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WATER IN YOUR LIFE

WHAT DO YOU USE WATER FOR?

If someone asked you this question, you would probably think right away of water for drinking. Then you would think of water for bathing, brushing teeth, flushing the toilet. Your list would get longer as you thought of water for cooking, washing the...
dishes, running the garbage grinder. Water for lawn watering, for play pools, for swimming pools, for washing the car and the dog. Water for washing machines and for air conditioning. You can hardly do without water for fun and pleasure—water for swimming, boating, fishing, water-skiing, and skin diving. In school or the public library, you need water to wash your hands, or to have a drink. If your home or school bursts into flames, quantities of water are needed to put it out.

In fact, life to Americans is unthinkable without large supplies of fresh, clean water. If you give the matter a little thought, you will realize that people in many countries, even in our own, may suffer from disease and dirt simply because their homes are not equipped with running water. Imagine your own town if for some reason—an explosion, perhaps—water service were cut off for a week or several weeks. You would have to drive or walk to a neighboring town and bring water back in pails. Certainly if people had to carry water themselves they might not be inclined to bathe very often; washing clothes would be a real chore.

Nothing can live without water. The earth is covered by water over three-fourths of its surface—water as a liquid in rivers, lakes and oceans, and water as ice and snow on the tops of high mountains and in the polar regions. Only one-quarter of our bodies is bone and muscle; the other three-fourths is made of water. We need water to live,
and so do plants and animals. People and animals can live a long time without food, but without water they die in a few days. Without water, everything would die, and the world would turn into a huge desert.

**HOW MUCH WATER YOU USE**

Can you guess how much water is used by the average person every day in America? It varies, of course, but in a typical home in Washington, D.C., it might be 60 or 70 gallons for *each* person, *every* day. This may sound like a lot, and it is, but it is easy to understand when you realize how much water it takes for ordinary home operations. To flush a toilet, it takes 3 gallons. A tub bath requires 30 to 40 gallons; washing dishes, 10 gallons; running the washing machine, 20 to 30 gallons.

Your father has to pay for this water. Or rather, he has to pay for the cost of having the water delivered to him. It cost a great deal of money to build a reservoir for your city, and install all the pipes that carry the clean water and take the used water away. Even so, water is still pretty cheap, about 27 cents per thousand gallons in Washington, D.C. But if water is wasted in your home, it can add several dollars to your father's water bill. For instance, a faucet that needs a new washer and leaks only one drop every second will waste 4 gallons a day.
WHAT WATER IS

As one is taught in science class, everything in the world is composed of atoms which are combined in different ways to form molecules. Molecules make up the every­day objects in life. Water consists of molecules composed of two atoms of hydrogen combined with one of oxygen. So the water molecule is described by the symbols H₂O.

WATER HAS THREE FORMS

Water may take the form of solid, liquid, or gas, depending on how far apart the individual molecules of the water are. A low temperature reduces the motion of the water molecules, and they lie very close together, bumping into each other only occasionally. In such a state H₂O has the form of ice.

At moderate temperatures, when the molecules are in a state of agitation, bumping into one another often, the substance is liquid water.

When highly agitated owing to high temperature, molecules knock each other about violently. They are relatively far apart due to this bumping, and then water is in the form of vapor, an invisible gas. The steam we see at the spout of a teapot is visible only because there are droplets of liquid water. When completely in vapor form, H₂O is colorless and invisible.
WATER EVAPORATES

Water is constantly on the move. In a river, a lake, or the ocean, its liquid molecules are changing into vapor, which drifts into the air. The process of change is called evaporation. Water may look as if it were standing still in a basin, but the same thing is happening. Some of the water is always changing into vapor, or evaporating. If you let water boil in a pot on the stove for a while, eventually it will boil dry. All the water will have evaporated.

VAPOR CONDENSES

The warmer it is, the more vapor the air can carry. When the air has a great deal of water vapor in it, we say the weather is humid. It makes us feel damp and sticky. If the air cools, the vapor changes back into water again, and falls as rain, or, if it is very cold, as snow. When water vapor changes back into liquid water, we say it condenses. If you set down a glass of lemonade in a warm room, there will soon be little drops of water on the outside of the glass. The cold glass has caused the water vapor in the air to condense.
WATER'S ENDLESS JOURNEY

Water evaporates from land and ocean, and is carried as vapor or clouds in the air. Then somewhere it falls as rain or snow, returning to the ocean or the land, to go through the same cycle all over again, around and around. It is wonderful to think of this life-giving process going on all about us, quietly (except in storms), and almost invisibly. The same drop of water that falls on the road today may evaporate and later may float over your head as a cloud, returning to earth as a snowflake falling on top of a mountain. Then it may melt and flow down a brook into a lake where you swim. Perhaps you swallow it. Later it appears on your forehead as perspiration, which once again evaporates into the air. Scientists call this endless journey the hydrologic cycle.
WATER FROM PLANTS

Water gets into the air by means of plants as well as by evaporation, for plants give up moisture through their leaves. This is called transpiration. An acre of corn, for example, gives off about 3,000 to 4,000 gallons of water a day to the air. A big oak tree gives off about 40,000 gallons a year! Water is taken up from the soil by the roots of a tree. It moves up the trunk as sap, and finally comes out through thousands of small holes on the underside of every leaf. Transpiration from plants is one of the important sources of water vapor in the air. Transpiration often produces more vapor than evaporation from lakes and streams. However, evaporation from oceans is the most important source of moisture in the air.

The underside of a leaf, magnified, showing the holes through which water escapes.
HOW RAIN AND SNOW FALL

What makes the air cold enough so that vapor condenses as rain or snow? The earth is wrapped in a layer of air which is warmer near the earth, and cooler farther away. It is warmer near the surface because of the great weight of air above it. When air near the earth is lifted higher in the sky it cools because there is less air above it and so it is under less pressure. Winds that blow toward hills or mountains rise up over them. Over the high peaks, the air is cooler and can hold less water vapor. The vapor changes to liquid water that falls as rain or snow. Sometimes, when a mass of warm light air meets a cold heavy mass, the lighter air rises over the heavier air. Again, the cooling of the warm light air will cause the vapor to condense and fall as rain.

CLOUDS

Clouds are made of many droplets of ice or liquid water which, unlike vapor in the air, we can see. The wispy clouds at high levels are composed of small crystals of ice. Dark, threatening storm clouds and fleecy, woolly-looking ones are made up of water droplets. Why are clouds usually white? Their color depends on the kind of light reflected from the cloud. Because it is usually a white light, clouds are generally white.
GROUND WATER

We can use water only when it is on the surface of the land, or when it is in the ground. Water in lakes, ponds, rivers and creeks is called surface water. What you do not see is the important water that is out of sight — called ground water, because it is in the ground.

WELL WATER

If you have ever visited a farm or the home of someone who lives quite far out in the country, you know that they probably get their water from a well. Perhaps you have wondered why there is water in the ground at just that place, or where the water in the ground comes from.

The surface of the land is like a screen or sieve. It has many very small holes or spaces between the grains of sand or dirt. When rain falls on a sandy or gravelly surface, it goes quickly through the sieve-like openings in the ground. Some soils have smaller openings than others. When rain falls on a fine soil like clay, it cannot pass through the smaller soil spaces so quickly. The part which cannot get through the holes runs off
into ditches and streams.

Some of the water absorbed by the soil is taken up by the roots of the plants. The rest of the water moves down deeper, pulled by gravity. It is this water deep in the ground that supplies wells.

HOW GROUND WATER MOVES

Water trickles down through holes or spaces between sand grains or small pebbles, or through holes made by worms, or where roots have decayed or died. At last it comes to rocks through which it moves more slowly, through holes or cracks or spaces in the rocks. Many of these openings have been made by weathering. Rain, wind, frost and heat act on rocks just as they do on house paint or garden tables or your family’s shiny new car. They wear out the surface of the rocks and cause tiny flakes to loosen from the harder rock beneath. Extreme changes of temperature freeze and thaw the soil. The ice crystals formed will make the rocks crack open. As you drive along a highway, watch the sides of the road. There you can see the different layers, as in our picture; from surface soil to underlying broken, cracked up rocks, and finally to the hard and solid bedrock. Water seeps down between these cracks and seams.

Besides the cracks in the rocks caused by weathering, there is another kind of hole that allows water to seep through. There are spaces between the grains of the rock itself. These are called pores. An example of rock with many natural pore spaces is sandstone. Sandstone used to be ordinary sand such as we see on a beach. When rain falls on a sandy soil, we can see that it moves quite easily through the holes or spaces between the grains of sand. When sand becomes cemented together to become sandstone, not
all the pores between the grains are filled up completely. For this reason water will move quite easily through sandstone. There are other porous materials, such as gravels, through which water will move easily. Some rocks are what we call "cavernous"; they have hollowed-out openings in them. Limestone is like this, and water often flows faster through limestone than it would through other rocks. You can actually see water flowing through underground channels if you visit Mammoth Cave in Kentucky or Carlsbad Caverns in New Mexico. In fine sand, water may only move a fraction of an inch a day. In a coarser material like gravel, it may move a few hundred feet a day. Even so, it takes ground water years to move several miles.

The name for a layer of rock which holds and carries water is an **aquifer**. The word aquifer comes from two Latin words, *aqua* or water, and *ferre*, to bring. The aquifer literally brings water—underground, of course. An aquifer is an underground layer of rock which is a good source of water. It may be a layer of gravel or sand, a layer of sandstone, or highly shattered rock, or of cavernous limestone. Underneath the aquifers, everywhere at some depth, is a layer of rock that is *impervious*, or watertight.
Imagine a dishpan half filled with sand, into which we pour water. The water is absorbed in the sand, seeping down through the spaces between sand grains until it comes to the watertight bottom of the pan. As more water is poured into the pan, the water surface rises gradually. When there is enough water in the dishpan to wet the bottom half of the sand, as in the picture, we can find the level of the water by poking a hole in the sand with a finger. This hole turns out to be partly filled with water. The water level in the hole is the same as the level of the water all through the sand. We call this level the *water table*. The water table is the top of the layer, or zone, of sand that is saturated, or completely soaked, with water.

Outdoors, rain falls on the surface of the ground and seeps through the soil to the layers of rock beneath. At some depth these will be a layer of impervious rock through which water cannot pass. This is like the bottom of the dishpan. Above this solid layer,
water collects in all the cracks, spaces and pores. The top of the zone of saturated rock is the water table.

The water table rises or falls depending on the amount of precipitation (rainfall or snowfall). Sometimes the water table will be high enough to emerge as a spring, or to seep into a stream channel. In a dry climate, small brooks and springs are dry between rains, because the water table sinks beneath the surface of the ground, even in low places. In some places in the world the water table is very, very deep underground. In those places the earth’s surface is a desert, where almost nothing can grow except prickly plants.

Sometimes the water table is very high, and the land nearby is hollowed out. What do you think happens in places where the water table is higher than the land? If you look at the bottom picture, you can see the answer. Lakes or ponds are formed in hollows that are lower than the water table.
HOW WELLS PROVIDE WATER

To picture how a well works, think of a drinking straw in a glass of water. A well is simply a hole dug deeply enough to reach the water table. After the well is dug or drilled, the sides of the hole are strengthened. Grandfather’s well was big enough to lose your dog in, and was lined with rocks to keep the earth sides from falling in. Modern wells are lined with pipe. To force water up through the straw in the glass of water, you use your lips for suction. But in most wells nowadays the water is forced up the pipe by a motor-driven pump.

Wells vary in the amount of water they supply. The water table can be found everywhere under the earth, at some depth, but the amount of water at any given place depends upon the aquifer. If the aquifer into which we dig or drill a well has a great deal of pore space saturated with water, then large amounts of water will be available to the well. But if the rock has only a small amount of pore space, the well may become dry very quickly. Geologists who study rocks and the earth’s history have the knowledge needed to say what rocks will contain water, and to estimate the depth of water.

WHAT HAPPENS WHEN A WELL GOES DRY

Newspapers often tell about wells going dry. When this happens, it means that the water table has become lower than the bottom of the well. This usually happens when more water is withdrawn from storage underground than can be replaced by new water. If many wells in the same area are heavily pumped and not much rain falls, the water table lowers. Sooner or later, rainfall will return the water table to the original level — if pumping from the wells can be stopped. Often it cannot, because a whole town or village may depend on the wells for water.
HOW AN AQUIFER REFILLS

As we have seen, ground water moves through rocks underground. There may be many miles between the place where the rain seeps into the earth's surface and the place where the water appears in a well or spring. It usually enters the ground where a layer of porous rock appears at or near the surface. We sometimes think of rock layers as being level horizontally. Sometimes they are, but more often they are on a slant, as in the picture. The end of the slanted layer of porous rock that reaches the surface is called the recharge area. Rain will fall on this porous area and trickle downward into the aquifer. The water moves slowly, sometimes as much as three feet a day, sometimes less. Because it moves so slowly, it may take years to refill an aquifer that has been over-pumped.

A well doesn't need to be dry to be unusable. As the water table gets lower and lower, the well must be dug or drilled deeper and deeper. The deeper it is, the more it costs for electricity to pump out the water. Finally, people may just have to stop using the well because its costs too much, even though there is still water in it.

There are many places in the United States, especially in the west, where water levels are going down and not enough rainwater is coming into the earth to recharge the aquifers. This is a serious problem for the towns, cities and farms in those areas. Some day soon pumping may have to be stopped in those places, and water brought in pipes from lakes and streams very far away.

HOW TO FIND GROUND WATER

Suppose your father buys a place in the country, and he wants to put down a well where there is a good steady supply of water. What should he do? The most reliable source of information about ground water is a geologist. There are private consulting firms which employ geologists, or your father may consult one at the nearest university which has a department of geology. Or he may consult the local offices of the Geological Survey of the United States. The geologist knows the rocks, and the amount and kind of water depend on the kind of rocks where the water is found.

Some people would ask a water witch, or dowser, where the best place for a well would be. A water witch is a person who says he can tell by magic means exactly where the best supplies of water can be found. He walks over the land with a forked stick
in his hand. He says that when the forked twig bends down toward the ground, of its own accord, that's where you should dig for water. Scientists know that this is nonsense. The real facts about ground water are explained here in this book, and in other scientific books on water. No magic is needed to understand the basic facts about water.

A geologist surveying to determine the extent or depth of a water-bearing rock formation.

WHO USES GROUND WATER

Ground water is used by homes and farms in country areas which are not close to a public water supply. Many cities which are not near rivers or lakes get their public supply from wells, so they depend on ground water too. Ground water has always been widely used in the west, where there is not so much rain, and less water is available from streams and lakes. As our needs for water grow, you can expect to hear more about people in the east looking for and using ground water. It is interesting to think that nearly everywhere in the world, wherever you walk on the earth's surface, there is some water trickling and seeping through the rocks under your feet.
WATER IN RIVERS

HOW RIVERS START

Some rivers begin when snow melts high up in the mountains. One trickle of melting snow joins another trickle until they become a brook. From looking at maps, or perhaps just from following a brook in your neighborhood to see where it goes, you know that usually little brooks run into creeks, and creeks into bigger rivers. Or a river may begin as a little brook flowing from a spring. The smaller brooks and creeks that run into the big rivers are called tributaries.

Water is under the influence of gravity like everything else on earth. It will find its way down the lowest depression, going around obstacles, but always flowing downhill. Because of this downhill direction, there is usually a ridge separating land draining into one river from land that drains into another. This ridge is called the divide. The area enclosed by the divide is called the drainage basin or watershed. Every stream or river has a divide and a drainage basin. The most famous divide is the Continental Divide. It separates the rivers that flow toward the Pacific from those that flow toward the Atlantic.
RIVERS CARRY SEDIMENT

Rainwater and snowmelt carry mud from the surface of the earth into rivers. The river water becomes muddy, and full of sediment. Sediment may mean anything from boulders to sand to the finest silt. If there is a brook or pond near you, stir up the water near the bottom, then scoop up some water in a jar. As soon as you set the jar down, the sediment begins to settle. The large pieces go to the bottom first. It may take several hours or even days for the fine particles to come to rest on top of the bigger pieces. In a flowing river, however, the sediment is shaken up and moved along. In the hills or mountains where the tributaries begin, rivers may dash along carrying pebbles or even boulders. Some of these pieces are dropped as the rivers move along. Others get broken into finer and finer pieces. Scoop up small pebbles from a stream near you. How round and smooth they are! They have been worn away into that round smooth shape by rubbing against each other in the river.

MOVING WATER MAKES LAND GROW

Great rivers like the Mississippi carry tons of sediment downstream. These rivers
drop their load at the rivermouth, as they flow into the sea. Year by year, the load piles up until it forms a delta. Smaller waterways have to be dredged often or dug out by a special boat so the sediment will not block the channel. When a dam is built, the water in the reservoir is quiet, at least quieter than a flowing river. The sediment load of the river tends to settle down in the reservoir. Gradually reservoirs fill with sediment and cannot be used for storage of water. This is a problem that our engineers have not been able to solve as yet.

When a river overflows its banks, it leaves some of the finer sediments on the nearby land. When the floods recede, the deposited sediment is often rich and fertile. Sometimes it is sandy and poor. The Nile in Egypt and the Mississippi in our country have made rich lands along the river valley, good for farming.
FLOODS

You probably have seen pictures of floods some time or other, perhaps in the movies or on T.V. You have seen people sitting on the roofs of their houses, waiting for others to row up in boats and rescue them. It looked like fun, but anyone who has ever been through a flood will tell you it is not fun. Homes are destroyed, or so covered with mud, slime and wreckage that they cannot be lived in. To fix them up again after the flood water is gone is very expensive. Sometimes people and cattle are drowned. Moving water is very powerful. It can rip out telephone poles and car tracks, and carry away trees, fences, cars, bridges, and even houses! Floods cause a lot of damage and suffering. What makes them happen?

HOW FLOODS ARE CAUSED

Floods happen when there is more water in the river channel than it can carry without overflowing its banks. Whenever there has been a great deal of rainfall all at once the rivers and creeks fill with water. If there is too much, they overflow. Or perhaps
Once in 50 years

Once in 10 years

Once each year

Twice each year

90 days each year

one sunny week in spring, the snow melts all at once and heavy rains follow. Then the rivers spill over their banks and cover everything that gets in the way.

But, you will say quite sensibly, why wasn't the channel naturally big enough to carry the largest streamflow without overflowing? The river makes its own channel, doesn't it? Yes, it does. But on most days the amount of water flowing through the river is just average—not too much and not too little. The river channel is just right for the average amount of streamflow. It is like a home for a family. It would not be practical for your father to build a house with a room for each member of the family, plus extra rooms for all the possible guests that might come. Instead, he buys a home with just enough rooms for the average number of people in it. If you have a lot of guests who stay overnight, your house overflows somewhat like a river channel in flood. Your guests' belongings spill out everywhere—however, so many people don't come often, so you put up with it. For a few days each year there will be enough rain to fill the river right up to the top of its banks. If you look at the diagram, you can see that the storms which cause the river to overflow occur only every few years. The really tremendous floods come seldom. The trouble is, we don't know exactly when they are coming—just as we don't know exactly when Aunt Jane and her six children and their dog will descend on the family again. We have to be prepared for floods all the time, so we'll be ready when they do come. The banks are part of the river. If we live or have factories on the river banks, we just have to expect a small flood every few years, and a big one once in a lifetime. It is not the river's fault if we are flooded. It is our fault for living or working too close to the level of the river. The flat land adjacent to the river is called the flood plain and it is part of the river.

HOW CAN FLOOD DAMAGE BE REDUCED?

The best way, as we've said, is for people not to live or work on the flood plain. Unfortunately, the flood plains are usually very fertile. Also, the flat land is a convenient place to build railroad lines or highways or warehouses. Then one day the river floods,
and most of the people who are in the way of the river suddenly wish they lived or worked on higher ground. Often they are living or working on the flood plain simply because they are not aware of the danger. The last flood in that place may have been many years ago. They do not realize that another one is bound to occur some day. One of the best ways to prevent flood damage is to warn people of flood danger—with maps, flood marks, and laws or regulations. Flood marks on buildings and streets show how high the water rose in the last flood, or in the greatest flood known in that area. Flood regulations might say that no one could live in areas subject to flooding, and that only certain businesses could locate in these areas. Such businesses might be parking lots, or factories in which the first floor wasn’t much used by people or for valuables. An excellent way to use the flood plain is as a park or recreation area.

HOW. DAMS AND RESERVOIRS HELP

One way of reducing flood damage is to build walls along the river banks to hold back the water. These flood walls are usually called levees. Another way is to build a dam which will hold the floodwaters back in a reservoir, or artificial lake. The flood water is then released slowly through big gates, so slowly that the river does not over-
flow. Look at the picture of the river and its tributaries—they spread out like the fingers of a hand. Suppose you wanted to stop the flow of blood in your hand. You would apply pressure on your wrist, not at the base of each finger. In the same way, a large dam on the main river is a more efficient way to control great big floods than little dams on the tributaries. The little dams are needed, however, because there are fairly frequent small floods on the tributaries, which damage farm land and crops. Both big dams downstream and small dams upstream are necessary to protect farms and cities from flood damages.

WHO PAYS FOR FLOOD-CONTROL

The people who live in the area of flood damage pay a small percent of the cost of the dams and reservoirs, but the Federal Government pays for most of it. That means all of us, through our taxes, support flood control projects, whether we live in an area which is occasionally flooded or not. Dams and reservoirs are very expensive engineering projects. Small towns and communities probably could not afford them. They must be helped because they are also paying for many other things—roads, bridges, schools. The Federal Government has spent about $3 1/2 billion dollars on flood-control dams since 1936. On the other hand, these flood-control reservoirs prevent about 300 million dollars of flood damage every year, in different parts of the country.
SOIL

If you've ever had a garden plot of your own, you know that dark fine soil that crumbles easily is best for plants. If the soil has hard clods of light color in it, it will harden when it is dry, and tender baby plants will not grow well in it. A good soil has plenty of humus. Humus is a mixture of all kinds of litter — roots, leaves, stems; dead insects and small animals. This humus mixed with the sand and clay from weathered rock is rich in minerals that plants need for growth. In the above picture of a roadbank you will see a dark band of humus right at the top. It is necessary, not only as food for
Crops must be planted before rain washes the exposed soil away. plants, but also because its loose crumbly texture allows air to circulate around the roots, and water to filter downward.

EROSION

It takes a long time for bits of weathered rock to become soil. The rock is broken by the wind, rain, sun and frost into smaller and smaller pieces. Then it gets mixed with bits of dead plants and animals. Millions of insects and bacteria help to break down the dead organisms. It may take hundreds of years to build an inch of good soil, but water can wash it away in a few days. This washing away of the soil is called erosion. If the rich topsoil is badly eroded, plants will not grow well. This has happened in many places in the United States.

CAN WE STOP EROSION?

The rich topsoil containing humus is needed to absorb the rain. Trees and small shrubs and plants catch some of the rain, too, and keep it from running off the land. There are parts of our country where there isn’t much rainfall, and water is badly needed. In these areas especially we can’t afford to have water running off the land and eroding the soil. Such conditions waste water and spoil good soil. Bare land will take in only about 5500 gallons an hour on each acre. Land with grass or other plants on it may absorb more than 25,500 gallons an hour on an acre. When all the trees are cut down and the grass plowed up, for a housing development, for instance, nothing is left to
hold rainwater until it can soak into the ground.

To put plants on the soil is one way of preventing erosion, and another way is to build humus. If your family has a garden, you know that sometimes peat-moss or manure is applied to the flower beds. The addition of this mixture of plant and animal remains keeps the soil loose so that it can absorb water. Once in the ground, some of the water will be used by plants, and the rest will sink slowly downward, to be stored as ground water and to emerge in springs or wells.

OTHER WAYS MOVING WATER CHANGES THE EARTH

We have seen how rainwater erodes unprotected soil, cutting little gullies into it. Riverwater also wears away the earth’s face. It cuts into the riverbanks, little by little, changing the shape of the channel. The Grand Canyon and other such deep cuts in rocks were worn away by the slow, persistent action of rivers. Geologists think it took about
ten million years to make the Grand Canyon. With the material removed from the canyons, the Colorado River is building a delta in the Gulf of California. Every now and then a chunk of rock breaks off the cliff of Niagara Falls. Gradually, the falls are cutting the cliffs back to Lake Erie.

The ocean, endlessly washing over the coastline, wears it away just as rivers wear away their banks. Sometimes waves cut under cliffs until they crash into the water. The average force of a wave may be as much as one ton for every square foot of land. Sand, mud or bits of rock may be dropped by the waves farther down the shoreline, or may be carried out to sea. These pieces gradually add to a shallow area surrounding all the continents called the continental shelf.

So the earth's face is torn down and rebuilt by the action of water. Once you understand the way this happens, you can see why the landscape looks the way it does. You can see what has happened to the earth in the past, and what may happen to it in the future.
SALTS IN WATER

WATER DISSOLVES VARIOUS MINERALS

As water drips upon rocks and trickles through them, it picks up and dissolves various minerals and chemicals that are in the rocks. Water stored in the ground usually contains more dissolved minerals and chemicals than water in rivers or lakes because it is in contact with rocks and soils for longer periods of time.

These chemicals in water are important to man. We do not want the water we drink to taste salty or to taste of epsom salts or calcium, but neither do we want it to be completely tasteless. Water made in laboratories by chemists, called distilled water, has a flat dull taste, but natural water has a tangy taste that comes from the salts in the water.

We also want our water to be "soft" enough to lather easily in the bath or dishpan. It is the dissolved minerals and chemicals called salts that give water its taste, and that make it either hard or soft. Do not confuse the term "salts" with ordinary table salt. Table salt, or sodium chloride, is just one of the many salts in water.

When water is "hard," the soap won't make suds easily, and the water leaves a ring around the tub. Calcium and magnesium in the water make it hard. Sodium chloride gives water a salty taste. A salt called floride that can discolor teeth will also protect them from decay if just a small amount is put into drinking water.
WHY THE SEA IS SALTY

Huge loads of salts are carried down to the sea by rivers, which have picked them up from the rocks over which they flow. Table salt is the most common of these. However, there are lesser amounts of other chemicals in the sea, such as magnesium chloride, calcium carbonate and so on. Sea water has about a teaspoon of ordinary salt in every glassful. Try putting a teaspoon of table salt in a glassful of water. If you stir it up, the salt disappears. You cannot see it, but if you take a sip, you know it is there. If you pour the salty water into a saucer and let it stand outside for a while, the water will evaporate, and salt crystals will form. Water in the sea is also constantly evaporating, leaving the salt behind. This salt comes from the rocks of continents which have been reduced by erosion and solution.

HOW SALTS IN WATER ARE MEASURED

We measure the amount of dissolved minerals and chemicals in the water in "parts per million." This means that for every million pounds of water there is a certain number of pounds of salts in the water. For example, rainwater contains less than ten pounds of dissolved minerals for every million pounds of water. The dissolved minerals and chemicals in rivers usually are less than 500 parts per million, but some rivers may contain 2,000 parts per million or more. A city water supply should not have more than 500 parts per million of dissolved minerals and chemicals. Sea water contains about 35,000 parts per million of salts. You can see how much saltier it is than tapwater or even river water. In an ordinary swimming pool filled with sea water there would be 56,000 cups of salt!

ARE SALTS IN WATER HARMFUL?

This is a question to which we must answer both yes and no. These minerals and chemicals give water an interesting taste. They are usually not harmful to the insides of
people. However, they tend to stick to the insides of hot water tanks or boilers in factories. If the coating of salt or scale, as it is called, gets thick enough, it adds to the cost of heating the water. A coating of salts one-half an inch thick makes it necessary to use about ten percent more fuel.

Certain salts can cause special troubles. Too much sodium in the water can be harmful to people who have heart trouble. In parts of the country where there is too much sodium in the water, such people must buy and drink distilled water. Calcium makes the water hard, which is not desirable for homes or factories. Boron is a mineral that is good for plants in small amounts. In very large amounts, it is poisonous. A little fluoride in the water keeps children from getting cavities in their teeth, but in very large amounts it makes spots on the white tooth enamel. Some towns and cities put just the amount needed in the public water supply, to protect the teeth of the children living there. You can see that salts in the water can be good or harmful, so it is important for public health and other town officials to know how much and what kind of salts are in our water.
Most city people never think about where and how water reaches them. They know vaguely that water is stored in reservoirs; they may even know where the local reservoir is located. If they go for a drive on Sunday and pass the sewage treatment plant, they probably have no idea what it is. They just take clean, running water for granted. Do you know where your reservoir is, and where the water in it comes from?

THE CITY WATER SYSTEM

Your city water system, or municipal system, as we usually call it, supplies all the homes and apartment houses and office buildings in the city. The city water supply is also used for street cleaning, for public parks, water fountains in schools and libraries, and perhaps most important, for fire fighting. But the largest use of water from municipal systems is by industry. Some factories have their own water supply, and we will talk about them later. But many others find it cheaper and more convenient to buy their water from the city system. If you imagine the use of water as represented by the pie in the sketch, how big a slice does industry take? Industries use one-third of the pie, or one-third of the total amount used from the municipal system.

Municipal water systems in America serve 115 million persons, almost two-thirds
of the entire population. We can be proud of the engineers who have made possible such a dependable supply of cheap, clean water. Of course we must also be glad that America is a country with such good natural sources of water.

HOW CITIES GET THEIR WATER

The water is usually pumped by electric power from the stream or well into a storage reservoir. From the reservoir, the water flows into the pipes, through which it runs all over the city and eventually into your tap. The main water pipe is usually made of cast iron. The pipes get smaller as they get nearer private houses, and they are usually made of galvanized iron or copper. Street mains are generally 4 or 6 inches across. The pipe leading to your house is usually 1 inch across.

Some cities like New York or Los Angeles bring their water from rivers or wells many miles away. They do this either because the sources nearby simply do not provide enough water for such big cities, or because the water in nearby streams is not clean enough to use. The rivers become dirty because sewage is dumped into them, as we shall explain in a moment.

A certain amount of water is always stored in the reservoirs for times when people use more water than usual, as they do in summer. The storage also serves another purpose. It makes the water flow out of your tap under pressure; that is, with enough force behind it to be useful. If there were no pressure, you would find rinsing dishes and taking a shower bath very difficult. The trickle of water would be so slow and gentle, it wouldn't rinse the soap off your shoulders or make the food scraps slide off the plate.

You may wonder what keeps the pressure high when people are drawing water all day long. The pressure of the water is due to the height of the water in the reservoir. Most reservoirs are big enough so that average public use doesn't lower the water level enough to lessen the pressure. When people use a great deal of water all at once, as in the summer, an automatic pumping station pumps in extra water to keep the water level high and to keep the pressure up.
HOW IS WATER PURIFIED?

Sometimes, especially when there has been building going on near your home, the water in the tap will be brownish and rather muddy-looking. That is when you really notice the water. The rest of the time you just take for granted that it will be pure and clear. But unless your city water comes from very deep wells, or from rivers far up in the hills away from man and his activities, it is not naturally pure and clear. In fact, if you live on a river below another town, the water may be anything but clean and clear by the time it gets to your town. It may have silt (very fine sediment) in it, as well as wastes from towns upstream.

Before it reaches your house, it goes through a treatment plant, which purifies it. In the treatment plant, the water is sprayed in the air and over rocks. In this way the water gets mixed with oxygen which improves its smell and taste. If there are impurities in the water, it is treated by settling and filtering. To settle the impurities, the water is run into a large tank. Then it is treated with a fine powder made of a chemical called alum. The impurities stick to this chemical, which then settle down to the bottom of the tank. Another way of screening out impurities is to filter the water through beds of clean sand. Many city treatment plants use several methods at once. First the water is settled with a chemical powder, then it is filtered through sand, then sprayed in the air. Finally, it is treated with a disinfectant called chlorine, which kills any bacteria that might be left. The City Health Department usually has very strict rules about how the water must be treated. Untreated water might carry very dangerous germs, or it might just smell unpleasant and not taste very good. All this treatment is expensive. It costs Washington, D. C. $62,000.00 a year to buy the chemicals to keep the water clean and clear.
WASTE WATER

Would you be surprised to know that most of the water used in our homes is for carrying off wastes? Drinking, cooking, or even watering lawns, use up less water than doing the dishes, bathing, flushing the toilet and running the garbage grinder in the kitchen sink. Wastes carried away by water from kitchens, bathrooms, and industries are called sewage. Sewage carried in city pipes as it enters the treatment plant is surprisingly clean looking, but it is dangerous if it remains untreated. Bacteria like to live in it. Washing or swimming in water with sewage in it can cause eye or ear infections, or water-borne diseases such as typhoid fever and dysentery.

GETTING RID OF WASTE WATER

Sewage from homes and factories is carried in the sewer system under the streets. Water in the sewer system flows in pipes, but it is not under pressure, as drinking water is. The pipes are slanted, so that the force of gravity carries the sewage downhill. The sewer pipes get bigger, as more and more pipes join together. The sewer pipe under a side street may be only six inches across, but the main sewer line may be several feet across.

In older cities, the sewer system not only carries waste but also the storm water from the streets. When there is a storm, these pipes have an overload. The pipes usually are arranged so that all sewage during the time of overload flows around the treatment plant and directly into the river without treatment. Of course, this makes the river even more polluted than it would have been. In more modern systems there are separate pipes for home wastes and for storm water. The wastes go to the treatment plant, and the storm water runs directly into the river.
HOW WASTES AFFECT RIVERS

If raw sewage is dumped into a clean, swift stream, the oxygen in the water will burn up, or consume, the sewage. This is the way sewage was disposed of in the early days of America. The rivers could easily handle the sewage load, and after a few miles of flow, exposure to the air caused the water to absorb enough oxygen to become fresh and clean again. But if the load of sewage is very great, as it is in many cities, there is not enough oxygen in the river water to destroy it. Then the sewage in the water starts to go bad. It not only goes bad, it gives off gases which smell terrible. Perhaps you know a river near you that smells like that in the summertime. A river with a sewage load too great to be handled by the natural oxygen in the water is said to be polluted.

To prevent pollution of river water, some modern cities treat the sewage before it goes into the river, but there are still many cities that do not. First the water goes through a screen that removes big things like sticks and rags. Then it flows slowly through a special room where sand and silt settle out. Then it flows into a larger settling tank, where other, finer solids settle to the bottom. Finally, the water is chlorinated and emptied into the stream. It flows on downstream, clean and ready for use by the next town.

According to the Public Health Service, only about half the sewage in the United States is treated. The rest of the waste is dumped untreated into rivers. This is a serious problem. It is true that polluted water can be treated by the next town downstream, to make it drinkable. But it is not pleasant for boating, it is dangerous for swimming, and it can kill off the fish population and other small animals and insects that live in the water.

The Federal Government and the State governments are working together to reduce the amount of untreated sewage dumped into rivers. You can help prevent water pollution. When you go picnicking or camping near water, you can put wastes of all kinds in covered containers, on the spot, or burn the refuse (if it is safe to build a fire), or take it home with you and dispose of it properly. Large boats should have special toilet and kitchen facilities that keep the wastes from being flushed into rivers.
WATER FOR INDUSTRY

When you see factories with their tall smokestacks and hear the sound of machinery, you do not think of water. Yet industry uses more water than city systems do! An individual person in his home uses an average of 50 or 60 gallons a day for drinking, washing, and other household purposes. Industries use 700 gallons per person each day! What is all this water used for?

WHAT INDUSTRIES USE WATER FOR

Ninety-four percent of it is for cooling. Steam power plants use great quantities of water for cooling. Water is also used for cooling in iron and steel furnaces. Water for cooling does not have to be of especially high quality, and it can be used over again for the same purpose.

Besides using water for cooling, industries also need water for processing. Process water is the water actually used in making the product. For instance, the pulp and paper
industry uses water for washing and pulpwood, cooking the woodchips and transporting the pulp to the paper machines.

A third way water is used is in cleaning and maintaining the factory. Such service uses are water for drinking, showers for workers, lawn watering, and fire fighting. Industries which need water only for service purposes usually get it from the public supply system. They need so little water (in comparison with factories which use it for cooling or processing) that it would not be worthwhile for them to set up their own water system.

WHERE INDUSTRIES GET THEIR WATER

When industries need and use enough water to make it worth the expense, they dig their own wells, or set up their own system to get water from a nearby river. Otherwise, they use water from the public systems. Quite often industries prefer to use ground water instead of surface water, if it is available. Ground water is generally purer and cooler than surface water, which makes it suitable for many industrial uses.

DO INDUSTRIES NEED SPECIAL QUALITY WATER?

The kind of chemicals that are in the water are important to industry. For instance, the producers of beer cannot use water with iron in it. Canneries must avoid hard water with much calcium in it, which would make peas and beans as hard as little bullets. If the right kind of water isn’t available, then it has to be treated to remove these chemicals. This is an additional expense to the manufacturer.

WHAT INDUSTRIES DO WITH WASTES

One very important use of water by industry is for disposal of waste products. Scraps of food, meat and plant life come from food-packing operations. Left-over chemicals come from many different industries. Soon there may be a new form of waste to worry about—the radioactive wastes from our atomic research and atomic power plants.
Warm water is returned to streams after having been used for cooling hot steel and steam boilers. Although heat is not exactly a waste product, it is considered a form of water pollution, because the warm water may cause fish to die and it makes green scum grow on the water.

Many industries treat their wastes to reduce the pollution load, but many others do not. Such manufacturers feel that the cost of treating the wastes, added to the cost of making the goods themselves, would make their products too expensive to sell at a profit. However, State Departments of Health with backing from the Federal Government will more and more insist that industrial wastes be treated before being dumped into rivers.

HOW CAN INDUSTRY SAVE WATER?

Industries are now using so much water, that they are beginning to worry a little about saving it. There are ways of cutting down the amount needed. The largest industrial use—water for cooling—can be reduced greatly by using the water several times over before disposing of it. Or air-cooling systems can be installed. Another method of water conservation is by using saline waters, that is, waters with salts in them. To use saline waters, the machinery must be specially built and coated to resist being eaten away by the salts. As fresh water gets more expensive and more difficult to locate, saline water will probably be used more and more. Industries using large amounts of fresh water will have to plan carefully for water supplies. If they cannot be established where there is a good supply of water, the expense of obtaining it may be very great.
FALLING WATER CAN TURN A WHEEL

If you have ever stared at Niagara Falls, or at any waterfall, you know what water power is. You can feel it in your bones, as you look. All those tons of water come crashing and thundering over the steep ledge onto the rocks and water below with tremendous force. Long ago, man used his own muscles or those of animals for doing heavy work. Then he discovered that the force of running or falling water would turn the mill wheel. The wheel in its turn would move machinery to grind grain or saw wood. About 100 years ago, the turbine was invented. The turbine is simply a variation of the water wheel, with many curved blades on it. To make water power, the water hits the blades with enough force to spin the wheels. This kind of direct water power isn’t much used any more. Nowadays, the turbines turn huge generators which produce electricity.

WATER AND ELECTRICITY

When man learned to use water power to make electricity, it was more efficient to carry the electricity on wires to the factories. The mills no longer had to be built close to a river. For a while, most electricity was produced by water power. But now, more and more electricity is being made by other means—in places using coal, gas or oil, or even atomic power. The energy or power comes from heat stored up in the fuel. The fuel heats water into steam, and steam under pressure makes the turbines turn. Water, however, is still needed to make the steam.
WATER FOR IRRIGATION

EXTRA WATER FOR DRY AREAS

Water is used not only in cities and factories, or for power. Farmers need a great deal of water, too. Or rather, the farmers’ plants need it. Some plants need much more water than others. For instance, alfalfa uses much more than wheat or barley. In parts of the country where there is not enough rain during the growing season, the land must be supplied with extra water. We call this extra watering irrigation. Nearly half of all the water used in the United States is for irrigation! Most of the irrigated land is in the west, where the rainfall is small. In 17 western states there are about 30 million acres of irrigated land.

HOW IRRIGATION IS CARRIED OUT

Irrigation not only uses a lot of water, but it is in some ways a wasteful use. The water is transported through the fields in canals or ditches. These ditches are not lined with any watertight material. The water in the ditch tends to seep into the ground and so a lot of it is lost on the way to the fields. The farmer therefore has to take more irrigation water than he actually uses.

Most of the water reaching the growing plants is then transpired or evaporated
by the leaves of the plants themselves. To give you an idea of how much water is used in irrigation, think of a group of farms, say 20,000 acres of irrigated land. These irrigated plants would transpire 24 billion gallons of water a year. Such an amount would support a city of 500,000 people, about the size of Cincinnati, Minneapolis or Seattle.

IRRIGATION PROBLEMS

Irrigation isn’t as simple as just turning the garden hose on the lawn. The rate at which the water is supplied is important. If it is too fast, the soil cannot absorb it all, and it runs off the surface and is wasted—at least as far as irrigation is concerned. Bumpy, lumpy fields collect too much water in the low spots and not enough on the mounds. Plants can be killed by too much water as well as by too little.

Some of this difficulty is avoided by using the newly developed method of sprinkler irrigation. You know yourself that it is more efficient to water the lawn with sprinkler than with the hose nozzle. For irrigation, the sprinkler heads are mounted on permanent standpipes. The main pipes are buried in the earth below the level where plows and other farm machinery would reach them. Obviously these sprinkler systems are much more expensive than the older systems of irrigation from an open ditch. This expense is only worth it where high-priced crops are being grown on a large scale.

The dissolved salts we’ve already talked about are another problem for the irrigation farmer. If too little water is applied to a field, the dissolved salts tend to stay in the soil just as the scum stays in the teakettle when the water boils away. Too much of these salts makes plants grow poorly. This is another reason more water is used than is really necessary. The extra water carries the salts down below the roots to the water table.

All the extra water being added to the ground water supply may raise the water table in irrigated areas. Then the land becomes water-logged, if drainage is not provided. Crops do not grow properly in water-logged land. Ditches must be dug to drain away the excess water. Almost all irrigated areas have drainage problems.

You can see that irrigation is an expensive, complicated business. A western farmer who wishes to run an irrigation farm needs a lot of know-how.
FARM PONDS

THE USES OF FARM PONDS

One of the most attractive sights on a farm is the pond, with ducks swimming happily about on it. Not every farm has one, but they are very useful. Eastern farmers use them for watering livestock, raising fish, as water for fire protection, or for swimming and skating. The western rancher calls his pond a "charco," and uses it mostly for watering cattle. There are millions of these farm ponds. Most of them were built on purpose, like reservoirs.

HOW FARM PONDS WORK

They are usually made by damming a little river in which water flows only when there is a heavy rainstorm. A deep pond holds water longer than a shallow one of the same size because it has less surface area from which water can evaporate. Large ponds lose much water by evaporation. A pond that is too small will overflow often, and may wash out completely. A careful pond builder will first dig up some earth where he wants to put the pond to see if the soil is tight enough to hold water. Clay is best for this purpose, but any good loam is suitable. A new pond will leak. However, silt brought by the river will eventually fill up the cracks and leaks. In fact, the silt will eventually cut down the size of the pond itself! Ponds have been built that were filled to the brink with sediment in the first year, or by the first flood.

Farm ponds trap a good deal of rain and storm water, and make it useful for watering stock, raising fish, or for recreation. But there are disadvantages, too. Much water is lost by evaporation and seepage. A poorly designed pond wastes water that people living downstream could use. A water-saving pond should be deep with a small surface area.
ARE WE RUNNING OUT OF WATER?

It is summertime and very hot. You like to go to the swimming pool two or three times a day. Every member of your family takes showers both morning and night, to cool off and freshen up. Dad runs the sprinkler for a couple of hours every evening so the lawn won’t turn brown and wither away. When anyone wants a drink of cold water, he just lets the water run until it is cold enough for a refreshing drink.

Now suppose sprinkling were forbidden. There is an announcement in the paper, and a burly policeman comes round to check and make sure you are not using the hose where it can’t be seen. Wading pools aren’t allowed either, and the public swimming pool is closed. You are asked to take only one shower every other day, and not to wash the family car. Certain days of the week are set apart as waterless days.

There is a water shortage.

It may sound to you like a bad dream, but it has happened—in New York and New England in the summer of 1949, in New Jersey in 1957, and many times in many places in the west. Yet if you look around at the rivers, lakes and seas, and think of the mighty oceans, it seems incredible that there might not be enough water. The trouble is that the seas are too salty to use, and the rivers and lakes are not all located where most people live.

Well, you say, there’s the rain. All that rain that fell last time you went camping, that kept you from playing tennis or spoiled your vacation at the beach. How much rain falls in the United States during a year?
HOW MUCH WATER DO WE HAVE?

Enough rain falls in the United States every year to cover the entire country 30 inches deep. This precious 30 inches of rain is our water income. It is like your allowance or your father's salary. It is what we depend on for our daily use of water.

There are two problems about this 30 inches of rain income. It doesn't fall evenly. Sixty inches may fall in the east, while the plains have to get along with only 6 inches, and the west coast with 24. That is one problem. The other is that 21 inches of the 30 never get used at all! Scientists have figured that about 21 inches of rain evaporate from wet surfaces, roads, roofs, etc., or from grass, trees and other plants. This 21 inches of rain cannot be used by man. As you can see, that leaves about 9 inches that we can use. In addition, there is a large amount of water stored in our lakes, and even more stored underground. We don't know exactly how much. However, we can call this stored water our water savings account.
HOW MUCH WATER DO WE USE?

Right now, we use about 3 inches of our 9-inch annual supply, or roughly a third of the water available to us. So we’re not exactly running out of water. The trouble is that in some places where there isn’t much rain, we are using up water from our “savings account,” and using it up very fast. Also, part of our 9-inch available supply is needed to refill the rivers, lakes, streams, and ground water supply. We cannot use it all, or there would be no bank account left for emergencies. Droughts are emergencies —days when no rain falls at all, sometimes for as long as a month. It is like being out of work, or having your allowance stopped for some reason. Then you have to fall back on your savings.

NATIONAL PLANNING FOR WATER

Since our annual 9-inch supply of water comes from the rain, weather forecasting is important to water resources planning. All the cities that get their water from streams, the industries and farms that use water, all want to know what the rainfall will be in the future, and how much water will be flowing in the streams. The U.S. Geological Survey has been keeping streamflow records for 75 years, in the hope that these records would show a pattern from which we could guess what future streamflows are likely to be. Unfortunately, the records do not show any regular pattern. All we know is that some ups and downs in rainfall and streamflow are to be expected. Long-term forecasts of weather or streamflow are not yet possible.

If we go on using water at the present rate or more, it will certainly be in short supply somewhere in the United States, at some time in the next 50 years or so. Water can be brought at great expense from places where there is a lot of water to places where there is little—if the towns or industries are willing to pay for it. The Congress and the President are taking more and more interest in planning the use of our water resources. Every good citizen should study and understand the proposed laws on the development of river basins and the control of water pollution.
Some day, when you have a home of your own, you may have to vote on a decision about water—whether to supply tax money for a new sewage treatment plant, for instance. Or you may have to make a decision yourself, for a town or an industry, that concerns water. Knowing the facts about water will help you—and other people—not to make foolish mistakes. Because you know how ground water occurs, you will know better than to consult a water witch. Because you know about evaporation and transpiration, you will understand that just pouring water on the land will not necessarily increase ground water supplies. You will know, too, that farm ponds and reservoirs should not have too great a surface area, because so much water is lost to evaporation.

Because you know that water is essential to cities, to industry, to farmers—in fact, to life itself—you will want to help save water in any way you can. Water conservation will become more and more important if we go on using water at the rate we’re using it now. Wasting water through leaky taps, unnecessary lawn sprinkling, or careless irrigation may mean that someone somewhere else goes without water. Citizens, young and old, should keep an eye on the way sewage is disposed of, for water is too precious to spoil with sewage. Alert citizens should know it is not a good plan to build a home where the river must flow during floods, and they should know from water maps and water marks exactly where danger from floods is greatest. Water conservationists will try to see that reservoirs are built economically—to get the most use of the available water supply.

The more you know about water, the more interesting it is, and the more you can help conserve it in the years to come.
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