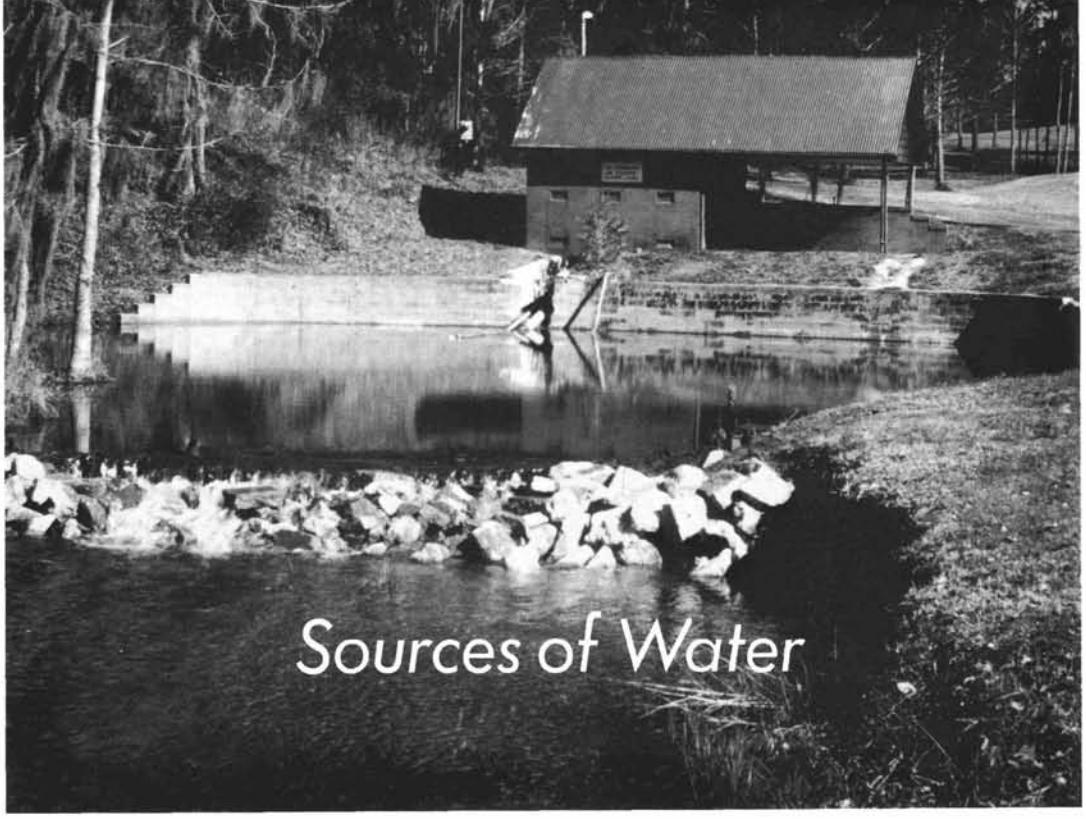

Sources of Water

by JAMES B. MONCRIEF, Southern Director, USGA Green Section

Rainfall is the original source of water. Records show that in Georgia we normally get enough rainfall in one year to cover the entire state to a depth of four feet. This is over one million gallons per acre. In some of the southwestern states it takes several years to receive this much water.

About 80 percent of the annual precipitation in Georgia returns to the atmosphere through evaporation from plant and soil surfaces and transpiration by plants. Most hydrologists often call this the total evapotranspiration. The remaining 20 per cent runs off the surface as immediate streamflow, or enters the soil and moves to the groundwater where it is available for pumping, or later returns as base flow in the streams.

Where a dense sod covers the land, less rain (2-3 per cent) leaves as surface water whereas on cultivated soil a high percentage of the water leaves as surface runoff. The type of soil will have much influence on loss of water by surface runoff.

Ponds, lakes, or reservoirs are important sources of water for industry, municipalities, and recreation. Groundwater has been used for thousands of years, and streams, springs, and wells no doubt were the first ground water sources used. Archeology of pre-historic people indicates that irrigation, or the application of water to lands by artificial methods, is a very old practice. Evidence points to Egypt as its place of origin. Ancient Egyptian paintings and sculptures show that water was bailed up for watering crops at least 4,000 years ago.

Modern irrigation was begun in the United States in 1847 by pioneers of Salt Lake Valley, Utah. Since that time, the practice has spread first into the richer and warmer valleys, and then generally throughout the arid part of the West. Golf courses are now being irrigated throughout the continental United States. Skinner Irrigation Co. was one of the first to design a sprinkler irrigation system in 1896.

There are seven principal methods of applying water to land:

1. Flooding—running water over a smooth field surface.
2. Furrow—applying water in furrows.
3. Check method—pooling water succes-

sively into checks or rather large pools or squares into which the fields may be divided.

4. Basin—similar to the check method except that the basins are smaller. This type is used primarily in orchards.
5. Border method—flood irrigation between controlling borders or ridges.
6. Sub-irrigation water below the surface accomplished by means of open drainage ditches and underground basins.
7. Sprinkler irrigation—application of water under pressure in pipes so that it comes through whirling sprinkler heads as a spray.

Most old, established courses of today are thinking of installing irrigation systems of some sort if they have not already done so. There are a few areas where precipitation is sufficient enough and irrigation is rarely needed. Such an area is Highlands, N.C., with a 36-year average of 82.63 inches annual rainfall, and Skamania County near Cougar, Wash., for an 11-year average of 117 inches annual rainfall. At the other end of the rainfall average is Agua Caliente, Ariz., with an 11-year average of 2.98 inches of rain per year.

Hydrology

In the middle ages, people believed that water in rivers flowed magically from the center of the earth. Late in the 17th Century, Edmund Halley, the famous English astronomer, calculated the amount of water flowing in rivers that empty into the Mediterranean Sea and found that their flow is about equal to the water falling in rain and snow on the area drained by the rivers. At about the same time, two Frenchmen arrived at the same conclusion.

Water is constantly being exchanged between the earth and the atmosphere. This exchange is accomplished by the heat of the sun and the pull of gravity. Water evaporates from wet ground, from the leaves of growing plants, and from lakes and reservoirs and is carried in the air as water vapor. When water vapor condenses, it changes from a gas to a liquid and falls as rain. The rain feeds the rivers and lakes, and the water is carried to the ocean by rivers. The water goes from earth to atmosphere to earth again and again. This process is called the hydrologic cycle. Hydrology is the study or knowledge of water. Hydro means having to do with water, and loge is a Greek word meaning "knowledge of."

Water in the Ground

Have you ever wondered where the water comes from which flows merrily along with not a cloud in the sky? Where has it been all the time?

One of the principal methods of applying water to turf.

Windmills are used to pump fresh water from top of saltwater.

In brief, it has been in the ground!

It is interesting to know how it got into the ground, how it moves from where it entered the ground to the place where it gets into the streams or rivers, and how long this takes.

You might compare the soil surface to a sieve. Water enters the soil and works its way down into cracks, crevices, and holes into larger cavities. On coarse sand or gravel there is fast movement into the earth. However, when rain falls on clay or fine-grained soils, the passage downward is slow and water may run off the surface. The water going into the soil is called infiltration.

Two forces are involved in the movement of water within the soil: capillarity and gravity. Capillarity can work both upward and downward where small particles are close enough together, very similar to cloth used as a lantern wick. When the soil strata are coarse, the water is pulled by gravity and flows downward more or less freely through the spaces. Similarly, water may flow downward through holes made by aerification, worms, or where roots decay. The water continues to move through various layers of soil, rocks, in caverns, gravel strata and from underground streams or lakes.

One of the deepest oil wells ever drilled is about 25,000 feet. This is almost 5 miles. Although this is deep, it is insignificant compared to 4,000 miles to the center of the earth. This well has penetrated deeper than the ordinary cracks found in the near surface rocks.

The soil or rock which contains or transmits water and is a source of underground water is known as an aquifer. An aquifer is an underground zone layer which is a relatively good source of water. Water can move from aquifer to aquifer, and the amount of water obtained can vary tremendously. One of the largest underground fresh water sources in the United States is in the north portion of Florida.

As water passes through different strata, it can collect minerals that affect its taste, color, or odor, and this can vary a great deal within a short distance. How long does it take water to move in the soil? Anywhere from a few feet per year to a few feet per day.

It may take hundreds of years for water to travel 20 miles, while in some areas the same distance may have taken months or a few years. In some of the arid parts of western United States water is being pumped that fell as rain during the ice age, or at least

10,000 years ago. Water being pumped from a well could have been stored underground for months, years, or centuries. If the water is pumped out faster than inflow to the storage basin, there is a lowering of the water table, but when the inflow equals the outflow, there is no change in the amount of storage water.

There are many places in the United States where the water levels are progressively going down because of overdrafts on the ground water supply. One such area is the Gila River Valley of Arizona; another is the high plains of northwest Texas.

Chemicals in Water

As water filters through various strata, chemistry can become complex. Rainwater usually contains less than 10 parts per 1 million of dissolved matter, or 1 million pounds of water contains 10 pounds of dissolved material. The dissolved material in rivers is usually less than 500 ppm, but some may contain 2,000 or more ppm. Most city water is less than 500 ppm, and any over this is considered undesirable. Brine water will contain as much as 10,000 ppm and is much too salty for use. Sea water contains about 35,000 ppm. The Great Salt Lake contains about 250,000 ppm.

Water from some areas of the shallow coastal plain aquifers of the late Pleistocene age generally is low in dissolved solids. In some areas, this water source also has a disagreeable odor caused by hydrogen sulfide. It may have a high iron content as well and is usually classified as hard water.

Silver Springs, near Ocala, Fla., has a flow of 500 million gallons of water per 24 hours and removes about 600 tons of dissolved solids (mostly calcium bicarbonate) per day.

Shallow water from dune sand along the coast in South Carolina is usually hard and contains dissolved solids. The water becomes softer because of base exchange in which calcium and magnesium ions are replaced by sodium ions resulting in sodium bicarbonate water having a pH of about 7.7 to 8.7. The base exchange has not been definetely identified, but a likely one is the glauconite, which occurs in formation of the Peedee and Black Creek of South Carolina. Another base exchange material in the coastal area is the clay mineral montmorillonite.

This gives some of the chemical reactions that can take place while water is in the ground. In other areas, you may find other chemicals in your source of water.

Unfortunately many golf courses are being built today without knowledge of the type of water available for irrigation purposes. Before considering any other factor in an improved irrigation system for your golf course, check on the availability, the purity and the amount of water you are going to require. Check your "water sources" first!

Good streams and ponds can add to the beauty of a golf course and to the members' enjoyment.