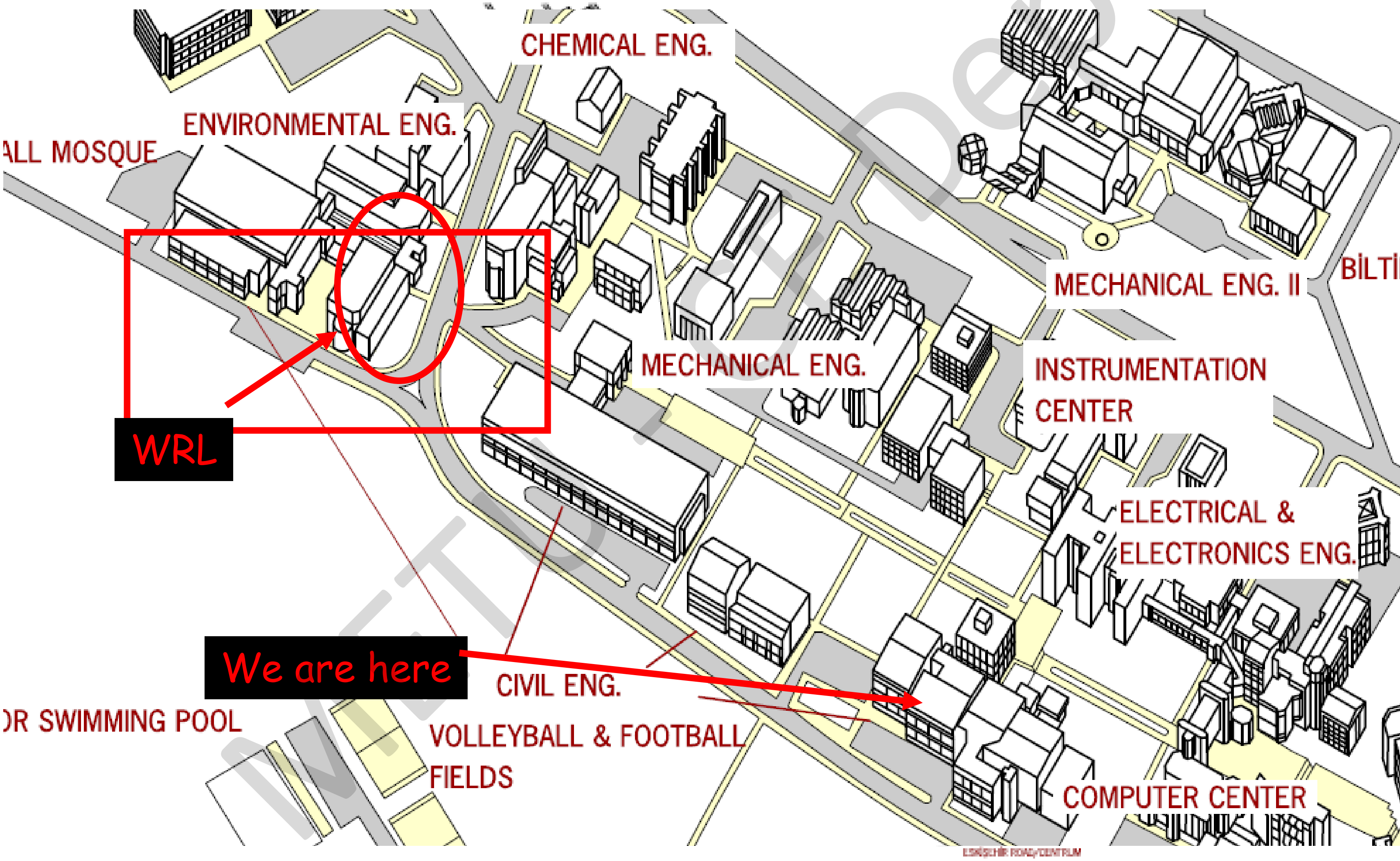
WATER RESOURCES ENGINEERING

CE378

METU - CE Dept.

Location of Water Resources Lab.



Who teach CE378 this term?

Dr. S. Zuhal Akyürek

- Surface hydrology
- GIS
- Remote Sensing

Dr. Melih Yanmaz

- Water Res. Eng.
- Bridge Hydraulics
- Hydrosys. Reliability

Dr. İsmail Yücel

- Hydroclimatology
- Remote Sensing
- Data Assimilation

Dr. Elçin Kentel

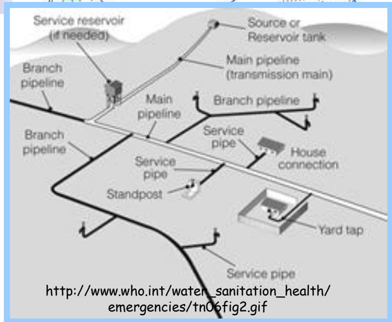
- Fuzzy Logic
- Water Res. Mgmt.
- Risk Analysis

Dr. Nuri Merzi

- Water Supply Sys.
- Water Distb. Sys.
- GIS in Hydrology

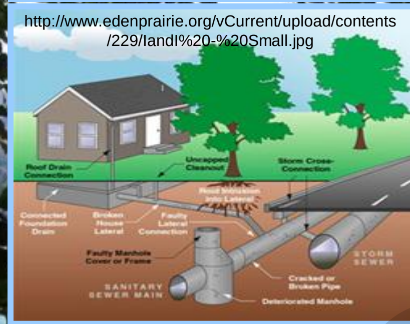
METU - CE Dept.

Water Supply



CE429

WW Collection



CE477

D. Weirs

CE422

http://www.thewallpapers.us/data/media/200/keban_baraj.jpg

Keban Dam

Irrigation

CE420

Urban Hyd. & Hydraulics

CE424

Hydrology

CE421

Tentative Course Outline

- Introduction (2 hours)
  - Scope
  - Hydrologic Cycle
  - System Concept
- Hydrologic Processes (8 hours)
  - Basin
  - Precipitation
  - Streamflow
  - Infiltration
- Hydrograph Analysis (9 hours)
  - Components of runoff
  - Hydrograph characteristics
  - Unit hydrograph theory
  - Synthetic unit hydrograph
- Reservoir Routing (2 hours)
  - Introductory remarks
  - Routing in reservoirs

METU - CE Dept.

Tentative Course Outline

- Dams and Spillways (15 hours)
  - Classification and parts of the dams
  - Planning of dams
  - Dam construction
  - Reservoir capacity determination
  - Concrete gravity dams
  - Arch dams
  - Dam safety and rehabilitation
  - Spillway design flow
  - Hydraulics of overflow spillway
  - Crest gates and spillway profile
  - Energy dissipation facilities
- Groundwater Hydrology (8 hours)
  - Fundamentals of groundwater flow
  - Groundwater flow equations
  - Well hydraulics
- Water Supply (5 hours)
  - Municipal water requirements and population estimation
  - Fluctuations in water use
  - Elements of municipal water supply systems
  - Hydraulics and operation of gravity pipelines
  - Design of transmission lines (gravity, pumped, and mixed lines)

METU CE Dept.

- Wastewater Collection and Removal (3 hours)
  - Introduction and flow in sewers
  - Design of storm sewer systems
  - Design of sanitary sewer systems
- Irrigation and drainage (4 hours)
  - Land classification
  - Irrigation system design principles
  - Land drainage facilities

GRADING

Midterm 1 .... 30%
Midterm 2 .... 30%
Final 40%

METU CE Dept.

TEXTBOOK:

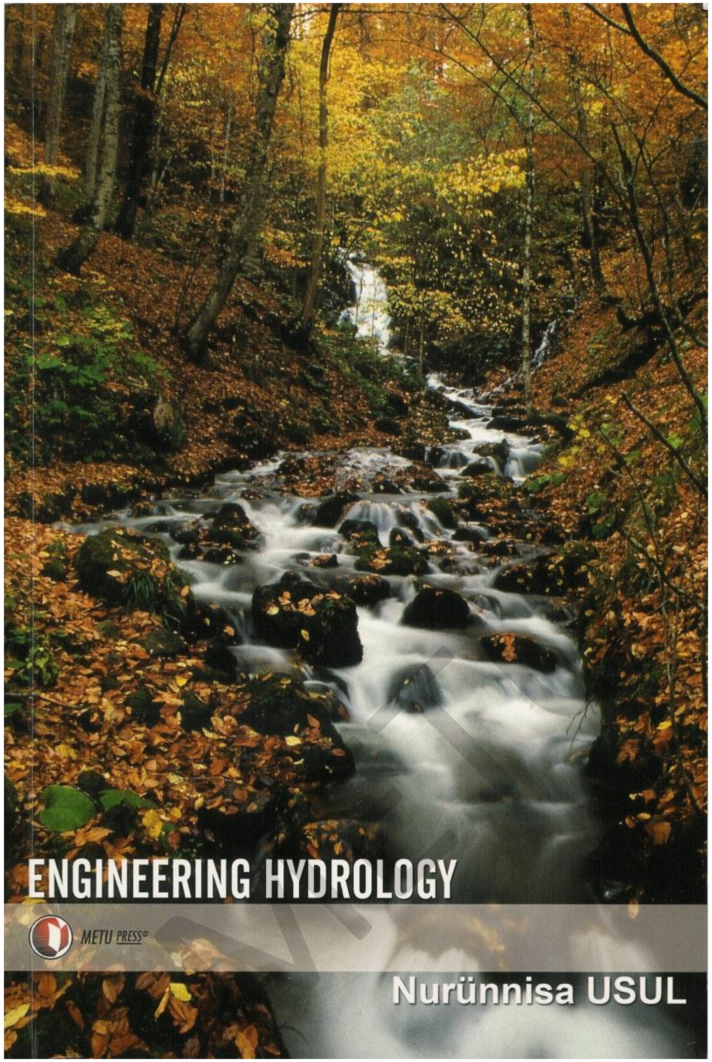
- Usul, N.: *Engineering Hydrology (3rd. Ed.)*, METU Press, Ankara, 2009.
- Yanmaz, M.: *Applied Water Resources Engineering (3rd Ed.)*, METU Press, Ankara, 2006.

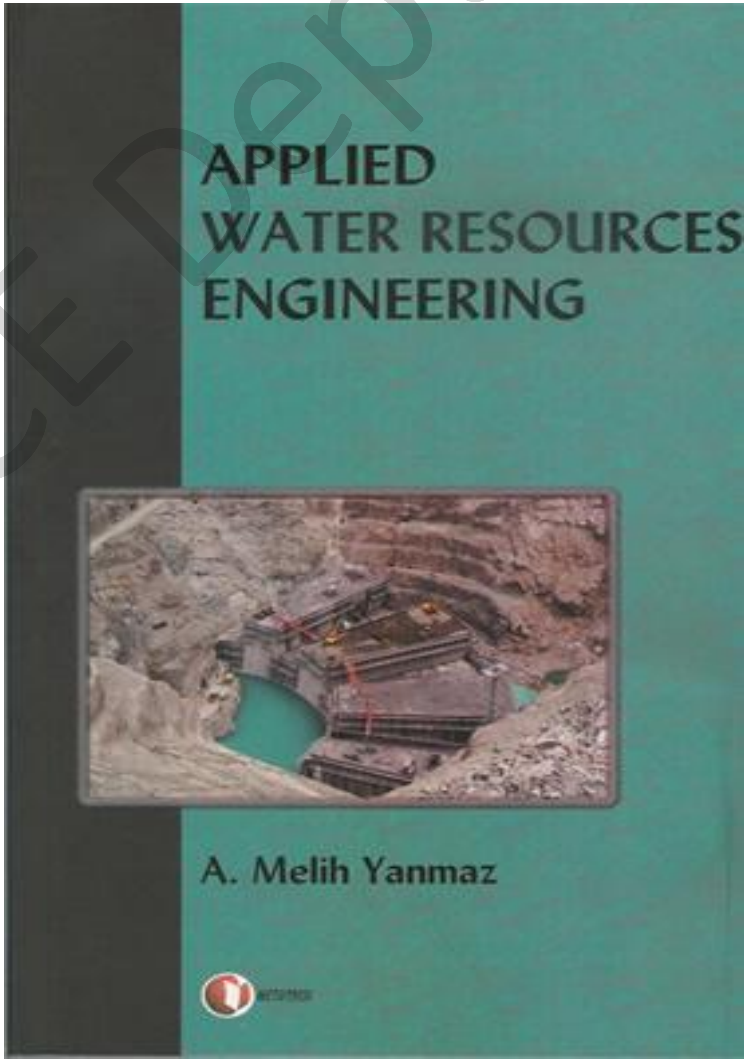
REFERENCES:

- Linsley, Kohler, and Paulhus, *Hydrology for Engineers* (SI Ed.), Mc Graw Hill, New York, 1982.
- Linsley, Franzini, Freyberg, and Tchobanoglous, *Water Resources Engineering*, 1992.
- Anonymous, USBR, *Design of Small Dams*, 1987.

METU - CE Dept.

OUR TEXT BOOKS





METU CE Dept.

Introduction: Water Need

A human being could survive on only 4 ~ 5 lt/day.

But to remain in good health, a person needs 10 ~ 20 times more: 50 ~ 100 lt/day.

10^9 people (1/4 of world population) do not have ready access to sufficient water supply of adequate quality.

1 kg cereal needs 1000 kg water to grow

1 kg rice needs 2000 kg water to grow

These facts clearly explain the

importance of the wise usage

&

fair sharing of the water

everywhere in the world.

METU - CE Dept.

Nature of Water Resources Problems

Relationship between SUPPLY and DEMAND?

- design
- analysis

- How much water of good quality is AVAILABLE?

  ↓ supply

- How much water will be REQUIRED?

  ↓ demand

METU - CE Dept.

Supply versus Demand

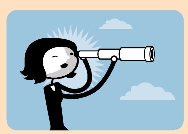
- Existing Water = f (time, space, quality, quantity)
- Water Demand = f (time, space, quality, quantity)

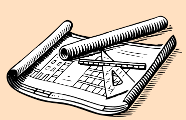
Supply & demand
need to be matched

METU - CE Dept.

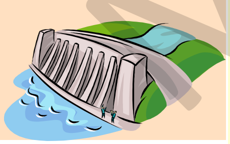
Water resources engineering


Conception


Planning


Design


Construction


Operation

of water resources systems

METU - CE Dept

Fields of Water Resources Engineering

- Water Control
  - Flood mitigation
  - Storm drainage
  - Sewerage collection
  - Highway culvert design

- Water use
  - Municipal water supply
  - Irrigation
  - Hydroelectric – power development
  - Navigation

- Water Quality Management
  - For municipal and irrigation uses

METU - CE Dept.

Water Control

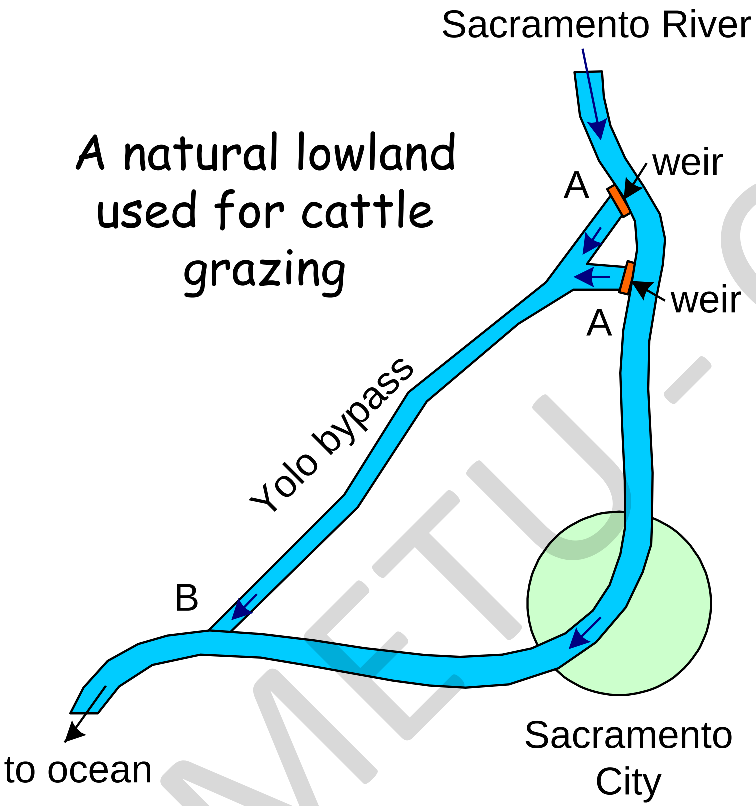
- Water Control is necessary in order to prevent
  - the loss of lives,
  - the damage to the property, and
  - the difficulties in communities encountered due to water related problems (floods).
- Measures taken for the solution of these problems: The design and construction of
  - flood control structures for excess water,
  - storm drainage and sewerage systems to get rid of the unwanted water, and
  - culverts for the roads and highways.

METU - CE Dept.

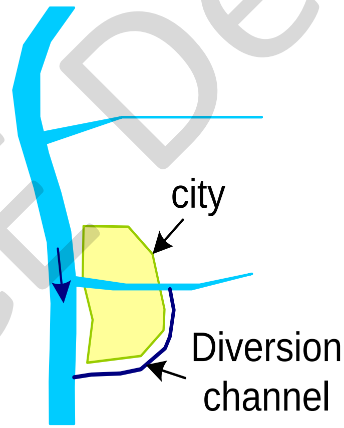
WATER CONTROL

Protection from water

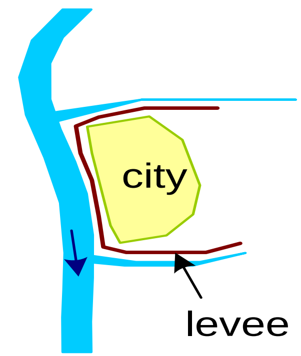
A natural lowland used for cattle grazing

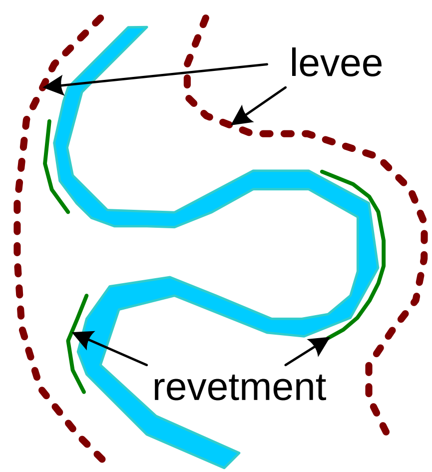


Diversion channel to protect a city



Levee tied into high ground





Levee around a meandering stream

METU - CE Dept.

Devrek, Zonguldak: 1998 flood

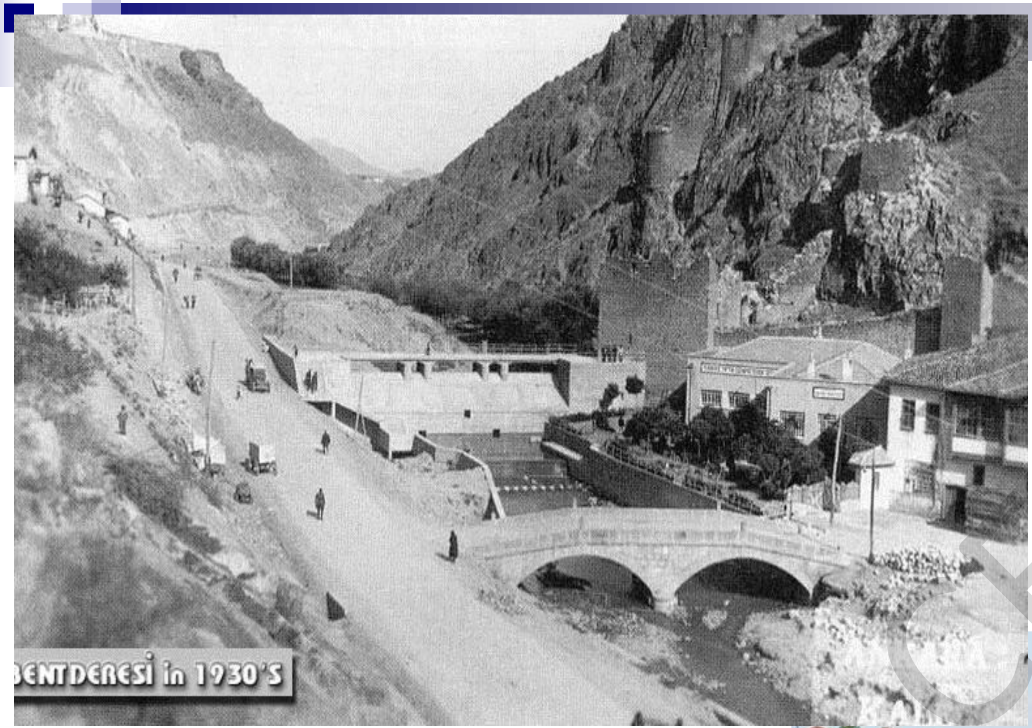
Devrek, Zonguldak: 1998 flood

Rize - Çamlıhemşin

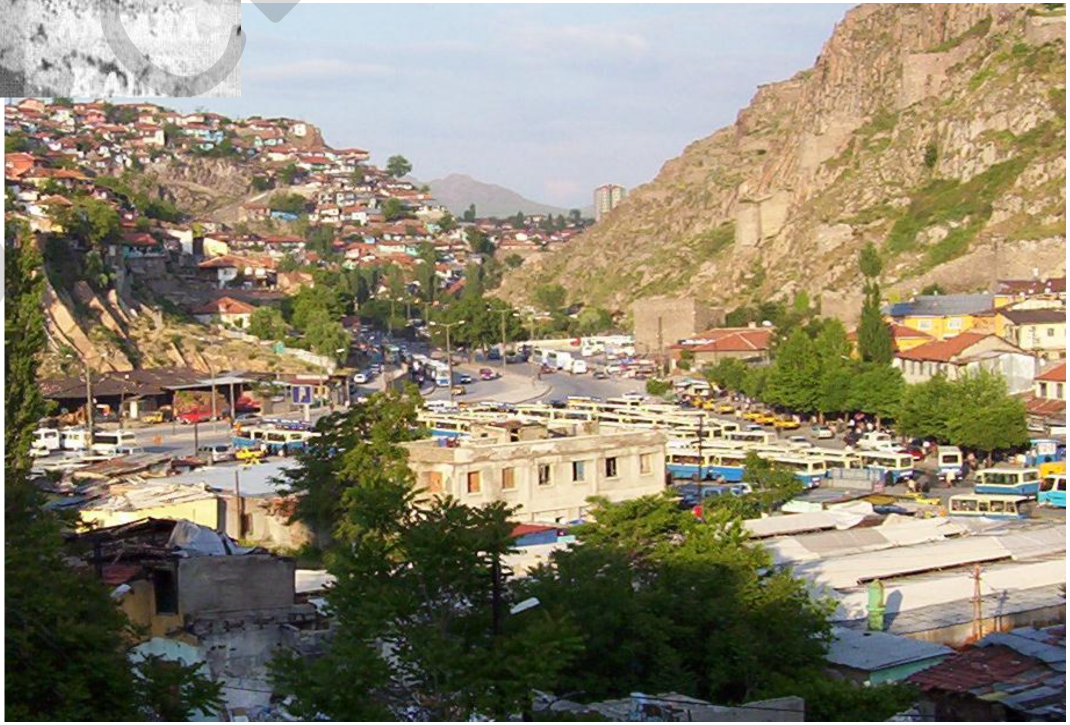
August - 2005

10 min. later…

METU - CE Dept.



Ankara - Bentderesi



METU CE Dept.

EDİRNE
11 - 20 March 2006

METU - CE Dept.

Tuz Gölü


http://www.math.umn.edu/~alayont/turkiye/icanadolu/tuzgolu2.jpg

http://kedikardesligi.com/wp-content/uploads/2009/10/tuzg%C3%B6l%C3%BCpg1.jpg


http://i.milliyet.com.tr/HaberAnaResmi/2008/08/20/fft17_mf90846.Jpeg

Drought

METU - CE Dept.

Water transmission

Quantity of Water

- How much water can be expected?
  - Peak rates → Control of water → Design/operation
  - Volume of flow → Water use → Design/operation
  - Location problem → Water transmission
  - Time problem → Water storage

Existing water = f (time, space)

(application of hydrology)

METU - CE Dept.

Water Quality

Problems related to

- Municipal water supply
- Irrigation
- Disposal of waste water

http://www.durhamcountync.gov/departments/ceng/images/Utility_Division/Wastewater_Treatment_Plant-001.jpg

METU - CE

Sustainable Development

- availability of fresh water in the world ?
- preservation of land and water resources !
- environmental impacts of projects !

Within this context, planners should incorporate
ecosystem, health, social & economic findings
in the final choice of project through multi-criteria analysis.

- In Turkey → EIA regulation

METU - CE Dept.

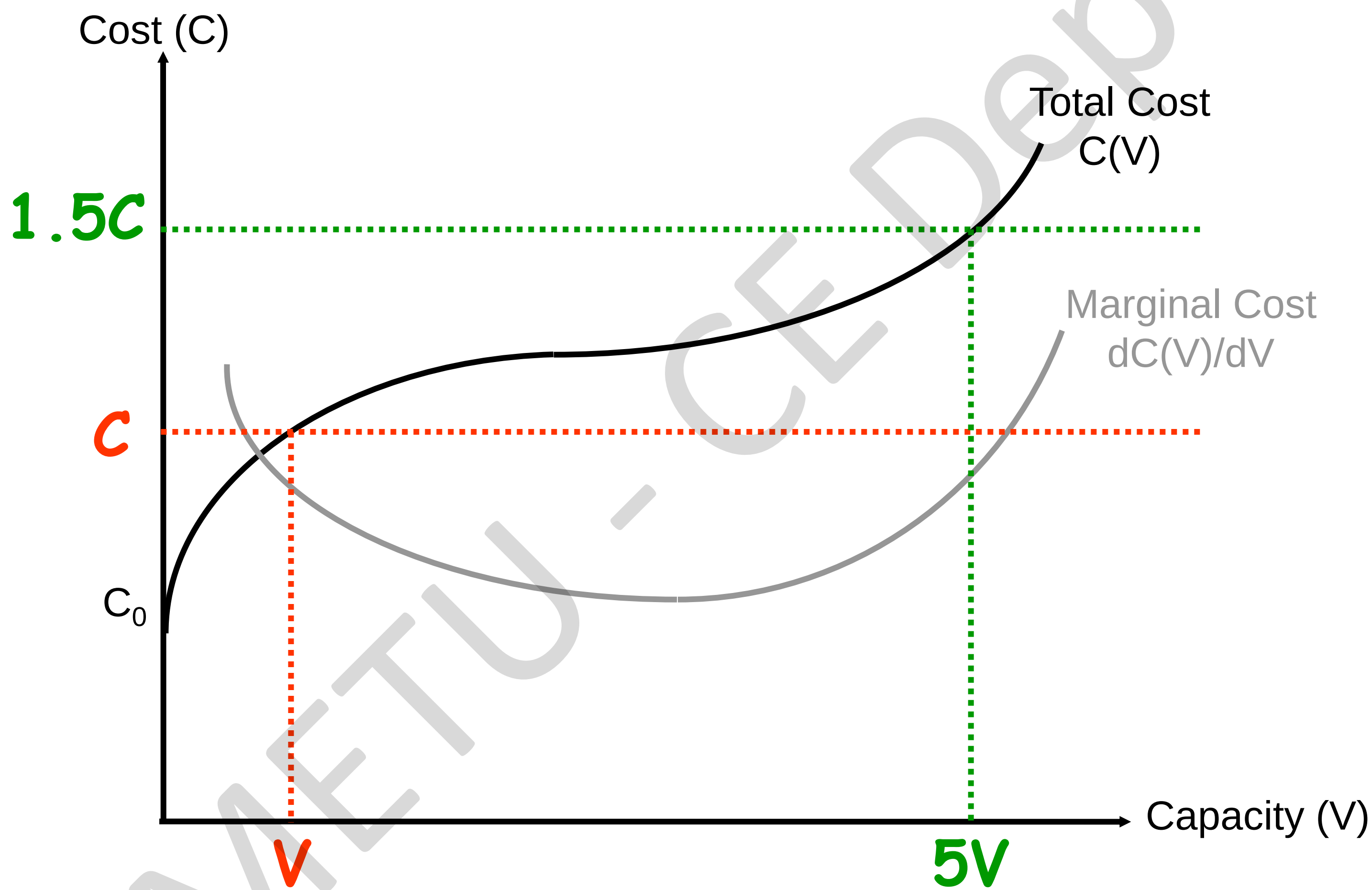
Characteristics of water resources projects

- Uniqueness
- Uncertainty
- Socio-economic aspect
- Forecasting
- Economy of scale
- Irreversibility

http://farm1.static.flickr.com/75/206460917_bf3fcce0eb_o.jpg

METU - Dept

Economy of scale

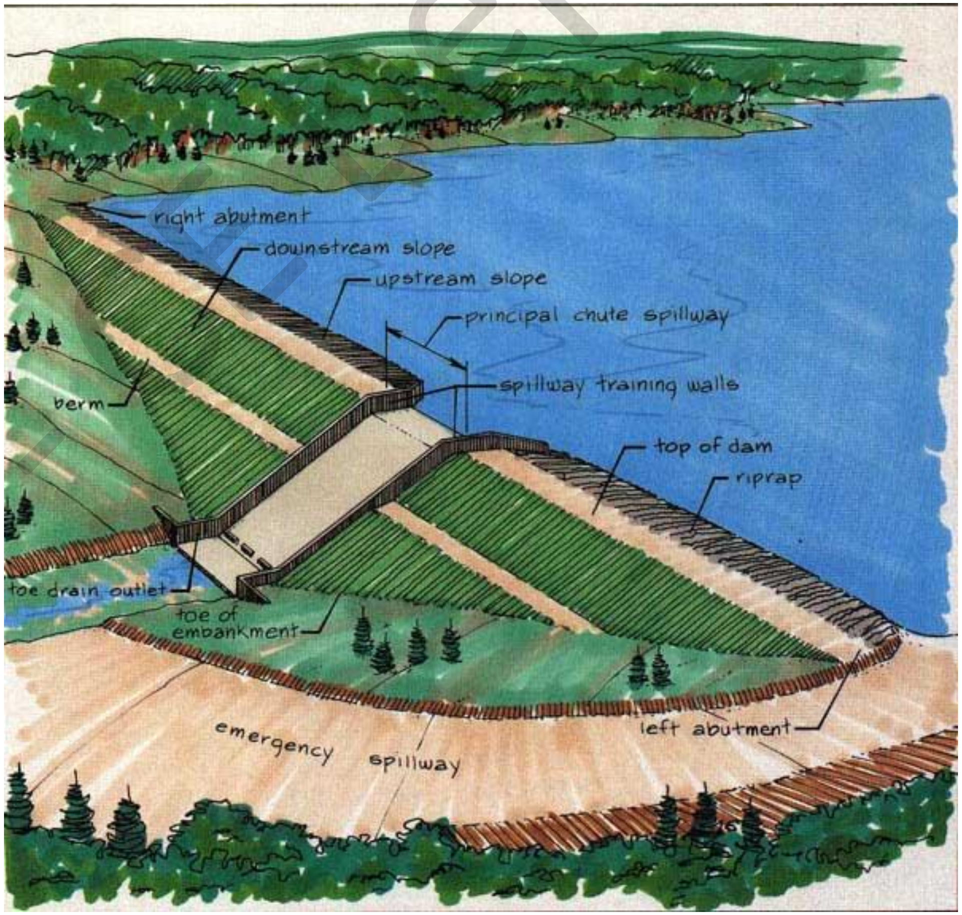


METU - CE Dept.

Cost-benefit analyses of all alternatives need to be carried out.

Design of Hydraulic Structures

1. Hydrologic Design
2. Hydraulic Design
3. Structural Design

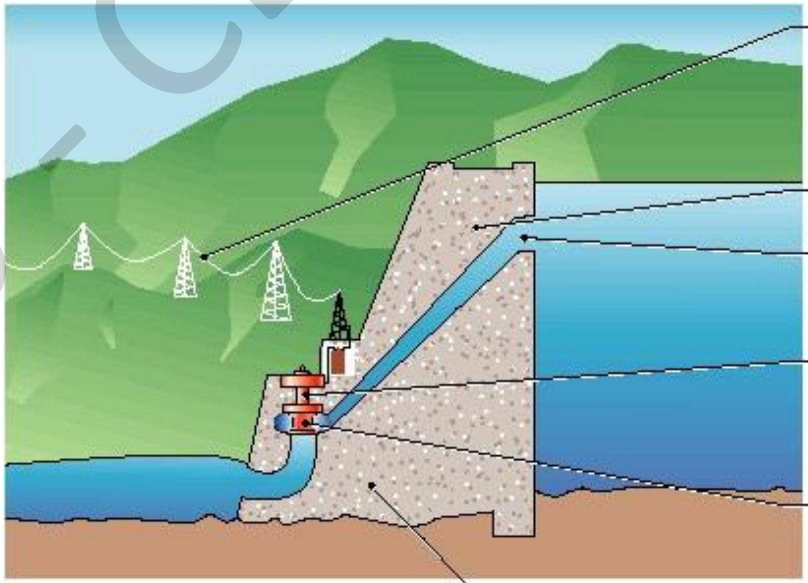


http://dnr.wi.gov/org/water/wm/dsfm/dams/images/parts.jpg

METU - CE Dept.

Applications

- Reservoir capacity (water use)
- Spillway design (water control)
- Highway drainage (water control)
- Irrigation and drainage (water use)
- Hydropower (water use)
- Navigation (water use)
- Recreation (water use)



http://hydropower.inel.gov/hydrofacts/images/howworks.jpg

Cross section of conventional hydropower facility that uses an impoundment dam

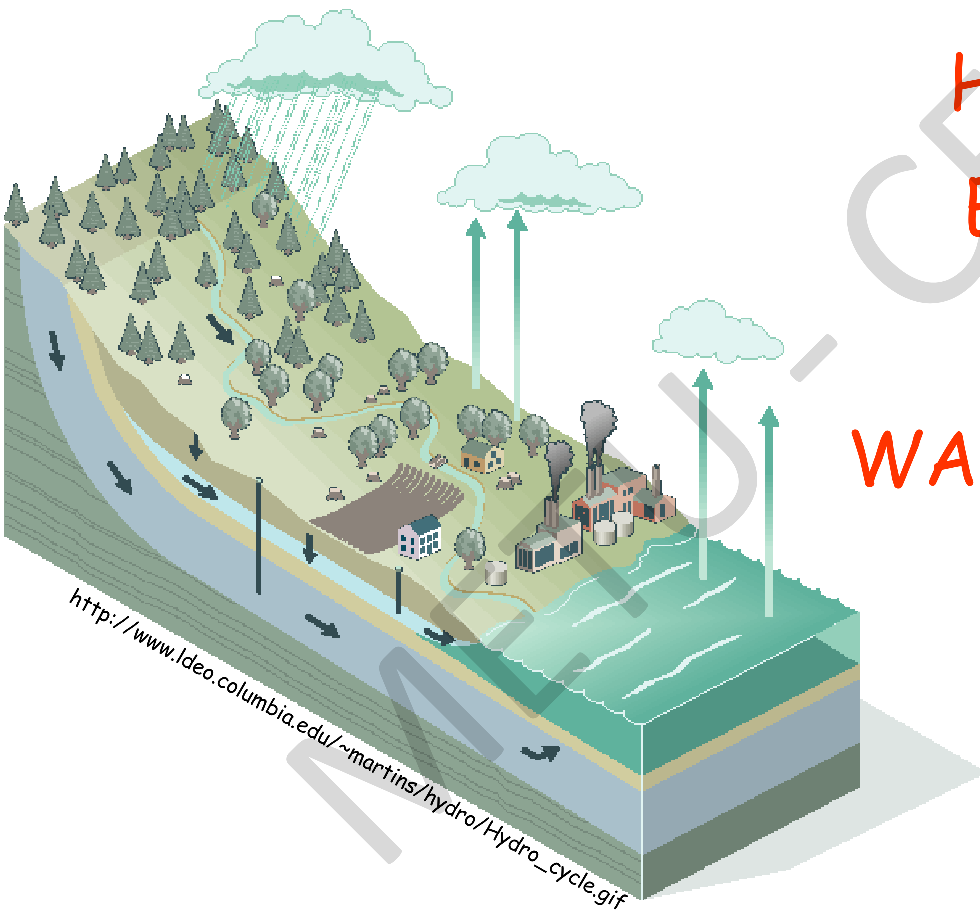
METU - CE Dept.

Water resources engineering is linked to

- hydrology, hydraulics
- structural engineering
- materials engineering
- geotechnics
- transportation
- construction management, engineering economy
- surveying and topographic detailing
- environmental engineering, geological engineering
- sociology, politics, law $\Rightarrow$ HYDROPOLITICS

METU - CE Dept.

Hydrologic Analysis in Water Resources Engineering



HYDROLOGY is an
EARTH SCIENCE
which deals with
WATERS of the EARTH

METU - CE Dept.

Hydrology deals with...

- Occurence
- Distribution
- Movement
- Properties

...of WATER

METU - CE Dept.

Hydrologic Cycle

- The main concept of Hydrology
- It is, the cyclic movement of water

  from SEA to ATMOSPHERE by EVAPORATION,

  & then back to EARTH by PRECIPITATION

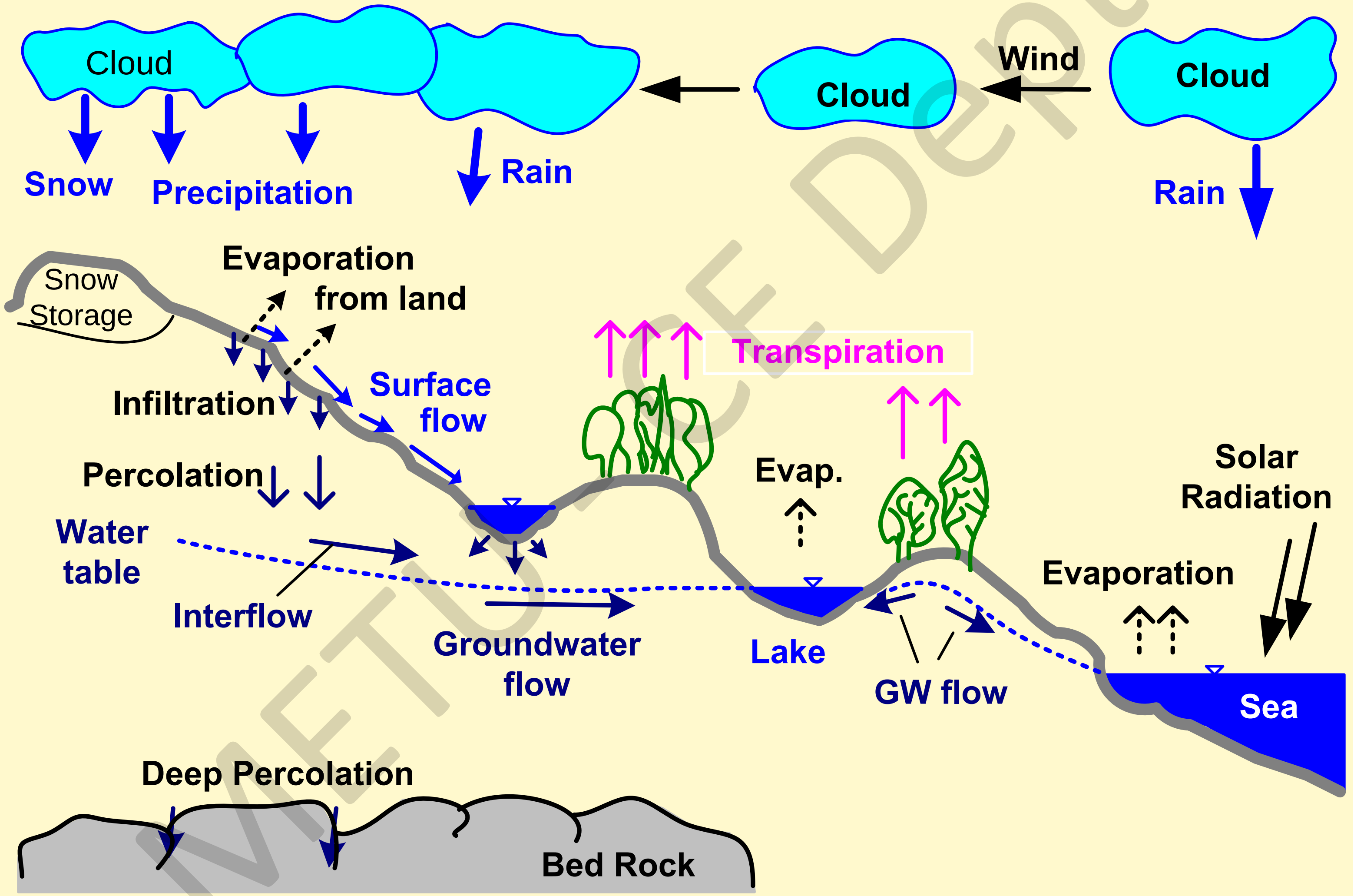
  then runs to SEA through STREAMS or GW

- Climatic (Hydrometeorologic) factors

  solar radiation, temp., humidity, wind, atm. pres.

  affect the elements of hydrologic cycle

METU - CE Dept.



METU CE Dept.

Figure 1.1 The hydrologic cycle

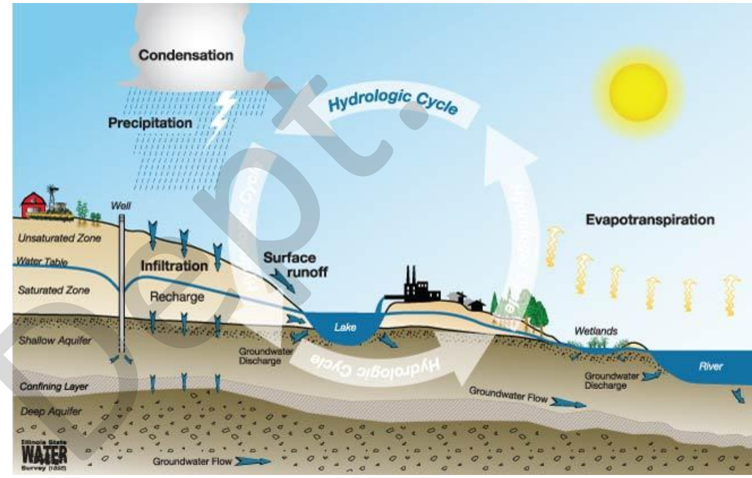
Hydrologic Cycle Elements

- Precipitation (humidity, temperature, wind)
- Interception
- Infiltration
- Surface Flow
- Subsurface Flow (interflow)
- Groundwater Flow (baseflow)
- Evaporation (temperature, wind, atm. pressure)
- Transpiration
- Percolation
- Deep Percolation

METU - CE Dept.

Hydrologic Cycle

- Cycle may take place in a large space
  - 900 m depth in litosphere
  - 16000 m height in atmosphere
- May be very complex
  - Seepage from lakes and rivers to groundwater
  - Contribution of GW to lakes and rivers
  - Snowfall
  - Subsurface flow
- There may be short circuits
- Water changes phase during cycle
- Cycle will be different → location & time
- Water quality changes during cycle
  - Pure when evaporates
  - Impurities may occur every other parts



METU - CE Dept.

Most Important Elements of Hydrologic Cycle

- Precipitation
- Streamflow
- Evaporation
- Infiltration

Problems for an engineer come from the extreme values of these elements

DROUGHTS (min. values) → WATER USE
FLOODS (max. values) → WATER CONTROL

METU - CE Dept.

Hydraulic Structures are built to solve the problems created by these extremes & to correct the maldistribution of water

in area → WATER TRANSMISSION

in time → WATER STORAGE

to fit the demands of people.

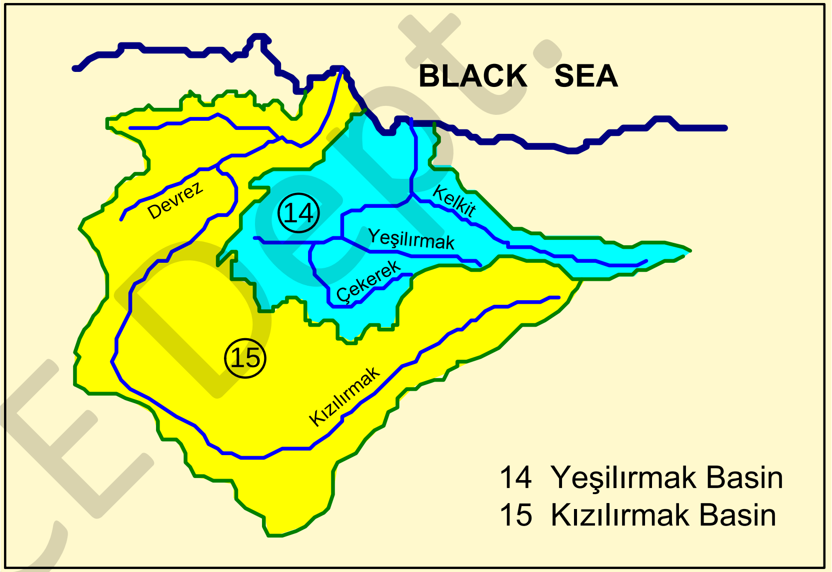
Distribution of Water on Earth

Water source	Water volume, in cubic kilometers	Percent of fresh water	Percent of total water
Oceans, Seas, & Bays	1,338,000,000	--	96.5
Ice caps, Glaciers, & Permanent Snow	24,064,000	68.7	1.74
Groundwater	23,400,000	--	1.7
Fresh	10,530,000	30.1	0.76
Saline	12,870,000	--	0.94
Soil Moisture	16,500	0.05	0.001
Ground Ice & Permafrost	300,000	0.86	0.022
Lakes	176,400	--	0.013
Fresh	91,000	0.26	0.007
Saline	85,400	--	0.006
Atmosphere	12,900	0.04	0.001
Swamp Water	11,470	0.03	0.0008
Rivers	2,120	0.006	0.0002
Biological Water	1,120	0.003	0.0001
Total	1,386,000,000	-	100

Available fresh water ~ 2.5 % (if not contaminated)

METU - CE Dept.

Example for Areal Distribution of Water



	Kızılırmak	Yeşilırmak
Catchment size (km^2)	75120	35959
Gaging station	1533 (İnözü)	1408 (Çarşamba)
Mean annual flow (10^6 m^3)	5900	5600
Mean annual discharge (m^3/s)	188	179
Mean annual precipitation (mm)	459	556
Runoff/rainfall ratio	0.17	0.28

METU - CE Dept.

System Concept

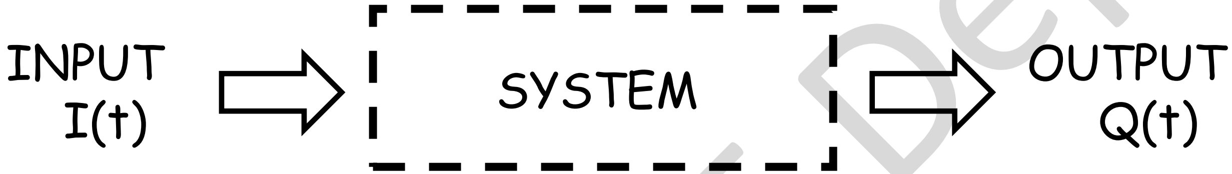
In hydrology,

- the change of parameters in TIME and SPACE is difficult or impossible to determine.
- the knowledge of physical behaviour of system is inadequate.
- systems are heterogeneous.

We use system concept...

METU - CE Dept.

System Concept



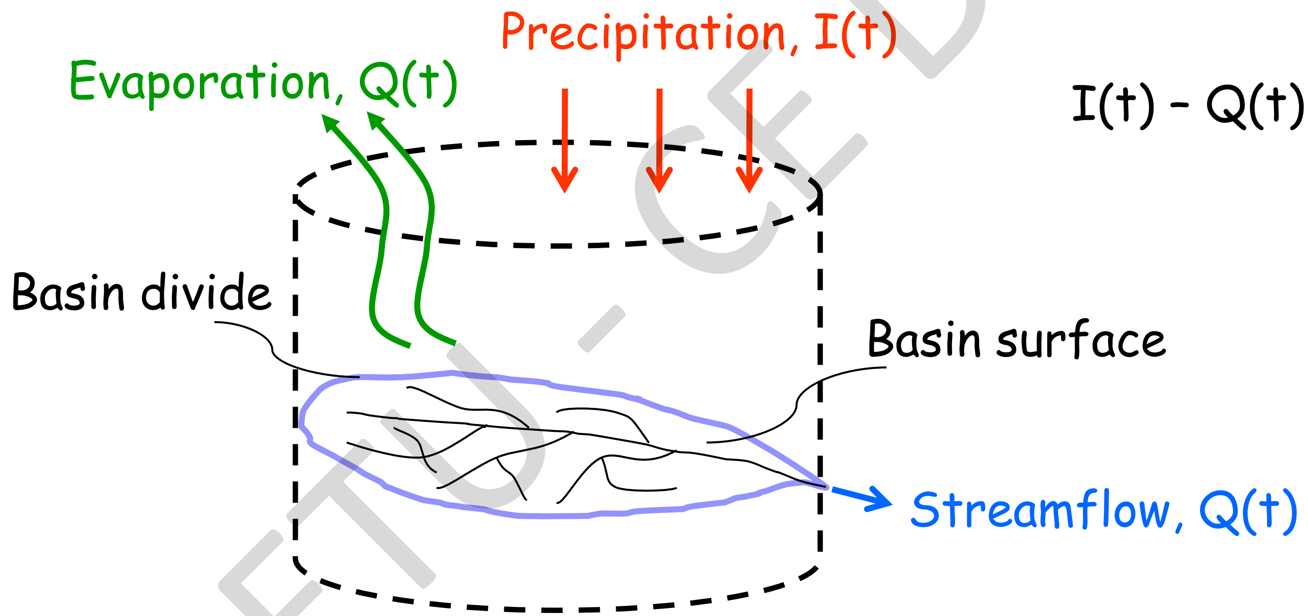
Φ
(System transfer function)

$Q(t) = \Phi\, I(t)$
Transformation Equation

A hydrologic system → a structure or volume in space, surrounded by a boundary, that accepts water and other inputs, operates on them internally, and produces them as outputs

METU-CE Dept.

Question: Represent the storm rainfall-runoff process on a watershed as a hydrologic system [1]



$I(t) - Q(t) = dS/dt$

METU - CE Dept

- Continuity equation for a linear reservoir is a transfer equation linking its inflow and outflow
- $dS/dt = I(t) - Q(t)$

  $I(t)$: inflow $Q(t)$: outflow dS/dt : change in storage

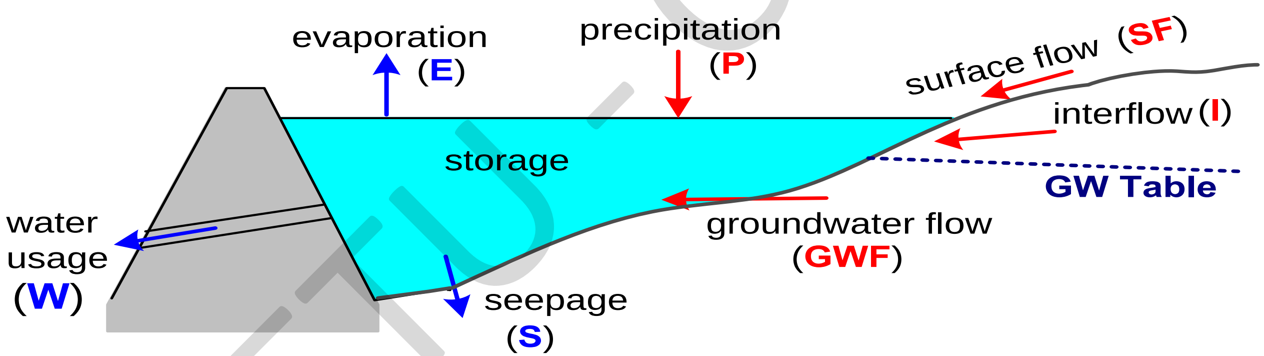


Figure 1.7 Reservoir as a system

$$\Delta S = (P + SF + I + GWF) - (S + W + E)$$

METU - CE Dept.

Subject Matter of Hydrology

DATA COLLECTION AND ANALYSIS

- Depth & intensity of precipitation
- River discharge
- Snow depth & density
- Lake level
- Infiltration rate
- GW table level
- Evaporation rate

AVERAGE VALUES
EXTREME VALUES
TIME HISTORIES

DMI, DSI, EIE,
Rural Services

METU - CE Dept.

Problem : Inadequate Data

- Estimation of extremes which are rarely observed in a small data
- Hydrologic characteristics at locations where no data have been collected
- Estimation of the effects of human actions on the hydrologic characteristics of an area

EACH HYDROLOGIC PROBLEM IS UNIQUE

specific basin + distinct set of physical conditions

METU CE Dept.

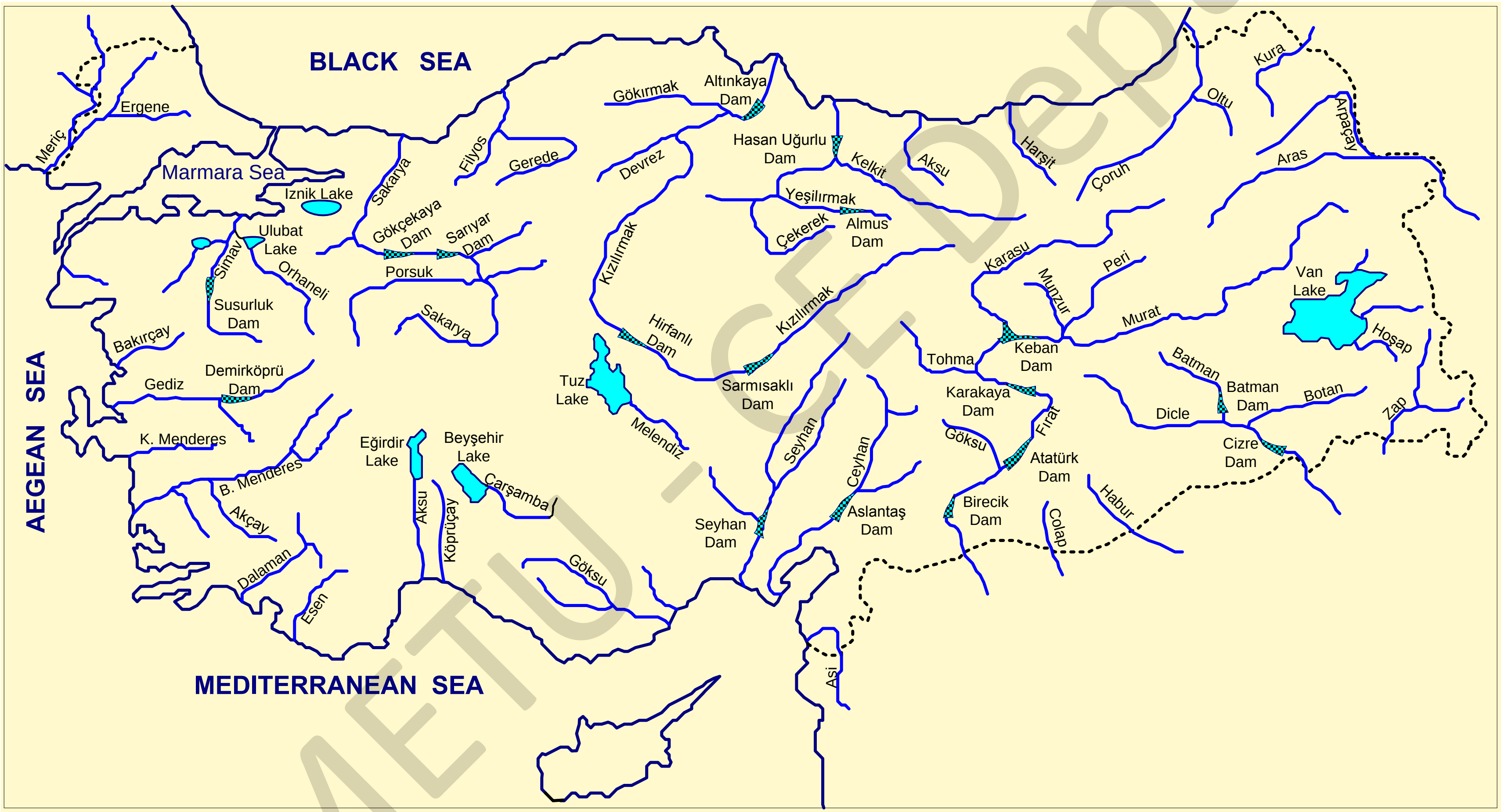


Figure 1.5 Major rivers, lakes and dams in Turkey

METU - CE Dept.

Land and water resources of Turkey

- Agricultural land .... $28*10^6$ ha
- Irrigable land .... $26*10^6$ ha
- Economically irrigable land .... $8.5*10^6$ ha

- Mean annual precipitation depth .... 643 mm
- Mean annual volume of precipitation .... 501 km^3

- Annual surface runoff volume .... 186 km^3
- Average runoff coefficient 0.37

- Annual extractable groundwater resource.................. 12.3 km^3

METU - CE Dept.