

**WATER QUALITY IN THE HASOUNA
WELLFIELDS, WESTERN JAMAHIRYA
SYSTEM, GREAT MAN MADE RIVER
PROJECT (GMRP)**

**by
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**A Thesis Submitted for the Degree of
DOCTOR OF PHILOSOPHY**

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VOLUME ONE

THESIS



CERTIFICATE

March 2006

I, Naser Sahli, do declare that this project is my own work, and that to the best of my knowledge and belief, all the references and sources of information have been acknowledged.

Naser. IM. SAHLI

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I would like to dedicate this work to the soul of my Mother who died during the preparation of this work and also to my daughter Alla who has been suffering from a brain tumour for the past 5 years and I wish her a speedy recovery from this disease.

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Contents

CERTIFICATE.....	ii
ACKNOWLEDGEMENTS.....	iii
CONTENTS.....	iv
LIST OF FIGURES.....	ix
LIST OF TABLES.....	xv
ABSTRACT	xx
1.0 Introduction.	1
1.1 Background.....	1
1.1.1 Great Man Made River Project.....	2
1.1.2 Major Groundwater Basins in Libya.....	4
1.1.3 Aims and Objectives.....	6
1.4 Previous Studies.....	7
1.1.5 Hydrogeology and Hydrogeochemistry.....	8
1.1.6 Regional Hydrogeochemistry and Isotope Analysis.....	10
1.1.7 Groundwater Recharge and Climate Change.....	10
1.2 Research Techniques and Methodology.....	11
1.2.1 Hydrogeology and Hydrochemistry.....	11
1.2.2 Isotopes.....	14
1.3 Structure of the Thesis.....	15
2.0 Hasouna-Jeffara System.....	16
2.1 Location	17
2.2 Regional Geology of the Western Jamahiriya System (WJS).....	19
2.2.1 Introduction.....	19
2.2.2 Stratigraphy.....	20
2.3 Geology of the Hasouna area.....	21
2.3.1 Hasouna Formation (Cambro-Ordovician).....	24
2.3.2 Zimam Formation (Upper Cretaceous - Palaeocene).....	25
2.3.2.1 The Lower Tar Member (Maastrichtian).....	25
2.3.2.2 The Upper Tar Member (Maastrichtian - Lower Palaeocene).....	26
2.3.2.3 The Had Member (Upper Palaeocene).....	26
2.3.3 Wadi and Eolian Deposits (Quaternary).....	26
2.4 Regional Hydrogeology in Western Jamahiriya System (WJS)...	27
2.4.1 Introduction.....	27
2.4.2 Aquifer System in WSJ.....	28
2.4.3 Aquifer characterized in WJS.....	30
2.4.3.1 The Upper Cretaceous (UC) Aquifer.....	30
2.4.3.2 The Jurassic-Lower Cretaceous (JLC) Aquifer.....	30
2.4.3.3 The Triassic-Jurassic-Lower Cretaceous (TRJLC) Aquifer.....	30
2.4.3.4 The Triassic (TR) Aquifer.....	30
2.4.3.5 The Cambro-Ordovician to Tertiary (CO-TE) Aquifer.....	31
2.4.3.6 The Cambro-Ordovician-Devonian (COD) Aquifer.....	31
2.5 Aquifer Branchings.....	33
2.6 Aquifer Recharge.....	34
2.7 Discharge.....	35
2.8 Groundwater Heads.....	35
2.9 Results of Exploration Activities in the Hasouna Wellfields.....	37
2.9.1 Exploratory 2.9.1 Well 29A/94 (REG 29-A).....	37
2.9.2 Exploratory Well 2DA (EXP2).....	37

2.9.3	Exploratory Well 4DA (EXP4).....	38
2.9.4	Exploratory Well 3DA (EXP3).....	38
2.9.5	Summary of the Exploratory Wells.....	38
2.10	Hydrogeology of the Hasouna Wellfields area.....	39
2.10.1	The Cambro-Ordovician (COD) Aquifer (Hasouna).....	39
2.10.2	The Zimam Aquifer.....	41
2.11	Type of Aquifers in the Hasouna Wellfields.....	42
2.11.1	Confined Aquifers.....	42
2.11.2	Unconfined Aquifers.....	43
2.12	Aquifer Parameter in Hasouna Wellfields.....	44
2.12.1	Calculated Transmissivity and Hydraulic Conductivity (K).....	44
2.12.2	Aquifer Pumping Test Analysis in the Jabal Al Hasouna Area....	47
2.12.3	Aquifer Test Analysis.....	52
2.12.4	Water level fluctuating phenomena.....	56
2.12.5	Hydraulic Properties.....	60
2.12.5.1	Transmissivity (T).....	60
2.12.5.2	Specific Yield (S).....	60
2.12.5.3	Hydraulic Conductivity (K).....	61
2.12.5.4	Drainage Factor (B).....	61
2.12.5.5	Boulton Delay Index.....	61
2.12.5.5	Conclusion.....	62
3.0	Field Measurements.....	64
3.1	Introduction.....	64
3.2	Water Temperature Measurement.....	64
3.3	pH value Measurement.....	68
3.4	Dissolved Oxygen (D.O.).....	70
3.5	Dissolved Carbon Dioxide (CO ₂).....	72
3.6	Dissolved Hydrogen Sulphide (as S ²⁻).....	75
3.7	Ammonium.....	76
4.0	Physical and General Parameters.....	77
4.1	Total Dissolved Solids (TDS).....	77
4.2	Electrical conductivity (EC).....	82
4.3	Oxidation – Reduction Potential (ORP).....	84
4.4	Calculated Eh value.....	85
4.5	Total Hardness.....	87
4.6	Total Alkalinity.....	89
4.7	Analytical Ionic Balance.....	91
4.8	Minor Chemical Constituents and Trace Elements.....	93
4.9	Iron (Fe ²⁺).....	95
4.10	Orthophosphate (as P ⁻).....	97
4.11	Boron (as B ³⁺).....	99
4.12	Fluoride (F ²⁻).....	102
4.13	Copper (Cu ⁺²).....	104
4.14	Manganese (Mn ²⁺).....	105
4.15	Zinc (Zn ²⁺).....	107
4.16	Nickel (Ni).....	109
4.17	Lead (Pb ²⁺).....	111
4.18	Cadmium (Cd ²⁺).....	112
4.19	Chromium (Cr).....	112
4.20	Arsenic (As).....	113

4.21	Mercury (Hg).....	114
5.0	Major Cations and Anions.....	115
5.1	Introduction.....	115
5.2	Schoeller Diagram.....	118
5.3	Piper Diagram (Trilinear Diagram).....	119
5.4	Stiff Diagram.....	121
5.5	Calcium (Ca ⁺²).....	123
5.6	Magnesium (Mg ⁺²).....	125
5.7	Sodium (Na ⁺).....	127
5.8	Potassium (K ⁺).....	128
5.9	Bicarbonate (HCO ₃ ⁻).....	130
5.10	Carbonate (CO ₃ ⁻²).....	132
5.11	Chloride (Cl ⁻).....	134
5.12	Sulphate (SO ₄ ²⁻).....	136
5.13	Nitrate (NO ₃ ⁻).....	138
5.14	Silica (SiO ₂).....	140
5.15	Analysis and Identification of Crystalline Phases within the Core Samples from Hasouna Wellfields.....	142
5.15.1	Introduction.....	142
5.15.2	Methodology.....	143
5.15.3	Result and Discussion.....	144
6.0	Hydrochemical Processes and Data Analysis.....	145
6.1	Introduction.....	145
6.2	Dissolution – precipitation.....	146
6.2.1	Saturation Index of Anhydrite.....	150
6.2.2	Saturation Index of Aragonite.....	151
6.2.3	Saturation Index of Calcite.....	153
6.2.4	Saturation Index of Dolomite.....	154
6.2.5	Saturation Index of Fluorite.....	156
6.2.6	Saturation Index of Gypsum.....	158
6.2.7	Saturation Index of Halite.....	160
6.2.8	Saturation Index of Magnesite.....	161
6.2.9	Saturation Index of Siderite.....	162
6.3	Ion Exchange and Mixing Processes.....	164
6.3.1	X-Y Plots.....	165
6.3.1.1	Chloride versus Sodium.....	165
6.3.1.2	Bicarbonate + Sulphate versus Calcium.....	166
6.3.1.3	Sodium versus Calcium.....	166
6.3.1.4	(Sodium – Chloride) versus (Calcium + Magnesium) – Bicarbonate - Sulphate	167
6.3.1.5	Calcium + Magnesium versus Bicarbonate.....	168
6.3.1.6	Sulphate versus Calcium.....	169
6.3.1.7	Sulphate versus Chloride.....	169
6.3.1.8	Chloride versus Bicarbonate.....	170
6.3.1.9	Sodium versus Calcium + Magnesium.....	170
6.3.1.10	Chloride versus Potassium.....	171
6.3.1.11	Total Dissolved Solids versus Magnesium to Calcium Ratio.....	171
6.3.1.12	Total Dissolved Solids versus Sodium to Chloride Ratio.....	172
6.3.1.13	Total Dissolved Solids versus Magnesium to Chloride Ratio.....	172
6.3.1.14	Total Dissolved Solids versus Sodium to Calcium Ratio.....	173

6.3.1.15	Total Dissolved Solids versus Calcium to Chloride Ratio.....	173
6.3.2	Stability Diagrams.....	174
6.3.3	Composition Diagrams.....	181
6.3.3.1	Cations versus TDI.....	181
6.3.3.2	Anions versus TDI.....	183
6.3.4	Expanded Durov Diagram.....	185
6.3.5	Anion and Cation Facies Classification Diagram.....	187
6.3.6	Pie diagrams.....	189
6.3.7	Eh – pH diagrams.....	194
6.4	Conclusion.....	197
7.0	Chemical Indicators of Corrosion and Water Aggressivity (Saturation Indices and Corrosion Indices).....	199
7.1	General.....	199
7.2	Langelier Saturation Index (LI).....	202
7.3	Ryznar Stability Index (RI).....	206
7.4	Calcium Carbonate Precipitation Potential (CCPP).....	209
7.5	Corrosivity Index (CI).....	212
7.6	Chloride Corrosion Index (CCI).....	216
7.7	Driving Force Index (DFI).....	219
7.8	Field study of corrosion in the Hasouna Wellfields.....	221
7.8.1	Metal Coupon Specifications	223
7.8.2	Coupon Treatment.....	226
7.8.3	Corrosion Behaviour.....	227
7.8.3.1	Carbon Steel.....	230
7.8.3.2	Zinc Galvanized Steel.....	233
7.8.3.3	Stainless Steel Type 304L.....	234
7.8.3.4	Stainless Steel Type 316L.....	239
7.8.3.5	Aluminium Bronze.....	240
7.8.3.6	Monel 400.....	241
7.8.3.7	Monel K500.....	242
7.9	Conclusions.....	243
7.9.1	Summary of Saturation Indices and Corrosion Indices.....	243
7.9.1.1	Saturation Indices with respect to CaCO ₃	243
7.9.1.2	Corrosion Indices.....	244
7.9.2	Summary of the Field study of corrosion.....	244
7.9.2.1	Corrosion Effects in Well 29.....	245
7.9.2.2	Corrosion Effects in Well 25.....	245
7.10	Summary Corrosion Potential of Hasouna Groundwater.....	245
8.0	Water Quality for Applications.....	247
8.1	General.....	247
8.2	Water Quality for Potable Use.....	248
8.2.1	Nitrate and Human Health.....	249
8.2.2	Nitrate and livestock.....	250
8.2.3	Nitrate Occurrence and Wellfield Operations.....	251
8.2.3.1	Controlling Nitrate in the Hasouna Wellfields.....	254
8.2.3.2	Removal of Nitrate by Treatment.....	254
8.2.4	Carbon Dioxide Concentration and Pipeline Corrosion.....	256
8.3	Water Quality for Irrigation.....	257

8.3.1	Alkali Hazard.....	258
8.3.2	Soluble Sodium Percentage (SSP).....	259
8.3.3	Sodium Hazard (SAR).....	260
8.3.4	Magnesium Hazard (MH).....	264
8.3.5	Conclusion	265
9.0	Isotopic Analysis of Hasouna Wellfields Water.....	266
9.1	Stable and Radiocarbon Isotopes in Hasouna Wellfields Water...	267
9.1.1	Stable Oxygen and Hydrogen Isotopes.....	267
9.1.2	Radiocarbon Isotope ¹⁴ C.....	269
9.2	Interpretation of Isotopic Analyses of Hasouna Wellfields Water	272
9.3	Isotopes Studies in the WJS, Eastern Libya and Neighbouring Regions.....	275
9.4	Nitrogen -15 Isotope Analysis for the Hasouna Wellfields Water	278
9.4.1	Nitrate and ¹⁵ N Isotope Methods.....	278
9.4.2	Nitrification and Denitrification Processes.....	280
9.4.3	Method of Study.....	282
9.4.4	Sample Preparation for Nitrogen Isotopic Analysis.....	282
9.4.5	Nitrogen-15-Analysis.....	282
9.4.6	Results Notation.....	283
9.4.7	Reference Standards.....	284
9.5	Result of nitrogen-15 for the Hasouna Wellfields.....	284
9.6	Interpretation of $\delta^{15}\text{N}$ Results.....	287
9.7	$\delta^{18}\text{O}$ analysis of nitrate in water.....	291
9.7.1	Oxygen -18 Isotope Analysis.....	291
9.8	Interpretation of oxygen-18 analysis.....	293
9.9	Future Nitrate Concentrations.....	296
10.0	Conclusion and Recommendation.....	297
10.1	Conclusion.....	297
10.2	Recommendation.....	311
11.0	References.....	317

APPENDICES

Chapter (2)		
A	Hydrogeological Data for All Hasouna Wellfields Area.....	1
B	Calculated Hydraulic Conductivity, Transmissivity, Measured SWL and Measured DWL.....	21
C	Pumping test data.....	45
Chapter (3)		
D	Results of the Chemical Analyses Field Measurements.....	68
Chapter (4)		
E	Results of the Chemical Analyses Physical and General Parameters.....	84
F	Analytical ionic Balance.....	100
G	Average Values of Minor Chemical Constituents.....	116
Chapter (5)		
H	Comparison of the Analytical Results (Cations mg/l) from GMRA and Phosyn Laboratories, Hasouna water.....	141
I	Average Major Cations and Anions, All Hasouna	

	Wellfields.....	161
J	Data and Analysis Results for the Identification of Crystalline Phases within the Core Samples from Hasouna Wellfields.	186
	Chapter (6)	
K	Saturation indices of Minerals using MINTEQA2, All Hasouna Wellfields water.....	204
L	Calculated Values of log activities of Silica and Potassium, Calcium Magnesium and Sodium over Hydrogen, Hasouna Wellfields Water.....	229
	Chapter (7)	
M	Chemical Indicators of Corrosion and Water Aggressivity (Saturation Indices and Corrosion Indices) All Hasouna Wellfields water.....	245
	Chapter (8)	
N	The Alkali Hazard Calculated using the Residual Sodium Carbonate, RSC, All Hasouna Wellfields water.....	291
O	The Calculated Soluble Sodium Percentage (SSP) All Hasouna Wellfields water.....	289
P	The Calculated The Magnesium Hazard (MH%) All Hasouna Wellfields water.....	307

List of Figures

CHAPTER 1:Introduction

Figure 1.1	Main Groundwater Basins in Libya.....	2
Figure 1.2	Layout of the Great Man-Made River Project.....	4
Figure 1.3	Main Groundwater Basins in Libya.....	6
Figure 1.3	Aquifer in the Northwest Sahara Aquifer System (NWSAS).....	9
	CHAPTER 2: Hasouna-Jeffara System	
Figure 2.1	Layout of All Hasouna Wellfields.....	16
Figure 2.2	Location Map of the Hasouna Wellfields (Study Area).....	17
Figure 2.3	Detailed Layout of the Hasouna Wellfields System.....	18
Figure 2.4	Tectonic map of Libya.....	19
Figure 2.5	Geological Map of Hasouna Wellfields Area.....	22
Figure 2.6	Outline of Western Jamahiriya System (WJS) and Regional Groundwater.....	26
Figure 2.7	Schematic cross-section (NE-SW (H-H') of Western Jamahiriya Aquifer System.....	28
Figure 2.8	Aquifer branching in Western Jamahiriya Aquifer System.....	29
Figure 2.9	Schematic cross-section (NE-SW (H-H') of WJS.....	31
Figure 2.10	Schematic cross-section (NE-SW(G-G') of WJS.....	32
Figure 2.11	Schematic cross-section (E-E') and (D-D') of WJS.....	32
Figure 2.12	Hydraulic head of the Cambro Ordovician aquifer in the CO aquifer in The Hasouna Wellfields.....	36
Figure 2.13	Contour map of Hasouna Formation Thickness.....	40
Figure 2.14	Contour map of Zimam Formation Thickness.....	41
Figure 2.15	Aquifer Types in the Hasouna Wellfields Area.....	43
Figure 2.16	Distribution of Transmissivity values m^2/day , Hasouna Wellfields Area.....	47
Figure 2.17	Typical Well Design, Hasouna Wellfields.....	48
Figure 2.18	Log-Log solution of time-drawdown (Observation Wells.....	53
Figure 2.19	Straight-line solution of time-drawdown (Pumping Wells).....	54

Figure 2.20	Straight-line solution of time-drawdown data.....	55
Figure 2.21	Response of water level to atmospheric pressure changes.....	59
CHAPTER 3: Field Measurements		
Figure 3.1	Variation in Water Temperature, Hasouna Wellfields.....	67
Figure 3.2	Variation in pH value, Hasouna Wellfields.....	69
Figure 3.3	Variation in Dissolved Oxygen, Hasouna Wellfields.....	71
Figure 3.4	Variation in CO ₂ mg/l, Hasouna Wellfields.....	73
Figure 3.5	The activity of CO ₂ species in Water.....	74
CHAPTER 4: Physical and General Parameters and Minor Chemical Constituents and Trace Elements.		
Figure 4.1	Variation in TDS mg/l, Hasouna Wellfields Area.....	80
Figure 4.2	Water Quality (TDS) and Groundwater Flow, Hasouna Wellfields and Wadi Ash Shati Areas	81
Figure 4.3	Variation in Electrical Conductivity (EC), Hasouna Wellfields...	83
Figure 4.4	Variations in ORP, Hasouna Wellfields Area.....	85
Figure 4.5	Variations in Eh, Hasouna Wellfields Area.....	87
Figure 4.6	Variations in Total Hardness (CaCO ₃) mg/l, Hasouna Wellfields Area.....	89
Figure 4.7	Variations in Total Alkalinity (CaCO ₃) mg/l, Hasouna Wellfields Area.....	90
Figures 4.8	Variation in Iron mg/l, Hasouna Wellfields Area.....	97
Figures 4.9	Variation in Orthophosphate mg/l, Hasouna Wellfields Area.....	99
Figures 4.10	Variation in Boron mg/l, Hasouna Wellfields Area.....	101
Figures 4.11	Variation in Fluoride mg/l, Hasouna Wellfields Area.....	103
Figures 4.12	Variation in Copper mg/l, Hasouna Wellfields Area.....	105
Figures 4.13	Variation in Manganese mg/l, Hasouna Wellfields Area.....	107
Figures 4.14	Variation in Zinc mg/l, Hasouna Wellfields Area.....	109
Figures 4.15	Variation in Nickel mg/l, Hasouna Wellfields Area.....	111
CHAPTER 5: Physical and General Parameters		
Figure 5.1	Schoeller Diagram of CO aquifer of the Hasouna Wellfields and Wadi Ash Shati).....	118
Figure 5.2	Piper Diagram of the (CO) aquifer of the Hasouna and Wadi Ash Shati.....	120
Figure 5.3	Stiff Diagram, Hasouna Wellfields).....	122
Figure 5.4	Stiff (pattern) Diagrams of variation of groundwater Chemistry, Hasouna Wellfields Area.....	123
Figure 5.5	Variation in Calcium mg/l, Hasouna Wellfields Area.....	124
Figure 5.6	Variation in Magnesium mg/l, Hasouna Wellfields Area.....	126
Figure 5.7	Variation in Sodium mg/l, Hasouna Wellfields Area.....	128
Figure 5.8	Variation in Potassium mg/l, Hasouna Wellfields Area.....	129
Figure 5.9	Variation in Bicarbonate mg/l, Hasouna Wellfields Area.....	131
Figure 5.10	Variation in Carbonate mg/l, Hasouna Wellfields Area.....	133
Figure 5.11	Variation in Chloride mg/l, Hasouna Wellfields Area.....	135
Figure 5.12	Regional Variation in Chloride mg/l, (CO) aquifer.....	136
Figure 5.13	Variation in Sulphate mg/l, Hasouna Wellfields Area.....	137
Figure 5.14	Variation in Nitrate mg/l, Hasouna Wellfields Area.....	139
Figure 5.15	Variation in Silca mg/l, Hasouna Wellfields Area.....	142
CHAPTER 6: Hydrochemical Processes and Data Analysis		
Figure 6.1	Variation in the SI of Anhydrite Versus a) Ca, b) SO ₄ and c) HCO ₃ , Hasouna Wellfields water.	151

Figure 6.2	Variation in the SI of Aragonite Versus a) HCO_3 , b) CO_3 and c) SO_4 , Hasouna Wellfields water.....	152
Figure 6.3	Variation in the SI of Calcite Versus a) HCO_3 , b) CO_3 and c) SO_4 , 326 Hasouna Wellfields water.....	154
Figure 6.4	Variation in the SI of Dolomite Versus a) HCO_3 , b) CO_3 and c) SO_4 , Hasouna Wellfields water.	155
Figure 6.5	Variations in the SI of Fluorite Versus a) Ca, b) HCO_3 and c) F, for Hasouna Wellfield water.....	157
Figure 6.6	Variation in the SI of Gypsum Versus a) HCO_3 , b) CO_3 , c) SO_4 and d) Ca, Hasouna Wellfields water.....	159
Figure 6.7	Variation in the SI of Halite Versus a) HCO_3 , b) CO_3 and c) SO_4 , Hasouna Wellfields water.....	161
Figure 6.8	Variation in the SI of Magnesite Versus a) Mg, b) HCO_3 and c) SO_4 , Hasouna Wellfields water.....	162
Figure 6.9	Variation in the SI of Siderite Versus a) Fe, b) CO_3 and c) HCO_3 , Hasouna Wellfields water.	164
Figure 6.10	Chloride versus sodium, concentration in meq/l.....	166
Figure 6.11	Bicarbonate + sulphate versus calcium, concentration in meq/l...	166
Figure 6.12	Sodium versus calcium concentration in meq/l.....	167
Figure 6.13	(Sodium – chloride) versus (calcium + magnesium) – bicarbonate – sulphate, concentration in meq/l.....	168
Figure 6.14	Calcium + magnesium versus bicarbonate, concentration in meq/l.....	168
Figure 6.15	Sulphate versus calcium, concentration in meq/l.....	169
Figure 6.16	Sulphate versus chloride, concentration in meq/l.....	169
Figure 6.17	Chloride versus Bicarbonate, concentration in meq/l.....	170
Figure 6.18	Sodium versus calcium + magnesium, concentration in meq/l.....	170
Figure 6.19	Chloride versus potassium, concentration in mg/l.....	171
Figure 6.20	TDS versus Mg/Ca, concentration in meq/l.....	171
Figure 6.21	TDS versus Na/Cl, concentration in meq/l.....	172
Figure 6.22	TDS versus Mg/Cl, concentration in meq/l.....	172
Figure 6.23	TDS versus Na/Ca, concentration in meq/l.....	173
Figure 6.24	TDS versus Ca/Cl, concentration in meq/l.....	174
Figure 6.25	Log $((\text{K}^+)/(\text{H}^+))$ versus log H_4SiO_4 diagram at 25°C and 1bar pressure, showing the Stability fields of Gibbsite, Kaolinite, K-mica, K-fieldspar, and Muscovite from Drever (1988), with all Hasouna Wellfields water have been plotted in the diagram.....	177
Figure 6. 26	Log $((\text{Ca}^{++})/(\text{H}^+))$ versus log H_4SiO_4 diagram at 25°C and 1 bar pressure, showing the Stability fields of Gibbsite, Kaolinite, Camontmorillonite and Ca-Feldspar from Drever (1988), with all Hasouna Wellfields water have been plotted in the diagram.....	178
Figure 6. 27	Log $((\text{Mg}^+)/(\text{H}^+))$ versus log H_4SiO_4 diagram at 25°C and 1bar pressure, showing the Stability fields of Gibbsite, Kaolinite, Mg-montmorillonite and Chlorite from Drever (1988), with all Hasouna Wellfields water have been plotted in the diagram.....	179
Figure 6. 28	Log $((\text{Na}^+)/(\text{H}^+))$ versus log H_4SiO_4 diagram at 25°C and 1bar pressure, showing the Stability fields of Gibbsite, Kaolinite, Namontmorillonite and Na-Fieldspar from Drever (1988), with all Hasouna Wellfields water have been plotted in the diagram.....	180

Figure 6.29	Total Dissolved Ions (TDI) versus Potassium meq/l, all Hasouna Wellfields water.....	181
Figure 6.30	Total Dissolved Ions (TDI) versus Magnesium meq/l, all Hasouna Wellfields water.....	182
Figure 6.31	Total Dissolved Ions (TDI) versus Calcium meq/l, all Hasouna Wellfields water.....	182
Figure 6.32	Total Dissolved Ions (TDI) versus Sodium meq/l, all Hasouna Wellfields water.....	183
Figure 6.33	Total Dissolved Ions (TDI) versus Bicarbonate meq/l, all Hasouna Wellfields water.....	183
Figure 6.34	Total Dissolved Ions (TDI) versus Sulphate meq/l, all Hasouna Wellfields water.....	184
Figure 6.35	Total Dissolved Ions (TDI) versus Chloride meq/l, all Hasouna Wellfields water.....	184
Figure 6.36	Hasouna Wellfields Water, plotted on Expanded Durov Diagram.....	186
Figure 6.37	WJS Groundwater, plotted on Expanded Durov Diagram.....	187
Figure 6.38	Hasouna Wellfields Water, plotted in Classification diagram, for anion and cation facies.....	188
Figure 6.39	Pie diagram showing percentage composition, (a) Maximum (b) Minimum, NEJH(S).....	189
Figure 6.40	Pie diagram showing percentage composition, (a) Maximum (b) Minimum, NEJH(N).....	190
Figure 6.41	Pie diagram showing percentage composition, (a) Maximum (b) Minimum, EJH(E).....	191
Figure 6.42	Pie diagram showing percentage composition, (a) Maximum (b) Minimum, EJH(W).....	192
Figure 6.43	Hasouna Wellfields Water, with Pie diagram distributed in the Wellfield area.....	193
Figure 6.44	Hasouna Wellfields Water, plotted in Eh-pH Stability Field for Sulphur Species (after Hem, 1985).....	195
Figure 6.45	Hasouna Wellfields Water, plotted in Eh-pH Stability Field for Manganese Species (after Hem, 1985).....	196
Figure 6.46	Hasouna Wellfields Water, plotted in Eh-pH Stability Field for Dissolved Iron Species (after Hem, 1985).....	197
Figure 6.47	Hasouna Wellfields Water, plotted in Eh-pH Stability Field for Equilibrium activity of dissolved Iron Species (after Hem, 1985).....	198
CHAPTER 7: Chemical Indicators of Corrosion and Water Aggressivity (Saturation Indices and Corrosion Indices)		
Figure 7.1	Cross section of Prestressed Concrete Cylinder Pipe, (GMRA, 2002).....	201
Figure 7.2	Langelier Index versus SI Calcite, Hasouna Wellfields water.....	204
Figure 7.3	Langelier Index versus SI Aragonite, Hasouna Wellfields water.....	204
Figure 7.4	Variation in Langelier Saturation Index (LI), Hasouna Wellfields water.....	205
Figure 7.5	Variation in Ryznar Saturation Index (RI), Hasouna Wellfields	208

	water.....	
Figure 7.6	Linear relations between indices of RI and LI Hasouna Wellfields water.....	209
Figure 7.7	Variation in Calcium Carbonate Precipitation Potential (CCPP), Hasouna Wellfields water.....	211
Figure 7.8	SI Calcite versus CCPP values, Hasouna Wellfields water.....	212
Figure 7.9	Total Alkalinity versus CCPP values, Hasouna Wellfields water.....	212
Figure 7.10	Variation in Corrosivity Index (CI), Hasouna Wellfields water.....	214
Figure 7.11	Variation in Corrosivity Index versus chloride, Hasouna Wellfields water.....	215
Figure 7.12	Variation in Corrosivity Index (CI) versus Sulphate, Hasouna Wellfields water.....	215
Figure 7.13	Variation in Corrosivity Index (CI) versus Total Alkalinity, Hasouna Wellfields water.....	215
Figure 7.14	Variation in Chloride Corrosion Index (CCI), Hasouna Wellfields water.....	217
Figure 7.15	Chloride Corrosion Index (CCI) versus Chloride, all Hasouna Wellfields water.....	218
Figure 7.16	Chloride Corrosion Index (CCI) versus Carbonate, all Hasouna Wellfields Water.....	218
Figure 7.17	Variation in Driving Force Index (DFI), Hasouna Wellfields water.....	220
Figure 7.18	Location Map of wells with corrosion coupons, Hasouna Wellfields.....	222
Figure 7.19	Layout of Corrosion Coupon Assembly for wells (25 and 29), Hasouna Wellfields. Backing plate is 6mm thick white Nylon, approx 140mm x 280mm Plate is mounted to rope by two 12mm diameter. stainless steel shackles.....	224
Figure 7.20	Detail of Coupon Mounting, used in Wells 25 and 29, Hasouna Wellfields.....	225
Figure 7.21	Typical Arrangement of Coupon Plates, well 25 and 29, Hasouna Wellfields.....	226
Figure 7.22	Corrosion Analysis from Wells 25 and 29, Weight loss varies (a & b) Depth m.....	229
Figure 7.23	Comparison of water chemistry and Corrosivity, 25 and 29, (a, b, c & d) NEJH(S).....	231
Figure 7.24	Corrosion Analysis for different coupons at wells 25 and (a & b) 29,Pitting Rate and Corrosion rate in mmpy.....	232
Figure 7.25	Results from Coupon Samples Well 29 and concentration of (a, b, & c) bacteria at different depths in Wells.....	236
Figure 7.26	Results from Coupon Samples Well 25 and concentration of (a & b) bacteria at different depths in Wells.....	238
Figure 7.27	Comparison of water chemistry and Corrosivity, statistical (a, b, c & d) average of all Hasouna Wellfields.....	241
CHAPTER 8: Water Quality for Applications		
Figure 8.1	Pie Diagram, Use of the GMRA water in Libya	248
Figure 8.2	Variation of nitrate mg/l versus TDS mg/l, all Hasouna Wellfields water.....	251

Figure 8.3	Calculation of mixing groundwater using Microsoft Excel worksheet, Hasouna Wellfields water.....	253
Figure 8.4	All Hasouna Wellfields water, plotted in Wilcox diagram	262
Figure 8.5	WJS Groundwater, plotted in Wilcox diagram	263
Figure 8.6	Magnesium Hazard (MH %) versus Electrical Conductivity (EC), all Hasouna Wellfields.....	265
CHAPTER 9: Isotopic Analysis of Hasouna Wellfields Water		
Figure 9.1	Location map of wells sampled for isotopic analysis, Hasouna Wellfields.....	267
Figure 9.2	Isotopic plot of $\delta^2\text{H} \text{‰}$ versus $\delta^{18}\text{O} \text{‰}$ for the groundwater samples from the Hasouna Wellfields. Also shown is the World Meteoric Line of Craig, (1961) and the value for weighted mean rainfall at the Sidi Barrani Station on the GNIP (Modified from BGS, 2001).....	274
Figure 9.3	Isotopic plot of $\delta^2\text{H} \text{‰}$ versus $\delta^{18}\text{O}$ for the groundwater samples from the WJS. Also shown the world Meteoric Line of Craig, 1961 and the value for weighted mean rainfall at the Sidi Barrani and Sfax Stations on the GNIP (Modified from BGS, 2001).....	275
Figure 9.4	Isotopic plot of $\delta^2\text{H} \text{‰}$ versus $\delta^{18}\text{O}$ for the East Libyan groundwater also shown the world Meteoric Line of Craig, 1961(after M.H., Sallum and N. Sahli, 2005).....	277
Figure 9.5	Sources of Nitrate in groundwater (modified from Hoefs, 1997 and Clark and Fritz, 1997 with data from Schmidt, 1987, Böttcher et al., 1990, and Letolle, 1980).....	279
Figure 9.6	Nitrogen cycle, the plot is located at (http://www.zymaxisotope.com/environmentaltracers.asp) (undated) downloaded 08/10/05.....	281
Figure 9.7	Variation in $\delta^{15}\text{N}$ values in the Hasouna Wellfields water.....	287
Figure 9.8	Variation in $\delta^{15}\text{N}$ and NO_3 mg/l in Hasouna Wellfields water....	289
Figure 9.9	Values of $\delta^{18}\text{O}$ and $\delta^{15}\text{N}$ from NO_3 , Hasouna Wellfields water base graph from Amberger and Schmidt,1987, and Kendall and McDonnell,1998).....	290
Figure 9.10	Figure 9.10 Compilation of nitrate $\delta^{18}\text{O}$ and $\delta^{15}\text{N}$ data from the following sources: Amberger and Schmidt (1987), Voerkelius (1990). Böttcher et al. (1990), Aravena et al. (1993), Durka et al. (1994). Wassenaar (1995), Kendall et al (1995b), Ging et al. (1996), Boolke et al. (1997), Aravena and Robertson (1998), Kendall et al. (in review), Bollwerk et al., (in preparation), unpublished data from S. Schiff (per. comm., 1998) Unpublished data B. Mayer (per. comm., 1998), and unpublished U.S Geological Survey data. A colored version of these plots is located at URL http://www.rcarnnl.wr.usgs.gov/isoig/isopubs/...	295
Figure 9.11	Figure 9.11 Schematic of typical ranges of $\delta^{18}\text{O}$ and $\delta^{15}\text{N}$ values of nitrate from various sources, simplified from data presented in Figure 9.10 Nitrification of ammonium and/or organic-N in fertilizer, precipitation. and organic waste can produce a large range of δ values, as shown. Soil waters tend to have NO_3 $\delta^{18}\text{O}$ values, and a larger range NO_3 $\delta^{18}\text{O}$ values, than groundwater because of the higher NO_3 $\delta^{18}\text{O}$ values of O_2 and/or	296

H₂O in soils.....

List of Tables

CHAPTER 1: Introduction

Table 1.1 Characteristics of Great Man Made River Project..... 3
 Table 1.2 Major Groundwater Basins in Libya..... 6

CHAPTER 2: Hasouna-Jeffara System

Table 2.1 Summary of aquifers and aquitard in WJS..... 33
 Table 2.2 Summary of aquifer characteristic in WJS..... 33
 Table 2.3 Summary of Results of Exploratory wells drilling (1994) North-East Hasouna Wellfields..... 37
 Table 2.4 Statistical Analysis Calculated Hydraulic Conductivity, Transmissivity, Measured SWL and DWL, All Hasouna Wellfields..... 44
 Table 2.5 Statistical Analysis Calculated Hydraulic Conductivity, Transmissivity, Measured SWL and DWL, NEJH(S)..... 45
 Table 2.6 Statistical Analysis Calculated Hydraulic Conductivity, Transmissivity, Measured SWL and DWL, NEJH(S)..... 46
 Table 2.7 Statistical Analysis Calculated Hydraulic Conductivity, Transmissivity, Measured SWL and DWL, EJH(E)..... 46
 Table 2.8 Statistical Analysis Calculated Hydraulic Conductivity, Transmissivity, Measured SWL and DWL, EJH(E)..... 46
 Table 2.9 Core samples Laboratory analysis results for the Exploratory wells and Piezometers in the Hasouna area..... 49
 Table 2.10 Core samples Laboratory analysis results for the Exploratory wells and Piezometers in the Hasouna area..... 50
 Table 2.11 Chemical analysis for the exploratory wells and piezometer wells in the Hasouna area..... 51
 Table 2.12 Hydraulic Properties for the Hasouna aquifer obtained by using Neumen Methods..... 56
 Table 2.13 Summary of Mechanisms that Lead to fluctuations in groundwater levels, (Freeze and Cherry, 1979)..... 57
 Table 2.14 Summary of Mechanisms that Lead to fluctuations in groundwater levels, (Freez R. Allan and Cheny John A., 1979).... 60
 Table 2.15 The relation between drainage factor, Boulton delay index and formation material..... 62

CHAPTER 3: Field Measurements

Table 3.1 Statistical Analysis of Field Measurements, Average Values, All Hasouna Wellfields..... 65
 Table 3.2 Statistical Analysis of Field Measurements, Average Values, NEJH(S)..... 65
 Table 3.3 Statistical Analysis of Field Measurements, Average Values, NEJH(N)..... 65
 Table 3.4 Statistical Analysis of Field Measurements, Average Values, EJH(W)..... 66
 Table 3.5 Statistical Analysis of Field Measurements, Average Values, EJH(E)..... 66

CHAPTER 4: Physical and General Parameters and Minor Chemical Constituents and Trace Elements

Table 4.1 Statistical Analysis of Physical and General Parameters, All Hasouna Wellfields..... 78

Table 4.2	Statistical Analysis of Physical and General Parameters, NEJH(S)	78
Table 4.3	Statistical Analysis of Physical and General Parameters, NEJH(N).....	79
Table 4.4	Statistical Analysis of Physical and General Parameters, EJH(W).....	79
Table 4.5	Statistical Analysis of Physical and General Parameters, EJH(E).....	79
Table 4.6	Statistical Analysis of Ionic balance, All Hasouna Wellfields.....	92
Table 4.7	Statistical Analysis of Ionic balance, NEJH(S).....	92
Table 4.8	Statistical Analysis of Ionic balance, NEJH(N).....	92
Table 4.9	Statistical Analysis of Ionic balance, EJH(W).....	93
Table 4.10	Statistical Analysis of Ionic balance, EJH(E).....	93
Table 4.11	Statistical Analysis Average Values Of Minor Chemical Constituents, All Hasouna Wellfields.....	94
Table 4.12	Statistical Analysis Average Values of Minor Chemical Constituents, NEJH(S).....	94
Table 4.13	Statistical Analysis Average Values Of Minor Chemical Constituents, NEJH(N).....	94
Table 4.14	Statistical Analysis Average Values Of Minor Chemical Constituents, EJH(W).....	95
Table 4.15	Statistical Analysis Average Values Of Minor Chemical Constituents, EJH(E).....	95
CHAPTER 5: Major Cations and Anions		
Table 5.1	Statistical Analysis of the Comparison (cations mg/l) from GMRA and Phosyn Laboratories Hasouna Wellfields water.....	115
Table 5.2	Statistical Analysis of the Comparison (anions mg/l) from GMRA and Phosyn Laboratories Hasouna Wellfields water.....	115
Table 5.3	Statistical Analysis Average Major Cations and Anions, All Hasouna Wellfields.....	116
Table 5.4	Statistical Analysis Average Major Cations and Anions, NEJH(S).....	116
Table 5.5	Statistical Analysis Average Major Cations and Anions, NEJH(N).....	116
Table 5.6	Statistical Analysis Average Major Cations and Anions, EJH(W).....	117
Table 5.7	Statistical Analysis Average Major Cations and Anions, EJH(E).....	117
Table 5.8	Selected wells for X-ray diffraction (XRD) and organic content analysis, in the Hasouna Wellfields.....	143
CHAPTER 6: Hydrochemical Processes and Data Analysis		
Table 6.1	Saturation Indices (SI) of various minerals resulted from MINTEQA2 and chemical composition, Hasouna Wellfields water.....	146
Table 6.2	Mineralogy and solubility of some carbonates (Thermodynamic data), after (Appelo and Postma, 1993).....	147
Table 6.3	Some Common Mineral Dissolution Reactions and Associated Equilibrium Constant, (Domenico and Schwartx, 1998).....	147
Table 6.4	Statistical Analysis Saturation indices of Minerals using	149

	MINTEQA2, ALL Hasouna Wellfields.....	
Table 6.5	Statistical Analysis Saturation indices of Minerals using MINTEQA2, NEJH(S).....	149
Table 6.6	Statistical Analysis Saturation indices of Minerals using MINTEQA2, NEJH(N)	149
Table 6.7	Statistical Analysis Saturation indices of Minerals using MINTEQA2, EJH(W).....	149
Table 6.8	Statistical Analysis Saturation indices of Minerals using MINTEQA2, EJH(E).....	149
Table 6.9	Statistical Analysis of log activities of silica and potassium, calcium magnesium and sodium over hydrogen for the all Hasouna).....	175
Table 6.10	Statistical Analysis of log activities of silica and potassium, calcium magnesium and sodium over hydrogen for the NEJH(S)	175
Table 6.11	Statistical Analysis of log activities of silica and potassium, calcium magnesium and sodium over hydrogen for the NEJH(N)	175
Table 6.12	Statistical Analysis of log activities of silica and potassium, calcium magnesium and sodium over hydrogen for the EJH(E)	176
Table 6.13	Statistical Analysis of log activities of silica and potassium, calcium magnesium and sodium over hydrogen for the EJH(W)	176
	CHAPTER 7:Chemical Indicators of Corrosion and Water Aggressivity (Saturation Indices and Corrosion Indices)	
Table 7.1	Statistical Analysis Saturation Indices and Corrosion Index, all Hasouna Wellfields.....	200
Table 7.2	Statistical Analysis Saturation Indices and Corrosion Index, NEJH(S).....	200
Table 7.3	Statistical Analysis Saturation Indices and Corrosion Index, NEJH(N).....	200
Table 7.4	Statistical Analysis Saturation Indices and Corrosion Index, EJH(W).....	200
Table 7.5	Statistical Analysis Saturation Indices and Corrosion Index, EJH(E).....	201
Table 7.6	Langelier Classified Saturation with respect to CaCO ₃ by the value of LI.....	203
Table 7.7	Ryznar Classified Saturation with respect to CaCO ₃ by the value of RI.....	206
Table 7.8	Classifies Saturation with respect to CaCO ₃ by the value of CCPP.....	209
Table 7.9	Classifies of Chloride Corrosion Index (CCI) values.....	216
Table 7.10	Classifies of Driving Force Index (DFI) values.....	219
Table 7.11	Metals Coupon used in the Hasouna Wellfields.....	223
Table 7.12	Summary of Corrosion Results from Wells 029 and 025.....	227
Table 7.13	Corrosion Analyses from Coupons in well 25, Hasouna Wellfields.....	228
Table 7.14	Corrosion Analyses from Coupons in well 29, Hasouna Wellfields.....	228
Table 7.15	Comparison of water chemistry and corrosivity between pumped samples and stagnant samples in wells 25 and 29.....	231
Table 7.16	Results from Coupon Samples Well 29 (NEJH(S)), Hasouna Wellfields.....	235

Table 7.17	Results from Coupon Samples Well 29 (NEJH(S)), Hasouna Wellfields.....	236
CHAPTER 8: Water Quality for Application		
Table 8.1	Safe Drinking Water Standards (WHO, 19 edition, 1995) and Average composition, Hasouna Wellfields water.....	249
Table 8.2	Suitability of water for irrigation, using Residual Sodium Carbonate (RSC) values.....	258
Table 8.3	Summary of RSC, Hasouna Wellfield water.....	259
Table 8.4	Summary of SSP, Hasouna Wellfield water.....	259
Table 8.5	Summary of SAR, Hasouna Wellfield water.....	260
Table 8.6	General classification of water based on values of sodium hazard and SAR values.....	261
Table 8.7	Major water divisions using Wilcox diagram, WJS.....	263
Table 8.8	Summary of MH%, Hasouna Wellfield water.....	264
CHAPTER 9: Isotopic Analysis of Hasouna Wellfields Water		
Table 9.1	Wells sampled for isotopic analysis, Hasouna Wellfields.....	266
Table 9.2	Results of $\delta^{18}\text{O}$, $\delta^2\text{H}$, ^{14}C (as A ^{14}C pmc) and $\delta^{13}\text{C}$ isotope measurements on 8 samples from the Hasouna Wellfields water..	268
Table 9.3	Radiocarbon ages from two different models based on variations $\delta^{13}\text{C}$ of soil CO_2 and rock carbonate inputs. Ages are calculated in ind of years (ka).....	271
Table 9.4	Quality Control and Reference Standards, used in $\delta\text{N}15$ analysis, Hasouna Wellfields water.....	283
Table 9.5	Quality Control and Reference Standards, used in N15 analysis, Hasouna Wellfields water.....	284
Table 9.6	Nitrogen-15, Hasouna Wellfields water	285
Table 9.7	Nitrogen-15, Hasouna Wellfields water	286
Table 9.8	Statistical Analysis of Nitrogen-15 Results, Hasouna Wellfields	286
Table 9.9	Quality Control and Reference Standards, used in $\delta^{18}\text{O}$ analysis of nitrate, Hasouna Wellfields water.....	292
Table 9.10	Quality Control and sodium nitrate control used in solution, $\delta^{18}\text{O}$ analysis, Hasouna Wellfields water	292
Table 9.11	Results of oxygen-18 analysis of nitrate extracted from Hasouna Wellfields Water.....	293
Table 9.12	Typical ranges of $\delta^{18}\text{O}$ and $\delta^{15}\text{N}$ of Types of NO_3 , (USGS, 2000).....	294

ABSTRACT

The Hasouna Wellfields, comprising 484 wells designed to produce 2.5million m³/day of water, are part of the Libyan Great Man Made River Project (GMRP). They are located about 700 km south of Tripoli, in an area of stony desert and sand dunes, forming a rolling topography of low to moderate relief. The water will be conveyed by pipeline for water supply and irrigation to the coastal regions west of Tripoli.

Geologically, the study area forms the northern edge of the Murzuq Basin and comprises rock formations ranging in age from Pre-Cambrian to Upper Cretaceous. There are two aquifers: the Cambro-Ordovician (CO) Hasouna Formation (the main aquifer), and the overlying Zimam Formation. The Zimam Formation, which contains saline water, is absent over the part of the field area where the freshwater-bearing, Hasouna aquifer is unconfined. The CO aquifer is major regional aquifer with a transmissivity range between 1500 to 2000 m²/day and a storativity range from 2.2×10^{-5} to 6.4×10^{-2} between the confined and unconfined areas of the Wellfields. Pumping tests have shown that the CO aquifer is leaky-confined type over part of the study area.

Water quality is good with average total dissolved solids (TDS) of 1039 mg/l, average chloride content of 600 mg/l and a positive redox-potential, indicating an oxidizing environment. However, the concentration of dissolved CO₂ ranges from 3.7 to 97 mg/l and nitrate ranges from 0.0 mg/l to 133 mg/l. These two constituents can result in wellfield operational and consumer health problems respectively.

The main objective of this study was to make a complete investigation of the water quality, hydrochemical processes and all the physical and chemical properties of these Wellfields.

Special attention was focussed on the problem of corrosion due to the CO₂ and the nitrate. This research used various methods, including the classification of water type, analysis of field data, study of major and minor cations, anions and trace elements, and the determination of water aggressivity supported by field study of corrosion coupons, hydrochemical processes, water quality for potable uses and isotopic analysis.

The calculated saturation and corrosion indices indicated that the Hasouna water is corrosive. The field study using corrosion coupons demonstrated that the corrosive properties of the water can change under short term non-pumping conditions to be scaling in character. Although the GMRP has addressed the problem of CO₂ by stripping it in degassing towers before it enters the pipeline, the results of this research will assist the process by identifying areas of high and low CO₂ concentration. A similar approach of blending low and high nitrate water can be used for the nitrate problem.

The origin of high nitrate levels in the Hasouna water is problematic. Similar high levels occur in Sirt and Kufra basins in Libya, (Edmunds and Wright, (1979)). The isotopic analysis of $\delta^{15}\text{N}$ (31 samples) and $\delta^{18}\text{O}$ (6 samples) from nitrate for the Hasouna water suggested the source could be precipitation and soil nitrate ($\delta^{15}\text{N}$ and $\delta^{18}\text{O}$). The $\delta^{15}\text{N}$ signature is similar to NH₄, NO₃, N₂ and effluent/manure. These sources imply a more humid climatic environment than the present. The stable isotope data indicate a meteoric origin for the groundwater, and the radiocarbon age is > 8 ka, which suggests that the Hasouna water is likely to have a late-Pleistocene or very early Holocene origin. At that time the climate was more humid than the present day arid conditions.

The water in Hasouna is classified to be class C3, for salinity hazard (High) and class S1/S2, for Sodium Hazard. This indicates that the blended water is suitable for irrigation with special management to control salinity.

The analysis of the speciation properties of the ionic composition of the water indicates undersaturation with all of the plausible mineral species. The hydrochemical processes, which control the composition of the Hasouna water are mixing, ion exchange and dissolution of gypsum and dolomite.