

LIST OF FIGURES

Fig. No.	Description	Page No.
1.1	Location Map of Kakrapar Left Bank Canal Project.	5
1.2	Isohyet Map of South Gujarat.	8
2.1	Geological Map of South Gujarat	17
2.2	Tectonic Framework of Western India.	23
2.3	Deep Seismic Profile Between Kosamba - Billimora.	24
2.4	Lineament Fabric of South Gujarat.	25
3.1	Altimetric Zones of South Gujarat.	27
3.2	Landforms Characteristics of South Gujarat.	31
3.3	Drainage Systems of South Gujarat.	32
3.4	Landuse Pattern of Kakrapar Left Bank Canal Command Area.	35
3.5	Decadal Change in Landuse Pattern, KLBC Area.	36
4.1	Hydrogeological Map of Gujarat.	40
4.2	Canal Network Map of KLBC Area.	43
4.3	Piper-Trilinear Plots of Canal Water.	46
4.4	Irrigation Water Quality of Canal Water (after Wilcox, 1955).	47
4.5	U.S.Salinity Chart for Irrigation Water Quality of Canal Water.	47
4.6	Geohydrological Map of KLBC Area.	49
4.7	Hydrogeomorphological Map of KLBC Area (based on LANDSAT – March, 1986).	51
4.8	Satellite Imagery (LISS – III) of KLBC Area.	54
4.9	Subsurface Geological Profile Along Bhada - Vihan (A-A') Section Line.	55
4.10	Subsurface Geological Profile Along Bhestan - Titwa (B-B') Section Line.	56
4.11	Subsurface Geological Profile Along Asundar - Tajpura (C-C') Section Line.	56
4.12	Subsurface Geological Profile Along Kothavasan - Gunsavel (D-D') Section Line.	57
4.13	Observation Well Locations in KLBC Area.	59

4.14	Static Water Level Contour Map of KLBC Area for the Pre Monsoon 1950.	60
4.15	Reduced Water Level Contour Map of KLBC Area for the Pre Monsoon 1950.	61
4.16	Reduced Water Level Contour Map of KLBC Area for the Pre Monsoon 1999.	63
4.17	Plots of Reduced Water Levels v/s Ground Elevations of Pre Monsoon 1999.	64
4.18	Net Seasonal Change in Water Table in KLBC Areas (Pre to Post Monsoon 1999).	65
4.19	Well Hydrographs Depicting Secular Behaviour of Water Level in KLBC Area.	66
4.20	Iso-TDS Contour Map, KLBC Area (pre-monsoon 2000).	70
4.21	Piper Trilinear Plots of Groundwaters in KLBC Area (pre-monsoon 1981).	75
4.22	Piper Trilinear Plots of Groundwaters in KLBC Area (pre-monsoon 2000).	76
4.23	Irrigation Water Quality Classification of KLBC Area (after Wilcox, 1955).	80
4.24	Classification of Irrigation Water of KLBC Area on U.S. Salinity Chart (USDA, 1954).	81
5.1	Soils of Gujarat.	84
5.2	Classification of Soils in KLBC Area.	86
5.3	Standard Textural Classification of Soil.	89
5.4	Schematic Diagrams of the Most Common Soil Structures.	91
5.5	Soil Water Constants and their Approximate Equivalents in kPa of Water Potential as They Affect the Relative Availability of Water to Plants.	94
5.6	Relationship Between Soil Texture, Field Capacity, Permanent Wilting Point, Available Water Capacity.	94
5.7	Land Irrigability Classification During Initial Phase (1970) of Canal Irrigation in KLBC Area.	111
5.8	Present (2001) Land Irrigability Classification in KLBC Area.	112
6.1	Geographical Distribution of Chalthan Branch Canal Command Area with Communication Network.	115
6.2	Ground Contour Map of Chalthan Branch Canal Command Area.	116

6.3	Drainage Map of Study Area.	116
6.4	Chalthan Branch Canal Network.	118
7.1	Rainfall-Time-Series Curve for Chalthan Branch Canal Command Area.	121
7.2	Influence of Rainfall on Canal Discharge in Chalthan Branch Canal Command Area.	122
7.3	Fence Diagram Showing Hydrogeological Characterization of Chalthan Branch Canal Command Area.	124
7.4	Observation Wells and Soil Sampling Locations in the Study Area.	126
7.5	Reduced Water Level Contour Plan of Chalthan Command Area (Pre & Post monsoon 1950).	128
7.6	Net Seasonal Change in Groundwater Storage in Chalthan Command Area (1950).	128
7.7	Reduced Water Level Contour Plan of Chalthan Command Area (Pre and post monsoon 1999).	129
7.8	Net Seasonal Change in Groundwater Storage in Chalthan Command Area (1999).	130
7.9	Spatial Hydrographic Profiles Along Karan - Kantali (A-A') Transact Showing Seasonal Changes in Groundwater Regime in Chalthan Command Area (1950).	131
7.10	Spatial Hydrographic Profiles Along Karan - Kantali (A-A') Transact Showing Seasonal Changes in Groundwater Regime in Chalthan Command Area (1999).	132
7.11	Secular Change in Groundwater Storage in Chalthan Command Area (1950-70).	133
7.12	Secular Change in Groundwater Storage in Chalthan Command Area (1970-80).	134
7.13	Secular Change in Groundwater Storage in Chalthan Command Area (1980-90).	134
7.14	Secular Change in Groundwater Storage in Chalthan Command Area (1990-95).	135
7.15	Secular Change in Groundwater Storage in Chalthan Command Area (1995-99).	135
7.16	Well hydrographs of the Selected Observation Wells in Chalthan Command Area.	136
7.17	Spatial Hydrographic Profile Along Karan - Kantali (A-A') Transact in Chalthan Command Area (1950-70-80).	137

7.18	Spatial Hydrographic Profile Along Karan - Kantali (A-A') Transact in Chalthan Command Area (1990-95-99).	137
7.19	Secular Change in Reduced Water Level Contour in Chalthan Command Area (1950-99).	138
7.20	Spatial Hydrographic Profiles Along Karan - Kantali (A-A') Transact Showing Secular Changes in Groundwater Regime in Chalthan Command Area (1950-99).	139
7.21	Iso-TDS (mg/l) Contour Diagram of Groundwater in Chalthan Command Area (pre monsoon 1970).	144
7.22	Iso-TDS (mg/l) Contour Diagram of Groundwater in Chalthan Command Area (pre monsoon 1985).	145
7.23	Iso-TDS (mg/l) Contour Diagram of Groundwater in Chalthan Command Area (pre monsoon 1999).	145
7.24	Secular Change in TDS (mg/l) of Groundwater in Chalthan Command Area (1970-99).	146
7.25	Geochemical Fields of Piper Trilinear Diagram.	155
7.26	Piper Trilinear Plots of Groundwater Samples in Chalthan Command Area (post monsoon 1998).	156
7.27	Piper Trilinear Plots of Groundwater Samples in Chalthan Command Area (pre monsoon 1999).	157
7.28	Piper Trilinear Plots of Groundwater Samples in Chalthan Command Area (post monsoon 1999).	158
7.29	Classification of Groundwater for Irrigation in Chalthan Command Area (Based on Electrical Conductance).	160
7.30	Relative Rate of Water Infiltration as Affected by Salinity and Sodium Adsorption Ratio (Hoffman, 1997).	161
7.31	U. S. Salinity Diagram Showing Seasonal Change in Quality of Groundwater (after Richards, 1954).	163
7.32	Irrigation Water Classification in Chalthan Command Area (after Wilcox, 1955).	164
7.33	Irrigation Water Classification Based on Permeability Index in Chalthan Command Area (after Doneen, 1964).	165
7.34	Irrigation Water Classification Based on RSC (Eaton, 1950) in Chalthan Command Area.	166
7.35	Irrigation Water Classification Based on SSP (Wilcox, 1948) in Chalthan Command Area.	167
7.36	Irrigation Water Classification Based on Schoeller Index (Schoeller, 1959) in Chalthan Command Area.	168

7.37	Irrigation Water Classification Based on Kelley's Ratio (Kelley et. al, 1940) in Chalthan Command Area.	169
7.38	Irrigation Water Classification Based on Adj. SAR (Ayers and Westcot, 1976) in Chalthan Command Area.	170
7.39	Irrigation Water Classification Based on Cl Concentrations (Scofield, 1933) in Chalthan Command Area.	172
7.40	Irrigation Water Classification Based on Potential Salinity (Doneen, 1963) in Chalthan Command Area.	172
7.41	Irrigation Water Classification Based on Sulfate (Scofield, 1963) in Chalthan Command Area.	173
7.42	Irrigation Water Classification Based on Magnesium (Szabolcs, 1989) in Chalthan Command Area.	174
7.43	Hydrogeological Map of Chalthan Branch Canal Command Area.	177
8.1	Schematic Diagram of an Ideal Soil Profile.	182
8.2	Soil Series Classification in Chalthan Branch Canal Command Area.	182
8.3	Pedomorphological Characteristics of Soil Profile at Mota Village.	184
8.4	Pedomorphological Characteristics of Soil Profile at Sanki Village.	185
8.5	Pedomorphological Characteristics of Soil Profile at Khoj-Pardi Village.	186
8.6	Pedomorphological Characteristics of Soil Profile at Bagumara Village.	186
8.7	Pedomorphological Characteristics of Soil Profile at Kantali Village.	187
8.8	Textural Characteristics of Soils in Chalthan Branch Canal Command Area.	190
8.9	Spatial Distribution Pattern of Soil Fractions at Different Depths Along A-A' Transact.	191
8.10	Soil Iso-MHC (%) Contour Map, Chalthan Branch Canal Command Area (0 - 50 cm).	193
8.11	Soil Iso-MHC (%) Contour Map, Chalthan Branch Canal Command Area (50 - 100 cm).	193
8.12	Soil Iso-MHC (%) Contour Map, Chalthan Branch Canal Command Area (100 - 150 cm).	194
8.13	Soil Iso-MHC (%) Contour Map, Chalthan Branch Canal Command Area (150 - 200 cm).	194

8.14	Soil Iso-Hydraulic Conductivity Contour Map, Chalthan Branch Canal Command Area (0 - 50 cm).	197
8.15	Soil Iso-Hydraulic Conductivity Contour Map, Chalthan Branch Canal Command Area (50 - 100 cm).	198
8.16	Soil Iso-Hydraulic Conductivity Contour Map, Chalthan Branch Canal Command Area (100 - 150 cm).	198
8.17	Soil Iso-Hydraulic Conductivity Contour Map, Chalthan Branch Canal Command Area (150 - 200 cm).	199
8.18	Aerial Distribution of Soil pH During Pre monsoon 1991 in Chalthan Branch Canal Command Area (0-50 cm).	201
8.19	Aerial Distribution of Soil pH During Pre monsoon 1999 in Chalthan Branch Canal Command Area (0-50 cm).	201
8.20	Aerial Distribution of Soil pH During Pre monsoon 1991 in Chalthan Branch Canal Command Area (100-150 cm).	202
8.21	Aerial Distribution of Soil pH During Pre monsoon 1999 in Chalthan Branch Canal Command Area (100-150 cm).	202
8.22	Depth Wise Spatial and Temporal Behavioral Pattern of Soil pH in Chalthan Branch Canal Command Area (along A-A' transact).	204
8.23	Aerial Distribution of Soil EC (mmhos/cm) During Pre monsoon 1991 in Chalthan Branch Canal Command Area (0-50 cm).	205
8.24	Aerial Distribution of Soil EC (mmhos/cm) During Pre monsoon 1999 in Chalthan Branch Canal Command Area (0-50 cm).	206
8.25	Depth Wise Spatial and Temporal Behavioral Pattern of Soil EC in Chalthan Branch Canal Command Area (along A-A' transact).	207
8.26	Aerial Distribution of Soil Exchangeable Sodium (meq/100 gm) During Pre monsoon 1991, Chalthan Branch Canal Command Area (0-50 cm).	212
8.27	Aerial Distribution of Soil Exchangeable Sodium (meq/100 gm) During Pre monsoon 1999, Chalthan Branch Canal Command Area (0-50 cm).	213
8.28	Depth Wise Seasonal and Secular Behaviour of Exchangeable Sodium (meq/100 gm) of Soils, Chalthan Branch Canal Command Area (along A-A' transact).	214
8.29	Aerial Distribution of Cation Exchange Capacity (meq/100 gm) During Pre monsoon 1991, Chalthan Branch Canal Command Area (0-50 cm).	216

8.30	Aerial Distribution of Cation Exchange Capacity (meq/100 gm) During Pre monsoon 1999, Chalthan Branch Canal Command Area (0-50 cm).	217
8.31	Depth Wise Seasonal and Secular Behaviour of Cation Exchange Capacity (meq/100 gm) of Soils, Chalthan Branch Canal Command Area (along A-A' transact).	218
8.32	Aerial Distribution of Soils Exchangeable Sodium Percentage (%) During Pre monsoon 1991, Chalthan Branch Canal Command Area (0-50 cm).	220
8.33	Aerial Distribution of Soils Exchangeable Sodium Percentage (%) During Pre monsoon 1999, Chalthan Branch Canal Command Area (0-50 cm).	221
8.34	Depth Wise Seasonal and Secular Behaviour of Exchangeable Sodium Percentage (%) of Soils Chalthan Branch Canal Command Area (along A-A' transact).	222
8.35	Aerial Distribution of Soils Organic Matter (%) During Pre monsoon 1991, Chalthan Branch Canal Command Area (0-50 cm).	225
8.36	Aerial Distribution of Soils Organic Matter (%) During Pre monsoon 1999, Chalthan Branch Canal Command Area (0-50 cm).	225
8.37	Depth Wise Seasonal and Secular Behaviour of Organic Matter (%) of Soils, Chalthan Branch Canal Command Area (along A-A' transact).	226
8.38	Aerial Distribution of Phosphorus (kg/acre) During Pre monsoon 1999 in Chalthan Branch Canal Command Area (0-50 cm).	228
8.39	Aerial Distribution of Potassium (kg/acre) During Pre monsoon 1999, Chalthan Branch Canal Command Area (0-50 cm).	229
8.40	Seasonal Behaviour of Potassium (kg/acre) of Soils (0-50 cm), Chalthan Branch Canal Command Area (along A-A' transact).	230
9.1	Flow Sheet Depicting Sources & Causative Factors of Waterlogging in Irrigation Project.	234
9.2	Secular (Net) Change in Groundwater Levels, Chalthan Command Area (1950-99).	235
9.3	Spatial Hydrographic Profiles Along Karan - Kantali (A-A') Transact Showing Secular Changes in Groundwater Regime, Chalthan Command Area (1950-99).	236
9.4	Hydro-Iso-Bath Map of Chalthan Branch Canal Command Area (pre monsoon 1970).	237

9.5	Hydro-Iso-Bath Map of Chalthan Branch Canal Command Area (pre monsoon 1985).	237
9.6	Hydro-Iso-Bath Map of Chalthan Branch Canal Command Area (pre monsoon 1995).	238
9.7	Hydro-Iso-Bath Map of Chalthan Branch Canal Command Area (pre monsoon 1999).	238
9.8	Hydro-Iso-Bath Trends in Chalthan Branch Canal Command Area.	240
9.9	Crop Water Requirement vis-à-vis Applied Irrigation Waters, Chalthan Branch.	246
9.10	Observed Annual Changes in Area Covered by Sugarcane in 03 villages of Chalthan Branch.	249
9.11	Flow Sheet Diagram Depicting Water and Salt Circulation in an Irrigated River Basin.	252
9.12	Land Irrigability Classification During Initial Phase of Canal Irrigation (1970) in Chalthan Branch Canal Command Area.	271
9.13	Present (1991) Land Irrigability Classification in Chalthan Branch Canal Command Area.	271
9.14	Long term Landuse Pattern Changes in Chalthan Branch Canal Command Area.	273
10.1	Management Options for Crop Production in Waterlogged and Saline Soils.	276
10.2	Schematic Sketch Illustrating the Role of Subsurface Drainage in Controlling Waterlogging and Salt Accumulation.	277
10.3	Command Area Demarcated for the Improvement of Surface and Sub-surface Drainage for Controlling Waterlogged Condition.	277
10.4	Distribution of the Land Holdings in the Chalthan Branch Command Area of Outlet Number 8R/H.	281
10.5	Spatial Hydrographic Profiles Along Karan - Kantali (A-A') Transact in Chalthan Command Area, Depicting Decline Water Levels due to Groundwater Utilization During Canals' Non-operational Period.	282