M.E – HWRE

OBJECTIVES

1. To prepare the students for a successful career as hydrologist and water resources engineers
2. To develop the ability among students to synthesis data and technical concepts for application in hydrology and water resources engineering
3. To provide students an opportunity to work as a part of interdisciplinary team
4. To provide students with a sound foundation in the mathematical, scientific and engineering fundamentals necessary to formulate, analyze, solve engineering problems and to prepare them for their career.
5. To promote student awareness of the life-long learning and to introduce them professional ethics and codes of professional practice in water resource engineering

OUTCOME

At the end of the course, students must be in a position to

1. Understand the application of fluid mechanics model studies and computers in solving a host of problems in hydraulic engineering
2. Study types and classes of hydrologic simulation models and design procedures for safe and effective passage of flood flows for design of hydraulic structures
3. Enable the students to understand the basic aquifer parameters and groundwater resources for different hydro-geological boundary conditions
4. The student is exposed to the application of systems concept, advanced optimization techniques to cover the socio-technical aspects in the field of water resources
5. Apply the principles and applications of remote sensing, GPS and GIS in the context to hydrological extreme flood and drought events in water resources engineering

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M.E.HYDROLOGY AND WATER RESOURCES ENGINEERING

CURRICULUM AND SYLLABUS I TO IV SEMESTERS (FULL TIME)

SEMESTER I

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HW8101	Advanced Fluid Mechanics	3	0	0	3
2	HW8102	Advanced Groundwater Hydrology	3	0	0	3
3	HW8103	Surface Water Hydrology	3	0	0	3
4	MA8161	Statistical Methods for Engineers	3	1	0	4
5		Elective I	3	0	0	3
6		Elective II	3	0	0	3
PRACTICAL						
7	HW8111	Advanced Hydraulics Laboratory	0	0	4	2
		TOTAL	**18**	**1**	**4**	**21**

SEMESTER II

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HW8201	Advanced Hydrologic Analysis and Design	3	0	0	3
2	HW8202	Open Channel Hydraulics	3	0	0	3
3	CM8251	Coastal Engineering	3	0	0	3
4	HW8253	Remote sensing and GIS for Water Resources	3	0	0	3
5	HW8254	Systems Analysis in Water Resources	3	0	0	3
6		Elective III	3	0	0	3
PRACTICAL						
7	HW8262	GIS Laboratory	0	0	4	2
		TOTAL	**18**	**0**	**4**	**20**

SEMESTER III

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HW8351	Computational Intelligence for Hydro Systems	3	0	0	3
2	HW8353	Water and Environment	3	0	0	3
3		Elective IV	3	0	0	3
PRACTICAL						
4	HW8311	Project Work Phase I	0	0	12	6
		TOTAL	**9**	**0**	**12**	**15**

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SEMESTER IV

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	HW8411	Project Work Phase II	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 68

ELECTIVES FOR M.E.HYDROLOGY AND WATER RESOURCES ENGINEERING

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1	HW8001	Aquifer Storage and Recovery	3	0	0	3
2	HW8002	Environmental Hydraulics	3	0	0	3
3	HW8003	Groundwater Modelling and Management	3	0	0	3
4	HW8004	Isotope Techniques in Water Resources Management	3	0	0	3
5	HW8005	Soil Aquifer Treatment Technology	3	0	0	3
6	CM8151	Wave Hydrodynamics	3	0	0	3
7	HW8071	Flood Modelling and Drought Assessment	3	0	0	3
8	HW8072	Research Methodology for Water Resources	3	0	0	3
9	HW8073	River Engineering	3	0	0	3
10	HW8074	Urban Water Resources Management	3	0	0	3
11	HW8075	Water Supply and Buried Pipelines	3	0	0	3
12	HW8076	Water Power and Dam Engineering	3	0	0	3
13	IM8154	Integrated Water Resources Management	3	0	0	3
14	IM8251	Climate Change and Water Resources	3	0	0	3
15	IM8351	Legal Aspects of Water Resources	3	0	0	3
16	IM8352	Watershed Conservation and Management	3	0	0	3
17	IW8071	Rehabilitation and Modernisation of Irrigation Systems	3	0	0	3
18	IW8252	Ground Water and Drainage Engineering	3	0	0	3

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M.E.HYDROLOGY AND WATER RESOURCES ENGINEERING

CURRICULUM AND SYLLABUS I TO VI SEMESTERS (PART TIME)

SEMESTER I

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA8161	Statistical Methods for Engineers	3	1	0	4
2	HW8101	Advanced Fluid Mechanics	3	0	0	3
3		Elective I	3	0	0	3
		TOTAL	**9**	**1**	**0**	**10**

SEMESTER II

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HW8201	Advanced Hydrologic Analysis and Design	3	0	0	3
2	HW8254	Systems Analysis in Water Resources	3	0	0	3
3	CM8251	Coastal Engineering	3	0	0	3
		TOTAL	**9**	**0**	**0**	**9**

SEMESTER III

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HW8102	Advanced Groundwater Hydrology	3	0	0	3
2	HW8103	Surface Water Hydrology	3	0	0	3
3		Elective II	3	0	0	3
PRACTICAL						
4	HW8111	Advanced Hydraulics Laboratory	0	0	4	2
		TOTAL	**9**	**0**	**4**	**11**

SEMESTER IV

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HW8202	Open Channel Hydraulics	3	0	0	3
2	HW8253	Remote sensing and GIS for Water Resources	3	0	0	3
3		Elective III	3	0	0	3
PRACTICAL						
4	HW8262	GIS Laboratory	0	0	4	2
		TOTAL	**9**	**1**	**4**	**11**

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SEMESTER V

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HW8351	Computational Intelligence for Hydro Systems	3	0	0	3
2	HW8353	Water and Environment	3	0	0	3
3		Elective IV	3	0	0	3
PRACTICAL						
4	HW 8311	Project Work Phase I	0	0	12	6
		TOTAL	**9**	**0**	**12**	**15**

SEMESTER VI

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	HW8411	Project Work Phase II	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 68

ELECTIVES FOR M.E.HYDROLOGY AND WATER RESOURCES ENGINEERING

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1	HW8001	Aquifer Storage and Recovery	3	0	0	3
2	HW8002	Environmental Hydraulics	3	0	0	3
3	HW8003	Groundwater Modelling and Management	3	0	0	3
4	HW8004	Isotope Techniques in Water Resources Management	3	0	0	3
5	HW8005	Soil Aquifer Treatment Technology	3	0	0	3
6	CM8151	Wave Hydrodynamics	3	0	0	3
7	HW8071	Flood Modelling and Drought Assessment	3	0	0	3
8	HW8072	Research Methodology for Water Resources	3	0	0	3
9	HW8073	River Engineering	3	0	0	3
10	HW8074	Urban Water Resources Management	3	0	0	3
11	HW8075	Water Supply and Buried Pipelines	3	0	0	3
12	HW8076	Water Power and Dam Engineering	3	0	0	3
13	IM8154	Integrated Water Resources Management	3	0	0	3
14	IM8251	Climate Change and Water Resources	3	0	0	3
15	IM8351	Legal Aspects of Water Resources	3	0	0	3
16	IM8352	Watershed Conservation and Management	3	0	0	3
17.	IW8071	Rehabilitation and Modernisation of Irrigation Systems	3	0	0	3
18.	IW8252	Ground Water and Drainage Engineering	3	0	0	3

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HW 8101 **ADVANCED FLUID MECHANICS** **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce students to concepts of fluid mechanics from both theoretical and applications perspective.
- Outcomes: The students will have sufficient mathematical and physical background to formulate real life problems in fluid mechanics.

UNIT I INTRODUCTION & BACKGROUND 9

Continuum hypothesis, fluid properties, basic thermodynamic relations, perfect gas, scalars and vectors, cartesian tensors, Gauss's theorem, Stokes theorem. Lagrangian and Eulerian description, material derivative and stream function.

UNIT II CONSERVATION LAWS AND DIMENSIONAL ANALYSIS 9

Control volume concepts, Reynolds transport theorem, conservation of mass, momentum and energy, Navier-Stokes equation, non-dimensional parameters determined from differential equations, Buckingham's Pi theorem, similitude and model testing.

UNIT III IDEAL FLUID FLOW 9

Stream function and velocity potential, Laplace equation, application of complex variables, flow at a wall angle, source, sink, doublet, flow past Rankine half-body, flow past a circular cylinder with circulation, source near a wall, method of images, conformal mapping and applications.

UNIT IV REAL FLUID FLOW 9

Laminar flow, analogy between heat and vorticity diffusion, steady flow between parallel plates, steady flow between concentric cylinders, impulsively started plate, high and low Reynold's number flows, creeping flow around a sphere, Hele-Shaw flow. Boundary layers, Blasius solution, von-Karman momentum integral equation, boundary layer separation and control.

UNIT V INSTABILITY AND TURBULENCE 9

Method of normal modes, thermal instability, Kelvin-Helmholtz instability, Orr-Sommerfield equation, inviscid instability of parallel flows, turbulence, averages, correlations and spectra, averaged equation of motion, kinetic energy budget of mean flow, kinetic energy budget of turbulent flow, turbulence production and cascade, wall shear flows, eddy viscosity and mixing length hypothesis, turbulence closure.

TOTAL: 45 PERIODS

OUTCOMES:

- The students will be able to get a basic knowledge of the applicability of physical laws is addressing problems in hydraulics and hydrology.
- They will gain the skills to take up research activities involving fluid motions.

REFERENCES:

1. Kundu P.K. and Cohen I.M. "Fluid Mechanics" 2nd edition Academic Press, Elsevier Science India 2002.
2. Schlichting H. and Gersten K. "Boundary Layer Theory", 8th edition. Springer-Verlag 2004, ISBN 81-8128-121-7
3. Yuan S.W. "Foundations of Fluid Mechanics" (SI unit edition) Prentice Hall of India 1970
4. Vallentine H.R. "Applied Hydrodynamics" Butterworths London 1959
5. White F.M. "Viscous Fluid Flow", 3rd edition McGraw Hill, New York, ISBN:007124493X
6. Tennekes H. and Lumley J.L. A First Course in Turbulence MIT Press 1972 ISBN 0 262 20019 8

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HW8102 ADVANCED GROUNDWATER HYDROLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

- The objective of this course is enable to the student to understand the basic empirical knowledge of the residence and movement of groundwater, as well as a number of quantitative aspects.
- At the end of the course, the student should be able to evaluate the aquifer parameters and groundwater resources for different hydro-geological boundary conditions.

UNIT I GROUNDWATER BASICS 8

Introduction to Groundwater – Hydro meteorology – Groundwater in Hydrologic Cycle – Occurrence of groundwater – zone of Aeration and Saturation – Hydrogeology — Types of aquifers soil sample analysis - Water bearing materials – Aquifer parameters and its determination.

UNIT II GROUNDWATER HYDRAULICS 10

Groundwater Movement - Darcy's law and its limitations - Stream lines and flow net analysis – Potential flow theory – Discharge and draw down for various condition of groundwater flow - Principles of groundwater flow and its equation – Dupuit – Forchheimer assumptions – Influent and Effluent streams - Evaluation of well loss parameters – Partial penetration of wells – Interference of wells

UNIT III PUMPING TEST ANALYSIS 10

Determining aquifer parameters for unconfined, leaky and non-leaky aquifers – steady and transient conditions - Slug test – Locating hydro geological boundaries – Image well theory – Determination of well characteristics and specific capacity of wells – Well characteristics of large diameter wells.

UNIT IV WELL DESIGN AND CONSTRUCTION 8

Well design criteria – Construction of wells – Well drilling methods – Filter design – Artificial and natural packing – Well casings and screens – Production test – Maintenance of production wells – Pumping Equipment – protection of wells and Rehabilitation – Horizontal wells - Collector wells and Infiltration galleries

UNIT V SPECIAL TOPICS 9

Methods of artificial groundwater recharge – Groundwater Basin Management and conjunctive use - Groundwater assessment and balancing – Regional Groundwater Modeling-
Seawater intrusion in coastal aquifers – Land Subsidence – Groundwater flow in Hard Rock System: conceptual models – structure and hydrodynamic properties of hard rock aquifers.

TOTAL: **45 PERIODS**

OUTCOME:

- Students are able to understand aquifer properties and its dynamics after the completion of the course. It imparts exposure towards well design and practical problems of ground water aquifers.

REFERENCES:

1. Todd D.K., "Groundwater Hydrology", John Wiley & Sons, Inc, New York, 1976.
2. Bear J., "Hydraulics of Groundwater", McGraw-Hill, New York, 1979.
3. Bouwer H., "Groundwater Hydrology", McGraw-Hill, New York, 1978.
4. Driscoll, "Groundwater and Wells", Johnson Filtration Systems, Inc., 1986.
5. Hantush M.S., "Hydraulics of wells in Advances in Hydro science", Academic Press, 1964.
6. Ojha, C.S.P, Berndtsson, R and Bhunya, P., "Engineering Hydrology", Oxford University Press,New Delhi, 2008.
7. A.K. Rastogi, "Numerical Groundwater Hydrology", 2011

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HW8103 **SURFACE WATER HYDROLOGY** **L T P C**
3 0 0 3

OBJECTIVE:

- This subject aims at making the students to understand the relevance of various components of hydrologic cycle, which are responsible for spatial and temporal distribution of water availability in any region.

UNIT I HYDROMETEOROLOGY **9**

Hydrologic cycle – Global water budget – Practical applications – Hydrometeorology – Constituents of atmosphere – Vertical structure of the atmosphere – general circulation – Transitory system – Air mass – Air front – cyclones – Formation of precipitation – Types and forms of precipitation – Climate and Weather – Meteorological Observations.

UNIT II PRECIPITATION **8**

Measurement of rainfall – Rain gauges – Radar Measurement of rainfall - Rainfall Hyetograph – Intensity Duration and Frequency analysis – Consistency – Missing data – Rain gauge network – Average depth of rainfall analysis – Spatial analysis using GIS – Annual rainfall of India and Tamilnadu

UNIT III ABSTRACTIONS **8**

Water losses - Initial losses – Interception and depression storage – Evaporation – Evaporimeters – Estimation of Evaporation - Evapotranspiration – Field Measurement – Empirical Equations - Infiltration – Infiltrometers – Infiltration Equations - Infiltration Indices.

UNIT IV STREAMFLOW MEASUREMENT **8**

Stage and Velocity Measurement – Gauges – Current meter and Doppler flow velocity meter - Discharge measurement – Area Velocity method - Area Slope method – Discharge Measuring Structures - Dilution Technique – Stage Discharge relationship – Selection of a Stream Gauging Site.
.

UNIT V RUNOFF AND WATER CONSERVATION **12**

Concept of catchment – Linear, Areal and Relief Aspects – Detailed study of Runoff process – Factors affecting Runoff – Hydrograph – Unit Hydrograph – Synthetic Hydrograph –Runoff estimation - Strange and SCS methods – Water Conservation – Rain water and Runoff Harvesting in Rural and Urban Areas - Reservoir Sedimentation.

TOTAL: 45 PERIODS

OUTCOMES:

- The students obtain the complete knowledge on hydrologic cycle, hydrometeorology and formation of precipitation.
- The students are able to apply the various methods of field measurements and empirical formulas for estimating the various losses of precipitation, stream flow and runoff.
- The students know the various methods of rainwater and runoff harvesting. Then apply the knowledge of soil erosion and sedimentation to estimate the life of the reservoir.

REFERENCES:

1. Chow V.T., Maidment D.R., Mays L.W., "Applied Hydrology", McGraw Hill Publications, New York, 1995.
2. Subramanya K., "Hydrology,Tata McGraw Hill Co., New Delhi, 1994.
3. Patra.K.C, "Hydrology and Water Resources Engineering", Narosa Publications, 2008, 2nd Edition, New Delhi.
4. Jeya Rami Reddy.P, "Hydrology, Laximi Publications, New Delhi, 2004

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MA8161 STATISTICAL METHODS FOR ENGINEERS

L	T	P	C
3	1	0	4

OBJECTIVES:

- To study and understand the concepts of Statistical methods and its applications in Engineering.
- To study the effect of estimation theory, testing of hypothesis, correlation and regression, randomized design, and multivariate analysis.

UNIT I ESTIMATION THEORY 9+3

Estimators: Unbiasedness, Consistency, Efficiency and Sufficiency – Maximum Likelihood Estimation – Method of moments.

UNIT II TESTING OF HYPOTHESIS 9+3

Tests based on Normal, t, X^2 and F distributions for testing of means, variance and proportions – Analysis of r x c tables – Goodness of fit.

UNIT III CORRELATION AND REGRESSION 9+3

Multiple and Partial Correlation – Method of Least Squares – Plane of Regression – Properties of Residuals – Coefficient of multiple correlation – Coefficient of partial correlation – Multiple correlation with total and partial correlations – Regression and Partial correlations in terms of lower order co-efficient.

UNIT IV DESIGN OF EXPERIMENTS 9+3

Analysis of variance – One-way and two-way classifications – Completely randomized design – Randomized block design – Latin square design.

UNIT V MULTIVARIATE ANALYSIS 9+3

Random vectors and Matrices – Mean vectors and Covariance matrices – Multivariate Normal density and its properties – Principal components: Population principal components – Principal components from standardized variables.

L: 45 + T : 15 TOTAL : 60 PERIODS

OUTCOME:

- On completion of this course the students will be able to solve various problems in the field of engineering employing probability and statistical methods.

REFERENCES:

1. Gupta.S.C., and Kapoor, V.K., "Fundamentals of Mathematical Statistics", Sultan Chand and Sons, Eleventh Edition, 2002
2. J.E. Freund, Mathematical Statistical", 5th Edition, Prentice Hall of India, 2001.
3. Jay L.Devore, "Probability and statistics for Engineering and the Sciences", 5th Edition, Thomson and Duxbury, Singapore, 2002
4. Murray.R. SpiegelandLarry J.Stephens, "Schaum'sou Tlines- Statistics", 3rd Edition, Tata McGraw-Hill, 2000
5. R.A.Johnson and C.B.Gupta, "Miller & Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 7th Edition, 2007
6. Richard A.Johnson and Dean W.Wichern, "Applied Multivariate Statistical Analysis", Pearson Education, Asia, 6th Edition, 2007

HW8111 ADVANCED HYDRAULICS LABORATORY

L	T	P	C
0	0	4	2

OBJECTIVE:

- To expose the students to experimental learning of fluid phenomena both in air and water, practical aspects of aquifer mapping and parameters.

LIST OF EXPERIMENTS

- Wave length, profile and group velocity as a function of wave period, water depth and wave height.
- Wave forces n cylinders and piers.
- Drag and lift characteristics of aerofoils.
- Hydraulic jump studies.
- Hele – Shaw model.
- Geophysical survey.
- Electrical Resistivity Method : Wenner and Schlumberger Configuration.
- Aquifer parameter Estimation : Infiltration test and Permeability Test.
- Borehole Dilution Method.
- Drum Culture Experiment.

TOTAL: 45 PERIODS

OUTCOME:

- The students will be able to design and construct experimental models related to open channel hydraulics and coastal engineering. The students will be able to conduct experiments to explore groundwater potential.

HW8201 ADVANCED HYDROLOGIC ANALYSIS AND DESIGN

L	T	P	C
3	0	0	3

OBJECTIVES:

- Introduce the concepts of systems approach to hydrological modeling.
- Analysis of Hydrologic time series and stochastic hydrologic models.
- Study types and classes of hydrologic simulation models.
- Design procedures used for safe and effective passage of flood flows and discuss the design methods

UNIT I HYDROLOGIC SYSTEM AND STATISTICAL ANALYSIS 9

Hydrologic cycle – System concept – Hydrologic system Model – Classification of Hydrologic Models – Statistical, Stochastic and Deterministic Approaches – Statistical characteristics of Hydrological Data – Probability distribution of Hydrologic Variables - Correlation Analysis – Developing Prediction Equation by Simple and Multiple Linear Regression – Reliability of the Model.

UNIT II HYDROLOGIC TIME SERIES ANALYSIS 10

Stochastic Process – Classification – Stationary Process – Time series – Classification – Component of Time series – Method of Investigation – Auto Correlation coefficient – Moving Average Process – Auto Regressive Process - Auto Regressive Moving Average Process - Auto Regressive Integrated Moving Average Process – Thomas Fiering Model – Box Jenkins Model – Model formulation – Parameter Estimation – Calibration and Validation – Application to hydrologic data Generation and Forecasting.

UNIT III DETERMINISTIC HYDROLOGIC SIMULATION 10

Classification of Deterministic Model – Black Box, Conceptual and Physically based Models – Rational method - Models of IUH, Nash and Chow-Kulandaiswamy Models – Lumped and Distributed Conceptual Models – Single event and Continuous Conceptual Models – HEC HMS, Tank Model, WBNM and other Models – Physically based Models – SWAT and MIKE SHE – Model Calibration and Validation

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UNIT IV DESIGN STORM AND ITS SYNTHESIS 8

Hydrologic Design Scale – Estimating Limiting Value – Hydrologic Design level – Hydrologic Design Data - Hydraulic structure Design methods - Estimation of PMP - Computation of Design Storm - IDF Relationships - Design Flows - Hydrologic Risk, Reliability and Safety Factor.

UNIT V HYDROLOGIC DESIGN 8

Hydrologic Design Standard and Criteria - Design storms for Minor and Major structures – Hydrologic Design of Culverts, Highway and Railway Bridges - Urban Storm Drainage Design – SWMM – Airport Drainage Design - Detention Storage Design – Design of Spillway.

TOTAL: 45 PERIODS

OUTCOMES:

- Students develop prediction equation between hydrologic variables using simple and multiple linear regression.
- Students apply the time series models for hydrologic data generation and forecasting.
- Student exposed to different types and procedure for calibration and validation of deterministic simulation models.
- Students apply the hydrologic design concepts and methods for estimating the design flows for minor, medium and major hydraulic structures.

REFERENCES:

1. V. T. Chow, David Maidment, and Larry Mays, "Applied Hydrology", McGraw Hill Publications, New York, 1995.
2. Singh, V. P. "Hydrologic Systems", Prentice-Hall Englewood Cliffs, NJ 1989.
3. Jayarami Reddy P., "Stochastic Hydrology", Laxmi Publications, New Delhi 1995.
4. Viessman W Jr and Lewis.G.L.," Introduction to Hydrology (5^{th} ed)" Pearson Education, Inc. 2008.
5. Haan C.T., "Statistical Methods in Hydrology" Iowa State Press 2002.

HW8202 OPEN CHANNEL HYDRAULICS

L	T	P	C
3	0	0	3

OBJECTIVES:

- Application of principles of fluid mechanics to the solution of problems encountered in both natural and constructed water systems.
- Use of model studies and computers in solving a host of problems in hydraulic engineering.

UNIT I BASIC PRINCIPLES 9

Basic concepts of uniform flow - computations. Specific energy and specific force concepts – applications.

UNIT II STEADY VARIED FLOWS IN OPEN CHANNELS 9

Dynamic equation for spatially varied flows. Flow profile computations. Introduction to HEC-RAS. Spatially varied flows and rapidly varied flows – applications.

UNIT III UNSTEADY FLOWS IN OPEN CHANNELS 9

Equations of motion. Uniformly progressive wave. Rapidly varied unsteady flow – positive and negative surges. Dam break problem.

UNIT IV SEDIMENT TRANSPORT 9

Sediment properties – inception of sediment motion – bed forms. Bed load suspended load – Total sediment transport. Design of stable channels and regime channels. Reservoir sedimentation and trap efficiency.

UNIT V FLOW MEASUREMENTS AND HYDRAULIC MODELING 9

Sharp-Crested weirs, broad-crested weirs, critical depth flumes. Recent advancement in open channel flow measurements. Physical modeling in hydraulics. Dimensional analysis. Modeling closed flows and free surface flows. Distorted models. Design of physical models.

TOTAL: 45 PERIODS

OUTCOMES:

- The students will be apply their knowledge about fluid mechanics in addressing problems in open channels.
- They will develop skills to solve problems using HEC-RAS software.
- They will be able to make flow measurements in fields.

REFERENCES:

1. Sturm T.W., "Open Channel Hydraulics" – 2nd edition. Tata-McGraw Hill New Delhi 2011. ISBN:978-1-25-900225-0
2. Wurbs R.A., and James W.P. "Water Resources Engineering". Prentice Hall of India, Eastern Economic Edition. ISBN: 81-203-2151-0, New Delhi, 2007.
3. Subramanya K., "Flow in Open Channels (2nd ed.) Tata McGraw Hill, ISBN 00-746-2446-6, New Delhi 2003.
4. Chaudhry M. H., "Open Channel Flow. Prentice Hall of India, Eastern Economic Edition , . ISBN: 81-203-0863-8,New Delhi. 1994.
4. Chow Ven-te "Open Channel Hydraulics McGraw Hill, New York NY 1959.
5. French, R. H., "Open Channel Hydraulics McGraw Hill, New York NY 1985.
6. Srivastava R. Flow through Open Channels Oxford University Press New Delhi 2008.

CM8251 COASTAL ENGINEERING

L	T	P	C
3	0	0	3

OBJECTIVE:

- The main purpose of coastal engineering is to protect harbors and improve navigation. The students to the diverse topics as wave mechanics, wave climate, shoreline protection methods and laboratory investigations using model studies.

UNIT I INTRODUCTION TO COASTAL ENGINEERING 9

Indian Scenario – Classification of Harbours. Introduction - wind and waves – Sea and Swell - Introduction to small amplitude wave theory – use of wave tables- Mechanics of water waves – Linear (Airy) wave theory, Introduction to Tsunami

UNIT II WAVE PROPERTIES AND ANALYSIS 9

Behaviour of waves in shallow waters, Introduction to non-linear waves and their properties – Waves in shallow waters – Wave Refraction, Diffraction and Shoaling –Hindcast wave generation models, wave shoaling; wave refraction; wave breaking; wave diffraction random and 3D waves- Short term wave analysis – wave spectra and its utilities - Long term wave analysis- Statistics analysis of grouped wave data.

UNIT III COASTAL SEDIMENT TRANSPORT 9

Dynamic beach profile; cross-shore transport; along shore transport (Littoral transport), sediment movement

UNIT IV COASTAL DEFENSE 9

Field measurement; models, groins, sea walls, offshore breakwaters, artificial nourishment - planning of coast protection works - Design of shore defense structures –Case studies.

UNIT V MODELING IN COASTAL ENGINEERING 9

Physical modeling in Coastal Engineering – Limitations and advantages – Role of physical modeling in coastal engineering – Numerical modeling – Modeling aspects – limitations – Case studies using public domain models, Tsunami mitigation measures

TOTAL: 45 PERIODS

OUTCOME:

- Students will understand coastal engineering aspects of harbors methods to improve navigation, shoreline protection and other laboratory investigations using model studies and to use the skills and techniques in ICM.

REFERENCES:

1. Mani J.S., "Coastal Hydrodynamics". PHI Pvt.Ltd. New Delhi – 2012.
2. Dean, R.G. and Dalrymple, R.A., "Water wave mechanics for Engineers and Scientists", Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1994.
3. Ippen, A.T., "Estuary and Coastline Hydrodynamics", McGraw-Hill, Inc., New York, 1978.
4. Sorenson, R.M., "Basic Coastal Engineering", A Wiley-Interscience Pub. New York, 1978.
5. "Coastal Engineering Manual", Vol. I-VI, Coastal Engineering Research Centre, Dept. of the Army, US Army Corps of Engineers, Washington DC, 2006.
6. Kamphuis, J.W., "Introduction to Coastal Engineering and Management"
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9. Narasimhan S., Kathiroli S. and Nagendra Kumar B. “Harbour and Coastal Engineering (Indian Scenario)” Vol.I and II.NIOT Chennai 2002.

HW8253 REMOTE SENSING AND GIS FOR WATER RESOURCES L T P C

3 0 0 3

OBJECTIVE:

- To teach the principles and applications of remote sensing, GPS and GIS in the context of water resources. At the end of the course, the student will appreciate the importance of remote sensing and GIS in solving the spatial problems in water resources.

UNIT I REMOTE SENSING 8

Physics of remote sensing, electromagnetic radiation (EMR), Interaction of EMR with atmosphere, earth surface, soil, water and vegetation; Remote sensing platforms – Monitoring atmosphere, land and water resources - LANDSAT, SPOT, ERS, IKONOS and others, Indian Space Programme.

UNIT II DIGITAL IMAGE PROCESSING 8

Satellite Data analysis - Visual interpretation – Digital image processing – Image preprocessing – Image enhancement – Image classification – Data Merging.

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UNIT III GEOGRAPHIC INFORMATION SYSTEM 9

Definition – Basic components of GIS – Map projections and co-ordinate system – Spatial data structure: raster, vector – Spatial Relationship – Topology – Geodatabase models: hierarchical, network, relational, object oriented models – Integrated GIS database -common sources of error – Data quality: Macro, Micro and Usage level components - Meta data - Spatial data transfer standards.

UNIT IV SPATIAL ANALYSIS 9

Thematic mapping – Measurement in GIS: length, perimeter and areas – Query analysis – Reclassification – Buffering - Neighbourhood functions - Map overlay: vector and raster overlay – Interpolation – Network analysis –Digital elevation modelling. Analytical Hierarchy Process, – Object oriented GIS – AM/FM/GIS – Web Based GIS

UNIT V WATER RESOURCES APPLICATIONS 11

Spatial data sources – 4M GIS approach water resources system – Thematic maps - Rainfall-runoff modelling – Groundwater modeling – Water quality modeling - Flood inundation mapping and Modelling – Drought monitoring – Cropping pattern change analysis –Performance evaluation of irrigation commands. Site selection for artificial recharge - Reservoir sedimentation.

TOTAL : 45 PERIODS

OUTCOMES:

- Introduce the technology and principles of Satellite Imaging
- Theoretical explanations on Image processing and information extraction from Satellite Data Products
- Functional elucidation of GIS integrating Satellite Data Products into the GIS platform for Decision making
- Potential of remote sensing and GIS is solving problems in water resources through case studies.

REFERENCES:

1. Lillesand, T.M. and Kiefer, R.W., "Remote Sensing and Image Interpretation" 3rd Edition. John Wiley and Sons, New York. 1993.
2. Burrough P.A. and McDonnell R.A., "Principles of Geographical Information Systems",.Oxford University Press. New York. 1998.
3. Ian Heywood Sarah, Cornelius and Steve Carver "An Introduction to Geographical Information Systems". Pearson Education. New Delhi, 2002.
4. "Centre for Water Resources", Change in Cropping Pattern in Drought Prone Chittar Sub-basin, Project Report, Anna University, Chennai, 2002.
5. "Centre for Water Resources", Post-Project Evaluation of Irrigation Commands

HW8254 SYSTEMS ANALYSIS IN WATER RESOURCES L T P C
3 0 0 3

OBJECTIVE:

- Students will be introduced to application of systems concept to water resources planning and management. Optimization technique for modeling water resources systems and advanced optimization techniques to cover the socio-technical aspects will be taught.

UNIT I SYSTEM CONCEPTS 7

Definition, classification, and characteristics of systems - Scope and steps in systems engineering - Need for systems approach to water resources and irrigation.

UNIT II LINEAR PROGRAMMING 9

Introduction to operations research - Linear programming, problem formulation, graphical solution, solution by simplex method - Sensitivity analysis, application to design and operation of reservoir, single and multipurpose development plans - Case studies.

UNIT III DYNAMIC PROGRAMMING 9

Bellman's optimality criteria, problem formulation and solutions - Application to design and operation of reservoirs, Single and multipurpose reservoir development plans - Case studies.

UNIT IV SIMULATION 9

Basic principles and concepts - Random variant and random process - Monte Carlo techniques - Model development - Inputs and outputs - Single and multipurpose reservoir simulation models - Case studies.

UNIT V ADVANCED OPTIMIZATION TECHNIQUES 11

Integer and parametric linear programming - Goal programming models with applications Discrete differential dynamic programming and incremental dynamic programming - Linear decision rule models with application - Stochastic dynamic programming models.

TOTAL: 45 PERIODS

OUTCOME:

- At the completion of the course the students will be able to understand the system behaviors and know how to apply the various simulation and optimization techniques to resolves the various socio-technical aspects of water resources systems.

REFERENCES:

1. Gupta P.K and Man Mohan, "Problems in Operations Research (Methods and solutions)". Sultan Chand and sons, New Delhi, 1995
2. Hiller F.S and Liebermann G.J., "Operations Research CBS Publications and distributions". New Delhi, 1992.
3. Chaturvedi. M.C., "Water Resources Systems Planning and Management". Tata McGraw Hill, New Delhi, 1997.
4. Mays L.W., and Tung YK, "Hydro systems Engineering and Management". McGraw Hill Inc., New York, 1992.
5. Goodman Alvin S., "Principles of Water Resources Planning", Prentice Hall Inc., Englewood Cliffs, New Jersey, 1995.
6. Course material, "Micro Computer Application to Systems Analysis in Irrigation Water Management", CWR, Anna University, 1992.
7. Wagner H.M., "Principles of Operations Research with Application to Management Decisions", Prentice Hall, India, New Delhi, 1993.

HW8262 GIS LABORATORY

L	T	P	C
0	0	4	2

OBJECTIVE:

- The hands on experiments in the image processing, GIS platforms and GPS will make the students to appreciate their importance in hydrology and water resource.

LIST OF EXPERIMENTS

- Georeferencing of toposheet and creating vector layers(MapInfo/ArcGIS)
- Creation of attribute tables and layout preparation (MapInfo/ArcGIS)
- Creation of Digital Elevation Model using Vertical Mapper.
- GPS Survey and its data transformation into GIS environment.
- Converting *.tab file to *.shp & vice versa using Universal Translator.
- Transformation of Google files to GIS environment.
- Creation of Vorronoi / Theissan diagram for points using MapInfo/ArcGIS.
- Use of D8 pointer algorithm for deriving flow direction, flow accumulation and watershed delineation.

- Interpolation of point data to create Spatial Maps.
- Overlay Analysis using ArcGIS.

TOTAL: 60 PERIODS

OUTCOMES:

- Expertise in digital image processing
- Good exposure to the Global positioning system in real time data processing
- Potential of Geographical Information System
- Data integration between Satellite data, GPS and GIS in Decision Making

HW8351 COMPUTATIONAL INTELLIGENCE FOR HYDROSYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVE:

- To develop skills of the students in software usage for simulation and water resources management. To enable the students to understand application of the latest information technology to water resources engineering

UNIT I ADVANCED COMPUTING TECHNIQUES 10

Computer methods in water resources - Computing techniques - Solution to ordinary and partial differential equation using Finite difference and Method of Characteristics- Numerical integration and differentiation Design of digital models - Visual programming - Graphical user interface - Interactive model concepts.

UNIT II ARTIFICIAL INTELLIGENCE 10

Heuristic search - Principle of Artificial Neural Network (ANN) - Application of ANN Model to Hydrology and Crop Water Requirement model. Fuzzy Logic concepts and Applications – Genetic Algorithms-Heuristic Optimization techniques.

UNIT III DIGITAL DATA MANAGEMENT 10

Data base structure - Data acquisition - Data warehouse - Data retrieval-Data format Attribute - RDBMS - Data analysis - Network data sharing - Statistical Analysis (SYSTAT) - Regression - factor analysis - histogram - scatter diagram - Goodness of fit.

UNIT IV SIMULATION SOFTWARE IN WATER RESOURCES 8

Surface water models (HMS) - Storm Water Management Models (SWMM) –culvert hydraulic design(HY) – River Analysis system models (HEC-RAS)-Ground Water Flow models – Groundwater transport models.

UNIT V SIMULATION MODELS IN IRRIGATION WATER MANAGEMENT 7

Soil water assessment simulation models (SWAT) - Basin simulation models (MITSIM, VASIM) Real time operation models - Water Resources Information System, Management Information System. Decision support system for Irrigation management.

TOTAL: 45 PERIODS

OUTCOMES:

- Students can able to enhance the computational knowledge in the field of water resources systems.
- Students could themselves develop the simulation models and use the latest intelligent technology and algorithms.

REFERENCES:

1. Aliev R. A, and Aliev Rashad "Soft Computing and its Applications World Scientific Publications" Co. Pte. Ltd. Singapore, 2001.
2. Janusz Kacprzyk "*Applied Decision with Soft Computing"* Springer, 2003
3. Carlos A. Coello Coello, David A Van Veldhuizen, Gary B Lamont, "Evolutionary Algorthms for Solving Multi-objective problems", Springer, 2002.
4. Tayfur Gökmen "Soft computing in water resources engineering", WIT Press, Great Britain,UK,20124.
5. John E. Gribbin, "Introduction to hydraulics and hydrology with applications for Storm water Management". DELMAR, Thomson Learning, USA,2002.
6. Remson I, Hornberger G.M. and Moiz F.J., "Numerical methods in Sub- Surface Hydrology". Wiley Inter Science, 1985
7. Kazda, I., "Finite element Techniques in ground water flow studies (with Applications in Hydraulic and Geotechnical Engineering)", Elsevier, 1990.
8. Abbott M.B, and Minns A.W. "Computational hydraulics" Ashgate, London,UK,2007.
9. Loucks Daniel P., Jery R Stedinger and Douglas, A. Haith, "Water Resources system Planning and Analysis". Prentice Hall Inc., Englewood Clifts, New Jersey, 1981.

HW8353	**WATER AND ENVIRONMENT**	**L T P C** **3 0 0 3**

OBJECTIVES:

- To understand the role of environment in conditioning water resources and study methods to assess them
- To expose basic management tools available to manage the quality of water

UNIT I ECOLOGICAL PRINCIPLES 7

Water as living medium – Aquatic ecosystems - Population and Communities – Nutrient Cycle – Energy flow – Water and Environment Interactions.

UNIT II WATER QUALITY 9

Chemical composition of water - Hydrological processes and water quality – Suspended and dissolved loads - Sediments and their composition – Eutrophication and its impacts - – Water quality standards.

UNIT III WATER POLLUTION 10

Sources and Types of water pollution – Organic and inorganic pollutants -- BOD – DO relationships – – NPS pollution – Waste water treatment - TMDL Concepts – Water quality models.

UNIT IV ENVIRONMENTAL ASSESSMENT 10

Environmental regulations and requirements – Types and role of EIA – Environment in water resources project planning – Methods of EIA – Hydrological and water quality impacts – Ecological and Biological assessments – ICID check list – EIS statement.

UNIT V ECOLOGICAL MANAGEMENT 9

In stream ecological water needs – Eco restoration strategies – Ecosystem services – Environmental monitoring programs - Public awareness and participation in decision making – Sustainable water resources management – Environmental Governance.

TOTAL: 45 PERIODS

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OUTCOME:

- Students will understand the intricate relationship of water resources with the environmental interactions and appreciate the need to manage water quality.

REFERENCES:

1 Odum, E. P. and G. W. Barrett, "Fundamentals of Ecology", India Edition, Thomson Brooks/cole, India, 2005

2 Canter L. W., "Environmental impact assessment", 2nd edition, Mc Graw Hill & Co., NY, USA, 1996

3 Vladimir Novonty, "Water Quality: Diffuse pollution and watershed Management", 2nd edition, John Wiley & Sons, , 2003

4 Jorgensen, S., J. G. Tundisi, J. M. Tundisi, "Handbook of inland aquatic ecosystem management", CRC Prerss, FL, USA, 2013.

5 Mackenzie L Davis, David A Cornwell, "Introduction to Environmental Engineering", McGraw-Hill 2006.

HW8001 AQUIFER STORAGE AND RECOVERY

L	T	P	C
3	0	0	3

OBJECTIVES:

- Students will be introduced to the new technology of aquifer recharge and their various issues;
- They will also be exposed to geochemical processes of parent groundwater and recharge water;

UNIT I INTRODUCTION **9**

Aquifer Storage and Recovery: A New Management Tool - Feasibility Assessment and Conceptual Design - Recharge Objectives - Regulatory and Water Rights Issues - Institutional Constraints Field Test Program - Site Selection - Outline of Test Program and Duration – ASR Well field Expansion - Recharge Water Quantity and Quality.

UNIT II DESIGN OF ASR SYSTEMS **9**

Design and Construction of Recharge Wells - Selection of ASR Storage Intervals - Wellhead Facilities - Pipeline Flushing and Waste flow Discharge – Pump sets - Cascading Control – Air and Vacuum relief – Pressure and Water Level Measurement – Flow Measurement - Disinfection and pH Adjustment – Advective and Dispersive Mixing.

UNIT III TECHNICAL ISSUES OF ASR **9**

Recovery Efficiency – Well Clogging Processes and Redevelopment – Measurement Methods - Normalization of Clogging Rate - Well head filtration – Pre and Post Treatment – Geo Chemical Processes and Models – Changes in Aquifer Characteristics -

UNIT IV NON-TECHNICAL ISSUES OF ASR **9**

Legal and Regulatory Issues – EPA Surface Water Treatment and Ground Water Quality Rule - Non-Degradation of Groundwater Quality – Seasonal vs Longterm Storage – Recovery Percentage – Water level Impacts – Location for Recovery of Stored Water – Environmental Impacts – Public Involvement

UNIT V ALTERNATIVE TO AQUIFER STROAGE RECOVERY **9**

Agricultural Applications of Treated Waste – Ground Water Recharge through Soil Aquifer Treatment – Reclaimed Water Injection - Technical Considerations – Regulatory Considerations – Economics - Driving Forces – Constraints – Opportunities – Case Studies.

TOTAL: 45 PERIODS

OUTCOME:

- This course enabled to design the ASR system with better understanding of technical and non technical issues of aquifer recharge.

REFERENCES

1. David Pyne. R., "Aquifer Storage and Recovery" in Wells, CRC press, 1995.
2. Karen J. Dawson, Jonathan D. Istok, "Aquifer Testing Design and Analysis of Pumping and Slug Tests", Lewis Publishers, 2002.
3. John T. Scholz and Bruce Stiftel. Editors, "Adaptive Governance Water Conflict – Anew Institutions for Collaborative Planning.
4. George F. Pinder, "Groundwater Modeling using Geographical Information System", John Wiley & Sons, Inc.
5. Charles R. Fitts, "Groundwater Science", Academic Press, An imprint of Elsevier, Elsevier Science Ltd, 2002.

HW8002	ENVIRONMENTAL HYDRAULICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To apply the knowledge of fluid mechanics to analyze and predict mixing in natural bodies of water.
- To study the hydrodynamic aspects of water quality management in natural bodies of water.

UNIT I INTRODUCTION TO ENVIRONMENTAL TRANSPORT PROCESSES 9

Concentration and units of measure – Conservation laws – Systems and Control Volume approach – Differential element approach – Sources, Sinks and box-models – Mixing. Advection-Diffusion equation. Analytical and numerical solution to Advection-Diffusion equation.

UNIT II GROUNDWATER FLOW AND QUALITY MODELING 9

Dupuit's approximation – Basic contaminant transport equation – Application of boundary layer approximations – Saltwater intrusion into aquifers – Non-aqueous phase liquid (NAPL) in groundwater – numerical modeling.

UNIT III TRANSPORT PROCESSES IN RIVERS 9

Mixing in Rivers – Continuous point discharges – Two rivers mixing – Dispersion in rivers.

UNIT IV TRANSPORT PROCESSES IN LAKES AND RESERVOIRS 9

Reservoir classification – External energy sources – Surface layer – mixing in the hypolimnion – inflows and outflows.

UNIT V TRANSPORT PROCESSES IN THE ESTUARIES 9

Classification – Forces – wind, tides, rivers – Trapping and pumping – Estuarine Circulation.

TOTAL: 45 PERIODS

OUTCOMES:

- The students will be able to gain a basic knowledge advection-dispersion processes in the environment.
- They will gain the skills to take up research activities solving environmental problems involving fluid motions.

Attested

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REFERENCES:

1. Fischer, H.B., List, E.G., Koh, R.C.Y., Imberger, J and Brooks, N.H. "Mixing in Inland and Coastal Waters" Academic Press, New York, 1979.
2. Clark, M.M., "Transport Modeling for Environmental Engineers and Scientists" John Wiley and Sons, New York. 1996.
3. Martin J.L. and McCutcheon S.C. "Hydrodynamics and Transport for Water Quality Modeling" CRC Press, Inc. ISBN:0-87371-612-4, 1999.
4. Chapra, S.C. "Surface Water Quality Modeling" McGraw Hill Book Co. Singapore, 1997.
5. M.Thomann, R.V. and Mueller, J.A. "Principles of Surface Water Quality Modeling and Control" Harper and Row, New York, 1987.
6. Csanady, G.T., "Turbulent Diffusion in the Environmen"t D.Reidel Publishing Co. Holland, 1973.
7. Rubin H. and Atkinson J. "Environmental Fluid Mechanics" Marcel Dekker, Inc. New York. 2001

HW8003 GROUNDWATER MODELLING AND MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVE:

- To introduce the students to the application of management models to estimate the groundwater quantity and qualities. After the completion of the course, the student should able to understand the inputs, system parameters, policy, variables and outputs of a groundwater management models.

UNIT I GROUNDWATER PROSPECTING **9**

Investigation and evaluation – Geophysical methods- Electrical Resistivity methods – Interpretation of data – Seismic method – Subsurface investigation – Test drilling – Resistivity logging – Application of remote sensing techniques.

UNIT II GROUNDWATER FLOW MODEL **9**

Physical models – Analog models – Mathematical modeling – Unsaturated flow models Numerical modeling of groundwater flow – Finite difference equations and solutions – Successive over Relaxation, Alternating direction implicit procedure – Crank Nicolson equation – Iterative methods - Direct methods - Inverse problem – Finite element method

UNIT III CONTAMINANT TRANSPORT MODEL **9**

Contaminant transport theory – Advection, dispersion equation – Longitudinal and transverse dispersivity – Hydrodynamic dispersion – Analytical models – Numerical simulation of solute transport – Solution methods - Sorption model – Density driven flow - Heat transport.

UNIT IV MODEL APPLICATIONS **9**

Data requirements – Conceptual model design : Conceptualization of aquifer system – Parameters, Input-output stresses, Initial and Boundary conditions - Model design and execution: Grid design, Setting boundaries, Time discretization and Transient simulation – Model calibration : steady state and unsteady state – sensitivity analysis – Model validation and prediction – Uncertainty in the model prediction

UNIT V GROUNDWATER MANAGEMENT MODELS **9**

Optimal groundwater development – Indian GEC norms – Conjunctive use models Modeling multilayer groundwater flow system -Modeling contaminant migration – Modeling fracture flow system – Artificial recharge feasibility through modeling – Simulation of movements of solutes in unsaturated zone – Stochastic modeling of groundwater flow - Groundwater contamination, restoration and management

TOTAL: 45 PERIODS

OUTCOME:

- Students are able to develop and apply numerical model for various application along with better understanding aquifer characteristics

REFERENCES:

1. Anderson M.P., and Woessner W.W., "Applied Groundwater Modelling : Simulation of flow and advective transport", Academic Press, Inc., 1992
2. Fetter C.W., "Contaminant Hydrogeology", Prentice Hall, 1999
3. Rushton K.R., "Groundwater Hydrology" : Conceptual and Computational Models, Wiley, 2003
4. Elango L. and Jayakumar, R. "Modelling in Hydrology", Allied Publishers Ltd., 2001
5. Remson I., Hornberger G.M. and Moltz F.J., "Numerical Methods in Subsurface Hydrology", Wiley, New York, 1971
6. Robert Willis and William W.G.Yenth, "Groundwater System Planning and Management", Prentice Hall, Englewood Cliffs, New Jersey, 1987.
7. "Groundwater Hydraulics and Pollutant Transport", Randall J.Charbeneau, Printice Hall, 2000
8. A.K. Rastogi, "Numerical Groundwater Hydrology", 2011

HW8004 ISOTOPE TECHNIQUES IN WATER RESOURCES MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVES:

- To introduce the student on the emerging tools such as isotope hydrology
- To demonstrate the application of this advance technique to solve practical problems in hydrology and water resources engineering

UNIT I BASIC PRINCIPLES **9**

Introduction to elements, nuclides, isotopes- Isotopes and their characteristics - Classification of isotopes -Theory of Radioactivity - Stable and radioactive isotope in hydrology;

UNIT II MEASUREMENT TECHNIQUES **9**

Sampling-sample preparation for isotope analysis-Mass spectrometric techniques – Instrumentation - Continuous Flow and Dual injection systems;

UNIT III HYDROMETEOROLOGY **9**

Isotope fractionation-partitioning of isotopes in the hydrologic cycle - Meteoric Water Line (MWL) - Deuterium excess - Rayleigh fractionation model - isotope effects distillation;

UNIT IV APPLICATIONS OF ISOTOPES IN SURFACE WATER HYDROLOGY **9**

Water balance - Lake dynamics- sub-surface inflow and outflow estimates sedimentation in lakes and reservoirs – seepage from dams, reservoirs, canals -stream flow measurements;

UNIT V APPLICATIONS OF ISOTOPES IN GROUND WATER HYDROLOGY **9**

Soil moisture movement - Groundwater velocity in saturated zone - Identification of source of recharge and recharge mechanism - Seawater intrusion - Contaminant hydrogeology;

TOTAL: 45 PERIODS

OUTCOME:

- Students are enabled to apply isotope fingerprints for better understanding of hydrological processes and mechanism for water resources development and management.

REFERENCES:

1. Rao S.M., “Practical Isotope Hydrology”, New India Publishing Agency, 2006.

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2. Clark I D and Fritz P, “Environmental isotopes in hydrogeology, Lewis Publishers, Boca Raton, The Netherlands, 1997.
3. Mook W.G. (Ed), “Environmental Isotopes in Hydrological Cycle, Principles and Applications”, IHP-V, Technical Documents in Hydrology, No 39, Vol 1, UNESCO, Paris, 2000.
4. Fritz P and Fontes J.Ch(Eds.) "Handbook of environmental isotope Geochemistry"-Vol I and II. Elsevier scientific publishing Company, The Netherlands, 1980
5. Criss R. E, "Principles of stable isotope distribution". Oxford University Press.1999.
6. “Use of Artificial Tracers in Hydrology”, Proc. Adv. Group Meeting, Vienna, IAEA, 1990.
7. Kendal C.
8. ,and McDonnell J.J., “Isotopes in Catchment Hydrology”, Elsevier, 1998.

HW8005 SOIL AQUIFER TREATMENT TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES:

- Students will be introduced to the new technique of groundwater reclamation and recharge
- Students will be exposed to the concept of simulation of flow and transport in an unsaturated zone

UNIT I SOIL PHYSICS OF UNSATURATED ZONE 9

Soil Solid Phase : Soil phases, texture, mineralogy and structure – Soil Water Content and Potential: Measuring Soil Water Content and Potential – The Soil Water Retention Curve – Capillary Rise Law and Hydraulic Capacity Function for Van Genuchten Equation.

UNIT II SOIL AQUIFER TREATMENT (SAT) CONCEPTS 9

SAT definition – process description – layouts – components – Dynamics – Filtration, Adsorption, Biodegradation, Ion exchange and precipitation – operation. Hydraulic loading rate, Water depth in the basin, wetting and drying cycles, water Quality improvement: Removal of pathogens, nitrogen, organic carbon and inorganic compounds. Soil clogging: Physical, Chemical & Biological.

UNIT III BASIC PROCESS RESPONSES AND INTERACTIONS 9

Fundamental relationships – movement of pollutants – Groundwater mounding – under drainage – Biodegradable organics removal of BOD – Removal of suspended solids – organic priority pollutants – removal methods – removal performance – travel time in soils – pathogens and metals – Aquatic, wetland and land treatment system – Nutrients : nitrogen, phosphorous, potassium and other micronutrient.

UNIT IV DESIGN OF SAT SYSTEM 9

Design objectives – site selection – Treatment performance – pre application treatment – Design procedure – Design considerations – hydraulic loading rates, nitrogen loading rates – organic loading rates – land requirements – Hydraulic loading cycle – Infiltration system design – construction considerations – operation and maintenance.

UNIT V GROUNDWATER FLOW AND TRANSPORT IN UNSATURATED ZONE 9

Steady flow in saturated and unsaturated soils – Measurement of Hydraulic Properties – Poiseuille Equation – Transient flow in soils – The Richards equation – Initial and Boundary Conditions – Numerical Solutions to the Richard equation – Groundwater Recharge and Discharge – Solute Transport Advection Dispersion Equation – Numerical Approaches for Solute Transport – HYDRUS Examples flow and transport.

TOTAL: 45 PERIODS

OUTCOME:

- Students are enabled to design the SAT system through which unsaturated zone processes and their interaction will be understood. In addition this course leads to learning of vadose zone modeling

REFERENCES:

1. "Natural Wastewater Treatment systems", Ronald W. Crites, Joe Middle brooks & Sherwood C. Reed, CRC Taylor & Francis, 2006;
2. "Soil Physics with HYDRUS, "modelling and applications" by Radcliffe, David E : Simunek, 2005.
3. "Soil Aquifer Treatment system concepts, operation and management", Thaer Abushbak, Lambert Academic Publishing, 2011.
4. "Soil Aquifer Treatment for sustainable water" use by Peter Fox, Sandra Houston and Pane Westernholf, 2001;
5. "Soil Treatability pilot studies to design and model" Soil Aquifer Treatment System, 1997;

CM8151	WAVE HYDRODYNAMICS	L	T	P	C
		3	0	0	3

OBJECTIVE:

- To make the students be aware of the mass, moment and wave energy transformations, Wave kinematics and wave loads that are happening in nature and enable them in the prediction and analysis of sediment distribution along coastal areas, shore protection and hazard management.

UNIT I CONSERVATION OF MASS, MOMENT AND ENERGY 9

Conservation of mass, moment and Energy; Euler Equation – Bernoullis Equation. Potential and Stream function.

UNIT II CLASSIFICATION OF OCEAN WAVES 9

Linear wave theory : Governing Equation, Boundary Conditions and solutions, Dispersion relation, Constancy of wave period.

UNIT III WAVE KINEMATICS 9

Wave celerity, water particle velocities, accelerations, displacements and pressures. Approximations for deep and shallow water conditions. Integral properties of waves: Mass flux, Energy and energy flux, Group speed, Momentum and momentum flux.

UNIT IV WAVE TRANSFORMATIONS 9

Shoaling, bottom friction and damping, refraction, reflection and diffraction. Wave Breaking: Type of breaking, Surf similarity parameter. Keulegan-Carpenter number, Ursell Parameter, Scattering parameter, Reynolds Number.

UNIT V WAVE LOADS 9

Non breaking wave forces on slender structures – Morison equation; Diffraction theory, source distribution method. Introduction to non-linear wave theories-Strokes, Cnoidal and Solitary wave theory. Mass transport velocity, Introduction to Random and directional waves.

TOTAL: 45 PERIODS

OUTCOME:

- Students become aware of wave energy transformations, wave kinematics and enable them in the prediction / analysis of sediment distribution along coastal areas, shore protection and hazard management.

REFERENCES:

1. Sarpkaya, T. and Isaacson, M., "Mechanics of Wave Forces on Offshore Structures", Van Nostrand Reinhold Co., New York, 1981
2. Dean, R.G. and Dalrymple, R.A., "Water wave mechanics for Engineers and Scientists", Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1994
3. Ippen, A.T., "Estuary and Coastline Hydrodynamics", McGraw-Hill Book Company, inc., New York, 1978
4. "Shore Protection Manual Volume I and II", Coastal Engineering Research Centre, Dept, of the Army, US Army Corps of Engineers, Washington DC, 1984
5. Sorenson, R.M., "Basic Coastal Engineering", A Wiley-Interscience Publication, New York, 1978.
6. Goda,Y. 2000.Random seas and Design of Maritime Structures. 2nd ed. Advance Series on Ocean Engineering. Vol.15. World Scientific Publishers Pvt.Ltd. 443pp.
7. Young,I.R.1999. "Wind generated Ocean Waves". Ocean Engineering Book Series. Vol.2. Elsevier. The Netherlands. 288pp.
8. Narasimhan,S., S.Kathiroli,S.and B.Nagendra Kumar (Eds). 2002. "Harbour and Coastal Engineering (Indian Scenario)" Vol.I. NIOT, Chennai. 729pp.
9. Reeves, D, Chadwick,A and Fleming,C. 2004. Coastal Engineering. Processes Theory and Design Practice. SPON Press, London. 461pp.

HW8071 FLOOD MODELLING AND DROUGHT ASSESSMENT

L	T	P	C
3	0	0	3

OBJECTIVE:

- This subject aims at making the students to understand the hydrologic extremes of floods and droughts, estimation of severity and extent of damages and the mitigation measures to combat them.

UNIT I FLOOD ESTMATION **9**

Hydrologic extremes – Flood – Types of Flood – Effects of Flood – Design Flood - SPF/MPF - Estimation of design flood – Physical Indicators - Envelope curves - Empirical methods – Rational method - Statistical methods – Frequency analysis – Unit hydrograph method.

UNIT II FLOOD MODELLING AND MANAGEMENT **9**

Hydrologic and Hydraulic Routing – Reservoir and Channel Routing - Flood Inundation Modelling – HEC HMS and HEC RAS software - Flood control methods – Structural and non structural measures - Flood Plain Zoning – Flood forecasting – Flood Mitigation - Remote Sensing and GIS for Flood modelling and management.

UNIT III DROUGHT AND IMPACTS **9**

Definition – Definitions based on rainfall, stream flow, vegetation and comprehensive aspects - Characterisation of Drought/water shortage/aridity/desertification - Types of Drought – NCA classification – Impacts of Drought – Environmental, Social and Economical aspects

UNIT IV DROUGHT ASSESSMENT **9**

Drought Severity Assessment – Meteorological Hydrological and Agricultural methods – Drought Indices – GIS based Drought Information system – Drought Vulnerability Assessment and Mapping Using GIS.

UNIT V DROUGHT MONITORING AND MANAGEMENT **9**

DPAP Programme - Drought Monitoring – Application of Remote sensing – Drought Mitigation – Proactive and Reactive Approach – Supply and Demand Oriented Measures – Long term and Short term Measures – Water Scarcity Management in Urban, Industrial and Agricultural sectors

TOTAL: 45 PERIODS

OUTCOMES:

- Students know the different methods of design flood estimation and perform channel reservoir routing. They carryout flood inundation modeling and suggest suitable flood control measures.
- Student acquires the knowledge about different types of drought and their impacts. They asses the severity, duration and frequency of drought using drought using drought indices.
- Students exposed to various approaches, measures and case studies of drought indices.

REFERENCES:

1. Chow V.T., Maidment D.R., Mays L.W., "Applied Hydrology", McGraw Hill Publications, New York, 1995.
2. Vijay P.Singh., "Elementary Hydrology", Prentice Hall of India, New Delhi, 1994.
3. Yevjevich V., Drought Research Needs, Water Resources Publications, Colorado State University, USA, 1977.
4. Rangapathy V., Karmegam M., and Sakthivadivel R., Monograph in Flood Routing Methods as Applied to Indian Rivers, Anna University Publications

HW8072 RESEARCH METHODOLOGY FOR WATER RESOURCES

L	T	P	C
3	0	0	3

OBJECTIVES:

- To introduce concepts of research process in hydrology and water resources and water management.
- To enable students to get basic understanding of scientific research methods.
- To develop capacity to independently analyse and define a research problem.

UNIT I SCOPE **10**

Objectives and types of research – Identification of research problem – Research process – Research design – Bibliography.

UNIT II SAMPLE **8**

Sampling theory and sampling design – Types of samples – Sources of data – Qualitative and quantitative data – Data collection methods.

UNIT III DATA **8**

Measurement levels and scaling – Types of errors – Sampling adequacy – Data collection and editing – Coding of data – Analysis and statistical inference.

UNIT IV REPORT **4**

Report preparation – Structure of report – graphs and illustration tools – Tables and charts – Draft – Finalising research report.

UNIT V DESIGN OF A RESEARCH PROJECT **15**

A mini project design

TOTAL: 45PERIODS

OUTCOME:

- Students will understand applied research methods in Science and Engineering and will able to define and formulate a research problem independently.

REFERENCES:

1. Upagade. V and A.Shende, Research Methodology, S.Chanda & Co., New Delhi, 2010.
2. Pannerselvam. R Research Methodology, ***Prentice-Hall of India Private Ltd., New Delhi, 2007.***

HW8073 **RIVER ENGINEERING** **L T P C**
3 0 0 3

OBJECTIVES:
- To understand theoretical concepts of water and sediment movements in rivers
- To inculcate the benefits of fluvial system to the society

UNIT I RIVER FUNCTIONS **8**
Primary function of a river – River uses and measures – Water and Sediment loads of river – Rivers in India, Himalaya and Peninsular.

UNIT II RIVER HYDRAULICS **10**
Physical Properties and Equations – Steady flow in rivers – uniform and non uniform – Turbulence and velocity profiles – resistance coefficients – Boundary conditions and back waters – Transitions – Rating Curve – Unsteady flow in rivers : Propagative of surface waves – Characteristics, flood waves – kinematic and diffusion analogy – velocity of propagation of flood waves – Flood wave –Maximum

UNIT III RIVER MECHANICS **9**
River Equilibrium : Stability of Channel – regime relations – river bend equilibrium – hydraulic geometry of downstream - Bars and meandering - River dynamics – degradation and aggradations of river bed – Confluences and branches – River Data base.

UNIT IV RIVER SURVEYS AND MODEL **9**
Mapping – Stage and Discharge Measurements – Sediments – Bed and suspended load Physical hydraulic Similitude – Rigid and mobile bed – Mathematical – Finite one dimensional – multi – dimensional – Water Quality and ecological model

UNIT V RIVER MANAGEMENT **9**
River training works and river regulation works – Flood plain management – waves and tides in Estuaries - Interlinking of rivers – River Stabilization

TOTAL: 45 PERIODS

OUTCOMES:
- The students will be able to appreciate the complex behavior of rivers.
- They will gain the skills to take up research activities in river engineering.

REFERENCES:

1 Janson PL.Ph., Lvan BendegamJvanden Berg, Mdevries A. Zanen (Editors), Principles of River Engineering – The non tidal alluvial rivers – Pitman, 1979.
2. Pierre Y. Julien ., "River Mechanics" ,Cambridge University Press, 2002.
3. K.L Rao , INDIA's WATER WEALTH – Orient Longman Ltd., 1979.

HW8074 **URBAN WATER RESOURCES MANAGEMENT** **L T P C**
3 0 0 3

OBJECTIVES:
- To introduce the concepts of urbanization and its impact on the natural water cycle
- The student is exposed to the use the urban storm water models for better storm water management.
- Students also exposed for the preparation of urban storm water master plan and different types of operation and maintenance.

UNIT I URBAN HYDROLOGIC CYCLE **9**
Water in the urban eco-system – Urban Water Resources – Major problems – Urban hydrological cycle – Storm water management objectives and limitations – Storm water policies – Feasibility consideration.

UNIT II URBAN WATER RESOURCES MANAGEMENT MODELS 9

Types of models – Physically based – conceptual or unit hydrograph based – Urban surface runoff models – Management models for flow rate and volume control rate – Quality models.

UNIT III URBAN STORM WATER MANAGEMENT 9

Storm water management practices (Structural and Non-structural Management measures) – Detention and retention concepts – Modelling concept – Types of storage – Magnitude of storage – Hydraulic analysis and design guidelines – Flow and storage capacity of urban components – Temple tanks.

UNIT IV MASTER PLANS 9

Planning and organizational aspects – Inter dependency of planning and implementation of goals and measures – Socio – economics financial aspects – Potential costs and benefit measures – Measures of urban drainage and flood control benefits – Effective urban water user organizations.

UNIT V OPERATION AND MAINTENANCE 9

General approaches to operations and maintenance – Complexity of operations and need for diagnostic analysis – Operation and maintenance in urban water system – Maintenance Management System – Inventories and conditions assessment – Social awareness and involvement.

TOTAL: 45 PERIODS

OUTCOME:

- At the completion of the course the student should be able to apply appropriate management techniques for planning, operating and maintaining the different components of urban and drainage system.

REFERENCES:

1. Geiger, W.F., Marsalek, F., and Zuidena, F.C., (Ed), manual ondrainage in urbanized areas – Vol.1 and Vol.II, UNESCO, 1987.
2. Hengeveld, H. and C. De Voch.t (Ed)., Role of Water in Urban Ecology, 1982.
3. Martin, P. Wanelista and Yousef, A. Yousef., Storm Water Management, John Wiley and sons, 1993.
4. Neil S. Grigg., Urban Water Infrastructure Planning, Management and Operations, John Wiley and Sons, 1986.
5. Overtens D.E. and Meadows M.E., Storm Water Modelling, Academic Press, New York, 1976.

HW8075 WATER SUPPLY AND BURIED PIPELINES L T P C
3 0 0 3

OBJECTIVE:

- To educate the students in detailed design concepts related to water transmission mains, water distribution system and buried pipes with emphasis on computer application

UNIT I WATER SUPPLY SYSTEMS 9

Water requirement – sources of water – water demand – reservoir storage – nodal hydraulic gradient level values - water supply consideration, Types of water supply systems- piping system- distribution network- labeling- network components – Network models – design – optimization in practice

UNIT II HYDRAULIC PRINCIPLES AND NETWORK PARAMETERS 10

Energy and hydraulic gradient lines – head loss in links – equivalent pipes – series – parallel pipes – path head loss and loop head loss – analysis of water distribution network- static node, dynamic node – network performance – flow analysis - Layout – in situ lining - pipes material – appurtenances – minimization of water losses – leak detection.

UNIT III STORM WATER DISTRIBUTION AND BURIED PIPES 9

Planning – runoff estimation – rainfall data analysis – storm water drain design Introduction to Buried pipes – external loads – gravity flow design, pressurized flow- rigid and flexible pipes – installation – trenchless technology

UNIT IV RELIABILITY ASSESSMENT AND DESIGN 8

Uncertainty and reliability – affecting events- assessment – reliability parameters- configurations. Design methodology - strengthening and expansion

UNIT V FLUID TRANSIENTS 9

Basic equations of unsteady flows through closed conduits. Method of characteristics. Transients caused by centrifugal pumps and hydroelectric power plants.

TOTAL: 45 PERIODS

OUTCOMES:

- The students will be able to get a basic knowledge of the design of pipe networks.
- They will be able to analyze pipe network problems using computer software like EPANET2.0

REFERENCES:

1. Bhave P. R, Optimal design of water distribution networks, Narosa publishing House, New Delhi, 2003
2. Bajwa. G. S, Practical handbook on Public Health Engineering, Deep publishers, Shimla 2003
3. Manual on water supply and treatment, CPHEEO, Ministry of Urban Development, GOI, New Delhi, 1999
4. B.A. Hauser, practical hydraulics Hand Book, Lewis Publishers, New York, 1991
5. Moser A. P, Buried pipe Design, 3rd Edition, American Water Works Association
6. Robert van Bentum and Lan K. Smout, Buried Pipe lines for surface Irrigation, The Water, Engineering and Development Centre, Intermediate Technology Publications,UK,1994
7. Wurbs R.A., and James W.P. Water Resources Engineering. Prentice Hall of India, Eastern Economic Edition. ISBN: 81-203-2151-0, New Delhi, 2007

HW8076 WATER POWER AND DAM ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- The student is exposed to the design aspects of hydro-power plants, various components of hydropower plants and their layout.
- Different types of dams design taking into account the suitability of the site and the different type loads that are likely to be encountered.

UNIT I HYDROELECTRIC POWER DEVELOPMENT 9

Introduction – Types of power development – Classification. Planning – Environmental Considerations - Data requirement for assessment of hydropower. Components of hydropower.

UNIT II DESIGN OF HYDROPOWER INSTALLATION 9

Components – Intake structure – water conductor systems – tunnels – surge tanks – penstocks – valves – anchor blocks.

UNIT III TYPES OF POWER HOUSE 8

Underground – semi-underground. Turbines and their foundations – structural and geotechnical aspects of power house design.

UNIT IV EMBANKMENT DAM ENGINEERING 9

Introduction. Nature and classification of engineering soils. Principles of design. Materials and construction. Internal seepage. Stability and stress. Settlement and deformation. Rock fill and rock fill embankments.

UNIT V CONCRETE DAM ENGINEERING 10

Loading: Concepts and criteria. Gravity dam analysis. Buttress dam analysis. Arch dam analysis. Design features and construction. Concrete for dams. Roller Compacted Concrete (RCC) Dams. Dam safety and instrumentation. Foundation measurements. Analysis of strain data.

TOTAL: 45 PERIODS

OUTCOME:

- The students will be able to get a basic knowledge of planning and designing hydropower plants.

REFERENCES:

1. Novak, P., Moffat, A.I.B., Nalluri, C. and Narayanan, R. Hydraulic Structures Unwin Hyman Ltd., London 1989.
2. Dandekar, M.M. and Sharma, K.N. Water Power Engineering Vikas Publishing House, New Delhi 1994.
3. USBR Design of Small Dams Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi 1974.
4. Sharma, H.D. Concrete Dams Metropolitan New Delhi 1981
5. Varshney, R.S. Concrete Dams Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi 1982.
6. Varshney, R.S. Hydro Power Structures – Nem Chand Bros. Roorkee 1973 Guthrie, Brown J. (ed) Hydro Electric Engineering Practice Blackie and Son, Glasgow 1970.

IM8154 INTEGRATED WATER RESOURCES MANAGEMENT L T P C 3 0 0 3

OBJECTIVES:

- Students will be introduced to the role of disciplines of ecology and socio-economics play in management of water resources.
- They will be exposed to global food security and public-private participation issues and legal and regulatory settings, in the context of IWRM

UNIT I CONTEXT FOR IWRM 8

Water as a global issue: key challenges and needs – Definition of IWRM within the broader context of development – Complexity of the IWRM process – Examining the key elements of IWRM process.

UNIT II WATER ECONOMICS 12

Economic view of water issues: economic characteristics of water good and services – Non-market monetary valuation methods – Water economic instruments, policy options for water conservation and sustainable use – Case studies. Pricing: distinction between values and charges – Private sector involvement in water resources management: PPP objectives, PPP options, PPP processes, PPP experiences through case studies – Links between PPP and IWRM.

UNIT III WATER SUPPLY AND HEALTH WITHIN THE IWRM CONSIDERATION 9

Links between water and human health: options to include water management interventions for health – Health protection and promotion in the context of IWRM – Health impact assessment of water resources development.

UNIT IV AGRICULTURE IN THE CONCEPT OF IWRM 10

Water for food production: 'blue' versus 'green' water debate – Virtual water trade for achieving global water security – Irrigation efficiencies, irrigation methods and current water pricing.

UNIT V WATER LEGAL AND REGULATORY SETTINGS 6

Basic notion of law and governance: principles of international and national law in the area of water management. Understanding UN law on non-navigable uses of international water courses – Development of IWRM in line with legal and regulatory framework.

TOTAL: 45 PERIODS

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OUTCOMES:

- There will be a paradigm shift in attitude of the students towards interdisciplinary research.
- The students will gain knowledge about economic aspects of water.
- They will gain a broad understanding of the complexities of dealing with water resources problems.

REFERENCES

1. Technical Advisory Committee, Integrated Water Resources management, Technical Advisory Committee Background Paper No: 4. Global water partnership, Stockholm, Sweden. 2002.
2. Technical Advisory Committee, Poverty Reduction and IWRM, Technical Advisory Committee Background paper no: 8. Global water partnership, Stockholm, Sweden, 2003.
3. Technical Advisory Committee, Regulation and Private Participation in Water and Sanitation section, Technical Advisory Committee Background paper No:1. Global water partnership, Stockholm, Sweden, 1998.
4. Technical Advisory Committee, Dublin principles for water as reflected in comparative assessment of institutional and legal arrangements for Integrated Water Resources Management, Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, Sweden. 1999.
5. Technical Advisory Committee, Water as social and economic good: How to put the principles to practice". Technical Advisory Committee Background paper No: 2. Global water partnership, Stockholm, Sweden, 1998.
6. Technical Advisory Committee, Effective Water Governance".Technical Advisory Committee Background paper No: 7. Global water partnership, Stockholm, Sweden, 2003.
7. Cech Thomas V., Principles of water resources: history, development,management and policy. John Wiley and Sons Inc., New York. 2003.

8 Mollinga .P. etal "Integrated Water Resources Management", Water in South Asia Volume I, Sage Publications, 2006

IM8251 CLIMATE CHANGE AND WATER RESOURCES L T P C
3 0 0 3

OBJECTIVES:

- Understanding the climate system, being aware of the impact of climate change on society, Understanding of adaptation in relation to water and climate change.
- At the end of the course, students must be in a position to describe the possible impacts, adaptations and remedies in relation to water resources and climate change.

UNIT I THE CLIMATE SYSTEM 9

Definitions- Climate, Climate system, climate change – Drivers of Climate change – Characteristics of climate system components - Green house effect – Carbon cycle – Wind systems - Trade Winds and the Hadley Cell – Ozone hole in the stratosphere - El Nino, La Nina – ENSO, Teleconnections

UNIT II IMPACTS OF CLIMATE CHANGE – OBSERVED AND PROJECTED 9

Global Scenario – Indian Scenario – Observed changes and projected changes of IPCC - Impacts on water resources – NATCOM Report –Impacts on sectoral vulnerabilities – SRES – Different scenarios

UNIT III TOOLS FOR VULNERABILITY ASSESSMENT 9

Need for vulnerability assessment – Steps for assessment –Approaches for assessment – Models – Quantitative models, Economic model, Impact matrix approach - Box models - Zero-dimensional models - Radioactive-convective models - Higher-dimension models - EMICs (Earth-system models of intermediate complexity) - GCMs (global climate models or general circulation models) – Sectoral models

UNIT IV ADAPTATION AND MITIGATION 9

Water-related adaptation to climate change in the fields of Ecosystems and biodiversity, - Agriculture and food security, land use and forestry, Human health, water supply and sanitation, infrastructure and Economy (insurance, tourism, industry and transportation) - Adaptation, vulnerability and sustainable development Sector-specific mitigation - Carbon dioxide capture and storage (CCS) , Bio-energy crops, Biomass electricity, Hydropower, Geothermal energy, Energy use in buildings, Land-use change and management, Cropland management, Afforestation and Reforestation - Potential water resource conflicts between adaptation and mitigation - Implications for policy and sustainable development.

UNIT V CASE STUDIES 9

Water resources assessment case studies – Ganga Damodar Project , Himalayan glacier studies, Ganga valley project - Adaptation strategies in Assessment of water resources- Hydrological design practices and dam safety- Operation policies for water resources projects - Flood management strategies - Drought management strategies - Temporal & spatial assessment of water for Irrigation - Land use & cropping pattern - Coastal zone management strategies.

TOTAL: 45 PERIODS

OUTCOMES :

- To orient towards the global climate change and its impact on water resources.
- To understand the climate change phenomenon and its related issues on water, irrigation and its social implications.

REFERENCES

1. IPCC Report Technical Paper VI – Climate change and water , 2008.
2. UNFCC Technologies for Adaptation to climate change, 2006.
3. P R Shukla, Subobh K Sarma, NH Ravindranath, Amit Garg and Sumana Bhattacharya, Climate Change and India: Vulnerability assessment and adaptation, University Press (India) Pvt Ltd, Hyderabad.
4. Preliminary consolidated Report on Effect of climate change on Water Resources, GOI, CWC, MOWR, 2008.

IM8351 LEGAL ASPECTS OF WATER RESOURCES L T P C
3 0 0 3

OBJECTIVES :

- To learn the basics of water law, in a context of historical development and evolving recognition of issues related to human and ecological needs of water.
- To understand how the policies, laws and judicial approaches tackle the recent water issues.
- To help formulate recommendations/responses that could resolve/avoid disputes.
- To emphasize water as a finite common property resource that must be used in public interest.

UNIT I HISTORICAL BACKGROUND AND CURRENT CHALLENGES 9

Introduction – Policy, Law, Bill, Act, Rules, Notifications – Nature of Rights: Natural Rights – Customary Rights – Doctrine of Riparian Rights – Doctrine of Prior Appropriation – Doctrine of Equality – Doctrine of Equitable Apportionment – Public Trust Doctrine – Doctrine of Inter-Generational Equity – Absolute Ownership Theory - Challenges in Water Management – Physical and Technical Challenges – Social and Economic Challenges - Role of Law in Water Management – Conceptions of Water: Commodity, Service, Human Right

UNIT II WATER LEGISLATION IN INDIA AND TAMIL NADU 9

Pre-Constitutional Water Laws – Constitutional Provisions: Article 14, Article 21, Directive Principles of State Policy, Fundamental Duties, State List-Entry 17 – 73rd and 74th amendments, Article 262 – Legislative Process: Legislative, Judicial, Executive – Natural Justice – Delegation of Powers - Tribunals – Post-Constitutional Water Laws – National-Level Enactments - The Overview of State

Acts with Case Laws: Indian Easements Act – Land-Related Legislation –Tanks – Irrigation Management – Cess – Protection of Water Sources – Groundwater – Drinking and Domestic Water Supply – Industrial Use – Water Pollution – Torts and Crimes

UNIT III WATER GOVERANCE: POLICIES AND LEGAL FRAMEWORKS 9

Water Governance and Water Policy – Legal Framework of Water – Substance of National Water Laws – Other key issues – Changing incentives through Regulation - National Water Policy – National-Level Commissions – Irrigation Management Transfer Policies and Activities – Legal Registration of WUAs – Legal Changes in Water Allocation, – Role of Local Institutions – Community Based Organizations – Water Policy Reforms: India, the Philippines, Bangladesh, and Indonesia

UNIT IV WATER CONFLICTS IN INDIA 9

Water conflicts and Tribunals - Contending Water Uses – Equity, Access and Allocation - Water Quality Conflicts - Sand Mining - Micro-level Conflicts, Dams and Displacement – Privatization – Case Studies

UNIT V TRANSBOUNDARY WATER ISSUES 9

International Water Law – Emerging Principles - International Law Commission – International Treaties and Protocols – Transboundary Water Issues: Indus Waters Treaty – India-Nepal Treaty – Indo-Bangladesh Cooperation – Sharing of Nile and Mekong River Basins

TOTAL: 45 PERIODS

OUTCOMES:

- Knowledge in legal perspective of Water Resources Management would be strengthened**.**
- Critical analysis of water conflicts is made possible, which could reveal the gaps that need to be filled up.

REFERENCES

1. Brewer, J., S. Kolavalli, A. H. Kalru, G. Naik, S, Ramnarayan, K.V. Raju and R. Sakthivadivel, Irrigation Management Transfer In India – Policies and Performance*,* Oxford and IBH Publishing Company, New Delhi,1999.
2. Bruns, Bryan Randolph and Ruth S. Meinzen-Dick. Ed. Negotiating Water Rights*,* Vistaar Publications, New Delhi, 2000.
3. Iyer R. Ramaswamy , Towards Water Wisdom: Limits, Justice, Harmony*.* Sage Publications, New Delhi, 2007.
4. Mollinga, Peter P., and Alex Bolding, The Politics of Irrigation Reform – Contested Policy Formulation and Implementation in Asia, Africa and Latin America*,* Ashgate, England, 2004,
5. Report of the Expert Group, 'Groundwater Management and Ownership'. New Delhi: Government of India, Planning Commission, http://planningcommission.nic.in/reports/genrep/rep_grndwat.pdf, 2007.
6. Row, Sanjiva Commentaries on The Indian Easements Act, 1882 and Licences, 5th Edition,Delhi Law House, . New Delhi, 2006.
7. Singh, Chhatrapati "Water Rights in India," Ed: Chhatrapati Singh. Water Law in India*:* The Indian Law Institute, New Delhi,1992.
8. "Law for Water Management – A Guide to Concepts and Effective Approaches", Ed: Jessica Vapnek, Brace Aylward, Christie Popp and Jamie Bartram, FAO, Rawat Publications, New Delhi, 2011.
9. "Water Conflicts in India – A Million Revolts in the Making" , Ed: K. J. Joy, Biksham Gujja, Subas Paranjape, Vinod Goud, Shruti Vispute, Rourledge, New Delhi, 2008.
10. "The Politics of Water – A Survey", Ed: Kai Wegerich and Jeroen Warner, Taylor and Francis Group, London, 2010.
11. Philippe Cullet (2010), Groundwater Regulation Need for Further Reforms International Environmental Law Research Centre, Geneva, Switzerland.
12. Heather L. Beach et. al., (2000), Transboundary Freshwater Dispute Resolution – Theory, Practice and Annotated References, UN University Press.

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IM8352	WATERSHED CONSERVATION AND MANAGEMENT	L	T	P	C
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OBJECTIVES :

- To provide the technical, economical and sociological understanding of a watershed.
- To provide a comprehensive discourse on the engineering practices of watershed management for realizing the higher benefits of watershed management.

UNIT I WATERSHED CONCEPTS 9

Watershed - Need for an Integrated Approach - Influencing Factors: Geology – Soil – Morphological Characteristics - Toposheet - Delineation – Codification – Prioritization of Watershed – Indian Scenario

UNIT II SOIL CONSERVATION MEASURES 9

Types of Erosion – Water and Wind Erosion: Causes, Factors, Effects and Control – Soil Conservation Measures: Agronomical and Mechanical - Estimation of Soil Loss - Sedimentation

UNIT III WATER HARVESTING AND CONSERVATION 9

Water Harvesting Techniques – Micro-Catchments - Design of Small Water Harvesting Structures – Farm Ponds – Percolation Tanks – Yield from a Catchment

UNIT IV WATERSHED MANAGEMENT 9

Project Proposal Formulation - Watershed Development Plan – Entry Point Activities – Estimation – Watershed Economics - Agroforestry – Grassland Management – Wasteland Management – Watershed Approach in Government Programmes –Developing Collaborative know how – People's Participation – Evaluation of Watershed Management

UNIT V GIS FOR WATERSHED MANAGEMENT 9

Applications of Remote Sensing and Geographical Information System - Role of Decision Support System – Conceptual Models and Case Studies

TOTAL: 45 PERIODS

OUTCOME :

- The students will be able to apply the knowledge of overall concepts of watershed which would help to comprehend and analyze for better management.

REFERENCES

1. Ghanashyam Das, Hydrology and Soil Conservation engineering, Prentice Hall of India Private Limited, New Delhi, 2000.
2. Glenn O. Schwab, Soil and Water Conservation Engineering, John Wiley and Sons, 1981.
3. Gurmail Singh, A Manual on Soil and Water Conservation, ICAR Publication, New Delhi, 1982.
4. Suresh, R. Soil and Water Conservation Engineering, Standard Publication, New Delhi, 1982.
5. Vir Singh, Raj , Watershed Planning and Management, Yash Publishing House, Bikaner, 2000.
6. Brooks, K. N., P. F. Ffolliott, H. M. Gregersen and L. F. DeBano. 1997. Hydrology and the Management of Watersheds. Second Edition. Iowa State University Press. Ames, Iowa. 502 pp. Heathcote, I. W. Integrated Watershed Management: Principles and Practice. 1988. John Wiley and Sons, Inc., New York.
7. Lal, Ruttan. 2000. Integrated Watershed Management in the Global Ecosystem. CRC Press, New York.
8. Heathcote, I. W. Integrated Watershed Management: Principles and Practice. 1988. John Wiley and Sons, Inc., New York.
9. Dhruva Narayana, G. Sastry, V. S. Patnaik, "Watershed Management", CSWCTRI, Dehradun, ICAR Publications, 1997.

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IW8071 REHABILITATION AND MODERNISATION OF IRRIGATION SYSTEMS **L T P C**
3 0 0 3

OBJECTIVE:

- To expose the students to the need and importance of the rehabilitation and modernization of irrigation systems and to train them in the related concepts and methods.

UNIT I IRRIGATION SYSTEMS **9**

Historical evolution of irrigation systems in India; its importance to agricultural production. Irrigation system classification – Nature of system modernization and rehabilitation. Distinction between rehabilitation and modernization; Rehabilitation and modernization objectives – Theory and Practice.

UNIT II SYSTEM MAINTENANCE **9**

Maintenance: essential, catch up, preventive and normal – Diagnostic analysis of flow, seepage and other parameters through Participatory Rural Appraisal, Rapid Rural Appraisal and Walk-through Survey – Development and maintenance programme – Kudimaramath **–** Turnover – WUA.

UNIT III DIAGNOSTIC ANALYSIS OF IRRIGATION SYSTEMS **9**

System performance: history of inflow, cropping pattern, system alterations, distribution performance – Operational constraints – Management constraints – Resources constraints.

UNIT IV REHABILITATION **9**

Baseline survey – Deferred maintenance – Causes – Criteria used for taking rehabilitation programmes –Service Delivery Concepts- Software and hardware improvements – Prioritization – Role of water users' association – Monitoring and evaluation.

UNIT V CASE STUDIES **9**

Rehabilitation and modernization programmes – Periyar Vaigai Project – Walawe Project – Tank Modernization Project – Water Resources Consolidation Project. IAM WARM Project - DRIP - Case study of Rehabilitation using Water Delivery Concept.

TOTAL: 45 PERIODS

OUTCOMES:

- The students will be familiar in understanding the different types of maintenance problems with respect to technical and social aspects, its occurrence and to overcome these problems by rehabilitation and modernization methods.
- The students will get an overall exposure to different types of irrigation system maintenance issues and to solve them for improving their performance based on service oriented approach.

REFERENCES:

1. CWR, Baseline Survey of Irrigation Commands, Centre for Water Resources, Anna University, Chennai. 2000.
2. IIMI and WALMI, The Case of Mahi Kadana, WALMI, Gujarat, India, 1994.
3. CSU, Diagnostic Analysis of Irrigation Systems Volume 2: Evaluation Techniques. Water Management Synthesis Project, Colorado State University, USA. 1984.
4. WAPCOS, Technical Report No. 19-A, Handbook for Improving Irrigation System Maintenance Projects, WAPCOS, New Delhi. 1989
5. CWR, Tank Modernization Project EEC Assistance: Monitoring and Evaluation. Final Reports. Centre for Water Resources, Anna University, Chennai. 2000.
6. CWR, Planning and Mobilization of Farmers Organization and Turnover. Tamil Nadu Water Resources Consolidation Project. CWR and OM, Anna University, Chennai, 1997.

IW8252 GROUNDWATER AND DRAINAGE ENGINEERING

L	T	P	C
3	0	0	3

OBJECTIVES:

- Students will be exposed to ground water, hydraulics of ground water related to drainage, drainage concepts, planning, design and management of drainage related work.
- They will learn about the latest developments in ground water applications to drainage on the basis of a clear understanding of the principles of drainage engineering.

UNIT I GROUND WATER COMPONENT AND MOVEMENT 8

Occurrence of Ground water – Utilization – Ground water component in hydrologic cycle – Geological formations – Types of aquifers and their characteristics – Ground water movement – Darcy's Law – Flow through layered soils – Stream Lines and Equipotential Lines – Boundary Conditions.

UNIT II GROUND WATER HYDRAULICS 10

Steady and unsteady flow of ground water– Ground water recharge – Dupuit-Forchheimer assumptions - Subsurface flow into drains – Steady and unsteady state drainage equations – Seepage from river into aquifers – Seepage from open channels.

UNIT III DRAINAGE PRINCIPLES AND CRITERIA 9

Factors to be considered in land drainage – Combined irrigation and drainage systems - Water balance – Equations for water balance – Drainage surveys – Agricultural drainage criteria – Effect of field drainage systems on agriculture.

UNIT IV SALINITY CONTROL 9

Salinity in relation to irrigation and drainage – Soil Salinity and Sodicity- Salt balance of the root zone – Salinisation due to capillary rise - Leaching process – Long term salinity level – Sodium Hazard of Irrigation Water – Reclamation of salt affected soils – Bio drainage – Environmental aspects of drainage.

UNIT V DESIGN AND MANAGEMENT OF DRAINAGE SYSTEMS 9

Drainage materials – Surface drainage systems, their components and applications in sloping areas – Subsurface drainage systems – Mole drainage - Tube well irrigation - Drainage application and design – Management and maintenance of drainage systems.

TOTAL: 45 PERIODS

OUTCOMES:

- This course impacts knowledge about the need for irrigation drainage system and its design.
- In addition it enabled to manage the salinity problems and leaching process.

REFERENCES:

1. Todd D.K. Ground Water Hydrology, John Wiley and sons, Inc, New York, 1976.
2. Raghunath, H.M., Ground Water, 2nd edition, Wiley Eastern Ltd., New Delhi, 1987.
3. Kessler J., Drainage Principles and Applications Vol. II and IV, International Institute of Land Reclamation and Improvement, Netherlands. 1979.
4. Ritzema H.P., Drainage Principles and Applications, Publication No. 16, International Institute of Land Reclamation and Improvement, Netherlands. 1994.
5. Bhattacharya A.K. and Michael A.M., Land Drainage Principles, Methods and Applications, Konark Publishers Pvt. Ltd., New Delhi. 2003.