INDIAN INSTITUTE OF SCIENCE

Water Resources Systems:

Modeling Techniques and Analysis

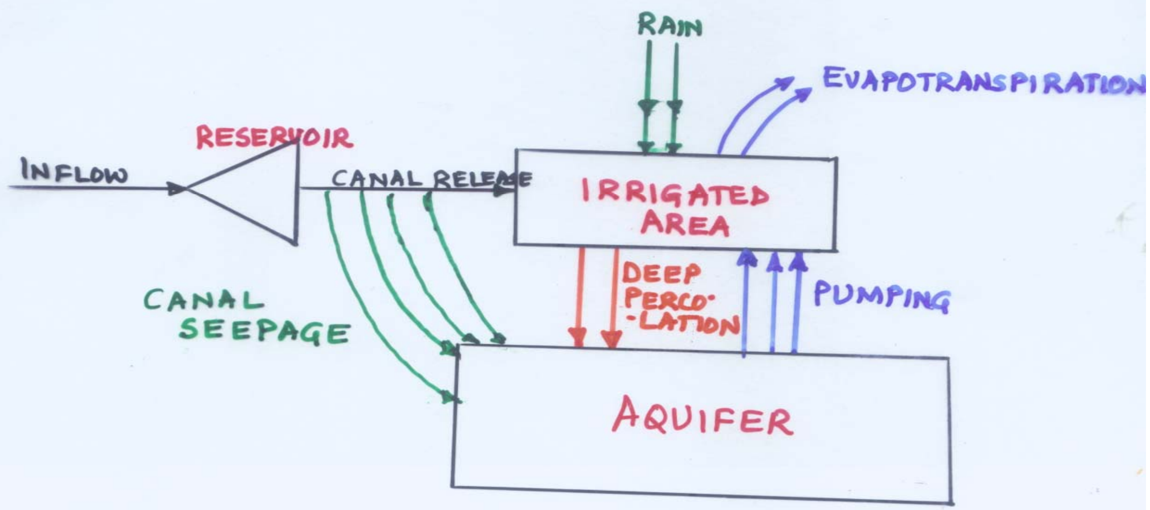
Lecture - 2

Course Instructor : Prof. P. P. MUJUMDAR

Department of Civil Engg., IISc.

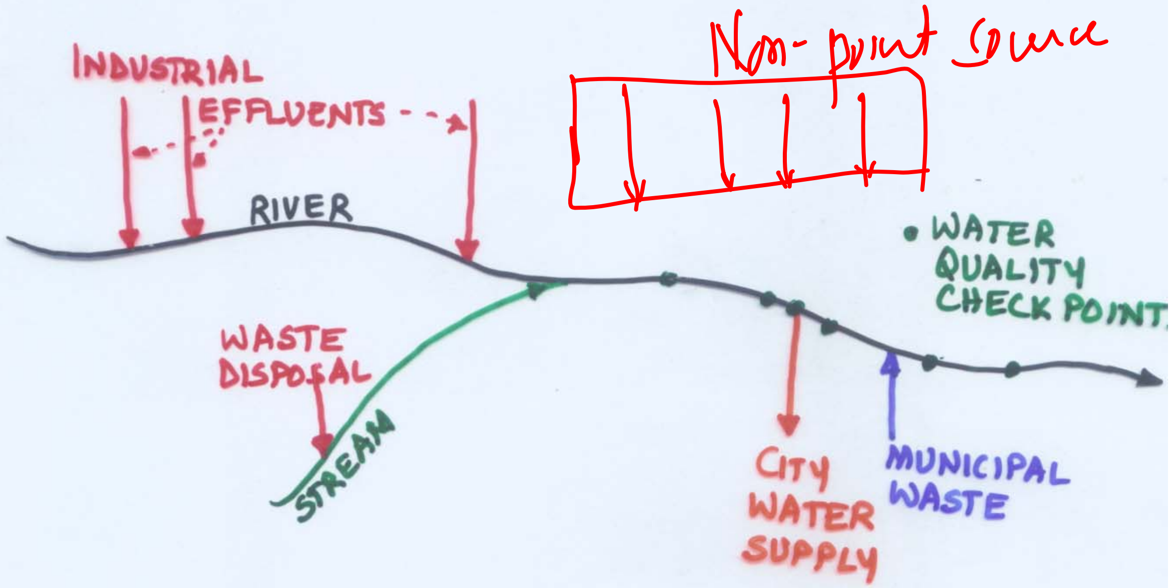
TYPICAL PROBLEMS IN WATER RESOURCES SYSTEMS

- CONJUNCTIVE USE OF SURFACE & GROUND WATER RESOURCES.



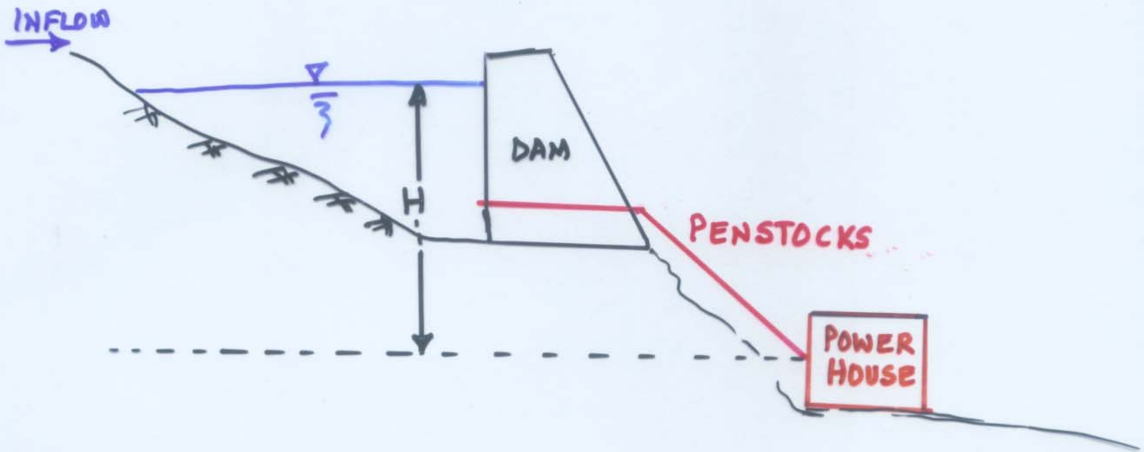
- HOW MUCH TO PUMP FROM AQUIFER
- HOW MUCH TO RELEASE FROM RESERVOIR
    - AQUIFER DRAWDOWN
    - WATERLOGGING
    - IRRIGATION DEMANDS

- SURFACE WATER QUALITY MANAGEMENT



- HOW MUCH OF EFFLUENT TO TREAT
    - WATER QUALITY CRITERIA
    - POLLUTANT TRANSPORT
    - TREATMENT COST

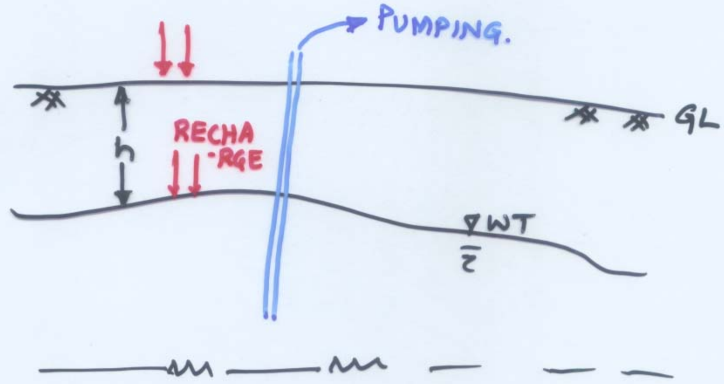
- HYDROPOWER SYSTEMS



- WHAT IS THE 100% RELIABLE POWER
- HOW MUCH CAN BE PRODUCED IN A SHORTAGE PERIOD

  - TURBINE CAPACITY
  - INFLOW UNCERTAINTY
  - MATCHING DEMAND WITH SUP

GROUND WATER PUMPING DECISIONS



- WT changes based on pumping & recharge
- SEQUENTIAL DECISIONS – MONTHLY PUMPING RATES.
- STATE OF THE SYSTEM – WATER TABLE LEVEL
  ↓
  INFLUENCED BY RECHARGE & PUMPING
  ↓
  [RAINFALL, IRRIGATION, SEEPAGE ETC]
- OBJECTIVE – TO MEET THE DEMANDS IN A SUSTAINABLE MANNER.

Sustainable Water Resource Systems

Sustainable water resource systems are those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental, and hydrological integrity (ASCE, 1998)

- Sustainability is intimately related to various measures of risk and uncertainty about a future we cannot know, but which we can surely influence (Loucks, 2000)

ASCE, 1998, Sustainability criteria for water reseources systems, Reston, Va, ASCE.
Loucks, D.P. (2000). Sustainable water resources management. *Water International*, 25 (1), 3–10

Introduction

- Reliability of Meeting Future Demands
  – How often does the system ‘Fail’ to deliver?

- Resiliency
  - How quickly can the system recover from failure?

  For most water resource systems, time at which failure occurs, is also a vital indicator

- Productivity Index
  – How much hydropower? How much flood reduction? --over a long future

- Vulnerability of the system
  – Losses due to failure (e.g., flood damages);

Introduction

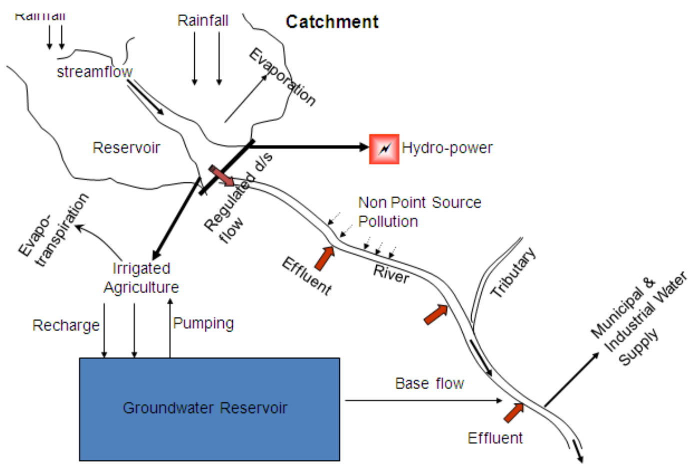
- A reservoir used only for hydro power (or water supply) performs better at full condition.
- A reservoir used only for flood control performs best when left empty until the flood comes.
- A single reservoir serving all the three purposes (hydro power, water supply and flood control) is to be managed better by knowing how much water to store and how it is operated.
- Conflicts exist where demands are more than supplies.
- Finding ways to manage and resolve these conflicts over time and space is one more reason for planning.

Source: Water resources systems planning and management: An introduction to methods, models and applications by Loucks D.P. and Eelco van Beek , UNESCO 2005

Definition of a system

- Definition of a system (Dooge, 1973)

  "any structure, device, scheme or procedure, real or abstract, that interrelates in a given time reference, an input, cause, or stimulus, of matter, energy, or information, and an output, effect or response, of information, energy or matter"



Dooge, J.C.I., (1973), Linear theory of hydrologic systems, Technical Bulletin No. 1468, Agricultural Research Service, US Department of Agriculture.

Types of systems

- Simple and complex systems
  - Simple – direct relation between input and output
  - Complex – combination of several sub-systems
- Linear and nonlinear systems
  - Linear – output is a constant ratio of input
  - Nonlinear – relation between input and output is nonlinear (principle of superposition is not valid)

Types of systems (contd.)

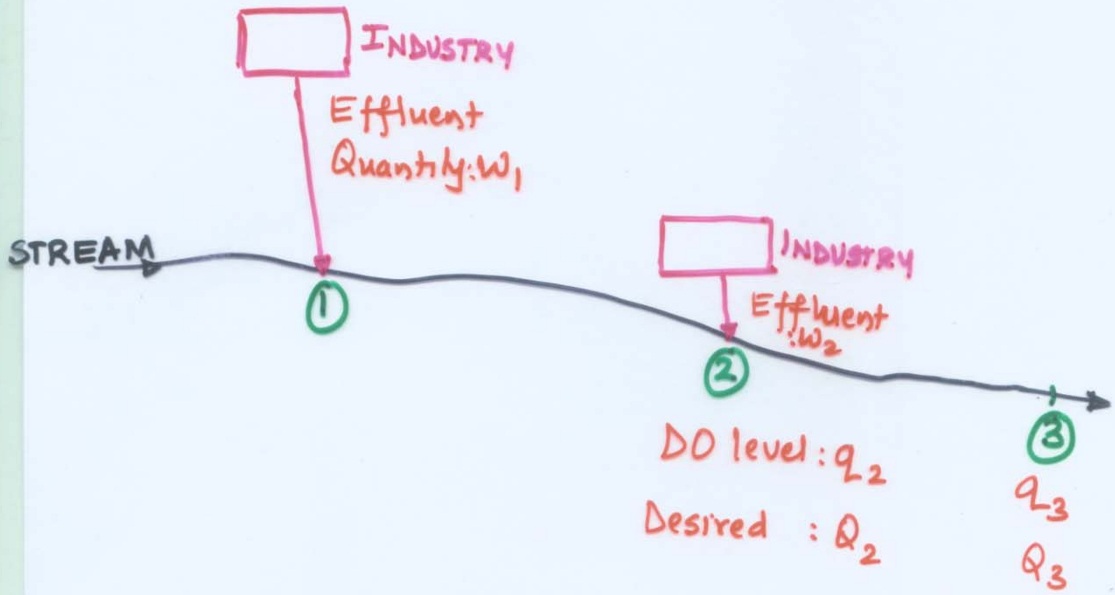
- Time variant and time invariant systems
  - Time invariant: input – output relation does not depend on time of application of input
- Continuous, discrete and quantized systems
  - Continuous: changes in system take place continuously
  - Discrete: state of system changes discrete intervals of time
  - Quantized: system changes only at certain discrete intervals

Types of systems (contd.)

- Lumped parameter and distributed parameter systems
  - Lumped parameter: variation in space is non-existant or ignored
  - Distributed parameter: variation in one or more spatial dimensions is considered
- Deterministic and probabilistic systems
  - Deterministic: a given input always produces the same output.
  - Probabilistic: input – output relationship is probabilistic
- Stable systems – output is bounded if the input is bounded

SIMPLE LP FORMULATIONS IN WATER RESOURCES

- WATER QUALITY MANAGEMENT MODELS.



- EACH UNIT OF WASTE LOAD REMOVED AT SITE 1 ENHANCES DO LEVEL AT SITE 2 BY a_{12} & THAT AT SITE 3 BY a_{13}.

- SIMILARLY a_{23} IS THE INCREASE IN DO LEVEL AT SITE 3 FOR EACH UNIT OF WASTE LOAD REMOVED AT SITE 2.