CONTENTS

Preface xiii
Definition of Terms xv

1 Watersheds, Hydrologic Processes, and Pathways 3

1 Introduction 7

Overview 7
Watersheds 10
Integrated Watershed Management 12
Sustainable Use and Development of Natural Resources 14
Watersheds, Ecosystem Management, and Cumulative
Effects 20
Reconciling Watershed and Political Boundaries 21
Summary and Learning Points 24

References 24 Webliography 26

2 Hydrologic Cycle and the Water Budget 27

Introduction 27
Properties of Water 27
The Hydrologic Cycle 30
Energy and the Hydrologic Cycle 38
Water Flow in Soil 43
Water Flow on Land and in Stream Channels 47
Summary and Learning Points 47
References 48

3 Precipitation 49

Introduction 49
Precipitation Process 50
Rainfall 53
Snowfall 63
Summary and Learning Points 78

References 78 Webliography 79

4 Evaporation, Interception, and Transpiration 81

Introduction 81
The Evaporation Process 82
Evaporation from Water Bodies 83
Evaporation from Soil Surfaces 85
Interception 85
Transpiration 92
Potential Evapotranspiration 103
Estimating Actual Evapotranspiration 105
Summary and Learning Points 109
References 110

5 Infiltration, Pathways of Water Flow, and Recharge 113

Introduction 113
Infiltration 113
Pathways of Water Flow 125
Summary and Learning Points 138
References 138

6 Streamflow Measurement and Analysis 141

Introduction 141
Measurement of Streamflow 141
Methods for Estimating Streamflow Characteristics 148
Summary and Learning Points 170
References 171
Webliography 172

7 Groundwater and Groundwater-Surface Water Exchange 173

Introduction 173
Groundwater 174
Groundwater-Surface Water Exchanges 187
Summary and Learning Points 193
References 194
Webliography 195

2 Physical, Chemical, and Biological Linkages of Water Flow 197

8 Soil Erosion Processes and Control 199

Introduction 199
Surface Soil Erosion 199
Erosion from Gullies and Ravines 221
Soil Mass Movement 230
Summary and Learning Points 237
References 238
Webliography 241

9 Sediment Supply, Transport, and Yield 243

Introduction 243
Sediment Supply and Transport 244
Measurement of Sediment 255
Sediment Yield 258
Cumulative Watershed Effects on Sediment Yield 260
Summary and Learning Points 263
References 264

10 Fluvial Processes and Implications for Stream Management 267

Introduction 267
Fluvial Geomorphology 268
Valley and Stream Evaluation and Classification 272
Stream Classification 285
Summary and Learning Points 293
References 293
Webliography 295

11 Water-Quality Characteristics 297

Introduction 297
Chemistry of Precipitation 298
Physical Characteristics of Surface Water 300
Dissolved Chemical Constituents 311
Biological Characteristics 319
Groundwater Quality 323

Cumulative Effects 324 Summary and Learning Points 325 References 326 Webliography 328

3 Integrated Watershed Management 329

Managing Wildland Watersheds 333 12

Introduction 333 Forests 333 Woodlands 364 Rangelands 367 Upland-Downstream Considerations 371 Cumulative Watershed Effects 377 Summary and Learning Points 379 References 380 Webliography 387

13 Managing Riparian Communities and Wetlands 389

Introduction 389 Riparian Communities 389 Wetlands 401 Cumulative Effects 422 Summary and Learning Points 422 References 423

Watershed Management Issues 427

Introduction 427 Fragmentation of Watershed Landscapes 427 Water Harvesting 439 Best Management Practices 442 Regulatory Compliance 446 Climatic Variability 451 Insufficient Information for Decision Making 455 Summary and Learning Points 456 References 458 Webliography 461

15 Socioeconomic Considerations in Integrated Watershed Management 463

Introduction 463 Policies and Policy Processes 464 Planning and Implementation 470 Economic Appraisals 475 Summary and Learning Points 486 References 487

16 **Tools and Emerging Technologies 489**

Introduction 489 Generalized Hydrologic Simulation Models 490 Technologically Advanced Tools 495 Using the Stable Isotopes of Hydrogen and Oxygen 500 Summary and Learning Points 507 References 508 Webliography 511

Appendix: Units Commonly Used in Hydrologic Work, USA 513 Index 517

Color plates appear between pages 512 and 513