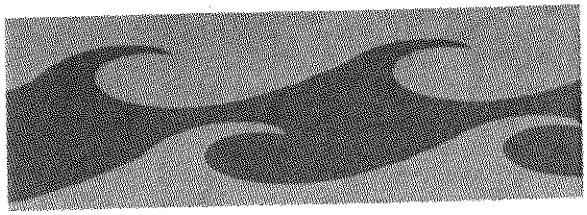
chapter 6



Water Distribution Systems

The objectives of a municipal water system are to provide safe, potable water for domestic use; adequate quantity of water at sufficient pressure for fire protection; and industrial water for manufacturing. A typical waterworks consists of a source-treatment-pumping and distribution system (Figure 6-1). Sources for municipal supplies are deep wells, shallow wells, rivers, lakes, and reservoirs. About two-thirds of the water for public supplies comes from surface-water sources. Large cities generally use major rivers or lakes to meet their high demand, whereas the majority of towns use well water if available. Often groundwater is of adequate quality to preclude treatment other than chlorination and fluoridation. Wells can then be located at several points within the municipality, and water can be pumped directly into the distribution system. However, where extensive processing is needed, the well pumps, or low-lift pumps from the surface water intake, convey the raw water to the treatment plant site. A large reservoir of treated water (clear-well storage) provides reserves for the high demand periods and the equalizing of pumping rates. The high-lift pumps deliver treated water under high pressure through transmission mains to distribution piping and storage.

The distribution consists of a gridiron pattern of water mains to deliver water for domestic, commercial, industrial, and fire fighting purposes. Elevated storage tanks, or underground reservoirs with booster pumps, reserve water for peak periods of consumption and fire demand. A short lateral line connects each fire hydrant to a distribution main. Shutoff valves are located at strategic points throughout the piping system to provide control of any section or service outlet, including hydrants. These valves are used to isolate units requiring maintenance and to insure that main breaks affect only a small section. A service connection to a residence includes a corporation stop tapped into the water main, a service line to a shutoff valve at the curb, and the owner's line into the dwelling, which incorporates a water meter and a pressure regulator or relief valve if necessary.

6-1 WATER QUANTITY AND PRESSURE REQUIREMENTS

The amount of water required by a municipality depends on industrial use, climate, and economic considerations. Although industries in the rural countryside frequently maintain private water systems, major plants in urban areas rely on the municipal waterworks. Approximately two-thirds of the water withdrawn in the United States is for nonconsumptive industrial uses; more than 90 percent is cooling water returned to the source.

Municipal water use in the United States averages 600 gpd (2270 l/d) per metered service including residential, commercial, and industrial customers. For residential customers, water consumption in eastern and southern areas is 210 gpd (790 l/d) and in central states 280 gpd (1060 l/d), while western regions use 460 gpd (1740 l/d) per household service. Only a small amount of water is sprinkled on lawns where the rainfall exceeds 40 in./yr (1000 mm/y), while in semiarid climates lawns and

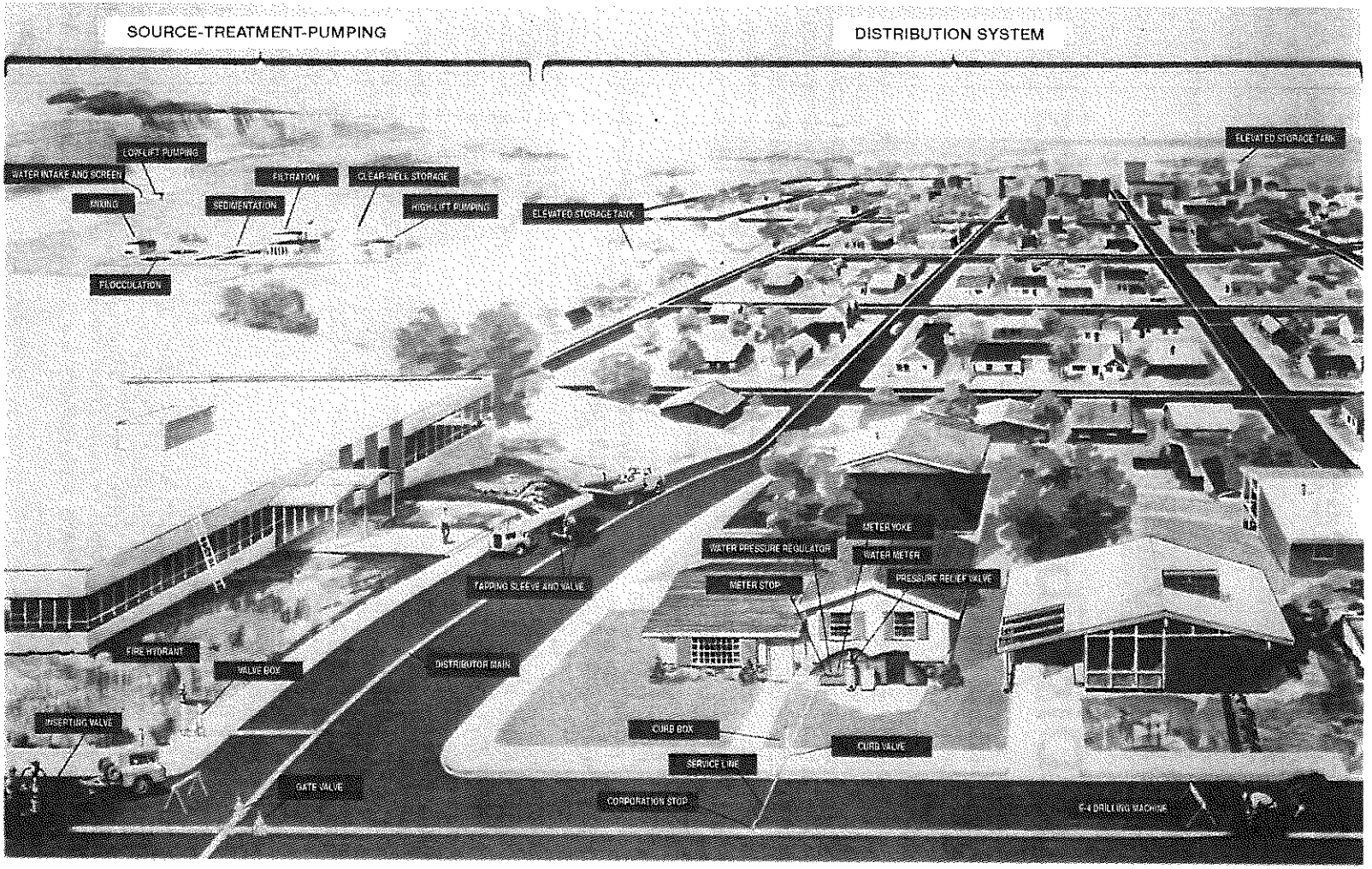


Figure 6-1 Sketch of a typical waterworks system that includes source, treatment, pumping, storage, and distribution.

gardens are maintained by irrigation. A typical city dweller uses about 90 gpd (340 l/d) for personal use.

Lawn sprinkling may have a striking influence on water demand in areas with large residential lots—50 to 75 percent of the total daily volume may be attributed to landscape irrigation. Other climatological factors, for instance, water-chilled air conditioning and swimming pools, influence water depletion.

Although water rates have increased significantly during the past decade, residential water use has continued to rise approximately 1 percent/yr. Most new houses have more water fixtures, modern appliances, spacious lawns, and other conveniences that consume larger volumes of water. A flat-rate residential water charge using a fixed fee per dwelling, rather than a rate based on water consumed, results in wasting of water by residents. For example, water may be allowed to run from a faucet continuously to have an instant cold supply. Metering of individual dwellings and establishing water rates on quantity of flow results in decreased waste and, consequently, in reduced water consumption. Municipalities that are entirely metered use approximately 60 percent of the amount that would be consumed based on flat-rate revenues. Increasing water rates have, in some instances, resulted in a decreasing water use by industry, particularly for cooling. Sewer use fees established in many cities bill industries for the quantity of wastewater discharged in municipal sewers. This has resulted in reduced wastewater production and, hence, in reduced water consumption by the industry.

Residential water use varies seasonally, daily, and hourly. Typical daily winter consumption is about 80 percent of the annual daily average, while summer use is 30 percent greater. Variations from these commonly quoted values for a particular community may be significantly greater depending on seasonal weather changes. Maximum daily demand can be considered to be 180 percent of the average daily, with values ranging from about 120 to more than 400 percent. Maximum hourly figures have been observed to range from about 1.5 to more than 10 times the average flow in extreme cases; a mean for the maximum hourly rate is 300 percent. Table 6-1 summarizes variations in residential water consumption for domestic and public uses only.

Water flows used in waterworks design depend on the magnitude and variations in municipal water consumption and the reserve needed for fire fighting. Quantities of water required for fire demand, as detailed in Section 6-2, are of significant magnitude and frequently govern design of distribution piping, pumping, and storage facilities. Water intakes, wells, treatment plant, pumping, and transmission lines are sized for peak demand, normally maximum daily use where hourly variations are handled by storage. Standby units in the source-treatment-pumping system may be installed for emergency use, for convenience of maintenance, or to serve as capacity for future expansion. The required design flow of maximum daily consumption plus fire flow frequently determines the size of distribution mains and results in additional pumping capacity and a need for storage reserves, in addition to that required to equalize pumping rates. If the maximum hourly consumption exceeds the maximum daily plus fire fighting demand, it may be the controlling criterion in sizing some units.

Table 6-1. Variations in Residential Water Consumption in Gallons per Capita per Day[a]

	Range	Average
Yearly average consumption	100 to 130	110
Mean winter consumption	50 to 130	100
Mean summer consumption	130 to 260	170
Maximum daily use	160 to 520+	230
Maximum hourly use	200 to 1300+	390

[a] 1.0 gal/capita/day = 3.78 liters/person·day

The recommended water pressure in a distribution system is 65 to 75 psi (450 to 520 kPa), which is considered adequate to compensate for local fluctuations in consumption. This level of pressure can provide for ordinary consumption in buildings up to ten stories in height, as well as sufficient supply for automatic sprinkler systems for fire protection in buildings of four or five stories. For a residential service connection, the minimum pressure in the water distribution main should be 40 psi (280 kPa). Pressures in excess of 100 psi (690 kPa) are undesirable, and the maximum allowable pressure is 150 psi (1030 kPa). At excessive levels, leaks occur in domestic plumbing requiring pressure reducers in service connections, and undue stress is placed on mains in the ground. Pipe and fittings used in ordinary water distribution systems are designed for a maximum working pressure of 150 psi.