Hydrology Source and Water Conservation

Maryland Center for Environmental Training
301-934-7500
info@mcet.org
www.mcet.org

Hydrology Source and Water Conservation

7 Contact Hours
9 CC10 Hours

Water supply hydrology and conservation are the important topics to be covered in this one-day class. The participant will be introduced to many issues surrounding water sources and conservation, specifically groundwater and surface water sources. Other topics covered will include options available for the facility during emergency situations; alternative water sources; use and conservation of water, and practical application of the information covered.

1. Describe the Hydrological Cycle;
2. Explain the differences between Unconfined Aquifers and Artesian Wells;
3. List sources of groundwater contamination;
4. Identify alternative water sources during emergency situations; and
5. Prioritize use and conservation during drought conditions.

8:00 AM to 9:00 AM	Introduction Hand out Materials Pre-test
9:00 AM to 9:45 AM	Water Supply Hydrology
9:45 AM to 10:30 AM	Groundwater Sources
10:30 AM to 12:00 PM	Surface Water Sources
12:00 PM to 1:00 PM	LUNCH
1:00 PM to 1:45 PM	Emergency and Alternative Water Sources
1:45 PM to 2:30 PM	Use and Conservation of Water
2:30 PM to 3:30 PM	Review Discussion
3:30 PM to 4:00 PM	Final Exam

Eddie Cope,
CET

Basic Water Production...

- Water Supply Hydrology.
- Groundwater Sources.
- Surface Water Sources.
- Emergency and Alternative Water Sources.
- Use and Conservation of Water.

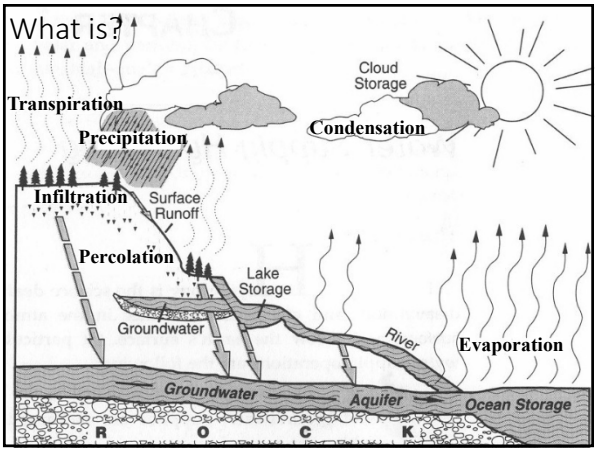
Water Supply Hydrology...

- How water is constantly replenished by the hydrological cycle.
- Recharging of groundwater and it's public use.
- Surface water and it's public use.
- Terminology used in the water industry for volume and flow of water.

What is the Hydrological Cycle?

- Water moves from earth to sky.
- Water vapor forms tiny droplets.
- Water falls back to earth.
- Water on earth penetrates ground or runs off.

What is?



Groundwater...

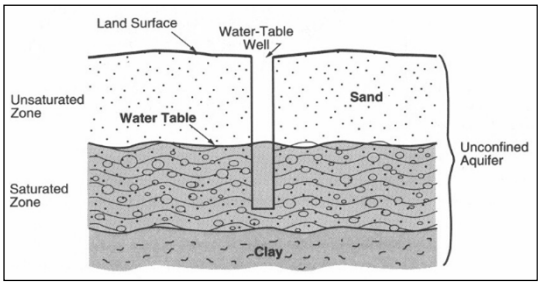
- Result of the infiltration and percolation of water down to the water table, which is the upper zone of saturation in an aquifer.

There are two types of aquifers:

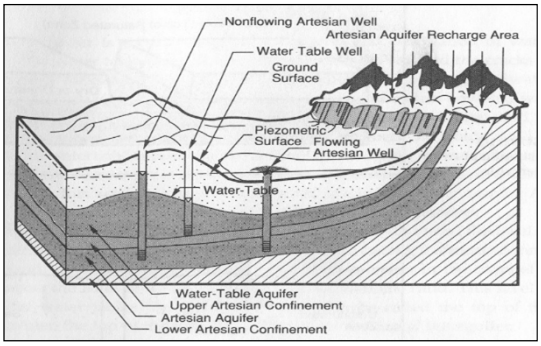
• **Unconfined** - upper saturated zone is free to rise and decline.

- **Confined** - the upper and lower layers of the aquifer are confined by low permeable formations.

Unconfined Aquifer.



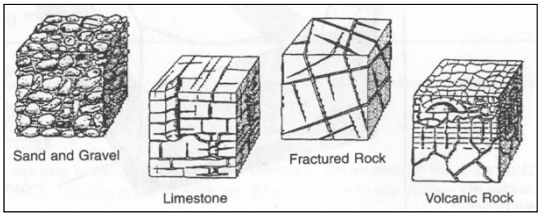
What is an Artesian Well?



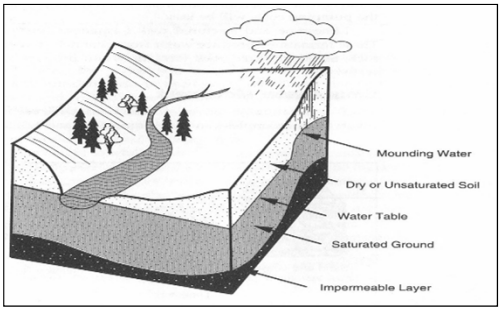
Does the composition of the material for an aquifer make a difference?

- What would water move through easier?
  - Fine sand or Coarse sand.

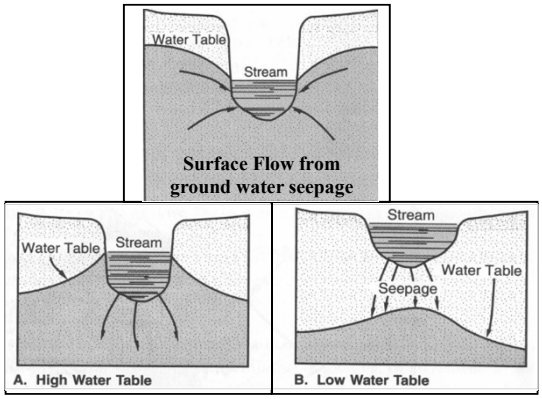
Aquifer Materials.



Formation of ground water.



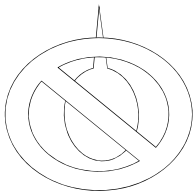
What happens if groundwater gets too high near a stream or river?



What is it when the water table intersects with the surface of the ground or a water bearing crevice through rock when it finds the surface...

- Springs.

Due to difficulty in determining a springs origin, they should be classified contaminated until proven otherwise.



Surface water...

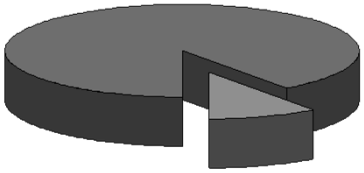
- Amount of surface water available varies widely by region and time of year.

Profile of Precipitation.

- very soft.
- low total dissolved solids.
- low alkalinity.
- slightly acidic pH.
- corrosive to most metals.

Amount impurities:

surface runoff.



rain & snow.

Precipitation that does not infiltrate into the soil or evaporate will travel across the land to a surface water body.

During this travel a variety of materials may be dissolved or taken into suspension.

- Turbidity.
- Limestone.
- Salt.

Surface water helps ground water, allowing water to be held on the surface for a long time will infiltrate into the ground and recharge aquifers.

Effects of water flowing <u>slowly</u> across the land surface:

- Less erosion.
- Less flooding.
- Increase mineral content.

Water on land runs to a primary water course, all land sloped towards the watercourse is the watershed.

- Example - Continental Divide.

Small residential communities or a pump station for a large system need accountability. All water passes through a meter indicating gallons or cubic feet produced.

Volume = Measurement of a quantity of water.

- Gallons.
- Millions of gallons.
- Cubic feet.

Flow Rate = Measurement of the volume of water passing by a point over a period of time.

- Gallons per minute (GPM).
- Gallons per hour (GPH).
- Gallons per day (GPD).
- Million gallons per day (MGD).
- Cubic feet per second (ft3/s) .

Formula's

1 cubic foot of water = 7.48 gallons
1 gallon of water = 8.34 pounds
1 psi = 2.31 feet of water
1 mgd = 694 gallons per minute
1 day = 24 hours
1 day = 1440 minutes

Area of a circle
3.14 x radius 2 (square)
0.785 x diameter 2 (square)

Area of a rectangle
length x width

Area of a triangle
1/2 base x height

Volume of a cylinder
3.14 x radius 2 (square) x height x 7.48 = total gallons

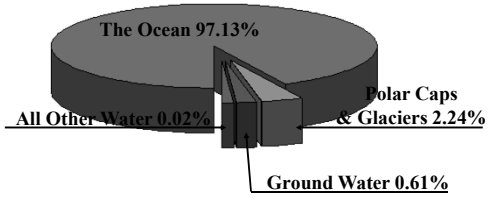
Volume of a rectangle
Length x width x height x 7.48 = total gallons

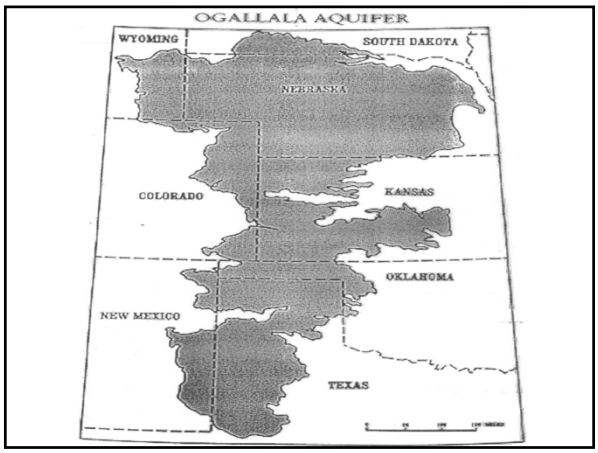
Other important flow rates for water system operations.

- Annual average daily flow.
- Peak-hour demand.
- Peak-day demand.
- Minimum-day demand.
- Peak-month demand.
- Minimum-month demand.

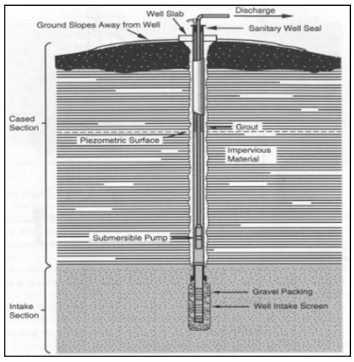
Groundwater Sources.

- 48% of the U.S. population uses groundwater as a primary source.

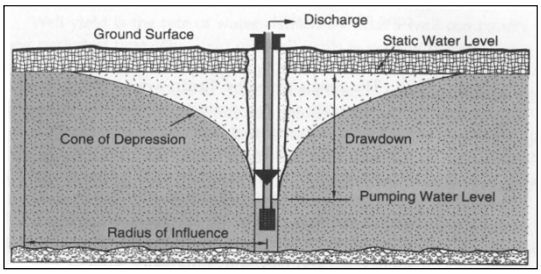




Highlight well casing, well slab, well grout, well screen.



Highlight static water level, pumping water level, draw-down, cone of depression.



Well Yield- Rate of water withdrawal that a well can supply over a long period of time .

- Example: Pumpage from an aquifer continuously exceeds the recharge to the aquifer, draw-down will extend and a safe yield will be reduced .

Sources of groundwater contamination.

- New well **must** be a safe distance from sources of potential contamination.
- Contaminants may be natural or synthetic occurring.
- Contaminants may be located above or below the ground surface.

TABLE 2-1 Potential sources of groundwater contamination

Source	Possible Major Contaminants
Landfills	
Municipal	Heavy metals, chloride, sodium, calcium
Industrial	Wide variety of organic and inorganic constituents
Hazardous-waste disposal sites	Wide variety of inorganic constituents (particularly heavy metals such as hexavalent chromium) and organic compounds (pesticides, solvents, polychlorinated biphenyls)
Liquid waste storage ponds (lagoons, leaching ponds, and evaporation basins)	Heavy metals, solvents, and brines
Septic tanks and leach fields	Organic compounds (solvents), nitrates, sulfates, sodium, and microbiological contaminants
Deep-well waste injection	Variety of organic and inorganic compounds
Agricultural activities	Nitrates, herbicides, and pesticides
Land application of wastewater and sludges	Heavy metals, organic compounds, inorganic compounds, and microbiological contaminants
Infiltration of urban runoff	Inorganic compounds, heavy metals, and petroleum products
Deicing activities (control of snow and ice on roads)	Chlorides, sodium, and calcium
Radioactive wastes	Radioactivity from strontium, tritium, and other radionuclides
Improperly abandoned wells and exploration holes	Variety of organic, inorganic, and microbiological contaminants from surface runoff and other contaminated aquifers

Problems caused by contaminants.

- Unpleasant taste.
- Disease-causing organisms.
- Odors.
- Contaminants above recommended health related limits.

Types of wells...

- D
- B
- Drilled wells
- D
- J

• Dug wells

• Drilled wells

Dug wells (found in rural areas).

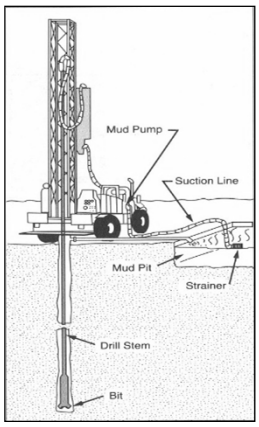
- Do not penetrate much below water table.
- May fail during drought conditions.
- Protection from surface contamination difficult.
- Only type of well **always** treated as a surface water source.

Drilled wells most commonly found in public water supply.

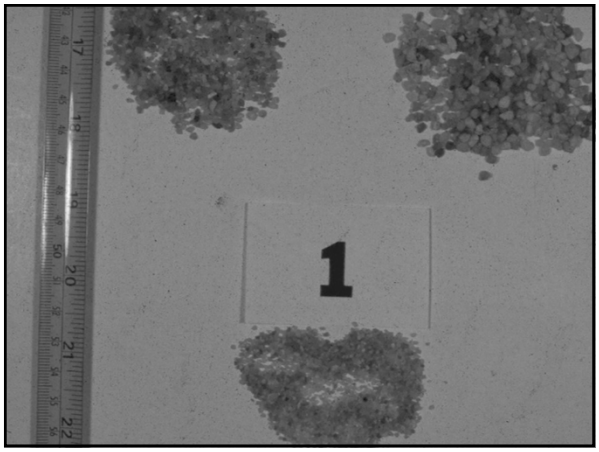
- Benefit - they can reach extreme depths and have large well diameters.

  (up to 4 feet and larger)

Drilling Rig



Mud Pit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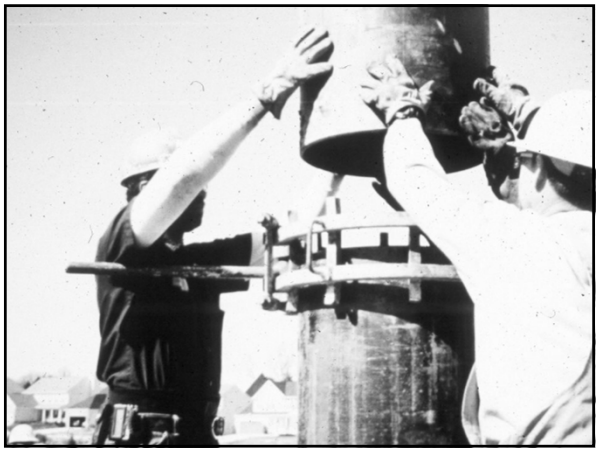
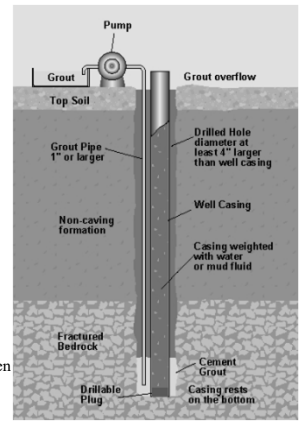


Ground Water Wells: Grouting Methods



Well casing is cemented by pumping grout through a pipe lowered into the annular space outside the casing.

Source: Ground Water and Wells, Johnson Well Screen Division, 1975

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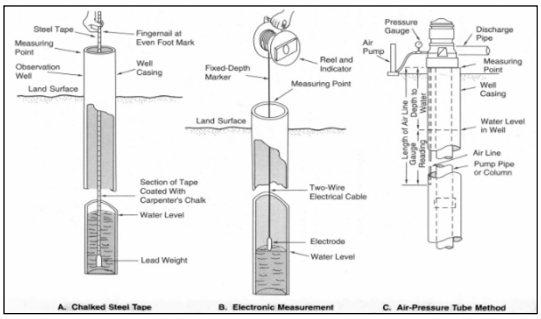
Aquifer Performance...

- Changes in an aquifer are measured by a small diameter test well called an Observation Well.
- Located near an operating well .

Aquifer evaluation can be measured manually or mechanically.



Surface Water Sources...

- Almost all large population centers must be served from surface water sources.

Examples: New York, Los Angeles, Chicago.

Surface Runoff...

- Originates directly from precipitation in the form of rain or snow.
- Groundwater from springs contribute flow to most streams.

How fast does surface water run off ?

- Rainfall intensity.
- Rainfall duration.
- Soil composition.
- Soil moisture.
- Ground slope.
- Vegetation cover.
- Human influence.

Surface water = Electricity.....
Both take the path of least resistance.

- All water in a watershed flows towards one primary carrier called a watercourse.
- Brooks.
- Creeks.
- Streams.
- Rivers.

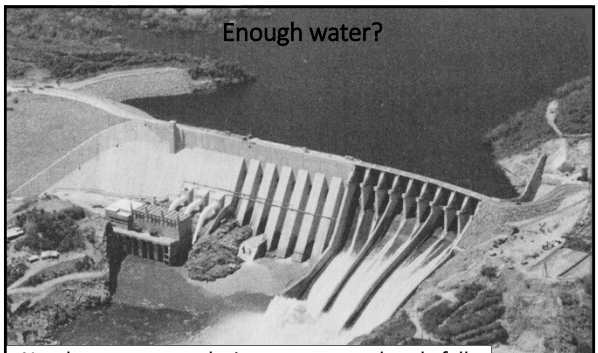
The 3 types of streams...

- **Perennial** - Flows continuously year round.
- **Ephemeral** - Flows occasionally (usually after a rainfall, supplied by surface water).
- **Intermittent** - Falls between the other two categories. May run for a week or a month at a time.

Constructed Watercourses...

- Ditches.
- Channels.
- Canals.
- Aqueducts.
- Tunnels.
- Pipe Lines.

Enough water?



- Needs are greatest during summer and early fall.
- To increase supply reliability, reservoirs can be constructed to store water.

Safe yield of a river is…
The amount of water that can be withdrawn during a period of lowest flow.

Considerations for a safe yield of a water source for public supply.

- Rainfall and flow considerations.
- Agricultural irrigation.
- Usage by other water systems.
- Increase due to population and business growth.

Water quality...

- May be more cost effective to pipe good quality water from a remote location than to treat poor-quality water available locally.

Important factors when considering a water source.

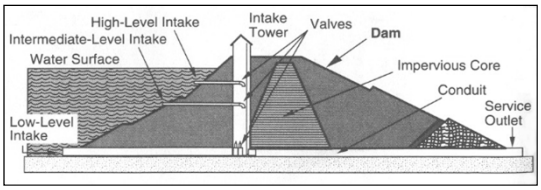
- Water temperature.
- Taste, odor, color.
- Excessive turbidity.
- Vulnerability to microbiological contamination.
- Vulnerability to chemical or radiological contamination.

Water storage...

- Natural means.
- Recharging of aquifers.
- **Impoundment's.**

Impoundment's or Dams.

- Embankment Dam - Constructed out of earth and rock with a impermeable inner core.



Masonry Dams (most common).

- Most important consideration.
- Subsurface condition.
- Soil below the dam must have sufficient strength and impermeable enough to withstand undermining.

Most dams are expected to overflow occasionally. Some release a constant flow to maintain downstream flows.

* DANGER *

Never let water overflow the top of a dam, washout will occur, causing severe damage or total destruction to the dam and downstream property.

Dams must be inspected and maintained to prevent failure. Spillways and slide gates need preventive maintenance in order to prevent failure.

Intake Structures...

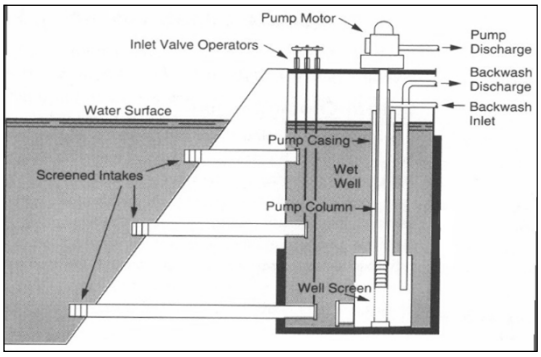
Surface intakes:

The main disadvantage of using a surface intake is that the water quality is not as good as it would be below surface.

Submerged Intakes...

- The best water quality in lakes and rivers can usually be found in deeper water.
- Have an advantage of presenting no surface obstruction.
- Intakes should not be located on the bottom, they will draw in silt and sand.

Multi Intake, Multi Water Quality.



Surface Problems...

- Stream/River contamination.
- Mercy of upstream users.
- Spills from barges.
- Leaks from tank facilities.

Lake Contamination...

- Vulnerable to natural and human contamination.
- Nitrates - runoff from farmlands .
  (also in rivers)
- Algae and weeds.
- Zebra Mussels.

Icing...

- Majority of the time it effects surface intakes.
- Clogging of intake screens can cut down or even stop intake flow.

Evaporation...

- Large impoundment's can expect to lose 6 to 8 feet of water a year trough evaporation.
- Reservoirs are designed larger than required to compensate for the loss.

Siltation...

- Silt will get deposited when water velocities slow down, making reservoirs a prime location .

Ways to minimize silt depositing in reservoirs...

- Create artificial wetlands.

  Enforce rules governing.

  - Farming.
  - Logging.
  - Road construction.

Ways to take care of silt problems in reservoirs...

- Remove by dredging.
- Draining of reservoirs and excavate the silt.
- Construct a new reservoir.

Emergency and Alternative Water Sources...

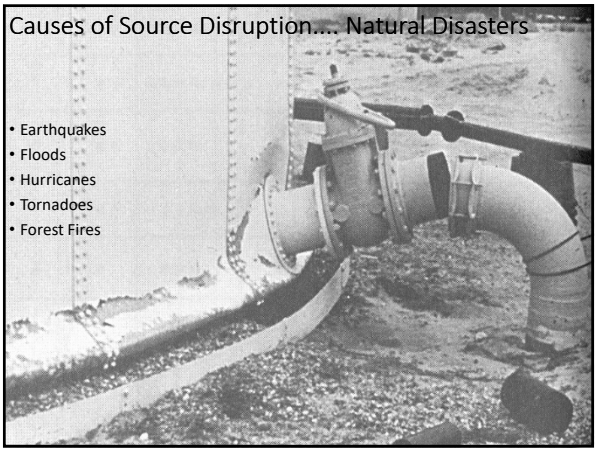
- Public health is the most important reason for maintaining a continual service to each and every customer.

Problems associated with a loss of service to a water system...

- Loss of pressure.
- Loss of fire protection.
- Microbiological and chemical contamination.
- Sanitary purposes.
- Diseases.

Causes of Source Disruption.... Natural Disasters

- Earthquakes
- Floods
- Hurricanes
- Tornadoes
- Forest Fires



Causes of Source Disruption.... Manmade Problems...

- Explosions.
- Vandalism.
- Terrorism.
- Strikes.
- Warfare.
- Breakdown and equipment failure.

Source Contamination...

- Contamination can shut down a public water supply for hours, weeks, years or permanently.

Three options dealing with a contaminated water supply...

- Shut off supply source and operate off stored water (hours).
- Change to an alternative water supply until episode is over (days, weeks).
- Treat contaminated water.

Loss of A Water Source...

- Earthquake has destroyed all of a water system's wells.
- Flooding has destroyed a system's intake facility .

First question to be asked...

- Is the facility repairable or can temporary facilities be installed?

Short-term options...

- Start water conservation.
- Supply water from tank trucks.
- Supply bottled water.
- Use water from an adjoining water system.

Long-term options...

- Drill new wells.
- Construct a new surface water source.
- Clean up the source of contamination.
- Purchase water from another water system.
- Construct a new raw water-water storage.

Evaluate the options...

- Technical and logistical feasibility.
- Reliability.
- Political considerations.
- Cost considerations.

Alternative Water Sources...

- Wise Thinking.
- Advanced planning should be done to prepare a water system in the event of a disaster.

Surface Water Systems...

- Provide two or more intakes at different locations in a lake or river.
- Provide more than one water source.

Groundwater Systems...

- Provide enough wells to meet demand when one or more wells are out of service.
- Locate wells in different aquifers.

All Systems...

- Have interconnections with other water systems if possible.
- Washington Suburban Sanitary Commission - Washington D.C., City of Rockville, City of Bowie.
- Anne Arundel County- City of Baltimore, City of Annapolis, Fort Meade.

Some advanced preparations to minimize potential emergencies...

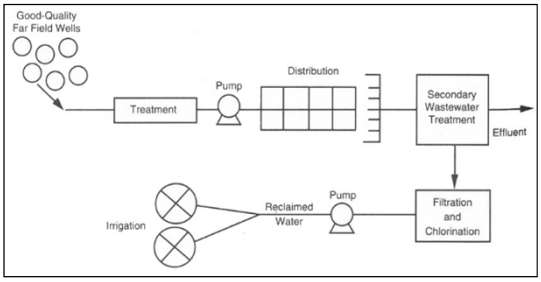
- Security - reduce vandalism and potential acts of terrorism.
- Standby power - eliminates complete dependence on commercial power.
- Locating facilities far enough from flood plains.

Water Reuse...

- Indirect Reuse- the use of water from streams that have an upstream discharge of wastewater.

Direct Reuse...

- Reclaimed water to golf courses, orchards, non-edible crops and flushing of toilets.



Dual Water Systems…

Delivers Potable and Non-Potable water to customers through separate distribution systems.

- Used where potable water is limited and a non-potable supply is plentiful.

Potable Usage...

- Drinking.
- Cooking.
- Bathing.
- Laundry.
- Dishwashing.

Non-potable Usage...

- Toilet flushing.
- Outdoor usage.

Location, Location, Location...

Exterior water usage.

- Pennsylvania - 7% of total water usage for exterior purposes.
- California - 44% of total water usage for exterior purposes.

Cities with dual-distribution systems...

- Tucson and Phoenix, Arizona.
- Colorado Springs and Denver, Colorado.
- Irvine, California.
- St. Petersburg, Florida.

Question - What would be one concern with dual distribution systems?

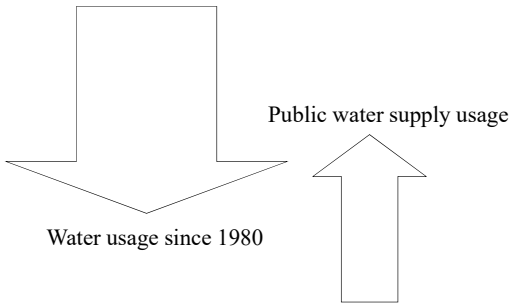
Use and Conservation of Water...

- **<u>Most important natural resource</u>**

Why has the cost of water increased?

- Answer - Costs of complying with the Safe Drinking Water Act and other environmental regulations.

Water Use...



Alot of water!!!

- Approximately 410 billion gallons of fresh water is used every day in the United States.

5 main uses for water...

- Public water supplies. 39 billion gallons
- Thermoelectric power. 195 billion gallons
- Irrigation. 137 billion gallons
- Other industrial usage. 30 billion gallons
- Rural water usage. 8 billion gallons

Us National average... Public Water Supply Use.

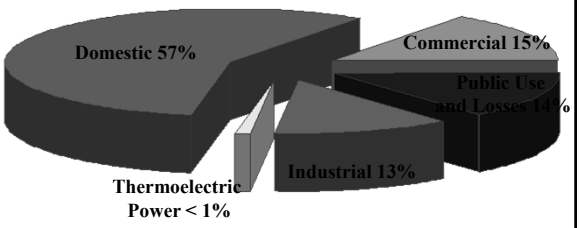


TABLE 5-1 Typical urban water use by a family of four

Type of Household Use	Daily Use: Per Family: Amount of Water Used, *gpd (L/d)*		Daily Use: Per Family: %	Daily Use: Per Capita Use, *gpcd (L/d per capita)*	
Drinking and water used in kitchen	8	(30)	2	2.00	(7.6)
Dishwasher (3 loads per day)	15	(57)	4	3.75	(14.2)
Toilet (16 flushes per day)	96	(363)	28	24.00	(90.8)
Bathing (4 baths or showers per day)	80	(300)	23	20.00	(75.7)
Laundering (6 loads per week)	34	(130)	10	8.50	(32.2)
Automobile washing (2 car washes per month)	10	(38)	3	2.50	(9.5)
Lawn watering and swimming pools (180 hours per year)	100	(380)	29	25.00	(94.6)
Garbage disposal unit (1 percent of all other uses)	3	(11)	1	0.75	(2.8)
Total	346	(1,310)	100	86.50	(327.4)

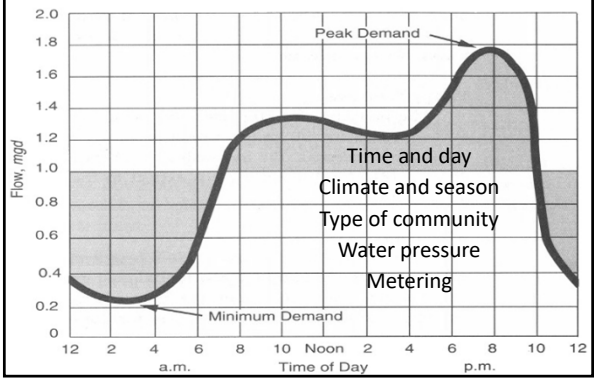
Commercial Use...

- Motels.
- Office buildings.
- Shopping centers.
- Airports.
- Car washes.

Public Use...

- Municipal buildings.
- Fire fighting.
- Public parks, golf courses, swimming pools.

Changes in Water Usage...



Conservation helps us all...

- Reduced demand on the supply source.
- Energy savings.
- Reduction of wastewater flow.
- Protection of the environment.
- Cost savings.

What could be a potential problem with water conservation?

- Loss of revenue for the utility.
- Delays in developing additional source capacity.
- Difficulty in dealing with drought conditions.

Looking into the future for your supply source!

- Maintain a good source of supply.
- Creation of long-range and short-range plans (5 year and 25 year).

Growth...

- Utility size should grow with production demands, seasonal use patterns, expansion planning.

Every drop should be accounted for...

- Meters are important in order to compare what the customer used compared to what is pumped.
- Unaccounted-for water on the average for a utility is 11-15%.
- Water wasted through leaks and unauthorized use.

Droughts...

Actions required during a drought emergency are:

- Locate an additional supply
- Reduce demands.
- Issue fines for unauthorized use during water restrictions.

Water Rights...

Who owns the water?

- Between individuals.
- Between communities.
- Between states.
- Between countries.

Surface Water Rights...
Two systems for allocating Surface Water.

- **Riparian Doctrine** - commonly used in the eastern part of the country
- **Appropriation Doctrine** - commonly used in the western part of the country

Riparian Doctrine...
"rule of reasonable sharing"

- Water should be shared among those who own the land abutting that body of water.
- Use as much as you like as long as it does not interfere with other riparian land owners.

Appropriation Doctrine... "first in time, first in right"

- Rest on two principles - Priority use and Beneficial use.

Priority use...

- Streams flow less than demand, use is prioritized by who has been using the water for the longest period of time.

Beneficial use...

- User must show that the water is being used beneficially. Waste is therefore theoretically prohibited.
- Non-use of the water for a long period of time may result in forfeiture of your water rights.