

*JAPAN INTERNATIONAL COOPERATION AGENCY*  
*MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT,*  
*MINISTRY OF PLANNING AND INVESTMENT*  
*SOCIALIST REPUBLIC OF VIETNAM*

***THE STUDY***  
***ON***  
***GROUNDWATER DEVELOPMENT IN***  
***THE RURAL PROVINCES OF***  
***THE CENTRAL HIGHLANDS***

**FINAL REPORT**  
**VOLUME IV**  
**DATA BOOK**  
**Dac Lac Province**



**AUGUST 2002**

***NIPPON KOEI CO., LTD.***  
***NIKKO EXPLORATION & DEVELOPMENT CO., LTD***

## Composition of the Final Report

Volume I	:	SUMMARY
Volume II	:	MAIN REPORT
Volume III	:	SUPPORTING REPORT
Volume IV	:	DATA BOOK
Volume V	:	SUMMARY in Japanese

### Currency Exchange Rates Adopted for the Study

US\$ 1.00 = VND 15,000 = JPY 120

As of August 2002



Kon Tum Province : Study Area

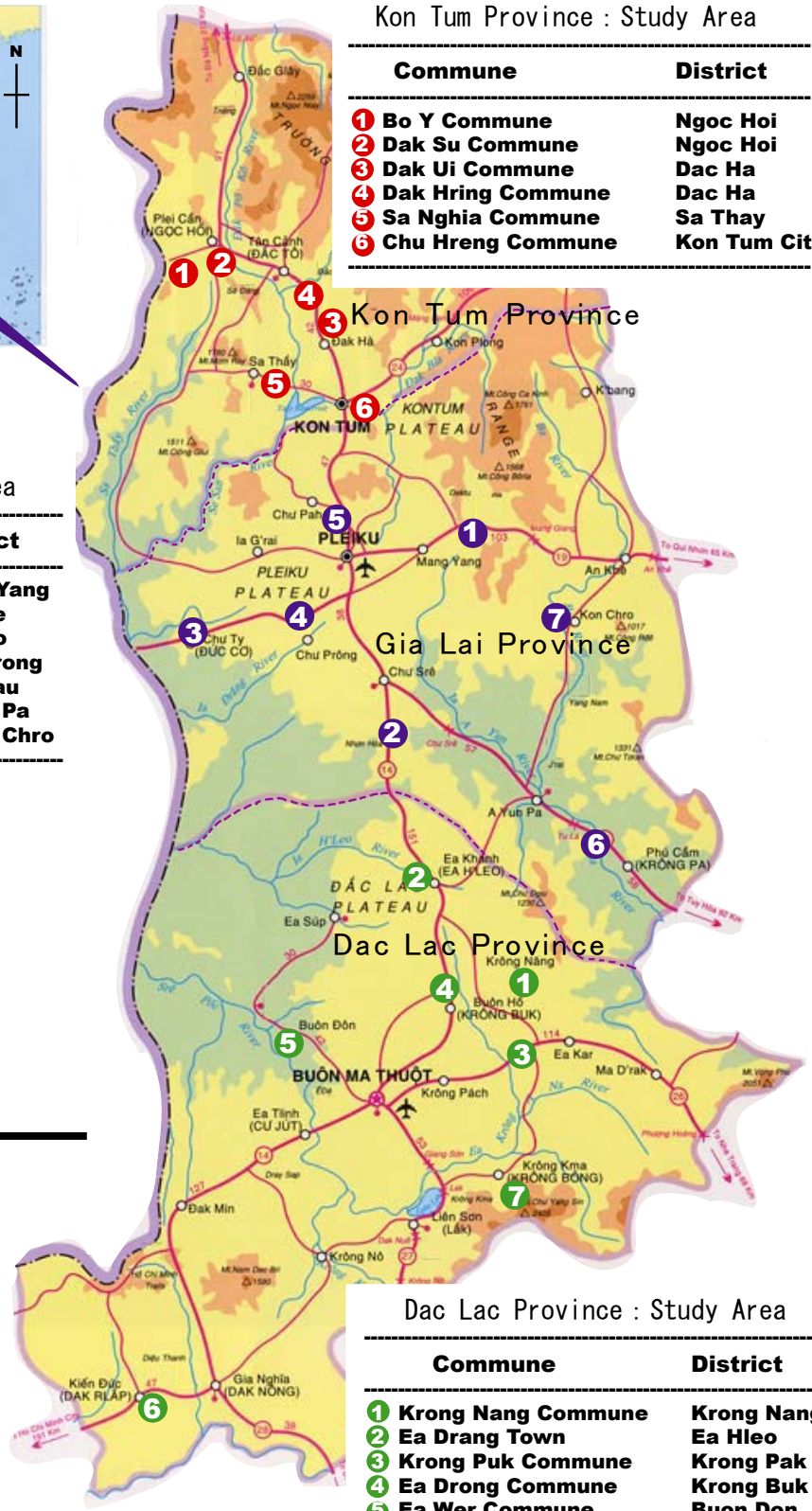
Commune	District
1 Bo Y Commune	Ngoc Hoi
2 Dak Su Commune	Ngoc Hoi
3 Dak Ui Commune	Dac Ha
4 Dak Hring Commune	Dac Ha
5 Sa Nghia Commune	Sa Thay
6 Chu Hreng Commune	Kon Tum City

Gia Lai Province : Study Area

Commune	District
1 Kong Tang Commune	Mang Yang
2 Nhon Hoa Commune	Chu Se
3 Chu Ty Town	Duc Co
4 Thang Hung Town	Chu Prong
5 Nghia Hoa Commune	Chu Pau
6 Ia Rsiom Commune	Krong Pa
7 Kong Yang Commune	Krong Chro



100km



Dac Lac Province : Study Area

Commune	District
1 Krong Nang Commune	Krong Nang
2 Ea Drang Town	Ea Hleo
3 Krong Puk Commune	Krong Pak
4 Ea Drong Commune	Krong Buk
5 Ea Wer Commune	Buon Don
6 Kien Duc Commune	Dac Rlap
7 Krong Kmar Town	Krong Bong

Location Map

**DATA BOOK    DAC LAC**

**TABLE OF CONTENTS**

- Chapter1    Social Survey**
- Chapter2    Data of Electro-magnetic Survey and Electrical Soundings**
- Chapter3    Well Inventory Data**
- Chapter4    Logging Graph**
- Chapter5    Pumping Test Data**
- Chapter6    Water Quality Test Data**
- Chapter7    Hydraulic Calculation Results**

	<u>Title</u>	<u>Page</u>
Figure D1. 1	Explanation of Symbols in the Maps of Social Survey	D1- 1
Figure D1. 2	Map of Social Survey Result in D1 Krong Nang Town	D1- 2
Figure D1. 3	Map of Social Survey Result in D2 Ea Drang Town	D1- 3
Figure D1. 4	Map of Social Survey Result in D3 Krong Buk Commune	D1- 4
Figure D1. 5	Map of Social Survey Result in D4 Ea Drong Commune	D1- 5
Figure D1. 6	Map of Social Survey Result in D5 Ea Wer Commune	D1- 6
Figure D1. 7	Map of Social Survey Result in D6 Kien Duc Town	D1- 7
Figure D1. 8	Map of Social Survey Result in D7 Krong Kmar Town	D1- 8
Table D2. 1	Quantity of Geophysical Prospecting Work	D2- 1
Figure D2. 1	Apparent resistivity sections	D2- 2
Figure D2. 2	Result of one-dimensional inversion	D2- 3
Figure D2. 3	Test Well and Geophysical Prospecting at Krong Nang Commune (D1)	D2- 4
Figure D2. 4	Resistivity sections in Krong Nang Commune	D2- 5
Figure D2. 5	Test Well and Geophysical Prospecting at Ea Drang Town (D2)	D2- 6
Figure D2. 6	Resistivity sections in Ea Drang Town	D2- 7
Figure D2. 7	Test Well and Geophysical Prospecting at Krong Buk Commune (D3)	D2- 8
Figure D2. 8	Resistivity sections in Krong Buk Commune	D2- 9
Figure D2. 9	Test Well and Geophysical Prospecting at Ea Drong Commune (D4)	D2- 10
Figure D2. 10	Resistivity sections in Ea Drong Commune	D2- 11
Figure D2. 11	Test Well and Geophysical Prospecting at Ea Wer Commune (D5)	D2- 12
Figure D2. 12	Resistivity sections in Ea Wer Commune	D2- 13
Figure D2. 13	Test Well and Geophysical Prospecting at Kien Duc Town (D6)	D2- 14
Figure D2. 14	Resistivity sections in Kien Duc Town	D2- 15
Figure D2. 15	Test Well and Geophysical Prospecting at Krong Kmar Town (D7)	D2- 16
Figure D2. 16(1)	Resistivity sections in Krong Kmar Town	D2- 17
Figure D2. 16(2)	Resistivity sections in Krong Kmar Town	D2- 18
Table D3. 1	Data Sheet : Existing Deep Well (more than 25m in Depth)	D3- 1
Table D3. 2	Data Sheet : Existing Deep Well (more than 25m in Depth)	D3- 2
Table D3. 3	Data Sheet : Hydrogeological Investigation Result of Krong Nang Town (D-1)	D3- 3
Table D3. 4	Data Sheet : Hydrogeological Investigation Result of Krong Nang Town (D-1)	D3- 4
Table D3. 5	Data Sheet : Hydrogeological Investigation Result of Ea Drang Town (D-2)	D3- 5
Table D3. 6	Data Sheet : Hydrogeological Investigation Result of Ea Drang Town (D-2)	D3- 6
Table D3. 7	Data Sheet : Hydrogeological Investigation Result of Krong Buk Commune (D-3)	D3- 7
Table D3. 8	Data Sheet : Hydrogeological Investigation Result of Krong Buk Commune (D-3)	D3- 8
Table D3. 9	Data Sheet : Hydrogeological Investigation Result of Krong Buk Commune (D-3)	D3- 9
Table D3. 10	Data Sheet : Hydrogeological Investigation Result of Ea Drong Commune (D-4)	D3- 10
Table D3. 11	Data Sheet : Hydrogeological Investigation Result of Ea Drong Commune (D-4)	D3- 11
Table D3. 12	Data Sheet : Hydrogeological Investigation Result of Ea Wer Commune (D-5)	D3- 12
Table D3. 13	Data Sheet : Hydrogeological Investigation Result of Ea Wer Commune (D-5)	D3- 13
Table D3. 14	Data Sheet : Hydrogeological Investigation Result of Ea Wer Commune (D-5)	D3- 14
Table D3. 15	Data Sheet : Hydrogeological Investigation Result of Kien Duc Town (D-6)	D3- 15
Table D3. 16	Data Sheet : Hydrogeological Investigation Result of Kien Duc Town (D-6)	D3- 16
Table D3. 17	Data Sheet : Hydrogeological Investigation Result of Krong Kmar Town (D-7)	D3- 17
Table D3. 18	Data Sheet : Hydrogeological Investigation Result of Krong Kmar Town (D-7)	D3- 18
Figure D4. 1	Geophysical Logging Test of D1, Krong Nang Town	D4- 1
Figure D4. 2	Geophysical Logging Test of D2, Ea Drang Town	D4- 2
Figure D4. 3	Geophysical Logging Test of D3, Krong Buk Commune	D4- 3
Figure D4. 4	Geophysical Logging Test of D4, Ea Drong Commune	D4- 4
Figure D4. 5	Geophysical Logging Test of D5, Ea Wer Commune	D4- 5

Figure D4.	6	Geophysical Logging Test of D6, Kien Duc Town	D4- 6
Figure D4.	7	Geophysical Logging Test of D7, Krong Kmar Town	D4- 7
Table D5.	1	Step-Drawdown Tests of JICA Test Wells	D5- 1
Table D5.	2	Result of the Constant Continuous Test and Recovery Test Analyzed by Theis Analysis Method	D5- 2
Table D5.	3	Result of the Constant Continuous Test and Recovery Test Analyzed by Cooper-Jacob and Recovery Analysis Methods	D5- 3
Figure D5.	1	Pumping Test of Borehole D-1 - Krong Nang Town - Krong Nang	D5- 4
Figure D5.	2	Pumping Test of Borehole D-2 - Ea Drang Town - Ea Hleo District	D5- 5
Figure D5.	3	Pumping Test of Borehole D-3 - Krong Buk Commune - Krong Pak	D5- 6
Figure D5.	4	Pumping Test of Borehole D-4 - Ea Drong Commune - Krong Buk	D5- 7
Figure D5.	5	Pumping Test of Borehole D-5 - Ea Wer Commune - Buon Don District	D5- 8
Figure D5.	6	Pumping Test of Borehole D-6 - Kien Duc Town - Dak Rlap District	D5- 9
Figure D5.	7	Pumping Test of Borehole D-7 - Krong Kmar Town - Krong Bong	D5- 10
Figure D5.	8	Step Drawdown Test at Borehole D-1	D5- 11
Figure D5.	9	Step Drawdown Test at Borehole D-2	D5- 12
Figure D5.	10	Step Drawdown Test at Borehole D-3	D5- 13
Figure D5.	11	Step Drawdown Test at Borehole D-4	D5- 14
Figure D5.	12	Step Drawdown Test at Borehole D-5	D5- 15
Figure D5.	13	Step Drawdown Test at Borehole D-7	D5- 16
Figure D5.	14	Constant Continuous Pumping Test Analyzed by Theis Analysis Method at D1, Krong Nang Town	D5- 17
Figure D5.	15	Constant Continuous Pumping Test Analyzed by Theis Analysis Method at D2, Ea Drang Town	D5- 18
Figure D5.	16	Constant Continuous Pumping Test Analyzed by Theis Analysis Method at D3, Krong Buk Commune	D5- 19
Figure D5.	17	Constant Continuous Pumping Test Analyzed by Theis Analysis Method at D4, Ea Drong Commune	D5- 20
Figure D5.	18	Constant Continuous Pumping Test Analyzed by Theis Analysis Method at D5, Ea Wer Commune	D5- 21
Figure D5.	19	Constant Continuous Pumping Test Analyzed by Theis Analysis Method at D7, Krong Kmar Town	D5- 22
Figure D5.	20	Calculation of Transmissivity and Storage Coefficient by Cooper-Jacob and Recovery methods at Borehole D-1	D5- 23
Figure D5.	21	Calculation of Transmissivity and Storage Coefficient by Cooper-Jacob and Recovery methods at Borehole D-2	D5- 24
Figure D5.	22	Calculation of Transmissivity and Storage Coefficient by Cooper-Jacob and Recovery methods at Borehole D-3	D5- 25
Figure D5.	23	Calculation of Transmissivity and Storage Coefficient by Cooper-Jacob and Recovery methods at Borehole D-4	D5- 26
Figure D5.	24	Calculation of Transmissivity and Storage Coefficient by Cooper-Jacob and Recovery methods at Borehole D-5	D5- 27
Figure D5.	25	Calculation of Transmissivity and Storage Coefficient by Cooper-Jacob and Recovery methods at Borehole D-6	D5- 28
Figure D5.	26	Calculation of Transmissivity and Storage Coefficient by Cooper-Jacob and Recovery methods at Borehole D-7	D5- 29
Figure D6.	1	Sampling Locations for Water Quality Analysis in Krong Nang Town	D6- 1
Table D6.	1	Data Sheet : Result of Water Quality Analysis	D6- 2
Figure D6.	2	Sampling Locations for Water Quality Analysis in Ea Drang Town	D6- 3
Table D6.	2	Data Sheet : Result of Water Quality Analysis	D6- 4
Figure D6.	3	Sampling Locations for Water Quality Analysis in Krong Buk Commune	D6- 5
Table D6.	3	Data Sheet : Result of Water Quality Analysis	D6- 6
Figure D6.	4	Sampling Locations for Water Quality Analysis in Ea Drong Commune	D6- 7
Table D6.	4	Data Sheet : Result of Water Quality Analysis	D6- 8
Figure D6.	5	Sampling Locations for Water Quality Analysis in Ea Wer Commune	D6- 9

Table D6. 5	Data Sheet : Result of Water Quality Analysis	D6- 10
Figure D6. 6	Sampling Locations for Water Quality Analysis in Kien Duc Town	D6- 11
Table D6. 6	Data Sheet : Result of Water Quality Analysis	D6- 12
Figure D6. 7	Sampling Locations for Water Quality Analysis in Krong Kmar Town	D6- 13
Table D6. 7	Data Sheet : Result of Water Quality Analysis	D6- 14
Table D6. 8	Data Sheet : Result of Simple Water Quality Analysis of Krong Nang Town (D-1)	D6- 15
Table D6. 9	Data Sheet : Result of Simple Water Quality Analysis of Ea Drang Town (D-2)	D6- 16
Table D6. 10	Data Sheet : Result of Simple Water Quality Analysis of Krong Buk Commune (D-3)	D6- 17
Table D6. 11	Data Sheet : Result of Simple Water Quality Analysis of Ea Drong Commune (D-4)	D6- 18
Table D6. 12	Data Sheet : Result of Simple Water Quality Analysis of Ea Wer Commune (D-5)	D6- 19
Table D6. 13	Data Sheet : Result of Simple Water Quality Analysis of Kien Duc Town (D-6)	D6- 20
Table D6. 14	Data Sheet : Result of Simple Water Quality Analysis of Krong Kmar Town (D-7)	D6- 21
Table D6. 15	KẾT QUẢ PHÂN TÍCH DIOXIN TRONG MÂU NƯỚC của trung tâm nước sạch và vệ sinh môi trường nông thôn (Results of Dioxin Analysis)	D6- 22
Table D6. 8	Dioxin Analysis	D6- 23
Table D6. 16	CÔNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM DỘC LẬP-TU DO- HANH PHÚC PHIÊU KIỂM NGHIỆM NƯỚC	D6- 24
Table D6. 17	CÔNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM DỘC LẬP-TU DO- HANH PHÚC PHIÊU KIỂM NGHIỆM NƯỚC	D6- 25
Table D6. 18	CÔNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM DỘC LẬP-TU DO- HANH PHÚC PHIÊU KIỂM NGHIỆM NƯỚC	D6- 26
Table D6. 19	CÔNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM DỘC LẬP-TU DO- HANH PHÚC PHIÊU KIỂM NGHIỆM NƯỚC	D6- 27
Table D6. 20	CÔNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM DỘC LẬP-TU DO- HANH PHÚC PHIÊU KIỂM NGHIỆM NƯỚC	D6- 28
Table D6. 21	CÔNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM DỘC LẬP-TU DO- HANH PHÚC PHIÊU KIỂM NGHIỆM NƯỚC	D6- 29
Table D6. 22	CÔNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM DỘC LẬP-TU DO- HANH PHÚC PHIÊU KIỂM NGHIỆM NƯỚC	D6- 30
Table D6. 23(1)	Microbiological Result (Total coliforms)	D6- 31
Table D6. 23(2)	Microbiological Result (Total coliforms)	D6- 32
Table D6. 24(1)	Result of Water Quality Analysis for Existing Water Resources	D6- 33
Table D6. 24(2)	Result of Water Quality Analysis for Existing Water Resources	D6- 34
Table D6. 25(1)	Result of Simple Water Quality Analysis for Existing Water Resources	D6- 35
Table D6. 25(2)	Result of Simple Water Quality Analysis for Existing Water Resources	D6- 36
Figure D6. 9	Stiff Diagram of Water Samples from Spring Water	D6- 37
Figure D6. 10	Stiff Diagram of Water Samples from Shallow Well (Dug Well)	D6- 38
Figure D6. 11	Stiff Diagram of Water Samples from Shallow Well (Dug Well)	D6- 39
Figure D6. 12	Stiff Diagram of Water Samples from Deep Well (Dug + Drilling Well)	D6- 40
Figure D6. 13(1)	Stiff Diagram of Water Samples from Deep Well (Drilling Well)	D6- 41
Figure D6. 13(2)	Stiff Diagram of Water Samples from Deep Well (Drilling Well)	D6- 42
Figure D6. 14(1)	Stiff Diagram of Water Samples from Deep Well (Drilling Well)	D6- 43
Figure D6. 14(2)	Stiff Diagram of Water Samples from Test Well	D6- 44

## Hydraulic Calculation

Title	Page
Figure D7-1 Layout of D1 system for Hydraulic Calculation	D7-1
Table D7-1 Dimension of Network system (1/2)	D7-2
Table D7-2 Dimension of Network system (2/2)	D7-3
Table D7-3 Results of Network Link (1/2)	D7-4
Table D7-4 Results of Network Link (2/2)	D7-5
Figure D7-2 Layout of D2 system for Hydraulic Calculation	D7-6
Table D7-5 Dimension of Network system (1/2)	D7-7
Table D7-6 Dimension of Network system (2/2)	D7-8
Table D7-7 Results of Network Link (1/2)	D7-9
Table D7-8 Results of Network Link (2/2)	D7-10
Figure D7-3 Layout of D3-1 system for Hydraulic Calculation	D7-11
Table D7-9 Dimension of Network system	D7-12
Table D7-10 Results of Network Link	D7-13
Figure D7-4 Layout of D3-2 system for Hydraulic Calculation	D7-14
Table D7-11 Dimension of Network system	D7-15
Table D7-12 Results of Network Link	D7-16
Figure D7-5 Layout of D4 system for Hydraulic Calculation	D7-17
Table D7-13 Dimension of Network system	D7-18
Table D7-14 Results of Network Link (1/2)	D7-19
Table D7-15 Results of Network Link (2/2)	D7-20
Figure D7-6 Layout of D4-2 system for Hydraulic Calculation	D7-21
Table D7-16 Dimension of Network system	D7-22
Table D7-17 Results of Network Link	D7-23
Figure D7-7 Layout of D5 system for Hydraulic Calculation	D7-24
Table D7-18 Dimension of Network system	D7-25
Table D7-19 Results of Network Link	D7-26
Figure D7-8 Layout of D6 system for Hydraulic Calculation	D7-27
Table D7-20 Dimension of Network system (1/2)	D7-28
Table D7-21 Dimension of Network system (2/2)	D7-29
Table D7-22 Results of Network Link (1/3)	D7-30
Table D7-23 Results of Network Link (2/3)	D7-31
Table D7-24 Results of Network Link (3/3)	D7-32



Figure D7-9	Layout of D7 system for Hydraulic Calculation	D7-33
Table D7-25	Dimension of Network system (1/2)	D7-34
Table D7-26	Dimension of Network system (2/2)	D7-35
Table D7-27	Results of Network Link (1/3)	D7-36
Table D7-28	Results of Network Link (2/3)	D7-37
Table D7-29	Results of Network Link (3/3)	D7-38

## **List of Abbreviations**

ADB	Asian Development Bank
As	Arsenic
ATP	Ability to Pay
AusAID	Australian Grant Aid
BARD	bank for Agriculture and Rural Development
B/D	Basic Design
CERWASS	Centre for Rural Water Supply and Sanitation
CHC	Community Health Centre
CIDA	Canadian International Development Assistance
CPC	Commune People's Committee
DANIDA	Danish International Development Assistance
DARD	Department of Agricultural Development
DF/R	Draft Final Report
DFID	UK, Department for International Development
DGMV	Department of Geology and Minerals of Vietnam
DHC or DHS	District Health (Services) Centre
DOF	Department of Finance
DOH	Department of Health
DOSTE	Department of Science, Technology and Environment
DPC	District People's Committee
DPI	Department of Planning and Investment
EIA	Environmental Impact Assessment
EM	Ethnic Minority
F	Fluorine
F/R	Final Report
F/S	Feasibility Study
FU	Farmer's Union
GAD	Gender and Development
GDP	Gross Domestic Product
GSO	General Statistical Office
HDPE	Hard PVC pipes
HRD	Human Resources Development
HC	House Connection
IEC	Information, Education and Communication

IC/R	Inception Report
IT/R	Interim Report
IEE	Initial Environmental Examination
JICA	Japan International Cooperation Agency
KI	Key Informant
kWh	kilo Watt(s) hours
lcd	litre per capita per day
LEP	Law on Environmental Protection
MARD	ministry of Agriculture and Rural Development
MCM	Million Cubic Meter
M/M	Minute of Meeting
MOC	Ministry of Construction
MOET	Ministry of Education and Training
MOF	Ministry of Finance
MOLISA	Ministry of Labour, Invalids and Social Affairs
M/P	Master Plan
NGO	Non-Governmental Organizations
NIPHEP	National Institute of Public health and Environmental Protection
NRWSS	National Rural Water Supply and Sanitation
VIWASE	Vietnam consultant for Water supply Sanitation and Environment
ODA	Official Development Assistance
O&M or O & M	Operation and Maintenance
PC	Portland Cement
PCERWASS	
PCM	Project Cycle Management
PDM	Project design Matrix
PDOSTE	Provincial Department of Science, Technology and Environment
PDPSC	Provincial Disease Prevention and Sanitation Centre
PHSC	Provincial Health Services Centre
PPC	Provincial People's Committee
P/R	Progress Report
PSCWS	Provincial Steering Committee for Water Supply and Sanitation
PE	Poly-Ethylene Pipe
pH or PH	Potential of Hydrogen
PT	Public Taps
PVC	Poly-Vinyl Chlorine Pipe

PWL	Pumping Water Level
QTT2	Quantification Theory Type II
RRA	Rapid Rural Appraisal
RWSS	Rural Water Supply and Sanitation
SPC	State Planning Committee
SRV	Socialist Republic of Vietnam
S/W	Scope of Work
SWL	Static Water Level
TEM	Transient Electromagnetic Method
TDEM	Time Domain Electromagnetic Method
THS	Town Health Services Centre
TPC	Town People's Committee
TV	Television media
UARD	Unit of Agriculture and Rural Development
UFW	
UNDP	United Nation Development Planning
UNICEF	United Children's Fund
USD	US Dollar
VHW	Village Health Worker
VIP	Ventilation type Improved Pit
VND	Vietnam Dong
VNYU or YU	(Vietnam) Youth Union
WB	World Bank
WATSAN	Water Supply and Sanitation
WHO	World Health Organization
WID	Women in Development
WTP	Willingness to Pay
WU or VWU	(Vietnamese) Women's Union

## Unit

bar	Pressure
h	Hour
pH	Potential of Hydrogen
$q_{\max}$	Maximum hourly demand
$Q_{\max}$	Maximum daily demand
$Q_{av}$	Average day demand
mg/l	milligram per litre
l	Litre
m	Medium
vh	Very high
l/c/d	Litre per capita per day
l/s	Litre per second
$m^3$	Cubic meter
$km^2$	Square kilometre
$\mu$	$1 \times 10^{-6}$
$\phi$	Diameter
$^{\circ}C$	Centi-degree
%	Percent
$\gamma$	Gamma (electrical logging)
k	Permeability coefficient
S	Storage capacity