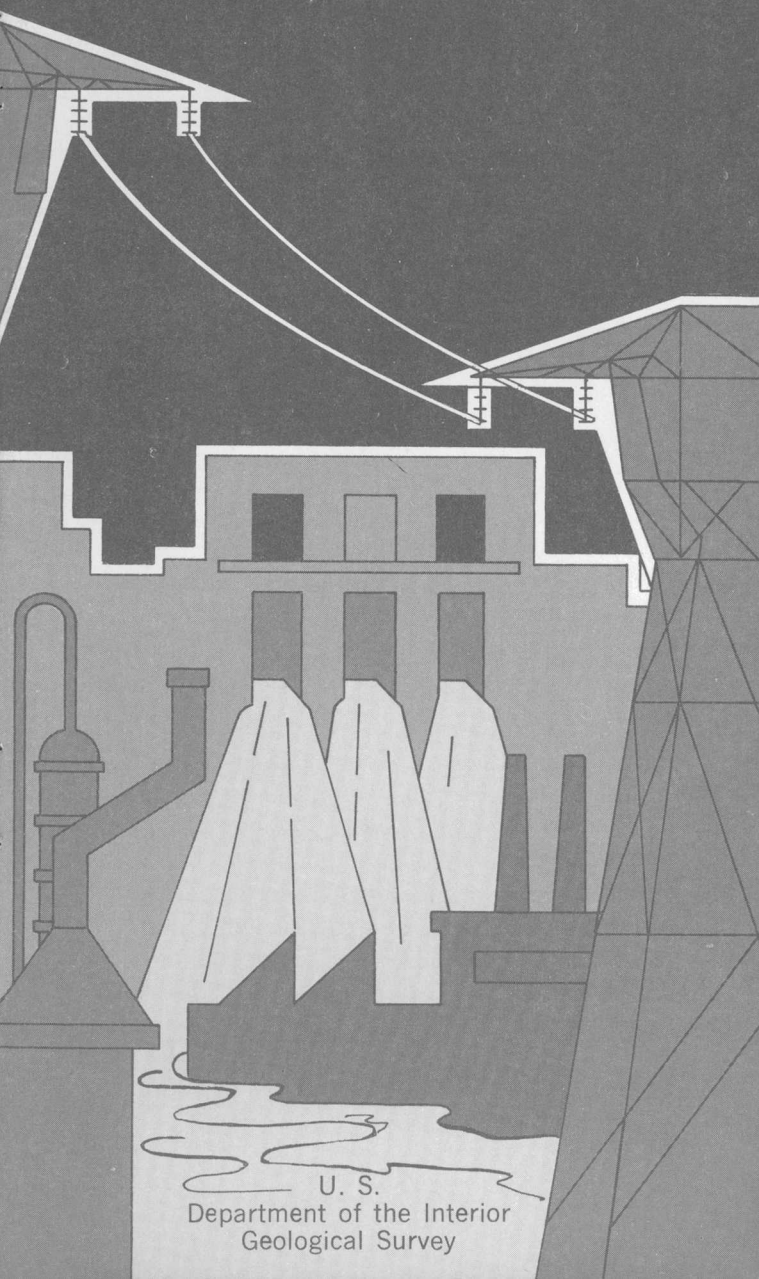
WATER AND INDUSTRY

in the United States



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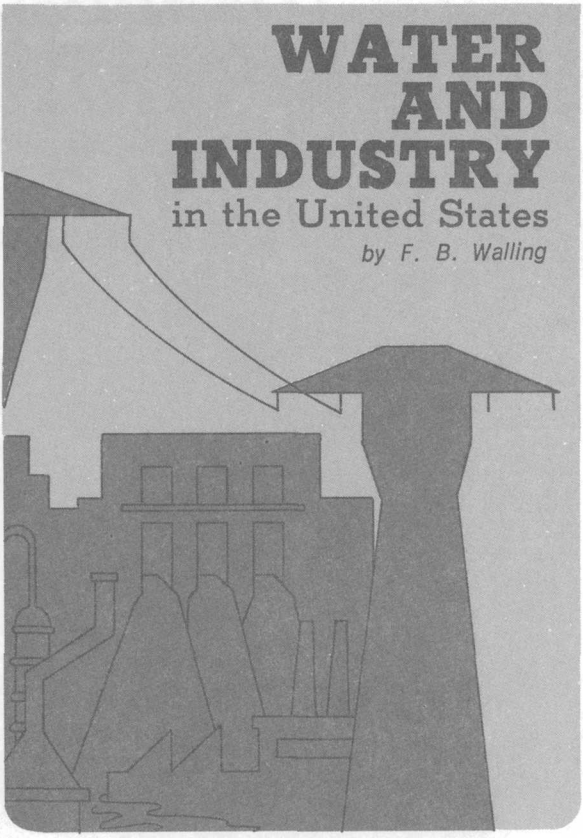


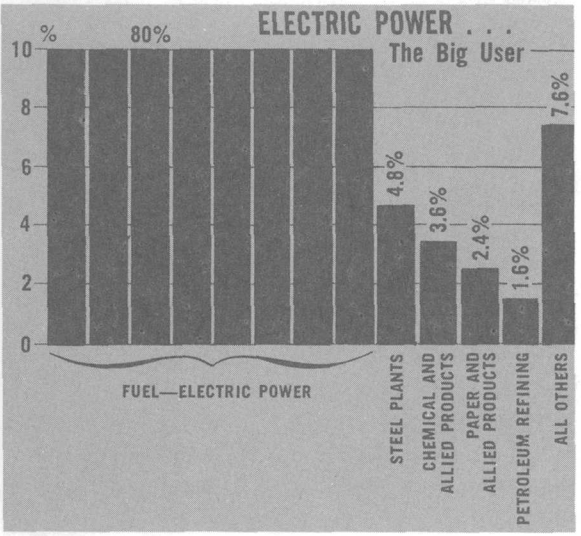
From the Beginning . . .

Man's economic and social progress depends on a plentiful and readily available supply of water. From his earliest days, man has found water to be an essential ingredient in improving his environment and the quality of life. Increased production of goods and continued introduction of new products have been accompanied by a phenomenal increase in water use. Industry, including hydroelectric power, now uses about 3 trillion gallons a day, or about seven times the average daily discharge of the Mississippi River.

Papermaking, a vital element in the advancement of our civilization, is perhaps the

best example of a manufacturing industry that has a steadily increasing need for water. Since its invention in China almost 2,000 years ago, papermaking has become one of the major water-using industries. Today the U.S. pulp and paper industry uses as much as 82,000 gallons of water to make a ton of Kraft paper. For better quality paper, more water is needed —as much as 184,000 gallons per ton of fine book paper. The paper in this leaflet (about ½ ounce of coated book paper) probably required 1½ to 3 gallons of water.

The first use of water to run machinery is lost in antiquity, but water was probably first used directly to drive pumps or grain mills. Today we still use water, indirectly, to drive most of our machinery: Water provides, or is instrumental in, the generation of nearly all electrical power. In the direct conversion of water power to electrical energy (hydroelectric power) in the United States, some 2.8 trillion gallons of water per day pass through turbines.



About 80 percent of the water withdrawn by industry is used to produce electric power. The percentage would be even larger, closer to 99 percent, if the in-stream use of water to generate hydroelectric power were included.

The electrical power produced by burning fuels (fuel-electric power) requires another 173 billion gallons of water per day, mostly for cooling.

Water withdrawn for the conversion of iron to steel, without which civilization as we know it could not exist, averages about 32,000 gallons per ton of finished steel. Some of the older steel plants may withdraw as much as 110,000 gallons of water to produce a ton of steel, whereas newer, more efficient plants may withdraw only about 1,300 gallons per ton of steel.

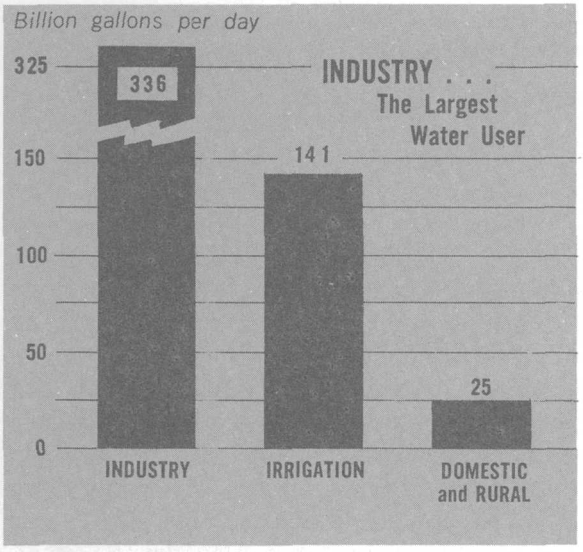
A gallon of the gasoline that is essential to the Age of the Automobile may require as much as 10 gallons of water in its refining. The petroleum industry as a whole uses an average of 468 gallons of water for every 42-gallon barrel of crude oil refined.

. . . Water Has Been Industry's Lifeblood

Water is truly the lifeblood of many industries. Compared to the major water-using industries noted above, many industries use little water. However, it is hard to name any major type of manufacturing industry that does not use any water.

Even excluding the huge demand of the hydroelectric industry (which is usually considered an instream "flow use" of water rather than a withdrawal use), industry in the United States withdraws or purchases water from various sources at the rate of 336 billion gallons per day. This is more than half as much as the average flow of the Mississippi River at Vicksburg, Mississippi (where the flow represents the runoff from about 40 percent of the total land area of the conterminous United States). It is easy to see how important water is to industry.

The gross amount of water used by industry is much greater than the amount withdrawn because much of the water is recirculated and reused. Gross water use is about 1.5, 2.5, and 4 times the withdrawal use for thermoelectric, manufacturing, and mineral production, respectively. Such reuse reduces significantly the amount of water that might otherwise be withdrawn. In addition to in-plant reuse, most of the water withdrawn is subsequently available for reuse elsewhere—at present, only



Even excluding the huge water demand of the hydroelectric industry, industry still withdraws water at an average rate of 336 billion gallons per day.

about 6 percent of the water withdrawn for use in manufacturing is actually consumed. (Water is considered to be consumed when it is evaporated or incorporated in a finished product and therefore is no longer available for use.) The water that is not consumed is returned to natural water bodies where it may be used again if it is of satisfactory quality.

Industry's use of water is increasing at a remarkable rate. It has increased more than

twentyfold since 1900, a period in which the population of the United States increased 2½ times. This means that for each person in the United States, industry uses more than 8 times as much water as it did in 1900. Industry in the United States now withdraws about 1,500 gallons per day per person. For comparison, an individual uses an average of only 60 to 70 gallons per day in his home, for drinking, washing, lawn watering, and other household purposes.

Is Industry Running Out of Water?

Public discussion of water needs and water shortages has induced the widespread notion that the United States will soon face a serious, permanent water shortage. This is not true; the overall supply exceeds the demand and will continue to do so in the foreseeable future.

In fact, the United States is water rich. Our streams carry an average of 1.2 trillion gallons of water every day to the oceans. Lakes in North America contain about 7,800 cubic miles of water (8.6 quadrillion gallons). The upper half mile of the Nation's ground-water reservoir holds some 50,000 cubic miles of water (55 quadrillion gallons). These vast stores of water dwarf industry's need for 336 billion gallons per day. Even allowing for an estimated 3- to 4-percent annual increase in industrial water needs, the United States as a whole has plenty of water for many years to come.

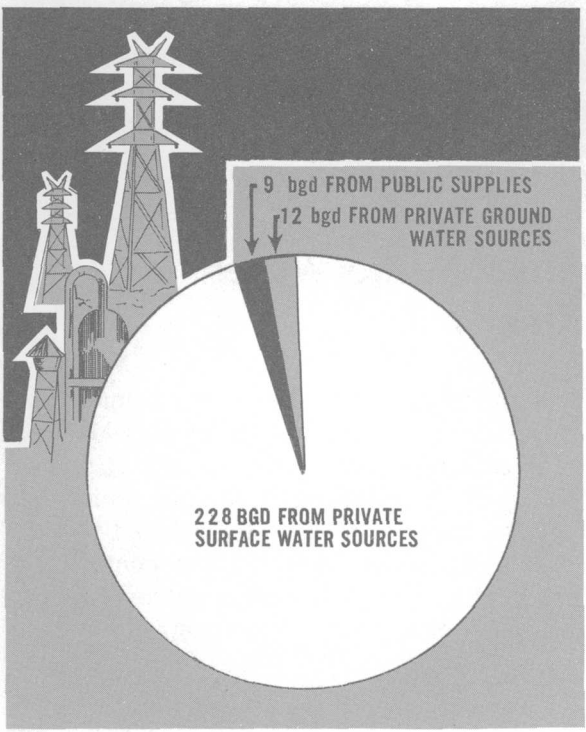
However, there may not be enough water of satisfactory quality at some places at the right times and at the right cost to support a given industrial plant. Of course, water can be provided for almost any conceivable purpose, but the cost may be prohibitive. Thus, cost, availability, and quality of water are some of the

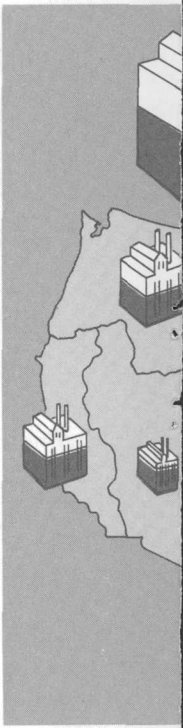
factors that must be considered in the selection of industrial sites.

Where Does Industry Find Its Water?

Of the total water used by industry, about 96 percent is obtained through private facilities and 4 percent is purchased from public water systems. Costs usually determine whether a company will purchase water or install its own system. For a company that uses a small amount, it is often less costly to purchase water; companies that use large amounts generally find their own systems more economical.

Sources of industrial water (including that for fuel-electric power) in billions of gallons per day.

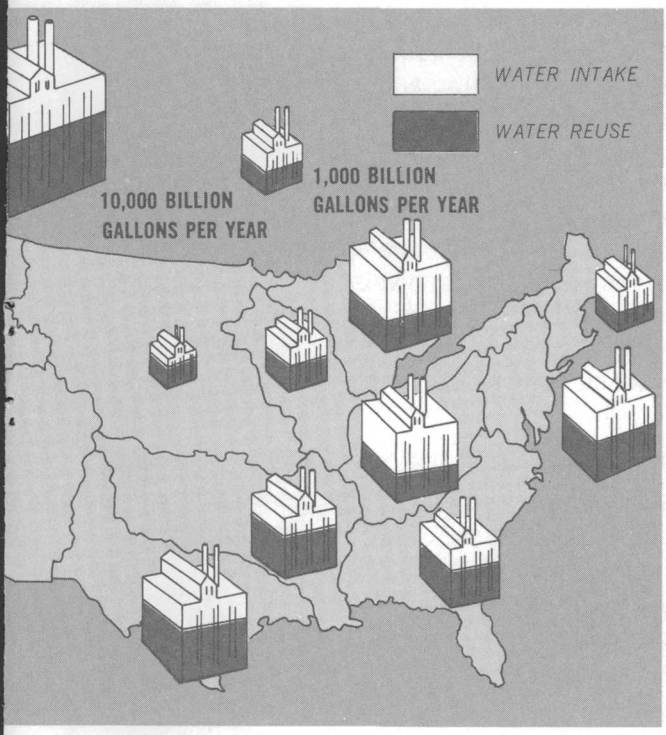




Quality is one of the determining factors in the cost of water. Of necessity, public water supplies must meet drinking water standards and may require extensive treatment, whereas water for some industrial needs may be used with little or no treatment. When the company water supply does not meet drinking water standards, a company may purchase the small amount of water needed for the personal use of its employees and provide water for other uses from its own sources. If water must be transported long distances, even companies that use large quantities may depend on public supplies. Most of the water used by industry, whether self-supplied or purchased, comes from streams or lakes. A lesser amount comes from wells and generally is used when water of high quality is required. In some places, ground water may be the only readily available and dependable source of water.

How is the Water Used?

Industry uses water for many different purposes. These uses are commonly divided into four categories: (1) cooling water, (2) process water, (3) boiler feedwater, and (4) sanitary and service water. Cooling water is used only for cooling and does not come into contact with the product or material being processed. Process water does come into contact with material being processed. Boiler feedwater is water converted to steam. Sanitary and service water is supplied for the personal use of the em-



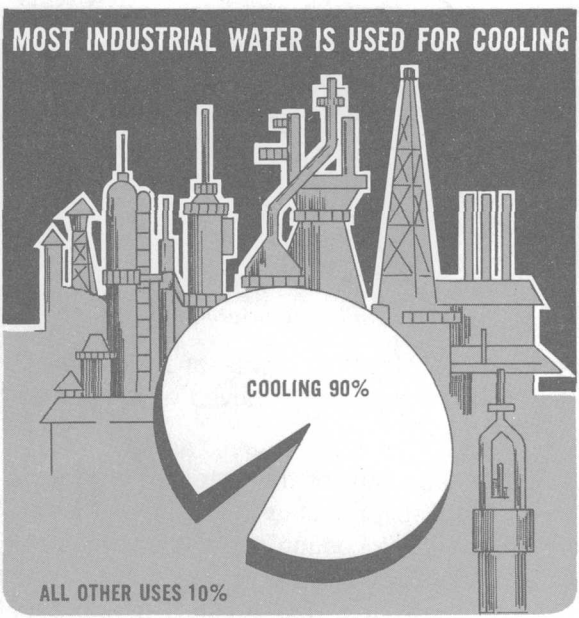
Regional water use in manufacturing.

ployees, for cleaning plants and equipment, and for the operation of valves and other apparatus.

About 90 percent of the water withdrawn by industry is used for cooling. Fuel-electric powerplants use more cooling water than all other kinds of plants combined. At first thought, one might suppose that the greatest amount of water used in fuel-electric power production is used for boiler feedwater, but such use is dwarfed by the amount of water needed for cooling condensers. Steam turbines operate most efficiently if the steam is condensed to liquid water after it passes through the turbines. This process also allows the condensed water to be recycled to the boilers. Cooling water is also used to condense many products of oil refineries and chemical plants and to protect industrial equipment from excessive

heat. A blast furnace in a steel plant may use as much as 30,000 gallons of cooling water for each ton of pig iron and may require as much as 35 million gallons of water per day.

Most manufacturing plants use process water at some point in the course of their operations. In 1964, industry in the United States used about 10 billion gallons per day as process water. In some plants the material being processed is in contact with water at almost every step in its conversion to the finished product. For example, in the production of pulp



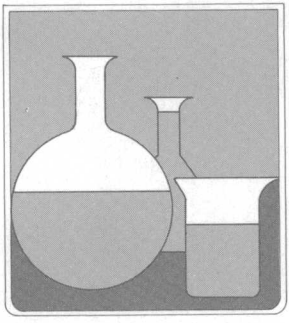
and paper, water is used for removing bark from pulp wood, moving the ground wood and pulp from one process to another, cooking the wood chips for removal of lignins, and washing the pulp. The cooling liquors are made up of various chemicals, such as sodium sulfite and sodium hydroxide that are dissolved in water. Water also serves as a solvent in many other chemical processes, and the food industry uses

large quantities of water for cleaning, cooking, and canning vegetables and meats.

Another industrial use of water is for disposal of waste products. At one time, streamflows were adequate to dilute, dissolve, or carry away these wastes. However, rivers in the United States are being progressively depleted by use and overloaded with wastes. This pollution not only upsets the delicate balance of nature among plants, insects, and fish but also poses problems of water quality for the people and industries downstream.

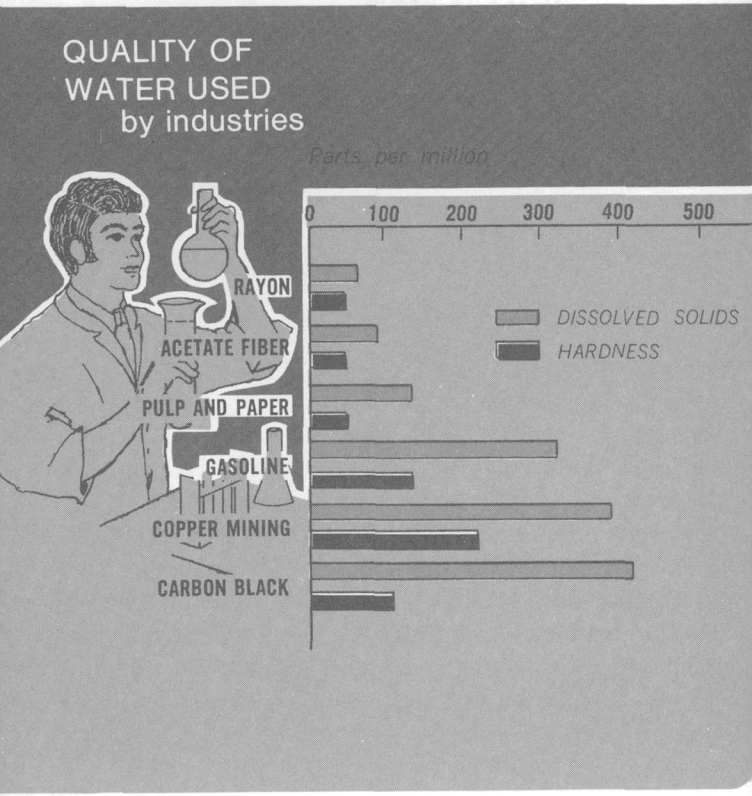
How Does Water Quality Affect Industrial Use?

Not only must industry's supply of water be adequate, but it must also be of suitable quality for the particular use. For some purposes, water should be as free of dissolved salts and other materials as possible. Feedwater for high-pressure boilers and process water for dyeing and washing textiles and for many chemical processes are in this category. Many natural waters that contain more dissolved salts than is desirable are demineralized by ion exchange or distillation. On the other hand, some salts are desirable in water used for other purposes. For example, the brewing industry requires water with a high calcium sulfate content but can tolerate very little nitrate, copper, or iron. Water that meets drinking



water standards suggested by the U.S. Public Health Service is good enough for most industrial purposes. In fact, many industries use water of much poorer quality. Saline water is used extensively for cooling. However, equipment designed to handle saline waters must be made of corrosion-resistant material, such as stainless steel, and is therefore more expensive.

Scale formation and corrosion are the two most common water-quality problems of industrial water systems. Scale formation is caused primarily by compounds of calcium and magnesium and, to a lesser extent, by other elements. Under certain conditions, especially when the water is heated, these elements precipitate as calcium carbonate, calcium sulfate, and other salts and become attached to ma-



chinery or container walls, especially heat-exchanger walls. One way to prevent scaling is to remove the scale-forming elements by softening the water before using it, but such softening is expensive when large amounts of cooling water have to be treated. A more common method is to use chemicals, such as sodium metaphosphate, to inhibit the formation of scale. Such chemicals interfere with the growth of crystals and thereby control the precipitation of scale-forming elements.

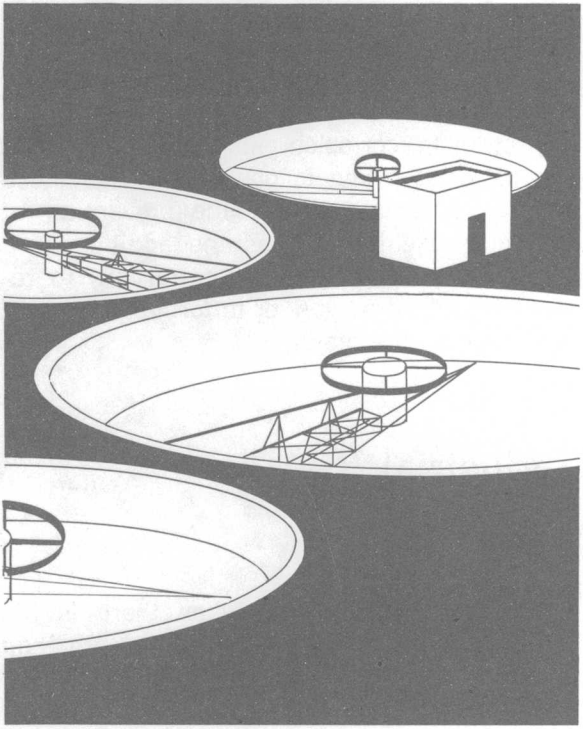
Corrosion in water systems results from many different causes, most of which are associated with the chemical content of the water. Corrosion may result from low pH content (acid solution) or very high pH content (alkaline condition). High dissolved-solids or high dissolved-oxygen concentrations generally promote corrosion. Many natural waters are corrosive owing to one or more of these conditions. Treatment for the prevention of corrosion usually involves the addition of a chemical or chemicals to control pH, to remove dissolved oxygen, or to form a protective coating over the metal.

Industrial Reuse of Water

What can industry do when there is not enough water of suitable quality? More than half of the manufacturing industry's water needs are met by reusing water. Industrial water reuse is most intense in the Western States where water is least abundant. In fact, several industrial plants in the West reuse water until it is completely consumed. No waste water comes from these plants. Such intensive reuse of water does have a built-in handicap. During each pass through a

plant, water quality is degraded by added contaminants or by an increase in the concentration of dissolved salts as the water is consumed. After repeated reuse, the dissolved salt can become too concentrated for a particular use, and the water must be either diverted to operations less sensitive to water quality or treated and returned to the stream or lake.

Water reuse also causes temperature problems. When it is used to cool other substances, water increases in temperature—by more than 50°F in some applications. As its temperature



increases, water loses its capacity for cooling: the warmer the water in relation to the substance being cooled, the less the cooling ability of the water. If the cooling water is to be reused, its cooling capacity is restored by

passing through a cooling tower, spray pond, or large lake. The water is cooled by (1) partial evaporation, (2) direct exchange of heat from the water to air, and (3) radiation. On the average, about 2 percent of the water is lost by evaporation for each 10°F decrease in temperature. For example, if 100 gallons of water at 100°F were cooled to 90°F in a cooling tower, about 2 gallons would be evaporated.

Another example of water reuse is the increasing use in industry of the effluents from municipal sewage treatment plants. Such reuse does present special problems. Even though the sewage may be treated to high standards, special precautions must be taken to prevent the growth of slimes and algae in a water system. A number of elements that promote biologic growth (particularly nitrogen and phosphorous) are abundant in these effluents.

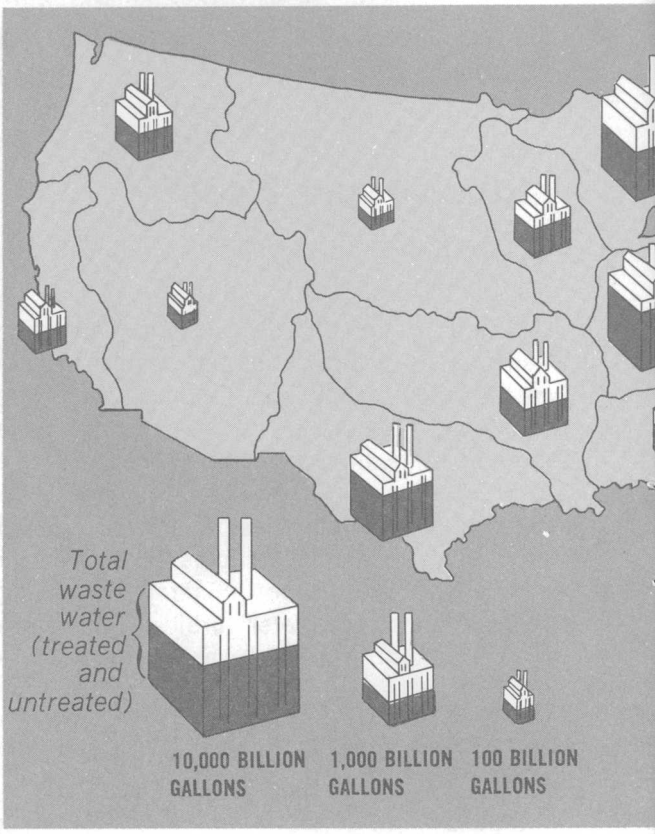
Industry and Water Pollution

Various kinds of pollution are caused by inadequately treated industrial wastes. Organic wastes come mostly from food-packing plants, petroleum refineries, petrochemical plants, and pulp mills. Inorganic wastes are chemicals, such as acids and cyanides, that come from many different industries. There is also pollution from insoluble particles (such as sand and other wastes from mineral processing) that may make the water turbid or may settle to the bottom and smother purifying organisms. Finally, there is thermal pollution produced when heated water is discharged to a stream or lake where it raises the receiving water temperature above the natural level.

Industry has a stake in the attempts to

improve the quality of our lakes and streams. Under Federal and State pollution control legislation, water quality standards have been established for most lakes and streams in the United States. All industries will have to contribute to this effort by treating waste water when necessary and by exercising greater care to prevent accidental discharge of potentially harmful substances. Industries are now tooling up for this effort through installation of waste water treatment works and through research on new and more efficient treatment methods to maintain the supply as well as the quality of the water.

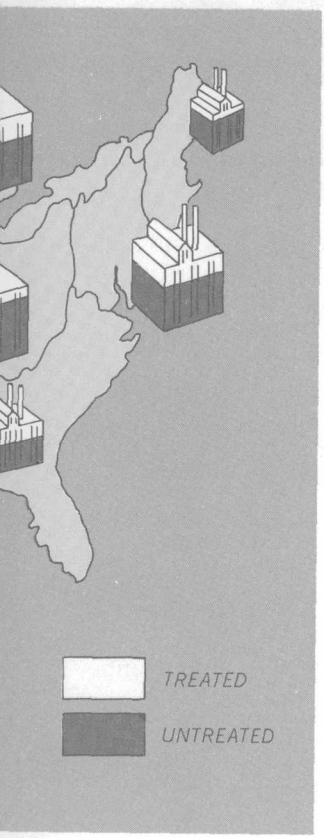
Regional annual discharge of treated and untreated waste water by manufacturing industries.



Water and Industry: The Future

The industrial water picture is obviously a complex one. National averages of industrial water use do not mean very much. Comparisons of supply and demand, even in a local area, are not very meaningful unless the quality of the available supply and the quality requirements of the industry also are considered. Requirements vary from plant to plant, depending on the product, the process used, the kind of water available, and the amount of recirculation practiced.

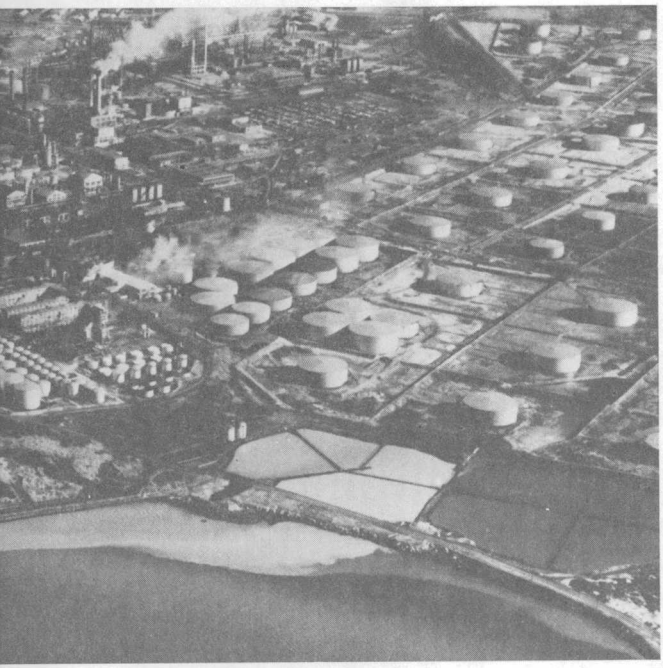
This complexity makes accurate forecasting of industrial water use for the future difficult. Products and processes become obsolete. Recirculation and other water-use practices change with the times. For example, the present trend in the textile industry is to replace natural fibers with synthetic materials, whose manufacture requires larger quantities of water.



The cheapest and most accessible sources of water have already been developed. Because of pollution, many of the easily developed water supplies now require treatment to make the water suitable for industrial use. As the

cost of water development and treatment increases, conservation practices will necessarily become more attractive and tend to cut back the amount of water used by industry. For example, the largest industrial use—freshwater for cooling—can be reduced greatly by using the water several times and by using saline water when it is available. The added cost of corrosion-resistant machinery may be offset by the lower cost of developing the saline water. As the cost of freshwater goes up, the use of saline water will be increasingly favored, just as air-cooling systems instead of water-cooling systems are being adopted in some industries.

Without a doubt, the demands and competition for our better quality freshwater supply are becoming critical in some areas, and this trend will continue. Industries using large quantities of water will be discouraged from locating in water-poor areas. The total cost to



An oil and chemical complex in Paulsboro, New Jersey.

industry of obtaining water and of treating industrial wastes will probably rise in the future because of more competition for freshwater and a greater demand for more intensive treatment of wastes. Although industry will have to plan more carefully for adequate water supplies and treatment in the future, the primary water problem does not appear to be the adequacy of the water supply but rather the cost of developing an adequate supply of usable quality.

* * *

For Further Information:

Murray, C. R., and Reeves, E. B., 1977, Estimated use of water in the United States in 1975: in preparation.

U.S. Bureau of the Census, 1975, Water use in manufacturing, in 1972 census of manufacturers: U.S. Gov't. Printing Off., 198 p.

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