

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	iv
บทกู้ดย่อ	v
ABSTRACT	vii
LIST OF TABLES	xi
LIST OF FIGURES	xii
CHAPTER 1 INTRODUCTION	1
1.1 Location of the study area	1
1.2 Objectives and scope	4
1.3 Methodology	4
1.4 Literature review	4
CHAPTER 2 HYDROGEOLOGICAL SETTING	12
2.1 Geology of area	12
2.2 Hydrogeology of area	13
2.2.1 Unconsolidated aquifers	13
2.2.2 Semi-consolidated aquifers	14
2.2.3 Consolidated aquifers	14
2.3 Hydrogeological cross section map	18
CHAPTER 3 DATA GATHERING AND DATA PREPARATION	21
3.1 Data Gathering	21
3.1.1 Hydrogeological data	21
3.1.2 Secondary data sources	22
3.1.3 Field investigation	29
3.2 Data Preparation	29
3.2.1 Depth to groundwater level	29
3.2.2 Net recharge	32
3.2.3 Aquifers type	32
3.2.4 Soil map and land use	33

3.2.5 Topography	33
3.2.6 Impact of vadose zone	33
3.2.7 Hydraulic conductivity	33
CHAPTER 4 DRASTIC METHOD	39
4.1 Principle	39
4.2 Geographic information system (GIS)	40
4.3 Data processing	40
4.4 Drastic vulnerability processing map	64
4.5 Comparison of DRASTIC and waste disposal site	70
CHAPTER 5 DATA UNCERTAINTY	72
5.1 Uncertainty from input data	72
5.2 Uncertainty analysis	73
5.2.1 Net recharge	73
5.2.2 Depth to groundwater level	76
5.2.3 Groundwater quality	80
CHAPTER 6 DATA INTERPRETATION AND CONCLUSION	84
6.1 Vulnerability map	90
6.2 Vulnerability map with Total Dissolved Solids from subsurface water	90
6.3 Vulnerability map with Total Dissolved Solids from groundwater	93
6.4 Conclusions and recommendations	96
6.4.1 Conclusions	96
6.4.2 Recommendations	97
REFERENCE	100
APPENDIX	102
Lithologic log data	103
VITA	136

LIST OF TABLES

Table		page
2.1	Summarized of hydrogeological units in Chiang Mai basin.	14
3.1	Groundwater database structure and wells of Chiang Mai basin.	21
3.2	Average rainfall of the year 1999-2002 in Chiang Mai basin.	22
3.3	Soil legends and soil occurrence.	24
4.1	Operator used in manipulated DRASTIC data.	41
4.2	Rated and weight of depth to groundwater level.	42
4.3	Rated and weight of net recharge.	45
4.4	Rated and weight of aquifers media.	48
4.5	Range and rating of soil media.	50
4.6	Range and rated of slope of terrain.	53
4.7	Example of drilled log of well in Chiang Mai basin.	56
4.8	Type and Rating of impact of vadose zone.	57
4.9	Pumping test analysis chart of well No. C0006	60
4.10	Range and rating of hydraulic conductivity.	60
4.11	Drastic index value of Chiang Mai basin.	65
4.12	Typical color assigned to vulnerability index map.	65
5.1	Groundwater quality (Total Dissolved Solids and Chloride in ppm).	80
6.1	Conductivity and pH measurement locations.	91

LIST OF FIGURES

Figure	Page
1.1 Map of Chiang Mai basin (Chiang Mai and Lumphun Province)	2
1.2 Topographic Map of Chiang Mai basin	3
1.3 Geologic map of Chiang Mai basin (modified from DMR, 2001).	5
1.4 Groundwater availability map of Chiang Mai basin (DGR, 2003).	7
1.5 Recommended waste disposal site map of Chiang Mai province.	9
2.1 Hydrogeological map of Chiang Mai basin (modified from aquifers map of DMR).	15
2.2 Provincial groundwater availability map	16
2.3 Hydrogeological cross section along line A-A'.	17
2.4 Hydrogeological cross section along line B-B'.	17
2.5 Line of cross sections of Chiang Mai basin	18
2.6 Hydrogeological cross section along line WE-1.	19
2.7 Hydrogeological cross section along line WE-2.	19
2.8 Hydrogeological cross section along line WE-5.	20
2.9 Hydrogeological cross section along line WE-6.	20
2.10 Legend used in cross sections.	20
3.1 Soil series map of Chiang Mai basin.	28
3.2 Wells location map of Chiang Mai basin.	30
3.3 Rain gauge stations and distribution of rainfall map.	32
3.4 Aquifers map of Chiang Mai basin.	35
3.5 Soil classification map of Chiang Mai basin.	36
3.6 Topographic map of Chiang Mai Basin.	37
3.7 Pumping wells location.	38
4.1 Depth to groundwater level map.	43
4.2 Rated depth to groundwater level map.	44
4.3 Map of rainfall intensity.	46
4.4 Rated annual rainfall map.	47
4.5 Rated aquifer map .	49

4.6	Soil type map.	51
4.7	Rated soil map.	52
4.8	Percent slope of topography.	54
4.9	Rated percent slope of topography.	55
4.10	Rated impact of vadose zone map.	58
4.11	Calculated hydraulic conductivity of well No. C0006	61
4.12	Hydraulic conductivity distribution map.	62
4.13	Rated hydraulic conductivity map.	63
4.14	Vulnerability index value map.	66
4.15	Re-classed vulnerability index map.	67
4.16	Re-classed vulnerability index map (in unconsolidated aquifers).	69
4.17	Vulnerability locations and waste disposal sites of Chiang Mai Province.	71
5.1	Net recharge of the wet period.	75
5.2	Net recharge of annual rainfall.	76
5.3	Rating of groundwater levels at drilled depth less than 100 meter.	78
5.4	Rating of groundwater levels at all drilled depths.	79
5.5	Distribution map of Total Dissolved Solids at drilled depth less than 100 meters.	82
5.6	Distribution maps of Total Dissolved Solids at all drilled depths.	83
6.1	Vulnerability index map of Chiang Mai basin.	86
6.2	Vulnerability index map of Chiang Mai basin (in unconsolidated aquifers).	87
6.3	Re-classed vulnerability index map of Chiang Mai basin.	88
6.4	Re-classed vulnerability index map of Chiang Mai basin (in unconsolidated aquifers).	89
6.5	Vulnerability index map and Total Dissolved Solids of dug well of Chiang Mai basin.	93
6.6	Vulnerability index map and Total Dissolved Solids of drilled well of Chiang Mai basin.	95