TABLE OF CONTENTS

ુ ગરાશમંદ્ર	Page
ACKNOWLEDGEMENTS	iii
ABSTRACT IN THAI	iv
ABSTRACT IN ENGLISH	v
LIST OF TABLES	viii
LIST OF FIGURES	ix
CHAPTER 1 INTRODUCTION	1
1.1 Statement of the problems	1
1.2 Purposes and scopes	2
1.3 Methodology	2
1.4 Location of the study area	3
1.5 Literature review	3
1.5.1 VOCs contamination of the study area	3
1.5.2 Groundwater modeling of the study area	4
CHAPTER 2 PHYSICAL, GEOLOGIC, AND HYDROGEOLOGIC SETTING	6
2.1 Physical setting	6
2.2 Tectonic setting and basin geology	7
2.3 Geologic setting	11
2.4 Hydrogeology of the study area CHAPTER 3 SUBSURFACE GEOLOGIC SETTING	12 15
Copyrigh 3.1 Stratigraphic units 3.2 Resistivity survey Mai University	15 26
3.2.1 Resistivity data acquisition	29
3.2.2 Resistivity data processing	32
3.2.3 Resistivity data interpretation	35

vi

CHAPTER 4 HYDROGEOLOGIC CHARACTERISTIC AND	
HYDROSTRATIGRAPHIC MODEL	36
4.1 Hydrogeologic characteristic	36
4.1.1 Hydrostratigraphic unit	36
4.1.2 Hydraulic properties of aquifers	37
4.1.3 Groundwater levels and flow directions	42
4.1.4 Groundwater quality	47
4.1.5 Groundwater quality with respect to VOCs	51
4.2 Hydrostratigraphic model	54
CHAPTER 5 GROUND WAT ER FLOW MODEL	56
5.1 Theory of ground water flow	56
5.2 Method of flow modeling set up	57
5.3 Conceptual model	° 59
5.4 Model design and construction	60
5.4.1 Model grids and layers	60
5.4.2 Model parameters	61
5.4.3 Boundary conditions	64
5.5 Model calibrations	68
5.5.1 Steady-state simulations	70
5.5.2 Sensitivity analysis	75
CHAPTER 6 DISCUSSION AND CONCLUSION	77
REFERENCES	80
APPENDICES	83
APPENDIX A LITHOLOGIC LOG DATA	84
APPENDIX B RESISTIVITY SURVEY DATA	131
APPENDIX C GROUNDWATER LEVEL DATA	147
APPENDIX D DISTRIBUTION OF HYDRAULIC CONDUCTIVITY	/
A OF MODEL LAYERS I C S C I V	e ₁₅₀
VITAE	165

LIST OF TABLES

Table	1918194 m	Page
3.1	Location of lithologic log wells.	17
3.2	Resistivity of some common rocks and other materials.	28
3.3	Resistivity survey locations.	33
4.1	Detailed of pumping test.	40
4.2	Pumping test results.	42
4.3	The measured water level location of dug wells.	43
4.4	The measured water level location of drilled wells.	44
5.1	Recharge rate estimates for the steady-state model.	66
	AI UNIVERSIT	

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright[©] by Chiang Mai University All rights reserved

LIST OF FIGURES

Figure	a19191	Page
1.1 Study a	rea (modified from Royal Thai Survey Department, 1996).	5
2.1 The Ce	nozoic intermontane basins of Thailand	
(Wattar	nanikorn et al., 1995).	8
2.2 Geolog	ic map of Chiang Mai – Lamphun Basin (Rhodes et al., 2005).	10
2.3 Geolog	ic and structural map of the study area and its immediate	
vicinity	(modified from Department of Mineral Resources, 2004).	13
2.4 Hydrog	eologic map of the study area. (modified from Department of	
Minera	l Resources, 2004).	14
3.1 Locatio	on of lithologic log wells and subsurface geologic cross sections	s. 16
3.2 Subsurf	face geologic cross-section of line A-B.	18
3.3 Subsurf	face geologic cross-section of line C-D.	18
3.4 Subsurf	face geologic cross-section of line E-F.	19
3.5 Subsurf	face geologic cross-section of line G-H.	19
3.6 Subsurf	face geologic cross-section of line I-J.	20
3.7 Subsurf	face geologic cross-section of line K-L.	20
3.8 Subsurf	face geologic cross-section of line M-N.	21
3.9 The iso	pach map of clay thickness in the sequence I.	25
3.10 The ele	ctric field between two electrodes for resistivity surveys	_
(modifi	ed from Todd, 1980).	30
3.11 Electro	de array in common (modified from Todd, 2005).	30
	vity surveys locations.	31
3.13 Schlum	berger field survey electrode array (modified from Todd, 1980)). 32
3.14 Electric	cal resistivity field surveys.	A ³⁴
3.15 Resistiv	vity modeling example.	35
4.1 Hydros	tratigraphic units of the study.	37
4.2 Locatio	on of pumping test.	39

	4.3	Pumping test analysis using WTAQ (Barlow and Moench, 1999)	
		and UCODE (Poeter and Hill, 1998) programs.	41
	4.4	Slug test analysis using type-curve matching method.	41
	4.5	Flow net in two dimensional approximations	
		(from Hamill and Bell, 1986).	43
	4.6	Flow direction of the shallow aquifer.	45
	4.7	Flow direction of the shallow aquifer. Flow direction of the deep aquifer. Sampling locations of shallow and deep groundwaters	46
	4.8	Sampling locations of shallow and deep groundwaters	
		(modified from DGR, 2007).	48
	4.9	Hydrochemical facies classification of the dug wells samples at	
		first sampling, September 2007 (DGR, 2007).	49
	4.10	Hydrochemical facies classification of the dug wells samples at	
		second sampling, December 2007 (DGR, 2007).	49
	4.11	Hydrochemical facies classification of the drilled wells samples at	
		first sampling, September 2007 (DGR, 2007).	50
	4.12	Hydrochemical facies classification of the drilled wells samples at	
		second sampling, December 2007 (DGR, 2007).	50
	4.13	Locations of dug wells that were contaminated with VOCs.	52
	4.14	Locations of groundwater wells that were contaminated with VOCs.	53
	4.15	The construction of hydrostratigraphic model.	55
	5.1	The experiment of Darcy.	56
	5.2	Model setup algorithms.	58
	5.3	Pictorial conceptual model of the study area.	60
ลิข	5.4	The finite difference grids and model layers of the study area.	62
	5.5	Distribution of hydraulic conductivity of layer 10 in the	
Co	ovr	steady-state model for the example. g Mai Univers	63
	5.6	Schematic of General Head Boundary.	64
	5.7	The recharge zone of the study area.	66
	5.8	Recharge distribution of the steady-state model.	67
	5.9	River package for the steady-state model.	69
	5.10	Mathematical and graphical scatter diagram comparing simulated	
		heads and observed heads of the steady-state model.	72

5.11	Comparison of groundwater flow between simulated and observed	
	heads of shallow aquifer for the steady-state simulation.	73
5.12	Comparison of groundwater flow between simulated and observed	
	heads of deep aquifer for the steady-state simulation.	74
5.13	The normalized root mean square from the sensitivity analysis.	75
5.14	The sensitivity analysis between river parameter and GBH parameter.	76



ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright[©] by Chiang Mai University All rights reserved