Here is yet another topic you asked to hear about.

DESALINATION and WATER CONSERVATION: What is the global $H_2O$ need, and how does conservation fit into the picture?
Just how much fresh water is available?

- Based on data from the World Resources Institute:
  - there is 41,000 km$^3$/year of rainfall on the land.
  - of this amount, 27,000 km$^3$/year runs off to the oceans.
  - and 5,000 km$^3$/year falls in uninhabited areas

NET: 9,000 km$^3$/year of freshwater available.

- Of the total water on earth:
  - Only 2.5% is available as fresh water and ≈ 2/3 of that amount is frozen in glaciers and polar ice caps.
Water use is increasing per capita consumption
Ghana: 48 m³/yr.
Jordan: 158 m³/yr.
France: 512 m³/yr.
Germany: 392 m³/yr.
Switzerland: 359 m³/yr.
United States: 1550 m³/yr.
reasons for water conservation

● 9,000 km³/year is enough for 20 billion people, BUT rain doesn’t conveniently fall where it is needed.

Example:

» Iceland: 68,500 m³ water/person*year

» Bahrain (an island in the Persian Gulf near Saudi Arabia): no natural fresh water

● Inefficient water use. Newly industrializing countries tend to put a lower priority on wastewater treatment.

» It is more difficult to remove diluted contaminants from water than to treat the sources and prevent contamination.
some examples of water conservation efforts

- use of treated wastewater effluents for irrigation
- recycle of water use in manufacturing processes
  » can result in 90% reduction in water use
- efficient irrigation of crops
  (more on this in a minute)
- create new water sources
  - develop groundwater resources
  - rainmaking
  - desalination
  - harvest icebergs (better move QUICK before they melt!!)
Irrigation of arid regions is a major way we use fresh water. It’s worth looking at the pros and cons of doing this.

PRO’s

- Increased agricultural productivity
  - food for the world’s population.
  - economic benefit.
  - makes use of fertile soil in regions with a long growing season.
Cons:

- **cost**
- **water loss**
  - only one in four gallons drawn for irrigation is actually absorbed by root systems
- **salinization**
  - accumulation of salt can eventually be toxic to plants causing farms to be abandoned
- **depletion of groundwater**
  - saltwater intrusion
  - land subsidence
- **habitat loss**
Since there’s plenty of salt water, is it reasonable to consider desalination?

- Sure! The major application of desalination is in the middle east.
  - The world’s largest plant in Saudi Arabia produces 128 MGD.

- In the U.S., several California municipalities (ex., Santa Barbara) have built desalination plants.
  - The practicality of doing this, however, is dictated by the fact that water is such a scarce (and expensive) resource in southern California.
  - The cost to Santa Barbara of water produced by desalination is $1,900/Acre -Foot vs. $35/AF from Lake Cachuma or $200/AF for groundwater (both existing sources, but of limited quantity).
A little more about desalination . . .

- There are several alternative engineered processes for production of potable water from salt water:
  - **Reverse Osmosis**: a membrane process in which high pressure is used to force water through a membrane that excludes dissolves solutes.
  - **Distillation**: feedwater is heated and then evaporated to separate out dissolved minerals.
  - **Electrodialysis**: a membrane process in which an electrical potential gradient is used to remove dissolved ions.

Reverse osmosis process schematic.

- Removes particles that would clog the membrane
- 10 to 500 ppm TDS
Getting water to southern California is an expensive proposition!

- **Interesting California facts:**
  - 70% of potentially usable water is in the northern 1/3 of the state.
  - 77% of the demand for water is located in the southern 2/3 of the state.
    - >22,000,000 people
    - 5 inches rainfall/yr.

- The result is the California Water Project (CWP)
About the CWP:

- It is one of the most complex and expensive water moving projects in the world.
  - 21 dams and reservoirs
  - 22 pumping plants
  - 685 miles of canals, tunnels and pipelines

- Cost: $2,000,000,000 (enough money to build six Panama canals).

- It is important to recognize that the cost of safe water is subsidized. If we paid the true cost of the water we use, we’d likely use less.
  - poor people in the developing world pay on average 12x more for each liter of water than fellow citizens connected to municipal systems.
Access to safe drinking water is a life and death issue

- Nearly 1 billion people have no access to safe water (approx. 1 of every 8 people)
  - Unsafe drinking water kills $3.5 \times 10^6$ people/yr (according to Water.org, 2009).
  - Every 20 seconds, a child dies from a water-related illness.

- Improvements to the standard of living in developing countries are linked to the availability of safe H$_2$O
  - Women spend 200 million hours a day collecting water.
  - The UN has set a goal of providing 1.6 billion people with adequate drinking water by 2015 at a estimated cost of $23 billion dollars.
Want to get involved?

Civil and Environmental Engineering

Home of the AguaClara Project
AguaClara Project

- Developing scalable drinking water treatment technologies for small communities
- Taking turbid surface water and turning it into clean, safe drinking water
- And making that transformation without access to electricity
Water Treatment Plant Designed by Cornell students in 2004

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We will only know the worth of water when the well is dry.

- Benjamin Franklin