Planning Alternatives

Groundwater Planning Alternatives

- Comparing different alternatives should be based on the following factors:
  - Technical aspects
  - Economic and finance feasibility
  - Environmental impacts
  - Political & legislation considerations
  - Social acceptability

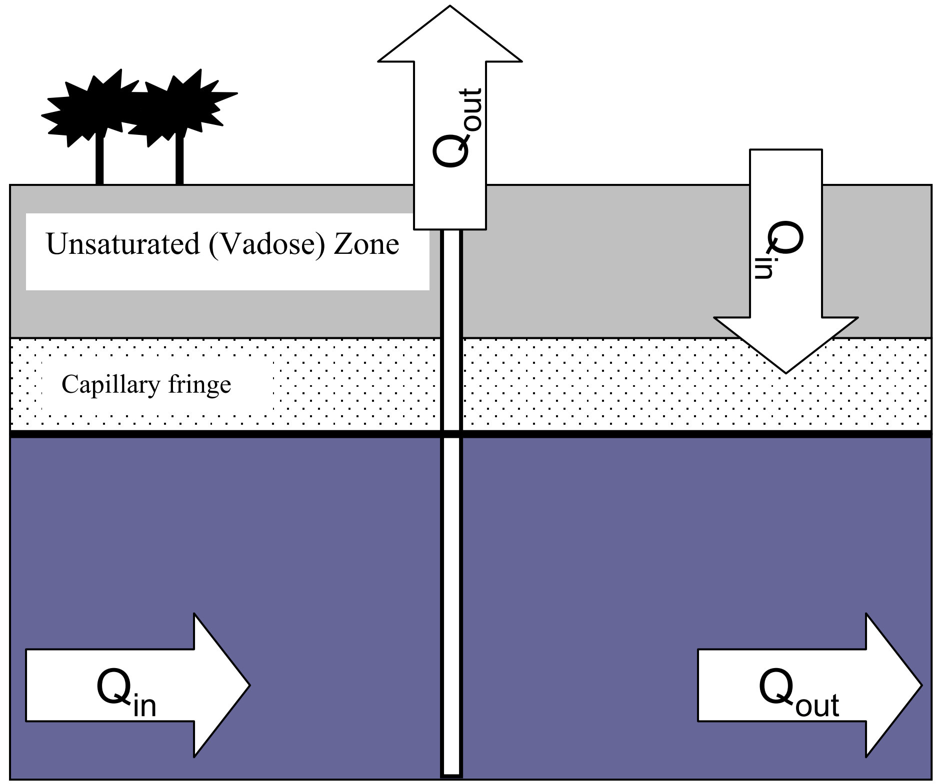
Technical Aspects

Is the selected aquifer going to supply water in an economic amount?

- How much water is available?
- **Water budget equation**

$$Q_{in} - Q_{out} = \Delta S$$

- For how long will the aquifer be used?
- Logistic & infrastructure support (e.g. pumps capacity, piping system, treatment plant, roads … etc.)
- Refer to Modules 1-6



Economic & Finance Feasibility

What is the most promising alternative?

- Once a groundwater project is completed:
  - It can be altered only with difficulty, or not at all
  - Possibility for multipurpose functions is very limited
    - Municipal well field will not serve
      - Irrigation, or
      - Industry … etc.
  - Can not be moved from its location

Economic & Finance Feasibility

Steps in Engineering Economy Studies

- Identify each promising alternative in physical and technical terms (e.g. investigation plans, infrastructure …. etc.)
- Translate physical & technical terms into **money estimates**
- Decide about the **project duration**
- Compare between alternatives on the basis of **money units**. Make your units comparable (e.g. use **annual cost comparison** methods)
- Recommend the best alternative to higher management

Economic & Finance Feasibility

A simple Example

- Two groundwater projects look promising.
- Project A has an estimated cost of $ 450,000 (estimated life of 100 years) and an annual maintenance cost of $ 4,000 / year.
- Project B has an estimated cost of its 1st element of $120,000 (estimated life of 100 years), a cost for its 2nd element of $ 50,000 (estimated life of 20 years), a cost for its 3rd element of $ 90,000 (estimated life 50 years), and an annual maintenance cost of $ 10,500
- Which project would you recommend?

Economic & Finance Feasibility

A simple Example

- To make money units comparable, use the concept of Annual Cost Comparison.
- The method converts all cash flows (e.g. cost) to an equivalent uniform annual series of cash flows over the planning horizon (White, J. et al., 1977, Principles of engineering economic analysis).
- The factor used to convert an investment (cost) into an equivalent annual cost is designated as Capital Recovery Factor (CRF). This factor is based on a specific interest rate and years of estimated life.

Economic & Finance Feasibility

CRF Table

TABLE 13.1
Capital recovery factors

	Interest rate, %							
Years	4	5	6	8	10	12	15	20
5	0.22463	0.23097	0.23740	0.25046	0.26380	0.27741	0.29832	0.33438
10	0.12329	0.12950	0.13587	0.14903	0.16275	0.17698	0.19925	0.23852
15	0.08994	0.09634	0.10296	0.11683	0.13147	0.14682	0.17102	0.21388
20	0.07358	0.08024	0.08718	0.10185	0.11746	0.13388	0.15976	0.20536
25	0.06401	0.07095	0.07823	0.09368	0.11017	0.12750	0.15470	0.20212
30	0.05783	0.06505	0.07265	0.08883	0.10608	0.12414	0.15230	0.20085
35	0.05358	0.06107	0.06897	0.08580	0.10369	0.12232	0.15113	0.20034
40	0.05052	0.05828	0.06646	0.08386	0.10226	0.12130	0.15056	0.20014
45	0.04826	0.05626	0.06470	0.08259	0.10139	0.12074	0.15028	0.20005
50	0.04655	0.05478	0.06344	0.08174	0.10086	0.12042	0.15014	0.20002
60	0.04420	0.05283	0.06188	0.08080	0.10033	0.12013	0.15003	
70	0.04275	0.05170	0.06103	0.08037	0.10013	0.12004	0.15000	
80	0.04181	0.05103	0.06057	0.08017	0.10005	0.12001		
90	0.04121	0.05063	0.06032	0.08008	0.10002			
100	0.04081	0.05038	0.06018	0.08004	0.10001			

(Grant, E., Engineering economy in water resources planning: in Linsley,R. et al, 1992, water resources engineering).

Economic & Finance Feasibility

A simple Example

- Use interest rate of **6%.**
- **Project A analysis**
  - Capital recovery cost for investment= $ 450,000 X 0.06018 = $27,081 /year
  - Annual maintenance cost $ 4,000 / year
  - Total annual cost **$31,081 /year**

- **Project B analysis**
  - Capital recovery cost for 1st element = $120,000 X 0.06018 = $ 7,222 /year
  - Capital recovery cost for 2nd element = $ 50,000 X 0.08718 = $ 4,359 /year
  - Capital recovery cost for 3rd element = $ 90,000 X 0.06344 = $ 5,710 /year
  - Annual maintenance cost of $10,500 /year
  - Total annual cost **$27,791 /year**

- Which project would you recommend? **2nd project**
- Apply benefit-cost analysis and payback period method to support the recommendation.

Environmental Impacts

Phases of environmental impact analysis:

- **Identification**
  - Specify impacts associated with the project (e.g. UST leakage … etc.)
  - Monitoring & sampling programs
- **Prediction**
  - Forecast the nature, magnitude, extent, duration of the environmental impact (e.g. a groundwater plume)
  - Risk assessment study
- **Evaluation**
  - Probability of being impacted
  - Environmental regulations baseline (e.g. PME, ARAMCO, SABIC … etc.)
  - Environmental impact & health exposure
  - Recommendations for decision-makers

Q: Is it an acceptable project or not?

Environmental Impacts

Consider the following environmental concerns when implementing a groundwater resources project:

- **Municipal**
  - Sewage pathogens
  - Sanitary systems & chemicals
  - Gas stations
  - Dump sites
- **Agricultural**
  - Chemical effluents
  - Biological & chemical fertilizers
- **Industrial**
  - Waste disposal ponds (e.g. oil refineries, petrochemical industries … etc.)
  - Mining & oil-gas drilling activities
  - Waste injection wells
  - AST & UST

Political and Legislation Considerations

- The problem
  - Arid region
  - Demand is exceeding supply
  - Future generations and ability to meet their own needs
  - Lack of good groundwater conservation policies!

- Groundwater use priorities (high to low):
  1. Domestic water use
  2. Municipal supplies
  3. Irrigation & livestock
  4. Mining & oil and gas drilling
  5. Recreation

Political and Legislation Considerations

- Groundwater Exploitation Legislations
  - **Aquifers shared by more than one state**
    - UER aquifer in the GCC countries
      - Legislation formula $Qc = Cc (x + y + 1/z)$ ➔ computes the groundwater share of every country
  - **Groundwater basins in one state**
    - Tabuk and Widyan basins
      - Beneficial and reasonable use without harming other users
      - Sustainability of water supply
  - **Wadis**
    - Wadi Fatima, wadi Khurais, wadi Al-Dwasir, wadi Hanifa … etc.
      - Follows almost similar roles as groundwater basins in one state

Social Acceptability

- Public awareness
- Wastewater reuse
- Water trade and marketing
- Water pricing
- Rights of people in shared groundwater resources
- Compensation for properties on top of groundwater resources