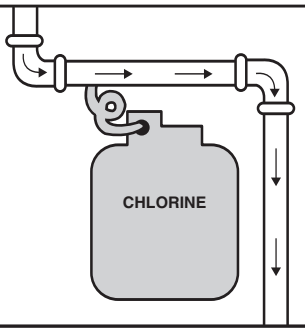
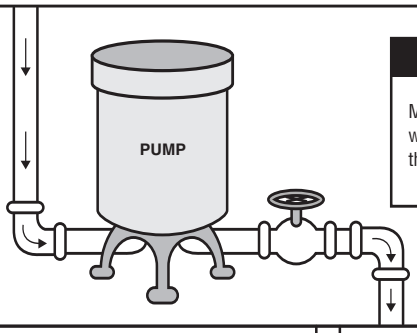
Water System Elements

WATER TREATMENT PLANT

PROTECTIVE DISINFECTION STEP

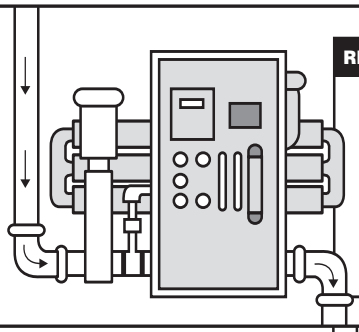
Cleans water to meet government standards. *Small amounts of chlorine are added to the water to keep it safe from bacteria until it reaches the top.*





PUMP

Mechanism that transports water under pressure through pipes.

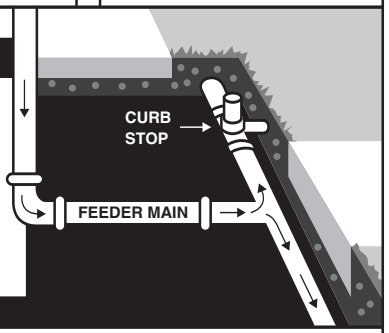


REVERSE OSMOSIS TREATMENT

A type of water treament used to treat "brackish" or salty water. Water is forced through a membrance that removes salt as well as chemicals and harmful organisms such as bacteria. This treatment replaces the disinfection and filtration steps used in the other water treatment plants.

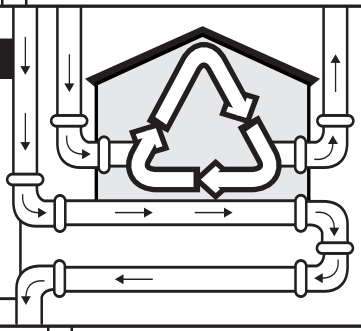
FEEDER MAIN

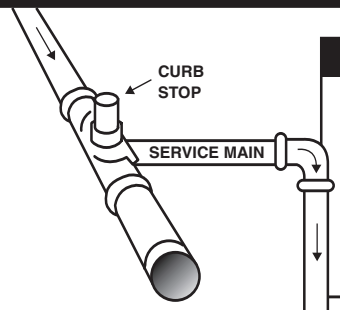
Large pipes that carry large volumes of water from a storage facility or pumping station to individual service mains. Feeder mains range from about 24 to 60 inches in diameter and are most often made of iron, reinforced concrete, steel, or PVC (polyvinyl chloride).



WATER RECYCLING PLANT

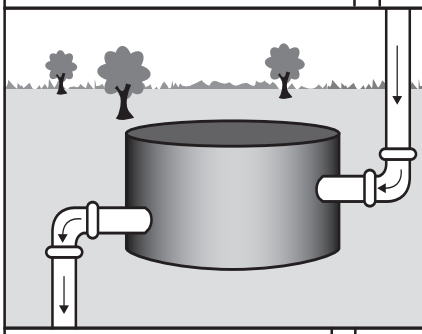
Water recycling treats water to a level suitable for specific uses in industry. Recycled water is transported to users in a separate system of pipes. Water recycling is a way for a city to "make" more water through reuse, to reduce the need for raw, untreated water from wells, reservoirs, or lakes.





SERVICE MAIN

Smaller pipes that carry water from the feeder mains to the homes, businesses, schools, and other locations where water is used. Service mains range from about 3/4 to 16 inches in diameter and are most often made of PVC (polyvinyl chloride), copper, or other metals.

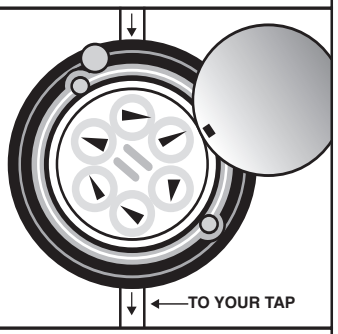


STORAGE

A large tank or covered reservoir in which treated water is held before being distributed to users.

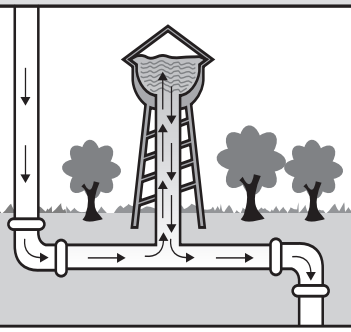
WATER METER

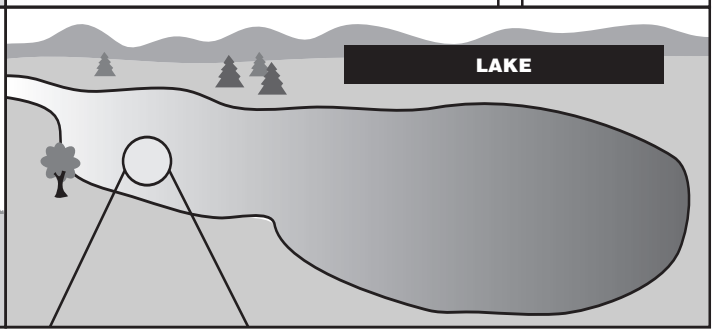
Measures and records the amount of water used at a home, business, school, or other location where water is used. Some cities are now installing water meters that can be read remotely by computer rather than be a water department employee who visits each meter to take monthly readings.



ELEVATED STORAGE

A raised storage tank or water tower into which water is pumped. No further pumping is needed to get the water from the tank to users because gravity does the work.

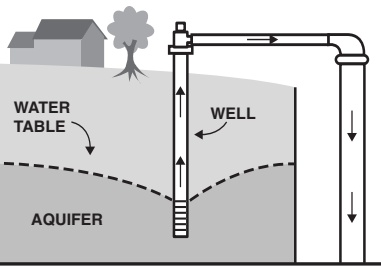




Water System Elements

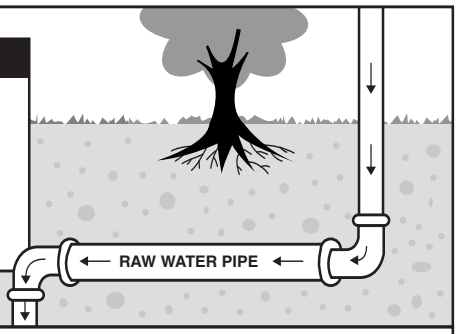
WELL

Provides access to water in aquifers underground.



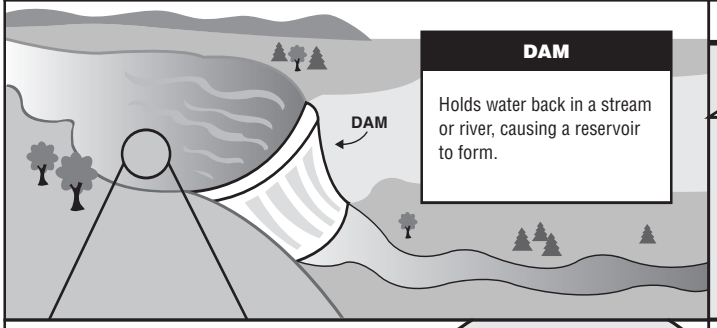
RAW WATER PIPE

Transports water from the source to the water treatment plant underground. Usually made of, or lined with, reinforced concrete to prevent leakage.



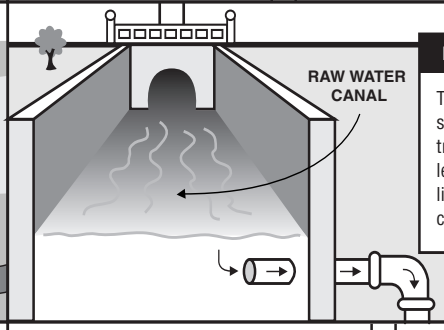
DAM

Holds water back in a stream or river, causing a reservoir to form.



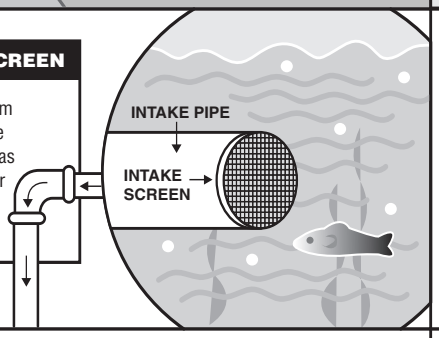
RAW WATER CANAL

Transports water from the source to the water treatment plant at ground level. Usually made of, or lined with, reinforced concrete to prevent leakage.



INTAKE PIPE WITH SCREEN

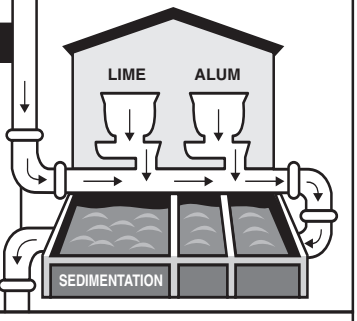
Intake pipe collects water from a reservoir or lake. The intake screen prevents debris such as branches, trash, fish, or other objects from entering the intake pipe.



WATER TREATMENT PLANT

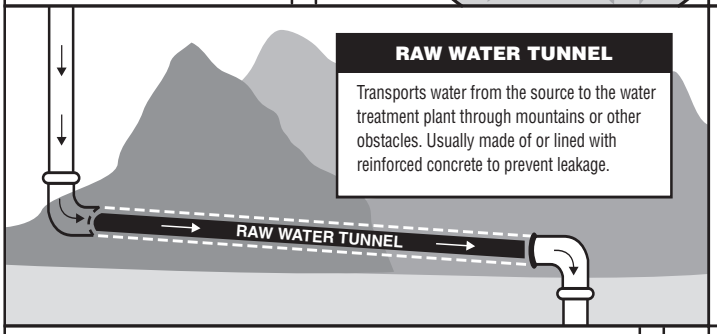
SEDIMENTATION STEP

Cleans water to meet government standards. *Substances such as alum or lime are added to the water to attract bacteria and dirt. Activated carbon may also be added to remove unpleasant tastes and odors. The combination of these substances settles to the bottom and is separated from the cleaner water.*



RAW WATER TUNNEL

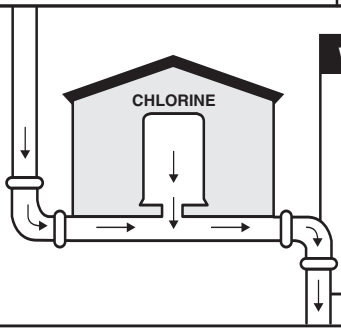
Transports water from the source to the water treatment plant through mountains or other obstacles. Usually made of or lined with reinforced concrete to prevent leakage.



WATER TREATMENT PLANT

DISINFECTION STEP

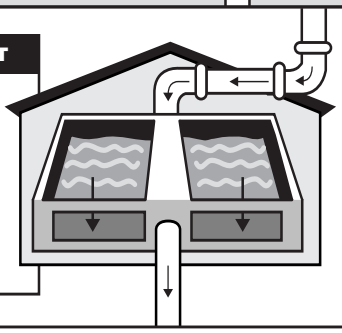
Cleans water to meet government standards. *Ozone, ultraviolet light, chlorine, or other chemicals are used to kill bacteria, viruses, and other harmful microorganisms. Most systems use some type of chlorine disinfection.*



WATER TREATMENT PLANT

FILTRATION STEP

Cleans water to meet government standards. *Water seeps through a bed of materials such as sand and anthracite coal that traps remaining contaminants and treatment chemicals.*



System Experts

You are the **Untreated or "Raw" Water Transport Expert.**

You know that:

Tunnels may be used under large bodies of water such as lakes or bays, and through steep mountains.

Canals may be used to move water long distances over relatively flat terrain.

Large pipes may be installed above or below ground to move water relatively short distances, through steep country, or in situations where canals might expose water to pollution or would cause other problems such as safety hazards.

You are the **Water Treatment Plant Expert.**

You know that:

Water treatment plants can be built to treat different amounts of water each day. This is called a plant's "capacity." The capacity of plants varies:
Large = 400 million gallons/day
Medium = 150 million gallons/day
Small = 50 million gallons/day

Water treatment plants are usually located close to the water source, unless the water source is far from the city. It is easier to transport large volumes of untreated water than it is to safely and cleanly transport large volumes of treated water.

A city with more than one water source may need more than one treatment plant to address different treatment requirements for the water from different sources. It may also be more convenient to build separate, smaller treatment plants close to different water sources rather than building one larger plant.

A city may need more than one water treatment plant to provide enough clean water for all of its residents' needs.

You are the **Water Storage Expert.**

You know that:

City water systems generally have enough storage for about a 1-day supply of water to ensure that the water doesn't run out and that water pressure can be maintained in the system. This water is usually not stored all in one place. Sizes range from storage tanks that hold 1–6 million gallons to larger, covered reservoirs that may hold up to 50 million gallons.

A water supply system may rely on a large number of smaller storage tanks to store and provide water for specific neighborhoods, especially when the population is spread out over a large area. A smaller storage tank may be placed uphill from a neighborhood to provide gravity-fed water to its residents, or water may be pumped into an elevated tank that then provides gravity-fed water to residents.

A water supply system may use larger storage reservoirs when the population is concentrated in a small area. Where possible, these reservoirs may be located uphill from the city to provide gravity-fed water to residents. Systems that must rely on pumps to transport water to users may have a storage facility associated with each major pumping station.

You are the **Pump Location Expert.**

You know that:

Pumps may be used in several parts of a water supply system. Water systems are often designed to use the fewest pumps possible because pumps are often more expensive to operate and maintain than letting gravity do the work. Pumps can be used to:
1. Move water up from an aquifer through a well.
2. Propel water from the source to the treatment plant.
3. Move water from the treatment plant to storage areas.
4. Push water from storage areas through mains to homes, businesses, and other locations where water is used.

Water flows downhill. Some cities are able to design their water supply systems so the water flows through them, assisted by gravity each step of the way. In other cities, such as those where the source of the water is downhill from the city or where there is not enough difference in elevation, more pumps are necessary.

City Circumstances

City by the Mountains

Your Task:
Design a water supply system to meet the needs of City by the Mountains using the ***Water System Elements*** cards and the information provided on the ***System Experts*** cards. Your system must:

- Provide enough clean water for the city's population. How much water is used per day? How many water treatment plants will you need? Of what size? Where will you put them?
- Get the water from the source to the treatment plant(s). How will you transport raw (untreated) water?
- Treat the water properly so it is safe to use. What water treatment processes will each water treatment plant include?
- Store the treated water. What type of storage will you use? Where will your water storage be located?
- Get the water to homes and businesses. How will you transport finished (treated) water to city residents? How will you determine what each water user's monthly bill will be?
- Rely on gravity as much as possible to move water through the system. Your water system may be less expensive to operate if you rely on gravity rather than using energy to run pumps.
- Account for any special circumstances in this city.

System serves: 1,000,000 people

Average use: 160 gallons/person/day

Water sources:

- Most of the water (80%) comes from a large reservoir located in the mountains about 40 miles from the city. The water from this reservoir is so clear that it is not required to go through the filtration step of the treatment process.
- The rest of the water (20%) comes from 6 smaller reservoirs closer to the city. The water from these reservoirs is not clean enough to be exempt from filtration.

Special circumstances:
As its name suggests, City by the Mountains is located close to the mountains, and mountainsides and hills are in or near every neighborhood.

In an average winter, the ground freezes to a depth of 4 feet below the surface. But during especially cold winters, the ground has been known to freeze as much as 6 feet deep! You may choose one or more of the following options, or come up with your own ideas:

1. Use insulated pipe for feeder mains and bury them 6 feet below the surface.
2. Use uninsulated pipe for feeder mains and bury them more than 8 feet deep.
3. Use copper pipe for service mains because these smaller diameter pipes are more prone to freezing, and copper is easier than other materials to defrost if pipes freeze.
4. Prevent freezing by installing insulated electric wire around service mains to provide a small amount of heat when it gets cold outside.
5. Educate people to keep a small amount of water running through their taps to prevent freezing when it gets extremely cold outside.

City Circumstances

City on the Lake

Your Task:
Design a water supply system to meet the needs of City on the Lake using the ***Water System Elements*** cards and the information provided on the ***System Experts*** cards. Your system must:

- Provide enough clean water for the city's population. How much water is used per day? How many water treatment plants will you need? Of what size? Where will you put them?
- Get the water from the source to the treatment plant(s). How will you transport raw (untreated) water?
- Treat the water properly so it is safe to use. What water treatment processes will each water treatment plant include?
- Store the treated water. What type of storage will you use? Where will your water storage be located?
- Get the water to homes and businesses. How will you transport finished (treated) water to city residents? How will you determine what each water user's monthly bill will be?
- Rely on gravity as much as possible to move water through the system. Your water system may be less expensive to operate if you rely on gravity rather than use energy to run pumps.
- Account for any special circumstances in this city.

System serves: 4,750,000 people

Average use: 160 gallons/person/day

Water source:

- This city is built on the shores of a large lake, and all the water the city needs can be taken from the lake.
- There are 3 water intake sites located at the bottom of the lake, 2 miles out from shore.

Special circumstances:
The water source for City on the Lake is lower than the whole city, which is built along its shoreline. No significant hills or mountains are in or near the city.

In an average winter, the ground freezes to a depth of 6 feet below the surface. But during especially cold winters, the ground has been known to freeze as much as 8 feet deep! You may choose one or more of the following options, or come up with your own ideas:

1. Use insulated pipe for feeder mains and bury them 8 feet below the surface.
2. Use uninsulated pipe for feeder mains and bury them more than 10 feet deep.
3. Use copper pipe for service mains because these smaller diameter pipes are more prone to freezing, and copper is easier than other materials to defrost if pipes freeze.
4. Prevent freezing by installing insulated electric wire around service mains to provide a small amount of heat when it gets cold outside.
5. Educate people to keep a small amount of water running through their taps to prevent freezing when it gets extremely cold outside.

City Circumstances

City on the Coast

Your Task:
Design a water supply system to meet the need of City on the Coast using the ***Water System Elements*** cards and the information provided on the ***System Experts*** cards. Your system must:

- Provide enough clean water for the city's population. How much water is used per day? How many water treatment plants will you need? Of what size? Where will you put them?
- Get the water from the source to the treatment plant(s). How will you transport raw (untreated) water?
- Treat the water properly so it is safe to use. What water treatment processes will each water treatment plant include?
- Store the treated water. What type of storage will you use? Where will your water storage be located?
- Get the water to homes and businesses. How will you transport finished (treated) water to city residents? How will you determine what each water user's monthly bill will be?
- Rely on gravity as much as possible to move water through the system. Your water system may be less expensive to operate if you rely on gravity rather than use energy to run pumps.
- Account for any special circumstances in this city.

System serves: 2,250,000 people

Average use: 160 gallons/person/day

Water sources:

- About 70% of the water comes from an aquifer that is tapped by wells in various locations about 25 miles north of the city.
- The rest of the water (30%) is from a different aquifer. The wells that bring up water from this aquifer are in various locations in the southern parts of the city.

Special circumstances:
City on the Coast is built in a relatively flat coastal area, with no significant hills or mountains in or near the city and little elevation change.

The aquifer below the south end of the city supplies brackish (somewhat salty) water, while the aquifer to the north of the city supplies fresh (not salty) water.

City Circumstances

City on an Island

Your Task:
Design a water supply system to meet the needs of City on an Island using the ***Water System Elements*** cards and the information provided on the ***System Experts*** cards. Your system must:

- Provide enough clean water for the city's population. How much water is used per day? How many water treatment plants will you need? Of what size? Where will you put them?
- Get the water from the source to the treatment plant(s). How will you transport raw (untreated) water?
- Treat the water properly so it is safe to use. What water treatment processes will each water treatment plant include?
- Store the treated water. What type of storage will you use? Where will your water storage be located?
- Get the water to homes and businesses. How will you transport finished (treated) water to city residents? How will you determine what each water user's monthly bill will be?
- Rely on gravity as much as possible to move water through the system. Your water system may be less expensive to operate if you rely on gravity rather than use energy to run pumps.
- Account for any special circumstances in this city

System serves: 890,000 people

Average use: 160 gallons/person/day

Water sources:

- Most of the water (90%) comes from deep underground aquifers. These wells are located in the mountains surrounding the city.
- The remainder of the water (10%) comes from a shallower aquifer in the coastal area, which is not mountainous.

Special considerations:
The island this city is built on is mountainous. The city is built between the coastline and the mountains, and some of its neighborhoods are built in valleys extending up into the mountains. Mountainsides and hills are in or near every neighborhood, except in the neighborhoods closest to the coast.

The water from the deep aquifers is sufficiently purified and protected so it needs no disinfection before it is safe to drink. The shallower aquifer is less protected and may be contaminated with bacteria, viruses, or other harmful microorganisms. The water from this aquifer also has an unpleasant odor and taste.

City Circumstances

City in the Desert

Your Task:
Design a water supply system to meet the needs of City in the Desert using the ***Water System Elements*** cards and the information provided on the ***System Experts*** cards. Your system must:

- Provide enough clean water for the city's population. How much water is used per day? How many water treatment plants will you need? Of what size? Where will you put them?
- Get the water from the source to the treatment plant(s). How will you transport raw (untreated) water?
- Treat the water properly so it is safe to use. What water treatment processes will each water treatment plant include?
- Store the treated water. What type of storage will you use? Where will your water storage be located?
- Get the water to homes and businesses. How will you transport finished (treated) water to city residents? How will you determine what each water user's monthly bill will be?
- Rely on gravity as much as possible to move water through the system. Your water system may be less expensive to operate if you rely on gravity rather than use energy to run pumps.
- Account for any special circumstances in this city.

System serves: 1,300,000 people

Average use: 160 gallons/person/day

Water sources:

- Most of the water (80%) comes from 2 reservoirs on a large river that is 225 miles north of the city and across relatively flat terrain.
- The remainder of the water (20%) comes from 3 reservoirs on a smaller river about 25 miles south of the city and across relatively flat terrain.

Special considerations:
City in the Desert is built in a relatively flat coastal area, with no significant hills or mountains in or near the city and with little elevation change.

Water shortages are common in City in a Desert. During the summer, especially, water demands rise as people use more water for watering lawns and landscaping. This time of year, when water levels in the reservoirs can be low because of low rainfall, there is not always enough water to meet everyone's demands.