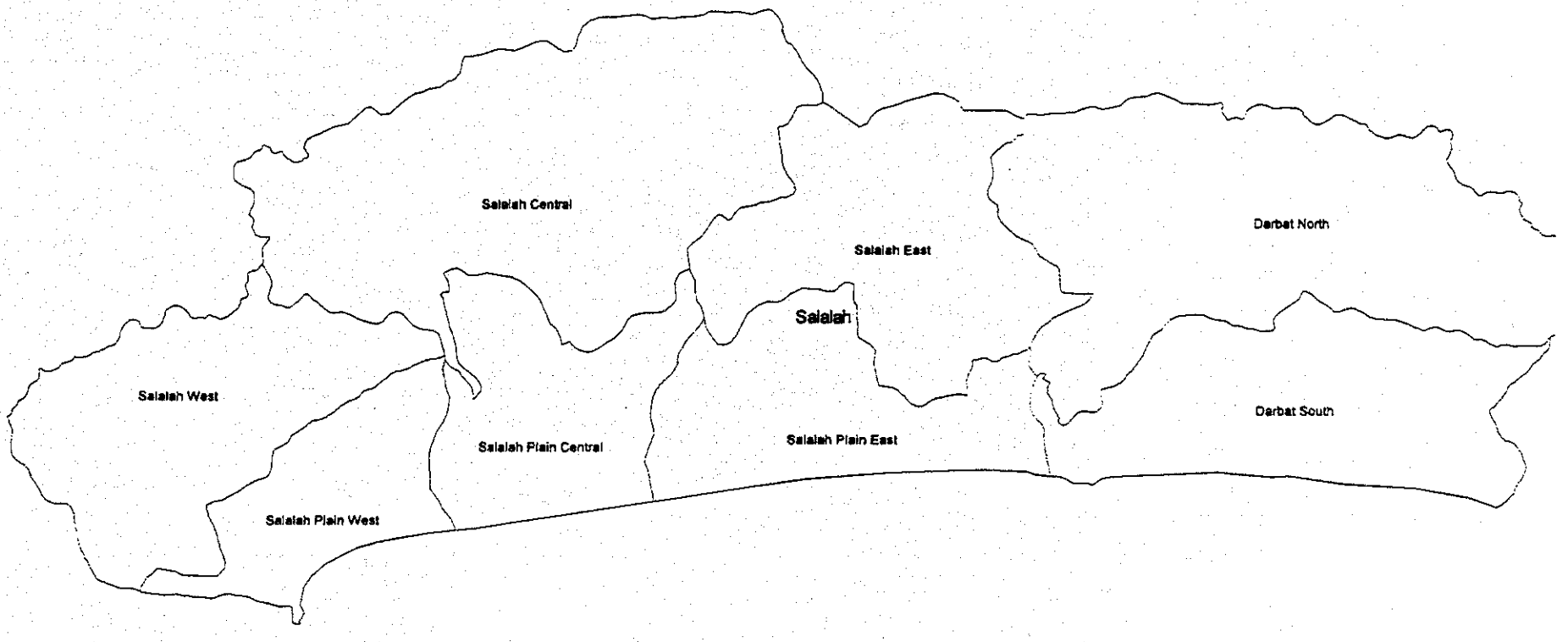


Figure 18.4.3 Water Assesment Unit Areas of Salalah WAA

Figure 18.4.3 Water Assesment Unit Areas of Salalah WAA