

1.8 Agreement on National Environmental Standards

Source: WREA



Lao People's Democratic Republic
Peace Independence Democracy Unity Prosperity

Prime Minister's Office

Water Resources and Environment Administration

No2734 /PMO.WREA

Vientiane Province, dated 7 Dec 2009

Agreement on the National Environmental Standards

- Based on the Environmental Protection Law No. 02/99/NA, dated 3 April 1999.
- Based on decree on mandate of Water Resources and Environmental Administration dated 149/PM, dated 10 May 2007.

**Minister to Prime Minister's Office,
Head of Water Resources and Environment Administration agreed that:**

Chapter I General Provisions

Article 1: Objective

This Agreement defines the National Environmental Standards as the basis for environmental monitoring and pollution control on water, soil, air and noise.

Article 2: Definitions

Ambient Environmental Standard means a value which specifies the quality of the ambient environment in terms of concentration or level of a parameter in an environmental media, generally soil, water, air and noise.

Emission Standard means a value which specifies the concentration or level of a parameter as the acceptable emission emitted from a source.

Pollution means chemical, toxic, hazardous, substances, radiation, dust, smoke, noise, smell, vibrations and heat contaminated in the air, water and soil with excessive concentration specified in the National Environmental Standards, which resulted from human activity or nature that may be harmful to human health, animal, biodiversity and other natural environments.

Concentration means the quantity of a chemical substance contaminated in water, soil or air and level of noise calculated according to measurement unit (E.g. weight per volume).

Parameters means indicators used to measure the level of concentration against the standards. The result of measurement could be shown in either numeric or alpha form.

Article 3: Scope of Application

This Agreement applies to any relevant person, enterprise and organization in order to protect the environment and to control pollution in Lao PDR.

Chapter II Type of National Environmental Standards

Article 4: Ambient Standards

4.1 Water Quality Standards includes: drinking water standards, drinking water in covered container standards, groundwater standards and surface water standards.

4.1.1 Drinking Water Quality Standards

A. Bacteriological Parameters

Parameters	Units	Concentration
Faecal Coliform	MPN/100ml	0
Total Coliform	MPN/100ml	<2.2
Enterovirus	MPN/100ml	0

B. Physical -Chemical Parameters

No.	Parameters	Symbol	Unit	Concentration	
				Minimum	Maximum
1	Aluminum	Al	mg/l	0.1	0.2
2	Ammonia	NH ₃	mg/l	0.5	1.5
3	Chloride	Cl ⁻	mg/l	200	250
4	Copper	Cu	mg/l	1.0	2.0
5	Iron	Fe	mg/l	0.3	<1
6	Manganese	Mn	mg/l	0.1	0.5
7	Sodium	Na	mg/l	200	250
8	Sulphate	SO ₄ ²⁻	mg/l	200	250
9	Hydrogen Sulphide	H ₂ S	mg/l	0.05	0.1
10	Conductivity	Ec	μs/cm	-	<1,000
11	Total dissolved solids	TDS	mg/l	500	600
12	Sodium Chloride	NaCl	mg/l	100	300-350
13	Potential of Hydrogen	pH	-	6.5	8.5
14	Temperature	T	°C	25	35
15	Hardness	-	mg/l	50	300
16	Turbidity	-	NTU	-	<10
17	Taste and Odour	-	-	-	Acceptable
18	Colour	-	TCU	-	5
19	Residual Chlorine (if Chlorine disinfection is used)	Cl ₂	mg/l	-	<0.2

C. Health Significant Chemical Parameters

No.	Parameters	Symbol	Unit	Maximum Concentration
1	Antimony	Sb	mg/l	0.005
2	Arsenic	As	mg/l	0.01-0.05
3	Barium	Ba	mg/l	0.7
4	Boron	B	mg/l	0.50
5	Cadmium	Cd	mg/l	0.003
6	Chromium	Cr	mg/l	0.05

No.	Parameters	Symbol	Unit	Maximum Concentration
7	Cyanide	CN ⁻	mg/l	0.07
8	Fluoride	F ⁻	mg/l	1.5
9	Lead	Pb	mg/l	0.01
10	Mercury	Hg	mg/l	0.001
11	Nitrate	NO ₃ ⁻	mg/l	50
12	Nitrite	NO ₂ ⁻	mg/l	3
13	Selenium	Se	mg/l	0.01

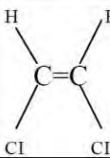
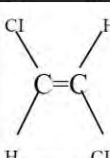
D. Priority Parameters

No.	Parameters	Symbol	Unit	Maximum Concentration
1	Iron	Fe	mg/l	<1
2	Manganese	Mn	mg/l	<0.5
3	Arsenic	As	mg/l	<0.05
4	Fluoride	F ⁻	mg/l	<1.5
5	Nitrate	NO ₃ ⁻	mg/l	50
6	Nitrite	NO ₂ ⁻	mg/l	3
7	Nitrite Nitrogen	NO ₂ -N	mg/l	1
8	Potential of Hydrogen	pH	-	6.5-8.5
9	Coliform	-	MPN/100ml	0
10	Conductivity	Ec	µs/cm	1000
11	Residual Chloride (if Chlorine disinfection is used)	Cl ₂	mg/l	0.2
12	Total Hardness	-	mg/l	<300
13	Turbidity	-	NTU	<10
14	Taste and Odour	-	-	Acceptable

4.1.2 Drinking Water Quality in Covered Container

No.	Parameters	Symbol	Unit	Permitted Concentration
1	Arsenic	As	mg/l	0.01-0.05
2	Barium	Ba	mg/l	0.7
3	Boron	B	mg/l	0.5
4	Cadmium	Cd	mg/l	0.003
5	Chromium	Cr	mg/l	0.05
6	Copper	Cu	mg/l	2
7	Fluoride	F ⁻	mg/l	1.5
8	Lead	Pb	mg/l	0.01-0.05
9	Manganese	Mn	mg/l	0.5
10	Mercury	Hg	mg/l	0.001
11	Nitrate	NO ₃ ⁻	mg/l	50
12	Iron	Fe	mg/l	0.3
13	Potential of Hydrogen	pH	-	6.5-8.5
14	Hardness	-	mg/l	100-300

4.1.3 Groundwater Quality Standards

No.	Substances	Symbol	Unit	Standard Value	Method of Measurement
I. Volatile Organic Compound					Purge and Trap Gas Chromatography or Purge and Trap Gas Chromatography/ Mass Spectrometry
1	Benzene	C ₆ H ₆	mg/l	0.005	
2	Carbon Tetrachloride	CCl ₄	mg/l	0.005	
3	1.2-Dichloroethane	CH ₂ Cl-CH ₂ Cl	mg/l	0.005	
4	1.1-Dichloroethylene	CCl ₂ =CH ₂	mg/l	0.007	
5	Cis-1.2-Dichloroethylene		mg/l	0.070	
6	Trans-1.2-Dichloroethylene		mg/l	0.1	
7	Dichloromethane	CH ₂ Cl ₂	mg/l	0.005	
8	Ethly benzene	C ₆ H ₅ -C ₂ H ₅	mg/l	0.7	
9	Styrene	C ₆ H ₅ -CH=CH ₂	mg/l	0.1	
10	Tetrachloroethylene	Cl ₂ C=CCl ₂	mg/l	0.005	
11	Toluene	C ₆ H ₅ -CH ₃	mg/l	1	
12	Trichloroethylene	Cl ₂ C=CHCl	mg/l	0.005	
13	1.1.1 Trichloroethane	Cl ₃ C-CH ₃	mg/l	0.2	
14	1.1.2 Trichloroethane	Cl ₂ CH-CH ₂ Cl	mg/l	0.005	
15	Total Xylenes	o, m, p (CH ₃ -C ₆ H ₄ -CH ₃)	mg/l	10	
II. Heavy Metals					Direct Aspiration/ Absorption Spectrometry or Inductively Coupled Plasma/Plasma Emission Spectroscopy
1	Cadmium	Cd	mg/l	0.003	
2	Hexavalent Chromium	Cr ⁺⁶	mg/l	0.05	
3	Copper	Cu	mg/l	1	
4	Lead	Pb	mg/l	0.01	
5	Manganese	Mn	mg/l	0.5	
6	Nickel	Ni	mg/l	0.02	
7	Zinc	Zn	mg/l	5	Hydride Generation/ Atomic Absorption Spectrometry or Inductively Coupled Plasma/ Plasma Emission Spectroscopy
8	Arsenic	As	mg/l	0.01	
9	Selenium	Se	mg/l	0.01	Cold-Vapour Atomic Absorption Spectrometry/ Plasma Emission Spectroscopy
10	Mercury	Hg	mg/l	0.001	
III. Pesticides					Liquid-Liquid Extraction
1	Chlordane	C ₁₀ H ₅ Cl ₈	mg/l	0.0002	

No.	Substances	Symbol	Unit	Standard Value	Method of Measurement
2	Dieldrin	C ₁₂ H ₈ Cl ₆ O	mg/l	0.00003	Gas Chromatography/ Mass Spectrometry or Liquid-Liquid Extraction Gas Chromatography (Method I)
3	Heptachlor	Cl ₇	mg/l	0.0004	
4	Heptachlor Epoxide	-	mg/l	0.0002	
5	DDT	DDT	mg/l	0.002	
6	2,4 D	2, 4 D	mg/l	0.03	Liquid-Liquid Extraction Gas Chromatography
7	Atrazine	C ₈ H ₁₄ ClN ₅	mg/l	0.003	
8	Lindane	C ₆ Cl ₆	mg/l	0.0002	Liquid-Liquid Extraction Gas Chromatography (Method I)
9	Pentachlorophenol	Cl ₅ C ₆ H ₅ OH	mg/l	0.001	Liquid-Liquid Extraction Chromatography or Liquid-Liquid Extraction Gas Chromatography/ Mass Spectrometry
IV. Others					
1	Benzo (a) pyrene	-	mg/l	0.0002	Liquid-Liquid Extraction Chromatography or Liquid-Liquid Extraction Gas Chromatography/ Mass Spectrometry
2	Cyanide	CN ⁻	mg/l	0.2	Pyridine Barbituric Acid or Colorimetric or Ion Chromatography
3	PCBs	PCB	mg/l	0.0005	Liquid-Liquid Extraction Gas Chromatography (Method II)
4	Vinyl Chloride	CH ₂ =CHCl	mg/l	0.002	Purge and Trap Gas Chromatography or Purge and Trap Gas Chromatography/ Mass Spectrometry

4.1.4 Groundwater Standards for Drinking Purposes

Characteristics	Parameters	Symbol	Unit	Permitted Standard Value	
				Suitable	Maximum
Physical	1. Colour	-	Platinum-Cobalt (Pt-Co)	5	15
	2. Turbidity	-	JTU	5	20
	3. Potential of Hydrogen	pH	-	7.0-8.5	6.5-9.2
Chemical	4. Iron	Fe	mg/l	≤0.5	1
	5. Manganese	Mn	mg/l	≤0.3	0.5
	6. Copper	Cu	mg/l	≤1.0	1.5
	7. Zinc	Zn	mg/l	≤5.0	15
	8. Sulphate	SO ₄ ²⁻	mg/l	≤200	250
	9. Chloride	Cl ⁻	mg/l	≤250	600
	10. Fluoride	F ⁻	mg/l	≤0.7	1
	11. Nitrate	NO ₃ ⁻	mg/l	≤15	45
	12. Total Hardness as	Total CaCO ₃	mg/l	≤300	500

Characteristics	Parameters	Symbol	Unit	Permitted Standard Value	
	CaCO ₃				
	13. Non-carbonate hardness as CaCO ₃	Non CaCO ₃	mg/l	≤200	250
Toxic chemical substances	14. Total solids	TS	mg/l	≤600	1,200
	15. Arsenic	As	mg/l	None	0.05
	16. Cyanide	CN ⁻	mg/l	None	0.1
	17. Lead	Pb	mg/l	None	0.05
	18. Mercury	Hg	mg/l	None	0.001
	19. Cadmium	Cd	mg/l	None	0.01
	20. Selenium	Se	mg/l	None	0.01
Bacteria	21. Coliform bacteria	Coliform	MPN/100 ml	<2.2	<2.2
	22. E. coli bacteria	E. coli	-	None	None
	23. Standard plate count	-	Colonies/ml	≤500	-

4.1.5 Surface Water Quality Standards

No	Substances	Symbol	Unit	Standard Value	Method of Measurement
1	Colour, Odour and Taste	-	-	N	-
2	Temperature	t	°C	N'	Thermometer
3	Potential of Hydrogen	pH	-	5-9	Electronic pH Meter
4	Dissolved Oxygen	DO	mg/l	6	Azide Modification
5	COD	COD	ml/l	5	Potassium permanganate
6	BOD ₅	BOD ₅	mg/l	1,5	Azide Modification at 20 degree C, 5 days
7	Total Coliform Bacteria	Coliform Bacteria	MPN/100 ml	5000	Multiple Tube Fermentation
8	Faecal Coliform Bacteria	Faecal Coliform	MPN/ 100 ml	1000	
9	Nitrate-Nitrogen	NO ₃ -N	mg/l	<5.0	Cadmium Reduction
10	Ammonia-Nitrogen	NH ₃ -N	mg/l	0.2	Distillation Nesslerization
11	Phenols	C ₆ H ₅ -OH	mg/l	0.005	Distillation, 4-Amin anti-pyrenne
12	Copper	Cu	mg/l	0.1	Atomic Absorption Direct Aspiration
13	Nickel	Ni	mg/l	0.1	
14	Manganese	Mn	mg/l	1.0	
15	Zinc	Zn	mg/l	1.0	
16	Cadmium	Cd	mg/l	0.005	
17	Chromium, Hexavalent	Cr ⁶⁺	mg/l	0.05	
18	Lead	Pb	mg/l	0.05	
19	Mercury	Hg	mg/l	0.002	Atomic Absorption Cold Vapour

No	Substances	Symbol	Unit	Standard Value	Method of Measurement
20	Arsenic	As	mg/l	0.01	Atomic Absorption Direct Aspiration
21	Cyanide	CN ⁻	mg/l	0.005	Pyridine-Barbituric
22	Alpha -Radioactive	α	Becquere l/l	0.1	Counting machine
23	Beta -Radioactive	β	Becquere l/l	1.0	
24	Total Organochlorine	-	mg/l	0.05	Gas Chromatography
25	DDT	C ₁₄ H ₉ Cl ₅	mg/l	1.0	
26	Alpha -BHC	α BHC	mg/l	0.02	
27	Dieldrin	C ₁₂ H ₈ Cl ₆ O	mg/l	0.1	
28	Aldrin	-	mg/l	0.1	
29	Heptachlor and Heptachlor Epoxide	-	mg/l	0.2	
30	Endrin	-	mg/l	None	

4.2 Soil Quality Standards

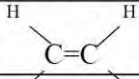
4.2.1 Soil Quality Standards for Residential and Agriculture

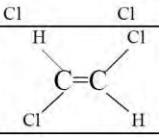
No.	Substances	Symbol	Unit	Standard Value	Method of Measurement
I. Volatile Organic Compound					Gas Chromatography or Gas Chromatography/. Mass Spectrometry (GC/MS) or other methods approved by WREA
1	Benzene	C ₆ H ₆	mg/kg	0.5	
2	CarbonTetrachloride	CCl ₄	mg/kg	89	
3	1,2 Dichloroethane	CH ₂ Cl-CH ₂ Cl	mg/kg	230	
4	1,1 Dichloroethylene	CCl ₂ =CH ₂	mg/kg	1,700	
5	Cis 1,2 Dichloroethylene	CHCl=CHCl	mg/kg	57	
6	Trans-1.2- Dichloroethylene	CHCl=CHCl	mg/kg	520	
7	Dichloromethane	CH ₂ Cl ₂	mg/kg	28	
8	Ethly benzene	lC ₂ ClC-CH ₃	mg/kg	630	
9	Styrene	C ₆ H ₅ . CH=CH ₂	mg/kg	8.4	
10	Tetrachloroethylene	C ₂ Cl ₄	mg/kg	210	
11	Toluene	C ₆ H ₅ -CH ₃	mg/kg	6.5	
12	Trichloroethylene	Cl ₂ C=CHCl	mg/kg	2.5	
13	1.1.1 Trichloroethane	Cl ₃ C-CH ₃	mg/kg	3.5	
14	1.1.2 Trichloroethane	Cl ₂ CH-CH ₂ Cl	mg/kg	43	
15	Total Xylenes	(CH ₃ -C ₆ H ₄ -CH ₃)	mg/kg	63	
II. Heavy Metals					Inductively Coupled Plasma-Atomic Emission Spectrometry or Inductively Coupled Plasma-Mass Spectrometry or Atomic Absorption, Gaseous Hydride or Atomic Absorption, Borohydride Reduction or other Methods Approved
1	Arsenic	As	mg/kg	3.9	
2	Cadmium and its compounds	Cd	mg/kg	37	

No.	Substances	Symbol	Unit	Standard Value	Method of Measurement
					by WREA
3	Hexavalent Chromium	Cr ⁺⁶	mg/kg	300	Coprecipitation or Colorimetric or Chelation/ Extraction or other Methods Approved by WREA
4	Lead	Pb	mg/kg	400	Inductively Coupled Plasma-Atomic Emission Spectrometry or Inductively Coupled Plasma-Mass Spectrometry or Atomic Absorption, Direct Aspiration or Atomic Absorption, Furnace Techniques or other Methods Approved by WREA
5	Manganese and its compounds	Mn	mg/kg	1,800	
6	Mercury and its compounds	Hg	mg/kg	23	Cold-Vapour Technique or other Methods Approved by WREA
7	Nickel, soluble salts	Ni	mg/kg	1,600	Inductively Coupled Plasma-Atomic Emission Spectrometry or Inductively Coupled Plasma-Mass Spectrometry or Atomic Absorption, Direct Aspiration or Atomic Absorption, Furnace Techniques or other Methods Approved by WREA
8	Selenium	Se	mg/kg	390	
III. Pesticides					
1	Atrazine	C ₈ H ₁₄ ClN ₅	mg/kg	22	Gas Chromatography or other Methods Approved by WREA
2	Chlordane	-	mg/kg	16	Gas Chromatography/ Mass Spectrometry (GC/MS) or other Methods Approved by WREA
3	2,4 D	-	mg/kg	690	Gas Chromatography or High Performance Liquid Chromatography/ Thermal Extraction/ Gas Chromatography/Mass Spectrometry (TE/GC/MS) or other Methods Approved by WREA
4	DDT	DDT	mg/kg	17	Gas Chromatography or Gas Chromatography/ Mass Spectrometry (GC/MS) or other Methods Approved by WREA
5	Dieldrin	C ₁₂ H ₈ Cl ₆ O	mg/kg	0.3	
6	Heptachlor	Cl ₇	mg/kg	1.1	
7	Heptachlor Epoxide	-	mg/kg	0.5	
8	Lindane	-	mg/kg	4.4	
IV. Others					
1	Benzo(a)pyrene	-	mg/kg	0.6	Gas Chromatography/ Mass Spectrometry (GC/MS) or Thermal Extraction Gas Chromatography/ Mass Spectrometry

No.	Substances	Symbol	Unit	Standard Value	Method of Measurement
					try (TE/GC/MS)Chromatography/ Fourier Transform Infrared (GC/FT-IR) Spectrometry or other Methods Approved by WREA
2	Cyanide and its compounds	CN ⁻	mg/kg	11	Total and Amenable Cyanide: Distillation, or Total Amenable Cyanide (Automated Colorimetric, with off-line Distillation), or Cyanide Extraction Procedure for Solids and Oils or other Methods Approved by WREA
3	PCBs	-	mg/kg	2.2	Gas Chromatography or other Methods Approved by WREA
4	Vinyl Chloride		mg/kg	1.5	Gas Chromatography or Gas Chromatography/ Mass Spectrometry (GC/MS) or other Methods Approved by WREA

A. Soil Quality Standards for Other Purposes

No.	Substances	Symbol	Unit	Standard Value	Method of Measurement
I. Volatile Organic Compound					
1	1,1 Dichloroethylene	CCl ₂ =CH ₂	mg/kg	0.5	Gas Chromatography or Gas Chromatography/ Mass Spectrometry (GC/MS) or other methods approved by WREA
2	Dichloromethane	CH ₂ Cl ₂	mg/kg	89	
3	Ethly benzene	C ₆ H ₅ -C ₂ H ₅	mg/kg	230	
4	Styrene	C ₆ H ₅ -CH=CH ₂	mg/kg	1,700	
5	Tetrachloroethylene	Cl ₂ C=CCl ₂	mg/kg	57	
6	Toluene	C ₆ H ₅ -CH ₃	mg/kg	520	
7	Trichloroethylene	Cl ₂ C=CHCl	mg/kg	28	
8	1,1,1 Trichloroethane	Cl ₂ ClC-CH ₃	mg/kg	630	
9	1,1,2 Trichloroethane	Cl ₂ CH-CH ₂ Cl	mg/kg	8.4	
10	Total Xylenes	<i>o, m, p</i> (CH ₃ -C ₆ H ₄ CH ₃)	mg/kg	210	
11	Benzene	C ₆ H ₆	mg/kg	6.5	
12	Carbon Tetrachloride	CCl ₄	mg/kg	2.5	
13	1,2 Dichloroethane	CH ₂ Cl-CHCl	mg/kg	3.5	
14	Cis 1,2 Dichloroethylene		mg/kg	43	

No.	Substances	Symbol	Unit	Standard Value	Method of Measurement
15	Trans 1,2 Dichloroethylene		mg/kg	63	
II. Heavy Metals					
1	Arsenic	As	mg/kg	27	Inductively Coupled Plasma-Atomic Emission Spectrometry or Inductively Coupled Plasma-Mass Spectrometry or Atomic Absorption Furnace Technique or Atomic
2	Cadmium and its compounds	Cd	mg/kg	810	
3	Hexavalent Chromium	Cr ⁺⁶	mg/kg	640	Co precipitation or Colorimetric or Chelation/Extraction or other Methods Approved by WREA
4	Lead	Pb	mg/kg	750	Inductively Coupled Plasma-Atomic Emission Spectrometry or Inductively Coupled Plasma-Mass Spectrometry or Atomic Absorption, Direct Aspiration or Atomic Absorption, Furnace Techniques or other Methods Approved by WREA
5	Manganese and its compounds	Mn	mg/kg	32,000	
6	Mercury and its compounds	Hg	mg/kg	610	Cold-Vapour Technique or other Methods Approved by WREA
7	Nickel, soluble salts	Ni	mg/kg	41,000	Inductively Coupled Plasma-Atomic Emission Spectrometry or Inductively Coupled Plasma-Mass Spectrometry or Atomic Absorption, Direct Aspiration or Atomic Absorption, Furnace Techniques or other Methods Approved by WREA
8	Selenium	Se	mg/kg	10,000	Inductivity Coupled Plasma-Atomic Emission Spectrometry or Atomic Absorption, Furnace Technique or Atomic Absorption, Gaseous Hydride or Atomic Absorption, Borohydride Reduction or other Methods Approved by WREA
III. Pesticides					
1	Atrazine	C ₈ H ₁₄ ClN ₅	mg/kg	110	Gas Chromatography or other Methods Approved by WREA
2	Chlordane	C ₁₀ H ₅ Cl ₈	mg/kg	110	Gas Chromatography/ Mass Spectrometry (GC/MS) or other Methods Approved by

No.	Substances	Symbol	Unit	Standard Value	Method of Measurement
					WREA
3	2,4 D	2.4D	mg/kg	12,000	Gas Chromatography or High Performance Liquid Chromatography/Thermal Extraction/ Gas Chromatography/ Mass Spectrometry (TE/GC/ MS) or other Methods Approved by WREA
4	DDT	DDT	mg/kg	120	Gas Chromatography or Gas Chromatography/ Mass Spectrometry (GC/MS) or other Methods Approved by WREA
5	Dieldrin	C ₁₂ H ₈ Cl ₆ O	mg/kg	1.5	
6	Heptachlor	Cl ₇	mg/kg	5.5	
7	Heptachlor Epoxide	C ₁₀ H ₅ Cl ₇ O	mg/kg	2.7	
8	Lindane	C ₆ Cl ₆	mg/kg	29	
9	Pentachlorophenol	Cl ₅ C ₆ H ₅ OH	mg/kg	110	Gas Chromatography or Gas Chromatography/ Mass Spectrometry (GC/MS) or Gas Chromatography/ Fourier Transform Infrared (GC/FT-IR) Spectrometry or other Methods Approved by WREA
IV. Others					
1	Benzo(a)pyrene	-	mg/kg	2.9	Gas Chromatography/ Mass Spectrometry (GC/MS) or Thermal Extraction/ Gas Chromatography/ Mass Spectrometry (TE/GC/MS) or Gas Chromatography/ Fourier Transform Infrared (GC/FT-IR) Spectrometry or other Methods Approved by WREA
2	Cyanide and its compounds	CN ⁻	mg/kg	11	Total and Amenable Cyanide: Distillation, or Total Amenable Cyanide (Automated Colorimetric, with off-line Distillation), or Cyanide Extraction Procedure for Solids and Oils or other Methods Approved by WREA
3	PCBs (C ₁₂ H ₇ Cl ₃)	PCBs (C ₁₂ H ₇ Cl ₃)	mg/kg	10	Gas Chromatography or other Methods Approved by WREA
4	Vinyl Chloride	CH ₂ =CHCl	mg/kg	8.3	Purge and Trap Gas Chromatography or Purge and Trap Gas Chromatography Mass Spectrometry

4.3 Ambient Air Quality Standard

Parameters	Symbol	Average Time Unit: mg/m3					Method of Measurement
		Hours			1 month	1 year	
		1 hr	8 hr	24 hr			
Carbon monoxide	CO	30	10.26	-	-	-	Non dispersive infrared detection
Nitrogen dioxide	NO ₂	0.32	-	-	-	-	Chemilumine scene method
Sulphur dioxide	SO ₂	0.78	-	0.30	-	0.10	UV Fluorescence (1hr, 24hr, 1yr) or Pararosaniline (1hr,4hr)
Total Suspended Particulate	TSP	-	-	0.33	-	0.10	Gravimetric
Particulate Matter less than 10 microns	PM-10	-	-	0.12	-	0.05	Gravimetric or Beta Ray or Taper Element Oscillating Microbalance or Dichotomous
Ozone	O ₃	0.20	-	-	-	-	Chemiluminescence or UV Absorption Phoptometry
Lead	Pb	-	-	-	1.5	-	Atomic Absorption Spectrometer

4.4 Noise Standard

Standards	Method of Measurement
Maximum Sound Level (L _{max}) should not exceed 115 dB(A)	Equivalent Sound Level (L _{eq}) from Fluctuating Noise
L _{eq} 24 hour not exceeding 70 dB(A)	Equivalent Sound Level (L _{eq}) from Steady Noise

4.4.1 Noise Standards for Other Places

Type of Area	Standard Value in dB(A)		
	6.00-18.00	18.00-22.00	22.00-6.00
Quiet areas: hospitals, libraries, treatment places, kindergarten and schools	50	45	40
Residential areas: hotels and houses	55	55	45
Commercial and service areas	70	70	50
Small industrial factories located in residential areas	70	70	50

Article 5: Emission Standards

5.1 General Industrial Wastewater Discharge Standards

5.1.1 Standards for General Industries

No.	Parameters	Symbols	Unit	Maximum Concentration
1	BOD ₅	BOD ₅	mg/l	40
2	Ammonia Nitrogen	NH ₃ -N	mg/l	4
3	Total Suspended Substances	TSS	mg/l	40
4	Potential of Hydrogen	pH	-	6-9.5
5	Total Dissolved Substances	TDS	mg/l	3,500
6	Phenols	C ₆ H ₅ OH	mg/l	0.3
7	Phosphorous	P	mg/l	1.0
8	Silver	Ag	mg/l	0.1
9	Zinc	Zn	mg/l	1.0
10	Sulphide	S	mg/l	1.0
11	Free Chlorine	Cl ₂	mg/l	1.0
12	Chloride	Cl ⁻	mg/l	500
13	Iron	Fe	mg/l	2.0
14	Fluoride	F	mg/l	15
15	Cyanide	CN ⁻	mg/l	0.1
16	Copper	Cu	mg/l	0.5
17	Lead	Pb	mg/l	0.2
18	Oil and Grease	-	mg/l	5
19	Nickel	Ni	mg/l	0.2
20	Mercury	Hg	mg/l	0.005
21	Manganese	Mn	mg/l	1.0
22	Arsenic	As	mg/l	0.25
23	Barium	B	mg/l	1.0
24	Cadmium	Cd	mg/l	0.03
25	Chromium	Cr ⁺⁶	mg/l	0.1
26	Total Chromium	Total Cr	mg/l	0.5

5.1.2 Sugar Cane Factories

No.	Parameters	Symbols	Unit	Maximum Concentration
1	BOD ₅	BOD ₅	mg/l	60
2	Total Suspended Substances	TSS	mg/l	100
3	Potential of Hydrogen	pH	-	6-9.5

5.1.3 Textiles and Garments Factories with Dyeing of Yarns

No.	Parameters	Symbols	Unit	Maximum Concentration
1	BOD ₅	BOD ₅	mg/l	40
2	Phenols	C ₆ H ₅ OH	mg/l	1
3	Total Suspended Substances	TSS	mg/l	40
4	Potential of Hydrogen	pH	-	6-9.5

5.1.4 Pulp Products

No.	Parameters	Symbols	Unit	Maximum Concentration
1	BOD ₅	BOD ₅	mg/l	90
2	Ammonia-Nitrogen	NH ₃ -N	mg/l	7
3	Phenols	C ₆ H ₅ OH	mg/l	1
4	Total Suspended Substances	TSS	mg/l	60
5	Potential of Hydrogen	pH	-	6-9.5

5.1.5 Paper Products

No.	Parameters	Symbols	Unit	Maximum Concentration
1.	BOD ₅	BOD ₅	mg/l	30
2.	Total Suspended Substances	TSS	mg/l	30
3.	Potential of Hydrogen	pH	-	6-9.5

5.1.6 Slaughtering Factories

No.	Parameters	Symbols	Unit	Maximum Concentration
1.	BOD ₅	BOD ₅	mg/l	40
2.	Ammonia-Nitrogen	NH ₃ -N	mg/l	4
3.	Total Suspended Substances	TSS	mg/l	40
4.	Potential of Hydrogen	pH	-	6-9.5

5.2 Standards for Specific Industries

5.2.1 Factories that Contain Organic Substances

No.	Types of Factories	Parameters		
		Max BOD ₅	Max pH	Max TSS
1.	Canned fish	40	6-9.5	50
2.	Beer	30	6-9.5	30
3.	Starch	70	6-9.5	80
4.	Tannery	40	6-9.5	40
5.	Yarn Dyeing	40	6-9.5	40
6.	Pharmacy	40	6-9.5	40

5.2.2 Factories that Contain Inorganic Substances: Metal Plating

No.	Parameters	Symbols	Unit	Permitted Concentration
1.	Potential of Hydrogen	pH	-	6-9.5
2.	Zinc	Zn	mg/l	5.0
3.	Cyanide	CN ⁻	mg/l	0.2
4.	Total Suspended Substances	TSS	mg/l	30
5.	Chrome	Cr ⁺⁶	mg/l	0.3
6.	Total Chrome	Total Cr	mg/l	2.0
7.	Nickel	Ni	mg/l	0.2
8.	Copper	Cu	mg/l	1.0
9.	Total Heavy Metals	-	mg/l	6.0
10.	Oil and Grease	-	mg/l	30

5.2.3 Battery Producing

No.	Parameters	Symbols	Unit	Permitted Concentration
1.	Lead	Pb	mg/l	0.2
2.	Copper	Cu	mg/l	0.5
3.	Zinc	Zn	mg/l	1
4.	Antimony	Sb	mg/l	1
5.	Cadmium	Cd	mg/l	0.03
6.	Chromium	Cr	mg/l	0.5
7.	Nickel	Ni	mg/l	1.0
8.	Mercury	Hg	mg/l	0.005
9.	Potential of Hydrogen	pH		6-9.5

5.3 Effluent Standards for Pig Farms

No.	Parameters	Symbol	Unit	Maximum Permitted Value		
				Standard A	Standard B	Method for Examination
1.	Potential of Hydrogen	pH	-	5.5-9	5.5-9	pH Meter
2.	Biochemical Oxygen Demand	BOD ₅	mg/l	60	100	Aside Modification or Membrane Electrode
3.	Chemical Oxygen Demand	COD	mg/l	300	400	Potassium Dichromate Digestion, Open Reflux or Closed Reflux
4.	Suspended Solids	SS	mg/l	150	200	Glass Fibre Filter Disc, Dry Evaporation 103-105 degree Celsius
5.	Total Kjeldahl Nitrogen	TKN	mg/l	120	200	Kjeldahl; Colorimetric or Ammonia Selective Electrode

Standard A: 1. Large Farm is more than 400 Livestock Units (LU)
2. Medium Farm is 60-400 LU.

Standard B: 1. Small Farm is 6-<60 LU.
2. 1 LU equals 500 kg.
3. Weight of breeding pig = 170 kg/head
4. Weight of fattened pig = 60 kg/head
5. Weight of nursing pig = 12 kg/head

5.4 Gas Station Effluent Standards

No.	Parameters	Symbol	Unit	Range or Maximum Permitted Values	Method of Examination
1.	Potential of Hydrogen	pH	-	5.5-9	pH Meter
2.	Chemical Oxygen Demand	COD	mg/l	200	Potassium Dichromate Digestion
3.	Suspended Solid	SS	mg/l	60	Glass Fibre Filter Disc
4.	Oil and Grease	-	mg/l	15	Extract with solvent

5.5 Wastewater Discharge Standards from the Urban Area

5.5.1 Wastewater Discharge Standards

No.	Parameters	Symbol	Standards				
			A	B	C	D	E
1.	Biochemical Oxygen Demand	BOD ₅	Not more than (mg/l)				
			30	40	50	60	200
2.	Suspended Solids	SS	Not more than (mg/l)				
			30	40	50	50	60
3.	Settle able Solids	-	Not more than (mg/l)				
			0.5	0.5	0.5	0.5	-
4.	Total Dissolved Solids	TDS	Not more than (mg/l)				
			3000	2500	2000	1500	-
5.	Chemical Oxygen Demand	COD	Not more than (mg/l)				
			120	130	150	350	400
6.	Sulphide	S ²⁻	Not more than (mg/l)				
			1.0	1.0	3.0	4.0	-
7.	Total Kjeldahl Nitrogen	TKN	Not more than (mg/l)				
			35	35	40	40	-
8.	Fat Oil and Grease	-	Not more than (mg/l)				
			20	20	20	20	100
9.	Temperature	t	Not more than (degree Celsius)				
			40	40	40	40	40
10.	Potential of Hydrogen	pH	Not more than				
			6-9.5	6-9.5	6-9.5	6-9.5	6-9.5

5.5.2 Classification of buildings according to the Wastewater Discharge Standards

No.	Types of Buildings	Size of Buildings	Standard
1.	Buildings	Less than 100 rooms From 101 to 500 rooms Above 501 rooms	D C B
2.	Hotels	Less than 60 rooms From 61 to 200 rooms Above 201 rooms	D C B
3.	Dormitories	From 10 to 50 rooms From 51 to 250 rooms Above 251 rooms	D C B
4.	Medical Centers, Hospitals, Clinic	No bed From 1 to 30 beds. Above 31 beds.	C B A
Classification of buildings per Area			
5	Residential, temple	From 5,000 to 10000 sq m Above 10001 sq m	E D
6	Entertainment zone, health center swimming pool, Fitness Center	From 1000 to 5000 sq m Above 5001 sq m	D B
7	School, Educational institutions, College, Universities	From 5000 to 25000 sq m Above 25001 sq m	B A
8.	Office, enterprises, foreign and private buildings, Hall	From 5000 to 10000 sq m. From 10001 to 55000 sq m Above 55001 sq m	C B A
9.	Commercial centers and Supermarkets	From 5000 to 25000 sq m Above 25001 sq m	B A
10.	Markets	From 500 to 1,000 sq m From 1001 to 1500 sq m From 1501 to 2500 sq m Above 2501 sq m	D C B A
11	Restaurants	Less than 100 sq m From 500 to 1000 sq m From 1001 to 1500 sq m From 1501 to 2500 sq m Above 2501 sq m	E D C B A
12	Auto service center (Motorbike, car)	From 500 to 1000 sq m From 1,001 to 1500 sq m From 1,501 to 2500 sq m Above 2501 sq m	D C B A
13	Terminal Stations, Airport.	From 5000 to 10000 sq m From 10001 to 55000 sq m Above 55001 sq m	C B A
14	Slaughterhouse in City	From 500 to 1000 sq m From 1001 to 1500 sq m From 1501 to 2500 sq m Above 2501 sq m	D C B A

5.5.3 Wastewater Treatment Standards for Public Areas

No.	Parameters	Symbol	Standards					Method of Examination
			A	B	C	D	E	
1	Biochemical Oxygen Demand	BOD ₅	Not more than (mg/l)					Manometric method at 20 Celsius for 5 consecutive days
			30	40	50	60	200	
2	Suspended Solids	Suspended solids	Not more than (mg/l)					Evaporation at about 150 Celsius during 1 hour
			30	40	50	50	60	
3	Settle able Solids	Settle able solids	Not more than (mg/l)					Glass fibre filter disc
			0.5	0.5	0.5	0.5	-	
4	Total Dissolved Solids	TDS	Not more than (mg/l)					Glass fibre filter disc
			3000	2500	2000	1500	-	
5	Chemical Oxygen Demand	COD	Not more than (mg/l)					Potassium Digestion
			120	130	150	350	400	
6	Sulphide	S ²⁻	Not more than (mg/l)					Titration method
			1.0	1.0	3.0	4.0	-	
7	Total Kjeldahl Nitrogen	TKN	Not more than (mg/l)					Kjeldahl method
			35	35	40	40	-	
8	Fat Oil and Grease	Oil and Grease	Not more than (mg/l)					Extraction by solvents and separation of the weight of fat and grease
			20	20	20	20	100	
9	Temperature	t	Not more than (degree Celsius)					Thermometer
			40	40	40	40	40	
10	Potential of Hydrogen	pH	Not more than					pH Meter
			6-9.5	6-9.5	6-9.5	6-9.5	6-9.5	

5.5.4 Type of Public Areas for Wastewater Discharge

Public Areas			
1	History and cultural tourism place	From 5000 to 10000 sq m From 10001 to 55000 sq m Above 55001 sq m	E D C
2	Public Park	From 5000 to 10000 sq m From 10001 to 55000 sq m Above 55001	C B A
3	Amusement Park	From 5000 to 10000 sq m From 10001 to 55000 sq m Above 55001 sq m	C B A
4	Water Park	From 5000 to 10000 sq m From 10001 to 55000 sq m above 55001 sq m	C B A
5	Marsh, Pond	From 5000 to 10000 sq m From 10001 to 55000 sq m Above 55001	C B A
6	Main water drainage, second water drainage, water drainage along the road	From 5000 to 10000 sq m From 10001 to 55000 sq m Above 55001 sq m	C B A

5.6 Air Emission Standards for Industrial Factories

5.6.1 Air Emission Standards for Industrial Factories

No.	Parameters	Type of Factories	Emission Limits
1.	Ammonia and ammonium compounds	Trade, Industrial or producing process	76 mg/Nm ³
2.	Antimony and its compounds	Trade, Industrial or producing process	5 mg/Nm ³
3.	Arsenic and its compounds	Trade, Industrial or producing process	1 mg/Nm ³
4.	Benzene	Trade, Industrial or producing process	5 mg/Nm ³
5.	Cadmium and its compounds	Trade, Industrial or producing process	3 mg/Nm ³
6.	Carbon monoxide	Trade, Industrial or producing process	625 mg/Nm ³
7.	Chlorine	Trade, Industrial or producing process	32 mg/Nm ³
8.	Copper and its compounds	Trade, Industrial or producing process	5 mg/Nm ³
9.	Dioxins and furans	Fuel burning equipment or wood industry	1.0 mg/TEZ/Nm ³
10.	Ethylene Oxide	Trade, Industrial or producing process	5 mg/Nm ³
11.	Fluorine, hydrofluoric acid or inorganic fluorine compounds	Trade, Industrial or producing process	50 mg/Nm ³
12.	Formaldehyde	Trade, Industrial or producing process	20 mg/Nm ³

No.	Parameters	Type of Factories	Emission Limits
13.	Hydrogen Chloride	Trade, Industrial or producing process	200 mg/Nm ³
14.	Hydrogen Sulphide	Trade, Industrial or producing process	7.6 mg/Nm ³
15.	Lead and its compounds	Trade, Industrial or producing process	5 mg/Nm ³
16.	Mercury and its compounds	Trade, Industrial or producing process	3 mg/Nm ³
17.	Oxides of nitrogen	Trade, Industrial, producing process, fuel burning equipment or wood industry	700 mg/Nm ³ Material
18.	Particulate substances	Trade, industrial, producing process, fuel burning equipment or wood industry	I. 100 mg/Nm ³ II. 100 mg/Nm ³ 200 mg/Nm ³
19.	Smoke	Fuel burning equipment or wood industry	Rangeland No.1 or equivalent opacity
20.	Styrene monomer	Trade, Industrial or producing process	100 mg/Nm ³
21.	Sulphur dioxide	Trade, Industrial or producing process	500 mg/Nm ³
22.	Sulphur dioxide and other acid greases	Fuel burning equipment or wood industry	500 mg/Nm ³
23.	Sulphur dioxide or Sulphuric acid mist	Trade, Industrial, producing process, fuel burning equipment or wood industry	100 mg/Nm ³
24.	Vinyl chloride monomer	Trade, Industrial or producing process	20 mg/Nm ³

5.6.2 Air Emission Standards for Cement Factories

Type of Cement Factory	Permitted Air Emission Standard Value		
	Particulate matter (mg/m ³)	Sulphur dioxide (ppm)	Dioxide of Nitrogen calculated in the form or Nitrogen dioxide (ppm)
Existing cement factories emitted air pollution			
(a) General cement burning plant	Not more than 300	Not more than 50	Not more than 600
(b) White cement burning plant	Not more than 300	Not more than 600	Not more than 600
(c) Cooling plant, cement crushing and coal crushing plant	Not more than 200	-	-

Type of Cement Factory	Permitted Air Emission Standard Value		
	Particulate matter (mg/m ³)	Sulphur dioxide (ppm)	Dioxide of Nitrogen calculated in the form or Nitrogen dioxide (ppm)
New cement factories emitted air pollution			
(a) General cement burning plant	Not more than 120	Not more than 50	Not more than 500
(b) White cement burning plant	Not more than 120	Not more than 500	Not more than 500
(c) Cooling plant, cement crushing and coal crushing plant	Not more than 120	-	-

5.6.3 Air Emission Standard for Power Plants

No.	Type of Substances or pollutant	Source	Permitted Emission Value	
1	Sulphur dioxide	Coal or Gas Power Plant	ppm	mg/m ³
		1. With the capacity of not more than 300 MW.	640	-
		2. With the capacity above 300 MW, not more than 500 MW	450	-
		3. With the capacity above 500 MW	320	-
2	Sulphur dioxide	Natural Gas Power Plant	20	-
3	Oxide of Nitrogen	Power Plant Generating Electricity From:		
		1. Coal	350	-
		2. Fuel	180	-
		3. Natural Gas	120	-
4	Particulate Substances	Power Plant Generating Electricity From:		
		1. Coal	-	120
		2. Fuel	-	120
		3. Natural Gas	-	60

5.6.4 Pollution Emission Standard for Iron Factory

Type of cement factories	Permitted Air Emission Standard Value		
	Dioxide of Nitrogen calculated in the form or Nitrogen dioxide (ppm)	Sulphur dioxide (ppm)	Dust (mg/m ³)
New Sources	800	180	120
Existing Sources	800	200	240

5.7 Air Emission Standards in the Workplace

5.7.1 Chemical Concentration in the Workplace

No.	Parameters	Symbols	Chemical Concentration mg/m ³
1	Aldrin	Aldrin	0.25
2	Azinphos-methyl	Azinphos-methyl	0.2
3	Chlordane	Chlordane	0.5
4	DDT	DDT	1
5	DDVP	DDVP	1
6	Dichlorvos	Dichlorvos	1
7	Dieldrin	Dieldrin	0.25
8	Dimethyl 1,2-dibromo 2,2dichloroethyl phosphate (Dibrom)	Dimethyl 1,2-dibromo 2,2dichloroethyl phosphate (Dibrom)	3
9	Endrin	Endrin	0.1
10	Guthion	Guthion	0.2
11	Lead asenate	Lead asenate	0.15
12	Lindane	Lindane	0.5
13	Melathion	Malathion	15
14	Methoxychlor	Methoxychlor	15
15	Nicotine	Nicotine	0.5
16	Systox	Systox	0.1
17	Thalium (soluble compounds)	Thalium (soluble compounds) as Ti	0.1
18	Thiram	Thiram	5
19	Toxaphene	Toxaphene	0.5
20	Parathion	Parathion	0.11
21	Phosdrin	Phosdrin	0.1
22	Pyrethum	Pyrethum	5
23	Warfarin	Warfarin	0.1
24	Carbaryl (sevin (R))	Carbaryl (sevin (R))	5
25	2,4-D	2,4-D	10
26	Paraquat	Paraquat	0.5
27	2,4,5-T	2,4,5-T	10
28	Acetic Acid	CH ₃ -COOH	25
29	Ammonia	NH ₃	35
30	Arsenic and its compounds	As and its compounds	0.5
31	Arsine	Arsine	0.2

32	Biphenyl	Biphenyl	1
33	Bisphenol	Bisphenol	2.8
34	Carbon dioxide	CO ₂	9,000
35	Carbon monoxide	CO	55
36	Chlorine	Cl ₂	3
37	Chlorine dioxide	ClO ₂	0.3
38	Chromium and its compounds	Cr and its compounds	1
39	Copper fume	Copper fume	0.1
40	Dust or mist of copper	Dust or mist of copper	1
41	Cotton dust (raw)	Cotton dust (raw)	1
42	Cyanide	CN ⁻	5
43	Ethyl alcohol	C ₂ H ₅ OH	1,900
44	Fluoride	F ⁻	2.5
45	Fluorine	F ₂	0.2
46	Hydrogen cyanide	HCN	11
47	Iron oxide fume	Iron oxide fume	10
48	Methyl alcohol	CH ₃ OH	260
49	Nikel carbonyl	Nikel carbonyl	0.007
50	Nickel, metal and soluble compounds	Ni, Metal and soluble compounds as Ni	1
51	Nitric acid	HNO ₃	5
52	Nitric oxide	Nitric oxide NO _x	30
53	Nitrogen dioxide	NO ₂	9
54	Nitroglycerin	Nitroglycerin	2
55	Sodium hydroxide	NaOH	2
56	Sulphur dioxide	SO ₂	13
57	Sulphuric acid	H ₂ SO ₄	1
58	Tetraethyl Lead	Tetra ethyl Lead (as Pb)	0.075
59	Tetra methyl Lead	Tetra methyl Lead(as Pb)	0.07
60	Tin and Inorganic compounds of tin	Tin and Inorganic compounds of Tin	2
61	Tin and Organic compounds of tin	Tin and Organic compounds of Tin	0.1
62	Phenol	C ₆ H ₅ OH	19
63	Phosgene (Carbonyl chloride)	Phosgene (Carbonyl chloride)	0.4
64	Phosphine	Phosphine	0.4
65	Posphoric acid	H ₃ PO ₄	1
66	Phosphorus (yellow)	P (yellow)	0.1
67	Phosphorus pentachloride	P-Cl ₅	1
68	Phosphorus pentasulfide	P-(SO ₄) ₅	1
69	Phosphorus	P	3
70	Xylene	Xylene	435
71	Zinc chloride fume	ZnCl ₂	1
72	Zinc oxide fume	ZnO	5

5.7.2 Atmospheric Chemical Substance Concentration in the Workplace

No.	Parameters	Symbols	Chemical Concentration mg/m ³
1.	Ally glycidyl ether	AGE	45
2.	Boron trifluoride	Boron trifluoride	3
3.	Butylamine	Butylamine	15
4.	Tert-Butyl chromate	Tert-Butyl chromate (as CrO ₃)	0.1
5.	Chlorine trifluoride	Chlorine trifluoride	0.4
6.	Chloroacetaldehyde	Chloroacetaldehyde	3
7.	Chloroform (trichloromethane)	Chloroform (trichloromethane) Chloroform	240
8.	o-Dichlorobenzen	o -Dichlorobenzen	300
9.	Dichloethyl ether	Dichloethyl ether	90
10.	1,1-Dichloro-1-nitroethane	1,1-Dichloro-1-nitroethane	60
11.	Diglycidyl ether	Diglycidyl ether (DGE)	2.8
12.	Ethyl mercaptan	Ethyl mercaptan	25
13.	Ethylene mercol glycol dinitrate and/or Nitroglycerin	Ethylene mercol glycol dinitrate and /or Nitroglycerin	1
14.	Hydrogen chloride	Hydrogen chloride	7
15.	Iodine	Iodine	1
16.	Manganese	Manganese	5
17.	Methyl bromide	Methyl bromide	80
18.	Methyl mercaptan	Methyl mercaptan	20
19.	α-Methyl styrene	α-Methyl styrene	480
20.	Methylene bisphenyl isocyanate	Methylene bisphenyl isocyanate	0.2
21.	Monomethyl hydrazine	Monomethyl hydrazine	0.35
22.	Terphenyls	Terphenyls	9
23.	Toluene-2,4-Diisocyanate	Toluene-2,4-Diisocyanate	0.14
24.	Vinyl chloride	Vinyl chloride	2.8

5.7.3 Atmospheric Chemical Substance Concentration in the Workplace

No.	Materials	Average Concentration during normal Work Period	Concentration for a Specified Time		Permitted Concentration Value
			Concentration	Permitted Exposure Period	
1	Benzene	10 ppm	50 ppm	10 min	25 ppm
2	Beryllium and its compounds	2 mg/m ³	25 mg/m ³	30 min	5 mg/m ³
3	Cadmium fume	0.1 mg/m ³	-	-	0.3 mg/m ³
4	Cadmium dust	0.2 mg/m ³	-	-	0.6 mg/m ³
5	Carbondisulfide	20 ppm	100 ppm	30 min	30 ppm
6	Carbontetrachloride	10 ppm	200 ppm	5 min in	25 ppm

No.	Materials	Average Concentration during normal Work Period	Concentration for a Specified Time		Permitted Concentration Value
			Concentration	Permitted Exposure Period	
				any 4 hours	
7	Ethylene dibromide	20 ppm	50 ppm	5 min	30 ppm
8	Ethylene dichloride	50 ppm	200 ppm	5 min in any 3 hours	100 ppm
9	Formaldehyde	3 ppm	10 ppm	30 min	5 ppm
10	Fluoride as dust	2.5 mg/m ³	-	-	-
11	Lead and its inorganic compounds	0.2 mg/m ³	-	-	-
12	Methyl chloride	100 ppm	300 ppm	5 min in any 3 hours	200 ppm
13	Methyl chloride	500 ppm	2000 ppm	5 min in any 2 hours	1000 ppm
14	Organo mercury	0.01 mg/m ³	-	-	0.04 mg/m ³
15	Styrene	100 ppm	600 ppm	5 min in any 3 hours	200 ppm
16	Trichloro ethylene	100 ppm	300 ppm	5 min in any 2 hours	200 ppm
17	Tetrachloro ethylene	100 ppm	300 ppm	5 min in any 3 hours	200 ppm
18	Toluene	200 ppm	500 ppm	10 min	300 ppm
19	Hydrogen Sulfide	-	50 ppm	10 min	20 ppm
20	Mercury	-	-	-	0.05 mg/m ³
21	Chromic acid and chromate salt	-	-	-	0.1 mg/m ³

5.8 Emission Standards from Mobile Sources

5.8.1 Emission Standards for New Vehicles

Type of vehicle	Standard Values			
New public transport and light vehicles	Particulate Matters (PM) (mg/km)	Nitrogen Oxide (NO _x) (mg/km)	Hydrocarbon (HC) (mg/km)	Carbon Monoxide (mg/km)
Benzene Engine Vehicle	-	150	200	2,300
Diesel Engine Vehicle	50	500	-	640

5.8.2 Emission Standard for Used Motor Vehicles (Motorcycles)

Pollutants	Standards	Equipment	Methods of Measurement
Carbon monoxide (CO)	4.5%	Non-dispersive Infrared Detection	Measure while parking the motorcycle at idle and no load
Hydrocarbon (HC)	10,000 ppm		
White Smoke	30%	Smoke Meter, Full Flow Opacity System	Measure while parking the motorcycle at idle and no load by quick acceleration the engine to 75% of maximum power rpm

5.8.3 Emission Standards for Used Motor Vehicles (Benzene Vehicles)

Type	Pollutants	Standard	Equipment	Method of Measurement
	Carbon monoxide CO (%)	Hydrocarbon HC (ppm)		
Benzene Vehicle	4.5	600	Non-Dispersive Infrared Detection	Measure while parking the car at idle and no load

5.8.4 Emission Standards for Used Motor Vehicles (Diesel Vehicles)

Type	Smoke SHU	Equipment	Method of Measurement
Diesel Vehicle	50%	Filter System	Measure while parking the car at load by quick acceleration the engine to maximum rpm
	45%	System Opacity	
	40%	Filter System	Measure while the car running steady on the roller at 60% of maximum power rpm
	35%	System Opacity	

5.9 Noise Pollution Standards

5.9.1 Noise Standards for Motor Boats

Standards	Method of Measurement
100 dB(A) at 5 meters from the boat's exhaust pipe	Diesel engines; accelerate until the engine reaches its highest rounds per minute.
Conduct the test twice and use the highest standard measured. If the difference is higher than 2 dB(A), perform the test again	Benzene engine; accelerate to 3/4 of the maximum round

5.9.2 Noise Standards for Vehicles

Type of Vehicles	Standards	Method of Measurement
Diesel vehicle	Measured at 7.5 meters: not exceeding 85 dB(A)	Accelerate until the engine reaches maximum speed.
	Measured at 0.5 meters: not exceeding 100 dB(A)	
Benzene vehicle	Car used in ways while it stays still and its engine is running without sound of horn	Measuring while parking the car at no load by acceleration the engine to 3/4 of maximum rpm.

5.9.3 Noise Standards for Motorcycles

Standards	Methods of Measurement
Measured at 0.5 meters: not exceeding 95 dB(A) for a car used in ways, while it stays still and its engine is running without sound of horn	- The engine shall be accelerated to be at 3/4 of the maximum rounds if the engine has the maximum rounds of not more than 5000 rpm. - The engine shall be accelerated to be at 1/2 of the maximum rounds if the engine has the maximum rounds of more than 5000 rpm.

Chapter III

Organizations Responsible for the Implementation and Monitoring of the National Environmental Standards

Article 6: Implementation Responsible Organizations

The implementation responsible organization is divided into two levels as follows:

- 6.1 Central Level; and
- 6.2 Provincial Level.

Article 7: Central Level Organizations

Central level organizations include the following:

- 7.1 Department of Environment, Water Resources and Environmental Administration (WREA)
- 7.2 Department of Water Resources, Water Resources and Environmental Administration (WREA)
- 7.3 Environmental and Social Impact Assessment Department, Water Resources and Environmental Administration (WREA)
- 7.4 Water and Environment Research Institute, Water Resources and Environmental Administration (WREA)
- 7.5 Other sectors at central level.

Article 8: Rights and Duties of Central Level Organizations

8.1 Department of Environment

Department of Environment, Water Resources and Environmental Administration shall be a focal point for coordination with other relevant divisions and local authorities to implement the administration and monitoring activities of this Agreement throughout the country.

8.2 Water and Environment Research Institute

Water and Environment Research Institute shall have the responsibilities to conduct further research, monitor, analyze and provide other services in relation to water and environmental quality throughout the country.

8.3 Department of Water Resources

Department of Water Resources shall have the responsibility to coordinate with other authorities to conduct surveys, and evaluate and monitor the quantity, quality and utilization of surface water and groundwater.

8.4 Environmental and Social Impact Assessment Department

The Environmental and Social Impact Assessment Department shall have the responsibility to review, monitor and evaluate the implementation of Environmental and Social Management and Monitoring Plans of each state or private investment project.

8.5 Other Sectors at Central Level

Other sectors at central level have duty of responsible to monitor and review the technical standards related to its responsibility in order to ensure the implementation of this Environmental Standard.

Article 9: Implementing Organization at Provincial Level

The implementing organizations at provincial level include:

- 10.1 Water Resources and Environment Offices in Vientiane Capital and all provinces; and
- 10.2 Other divisions at provincial level.

Article 10: Rights and Duties of Provincial Level Organizations

- 10.1 Water Resources and Environmental Office in Vientiane Capital and all provinces shall be a focal point to coordinate with other divisions and other local authorities to implement the administration and monitoring activities in respect of environment within their authority and jurisdiction.
- 10.2 Other sectors at provincial have duty of responsible to monitor and review the technical standards related to its responsibility in order to ensure the implementation of the National Environmental Standards.

Chapter IV

Rewards and Sanctions

Article 11: Rewards

The Individuals, consumers, producers and other related organizations that facilitate or provide any services in good compliance with this agreement will be commended and will receive the compliment certificate from Water Resources and Environmental Administration.

Article 12: Sanctions

Individuals, consumers, producers and other related organizations violating the provision of this agreement will be warned, be fined or subject to criminal punishment, depending on the severity of the violation.

Chapter V

Final Provisions

Article 13: Dissemination

Department of Environment shall have the duty to coordinate with other relevant organizations from the central level to the local level in order to disseminate this Agreement.

Other related organizations can research and issue additional specific standards subject to consultation and agreement with WREA.

Article 14: Implementation

Offices, departments, institutions, other sectors in central level and local authority shall acknowledge and perform strictly in compliance with this agreement.

Article 15: Effective

This agreement is affective since its promulgation, every term and provisions inconsistent with this agreement are hereby terminated.

Minister to Prime Minister's Office
Head of Water Resources and Environmental Administration

Khempheng Pholsena

CHAPTER 2. HYDROLOGY

2.1 Hydrological Survey

Table 2.1.1 Historical Rainfall Data at Vientiane in Lao P.D.R

No	Date	Maximum Daily Rainfall (mm/day)	Yearly Rainfall (mm/Year)	No	Date	Maximum Daily Rainfall (mm/day)	Yearly Rainfall (mm/Year)
1	1951.10.23	73.2	1816.3	31	1981.7.20	181.0	1921.8
2	1952.9.18	130.0	1876.8	32	1982.8.10	133.2	1641.5
3	1953.9.6	101.4	1749.1	33	1983.9.10	114.4	1304.3
4	1954.8.15	106.7	1530.5	34	1984.8.18	73.9	1635.7
5	1955.7.30	132.9	1566.1	35	1985.9.12	82.2	1253.5
6	1956.8.27	101.3	2004.1	36	1986.8.25	119.7	1747.3
7	1957.7.5	85.0	1458.8	37	1987.6.1	162.0	1676.9
8	1958.6.26	89.3	1199.9	38	1988.5.14	162.2	1608.4
9	1959.9.2	138.7	1986.2	39	1989.9.6	90.5	1506.8
10	1960.9.28	106.1	1593.7	40	1990.9.14	102.5	1497.6
11	1961.8.21	121.2	2065.6	41	1991.9.3	184.8	1514.0
12	1962.5.18	100.2	1696.0	42	1992.6.4	151.5	2016.5
13	1963.6.3	106.6	1328.4	43	1993.8.5	87.6	1116.6
14	1964.9.6	91.1	1857.8	44	1994.6.9	77.6	1911.9
15	1965.9.14	112.0	1920.6	45	1995.8.29	134.6	2019.8
16	1966.8.13	110.5	1659.5	46	1996.7.11	123.5	1696.7
17	1967.9.20	137.3	1544.0	47	1997.7.15	85.5	1599.3
18	1968.7.23	93.1	1495.8	48	1998.8.31	110.0	1467.0
19	1969.7.11	134.8	1446.2	49	1999.5.5	161.6	2192.2
20	1970.8.17	116.3	2047.2	50	2000.6.17	145.9	1499.8
21	1971.5.6	84.7	1407.6	51	2001.5.29	80.5	1659.0
22	1972.4.12	75.9	1521.6	52	2002.6.26	94.2	1846.7
23	1973.5.28	96.2	1531.9	53	2003.6.3	64.0	1475.0
24	1974.8.16	133.5	1329.1	54	2004.8.7	104.0	1629.6
25	1975.6.19	94.0	2006.2	55	2005.8.21	82.9	1667.8
26	1976.8.26	224.2	1614.9	56	2006.10.9	160.1	1930.3
27	1977.6.19	95.4	1142.0	57	2007.8.24	98.0	1467.6
28	1978.9.16	82.7	1980.7	58	2008.3.20	74.8	2201.6
29	1979.5.24	81.2	1301.1	59	2009.4.25	127.4	1482.9
30	1980.7.24	86.8	2290.3				
Average						112.1	1663.7

Source: Metrological and Hydrological Year Book published by MRC

Table 2.1.2 Historical Rainfall Data at Nong Khai in Thailand

No	Date	Maximum Daily Rainfall (mm/day)	Yearly Rainfall (mm/Year)	No	Date	Maximum Daily Rainfall (mm/day)	Yearly Rainfall (mm/Year)
1	1952.9.18	467.0	2085.1	31	1982.8.15	103.3	1761.5
2	1953.5.12	110.2	1626.0	32	1983.9.6	79.7	1469.5
3	1954.6.11	132.1	1675.2	33	1984.8.14	87.6	1781.1
4	1955.8.7	95.2	1349.9	34	1985.7.11	86.9	1322.6
5	1956.9.10	68.2	1669.6	35	1986.8.25	137.6	2056.2
6	1957.8.19	106.5	1468.8	36	1987.6.8	140.3	1359.0
7	1958.5.2	73.1	1106.2	37	1988.5.27	78.5	1378.0
8	1959.9.10	192.3	1975.2	38	1989.9.23	77.1	1322.5
9	1960.9.8	176.4	1745.8	39	1990.6.3	54.1	1565.9
10	1961.8.21	141.5	1661.8	40	1991.6.5	51.4	1093.9
11	1962.9.22	91.6	1911.1	41	1992.7.9	117.7	1425.6
12	1963.4.7	122.1	1600.4	42	1993.5.20	69.2	1122.9
13	1964.6.20	71.4	1686.3	43	1994.6.9	104.9	2004.2
14	1965.5.16	88.4	1322.6	44	1995.7.31	120.8	1591.2
15	1966.8.16	88.8	1625.5	45	1996.6.16	60.5	1372.4
16	1967.9.20	316.6	1625.8	46	1997.6.16	113.4	1711.2
17	1968.6.10	85.0	1519.7	47	1998.6.5	75.7	1177.5
18	1969.7.11	151.0	1793.6	48	1999.5.5	82.4	2054.7
19	1970.6.20	103.8	2163.7	49	2000.7.11	64.6	1541.9
20	1971.5.25	124.2	1809.1	50	2001.8.13	82.1	1753.6
21	1972.6.5	91.8	1405.5	51	2002.8.18	130.2	1860.7
22	1973.9.18	74.0	1266.6	52	2003.5.29	120.5	1684.8
23	1974.7.21	140.0	1429.6	53	2004.7.20	138.3	1621.1
24	1975.8.28	136.9	2119.3	54	2005.9.18	90.4	1747.2
25	1976.6.2	71.2	1484.4	55	2006.7.30	71.0	1073.9
26	1977.8.22	103.8	1150.0	56	2007.6.28	109.2	1453.1
27	1978.8.8	111.0	1814.3	57	2008.8.19	81.7	1885.2
28	1979.5.24	80.3	1176.5	58	2009.8.23	75.3	1609.3
29	1980.5.8	73.9	1968.3				
30	1981.7.6	75.2	1719.9				
				Average		109.8	1599.2

Source: Metrological and Hydrological Year Book published by MRC

Table 2.1.3 Historical Evaporation Data at Vientiane

No	Date	Maximum Daily Evaporation (mm)	Date	Minimum Daily Evaporation (mm)	Yearly Evaporation (mm)
1	N/A	N/A	N/A	N/A	N/A
2	1961.5.10	12.0	1961.10.2	1.0	1,808.0
3	N/A	N/A	N/A	N/A	N/A
4	1963.4.27	13.0	1963.12.8	0.1	1,556.5
5	1964.12.1	0.0	1964.12.1	0.0	
6	1965.7.2	13.0	1965.5.24	0.5	2,135.7
7	1966.3.25	10.6	1966.10.5	0.6	2,015.0
8	1967.6.16	13.0	1967.9.6	0.1	1,790.0
9	1968.6.3	15.2	1968.3.8	0.1	1,620.2
10	1969.7.7	10.8	1969.5.26	0.6	1,643.9
11	1970.10.17	14.0	1970.6.19	0.4	1,820.1
12	1971.4.24	19.0	1971.7.25	0.7	1,720.1
13	1972.5.11	13.8	1972.8.24	0.2	1,963.1
14	1973.4.16	12.0	1973.8.20	0.4	1,718.8
15	1974.5.15	9.0	1974.9.27	0.2	1,530.4
16	1975.4.26	9.0	1975.8.20	0.4	1,324.2
17	N/A	N/A	N/A	N/A	N/A
18	1977.8.10	8.0	1977.8.16	0.2	1,505.8
19	1978.7.5	8.0	1978.8.7	0.2	1,434.2
20	1979.4.4	9.5	1979.8.9	0.4	1,510.6
21	N/A	N/A	N/A	N/A	N/A
22	1981.3.18	6.1	1981.7.6	0.3	1,004.5
23	N/A	N/A	N/A	N/A	N/A
24	N/A	N/A	N/A	N/A	N/A
25	1984.4.10	7.2	1984.9.3	0.7	1,303.4
26	1985.4.12	7.0	1985.6.29	1.0	1,364.7
27	1986.3.27	7.3	1986.7.21	0.2	944.5
28	1987.5.27	8.5	1987.8.31	0.1	1,764.0
29	1988.5.25	9.5	1988.3.6	0.5	1,792.9
30	1989.7.16	8.5	1989.7.6	0.4	1,695.7
31	1990.4.10	8.5	1990.6.27	0.4	1,695.6
32	1991.4.19	8.6	1991.8.18	0.4	1,713.4
33	1992.11.9	10.0	1992.8.1	0.1	1,679.7
34	1993.3.2	10.0	1993.8.16	0.2	1,789.5
35	1994.5.16	10.8	1994.12.3	0.1	1,684.0
36	1995.4.15	10.0	1995.8.13	0.2	1,937.4
37	1996.7.8	9.5	1996.8.12	0.3	1,831.4
38	1997.6.4	10.0	1997.9.27	0.2	1,802.6
39	1998.5.2	9.8	1998.7.3	0.9	1,817.7
40	1999.4.1	8.0	1999.9.17	1.0	1,705.0
41	2000.11.15	9.0	2000.9.2	1.0	1,869.0
42	2001.6.19	10.0	2001.7.21	1.0	1,967.0
43	2002.5.6	10.0	2002.9.4	1.0	1,891.0
44	2003.5.4	10.0	2003.8.21	1.0	2,154.0
45	2004.4.30	10.0	2004.9.8	1.0	1,967.0
46	2005.4.9	11.0	2005.7.22	1.0	2,006.1
47	2006.5.13	11.0	2006.4.29	0.6	1,950.0
48	2007.7.12	11.0	2007.12.1	0.6	1,957.0
49	2008.2.26	10.2	2008.11.1	0.8	1,811.9
50	2009.6.14	10.0	2009.7.12	0.4	1,682.1
Average		10.0		0.5	1,718.1
Maximum		19.0		1.0	2,154.0
Minimum		0.0		0.0	944.5

Source: Metrological and Hydrological Year Book published by MRC

Table 2.1.4 Historical Temperature Data at Vientiane

No	Date	Maximum Temperature (degree)	Date	Minimum Temperature (degree)	Yearly Average (degree)
1	1971.5.10	31.3	1971.1.5	16.1	25.3
2	1972.5.1	31.3	1972.1.15	16.6	26.0
3	1973.4.12	32.7	1973.12.31	14.8	26.1
4	1974.7.11	30.5	1974.1.2	13.8	25.6
5	1975.4.29	33.2	1975.12.30	12.5	26.0
6	1976.4.16	30.9	1976.1.1	16.3	25.6
7	1977.6.9	32.6	1977.1.4	18.0	26.0
8	1978.4.6	31.2	1978.12.16	18.2	25.9
9	1979.4.8	31.7	1979.2.1	18.3	26.4
10	1980.4.24	33.6	1980.12.24	19.6	26.8
11	1981.4.7	32.2	1981.12.20	16.6	26.1
12	1982.5.12	32.4	1982.12.21	15.9	26.2
13	1983.4.16	33.7	1983.1.22	14.0	26.0
14	1984.4.6	32.2	1984.1.9	16.5	25.9
15	1985.4.13	32.8	1985.12.24	17.0	26.0
16	1986.4.11	31.4	1986.3.2	13.7	26.0
17	1987.5.21	31.9	1987.12.8	16.2	26.4
18	1988.4.22	33.4	1988.2.19	17.3	26.2
19	1989.4.22	32.6	1989.3.8	17.6	26.1
20	1990.4.24	32.2	1990.12.2	17.4	26.4
21	1991.4.18	32.9	1991.12.29	15.8	26.7
22	1992.5.10	34.4	1992.12.25	15.7	26.2
23	1993.5.3	32.8	1993.1.29	16.4	26.2
24	1994.5.3	32.5	1994.3.24	18.7	26.4
25	1995.4.23	33.5	1995.12.30	16.5	26.5
26	1996.7.9	30.8	1996.2.21	14.5	26.1
27	1997.5.7	33.0	1997.1.11	18.4	26.4
28	1998.5.2	33.1	1998.2.5	19.4	27.4
29	1999.4.2	31.9	1999.12.24	12.9	26.0
30	2000.4.4	31.4	2000.3.1	16.4	26.0
31	2001.4.22	32.9	2001.12.24	18.2	26.5
32	2002.4.21	31.7	2002.3.7	18.7	26.5
33	2003.5.7	33.6	2003.12.21	18.3	27.0
34	2004.5.1	31.9	2004.2.6	15.9	26.6
35	2005.4.11	32.7	2005.1.1	17.1	27.3
36	2006.3.26	31.6	2006.12.23	17.8	27.2
37	2007.4.24	33.8	2007.1.30	18.5	27.2
38	2008.4.12	31.5	2008.2.3	16.7	26.3
39	2009.4.17	32.5	2009.1.11	16.5	27.2
Average		32.4		16.6	26.3
Maximum		34.4		19.6	27.4
Minimum		30.5		12.5	25.3

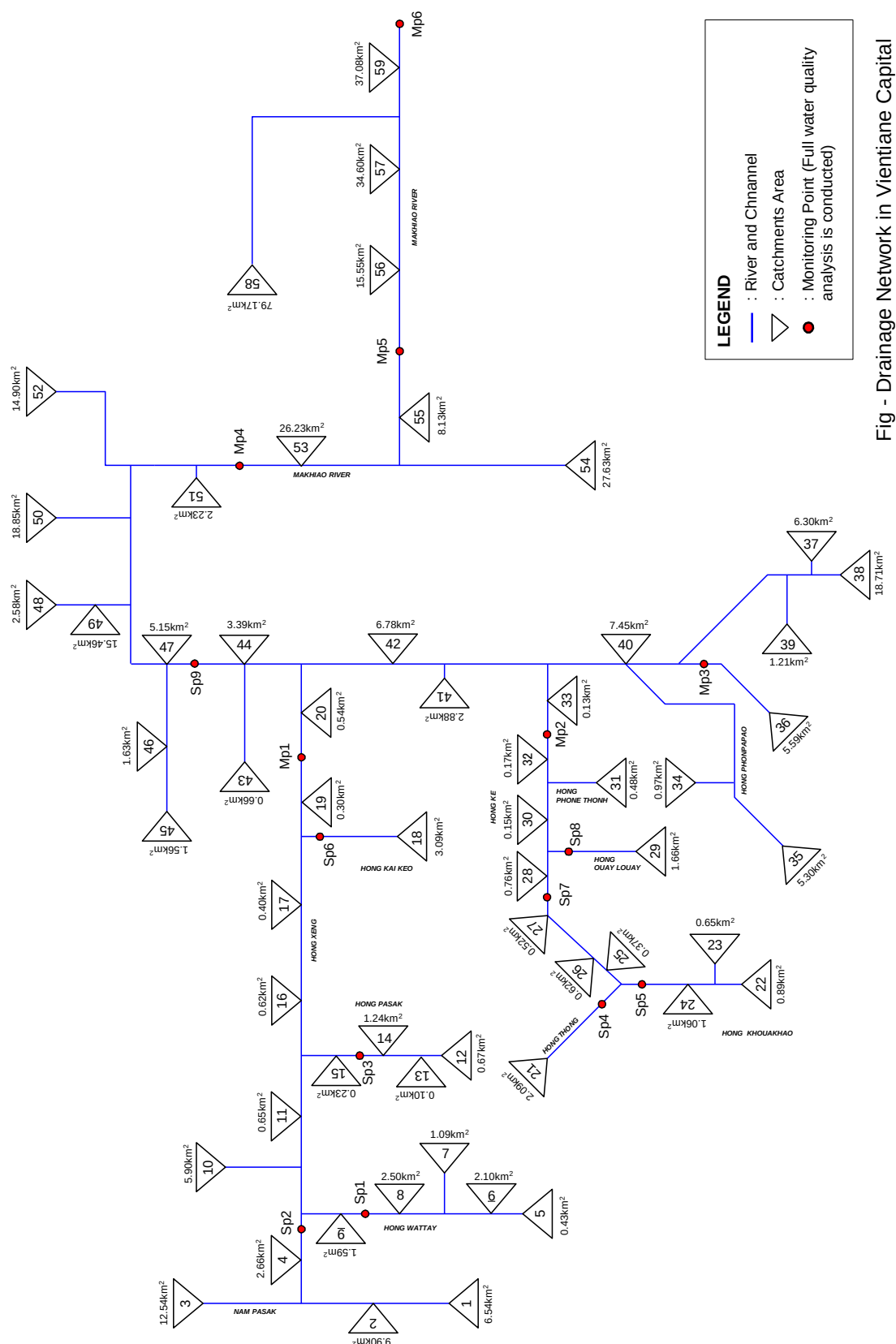
Source: Metrological and Hydrological Year Book published by MRC

Table 2.1.5 Land Use Condition (2000)

(unit: m²)

Sub-Cat chment No.	Build up area	Marsh	Water Body	Cultivated Land	Forest	Natural Field	Park	Rice Field	Total
1	2,294,839	251,223		1,974	71,457	2,426,663	33,018	1,461,826	6,541,000
2	1,073,084	124,397	24,701	233	145,071	137,788		8,410,294	9,915,570
3	2,899,818	203,151	26,329	275,693	1,666,714	857,454	23,580	6,585,494	12,538,233
4	1,128,411	93,299	140,010	150	138,789	118,522	5,141	1,036,771	2,661,093
5	396,750	8,312				21,504		3,651	430,217
6	1,514,034	106,495				45,048		431,652	2,097,229
7	762,731	122,114				59,643		147,136	1,091,623
8	1,099,787	48,658				40,676		1,337,125	2,526,246
9	889,458	23,464				23,343		652,627	1,588,892
10	3,600,290	765,846		8,225	384,303	345,751	7	799,737	5,904,157
11	391,059	23,520	22,167			122,902	11,766	78,489	649,904
12	671,458	7,887				12			679,357
13	96,123	3,612							99,736
14	1,044,152	81,023					545	127,070	1,252,789
15	197,057	11,414	23			21,818			230,312
16	499,669	9,135	9,887			27,793		73,264	619,748
17	259,180	10,200	13,120			26,205		95,098	403,802
18	2,529,249	78,634	29,244			57,098	7,686	422,851	3,124,761
19	245,798	3,401	12,269			96		34,227	295,791
20	329,886	11,693	22,826			1,633		176,257	542,294
21	2,044,125	11,654				22,558	14,246		2,092,582
22	856,208	14,726				23,069			894,003
23	555,999	14,752				79,948		5,829	656,528
24	1,021,638	37,159				2,632	3,391	9,335	1,074,156
25	334,136	47,183							381,319
26	587,914	22,660				11,425			622,000
27	417,787	16,631		25,091		31,911		26,026	517,445
28	696,596	13,153				7,049		45,873	762,670
29	1,400,477	37,229				30,116		203,990	1,671,811
30	140,134	4,477						760	145,371
31	429,316	24,014				28,025			481,355
32	157,417	8,150				59		4,239	169,866
33	32,285	13,505				8,767		80,325	134,882
34	861,746	29,142		10,720				66,237	967,845
35	3,531,087	77,565			15,345	96,491		1,582,344	5,302,833
36	2,788,973	169,276		1,277	313,902	146,039		2,174,198	5,593,665
37	642,913	68,311		43,082	1,340,134	1,424,451	89,315	2,696,363	6,304,570
38	2,880,232	401,458		471,565	4,576,603	1,485,980	42,458	8,851,814	18,710,111
39	500,632	28,239			538,559	96,895		46,224	1,210,549
40	1,104,721	536,016	50,209		18,523	383,307	10,131	5,351,774	7,454,682
41	1,581,127	64,137	17,039			15,409	1,520	1,207,997	2,887,229
42	2,638,595	162,111	27,703	32,609	950,847	618,407	45,417	2,318,724	6,794,413
43	286,367	5,204				7,135		365,681	664,388
44	1,357,967	41,303	16,383		22,355	145,677	20,600	1,782,639	3,386,924
45	1,232,442	36,287			1,006	48,328		241,353	1,559,417
46	1,298,202	98,845				7,491		220,955	1,625,492
47	2,768,515	198,220	15,036		274,834	30,117		1,864,847	5,151,570
48	797,352	82,722		236	303,513	190,646		1,203,714	2,578,183
49	4,879,946	547,425	18,218	50,919	484,966	927,287	20,437	8,529,568	15,458,767
50	1,625,868	303,139	6,441	79,887	5,717,224	483,377		10,634,065	18,850,002
51	1,074,943	118,472	20,054	16,973	374,320	188,558		437,596	2,230,916
52	519,450	52,150	23,604	47,491	4,447,605	88,722	55,882	9,661,924	14,896,829
53	2,195,589	221,233	87,162	86,319	6,576,081	2,550,618	231,564	14,288,424	26,236,991
54	2,995,944	371,849	6,773	408,884	10,572,267	3,589,576		11,566,571	29,511,862
55	349,253	376,581	197,656	80,836	3,554,147	453,982		3,114,417	8,126,871
56	271,560	102,066	102,556	635,224	8,617,827	197,913		5,622,797	15,549,943
57	491,837	57,403	989,629	88,787	19,436,184	1,311,369		12,228,653	34,603,861
58	5,084,468	613,318	395,543	1,409,842	34,321,961	2,221,951	2,842	37,025,611	81,075,537
59	652,260	183,503	620,734	982,905	23,845,361	1,217,584		9,883,631	37,385,978
Total	75,008,854	7,198,749	2,895,315	4,758,923	128,709,901	22,506,817	619,547	175,218,067	416,916,173

Source: Geography Bureau in Lao PDR and CA Study Team



Mak Hiao River Drainage Network (Existing)

Fig. 2.1.1.1

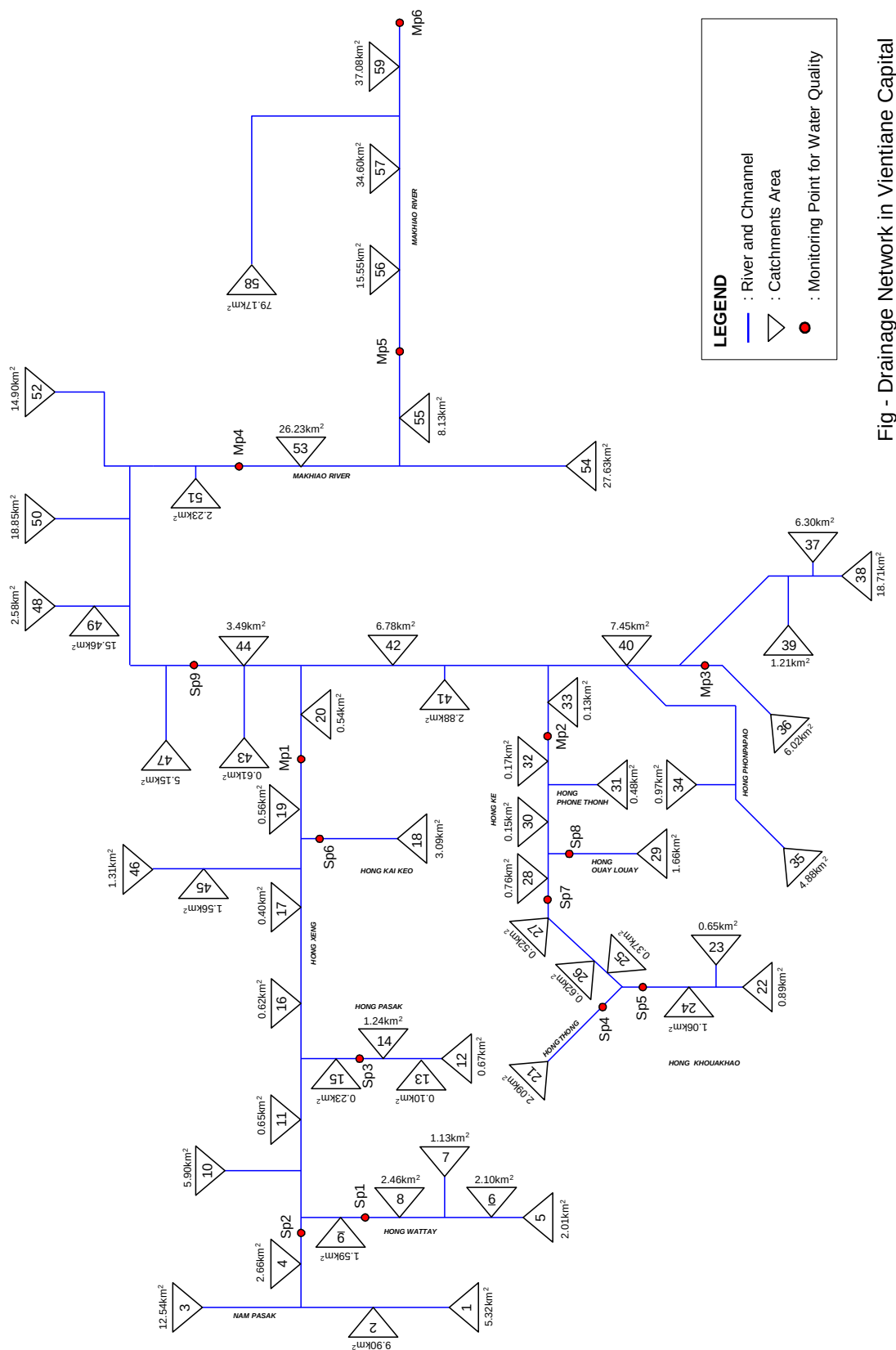


Fig. 2.1.2 Mak Hiao River Drainage Network (Near Future Condition)

Table 2.1.6 Specification on Sub-catchment Area

Sub-Catchment Num	i) Area (km ²)	ii) River Length (km)	i) / ii)	ii) / i)
1	6.541	3.020	2.166	0.462
2	9.901	4.251	2.329	0.429
3	12.537	3.253	3.854	0.259
4	2.661	2.861	0.930	1.075
5	0.430	0.560	0.768	1.302
6	2.097	1.886	1.112	0.899
7	1.092	0.733	1.490	0.671
8	2.501	1.643	1.522	0.657
9	1.589	1.108	1.434	0.697
10	5.900	3.607	1.636	0.611
11	0.650	1.094	0.594	1.683
12	0.672	0.902	0.745	1.342
13	0.099	0.231	0.429	2.333
14	1.239	1.348	0.919	1.088
15	0.225	0.590	0.381	2.622
16	0.620	0.825	0.752	1.331
17	0.404	0.924	0.437	2.287
18	3.089	1.358	2.275	0.440
19	0.296	0.820	0.361	2.770
20	0.542	1.901	0.285	3.507
21	2.088	1.789	1.167	0.857
22	0.886	0.804	1.102	0.907
23	0.653	0.852	0.766	1.305
24	1.059	1.764	0.600	1.666
25	0.365	0.924	0.395	2.532
26	0.622	0.924	0.673	1.486
27	0.517	0.486	1.064	0.940
28	0.763	0.533	1.432	0.699
29	1.662	1.844	0.901	1.110
30	0.145	0.440	0.330	3.034
31	0.480	0.936	0.513	1.950
32	0.170	0.533	0.319	3.135
33	0.128	0.724	0.177	5.656
34	0.967	1.325	0.730	1.370
35	5.302	5.590	0.948	1.054
36	5.593	4.919	1.137	0.879
37	6.304	4.224	1.492	0.670
38	18.707	4.623	4.047	0.247
39	1.211	2.544	0.476	2.101
40	7.449	3.444	2.163	0.462
41	2.876	2.017	1.426	0.701
42	6.778	4.252	1.594	0.627
43	0.664	0.732	0.907	1.102
44	3.387	2.162	1.567	0.638
45	1.559	0.809	1.927	0.519
46	1.625	1.840	0.883	1.132
47	5.147	2.769	1.859	0.538
48	2.578	0.439	5.872	0.170
49	15.458	4.854	3.185	0.314
50	18.849	5.526	3.411	0.293
51	2.231	2.989	0.746	1.340
52	14.896	6.882	2.164	0.462
53	26.233	5.778	4.540	0.220
54	27.630	7.966	3.468	0.288
55	8.127	5.330	1.525	0.656
56	15.549	2.749	5.656	0.177
57	34.602	17.309	1.999	0.500
58	79.169	19.701	4.019	0.249
59	37.075	18.376	2.018	0.496

Source: JICA Study Team

Table 2.1.7 The Result of Runoff Analysis (1/2)

Table - Runoff Analysis with Rational Formula (near future condition)

Sub-catchment Number		1	2	3	4	5	6	7	8	9	10	11	12	13-14	15	16	17	45	46	
1. General																				
River Name		-	Nam Pasak				Hong Wattay				Hong Ta Nhay	Hong Xeng	Hong Pasak			Hong Xeng				
Catchment Area	km ²	5.32	9.90	12.54	2.66	2.01	2.10	1.13	2.46	1.59	5.90	0.65	0.67	1.34	0.23	0.62	0.40	1.56	1.31	
Inflow Area	km ²	-	-	3.73	-	-	-	0.47	-	-	1.16	-	0.17	-	-	-	-	-	-	
Main River Length	km	3.02	4.25	0.20	2.86	2.65	1.89	0.00	1.64	1.11	0.00	1.09	0.90	1.58	0.59	0.83	0.92	-	-	
Average River Velocity	m/s	0.21	0.21	0.23	0.25	0.19	0.23	-	0.19	0.14	-	0.16	0.12	0.17	0.21	0.21	0.21	-	-	
Tributary Length	km	-	-	3.25	-	-	-	0.98	-	-	3.61	-	-	-	-	-	-	-	-	
Average River Velocity	m/s	-	-	0.04	-	-	-	0.17	-	-	0.03	-	-	-	-	-	-	-	-	
Average River Wide	km	1.76	2.33	3.85	0.93	0.76	1.11	1.16	1.50	1.43	1.64	0.59	0.75	0.85	0.38	0.75	0.44	-	-	
=																				
2. Land Use																				
1 Dense Urban (1999)	km ²	0.30	0.11	0.16	0.08		0.28	0.19	0.16	0.09	0.29	0.06	0.19	0.27	0.03	0.10	0.03			
1 Dense Urban (1.3倍して)		0.39	0.14	0.20	0.11	1.97	0.35	0.25	0.21	0.12	0.37	0.08	0.24	0.35	0.04	0.13	0.04	1.23	0.98	
2 Sparse Urban		0.01	0.01	0.01	0.003	0.004	0.01	0.01	0.01	0.01	0.02	0.002	0.02	0.02	0.002	0.0004	0.0004	0.01	0.00	
3 Field		2.52	0.25	1.63	0.25	0.02	0.07	0.16	0.05	0.02	1.05	0.13	0.00	0.04	0.02	0.03	0.03	0.05	0.03	
4 Paddy field		1.45	8.38	6.54	1.04	0.004	0.43	0.15	1.34	0.65	0.80	0.08	0.00	0.13	0.00	0.07	0.10	0.24	0.22	
5 Mountain Area		0.00	0.01	1.15	0.01	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
6 Water Body		0.16	0.15	0.23	0.23	0.01	0.08	0.03	0.04	0.03	0.28	0.05	0.01	0.04	0.01	0.02	0.02	0.04	0.07	
7 Others		0.78	0.96	2.78	1.02	0.00	1.15	0.55	0.82	0.75	3.21	0.31	0.41	0.76	0.15	0.37	0.22	0.00	0.00	
Total		5.32	9.90	12.54	2.66	2.01	2.10	1.13	2.46	1.59	5.90	0.65	0.67	1.34	0.23	0.62	0.40	1.56	1.31	
3. Accumulate Data																				
Land Use																				
Dense Urban	km ²	0.39	0.52	0.20	0.83	1.97	2.32	0.25	2.78	2.90	0.37	2.97	0.24	0.59	0.62	3.73	3.77	5.00	5.97	5.97
Sparse Urban		0.01	0.02	0.01	0.03	0.00	0.02	0.01	0.03	0.04	0.02	0.04	0.02	0.04	0.04	0.09	0.09	0.09	0.10	0.10
Field		2.52	2.77	1.63	4.65	0.02	0.09	0.16	0.30	0.32	1.05	0.45	0.00	0.04	0.06	0.55	0.57	0.62	0.66	0.66
Paddy field		1.45	9.83	6.54	17.41	0.00	0.44	0.15	1.92	2.57	0.80	2.65	0.00	0.13	0.13	2.85	2.95	3.19	3.41	3.41
Forest		0.00	0.01	1.15	1.17	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Body		0.16	0.31	0.23	0.78	0.01	0.09	0.03	0.16	0.18	0.28	0.24	0.01	0.05	0.06	0.32	0.34	0.38	0.45	0.45
Others		0.78	1.75	2.78	5.55	0.00	1.15	0.55	2.51	3.27	3.21	3.57	0.41	1.16	1.32	5.26	5.47	5.47	5.47	5.47
Total		5.32	15.22	12.54	30.42	2.01	4.10	1.13	7.69	9.28	5.90	9.93	0.67	2.01	2.24	12.79	13.19	14.75	16.06	16.06
Runoff Coefficient		0.636	0.665	0.645	0.653	0.896	0.757	0.632	0.703	0.689	0.581	0.683	0.652	0.641	0.635	0.672	0.670	0.690	0.703	0.703
Flood Concentration Time (Manual for River Works in Japan)																				
Flood Concentration Time (Manual for River Works in Japan)	min	-	-	41	-	-	-	15				23		9						
Flood Concentration Time (Kerby formula)		2		12	-	-	-	2				2								
Design River Velocity (mainstream)		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
Design River Velocity (tributary)				0.9				0.9				0.9								
Flood Flow Time (mainstream)		56	79	4	53	49	35	0	30	21	0	20	17	29	11	15	17	0	0	
Flood Flow Time (tributary)		-	-	60	-	-	-	33	-	-	90	-	-	-	-	-	-	-		
Flood Concentration Time (Each River Basin)																				
Flood Concentration Time (Each River Basin)		56	79	101	53	49	35	33	30	21	90	20	26	29	11	15	17			
Flood Concentration Time		56	135	101	191	49	84	33	114	135	90	155	26	55	66	170	188	188	188	
Rainfall Intensity																				
1/2	mm/hr	49.2	29.9	35.9	23.3	52.2	40.0	60.7	33.2	29.8	38.5	27.1	65.6	49.6	45.5	25.3	23.6		23.6	
1/5		69.9	42.1	50.7	32.8	74.2	56.6	86.4	47.0	42.1	54.5	38.2	93.5	70.5	64.5	35.7	33.3		33.3	
1/10		83.7	50.1	60.5	39.0	88.9	67.6	103.8	56.0	50.1	65.0	45.5	112.5	84.4	77.2	42.5	39.6		39.6	
1/20		96.8	57.7	69.7	44.8	102.9	78.0	120.5	64.5	57.7	75.0	52.3	130.8	97.7	89.2	48.8	45.4		45.4	
1/50		114.0	67.3	81.7	52.2	121.4	91.6	142.6	75.4	67.4	88.0	61.0	155.1	115.0	104.9	56.9	53.0		53.0	
Peak Discharge																				
				LB01	LB02	LB03	SP1	LB04	LB06	LB07	SP3	LB8	LB09	LB09						
1/2	m ³ /s	1	2	3	4	5	6	7	8	9	10	11	12	13-14	15	16	17	45	46	
1/5		46.2	84.1	80.6	128.5	26.1	34.5	12.0	49.9	52.9	36.6	83.5	8.0	17.8	18.0	92.8	90.3		106.4	
1/10		65.7	118.4	113.9	180.8	37.0	48.8	17.1	70.6	74.8	51.9	104.4	11.4	25.3	25.5	117.6	114.1		136.8	
1/20		78.6	140.9	135.9	215.0	44.4	58.3	20.6	84.2	89.0	61.8	118.2	13.7	30.2	30.5	133.8	129.6		156.6	
1/50		90.9	162.2	156.5	247.0	51.4	67.3	23.9	96.9	102.5	71.4	131.0	15.9	35.0	35.2	148.9	143.8		174.8	
1/50		107.1	189.2	183.5	287.8	60.6	79.0	28.3	113.3	119.7	83.7	147.4	18.9	41.2	41.4	168.2	162.5		198.6	
Discharge Rate																				
1/2	m ³ /s/km ²	8.7	5.5	6.4	4.2	13.0	8.4	10.6	6.5	5.7	6.2	8.4	11.9	8.8	8.0	7.3	6.8		6.6	
1/5		12.4	7.8	9.1	5.9	18.5	11.9	15.1	9.2	8.1	8.8	10.5	17.0	12.6	11.4	9.2	8.6		8.5	
1/10		14.8	9.3	10.8	7.1	22.1	14.2	18.2	10.9	9.6	10.5	11.9	20.4	15.0	13.6	10.5	9.8		9.7	
1/20		17.1	10.7	12.5	8.1	25.6	16.4	21.2	12.6	11.0	12.1	13.2	23.7	17.4	15.7	11.6	10.9		10.9	
1/50		20.1	12.4	14.6	9.5	30.2	19.3	25.0	14.7	12.9	14.2	14.8	28.1	20.5	18.5	13.2	12.3		12.4	
Peak Discharge (Final)																				
				LB01	LB02	LB03	SP1	LB04	LB06	LB07	SP3	LB8	LB09	LB09						
1/2	m ³ /s	29	84	81	129	17	35	7	50	53	37	83	5	16	18	88	90		95	
1/5		41	118	114	181	24	49	10	71	75	52	104	8	23	26	111	114		123	
1/10		49	141	136	215	28	58	12	84	89	62	118	9	27	31	126	130		141	
1/20		57	162	157	247	33	67	14	97	103	71	131	11	32	35	139	144		157	
1/50		66	189	184	288	39	79	17	113	120	84	147	12	37	41	158	162		179	

Table 2.1.8 The Result of Runoff Analysis (2/2)

Table - Runoff Analysis with Rational Formula (near future condition)

Sub-catchment Number					18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33					
1. General																									
River Name		-	Hong Kai Kao	Hong Xeng		Hong Thong	Hong Khouakhao			Hong Ke				Hong Ouay Loay	Hong Ke	Hong Phone Thong	Hong Ke								
Catchment Area	km ²	3.09	0.56	0.54	2.09	0.89	0.65		1.06	0.37	0.62	0.52	0.76	1.66	0.15	0.48	0.17	0.13							
Inflow Area	km ²	-	-	-	-	0.19	-		-	-	-	-	-	0.19											
Main River Length	km	0.00	0.82	1.90	0.00	0.80	0.00		1.76	0.92	0.92	0.49	0.53	0.00	0.44	0.00	0.53	0.72							
Average River Velocity	m/s	-	0.23	0.18	-	0.28	-		0.28	0.07	0.07	0.07	-	0.08	-	0.10	0.04								
Tributary Length	km	2.72	-	-	1.79	-	0.85		-	-	-	-	-	1.84	-	0.94	-	-							
Average River Velocity	m/s	-	-	-	0.13	-	0.09		-	-	-	-	-	0.16	-	0.26	-	-							
Average River Wide	km	1.13	0.68	0.29	1.17	1.10	0.77		0.60	0.40	0.67	1.06	1.43	0.90	0.33	0.51	0.32	0.18							
2. Land Use																									
1 Dense Urban (1999)	km ²	0.54	0.05	0.05	0.58	0.09	0.06		0.22	0.06	0.15	0.25	-	0.23	0.02	0.06	0.03	0.0002							
1 Dense Urban (1.3倍して)		0.70	0.06	0.07	0.75	0.12	0.08		0.28	0.08	0.19	0.13	0.19	0.30	0.03	0.07	0.04	0.00							
2 Sparse Urban		0.03	0.001	0.002	0.07	0.04	0.02		0.03	0.004	0.01	0.01	0.01	0.01	0.003	0.004	0.00	0.00							
3 Field		0.10	0.0001	0.002	0.04	0.02	0.08		0.01	0.00	0.03	0.03	0.04	0.03	0.00	0.03	0.0001	0.01							
4 Paddy field		0.42	0.03	0.18	0.00	0.00	0.01		0.01	0.00	0.00	0.03	0.04	0.20	0.001	0.00	0.004	0.08							
5 Mountain Area		0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
6 Water Body		0.08	0.02	0.03	0.01	0.03	0.01		0.04	0.23	0.01	0.01	0.02	0.04	0.004	0.02	0.01	0.01							
7 Others		1.77	0.45	0.26	1.23	0.67	0.44		0.70	0.06	0.39	0.32	0.47	1.08	0.11	0.35	0.12	0.03							
Total		3.09	0.56	0.54	2.09	0.89	0.65		1.06	0.37	0.62	0.52	0.76	1.66	0.15	0.48	0.17	0.13							
3. Accumulate Data																									
Land Use		km ²	0.70	6.73	6.79	0.75	0.12	0.08	0.20	0.49	1.31	1.50	1.63	1.81	0.30	2.14	0.07	2.25	2.25						
Dense Urban	0.03		0.12	0.13	0.07	0.04	0.02	0.07	0.10	0.17	0.18	0.18	0.19	0.01	0.20	0.00	0.21	0.21							
Sparse Urban	0.10		0.75	0.75	0.04	0.02	0.08	0.10	0.11	0.15	0.17	0.20	0.24	0.03	0.27	0.03	0.29	0.30							
Field	0.42		3.87	4.04	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.04	0.09	0.20	0.29	0.00	0.30	0.38							
Paddy field	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
Forest	0.08		0.55	0.58	0.01	0.03	0.01	0.05	0.08	0.33	0.33	0.35	0.36	0.04	0.41	0.02	0.44	0.45							
Water Body	1.77		7.70	7.96	1.23	0.67	0.44	1.11	1.81	3.09	3.48	3.79	4.26	1.08	5.45	0.35	5.93	5.95							
Others	3.09		19.71	20.25	2.09	0.89	0.65	1.54	2.60	5.05	5.67	6.19	6.95	1.66	8.76	0.48	9.41	9.54							
Total	0.626		0.687	0.685	0.655	0.575	0.578	0.576	0.594	0.625	0.626	0.626	0.625	0.602	0.620	0.572	0.617	0.617							
Runoff Coefficient																									
Flood Concentration Time (Manual for River Works in Japan)		min	-	-	-	-	9	-	-	-	-	-	-	-	9	-	-	-	-						
Flood Concentration Time (Kerby formula)			2	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-						
Design River Velocity (mainstream)			0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9						
Design River Velocity (tributary)			0.9	-	-	-	0.9	-	-	-	-	-	-	-	0.9	-	0.9	-	-						
Flood Flow Time (mainstream)			0	15	35	0	15	0	33	17	17	9	10	0	8	0	10	13							
Flood Flow Time (tributary)			50	-	-	33	-	16	-	-	-	-	-	-	34	-	17	-	-						
Flood Concentration Time (Each River Basin)																									
Flood Concentration Time		50	15	35	0	24	16	33	17	17	9	10	43	8	0	10	13	13							
		50	203	238	33	24	16	48	66	66	75	84	43	83	17	93	106								
Rainfall Intensity																									
1/2	mm/hr	51.6	22.3	19.7	60.6	66.8	73.6	91.4	52.5	45.6	45.6	42.7	39.9	55.0	40.3	72.2	37.8	34.9							
1/5		73.3	31.4	27.7	86.3	95.3	105.1	131.1	74.5	64.7	64.7	60.5	56.5	78.2	57.1	103.1	53.5	49.3							
1/10		87.8	37.3	32.9	103.7	114.7	126.8	159.0	89.3	77.4	77.4	72.3	67.4	93.8	68.2	124.3	63.9	58.8							
1/20		101.7	42.8	37.8	120.4	133.5	147.9	186.5	103.5	89.4	89.4	83.5	77.8	108.8	78.7	144.9	73.6	67.7							
1/50		119.8	49.9	44.0	142.5	158.3	175.8	223.4	122.0	105.2	105.2	98.1	91.3	128.4	92.4	172.2	86.3	79.3							
Peak Discharge																									
		Sp6(LB10)Mp1(LB11				LB12		Sp4(LA03)		LA01			Sp5(LA02)		Sp7(LA04)			Sp8(LA05)		LA06		Mp2(LA07		LA08	
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33										
1/2	m ³ /s	27.7	116.2	108.3	23.0	9.4	7.7	22.5	22.5	40.0	45.0	45.9	48.2	15.3	60.8	5.5	61.0	57.1							
1/5		39.4	150.4	139.1	32.8	13.5	11.0	32.3	32.0	56.7	63.8	65.1	68.2	21.7	86.1	7.9	86.3	80.6							
1/10		47.2	172.6	159.2	39.4	16.2	13.3	39.2	38.3	67.9	76.4	77.8	81.4	26.1	102.9	9.5	103.1	96.2							
1/20		54.7	193.3	178.1	45.7	18.9	15.5	45.9	44.4	78.4	88.2	89.8	93.9	30.2	118.7	11.0	118.7	110.7							
1/50		64.4	220.0	202.0	54.1	22.4	18.4	55.0	52.3	92.2	103.8	105.5	110.2	35.7	139.4	13.1	139.2	129.7							
Discharge Rate		m ³ /s/km ²	9.0	5.9	5.3	11.0	10.6	11.8	14.6	8.7	7.9	7.9	7.4	6.9	9.2	6.9	11.5	6.5	6.0						
1/2	12.8		7.6	6.9	15.7	15.2	16.8	21.0	12.3	11.2	11.2	10.5	9.8	13.1	9.8	16.5	9.2	8.5							
1/10	15.3		8.8	7.9	18.9	18.3	20.4	25.5	14.7	13.4	13.5	12.6	11.7	15.7	11.7	19.8	11.0	10.1							
1/20	17.7		9.8	8.8	21.9	21.3	23.7	29.8	17.1	15.5	15.5	14.5	13.5	18.2	13.6	22.9	12.6	11.6							
1/50	20.8		11.2	10.0	25.9	25.3	28.2	35.7	20.1	18.3	18.3	17.0	15.8	21.5	15.9	27.3	14.8	13.6							
5.9																									
Peak Discharge (Final)																									
		Sp6(LB10)Mp1(LB11				LB12		Sp4(LA03)		LA01			Sp5(LA02)		Sp7(LA04)			Sp8(LA05)		LA06		Mp2(LA07		LA08	
18	m ³ /s	18	105	108	17	7	5	12	21	40	45	46	48	12	52	3	56	57							
1/5		24	135	139	23	10	7	17	29	57	64	65	68	16	74	4	80	81							
1/10		27	155	159	28	12	9	21	35	68	76	78	81	20	88	5	95	96							
1/20		30	173	178	32	14	10	24	40	78	88	90	94	23	102	6	109	111							
1/50		34	197	202	38	16	12	28	47	92	104	106	110	26	119	7	128	130							

Yellow box: If concentration time is less than 60 minutes and rainfall intensity during flood time is over-estimated, discharge is calculated with the discharge rate at downstream.

Yellow box: If rainfall intensity is under-estimated due to long concentration time and calculated discharge at downstream becomes lower than at upstream, discharge at upstream is calculated with discharge rate at downstream.

CHAPTER 3. DRAINAGE NETWORK

3.1 Drainage Channels

Table 3.1.1 Drainage Channels of Hong Xeng and Hong Ke Systems

Channel	Stretch	Organization	Completion Year	Project
Hong Xeng System				
Hong Xeng	D/S 1.5 km	VUDAA	2009	
	4.2 km	VUDAA	2006	VUIISP ¹⁾
Hong Kai Keo	1.3 km	VUDAA		VIUDP ²⁾
Hong Pasak	D/S 1.7 km	VUDAA	2000	VIUDP
	U/S 1.5 km	MCTPC	1995	Rehabilitation of Sihom Area Project
Hong Wattay	D/S 2.7 km	VUDAA	2005	Drainage System and T2 Road Improvement Project
	U/S 2.3 km	VUDAA	2006	VUIISP
Hong Ke System				
Hong Ke	3.4 km	VUDAA	2001	VIUDP
Hong Phone Thanh	0.95 km	VUDAA		VIUDP
Hong Ouay Louay	1.8 km	VUDAA		VIUDP
Hong Khoua Khao	2.55 km	VUDAA	2001	VIUDP
Hong Thong	1.75 km	VUDAA	2001	VIUDP

Note: 1) VUIISP: Vientiane Urban Infrastructure and Service Project

2) VIUDP: Vientiane Integrated Urban Development Project

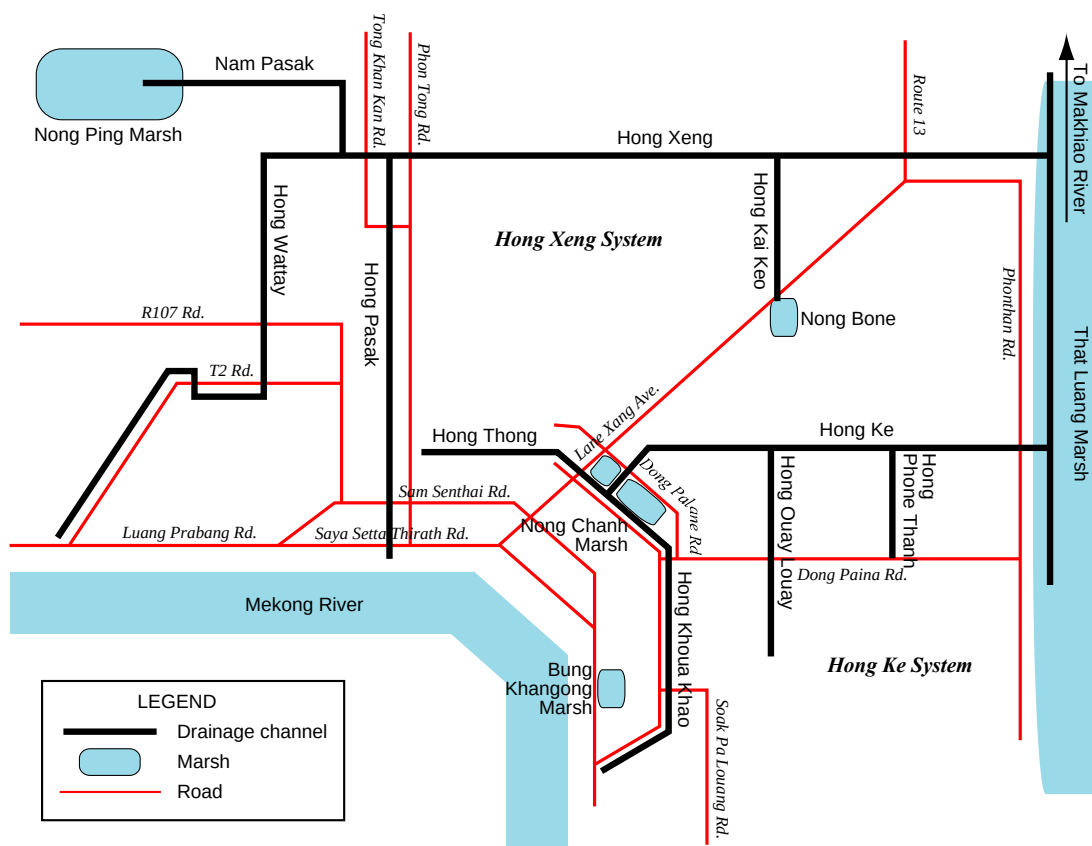


Fig. 3.1.1 Drainage System in the Urban Area of Vientiane City

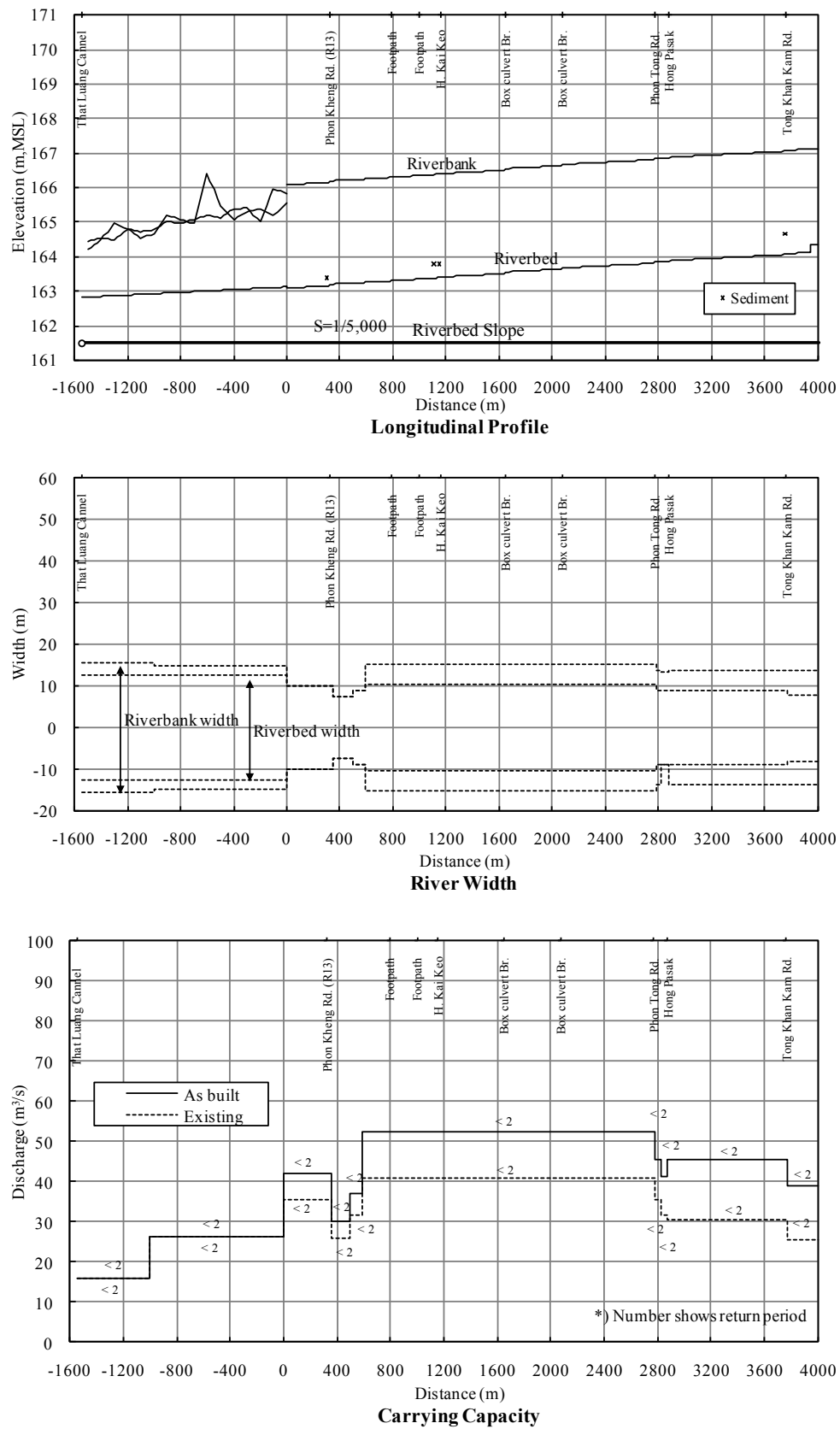


Fig. 3.1.2 Channel Characteristics (Hong Xeng)

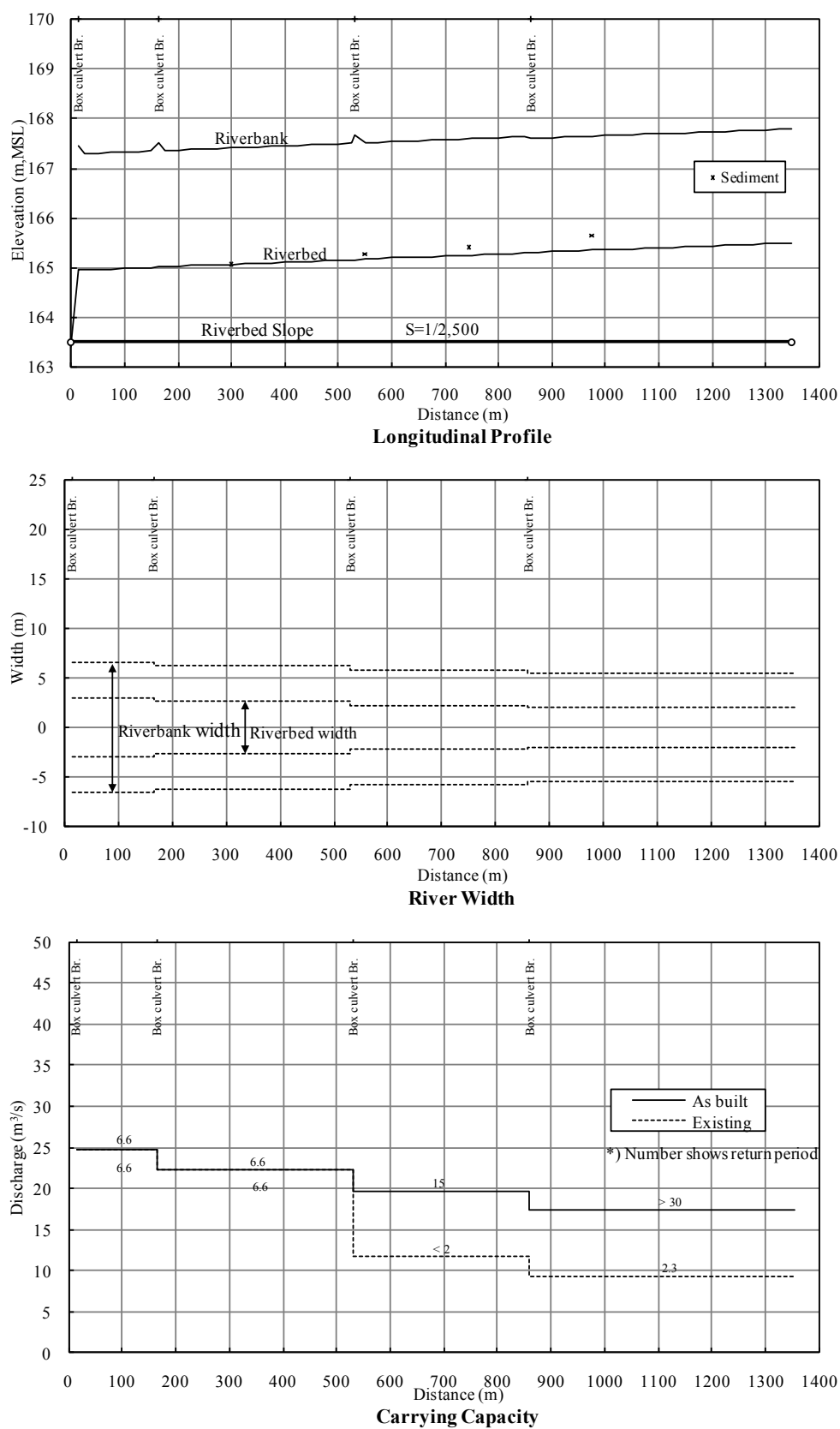


Fig. 3.1.3 Channel Characteristics (Hong Kai Keo)

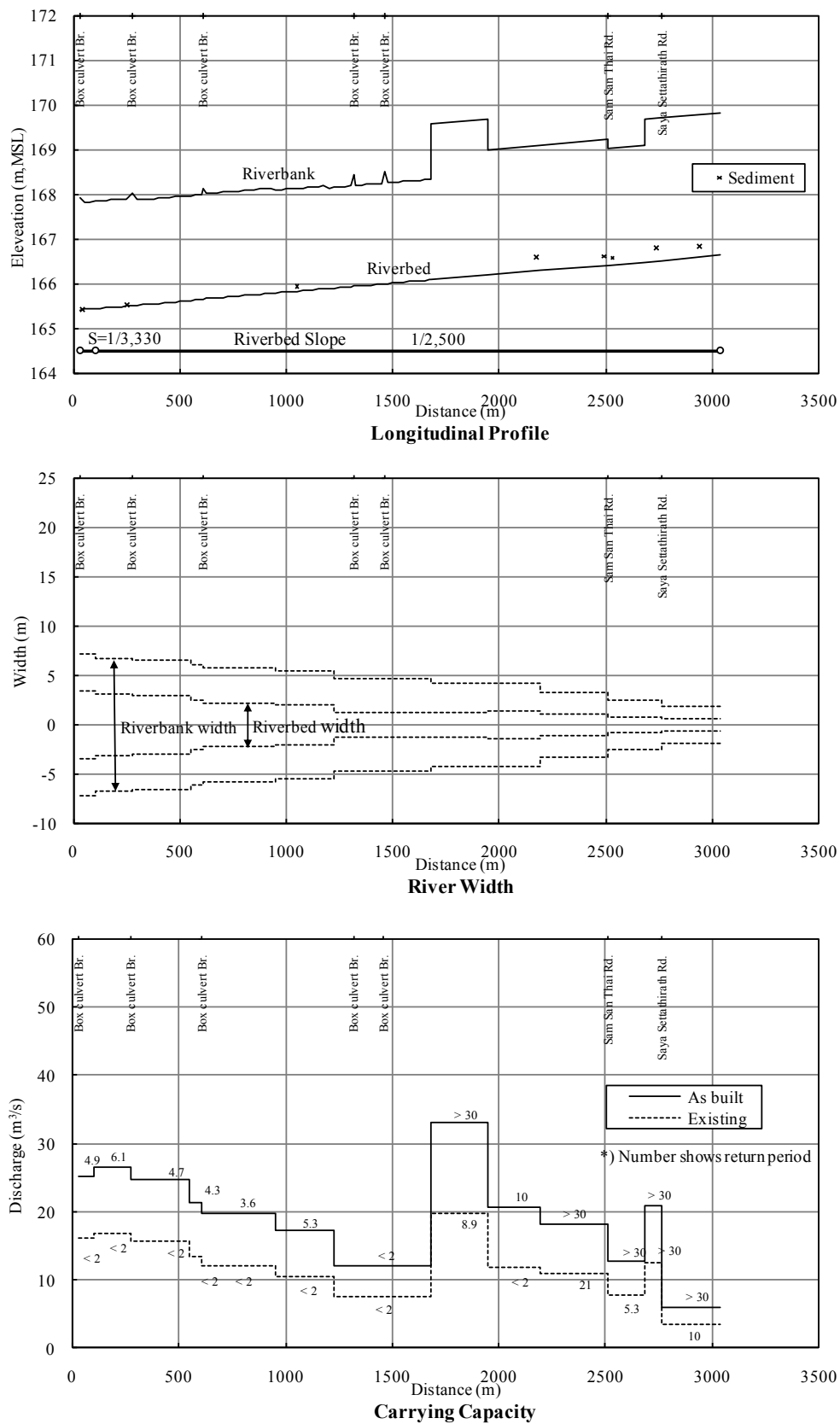


Fig. 3.1.4 Channel Characteristics (Hong Pasak)

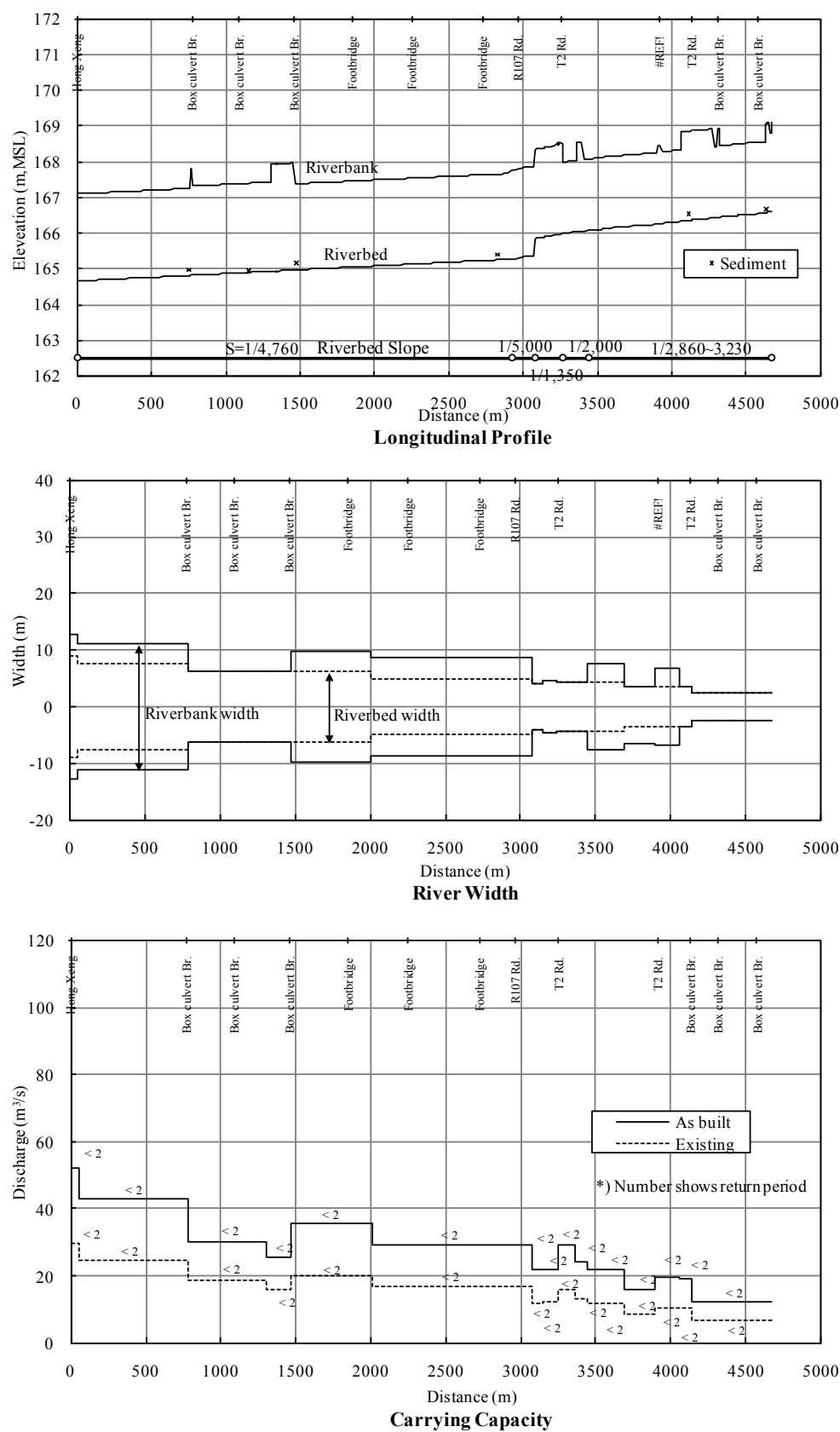


Fig. 3.1.5 Channel Characteristics (Hong Wattay)

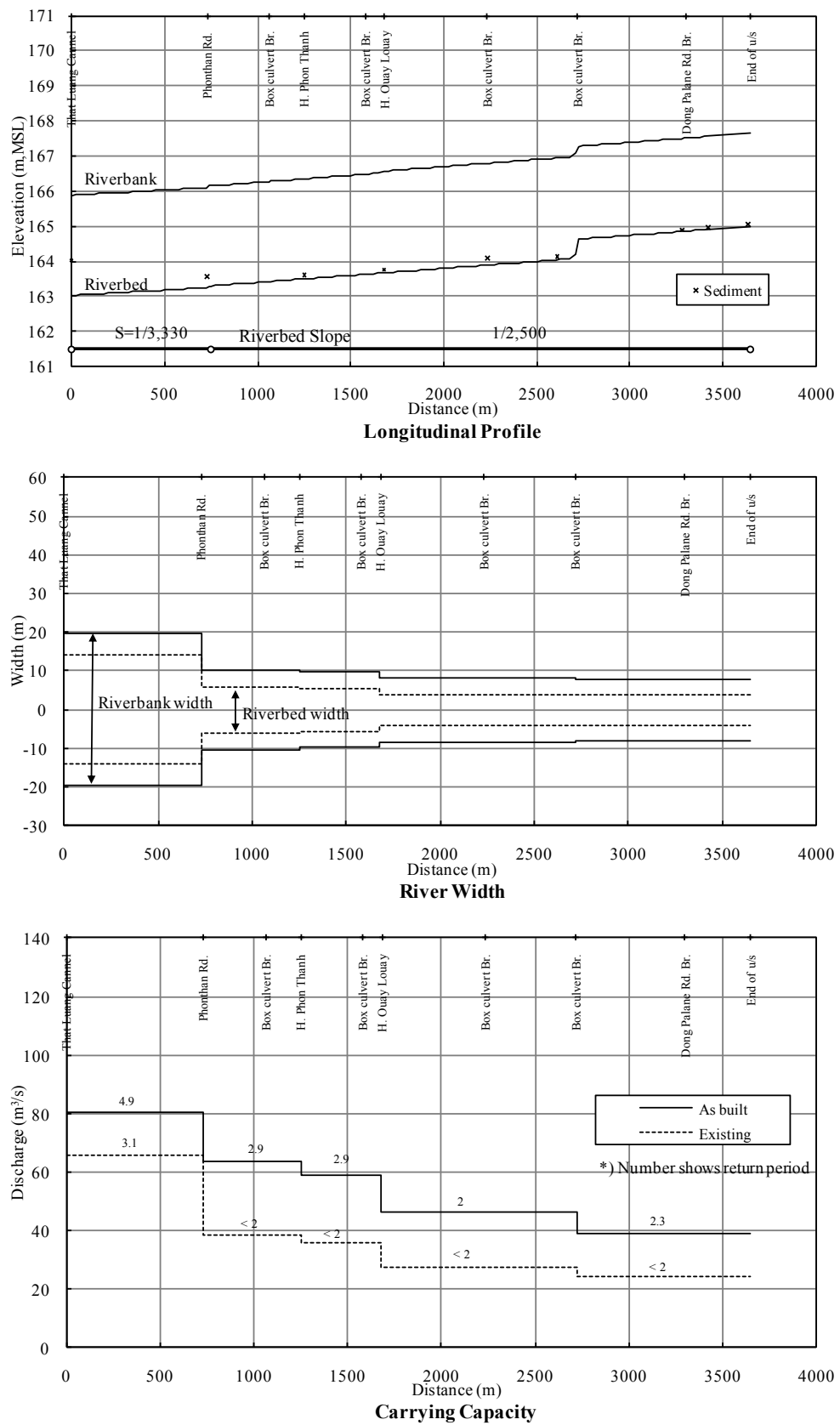


Fig. 3.1.6 Channel Characteristics (Hong Ke)

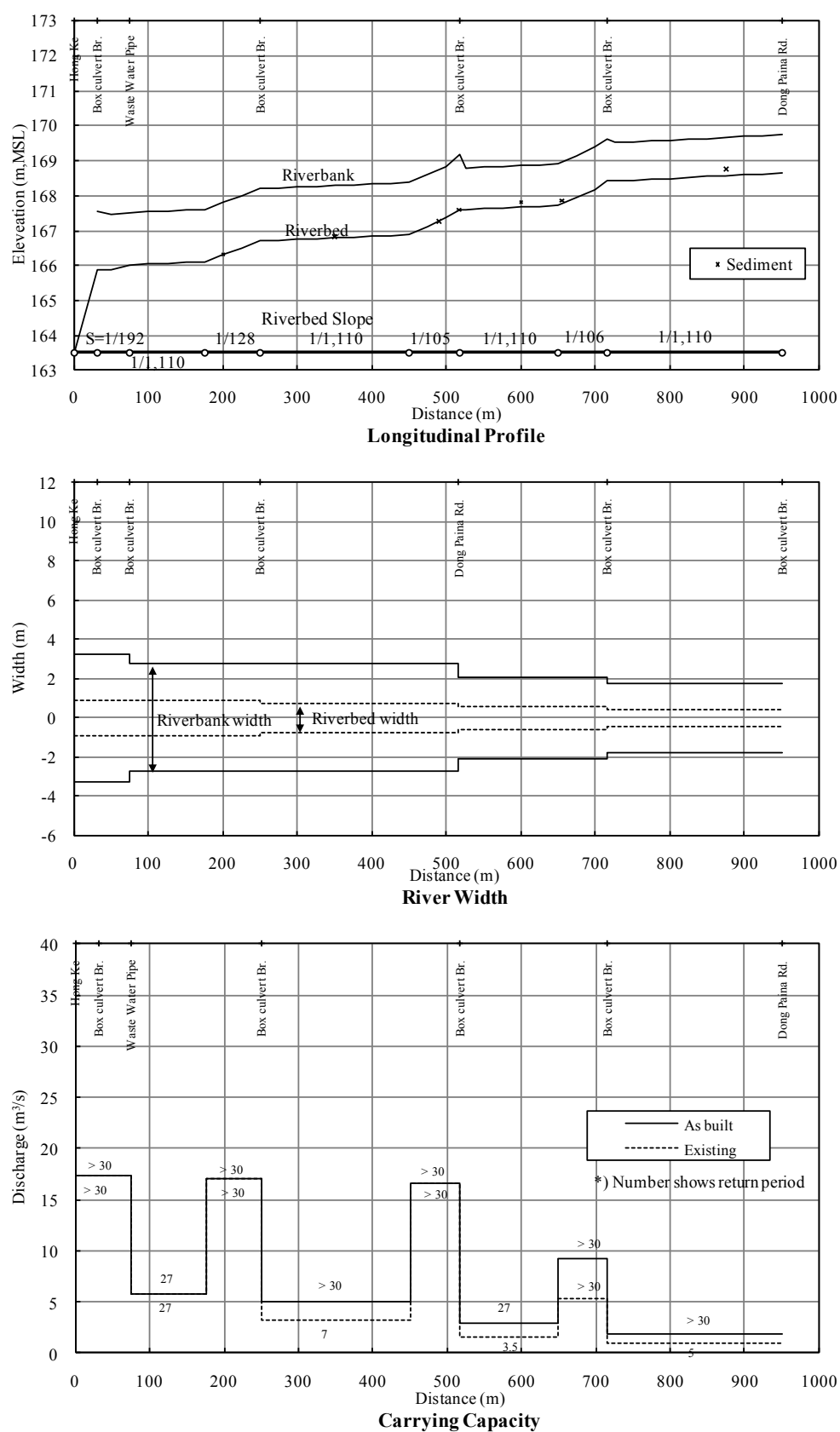


Fig. 3.1.7 Channel Characteristics (Hong Phone Thanh)

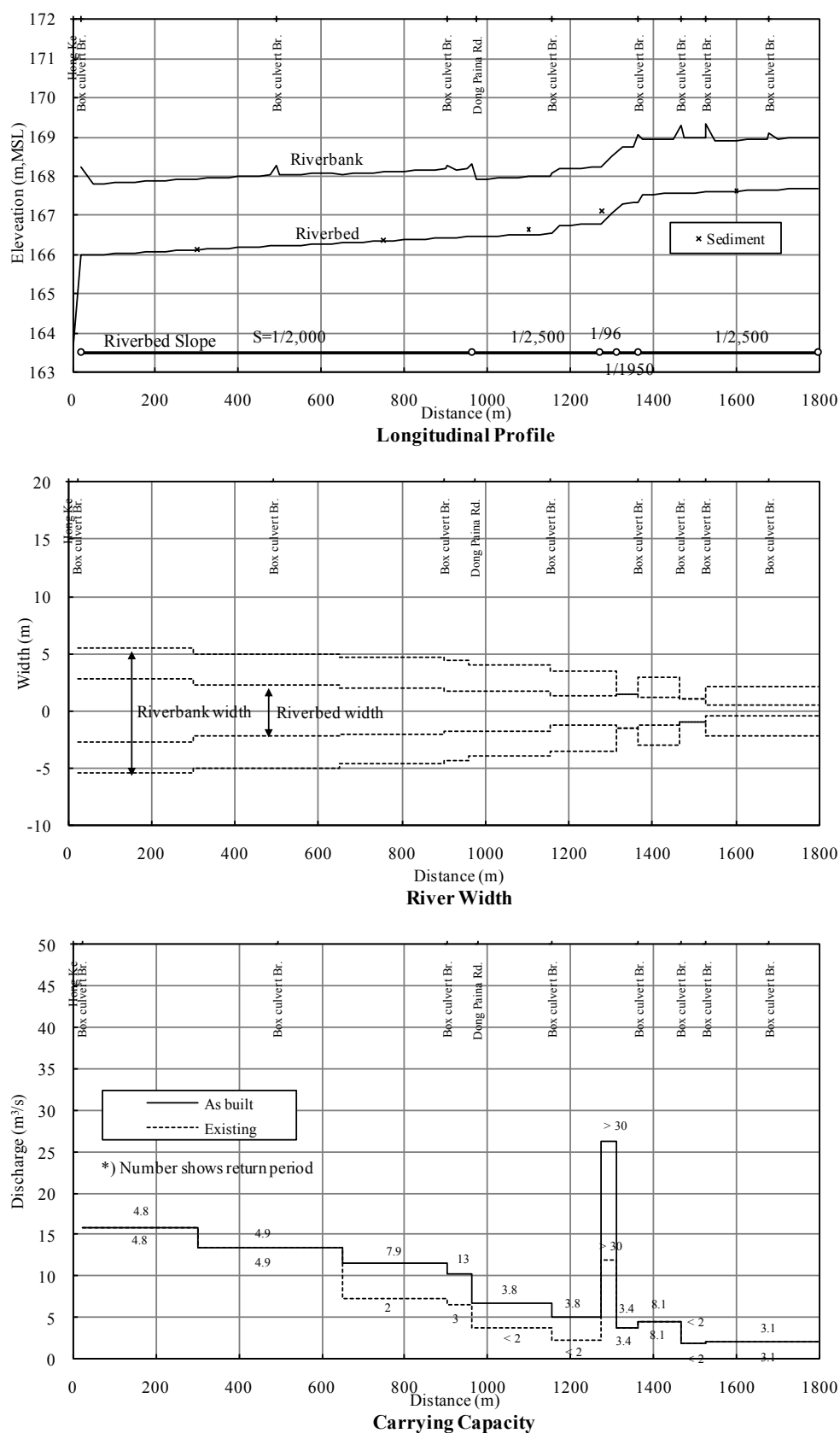


Fig. 3.1.8 Channel Characteristics (Hong Ouay Louay)

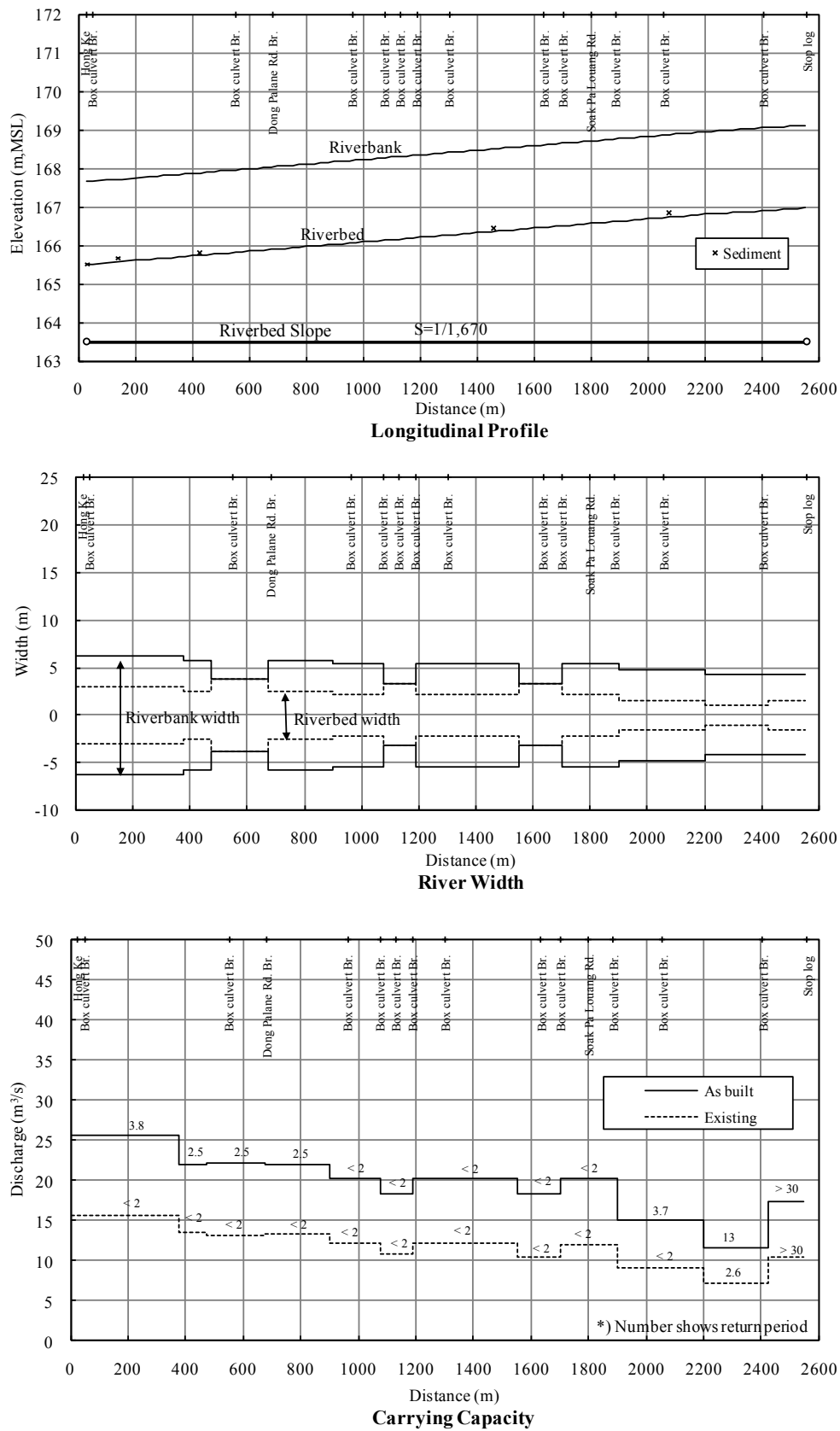


Fig. 3.1.9 Channel Characteristics (Hong Khoua Khao)

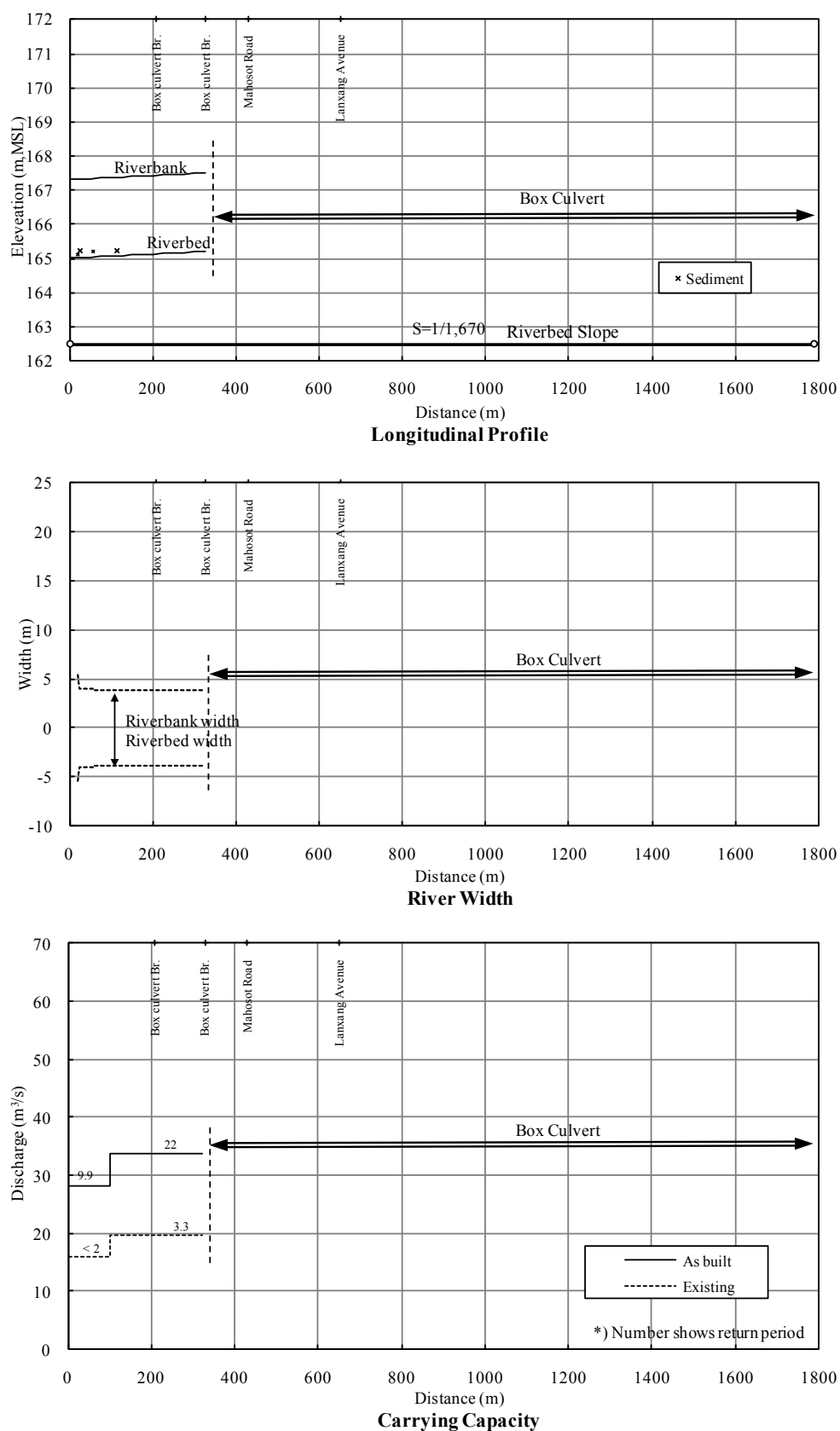


Fig. 3.1.10 Channel Characteristics (Hong Thong)

CHAPTER 4. WATER QUALITY

4.1 Monitoring Results

Table 4.1.1 Monitoring Results of Periodical Monitoring in February 2009

Name of Monitoring Point		Date of Sampling		Weather		Stream Flow (m ³ /s)		February 2009																			
		Time		Previous day		On the day																					

March 2009

Name of Monitoring Point																	
Date of Sampling																	
Time																	
Weather	Previous day		On the day														
	Stream Flow (m ³ /s)																
No.	Classification	Items	Unit														
1	1	Odor	-														
2	2	Codor	-														
3	3	Air Temperature	celsius														
4	4	pH	-														
5	5	Electric conductivity	mS/cm														
6	6	Turbidity	NTU														
7	7	DO	mg/l														
8	8	Water temperature	celsius														
9	9	TDS	g/l														
10	10	ORP	mV														
11	11	NH ₃ (NH ₃ -N)	mg/l														
12	12	NO ₂ (NO ₂ -N)	mg/l														
13	13	NO ₃ (NO ₃ -N)	mg/l														
14	14	PO ₄ (PO ₄ -N)	mg/l														
15	15	Sulfide	mg/l														
16	16	Hardness	mg/l														
17	17	Acidity	mg/l														
18	18	Alkalinity	mg/l														
19	19	Zinc(Zn)	mg/l														
20	20	Iron(Fe)	mg/l														
21	21	Manganese(Mn)	mg/l														
22	22	COD _{Mn}	mg/l														
23	23	BOD ₅	mg/l														
24	24	SS	mg/l														
25	25	Total coliform	MPSU/100ml														
26	26	Fecal coliform	CFU/100ml														
27	27	Cadmium(Cd)	mg/l														
28	28	Mercury(Hg)	mg/l														
29	29	Selenium (Se)	mg/l														
30	30	Lead(Pb)	mg/l														
31	31	Arsenic(As)	mg/l														
32	32	Hexavalent chrome(Cr ⁶⁺)	mg/l														
33	33	Simazine	µg/l														
34	34	Thiram	µg/l														
35	35	Diethenarb	µg/l														
36	36	Pesticide															
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Table 4.1.3 Monitoring Results of Periodical Monitoring in June 2009

Name of Monitoring Point		June 2009																Remark		
Date of Sampling		SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	MP1	MP2	MP3	MP4	MP5	MP6	Detection Limit	Remark		
Time		24-Jun	24-Jun	24-Jun	22-Jun	22-Jun	24-Jun	22-Jun	22-Jun	24-Jun	24-Jun	22-Jun	22-Jun	22-Jun	23-Jun	23-Jun	23-Jun			
Weather	Previous day	Sunny-Rainy	Sunny-Rainy	Sunny-Rainy	Rainy	Rainy	Sunny-Rainy	Rainy	Rainy	Sunny-Rainy	Sunny-Rainy	Rainy	Rainy	Sunny	Sunny	Sunny				
	On the day	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny				
Stream Flow (m ³ /s)		0.430	4.064	0.123	0.294	0.091	0.210	0.399	0.061	10.263	5.850	2.305	0.659	11.688	23.706	28.935				
No.	Classification	Items																		
1	1	Odor	No odor	No odor	A little bad	Bad	A little bad	No odor	Bad	No odor	No odor	No odor	No odor	No odor	No odor	No odor	No odor			
2	2	Color	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow			
3	3	Air Temperature	28.0	28.0	30.0	33.5	31.5	34.5	34.5	33.0	33.0	34.5	35.0	34.0	33.5	33.0				
2	1	pH	7.10	6.91	7.27	7.23	7.63	7.17	7.24	7.29	6.98	6.92	7.10	6.99	7.05	7.26	7.53	Horiba U-52G		
3	2	Electric conductivity	0.357	0.113	0.500	0.506	0.397	0.363	0.412	0.296	0.185	0.153	0.393	0.181	0.194	0.128	0.106	Horiba U-52G		
4	3	Turbidity	59.1	172.0	49.3	62.3	24.6	46.4	23.0	101.0	158.0	29.2	427.0	123.0	97.9	184.0		Horiba U-52G		
5	Basic item(1)	DO	2.82	3.99	2.68	3.46	8.11	7.86	6.14	11.10	5.24	2.79	11.43	6.99	6.15	5.13	6.24	Horiba U-52G		
6		Water temperature	20.18	21.48	20.71	21.72	24.02	21.68	24.87	27.62	24.42	21.79	24.02	30.04	24.58	22.63	21.53	Horiba U-52G		
7		TDS	0.232	0.074	0.320	0.324	0.258	0.236	0.268	0.193	0.120	0.099	0.255	0.118	0.126	0.083	0.069	Horiba U-52G		
8		ORP	122	112	41	-58	100	68	136	119	141	132	140	129	151	133	123	Horiba U-52G		
3	1	NH ₃ (NH ₃ -N)	4.5	1.0	6.0	4.5	8.0	3.5	5.0	3.5	0.5	1.0	6.0	0.5	2.5	1.0	1.0	Hach 850		
2	2	NO ₂ (NO ₂ -N)	0.000	0.001	0.004	0.003	0.003	0.008	0.018	0.028	0.006	0.001	0.003	0.000	0.022	0.021	0.010	Hach 850		
3	3	NO ₃ (NO ₃ -N)	0.6	0.5	0.3	0.5	0.5	0.5	0.6	0.1	0.7	0.3	0.5	0.5	0.7	0.6	0.6	Hach 850		
4	4	PO ₄ (PO ₄ -N)	0.91	0.68	0.73	0.57	0.46	0.62	0.38	0.18	0.52	0.46	0.02	0.12	1.96	0.29		Hach 850		
5	Basic item(2)	Hardness	121	78	169	132	135	134	157	124	113	103	161	89	80	129	108	Hach 850		
6		Sulfide	0.05	0.26	0.08	0.00	0.02	0.01	0.01	0.03	0.10	0.26	0.02	0.33	0.11	0.16	0.22	Hach 850		
7		Acidity	89	34	98	92	65	98	85	69	45	51	101	50	43	49	36	Hach 850		
8		Alkalinity	137	68	176	147	145	131	140	108	71	52	84	79	65	41	25	Hach 850		
9	9	Zinc(Zn)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Hach 850		
10	10	Iron(Fe)	1.33	4.08	1.13	0.11	1.20	1.95	0.47	3.28	2.40	3.98	1.45	5.50	1.78	2.50	2.74	Hach 850		
11	11	Manganese(Mn)	0.3	0.1	0.6	0.3	0.3	0.2	0.5	0.2	0.1	0.0	0.5	0.1	0.0	0.1	0.0	Hach 850		
4	1	COD _{Mn}	15	20	25	25	20	20	20	20	25	15	20	25	15	20	20	Peak test		
2	2	BOD ₅	9.5	2.2	14.3	15.4	11.6	9.7	7.0	5.6	6.9	3.3	7.1	2.4	5.0	3.1	2.1	UAE		
3	3	SS	30.5	50.7	25.2	41.5	16.3	29.4	13.5	28.4	63.2	68.5	29.1	184.0	83.9	31.0	90.4	UAE		
4	Organic Pollutant	Total coliform	MPN/100ml	1,700	>160,000	>160,000	>160,000	>160,000	>160,000	>160,000	>160,000	>160,000	>160,000	2,300	92,000	1,300	11,000	UAE		
5		Fecal coliform	MPN/100ml	240	>160,000	>160,000	>160,000	>160,000	>160,000	>160,000	>160,000	>160,000	>160,000	790	17,000	49	3,300	UAE		
5		Cadmium(Cd)	mg/l															0.006	UAE	
2		2	Mercury(Hg)	mg/l															0.0005	UAE
3	Heavy metal	Selenium(Se)	mg/l															0.0005	UAE	
4		Lead(Pb)	mg/l															0.008	0.003	UAE
5		Arsenic(As)	mg/l															0.0007	0.0003	UAE
6		Hexavalent chromet(Cr ⁶⁺)	mg/l																0.006	UAE
6	Pesticide	Simazine	µg/l															0.5	UAE	
1		Thiram	µg/l															10	UAE	
3		Thiobencarb	µg/l															0.50	UAE	

November 2009

Name of Monitoring Point																					
Date of Sampling																					
Time																					
Weather	Previous day																				
	On the day																				
Stream Flow (m ³ /s)																					
No.	Classification	Items	Unit	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	MP1	MP2	MP3	MP4	MP5	MP6	Decom Unit	Remark	
1	1	Odor	-	No odor	No odor	Bad	Bad	A little bad	No odor	Bad	No odor	A little bad	No odor	No odor	No odor	No odor	No odor	No odor			
	2	Color	-	Light yellow	Yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow			
	3	Air Temperature	celsius	32.0	33.0	33.0	31.0	34.0	33.0	33.0	33.0	31.0	33.0	34.0	33.0	31.0	33.0	31.0			
2	1	pH	-	7.53	7.78	7.92	7.59	8.14	7.68	8.22	8.22	7.58	7.76	7.58	8.19	7.36	6.81	7.23		Horiba U-526	
	2	Electric conductivity	mS/cm	0.411	0.618	0.486	0.435	0.391	0.398	0.400	0.440	0.433	0.457	0.463	0.263	0.554	0.401	0.336		Horiba U-526	
	3	Turbidity	NTU	52.5	226.0	42.9	42.1	20.2	26.8	33.3	33.3	93.4	27.1	33.9	560.0	135.0	254.0	46.9		Horiba U-526	
4	Basic item(1)	DO	mg/l	5.71	5.96	7.21	1.64	10.25	10.22	14.70	14.17	3.26	9.14	1.21	9.45	6.91	4.68	3.53		Horiba U-526	
	5	Water temperature	celsius	18.92	18.61	20.21	20.18	19.45	21.95	21.64	21.64	22.17	22.12	20.58	27.56	25.07	21.88	18.81		Horiba U-526	
	6	TDS	g/l	0.267	0.395	0.316	0.283	0.254	0.259	0.260	0.260	0.282	0.297	0.301	0.171	0.355	0.261	0.218		Horiba U-526	
	7	ORP	mV	68	103	27	-107	25	66	79	79	128	98	-115	68	124	125	90		Horiba U-526	
3	1	NH ₃ (NH ₃ -N)	mg/l	7.5	0.5	7.5	9.5	8.0	9.0	7.5	4.5	5.0	5.0	8.5	1.5	4.5	2.0	1.0		Hach 850	
	2	NO ₂ (NO ₂ -N)	mg/l	0.004	0.003	0.008	0.007	0.010	0.012	0.009	0.058	0.007	0.002	0.001	0.063	0.021	0.034	0.280		Hach 850	
	3	NO ₃ (NO ₃ -N)	mg/l	0.5	0.0	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.5	0.5	1.0	0.5	1.0	1.5		Hach 850	
	4	PO ₄ (PO ₄ -N)	mg/l	0.65	0.03	0.75	0.86	0.65	0.54	0.67	0.36	0.31	0.31	0.88	0.15	0.18	0.06	0.07		Hach 850	
	5	Hardness	mg/l	113	76	156	147	133	131	146	90	108	132	145	90	108	76	77		Hach 850	
6	Basic item(2)	Sulfide	mg/l	0.06	0.18	0.05	0.08	0.05	0.05	0.06	0.03	0.09	0.03	0.06	0.56	0.19	0.40	0.09		Hach 850	
	7	Acidity	mg/l	86	59	112	109	101	107	87	61	62	91	98	77	76	54	59		Hach 850	
	8	Alkalinity	mg/l	170	40	105	149	190	169	149	97	115	133	166	86	102	79	47		Hach 850	
	9	Zinc(Zn)	mg/l	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		Hach 850	
	10	Iron(Fe)	mg/l	0.64	3.21	0.64	0.56	0.92	1.76	1.00	1.77	1.57	0.39	2.04	0.25	1.25	3.62	1.34		Hach 850	
	11	Manganese(Mn)	mg/l	0.4	0.7	0.7	0.7	0.5	0.3	0.5	0.5	0.5	0.5	0.4	0.2	0.6	0.1	0.7		Hach 850	
4	1	COD _{Mn}	mg/l	20	20	30	30	30	30	30	30	20	30	30	25	30	20	20		Pack test	
	2	BOD ₅	mg/l	14.1	2.4	13.6	15.8	12.2	13.2	11.8	10.6	5.0	10.3	14.1	4.8	4.0	2.9	2.9		UAE	
	3	SS	mg/l	27.0	43.6	11.2	21.6	9.4	19.0	15.6	14.5	48.4	18.6	24.9	151.0	71.0	95.0	36.6		UAE	
	4	Total coliform	MPS/100ml	79,000	23,000	>16,000,000	16,000,000	3,500,000	5,400,000	9,200,000	790,000	490,000	2,400,000	16,000,000	23,000	130,000	140	1,300		UAE	
	5	Fecal coliform	MPS/100ml	33,000	2,200	5,400,000	5,400,000	1,700,000	310,000	280,000		330,000	33,000	5,400,000	13,000	33,000	79	6.8		UAE	
5	1	Cadmium(Cd)	mg/l															ND		0.006	UAE
	2	Mercury(Hg)	mg/l										0.0011	0.0006	ND	0.0010	ND	0.0010		0.0005	UAE
	3	Selenium (Se)	mg/l										ND	ND	ND	ND	ND	ND		0.0005	UAE
	4	Lead(Pb)	mg/l									0.006	0.006	0.019	0.007	0.014	0.006	0.003		0.003	UAE
	5	Arsenic(As)	mg/l									ND	ND	ND	ND	ND	ND	ND		0.0003	UAE
	6	Hexavalent chrome(Cr ⁶⁺)	mg/l									ND	ND	ND	ND	ND	ND	ND		0.006	UAE
6	1	Sinazine	µg/l									ND	ND	ND	ND	ND	ND	ND		0.5	UAE
	2	Thiam	µg/l									ND	ND	ND	ND	ND	ND	ND		10	UAE
	3	Thiobercarb	µg/l									ND	ND	ND	ND	ND	ND	ND		0.50	UAE

Table 4.1.5 Monitoring Results of Periodical Monitoring in December 2009

Name of Monitoring Point		December 2009																	Remark																
Date of Sampling		Detection Limit																																	
Time																																			
Weather	Previous day																																		
	On the day																																		
Stream Flow (m ³ /s)																																			
No.	Classification	Items	Unit	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	MP1	MP2	MP3	MP4	MP5	MP6																	
1	1	Odor	-	No odor	No odor	Bad	A little bad	No odor	A little bad	A little bad	No odor	No odor	No odor	A little bad	No odor	A little bad	No odor	No odor																	
	2	Color	-	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow																	
	3	Air Temperature	celcius	34.0	32.0	33.0	27.0	27.0	31.0	29.0	29.0	35.0	31.0	30.0	35.0	32.0	31.0	30.0																	
2	1	pH	-	8.15	8.44	8.69	8.05	8.78	8.13	8.13	8.36	8.51	8.27	7.82	8.26	8.86	7.84	7.25	Horiba U-52G																
3	2	Electric conductivity	mS/cm	0.414	0.517	0.511	0.450	0.383	0.416	0.416	0.329	0.674	0.527	0.520	0.291	0.635	0.517	0.546	Horiba U-52G																
4	3	Turbidity	NTU	51.5	79.7	47.1	36.8	25.1	45.5	24.0	20.4	48.5	81.6	40.2	150.0	110.0	249.0	62.5	Horiba U-52G																
5	4	DO	mg/l	7.01	13.90	13.82	2.18	11.99	9.67	12.48	16.45	16.96	14.57	1.71	8.68	21.63	9.06	10.11	Horiba U-52G																
6	5	Water temperature	celcius	22.35	18.29	22.50	16.97	17.34	22.51	17.38	19.87	19.28	18.06	16.74	23.36	19.10	15.94	13.13	Horiba U-52G																
7	6	TDS	g/l	0.280	0.331	0.327	0.293	0.249	0.271	0.270	0.214	0.414	0.338	0.330	0.183	0.407	0.331	0.330	Horiba U-52G																
	7	ORP	mV	125	98	84	-40	41	98	38	66	109	50	-143	115	102	127	113	Horiba U-52G																
3	1	NH ₃ (NH ₃ -N)	mg/l	12.0	2.0	9.0	11.5	9.0	4.5	9.0	7.5	7.5	7.5	13.0	0.5	5.0	3.0	1.5	Hach 850																
2	2	NO ₂ (NO ₂ -N)	mg/l	0.008	0.000	0.014	0.007	0.009	0.007	0.009	0.041	0.085	0.022	0.002	0.022	0.255	0.105	0.170	Hach 850																
3	3	NO ₃ (NO ₃ -N)	mg/l	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.0	0.1	0.6	0.2	0.8	Hach 850															
4	4	PO ₄ (PO ₄ -N)	mg/l	1.05	0.15	0.80	1.15	0.65	0.60	0.80	0.40	0.20	0.55	1.30	0.15	0.40	0.10	0.15	Hach 850																
5	5	Hardness	mg/l	129	68	162	132	131	105	138	106	141	129	140	94	120	96	96	Hach 850																
6	6	Sulfide	mg/l	0.06	0.07	0.07	0.09	0.03	0.04	0.04	0.02	0.04	0.03	0.07	0.10	0.06	0.30	0.09	Hach 850																
7	7	Acidity	mg/l	118	44	135	120	91	103	116	102	99	102	125	56	82	61	56	Hach 850																
8	8	Alkalinity	mg/l	188	47	198	175	153	155	164	125	171	190	190	79	123	92	75	Hach 850																
9	9	Zinc(Zn)	mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Hach 850																
10	10	Iron(Fe)	mg/l	0.74	0.93	0.78	0.36	1.03	2.22	1.04	1.47	0.53	0.33	1.82	1.63	0.44	1.58	1.18	Hach 850																
11	11	Manganese(Mn)	mg/l	0.1	0.1	0.3	0.2	0.0	0.1	0.3	0.2	0.3	0.3	0.4	0.0	0.1	0.0	0.4	Hach 850																
4	1	COD _{Mn}	mg/l	20	25	25	30	20	25	30	25	20	25	25	30	30	30	25	Peck test																
2	2	BOD ₅	mg/l	16.8	<2.0	19.1	28.3	12.3	12.7	13.3	10.3	4.3	29.2	21.7	5.0	7.6	2.8	2.1	UAE																
3	3	SS	mg/l	27.6	32.1	25.3	22.3	23.3	26.5	11.2	10.4	47.7	33.3	30.0	105.0	95.5	168.0	44.0	UAE																
4	4	Total coliform	MPS/100ml	490,000	7,900	1,300,000	2,400,000	110,000	2,400,000	1,300,000	130,000	3,300	490,000	3,500,000	230,000	7,900	4,900	330	UAE																
5	5	Fecal coliform	MPS/100ml	490,000	4,900	330,000	2,400,000	70,000	330,000	280,000	49,000	2,300	46,000	1,300,000	130,000	330	3,300	230	UAE																
5	1	Cadmium(Cd)	mg/l																ND	ND	0.006	UAE													
2	2	Mercury(Hg)	mg/l																ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0005	UAE	
3	3	Selenium (Se)	mg/l																ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0005	UAE	
4	4	Lead(Pb)	mg/l																ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0018	0.003	UAE
5	5	Arsenic(As)	mg/l																ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0025	0.0003	UAE
6	6	Hexavalent chromet(Cr ⁶⁺)	mg/l																ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.006	UAE	
1	1	Smazine	µg/l																ND	ND	ND	0.5	UAE												
2	2	Thiram	µg/l																ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10	UAE	
3	3	Thiobencarb	µg/l																ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.50	UAE	

February 2010

[illegible]

July 2010

Name of Monitoring Point		SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	MP1	MP2	MP3	MP4	MP5	MP6	Detection Limit	Remark	
Date of Sampling		6-Jul	6-Jul	6-Jul	6-Jul	6-Jul	6-Jul	6-Jul	6-Jul	5-Jul	6-Jul	6-Jul	5-Jul	5-Jul	5-Jul	5-Jul			
Time		13:40	13:10	12:55	9:30	10:45	12:30	10:10	10:35	11:30	11:20	11:50	14:00	12:20	11:35	10:10			
Weather	Previous day	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny			
	On the day	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny			
	Stream Flow (m ³ /s)	0.343	3.990	0.034	0.071	0.072	0.178	0.323	0.023	2.661	2.550	0.249	0.287	6.345	4.551	5.120			
No.	Classification	Items																	
1	1	Odor	A Little	Very bad	Bad	A Little	A Little	Very bad	A Little	No smell	No smell	Very bad	No smell	No smell	No smell	No smell			
2	2	Color	-	Black						Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow			
3	3	Air Temperature	36.0	36.0	35.0	33.0	35.0	33.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	32.0			
2	1	pH	-	7.31	7.18	7.48	6.89	7.44	7.04	7.04	7.49	6.11	7.30	7.24	6.61	6.21	6.46	Horiba U-52G	
	2	Electric conductivity	0.418	0.140	0.539	0.504	0.442	0.417	0.440	0.381	0.233	0.162	0.503	0.301	0.273	0.389	0.389	Horiba U-52G	
	3	Turbidity	NTU	69.7	207.0	44.6	47.7	33.4	24.1	29.3	18.0	152.0	135.0	27.1	39.0	118.0	183.0	Horiba U-52G	
	4	DO	mg/l	4.86	2.37	9.02	2.94	9.19	10.49	5.69	12.54	2.06	1.90	1.74	6.37	3.81	7.97	7.97	Horiba U-52G
	5	Water temperature	°Celsius	25.65	25.11	26.00	22.23	22.99	25.39	22.16	25.20	23.02	23.44	23.04	26.75	23.32	23.62	23.62	Horiba U-52G
	6	TDS	g/l	0.272	0.090	0.345	0.322	0.287	0.271	0.286	0.284	0.151	0.104	0.322	0.195	0.177	0.253	0.253	Horiba U-52G
	7	ORP	mV	161	112	131	-29	116	147	102	114	157	106	-117	228	209	217	217	Horiba U-52G
3	1	NH ₃ (NH ₃ -N)	mg/l	6.00	0.18	8.00	10.00	6.50	4.00	5.00	4.00	0.60	1.00	8.50	0.50	0.50	0.15	Hach 850	
	2	NO ₂ (NO ₂ -N)	mg/l	0.004	0.002	0.014	0.009	0.005	0.012	0.007	0.004	0.002	0.001	0.003	0.005	0.025	0.037	0.022	Hach 850
	3	NO ₃ (NO ₃ -N)	mg/l	0.05	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.05	0.10	0.10	0.10	0.15	Hach 850
	4	PO ₄ (PO ₄ -N)	mg/l	1.70	0.16	1.20	0.89	1.00	0.47	0.79	0.63	0.24	0.14	0.80	0.13	0.22	0.06	0.10	Hach 850
	5	Hardness	mg/l	131	68	167	168	142	124	143	119	59	65	148	95	96	78	81	Hach 850
	6	Sulfide	mg/l	0.07	0.29	0.06	0.08	0.04	0.01	0.05	0.02	0.21	0.18	0.05	0.02	0.14	0.10	0.18	Hach 850
	7	Acidity	mg/l	82	48	100	87	76	93	84	88	57	52	106	50	34	44	40	Hach 850
	8	Alkalinity	mg/l	149	33	189	179	180	155	162	132	72	58	182	109	61	64	51	Hach 850
	9	Zinc(Zn)	mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Hach 850
	10	Iron(Fe)	mg/l	1.56	1.50	0.88	0.66	1.20	2.08	1.15	3.74	2.85	2.78	1.85	1.88	2.77	1.42	1.70	Hach 850
4	1	Manganese(Mn)	mg/l	0.3	0.3	0.3	0.2	0.3	0.6	0.3	0.6	0.1	0.3	0.5	0.5	0.1	0.3	0.1	Hach 850
	2	COD _{Mn}	mg/l	30	15	20	30	20	25	20	20	20	15	20	20	25	25	20	Pack test
	2	BOD ₅	mg/l	10.3	<2.0	19.6	19.9	10.5	6.0	8.6	7.2	<2.0	<2.0	17.8	<2.0	2.4	<2.0	2.4	UAE
	3	SS	mg/l	26.0	114.0	17.2	22.5	15.1	16.6	11.8	14.4	99.4	79.4	18.0	15.4	67.7	68.0	93.7	UAE
	4	Total coliform	MPS/100ml	7,900,000	4,900	7,900,000	35,000,000	3,300,000	3,300,000	5,400,000	3,300,000	23,000	220,000	24,000,000	23,000	1,300,000	46,000	110,000	UAE
	5	Fecal coliform	MPS/100ml	3,300,000	4,900	4,900,000	54,000,000	4,900,000	2,300,000	7,900,000	3,300,000	23,000	70,000	4,900,000	4,900	130,000	4,900	7,900	UAE
	5	Cadmium(Cd)	mg/l																UAE
	2	Mercury(Hg)	mg/l																UAE
	3	Selenium(Se)	mg/l																UAE
	4	Lead(Pb)	mg/l																UAE
	5	Arsenic(As)	mg/l																UAE
6	Hexavalent chrome(Cr ⁶⁺)	mg/l																UAE	
6	Simazine	µg/l																UAE	
	2	Thiram	µg/l															UAE	
	3	Thiobencarb	µg/l															UAE	

November 2010

Name of Monitoring Point		SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	MP1	MP2	MP3	MP4	MP5	MP6	Remark		
Date of Sampling		23-Nov	23-Nov	23-Nov	23-Nov	23-Nov	23-Nov	23-Nov	23-Nov	22-Nov	23-Nov	23-Nov	22-Nov	22-Nov	22-Nov	22-Nov			
Time		13:30	13:20	13:00	9:45	9:55	12:40	10:15	10:30	14:50	11:40	11:00	14:15	12:55	12:00	10:45			
Weather	Previous day	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny			
	On the day	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny			
Stream Flow (m³/s)		0.162	0.056	0.055	0.130	0.078	0.094	0.191	0.039	1.394	0.497	0.318	0.023	1.586	1.395	0.984			
No.	Classification	Items															Unit		
1	1	A Little	No	A Little	Bad	A Little	A Little	A Little	A Little	No	A Little	Bad	No	No	No	No			
2	2	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow			
3	3	Air	Temperature	celsius															
2	1	8.30	8.20	9.10	8.23	8.54	8.27	8.26	8.09	8.19	8.08	8.02	8.32	8.09	8.05	7.31	Horiba U-52G		
2	2	0.468	0.716	0.531	0.440	0.393	0.421	0.409	0.365	0.534	0.535	0.482	0.323	0.624	0.628	0.475	Horiba U-52G		
3	3	Turbidity	NTU	64.7	206.0	49.8	50.2	23.2	35.1	28.3	20.1	56.6	38.0	35.4	119.0	149.0	95.0	Horiba U-52G	
4	Basic item(1)	DO	mg/l	1.82	5.04	12.57	1.57	7.94	11.32	9.56	3.62	2.47	1.54	8.79	5.05	4.05	7.80	Horiba U-52G	
5		Water temperature	celsius	23.81	19.06	23.54	18.16	17.71	22.27	18.82	20.07	19.43	18.59	17.63	24.35	20.86	18.28	Horiba U-52G	
6		TDS	g/l	0.304	0.458	0.340	0.286	0.225	0.274	0.266	0.237	0.432	0.342	0.314	0.210	0.400	0.402	Horiba U-52G	
7		ORP	mV	70	66	27	-142	-5	20	57	21	90	12	-165	85	83	76	-1	Horiba U-52G
3	Basic item(2)	NH ₃ (NH ₃ -N)	mg/l	14.00	1.00	10.50	12.50	10.00	10.00	9.00	6.50	9.00	9.50	11.50	2.00	7.50	6.50	Hach 850	
1		NO ₂ (NO ₂ -N)	mg/l	0.005	0.086	0.016	0.007	0.006	0.001	0.008	0.007	0.002	0.003	0.074	0.001	0.031	0.240	Hach 850	
2		NO ₃ (NO ₃ -N)	mg/l	0.10	0.40	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.20	1.50	Hach 850	
3		PO ₄ (PO ₄ -P)	mg/l	0.81	0.08	0.71	0.48	0.39	0.21	0.64	0.15	0.41	1.00	1.22	0.82	0.40	0.38	0.07	Hach 850
4		Hardness	mg/l	134	80	174	148	161	147	158	93	139	146	162	93	138	121	95	Hach 850
5	Basic item(2)	Sulfide	mg/l	0.08	0.23	0.08	0.09	0.04	0.04	0.01	0.04	0.01	0.04	0.06	0.09	0.06	0.31	0.14	Hach 850
6		Acidity	mg/l	123	60	81	105	62	105	104	85	100	92	74	78	78	71	68	Hach 850
7		Alkalinity	mg/l	168	72	182	176	135	153	152	122	141	152	164	89	130	118	65	Hach 850
8		Zinc(Zn)	mg/l	0.01	0.00	0.00	0.00	0.00	0.04	0.03	0.00	0.00	0.02	0.01	0.00	0.00	0.00	Hach 850	
9		Iron(Fe)	mg/l	1.23	2.89	0.96	0.51	1.15	0.65	1.23	1.87	1.33	1.08	2.13	0.68	0.99	2.00	2.02	Hach 850
10	Organic Pollutant	Manganese(Mn)	mg/l	0.5	0.7	0.4	0.3	0.3	0.7	0.8	0.5	0.5	0.5	0.5	0.6	0.4	0.5	0.9	Hach 850
11		COD _{Mn}	mg/l	25	20	30	30	25	20	25	25	25	25	30	25	25	30	20	Pack test
4		BOD ₅	mg/l	14.6	2.0	32.6	26.7	15.8	10.5	12.8	15.5	6.9	12.9	14.3	3.3	6.4	3.1	<2.0	UAE
3		Total coliform	MPN/100ml	8,400,000	3,300,000	4,900,000	35,000,000	14,000,000	35,000,000	54,000,000	3,300,000	54,000,000	2,300,000	33,000	130,000	140,000	3,300	3,300	UAE
4		Fecal coliform	MPS/100ml	7,900,000	2,300,000	3,300,000	24,000,000	11,000,000	9,400,000	4,900,000	54,000,000	3,300,000	54,000,000	2,300,000	7,900	7,900	2,300	790	UAE
5	Heavy metal	Cadmium(Cd)	mg/l															0.006	UAE
1		Mercury(Hg)	mg/l															0.0005	UAE
2		Selenium(Se)	mg/l															0.0005	UAE
3		Lead(Pb)	mg/l															0.003	UAE
4		Arsenic(As)	mg/l															0.0017	UAE
5	Pesticide	Hexavalent chrome(Cr ⁶⁺)	mg/l															0.0003	UAE
6		Simazine	µg/l															0.006	UAE
1		Thiram	µg/l																UAE
2		Triphenylmethane	µg/l																UAE
3		Triphenylmethane	µg/l																UAE

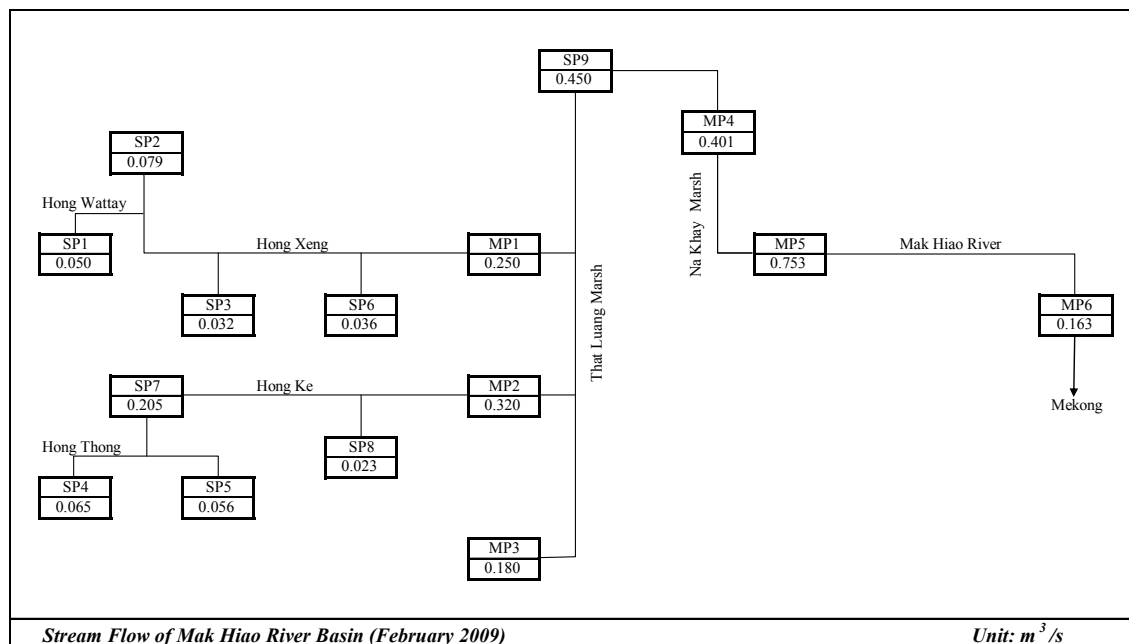


Fig. 4.1.1 Stream Flow of Periodical Monitoring in February 2009

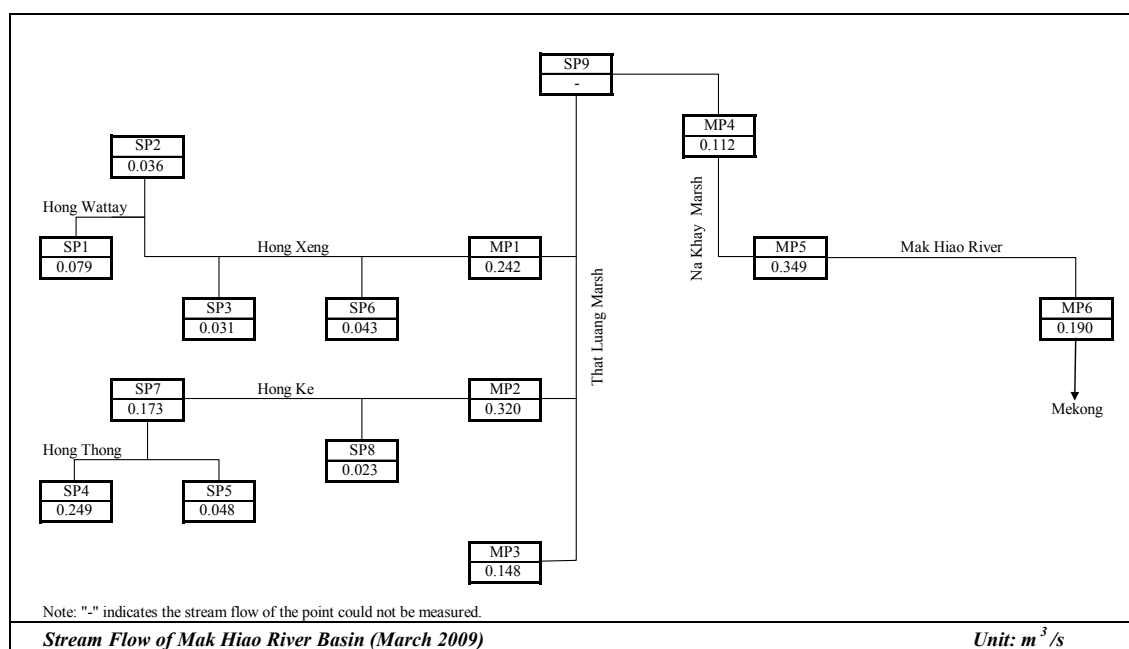


Fig. 4.1.2 Stream Flow of Periodical Monitoring in March 2009

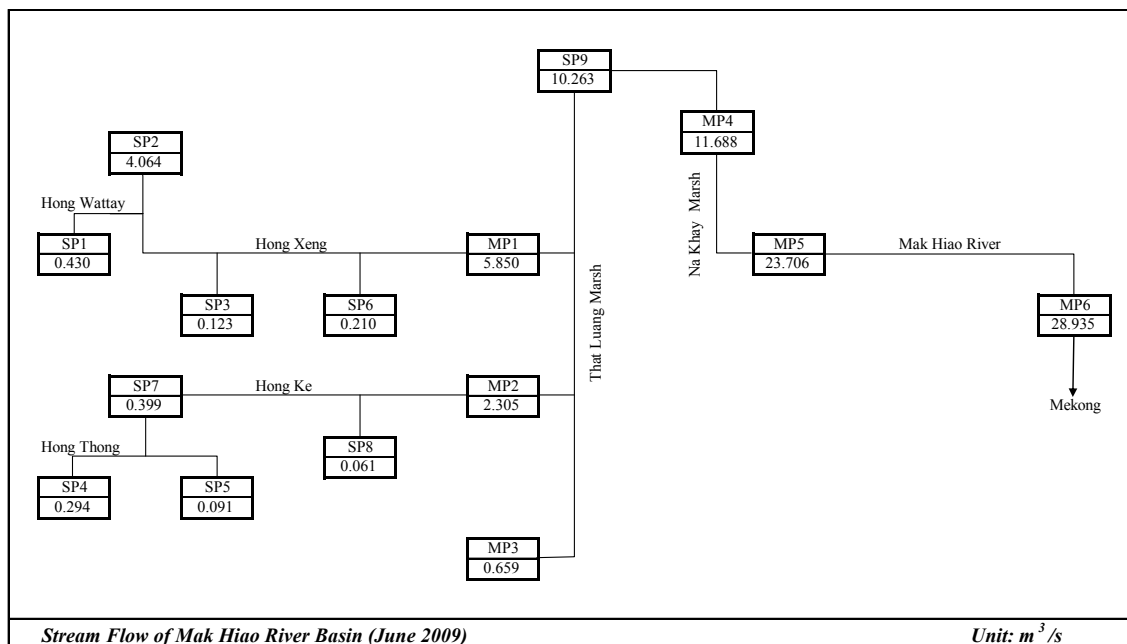


Fig. 4.1.3 Stream Flow of Periodical Monitoring in June 2009

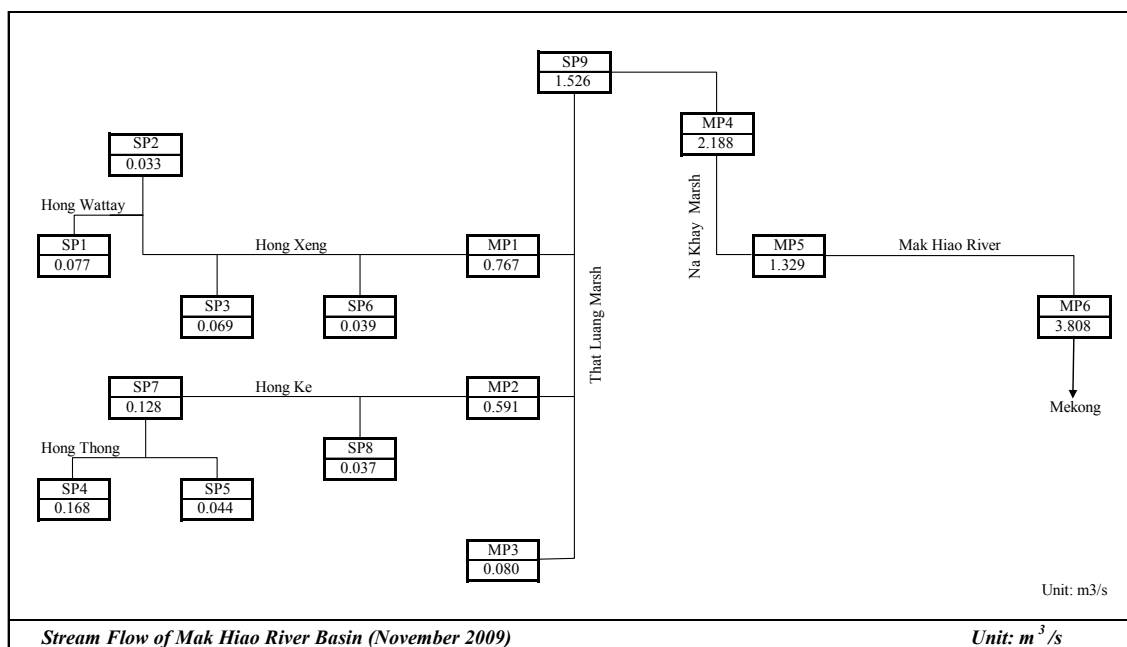


Fig. 4.1.4 Stream Flow of Periodical Monitoring in November 2009

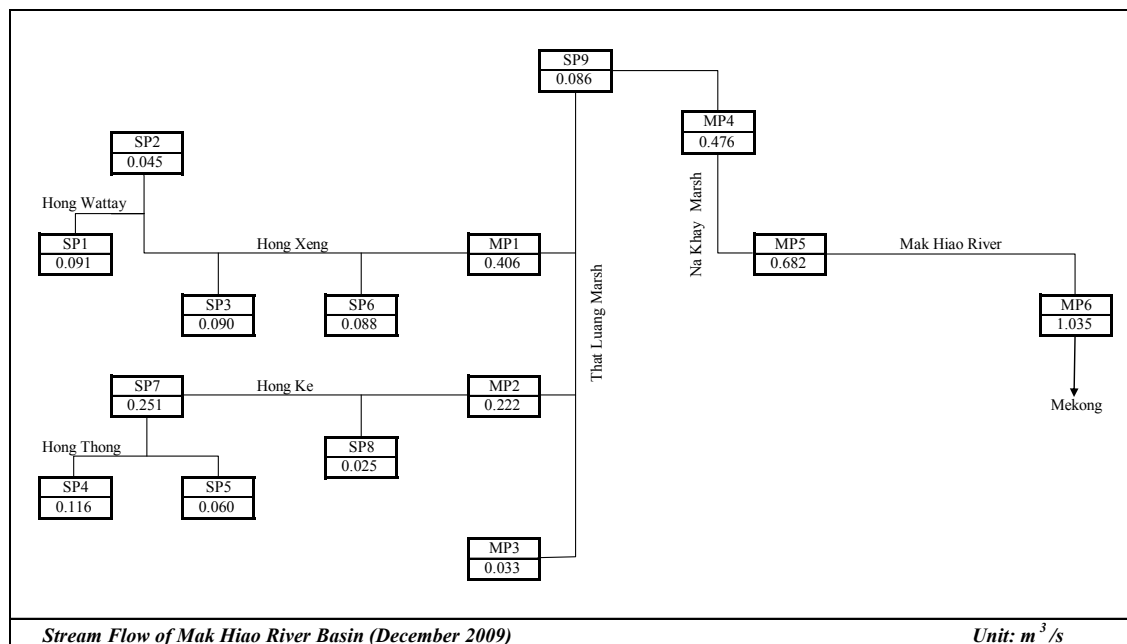


Fig. 4.1.5 Stream Flow of Periodical Monitoring in December 2009

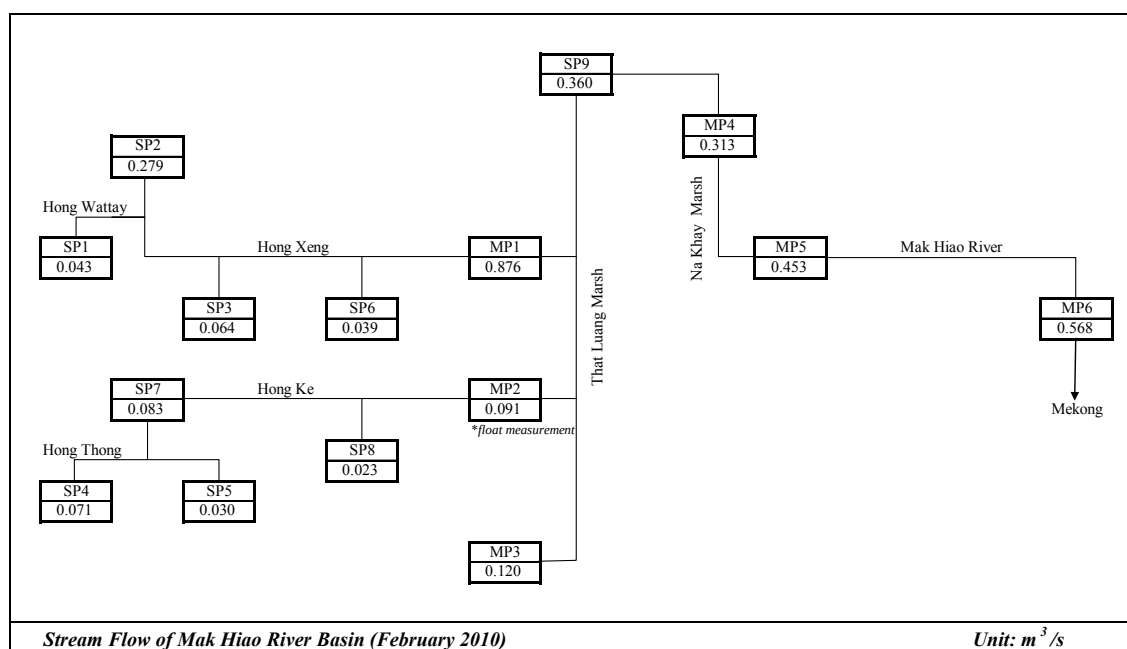


Fig. 4.1.6 Stream Flow of Periodical Monitoring in February 2010

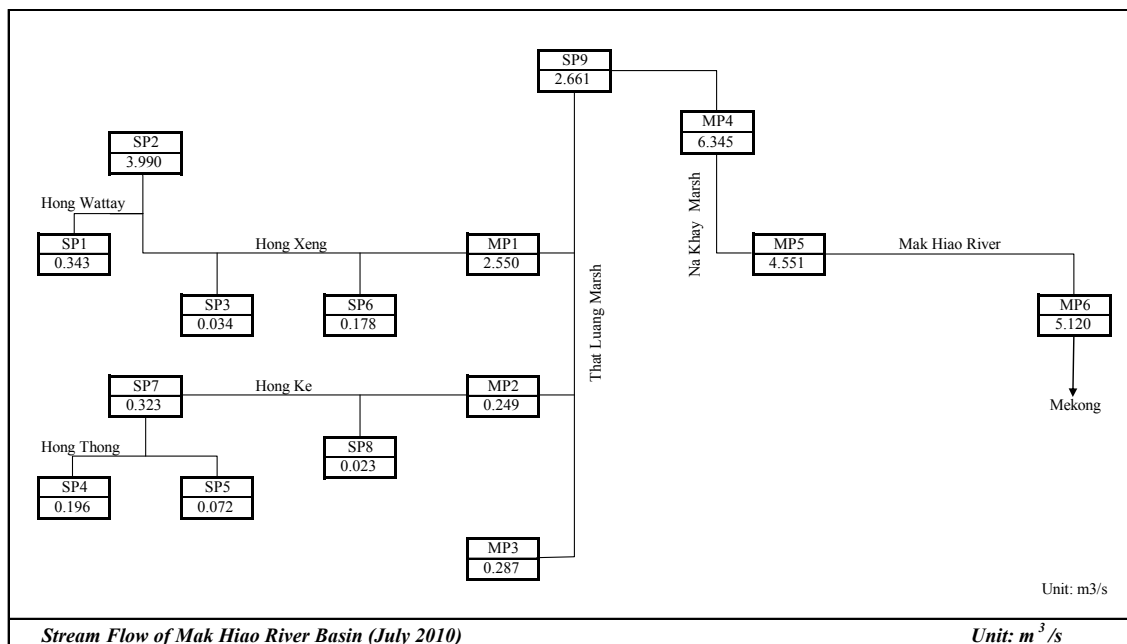


Fig. 4.1.7 Stream Flow of Periodical Monitoring in July 2010

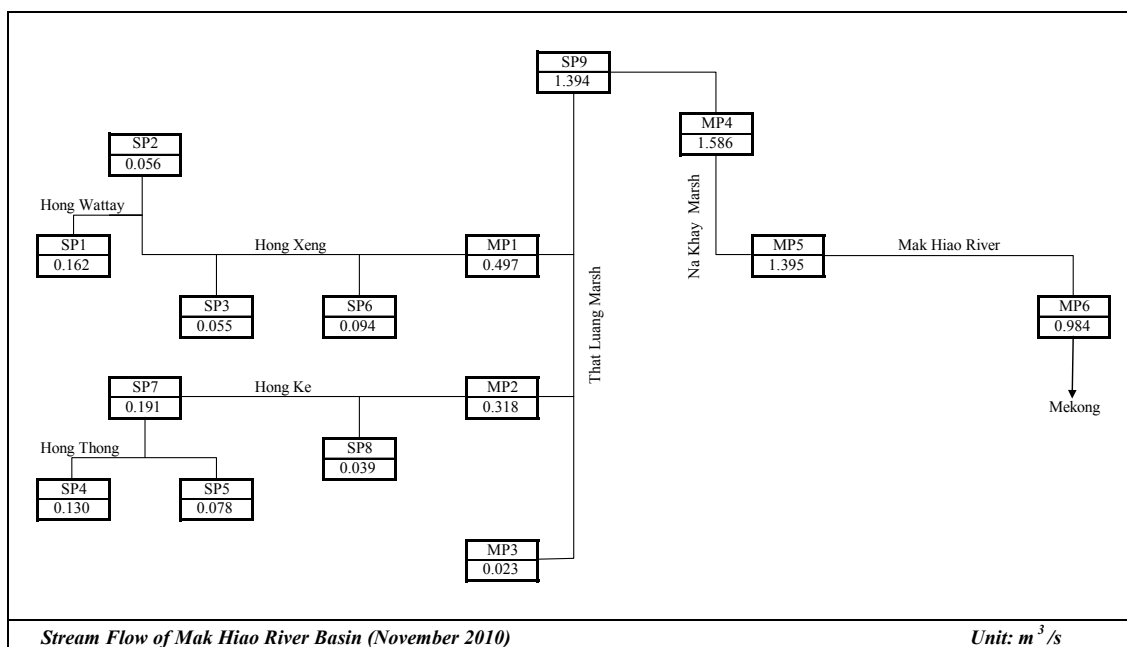


Fig. 4.1.8 Stream Flow of Periodical Monitoring in November 2010

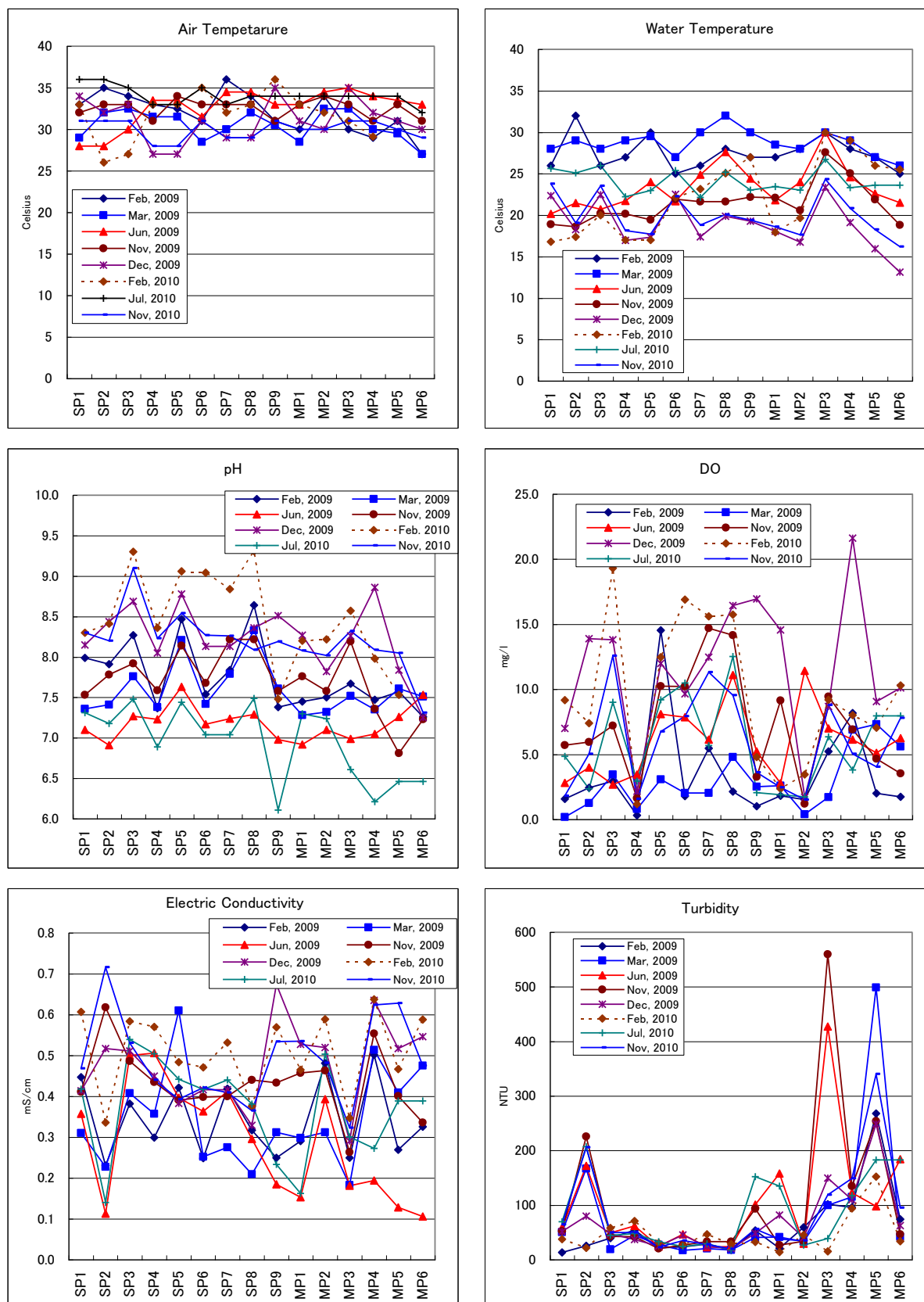


Fig. 4.1.9 Water Quality of Periodical Monitoring (1/5)

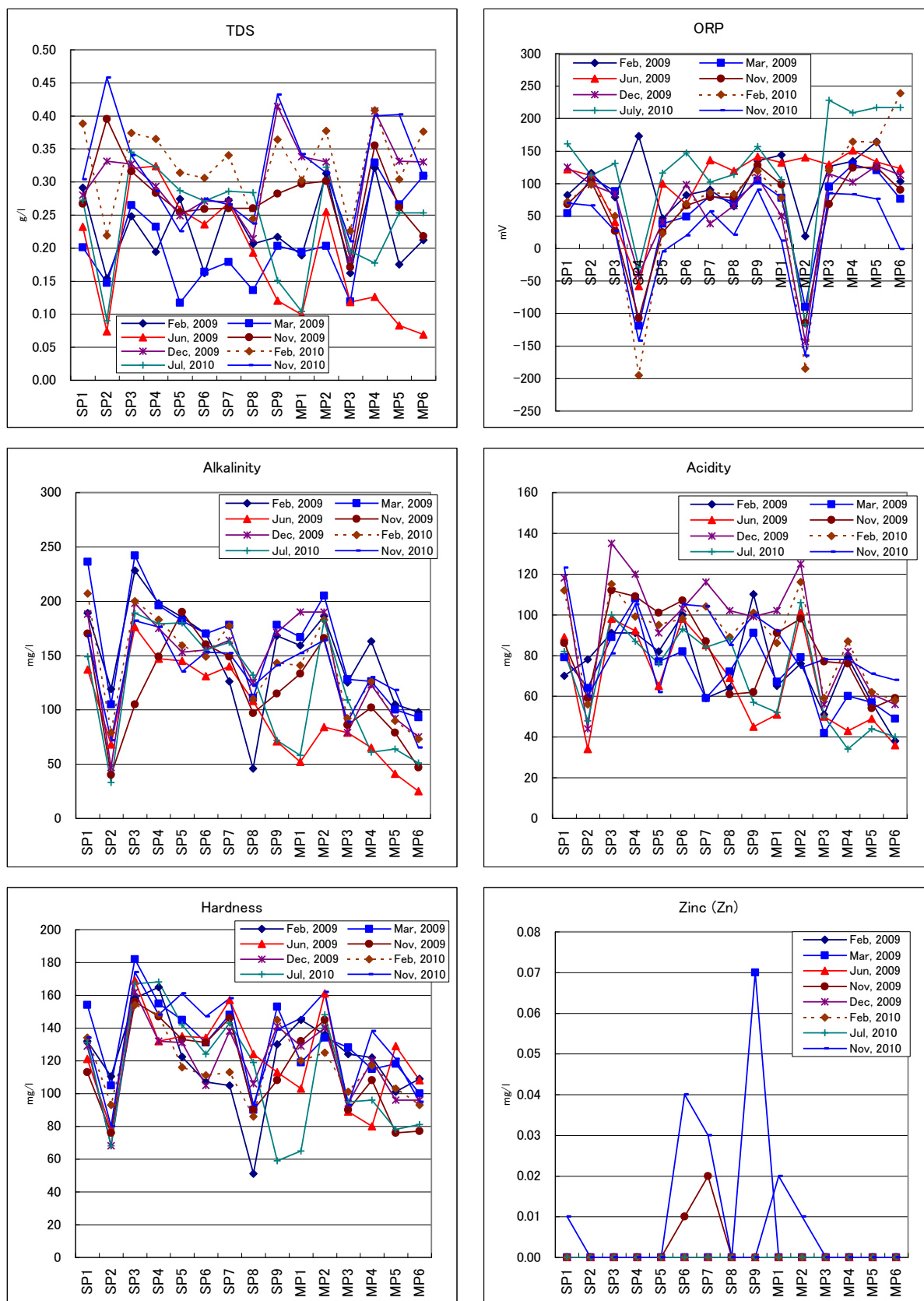


Fig. 4.1.10 Water Quality of Periodical Monitoring (2/5)

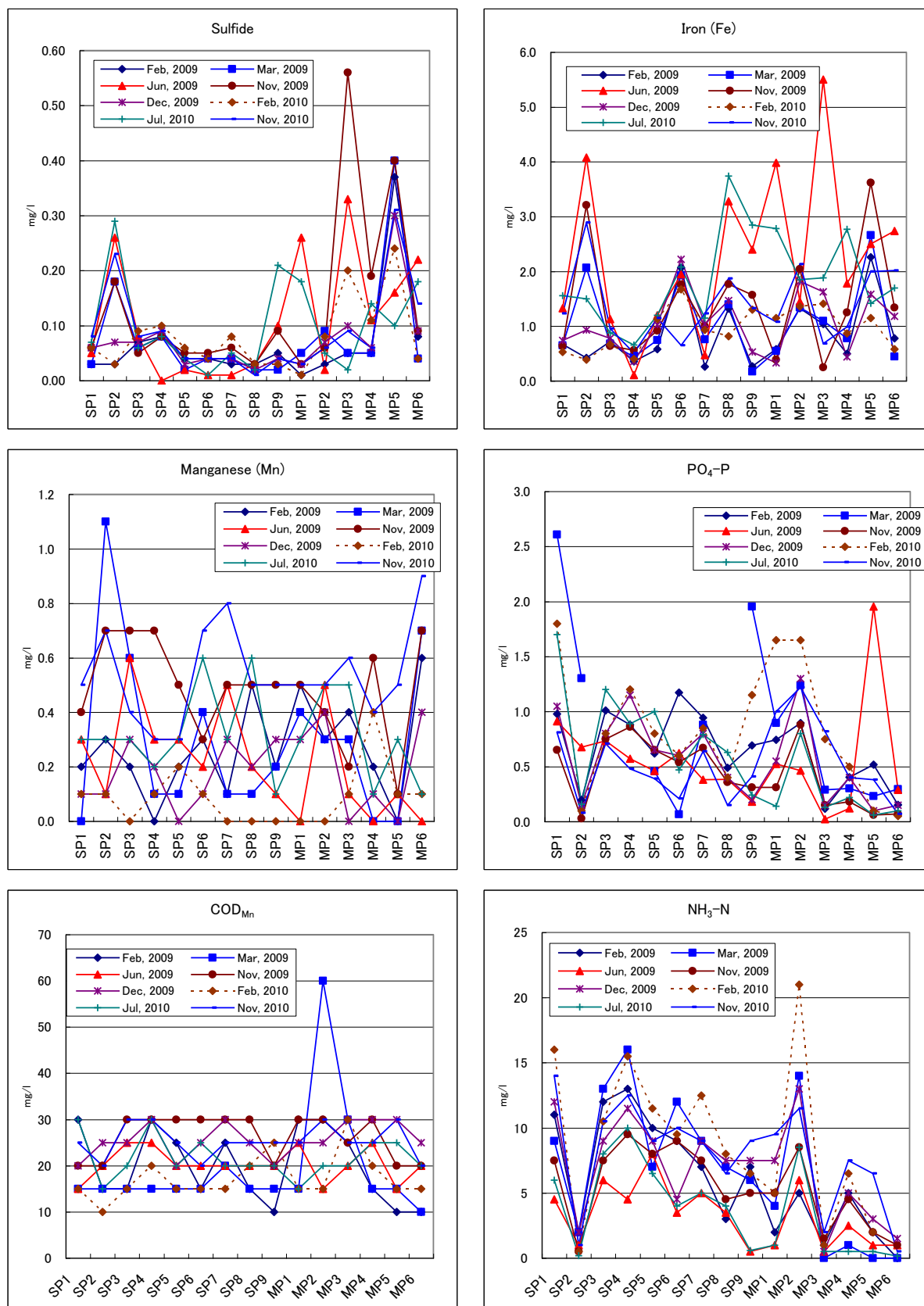


Fig. 4.1.11 Water Quality of Periodical Monitoring (3/5)

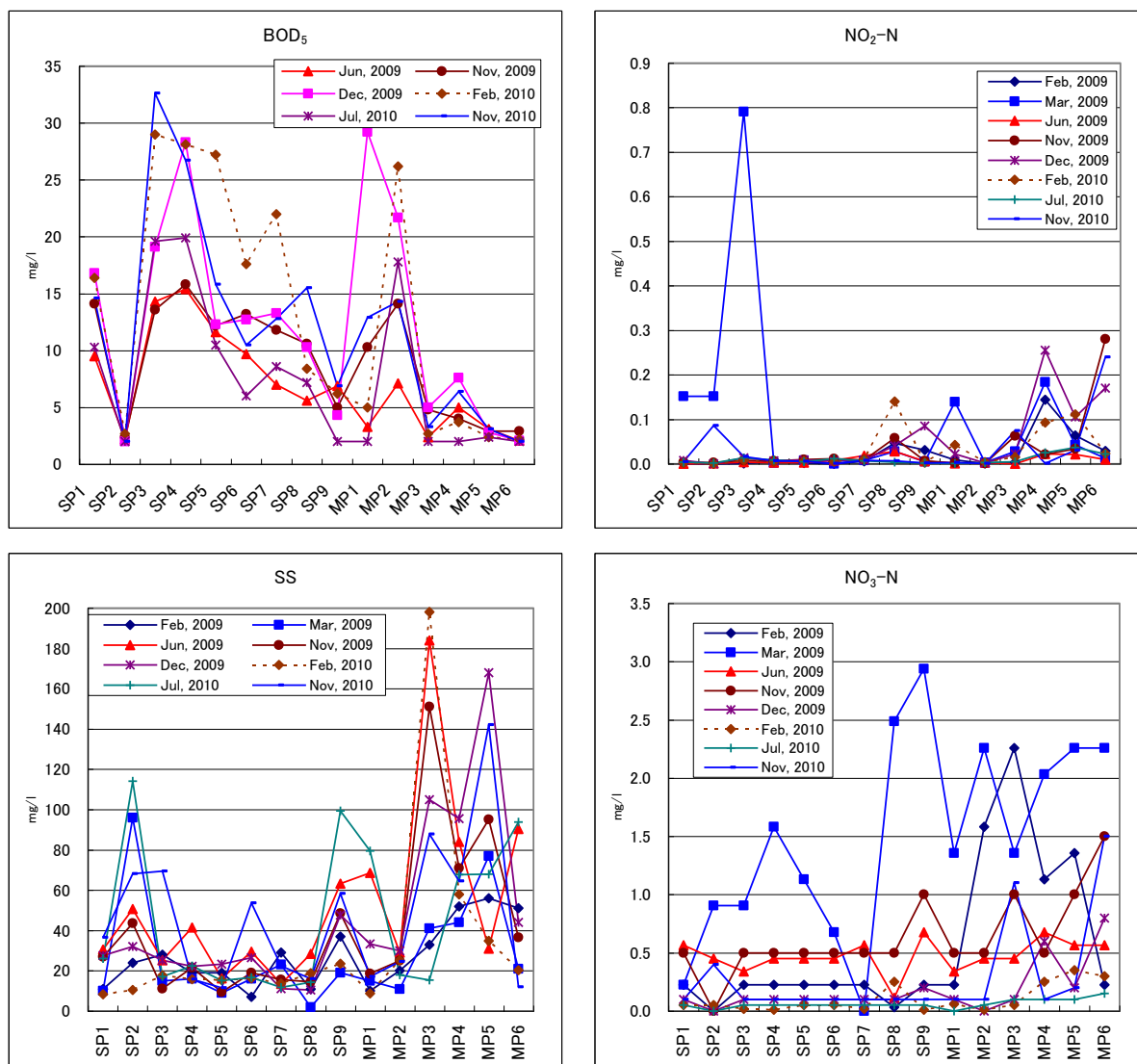


Fig. 4.1.12 Water Quality of Periodical Monitoring (4/5)

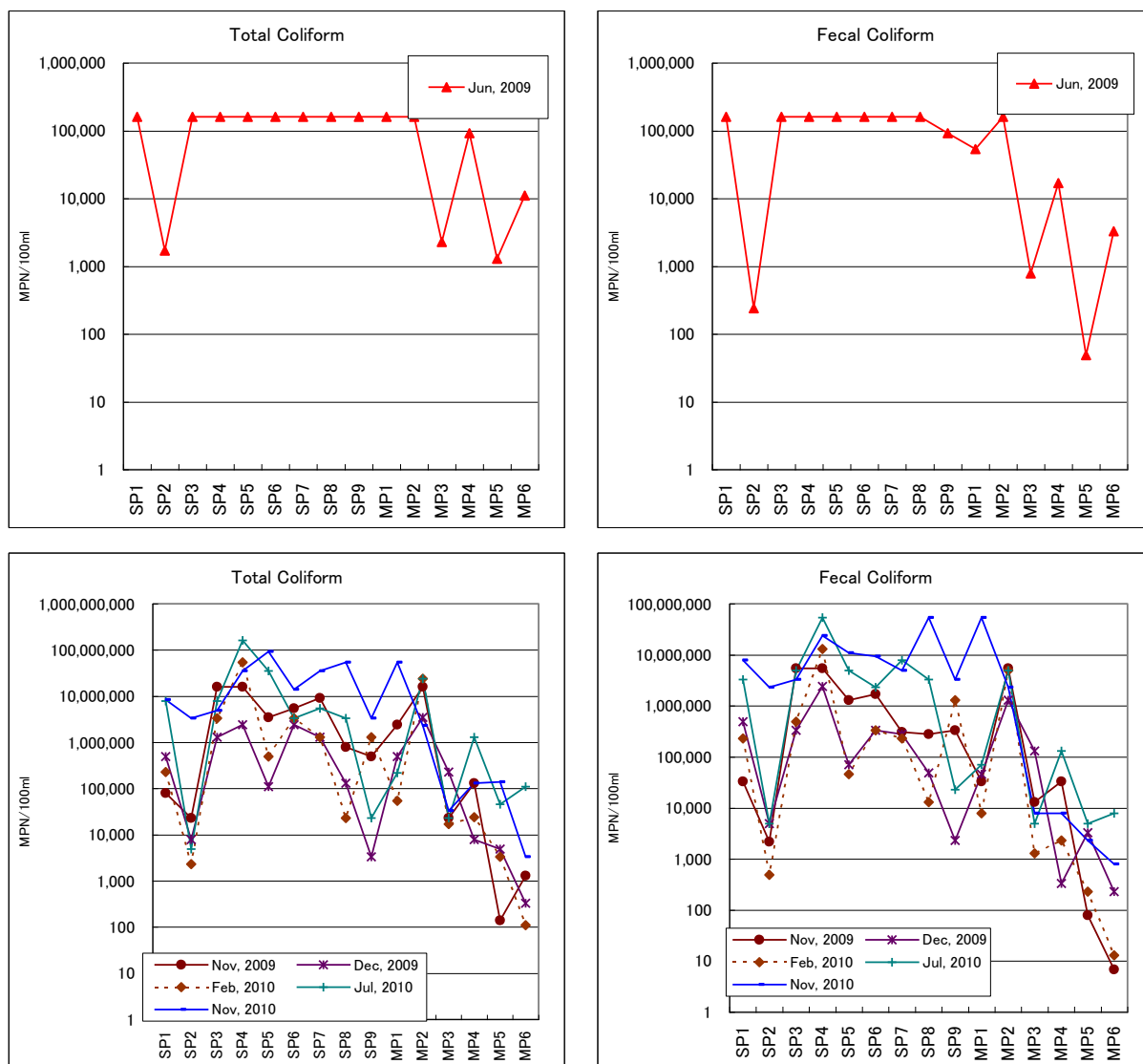


Fig. 4.1.13 Water Quality of Periodical Monitoring (5/5)

Table 4.1.9

Name of Monitoring Point		LA1	LA2	LA3	LA4	LA5	LA6	LA7	LA8	LA9	LBI	LB2	LB3	LB4	LB5	LB6	LB7	LB8	LB9	LB10	LB11	LB12	LB13	LB14	Remark
Date of Sampling		2-Jun	2-Jun	2-Jun	2-Jun	2-Jun	2-Jun	2-Jun	2-Jun	2-Jun	1-Jun	1-Jun	1-Jun	1-Jun	1-Jun	1-Jun	1-Jun	1-Jun	1-Jun	1-Jun	1-Jun	1-Jun	1-Jun	1-Jun	
Time		10:45	11:05	11:20	13:00	13:10	13:25	14:00	14:30	14:35	9:20	10:00	10:20	10:50	11:00	13:00	12:25	12:50	13:48	13:40	14:30	15:20	15:10	13:50	
Weather		Rainy	Rainy	Rainy	Rainy	Rainy	Rainy	Rainy	Rainy	Rainy	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	
On the day		Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	
Stream Flow (m ³ /s)		0.073	0.084	0.180	0.359	0.061	0.023	1.980			0.083	0.228	0.072	0.352	1.915		0.021	0.074		0.172	5.670				
No.	Classification	Items	Unit																						
1	1	A little bad	A little bad	Bad	A little bad	No odor	No odor	A little bad	No odor	No odor	No odor	Very bad	No odor	No odor	No odor	No odor	A little bad	No odor	No odor	No odor	No odor	No odor	No odor	No odor	
2	2	Color	-	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Dark gray	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	
3	3	Air temperature	°Celsius	32.0	35.0	36.0	34.0	32.5	33.0	35.0	32.0	32.0	32.0	33.0	33.0	35.0	35.0	36.0	35.0	35.0	35.0	34.0	34.0	29.5	
4	2	pH		7.05	7.55	7.29	7.31	7.24	6.73	6.94	7.19	6.90	7.13	7.04	6.97	7.02	6.86	7.05	7.24	8.23	6.98	7.16	6.93	6.73	6.80
5	3	Electric conductivity	mS/cm	0.321	0.378	0.483	0.368	0.306	0.279	0.362	0.369	0.255	0.403	0.388	0.515	0.352	0.148	0.186	0.533	0.475	0.222	0.373	0.227	0.234	0.296
6	Basic item(1)	Turbidity	NTU	52.2	25.0	58.3	34.3	18.7	26.4	40.9	94.3	41.5	57.5	35.9	96.9	31.5	113.0	98.4	46.5	28.6	87.1	31.4	47.3	91.3	40.4
7	Basic item(2)	Water temperature	°Celsius	4.36	8.40	1.27	9.9	14.37	8.68	11.67	1.94	4.09	2.28	4.49	2.08	4.22	4.83	2.93	1.88	17.88	2.36	8.40	2.41	2.15	6.70
8	5	TDS	g/l	0.209	0.246	0.314	0.239	0.199	0.181	0.216	0.240	0.165	0.262	0.252	0.330	0.229	0.096	0.121	0.341	0.309	0.144	0.242	0.148	0.152	0.192
9	1	ORP	mV	-14	-7	-48	128	92	-11	131	93	117	-53	79	-252	147	126	87	-135	89	119	131	150	197	175
10	3	NH ₃ (NH ₃ -N)	mg/l	2.5	6.5	4.5	3.5	3.0	4.5	6.0	0.5	3.5	2.5	10.5	2.5	0.5	1.0	6.5	5.5	1.0	5.0	1.0	2.0	1.0	1.0
11	2	NO ₂ (NO ₂ -N)	mg/l	0.005	0.006	0.006	0.007	0.013	0.008	0.003	0.000	0.000	0.006	0.004	0.005	0.003	0.001	0.003	0.010	0.012	0.002	0.008	0.002	0.002	0.002
12	3	NO ₃ (NO ₃ -N)	mg/l	0.7	0.5	0.9	0.6	0.5	0.7	0.8	0.7	0.8	0.6	0.6	0.7	0.7	0.6	0.6	0.7	0.5	1.6	1.1	1.6	1.4	3.6
13	4	PO ₄ (PO ₄ -N)	mg/l	0.41	0.60	0.83	0.42	0.33	0.09	0.30	0.50	0.07	0.63	0.68	2.41	0.32	0.11	0.11	0.18	0.56	0.25	0.24	0.20	0.19	0.16
14	4	COD _{Mn}	mg/l	25	20	15	20	20	15	15	20	15	25	30	15	15	15	20	15	20	15	15	15	15	20
15	Organic pollutant	BOD ₅	mg/l	5.4	11.4	24.1	8.9	7.4	26.8	12.3	27.9	7.4	15.4	8.1	48.3	6.8	-52.0	31.1	37.6	10.1	3.7	9.5	4.4	5.2	4.9
16	2	Hardness	°dH	32.3	14.8	27.1	17.1	17.0	20.3	22.8	40.3	22.0	30.5	17.5	92.2	22.5	27.5	24.6	14.9	37.3	21.3	20.6	19.5	20.6	19.4

Table 4.1.10 Monitoring Results of Longitudinal Simultaneous Monitoring in November 2009

Name of Monitoring Point		LA1	LA2	LA3	LA4	LA5	LA6	LA7	LA8	LA9	LB1	LB2	LB3	LB4	LB5	LB6	LB7	LB8	LB9	LB10	LB11	LB12	LB13	LB14	Remark
Date of Sampling		23-Nov	23-Nov	23-Nov	23-Nov	23-Nov	23-Nov	23-Nov	23-Nov	23-Nov	24-Nov	24-Nov	24-Nov	24-Nov	24-Nov	24-Nov	24-Nov	24-Nov	24-Nov	24-Nov	24-Nov	24-Nov	24-Nov	23-Nov	
Time		9:35	10:10	10:20	10:45	11:00	11:30	12:40	13:05	13:10	9:55	10:30	10:15	10:45	11:10	11:45	9:30	11:35	13:00	12:55	13:20	13:50	13:55	13:45	
Weather		Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	
Previous day																									
On the day																									
Stream Flow (m ³ /s)		0.023	0.044	0.126	0.189	0.042	0.008	0.597			0.016	0.070	0.025	0.118	-0.044		0.017	0.053		0.131	0.732			1.212	
No.	Classification	Items	Unit																						
1	1	Odor	-	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	Good
		Color	-	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	
		Air temperature	°Celsius	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	27.0	27.0	28.0	28.0	28.0	24.0	28.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
2	2	pH	-	7.41	7.81	7.81	8.29	7.82	7.40	7.60	7.82	7.61	8.09	7.85	7.41	8.24	7.97	7.73	7.85	7.98	7.78	7.96	7.78	8.00	7.73
		Electric conductivity	mS/cm	0.337	0.393	0.455	0.412	0.350	0.293	0.436	0.481	0.351	0.515	0.446	1.110	0.412	0.922	0.539	0.520	0.515	0.436	0.518	0.591	0.478	0.503
		Turbidity	NTU	33.2	11.4	47.8	19.7	90.7	10.1	28.1	33.4	99.9	66.3	27.5	310.0	31.4	71.5	36.3	46.4	60.0	23.4	126.0	38.9	30.4	97.3
3	3	DO	mg/l	6.02	8.47	1.79	18.71	8.82	9.91	6.66	4.37	5.50	2.45	8.50	3.25	17.84	10.41	5.37	2.90	7.23	7.57	7.68	3.51	8.16	3.40
		Water temperature	°Celsius	14.09	15.16	17.53	18.31	19.38	19.56	17.67	18.38	17.69	16.15	16.32	14.46	17.12	14.95	17.34	15.48	18.02	21.96	16.71	19.04	19.43	15.06
		TPDS	g/l	0.219	0.256	0.296	0.268	0.228	0.191	0.283	0.313	0.228	0.330	0.290	0.711	0.268	0.590	0.358	0.333	0.330	0.342	0.284	0.332	0.379	0.310
4	4	ORP	mV	-16	67	-61	72	9	-36	83	92	98	-105	-21	-149	70	75	43	-162	71	79	51	-8	87	96
		NH ₃ (NH ₃ -N)	mg/l	3.5	8.0	9.0	7.0	6.0	4.5	7.5	10.0	2.0	13.5	8.0	34.0	8.5	2.0	7.5	5.5	8.5	6.5	8.0	7.0	8.5	6.0
		NO ₂ (NO ₂ -N)	mg/l	0.013	0.005	0.003	0.013	0.008	0.005	0.003	0.002	0.030	0.010	0.009	0.024	0.008	0.002	0.005	0.011	0.013	0.006	0.026	0.002	0.009	0.008
5	5	NO ₃ (NO ₃ -N)	mg/l	0.5	0.5	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		PO ₄ (PO ₄ -N)	mg/l	0.55	0.66	0.82	0.49	0.13	0.10	0.56	0.83	0.11	1.08	0.69	6.70	0.49	0.15	0.28	1.14	0.60	0.41	0.31	0.44	0.29	0.41
		COD _{Mn}	mg/l	20	30	30	25	25	15	15	25	25	20	25	60	20	25	30	30	30	25	30	25	20	15
6	6	BOD ₅	mg/l	7.3	9.8	28.0	9.6	9.1	8.5	9.8	14.4	4.9	27.0	362.0	11.9	2.7	4.4	35.2	15.1	7.8	13.2	12.7	6.2	9.6	5.4
		SS	mg/l	21.2	9.4	11.1	31.9	49.6	15.2	18.3	17.3	45.6	21.5	12.4	262.0	17.9	40.0	23.1	22.8	16.0	51.7	21.6	47.2	26.8	26.8

Table 4.1.11 Monitoring Results of Longitudinal Simultaneous Monitoring in November 2010

Name of Monitoring Point				Date of Sampling										Weather		November 2010										Remark		
Date of Sampling				Previous day										On the day														
Stream Flow (m ³ /s)																												
No.	Classification	Items	Unit																									
1	Basic item(1)	Odor	-	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	A little bad	No odor	No odor
2		Color	-	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow
3		Air temperature	°C	25.0	26.0	26.0	28.0	29.0	28.0	28.0	28.0	28.0	26.0	26.0	26.0	27.0	28.0	29.0	29.0	29.0	29.0	29.0	28.5	28.5	28.5	28.5	28.5	28.5
2	Basic item(1)	pH	-	6.83	7.22	7.37	7.60	7.39	7.11	7.61	7.73	7.64	8.17	7.86	7.58	8.17	7.86	8.42	8.24	8.02	8.02	8.19	8.12	7.99	7.57	7.70	Horiba U-52G	Horiba U-52G
3		Electric conductivity	mS/cm	0.318	0.364	0.427	0.405	0.320	0.306	0.450	0.425	0.282	0.405	0.450	0.34	0.34	0.303	0.338	0.469	0.446	0.390	0.395	0.389	0.447	0.339	0.372	Horiba U-52G	Horiba U-52G
4		Turbidity	NTU	30.2	26.8	45.1	28.4	16.0	33.7	35.0	33.5	50.0	60.2	35.3	155.0	229.0	51.2	159.0	122.0	56.8	39.0	98.3	26.2	72.0	50.6	98.2	65.7	Horiba U-52G
5	Organic pollutant	DO	mg/l	4.77	10.49	1.22	9.72	11.51	7.51	2.17	3.35	6.71	1.48	3.81	2.02	10.30	9.53	4.69	5.98	17.03	5.71	10.17	7.42	6.97	3.34	3.24	Horiba U-52G	Horiba U-52G
6		Water temperature	°C	15.05	16.55	18.43	17.36	19.73	21.16	15.67	17.37	17.53	17.86	16.67	14.34	17.82	14.28	17.75	16.49	21.22	20.20	21.82	19.22	19.51	17.91	16.36	Horiba U-52G	Horiba U-52G
7		TDS	g/l	0.207	0.236	0.277	0.263	0.208	0.199	0.292	0.277	0.183	0.302	0.292	0.598	0.271	0.197	0.219	0.305	0.290	0.253	0.257	0.251	0.291	0.220	0.242	Horiba U-52G	Horiba U-52G
3	Basic item(2)	ORP	mV	-37	107	-103	86	69	-48	-97	-71	3	-66	-10	-167	28	59	45	-25	19	77	63	-17	102	105	93	Horiba U-52G	Horiba U-52G
4		NH ₃ (NH ₃ -N)	mg/l	4.0	8.0	10.5	6.0	5.5	5.0	8.0	8.5	0.3	12.0	11.0	68.0	7.5	4.0	7.0	12.5	9.5	7.5	10.5	8.0	4.5	3.5	3.5	Hach 850	Hach 850
5		NO ₂ (NO ₂ -N)	mg/l	0.011	0.009	0.008	0.006	0.012	0.002	0.002	0.002	0.003	0.005	0.009	0.013	0.030	0.004	0.050	0.015	0.027	0.030	0.027	0.012	0.014	0.007	0.001	0.004	Hach 850
4	Organic pollutant	NO ₃ (NO ₃ -N)	mg/l	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	Hach 850	Hach 850
5		PO ₄ (PO ₄ -P)	mg/l	0.14	0.60	1.04	0.58	0.42	0.15	0.66	0.35	0.07	0.83	0.48	7.50	0.56	0.06	0.31	0.58	0.69	0.36	0.20	0.22	0.53	0.28	0.71	Hach 850	Hach 850
6		COD _{Mn}	mg/l	20	20	25	20	20	20	20	20	20	20	20	20	60	20	20	20	20	15	20	20	20	10	15	20	Pack test
3	Organic pollutant	BOD ₅	mg/l	5.5	10.6	19.7	11.2	7.2	10.7	12.0	13.4	3.6	15.9	12.1	209.0	14.3	-2.0	4.5	29.3	18.3	6.3	10.1	6.0	5.8	4.6	4.6	UAE	UAE
4		SS	mg/l	32.1	11.6	11.6	15.7	24.3	29.5	21.3	34.3	47.3	14.9	59.5	208.0	24.8	84.5	56.9	30.4	20.6	65.0	11.4	43.3	24.8	47.3	29.9	UAE	UAE
5																												

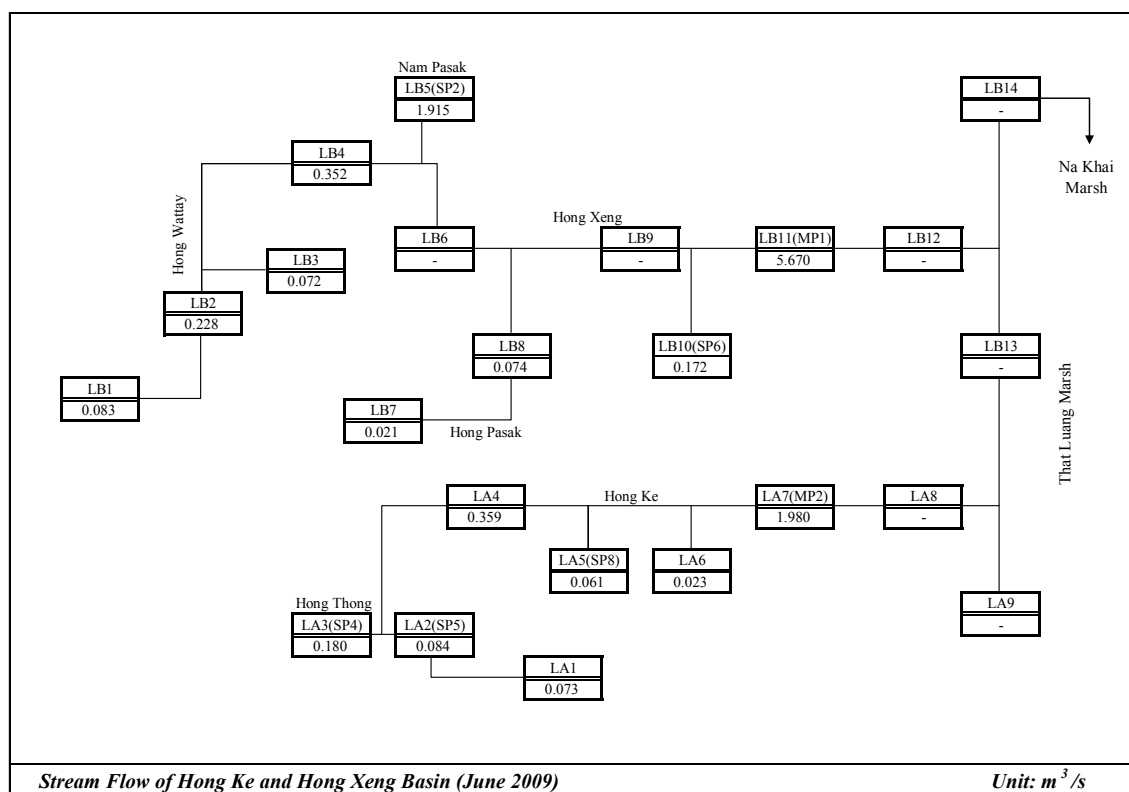


Fig. 4.1.14 Stream Flow of Longitudinal Simultaneous Monitoring in June 2009

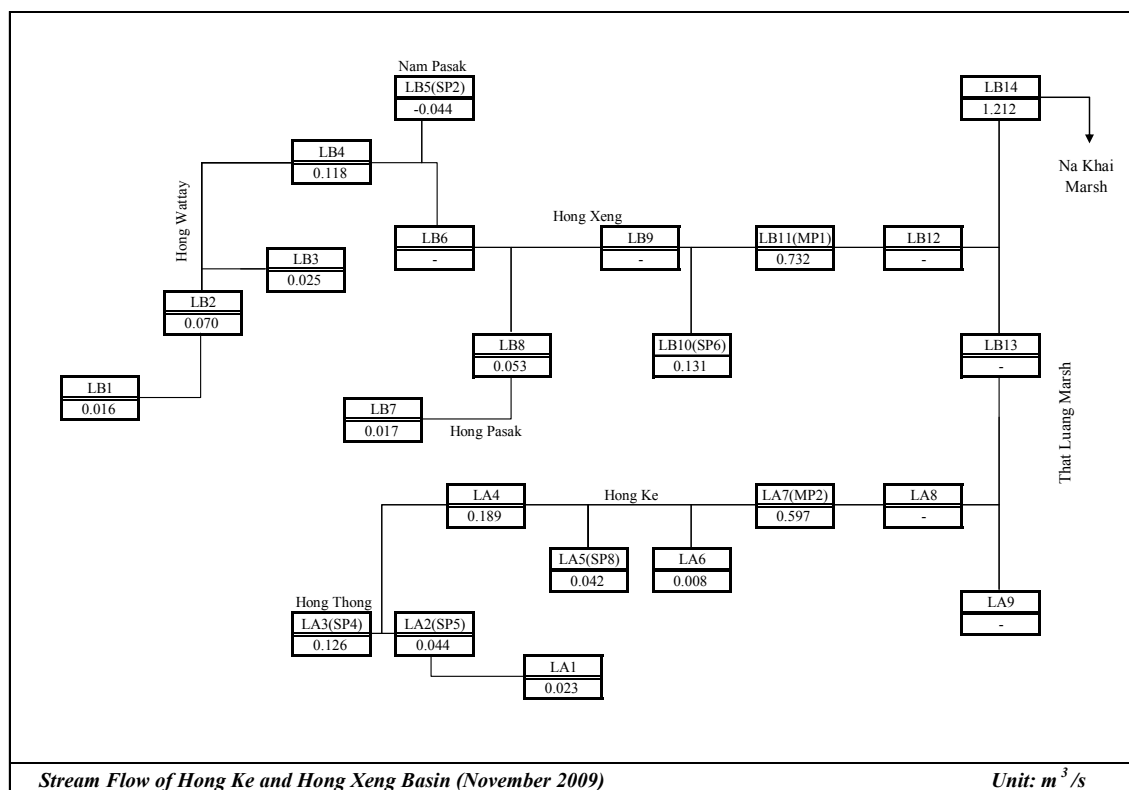


Fig. 4.1.15 Stream Flow of Longitudinal Simultaneous Monitoring in November 2009

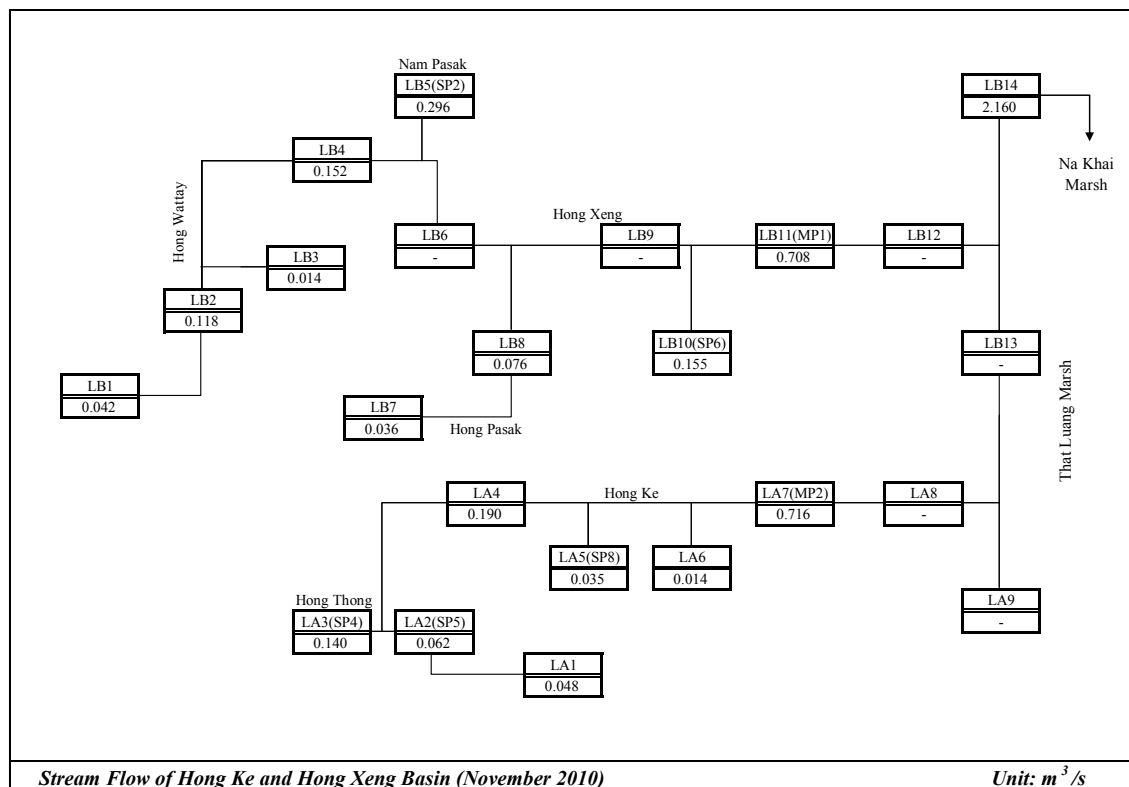


Fig. 4.1.16 Stream Flow of Longitudinal Simultaneous Monitoring in November 2010



Fig. 4.1.17 Water Quality of Longitudinal Simultaneous Monitoring (1/2)

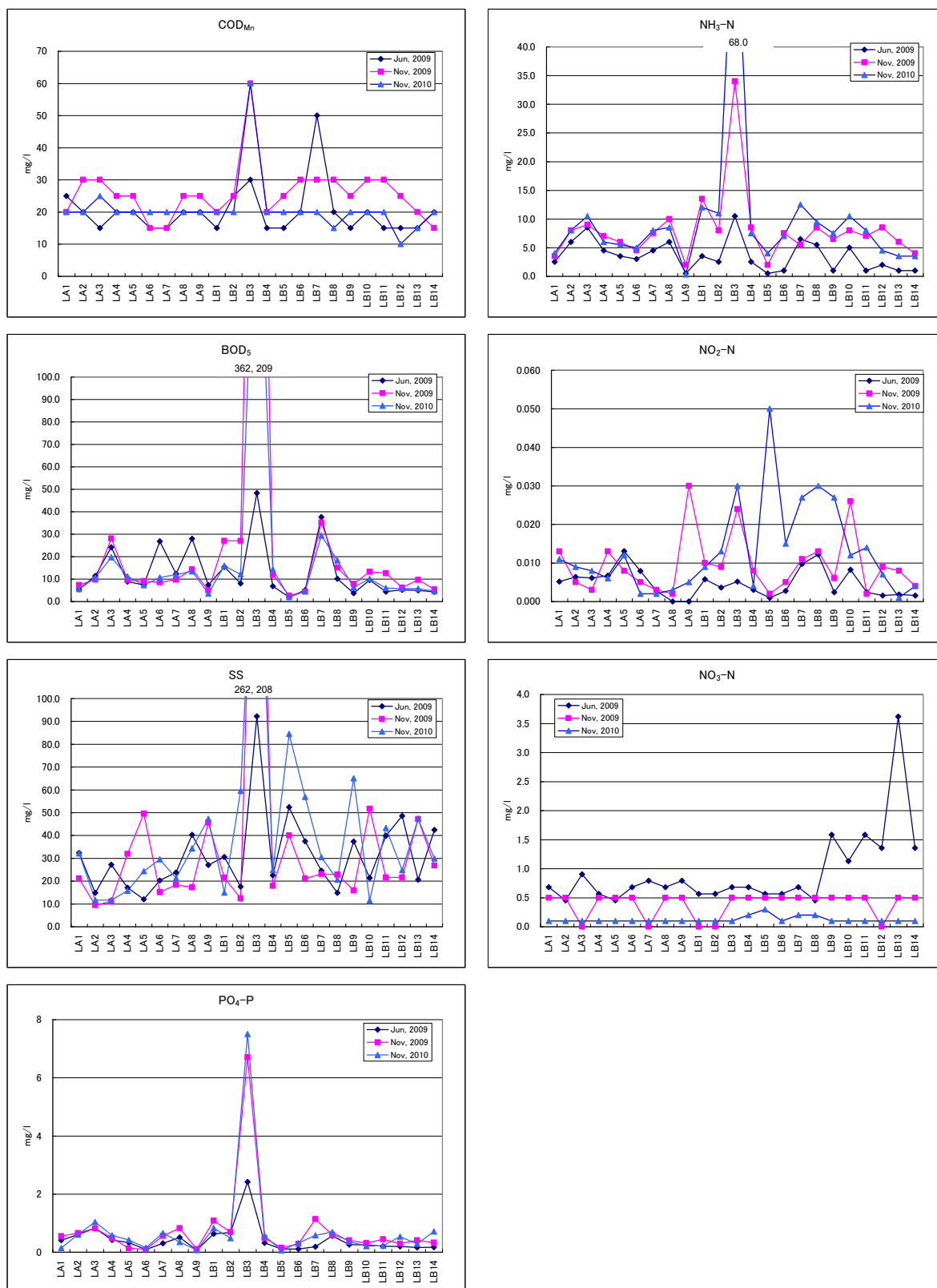


Fig. 4.1.18 Water Quality of Longitudinal Simultaneous Monitoring (2/2)

4.2 Cost Estimation

Table 4.2.1 Basic Information (Alternative 1)

Alternative-1

	Total population	Name of plant	Population treated	Wastewater		BOD			Treatment method	Sludge volume (m ³ /d)	Remarks
				daily avg. (m ³ /d)	daily max. (m ³ /d)	in (mg/l)	out (mg/l)	removal rate (%)			
Pasak	10,931	-	10,931	2,230	2,973	31	9	70	Contact aeration process	1.170	
Hong Ke	44,173	-	44,173	9,012	12,016	31	9	70		4.727	
Kai Keo	16,499	-	16,499	3,366	4,488	31	9	70		1.766	
Total			71,603	14,608	19,477					7.663	

	Wastewater daily max. (m ³ /d)	Pump house& Grit chamber			Contact aeration reactor						Remarks
		Width (m)	Length (m)	Area (m ²)	Width (m)	Length (m)	Depth (m)	No.	Volume (m ³)	HRT (hr)	
Pasak	2,973	19.5	9.5	185	4.5	68.0	2.5	4	3,060	24.7	
Hong Ke	12,016	79.5	9.5	755	4.5	69.0	2.5	16	12,420	24.8	
Kai Keo	4,488	39.5	9.5	375	4.5	51.0	2.5	8	4,590	24.5	
Hong Thong	2,813	19.5	9.5	185	4.5	64.5	2.5	4	2,903	24.8	
Total											

	Sedimentation tank						Vegetation pond				
	Width (m)	Length (m)	Depth (m)	No.	Volume (m ³)	HRT (hr)	Width (m)	Length (m)	Depth (m)	No.	Area (m ²)
Pasak	19.5	15.5	2.5	1	756	6.1	19.5	14.5	1.0	1	283
Hong Ke	79.5	15.0	2.5	1	2,981	6.0	79.5	14.5	1.0	1	1,153
Kai Keo	39.5	11.5	2.5	1	1,136	6.1	39.5	14.5	1.0	1	573
Hong Thong	19.5	14.5	2.5	1	707	6.0	19.5	14.5	1.0	1	283
Total											

Note:

Sludge volume (contact aeration process)

$$= (S_o \times a/k) \times (1-b) \times ((1 - \exp(-k \times t)) + S_o \times (1-a) \times t$$

where: S_o : SS removed (gram/day)
 a : ratio of decomposable SS
 k : degradation coefficient of organic sludge (0.01/day)
 b : initial degradation rate of decomposable SS (35%)
 t : detention time (day)

Source: Manual of contact aeration process

(Kinki Regional Development Bureau, The Ministry of Land, Infrastructure, Transport and Tourism)

Table 4.2.2 Basic Information (Alternative 2)

Alternative-2

Alternative 2

	Total population	Name of plant	Population treated	Wastewater		BOD			Sludge volume (m ³ /d)
				daily avg. (m ³ /d)	daily max. (m ³ /d)	in (mg/l)	out (mg/l)	removal rate (%)	
1. WTP (anaerobic treatment plant)									
Pasak upstream	4,254	T1(SBS)	585	101	135	31	9	70	0.015
		T2	293	59	79	31	9	70	0.009
		T3	182	37	49	31	9	70	0.005
		T4	244	50	66	31	9	70	0.007
		T5	247	50	67	31	9	70	0.007
		T6	159	32	43	31	9	70	0.005
		T7	98	20	26	31	9	70	0.003
		T8	308	62	83	31	9	70	0.009
		Total(T2-T8)	1,531	310	413				0.045
		Others	-	60	80	31	9	70	0.009
Total	2,116	471	628				0.069		
Pasak downstream	6,677	-	3,172	647	863	31	9	70	0.095
Kai Keo	16,499	-	8,250	1,683	2,244	31	9	70	0.247
Khoua Khao	16,011	-	8,006	1,633	2,177	41	12	70	0.316
Ouay Louay	7,800	-	3,900	796	1,061	31	9	70	0.117
Phone Thanh	1,525	-	763	156	208	21	6	70	0.016
Sub-total	52,766		26,207	5,386	7,181				0.860
2. Contact aeration plant									
Hong Thong	10,342	-	10,342	2,110	2,813	31	9	70	1.107
Total			36,549	7,496	9,994				1.967

Note:

Sludge volume (anaerobic treatment plant) = 0.005 liters/gram BOD removed

Source: Decentralised Wastewater Treatment Systems (DEWATS)

and sanitation in Developing Countries (BORDA)

Table 4.2.3 Cost Estimation (Alternative 1)

Alternative 1							(1/2)
1.Contact aeration plant							
Pumping station							
Construction cost							1US\$= 80.66 JPY
Basin	Wastewater (daily average)				Cost	Cost	
	(m ³ /d)×1	(m ³ /d)×2	(m ³ /s)×2	(m ³ /min)	(JPY)	(US\$)	
Pasak	2,230	4,460	0.05	3.1	8,495,000	105,319	
Hong Ke	9,012	18,024	0.21	12.5	29,079,000	360,513	
Kai Keo	3,366	6,732	0.08	4.7	12,792,000	158,592	
Total	14,608	29,216	0.34	20.3	50,366,000	624,424	
O&M cost (Electricity) per year							1US\$= 8,000 kip
Basin	Electricity (kW)	Operation hour (hr)	Electricity (kW)	Unit cost (Kip/kW)	Cost (Kip)	Cost (US\$)	
Pasak	5.9	24	51,684	800	41,347,200	5,168	
Hong Ke	23.5	24	205,860	800	164,688,000	20,586	
Kai Keo	8.9	24	77,964	800	62,371,200	7,796	
Total	38.3		335,508		268,406,400	33,550	
Treatment plant							
Construction cost							
Basin	Stream flow (m ³ /d)		Land req.	Cost (JPY)			
	(daily avg.)	(daily max.)	(m ²)	Civil	Aerator	Contact media	Total
Pasak	2,230	2,973	2,190	225,636,364	14,865,000	8,919,000	249,420,364
Hong Ke	9,012	12,016	8,800	906,666,667	60,080,000	36,048,000	1,002,794,667
Kai Keo	3,366	4,488	3,540	364,727,273	22,440,000	13,464,000	400,631,273
Total	14,608	19,477	14,530	1,497,030,304	97,385,000	58,431,000	1,652,846,304
1US\$= 80.66 JPY							
Basin	Stream flow (m ³ /d)		Cost (US\$)				
	(daily avg.)	(daily max.)	Civil	Aerator	Contact media	Total	
Pasak	2,230	2,973	2,797,376	184,292	110,575	3,092,243	
Hong Ke	9,012	12,016	11,240,598	744,855	446,913	12,432,366	
Kai Keo	3,366	4,488	4,521,786	278,205	166,923	4,966,914	
Total	14,608	19,477	18,559,760	1,207,352	724,411	20,491,523	
O&M cost (Electricity) per year							1US\$= 8,000 kip
Basin	Electricity (kW)	Operation hour (hr)	Electricity (kW)	Unit cost (Kip/kW)	Cost (Kip)	Cost (US\$)	
Pasak	16.0	24	140,160	800	112,128,000	14,016	
Hong Ke	66.0	24	578,160	800	462,528,000	57,816	
Kai Keo	25.0	24	219,000	800	175,200,000	21,900	
Total	107.0		937,320		749,856,000	93,732	

Alternative 1

(2/2)

O&M cost for 1 yr (Sludge disposal)

1US\$=8,000 kip

Basin	Sludge volume (m ³ /day)	Sludge Vol. (m ³ /year)	Unit cost (Kip/m ³)	Cost (Kip)	Cost (US\$)
Pasak	1.170	427.1	125,000	53,387,500	6,673
Hong Ke	4.727	1,725.4	125,000	215,675,000	26,959
Kai Keo	1.766	644.6	125,000	80,575,000	10,072
Total	7.663	2,797.1		349,637,500	43,704

Land cost

Basin	Land req. (m ²) (1)	Land req. (m ²) (1) × 1.3	Unit cost (US\$)	Cost (US\$)
Pasak	2,190	2,847	100	284,700
Hong Ke	8,800	11,440	100	-
Kai Keo	3,540	4,602	100	460,200
Total	14,530	18,889		744,900

Total cost of Alternative 1

Basin	Construction		O&M		Total (US\$)
	WTP (US\$)	Contact aeration (US\$)	WTP (US\$)	Contact aeration (US\$)	
Contact aeration		21,860,847		170,986	22,031,833
WTP					0
Total	0	21,860,847	0	170,986	22,031,833
		21,860,847		170,986	

Table 4.2.4 Cost Estimation (Alternative 2)

Alternative 2							(1/2)
1. WTP (anaerobic treatment method)							
This cost other than Hong Pasak pre F/S area and Pakpasak domitory, is estimated by using the following unit cost (including WTPs, interceptors and control boxes) in pre F/S area.							
2,040 US\$/m ³ , dairy max= 1,280,885 US\$/ 628 m ³ /day							
	Total pop. (1)	Pop. Treated by WTP (2)	Percentage (2)/(1)	Wastewater Total (m ³)	(daily avg.) WTP area	(daily max.) WTP area	Total cost
Hong Xeng Basin							
Hong Pasak							
-Pre F/S area 1)	4,254	1,531	40.0%	868	310	413	896,840
-Pakpasak and others 2)		585			161	215	384,045
-Others	6,677	3,172	47.5%	1,362	647	863	1,760,520
Hong Kai Keo	16,499	8,250	50.0%	3,366	1,683	2,244	4,577,760
Hong Ke Basin							
Hong Khoua Khao	16,011	8,006	50.0%	3,266	1,633	2,177	4,441,080
Hong Ouay Louay	7,800	3,900	50.0%	1,591	796	1,061	2,164,440
Hong Phone Thanh	1,525	763	50.0%	311	156	208	424,320
Total	52,766	26,207		10,764	5,386	7,181	14,649,005
Note: 1),2) Cost calculated in pre F/S							
O&M cost (Sludge disposal) per year 1US\$= 8,000 kip							
Basin	Sludge volume (m ³ /day)	Sludge Vol. (m ³ /year)	Unit cost (Kip/m ³)	Cost (Kip)	Cost (US\$)		
Pasak U/S	0.069	25.2	125,000	3,150,000	394		
Pasak D/S	0.095	34.7	125,000	4,337,500	542		
Kai Keo	0.247	90.2	125,000	11,275,000	1,409		
Khoua Khao	0.316	115.3	125,000	14,412,500	1,802		
Ouay Louay	0.117	42.7	125,000	5,337,500	667		
Phone Thanh	0.016	5.8	125,000	725,000	91		
Total	0.860	313.9		39,237,500	4,905		

Alternative 2							(2/2)
2. Contact aeration plant							
Pumping station							
Construction cost							1US\$= 80.66 JPY
Basin	Wastewater (daily average)				Cost	Cost	
	(m ³ /d)×1	(m ³ /d)×2	(m ³ /s)×2	(m ³ /min)	(JPY)	(US\$)	
Nong Chang (Hong Thong)	2,110	4,220	0.05	2.9	8,495,000	105,319	
O&M cost (Electricity) per year							1US\$= 8,000 kip
Basin	Electricity (kW)	Operation hour (hr)	Electricity (kW)	Unit cost (Kip/kW)	Cost (Kip)	Cost (US\$)	
Nong Chang (Hong Thong)	5.4	24	47,304	800	37,843,200	4,730	
Treatment plant							
Construction cost							
Basin	Stream flow (m ³ /d)		Land req.	Cost (JPY)			
	(daily avg.)	(daily max.)	(m ²)	Civil	Aerator	Contact media	Total
Nong Chang (Hong Thong)	2,110	2,813	2,100	216,363,636	14,065,000	8,439,000	238,867,636
1US\$= 80.66 JPY							
Basin	Stream flow (m ³ /d)		Cost (US\$)				
	(daily avg.)	(daily max.)	Civil	Aerator	Contact media	Total	
Nong Chang (Hong Thong)	2,110	3,165	2,682,416	174,374	104,624	2,961,414	
O&M cost (Electricity) per year							1US\$= 8,000 kip
Basin	Electricity (kW)	Operation hour (hr)	Electricity (kW)	Unit cost (Kip/kW)	Cost (Kip)	Cost (US\$)	
Nong Chang (Hong Thong)	17.0	24	148,920	800	119,136,000	14,892	
O&M cost for 1 yr (Sludge disposal)							1US\$= 8,000 kip
Basin	Sludge volume (m ³ /day)	Sludge Vol. (m ³ /year)	Unit cost (Kip/m ³)	Cost (Kip)	Cost (US\$)		
Nong Chang (Hong Thong)	1.107	404.1	125,000	50,512,500	6,314		
Total cost of Alternative 2							
Basin	Construction		O&M		Total		
	WTP (US\$)	Contact aeration (US\$)	WTP (US\$)	Contact aeration (US\$)	(US\$)		
Contact aeration		3,066,733		25,936	3,092,669		
WTP	14,649,005		4,905		14,653,910		
Total	14,649,005	3,066,733	4,905	25,936	17,746,579		
	17,715,738		30,841				

Table 4.2.5 Basic Information (Pre F/S)

Basic Information						
Zone	Pop.	Wastewater			WTP Number	Remarks
	(person)	Pcpd (l/d)	comm. × 0.2	Daily. Max /0.75(l/d)		
M 1	92	170	205	270	T5	
M 2	152	170	205	270		
M 3	149	170	205	270	T7	
M 4	247	170	205	270	T6	
M 5	10	170	205	270	T8	
M 6	98	170	205	270	T11*	
M 7	212	170	205	270	T9, T10	
M 8	96	170	205	270	T11*	
U 1	45	170	205	270	T2	Including college
U 2	185	170	205	270		
U 3	63	170	205	270		
U 4	6	170	205	270	cannot collected	
U 5	125	170	205	270		
U 6	126	170	205	270	T4	
U 7	56	170	205	270		
Sub-total	1,662					
College	585	170	170	230	T1	
Total	2,247					

Table 4.2.6 Cost estimation (Pre F/S) (1/2)

Interceptor and Control box								
	Interceptor or <i>discharge pipe</i>							Remarks
	Length 1 (m)	Length 2 (m)	Length 3 (m)	Length 4 (m)	Total (m)	Unit cost (US\$/m)	Cost (m)	
T1	50	50			100	60	6,000	
T2	250	10			260	60	15,600	
T3	170	10	10	10	200	60	12,000	
T4	160	10	10		180	60	10,800	
T5	120	40	10	10	180	60	10,800	
T6	90	10			100	60	6,000	
T7	170	170	10		350	60	21,000	
T8	30	30			60	60	3,600	
Others					0	60	0	
Total	1,040	330	40	20	1,430		85,800	

	Control box							Remarks
	Number 1	Number 2	Number 3	Number 4	Total	Unit cost (US\$/No.)	Cost (m)	
T1	4	4	0	0	8	65	520	
T2	10	2	0	0	12	65	780	
T3	8	2	2	2	12	65	780	
T4	7	2	2	0	11	65	715	
T5	6	3	2	2	11	65	715	
T6	5	2	0	0	7	65	455	
T7	8	8	2	0	18	65	1,170	
T8	3	3	0	0	6	65	390	
Others	0	0	0	0	0	65	0	
Total	51	26	8	4	85		5,525	

Table 4.2.7 Cost estimation (Pre F/S) (2/2)

Size of compartments																
Wastewater			Width		Length (m)			Number		Depth		HRT (hr)		Remarks		
	Volume (m ³ /d)	Outer (m)	Inner (m)		Sedimentation tank	Anearobic reactor	Anearobic filter	Sedimentation tank	Anearobic reactor	Anearobic filter		Sedimentation tank	Anearobic reactor	Anearobic filter		
T1	135	2.5	2.1		2.00	0.90	1.50	9	40	12	1.8	12.1	24.2	12.1	48.4	
T2	79	2.5	2.1		1.60	0.90	1.40	7	24	8	1.8	12.9	24.8	12.9	50.6	
T3	49	2.5	2.1		1.40	0.90	1.40	5	15	5	1.8	13.0	25.0	13.0	51.0	
T4	66	2.5	2.1		1.60	0.90	1.40	6	20	7	1.8	13.2	24.7	13.5	51.4	
T5	67	2.5	2.1		1.60	0.90	1.40	6	20	7	1.8	13.0	24.4	13.3	50.7	
T6	43	2.5	2.1		1.50	0.90	1.30	4	13	5	1.8	12.7	24.7	13.7	51.1	
T7	26	2.5	2.1		1.30	0.90	1.30	3	8	3	1.8	13.6	25.1	13.6	52.3	
T8	83	2.5	2.1		1.60	0.90	1.50	8	25	8	1.8	14.0	24.6	13.1	51.7	
Others	80	2.5	2.1		1.60	0.90	1.40	7	24	8	1.8	12.7	24.5	12.7	49.9	
Total	628															

Concrete volume																
Top, bottom slab (m)			Side wall (m)		Partition wall (m)		Thickness (m)	Number		Volume (m ³)			Partition 1	Partition 2	Total	
Width	Length	Height	Length	Height	Width	Height		Top	Bottom	Side	Partition 1	Partition 2				Top
T1	2.5	85.6	85.6	2.3	2.1	2.3	0.2	2	2	64	12	85.6	78.8	61.8	16.2	242.4
T2	2.5	53.2	53.2	2.3	2.1	2.3	0.2	2	2	42	8	53.2	48.9	40.6	10.8	153.5
T3	2.5	33.9	33.9	2.3	2.1	2.3	0.2	2	2	28	6	33.9	31.2	27.0	8.1	100.2
T4	2.5	45.4	45.4	2.3	2.1	2.3	0.2	2	2	36	8	45.4	41.8	34.8	10.8	132.8
T5	2.5	45.4	45.4	2.3	2.1	2.3	0.2	2	2	36	8	45.4	41.8	34.8	10.8	132.8
T6	2.5	30.0	30.0	2.3	2.1	2.3	0.2	2	2	25	6	30.0	27.6	24.2	8.1	89.9
T7	2.5	19.2	19.2	2.3	2.1	2.3	0.2	2	2	17	5	19.2	17.7	16.4	6.8	60.1
T8	2.5	56.9	56.9	2.3	2.1	2.3	0.2	2	2	44	9	56.9	52.3	42.5	12.2	163.9
Others	2.5	53.2	53.2	2.3	2.1	2.3	0.2	2	2	42	8	53.2	48.9	40.6	10.8	153.5
Total		422.8	422.8					18	18	334	70	422.8	389.0	322.7	94.6	1,229.1

Cost (Treatment Plant)																
Concrete structure					Excavation			Leveling (gravel and plain concrete)			Backfill		Total cost		Remarks	
Wastewater (m³/d)	L. reqmnt (m³)	Concrete Volume (m³)	Unit cost (US\$) (*1)	Cost (US\$)	Volume (m³)	Unit cost (US\$)	Cost (US\$)	Cost (US\$)	Unit cost (tUS\$)	Volume (m³)	Unit cost (US\$)	Cost (US\$)	Cost (US\$)			
T1	135	230	242.4	600	145,440	1,541	10	15,410	250	34.5	8,625	514	15	7,710	177,185	
T2	79	140	153.5	600	92,100	958	10	9,580	250	21.0	5,250	319	15	3,485	111,715	
T3	49	90	100.2	600	60,120	610	10	6,100	250	13.5	3,375	203	15	3,045	72,640	
T4	66	120	132.8	600	79,680	817	10	8,170	250	18.0	4,500	272	15	4,080	96,430	
T5	67	120	132.8	600	79,680	817	10	8,170	250	18.0	4,500	272	15	4,080	96,430	
T6	43	80	89.9	600	53,940	540	10	5,400	250	12.0	3,000	180	15	2,700	65,040	
T7	26	60	60.1	600	36,060	346	10	3,460	250	9.0	2,250	115	15	1,725	43,495	
T8	83	150	163.9	600	98,340	1,024	10	10,240	250	22.5	5,625	341	15	5,115	119,320	
Others	80	140	153.5	600	92,100	958	10	9,580	250	21.0	5,250	319	15	4,785	111,715	
Total	628	1,130	1,229.1		737,460	7,611		76,110		169.5		42,375		38,025	893,970	

Note:
*1 Including temporary works.
*2 Leveling thickness 0.15 m

Table 4.2.8 Summary of Cost estimation (Pre F/S)

Summary of Construction Cost

	Treatment plant	Interceptor	Control box	Total	Remarks
Direct cost					
T1	177,185	6,000	520	183,705	
T2	111,715	15,600	780	128,095	
T3	72,640	12,000	780	85,420	
T4	96,430	10,800	715	107,945	
T5	96,430	10,800	715	107,945	
T6	65,040	6,000	455	71,495	
T7	43,495	21,000	1,170	65,665	
T8	119,320	3,600	390	123,310	
Others	111,715	0	0	111,715	
Total	893,970	85,800	5,525	985,295	
Indirect cost 30% of direct cost				295,590	
Grand total				1,280,885	

For Alternative 2

Total of T2-T8 (pop 1,662 person) direct	689,875
total including 30% indirect	896,840