AGE 514 – WATER RESOURCES DEVELOPMENT

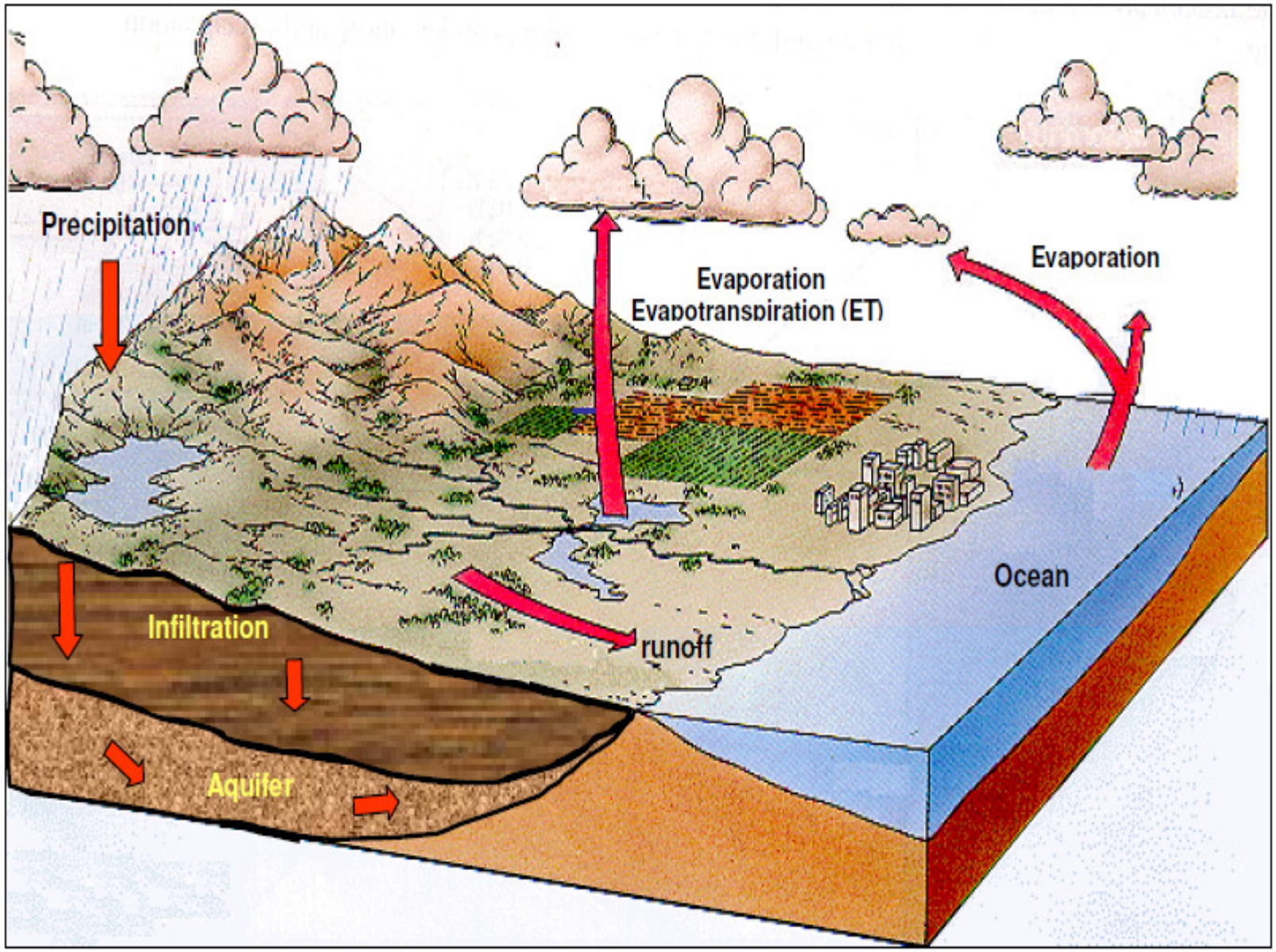
Course Outline:

- Sources of Water for Development
- Surface water Development
- Groundwater Development
- Water Supply Planning
- Water Quality Management
- Water Law
- Integrated Water Resources Management (IWRM)

Sources of Water for Development

- Water is considered one of the major resources for development in any nation. Its supply in sufficient quantity, adequate quality at the right time is critical to all aspect of civilization.
- Early civilizations flourished along river valleys where there was abundant supply of water to support life
- The ultimate sources of water on earth are indicated in the **Hydrological cycle**, this is the cyclic exchange of water between the land, sea and Air systems on earth. The figure below explains the cycle better:

Hydrological Cycle



In summary, the water sources of the earth can be categorized as follows:

- Atmospheric water – Rainfall, Dew, Snow etc.
- Surface water – Rivers, Sea, Oceans, Streams, Lakes, Springs etc.
- Groundwater – Aquifers

- Water generally occurs in three states, Solid (ice), Liquid (water) and Gaseous (moisture). When water is evaporated from rivers, lakes and ponds, it is converted into gaseous state (vapor) in the atmosphere to form atmospheric water; this is in turn released back to the earth as rainfall, dew, or snow as the case may be depending on the geographical location, season and time.

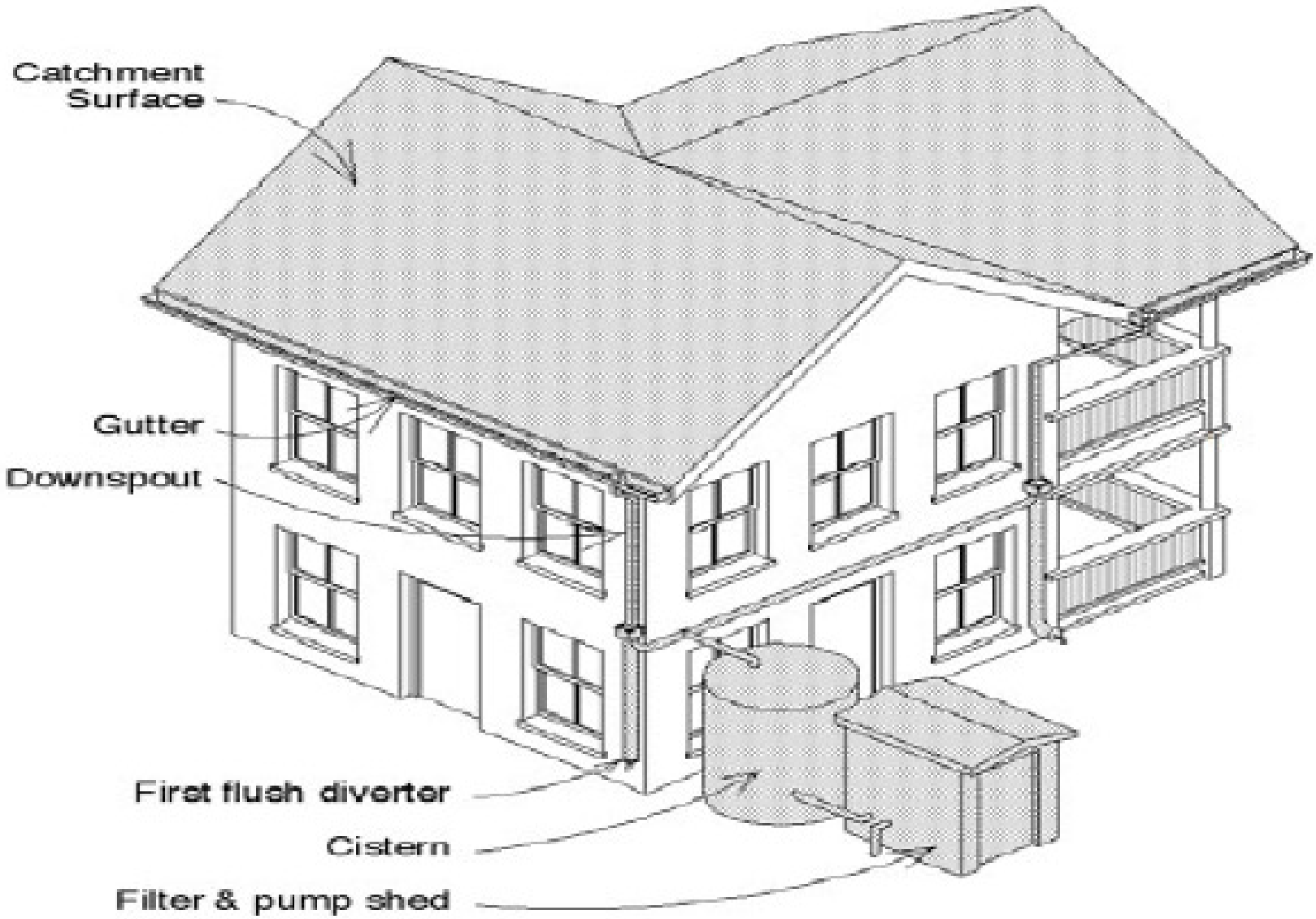


Figure 2: Rainwater harvesting for domestic Use

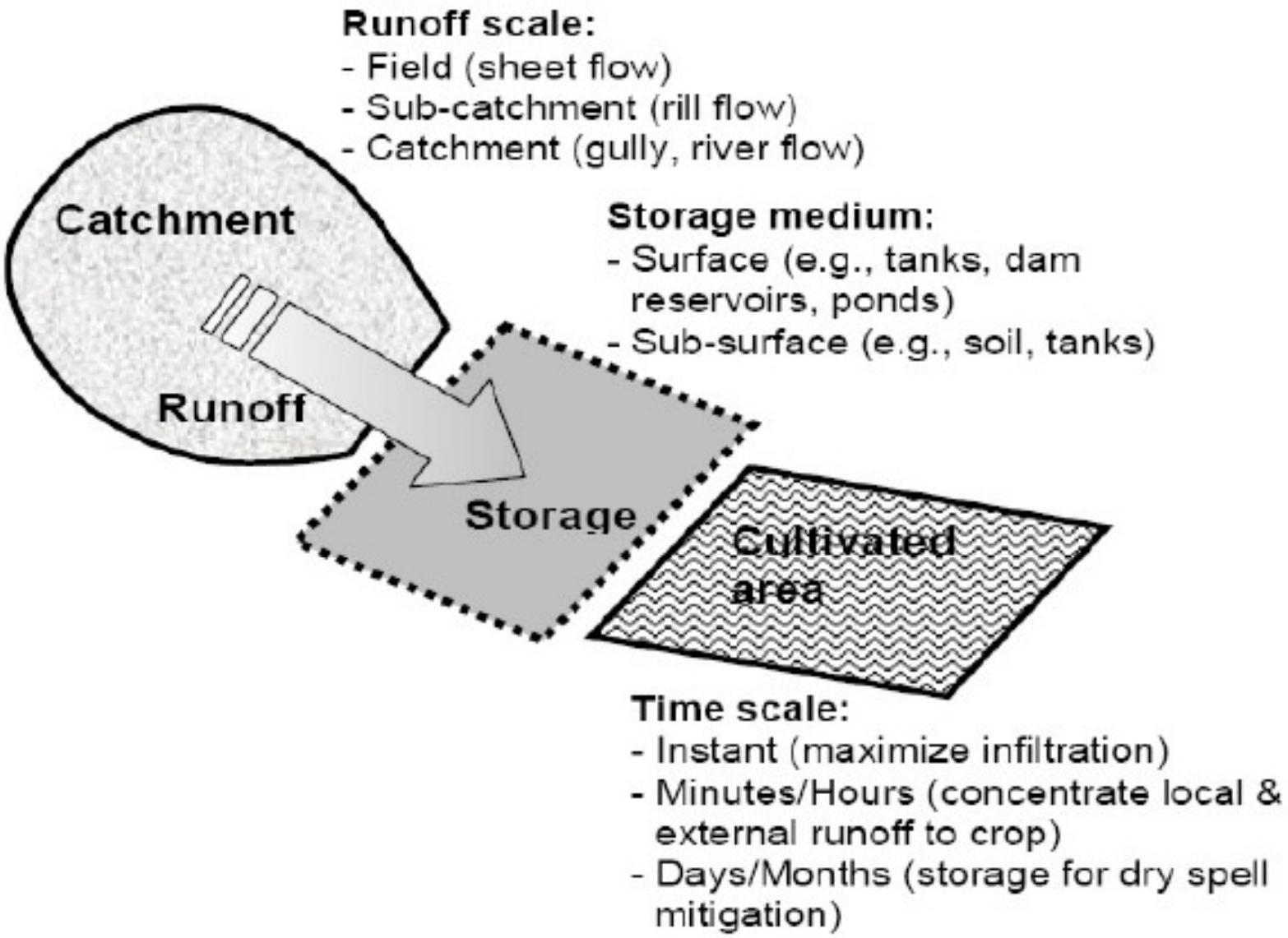


Figure 3: Rainwater harvesting for crop production

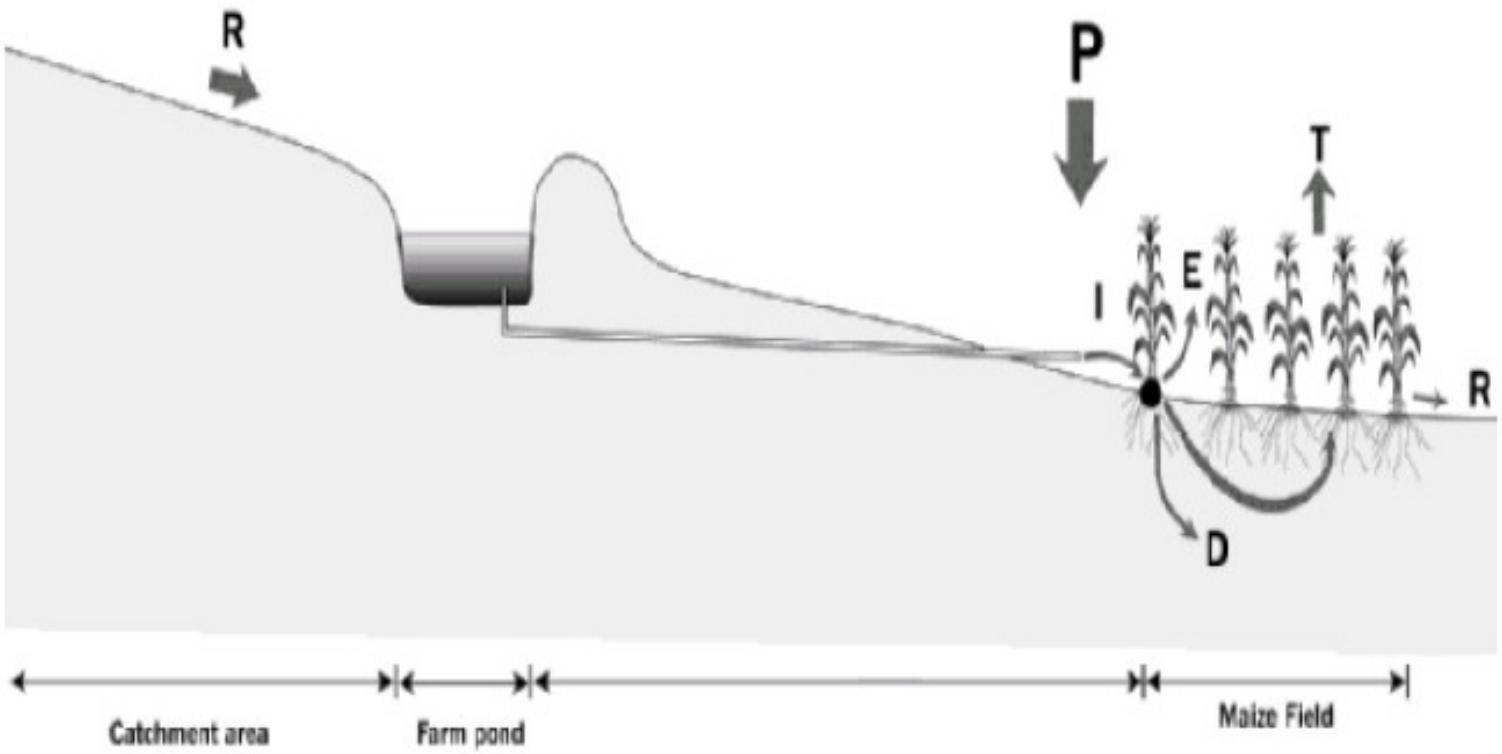


Figure 4: A typical on-farm pond for irrigation

- **Surface water Development**

- As earlier explained, rivers, streams etc. usually receive a lot of water from the contributing catchment in the wet season; the water in the rivers can be developed for the use of man. The development of the surface water of a river for example may require the construction of a dam in order to impound the water in a reservoir created by reason of the damming or the construction of an intake structure from which part of the flow in the river can be abstracted for use.
- A reservoir is created on rivers to store water during the wet season and is later released in the dry season when the flow is low in order to meet demand.

- A reservoir is constructed for a number of purposes which may include:
  - Irrigation
  - Municipal and industrial water supply
  - Flood control
  - Hydropower
  - Recreation
  - Development of fish and wild life
  - Soil conservation

Figure 5: A masonry dam impounding surface water in Kenya

Reservoir Planning

- The most important characteristics of reservoir is its storage capacity, hence the amount of water that can be impounded depends on the flow regime of the river, topography of the area etc. Reservoir planning requires a number of studies which are required to provide baseline information about the area, the studies include: Engineering surveys- topography (contour map), Geologic investigations and Hydrologic studies.
- It is important to prepare **area-elevation** and **Storage-elevation curves** for the area. An area-elevation curve is constructed by planimetering the area enclosed by each contour within the reservoir site.

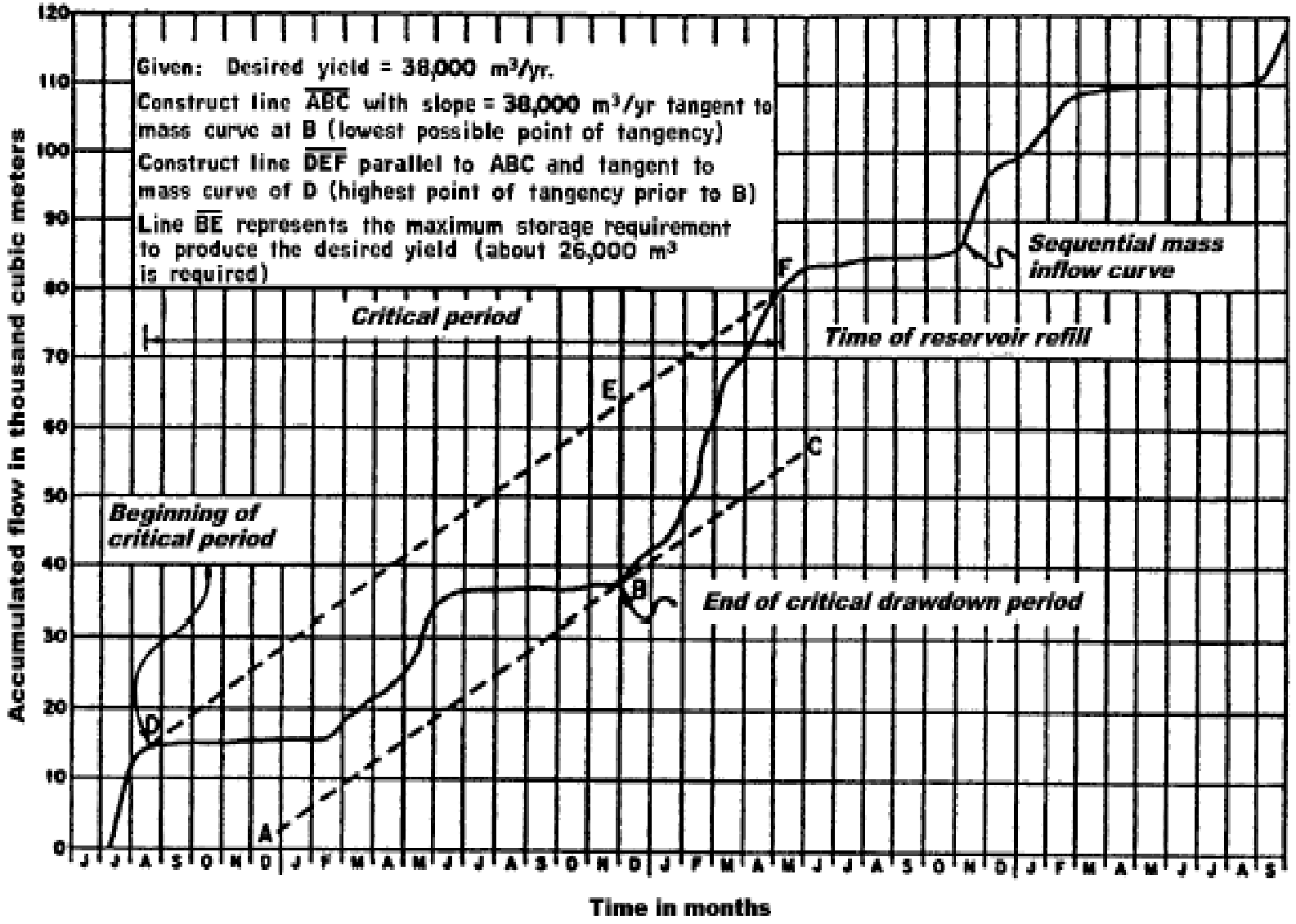


Figure 6: Mass curve of a River for estimating reservoir capacity

Groundwater Development

- The first activity in groundwater resources development is the exploration of the groundwater in the area of concern. This type of investigation is required as a guide to choosing the appropriate location of the project, provide an estimate of available water that can be abstracted, provide advisory information on possible source of contamination to ground water etc.
- Abstraction of groundwater can be done through the construction of water wells. A water well is a hole usually vertical excavated in the ground for bringing groundwater to the surface. Wells also serve other purposes such as sub surface exploration and observation, artificial recharge, and disposal of waste water.

- Two methods of well construction are common: Cable tool percussion method and Rotary drilling method. A combination of the methods is also available known as Rotary percussion method. Each method has particular advantages, so experienced drillers endeavour to have equipment available for a diversity of drilling approaches. The construction procedure of a successful well depends on local conditions encountered during drilling.

Figure 7: A typical borehole drilling rig

Water Supply Planning

- The development and utilization of available water resources require adequate planning and design. In order to select a suitable water supply source, the demand that will be placed on it must be known. The elements of water demand include the average daily water use and the peak rate of demand.
- In the planning process, the ability of the water source to meet demands during critical periods (when surface flows and groundwater tables are low) must be determined. The "peak demand rate" must be estimated in order to determine plumbing and pipe sizing, pressure losses and storage requirements necessary to supply enough water during periods of peak water demand.

Water Quality Management

- The quality of water is determined by its physical, chemical and biological properties. Naturally existing water contains impurities which need to be removed by treatment. Natural waters contains suspended solids as well as dissolved substances, these must be either removed or kept at within certain limits to make the water potable.
- The tolerable limit of impurities in water depends on the purpose for which it is to be used for, water that is completely free from suspended or dissolved matter eg. Distilled water is unpalatable.
- Water for domestic purposes must not contain disease-causing organisms, water for washing in a laundry or textile factory should be free of suspended matter.

- Substances found in surface water depend on the catchment where it was generated, impurities like clay, organic and inorganic mineral matter, algae, bacteria and protozoa may be found in suspended or colloidal form.
- Dissolved gasses like oxygen, nitrogen, carbon dioxide and hydrogen sulphide may also be present. Organic matters found in water may include ammonia, organic acids, chlorides, nitrites and nitrates; they may be found in dissolved state. Pollution of surface water may also occur as a result of the following activities of man:
- Discharge of effluents from industries
- Discharge of domestic wastes from homes, abattoirs etc.
- Leaching and discharge of contaminants from agricultural lands eg. Fertilizers, herbicides, pesticides etc
- Acid rains due to heavy air pollution from industrial estates or parks.

- Physical properties of water
  - Colour
  - Turbidity
  - Taste
  - Odour

- Chemical properties of water
  - pH value
  - Hardness
  - Carbon dioxide
  - Chlorides
  - Iron
  - Manganese
  - Dissolved oxygen

Water Law

- In regions where the available water is inadequate to meet the needs of potential users, a system of laws has been developed to determine who has the right to water when shortages occur. Water law plays a major role in the economic aspects of water development since limitations on who may develop water often control how it is developed and utilized.

Riparian Rights

- The doctrine of riparian rights evolved from Europe and has been adopted world wide with little or no modification. The doctrine holds that the owner of the land adjacent to a stream is entitled to receive the full natural flow of the stream without change in quantity and quality.

- **Prior Appropriation**
  - This doctrine evolved as a result of the failure of the riparian doctrine to meet modern challenges of allocating water equitably. This gives room of access to water for land owners who are not located in close proximity to the stream. Water is appropriated based on the principle of "first in time, first in right"
- **Groundwater Law**
  - Under the common law, rights to groundwater are inherent in the overlying property; the owner of this property is free to abstract the water. This can only hold if the groundwater resource is vast, but if the water is inadequate to meet all needs problems will emerge and this often lead to court cases which brought about decisions that tends towards the doctrine of reasonable use.

National water policy

- The nation's water sources are under serious threat from inadequate catchment management and widespread pollution, including the indiscriminate disposal of hazardous substances.
- The National Water Resources Policy aims at providing a framework for addressing these challenges in order to achieve the following:
- Clear and coherent regulation.
- Clear definitions of the functions and relationship of sector institutions.
- Coordination Finds solution to the problem of dwindling funds.
- Reliable and adequate data for planning and projections.
- Decentralization in order to boost efficiency, performance and sustainability.
- Autonomy of water supply agencies.
- Regard water as an economic good.
- Create public awareness about water conservation and management.

- **Integrated Water Resources Management (IWRM)**
- At its simplest, integrated water resources management is a logical and appealing concept. Its basis is that the many different uses of water resources are interdependent.
- High irrigation demands and polluted drainage flows from agriculture mean less freshwater for drinking or industrial use; contaminated municipal and industrial wastewater pollutes rivers and threatens ecosystems; if water has to be left in a river to protect fisheries and ecosystems, less can be diverted to grow crops.
- There are plenty more examples of the basic theme that unregulated use of scarce water resources is wasteful and inherently unsustainable.

- **Integrated water resources management is therefore a systematic process for the sustainable development, allocation and monitoring of water resource use in the context of social, economic and environmental objectives.**
- A meeting in Dublin in 1992 gave rise to four principles that have been the basis for much of the subsequent water sector reform:

- *Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.*
- *Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels.*
- *Women play a central part in the provision, management and safeguarding of water.*
- *Water has an economic value in all its competing uses and should be recognised as an economic good as well as a social good.*

- Suggested Text Books:
  - Manual of Individual and Non-Public Water Supply Systems. United States Environmental Protection Agency. EPA 570/9-91-004
  - Water Measurement with Flumes and Weirs. Publication 58. International Institute for Land Reclamation and Improvement (ILRI), Netherlands
  - Smart Water Harvesting Solutions. Netherlands Water Partnership.
  - Design of Small Dams, Bureau of Reclamation , United States Department of Interior. 3rd Edition 1987
  - Integrated Water Resources Management Plan. Training Manual and Operational Guide. CAPNET, GWP, UNDP
  - Hydrologic Analysis and Design. 2nd Edition by McCuen R.H. Patience Hall Publishers.
  - Groundwater Hydrology. US Army Corps of Engineers. EM-1110-2-1421.