ENVR 104
Water Resource Management Module (Characklis)
Lecture 1

[REVIEW THESE NOTES WITH "ENVR 104 LECTURE 1 SLIDES.PDF"]

<u>COVER SLIDE</u>

- At its most basic, we are here to try to figure out how to effectively manage an increasingly scarce water resource

- Managing water resources has a number of technical challenges, but also has

- Social
- Economic
- Environmental

} dimensions

And these can make it much more difficult to formulate management strategies

- The objective of this module is to introduce students to basic methods of quantitatively evaluating various management approaches, but also to make them aware of some of the broader issues involved.

- So, how do we manage our increasingly scarce water resources

    - I say <u>increasingly</u>, because there are many areas in the world where water is relatively abundant.
    - However, the number of these places is declining. Why?
    - Because water is a finite resource, and this is particularly true for freshwater

<u>SLIDE 2</u>

- What % age of world's water is fresh? Not much ~ 2.5%
    - Freshwater lakes
    - Rivers
    - Groundwater (fresh)
        - Remember that efficient pumps were not available prior to the 1930s and 40s, so water supplies were mostly based on rivers and lakes up to that point
        - Big impact on the way civilizations developed
            - Most cities that developed pre WWII did so on rivers/lakes
            - Only in the last 50-60 yrs did this begin to change
                - Las Vegas
                - Los Angeles

- So, water is everywhere, but only a relatively small fraction of it is usable without incurring some considerable expense (i.e. desalination)

- Nonetheless, we are still talking about $35 \cdot 10^6$ km^3 of freshwater available globally

    - With $6 \cdot 10^9$ people in the world, this works out to about 0.006 km^3/person ~ 6,000,000 m^3/person
    - Avg. person in developed world probably uses 0.3 – 0.5 m^3/cap/day, 100-150m^3/cap/yr (those in the developing world use much less)

- Even if we assume 90% of this freshwater (or more) is totally inaccessible, it is still clear that there would be no scarcity if water were perfectly distributed (both temporally and spatially) to meet human needs

But, that is clearly not the case

SLIDE 3

(values are normalized such precipitation on land = 100)

- We are largely dependent on the hydrologic cycle to determine when and where water is available.
- In the end, it comes down to rainfall that runs off into rivers and lakes, or percolates into aquifers.
- Rainfall has cycles, both seasonal and climatic (drought), so in order to develop the reliable supplies that we need to keep society moving, we need to be able to "smooth out" our supply
- We do this by storing excess water during periods of abundance and using the stored amount when water is scarce.
    - o Nature does some of this for us ⇒ aquifers
    - o We have learned to do this for ourselves ⇒ dams

But, there is a catch

SLIDE 4

- We have begun to exhaust the sustainable supply of groundwater, at least in the areas where it is most needed.
    - o U.S. usage peaked in 70s-80s, and has hit a plateau. The rate of usage has even declined slightly, suggesting that some aquifers have been pumped at levels exceeding their recharge rates

SLIDE 5

- A similar situation exists with respect to dams/reservoirs, as the United States has drastically slowed its development of these structures

- 2 primary reasons
  - (1) Used up many of the most attractive sites
    - deep, wide valleys, with narrow openings
    - those that remain are increasingly expensive to develop
  - (2) Growing awareness of the environmental impacts of dam building and increasing public sentiment that these outweigh dam benefits in many cases.

- So, we are beginning to run up against limits in our ability to modify the temporal variations in water availability

SLIDE 6

- But, we also have issues of spatial variability
  - Rain/snow does not fall equally in all places
  - Presumably, we could move water from where it is, to where it isn't.
  - Nature does some of this for us by means of rivers (e.g., Colorado, Missouri, Snake, Columbia)
  - We also know how to do this ourselves,
    - pipeline
    - aqueducts
  - But, there are a couple problems
    - Expensive!! Water is heavy. Capital & O&M costs are high.
    - Environmental consequences
    - Political implications

SLIDE 7

- Nonetheless, we have installed large conveyance networks in several areas of the U.S.
  - Southern California gets water from everywhere
    - Northern CA ⇒ State water project
    - Colorado River ⇒ Colorado Aqueduct
    - Owens Valley ⇒ L.A. Aqueduct ("Chinatown")
  - Denver, transfers from the West slope of the Rockies ⇒ East slope (e.g., Colorado-Big Thompson project)
  - Phoenix/Tucson ⇒ Colorado River water conveyed via the Central Arizona Project

- So, if it is becoming more expensive and more difficult to develop new sources of water, it makes sense to begin to explore how we can use existing sources more efficiently.

- If we are going to think about these issues we probably ought to know something about how water is currently being used.

SLIDE 8

- Vast majority of consumptive water use in the U.S. is for irrigation

  - Most estimates indicate that less than half of the water diverted from rivers and streams is actually put to productive use in crop growth, with the remainder being attributable to:
    - Conveyance losses
    - Flood irrigation
      - Runoff
      - Seepage/evaporative losses

- Most economists place the productive value of water in agriculture far below that of municipal and industrial uses

  - Presuming that we accept that the supply of water in U.S. is relatively fixed and presuming that we want to continue to effectively support economic growth, we would appear to have two options
    - 1. Undertake conservation efforts
    - 2. Transfer water to more highly valued activities

SLIDE 9

- While there is considerable anecdotal evidence that greater conservation efforts are being made, it is also clear that water is moving toward more highly valued activities (e.g., agricultural to urban transfers), a trend that is projected to continue.

Texas

1995 $\Rightarrow$ 2050 Municipal and Industrial (M&I) use increases by half, even as the total quantity of available water declines slightly.

- This brings up policy-related questions as to how these transfers should take place,

  - 2 Extremes
    - Government decides
    - Turn water into private property and let people trade it like any other commodity (i.e. market decides)

- As with many things, the most practical solutions generally lay between these two extremes.

- There is also the issue of society's growing environmental awareness and the increasing attention that is being give to environmental uses of water (e.g., maintenance of instream flows)

SLIDE 10

- In the end, the flow of water in this country (and probably many other developed countries) could be viewed as similar to the conceptual schematic on the last slide

- Water from agriculture and new sources will flow toward M&I uses, with concessions in all areas made for the sake of the environment.

- The job of a water resource engineer/planner is to develop the tools that will allow them to evaluate different approaches for managing resources

- In doing so, these individuals incorporate consideration of

    - Technical factors
    - Economic factors
    - Regulatory factors
    - Political factors

- The water resource engineer/planner needs to develop the quantitative and problem solving skills that will allow him or her to characterize these systems mathematically.

- But, there is also a substantial amount of non-quantitative information that must also be incorporated into these analyses

This makes the field of Water Resource Management both exciting and challenging in ways that are a little different from many traditional technical disciplines