HYDROGEOLOGICAL AND GEOMORPHOLOGICAL STUDIES ON THE ABU DHABI - DUBAI - AL AIN TRIANGLE, UNITED ARAB EMIRATES

A thesis submitted

By

Fathy
Hassan Kamel F. Garamoon
B. Sc. in Geology, Ain Shams University, 1979
Diploma in Hydrogeology, ITC-Enschede, The Netherlands, 1986
M. Sc. in Hydrogeology, Ain Shams University, Egypt, 1987
M. Sc. in Hydrogeology, ITC-Enschede, The Netherlands, 1990

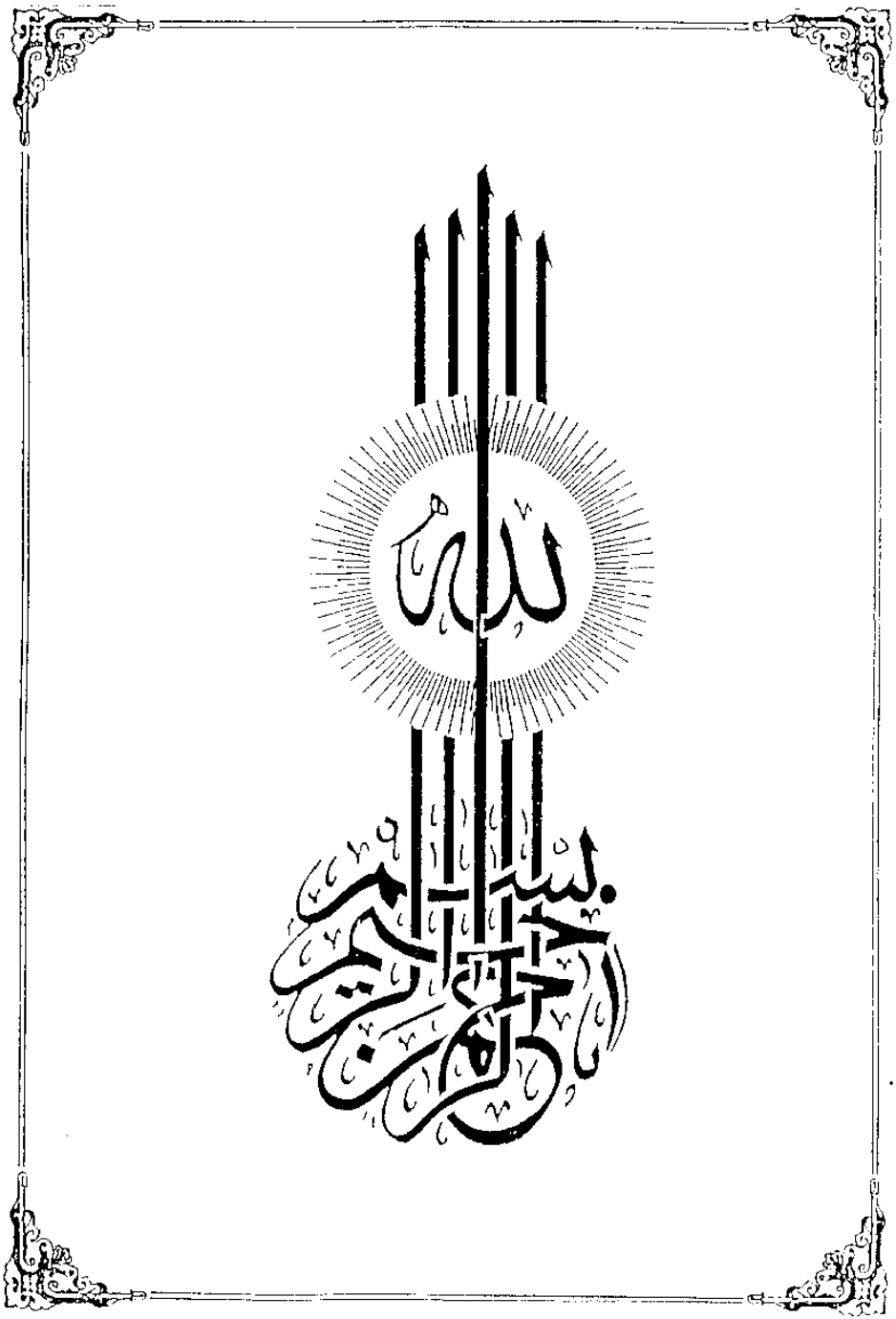
To

Geol. Dept., Fac. of Sci., Ain Shams Univ.

For

The Degree of Ph. D.
(HYDROGEOLOGY)

1996



HYDROGEOLOGICAL AND GEOMORPHOLOGICAL STUDIES ON THE ABU DHABI - DUBAI - AL AIN TRIANGLE, UNITED ARAB EMIRATES

A thesis submitted

By

Hassan Kamel F. Garamoon
B. Sc. in Geology, Ain Shams University, 1979
Diploma in Hydrogeology, ITC-Enschede, The Netherlands, 1986
M. Sc. in Hydrogeology, Ain Shams University, Egypt, 1987
M. Sc. in Hydrogeology, ITC-Enschede, The Netherlands, 1990

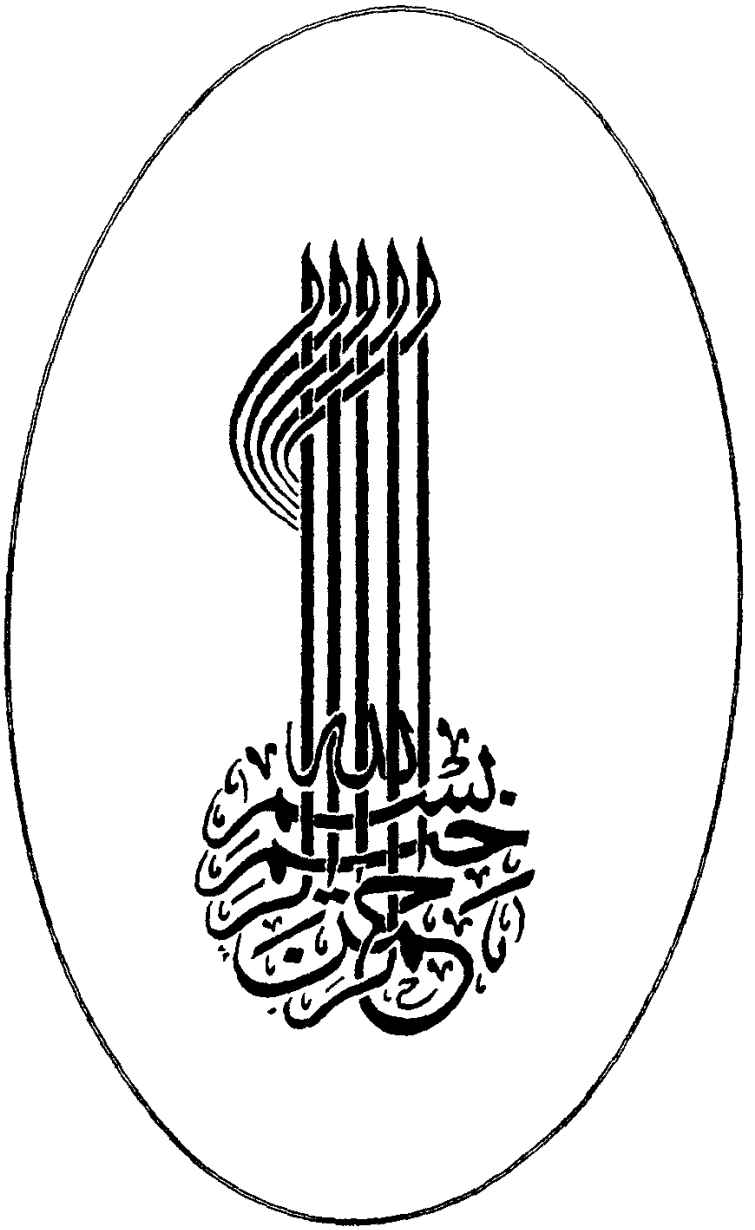
To

Geol. Dept., Fac. of Sci., Ain Shams Univ.

For

The Degree of Ph. D.
(HYDROGEOLOGY)

1996



HYDROGEOLOGICAL AND GEOMORPHOLOGICAL STUDIES ON THE ABU DHABI - DUBAI - AL AIN TRIANGLE, UNITED ARAB EMIRATES

By

Hassan Kamel F. Garamoon

Thesis Advisors

Prof. Dr. M.Ezz El-Din Hilmy
Prof. of Mineralogy and Petrology
Geology Department, Faculty of Science,
Ain Shams University, Egypt

Prof. Dr. M. Fathi El-Kiki
Professor of Hydrogeology,
Geology Department, Faculty of Science,
Cairo University, Egypt

Prof. Dr. Hassan A. El-Etr
Professor of Applied Geology,
Geology Department, Faculty of Science,
U. A. E. University, U. A. E.

Dr. Zeinelabidin S. A. Rizk
Lecturer of Hydrogeology,
Geology Department, Faculty of Science,
U. A. E. University, U. A. E.

Approved by:

Prof. Dr. W. Abdelmalik
Head of Geology Department

ACKNOWLEDGMENTS

I would like to express my gratitude to Prof. Dr. M. Ezz El-Din Hilmy, Ain Shams University for his supervision, his support, and valuable advice during this study, to Prof. Dr. M. Fathi El-Kiki, Cairo University for his supervision and critical reading of the final manuscript, and to Prof. Dr. Hassan A. El-Etr, U. A. E. University for his supervision, useful comments, and critical reading of the manuscript.

I would like also to extend my deep thanks and appreciation to Dr. Zeinelabidin S. Rizk, U. A. E. University for direct supervision, fruitful discussions, valuable advice during the whole study, and critical reading and help in writing of the manuscript.

Special thanks are due the Faculty of Science, U. A. E. University, especially Prof. Dr. Abdul Rahman S. Alsharhan, Dean of the Faculty of Science, and Prof. Dr. Ahmed El-Kammar, Head of the Geology Department, for allowing use of technical facilities.

I greatly appreciate the help and support of the staff members of the Geology Department, Faculty of Science, Ain Shams University, especially Prof. Dr. W. Abdelmalik, Head of the Department and Prof. Dr. M. A. Bassuoni.

Thanks are due Eng. Ayman H. Nasr, Remote Sensing Laboratory, Geology Department, U. A. E. University for his cooperation during the remote sensing work. Thanks also are due Eng. Tarek Mohammed, Computer Research Laboratory for his sincere help.

I am also grateful to staff of the National Drilling Company, Al-Ain, U. A. E., for their help. Thanks are also due those who directly or indirectly provided help during the progress of this work.

ABSTRACT

The extremely fast development in U. A. E. during the last few decades impose tremendous pressures on natural resources. As one of these, ground water suffered from excessive pumping, depletion and quality problems.

The main objective of this thesis is to study the hydrogeological and geomorphological conditions affecting ground water in the Abu Dhabi - Al-Ain - Dubai triangle, with special emphasis on the Al-Ain area. The specific objectives are to (1) investigate the possibility of ground-water recharge (2) determine the hydraulic properties of sand dunes and interdune areas from the grain-size analysis and measurements of infiltration-rate (I_r) and hydraulic conductivity (K), (3) apply rainfall data, (I_r) and morphometry to estimate and predict surface-runoff events of the major drainage basins dissecting the northern Oman mountains and Jabal Hafit, (4) use of remote-sensing and technique for locating areas of shallow water table and determining the volume of natural evaporation from discharge areas, (5) analyze pumping-test data and calculate the hydraulic properties of the Al-Ain aquifers, (6) study the chemical characteristics of ground-water and evaluate its suitability for different uses.

To achieve these objectives the author has collected the climatic data of 11 meteorological stations, 17 undisturbed soil samples for hydraulic conductivity (K) measurement, 75 sediment samples for grain-size analysis and 105 ground-water samples for chemical analysis. He measured the (I_r) at 27 sites, covering an area of 10,000 km^2. Grain-size of sediment samples and chemical analysis of water samples were conducted by the student in the Geology Department, U. A. E. University. He used five Landsat scenes and ERDAS package for the remote-sensing study, the THCVFIT and SATEM computer programs for analyzing pumping-test data. He also wrote short QBASIC programs for calculating potential evapotranspiration (PET), water surpluses, sodium-adsorption ratio (SAR) and ground-water dissolved salts.

Results indicate that the rainfall which can contribute to ground-water recharge, > 140 mm, occurs during cycles of 4 to 5 years. The uniformity coefficients (C_u) of sediment samples are < 2 for sand dunes, 2-5 for interdune areas, and > 5 for gravel plains. The (C_u) of dunes and interdune areas decreases from east to west, with increasing sediment's effective porosity, infiltration rate (I_r) and hydraulic conductivity (K). Infiltration rate (I_r) of sand dunes increases from < 12.5 mm/min in the east to > 20 mm/min in the west, and the (I_r) of interdunes areas increases from < 1 mm/min in the east to > 5 mm/min in the west. The hydraulic conductivities (K) of sand dunes are 2 to 3 times those of interdune areas. The volumes of surface runoff on main wades range from 3 $x10^6$ m^3 (MCM) in the northeast to 0.25 MCM in the southwest, and the percentage of rainfall as runoff varies between 4.5 in the basins of northern Oman mountains and 3.5 in Jabal Hafit basins.

Based on field investigation and remote-sensing analysis, the interdune areas were classified according to their soil-moisture content (%) into four classes: C1 (standing water), C2 (> 50%), C3 (50-25%) and C4 (< 25%). The natural evaporation, calculated from the output of remote-sensing classification of standing water and near-surface ground water, is 6.35 x 10^6 m^3/yr. According to their(C_u) and (I_r), sand dunes were subdivided from east to west into three classes: C5, C6 and C7, with high (C_u) and low (I_r) in the east and low (C_u) and high (I_r) in the west.

The Quaternary gravels and sands represent the main aquifer in the study area. Its thickness minimum on the flanks of Jabal Hafit anticline and increases to the east and west, reaching > 300 m west of Jabal Hafit. The 1982 and 1995 hydraulic-head maps indicate that the ground water flows from the east and northeast towards the west and southwest. Topography and geological structures, however, can locally deflect the direction of ground-water flow. Excessive ground-water pumping has lowered the water table > 50 m in some areas, increased ground-water salinity and induced salt-water intrusion from the sabkha areas in the southwestern part of the study area. Pumping-test analysis indicates that the average transitivity (T_{av}) of the aeolian-sand aquifer west of the Al-Ain = 50 m^2/d and its average storativity ($S_{av.}$) = 0.01, the $T_{av.}$ of the alluvial-gravel aquifer east of Al-Ain area = 5000 m^2/d and its $S_{av.}$ = 0.0005 and the $T_{av.}$ of the fractured-limestone aquifer in the north = 485 m^2/d and its $S_{av.}$ = 7.0 x 10^{-7}.

The TDS contents of ground water in the Quaternary aquifer in the study area increases from < 1,000 mg/l in the east to >10,000 mg/l in the west. The sequence of cations dominance has the order: Mg^{2+}> Na^+> Ca^{2+}> K^+ in the east, Na^+> Mg^{2+}> Ca^{2+}> K^+ in the center and Na^+> Ca^{2+}> Mg^{2+}> K^+ in the west, whereas the sequence of anions dominance has the order: HCO_3^- > Cl^-> SO_4^{2-}> CO_3^{2-} in the east, SO_4^{2-}> Cl^-> HCO_3^-> CO_3^{2-} in the center and Cl^-> SO_4^{2-}> HCO_3^-> CO_3^{2-} in the west. The hypothetically ground-water dissolved salts in the study area are (a) $Mg(HCO_3)_2$, $Ca(HCO_3)_2$, $NaHCO_3$ and $CaCO_3$ in the east, (b) $MgSO_4$, $CaSO_4$ and Na_2SO_4 in the center and (c) $Ca(Cl)_2$ and NaCl salts in the west. The ground-water types are: (a) $Mg(HCO_3)_2$ in the east, $CaSO_4$ and $MgSO_4$ in the center and NaCl water in the west.

Iso-concentration maps of major ions and hydrochemical profiles reflect the presence of a buried alluvial channel which runs in a NE-SW direction across Al-Ain city and is responsible for the presence of relatively fresh ground-water within the city. According to the electrical conductivity (EC) and SAR values, ground water in the east, north and within the Al-Ain area is suitable for irrigation, whereas ground water west and southwest of the area is mainly saline and harmful for irrigating traditional crops.

Sulin, Ovitchinikov and Parson classifications indicate that the deeply percolating meteoric is the main source of ground water in the study area, with a minor contribution of old marine water.

CONTENTS

Page