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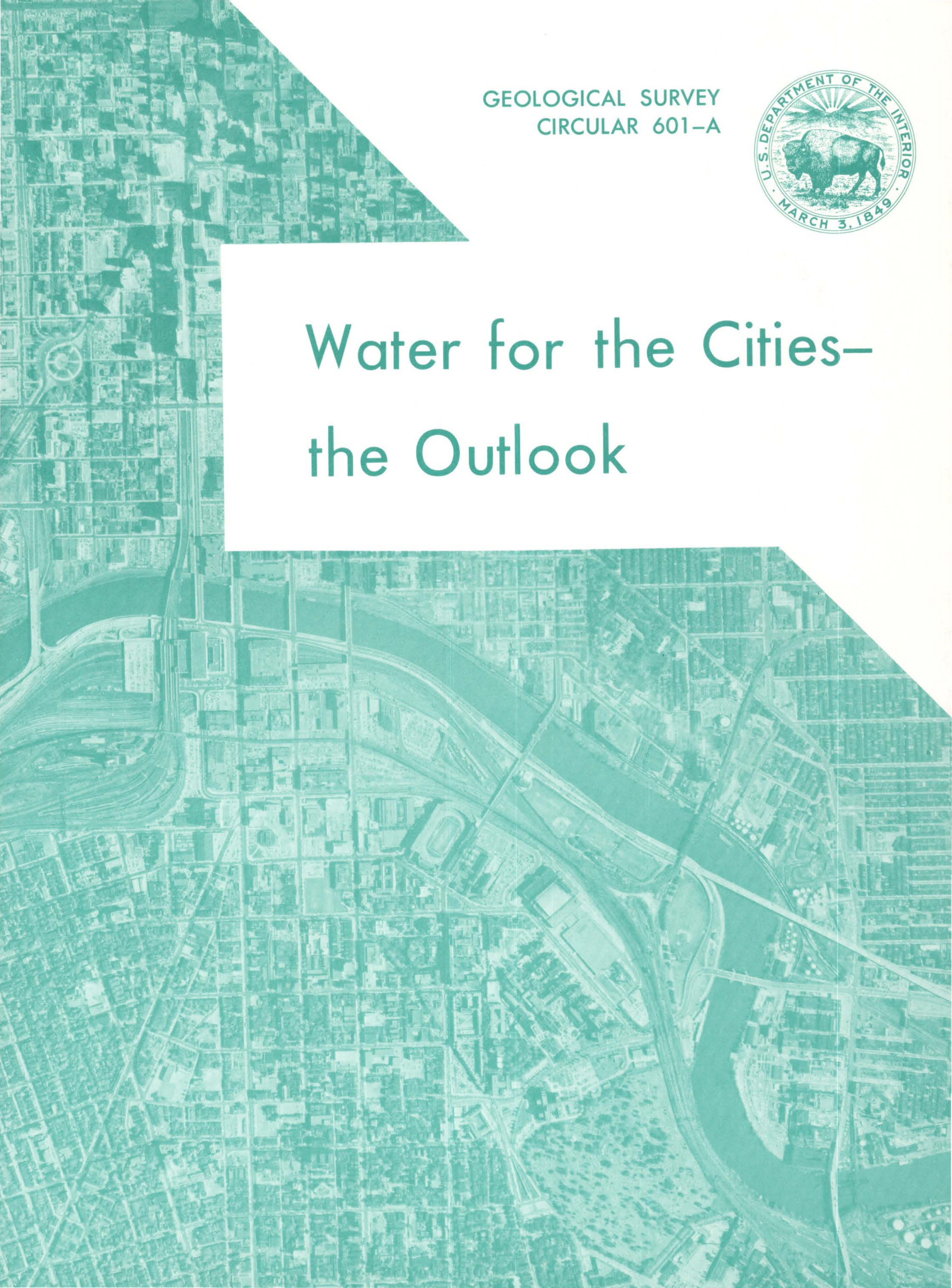
Water for the Cities–the Outlook



Water for the Cities—the Outlook

By William J. Schneider and Andrew M. Spieker

WATER IN THE URBAN ENVIRONMENT

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FOREWORD

Urbanization—the concentration of people in urban areas and the consequent expansion of these areas—is a characteristic of our time. It has brought with it a host of new or aggravated problems that often make new demands on our natural resources and our physical environment. Problems involving water as a vital resource and a powerful environmental agent are among the most critical. These problems include the maintenance of both the quantity and quality of our water supply for consumption, for recreation, and general welfare and the alleviation of hazards caused by floods, drainage, erosion, and sedimentation.

A prerequisite to anticipating, recognizing, and coping intelligently with these problems is an adequate base of information. This series of reports is intended to show the relevance of water facts to water problems of urban areas and to examine the adequacy of the existing base of water information.

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ABSTRACT

Except perhaps for the arid Southwest, water resources are generally sufficient to meet the needs of cities for the foreseeable future. Cities will continue to expand and additional rural areas will be converted to urban and suburban complexes. Demands for urban water will continue to rise and this will place a heavy strain on existing systems.

Cities have always faced water problems. This has largely been the result of "crisis planning" or apathy. Immediate needs and minimum cost have been the governing criteria in solving water problems, as cities developed local supplies unilaterally and only at scales to meet local foreseeable demands. Most city water problems, however, have not been the result of shortages of sources of water, but rather the result of overtaxed collection, storage, and distribution systems. This is verified by the experience of the Northeast during the recent prolonged drought.

Rapid expansion of urban areas, particularly in the large metropolitan complexes of the United States, is placing urban political entities in ever closer juxtaposition to each other. The large demand for water for each entity is resulting in competition for available sources and is rapidly reaching critical proportions. Increasing awareness of the role of water in our society further complicates this competition. Pollution abatement, recreation, wildlife conservation, and aesthetics are demands now recognized by both rural and urban areas. Future development of water resources must consider regional demands and resources. Only in this way can our reasonably abundant water resources meet the severe demands imposed by our rapidly expanding urban areas.

[1]This paper was presented at a symposium on "Geology and the urbanization process," at a meeting of the Northeastern Section of the Geological Society of America, Albany, N.Y., March 14, 1969.

THE PROBLEM

If water is used as a criterion of evaluation, we are indeed an affluent society. All economic levels of our society use it extravagantly. This is especially true of the urban dweller and his suburban neighbor who are accustomed to an almost unlimited supply at the turn of a faucet handle. Our society in 1965 used more than 150 bgd (billion gallons per day) of water to meet its needs and satiate its desires, exclusive of rural and agricultural uses. In addition to this direct use, the social impact of water resources is increasing demands for its consideration for fish and wildlife conservation, recreation, and aesthetics. Because water is neither created nor destroyed in sufficient quantity to alter significantly its total amount on earth, our supply is essentially limited. But is this supply sufficient? Are we running out of water? To answer this, though, we must also consider a related question: Why do our cities now face water problems?

The United States is rapidly becoming an urbanized society. According to Bureau of Census figures, about 130 million people—two out of every three persons—lived in metropolitan areas in 1965. Between 1960 and 1965, this urban population increased by more than 11 million people—an increase of over 9 percent. To meet the demands for this urban population, municipal water systems are supplying more than 24 billion gallons of water per day.

If population predictions can be relied upon and existing water-use practices are continued, during the next decade and a half the United States will be called upon to provide more than twice this amount of water to meet the demands of the metropolitan areas. Population predictions estimate that by the year 2000, about 280 million people will live in metropolitan areas—about 85 percent of the population of the United States. Supplying water for this urban growth will be a major challenge to the urban planner, the engineer, and the geologist.

Lewis Mumford (1956, p. 395) sums up the urban water demand as follows: "Already, New York and Philadelphia*** find themselves competing for the same water supply, as Los Angeles competes with the whole state of Arizona. Thus, though modern technology has escaped from the limitations of a purely local supply of water, the massing of population makes demands that even apart from excessive costs (which rise steadily as distance increases), put a definite limit to the possibilities of further urbanization. Water shortages may indeed limit the present distribution long before food shortages bring population growth to an end."

Mumford may be overly pessimistic in his outlook, though. Hydrologic data indicate that enough water is generally available for man's needs, but not always where and when he needs it or at a cost he considers reasonable. According to the Water Resources Council's First National Assessment (1968), water demands for all uses totaled 270 bgd in 1965, with a consumptive use of 78 bgd. Projected requirements for the year 2020 show total demands will be at 1,368 bgd and consumptive use, at 157 bgd. This current demand is less than 7 percent of the average of 4,200 bgd precipitation that falls on the conterminous United States, and the projected demand is less than 33 percent of the present average. However, seasonal and spatial variability in precipitation make these figures misleading; the history of water supplies for urban areas has been a constant cycle of shortage and development. A look at the history of municipal supply for two major cities and at the regional effect of the recent Northeast drought will illustrate this point.

MIAMI, FLA.

Miami, Fla., derives its water supplies from ground water in the Biscayne aquifer—a highly permeable water-bearing limestone that underlies much of southern Florida. The first wells were drilled into the Biscayne aquifer in 1896 to supply water for the newly constructed Royal Palm Hotel and for the Miami Hotel, heralding the start of massive urbanization of the area. In 1900, the local water system served a population of 1,680; by 1925 the population had increased to 30,200. New wells, added in 1907 to the existing location at Spring Garden, supplied municipal water at rates that lowered the water table until salt water encroached on the well field and forced its abandonment in the early 1920's, only 2 years after pumps were added to obtain the necessary flow.

In 1925, the Spring Gardens well field was abandoned, and new wells were drilled in the Hialeah-Miami Springs area. However, increased demand for water coupled with the need to lower water levels for flood protection caused salt-water intrusion at this site, and stringent remedial measures have been necessary to insure protection of this source. Only through concerted efforts at preventing overdrainage and controlling water levels through construction of salt-water barriers in drainage canals has further contamination of Miami's water supply been averted.

Despite present conservation measures, increased water use by an expanding population will undoubtedly cause further problems in water availability, in salt-water intrusion, and in pollution. Population estimates by the Dade

County Development Department, for example, predict an increase for the Miami area from 1 million people in 1960 to 4 million people in 1995. Daily water use is also expected to rise, from 145 gallons per person in 1960 to 220 gallons per person in 1995. The per capita increase results from a projected expansion in industrial water use. The total increase in water use will require 1.4 bgd as compared with the present use of 230 mgd (million gallons per day).

To supply this 1.4-bgd requirement in the future, Kohout and Hartwell (1967) estimate that the entire amount of rainfall over a 500-square-mile area would need to be collected. They point out, however, that total rainfall is never available for man's use; in the Everglades, almost 80 percent of the rainfall is consumed by evapotranspiration. Therefore, if the remaining 20 percent—10½ inches per year—were diverted to the Miami well fields, it would require an area of 2,800 square miles to supply Dade County alone in 1995. This is an area as large as the entire Everglades from Lake Okeechobee to Cape Sable.

The Miami case is an excellent example of a large metropolitan water system where careful planning has averted shortages and assured an adequate supply to meet future demands. The increased demands will probably be met by water management practices such as reduction of fresh-water discharge to the ocean via canals, by backpumping excess water to inland storage reservoirs, and by reuse of water. Water is a reusable resource, and advanced technology and enlightened water management should insure a continuing supply of fresh water in southern Florida.

NEW YORK CITY

The history of the New York City water-supply system presents a somewhat different situation. Whereas Miami has an abundant supply locally available, New York has had to go to great lengths—literally—to meet its demands.

In its early years, New York's water was supplied by shallow wells and small reservoirs, all privately owned. None of these sources was satisfactory, and epidemics were frequent. By the 1820's it was clear that a public supply was needed, but there were no adequate reservoir sites nearby. New York's population was then approaching 300,000. A proposal to build a 37-mile aqueduct to a reservoir site near Croton was first considered preposterous but gradually became accepted as a necessity. A cholera outbreak in 1832 killed 3,500 people and dramatized the necessity of a new supply, which was authorized in 1834. A disastrous fire in 1835 further demonstrated the desperate need and construction was accelerated. The system was completed in 1842.

At that time the Croton Reservoir was no doubt regarded as the ultimate answer to New York's water needs. Within 20 years, however, it had to be enlarged. Several new reservoirs and a larger aqueduct were needed before the turn of the century. By then, all satisfactory sites in the Croton watershed had been exhausted, and the demand was fast catching up with the available supply. Clearly, new sources of supply would have to be sought.

The Catskill Mountains, about 120 miles from New York, were chosen for the new reservoir sites. Construction began in 1907, and the system was completed in two stages: the Ashokan Reservoir was completed in 1917 and the Schoharie Reservoir, in 1928. Although addition of the Catskill system more than doubled the previous supply, the new supply was barely able to keep up with the rapidly increasing demand. By the late 1920's another water crisis was in sight.

This time alternatives were considered. The Hudson River was ruled out because of its allegedly inferior quality. New Yorkers insist on drinking pure mountain water. The Adirondacks were eliminated because of the excessive distance. In 1928, then, it was decided to expand the Catskill system and to develop new reservoirs in the headwaters of the Delaware

River basin. The Delaware River is an interstate stream, so the consent of New Jersey and Pennsylvania was needed to divert water from this basin. The issue was resolved after considerable litigation in 1931 by a decree of the U.S. Supreme Court that allowed New York to divert no more than 440 mgd from the Delaware River basin. First the depression, then World War II delayed construction. The first operational phase of the expansion consisted of an emergency diversion from Rondout Creek to the new Delaware aqueduct from 1944 to 1951.

In the meantime, yet another crisis occurred. The postwar urbanization explosion strained the Croton and Catskill systems almost to their limit. Average pumpage exceeded 1 bgd. Abundant rainfall deferred the day of reckoning until 1949, when reservoir levels dropped to the danger point. Stringent water conservation measures were enforced, and for the first time the Hudson River was tapped at Chelsea as an emergency source of supply.

Rondout Reservoir, an expansion of the Catskill system, became operational late in 1950 and the diversion from the Hudson was discontinued. Neversink and Pepacton Reservoirs, with their diversion appurtenances, began being used in 1953, but full use of the Delaware system was not achieved until 1955.

History repeats itself. The crisis of 1949 and the forecasts of the even greater population explosion to come made the water planners all too painfully aware that even the Delaware River basin supply system under construction would only temporarily satisfy the city's needs. An additional source would be needed. Thus, planning began for a new reservoir in the Delaware River basin. In 1954 the Supreme Court authorized New York to increase its diversion and in 1955 construction started on the Cannonsville Reservoir. Planners estimated that, with this new addition, the system would have total capacity of 1,800 mgd, sufficient to meet demands through 1980.

The record breaking drought of 1961–66 occurred, however, before the Cannonsville Reservoir was completed. At one time the existing reservoirs were drawn down to 26 percent of capacity (near the minimum safe drawdown for which the system was designed). The most stringent water-use controls in the city's history were put into effect, and the Chelsea pumping station on the Hudson River was rebuilt. By 1967 abundant rainfall eased the crisis, and the situation returned to "normal." But if history can be taken as any guide, it will not be too long before New York is again faced with a water crisis. Indeed, planning has already started an alternative means of meeting expanded needs.

The history of the New York water system has been one of continuing crisis in order to satisfy the demands of the population explosion. Yet part of the water demand might be regarded as unnecessary or artifical. Wasteful and inefficient use of water is encouraged by the absence of metering and unrealistic pricing. While the elaborate network of reservoirs and aqueducts has been built at great cost, the Hudson River, which might supply New York's needs many times over, has, like many other rivers, been allowed to degenerate in quality. The State's Pure Water Program improvements show promise of effecting some regeneration. Planning decisions must be sensitive to economics, politics, and public attitudes. The citizens of New York have become conditioned to drinking "mountain water," and any change in established practices of water supply would require a massive campaign of public information and education.

NORTHEAST DROUGHT OF 1961–66

The recent drought in the Northeastern United States points out the regional impact of natural catastrophic events on water for urban areas. In September 1961 precipitation and water levels throughout the northeastern part of the United States fell below normal. Although unheralded at the time, it marked the beginning of a drought—the largest, longest, and most severe in the history of the Northeast United States.

For over 5 years the drought persisted over a 13-state area extending from Maine to North Carolina, an area of more than 400,000 square miles. Each year since 1962 there was a reduction in yields of crops and pasture lands and an increasing threat and occurrences of forest fires. The effects on public water supplies increased with the duration and intensity of the drought. The effect was cumulative from year to year as reserves were depleted and streamflow and ground-water levels dropped to record lows. During the early part of the drought, the effects were largely absorbed by the built in resiliency and planned reserves of the water supply systems. By the summer of 1965, though, about one public water system out of every eight found its reserves at critically low levels.

Drought-related water shortages and problems in 1965 were severe enough to warrant emergency actions by federal, state, and local agencies In Maine, 21 supply systems restricted water use; more than 50 towns and cities in Massachusetts imposed restrictions; 14 systems in New York faced water shortages; and northern New Jersey, with its interconnected water companies, was also seriously affected. At one time, storage in the New York City reservoir system was reduced to 124 billion gallons, only 26 percent of maximum capacity, and the chloride concentration in the Delaware River at the Philadelphia water intake at Torresdale reached over 50 mg/l (milligrams per liter), with the 250 mg/l isochlor located only 8 miles downstream. At the height of the drought, the water-use habits of more than 20 million people were directly and drastically affected.

Only concerted efforts at all levels enabled the region to continue to supply the water needs. Stringent conservation measures such as bans on use of water for air conditioning, car washing, and lawn sprinking were enacted. A "water bank" was established in the New York City reservoir system to retain the 200 mgd which normally would be released for flow augmentation in the Delaware River and permit greater flexibility in management of that system. Emergency actions were taken to rehabilitate the Torresdale water intake for Philadelphia.

Many wells in the region, both individual and public supplies, "went dry" and had to be deepened, redeveloped, or replaced with wells of greater capacity. Here again, these well failures usually did not reflect insufficient sources of supply, but rather inadequately planned or constructed wells.

Despite the critical water shortages, it should be emphasized that never during the drought was there an overall shortage of water in the region. During the entire emergency there was only one outright failure of a city water-supply—that of Lancaster, Pa. The shortage was rather one of facilities for its collection, treatment, storage, and delivery to points of need. The execution of carefully prepared long-range plans can without doubt meet all water requirements of the Northeast for many years.

OUTLOOK

The experiences of Miami, New York, and the Northeast region point out the universal problem of municipal water supply: population growth has tended to outstrip development. In the past, many municipal water systems have operated on marginal conditions. Because of the massive investments involved water utilities seldom manage to keep far enough ahead of our burgeoning population.

These marginal operating conditions suddenly become critical when faced with catastophic events such as salt-water contamination of a well field or a series of near-dry reservoirs resulting from drought. This situation points more to lack of planning and development rather than to actual water shortages. Water is available for the cities, but the cities must plan effectively and in coordinated fashion if the requirements of all are to be met.

Predicted demands for municipal water are expected to increase from 23.7 bgd in 1965 to 74.3 bgd in 2020, an increase of 213 percent (Water Resources Council, 1968, p. 4–1–4). This demand will strain our ability to meet water requirements for the cities, but the job can and must be done.

Planning will play a major role in insuring adequate water for the cities. Regional planning must supersede local-interest planning as cities are ever increasingly forced to expand their sources of supply. As these sources of supply overlap, jurisdictional disputes will undoubtedly develop. Regional planning must replace uncoordinated unilateral development if chaos is to be avoided.

Moreover, the water-resources planners of the future will have to use considerably more imagination than has been evident in some of the plans of the past and the present if the job is to be done. Management of both the resource and its use may be necessary as the demand approaches the available supply. All alternative sources of supply should be considered in order to arrive at an optimal plan. For example, ground water could be used to supplement a surface reservoir or vice versa. The conjunctive use of surface and ground water should be considered; in many situations this may be the most efficient solution to the water-supply problem. Research is needed in advanced techniques of treatment that could convert marginal or unsatisfactory sources into usable supplies. Desalination, as it becomes economically viable, must be considered as an alternative.

The management of water use could be fully as important as the management of water supplies. It has already been demonstrated that water use can be substantially reduced by judicious management. Industrial water systems can be designed so that most of the water is reused. Saline water could be used in some instances for cooling, which accounts for a large part of industrial water use.

Water-use management need not be confined to industry, however. Municipal supplies can be made more efficient by systematic detection and repair of leaks in water mains. Modern plumbing fixtures generally use less water than outmoded ones. In this regard, building codes can require such fixtures in new construction. Water of less than drinking-water quality could be used for some domestic purposes such as lawn watering and air conditioning. Realistic pricing would exert a strong influence on water-use habits. Public education and information campaigns might be necessary to gain widespread public acceptance of such changes in traditional water-use practices.

The outlook for water for the cities then, can be regarded as cautiously optimistic. Though the population explosion of the next half century will strain existing systems, the water demands for our cities can be met. To meet these demands, however, coordinated comprehensive planning that gives adequate consideration to all viable alternatives must replace the crisis planning that has characterized much of the water-resources development of the past.

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