Tables and Figures for Chapter 3

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Table 3.1-1 Land Use Distribution in Project Area

Location	Land Use Types	Areal Coverage	
		km²	%
Area A: Site Area to the road	- Grassland	0.383	66.84
Total Area of 0.573 km²	- Brush / secondary forest	0.110	19.20
	- Pond	0.038	6.63
	- Sea	0.024	4.19
	- Sand bank	0.012	2.10
	- Sand dune	0.004	0.70
	- Sand pit	0.001	0.17
	- Residential area	0.001	0.17
Area B: Fuel pipeline	- Grassland	0.174	59.59
Total Area of 0.292 km²	- Industrial / built up	0.088	30.14
	- Sand bank	0.016	5.48
	- Residential area	0.014	4.79
Area C: 30-km radius from the site	- Forest	555.988	58.18
Total Area of 955.58 km²	- Agricultural land	135.027	14.13
	- Grassland	127.559	13.35
	- Shrubland	114.722	12.01
	- Soils & rocks	18.194	1.90
	- Urban, built up	2.998	0.31
	- Water features	1.092	0.11
Area D: Laydown area for Unit 3.	- Grassland	0.0889	74.96
Total Area of 0.1186 km²	- Forest	0.0295	24.87
	- Residential area	0.0002	0.17

Table 3.6-1 List of Fish Species Found in the Dry and Wet Seasons in the Reservoir **near the Hun Sen Dam closeed to Stung Hav Village (*WAQF1*)**

Family / Species	WAQ_F1			
	English Common Name	Number (Individual)	Total Length (min. - max.) (cm.)	Total Weight (g)
DRY SEASON				
30 November - 2 December 2000				
Family Clarridae				
Clarias macrocephalus	Gunther's walking catfish	1	18.4	51.9
Family Anabarrtidae				
Anabas testudineus	Common climbing perch	1	16.5	112.4
Trichogaster trichopterus	Spoted gourami	1	7.5	7.6
Family Channidae				
Channa striata	Snake-head fish	2	25-26	343.6
Channa lucius	Blotched snake-head fish	2	23-24.5	286.6
Family Cyprinidae				
Cycloheilichthys apogon	Indian river barb	2	12-16	87.6
Puntius orphoides	Red-cheek brab	2	10-12	45.4
Total 4 families 7 species		**11**	**7.5-26.0**	**935.1**
WET SEASON				
11-18 June 2001				
Family Channidae				
Channa striata	Snake-head fish	1	20.0	92.0
Channa lucius	Blotched snake-head fish	4	24-30	893.7
Family Cyprinidae				
Puntius brevis	Golden little barb	27	9.0-12.0	463.8
Cirrhinus spilopleura	Carp	11	9.0-13.0	231.8
Family Clariidae				
Clarias macrocephalus	Gunther's walking catfish	1	22.0	76.8
Clarias batrachus	Batrachian walking catfish	1	30.0	248.3
Family Anabantidae				
Trichogaster trichopterus	Spoted gourami	2	8.0	17.4
Total 4 families 7 species		**47**	**8.0-30.0**	**2,023.3**

Table 3.6-2 List of Fish Species **Found in the** *Dry and Wet Seasons* **in the Prey Treng Pond***(WAQF3)*

Family / Species	WAQ_F3			
	English Common Name	Number (Individual)	Total Length (min. - max.) (cm.)	Total Weight (g)
DRY SEASON				
(3-5 December 2000)				
Family Cyprinidae				
Puntius orphoides	Red-cheek barb	14	9.5-12.5	224
Cycloheilichthys apogon	Indian river barb	13	9.5-11.5	208.8
Family Clarridae				
Clarias batrachus	Batrachian walking catfish	1	26	134.3
Family Anabantidae				
Trichogaster trichopterus	Spoted gourami	24	7.0-8.5	188.5
Family Chichlidae				
Oreochromis niloticus	Nile tilapia	11	9.0-16.5	353.5
Total 4 families 5 species		**63**	**7.0-26.0**	**1,109.1**
WET SEASON				
(16-18 June 2001)				
Family Chichlidae				
Oreochromis mossambica	Jiva tilapia	12	10.0-21.0	757.3
Family Clariidae				
Clarias batrachus	Batrachian walking catfish	4	16.5-25.0	374.7
Clarias macrocephalus	Gunther's walking catfish	1	28.0	247.5
Family Cyprinidae				
Puntius brevis	Golden little barb	3	10.5-12.5	65.1
Family Anabantidae				
Trichogaster trichopterus	Spot gourami	3	8.5-9.5	39.6
Family Centropomidae				
Ambassis kopsi	Glass fish	1	10.0	13.8
Family Channidae				
Channa lucius	Blotched snake-head fish	1	21.0	91.2
Parambassis apogonoides	Iridescent glassy perchlet	1	10.5	23.5
Total 6 families 8 species		**26**	**10.0-28.0**	**1,612.7**

Table 3.6-3 List of Species and Abundance of Aquatic Plants Commonly Found in the Dry and Wet Seasons

Family / Scicentific Name	Dry Season			Wet Season		
	WAQ_F1	WAQ_F2	WAQ_F3	WAQ_F1	WAQ_F2	WAQ_F3
Lentibulariaceae						
Utricularia aurea	-	-	-	++	-	-
Cyperaceae						
Eleocharis dulcis	+++	-	+++	+++	-	+++
Numphaeaceae						
Nymphaea stellata	++	-	+	++	-	+
Cheratophyllaceae						
Ceratophyllum demersum	+++	+	+++	+++	+	+++
Hydrocharitaceae						
Vallisneria spiralis	++	-	-	++	-	-
Polypodiaceae						
Acrostichum aurcum	+	-	++	+	-	++
Gramineae						
Panicum repens	+	-	++	+	-	++
Imperata cylindrica	++	-	+++	++	-	+++
Myrtaceae						
Melaleuca leucadendra	+++	++	-	+++	++	-
Dennstaedfiaceae						
Acrostichum aureum	-	-	-	-	-	+

Remark :

WAQ_F1 = In the Reservoir near the Hun Sen Dam Close to Stueng Hav Village

WAQ_{F2} = In the Stream downstream from Hun Sen Dam

WAQ_F3 = Prey Treng Pond

Abundance : + = Low Density

++ = Medium Density

+++ = High Density

Table 3.6-4 Standard Methodology used for Water Quality Analysis

Parameters	Unit	Method of Analysis
1. In Situ Measurement[1/, 2/]		
- Colour / Odor	-	Observation Method
- Temperature	°C	Thermometer
- pH	-	pH meter
- Salinity	ppt	Hand Refractometer
- Transparency	m	Secchi Disc
- Dissolved Oxygen (DO)	mg/l	Oxygen Meter
- Depth of Water Body	m	Meter Stick
2. Analysis in Laboratory		
- Turbidity[1/,2/]	NTU	Nephelometric Method
- Total Hardness[1/]	mg/l $CaCO_3$	EDTA Titrimetric Method
Total Hardness Solids[2/]	mg/l	Dried at 180 °C
- Total Suspended Solids[1/,2/]	mg/l	Dried at 103-105 °C
- Total Solids[1/]	mg/l	Dried at 103-105 °C
- Alkalinity[1/]	mg/l	Titrimetric Method
- Carbon Dioxide[1/]	mg/l	Titrimetric Method
- Cations[1/]		
Sodium (Na)	mg/l Na	Flame AES Method
Potassium (K)	mg/l K	Flame AES Method
Calcium (Ca)	mg/l Ca	EDTA Titrimetric Method (in FY 2000) Flame AAS Method (in FY 2001)
Magnesium (Mg)	mg/l Mg	Calculation Method (in FY 2000) Flame AAS Method (in FY 2001)
Maganese (Mn)	mg/l Mn	Flame AAS Method
Iron (Fe)	mg/l Fe	Flame AAS Method
Ammonia (NH^+_4)	mg/l NH^+_4	Distillation Nesslerization Method (in FY 2000) Phenolhy Pochlorite Method (in FY 2001)
- Anions[1/]		
Chloride (Cl^-)	mg/l Cl	Argentometric Method
Bicarbonate (HCO^-_3)	mg/l $CaCO_3$	Titrimetric Method
Sulfate (SO_4^{2-})	mg/l SO^{2-}_4	Tubiditimetric Method
Silica (SiO_2)	mg/l SiO_2	Molybdosilicate Method
- Oil and Grease[1/,2/]	mg/l	Soxhlet Extraction Method
- Chemical Oxygen Demand[1/,2/]	mg/l	Dichromate Reflux Method
- Total Coliform Bacteria[1/,2/]	MPN/100 ml	Multiple-Tube Fermentation Technique

Remark : Water Samples were Analyzed by UAE Lab in Bangkok, This Laboratory Passes ISO/IEC Guide 25 Certification.

1/ = Parameters of Freshwater Quality

2/ = Parematers of Marine Water Quality

Table 3.6-5 Results of Freshwater Quality Analysis in the Dry and Wet Seasons

Parameters	Unit	Dry Season (FY 2000)			Wet Season (FY 2001)				
		WAQ_Y1	WAQ_Y2	WAQ_Y3	$WAQ_Y1.0$	$WAQ_Y1.1$	WAQ_Y2	$WAQ_Y3.0$	$WAQ_Y3.1$
1. In Situ Measurement									
- Colour / Odor	-	yellowish/ no odor	yellowish/ no odor	yellowish/ no odor	yellowish/ no odor	yellowish/ no odor	yellowish/ no odor	yellowish/ no odor	yellowish/ no odor
- Temperature	°C	28	28.5	30.0	29	29	29	32	33
- pH	-	7.3	7.4	9.0	5.7	5.4	7.4	6.9	7.1
- Salinity	ppt	0	7	0	0	0	0	0	0
- Transparency	m	2.0	2.0	1.3	1.5	1.1	0.9	2.2	2.1
- Dissolved Oxygen (DO)	mg/l	4.2	5.0	5.3	6.1	4.8	6.4	6.8	6.2
- Depth of Water Body	m	2.5	2.0	1.3	1.5	1.1	1.3	2.2	2.1
2. Analysis in Laboratory									
- Turbidity	NTU	2.6	1.9	3.2	4.03	3.6	-	3.6	2.9
- Total Hardness	mg/l $CaCO_3$	12.0	2,000	12.0	4.04	6.06	-	8.08	8.08
- Total Suspended Solids	mg/l	3.3	10.5	1.0	2.5	4.5	-	2.0	1.5
- Total Solids	mg/l	128.0	12,732.0	65.0	14.0	34.0	-	36.0	18.0
- Alkalinity	mg/l	-	-	-	4.14	4.14	-	2.07	4.14
- Carbon Dioxide	mg/l	3.87	7.04	2.11	-	-	-	-	-
- Cations									
Sodium (Na)	mg/l Na	4.207	4,039.554	3.142	2.20	1.97	-	2.60	2.45
Potassium (K)	mg/l K	0.543	208.335	0.809	0.124	0.154	-	0.315	0.351
Calcium (Ca)	mg/l Ca	ND	27.25	ND	ND	ND	-	ND	ND
Magnesium (Mg)	mg/l Mg	2.92	403.38	2.92	0.98	1.47	-	1.96	1.96
Maganese (Mn)	mg/l Mn	ND	ND	<LOQ	ND	ND	-	ND	ND
Iron (Fe)	mg/l Fe	0.870	0.121	0.918	0.853	0.535	-	0.731	0.732
Ammonia (NH^+_4)	mg/l NH^+_4	0.195	0.624	0.185	0.12	0.08	-	0.14	0.11
- Anions									
Chloride (Cl)	mg/l Cl	3.33	5,831.0	4.76	4.85	4.12	-	5.82	5.82
Bicarbonate (HCO^-_3)	mg/l $CaCO_3$	12.0	2000.0	12.0	4.14	4.14	-	2.07	4.14
Sulfate (SO_4^{2-})	mg/l SO^{2-}_4	1.9	721.5	3.1	3.8	3.5	-	2.1	3,783.0
Silica (SiO_2)	mg/l SiO_2	1.93	1.3	28.0	3.23	3.32	-	4.06	3.83
- Oil and Grease[1/2/]	mg/l	ND	ND	ND	ND	ND	-	ND	ND
- Chemical Oxygen Demand	mg/l	16.97	59.88	35.93	5.98	11.95	-	37.85	5.98
- Total Coliform Bacteria[1/2/]	MPN/100 ml	46	1,600	23	49	33	1,600	33	350

Remark : **FY 2000**

ND = Non-detectable (Managnese 0.03 mg/l, Calcium 2.0 mg/l, Oil and Grease < 1.0 mg/l)

<LOQ = Limit of Quantitation (Managese < 0.03 mg/l and 0.09 mg/l

- = No Analysis

WAQ_Y1 = In the reservoir near the Hun Sen Dam close to Stueng Hav

WAQ_Y2 = In the stream downstream from Hun Sen Dam

WAQ_Y3 = Prey Treng Pond

FY 2001

ND = Non-detectable (Managnese < 0.03 mg/l, Calcium <4.0 mg/l, Oil and Grease < 1.0 mg/l)

- = No Analysis

$WAQ_Y1.0$ = The middle part of the reservoir near the Hun Sen Dam close to Stueng Hav Village

$WAQ_Y1.1$ = Near the respective Hun Sen Dam close to Stueng Hav Village

$WAQ_Y2.0$ = In the stream downstream from Hun Sen Dam

$WAQ_Y3.0$ = The middle of stream near the Prey Treng Pond edge

$WAQ_Y3.1$ = Near the respective pump house in Prey Treng Pond

Source : - Field Survey by TEAM Consulting Engineering and Management Co., Ltd., December 2000 and June 2001.

- Water Quality Analysis by UAE Lab in Bangkok, Thailand.

Table 3.7-1 Summary of Abundance of Ichthyoplankton's Surveys in Dry and Wet Seasons

Date of Ichthyoplankton Sampling	Number of Ichthyoplankton / 1,000 cu.m.					
	IP1	IP2	IP3	IP4	IP5	IP6
1. 30 September 2000						
- Fish Larvae	1,496	1,528	2,329	4,073	3,557	4,206
- Fish Eggs	6,712	2,388	2,756	9,746	2,249	2,115
- Salinity (ppt)	24	25	31	30	30	31
2. 28 October 2000						
- Fish Larvae	188	181	339	593	255	519
- Fish Eggs	938	441	570	200	131	327
- Salinity (ppt)	25	26	30	26	26	25
3. 2 December 2000						
- Fish Larvae	1,064	677	1,467	1,030	1,128	1,331
- Fish Eggs	152	1,111	33	401	127	489
- Salinity (ppt)	34	34	33	32	33	34
4. 6 January 2001						
- Fish Larvae	529	679	1,712	3,145	6,439	2,068
- Fish Eggs	89	210	624	386	250	1,001
- Salinity (ppt)	33	32	35	32	32	33
5. 1 February 2001						
- Fish Larvae	374	60	1,326	548	2,633	2,835
- Fish Eggs	90	258	751	441	275	1,253
- Salinity (ppt)	34	30	32	31	30	30
6. 16 June 2001						
- Fish Larvae	184	76	104	159	387	1,067
- Fish Eggs	307	434	374	434	95	38
- Salinity (ppt)	32	34	30	31	32	33
7. 6 July 2001						
- Fish Larvae	65	67	447	982	1,326	1,035
- Fish Eggs	25	14	60	115	471	94
- Salinity (ppt)	15	15	16	16	16	16
8. 4 August 2001						
- Fish Larvae	181	275	694	1,067	1,707	1,590
- Fish Eggs	896	1,080	304	413	1,068	342
- Salinity (ppt)	24	24	24	24	24	24

Remark : Ichthyoplankton = Fish Eggs + Yolk Sac Larvae + Flexion Larvae
Fish Larvae = Yolk Sac Larvae + Flexion Larvae

Source : Field Survey by TEAM Consulting Engineering and Management Co., Ltd.

Table 3.7-2 Diversity and Abundance of Marine Benthic Animal Found in the Dry and Wet Seasons

Group / Species	Dry Season									Rainy Season								
	BT1	BT2	BT3	BT4	BT5	BT6	BT7	BT8	BT9	BT1	BT2	BT3	BT4	BT5	BT6	BT7	BT8	BT9
PHYLUM ANNELIDA																		
Class Polychaeta																		
Family Nereidae	286	264	44	66	704	264	143	22	-	264	-	-	176	44	88	-	132	88
Family Capitellidae	748	242	132	44	336	-	572	99	66	-	-	44	88	-	132	-	44	-
Family Cirratulidae	-	-	-	-	88	-	-	-	44	-	-	-	-	214	-	-	-	-
Family Glyceridae	-	220	-	66	44	110	33	-	22	-	-	-	-	-	132	-	-	-
Family Maldanidae	-	-	-	-	-	-	-	-	-	-	-	-	-	220	-	-	44	-
PHYLUM ARTHRPOPODA																		
Class Decapoda																		
Order Amphipoda																		
Family Talitridae	198	-	-	66	22	44	99	22	11	-	-	-	44	-	-	-	44	-
Order Tanaidacea																		
Family Apseudidae	-	-	-	-	-	-	11	11	22	-	-	-	-	-	-	-	44	44
PHYLUM ECHINODERMATA																		
Class Asteroidea																		
Star fish	-	-	-	-	-	-	-	-	-	-	-	44	-	-	-	-	-	-
Class Ophiuroidea																		
Brittle star	-	-	-	-	-	-	-	-	-	-	-	-	-	44	-	-	-	-
Class Holothuroidea																		
Sea cucumber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	44
PHYLUM SIPUNCULIDA																		
Peanut worms	-	-	-	-	-	-	-	-	-	-	-	-	132	-	-	-	-	-
SUPPHYLUM CEPHALOCHORDATA																		
Aphioxus	-	-	-	-	-	-	-	-	-	-	-	-	44	-	44	-	-	-
PHYLUM MOLLUSCA																		
Class Bivalvia																		
Order Eulamellibranchiata																		
Family Donacidae																		
Donax sp.	22	-	-	-	22	-	-	-	-	-	-	-	88	-	-	-	-	-
Family Veneridae																		
Meretrix sp.	-	-	-	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family Tellinidae																		
Tellina sp.	-	-	-	-	-	44	-	-	-	-	-	-	-	-	-	-	-	-
Order Taxodonta																		
Family Arcidae																		
Anadara sp.	132	-	-	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class Gastropoda																		
Order Mesogastropoda																		
Family Turritellidae																		
Turritella sp.	-	-	-	-	-	44	11	-	-	-	-	-	-	-	-	-	-	-
Total (Individuals/sq.m.)	**1,386**	**726**	**176**	**330**	**1,216**	**506**	**869**	**154**	**165**	**264**	**-**	**88**	**572**	**522**	**396**	**-**	**308**	**176**

Remark :
BT 1 = The Seabed is grey fine sand
BT 2 = The Seabed is grey fine sand
BT 3 = The Seabed is grey fine sand
BT 4 = The Seabed is grey fine sand
BT 5 = The Seabed is grey fine sand
BT 6 = The Seabed are grey fine sand and shell
BT 7 = The Seabed are grey coarse sand and shell
BT 8 = The Seabed are grey fine sand, clay and shell
BT 9 = The Seabed are grey fine sand, clay and shell

Source : Field Survey by TEAM Consulting Engineering and Management Co., Ltd., December 2000 and June 2001.

Table 3.7-3 Results of Seabed Sampling in the Wet Season, June 16, 2001

Parameters	Unit	Sampling Station			
		SB 1.0	SB 1.1	SB 2.0	SB 2.1
Analysis in Laboratory					
- Sample Condition	-	Gray Sand	Gray Sand	Gray Sand	Gray Sand
- Moisture Content	%	38.9	31.6	24.5	35.9
- pH	-	8.2	8.0	8.3	8.2
- Ignition Loss	% w/w	6.11	13.86	5.67	9.48
- Oil and Grease	mg/kg	128.2	42.0	ND	23.2
- Cyanide	mg/kg CN	ND	ND	ND	ND
- Arsenic	mg/kg As	0.28	0.22	0.27	0.27
- Mercury (Hg)	mg/kg Hg	0.50	0.11	0.04	0.03
- Lead (Pb)	mg/kg Pb	19.2	21.6	6.0	12.1
- Cadmium (Cd)	mg/kg Cd	1.6	2.0	1.9	1.9
- Zinc (Zn)	mg/kg Zn	21.0	17.6	14.4	17.8
- Copper (Cu)	mg/kg Cu	3.9	3.8	2.4	3.7

Remark : ND = Non-detectable (Oil and Grease < 5 mg/l, Cyanide < 0.005 mg/kg)

SB 1.0 = In the shallower of the discharge structure
SB 1.1 = In the deeper of the discharge structure
SB 2.0 = In the shallower of the intake structure
SB 2.1 = In the deeper of the intake structure

Source :
- Field Survey by TEAM Consulting Engineering and Management Co., Ltd., June
- Water Quality Analysis by UAE Lab in Bankok, Thailand

Table 3.7-4 (1) Results of Sieve Analysis and Hydrometer Analysis

Location : Seabed in the Shallower of the Discharge Structure (SB 1.0)
Soil Type : Silty Sand

Sieve Analysis:

Sieve Analysis No.	Accum. wt. Retained	% Retained	% Passing
1"			
3/4"			
3/8"			
# 4			
# 10	0	0	100
# 40	18.0	3.6	96.4
# 200	376.0	74.5	25.5

Hydrometer Analysis

Elaped Time min.	Temp. °C	Act. Hyd. Reading Ra	Cor. Hyd. Reading Rc	% Finer	Hydro. Cor. Meniscus R	Part. Size
0	30	-	-	25.5	-	0.0740
1	30	30	36.8	23.9	31	0.0414
2	30	25	31.8	20.7	26	0.0303
4	30	22	28.8	18.7	23	0.0219
8	30	18	24.8	16.1	19	0.0159
15	30	15	21.8	14.2	16	0.0118
30	30	11	17.8	11.6	12	0.0085
60	30	9	15.8	10.3	10	0.0061
120	30	8	14.8	9.6	9	0.0043
240	30	7	13.8	9.0	8	0.0031
480	30	6	12.8	8.3	7	0.0022
1440	30	5	11.8	7.7	6	0.0013

Distribution Curve of Grain Size

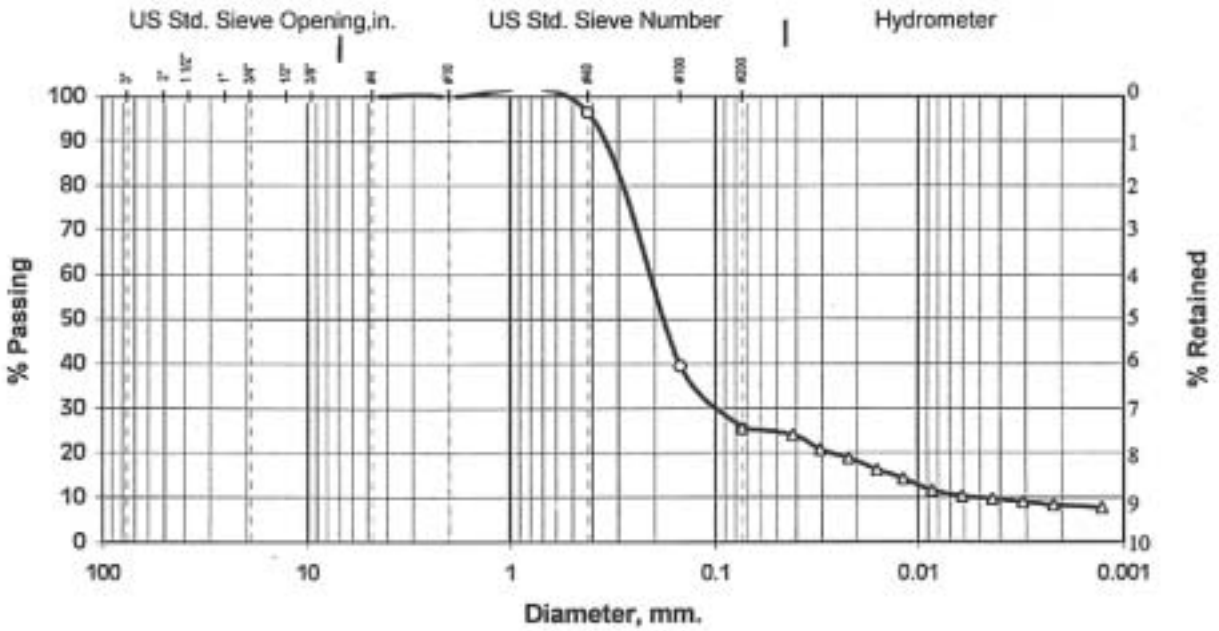

Table 3.7-4 (2) Results of Sieve Analysis and Hydrometer Analysis

Location : Seabed in the Deeper of the Discharge Structure (SB 1.1)
Soil Type : Silty Sand

Sieve Analysis:

Sieve Analysis No.	Accum. wt. Retained	% Retained	% Passing
1"			
3/4"			
3/8"			
# 4			
# 10	0	0	100
# 40	32.6	3.6	96.4
# 200	685.6	75.1	24.9

Hydrometer Analysis

Elaped Time min.	Temp. °C	Act. Hyd. Reading Ra	Cor. Hyd. Reading Rc	% Finer	Hydro. Cor. Meniscus R	Part. Size
0	30	-	-	24.9	-	0.0740
1	30	37	43.8	23.1	38	0.0386
2	30	31	37.8	19.9	32	0.0286
4	30	27	33.8	17.8	28	0.0208
8	30	24	30.8	16.2	25	0.0150
15	30	22	28.8	15.2	23	0.0111
30	30	19	25.8	13.6	20	0.0080
60	30	15	21.8	11.5	16	0.0058
120	30	11	17.8	9.4	12	0.0042
240	30	10	16.8	8.9	11	0.0030
480	30	9	15.8	8.3	10	0.0021
1440	30	8	14.8	7.8	9	0.0012

Distribution Curve of Grain Size

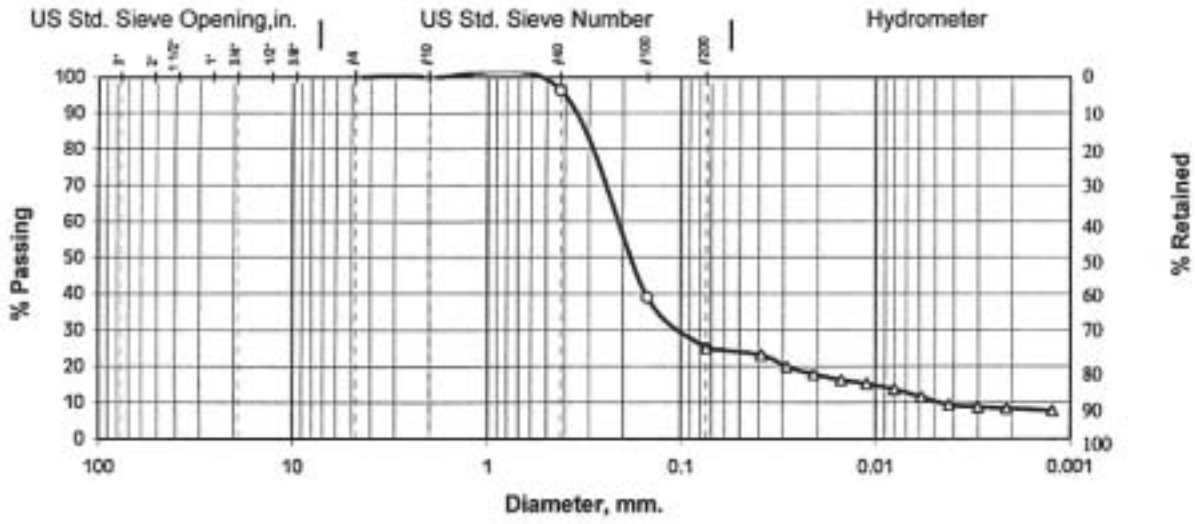

Table 3.7-4 (3) Results of Sieve Analysis and Hydrometer Analysis

Location : Seabed in the Shallower of the Intake Structure (SB 2.0)
Soil Type : Silty Sand

Sieve Analysis:

Sieve Analysis No.	Accum. wt. Retained	% Retained	% Passing
1"			
3/4"			
3/8"			
# 4			
# 10	0	0	100
# 40	20.9	4.6	95.4
# 200	405.1	90.1	9.9

Hydrometer Analysis

Elaped Time min.	Temp. °C	Act. Hyd. Reading Ra	Cor. Hyd. Reading Rc	% Finer	Hydro. Cor. Meniscus R	Part. Size
0	30	-	-	9.9	-	0.0740
1	30	22	28.8	8.1	23	0.0437
2	30	17	23.8	6.6	18	0.0319
4	30	14	20.8	5.8	15	0.0230
8	30	12	18.8	5.3	13	0.0164
15	30	10	16.8	4.7	11	0.0122
30	30	9	15.8	4.4	10	0.0086
60	30	8	14.8	4.1	9	0.0061
120	30	7	13.8	3.9	8	0.0044
240	30	6	12.8	3.6	7	0.0031
480	30	5	11.8	3.3	6	0.0022
1440	30	4	10.8	3.0	5	0.0013

Distribution Curve of Grain Size

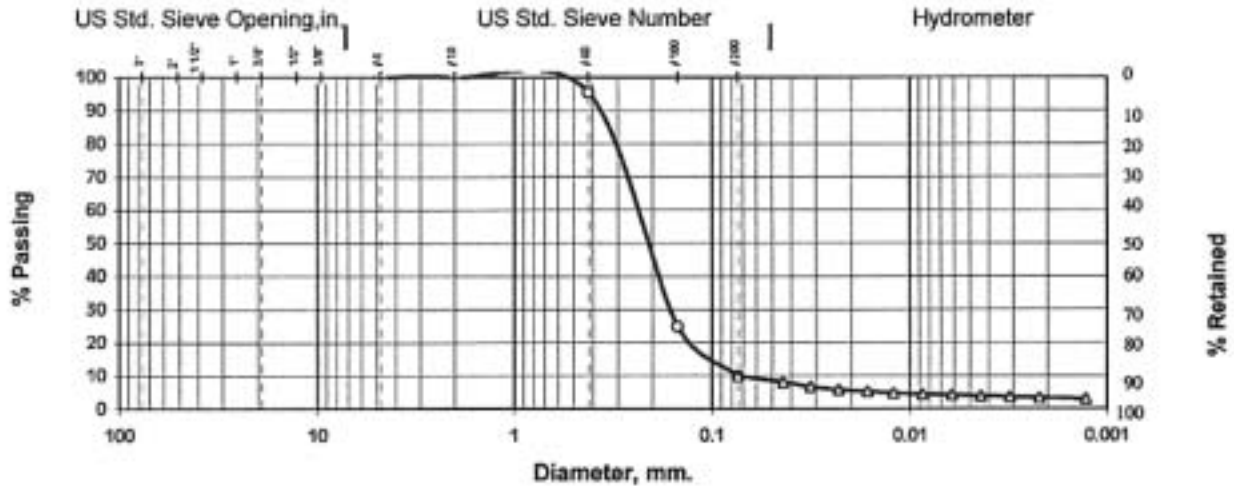

Table 3.7-4 (4) Results of Sieve Analysis and Hydrometer Analysis

Location : Seabed in the Deeper of the Intake Structure (SB 2.1)
Soil Type : Silty Sand

Sieve Analysis:

Sieve Analysis No.	Accum. wt. Retained	% Retained	% Passing
1"			
3/4"			
3/8"			
# 4			
# 10	0	0	100
# 40	17.4	3	97
# 200	448.3	78.4	21.6

Hydrometer Analysis

Elaped Time min.	Temp. °C	Act. Hyd. Reading Ra	Cor. Hyd. Reading Rc	% Finer	Hydro. Cor. Meniscus R	Part. Size
0	30	-	-	21.6	-	0.0740
1	30	34	40.8	20.7	35	0.0402
2	30	28	34.8	17.7	29	0.0297
4	30	23	29.8	15.1	24	0.0217
8	30	20	26.8	13.6	21	0.0157
15	30	16	22.8	11.6	17	0.0117
30	30	12	18.8	9.6	13	0.0085
60	30	10	16.8	8.5	11	0.0061
120	30	8	14.8	7.5	9	0.0043
240	30	7	13.8	7.0	8	0.0031
480	30	6	12.8	6.5	7	0.0022
1440	30	5	11.8	6.0	6	0.0013

Distribution Curve of Grain Size

Table 3.7-5 Results of Marine Water Quality in the Dry and Wet Seasons

Parameters	Unit	Dry Season		Rainy Season	
		WQ_o1	WQ_o2	WQ_o1	WQ_o2
1. In Site Measurement					
- Colour / Odor	-	Clear/no odor	Clear/no odor	Clear/no odor	Clear/no odor
- Temperature	°C	30.0	29.0	30.5	29.5
- pH	-	8.4	8.3	8.3	7.5
- Salinity	ppt	30	31	28	30
- Transparency	m	1.8	4.1	1.0	2.1
- Dissolved Oxygen (DO)	mg/l	7.4	7.0	6.2	6.6
- Depth of Water Body	m	1.8	7.0	2.5	7.0
2. Analysis in Laboratory					
Turbidity					
- Surface	NTU	ND	ND	10.0	1.4
- Bottom	NTU	ND	ND	9.3	3.6
Total Suspended Solids (SS)					
- Surface	mg/l	3.0	0.5	16.3	4.0
- Bottom	mg/l	1.0	0.5	14.5	7.0
Total Dissolved Solids (TDS)					
- Surface	mg/l	33,772.0	43,719.5	34,219	36,446
- Bottom	mg/l	39,068.0	36,407.5	34,964	36,616
Oil and Grease					
- Surface	mg/l	ND	ND	ND	ND
- Bottom	mg/l	ND	ND	ND	ND
Chemical Oxygen Demand					
- Surface	mg/l	47.0	62.0	61.75	65.74
- Bottom	mg/l	20.0	36.0	59.76	83.66
Total Coliform Bacteria					
- Surface	MPN/100 ml	<2	<2	9	1,600
- Bottom	MPN/100 ml	<2	<2	920	94

Remark : In Dry Season

ND = Non-detectable (Turbinity <0.7 NTU, Oil and Grease <1.0 mg/l)

In Rainy Season

ND = Non-detectable (Oil and Grease<1.0 mg/l)

WQ_O 1 = At shoreline beyond the discharge structure

WQ_O 2 = 3 km. beyond the intake and discharge structure

Source : - Field Survey by TEAM Consulting Engineering and Management Co., Ltd., December 2000 and June

- Water Quality Analysis by UAE Lab in Bankok, Thailand.

Table 3.8-1 Analysis Results of Ambient Air Quality

Stations	Date	SO_2 (μg/m³)		NO_2 (μg/m³)	
		1-hr.	24-hrs.	1-hr.	24-hrs.
Station : AQ1					
Tamnop Rolok School,	1-2 Dec. 2000 (Dry Season)	4.15*	2.45	77.52*	45.75
Stung Hav district	15-16 June 2001 (Wet Season)	5.79	3.42**	4.95	2.92**
Station : AQ2					
Meteorological Station, Sihanoukville city	30 Nov. – 1 Dec. 2000 (Dry Season)	4.98*	2.94	111.68*	65.91
Mittakpheap district	13-14 June 2001 (Wet Season)	9.03	5.33**	2.27	1.34**
Cambodia Standard		**500**	**300**	**300**	**100**
World Bank Standard		**-**	**150**	**-**	**125**

Remark : * Calculated by the variation of calculated concentration with sampling time (24-hr to 1-hr); Turner, D. Bruce, 1994.

** Calculated by the variation of calculated concentration with sampling time (1-hr. to 24-hrs.); Turner, D. Bruce, 1994.

Source : Field data of TEAM Consulting Engineering and Management Co., Ltd., December 2000 and June 2001.

Table 3.10-1 Stack Characteristic and Emission Rates

Item	Unit	Natural Gas Firing	Diesel Oil Firing
OPTION I			
Stack Characteristics			
Stack height	m	30, 40, 50, >50	30, 40, 50, >50
Stack inner diameter	m	2.3	2.3
Exit velocity of flue gas	m/s	18.8	21.1
Exit temperature of flue gas	°C	121	169
Emission Rates			
NO_2	ppmvd	150	250
SO_2 (0.5% S content)	ppmvd	0	102
SO_2 (0.2% S content)	ppmvd	0	41
CO	ppmvd	10	10
PM	mg/Nm^3	5	30
OPTION II			
Stack Characteristics			
Stack height	m	30, 40, 50	30, 40, 50
Stack inner diameter	m	3.9	3.9
Exit velocity of flue gas	m/s	21.8	19.7
Exit temperature of flue gas	°C	121	169
Emission Rates			
NO_2	ppmvd	150	250
SO_2 (0.5% S content)	ppmvd	0	102
SO_2 (0.2% S content)	ppmvd	0	41
CO	ppmvd	10	10
PM	mg/Nm^3	5	30

Table 3.10-2 Simulated Maximum Ground Level Concentration of Flue Gas Emissions

Unit : $\mu g/m^3$

Type of Fuel	Stack Height	The Maximum Ground Level Concentration																			
		NO_2						CO (1-hr)			TSP (24-hrs)			SO_2 (24-hrs)			SO_2 (1-hrs)				
		Stage 1		Stage 2		Stage 3		Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 2A	Stage 3A
		1-hr.	24-hrs.	1-hr.	24-hrs.	1-hr.	24-hrs.														
1. NATURAL GAS FIRING	OPTION I																				
	- 30 m.	148.75	30.98	291.95	59.88	426.56	86.66	30.16	59.19	86.48	2.46	4.75	6.88	-	-	-	-	-	-	-	-
	- 40 m.	131.81	27.52	256.50	53.15	372.76	76.87	26.73	52.01	75.58	2.18	4.22	6.11	-	-	-	-	-	-	-	-
	- 50 m.	120.71	25.06	234.84	48.37	346.88	69.93	24.47	47.61	69.18	2.00	3.86	5.60	-	-	-	-	-	-	-	-
	- 65 m.	-	-	-	-	288.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OPTION II																				
	- 30 m.	114.59	20.51	200.59	40.07	282.16	58.58	23.26	40.72	57.28	1.89	3.36	4.76	-	-	-	-	-	-	-	-
	- 40 m.	95.40	16.58	165.74	32.41	232.54	47.42	19.36	33.64	47.20	1.59	2.80	3.95	-	-	-	-	-	-	-	-
	- 50 m.	78.07	14.36	134.32	25.55	187.84	37.42	15.85	27.27	38.13	1.31	2.29	3.22	-	-	-	-	-	-	-	-
2. DIESEL OIL FIRING	OPTION I																				
	- 30 m.	234.88	46.59	460.98	90.35	673.52	130.88	28.61	56.16	82.05	13.95	26.94	39.05	135.47	261.70	379.31	653.17	1,272.20	1,847.85	508.86	739.11
	- 40 m.	208.13	41.00	404.99	79.45	570.42	115.14	25.35	49.34	71.70	12.39	23.92	34.66	120.39	232.38	326.89	572.73	1,115.25	1,619.39	446.08	647.73
	- 50 m.	190.59	35.76	370.81	69.28	490.99	100.41	23.22	45.17	65.63	11.36	21.92	31.75	110.38	212.97	285.05	492.62	959.58	1,393.91	383.82	557.52
	- 60 m.	-	-	275.16	-	-	83.84	-	-	-	-	-	-	-	-	-	-	-	-	-	454.57
	- 75 m.	-	-	-	-	277.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	- 100 m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	498.17	-	-	-
	- 145 m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	478.06	-	-
	OPTION II																				
	- 30 m.	154.56	27.55	301.96	53.87	441.63	78.85	18.82	36.77	53.78	9.47	18.50	27.04	92.01	179.69	262.68	366.99	717.85	1,051.23	287.11	420.44
	- 40 m.	126.96	23.90	248.14	43.09	363.08	63.12	15.46	30.22	44.21	7.83	15.30	22.37	76.07	142.61	217.33	303.03	593.40	870.17	237.33	348.02
	- 50 m.	102.05	21.96	199.63	37.81	292.36	52.78	12.43	24.31	35.60	6.35	12.42	18.17	61.69	120.60	176.51	278.19	544.70	798.66	217.85	319.42
	- 70 m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	484.36	-	-	-
	- 120 m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	442.15	-	-
Cambodian's Standard		300	100	300	100	300	100	40,000 (1-hr)			330 (24-hr)			300			500				
World Bank's Standard		-	150	-	150	-	150	-			125 (24-hr)			170			-				

Remark : - Stage 1 = 90 MW, Stage 2 = 180 MW, Stage 3 = 270 MW
- Option I = Total 9 Stack, Option II - Total 3 Stack
- Coordinate of Max. concentration are 343000E, 1180000N, and 343000E, 1181000N and these location are hills
- The simulation of SO2 for 24-hrs and 1-hr concentration are base on the sulfer content in Deisel Oil of 0.5% of most case except for SO2 (1-hr) of stage 2A and 3A, the sulfer content of 0.2% is used.

Table 3.10-3 Simulated Annual Average Maximum Ground Level Concentration of Flue Gas Emission

Unit : $\mu g/m^3$

Type of Fuel	Stack Height	The Maximum Ground Level Concentration											
		NO_2			CO			TSP			SO_2		
		Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
1. NATURAL GAS FIRING	OPTION I												
	- 30 m.	6.62	12.61	17.62	1.34	2.55	3.57	0.54	1.02	1.43	-	-	-
	- 40 m.	5.89	11.21	15.66	1.19	2.27	3.17	0.48	0.91	1.27	-	-	-
	- 50 m.	5.34	10.17	14.21	1.08	2.06	2.88	0.43	0.82	1.15	-	-	-
	OPTION II												
	- 30 m.	4.17	8.05	11.10	0.85	1.63	2.25	0.34	0.65	0.90	-	-	-
	- 40 m.	3.36	6.48	8.94	0.68	1.31	1.81	0.27	0.52	0.72	-	-	-
	- 50 m.	2.63	5.08	7.02	0.53	1.03	1.42	0.21	0.41	0.57	-	-	-
2. DIESEL OIL FIRING	OPTION I												
	- 30 m.	9.78	18.64	26.04	1.19	2.27	3.17	2.86	5.45	7.61	27.79	52.92	73.94
	- 40 m.	8.59	16.36	22.86	1.04	1.99	2.78	2.51	4.78	6.68	24.39	46.45	64.89
	- 50 m.	7.38	14.07	19.68	0.90	1.71	2.39	2.15	4.11	5.75	20.97	39.96	55.88
	OPTION II												
	- 30 m.	5.51	10.64	14.69	0.67	1.29	1.78	1.61	3.11	4.29	15.65	30.22	41.70
	- 40 m.	4.39	8.48	11.72	0.53	1.03	1.42	1.28	2.48	3.42	12.46	24.08	33.26
	- 50 m.	3.39	6.56	9.07	0.41	0.79	1.10	0.99	1.91	2.65	9.63	18.62	25.75
US.EPA		100			-			-			80		
WHO's Guidelines		40-50			-			-			50		
Cambodian's Standard		100			-			100			100		

Remark : - Stage 1 = 90 MW, Stage 2 = 180 MW, Stage 3 = 270 MW
- Option I = Total 9 Stack
- Option II = Total 3 Stack
- Location of Max. Concentration is the Foot of Hill near Boundary of Khet Kampot (343000E, 1181000N)

Table 3.10-4 Simulated Ground Level Concentration at Three Main Receptors for Case of Natural Gas Firing

Unit : $\mu g/m^3$

Contition	Stage	Stack (m.)	Stung Hav District				SOKIMEX Community				SHV City			
			NO_2 (1-hr.)	NO_2 (24-hr.)	CO (1-hr.)	TSP (24-hr.)	NO_2 (1-hr.)	NO_2 (24-hr.)	CO (1-hr.)	TSP (24-hr.)	NO_2 (1-hr.)	NO_2 (24-hr.)	CO (1-hr.)	TSP (24-hr.)
Option I	1	30	17.37	3.52	3.52	0.29	12.14	1.95	2.46	0.16	15.66	1.59	3.17	0.13
		40	13.89	2.87	2.81	0.23	11.64	1.76	2.36	0.14	12.10	1.24	2.45	0.10
		50	11.11	2.34	2.25	0.19	11.13	1.62	2.25	0.13	9.31	0.99	1.88	0.08
	2	30	34.10	7.44	6.92	0.61	24.53	3.90	4.97	0.32	31.22	3.08	6.33	0.25
		40	25.89	6.06	5.25	0.49	23.47	3.53	4.76	0.29	24.14	2.41	4.89	0.20
		50	20.71	4.95	4.20	0.40	22.41	3.26	4.54	0.26	18.59	1.93	3.77	0.16
	3	30	52.91	11.69	10.73	0.95	36.94	5.79	7.49	0.47	46.84	4.31	9.50	0.35
		40	36.36	9.52	7.37	0.77	35.27	5.26	7.15	0.43	36.29	3.39	7.36	0.27
		50	29.20	7.79	5.92	0.63	33.57	4.87	6.80	0.39	28.01	2.74	5.68	0.22
Option II	1	30	8.21	2.02	1.67	0.16	2.56	0.30	0.52	0.02	5.82	0.62	1.18	0.05
		40	6.51	1.62	1.32	0.13	2.51	0.27	0.51	0.02	4.48	0.54	0.91	0.04
		50	5.14	1.31	1.04	0.11	2.47	0.24	0.50	0.02	3.63	0.47	0.74	0.04
	2	30	16.12	4.25	3.27	0.34	5.32	0.57	1.08	0.05	11.81	1.20	2.40	0.09
		40	12.78	3.42	2.59	0.28	5.21	0.50	1.06	0.04	9.10	1.05	1.85	0.08
		50	10.10	2.75	2.05	0.22	5.13	0.45	1.04	0.04	7.20	0.94	1.46	0.07
	3	30	23.73	6.63	4.82	0.54	8.35	0.79	1.69	0.06	17.97	1.75	3.65	0.14
		40	18.80	5.33	3.82	0.43	8.17	0.69	1.66	0.05	13.86	1.54	2.81	0.12
		50	14.85	4.29	3.01	0.35	8.04	0.63	1.63	0.05	10.70	1.38	2.17	0.11
Cambodian's Standard			300	100	40,000	330	300	100	40,000	330	300	100	40,000	330
World Bank's Standard			-	150	-	125	-	150	-	125	-	150	-	125

Remark : Coordonate of Stueng Hav District, SOKIMEX and SHV City are 349850E, 1187550N; 341550E, 1184800N and 339400E, 1174000N, respectively.

Table 3.10-5 Simulated Ground Level Concentration at Three Main Receptors for Case of Diesel Oil Firing

Unit : μg/m³

Contition	Stage	Stack (m.)	Stung Hav District (349850E, 1187550N)						Sokimex Community (341550E, 1184800N)						SHV City (339400E, 1174000N)					
			NO_2 (1-hr.)	NO_2 (24-hr.)	SO_2 (1-hr.)	SO_2 (24-hr.)	CO (1-hr.)	TSP (24-hr.)	NO_2 (1-hr.)	NO_2 (24-hr.)	SO_2 (1-hr.)	SO_2 (24-hr.)	CO (1-hr.)	TSP (24-hr.)	NO_2 (1-hr.)	NO_2 (24-hr.)	SO_2 (1-hr.)	SO_2 (24-hr.)	CO (1-hr.)	TSP (24-hr.)
Option I	1	30	22.00	4.72	62.44	13.40	2.67	1.38	14.01	2.18	39.77	6.19	1.70	0.64	18.49	2.05	52.49	5.82	2.25	0.60
		40	17.51	3.82	49.70	10.85	2.13	1.12	13.75	1.99	39.03	5.67	1.67	0.58	14.25	1.63	40.46	4.63	1.74	0.48
		50	13.92	3.11	39.52	8.82	1.69	0.91	13.55	1.86	38.46	5.29	1.65	0.54	10.91	1.32	30.98	3.76	1.33	0.39
	2	30	41.01	9.96	116.42	28.28	4.99	2.91	28.83	4.32	81.85	12.27	3.51	1.26	36.90	3.97	104.76	11.27	4.49	0.02
		40	32.63	8.07	92.63	22.90	3.97	2.36	28.29	3.96	80.33	11.25	3.45	1.16	28.47	3.17	80.83	8.99	3.47	0.01
		50	25.93	6.56	73.62	18.61	3.16	1.92	21.88	3.70	79.16	10.49	3.39	1.08	21.83	2.58	61.97	7.33	2.66	0.01
	3	30	58.99	15.63	167.49	44.37	7.19	4.57	45.79	6.38	130.01	18.12	5.57	1.86	54.15	5.59	155.15	15.86	6.66	1.63
		40	47.06	12.67	133.61	35.96	5.73	3.70	44.95	5.87	127.61	16.66	5.47	1.72	42.23	4.48	119.89	12.73	5.14	1.32
		50	37.54	10.30	106.59	29.24	4.57	3.01	44.31	5.49	125.79	15.58	5.39	1.60	32.44	3.68	92.09	10.44	3.95	1.08
Option II	1	30	11.12	2.80	31.56	7.94	1.35	0.82	4.08	0.33	11.58	0.94	0.49	0.10	7.48	0.90	21.24	2.56	0.91	0.26
		40	8.81	2.25	25.01	6.38	1.07	0.66	3.99	0.29	11.33	0.82	0.48	0.08	5.76	0.80	16.35	2.26	0.70	0.23
		50	6.95	1.81	19.72	5.12	0.84	0.53	3.93	0.26	11.15	0.74	0.48	0.07	5.34	0.71	15.15	2.02	0.65	0.21
	2	30	21.87	5.88	62.09	16.69	2.66	1.72	8.47	0.62	24.04	1.75	1.03	0.18	15.05	1.77	42.71	5.03	1.83	0.52
		40	17.32	4.72	49.18	13.41	2.11	1.38	8.29	0.59	23.53	1.53	1.01	0.16	11.59	1.56	32.93	4.44	1.41	0.46
		50	13.65	3.79	38.76	10.77	1.66	1.11	8.15	0.48	23.15	1.37	0.99	0.14	10.50	1.40	29.82	3.98	1.27	0.41
	3	30	32.09	9.17	91.09	26.02	3.91	2.68	13.28	0.85	31.69	2.42	1.62	0.25	22.90	2.59	65.02	7.38	2.79	0.76
		40	25.40	7.37	72.11	20.91	3.09	2.15	12.99	0.74	36.89	2.10	1.58	0.22	17.67	2.30	50.16	6.54	2.15	0.67
		50	20.01	5.92	56.81	16.79	2.44	1.73	12.78	0.66	36.28	1.89	1.56	0.19	15.47	2.07	43.93	5.87	1.88	0.60
Cambodian's Standard			300	100	500	300	40,000	330	300	100	500	300	40,000	330	300	100	500	300	40,000	330
World Bank's Standard			-	150	-	170	-	125	-	150	-	170	-	125	-	150	-	170	-	125