

Contents

ACKNOWLEDGMENT	6
EXTENDED SUMMARY	7
1. INTRODUCTION	9
1.1 Background of the Study	9
1.2 Objective and Scope	10
1.3 Location and Accessibility of the Study Area	11
1.4 Population of the Study Area	13
1.5 Water Demand	13
1.6 Previous Work	13
1.7 Methods and Procedures of the Study	13
2. SELECTED PHYSIOGRAPHIC and GEOGRAPHICAL SETTINGS	15
2.1 Physiography	15
2.2 Vegetation	16
2.3 Soil Types	17
2.4 Land Use and Land Cover	18
3. CLIMATE and HYDROLOGY	19
3.1 Climate	19
3.1.1 Precipitation.....	20
3.1.2 Temperature	21
3.1.3 Sunshine Hours	23
3.1.4 Wind Speed	24
3.1.5 Evapotranspiration.....	24
3.2 Hydrology	28
3.2.1 Drainage System	28
3.2.2 Runoff.....	28
3.2.3 Baseflow.....	32
4. GEOLOGICAL SETTINGS	35
4.1 Alge Group (ARI)	35
4.2 Baro Group (ARb)	35
4.3 Birbir Group (PR2b)	36
4.4 Early Granitoid Complex (dt, tn, gd, gt1, gt2)	36

4.5 Makonnen Basalts (PNmb)	37
4.6 Jima Volcanics (Pjb and Pjr)	37
4.7 Quaternary Basalt (Qb1) (Tepi shield)	37
4.8 Quaternary Deposits	37
4.9 Structures	37
5. HYDROGEOLOGY	39
5.1 General Hydrogeological Characteristics of the Area	39
5.2 Hydrogeological Characteristic of Lithological Units of the Area	40
5.3 Elements of the Hydrogeological System of the Area	40
5.3.1 Porous Aquifers.....	41
5.3.2 Fissured and Mixed Aquifers.....	42
5.3.3 Extensive and Low Productive Aquifers in Basement.....	44
5.3.4 Aquitards.....	45
6. GROUNDWATER POINT INVENTORY	46
6.1 Boreholes.....	46
6.2 Dug Wells.....	46
6.3 Springs	47
6.4 Marshes	48
6.5 Rivers and Lakes	48
7. GROUNDWATER FLOW, RECHARGE, DISCHARGE and HYDROGEOLOGICAL CONCEPTUAL MODEL ...	50
7.1 Groundwater Flow	50
7.2 Groundwater Recharge	50
7.3 Groundwater Discharge	50
7.4 Hydrogeological Conceptual Model	51
7.5 Groundwater Resource Evaluation and Development	51
8. HYDROCHEMISTRY	53
8.1 General Hydrochemistry	53
8.2 Sampling and Analysis.....	53
8.3 Ionic Relationships and Groundwater Chemistry	54
8.4 Major Ionic Compositions and Groundwater Chemistry	57
8.5 Total Dissolved Solids.....	57
8.6 Water Hardness.....	59
8.7 Classification of Natural Water.....	60

8.8 Water Quality	62
8.8.1 Drinking Water Quality	62
8.8.2 Irrigation Water Quality	65
8.8.3 Water Quality for Industry	66
9. GROUNDWATER RESOURCES ASSESSMENT and DEVELOPMENT	68
9.1 Groundwater Resources Assessment	68
9.2 Groundwater Resources Development	69
10. CONCLUSIONS and RECOMMENDATIONS	71
10.1 Conclusions	71
10.2 Recommendations	71
REFERENCES	72