

## CONTENTS

		<b>Page</b>
<b>PREFACE</b>		iii
<b>ACKNOWLEDGEMENTS</b>		v
<b>DECLARATION</b>		vi
<b>ABSTRACT</b>		vii
<b>ABSTRAK</b>		viii
<b>CONTENTS</b>		ix
<b>LIST OF FIGURES</b>		xiv
<b>LIST OF TABLES</b>		xxi
<b>LIST OF PHOTOGRAPHS</b>		xxiii
<b>LIST OF SYMBOLS AND ABBREVIATIONS</b>		xxv
<b>CHAPTER I</b>	<b>INTRODUCTION</b>	
1.1	Description of the Study Area	1
	1.1.1 Geology	3
	1.1.2 Hydrology	5
	1.1.3 Groundwater status	8
1.2	Objectives	9
1.3	Scope of the Study	10
1.4	Importance of the Study	10
1.5	Modeling Approach	11

<b>CHAPTER II</b>	<b>LITERATURE REVIEW</b>	
2.1	Hydrologic Cycle	13
2.2	Watershed Hydrology	14
2.3	Water Resources Management Problems	17
	2.3.1 Water resources problems in Malaysia	18
2.4	Soil Hydraulic Parameters	23
2.5	Ramsar Convention on Wetlands	25
	2.5.1 Ramsar listed wetlands of Malaysia	26
2.6	Modelling	27
	2.6.1 Watershed models	30
<b>CHAPTER III</b>	<b>MODELLING TOOL</b>	
3.1	Hydrological Description	46
3.2	Hydrological Description	47
	3.2.1 Interception and evapotranspiration components	49
	3.2.2 Overland and channel flow component	53
	3.2.3 Unsaturated zone components	56
	3.2.4 Saturated zone components	58
<b>CHAPTER IV</b>	<b>MODEL INPUT DATA</b>	
4.1	Hydro-meteorological Data	63
	4.1.1 Rainfall	63
	3.1.3 Evapotranspiration	66
4.2	Landuse and Vegetation	67
4.3	Surface Topography	69
4.4	Overland Flow and River Network	72
	4.4.1 Overland flow	73
	4.4.2 Flooded area	74

	4.4.3	Cross sections and bathymetry data	75
4.5		Unsaturated Zone	77
	4.5.1	Types of soils	77
	4.5.2	Soil water	78
	4.5.3	Soil sampling and insitu measurements	81
	4.5.4	Soil characterization	84
	4.5.5	Presentation of soil tests results	89
4.6		Saturated Zone	91
	4.6.1	Geological model	91
	4.6.2	Aquifers characteristics	95
	4.6.3	Interactions between the surface and subsurface flow	96
	4.6.4	Groundwater abstraction	96
4.7		Surface water and Groundwater Timeseries Data	98
4.8		Model Set-up	98
	4.8.1	Boundary conditions	99
	4.8.2	Surface water flow system	103
4.9		Conceptual Model	105
4.10		Model Domain and Discretization	108
4.11		Model Development	110
	4.11.1	Simulation time step	111
	4.11.2	Model Calibration	112
	4.11.3	Model Validation	112
	4.11.4	Model Performance	112
<b>CHAPTER V</b>		<b>MODEL CALIBRATION AND VALIDATION</b>	
5.1		Calibration	117
	5.1.1	Calibration targets	118
	5.1.2	Primary calibration parameters	119
5.2		Calibration Results	120
	5.2.1	Simulation of surface water level	120
	5.2.2	Simulated groundwater heads	127

	5.2.3	Simulation of channel flow	132
5.3		Assessment of Calibrated Model	135
	5.3.1	Performance of the coupled model	136
	5.3.2	Assessment of model predictive capability	141
5.4		Validation	144
	5.4.1	Validated surface water flow	145
	5.4.2	Validated groundwater head	150
	5.4.3	Validation of channel flow	151
5.5		Assessment of the Validated Model Performance	155
	5.5.1	Performance of the coupled model	155
	5.5.2	Assessment of model predictive capability	157
5.6		Sensitivity Analysis	159
	5.6.1	Effect of increment of evapotranspiration rate	162
	5.6.2	Effect of depletion of the inflow	165
<b>CHAPTER VI</b>		<b>MODEL OUTPUTS</b>	
6.1		Water Balance	170
6.2		Saturated and Unsaturated Flow Interactions	176
	6.2.1	Overland flow	176
	6.2.2	Flow exchange between unsaturated and saturated zones	177
	6.2.3	Saturated zone and river lateral flow	180
6.3		Hydrological Impact of Groundwater Abstraction	181
<b>CHAPTER VII</b>		<b>SCENARIOS</b>	
7.1		Cyberjaya Development Flagship Zone: Phase II	186
7.2		Cyberjaya Full Development and the E-village	188
7.3		Replacement of Peat Layer	191
7.4		Groundwater over- abstraction	194

<b>CHAPTER VIII</b>	<b>SUMMARY AND CONCLUSIONS</b>	
8.1	Summary	196
8.2	Conclusions	197
<b>CHAPTER IX</b>	<b>RECOMMENDATIONS</b>	
9.1	challenging Issues	201
9.2	Recommendations	202
<b>REFERENCES</b>		204
<b>APPENDICES</b>		
A	Criteria for the Designation of Wetlands of International Importance	220
B	Ramsar-nominated Wetlands of Malaysia	221
C	Polynomial Approximation of IDF Curves	226
D	Monthly Rainfall at the Paya Indah Wetland Catchment	232
E	Monthly Evapotranspiration at the Paya Indah Wetland Catchment	233
F	River-cross Section Data	234
G	Malaysian Soil Series	237
H	Soil Profile Definition and Soil Parameters used in the Model	238
I	Engineering Borehole Log for PI 1	241
J	Pumping Test Data	244
K	Album	254