Contents

Hydrology – Water			**1 - 21**
1	1.1	Definition of hydrology	1
	1.2	History of hydrology	1
	1.3	Hydrology in relation to water resources development	2
	1.4	Hydrologic cycle	4
	1.5	Necessity for hydrologic data	5
	1.6	Availability of water	5
	1.7	Water resources of India	16
Meteorology			**22 - 50**
2	2.1	Weather and atmosphere	22
	2.2	Temperature in atmosphere	25
	2.3	Pressure and winds	32
	2.4	Wind measurement	37
	2.5	Air masses and fronts	38
	2.6	Atmospheric humidity	46
	2.7	Terminology	48
	2.8	Change in the world's climate	49
Statistical & Probability Analysis			**51 - 124**
3	3.1	General	51
	3.2	Fundamental terms	51
	3.3	Probability - basic concepts	68
	3.4	Probability distribution	72
	3.5	Correlations	83
	3.6	Plotting position	89
	3.7	Tests of significance	91
	3.8	Confidence limits	104
	3.9	Analysis of variance	105
	3.10	Analysis of time series	107
	3.11	Queueing theory	109
	3.12	Project yields by probability methods	115
	3.13	Reservoir capacity yield procedure	116

Systems Methodology & Mathematical Models **125 - 157**

4
4.1 General 125
4.2 System concepts – definitions 125
4.3 Methodology of system design 127
4.4 Optimal design 131
4.5 Classical optimisation techniques 137
4.6 Simulation analysis 142
4.7 Mathematical models in hydrology 148

Simulation Technique & Sequential Generation **158 - 183**

5
5.1 Generating process 158
5.2 Monte Carlo method 159
5.3 Simulation technique and sequential generation of rainfall data 159
5.4 Generation of synthetic sequences of a single hydrological variable 165

Precipitation **184 - 231**

6
6.1 Forms of precipitation 184
6.2 Snow formation 184
6.3 Factors affecting the accuracy of stream flow records under ice conditions 187
6.4 Measurement of snow 187
6.5 Snow run-off-snow melt 189
6.6 Glaciers 192
6.7 Rainfall 196
6.8 Rainfall measurement 198
6.9 Typical and record rainfall data 203
6.10 Adequacy of raingauges 215
6.11 Intrapolation and adjustment of missing data 218
6.12 Average depth of rainfall over area 219
6.13 Presentation and processing of precipitation data 224

Evaporation and Transpiration **232 - 251**

7
7.1 Definitions 232
7.2 Evaporation 233
7.3 Estimation of reservoir evaporation 237
7.4 Evaporation control from reservoirs 244
7.5 Transpiration 245
7.6 Evapo – transpiration 246

Ground Water **252 - 275**

8	8.1	General	252
	8.2	Types of aquifers	255
	8.3	Ground water movement	256
	8.4	Well hydraulics	259
	8.5	Wells	270
	8.6	Ground water fluctuations	270
	8.7	Artificial recharge of groundwater	273
	8.8	Sources and temperatures of under ground water	273
	8.9	Safe yield and overdraft	274
Run – off			**276 - 343**
9	9.1	Phases of run-off	276
	9.2	Disposal of rainfall	279
	9.3	Streamflow stations network – densities	279
	9.4	Discharge measurements	280
	9.5	Factors affecting the run-off	287
	9.6	Geo-morphic characteristics of drainage net	302
	9.7	River basins in India	305
	9.8	Infilling missing flow data	309
	9.9	Estimation of run-off	310
	9.10	Run-off calculation from the estimation of losses	318
	9.11	Run-off calculation by infiltration method	319
	9.12	Rational method of estimating run-off	333
Design Flood & Design Storm			**344 - 390**
10	10.1	Unpredictability of floods	344
	10.2	Meteorology of storms	345
	10.3	General – design flood definitions	345
	10.4	Design flood assessments	346
	10.5	Policy criteria	347
	10.6	Flood estimation approach	355
	10.7	Estimation of design storm	361
	10.8	Method of estimating PMS	366
	10.9	Probable maximum storm for mountainous regions – depth duration analysis	379
	10.10	Estimation of standard project storms	380
	10.11	Time adjustment of design rainfall	381
	10.12	Duration of the design storm	381
	10.13	Critical pattern of storm rainfall	381
	10.14	Estimation of runoff potential	382
	10.15	Design storm hyetograph & convolution of design flood (after CWC)	384
	10.16	Maximum probable flood – useful data	385

Empirical Formulae and Envelope Curves **391 - 406**

11
11.1 General 391
11.2 Empirical flood formulae 391
11.3 Envelope curves 403

Extension of Short Term Stream Flow Records **407 - 434**

12
12.1 General 407
12.2 Fitting distributions to peak discharges 408
12.3 Extrapolation of runoff data 408
12.4 Estimation of flows where rainfall data is available of considerable length but runoff data is short or is not available 432
12.5 Estimation of floods with given return period for basins without streamflow records, and without reliable rainfall record 434

Flood Frequency Methods **435 - 501**

13
13.1 General 435
13.2 Some definitions 439
13.3 Processing of data 441
13.4 Methods of determining flood frequencies 451
13.5 Confidence bands 495
13.6 Transference of flood frequencies to adjacent water sheds 497
13.7 Risk reliability and safety factor 500

Surface Flow Hydrographs **502 - 585**

14
14.1 Characteristics of the hydrograph 502
14.2 Indirect and artificial drainage 509
14.3 Unit hydrograph 511
14.4 Derivation of the unit hydrograph for gauged drainage areas – simple hydrograph 517
14.5 Unit hydrograph from a complex hydrograph 527
14.6 S - hydrograph (summation hydrograph) 535
14.7 Synthetic hydrograph-derivation of unit hydrograph for ungauged areas 538
14.8 Dimensionless unit hydrograph 554

14.9 Selection of unit hydrograph for design flood computation 557
14.10 Unit hydrographs for computation of inflow into major reservoirs 559
14.11 Computation of design flood hydrograph C.W.C.'S criteria 561
14.12 Instantaneous unit hydrograph 563

Ground-Water Hydrographs **586 - 591**

15 15.1 Introduction 586
15.2 Theory 586
15.3 Applications 590

Hydrology of Coastal Areas **592 - 609**

16 16.1 Introduction-problem of salt ingress 592
16.2 Sea water intrusion in coastal aquifers 593
16.3 Analysis of salt water intrusion 596
16.4 Water management 601
16.5 Prevention and control of sea water intrusion 607

Hydrology of Forest Areas **610 - 618**

17 17.1 General 610
17.2 Tree morphology 611
17.3 Influence of vegetation 612
17.4 Forest characteristics and interaction between forest cover and hydrology 612
17.5 Hydrologic processes affected 613
17.6 Effect of forests on various hydrological parameters 613
17.7 The influence of the forest in reducing fluctuations in the outflow of water from the watershed 615
17.8 Hydrologic evaluation of land treatment 615
17.9 Researches in India 617

Environmental Flow **619 - 626**

18 18.1 The problem 619
18.2 Environmental flows and river management 619
18.3 The significance of different flows 621
18.4 Methods for quantifying environmental flows 622
18.5 Environmental flows in the decision making process 625

Flood Routing **627 - 685**

19	19.1	Basic principles	627
	19.2	Reservoir routing	628
	19.3	Channel routing	658
	19.4	Lag methods	675
	19.5	Graphical method	679
	19.6	Basin outflow by routing	681
	19.7	Routing machines	682
	19.8	Simulation of dam break flood waves	683
Flood Forecasting			**686 - 707**
20	20.1	General	686
	20.2	Flood forecasting system operation	687
	20.3	Flood forecasting in India	688
	20.4	Flood forecasting in other countries	692
	20.5	Forecasting (unit hydrograph method)	694
	20.6	Flood forecasting from meteorological and snow data – after Michael C. Quick	695
	20.7	Rainfall measurements and storm tracking with the help of radar	699
	20.8	Radioactive tracers in hydrometeorology	702
	20.9	Applications of remote sensing to hydrology	702
Reservoir Sedimentation			**708 - 748**
21	21.1	The problem	708
	21.2	Erosion	710
	21.3	Sediment transport	712
	21.4	Sediment characteristics – density of sediment deposited in reservoir	718
	21.5	Trap efficiency of reservoirs	720
	21.6	Sedimentation rate	721
	21.7	Distribution of sediment	728
	21.8	Useful life of reservoirs	737
	21.9	Density currents	740
	21.10	Trend of sedimentation in reservoirs in India	741
	21.11	Delta formation	742
	21.12	Control of sedimentation in reservoirs – soil conservation measures	743
	APPENDIX - Definitions		749
	REFRENCES		760
	AUTHOR INDEX		767
	SUBJECT INDEX		772