

Content

Preface

vii

1. Introduction

1

- 1.1 Introduction 1
- 1.2 Hydrologic Cycle 1
- 1.3 Water-Budget Equation 4
- 1.4 World Water Balance 7
- 1.5 Global Freshwater Resources 10
- 1.6 History of Hydrology 11
- 1.7 Applications In Engineering 12
- 1.8 Sources of Data 13
 - References* 14
 - Revision Questions* 14
 - Problems* 14
 - Objective Questions* 15

2. Precipitation

17

- 2.1 Introduction 17
- 2.2 Forms of Precipitation 18
- 2.3 Weather Systems for Precipitation 18
- 2.4 Characteristics of Precipitation in India 20
- 2.5 Measurement of Precipitation 25
- 2.6 Raingauge Network 29
- 2.7 Preparation of Data 31
- 2.8 Presentation of Rainfall Data 37
- 2.9 Mean Precipitation Over An Area 40
- 2.10 Depth-Area-Duration Relationships 45
- 2.11 Frequency of Point Rainfall 49
- 2.12 Maximum Intensity/Depth-Duration-Frequency Relationship 53
- 2.13 Probable Maximum Precipitation (PMP) 60
- 2.14 World's Greatest Observed Rainfall 61
- 2.15 Monsoon Studies in India 61
- 2.16 Rainfall Data In India 63
 - References* 64
 - Revision Questions* 64
 - Problems* 65
 - Objective Questions* 70

3. Abstractions from Precipitation	73
3.1 Introduction	73
3.2 Evaporation Process	73
3.3 Evaporimeters	75
3.4 Empirical Evaporation Equations	77
3.5 Analytical Methods of Evaporation Estimation	79
3.6 Reservoir Evaporation and Methods for its Reduction	82
3.7 Transpiration	84
3.8 Evapotranspiration	84
3.9 Measurement of Evapotranspiration	86
3.10 Evapotranspiration Equations	86
3.11 Potential Evapotranspiration Over India	93
3.12 Actual Evapotranspiration (AET)	94
3.13 Interception	95
3.14 Depression Storage	96
3.15 Infiltration	97
3.16 Infiltration Capacity	98
3.17 Measurement of Infiltration	100
3.18 Modelling Infiltration Capacity	102
3.19 Classification of Infiltration Capacities	109
3.20 Infiltration Indices	110
<i>References</i>	115
<i>Revision Questions</i>	116
<i>Problems</i>	116
<i>Objective Questions</i>	119
4. Streamflow Measurement	122
4.1 Introduction	122
4.2 Measurement of Stage	123
4.3 Measurement of Velocity	126
4.4 Area-Velocity Method	131
4.5 Dilution Technique of Streamflow Measurement	135
4.6 Electromagnetic Method	138
4.7 Ultrasonic Method	139
4.8 Indirect Methods	140
4.9 Stage-Discharge Relationship	145
4.10 Extrapolation of Rating Curve	153
4.11 Hydrometry Stations	155
<i>References</i>	157
<i>Revision Questions</i>	157
<i>Problems</i>	158
<i>Objective Questions</i>	161
5. Runoff	164
5.1 Introduction	164

- 5.2 Hydrograph 167
- 5.3 Runoff Characteristics of Streams 168
- 5.4 Catchment Characteristics 169
- 5.5 Runoff Volume (Yield) 173
- 5.6 SCS-CN Method of Estimating Runoff Volume 185
- 5.7 Flow-Duration Curve 194
- 5.8 Flow-Mass Curve 197
- 5.9 Sequent Peak Algorithm 206
- 5.10 Droughts 210
- 5.11 Surface-Water Resources of India 218
- 5.12 Glacier Resources of Indian Himalayas 224
- 5.13 Environmental Flows 225
 - References* 231
 - Revision Questions* 232
 - Problems* 233
 - Objective Questions* 238

6. Hydrographs

240

- 6.1 Introduction 240
- 6.2 Factors Affecting Runoff Hydrograph 241
- 6.3 Components of a Hydrograph 245
- 6.4 Base Flow Separation 248
- 6.5 Effective Rainfall (ER) 250
- 6.6 Unit Hydrograph 252
- 6.7 Derivation of Unit Hydrograph 259
- 6.8 Unit Hydrographs of Different Durations 263
- 6.9 Use and Limitations of Unit Hydrograph 270
- 6.10 Duration of the Unit Hydrograph 270
- 6.11 Distribution Graph 271
- 6.12 Synthetic Unit Hydrograph 272
- 6.13 Instantaneous Unit Hydrograph (IUH) 282
 - References* 287
 - Revision Questions* 287
 - Problems* 287
 - Objective Questions* 292

7. Floods

296

- 7.1 Introduction 296
- 7.2 Rational Method 296
- 7.3 Empirical Formulae 302
- 7.4 Unit Hydrograph Method 304
- 7.5 Flood Frequency Studies 305
- 7.6 Gumbel's Method 308
- 7.7 Log-Pearson Type III Distribution 317

- 7.8 Partial Duration Series 321
- 7.9 Regional Flood-Frequency Analysis 322
- 7.10 Extremes of Extremes-Envelope Curve of Highest Floods in the World 322
- 7.11 Data for Frequency Studies 324
- 7.12 Design Flood 324
- 7.13 Design Storm 326
- 7.14 Risk, Reliability and Safety Factor 329
 - References* 331
 - Revision Questions* 332
 - Problems* 332
 - Objective Questions* 337

8. Flood Routing **340**

- 8.1 Introduction 340
- 8.2 Basic Equations 341
- 8.3 Hydrologic Storage Routing (Level Pool Routing) 342
- 8.4 Attenuation 351
- 8.5 Hydrologic Channel Routing 352
- 8.6 Hydraulic Method of Flood Routing 359
- 8.7 Routing in Conceptual Hydrograph Development 360
- 8.8 Clark's Method for IUH 360
- 8.9 Nash's Conceptual Model 364
- 8.10 Flood Control 373
- 8.11 Flood Control in India 377
- 8.12 Global Warming and its Impact on Water Resources of India 378
 - References* 381
 - Revision Questions* 382
 - Problems* 382
 - Objective Questions* 386

9. Groundwater **389**

- 9.1 Introduction 389
- 9.2 Forms of Subsurface Water 389
- 9.3 Saturated Formation 391
- 9.4 Aquifer Properties 393
- 9.5 Geologic Formations as Aquifers 400
- 9.6 Compressibility of Aquifers 401
- 9.7 Equation of Motion 404
- 9.8 Wells 415
- 9.9 Steady Flow into a Well 416
- 9.10 Open Wells 421
- 9.11 Unsteady Flow in a Confined Aquifer 424
- 9.12 Well Loss 430
- 9.12 Specific Capacity 431

9.13	Sea-Water Intrusion	431
9.14	Recharge	432
9.15	Groundwater Resource	437
9.16	Groundwater Monitoring Network in India	441
	<i>References</i>	442
	<i>Revision Questions</i>	442
	<i>Problems</i>	443
	<i>Objective Questions</i>	448
10.	Erosion and Reservoir Sedimentation	452
10.1	Introduction	452
10.2	Erosion Processes	452
10.3	Estimation of Sheet Erosion	454
10.4	Channel Erosion	457
10.5	Movement of Sediment from Watersheds	459
10.6	Sediment Yield from Watersheds	460
10.7	Trap Efficiency	465
10.8	Density of Sediment Deposits	467
10.9	Distribution of Sediment in the Reservoir	472
10.10	Life of a Reservoir	483
10.11	Reservoir Sedimentation Control	484
10.12	Erosion and Reservoir Sedimentation Problems in India	485
	<i>References</i>	489
	<i>Revision Questions</i>	490
	<i>Problems</i>	490
	<i>Objective Questions</i>	493
	Appendix A – Multiple Choice Questions	495
	Appendix B – Abbreviations	509
	Appendix C – Conversion Factors	512
	Appendix D – Answers to Objective Questions	513
	Appendix E – Answers to Problems	514
	Index	526