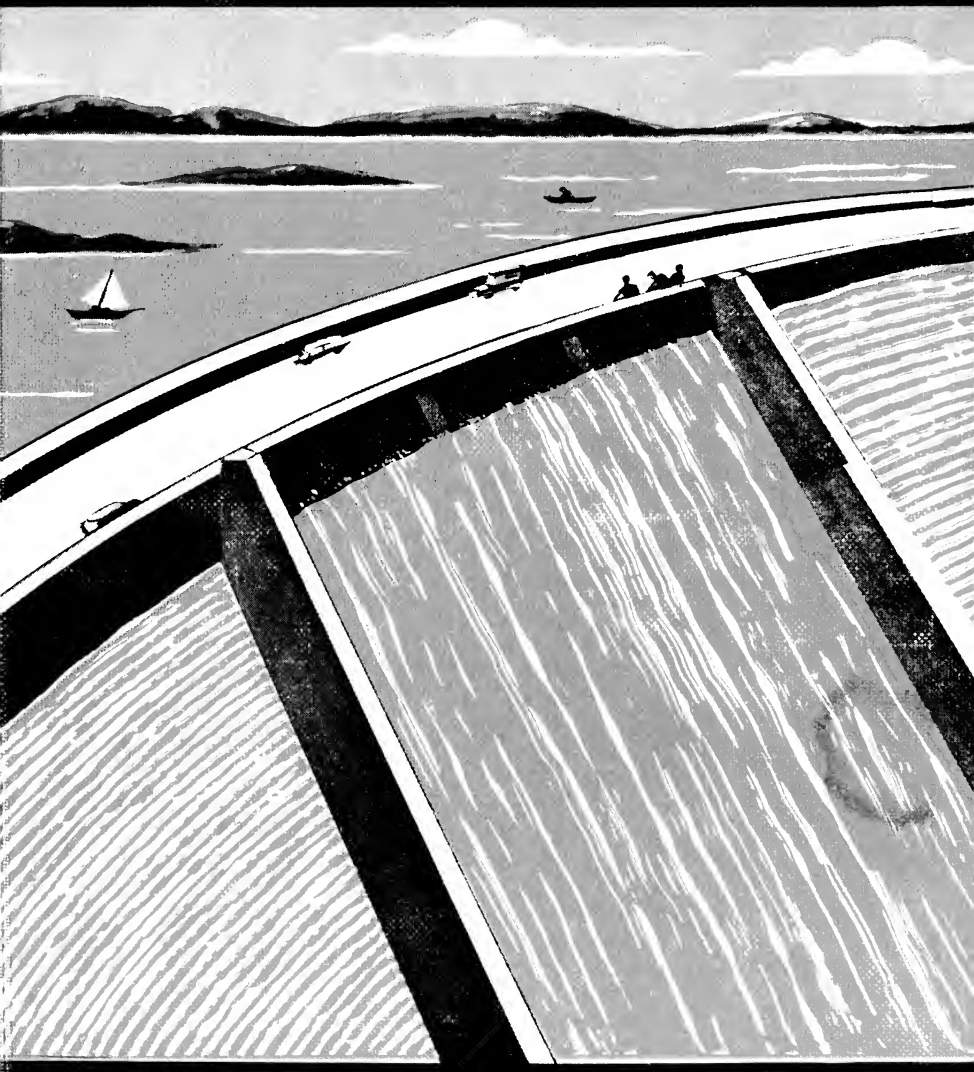
WATER FOR THE WORLD



Elizabeth S. Helfman

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WATER FOR THE WORLD

To
my son
ROBERT

Water for the World

by

ELIZABETH S. HELFMAN

Illustrated by
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DAVID McKAY COMPANY, INC.
NEW YORK

WATER FOR THE WORLD

PUBLISHED SIMULTANEOUSLY IN THE DOMINION OF CANADA

FIRST EDITION OCTOBER 1960
REPRINTED JULY 1962

LIBRARY OF CONGRESS CATALOG CARD NUMBER 60–10883

Printed in the United States of America

Foreword

This is a story about water and what it means in the lives of people, here in this country and all over the world. In the past, the abundance or scarcity of fresh water has changed the lives of whole peoples, and sometimes even the course of history. This can happen today.

Though most of the earth is covered with oceans full of water, there is not much about oceans in this book. We are concerned only with "usable" water, and that means water we can drink and wash with and use to grow our food and help run our industries. We have not been able so far to use the oceans for these purposes, to any extent.

Some of the people in this book are imaginary, but the circumstances that affect them are real. Others are real people whom you might meet on the street or along a country road, any day.

Most of us take water for granted. We are sure we will always have enough. It is one purpose of this book to make you just a little less sure about this, to help you to think about the meaning of water for the people of the world.

E. S. H.

Acknowledgments

It would be impossible to mention by name all the people who have helped with this book. They include those who clipped articles for me from the daily paper; those who sent information from faraway places; a friend who could somehow always suggest the right book; and my son, who helped by "not being a bother," so I could find time to write.

The following people, however, deserve my special thanks: Lucy Sprague Mitchell, who taught me years ago to think in a new way about man's relationship to the world he lives in; and Luna B. Leopold and his fellow hydrologists of the United States Geological Survey, who read the manuscript and made helpful suggestions.

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Contents

CHAPTER 1

Water Itself

We all know what water is. We drink it every day. We have felt the rain on our faces. In the heat of summer we have cooled ourselves by plunging into a lake or the ocean. Sometimes we call water H_2O, and if someone asks what that means, most of us answer, correctly, that it means two parts of hydrogen to one of oxygen. To be more exact, each molecule of water is made up of two hydrogen atoms and one oxygen atom.

Hydrogen itself is a gas, and so is oxygen. It is rather amazing that when they combine they form something so different from themselves—a liquid, water. How could this possibly happen? We know that if hydrogen and oxygen are ignited with a spark, there is a violent explosion, and the result is water. The German airship *Hindenburg,* which made its last trip in 1937, was filled with hydrogen. When it caught fire over Lakehurst, New Jersey, the heat of the fire made some of the hydrogen combine with oxygen in the air, and the result was plain ordinary water. Water, falling out of a fire so hot nobody could put it out.

Water is seldom made now except in the laboratory. There are no natural water-forming explosions any more. The water

on earth was formed long ago, when the earth itself was made. We cannot even imagine what terrific explosions of gases there must have been to make so much water.

Most water is the same H_2O with which we are familiar, though it doesn't always taste the same. But "heavy water" is different. About one in every 4500 molecules of water is "heavy," that is, actually eleven per cent heavier than ordinary water, because the hydrogen atoms are heavier. Heavy water is used in the production of atomic energy.

"Juvenile water" is different in another way. It is water that has been part of hot liquid rock solutions deep inside the earth, where there is no "free" water. As this liquid rock rises to a higher level and finally forms solid rock, water is driven off. Sometimes, too, juvenile water escapes from deep in the earth to higher levels. In a way, it was there all the time. But it seems new, and so it is called "juvenile."

"Ordinary" water behaves rather strangely in some ways. Most substances on earth contract, get smaller, when they freeze. Water expands, it gets bigger and lighter, when it freezes to ice. This is a good thing. If this didn't happen, ice would sink to the bottom of all the lakes and rivers in the world, and even parts of the ocean. After a time all the lakes and rivers would be frozen solid, with layer after layer of ice. No fish could survive that kind of a winter! The ice at the bottom of lakes wouldn't even thaw in the spring.

Water looks quiet on the surface, unless the wind blows, but it is moving all the time. Molecules at the surface of water are

becoming water vapor, wandering off into the air. Warm water does it faster. At 212 degrees (at sea level) water "boils"; that is, it changes to steam. Steam is hot water vapor. Water vapor itself is an invisible gas. It is not even wet. What you do see coming out of a boiling teakettle is droplets of water that were invisible steam just a moment before. Steam changes back to water as it cools.

Water has been busy for thousands of years in remaking the surface of our earth. Water rushing over rocks has worn them away. Ice expanding in crevices of rock has cracked them open. Glaciers, which are just big sheets of ice, in past ages have covered much of the earth and left their mark as they moved over the earth and finally melted. In the cold north, glaciers still cover parts of the earth.

Many things will dissolve in water, and most water has something dissolved in it. The ocean is full of dissolved salt. Even our drinking water has minerals in it. If it didn't, it would taste very flat. In fact, water without anything dissolved in it has no taste at all. Water with something dissolved in it may be a cool drink of lemonade on a hot day, orange juice for breakfast, maple syrup on your pancakes, or a dose of medicine when you are sick. It is very convenient for us that water dissolves so many things.

The amount of water in the world has hardly changed at all since the earth was made. Perhaps this seems impossible. We watch water running down the drains of our sinks. We see it rushing down rivers to the ocean. We are told not to waste

water, and farmers are sometimes frantic because they do not have enough for their crops.

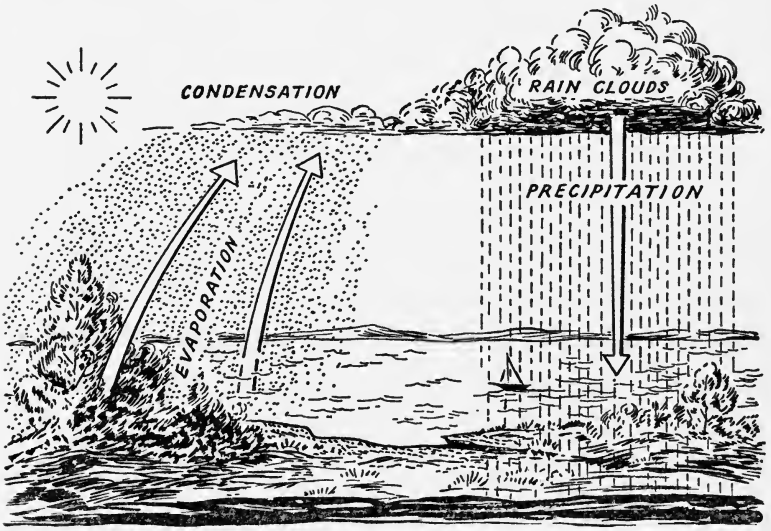
Water cannot really be destroyed, and the amount of it in the world does remain just about the same. But a great deal of water is in the salty ocean, and the rest of it isn't always where we need it, when we need it.

The water in the world goes through its own cycle all the time, a sort of circular journey from ocean to sky to earth and back to ocean again. The heat of the sun evaporates water from the oceans and lakes and rivers. This water, which becomes water vapor as it is evaporated, forms clouds in the sky, and when the clouds are chilled, water condenses and falls to earth as rain or snow. (Warm air can hold more moisture than cold air.) When it reaches the earth, some of the water runs across the ground into the rivers and down to the sea again. Salt from the earth pours into the sea with the rivers, and this makes the sea saltier and saltier all the time. Some of the water that falls as rain evaporates back into the air. A good deal of it sinks into the earth, and some even goes down so deep that it never comes out again. Water under the earth is called "ground water," which really means water *under* the ground. If it is near the surface, it may bubble up as a spring. But deep under the earth some water has remained for thousands of years. The rain that it came from may have fallen on the earth before history began.

There is water somewhere under all the earth, even under the

Sahara Desert. This is not always usable water. Some of it will not fill a well fast enough to do us any good. Some of it is salt. But we can say, just the same, that this "dry land" of ours rests everywhere on water.

The water cycle has no beginning or end. It is a constantly moving circle. But since we have to begin describing it somewhere, we have started with the oceans, which cover about three fourths of the earth. It is fortunate for us that the oceans are so big. Actually only $\frac{1}{3000}$ of all the water on the surface of the earth is evaporated each year. If the oceans were much smaller, we would just not have enough rain. There would be too many deserts in the world.



There are too many deserts on the moon. There is no water

there at all, and no life. No one on earth has ever taken a trip to the moon, but one of these days someone probably will. Whoever he is, he will have to take his own water supply with him. That will be quite a problem. Drinking water for a month would weigh tons. Water for just a week would weigh enough to slow down the trip considerably. Perhaps some way can be discovered of manufacturing water in space.

No one has gotten as far as planning a trip to Mars, but water would be a problem there, too. Most of Mars is a desert. There is some water in the atmosphere, but much less than there is on our earth. It never rains. Whoever goes there, too, will have to take water with him.

Without water there would be no life on earth at all, any more than there is on the moon. It seems a miracle that water is adapted in so many ways to our lives. Or perhaps over the long years of growth and change it is we who have adapted to water. That would seem a miracle, too.

CHAPTER 2

Water and the Beginning of Life

The story of water is much older than the story of man. It goes back to a time when there were no living creatures at all on the dry land of this earth. For hundreds of millions of years the only life in the world was in the water. Strange plants with waving leaves grew under the water. Fish swam about in the deep. Animals with weird shapes and waving tentacles squirmed about in the mud at the edge of the water, feeling the warmth of sunlight upon them and tasting whatever drifted into their mouths.

The land was without animals or growing things. It was just bare rocks and soil.

As the water on the edges of the seas flowed up and back with the tides, some animals were left on the shore. Most of them died. But some could live until the water came again. And finally, after millions of years had passed, there crawled up onto the wet sand on the shores of the seas a creature that could breathe both air and water. No one knows how many years passed before there were other creatures who could live

on land alone, but in time there were land animals and water animals which were quite different from each other.

This was still a long way from anything that could be called man, or even from animals as we know them. But somewhere in our distant past, stirring about in the wet mud of countless shores, life on land was beginning. Slowly, through millions of years, the life we know on this earth grew from those small salty beginnings.

The water in which life began was the salt water of the seas. In our veins still flows a salty solution not unlike the water of the sea, and our bodies are two-thirds water. Even the "dry land" on which we live is not so very dry.

The beginning of the story of life on this earth is also the beginning of the story of water. There is really not much we can find out about these beginnings. The little we do know is the result of years of study by scientists who have dug into the past as far as they could, exploring the bottom of the sea, staring at fossil remains, puzzling out things no man in history has ever seen for himself.

But people have never wanted to stop thinking about things just because there wasn't much they could find out about them. As long as man has been able to put his thoughts into words, he has wondered about the beginning of life. Before there was such a thing as science, there were other ways of explaining things. The writer of the book of Genesis in the Old Testament wrote: "And the earth was without form, and void; and darkness was upon the face of the deep. And the Spirit of God

moved upon the face of the waters." After that, according to Genesis, God created light. Then He made the earth and the life that is upon it. He separated the waters from each other and from the dry land. The writer of Genesis was not a scientist. But somehow, out of the depths of his thinking about life, there came to him the idea that there were watery beginnings in the world.

Other people, too, thought of water as the source of life. The Upanishads, ancient religious books of India, told that "life comes from water . . . What is the root of all? What but water?" The ancients were not scientists, but in their own way had found the truth.

An ancient Hindu book says, "Verily, in the beginning this universe was water, nothing but water . . ."

And in the Egyptian religious literature we find these words, spoken by the "Lord of All":

"I am he who came into being as Khepri.
Heaven had not come into being,
The earth had not come into being,
The creatures of the earth and the reptiles had not
been made in that place.
I lifted myself up from among them, out of the watery
mass . . ."

The philosophers of ancient Greece thought a great deal about the beginnings of life. There were "seven wise men" who tried to discover what the world is really made of. They

were not very scientific; each came up with a different answer. But the most remembered answer was that of Thales, who declared that everything in the world came from water. There is no telling what brought him to this answer, but he, too, may have had some intuition of the beginnings of life.

We have taken a quick look at the "watery mass" that was the beginning of life. Now we are going to journey through human history, from early man with his confused wondering to the more knowing and more complicated people of today. We will discover that water has meant much more to people than just something to drink. The way people have lived and even the way they thought about life very often depended on whether they had enough good water to use; sometimes on whether they had too much. There have been wars for water, and the struggle to control it has made history.

We do not often think of this. We turn on a faucet and water comes out. That seems to be all there is to it. But really water means much more in our lives than this.

There is no life without water. The wheat on the Great Plains, the forests covering our mountains, the flowers in your garden, all the animals on the earth and the fish in the sea must have water or they will die. The two-thirds of our bodies that is water must be replenished all the time.

CHAPTER 3

Early Man and Water

It was early on a summer morning, somewhere in the world, so long ago that history tells us nothing about it. A man crept carefully through rough underbrush to the brook near the cave where he lived. The green woods all around him were full of the sounds of birds and insects. He was used to being cautious, and he listened to these sounds. If a wild animal had as much as stirred in the bushes, he would have heard. Now he listened to the sound the brook made, a murmur of running water.

The day was already hot, and the man was thirsty. He glanced around him and then stretched out flat on the bank so his face touched the water, and he could drink. He gulped big mouthfuls of water. This good cool drenching of his thirsty throat brought him as near to joy as anything could in his uncertain world. Suddenly he wanted to share his joy. He scooped up water in his hands to bring it to his child, whom he had left sleeping near its mother in the cave. But the water only leaked through his fingers and he dropped his hands. This was something he could not do.

Then he looked again at the brook. Only yesterday there had been more water in it. In spring, which was not long ago, the brook had been full of roaring water.

Water growing less could not be good. Though he was not

sure what was happening to the brook, for a moment this cave man was afraid. He knew very little about himself, but he did know that he must have water to keep alive.

For many days and nights it had not rained, and the woods were dry underfoot. The man remembered the cool wet feel-

ing of rain against his face. He turned his face up to the sky, wondering. There was no rain there.

The days and nights kept on being dry. Dry leaves rustled on the trees and the ground was dry and hard under the feet of the people. There came a day when there was only a trickle of water between wet banks. Fear was in people's eyes as they looked at each other across the fire at night. Around the fire they did a dance to please the gods they thought controlled the rain. With wild helpless cries they raised their faces to the stars.

But it did not rain. At last there was no water in the brook at all. No one could even squeeze a little from the mud where the brook had been.

People drank the blood of animals they had killed. For a while the berries were still juicy on the hillside, but there were never enough, and soon they, too, were dry. Even the roots the people used to eat dried up in the earth.

Now there were few animals in the woods, because they, too, must live near water. Soon there was hunger as well as thirst. People could not live this way.

The cave man's throat was so dry that he could hardly swallow. His wife sat all day by the cave and held their crying child.

One morning he picked up his stone ax and his spear, which was all he had to carry. His wife took the sharp stone she used for scraping skins. She carried the child. They did not look for

the others, and they did not again go to look for water where the brook had been.

Silently they made their way, pushing and stumbling through dry fallen branches, up over the mountain behind their cave. The cave man thought he remembered that much water lay on the other side of that mountain. His thirst made him forget that fierce people lived beside that water. He had met them once and been driven back, sore and bleeding.

Slowly they went down the mountain on the other side, until a wide blue lake lay before them. There they stopped, their eyes full of the sight of this water, wanting to taste it with their dry mouths.

The cave man's wife put down the child and let him stumble along beside them. They ran to the shore of the lake, threw themselves down, and drank. The man lay for a while there on his stomach, with his face in the cool water, tasting it over and over again. He felt nothing but that coolness on his face, in his throat, even in his grasping hands. For a moment he forgot that his own life and that of his family must depend on his watchfulness, his forever looking to see if danger were near. This he had never forgotten before.

There was a wild cry behind him. A leap, and a strange man was on his back. The man's wife and child huddled together in fear. Together the two men fought, growling like animals, rolling over and over on the shores of the lake.

When it was all over, the cave man had won his place on

the shore of that lake. His attacker slunk away into the woods, ashamed and beaten.

So for the moment one man's problems were settled, as far as anything could be settled in that uncertain world.

Another time, this cave man might not be the lucky one. He might be beaten by the other man. Or he might wander over another mountain in a dry year and not find water. He and his family might just die of thirst and hunger.

Winter was long and hard and full of hunger. Early man did not even have the comfort of knowing that spring would come again. He did his best to please the spirits who he thought would bring the spring and the warm rain to water the earth. He cried out to these spirits, danced for them, and offered them some of the wild animals he killed. When spring finally came, and the warm rain with it, he went into wild ceremonies of thanks and rejoicing.

Early man worked under handicaps we can hardly even imagine today. Just not having water to use whenever you need it would seem an almost impossible handicap. But early man could not have conceived of any other way to live. This was his life; he did the best he could with it. And over the many centuries of his way of life, he learned many things that made life easier. Some of these had to do with his use of water. He learned to carry water in a bag made of an animal skin gathered up around its edges. He learned to make pots of clay dug out of the earth, and in time he even learned to bake the clay. Water could be carried in these pots. He could take

water with him on the hunt, instead of always taking himself to water.

It did not occur to early man to dig a well. He did not know that water lay deep under the earth. Digging must have been hard to do, in any case, with only his fingers and a few stones to dig with. But after hundreds of years someone did think of scooping out a shallow hole in the earth to hold the water when it rained.

Thousands of years later, as we shall see, man had made even more important discoveries. He was no longer just a hunter and gatherer of food. He became a farmer, too. And it was more important than ever for him to have water when and where he needed it.

CHAPTER 4

The First Farmers

It was a long time before people thought of growing their own food. Many thousands of years. The men hunted small animals and people ate their flesh. The women gathered fruits and berries and grain that grew wild in the fields and the woods. They did not know any other way to live.

People did know that the fruits were tasteless and the berries hard and dry when there was not enough rain to water them. If the fruit trees and the berry bushes were not too far from a stream, the women would carry water in skin bags or containers made of bark and pour it onto the earth around them.

Sometimes this was hard work. The fruit trees and the berry bushes were too far away. Then the women would dig up some of the bushes with their hands and carry them nearer the water, much closer to the home cave. They would dig a hole there with their hands or a sharp stone or piece of wood, and plant the bush in it. There they could pick berries and at the same time watch the children as they played outside the cave. There they could easily bring water to the bushes when there

was not enough rain. Wild grain could be brought close to the cave, too, but it was impossible to bring enough.

Of course, if the rain did not fall for a long time there would be no water left in the stream, no water for either the plants or the people. Animals would not stay in a place that had no water. People would have to move on, too.

Wherever they were, women watched plants grow. They saw seeds fall from the plants. Day after day as they gathered fruits and berries, they watched new plants growing where the seeds had fallen to the earth. They watched and they wondered. Weeds grew up around the young plants, ready to crowd them right out of their patch of earth. The women pulled up the weeds.

In those days, people spent most of their time at the difficult business of keeping alive. They were too busy to think much about what went on around them. Besides, they did not have enough words to put their thoughts together. But as thousands of years went by, a sort of language was invented, and people did begin to use their minds. It is amazing that they learned as much as they did. Man could already do much more with his mind than any of the animals.

Still, people were not yet ready to discover what the planting of seeds could mean in their lives. It did not occur to them to grow their own grain, beside their own caves. There was much that they still could not understand.

Then there must have been one woman, somewhere in what is now Europe, ten or twelve thousand years ago, who did

more thinking than the others. She decided to do something with the seeds that fell to the ground. What she did seems very simple, but it was unheard of in those days. She took a handful of seeds and scattered them into the soft earth beside her cave. Wild wheat grew up, more of it than she had ever been able to carry home by digging up the plants. Without

going away from her cave this woman could gather a potful of grain to grind between her grinding stones.

Scattering seeds wasn't really a good way of planting. It didn't produce much grain. But it was the only way people knew, until at last someone thought of digging up more of the earth with a sharp stick or a stone. That way more earth could be made ready for the seeds. If the people planted many

seeds, they would even have enough grain to last until spring. It could be ground and stored in pots for use during the cold lean days of winter.

These people were the first farmers. The chances are that they weren't good ones. But they learned, and other people learned with them. Now they could stay by their favorite river until their grain had ripened and they could gather it. That is, they could if there was enough rain. It wasn't much use to plant your seeds by the river if your land was drying up under the hot summer sun. No use at all. In a dry summer people would still have to go away from the river, searching for a place where there had been enough rain for the wild grain to grow. These were still wandering people. Very few lived in one place for a lifetime.

It was hundreds, maybe thousands, of years before anyone thought of a really practical way of watering many plants without rain. Somewhere in the world a group of farmers (men were all farmers and hunters then) had planted a good garden in a dry year. Little green spears of wheat and other grains had pushed their way up out of the earth. Then there had been no rain. All the grain was turning brown under the hot sun. No grain would mean a starving winter. The people could not stay by this river.

One of the farmers looked at the water in the river and then at his dry garden. He wanted a way to get the two together. He had tried filling a clay pot with water from the river and pouring it on his plants, the way the women used

to do. His neighbors had done that, too. It helped, but a man couldn't pour water on the gardens all day. There would be no time left for the everyday business of living.

Still it didn't rain. This little watering would never be enough. Prayers were sent up to the rain god. There were dances to please him. But it seemed he was not pleased.

The farmer kept thinking about better ways of bringing the river to his garden. And at last he thought of an idea that was to change history itself. With his stone hoe he dug a ditch through the river bank and across his garden. It took him a long time to dig this ditch. He had to make it deep enough so the water would run down into it and across all his garden. After that he dug more ditches. This time, too, his neighbors did as he had done.

This was the first irrigation. At least, this is how we can imagine it must have been. No one wrote down what happened in those days. These were not civilized people. They did not have time to be civilized. Nearly all their time was taken up with getting enough to eat. But they had made a beginning. At last people could settle in one place and build homes for their families beside the river. If they had chosen a good river, they could be sure that even the hot sun of a rainless summer would not drive them away.

Water in ditches across the fields changed the lives of early people. But water changed their lives in other ways, too.

Early man lived a lonely life. He had not learned really to live with other people. But the need for water, among other

things, helped to bring people together. There was room for more than one family beside the river. People settled together along the rivers at first just because rivers were a good source of water. Later, when groups of families became villages, rivers were the only easy way of journeying from one village to another. They were the only boundary lines plain enough for everyone to see. Where rivers washed down rich soil from the uplands and spread it out over the fields, people could grow tall grain.

In time, men learned to dig wells, and then they did not always have to live close to a brook or a river. Digging a well was a big job with the few tools they had, but people working together could dig a well for the use of everyone. Villages grew up around good wells.

People working together could dig bigger ditches for irrigating their fields. And they were stronger against their enemies than they ever could be alone.

Life was a little easier when people lived together. There was time to do more than just exist, time even to enjoy life. Early culture could not have developed if man had continued to live alone in the woods. But any way of living depended on having enough water. Some cultures just disappeared, or the people moved away, when there was no longer enough rain where they lived and even the rivers dried up.

In North America, early Indians lived for hundreds of years in what is now desert country in Arizona and New Mexico. Geologists have discovered that there once were rivers and

lakes in that desert. Meadows of green grass grew along the rivers, forests of trees on the higher ground. Then this became a dry country, probably because there was no longer enough rain. Archaeologists, digging into the earth, have found bones of people. Here, long ago, people lived together in villages and grew maize which they ground into meal for bread. But they deserted their land and moved into the uplands when the good rain no longer fell on their maize to make it grow and the rivers dried up, too. This land has been a desert ever since. The same story can be told of other parts of the world.

The people we have been talking about lived so long ago that we speak merely of "many thousands" of years, not knowing just how many. It was still more thousands of years before the period of history which we call "ancient." This began almost six thousand years ago and lasted for more than four thousand years, until the end of the Roman Empire.

Civilization began in the valleys of great rivers, the Tigris and Euphrates in Asia Minor and the Nile in northern Africa. Here people lived surrounded by mountains or deserts, so they could for a time keep away their enemies. Here they invented government to protect men from each other. Here, too, they could grow grain and water it with the good rain or the plentiful rivers. And there were animals to eat because they, too, ate the plants that grew beside the river. The business of keeping alive became a little easier. There was time for other things.

CHAPTER 5

Irrigation in Ancient Times

"I brought the waters and made the desert to bloom."
Hammurabi, King of Babylonia, 2100 B.C.

The ancient Egyptians lived in a land almost without clouds and rain. And yet the rich land along the River Nile grew grain such as grew nowhere else in the world. This was not because the Egyptians were more industrious than other people. It was the river itself that made the difference.

Every summer, tons of water flowed down the river from the distant uplands, through the far mountainous countries beyond Egypt, into Egypt itself. This was not water from the spring melting of snows, as happened in so many parts of the world. It was water from torrential summer rains in the part of Africa which is now called Ethiopia.

When this roaring swirling water reached the broad valley that was most of Egypt, it spread out quietly over the waiting fields. Then slowly, as the water grew less abundant, it retreated into the river again. An Egyptian farmer watching this learned irrigation from the river. He could dig ditches to

keep the water close to his farthest fields. And when the flood had gone he could plant his grain in the wet earth and be sure of a good crop in the spring.

In early times this flooding of the river each year seemed too good to be true. People just could not believe it would happen again. They did not know where this river came from; no one had ever explored its beginnings. So they prayed to the river god, begging him to water their crops another year. They brought gifts and sang to him:

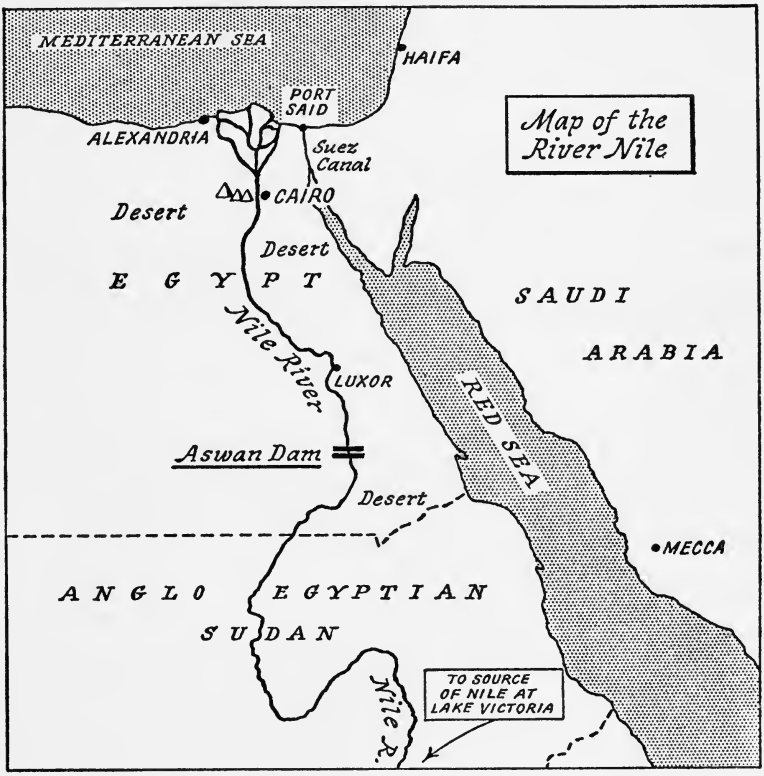
> "Offerings are made to thee,
> oxen are slain to thee,
> great festivals are kept for thee,
> beasts of the field are caught for thee,
> pure flames are offered to thee."

But the great Nile never failed. It not only flooded the valley but emptied onto it much fertile earth it had brought down from the mountains. This was something man himself could not do.

Sometimes, though, the flood was lower than at other times. And sometimes the dry season seemed too long. So it was wise to be sure that there were plenty of canals to take the water through the fields.

There were other methods to use when the canals were not full enough of water or the banks along the river were too high. Carrying water in skin buckets was one way, but that was hard. More water could be gotten onto the fields by using

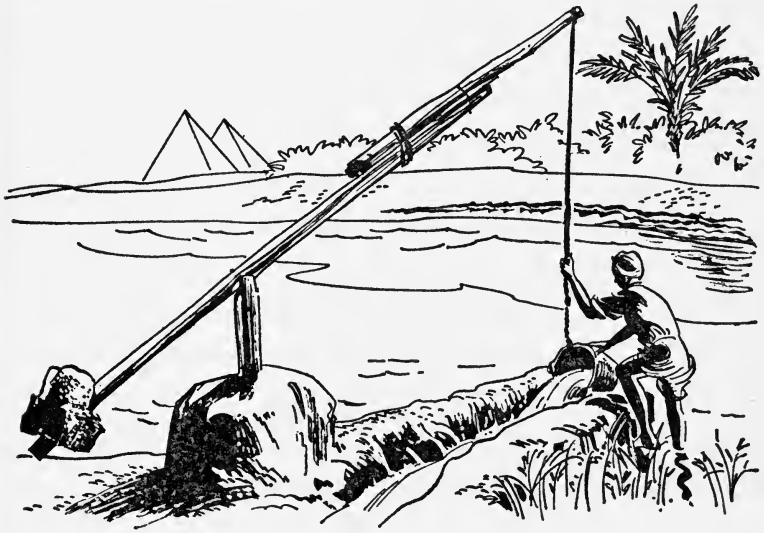
what the Egyptians called a "shadoof." This was something like the "well sweeps" which you sometimes see here in the country. It was made of two upright poles beside the river,



with a crosspiece near the top. Across this was placed a pole with a clay weight on one end and a skin bucket on the other. The bucket could be pulled down to the river with a rope, and when it was full the clay weight on the other end of the pole would help bring the bucket up and empty it into the ditch.

The Egyptian fellah or peasant still uses his shadoof when the water is low.

There was another way. A sort of water wheel with buckets fastened to it could be turned by oxen going around and around. The buckets would fill up in the river as the wheel



turned and then the water would pour out into the ditches. This was called a "sakia." Its endless creaking and the splash of water were pleasant sounds to hear during the long busy days.

The Egyptians who lived on the fertile earth of the Nile valley did not need to spend all their time just keeping alive. This was one reason, and an important one, why they developed one of the greatest civilizations the world has ever known.

Some of the people, at least, had time for singing and dancing, for painting beautiful pictures, for exploring the unknown and writing their thoughts about it. They had time to develop a comfortable and gracious way of living. To be sure, this way of living was not for everyone. Many of the people were slaves.

The ancient Egyptians in their valley, surrounded by mountains and seas, felt as secure as anyone could in those uncertain times. No one could take their river from them. At least, so it seemed most of the time. But every now and then one of the Ethiopian princes, who lived along the upper Nile, would threaten to dam up the Nile or make its waters flow in another direction, so it would not flow down to Egypt. The Ethiopians never carried out this threat; it would have been quite an engineering feat if they had. But it was a terrible threat just the same. The Egyptian rulers took it seriously enough to send large gifts to the Ethiopians.

There were other famous rivers of ancient times. The valley of the Tigris and Euphrates Rivers, in Asia Minor, was the home of one of the first civilizations. Archaeologists think it may been the home, too, of the Garden of Eden which we read about in the Bible.

The Sumerians settled in this valley, in the southern part of what is now Iraq, over six thousand years ago. Like the valley of the Nile, this was a land of very little rain, a land of fertile earth that would grow good grain only if water could be brought to it from the river. It seemed a fairly safe valley for a while. Probably no one wanted to bother people who

chose to live in a desert. But as irrigation canals were dug and wheat began to grow, this was no longer a desert. It was good land, and other people wanted it. Invaders swooped down from between the surrounding mountains. About the year 2100 B.C., the Babylonians took over.

The Tigris and Euphrates Rivers brought down fertile soil from the mountains after the spring rains, but they did not flood the valley as the Nile did in Egypt. The Babylonians depended even more than the Egyptians on the canals that irrigated their fields. Miles of these canals carried water from the rivers to water their crops. The desert was green with growing things. These were prosperous people, and they had time to be really civilized. They loved singing and dancing; their artists worked on massive and dignified sculpture. All this would have been impossible without good water and good earth. One of their laws decreed death to anyone who spoiled the earth or wasted water.

Unfortunately, there was a less happy side to this picture. The rivers were bringing down too much earth from distant hillsides. These hillsides had probably been stripped of trees and their shrubs chewed off by sheep. There was nothing to hold the earth on the hills when the rains poured down them.

The Babylonians had only one way of getting this silt out of their canals: they took it out in baskets. Baskets were good for straining out most of the water. Hundreds of people had to work at this. Then more and more silt kept coming, and thousands of people had to do it. Every year more people spent

most of their time hauling baskets of silt out of the canals. The long ridges where they dumped it grew higher and higher. They didn't dare stop; the lives of all the people depended on keeping the canals clear.

The canals did not become such a problem all at once. This went on for hundreds of years. At first people probably weren't much worried about their land becoming a desert. But as years went by, so many people spent so much time carrying baskets of silt out of the canals that the people of Babylonia just didn't have time for other things. It takes time to dance and sing and make fine sculpture.

There were other reasons, too, why Babylonia became less and less civilized. But this was an important one. The country survived many invasions, from the Assyrians who lived to the north, the Persians, and Alexander the Great. Much later, only about seven hundred years ago, the Mongols from eastern Asia swept over the land. It was impossible for the people to keep them out. The Mongols destroyed everything they could lay their hands on, and that included the whole intricate irrigation system. People could not live there any more, except perhaps a few wandering desert tribes.

And so the land between the rivers went back to desert. If you had gone, only a few years ago, to the part of Iraq that lies west of the Euphrates River, you would have found yourself in a desert. You could have kicked around in the dry sand with your foot and uncovered some old broken pieces of pottery. These were perhaps some family's dishes, in ancient

Babylonia. Right where you were standing, there may have been a village, three or four thousand years ago. This would seem impossible as you looked around. There is nothing left of this village but the broken pottery at your feet. Off in the distance you would have seen a mound of sand which somehow didn't look like a natural hill. That was once a town. There are still mounds like this in the desert. Many have been dug into by archaeologists, whose job it is to discover ancient buried things and places. The biggest mound of all was the great city of Babylon.

Somewhere in this desert, too, you would have found two long banks, miles of them, like railroad banks, sometimes more than twice as tall as a man. The wind can't make sand look that way. Those banks are what is left of the silt people piled up by millions of basketfuls for hundreds of years. As you looked you would have understood how the need for water changes the lives of people and even history itself.

Now, nearly seven hundred years after the canals were destroyed, this desert is being irrigated again. The government of Iraq is building dams and irrigation canals, because they know that if this was once good land it can become so again. All over the land farmers are beginning to plant their seed and grow their grain, because the water of the rivers will flow through their fields in the long canals. This land which has been a desert for so many years will be green with growing things. People will flourish there again.

Man has always wanted to conquer the deserts of this world.

Some of the finest civilizations in all of history flourished partly because people learned how to change their deserts into gardens. The Babylonians and the Egyptians were not the only such people.

In the same part of the world, the ancient Romans watered the deserts of North Africa and made them their richest source of grain. The Greeks watered deserts, too, and so did people of other nations on the shores of the Mediterranean Sea. If the Phoenicians had not irrigated their fields and prospered, we might never have had our alphabet.

Ancient people in what is now Mexico and Central America depended on irrigation canals to keep their fields green. So did the Inca Indians of Peru, who had an intricate system of canals controlled entirely by their government, for the use of everyone.

On the other side of the world, in China, people dug irrigation ditches more than two thousand years ago, to bring the water of rivers to their fields. The Tukiangyen system was a complicated engineering project with dams and dikes which controlled the Min River and let its waters run through half a million acres of land that had been a desert.

These were people who knew how to produce lush harvests of grain in what looked like hopeless deserts. And they developed civilizations which are still a source of wonder to us today.

CHAPTER 6

Land and Water in Ancient Times

Ancient civilizations depended on land just as much as they depended on water. It was both together that made possible the abundance that brought the beginning of civilization.

But when man learned to use the land for growing much grain, he also learned to ruin it. Nature covers the land with growing things, and their roots hold the earth fast when the rain sweeps over it. Man has often laid bare the land and left it bare. He still does this today.

Misuse of the land was not a problem for early man. He couldn't do much damage with just his bare hands or a stone hoe. And he seldom stayed long in one place. Besides, there really were not many people then. Only a handful compared with the millions there are now.

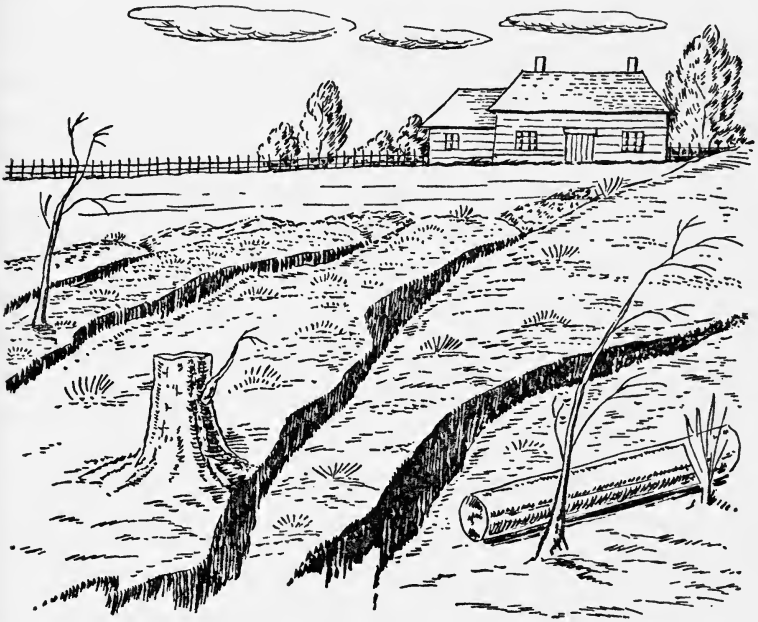
Misuse of the land *did* become a problem when men could plow up the fields and keep them plowed. They had no idea there was a right and a wrong way to do it. When they plowed up a hillside, it simply didn't occur to them that the next rain might wash half the earth off it. And if they had known this, they might just have decided that there were plenty of other

hills. It was thousands of years before men could think ahead beyond their own needs and plan for the people who would be living on their part of the earth when they were through with it.

The longer civilization kept going, the more problems there were in the use of water and the land. We have seen how the Babylonians fought a losing battle with the silt that washed into their canals. We don't know whether any Babylonian ever wrote about why the canals filled up with silt. The silt must have come from far up the rivers. Very likely the hills that the silt came from were not in Babylonia at all. The Assyrians, to the north, where the rivers came from, certainly never cared what happened to the Babylonians. They may have stripped the trees off their hills without thinking about what would happen to the earth in the heavy rains.

In Greece, however, the famous philosopher Plato had something to say about the ruined hillsides in his country. Scholars have just recently discovered what he wrote about this: "There are mountains in Attica [Greece] which can keep nothing but bees, but which were clothed, not so very long ago, with fine trees producing timber suitable for roofing the largest buildings. . . . The annual supply of rainfall was not lost, as it is at present, through being allowed to flow over the denuded surface into the sea, but was received by the country, where she stored it in her impervious potter's earth. . . ." From this water in the earth, says Plato, came springs and rivers bringing water to the entire country.

People of ancient times did not always spoil their land. Many of them knew how to use the land well and how to restore it when it had been used too much or too long. Sometimes they could not control what happened and in spite of themselves



their land would be damaged by wind and weather. But here and there, throughout history, man has abused the land, and voices like Plato's have been raised in warning. When we come to modern times we will see how the use of land and water affects the lives of people today.

No matter what different uses for water were discovered,

the most important use was always water for the use of man himself, as he went about the daily business of living. Water to drink. Water for washing. One of man's problems has always been to find enough water, in a place where he can use it. Early man solved this problem by taking himself to the water. But ever since there have been civilizations, man has brought water to himself. For one reason or another, people have often chosen to live in places where water was scarce and hard to get.

The Bible tells us that Moses had a hard time finding water after he had brought the Israelites out of Egypt. "There was no water for the people to drink." Thirsty people are apt to become wild and unruly. "The people murmured against Moses, and said, Wherefore is this that thou hast brought us up out of Egypt, to kill us and our children and our cattle with thirst?" Moses was sure that the people were ready to stone him, and he cried for help to the Lord. Moses was told by God to speak to a certain rock. Instead, he struck it and water flowed from it.

The Israelites were wandering in the desert not because it was a good place to live but because they were seeking freedom from slavery and a "promised land" which was sure to be "flowing with milk and honey," with fresh water for everyone.

But people *have* lived in deserts. They have even built cities in places where good water was scarce or there was none at all. They have built fantastically complicated structures for bringing water to their cities, rather than move their cities nearer

the water supply. Of course, there were reasons for this. Sometimes there was no choice: other and stronger people occupied the land near the water. Sometimes the water in the river beside the city was not clean enough to use. Or a city would be built near the sea, where its boats could come and go. The people could not drink the water from the sea.

Water was brought to cities and towns in aqueducts, and it still is today. An aqueduct is any structure for conveying water from one place to another. It is usually a big and important structure. If you run a pipe down to your house from the spring on your hillside, you don't call it an aqueduct. But the enormous tunnels that bring water to New York City and other cities today are called aqueducts, and so were ancient tunnels and such.

Among the first aqueducts in the world were tunnels dug into the earth, like horizontal wells, in North Africa and Persia. In many of the dry desert valleys it was impossible to find water by digging straight down into the earth. There might be water there somewhere, but it was down too deep. So, instead, miles of tunnels were dug under the desert, reaching back into the hills where there were springs or underground rivers. Then wells were sunk along the tunnel. Villages grew up around the wells.

It took hundreds of people to dig these dark and narrow tunnels. Slaves did the digging, and when slaves were no longer available, the tunnels could not be kept up. In North Africa today there are many of these tunnels that could still

be repaired and used. This has been done in southern Algeria, with much success.

The most famous builders of aqueducts in ancient times were the Romans. Many of the tunnels in North Africa were dug by the Romans. There, too, they dug huge caverns called "cisterns," for storing water.

The city of Rome was supplied with water from springs and brooks on nearby hills. The first Roman aqueduct was called Aqua Appia, and it brought water to the poorer part of the city, where there were no springs.

Roman aqueducts were built of stone, because their lead pipes were not strong enough and bronze was too expensive. Usually the aqueducts were on the surface of the land, or just underneath. But the parts of aqueducts which we can still see today are the enormous arched bridges which carried water in stone pipes across the valleys. Too much water pressure would have been lost if the water had been allowed to flow down to the low level of the valleys.

Water ran through the aqueducts into reservoirs in the city of Rome, and from there it was piped into fountains where people brought jars to fill with water and carry home. Some of the more fortunate had water piped into their houses.

There seemed to be no end to Roman engineering skill. Aqueduct bridges were built in Roman colonies in other parts of Europe. Tunnels were dug through mountains. Digging through rock meant just chiseling away at it, because the

Romans had no explosives. Skilled workers kept the aqueducts in repair. The water itself was kept pure. The Romans built elaborate "baths" where people went to bathe and relax. These were people who liked comfort and luxury, though they used slaves to help give it to them. Comfort and luxury, as the Romans saw it, depended to a great extent on having plenty of pure water.

The Romans were not the only ancient people with intricate systems for getting water. King Solomon, in ancient Palestine, directed the building of an aqueduct leading from the "Pools of Solomon" into the city of Jerusalem. Fifty centuries ago a civilization in the valley of the Indus River, in what is now Pakistan, had a well-designed water system with tanks and swimming pools and baths. Wealthy people there had showers in their houses, small rooms paved with tile in which water could be poured over a person from large jars. The water would then run off into sewers beneath the streets.

There were others, too.

Water supply depended then, as now, on people, their skill in planning, their willingness to work together. Aqueducts and tunnels in ancient times required enormous amounts of energy from people. The Romans were brilliant engineers, but for the actual building of their waterworks they depended on slave labor.

Rome was finally conquered and ruined by the Goths and Vandals. You might think that the conquerors would have been

impressed by the Roman waterworks and been glad to use them. But not the Goths and Vandals. They were not civilized enough to care. They came to conquer and destroy.

Even so, many of the Roman aqueducts remained. They were strong enough to last a long time. But they could not survive centuries of neglect. Some of the bridges are still standing, but most of the Roman waterworks were never used again. People in Europe could have repaired and used them during the Middle Ages, but their civilization was a different one from that of ancient Rome. Water did not have the same meaning for them. Bathing and keeping clean were considered rather wicked luxuries. People were taught to keep their minds on the things of the spirit, and on a happy hereafter. These were people who could work hard together to build cathedrals for their God, but it did not occur to them to work together to bring clean water to their towns for the comfort and health of man. Any well, clean or not, was considered good enough to use.

So we see that the use people make of water depends on their civilization. And their attitude towards themselves determines whether they care about bringing water into the towns and cities for the use of everyone. This is still true today.

It is just as true that civilization itself depends on how people use the water that is available to them. Almost everywhere, great civilizations have developed in places where people knew how to water their fields and bring good water to their towns and cities.

CHAPTER 7

War and Water

Battles have been fought for water ever since man walked the earth. At first these were just struggles between one man and another, fighting for the use of a spring or a place beside the brook. Later, in ancient times, there were wars for water between cities.

Water has played a part in all the wars in history. You may not find much about this in the history books. Historians have a way of saying nothing at all about such everyday problems. Men who fought wars had to find water somehow, every single day, to stay alive.

Hannibal, for instance, in 218 B.C. set out from Carthage in North Africa to conquer Rome itself. He had decided to do it in a grand way, so he took along not only an enormous army but a herd of elephants. His route to Rome lay over the highest mountains in Europe, the Alps. It is hard to imagine how Hannibal could have fed and watered so many men and elephants on that journey. Certainly the army could not have carried enough water, and the melting snows and brooks could not always have provided enough. Many elephants fell over the

cliffs in the mountains. Many died, perhaps of thirst and cold and hunger. Even so, some survived, and Hannibal put up a stiff fight not far from Rome and almost conquered it.

Supplying water and food to an army has always been a problem in war. One of the worst things any army could do to the enemy was to cut off his water supply. An old Chinese maxim warns commanders of armies not to let the enemy get upstream where he could cut off the water or poison it. Armies were often defeated this way, anywhere in the world. Another trick was to flood the enemy by tearing down a dam, or to change the course of a river by building a dam.

There have been people in the world who have wasted all their energies in fights for water. This was true of the Turkmenians, who still live in a dry part of southwestern Asia.

There is an old saying of the Turkmenians: "Water, not earth, gives life." For centuries, since ancient times, these people fought for the water that gave them life.

In their dry desert the Turkmenians built their cities and towns, because it was their home. They had been there so long that they had forgotten why they had settled there in the first place. Tougher tribes may long ago have driven them away from a land of rivers and cool rain.

Each Turkmenian tribe had its own canal, filled with water from distant rivers or the infrequent rain. Water for growing grain was just as necessary as water to drink. Sometimes there was not enough. Then one tribe would swoop across the desert, brandishing knives, massacre another tribe, and take its water.

Even within the tribe itself there were fights. Water was measured by time. A family might have fifteen minutes of water once in twelve days. This was enough. But a poor man with only three minutes of water did not have enough. He would have to sell his three minutes to a rich man and go to work for him. Water for irrigating crops was only for families. Bachelors could not have it; neither could widows or orphans.

Not everyone accepted these rules. There were those who would fight for more water than they had. This was sure to be a losing fight. The ruler of the tribe could shut off water from the fields of the unruly ones. He could keep them from drawing water at the wells.

So for centuries the Turkmenians fought the desert and each other for survival. When the armies of the Russian Czar came in 1873 to conquer them, they fought the Russians by throwing dead dogs into the wells to poison them. Thousands of Russians died in the dry desert heat before they finally conquered the Turkmenians and built a railroad across the desert.

The Turkmenians retreated into the dry hills where water was harder to find and grain harder to grow. There in their thirst and hunger they fought each other more fiercely than ever before. There were not many left when the Soviet government set up the Turkmenian Republic in 1924. They were a wild primitive people, scattered in the hills around their few wells.

Now things are a little better for the Turkmenians. They

have been taught new ways of irrigating the desert. Wheat that needs little rain has been developed for growing there. There are green pastures in the desert once more. Now at last these people do not have to fight each other to survive.

The Turkmenians are by no means the only people who have fought each other for water. The Bible often speaks of struggles between people for the possession of a well. Most such fights have never been written about at all. In remote parts of the earth primitive tribes still fight each other for the possession of a well or spring.

Our journey through parts of the ancient world is ended. Now we are going to take a great leap through history to modern times. With only an occasional glance backward, we will discover what water means in the lives of people today. We will find that there are still people who cannot get all the water they need, and occasionally those who suffer with too much.

There are many more uses for water now than ancient people could have dreamed of. But the most important of them all is still our everyday use of water to keep ourselves alive.

CHAPTER 8

Water for People Today

There is an old song that goes, "You never miss the water till the well runs dry." This is as true today as it was when the song was written. We turn on the faucet and water runs out; we don't think twice about it. We would do a good deal of thinking if, one morning, we turned on the faucet and *nothing* came out.

This happened one winter morning to the Butterfield family on a New Hampshire farm. The temperature outside was twenty degrees below zero. The pipes that carried water to the Butterfields' farmhouse from a spring on the hill had frozen, even though they were under the ground. It is upsetting to turn on your faucet and have nothing happen at all. You stand there looking at it, as if you thought water might still come out if you just waited long enough. It doesn't come.

Melted snow, as long as it's clean, will do for drinking water for a while. You can wash your face in it, too. But in the long run it won't do for baths and cooking and washing clothes. A pailful of snow melts down to such a little bit of water.

The Butterfields decided that this would be a good time to

visit their cousins in New York City. They sent off a hasty telegram, packed their bags, and left.

Their cousins lived on the sixteenth floor of a big apartment house. Water won't run up that high in New York City by itself; it has to be pumped first into a tank on the roof. This time the pump wasn't working. When the Butterfield boys cheerfully greeted their cousins and rushed into the kitchen to try turning on the faucet, no water came out. All the water anyone had was what the elevator man brought around in jars.

"We could have stayed home," the boys wailed. And it was true that they could have had more water by carrying pailfuls down from their spring, once they had chopped through the ice on top.

The pump in the cellar of the New York apartment house was all fixed by the next morning. It would have taken longer than that for the ice to thaw in the Butterfields' pipes in New Hampshire. Still longer, if the pipes had burst. But the Butterfields would never again take water for granted, even in the city.

Most of us, though, do take it for granted that water will keep on running out of our faucets. But the Arabs who came to Paris for peace conferences after World War I had never seen faucets at all. To them it seemed a miracle that you could turn a little handle and water would come out of a spout. Surely, they thought, if they took these gadgets home they,

too, could have running water. It was not easy to persuade them that this would not work.

Maybe this story sounds like something out of the remote past. But it happened less than fifty years ago, and in many countries right now there are no faucets in people's houses, and often not even a pump beside the kitchen sink.

If you lived in Nome, Alaska, you would find yourself in much the same fix in winter as the Butterfields on their New Hampshire farm, only it would last all winter. In Nome, all the water mains are frozen by mid-September. People buy water from tank trucks at two-and-a-half cents a gallon. Fairbanks, also in Alaska, manages to avoid this situation by keeping the water in their mains running at the rate of three feet a minute, so it can't freeze.

If you were an Eskimo living still farther north, you wouldn't have any water mains to worry about. Melted snow would provide all the water you needed. And you would have learned that the water that melts from icebergs is good fresh water. Icebergs are pieces of fresh-water glaciers floating in the salt water of the seas.

Suppose, on the other hand, you lived in an entirely different part of the world, the Middle East. In Egypt, you would see water carried from the Nile River in skin bags on camels or donkeys. Street vendors sell it by the cupful. You would buy water in the streets, too, in other countries of the Middle East.

The island of Bahrein, in the Persian Gulf, for a long time could get almost no fresh water. The well water was brackish, that is, partly salty. People had to use it anyway in spite of its bad taste. The only fresh water they had came from, of all places, the bottom of the Persian Gulf. Fresh-water springs bubble up there, though the Gulf itself is salty. Divers would swim to the bottom carrying collapsed goatskin bags. These would be filled with fresh water from the springs. Then the divers would swim back up with the bags.

Now there are machines in Bahrein for taking the salt out of the well water. The pure water is carried away in carts or on the backs of donkeys, to be sold in the streets. The desalting machines are more efficient than the divers, but fresh-water springs will go on bubbling at the bottom of the Persian Gulf near Bahrein.

Not far away, still in the Middle East, is Iran, which used to be called Persia. In Teheran, its capital, there is always a murmur of water running in the streets. Water for the use of everyone flows along in open gullies. At the street corners, people cross the gullies on little stone bridges. The water comes from wells at the foot of mountains many miles away, through long tunnels called "qanats." It is pure water to start with, but it is not clean as it runs in the streets. People wash themselves and their clothes in it. Horses drink. Orange peels and other refuse are thrown in. Only the poor have to drink this water. Many of them die of diseases carried by it. People who can afford it buy drinking water from carts that carry it through the streets in barrels.

All this may seem very far away from us. But early in 1957, after almost eight years of drought in our Southwest, people bought pure drinking water in jugs in parts of Texas for fifty cents a gallon.

Most people in this country do have plenty of water. We have enough to drink, to wash with, and enjoy. There is usually enough for industries and agriculture. But, as we have seen, this is not so everywhere.

The way people live, anywhere in the world, depends to a large extent on how much water is available for everyone. There are tribes in southwest Africa that drink by digging a hole in the ground and sucking up sand and water through a tube. You do not know much about being civilized if you are content to drink water that way.

Two villages in Asia can show us the difference between having plenty of water and seldom having enough. One is Tosie Bazaar, far off in the mountains of Nepal. People there live close to the earth, and for them the earth is rich with growing corn. Life is not easy, but there is time for laughter on the carved balconies above the village street, time for red geraniums along the eaves of the houses. There is no fear of starving as long as clear water runs around the village in a stream from Mount Everest, and the rains come.

The other village is Tigra, in India. Here life is really hard, and it is not easy to laugh. Wheat is planted in the fields, but no one ever knows whether it will grow enough to give grain for people to eat. Some years there is almost no rain, and the fields are baked hard under the sun. People live with the fear of hunger, in their mud huts. When the monsoon rains come in June there will suddenly be too much water, and even the mud huts will be washed away. So will much of the poor baked earth. Huts will be built again, and life will start over as if the rains had never come. Again there will be fear of hunger under the hot sun.

These are only two villages. There are many others. There are very different ways of living. Often the difference is water —or lack of water.

CHAPTER 9

Water from Wells

Wells and springs are among the most ancient sources of water for people, and they are still in use all over the world. Some towns and a few cities get all their water by pumping it up from deep wells. If you live in the country, or in a small town that has no community water supply, water for you and your family may come from a well or a spring. But perhaps, on the other hand, there isn't a well or a spring near enough for you to use. Then, if you can't have a well dug yourself, you will try to get water from a nearby lake or stream. If that doesn't work out, either, or if you can't get enough water by any other method, you will install an outdoor cistern or a barrel to catch the rain water from the roof.

Most of us know what a well is. But a good many people today have never seen one. A well is a hole in the ground dug or drilled down below the water table, which is the top of the underground supply of water. Water cannot be found everywhere under the earth, but in places there are great underground reservoirs of it. The water table anywhere under the

earth is always changing with the amount of rain and the amount of ground water that is used.

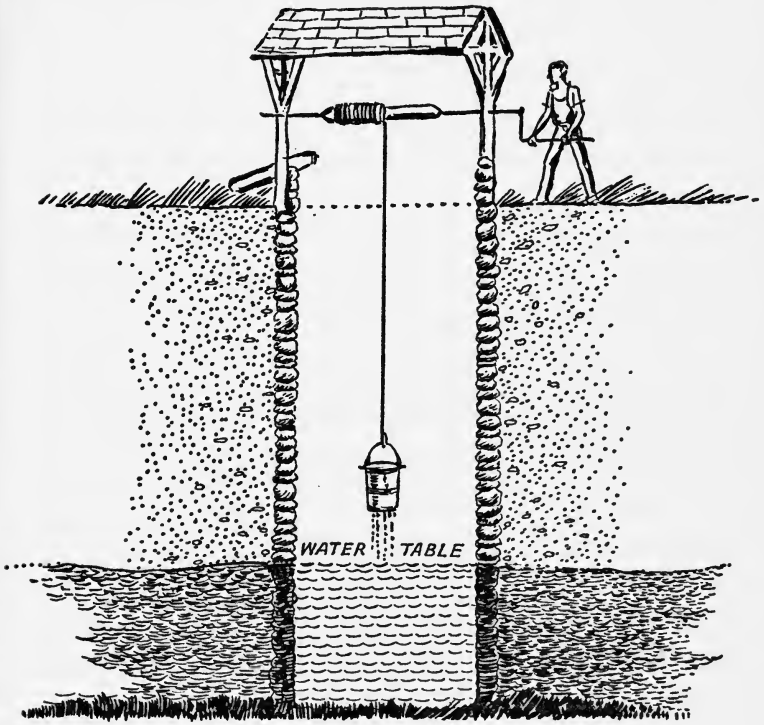
In North Africa, wells as deep as three hundred feet have been scooped out by hand. If water is too far down under the earth, however, it cannot be reached by digging even with a shovel. To reach this water a well must be drilled deep into the earth, often through rock. You may have heard the rhythmic clang of well-drilling machinery at work, pounding away at the rock deep in the earth.

Sometimes underground water is squeezed tight, under pressure, between layers of rock. This water has seeped in from a higher level and keeps pushing down between rock layers by the force of gravity. When this water is reached by drilling, it pushes up by itself, without lifting or pumping. It may even gush up into the air in a fountain. This kind of well is called *artesian*. It sometimes has to be capped to keep the water from running away. The pressure in an artesian well will remain the same only if the amount of underground water stays about the same. More water will keep seeping in. But if too much is used, there will be no more water under pressure, and finally no water in the well at all.

In some parts of the country, any drilled well may be called artesian, but this is not always accurate. A drilled well does not necessarily reach water under pressure.

Once a well is dug, it must be lined to keep the sides from falling in and to keep surface water, which may not be pure, from running in. There should be a cover over the top, too.

In ancient times wells were sometimes lined with wood, but stone or concrete is better. A drilled well is lined with a long metal or plastic pipe, unless its walls are solid rock. Then it needs no lining, except near the top.



Water that comes up from the rock layers under the earth is apt to be "hard." That is, it has a good many minerals dissolved in it. If there are too many minerals, soap will not lather in the water and washing with it will be difficult. But the right combination of minerals makes water taste delicious.

Suppose you have had a well dug on your land. There is plenty of water ready for use, down in the earth. Your next problem will be how to get that water out of your well. One way, which is as old as wells are, is to let down a bucket or a skin bag into the well on a rope. This is still done in many places. A windlass built in just above the well makes it easier to pull up the bucket. A windlass is simply a cylinder which the rope can wind around, and a crank that can be turned to wind it. Many of these are still in use.

The well sweep is another device for bringing up water from a well. A long pole (or "sweep") is raised into the air on a post ten to twenty feet high. The pole is attached, near its middle, to the top of the post. A bucket is tied to one end of the pole by a rope, and a weight to the other end. The bucket is then lowered into the well. When it is full of water, the weight on the other end of the pole helps to bring the bucket up. You may have seen these well sweeps on old farms in the country. Perhaps you have even used one. A well sweep is very much like the shadoof which the Egyptian farmer often still uses to bring water to his fields from the River Nile.

In ancient times, wells were sometimes built quite differently from those we know. Instead of standing beside the well and drawing up water, a person could go down into the well on stone steps, to the level of the water, fill a bag or jar, and carry it up the steps. Wells like these are spoken of in the Bible, which calls them "pools." One of these, the Pool of Gibeon, has just recently been rediscovered. It is a huge well with

massive stone steps going around and around inside it, from top to bottom.

It was most often the women who drew water from wells, and this is still true where wells are used. In some places, even today, there is just one well for a whole village. There the women can pause to talk while they wait to fill their jars. There they can exchange news of the village and the world.

Recently, in Iraq, an engineer from the United Nations Food and Agricultural Organization proposed to pipe running water from wells into village houses in the desert. He took it for granted that this would be a popular idea. But the village women would have none of it. No one could persuade them to give up their daily session of gossip at the village well.

In time, pumps were invented to make it easier to get water out of a well. The lift pump, which lifts water up out of a well by air pressure, is still widely used in country places. It may be out in the yard, just over the well, or inside the house, right beside the kitchen sink. Raising and lowering a long iron pump handle forces air out of the pump. Water takes its place and comes up in spurts. A valve at the bottom of the pump closes and keeps the water from falling back into the well. Great invention though this was, the continual raising and lowering of the pump handle involves a tremendous waste of energy. Water cannot come out in a steady stream. This kind of pump, too, cannot bring water up from a deep well.

The force pump uses compressed air, too, but it does a better

job and can bring water up from a deeper well. Water comes up faster, in a steady stream, because the force pump has an extra chamber in which compressed air keeps pushing the water out. These pumps are often run by motors. Fire engines use force pumps.

A windmill can provide the power for a pump, when there is enough wind.

But for year-round use electric (or gasoline) centrifugal or jet pumps are best, for people who have electricity and can afford to buy and install the pump. There are still some people, even in this country, who can afford neither of these things. The centrifugal pump works something like an electric fan, sucking in water at its center and then forcing it outward. For a deep well, a jet pump is needed, and there are still other pumps for irrigation wells.

The Chases, who are neighbors of the Butterfields in New Hampshire, get their water from a well dug near a small brook. They wanted to be sure their well would store enough water, so they had it dug in the shape of a jug, instead of straight down. The top, or neck, of the jug is lined with cement to keep surface water from getting in. The bulging bottom part is lined with stones. Water can seep in between the stones. This is not a deep well, but it has never gone dry.

The Chases' well is on a lower level than their house, so the water cannot run into the house by itself. An electric centrifugal pump forces the water into a pressure tank in the basement. In this tank, air is compressed as the water is forced

in. The pressure of the air pushes the water out when a faucet is turned on.

The Butterfields' water runs downhill by gravity from their spring on the hillside. They do not need a pump.

A spring bubbles up wherever ground water touches the surface of the earth. Many springs are on hillsides. If they are high enough, water will flow down from these springs into a house without pumping.

Not all wells or springs will give enough water, even for a single family. Some places where people try to dig or drill a well do not produce any water at all, at a depth that it is practical to reach. It is not easy to decide, by looking at the surface of the land, where there may be water underneath.

One of the oldest ways of deciding this is by "dowsing" or "water witching." Dowsing is done by a person who claims that he can locate underground water by holding a forked stick over the earth as he walks along. When he is over moving water, the stick will twist or bend downward. Here is an account of dowsing by a dowser himself, writing in *Water,* Yearbook of the United States Department of Agriculture for 1955: "I grasp the ends of the twig firmly with palms upward. As I start, I have the butt of the stick pointed up. As I near moving water, I can feel the pull as the butt end begins to dip downward. When I am over the water, it is straight down, having turned through an arc of 180°. A stick of brittle wood will break under my grip as the butt dips downward. Pliable twigs will twist down despite efforts to hold them straight."

This is not a statement by a back-country quack who likes to fool people. Neither is it a statement by an expert in the study of water. The author is a forester in the United States Department of Agriculture. Dowsing is his hobby, and he takes it seriously. In the country you will often hear of how a good dowser has found water on a farm where no one else could. But not many people seem to have this ability.

There are scientists, on the other hand, who insist that dowsing is just nonsense. They have tried investigating it and have decided that it cannot have any basis in fact.

Those who believe in dowsing answer that they do not know why it works, but it does. Wayside Gardens, a large commercial plant nursery in Mentor, Ohio, published an account of their experience with dowsing in their 1956 catalogue. A nursery can be ruined by lack of sufficient water. The young plants will simply die. There had been dry summers at Wayside Gardens. Well-drilling experts had not found good places for wells. One well even produced useless salt water. The situation seemed desperate.

The people at Wayside Gardens consulted the author Kenneth Roberts, who had written a book about an apparently infallible dowser named Henry Gross. Mr. Gross came to Wayside and with the use of his dowsing stick showed the people where water could be found. Water was found everywhere that he said it would be, and at just the depth he stated.

But still there are some scientists who say this cannot be. No doubt, too, there are people who pretend they have the ability

of dowsing when they do not. There are laws against accepting pay for dowsing in some states.

Surely the fairest judgment most of us can make is to decide that we really do not know whether dowsing does or does not work. There is evidence on both sides. This is an ancient art, believed in by many people through hundreds of years. Perhaps it is one of the many things still left in the world which people do not understand and cannot explain.

Wells are primarily for country use. Most of the people in the cities of industrialized countries like ours do not have well water running out of their faucets. But cities use enormous amounts of water. Supplying that water takes all the ingenuity our engineers have got. How this is done will be the next part of our story of water.

CHAPTER 10

Water for Cities

Every time you take a bath, you use about thirty gallons of water. If you had a billion gallons of water, you would have enough for a bath every day for 91,000 years. That is about the amount of water that actually is used in New York City every day.

Not much more than one hundred years ago, a few pails of water each day were supposed to be enough for a family living in New York City. Now, the amount of water used by every big American city averages about 145 gallons a day for each person. Small towns use much less. People in a town of five hundred use only about sixty gallons a day apiece. And there are families in country places who still manage with only a few pailfuls.

Why such a difference? Maybe people in a small town know the value of water and just don't let gallons of it go pouring down drains. Maybe they don't have to do as much laundry as city people. Perhaps not as many of them have washing machines. But the needs of people in small towns are not, after all, so different from the needs of people in cities. There are

other reasons why big cities use more water. They need water for their commercial laundries, for food processing, street washing, air conditioning. All the industries in a city use quantities of water. So the average amount of water used per person is high. This does not tell us much about how water is used by individuals. The use of water in our modern world has become very complex.

And yet the cost of the water we use is surprisingly low. Your thirty-gallon bath costs less than a penny. The cost of water delivered to your kitchen, in most cities, is not even six cents a ton.

Where do the cities of the United States get such tremendous amounts of water?

There are a number of ways in which cities get their water. It comes from reservoirs nearby or in far-off mountains, from rivers or lakes, or from deep wells.

If you live in New Orleans, Louisiana, or in one of a number of other cities along the Mississippi River, water from the river comes out of your faucets. If you have ever stood on a levee and watched the muddy Mississippi, you must have wondered how anyone could possibly drink that water. No one could, if it were not purified. New Orleans has a tremendous modern purifying system, and by the time the muddy Mississippi comes out of anyone's faucet, it is clear and pure.

In Philadelphia, Pennsylvania, you would drink water from the Schuylkill and Delaware Rivers, which look just as unpromising as the Mississippi as they flow past you. This water

of course is purified, too. All the mud and dirt has to be filtered out, and chlorine is added to kill the germs.

Only big rivers, however, can be used for city water supply. Small ones do not have enough water. And only a big city could afford the expensive process of purifying such water. Rivers are used only if there is no better source of water.

Lakes sometimes supply water for cities. Chicago gets its water from Lake Michigan. Several miles out in the lake there are "intake cribs," huge pipes with openings to let the water in. In the winter it may be a heroic job to keep these openings free of ice. Sometimes even dynamite is used to blast it out. Far out on the lake, like little man-made islands, stand the round brick or concrete buildings which cover the cribs. From the cribs, water reaches the city through big tunnels under the lake and under the land.

Lake water, like river water, needs a good deal of purifying. And like river water, it has to be pumped. Chicago has the largest pumped water supply in the world.

Not many big cities use ground water as their only source of water. There is hardly ever enough. However, Salt Lake City, Utah, on the shore of a huge but unusable salt lake, gets its water from artesian wells. And there are smaller communities where this is done.

A city is fortunate if it can get its water from reservoirs in the mountains. Such water needs very little purifying, and it will flow down from the mountains and up into buildings by gravity, unless it has to cross higher mountains on the way.

People in San Francisco, California, since 1934 have been supplied with water from an enormous reservoir behind the O'Shaughnessy Dam, in the Sierra Nevada Mountains. This reservoir used to be called by the Indian name for the grass that grew in that valley: Hetch-Hetchy. Good water was hard to find near San Francisco, and the city had to have a sure supply of it. Otherwise its industries could not continue to grow, and it could not supply clean water to its increasing numbers of people.

Los Angeles, California, has had to go very far into the mountains to find enough water. At present it gets water from reservoirs in the mountains of southern California, not far away; from the Owens River, about 240 miles away; Lake Mono, 350 miles away; and from the Colorado River, through 450 miles of aqueducts. That is about as far as the city engineers expect they will have to go.

At the beginning of this century, no one in Los Angeles could possibly have dreamed that the city would have to get water from a river as far away as the Colorado. To be sure, the Los Angeles River and a few wells had not provided anywhere near enough water. But when the Owens River, fed by the snows of the Sierra Nevada Mountains, was dammed to form four reservoirs in 1913, the city engineers felt sure the city would have enough water for a long time to come.

They were wrong. In 1928 the people of Los Angeles faced a serious water shortage. There were just too many people for the amount of water that was available.

Seven years later Boulder Dam, now called Hoover Dam, was finished, on the Colorado River between Arizona and Nevada. This dam was built by the federal government. Years of planning had gone into this project. The Colorado River had been a wild river which poured down terrible flood waters. The dam tamed it. Now flood waters are stored behind the dam and used when they are needed. Electricity is generated by the power of the water.

Los Angeles and other cities of southern California are allowed to use their share of the flood waters stored behind the dams. Water is pumped to Los Angeles from the Parker Dam, 150 miles below Hoover Dam. It has to be lifted 1618 feet over the mountains, since it would be impossible to build a level tunnel through them. This is a tremendous pumping job. Electric power generated by water at the two dams runs the pumps.

Water from the Colorado River has to cross many miles of rough country on its way to Los Angeles. When the aqueduct was built, over a hundred miles of this country had no roads, no electricity, no telephone lines, not even water for the workmen to drink. Roads had to be built and wires strung up across the desert. Water for the workers was piped in from a few wells dug along a pipe line.

Los Angeles would not have gone 450 miles for its water supply if it could have gotten water nearer home. The expense of bringing water across deserts and over high mountains was terrific. But at last, Los Angeles and other cities of southern

California have plenty of water. The aqueduct which brings water from the Colorado River has been built much larger than it needs to be at present. More pumps can be added. Perhaps now this water supply really is adequate for a long time to come.

It has been a tremendous job, too, to provide enough water for the second largest city in the world, New York City.

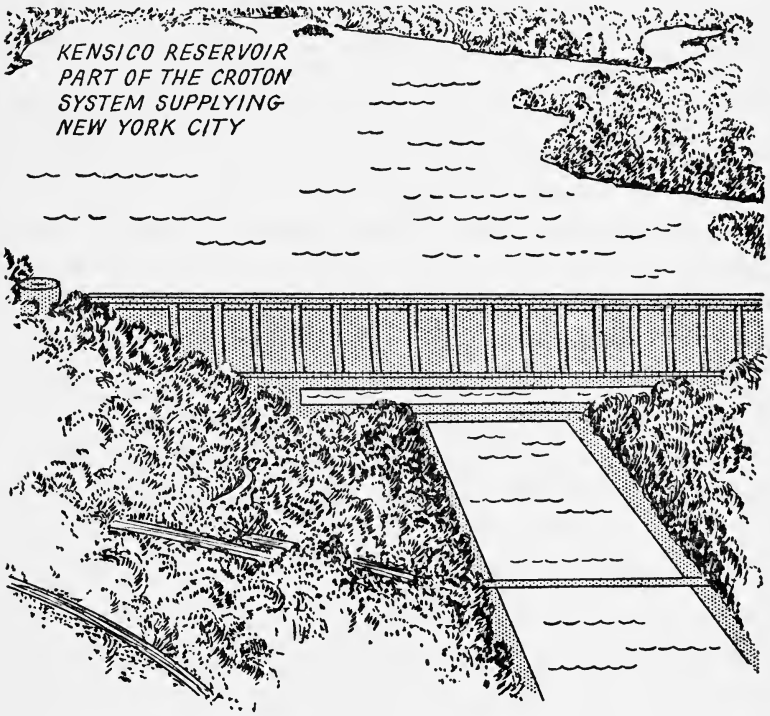
During the first part of the last century, New Yorkers were still getting their water from wells and from cisterns that held rain water. The well water was stored in large reservoirs and pumped around the city in pipes. The oldest pipes were made of wooden logs, and they often burst. Cast-iron pipes replaced them, and these lasted much longer.

One of the early New York City wells went down through 112 feet of sand, gravel, and solid rock. At the bottom, two long galleries extended out into the rock. This well produced 21,000 gallons of water a day. That seems like a good deal of water to get from a well. But the amount of water is not the whole story.

New York City water was not palatable. It was much too hard and not very clean. For two cents a pail people could buy soft spring water that came from the northern part of the city, and many of them considered a pail of good water worth paying for.

This state of affairs went on until July 4, 1842, when the Croton aqueduct first brought water to the city. This water

system began with a dam across the Croton River, about forty miles north of the city. The tunnel or aqueduct that carried the water was made of stone and lined with brick. When it reached the Harlem River, just north of Manhattan Island,



the aqueduct went *over* the river through a stone arched bridge which reminds us of the ancient Roman aqueducts. It is still there and you can walk across it. Water was then stored in reservoirs and distributed through pipes all over the city.

New York had never before had such a water system. This was

something to celebrate, and the people did celebrate. Water ran in the streets and fireworks brightened the sky. Important people gave speeches.

The Croton water system, like the Owens River water supply for Los Angeles, was supposed to give New York City enough water for a very long time, no matter how big the city became. That was what the engineers thought when they planned it. But again they were wrong. They simply could not foresee how quickly the city would grow. They had no way of knowing that people would use many more gallons of water every day when it was so easy for them to get all they wanted.

About fifty years later, another and larger Croton aqueduct was built. Then, although there were already several reservoirs, a new large Croton reservoir was made by building a bigger dam across the Croton River. This time the engineers could see that even this supply of water was not going to be enough.

It was just not going to be easy to get more water for New York City. There was not much available nearby. The engineers decided that they would have to go one hundred miles north into the Catskill Mountains to find enough water. Esopus Creek, a brook in those mountains, was dammed, and the lake that formed behind it, twelve miles long, was called the Ashokan Reservoir. An aqueduct tunneled its way down to the city, carrying water from the new reservoir. This was fresh mountain water, good to taste and to use.

The Catskill aqueduct is a big concrete tunnel, sometimes along the ground and sometimes under it. It goes deepest under

the Hudson River, and then on into the Kensico Reservoir, thirty miles north of the New York City Hall. Kensico is a storage reservoir. Two months' supply of water for the city can be stored there. This can be very useful when the Catskill aqueduct is shut off for repairs.

Two tunnels then take the water to Hill View Reservoir, nearer the city. This is a storage reservoir, too. Here the level of the water is kept about the same, hour by hour, by letting in more or less water and letting out always enough to keep up with the amount the city is using. This reservoir is 295 feet above sea level, high enough so that water runs down to the city by gravity with considerable pressure. There is pressure enough so that water will run up to the level of five or six stories in city buildings. Higher than that, it has to be pumped.

This is what is called the "first stage" of the Catskill Project, finished in 1917. It was even more of an accomplishment then than it would be now, without our high-powered machines.

Again, this called for a celebration. The city celebrated for three whole days, in October of 1917. On the first day, thousands of people gathered on the Sheep Meadow in Central Park. Flags waved, bands boomed and blared into the autumn sky. Speeches were shouted out of loudspeakers. At a signal from the mayor, a fountain was turned on and good clear Catskill Mountain water sprayed up into the sky. A thousand college girls and fifteen thousand school children presented a pageant called "The Good Gift of Water." The sound of their voices singing the national anthem rose from the meadow.

They danced. They became Indians and prayed for rain to water their crops. They were priests of the ancient Orient and they asked for rain from the sky. And it came! First a few drops, then a downpour, all the rain the children hadn't *really* meant to ask for! Laughing, they scattered to far corners of the park.

There has not been such a celebration for water in New York City since that time. Other reservoirs have been built, other aqueducts. But most of the people take it all for granted. None of the later water projects have been as exciting as the first time fresh pure mountain water came to the city from the Catskills, one hundred miles away.

The second part of the Catskill system was finished when the Schoharie Creek, which flowed north, was dammed and made to flow south into its own reservoir, then through a tunnel under the mountains and into the Ashokan Reservoir.

By this time, the Board of Water Supply was looking farther ahead. Plans were already being made to use the water of the upper Delaware watershed; that is, the streams that run into the upper Delaware River and the springs and mountain brooks that feed those streams. But this was not easy to do. The Delaware River begins in New York State, but then it flows south and forms the boundary between New Jersey and Pennsylvania. These states did not want New York to use quantities of Delaware River water before it ever reached them. The United States Supreme Court finally ruled that New York *could* use some of the water.

The Delaware reservoirs were still not ready in 1949. There was a drought that year, all over the northeastern part of this country. This drought is a separate story. It was important for New Yorkers because it showed them that they could run out of water. World War II again delayed work on the Delaware system. But now four large reservoirs have been finished. There is so much water available that it really is hard to see how New York City could ever have a real water shortage.

Water now flows into the city through two city tunnels, from three watersheds: the Delaware, Catskill, and Croton. The tunnels are so huge that a man could stand upright in one with another man standing on his shoulders, and still have space left over. So much water flows through the tunnels that in just one day it could fill a seven-foot-deep swimming pool covering Central Park. Central Park is two and a half miles long and a half mile wide, so that would be quite a pool.

From the New York City tunnels, water is distributed in smaller pipes. These are the "water mains." They are made of cast iron or steel and may be almost any size, from two to seventy-two inches across. Most of them are four inches or more across. Still smaller pipes take water from the mains into people's houses.

Water runs safely under the city streets. We seldom think about it. We may see the round metal manhole covers in the streets without even asking ourselves what they are for. They lead to gate valves in the water mains. Here and there you may find, in New York City, a cover that reads "Croton Water."

These are the oldest covers still in use. New Yorkers were proud of their good Croton water.

When a water main breaks, however, it is news. Water in mains is always under pressure, running fast. When a main breaks, what is let loose is unwanted water power. Water may rise in the air like a geyser for three feet or more. Concrete and asphalt streets are torn up, cellars are flooded, sidewalks sag, subway tracks may be so full of water that the trains cannot run.

Usually the break is found and that section of the city water supply is shut off within a few hours. Firemen pump water out of subways and cellars, and repairs are made.

But one cold day in 1958, in Jersey City, New Jersey, a water main broke and no one could find the break. The people who depended on that water had been getting muddy trickles out of their faucets. Now they were not getting any water at all. This went on until the pipes leading to their houses were connected with a different main, bringing water from a different reservoir.

Millions of gallons of water ran loose under the city streets, over a million more each hour. Enough to flood a typical one-acre city block with four feet of water every hour. The Department of Public Works had men searching the water mains under all the area to find the leak. For a while it looked as if the streets might cave in. All that water had to go *somewhere,* and it seemed to be all under the streets. It might be gouging out a huge cavern down there. But as the hours went

by, the men felt that a cave-in would be welcome. Then at least they would know where the leak was.

A hundred thousand people lived on those streets. No one knew whether they were really in danger. Schools were closed. Some industries were ordered shut.

The leak had started Sunday night. On Tuesday the men had still not found it. Miles and miles of pipes were being checked. And then the leak was found. It was in a thirty-six-inch cast-iron pipe eight feet below the Hackensack River. Meanwhile it was discovered that on Monday workmen had closed off the leak without knowing they had done so. There had not been any real danger since then.

Most breaks in water mains are not as hazardous as this one. But this episode does show how important such a leak can be.

Use of water depends often on the weather. Here is what sometimes happens in the city on a very hot day: The temperature rises to 92°. It is humid, which means that there are too many droplets of water in the air for people's comfort. Air-conditioning systems in offices and in other buildings are busy cooling people off. They use quantities of water in the process. Along some of the streets that are crowded with hot and restless children, hydrants are turned on by firemen. On still other streets, children turn them on themselves. Welcome cool water gushes out in streams onto the streets. Children dance in and out of the water, shrieking at its coldness. On the outskirts, people here and there are watering their lawns. The hose runs slowly. People complain about the low pressure

and wonder why it is low. All over the city people take cool showers. After a while the telephone switchboards at the Department of Water, Gas, and Electricity are buzzing with calls from hospitals and other institutions. What can be the matter? Water pressure is getting low. If it gets any lower there may not be enough coming through. Some people for a while get no water out of their faucets at all. Firemen are busy turning off the hydrants the children should not have turned on. There is enough water, yes. But when so many people suddenly use so much, the water mains and pipes cannot keep on carrying enough water to keep the pressure up. This could be disastrous if too many hydrants were turned on all over the city, all at once.

Water is brought into New York City, as into all cities, for the use of people. All the plans of the engineers, the reservoirs and tunnels and aqueducts, are there so people can have good water to use. But the people in the city are not the only ones who have played a part in the building of these reservoirs. Ask a farmer who used to farm on land which is now at the bottom of the Neversink Reservoir, in the Delaware watershed. He was paid for the land he lost, yes. It was good land, green with pastures and woods. He was paid for the buildings that had to go. But he had not wanted to move. This farm had belonged to his father, and his father's father before him. It felt queer to be moving away. Still, the new house was a good one, on good land, and his sons had liked it better. There wasn't much anyone could do. The city had to have its water.

Ask the people who lived in the village of Pepacton. Ask the people who lived in Shavertown, Union Grove, or Arena; or in any of the other villages that were flooded by the Delaware Project. They fought to keep their homes and their towns. They didn't want to go.

There really wasn't anything they could do about it. The city did not want to destroy any villages at all. There simply wasn't another good place where the reservoirs could be built. A city or state does have the right to take land from people when it is really needed.

Many of the people from these villages have better homes now than they had before. Their children are not sorry they left the old towns they can hardly remember. As time goes on there will be very few who remember.

The people from these villages are just one part of the whole complicated problem of getting enough water for our cities. It is mainly an engineering problem. There is always water to be had somewhere. It can be taken out of rivers or lakes. It can be dammed up into reservoirs in the broad valleys between faraway mountains. No expense is too great for bringing water to people. Without good water a modern community cannot exist.

But it takes years to build a big dam. There have been times when all the planning of our engineers did not seem enough.

CHAPTER 11

Drought in the East

It was the summer of 1949 in New York City. The water supply was getting low. There was plenty of water in the ocean and in the salty rivers around New York City, but that wasn't what mattered. Nobody could use that water. What mattered was the reservoirs that supplied all the water the people in New York City *could* use. There had not been enough rain for several months, and the water wasn't going into those reservoirs anywhere near as fast as the city was taking it out.

People weren't worried—yet. Water always *had* run out of their faucets, hadn't it? Why should it stop now?

So for the rest of the summer New York City kept on using more than a billion gallons of water every day. Of course this water wasn't all used by people turning on faucets to get a drink of water or to wash the dishes. The many industries in the city used even more water than individuals. Every car laundry used more water than ten families. But the industries and the car laundries weren't worried, either.

The engineers who took care of the New York water supply

were worried. They could really see what was happening. By the end of the summer the reservoirs were only half full. The engineers could hope that it would rain, but there wasn't much else they could do just then, because New York City was not prepared for a big drought. There wasn't any extra water they could pump into the pipes.

Sam Smith and his family lived in a New York apartment in 1949. The summer was hot and they cooled off by taking showers two or three times a day. Mrs. Smith washed a load of laundry in her machine every day. She always washed dishes under a running stream of water. Tommy Smith was only three and he sailed boats by the hour in the bathtub while he sat soaking. Susie Smith was a teen-ager and she was always washing her hair. Whenever anyone in the family wanted a cool drink of water, he would just let the faucet run until the water came fresh and cool. Lots of water went down the drain that way, but the Smiths were not the only ones who didn't care. When they turned off the faucet, water still kept on dripping, because the faucet needed a new washer. No one thought of finding out how much water was wasted just by that constant dripping. No one cared.

In short, for this family as for most city families, water was just something that came out of your faucet when you needed it and probably always would.

Then one morning in October Sam Smith read in his morning paper that the reservoirs were dangerously low. Rules were being set up by the city for the use of water: no leaky faucets,

no washing dishes under running water, no rinsing laundry any more than you have to, and so on. The city had turned off all the fountains in the parks and stopped washing most of the streets.

When Mrs. Smith turned on the radio for the nine-o'clock

news, she heard the same rules, right at the beginning of the program, because there wasn't any more important news that day.

Later that morning Mrs. Smith went shopping. In the subway she saw men putting up posters with pictures of water dripping out of a faucet. "Don't be a drip, save every drop!" the posters said. Mrs. Smith simply hadn't thought about that

before, but now she felt a little guilty because she knew there was a faucet dripping right in her own kitchen.

In the next subway station there were other posters going up. "Stop Water Waste!" People began to take notice.

That evening there were more warnings on the radio. Mrs. Smith wondered if she could manage without doing any laundry the next day.

There was still very little rain. By December the papers said the reservoirs held only enough water to last about two months. Car laundries and car owners would have to stop washing cars. The Smiths' neighbor washed his car anyway and was fined ten dollars. A "water warden" called at the Smiths' to remind them of all the ways they could save water. He wore a badge on his sleeve that read "Save Water" and he left a printed list of rules labeled "Stop Waste—Save Water."

One Sunday morning Mr. Smith piled his family into their car and they all drove up to the Ashokan Reservoir to have a look. As the Smiths looked down on the reservoir they could see the little water that was left, right in its center. The rest of it was brown mud, where the water had been. Here and there were deep ruts of wagon wheels that had passed there many years before. Wagons drawn by horses, perhaps families going visiting on a Sunday like this. Stone foundations of buildings that had been covered by water stood looking lost and abandoned. This had been a valley where people lived. Susie Smith wondered who had lived there and whether they had wanted to move away. Maybe they had just hated having

their homes flooded. Sam Smith wondered where the city was going to find more water. Tommy had dreams of mud pies, and Mrs. Smith thought about her laundry.

All that month the radio kept on talking about the water shortage. The newspapers kept on about it, too. You could get a fine of two dollars or even five dollars if you didn't fix a leaky faucet. The Smiths had theirs fixed.

New Yorkers like the Smiths, who had always taken water for granted, began to realize what it meant to them. Now they *were* worried. Water really *might* stop running out of their faucets. What would they do then? Here they were practically surrounded by the ocean, and rivers full of water, and yet there might not be enough to drink.

"Waterless" days were set up, on which people were to take no baths and not use any water they didn't absolutely need. Car laundries started digging wells so they could keep going. One big hotel reopened a well that had been dug years ago beneath its foundation.

Sam Smith let a dark stubble of beard grow on his face on "dry Friday" and was proud of it. Mrs. Smith found she could manage to do less laundry by letting everyone's clothes get a little dirtier. She was careful to wash dishes in a dishpan without the water running. Little Tommy found that he could sail boats in a basin of water. Susie grumbled a bit about not washing her hair so often, but then she, too, began to wonder what she would do if no water came out of the faucet when she turned it on. She was the one who stowed away two gallon

jugs of water in her closet. If water really stopped running, she thought, the family would at least have some to drink.

Susie and her friends went around singing a Western song called "Cool Water." It made them feel as if they were living in a desert, looking for water.

People all over the city helped to save water. Industries managed to use less. The engineers had figured that 196,800,000 gallons of water a day could be saved if people really stopped wasting it. Even more than that was saved. Like people anywhere, the people of New York City could help out in an emergency when they really knew there was one.

All this was good, but everyone was afraid it would still not be enough.

And yet, things were not really tough in New York City. Nowhere near as tough as they were in other places. Not far away, in Rhode Island, beach-side hotels had to have water carried to people in buckets that summer. The bellboys did all the work, so for the people on vacation this was at least easier than having to carry their own water.

Country people in parts of New England and New York State were not even that lucky. Many springs and wells went dry that summer and stayed dry until winter. In one place in Rhode Island fifty families had to get water from one old well.

The Butterfield family in New Hampshire was another family with water troubles. On a nearby hillside their spring water collected in a wooden spring house before it ran down the hill through a pipe and up into the Butterfields' kitchen

and bathroom. It was good clear water and there had always been enough. But just the same the Butterfields would always send one of the boys up to look into the spring house whenever it hadn't rained for a week or so. The boy would push a dry stick into the pool of water until it touched the bottom. Then he would pull it out and measure the wet part of the stick.

That summer the corn stood short and brown in the fields. Its dry leaves rattled in the hot wind. Cabbages were stunted and tasteless to eat. Cows waded knee-deep in mud to reach the last trickle of water in the brook. Every drop of water from the faucet was saved for use. When the measuring stick in the spring house showed only a few inches of water, the Butterfields stopped measuring and just hoped. For a bath they took a cake of soap and went to the lake, half a mile away. Clothes were washed there, too, with a big tub and washboard. The lake water would last a long time, because only a few people used it. You could even drink it if you boiled it first, but boiling water is a nuisance and boiled water isn't pleasant to the taste because all the air has gone out of it. So the Butterfields hoped that somebody's well would keep from drying up.

Then one morning the water came muddy from the Butterfields' faucet. After that it ran slowly, dripped a little, and stopped.

There were gallon jugs of water in the refrigerator. That was for drinking; Mrs. Butterfield had seen to that. Five pails of water stood in the shed behind the kitchen. But these would

have to stay there; they were for putting out a fire, and fire was only too likely in this dry weather.

The Butterfields were not completely unprepared. Country people have to be ready for almost anything. They have to help themselves, and they'll gladly help their neighbors, but each family must be responsible for its own water supply.

After breakfast the Butterfields put as many big milk cans as they could find into the pickup truck and drove over to the lake. When the cans were all filled and taken back to the farm, they took three of the smaller milk cans and drove over the hill a mile away to see if the Chases' well was still good. The Chases' well had never gone dry, and even this time it hadn't. But other wells had.

All the neighbors were there, five families, waiting their turn to pump water into pails and milk cans. The Butterfields talked over the local news while they waited. Then they filled their cans, thanked the Chases, and drove back to their own farm. Getting water was going to be one more chore on the farm now, every day. And one more chore was not something the Butterfields were afraid of—if the Chases' well didn't go dry, too.

All these people we have been talking about were really among the more fortunate people in the world.

The water situation in New York City *did* seem hazardous for several months, but finally the rain came, and in spring the winter snows melted and ran into the reservoirs. They filled up again. The engineers were already at work on the reservoirs of the new Delaware system.

People in the seaside resorts went home long before winter came, and in the spring the hotel owners started having more wells dug.

In the little community where the Butterfields lived, those who could afford it had deep wells drilled on their farms. Those who could not afford it knew they could depend on their neighbors.

So none of these people will be without a reasonable amount of water in the near future. They were scared once, and that was enough.

But maybe people everywhere should be a little more scared about what is happening to water in other parts of this country, and in the world. Maybe we shouldn't feel so secure, after all.

The very dry summer of 1957 hardly impressed New Yorkers at all. By that time there was plenty of water in the reservoirs of the upper Delaware watershed. But people right next to New York City, in Yonkers, were not so fortunate. For several days in June they had no water at all in their homes. Firemen brought water around in buckets. People in northern New Jersey were short of water. They had to be as careful as New Yorkers in 1949. And the crops of many farmers in New Jersey and New England dried up because there was so little rain. This same year of 1957 brought too much rain to the Great Plains and the Southwest, where there had been a drought over the dry earth for nearly eight years.

So water problems can happen anywhere. And ours is not

the only country that has them. This is as true today as it was hundreds of years ago.

We know there is enough water in the world—142,000,000 square miles of water and only 55,000,000 square miles of land. Look at the oceans, full of water and in places a mile deep. Look at the rivers and lakes. Surely there is water everywhere. But the ocean is salt and impossible to drink. And there are no rivers and lakes in the dry deserts of this world. Yes, there is plenty of water, but it is not always usable and not always in the right places. Man's problem is to find enough *usable* water for everyone.

CHAPTER 12

Drought in the Southwest

Tommy Sanders was reading a book about some of the early explorers of what are now our Great Plains. For him this was a story of long ago, but not far away, because he lived right in the Great Plains area he was reading about. His father's farm was near Amarillo, Texas, in the section called the Texas Panhandle.

It was in the spring of 1957. There hadn't been what old Texans call a "public rain" since 1949. Nearly eight years of drought. Tommy wondered if there had been droughts like this when the early explorers came across the plains. There was certainly no such drought in Coronado's time. He found the Texas plains covered with miles and miles of lush grass. To him and his men it looked like fertile land with plenty of water. But some of the early American pioneers, later than Coronado, crossed the plains in dry years. To them it was a desert where the Indians could not even grow maize. Maps made before 1860 labeled this part of the country the "Great American Desert."

Still, there were enough wet years after 1860 to make the land

look good to people in the East. In the 1880's many of them moved westward to the plains and set up farms there. Many others set up ranches for raising cattle. It looked as if those grassy plains would provide good fodder forever. Katharine Lee Bates wrote about "amber fields of grain" in her song. This was "America the Beautiful."

Thousands of cattle roamed the ranges that had not been plowed for crops. The southern plains did have a major drought about once every twenty years; the northern plains not so often. Small local droughts were troublesome. But this looked like good settled land for many years to come.

Men plowed the land any way they wished, without planning much for the future. If land would grow a crop one year, they wouldn't worry about the next. Some of the earth had only a thin layer of topsoil. After having a try at growing something on it, a farmer would just leave it bare. There was always more land.

After a number of years some ranchers found out that too many cattle on the range *could* eat all the grass off it. They weren't worried about it as long as there were other ranges to try.

To be sure, there were a few warning voices telling them what would happen to this earth if dry years came. And the same warning voices told them what would happen if there was too much rain. Some people did listen. Some took good care of their land. Too much rain or too little rain wasn't something they could do much about. No one has ever yet thought up a

scheme for irrigating the whole of the Great Plains. But the land was something they *could* do something about.

Then came the great drought of the 1930's, starting in the summer of 1931. Corn stood dry and yellow in the fields. Wheat was stunted and could not grow. The grass the cattle ate was brown and dry. Cotton growers in the southern plains had no crop. Everyone thought that it might rain "next year."

But it didn't rain enough the next year, nor the next. And then the land began to blow. All of it was dry. Too much of it was bare. Some of it had nothing growing on it at all; some had only a few stalks of corn or cotton that couldn't grow, or stubs of wheat. It wasn't enough. Too many people hadn't counted on years of drought.

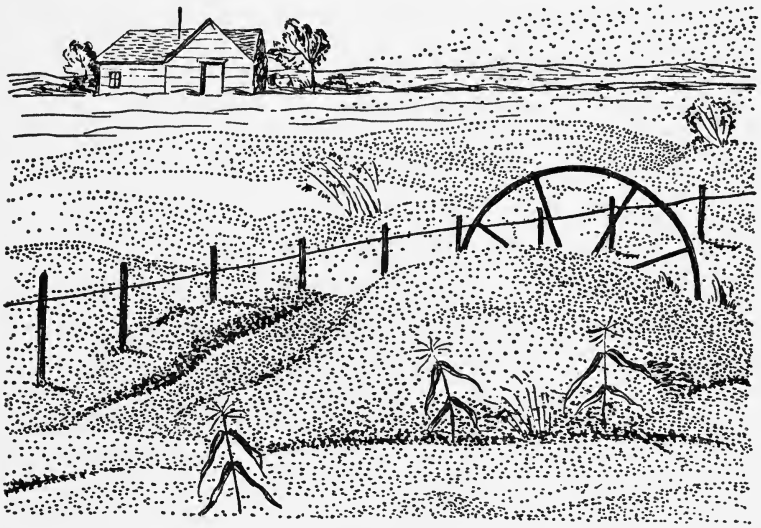
A whole foot of topsoil blew off some farms. Sand blew for miles and piled up in dunes on farms that were never sandy before. In most places there was water to drink, because it lay deep under the earth where you could sink a well, but water to drink isn't everything. Thousands of farmers packed up their belongings and went East or West. From the Rocky Mountains to the Atlantic Ocean, the sun was darkened by clouds of dust from the Great Plains.

Someone wrote a song called "Cool Water." It was about looking for water in a dry land, and it was popular all over the country.

And still the soil blew. They called the southern Great Plains the Dust Bowl. The Dust Bowl lasted until 1938; seven years of drought.

Good rains came again. In the Great Plains they always do. Millions of acres of abandoned and eroded crop land were planted with grass. Some acres were still bare and blew whenever there was a dry spring. But wheat grew well in these years.

This was when Frank Sanders, Tommy's father, decided to buy a farm in the Texas Panhandle. He knew about the Dust



Bowl. He knew the importance of good land and good water. He had been working in an office of the United States Department of Agriculture and he was tired of sitting at a desk and hearing about the farmers' problems. He wanted to *be* a farmer.

So he bought a good farm near Amarillo. He had found out about the soil before he bought it. It went deep enough and hadn't been misused. The water supply was good, too, though

it was so deep under the earth that someone had called it a "water mine."

Frank Sanders remembered the thousands of letters from farmers that had poured into the Department of Agriculture offices during the Dust Bowl, asking what they could do to save their farms.

He planted mostly wheat, a summer crop and a winter crop. The land had something growing on it practically all the time, but not always the same thing. Where wheat grew one year, another grain or hay was planted the next. Where his land was hilly, Frank Sanders made terraces, with ditches to hold the rain.

Frank Sanders' neighbors were not so careful. He tried to tell them, but they didn't want to hear. They said they knew about the Dust Bowl, sure they did. But that was all over and done with. There wouldn't be anything like that again, not in their lifetime anyway.

But it did happen again. The summer of 1950 was a dry one in most of Texas, and 1951 was worse, all over the southern plains. Land was getting drier all the time, and ready to blow.

Rain still didn't come. It was the spring of 1954. Frank Sanders didn't talk to his neighbors any more about their land. Some of them had been caught with acres of empty land, not even grass on it. They didn't talk about it, either.

Some of the thin sandy soil in western Texas had already been blown into dunes the year before. But the land farther north held firm.

Then came the big winds, with no rain in them. Tommy was on a horse out in the dry wheat fields when wind came suddenly, so fast that he could hardly breathe. There was sand in that wind, stinging against his face. He raced back to the farmhouse. His mother was already fastening down the windows. His father was standing in the yard, his hat pulled down nearly to his eyes, looking.

Suddenly what looked like a great red-brown cloud came whirling across the wheat fields. Frank Sanders just watched, with Tommy beside him. Their earth *couldn't* blow like that in *any* wind!

The sting of sand in the wind was too sharp on their faces. They went inside.

When the wind had stopped they went outside to see. It *wasn't* their land that had blown. The dry wheat and grass had held wherever it could. But over on the west side were big piles of sandy earth that never had been theirs, their neighbors' earth blowing over to ruin the land they had cared for so well.

The southern plains were a Dust Bowl again. It wasn't as bad as the thirties, because many people had taken care of their earth. But it was bad enough. People with good wells could irrigate some, but they were using up the water too fast, and they knew it. No crops meant no money, and Texans were, as they put it, "between a rock and a hard place."

Weather was still dry early in 1957, and more soil blowing,

cutting down the dry wheat on the Sanders' farm, so that even their soil would be blowing soon.

On Saturday, March 23, Tommy Sanders sat reading about the early explorers. It didn't help much to find out that there were no droughts here three hundred years ago. It didn't help the wheat to grow right now, so they could sell it and pay the grocery bill. Only rain could do that.

Rain. It was a cloudy day that would have meant rain any other year. Today it was too cold for rain. Tommy looked out of the window. Big black clouds were gathered overhead. In the barnyard, his father stood looking up at the sky. He just stood there as snowflakes came drifting out of that sky.

Snow! It couldn't be snowing. It hadn't even rained enough to say so since 1949; it hadn't snowed in Texas for much longer than that.

But it *was* snowing. Tommy's father was still standing out in the barnyard. Snowflakes fell cool against his face. Then the whole sky was full of white snow, blowing cold against him. Snow was coming down so fast you couldn't see how much there was. Frozen snow, not even wetting the dry earth—yet.

Tommy grabbed his coat and cap and ran outside. He stood there watching with his father. White snow covered the barn roof. Soon the barnyard and the road and the fields on the other side of it all looked the same, white and smooth and not quite real. How could the world change so fast?

Tommy tried to say something to his father, but the words came out in a jumble and so did his father's answer. Their faces were stiff with cold. They went inside.

Good thing the cows were in the barn.

They had hoped for rain, but snow was welcome, too. Snow would melt and wet the dry earth just as surely as rain.

Maybe this would be a year they could plant wheat and see it grow.

But as the wind kept howling across the empty fields, and the snow kept drifting against the house and barn, the Sanders stopped thinking about the wheat they were going to plant. They were thinking instead of Tommy's mother, who had driven to town that morning with Sam, one of the farm hands. No one could drive in this storm. You couldn't see where you were going. You couldn't even see the road. The drifts across it looked taller than Tommy's father.

Frank Sanders got ready to go out and look for Tommy's mother and Sam. He didn't say much, but he was worried. His face showed it.

He went out into the snow. Five minutes later he was back. You couldn't go anywhere in those drifts. If people were out there, you couldn't find them.

Wind whipped against the windows. Snow piled up against them. You couldn't see out. It was almost as dark as night. All they could do was wait.

Then there was a pounding on the door. Tommy's heart beat loud inside him. It took all Frank Sanders' strength to open the

door into the wind and drifted snow. There was Sam, and beside him Tommy's mother, looking very cold and tired.

They came inside and just sat for a while in the nearest chairs, glad to be out of the wind and snow.

They hadn't been far from the farm when the storm came. They had left the pickup truck in a drift and struggled on to the house somehow. Luckily the wind had been behind them. It had taken them an hour and a half to walk a quarter of a mile.

They were lucky. That storm was a bad one in the Texas Panhandle. More than a thousand people were stranded in cars and buses on remote roads. The storm kept on for a day and a half. Many cattle on the range were killed, suffocated by snow and dust blown hard against their faces.

When the storm was over it left behind a suddenly calm white world. White, that is, except where the wind had blown the snow into great drifts and left the red-brown earth bare again.

It had snowed. Maybe this would be a year they could plant wheat and see it grow.

Maybe it would be that kind of year. But no one dared to be sure of it—yet. Newspapers all over the country printed news of the snow. The weather seemed to have gone berserk that year. There were tornadoes in Texas in April. It rained. Late that month there were floods from the Red River to the Gulf of Mexico. Nobody thought floods were good news, but a break in the drought would be. *The New York Times* said,

"The fearful reign of drought that has beset the region for seven years may have come to an end."

No one dared to be sure. The land looked wet, but underneath it there still wasn't as much ground water as there used to be.

The Sanders cleaned up as much of their land as they could, planted their seeds, and waited.

In May, Texas had flash floods, and more tornadoes. Half of the Sanders' wheat washed off and had to be planted again. They didn't complain about that as long as the tornadoes didn't hit them.

June was a little better. There were floods in other places. Green spears of wheat were coming up in the red-brown earth, all over the Sanders' fields.

That was the thing Tommy was going to remember most about that spring—the greenness everywhere. Miles of green grass and new wheat across the land. Wild flowers full of color along the road. Enormous red roses in his mother's garden. Larkspur as tall as his father. Tommy could not remember having seen any of these things before. There was a whole new colorful earth that spring.

In June, the government declared the drought officially broken.

Frank Sanders wondered whether now his neighbors would start taking proper care of their land. Some had just given up and moved out. The time was surely past for letting any farmer ruin his own land through carelessness, often also his

neighbor's land. Past, too, for letting people use up as much ground water as they pleased, when it wasn't being replaced anywhere near as fast as they used it.

People couldn't do everything. They hoped that nature would help, too. There had to be enough rain, or enough water under the earth or from somewhere else. There had to be at least some of the right kind of weather.

But people could work with nature instead of against it.

The community would have to get together and plan for the use of all the land and all the water. There might be another drought like this one in twenty years.

CHAPTER 13

Floods

"When it rains, we forget about the dust bowl; when it is dry, we forget about floods." *Water,* Yearbook of the United States Department of Agriculture for 1955; p. viii.

Much of this book has been about how the lack of water affects the lives of people. The wanderings of early man were mostly for the purpose of getting away from places that didn't provide enough food and water and finding places that did. Dread of thirst and hunger haunted him. Later, people were affected in more complicated ways by not having enough water for themselves and their animals, and for the grain they grew in their fields.

The falling of rain is still in many ways a mystery. We still do not always know why, in some years, in some places, it simply does not rain. It is no wonder that primitive people have sought to win the favor of the god they think controls the rain. Some supernatural being must be displeased, they think, to bring such suffering upon them.

No one knew why it rained so little in 1949 in the north-

eastern part of this country. But the drought that year was not a disastrous one for New York City. The water supply did not really give out, after all. Much more serious, in prehistoric and ancient times, were the long droughts that changed whole countries into deserts and ruined cities that otherwise might have had a place on the map of the world forever.

It seems unlikely that anything like that will happen again. We have more control, now, over the sources of water. There is certainly enough water in the world.

Enough water is good to have. Plenty of water. But too much water is as bad as too little. This chapter is about floods.

Most floods are disastrous both to people and to the land. Only a few have ever done us good, and of these the greatest was the annual flooding of the River Nile in Egypt. This flood, as we have seen, brought life to the earth of Egypt every summer. Most floods, however, cannot be predicted. They do not come as often as the flooding of the Nile, but they give us little warning.

According to the Bible, Noah did have some warning of his flood. He had time to build an ark that would be safe against the waters. Noah's flood was a big one. The Bible says: "The waters prevailed exceedingly upon the earth; and all the high hills, that were under the whole heaven, were covered . . . And all flesh died that moved upon the earth . . . And the waters prevailed upon the earth an hundred and fifty days." Only Noah and his family survived, and the creatures, two of each, who were with him in the ark.

Archaeologists tell us that there really was a tremendous flood in the Middle East about 3500 B.C., and this must have been Noah's. Whole cities were swept away. So were the villages of all the people living in the low places of that part of the world.

There are many stories of floods in the literature of ancient times. In the Bible story Noah's flood was brought about because of the wickedness of the people of the earth. The god of the Hebrews, Jehovah, saw that "the wickedness of man was great in the earth," and He sent the flood to drown all the people except Noah and his family.

We find a similar story in Greek mythology. The father of the gods, Zeus, could not endure the wickedness of human beings and so drowned them all, except one man and one woman, Deucalion and Pyrrha.

There are also Hindu stories of a great flood, Zoroastrian ones, a Babylonian story much like Noah's, and many others.

In an entirely different part of the world, the Navajo Indians had their own story of a flood. In this story, the people of the world, in the midst of the waters, climbed up the inside of a giant reed, out of the water and into the sky, which became a new world.

There really were devastating floods in ancient times, and more recently, too. But perhaps these stories mean more than this. Perhaps they really tell about a deluge of misfortune that descended on the people. Or perhaps they mean to convey

man's feeling of being overwhelmed by the many things he cannot understand about his life on this earth.

Some floods are partly man-made. Land that has been stripped of trees and other growing things cannot hold back the water that flows over it. No one really knows how many little floods become big ones because of this.

But other floods are not in any way the responsibility of man, until he takes steps to control them. Control of flood waters, where it has been done, is one of man's greatest accomplishments.

The worst floods have happened along the rivers of this world. People have lived by rivers ever since they learned to live together in villages. They could water their wide fields with the water of the river. They could travel in boats upon it. In boats, too, they could trade with their neighbors.

The Mississippi is our biggest river, and along its banks have grown up some of our biggest cities, for just the same reasons that people have always lived by rivers. And the Mississippi has had our most disastrous floods.

The Mississippi is many rivers. It is all the rivers that flow into it, and you could chant the list of them: the Allegheny and the Monogahela becoming the Ohio, the Ohio flowing into the Mississippi; the Missouri, White, Arkansas, Yazoo, the Red, and that's not all. The Indians named the Mississippi the Father of Waters, and that is still its name.

The Mississippi is a long waterway, from the northern part of the country all the way south to the Gulf of Mexico. Trading

and traveling by boat are still good reasons for living by rivers.

The Mississippi Valley is a broad fertile valley, well-watered and good for growing things. This is another reason for living there.

Water was high on the Ohio River in 1913. The Mississippi had terrible floods in 1927. People thought they were pretty well prepared for the next one, whenever it came. The long banks called levees were built higher along the river, to keep floods away from the land. No one could have foreseen what the flood of 1937 would be like.

What made the river flood that year? Too much water, of course, too much rain. But why just then? The weather was strange that winter of 1936–37. Cold hung still and silent over all the country west of the Mississippi. Cold hung over the East. Two walls of cold, east and west. Up the river from the Gulf of Mexico warm wet air came on the wind and hit the cold. For days rain had dripped from the clouds. Then the warm clouds cooled off against the walls of cold, east and west. Water vapor in the cold clouds condensed into raindrops, more and more of them, until the clouds were full to bursting. And then they unloaded. One hundred and sixty-five billion tons of water came down, out of the cold gray sky.

There was too much water over the land. Too much water in the brooks and little streams. Too much water in the Ohio River, in the Mississippi, going down to the Gulf. Muddy swirling water.

This is the way it was described in a radio program called "Disaster," put on by the Red Cross in 1957: "One hundred and sixty-five billion tons of water! Oh—not all at once. Naturally not. It merely came down out of that leaden sky; out of that cold sky; out of that damp miserable sky. It came down onto the cities; onto the fields; onto the forests. It tumbled along the gutters, ran through the sewers. It trickled along the winter furrows, dribbled across barnyards. It dripped from the branches, onto the loam under the trees; dripped from each twig onto the loam under the winter-naked trees. . . . After all—it had to go *some* place—all that water!"

People began to wonder. People watched and waited. There were the new high levees, down on the Mississippi. They would be sure to hold—wouldn't they?

The Red Cross people watched and waited. And they got ready, they weren't sure for what. They had to be ready for anything.

January 24 was "Black Sunday." "One hundred and sixty-five billion tons of rain water. And it had to go *some* place! . . . It roared through the valleys, ripping, tearing, crushing. It rose on the great thriving cities. It swallowed the towns. It drowned the farms."

This was the flood of water. Before it there went another flood, the flood of people going somewhere, anywhere, away from the water. They couldn't take much with them. They bundled up against the cold. They took blankets if they had

time. That was all. People were wet and afraid in the cold night. Some of them rowed boats on the water among the roof tops. They went where the Red Cross people told them to go.

The Red Cross had trucks in places where there was still dry land. They found shelters for the people, and they brought food. People who thought they had lost everything found warmth and kindness. So many people had lost so much; you couldn't cry just for yourself.

Water kept on rising. Green-brown water swirled through cities, crumpling up the houses in the towns, throwing them up in untidy heaps on the wet land. Good earth on the farms was covered with sand. Drinking water had to be shut off; electricity and gas, too. The only way to travel was by boat, and that wasn't very safe. Part of somebody's house could crash into your boat and sink it, fast.

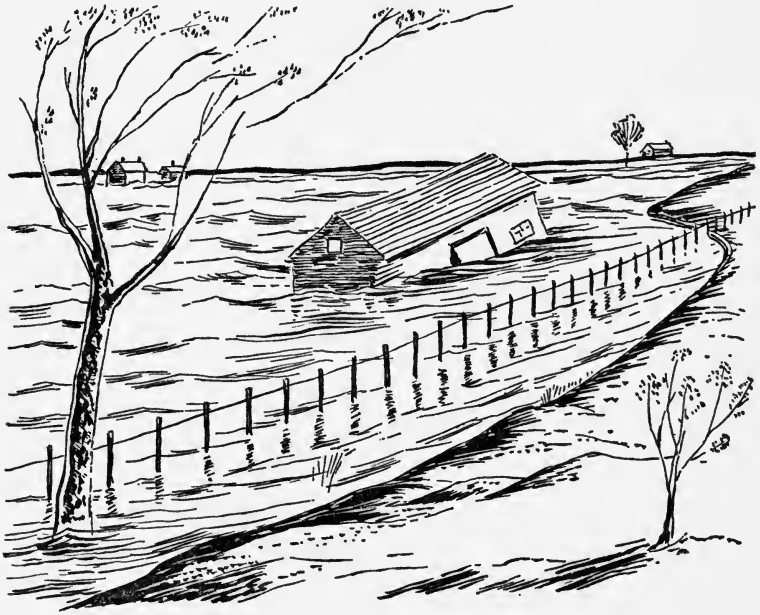
There was fire, too. Oil and gas floating on the water was now ablaze. Almost 1,500,000 people were wet, homeless, or lost. Too many people. In some cities everyone had left. In others, nearly everyone.

The water went down, slowly. For weeks there was water in the fields and water in the towns. People waited all along the river in the Red Cross refuge centers.*

Houses that were left standing were full of mud. Doors sagged open, too warped to close. Tables and chairs lay askew in the mud, looking as if no one could ever use them again.

* This account of the 1937 flood is from a radio script called "Disaster," by Ira Marion, broadcast by the American Broadcasting Company and the American Red Cross on September 8, 1957.

In the Jackson house, in Cairo, Illinois, a tipsy pudding with whipped cream on top had been standing in the middle of the dining room table when the flood came. It floated up to the ceiling in its bowl, left a greasy mark there, and settled down again on the table as the water receded. Except for a few streaks



of mud, it still looked good enough to eat. But nothing else on the first floor of the house was saved, and no one felt like eating tipsy pudding.

Looters wandered through the streets, people to whom doors that couldn't be closed meant take anything you want. The police could not possibly catch them all.

What happens to a town after a flood like this? What happens to the people?

The little town of Leavenworth, Indiana, was just one such place. It wasn't a big important city like Pittsburgh, Cincinnati, or Louisville. In 1937 it was a quiet town of four hundred people, built close to the Ohio River. The valley is not broad there. Behind Leavenworth rose high bluffs.

There was nothing to protect Leavenworth from the flood of 1937. Nothing at all. There were no levees. In the 117 years since the town had been founded, there had been eleven floods. This one was the worst.

When the flood was over there was no one left in Leavenworth. The town was not just empty. There wasn't any town. There were not enough buildings left standing to give the place a name.

The Red Cross told the people of Leavenworth that they would help rebuild their town if they would build it in a place where floods could never reach it again.

And the people gladly agreed. Leavenworth was built again, high above the river.

The people and the government of this country determined that a flood like the one of 1937 must not happen again. It is hard to make sure of this, as long as we cannot control the weather. But much has been done. Dams have been built on the tributaries of the Ohio River so that flood waters can be stored in reservoirs for later use. Many basins, big areas of low land, are kept ready to hold water when there is too much.

The Yazoo Basin is one of these. Spillways can release water from the river and send it somewhere else. One of these is the Bonnet Carré Spillway above New Orleans, which can carry tons of water off into Lake Pontchartrain and then on to the Gulf of Mexico. Levees all along the Mississippi are kept in good repair. There are some two thousand miles of them, about eight feet wide on top and one hundred feet wide at the bottom.

Even so, there was a big flood on the Mississippi in 1947, with damage figured in millions of dollars. Upstream, millions of tons of topsoil were washed away, and no one figured the cost of that. No one has figured the cost of the waste of tons of topsoil in all the smaller floods that happen all over the country, sometimes without much damage to towns and cities. People must take better care of the country's watersheds, plant them with trees or other growing things that will keep the good earth from washing away. Dams must be built to hold back the water and let it run out slowly.

Leavenworth, Indiana, was safe from the flood of 1947. Leavenworth cannot be reached by floods any more. Other towns, too, have moved up into the hills. And there are some places where the land beside the river was kept for meadows from the beginning and the towns built higher up.

In the spring and summer of 1957 there were many floods in this country, in Texas, in Oklahoma, Missouri, and other states. The great Midwestern drought ended with wild weather.

At the same time, there were droughts in other places, in the

east of this country, in India where the usual rains did not come and much of the rice crop was ruined. China had both droughts and floods.

In the fall of that year, much corn in our Midwest stood rotting in wet fields. You could not call this a flood, but there was too much water.

Not all floods happen on rivers. Not all are caused by too much rain. In the spring, too much water may suddenly rush down the mountains from melting snows. Sometimes men go up into the mountains in early spring to measure the snow, so that at least the people in the valleys below will know what to expect when it melts.

Then there is the flash flood in the desert. This is not apt to be very destructive, but it can be pretty startling if you are anywhere near one. It comes from a sudden cloudburst up in the hills. You hear a rumbling like thunder, under a cloudless sky. A roaring flood of water comes rushing down, following a gully where other floods have gone. Soil and shrubs are washed away. The little animals of the desert are flooded in their tunnels. Then the raging flood is gone; the water spreads out quietly over the flats. If you are driving across the desert when this happens, you had better wait until the flood is no longer pouring across your road.

We are learning to control floods. But that is not all. More and more the story of water becomes a story not just of what water does but of what people do to water and the land.

CHAPTER 14

Water and Land Today

Rain falls on the land. Rivers flow across the land. Floods flood it and droughts dry it up when there is too little rain. Much of the story of water is about its contact with the land.

Land without water is a desert. But the water that flows over the land may do good to it or may ruin it. Often the difference depends on how man changes the land. If he uses the land well, water can make it good for growing things. If he does not use the land well, even the rain will destroy it.

The problem of land and water use is an ancient one. We have seen how irrigation made dry land fertile in ancient times, and how misuse of the land could cause disaster.

Now we are going to see how, in recent times, man has irrigated his land so he could grow food upon it, and how he has sometimes neglected or spoiled his land and let wind and water ruin it.

Three-fourths of the surface of the earth is water, but the land is where we live. We not only live on the land, we depend on it for most of our food. To be sure, the cattle that make our

beefsteaks don't grow out of the land, but the fodder they eat does. So does much of what we eat: vegetables and fruit, wheat and other grains. The only things most of us eat that have nothing to do with the land are fish and shellfish.

Since the land is so important to us, it makes good sense to take care of it. Taking care of the land may mean just letting it alone. It may mean using it wisely for growing things. But most of all it means *not* doing certain things. Not stripping all the trees off the hillsides, not letting cattle and sheep chew up most of the grass on pastures and plains, not plowing fields too much and leaving them bare.

This is where water comes in. As we have seen, land without growing things to protect it can be ruined by water. When a heavy rain pours down a bare hillside, there is nothing to slow it up. There are no leaves to hold back the water, no twigs or branches. Very little water can sink into the tight ground. The soil doesn't have the roots of plants to hold it together. Tons of soil wash down into the brooks and rivers. Lakes may even fill up with it.

Overgrazed pastures, too, can lose much soil. Water rushes off towards streams and rivers, muddy with the soil it is carrying away. Waterways become ditches and then gullies which grow deeper each time it rains. New gullies form.

The soil that is washed down the gullies and rivers is gone from the land forever. This is usually the best fertile part of the earth, and in most places it is only about six or seven inches deep. Once it is gone, man cannot just put it back. He

must go to considerable trouble and expense to help nature replace it.

It isn't only running water that damages the earth. Raindrops splatter and gouge the land, where it is bare or not covered enough. Millions of them pound on the bare earth. All this muddy splashing closes up the surface of the soil so water can't sink in. Instead, it rushes away.

You will see this happening yourself, if you can get out to a woods and pasture in the rain. First find some woods, in a park or in the country, or even a group of trees where the fallen leaves have been allowed to stay on the ground. Watch the raindrops as they fall and sink into the soft earth. Try poking a thin sharp stick into the ground. It will go in easily.

Then, if you can, go to a pasture where cows or sheep have eaten off most of the grass and shrubs. The ground will be hard under your feet. Water will make muddy puddles on the surface or it will run away. Try to poke your stick into this earth. It won't go in.

Find a brook if you can. If it is very muddy you will know that it is carrying loads of good earth away.

If you are in the city, watch the water running down the gutters in the street after a heavy rain. Leaves and pebbles are swept along. Water rushes faster and faster. The street has been paved, so it won't wash away, but you can see the force there is in the moving water.

The wearing away of the land is called erosion. A certain amount of erosion goes on in nature anyway. But it is usually

very slow. By not taking care of the land, man has let erosion ruin many of his hills and fields, much faster than it would happen otherwise.

We can't do anything about the rain. We wouldn't even want to, except for getting more of it in dry places. But we can keep our good earth covered with growing things, to protect it from too much wind and rain.

On this continent called North America, the land has been used both well and badly. Over a thousand years ago, the Pueblo Indians used the land well. They dug primitive irrigation ditches through the valleys where they lived, in the part of our country which is now Arizona and New Mexico. When too much water sank into the soft earth, they lined the ditches with clay. There they grew the maize which was so important in their lives. There were other Indians, too, who irrigated their fields.

Later, Mexicans and Spanish conquerors of Mexico came north and settled along the big rivers, such as the Rio Grande, where they could use the water of the rivers in their fields. They brought with them the methods that had been used for centuries in Spain.

The first people who practiced what might be called "modern" irrigation in this country were the Mormons. These people had been driven from one part of the country to another because other people did not like their religion. They finally settled, in 1847, on land which is now part of the state of Utah. This was a dry land, with little rain. The Mormons were safe

there, because no one else wanted that land at all. No one, that is, except a few wandering Indians. These became friendly Indians, because the Mormons gave them food.

The Mormons had never before irrigated a single acre of land. But if they must live in this dry land, they were determined to learn how to use it. They did not have to learn every step from the beginning. They could study books that told them how other people had used irrigation, in other parts of the world.

Still, it was hard at first. There was no one to tell them how best to irrigate the particular land they were living on. And they had to grow enough to feed many people the very next season. Early man's methods never would have been good enough.

The men all worked together, digging the first irrigation ditches. But they couldn't just let a river flow through these ditches. They didn't *have* a river. They had to depend on mountain streams and creeks. These streams were full of water after the rainy winter, and after the snow on the mountains had melted. But they could be nearly empty during the dry summer months, when it did not often rain, even in the mountains. So the Mormons built dams across the streams to hold back some of the water until they needed it. They had never built dams before and they didn't have time to find out the best way to do it. They used whatever materials they had around them. They built with rocks. They cut down trees and piled up logs the way the beavers did. In fact, there had been beavers

building dams across those streams long before the Mormons came. It was a sad thing for the land that trappers had killed them all.

Getting water was a community problem. It affected the lives of everyone. But because you can't depend on everyone to do the right thing, there were laws about the use of water. Water was declared public property. When this Mormon law was repealed in 1880, there was confusion all over the Territory (Utah was not a state as yet). A farmer could let all the water from the creek run across his own fields, instead of leaving some for his neighbors farther down. Many of them did. Many were just careless about how much water they used. This went on until the state of Utah passed a law in 1903 to have water owned by the state.

As time went on, land was not always used well in Utah. There are people living in two towns of Utah who know only too well what happens when mountain slopes are well cared for, and what happens when they aren't. One of the towns is called Farmington, and it is at the foot of one of the Wasatch Mountains. The other is Centerville, and it is at the foot of another of the Wasatch Mountains.

Both of these towns had been founded by the Mormons. But as time went on other people came to live there, too.

Life in Farmington was pleasant at the beginning of this century. There were not many families. Most of them were Mormon farmers and all of them had neat prosperous farms. Miles of irrigation canals carried water across their fields from

the streams that flowed down from the Wasatch Mountains. Potatoes grew big in the well-watered earth. Apples, peaches, and other fruits brought good prices in nearby Salt Lake City.

The farmhouses of Farmington were well kept and clean. Barns were big and full of grain for the horses and cows. One of these farms belonged to the Grant family. Mr. Grant used to sit before his red brick farmhouse on summer evenings after his work in the fields. He would look across the bright flowers of his wife's little garden to his wide fields. The water in the irrigation canals reflected the light of the setting sun. This was a good life. But sometimes Mr. Grant wondered if they weren't all too sure of it, if they didn't take their prosperity too much for granted. He'd like to be certain that this farm would be just as good ten years from now, for his three sons who worked with him in the fields. And somehow he wasn't certain.

If Mr. Grant had thought beyond his vague doubts, he might have helped prevent what finally did happen.

One midsummer day in 1923 there was a terrific storm. Rain poured out of the skies so fast that people almost felt they were under water. The mountain streams became roaring torrents as they swept down the canyons onto the farm land below, carrying mud and rocks.

All day the water rose higher and higher, muddy water rushing down the roads and across the fields, drowning the wheat and filling the irrigation canals with rocks and mud.

The Grant family watched helplessly from inside their house.

The boys ran from window to window, excited by the rising water all around them. Mr. Grant only sat by his front window and waited, full of despair, while his fields and crops were ruined by the muddy waters.

But the Grants were lucky, after all. Their house stood on higher ground than some and it held firm. Only the cellar was flooded, all the way to its ceiling. Some of the other people were not so lucky. Their houses were crushed by the swirling water and the rocks that were hurled up against them. Houses that weren't smashed were full of mud. Roads were blocked by piles of mud and stones. Six people lost their lives.

The trees in Mr. Grant's apple orchard had most of their green apples washed away and plenty of branches torn off. There wouldn't be enough apples to sell that year, at all. Or any wheat. Mr. Grant didn't think ahead to the next year. There wasn't any use of thinking ahead until the irrigation ditches had all been dug again.

Mrs. Grant didn't say anything about her flower garden. It was gone, but there were more important things to think about.

The boys were not so excited any more.

This flood wasn't the only one in Farmington. As the years of the 1920's went by there were more floods, none of them quite as bad as the earlier one, because it didn't rain as hard. Then there was a bad one in 1930, too much like the one in 1923.

Mud and rocks washed through the first floor of Mr. Grant's house that time. If there was any future in that farm, he

couldn't see it. A farmer who lived at the foot of Farmington Canyon could never be sure that the seeds he planted would get a chance to grow and bear fruit. Mr. Grant would have liked to sell his farm and move away, but no one would buy his farm now, or any other farm in that area.

Mr. Grant's oldest son got married and built a little house of his own near Centerville, a few miles south of Farmington. Centerville was a good place for farming. It rained just as hard in Centerville, when it *did* rain, but there had been no floods.

Why did Farmington have these floods? Why did Centerville, a few miles away, not have any?

It took time to find the answers to these questions. In 1930 the people of Farmington and vicinity organized a Flood Control Committee. They asked the Governor of the state of Utah for help. He appointed a Flood Control Commission to study the causes of the floods and to decide what should be done.

The men on the Commission found, first of all, that these were not natural floods. Before 1923, such flood waters had seldom poured down the canyons. Then the Commission found out why the floods came. Too many cattle and sheep had been grazing on the mountain slopes above Farmington. They had eaten up all the grass and small shrubs, until there wasn't anything to hold the water back. Some of the land, too, had been burned over by the owners, who thought that was a good way to clear it. Instead, they ruined it. Too much of the land was laid bare. Not all the land. Not even a quarter of it. But enough

to let the waters of a heavy rain go rushing down the gullies and the canyons, flooding the farms below.

This did not happen in Centerville. Long before the floods came to Farmington, people in Centerville had looked up the Centerville Canyon to the green mountain slopes on each side. They had seen cattle and sheep eating too much grass off the steep mountain sides. So they banded together and bought or leased the land where the mountain streams had their beginnings. They kept cattle and sheep off some of the land until the grass and shrubs could grow again. They arranged with the owners of the rest of the land to graze their cattle and sheep lightly, never letting them lay bare the soil. Grass and trees held back the rushing water from heavy rains. Much of the water soaked into the ground. There were no floods in Centerville.

The people of Farmington felt that something must be done to save their farms. Maybe even now it was not too late. Land on the slopes was bought by the people, as had been done in Centerville. Some of it became part of Wasatch National Forest, and the United States Forest Service would take good care of that. Contour trenches were dug around the slopes to hold back the water when it rained. Dams were built across the trenches at intervals. Once that was done, grass and other cover plants could be planted. Bulldozers did some of the work, but horses and plows had to be used on the rocky slopes, and men with hand shovels were needed to make sure the trenches themselves were flat on the bottom. All this work cost a lot of money, much more than the land itself had ever been worth.

Mr. Grant still did not have much of a future in Farmington. There was too much to be done. But his two younger sons could look forward to a better future, because once the grass was growing on the mountains and all the watershed was taken care of, there would be no more floods coming down the canyons.

Land has been ruined in too many places, all over our country. Farmington is only one small place where this has happened.

The Navajo Indians in Arizona and New Mexico have ruined much of their land without even knowing they were doing it. The use of the land was never a problem to the Indians when all of it was theirs. They could always move on when the place where they were living no longer provided enough food for themselves and their animals.

The Navajos' troubles began when they were confined to reservations of land not of their own choosing. Some of the troubles happened when the Navajos tried to raise too many sheep.

The land on the Navajo reservation was never really good land. It was mostly desert. But sheep could graze on some of it. Indians turned sheep loose on broad meadows like those at the foot of Chaca Canyon. There they grazed all day in the midst of grass and flowers that grew so high you couldn't even see the sheep. Corn grew tall in the Indians' fields along the few streams.

None of this is true now. There are too many people

trying to force a living from this land. There are too many hungry sheep. They have eaten all the grass and flowers on their pastures. When it rains, the soil washes away. Deep gullies have been cut into land that already had too many. Water in the streams is full of mud, and some of the mud even washes down into Lake Mead, the great reservoir above Hoover Dam on the Colorado River.

For long periods of time it doesn't rain. Then most of the corn in the fields grows brown and dies, because the Navajos cannot irrigate much of it.

These have been an unhappy people. Often they have been a hungry people. They have many problems, and not the least of these are land and water.

The United States government is trying to help the Navajos. The Indian Service and the Soil Conservation Service are working with them, teaching them to raise fewer sheep and grow more grass, so that the rain will not wash away the land. Maybe here, too, it is not too late.

Ours is not the only country with problems in its use of land and water. In Mexico, the state of Oaxaca, which is not a desert now, may be one fifty years from now. Hillsides have been stripped of timber and planted carelessly. The land is not fit for growing things, but farmers are using it to grow whatever food they can. They have to eat. But ruined land does not provide either enough food or enough water. Thousands of people there have to walk five miles under the hot sun for their drinking water.

In the Vale of Kashmir, in India, there were terrible floods in the summer of 1957. There had been too much rain. But also too much earth on the steep slopes above the valley had been plowed up by wandering tribes that grow maize there in summer. You could say it wasn't their fault; they didn't know what would happen when the rains came. But that could not be much comfort to the people in the valley when the floods swept over them.

Maybe it is not too late to save the land that is washing away all over the world. But it will be, unless more people learn to care about what happens to the land on which they live. That means caring not just about the land but about the people who are going to live on it hundreds of years from now.

CHAPTER 15

Irrigation and Water Rights

The owner of a large farm today has complicated problems in his use of land and water. More complicated than at any other time in history. Suppose his farm is on a dry part of the Great Plains in the western part of our country. He doesn't just go out and dig a ditch so water from a stream can flow through his fields. He must irrigate many more acres than early man ever dreamed of cultivating, more than the first Mormon farmers ever used.

First of all, he has to make sure that there is enough water, near enough for him to use, and that he has a legal right to use it. If a river runs through his fields, it is not just his. In fact, the water itself does not belong to him at all. He has a right to use some of it. But he will have to find out if the people downstream have been granted legal rights to use most of the water of that river.

Besides this, rivers do not always stay the same. Plenty of rain means more water in the river. So does a heavy snowfall, when it melts in the spring. A sudden warm spring day may

melt the snow too fast and bring a flood down the river. A dry season may leave only a little water in it.

This is too much for the farmer to figure out. He will call in an engineer who knows about water problems and ask him to help plan for his use of water. Records of the behavior of this river in past years will help. The water laws of the state will have to be considered, too, before the farmer can decide how much water he should use.

Some farms do not have a river flowing past them. The farmer who has no river, and no stream of water big enough to use, has still different problems. There may be plenty of ground water under his earth. He may be able to use this water to irrigate his fields for many years, even if he is using it up faster than it is being replaced. Many acres of land in the high plains of the Texas Panhandle are being irrigated in this way, and the supply of water is expected to last for a long time.

This is not possible everywhere. Without either a river or enough ground water, the farmer will have to find some other way to water his fields. In many parts of our Great Plains he cannot depend on the rain.

Rain does fall on the hills beyond the farmer's fields. Snow falls there in winter and runs down the hillsides in torrents when it melts in the spring. This is the water the farmer must use. Some of it may run through his fields in a little stream, but never enough. The farmer must store this water behind a dam, so he can have it to use when he needs it.

If his need for water is not too great, he may be able to build small dams such as the Mormon farmers built, and the little reservoirs behind them will hold enough water. But he may need much more water than can be stored behind any dam he could build himself or have built for him. He cannot afford to build a dam that's big enough. So he goes to see his neighbors. Summers have been dry and they want to irrigate their fields, too. They discuss their needs and decide where to build the dam, so that water can be piped from their reservoir to all their fields, or can be made to run through the fields in ditches.

When this is done the farmer must still decide what kind of irrigation will be best for his crops. If he is growing alfalfa or wheat, he will probably want to flood his fields, since grains like these are not grown in rows. He may have a portable dam, made of iron or of a metal frame covered with canvas. With this he can make little floods all along his irrigation ditch. But most plants will rot if they stand in too much water, so these little floods must be carefully controlled. The extra water must have somewhere to go.

If this farmer is growing crops that grow in rows, such as potatoes or corn, he will have ditches dug between the rows. Into these ditches water will run from the reservoir in the hills. Water in the ditches will soak down into the earth and sideways, too.

The earliest farmers did not have reservoirs, but they too had ditches of water between the rows in their gardens. The dif-

ference is that the modern farmer has more land, he needs more water and he has better ways of getting it. He has modern machinery and he can grow much more food than just his own family needs. His grain or his corn may be sent all over the country, or even across the sea.

But he has something in common with the early farmer after all. Some of their needs are the same. There is always the simple need for water, for himself, for the food a man grows for himself and for his family, for the animals that also give him food. Water for keeping alive. There is always the need for the earth that comes alive with the water and the seed he plants in it.

How does this farmer feel as he looks out across his fields in the evening when his work is done? Dark green rows of plants stretch off into the distance, until he cannot see them any more. Ditches between the rows are silver strips of water, bright in the light of the setting sun.

This is his land, made good by the water he has brought to it. These are his green-growing fields, where before there was only brown grass in the dry months, and brown dust blown on the wind. This is his good earth as long as he uses it well.

Nowhere in the world is there enough land so man can afford to waste it. Certainly not in this country. Better ways of using our land are being worked out all the time. Irrigation plays an important part in this.

Right now, you may see among the orange groves of south-

ern California one acre with bright flowers along its border and rows of fruit trees beyond, the next acre dry and brown. One acre with water, the next without, because no one has brought water to it. Before long all this land may be watered, because land is needed for growing food, and it is worth what it costs to water it.

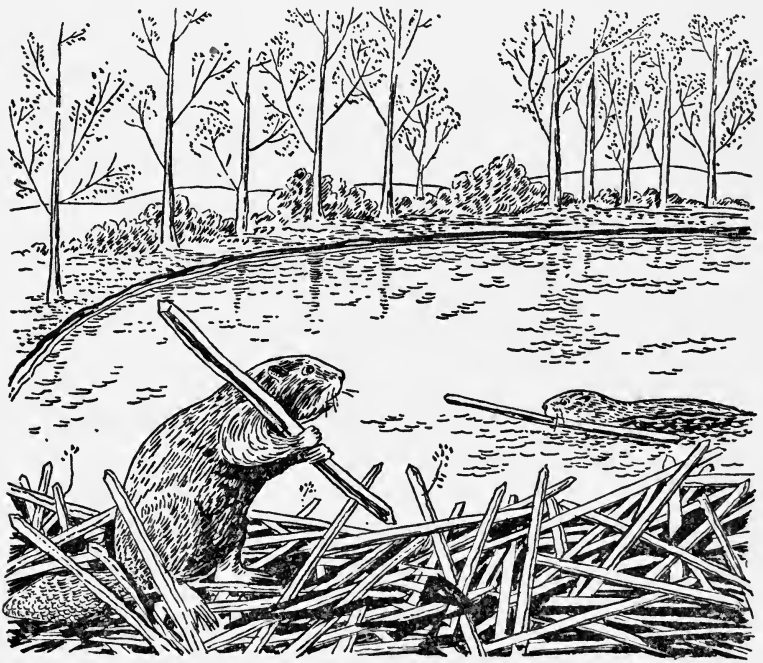
There will be more irrigation in the eastern part of this country, where there is usually enough rain but you cannot be sure of it. Seabrook Farms in New Jersey, which grows and freezes vegetables to sell, has a modern irrigation system in an area which never used to be irrigated at all. The people there find they can grow more and better crops if they are sure of the right amount of water at the right time, no matter what the weather. They cannot depend on the rainfall in New Jersey.

Much of the irrigation in this country involves so much water and so much money that individual farmers or groups of farmers could not possibly manage it themselves. Water that falls in wet seasons must be stored in huge reservoirs for use in dry seasons. Engineers must study the rivers, the rainfall, the soil, and even the rate of evaporation of water in that area. This is where the federal government comes in. Studies are made by the United States Geological Survey, the Weather Bureau, and the Department of Agriculture. Plans are drawn up for building dams behind which there will be reservoirs covering many miles of land. It would hardly be possible for a small group of farmers to pay for such a project.

The Bureau of Reclamation has built huge dams in the

western and southwestern parts of this country, so that water can be stored and used for many purposes. You have heard of the Hoover Dam on the Colorado River. This is just one of the big dams that have been built. Because of it, the Colorado River, once so wild and destructive, is now of use to man. Irrigation is one of its uses. Water is carried to miles and miles of fields in huge concrete tunnels.

The dams on the Colorado River were planned and built with all the skill of modern engineering. But there have been other, much smaller, dams along the river. Not long ago a



beaver was found busily constructing his own kind of dam below Glen Canyon. He had his own reasons for building it.

You have some idea, now, of what irrigation means in this country. What about the rest of the world? Many places in the world depend on irrigation for growing food, but nowhere is it more important than it is in the Middle East.

It is easy to think of Egypt as having all its irrigation done for it by the flooding of the Nile. This was never entirely so. Men dug canals to take the water to the fields when the flood was over, and there were dry seasons when nothing could be grown. But the whole pattern of the flooding of the Nile has been changed since the Aswan Dam was built in 1902. This dam was built far up the river, in the mountains, to hold back the flooding water of the Nile, so it could be let out a little at a time as it was needed. Since the dam was built, the Egyptians have been able to use their land for growing crops all year round, without fear of drought. Twice the dam has been made higher, to hold back more water. Now the government of Egypt is building another, the Aswan High Dam. This dam will provide not only more water for irrigation but also water for generating electricity. With this electricity Egypt can build new industries and give work to many of its people.

There are still canals across the Egyptian fields, and water from the river flows into them. There is almost always enough. But the river does not flood the field as it did before the dam was built and it does not spread across them the rich layer of

soil that it used to bring down from the uplands. Fertilizer must be used instead.

This is only one of the problems the Egyptians are facing in the use of their land. Times have changed. There are millions more people in the world than there were a few hundred years ago. The population of the world doubles about every seventy years. The population of Egypt is increasing even faster than that. One crop per year on the broad fields of the Nile Valley used to be enough to feed everyone, and this was good for the land. Now this is not enough. The land must be planted twice, or even three times, each year. Besides grain, fine Egyptian cotton and tobacco are grown and sold around the world. The land is being worn out, and sometimes there is not even enough water.

Elsewhere in the Middle East, the people of the new state of Israel are bringing water to dry parts of their country. A huge pipe line now carries water from the Yarkon River, in the northern part of the country, to the Negev desert in the south. This is a part of the great Jordan River Development Plan which the Israeli government hopes some day to carry through. The Negev has been a bare dry desert for hundreds of years, but its soil is good. There was a time long ago when there were wells in the Negev and the rich soil grew food for the people. Some of these wells have been rediscovered today.

Now it seems that again the prophecy of Isaiah in the Old Testament of the Bible may be fulfilled: "The desert shall

rejoice, and blossom as the rose. It shall blossom abundantly, and rejoice even with joy and singing. . . ."

There *can* be enough usable water in many of the dry places of this world. Irrigation can help change the face of the earth, for the good of everyone.

Irrigation in some places involves enormous quantities of water. It also involves a wise use of water in places where there is barely enough. We cannot depend on people to use only their just share. Use of water must be regulated by law.

This is nothing new. There were many laws about water use in ancient Babylonia and Egypt. The Babylonian King Hammurabi decreed death to anyone who wasted water. The Koran, book of the Mohammedan religion, laid down this rule for the use of rivers: "All who have need of a river may use it, no one may own it, and no one may make a profit by selling its waters."

Among the Arabs, who know the value of water in their desert land, there are still rules about water which must never be broken. Anyone who is thirsty must be given a drink, even if he is your enemy and you are about to fight him. Water is so precious in Arab countries that a guest is expected to comment on its special flavor as he drinks.

The rights of people to use the water of streams beside their own land are called "riparian rights." ("Riparian" comes from the Latin *riparius,* which means "belonging to a bank or shore.") Our own idea of riparian rights developed long ago

in England. It provided that each landowner along a stream had equal right to use the water that flowed across his land or beside it. He could use the water, though he didn't really own it. But as the western part of the United States was settled, the first man to settle by a stream often considered that he had first claim to its water. A man living on a small stream might use up most of its water in a dry year and not leave any for those who lived downstream. This was the idea of "first come, first served." The people downstream had no rights.

It was pretty obvious that this arrangement wasn't fair. There was no trouble as long as there was water enough for everyone. But in years of little rain there were disputes over water, and someone was sure to lose. Out of the need of the people for water there developed the "common law" about water use, based on the common-sense rules of the people. The laws on water use in the various states of our country have been based on this common law. In the East, the result has been pretty much the same as the old riparian law. In the West, laws have had a tendency to favor those who use water for irrigation. Others cannot always get enough.

Any common law about water rights is based on a "fair share" of the water of a stream. The problem always has been to decide what *is* a fair share. Five people might have five different opinions about that.

The old laws have not been good enough for the complicated water problems of today. Different states have drawn up very different laws, some better than others. Claims to water rights

have often had to be settled by the law courts. We need better laws, to prevent waste of water by people owning land along the streams of this country. It is not enough to let each owner have some sort of share of the water, though his rights must be respected. Water must be used for the benefit of everyone.

In 1957 a California lawmaker warned state and local officials to get their water laws in order. He was not the only one to advise this. There have been disputes over water ever since this nation began. There are going to be battles, this time in the courts, as more and more water is needed for our everyday way of living and especially for irrigation in the West and Southwest of this country. One of the biggest disputes is the one that has been going on for about fifty years between California and Arizona, about the waters of the Colorado River. Southern California uses the Colorado for much of its water supply, Arizona wants it for irrigation, and Indians in Arizona have a right to a large share of it because of a treaty which our government signed with them in 1848. Somehow all these claims are being settled.

The dispute over the Colorado River involves only one country. It is much harder to settle disputes between different countries. International law states that when a river flows through more than one country, the countries must share the water. But international law is hard to enforce, and most countries want to take care of their own people first, regardless of others. There is a dispute going on right now in Asia about the Indus River and its five main tributaries. These rivers flow

partly through India and partly through Pakistan. India needs their water for irrigation, so she can grow food for her increasing millions of people. Pakistan needs it for the same reason, perhaps even more than India. So far it has been impossible for the two countries to agree on a solution.

India and Pakistan will settle the problem of the Indus River in time, and without violating international law. Some progress has already been made towards resolving their differences. They will certainly settle the problem without going to war. Surely this is better than the way of the Turkmenians, who wore themselves out fighting for water in the desert where they all had to live.

Most countries with rivers along their boundaries run into some problems in sharing the water of these rivers. Usually these are settled without much trouble. The United States has the Rio Grande River on its southern boundary, with Mexico just across the border. Part of its northern boundary is the Saint Lawrence River, with Canada on the other side. International commissions with representatives from each set of countries settle any problems that come up in the use of these rivers.

Perhaps the most impressive example of co-operation in the use of a river is the Saint Lawrence Seaway. The United States and Canada together planned and built the tremendous dams and canals with locks which make it possible for large ships to carry goods and people all the way from the Atlantic Ocean to our Great Lakes.

We know much more now about the use of water than early man did when he camped beside the brook. No people in the civilized world need fight for water to keep alive. But we do not want just water to keep alive. We have bigger plans for the water that runs over our earth.

CHAPTER 16

The Brandywine Valley Association

The people of the Brandywine Valley in southeastern Pennsylvania had a big problem on their hands in 1945. It was not a new problem, but until 1945 it had not been doing much except getting worse.

The valley had once been rich farm land, with the clear and lovely Brandywine Creek flowing through it, full of fish. Now it was mostly a land of poor farms, crossed by bare and ugly gullies. In every heavy rain, floods of water poured down these gullies, carrying away much fertile earth. So much earth went down the creek that the water was muddy all the way. You couldn't even see through that water. Mud washed into the waterworks downstream at Wilmington, Delaware, and the Water Department had to spend a lot of money disposing of it. Mud poured into the Wilmington Marine Terminal, where the big ships come up from Delaware Bay. Twelve feet of mud settled to the bottom there every year, and the United States Army Engineers had to keep dredging it out, so the ships could get in. Every year they scooped out enough mud to cover a

thousand football fields about seven feet deep, and it cost around $300,000.

Mud washed across the highways in the valley, and the State Highway Department had to cart it away.

You can't grow corn on the highways. You can't grow corn in the Cherry Island Marsh, where they dumped the mud they took out of the Marine Terminal. And none of the soil in that mud would ever get back to the farms it came from.

The Brandywine Creek itself wasn't just muddy. It smelled bad. Steel mills and paper factories along its banks dumped wastes into it. Towns dumped sewage and rubbish. Most of the fish in the creek were dead.

In spite of all this, some of the people in the valley didn't even seem to know there was a problem. Or perhaps they didn't care. But there was a man named Clayton Hoff who cared a great deal, and he decided to do something about it. He liked to go fishing, but you couldn't catch any fish in the Brandywine. He liked to tramp over miles of beautiful countryside, but the Brandywine Valley was fast becoming very unlovely countryside. If people didn't understand what was happening to their own valley, Mr. Hoff would show them.

He began by taking photographs of the wasted fields and hillsides in people's own back yards. He took pictures of the open sewers in the creek, of all the signs that read, "No Swimming Allowed Here—Polluted."

People who saw those pictures were impressed. A farmer would feel pretty uneasy when his neighbor said, "Hey, Joe!

Isn't that a picture of the gullies in your back pasture?" But people didn't know what to do, and they were afraid that whatever they did would cost money.

That was why the Brandywine Valley Association was founded: to help people in the valley to learn how to save their land, use their water well, and clean up their streams. The Association would help pay for it. Everyone paid dues of two dollars a year and later three dollars. Some paid more. Industries and organizations in the neighborhood offered their help.

The Association printed pamphlets and gave them out all over the valley. They gave lectures with slides to adults and to school children, explaining what needed to be done. They conducted workshops for those who wanted to learn more. Tours were taken around the valley itself. The bulletin of the Association was called *The Watershed News,* and it kept everyone up to date on the progress of the work. The United States Soil Conservation Service helped with plans and information.

A project like this can't be a success unless people can be persuaded to work together. And if they are going to work together to improve the land and the water, they've got to see for themselves how it's done. With the help of fifteen different experts, the Brandywine Valley Association staged a huge demonstration of what can be done for a farm. Six bulldozers, twenty-five tractors, and other farm machines, roared into the run-down farm of a young navy veteran one day and just about made it all over, the way it *should* be done.

Fields were plowed, with the plow going across the sides of the hills instead of up and down them. This is contour plowing, following the shape of the land. This way there are no downhill furrows for water to run down, washing away too

much of the soil. Terraces were made along some of the hills to hold the water even better. Seeds and trees were planted. Roots of trees and plants would help hold the soil when rain washed over the earth.

A hole was dug in a place where the experts knew that water would stay even in dry weather. Then a ditch was dug to bring water to the hole from a little stream that had never seemed of

much use before. This gave the farm a pond, good for keeping water for many uses. There would be swimming in the pond in summer, skating on it in winter.

Twenty thousand people saw this demonstration, and the Governor of Pennsylvania made a speech. It would have taken one man about ten years to do all that work, but seeing it done in two days proved to people that it could be done, and showed them how to do it.

Getting factories to stop polluting the creek was a different problem. It hadn't been too hard to make people on the farms see what needed to be done. Farmers could see the difference when their land grew more crops and they made more money. But all these arguments wouldn't mean much to the manager of a paper factory or a steel mill. Factories had been dumping wastes of all sorts of colors and odors into the creek for years. Every now and then people who didn't like the idea had raised a row. They wrote insulting letters about it to the newspapers. They made speeches. Managers of factories were made to feel like incorrigible villains. This didn't make them want to do anything about the creek. It just made them mad.

Mr. Hoff's approach was different. He would go to the manager of a mill and ask if he could take a picture of his stream. The manager would ask what for, and Mr. Hoff would say it was for publicity. This made the manager suspicious. He would want to know if Mr. Hoff was going to show people what the factory was doing to the stream. Pleasantly Mr. Hoff would

say he hoped to show people what the manager was *going* to do to the stream. This would start the manager thinking in the right direction.

When members of the Brandywine Valley Association approached the factory people, they didn't blame them or threaten them. They presented the facts about pollution of the creek and then said, "How can we help?" The factory managers decided they wanted to clean up the creek, and they were glad to have help.

At the Downington Paper Company, for instance, the waste water coming out of the plant was so gray and dense that you could hardly see light through it. Now this sludge is taken out in a big treatment plant, and the water is returned to the Brandywine actually cleaner than it was when it came in. People take trips to the plant to see how it's done. This is an expensive process and it makes the paper made by this mill cost a little more. A paper mill could lose money on this project unless other paper mills treated their wastes, too. Others along the Brandywine have started to do so.

There are other kinds of factories up and down the river. Steel mills use plenty of water. The Lukens Steel Mill in Coatesville now has a plant for purifying water. The same water is used over and over again several times and then returned to the creek without polluting it.

Towns and cities had to stop dumping sewage into streams in Pennsylvania when a law against pollution was passed in 1945. You will read more about this in another chapter.

The Brandywine Valley Association has accomplished much of what it set out to do. But that doesn't mean that they can close down their office and go home. Care of land and water needs continual help and encouragement. People can forget what happens when they're careless. But the amount of topsoil washed down the creek in a heavy rain has been cut almost in half, because most of the farmers now take care of their land.

Today you would have trouble finding a washed-out gully on a farm in the Brandywine Valley. You can catch fish in the creek. Most places you can even swim in it.

And this is not just one lone little valley with a plan for its land and water. There are Watershed Associations all over the country. There is even a national organization, the American Watershed Council. After all, most people live in river valleys. And every farm, little or big, every washed-off hillside, is important in the life of the whole valley.

The Carson family moved onto a farm in the Brandywine Valley in the 1930's. They wanted to live in the country. But Mr. Carson wasn't a farmer, so he kept on selling insurance and hired a local farmer to manage the farm. If Mr. Carson could make enough money from it to pay his manager and pay for the farm itself, he and his family could keep on living in the country.

But the farm was a miserable failure. The farmer Mr. Carson had hired did the best he knew how, but he couldn't get a profit out of that land. In 1940, Mr. Carson was all ready to

sell the farm and take his family back to Coatesville, where they had lived before.

Mr. Carson's two teen-age sons, Bob and Steve, didn't want to go back. They wanted to stay on the farm and become farmers themselves. It seemed to them that there ought to be *some* way of making that farm pay. Mr. Carson wasn't so sure. But he said the boys could try.

The boys had already started a chick-raising project. And they were both studying farming in school. If there was any good way of managing this land, they were going to find it. For the first few years they just raised chickens and vegetables and a few pigs. It was hard work, because they didn't have much machinery.

In 1940, the boys really went to work on improving their farm. They borrowed money to buy a tractor and other equipment. Then they took a good look at the land they had to work with. Land on the farm was hilly, and for years every heavy rain had washed the soil away. Now there were deep gullies where the rain water had poured down.

The boys knew what to do. They had learned how to take care of the land. What they needed, on their hilly land, was contour strip farming. First they asked the Soil Conservation Service to help them draw up a plan. Then they got to work.

They put dams of earth and grass across the gullies to stop the water from rushing down them. Then they filled in the gullies as much as they could and planted them with pine and locust trees.

Their next job was plowing around each slope in even strips, on the level. This was where the Soil Conservation Service was the most help, in finding out what *was* level. A hill is never all flat on its sides. It has humps and hollows. Plowing on the level over all those humps and hollows isn't an easy job.

The contours were finally all plowed. Little "check dams" would have to be set up along the rows every time they were cultivated, because no furrow could be perfectly level all the way. Without the dams, there might be too much water in one part of the furrow and not enough in another part.

The boys planted one strip with corn and the next with hay, then corn again, and so on. Corn can't hold back water, because there is bare earth around it. But hay is a good water holder, so the strips of hay did the job the corn couldn't do.

The Carsons stayed on the land. Theirs was one of the first farms in the community to practice contour farming, and it was a great success. They got more corn from an acre of land than anyone thought they could, even in good soil. By that time, their soil *was* good. The chickens remained a good business.

Now both Bob and Steve are married and raising their own families on their farm, where they want to be. They aren't living there just because they like living in the country. They are there also because they are making a good living from the land.

When the Brandywine Valley Association was founded in 1945, the Carson brothers became enthusiastic members. They

wanted to help other people to make their farms prosper, as theirs had.

For a while it had seemed as if most of the people in the Brandywine Valley were going to just sit and let the land wash away all around them. But it wasn't really because they didn't care. They just didn't know what to do. Most people are willing to work together for the good of everyone, once they know how.

CHAPTER 17

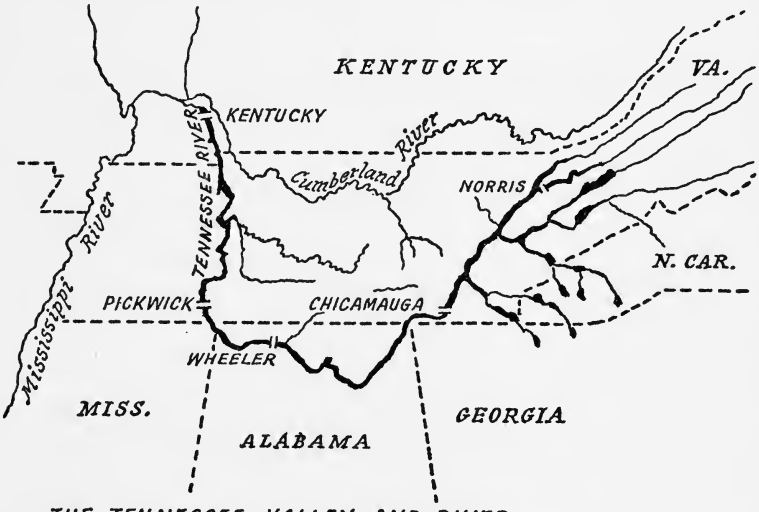
The Tennessee Valley Authority

The people of the Tennessee Valley never could have done what the people of the Brandywine Valley did. That is, they could not have gotten together and done a good job of improving their river and the land beside it, without much outside help. There was too much wrong with the Tennessee Valley. The job was too big for the people by themselves. Too big for the separate government agencies that had been trying to help out here and there.

There are 630 miles of the Tennessee River. It flows southwest first, from Knoxville, Tennessee, in sight of the Great Smoky Mountains, into the northern part of Alabama. There it turns west, swings in a big curve through northern Alabama, then north through Tennessee again, and finally into the Ohio River at Paducah, Kentucky, north of Tennessee and just across the river from Illinois. Much of the time this wandering river seems to flow *up* the map, but of course directions on the map are not really either up or down.

This was the Tennessee Valley, in the years before 1933: There was always plenty of rain, more rain than in any other

big valley in the whole country. There was enough warm weather. But you couldn't get a good living out of the land, the way you used to. Many of the people were poor tenant farmers, working someone else's land and not getting much out of it. Only one farm in twenty-eight had electricity. That



THE TENNESSEE VALLEY AND RIVER
SHOWING SOME OF THE DAMS

didn't matter as much as not having enough to eat or decent clothes to wear. Life hadn't always been like this in the valley. Something was wrong with the land.

There were people who knew what was wrong with the land. For two hundred years, trees had been cut off the hills. Ever since Civil War days, cotton or corn or tobacco had been grown on the land in summer. There was nothing growing on it the rest of the year, and when the heavy rains came in the

winter they washed off tons of soil. Each year more of the good earth was washed off, into the muddy river. There were floods, too; any winter could bring floods, even before the trees were cut down.

The people in this valley couldn't manage either the land or the water. There were too many people on the land, trying to manage; too many people not knowing what to do.

Then came the Tennessee Valley Authority. The bill creating this Authority was signed by President Roosevelt in May, 1933. But years of planning had been done before that. The Authority was to carry out a single plan for the entire valley. Land and water in the valley would be put to good use. Dams and reservoirs would be built. Better ways of farming would be taught to the people. This plan was meant first of all for the people, to give them a better life than they could make for themselves. But the people had to want this, too, enough to work for it. No one was going to *make* them into better farmers. They had to be shown, first of all, that the new methods worked.

Working with the land always means working with water, too. The wild Tennessee River was hard to work with, but it was finally tamed for the use of man. The TVA built twenty new dams and improved some old ones. There is Norris Dam on the Clinch River, a branch of the Tennessee; Hiwassee on the Hiwassee River; Chickamauga, Guntersville, Wilson on the Tennessee itself, and many more. Dams may have various uses. These dams were all built for more than one use.

The river used to flood in winter, but often in summer there would not be enough water so big boats could travel on it. Now the level of the river is controlled. Dams hold back the water when there is too much. They can let water out to raise the level of the river when there is not enough. Beside the dams there are locks like those in the Panama Canal to raise boats up to the higher level above the dams or let them down to the lower level below the dams. Barges carry automobiles, aluminum, iron and steel, grain, up the river. Trade was one of the earliest uses of rivers. The Tennessee is now busy with trade. Sleepy little towns have become bustling river ports. People can be sure, too, of enough water for their own use, and there is enough for all the industries that have grown up along the river.

Controlling the level of the river means controlling floods, too. Flood waters that used to rush all the way down the Tennessee to the Ohio River can be held back now. Few people in this valley need be afraid of floods.

In 1942 there was too much rain in Tennessee, too much water pouring into the rivers. People waited and wondered, some of them afraid. There was a flood at Chattanooga on the Tennessee River that year, but not a bad one. The steel gates in the Hiwassee Dam were closed; all it took to do it was the pushing of a button. The dam held back the waters of the Hiwassee River. Without it, flood water would have poured on down the Tennessee River and over miles of farm land beside it. Chattanooga might have been ruined.

Water pouring over dams means power. The force of falling water can be used to generate electricity. Of course, the water that pours over the dams is not the water that does the work. That water just goes on downstream. The work is done by the water that pours through huge pipes into the turbines that generate electricity.

In the Tennessee Valley, more than half of the electric power is now generated by steam. Water is used for that process, too, but less than is needed in hydroelectric plants. You will read more about this in the chapter on industrial uses of water.

All over the Tennessee Valley, homes that were lighted with kerosene lamps not long ago now have electric lights. There is plenty of water power on the Tennessee River, and electricity is cheap. People who never thought they'd own them have electric refrigerators. Dairy barns have electric lights.

Water power and cheap electricity mean more than lighted houses, important though that is. It means also electricity to run the machines of industry. Factories have been built all along the river. Thousands of people in the valley have gone to work in these factories. The government has a fertilizer plant at Muscle Shoals, Alabama, where there are experiments in making good fertilizers. The huge atomic energy plant at Oak Ridge, Tennessee, could not have been built there without the power provided by TVA. Oak Ridge is now a city of over thirty thousand people on the Clinch River, eighteen miles from Knoxville, but before 1943 it wasn't even there. The whole city was built secretly during World War II, while the

atomic bomb was being developed. So the TVA played its part in the war, too.

There is no doubt that dams are important for flood control, and for creating water power which generates electricity for people and for industry. But that is not all. If you will look at a recent map of Tennessee, you will see long lakes all along the Tennessee River and its branches. A man-made lake is just as good for swimming as a natural one. It is just as good, too, for fishing and boating. Thousands of people do fish there. The lakes are dotted with boats. People come from all over the country to spend their vacations there. You can take a 630-mile cruise through the whole length of the lakes.

Recreation can become a big business for the people who run it. This, too, has helped bring prosperity to the valley.

New reservoirs hardly ever cover land that has been lying empty. We have seen how the reservoirs for the New York City water supply covered villages and farms. People used to live, too, where there are now so many lakes in the valley of the Tennessee River.

What happened to the people? They had to move, and it wasn't easy for them to leave the houses where, very often, they had spent their whole lives. But the TVA people helped them to plan, helped them to settle as much as possible in places chosen by themselves. Even cemeteries were carefully moved to wherever people wanted them in their new towns.

The people in Guntersville, Alabama, were dismayed when they found that the water back of Guntersville Dam was going to flood some of the streets right in their business section. But they were willing to see what could be done about it. A plan for the use of their new water front was drawn up before the dam was even completed. Guntersville found it could *use* that water front for shipping. Now this is an important port, much busier and more prosperous than it ever was before.

It would be fine if we could say that everyone in the Tennessee Valley is better off now. But that is not quite so. There are still people up in the hills and in the smaller valleys whose lives have not been touched by what has happened down below. They are living in miserable little cabins in the midst of their washed-out land, and they haven't enough money to do any better. There are still little rivers in the smaller valleys that pour flood waters over the farmer's land. There is still work to be done.

But the TVA has shown what can be done when there is a plan for a whole river and its valley. This is a plan for the things man needs the most. Anywhere in the world "the things the people live by are the same; the soil and the water, the rivers in their valleys, the minerals within the earth. It is upon these everywhere that men must build. . . . These are the foundations of all their hopes for relief from hunger, from cold, from drudgery, for an end to want. . . ." These words were written by David Lilienthal, who directed the carrying out of the great TVA plan.

The TVA is more than a plan which has changed the lives of people in a single valley. For hundreds of years one of man's dreams has been the taming of wild rivers for the good of mankind. The TVA was only one such dream, but it has shown what can be done with rivers in other parts of the world. People have come from nearby countries and faraway countries to see what the TVA has accomplished. Some of these people have gone back to plan river projects in their own countries. There is a plan for the Rhone River in France, for the Indus in Pakistan. In Israel, there is the Jordan Development Plan, based on the plans of an American who had worked on the TVA.

In Russia, the Soviet Union is carrying out an astonishing plan on the Volga River and the Caspian Sea. There, as in other parts of the world, for many years so many trees were cut off the hills that rain water could not be held back. This made the Volga River unmanageable in times of heavy rains, and full of mud from the hills. The Soviet government therefore decided to control the Volga with dams and reservoirs and to use its water for irrigating nearby fields.

This may sound reasonable, but there was one great complication. The Volga River doesn't flow into the ocean. If it did, building a dam across it would be all right. Much of the water would stay in a reservoir instead of flowing into the ocean, but the ocean is so big that this would not make any difference. The Volga River, however, flows into the Caspian Sea. This is bigger than a lake, but nowhere near as big as an ocean, and it

is completely surrounded by land. The plan for the Volga would use so much water that the Caspian Sea would become smaller. Cities and towns on its banks would be left high and dry, with an expanse of mud instead of a lake in front of them. Ships could not reach the towns. Factories could not ship their goods by water. There would be fewer fish, and fishing is an important industry there.

It would never do to take that much water away from the Caspian Sea. But instead of giving up the whole idea of using the Volga, the Soviet planners looked around for other rivers that might be made to flow into the Volga and then into the Caspian Sea, or directly into the Caspian Sea.

This seems impossible. How can you *make* rivers flow anywhere except where they already flow? Somehow, it seems you can. The Russians are doing it.

First of all, they considered the Amu River (which all through history was called the Oxus). This river flows into the southern end of Lake Aral, east of the Caspian Sea, in the Turkmenian Republic. We have heard of the Turkmenians and their long fight for water. In the midst of their Kara-kum desert, one of the largest and most lifeless deserts in the world, the Amu waters a chain of oases.

In ancient times this river flowed west into the Caspian Sea, instead of into Lake Aral. But the sand and silt it brought with it filled up its mouth and turned it back to Lake Aral.

Now the Russians are building the Kara-kum Canal to bring this river back to its ancient course, so it will flow into the

Caspian Sea again. This will help keep the level of the Caspian Sea from falling after the Volga dams are built. And it will make it possible for the Turkmenians to irrigate a vast desert which is now too dry for growing anything but occasional desert grass. Even this desert can be made green with growing things under the sun, golden with a harvest of wheat.

There are other plans, too, for keeping up the level of the Caspian Sea. Russia has rivers that flow north into the Arctic Ocean. These rivers are not of much use, because the Arctic Ocean is frozen most of the year. One of these rivers is the Ob. If a dam could be built on the Ob, its waters could be made to back up into a valley which is now a swamp. From the lakes thus formed in this valley, the water would be sent in canals though the hills to the Caspian Sea and Lake Aral. This scheme was first thought of by a Russian scientist in 1871. Everyone thought it was a wild idea then. It is still a tremendous project. But it no longer seems impossible.

The New York Times in the summer of 1958 published this headline: "Dams Reshaping the World's Face." It is the water behind the dams that is changing the face of the world. *The Times* continues: "Waters caught in made-to-order lakes and inland seas are giving new food to the hungry, new power to machines and new safety from floods."

Nowhere is this changing of the earth more dramatic than in India. Seven important dams have been started or finished there already. This means water all year round on the dry dusty plains that used to have water only during the heavy monsoon

rains. This means, too, that the villages of mud huts, where people could grow barely enough food to keep alive, can look forward to a better life. Grain will grow in the fields. Factories will be built near the dams and people who never before have earned anything at all will take home money every week. They will be doing more than just keeping alive. Neat little houses will replace the mud huts. Children will go to school. These dams mean so much to the people that they have been called "modern temples."

Similar changes are going on in Africa, where huge dams are being built. There is one across the Zambezi River in Southern Rhodesia. Behind it the river has poured in to make a lake 175 miles long. This lake presented very special problems when it was filling up with water. Thousands of wild animals who lived on islands in the river were in danger of drowning. Men rowed to the islands, caught the smaller animals in bags, and then let them loose on the shores of the lake. But some of the animals were too big. You can't catch an elephant in a bag. Elephants were encouraged to swim ashore, but they didn't always get the idea. Sometimes, instead, they charged the men and sent their boats flying.

Postage stamps tell us something about what a country considers worth celebrating. There have been a number of postage stamps with pictures of dams. In 1935 this country issued a three-cent stamp showing Boulder Dam, now called Hoover Dam. Grand Coulee Dam appeared on a special stamp in 1952 with the words: "Reclamation: irrigation, power."

In 1960, a special stamp for water conservation showed a watershed with small dams for water storage.

Uganda and Kenya, in Africa, have put out stamps with a picture of Owen Falls Dam, high in the mountains on the White Nile in Uganda. India has one of her dams on a stamp. You can find others. Dams are symbols of progress.

The water of rivers can be controlled. Water of rivers behind the dams can be made to turn the machines of industry. All over the world, people are finding out that rivers can be made to work *with* people instead of against them.

CHAPTER 18

Industrial Uses of Water

Anyone can see water power in action. Water power is simply the force of large amounts of water running downhill. Gravity makes the water run down. Suppose you pour a glass of water over the back of your hand. You can feel it, but it hasn't much force. When you take a shower, there is much more water pounding down on you, from a greater distance. It has more force. But when we talk about water power, we usually mean whole waterfalls of water, enough to turn a water wheel or make a turbine go around.

Try standing on a bridge over a rushing waterfall. Look down into the water. One good place to do this is at Great Falls of the Potomac. Or Niagara Falls! If you can't get *over* a waterfall, stand on the bank beside one. Look into the water. There is so much of it, rushing downstream so fast, over the rocks. You can feel the power in it. If you look long enough, you will feel as if that power were inside of you, too, as if you were being swept away with it, downstream.

This is water power.

Water power is one of the oldest sources of energy that man

has learned to use. Water used for power has the great advantage that it is never used up. It can be used over and over again.

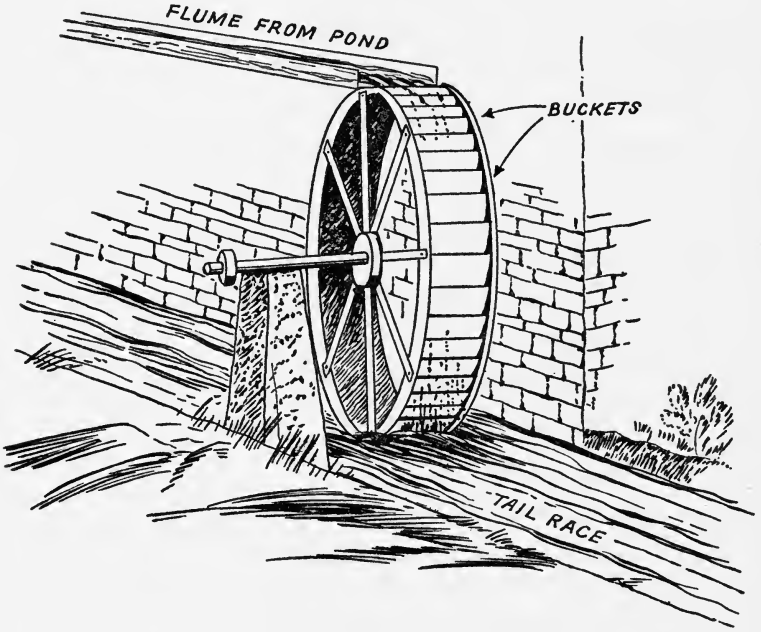
Early man may have first discovered the power of water by watching a river flow past him. He did not know what made it move; perhaps it was alive. This was something he could not understand, and so he was afraid.

It was many years before man conquered his fear enough to use the power of this water. First, he discovered that if he put a log into a stream it would be carried downstream without his having to do a single thing about it. Then he found that if he clung to a log as it went downstream he could make a quick journey, a little easier than crashing through the woods. It was a dangerous journey, if there were waterfalls.

It must have been thousands of years before someone invented the water wheel. That was a long step forward in the history of man. Before that, people had thought up various devices for getting water from the river onto their planted fields. The first water wheels did the same job and did it better, but they could do more than that. The force of water pushing against the paddles of a wheel could turn other things besides the wheel itself. It could turn the heavy stones that ground wheat. It could make the wheels of simple machines go around. At last water was put to work at tasks that until then could only be done by men or their beasts.

The earliest kind of water wheel was the undershot wheel. This was placed in the river where the running water could push the paddles at the bottom of the wheel. An overshot

wheel produces much more power. Instead of paddles around its rim, it has buckets. Water pours down into these buckets from a waterfall or from a trough or "flume" leading out from a millpond. The weight of the water in the buckets makes the



wheel turn. Gravity makes the full buckets keep going down. As each bucket reaches the bottom, it dumps its load of water into the "tailrace," and from there the water goes back into the brook or river. The empty buckets keep on going around, and again they are weighted down with water. This keeps the wheel turning and turning.

The more water flows over a water wheel, the more power

the wheel can produce. The higher the waterfall, the more power, too. It did not take people long to discover that they could make a waterfall themselves by building a dam across the river or the brook.

The power of the water wheel by itself is useless. It must be made to turn other wheels. This is done by using simple gears, but a water wheel turns so slowly that a good many gears, shafts, and moving belts are needed to deliver power to a machine.

Every water wheel has an axle through its center, called a "shaft." The cogs on the axle mesh into the cogs of another wheel, and this in turn could mesh into the axle in the center of the round horizontal stone that was used to grind grain by turning against another stone.

In much the same way, with more axles and belts, the wheels of a factory were turned. Looms of early New England cloth factories were run by water power. Other kinds of mills, too. Water never touched the wheels that did the work, but they were run by water power as surely as if it had.

In this country, water power is now very seldom used to move machinery directly. In a few places you will find a water wheel still turning the old millstones to grind grain. There are people who like the simplicity of the old ways of doing things. You can even buy an old-fashioned mill wheel if you insist on having one.*

* For more information on present-day water wheels consult the following: Campbell Water Wheel Co., Philadelphia, Pa.; Fitts Water Wheel Co., Hanover, Pa.

We have already met the Chases, on their New Hampshire farm, when we found out about their well that never goes dry. The Butterfields, too, with their spring on the hill. Both these families live in a little community called Mill Hollow. It has no post office of its own. You will not find it on most maps. It is a quiet community of small farms and homes.

This was not always so. Less than one hundred years ago, this was a small but busy industrial community with as many as six mills along the part of the brook that runs through the hollow and down the hill below it. One of the mills was at first a grist mill, grinding grain. It later was used for such varied purposes as making wool hats, carding wool, sawing and turning wood. All this involved machines, and the machines were turned by water power. Water from a little millpond, made by damming up the brook, poured over the top of a big water wheel beside the mill and into its many buckets. From there the water went on downstream and was used again, to turn the wheels or turbines of other mills. It would have to travel nearly two hundred miles, down the Connecticut River, before it reached Long Island Sound and the ocean.

Across the brook from the grist mill, using the same millpond, was a "fulling mill" which washed the cloth woven on home looms, pounded and shrunk it. Farther down the brook was a saw mill, still farther a mill that made starch from potatoes. Around the bend of the brook, at the bottom of the hill, a forging mill turned out metal work. Beyond that was the spinning mill, famous in its day for its fine thread. Most of

these mills changed their line of work at one time or another.

These small mills, running their machines by water power from little millponds, do not seem very practical any more. There is only one such mill in Mill Hollow today, built in 1918 on the site of the old grist mill. The others are gone. If you looked for them, all you would find is the stone foundations of some of the mills themselves and a few crumbled stone walls that used to be the dams.

The one mill that is still standing seems practical enough to Heman Chase, who owns it. It is a wood-working shop, and three of the machines are run directly by water power. The water wheel is gone, but the mill still has its dam, and water from the little millpond pours through a big pipe called a penstock into a turbine which revolves horizontally. A turbine is just a variation of the water wheel. It is a small wheel with many curved fins for paddles, inside a case that keeps the water flowing against the metal fins instead of splashing wildly. There is a gate between the penstock and the turbine. When the gate is lowered, no water can get through. When it is raised by turning a wheel up above it, water rushes in against all the little fins of the turbine. The more water pours in, the faster it goes.

When it is running, this turbine turns a vertical rod which keeps a horizontal belt wheel turning, on the floor above the turbine. A belt goes around this wheel and around another wheel, this time a vertical one, with a shaft leading up to a

third wheel and then to the machines. With these wheels turning busily, power is ready for use.

Deep in the works of the mill Mr. Chase has set up a smaller vertical turbine, with its own little penstock. This turbine he made himself, carefully hammering out all the little metal fins, cupped to catch the water. The cover can be taken off when the turbine is running slowly, so you can see all the little fins going around, splashing out water. This is a kind of water wheel, too. It is too small, of course, to produce much power. When it is attached to a small generator, it will light a light bulb. No one would claim that this is a very useful turbine. But no one cares. It was built for the children of Mill Hollow.

Direct water power is certainly not a very practical way of making the machines in a modern factory keep moving. Instead, running water is often used to make electricity, and then the electricity can make the machines run, or provide light for towns and cities. Most factories do not generate electricity themselves. They buy it from a power company that sends it to them on wires.

But it is still a variation of the water wheel that makes it possible for running water to generate electricity. Tons of water pour through a turbine, much bigger and more complicated than the one in Mill Hollow. The jacket around this turbine has blades that open and shut like a set of Venetian blinds, to control the flow of water. Water hits all the wheel blades at once, with tremendous speed and force. Huge generators are turned by these turbines and the generators make electricity.

The old-fashioned water wheel would hardly do for such a process, and it doesn't even look as if it were any sort of relation to the giant turbines of today. But they both grew out of the same idea.

You can go to see an old-fashioned water wheel if there is one near you. But you are not likely to get a good look at a modern water-driven turbine. It does its work under water.

Power generated from a water-driven turbine is called hydroelectric power. (*Hydro* at the beginning of a word means "water.") This would be the best way in the world of producing electricity if only we had enough water running down steep hills, in the right places. Of course, big dams are often built to *make* the water run down hill, fast. We have seen how the dams on the Tennessee River made it possible for industries to develop there.

Sometimes, too, turbines that run generators are driven by steam. Until recently this was always called steam power. Now it is more often called thermal power, which means power from heat. The energy or power comes from the heat stored up in the coal, oil, or gas that is used for fuel. Recently some engineers have even been using nuclear energy to supply this heat. In this country, about three times more electricity is now generated from thermal power plants than from hydro power plants. The power of a hydroelectric plant is limited by the amount of water that is available, and the distance it falls. This is not true of steam power.

In a thermal power plant, heat is used to make steam. Steam

under pressure is what makes the turbines turn, and it has tremendous power. Very little water is needed to produce this steam, but it has to be very pure water. The whole process uses quantities of water, however, mostly for cooling the giant boilers and cooling the steam so it can condense back into water after it has gone through the turbines. This is why thermal electric plants are located on large rivers or lakes or bays, just as hydroelectric plants are. If the water supply is still limited, water for cooling can be used over again by being put through its own cooling process.

The Consolidated Edison Company of New York has ten thermal electric plants on the rivers and harbors around New York City. The water they use for cooling is salty or brackish, but this does not matter. There is plenty of it, and these plants use more than the whole New York City water supply, every day. When the water is through with cooling, it goes back into the rivers and harbors.

The most highly developed nations have the most hydroelectric power or thermal electric power. It is that important in the modern world.

Water to make electricity is important. But it is only one of the industrial uses of water.

A front-page headline in *The New York Times* on April 17, 1958, read: "Water and Taxes Termed Threat to Jersey's Future."

What the paper meant was that *lack* of enough water had

become a threat. There is usually enough rain in the state of New Jersey, but the summer of 1957 had brought a drought. People were thinking about water as they never had before. New Jersey needed more reservoirs, little and big ones, more places to store water so there would be enough even when it didn't rain for months.

Of course water was needed for people, for millions of homes. Even more would be needed in dry weather to irrigate the farm lands. But at least as much water was used for the manufacturing that went on all over the state. No one dared to go on having just barely enough.

New Jersey is only one part of the picture. Industries all over the United States use tons of water, between eighty and eighty-five billion gallons every day. Why so much?

Most of that water is used for cooling. Think of a steel mill, for instance. Iron ore, coke, and limestone have to be heated to tremendous temperatures in blast furnaces to make the pig iron which is going to be steel. Iron is bright with heat and sparks when it is poured into the steel-making furnaces. This is red-hot liquid iron, with a temperature of 3000° Fahrenheit. (Boiling is only 212° at sea level.) Steel can't be made without this heat. But it is hard on the furnaces. And nobody could work anywhere near those furnaces, if they were not cooled all the time by water circulating through jackets on the outside. This takes quantities of water, about 270 tons of water for each ton of steel.

There are other ways in which water can be used for cooling.

Maybe your dentist runs a little stream of water onto your tooth as he cheerfully drills it. He can keep drilling much longer that way. The drill creates friction, and friction creates heat. If he didn't cool your tooth with water while he drills it, your dentist would have to stop pretty often to let it cool off by itself.

Perhaps you have sharpened a knife or a sickle on an old-fashioned grindstone. If you have, you know that it gets hot, too, as you grind it. Friction again. Unless you can rig up some device to keep water dripping onto the grindstone, you'll have to stop now and then to let it cool off.

In a pulp paper factory, logs are forced against a rough grindstone as they are ground up into pulp. Water cools and washes the grindstone.

But the rest of the paper-making process uses a great deal of water, and this cannot so easily be used over again. Wood fibers are "cooked" in a water solution. The pulpy wet mixture flows in a thin layer onto a wire screen, where most of the water drips through. Then this wet sheet of pulp is squeezed and pressed between rollers. More water is squeezed out. There isn't a trace of water left when the paper is finished, and yet no one could make paper without water.

The water that is squeezed out of the wood pulp when paper is made is far from clear. It is so full of fibers and fiber juice that you can't see through it at all. Even so, this water can be used again if it is put through a purifying process. This costs a good deal more than just cooling the water, but, as we saw

in the Brandywine Valley, it is better than pouring filthy water back into our streams.

Plenty of other industries need quantities of water. Rayon, for instance, soap making, canned foods. Atomic energy plants use enormous amounts of water. Usually industries cannot use just any water; it has to be good water.

We have come a long way in our use of water from the day when early man floated his first log downstream. He could not have dreamed of how our use of water, and water power, would change the world.

CHAPTER 19

Control of Water

Often the story of water is about how people have tried to change its ways. We have channeled its power into our mill wheels and turbines. We have made it run through ditches across our dry fields. We have even held back flooding waters with our levees and spillways and dams.

But we have not yet learned as much about controlling the rain, which is the source of nearly all our water. Man has always wanted to be able to make the rain fall from the sky. Until recently his only ways of trying to do this were by ceremonies or magic. Not long ago fakers went around in dry seasons selling gadgets that were supposed to produce rain. Cannons were sometimes fired at unco-operative clouds. Even now, in the far-off country of Nepal, in Asia, cows are milked into the dry river to make it rain. In some parts of Rumania, a clay figure representing drought is put into a coffin, carried in a funeral procession, and then thrown into a stream or a well. Equally fantastic things are tried in other places. Sometimes it *has* rained after these procedures. But it was always by chance. Magic can't really bring rain.

The modern "rainmaker" uses science instead of magic. He knows, for one thing, that nothing can make rain fall unless there are already clouds in the sky. But not all clouds will produce rain. The droplets of water in the clouds must first become snowflakes or raindrops, heavy enough to fall to the ground by force of gravity. The rainmaker cannot really "make" rain; he can only try to induce the clouds to make raindrops which will be heavy enough to fall.

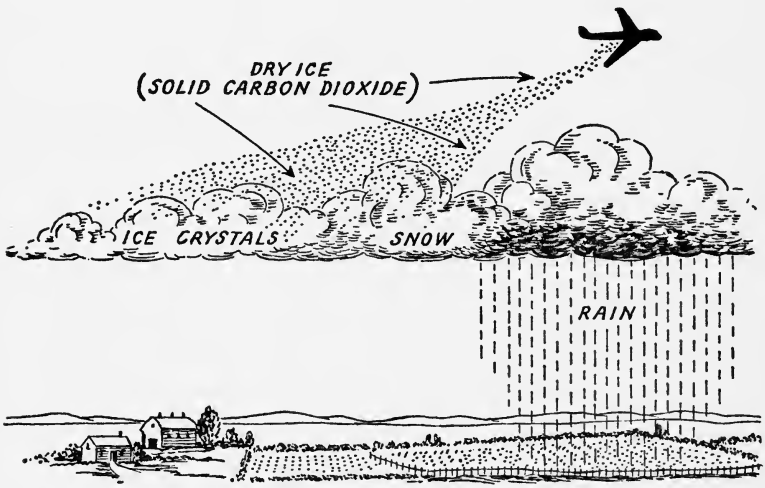
The sky may be full of clouds in a dry season. There is nothing more exasperating to a farmer than seeing lush clouds floating over his dry fields without letting fall a single drop of rain.

The formation of raindrops is a rather complicated process. Each raindrop is made up of tiny droplets which gather around a little particle or "nucleus." Dust in the air may provide these particles. One of the first modern methods of rainmaking used this principle. Particles of dry ice (solid carbon dioxide) were sprinkled on the clouds from an airplane. The moisture in the clouds gathered around the dry ice particles. Dry ice is very cold, and that helped, too. Snowflakes formed, and when they were heavy enough they fell from the clouds and then melted into rain on the way down to earth. Clouds in warm places have been sprayed with water from airplanes, with similar results.

These methods are sometimes pretty hard on the airplane pilots. They try to fly above the weather, but sometimes they fly right into it. However, the rainmaker in the sky has one

great advantage. He can be sure of his results. He can spray his dry ice all over the clouds and actually see the rain start falling beneath him. He must feel pretty important up there.

Another method of rainmaking is used more often now than dry ice, though it is based on the same idea. Crystals of a



chemical called silver iodide are released into the air from "ground generators." The crystals float up, and when they reach the clouds, raindrops can form around them at a much lower temperature than they usually need.

The rainmakers claim that they can make plenty of rain this way. Some scientists are not so sure. It's hard to prove who is right, since we never know how much rain would have fallen anyway. We can only judge by how much rain usually falls in a given area, or how much is *not* falling in nearby areas

without the rainmaker's help. There seems to be no doubt, however, that the rainmakers often do make rain fall.

There are some pretty serious difficulties about rainmaking. Suppose the farmers in one state in a dry season hear about how cloud-seeding in the next state has given farmers there plenty of rain. These dry farmers may be hopping mad because they are sure some of that rain would have fallen on their own farms if the cloud-seeders had let things alone. So far no one can prove they are wrong.

Another problem is that rain may fall not only where it's wanted but also where it isn't. Melon growers on the Arkansas River were all ready one year to harvest their crop when hail fell, big pounding pieces of ice out of the sky. Most of the melons were ruined. Farmers blamed cloud-seeding in nearby Colorado; they said the wind had blown the clouds over. Nothing could be proved, one way or the other.

Summer resorts in the midst of cloud-seeding areas have complained that their business was ruined by too much rain. Somehow people don't like rainy vacations.

The rainmakers foresee a bright future for themselves, and they may be right. But there will have to be laws to regulate what they do. And maybe after all it isn't a good idea to try to change nature too much. People learn to manage with the amount of rain they usually get. It is only the extremes of drought or flood that are impossible to live with.

Before there is much more rainmaking, we will have to learn more about the sky and the rain. This isn't easy. As the Depart-

ment of Agriculture Yearbook *Water* says, "The sky is a wild and unpredictable laboratory; research in weather is difficult and often frustrating." Now that rockets can send back information from the outer atmosphere, we can learn more.

There is another way in which we are learning to control water. We are cleaning up our polluted streams.

Many cities today have the most efficient methods of disposing of waste and sewage that the world has ever known. It is an expensive and complicated process, because there are so many people in these cities. But the fact is that we don't have to have any unclean water at all in our brooks and rivers. Rivers can be polluted in various ways. Cities and towns may dump sewage into them, through pipes leading from people's kitchens and bathrooms. Factories may pour their waste materials into them. And rivers may be muddied with silt that has been washed off the land upstream.

Polluted water is no good for drinking or washing. Most factories cannot use it for processing. It can't be used for irrigating crops and it spoils the swimming and fishing. In fact, it kills the fish.

A great deal of cleaning up has been done in this country. You have already read about how the Brandywine Valley Association persuaded factory owners to clean up their streams in that area.

The cleaning up that was done in the Brandywine Valley was only a part of what has been done in the state of Pennsyl-

vania. In 1945 there were so many polluted rivers in Pennsylvania that the state government passed a law requiring that all the rivers in the state be cleaned up. This couldn't be done overnight. It is almost always harder to undo the damage you've done than to keep from doing it in the first place. But much has been accomplished. It wouldn't have been done so fast without a law, because some people don't care and some people even think the rivers are *meant* for dumping wastes into.

Two of the worst rivers in Pennsylvania were the Schuylkill and the Delaware, in the eastern part of the state. Coal mines 130 miles up the Schuylkill washed their coal and then dumped black sludge into the river, forty million tons over the years. More than five hundred industries emptied their wastes into this same river. Towns and cities poured in sewage. The Schuylkill joins the Delaware River in Philadelphia and the filth flowed on into Delaware Bay and then into the ocean.

The water from the Schuylkill and the Delaware Rivers was and still is Philadelphia's water supply. Of course it has to be purified before it can be used by the city, and this is quite a process. Even then the taste and color of the water often isn't what you would expect from pure water. You can't really tell much by the taste and look of water, but you don't like to drink it if it looks muddy and tastes queer. Even today many people don't like the taste of Philadelphia water, though it looks clear and does not often taste of the chlorine which is put in it to kill germs.

The Schuylkill River is much cleaner now than it was ten years ago. The mines upstream still wash their coal, but they don't dump any black sludge into the river. Instead, they use it for fuel and building blocks. The old coal sludge is all being cleaned out of the rivers. This is costing fifty million dollars. Towns and industries are spending twice that much to treat sewage and keep out factory wastes. Now you can catch fish up the Schuylkill where a few years ago fish couldn't even survive long enough to get caught.

It is easy to say now that the rivers should have been kept clean in the first place. But it wasn't long ago that very few people cared what happened to the rivers. Even when people do care, it is not always easy to get something done.

You know something about pollution if you have sat on the banks of a dirty river and turned away from it because you couldn't stand the smell. You know what cleaning up means if you have gone back a few years later and seen the same river flowing clear and sweet, with fish in the quiet pools, bright sun reflected on the ripples, and green plants growing on the banks where there was only black mud before.

Rivers are being cleaned up all over America: the Kansas River, the Ohio, the Willamette in Oregon. But there is still much to be done.

Rivers are not cleaned up just so they will look better. They are not cleaned up just so people can go swimming in them, row boats and catch fish. Those things are important, yes; they might be reason enough for cleaning up rivers. But besides all

this, many of these rivers are the whole water supply for towns and cities. Philadelphia is not the only such city. You can't safely drink river water just as it is, even if it looks clean. But the dirtier it is, the harder it is to purify it so it is fit to drink, and the more dangerous it is for everyone when any one part of the purification system goes wrong.

Water can be dangerous because disease germs or viruses are carried in it. Even after all the mud and dirt is filtered out of their water, cities must put chlorine in it to kill any germs that may remain.

It isn't just city water that needs watching. Only half of the people of the United States have public sewage disposal. And people in the country have to supply their own water. Even well water isn't always pure. It may look clean and taste sweet and still have germs in it. It won't be safe to drink if anyone's cesspool or septic tank full of sewage can leak into it through the ground. Spring water may be safe, but it's a good idea not to drink water from a spring below a field where horses or other animals are kept.

Even so, getting clean water isn't usually too great a problem in the country, once the well is dug in the right place or the right spring chosen. The deeper the well the purer the water. Surface water is the least reliable. It is important to have any water tested now and then to make sure it is pure. You can add chlorine to country water if it isn't safe without it, just as it is added to city water, in the same proportions.

We know that some of the worst diseases that have ever

plagued humanity come from drinking impure water. It seems amazing that it took people so long to find this out.

In medieval times, people by thousands came down with diseases from bad drinking water, and many died. Later times did not fare much better. Several kings of France died of dysentery or cholera, both water-borne diseases. George Washington had dysentery while he was fighting our Revolutionary War. The wife of another president died of typhoid fever. Thousands of people whose names were never written in history died, too. All of these diseases, such as dysentery, cause violent intestinal sickness, and all are most often, though not always, caused by impure drinking water. No one knows how many wars in history were lost because too many soldiers were dead or dying with water-borne diseases.

The pioneers who went west in this country around the years 1860–70 often suffered from cholera as they tried to cross the Mississippi Valley. Many died. This is one part of pioneer life which is not always mentioned in glamorous accounts of brave people traveling west in covered wagons.

Some time ago, even before germs were discovered, people did begin to suspect drinking water as the source of some diseases. In Europe, water was often drawn from dirty wells, ditches, rivers where sewage was dumped. Most of the well water used by New York City during the first half of the nineteenth century was polluted with sewage.

We may wonder why people went on drinking this water. They just didn't know how bad it was. It didn't always look

dirty. And it was hard to prove that water caused disease, when little was known about germs. There were always people who pooh-poohed the whole idea. One "expert" in London even wrote that muddy water was better than clear water. And why? Because cows usually muddy the water in a brook before they drink it!

There are still outbreaks of cholera in Asia. But it is almost unheard of in this country, and typhoid fever and amoebic dysentery are rare. (Other forms of dysentery are not so rare.)

We don't have to be afraid of drinking water from any city water supply anywhere in this country today. Pipes and valves and other equipment have to be kept in good condition all the time, sewer pipes kept separate from incoming water pipes.

You can feel safe about water in many countries besides ours. But in some less advanced countries you may have to take measures yourself to see that the water you drink is pure. Certainly in Asia. And even in Mexico, across our southern border.

Today we are changing not only the ways of water but the ways of man in his use of water. Maybe we cannot be sure of making rain fall from the sky wherever we want it. But people *can* have pure water to drink anywhere in the world, if enough of them want it, and if they can manage to pay for it. Let's hope that someday this will be so everywhere.

This is only one part of the story of water in our future.

CHAPTER 20

Water in Our Future

What about water in the future of the world? Will there always be enough? It is easy to answer this by saying that of course there will always be enough. The amount of water in the world won't change in the future, any more than it has in the past. But that is really not the point. The population of the world is increasing at a rate that has never been heard of before. Is it going to be possible to supply all these people with enough clean water, all the time, wherever they are? Will there be enough for the industries that supply the many things these people need and want? And how are we going to water all the land that must be used for growing their food?

All this can be done. But doing it will be complicated and expensive.

The largest supply of water in the whole world is in the oceans, but it is of almost no use to us as long as it is salt. It has been a dream of man for hundreds of years to make this water fit for human use.

The sun evaporates water from the sea all the time. From the salty water of the seas it draws up the fresh water that falls

on the earth as sweet rain. If man could do this, too, all the dry deserts of the world could be made to bloom.

There is no secret about how this evaporation is done. For a long time we have known how to get fresh water from salt by boiling salt water, collecting the steam, and cooling it. The salt stays behind, and the result is pure water. You can do this in your own kitchen, with very simple equipment, like this: Boil some salt water in a teakettle. Hold a cold piece of glass or metal in front of the spout where the steam comes out. Drops of water will collect on the cold metal or glass, and you can let them drip into a jar. This process is often called "distillation." Distilled water can be bought in bottles or jars for use in steam irons or car batteries. Chemists and other scientists have many uses for it.

Distillation is a simple process. But it is not simple to do it on a large scale. The sun evaporates fresh water slowly from miles and miles of ocean. Man is trying to evaporate it from a much smaller area, fast enough so that there will be enough for practical use.

Evaporators have been developed which *can* produce quantities of fresh water from sea water, but it is still a pretty expensive process. Navies and most ocean-going passenger ships are supplied with fresh water this way.

A big hotel on the island of Bermuda has installed an evaporating plant which produces 15,000 gallons of water a day. Otherwise the hotel would use rain water for drinking and slightly brackish well water in its plumbing.

In the Middle East, on the Persian Gulf, there is a little sheikdom called Kuwait. For centuries the only source of water in Kuwait was shallow wells the people dug by hand. All of these wells gave salty water. When the Kuwait Oil Company was set up by the Anglo-Iranian and Gulf Oil Companies, its managers didn't take long to decide that they couldn't stand drinking the water of the local wells, or even washing with it. Something had to be done. In 1950 the company installed six huge evaporators made in the United States. Thousands of gallons of sea water were converted into fresh water every day. The Sheik of Kuwait heard about this and asked for a sample of the water. Distilled water does not really have any flavor, but after years of drinking brackish well water, the taste of this fresh water seemed just wonderful. The Sheik ordered more evaporators for the use of himself and his people. Now distilled water is blended with Kuwait's well water, in just the right amounts to make it taste good. This blended water is distributed to the people. Their wells never gave them water like this. To them it seems a miracle. It is a miracle which the sheik could pay for because his country is rich in oil.

Two islands in the Caribbean Sea, Curaçao and Aruba, have their water supplied in the same way. Here there is very little ground water. The islands are small. The soil is heated by the hot tropical sun, and when the warm rain falls much of it evaporates into the air.

The "solar still" is another, smaller, kind of evaporator, using the heat of the sun. A compact solar still was put into

every flier's emergency kit during World War II. It could produce about a quart of fresh water every day, and that is enough to keep a man alive.

There are other solar stills for civilian use. The simplest ones consist essentially of a tray of salt water with a slanting piece of glass above it. Water is evaporated by the sun, condenses on the glass, and runs down into a gutter where it is collected.

The Australian government supplies a "build it yourself" chart to sheep growers, so they can make a solar still themselves. Many wells and even rivers in Australia are brackish, because salt spray blows across the land on the wind and seeps into the soil. The sheep grower is grateful if he can obtain even a little fresh water with his homemade solar still.

Meanwhile research is going on all the time, in this and other countries. A cheaper way of making quantities of fresh water from the sea must be developed before it can be used for irrigating farm land. Some authorities say that sea water may be widely used for irrigation one hundred years from now. Maybe then we can really begin to change the deserts to gardens.

Evaporation is not the only way of producing fresh water from the sea. It is possible that other processes will prove to be cheaper. In Israel an inventor is working out a freezing process which looks promising. The United States Department of the Interior has set up an Office of Saline Water, which is working towards finding the cheapest and most efficient methods of desalting sea water. Five demonstration plants are being built

in different parts of this country, to show what can be done with sea water and brackish water.

There is not much chance of your drinking sea water tomorrow, or even next year, unless you go to Kuwait or to one of the islands where sea water is used. If you are shipwrecked, though, you will find that life rafts are equipped with chemical desalting kits, so you cannot die of thirst surrounded by a sea of water.

Another new way of increasing our supply of fresh water is by preventing it from evaporating. There is a kind of alcohol in whale oil which can be spread on the surface of lakes and ponds. This keeps most of the water from evaporating. Oxygen can go through the film of alcohol and down into the water, so the water stays fresh and the fish can go on living as usual. This may prove to be a good way of saving water in the future, especially in hot dry countries. Other chemicals may prove practical for the purpose, too.

It is hard to see much of a future in some of our deserts. What about the Sahara Desert, in Africa? There are two million dry square miles of it. But there have been plans to change it.

In 1903 a Frenchman, Jacques Lebaudy, decided that the Sahara Desert ought to have a future, and he was going to see to it himself. Five hundred soldiers were willing to risk the journey with him, and they all set out for Africa, where they landed on the northwest coast. Lebaudy raised a flag and an-

nounced that he was Emperor of the Sahara. He was going to build a city, then cut a wide canal from the Atlantic Ocean into the desert. The theory behind this plan was simple. Lebaudy figured that a large body of water in the desert would evaporate enough water into the air to change the climate. Rain would then bring the desert to life. He never had a chance to try it. Moors who were living in that part of Africa attacked him, and Spaniards made off with his yacht. Lebaudy and the men he still had with him got back to France somehow.

Now it looks as if Lebaudy's dream might become a reality after all, though not just the way he planned it. With the number of people in the world increasing so fast, it is no longer practical to ignore the deserts. Almost one third of all the land on this planet is desert. We are going to need that land for growing food.

Even the driest deserts can be made to bloom, if water can be found under them or if it can be brought to the land from distant wells and rivers.

There was a time very long ago when the Sahara was not a desert at all. What is now sand was good earth, because there was water. Forests full of trees grew there. Now trees grow only here and there in the infrequent oases.

But there is water under that desert. When we walk across miles of dry sand, up and down the hot treeless hills of the Sahara Desert, we are walking over water. Underground reservoirs are there. In the northern Sahara, water from the Atlas

Mountains lies underground for thousands of square miles. Some of it may have been there for thousands of years.

Water under the deserts may be brackish, as it is in Kuwait. But much of it is fresh and good to drink.

Dew falls heavily during the cool desert nights. Scientists think that this moisture may sink down through the sand to form underground fresh-water pools. These pools may prove to be of more use to the land than the occasional heavy rains that pour down the desert hills and rush away.

Dew is mentioned in the Old Testament as a source of water in the desert. Archaeologists exploring the Negev have found little circular stone walls, each surrounding the remains of the roots of one olive tree or one grapevine. Moisture from the air condenses inside these walls as the wind blows through the loose stones. This is the dew. It was enough to keep a tree or a vine alive even in the desert. Farmers in the modern state of Israel have used these little dew collectors, and scientists there are finding new ways of using dew in the desert.

Wherever a well is drilled down to fresh water, deep in the desert, there can be a green and growing oasis. Wells are being drilled. Oases are being made so much bigger that they become cities of people. New oases are being built. But they still seem few and far between in the vast expanse of the Sahara. Water lies very deep under the desert, and heavy machines must be used to reach it. This is often too expensive, especially far inland.

Sometimes horizontal wells are used, as they often were in

ancient Roman times. These are long tunnels reaching back into the green hills, where water is nearer the surface than it is in the desert.

More wells will be drilled. Trees will be planted. Sand will become good soil once it has water and plants can grow and decay and create the humus that makes earth good for growing things. In time, as we have seen, sea water will be purified and used for irrigating land even where there is almost no rain.

Meanwhile there are already experiments being done in growing food on the deserts in the vicinity of the Mediterranean Sea. The success of these experiments is amazing, but the amount of land involved is so far very small.

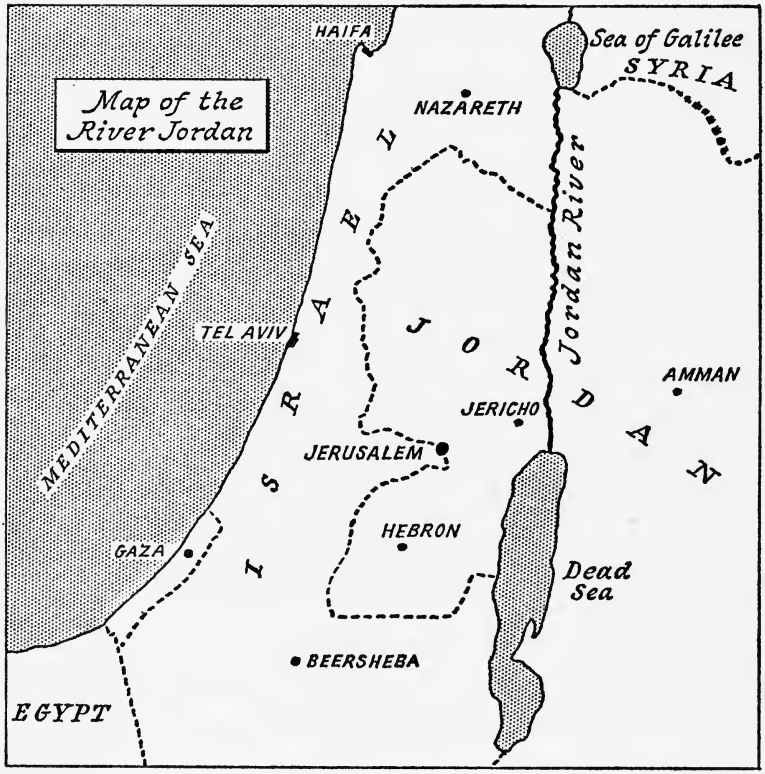
One such place is called Abadla, in Algeria. It is in the midst of a desolate valley where nothing can grow. Yet at Abadla there are lush fields of wheat, gardens full of flowers, trees heavy with fruit. This was made possible because French engineers discovered that what looked like solid rock in a valley was really a deep layer of silt that had washed down in the seasonal floods and then baked hard by the desert sun. Heavy tractors and soil breakers were used to break up this crust, and underneath it was damp rich soil. Maybe this can be done with other barren places on our earth. And this is only one way of cultivating the desert.

Plants that need little water are being developed, for growing in places where there is not much rain.

No part of the world needs water more than does the Middle

East. Its future depends on what is done with the little water available for its deserts. To a large extent, it depends on what is done with its rivers.

We have seen that in ancient times the valley of the Tigris and Euphrates Rivers was one of the garden spots of the world. The desert of the Negev, too, was lush with grain and fruit in Roman times.



Today, the people of these Middle East countries cannot look forward to a better way of life for themselves and their children unless the rivers again can water the desert and make it "blossom as the rose."

Israel alone in that area is using its water resources well. But Israel cannot carry out its great Jordan Valley plan, because the Jordan River does not flow entirely within its boundaries. The adjoining country of Jordan controls more of the river than Israel, and it will not co-operate. Carrying out the plan would mean water for the dry deserts of Jordan as well as Israel. But Jordan says no.

Iraq has begun to use the water of the Tigris and Euphrates Rivers, as it was used in ancient times. But what is needed most is big plans for the rivers, plans like that of our TVA. Rivers do not always follow the boundaries of countries. There can be no big river plans for the countries of the Middle East until they decide to work together. Anything less will keep most of the people miserably poor, as they have been for so many years.

The deserts of the world may have a future which even now seems impossible to believe. Deserts will not be deserts any more.

For millions of years water has played its part in shaping the earth. For thousands of years it has done much to shape the lives of men. This will be true in the future, too. But man will be able to control what happens to an extent that he never has before. This gives him a great responsibility. He will have

to learn to look ahead, to plan for the needs of people who will be living on earth hundreds of years from now. He will have to learn not just to control nature but to work with nature, because he is a part of it, with all the other living creatures in the world.

If we use it wisely, the water on the earth and under the earth can help to bring a better life to everyone.

CHAPTER 21

The Symbolic Meaning of Water

"Ho, everyone that thirsteth, come ye to the waters."

Isaiah 55:1

You must at some time have felt so thirsty that nothing seemed to matter except finding a good cool drink of water. Without it you could not enjoy the world. You could not even be at peace with yourself. Then you had your drink. Cool water filled your mouth and poured down your hot dry throat. You could feel the relief of it down to the tips of your fingers and toes. Your thirst was quenched, but that wasn't all. You were at peace with yourself and with the world.

If you waited a long time for your drink of water, your joy at finding it was greater still.

"As cold waters to a thirsty soul," says the Bible, "so is good news from a far country."

Through all his history man has celebrated in one way or another his need for water, the joy of finding water after a long thirst. He has found peace beside still waters. In wild and angry waters he has felt some of the anger and wildness of his own spirit. As he looked into the deep waters of the sea

or of a well he has felt that many mysteries could be solved if he could somehow learn understanding from the depths.

The writers of the Old Testament of the Bible had much to say about water. They knew the meaning of thirst. It seemed to them that it was a good God who gave water to His people.

Isaiah says, speaking for his God, "When the poor and needy seek water, and there is none, and their tongue faileth for thirst, I the Lord will hear them, I the God of Israel will not forsake them."

To a writer of the Psalms, too, God was the giver of water: "He sendeth the springs into the valleys, which run among the hills. They give drink to every beast of the field: the wild asses quench their thirst. By them shall the fowls of the heaven have their habitation, which sing among the branches. He watereth the hills from his chambers . . . He causeth the grass to grow for the cattle, and herb for the service of man. . . ."

And in the twenty-third Psalm, the psalmist can think of nothing more peaceful in the whole world than this: "He maketh me to lie down in green pastures: he leadeth me beside the still waters."

"As in water face answereth to face, so the heart of man to man." This is found in Proverbs.

The book of the Mohammedan religion, the Koran, says, "By water everything lives." There was more meaning in this than just the need of man for water to keep himself alive.

The ancient Greeks, too, knew the value of water. Their mythology includes many tales of punishments for misdeeds.

But one of the worst punishments was that of the mythical Tantalus, who was condemned to stand forever in a pool with his chin level with the water. Whenever he tried to drink, the water would flow away, leaving his feet dry and no water in his mouth. Perhaps the worst of this punishment was that though Tantalus was forever thirsty, he had to keep on living.

Through all of his history, man has done more than just speak words and tell stories about water. He has used water itself in some of his ceremonies, religious and otherwise, and he has made special ceremonies to please the gods so they would send rain.

Many peoples have held a ceremony of rejoicing in the middle of winter, when the days begin to grow longer and spring must be coming again to warm the earth. The followers of the ancient Persian prophet, Zoroaster, held such a ceremony. In the midst of it they sang a hymn to the sun, because the warm sun would bring the spring: "And when the sun rises up, then the earth . . . becomes clean; the running waters become clean, the waters of the wells become clean, the waters of the sea become clean, the standing waters become clean; all the holy creatures, the creatures of the Good Spirit, become clean." Spring was the beginning of a new life; the life-giving waters would be made pure by the sun.

Water has often meant purity or cleanliness. The ancient philosopher Confucius spoke of washing hands and clothes at a certain stream in order to get rid of evil. The strict follower

of the Jewish religion, Judaism, washes his hands before he prays.

Religions use water in the ceremony of baptism because it is a symbol of purity. For most Catholics and Protestants a little water from the hand of the priest or minister is enough. But some believe that the whole of a person must go into the water.

Baptism has not been only a Christian ceremony. It is more ancient than Christianity. Nearly two thousand years ago, on the shore of the River Jordan, in what is now Israel, John the Baptist baptized people with the water of the river. People who came to John in those days went away feeling that they had somehow been made clean and could start life over again. It was John who baptized a little-known teacher named Jesus who was to be called Christ.

People living by rivers, long ago, felt that the river flowing past them must be a living thing, or must be the home of a god or goddess. A river flowed on forever, without seeming to have a beginning or an end. Somewhere, out of sight, it might control the beginning and the end of life.

Religion in Egypt centered around the Nile River. In India, all rivers were considered sacred, but the Ganges most of all. Each year hundreds of thousands of pilgrims still journey to the Ganges, because they believe that its waters will wash away their sins.

Water has often been considered magic without having anything to do with religion at all. Ancient fountains and pools were supposed to have healing powers. The Spanish explorer

Ponce de León followed for years his quest of the mythical Fountain of Youth, which he had been told was somewhere in Florida. He never found it, but he could not quite believe that it did not exist.

We still like to believe that there is such a thing as a wishing well. In pagan times, people asked for some favor as they threw offerings into the well or left them near it, for the water sprite. Now we make a wish as we throw in a coin.

Most of the water or rain ceremonies which we have talked about have belonged to the past. But there are some that take place today, in much the same way that they have for hundreds of years. You might even see one of these yourself, if you could be in the right place at the right time.

The Hopi Indians in Arizona carry on a whole series of dances and ceremonies for rain, all year long. These are much more than just tricks or devices to make rain fall from the clouds. They are a real part of the religion of these people, with their own place on the calendar of their year, whether or not the season is a dry one.

Some of the ceremonies are masked dances to summon the Kachina "cloud fathers" who will bring rain. They sing:

"Listen, my mothers.
You have prayed
That it would rain on your plants.
Li-i- hi-la

Listen, listen
Listen, my fathers.
You have prayed
That it would rain on your plants.
Li-i hi-la.

"When you look after the rain
You shall see what you prayed for.
Li-i hi-la.
When rain falls among your plants
You shall see pools of water,
My fathers.
This is what you prayed for. . . ."

Most famous of all the Hopi ceremonies is the snake dance. This is performed once every two years, during the last days of August.

Snakes are supposed to have their own kind of magic. Snakes, which are symbols of lightning, can carry messages from the people to the god who can send rain.

But first there are eight days of ceremonies.

Snakes are gathered by the snake priests from all over the countryside. But they are not yet fit to take the message of the people to the gods. They must first be purified and blessed. With the snake and antelope priests and all the people, the snakes must go through the strange and exciting ceremony of the dance.

The snakes are washed in water and thrown onto a sacred

sand painting. Then, on the floor of the kiva, the sacred house, they must wait for the dance on the last day of all the ceremonies.

This day begins early. Men and boys race before dawn to distant springs and back to the snake kiva. People in the village crowd along the paths to watch. Then hours pass, with tense and hurried preparation. Everyone waits. At last, an hour or so before sunset, the dance begins.

Antelope priests enter, with white kilts and painted bodies. Three times they circle the plaza in the center of the village, with a rhythmic dance step. All the while they are singing a strange chant, over and over.

Then come the snake priests, painted with black faces and red bodies. They, too, circle the plaza three times. They line up opposite the antelope men.

The people watch quietly, entranced. It is as if they, too, were part of the ceremony. They, too, feel the rhythm of the chanting, the tense anticipation of what is to come.

The gourd rattles of the priests vibrate; they sound very much like rattlesnakes. The chanting goes on. The priests sway.

Then suddenly the lines of priests break up and they form into groups of three. Groups of three file past a bower of cottonwood branches. There another priest is waiting, with the snakes.

He hands one to the first man of every group. This man holds the snake tight in his mouth. Around the plaza they go.

Priests chant, music rises and falls. After four times around the circle, the priests who hold the snakes drop them. The third man in each group picks them up. Around they go again.

Then suddenly all the snakes are tossed onto a design on the

ground, made with sacred corn meal. Snakes wriggle all over. People try to keep them heaped up on the design. Some of them escape. Then there is laughter, the good relief of letting go in laughter after the tense hours of waiting and watching.

Snake priests pick up the snakes in handfuls and rush down the trails outside the village and let them go.

Now the snakes are ready to return to the rain gods. They can tell the gods that these are good people who have done their ceremony well. Surely they deserve good rain.

Now the whole village can relax. For four days there are games and races and special foods to eat.

Often it does rain after the snake dance. Sometimes there is even a cloudburst. You will not convince the Indian if you tell him that his dance had nothing to do with the falling of the rain. And perhaps we should not tell him. This is his religion, his way of speaking to the gods he thinks control the skies. For him it is a good way.

Other Indian tribes have other ceremonies for bringing down rain. And there are ceremonies in other parts of the world, not always for bringing rain, but for rejoicing in water.

In her book *The Good Master,* Kate Seredy tells about an Easter celebration among country people in Hungary. Easter for these people on the land meant the beginning of spring, life beginning again with sunshine and soft rain. On the Monday after Easter, the boys and young men went to visit families that had girls. One of them would speak the traditional words:

"Glory be to the Holy Father
Who gave us food and pure water.
As we water the rose to make it bloom,
We sprinkle the rosebud in this room.
May you live long,

Old and young.
Peace be with you on this holy day of Easter."

Then dignity would be forgotten as the boys brought out little bottles of water. They would sprinkle the girls while they screeched and tried to hide. The boys would then go home gaily, laden with meat and cakes and Easter eggs.

On Tuesday, the girls would sprinkle the boys.

This was fun, but it was more than fun. As the "good master" in the book says, "Every living thing depends on sunshine and water. So we celebrate Easter by giving each other the sunshine of hospitality, and we sprinkle each other with fresh, pure water."

There are still such ceremonies in some of the little villages of other countries in southeastern Europe, where the people have kept their old ways of doing things. One custom is to pour a pail of water over a boy or girl clothed in flowers or corn or grass. Then surely the rain will come! Or a boy may be dressed in leaves, crowned king of the rain, and sprinkled with water by all the villagers.

On the other side of the world from us, in Burma, the people have their own ways of celebrating water. Off in remote regions there are people who stage a tug of war to create excitement for the sky spirits, who will not produce rain unless they are excited. In the cities and towns, there is a spring festival devoted to water, called Thingyan. It comes in their hottest season. In former times, water was sprinkled sedately on the

older people. Now, for three days everyone goes around getting everyone else as wet as possible and letting themselves get wet. Boys merrily squirt every passer-by with water pistols. Girls toss water from pans and buckets. Young men drive around in jeeps with barrels of water to hurl at people. Someone grabs the fire hoses and turns them on the people in the streets.

There are parades and songs and dances, too. This is the water festival. When it is over everyone has cooled off a good deal, inside and out.

Water means many things to many people.

CHAPTER 22

Water and You

There are experiences with water which have nothing to do with water supply or industry or farming, or even with our own thirst. These are our experiences with the rain and the snow that fall from the sky.

All of us are acquainted with rain. But we do not all feel the same way about it.

In a big city like New York we may only complain about the rain. Raincoats are heavy to wear. Our good shoes may be spoiled. The baseball game is rained out. The cool touch of rain hardly reaches us under our umbrellas and rain bonnets. "Rain! What a bother!" we say.

This is not what we would say if we lived near Santa Fe, in our dry Southwest. Rain does not come often there, but it is apt to come fast and hard, with thunder and lightning. It is welcomed gladly by the dry earth and by the people, who waited so long for it. Rain for Santa Fe comes mostly from the West, across miles of Indian country, where the Indians concentrate on prayers for rain, dances for rain, and the night-long chants of the Navajos for rain:

"Far as man can see,
Comes the rain,
Comes the rain with me."

You may scoff at the Indians' way with rain, as you sit in your city apartment in the East, watching the showers in the streets. But in Santa Fe, after long dry weeks, it is easy to think that the Indians may have something to do with the falling of rain, after all. They are so sure of this themselves.

We do not have to endure weeks of dry weather before we can enjoy the rain. Go to the country. Walk through rain in the summer woods. Tree trunks are dark with wetness. Leaves on the trees are shiny with rain. Water runs together in the middle of leaves and drips onto the soft earth below. There is a murmuring sound of rain everywhere around us, everywhere in the world, it seems. That, and the steady drip-splash of drops from the trees.

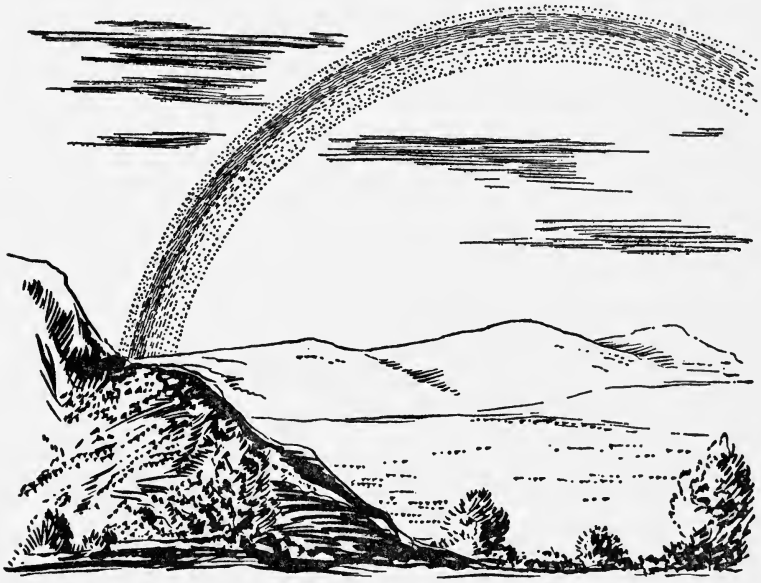
We cross the field, with the wet tickle of grasses against our legs. Here where often we have been so hot under the summer sun, we lift our faces for the cool touch of rain.

Now there is too much wind. We go inside. Rain on the roof makes a faraway roaring sound, though it is right above our heads. Water blows against our windows with sudden sting and fury. Little streams of water run down the pane.

We take off our wet shoes and warm our feet before the fire. Only on rainy days do we feel quite so comfortable and secure inside our house.

We go out again when we think the rain is over. The sun is shining over a wet world. Across the sky stretches the wide bright arch of a rainbow.

People sometimes dream of the rain. This, too, means different things to people in different places. Dreaming about the rain, or any water, in the dry Middle East, is considered good



luck. Dreaming about the sun means bad luck, because the sun in these countries shines too much and often destroys whatever grows in the earth. In northern countries that have plenty of rain, to dream about the sun is good. To dream about water is not always so, especially if the dream is of raging floods or storms. People who live near the great marsh in the heart of

the central Russian plain will tell you that to dream about water is very bad luck. They have too much water under foot, all the time.

Water that falls from the sky is not only rain. There is dew on summer evenings. Dew falls so quietly out of the cool evening sky that we do not see or hear it. In the city, we do not even know it is there. In the country, it is a fine mist over the leaves of plants in the garden. Early in the morning, we look out of our windows and see the neat patterns of spider webs across the grass outlined in silver with drops of dew. We hurry out in our bare feet. All the grass is wet, every blade with its own drops of water, though it has not rained. Someone has told us that if we wash our faces in the morning dew we will surely be beautiful. We scoop up water from the grass blades with our hands and rub it over our faces, half believing that this may be true.

All this is in the summer. But there is water in the winter, too. Outside, in the cold parts of this earth, water becomes ice. We skate over the ice of the lake with wide free strokes. Wind is cold on our faces. There is the sudden exciting *boom* of ice as it thaws or freezes.

Snow is not wet until it starts to melt, but it is water just the same, tiny crystals of water vapor that have frozen in the cold air high above the earth. There is no quietness like the sound of snow falling. Soft snow along the edge of roofs and wires and branches makes the world suddenly a hushed white place.

It seems a simple thing, this enjoyment of the rain and the

snow. And so it is. No matter what complicated uses are discovered for water, people will go on enjoying the rain from the sky, the wide rainbow that the sun makes shining through the rain, and the snow that falls so quietly around us in the winter time. This, too, is part of the story of water.

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