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Water: No Cholesterol, Fat Free, Zero Sugar

You never miss the water till the well runs dry.
—Rowland Howard, *You Never Miss the Water*, 1876

The amount of water used in the United States is staggering. In 2005, it was 410 million gallons *per day*, not including the 15 to 20 percent lost to leaky pipes. Total consumption has varied by only 3 percent since 1990. Per capita use peaked in 1970 at 1,815 gallons but has since declined continuously to 1,363 in 2005, a result of conservation by industry, agriculture, and home owners (table 1.1). Power plants use about half of the 410 million gallons, agriculture 31 percent, homes and businesses use 11 percent, and the remaining 8 percent includes use by mining, livestock, aquaculture, and individual domestic wells.[1]

But despite conservation efforts, water shortages are spreading, and experts believe we are moving into an era of water scarcity throughout the United States. We are used to hearing of shortages in the arid and semiarid Southwest, but there are now problems in the Midcontinental grain belt, South Carolina, New York City, southern Florida, and other areas most Americans think of as water rich. In 2003, the General Accounting Office published a survey that found that water managers in thirty-six states anticipate water shortages locally, regionally, or state-wide within the next ten years. There already is a tristate water war among Alabama, Florida, and Georgia.[2]

Unfortunately, the gravity of the situation has not yet set in for most Americans, who tend to view water shortages as temporary—the result of short-term droughts, poor water management by local authorities, or an unusually light snowfall in mountain areas. The erroneous nature of this view is reflected in the fact that between 2002 and 2007, municipal water use rates in the United States increased by 27 percent. People in other nations have seen even larger increases: 32 percent in the United

Table 1.1
U. S. water withdrawals per day, 1975–2000

	Total (billion gal.)	Per capita (gallons)	Irrigation %	Public supply %	Rural %	Industrial %	Steam electric utilities %
1975	420	1,972	33.3	6.9	1.7	10.7	47.6
1980	440	1,953	34.1	7.7	1.3	10.2	47.7
1985	399	1,650	34.3	9.5	2.0	7.8	46.9
1990	408	1,620	33.6	10.0	1.9	7.4	47.8
1995	402	1,500	33.3	10.0	2.2	7.2	47.3
2000	408	1,430	33.6	10.5	2.3	5.6	48.0

Source: "Estimated Use of Water in the United States," U.S. Geological Survey Circular 1268, 2005.

Kingdom, 45 percent in Australia, 50 percent in South Africa, and 58 percent in Canada.[3]

The water problems foreseen decades ago by hydrologists threaten farm productivity, limit population and economic growth, increase business expenses, and drive up prices. Nearly every product uses water in some phase of its production. Reclaimed sewer water is now in wide use for agricultural and other nondrinking purposes. Desalination plants are springing up around the country.

About 30 percent of the water American families consume is used outdoors for watering lawns and gardens, washing cars, maintaining swimming pools, and cleaning sidewalks and driveways.[4] Clearly, nearly all these uses are unnecessary. They remain from the days when the nation had a lower population, fewer houses with large lawns, fewer cars to wash, and fewer swimming pools, and Americans were more willing to expend energy by using a broom on driveways and sidewalks.

The lack of water is imposing limits on how the United States grows. Freshwater scarcity is a new risk to local economies and regional development plans across the country. In 2002, California put into effect a state law that requires developers to prove that new projects have a plan for providing water for at least twenty years before local water authorities can approve their projects. Builders in the humid Southeast are facing limits to planting gardens and lawns for new houses.

The Water Future

According to Peter Gleick in 2008, president of the Pacific Institute, a think-tank specializing in water issues, "The business-as-usual future is a bad one. We know that in five years we'll be in trouble, but it doesn't have to be that way. If there were more education and awareness about water issues, if we started to really think about the natural limits about where humans and ecosystems have to work together to deal with water, and if we were to start to think about efficient use of water, then we could reduce the severity of the problems enormously. I'm just not sure we're going to."[5] It seems that no one has looked at the subject from the point of view of what is sustainable. There does not seem to be anyone in state or federal governments thinking about the long-range big picture that would put the clamps on large-scale development. Politicians rarely want to tell their constituents that they must curb their insatiable appetites for anything.

Where Does Our Water Come From?

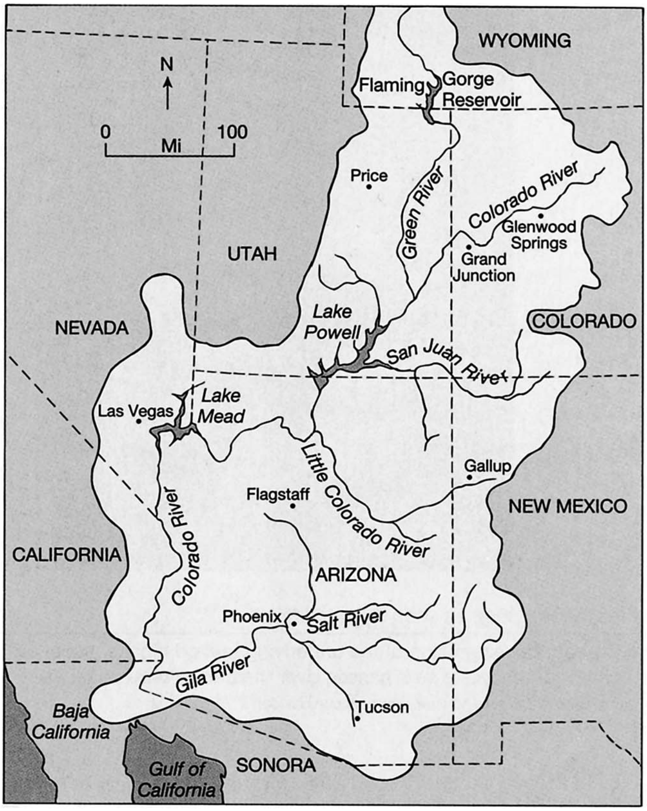
The water our lives depend on originates in the world's oceans, from where it evaporates and is carried by air currents over land surfaces. The chief proximate sources are large river systems such as the Mississippi and Ohio in the East and Midwest, and the Colorado and Rio Grande in the West; large lakes such as the five Great Lakes along the Canadian border; and underground aquifers such as the Ogallala in the Midcontinent from north Texas to South Dakota. The water in each of these sources is either decreasing or experiencing increased pollution from the artificial chemicals we inject into it—or both. The Colorado and Rio Grande no longer reach the sea year round because a growing share of their waters are claimed for various uses.

The Colorado River

The Colorado River, with an annual flow of 5 trillion gallons of water, is perhaps the best example of the unsustainable overuse of river water in the United States. A common misconception of water use in the basin and in the West in general is that rapidly growing urban areas are the main users of the region's limited water. In fact, 85 to 90 percent of the water is used in agriculture, mainly to grow food for cattle.[6] Only 10 to 15 percent of the water is used directly by the 25 million people served by the river who live in Los Angeles, Phoenix, and other communities. How much of the water is used to keep swimming pools filled and lawns watered in this dry climate is unknown. But clearly the river's water is oversubscribed, because the river's channel is dry at its entrance into the Gulf of California (figure 1.1). Five trillion gallons of water per year is not enough to satisfy both the needs and wants of 25 million people.

The shortage of water in the Colorado River was recognized many decades ago, and there have been many lawsuits by those who felt slighted by their legislated allocations. The problem was most severe in years when annual rainfall was less than average, so to alleviate this problem, the federal government built many dams and reservoirs along the river to store water and smooth out yearly variations. But lawsuits persisted.

Finally, after years of wrangling and facing the worst drought in a century, and with the prediction that climate change will probably make the Southwest drier in the future, federal officials in 2007 forged a new pact with the states on how to allocate water if the river runs short. The pact puts in place new measures to encourage conservation and manage



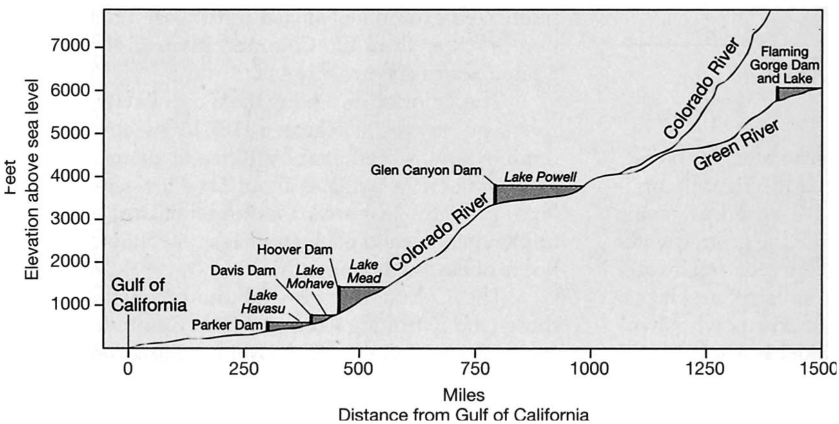


Figure 1.1
Drainage area served by the Colorado River and the dams constructed to minimize the effect of yearly variations in precipitation.

the two primary reservoirs, Lake Mead and Lake Powell, which have gone from nearly full to half-empty since 1999.[7] Some environmentalists have complained that managing expected population growth was emphasized at the expense of conservation measures, but the government believes the new agreement was the best that could be achieved among the many competing interests.

The Great Lakes

The Great Lakes contain 6 quadrillion gallons of freshwater, 20 percent of the world's supply (see figure 1.2 and table 1.2). Only the polar ice caps contain more. However, the Great Lakes supply only 4.2 percent of America's drinking water, despite the fact that they contain 90 percent of the nation's freshwater supply. Communities within the Great Lakes' drainage basin are awash in freshwater, and businesses and residents in

Figure 1.2
Drainage basin of the Great Lakes. (Atlas of Canada)

Table 1.2
Numerical information about the Great Lakes

	Lake Ontario	Lake Erie	Lake Huron	Lake Michigan	Lake Superior
Surface area (sq. miles)	7,540	9,940	23,010	22,400	31,820
Water volume (cu. mil.)	393	116	849	1,180	2,900
Elevation (feet)	246	571	577	577	609
Average depth (feet)	283	62	195	279	483

the area want to keep it that way. In October 2008 their desires were codified when President George W. Bush signed the Great Lakes–St. Lawrence River Basin Water Compact that had previously been approved by the eight states bordering the lakes and the adjacent Canadian provinces. Ken Kilbert, director of the Legal Institute of the Great Lakes, stated that the document was "the best legal step so far to protect the most important resource in our area from diminishment."[8]

Water withdrawals from the Great Lakes total 43 million gallons per day, with almost two-thirds withdrawn on the U.S. side. Nearly all of the water is returned to the basin through runoff and discharge. Only 5 percent is made unavailable by evapotranspiration or incorporation into manufactured products.[9] Considering that the water volume in the five lakes totals 5,438 cubic miles and climate change is forecast to increase precipitation in the area of the Great Lakes, there is not a looming problem with water supply for those with access.

The compact protects against most new or increased diversions of water outside the Great Lakes Basin. Diversions refer to the transfer of water from the Great Lakes to areas outside the Great Lakes watershed. The compact also promotes conservation and efficiency programs that enforce better use of water within the basin, 72 percent of which is used in power plants and is recycled. Public water systems use 13 percent, industry consumes 10 percent, and other uses total 5 percent.[10]

Many politicians believe they see water wars on the horizon, and there is no way for the Great Lakes states to prevent the federal government from taking the water if it wants to do so. Probably the Great Lakes Compact will not be the final word on distribution of the water in the lakes. The balance of political power in Washington has been tilting south and west for decades, and agricultural interests in the nation's midwestern breadbasket will increasingly covet the water in the lakes as water levels in the Ogallala aquifer they depend on continue to drop.

The Ogallala Aquifer

Twenty percent of America's water use comes from underground aquifers, the largest of which by far is the series of sandstones and conglomerate called the Ogallala Formation (figure 1.3).[11] It extends over an area of about 174,000 square miles in parts of eight states, from Wyoming and South Dakota in the north to New Mexico and Texas in the south. About 27 percent of the irrigated land in the United States overlies this aquifer system, which yields about 30 percent of the nation's groundwater used for irrigation. Water from the Ogallala aquifer serves an area that produces 25 percent of U.S. food grain exports and 40 percent of wheat, flour, and cotton exports. In addition, it provides drinking water to 82 percent of the people who live within the aquifer boundary.[12]

Ogallala water irrigates more than 14 million acres of farmland, areas with only 16 to 20 inches of rainfall—not enough for the abundance of corn, wheat, and soybeans American farmers have come to expect. The aquifer averages 200 feet thick and holds more than 70 quadrillion gallons of water (70,000,000,000,000,000 gallons) in its pores. The water accumulated undisturbed from rainfall over millions of years, but for the past eighty-five years, the water has been withdrawn from thousands of wells at a rate that is eight times the current replenishment rate from the low annual rainfall.[13] Farmers are pumping more groundwater. In 1950, 30 percent of irrigation water came from aquifers; in 2005, 62 percent did.[14] Water levels have declined 30 to 60 feet in large areas of Texas, and many farmers in the High Plains are now turning away from irrigated agriculture. Wells must be deepened, and the costs of the deepening and increased pumping have caused some agricultural areas to be abandoned. If overpumping of the Ogallala continues, the aquifer may be effectively dry within a few decades, with disastrous effects on the economy of a large area of the United States.

Prospects for the Future

Our ability to irrigate at low cost is coming to an end, not only in the Midcontinent but in other areas as well. As noted earlier, the Great Lakes will come under increasing pressure from states in the Midwest and Southwest up to 1,500 miles away to share the enormous volume of water currently under the control of the eight states bordering the lakes.

The cost of transporting water is determined largely by how far it has to be carried and how high it has to be lifted. The elevations of the three largest Great Lakes are between 577 feet and 609 feet, but the elevations of the area served by the Ogallala range from about 2,000 feet to 3,600

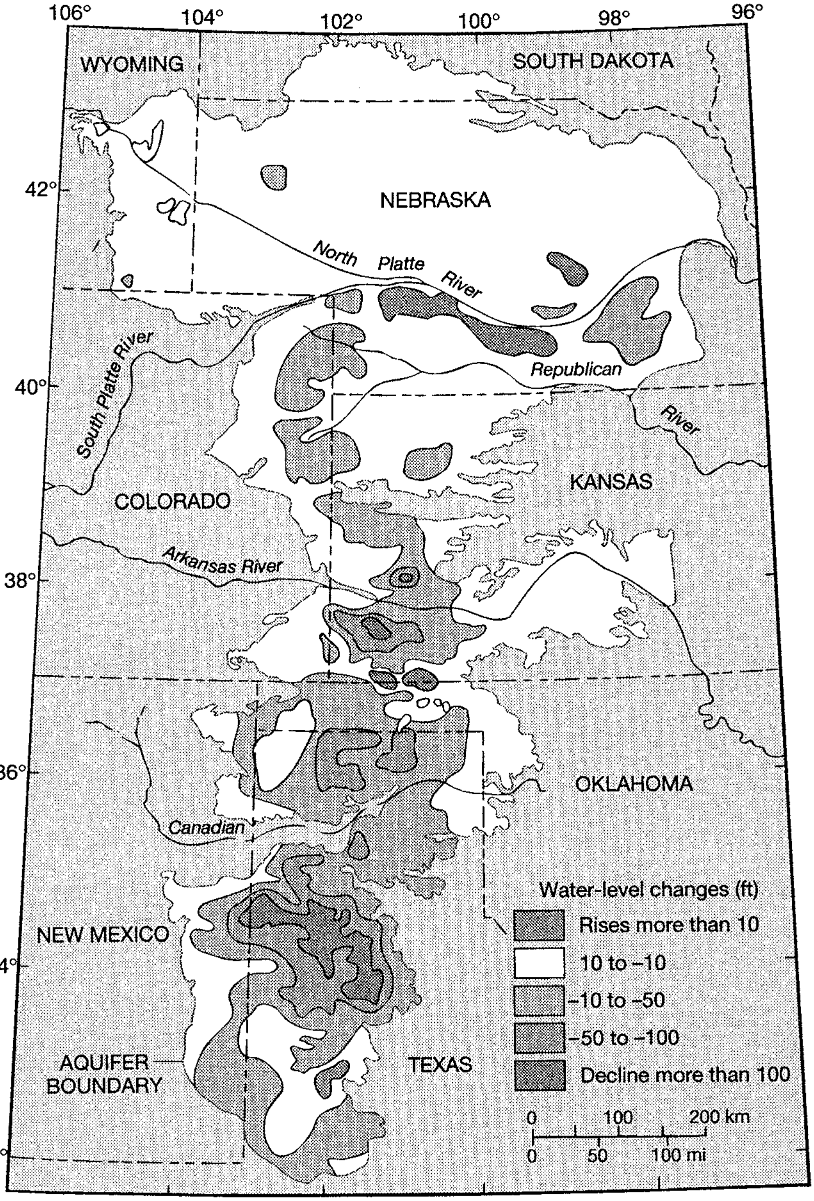


Figure 1.3
Changes in water level in the Ogallala aquifer between 1850 and 1980. The declines have continued to the present day. (U.S. Geological Survey).

feet, so considerable lifting of water would be necessary to tap into the Great Lakes, in addition to the pipelines that would need to be laid. Pumping water over the land is energy intensive, and pumping it to higher elevations is even more energy intensive. About 20 percent of California's energy is used to move water from the wetter north to the drier south.[15]

A novel method for obtaining water has been pioneered by a firm in Israel that has developed a machine that extracts water from the humidity in the air. The method uses a solid desiccant to absorb the moisture and an energy-saving condenser that reuses more than 85 percent of the energy input to the system.[16] The cost of the water is similar to water produced by desalination.

Virtual Water: Now You See It, Now You Don't

Virtual water is an economic concept referring to the amount of water consumed in the production of an agricultural or industrial product. A person's water footprint is the total amount of freshwater consumed in the production of the goods and services that that individual consumes. Virtual water is a hidden part of a person's water use. The water is said to be virtual because once the grain is grown, beef produced, jeans fabricated, or automobile manufactured, the real water used to grow it is no longer actually contained in the product as water. It has been consumed or transformed into other chemicals and cannot be recycled or recovered (table 1.3).

Each person's water footprint is determined largely by eating habits. Vegetarians have a lower water footprint than omnivores because of the large amount of virtual water needed to produce meat and associated dairy products. Producing a pound of corn, wheat, or potatoes requires only 30 to 160 gallons of water; beef, however, can require almost 1,900 gallons (figure 1.4). The 10 percent of Americans who do not own cars and families with fewer cars have lower water footprints than those who are more affluent. The water footprint of the United States is about 700 gallons per year per person, about double that in the United Kingdom.[17]

Nations with shortages of freshwater should not compound their problem by producing and exporting products that require large amounts of water in their production. For example, in Israel, a nation that is mostly arid to semiarid and where water shortages are common, the export of oranges has been discouraged since the 1980s because it is a relatively thirsty crop and it makes no sense to send Israel's water to

Table 1.3
Virtual water in various food and manufactured products

Amount of product	Water consumed (gallons)
FOOD	
1 cup coffee	37
1 pound corn	108
1 pound wheat	156
1 pound rice	185
1 quart milk	208
1 pound soybeans	363
1 pound broken rice	407
1 pound poultry	542
1 dozen large eggs	592
1 pound pork	608
1 pound beef	1,800
MANUFACTURED	
Diaper	215
Cotton shirt	300
Bed sheet	2,584
Jeans	2,875
Passenger car	106,000
Average house	1,590,000

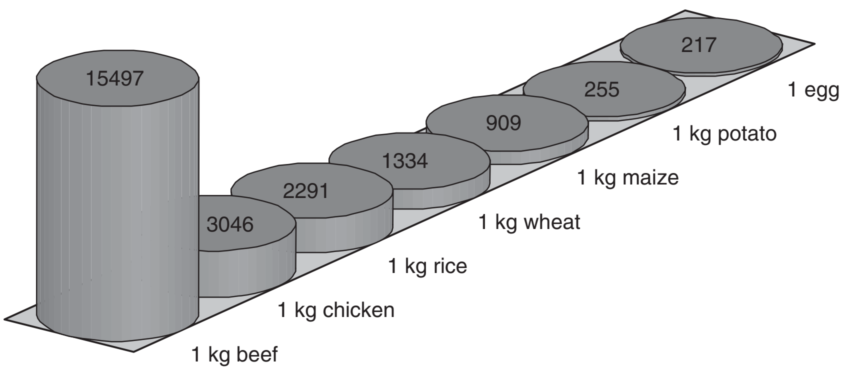


Figure 1.4
Amounts of virtual water in various foodstuffs, expressed in liters per kilogram. (Office for Economic Co-operation and Development)

more water-rich countries. The United States exports huge amounts of virtual water in its agricultural products and automobiles. The United States and the European Union countries export to the Middle East and North Africa as much water as flows down the Nile into Egypt for agriculture each year. The volume is more than 40 billion tons, embedded in 40 million tons of grain.

How Do We Use It?

Water is used in three main areas: agriculture, industry, and homes. Usage grew three times faster than America's population during the twentieth century. The increase was due largely to the expansion of agriculture, by far the biggest consumptive user of water in the United States.

Agriculture

Farming drinks 34 percent of the nation's water, most of it from groundwater. The profligate use of groundwater is the reason a large part of America's most productive cropland can be located in areas with relatively low annual rainfall. Much of the midcontinental grain belt averages less than 25 inches of rain per year; the San Joaquin Valley in California produces half of the nation's fruits and vegetables but receives only 8 to 12 inches of rainfall in an average year. If farming were restricted to areas of adequate rainfall, agricultural production in the United States would be drastically reduced and would flourish only in areas where rainfall was at least 30 inches annually, roughly the eastern half of the country (figure 1.5).

Another reason agriculture is so widespread in the United States is government water and crop subsidies. Water for farming from the federal Bureau of Reclamation sells for $10.00 to $15.00 per acre-foot, and the cheapest subsidized water sells for as little as $3.50 per acre-foot, even though it may cost $100.00 to pump the water to the farmers. Households in Palo Alto, California, pay $65.00 per acre-foot, and some urban users in California pay as much as $230.00.[18] In California's San Joaquin Valley, 6,800 farms receive water from the federally funded Central Valley Project, built in 1936 for $3.6 billion. The Environmental Working Group reported in 2005 that in 2002, farms received $538 million in combined water and crop subsidies, $416 million of which was for water. In 2002, the average price for irrigation water from the Central Valley Project was less than 2 percent of what residents of Los Angeles

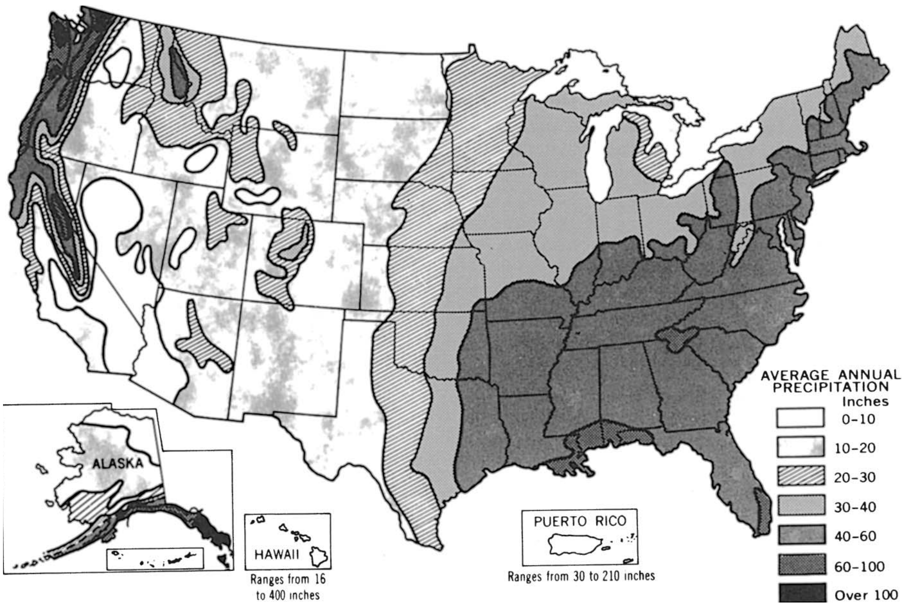


Figure 1.5
Average annual precipitation in the United States. (U.S. Water Resources council, 1968, *The Nation's Water Resources,* 1968)

paid for drinking water, one-tenth the estimated cost of replacement water supplies, and about one-eighth of what the public paid to buy its own water back to restore the San Francisco Bay and delta.[19]

Increased agricultural efficiency in water use has contributed significantly to water conservation efforts in the United States. Irrigation methods have been improved by decreasing the use of flood irrigation and up-into-the-air water sprinklers in favor of techniques such as having drip tubes extending vertically from the sprinkler arm immediately above the plants. Another efficient method is drip irrigation, pioneered in Israel, in which water is released in measured amounts from tubes on the ground directly above the plant roots. Losses of water to evaporation and runoff are nearly eliminated by these methods.

Industry

Nearly half (48 percent) of the 408 billion gallons used in the United States goes to power plants, which have greatly reduced their water requirements from the past. They have made the biggest reduction in water use in recent decades, a result of water-saving technology driven by energy-saving and environmental protection laws passed in the 1970s. Utilities that once needed huge amounts of water to cool electrical generating plants now conserve water by recirculating it in a closed loop (nonconsumptive use).[20] Consumptive use by power plants is only 2.5 percent of total water use.[21]

Home Use

About one-fifth of the nation's water use is in the home, so a significant part of the reason for our increasing water stress is the nearly universal access Americans have to modern plumbing. Bathrooms are the major users of water in homes, with dishwashers, present in 57 percent of American homes, ranking second (table 1.4).

The use of water in our homes can be easily reduced. Toilets are a particular concern, but water use can be reduced by more than 50 percent with the newer models that use less than 1.3 gallons per flush rather than older models that used as much as 5 gallons (table 1.5). America is a flush-oriented society, but water use can be reduced by adhering to the maxim, "If it's yellow, let it mellow. If it's brown, flush it down." Unfortunately, most Americans appear to want closure after toilet use, and this can be provided by flushing. No-flush urinals have been available for many years, but consumers have resisted them.

The silent toilet bowl leaks in American bathrooms are only slightly less scandalous than the breaks in city water mains that lose 15 to 20 percent of the water piped through them (chapter 2). It has been esti-

Table 1.4
Allocation of water indoors in the typical American home

Use	Gallons per capita, daily	Percentage
Toilets	18.5	26.7
Clothes washers	15.0	21.7
Showers	11.6	16.8
Faucets	10.9	15.7
Leaks	9.5	13.7
Baths	1.2	1.7
Dishwashers	1.0	1.4
Other uses	1.6	2.2
Total	69.3	100.0

Source: American Water Works Association, "Water Use Statistics," 2010 Available at http://google.co.il/#hl=en&sourceehp&q=Allocation+of+Water+indoor+in+the+typical+American+home.

Table 1.5
Daily indoor water use

Use	Gallons per capita	Percentage
Toilets	8.2	18.0
Clothes Washers	10.0	22.1
Showers	8.8	19.5
Faucets	10.8	23.9
Leaks	4.0	8.8
Baths	1.2	2.7
Dishwashers	0.7	1.5
Other uses	1.6	3.4

mated that 20 percent of all toilets leak, and this accounts for 14 percent of home water use.

Clothes washers are present in 81 percent of American homes. Newer models use half the water of older models, but washing machines are durable and are not replaced often, so the change to newer models will be slow. Rapid change can be instituted in our showering habits, not by showering less frequently but by running the water briefly, only before and after soaping, instead of the common American habit of standing under the full flow for perhaps five minutes to relax a stressed body.

Conservation is the most cost-effective solution to water scarcity.

Forty million acres of America are covered in lawns, our largest irrigated crop, and one that can be accurately described as ecological genocide. Home lawn and landscape irrigation consumes an average of more than 8 billion gallons of water daily, equivalent to 14 billion six-packs of beer.[22] According to the Environmental Protection Agency (EPA), one-third of all residential water use in the United States is devoted to irrigation—almost none of it necessary. Many cities and some states in the Southeast and Southwest report that 50 percent of their residential water use is outdoors, primarily for lawns. In 2008, satellite data revealed that lawns (99.96 percent) and golf courses (0.04 percent) in the United States cover nearly 50,000 square miles, or 32 million acres, an area roughly the size of New York State.

Probably the largest manicured and watered lawn in the United States surrounds the White House. It extends over 18 acres and is under the jurisdiction of the National Parks Service. In order to encourage better uses of America's lawn areas, President Obama in 2009 authorized the cultivation of an organic vegetable garden fertilized with compost for his family over 1,100 square feet (0.01 acres) of the lawn, the first garden at the White House since a Victory Garden in 1943. At the height of the Victory Garden movement during World War II, gardens were supplying 40 percent of the nation's fruits and vegetables. Someday the pampered front lawn that today's Americans admire so much may be considered an ugly vestige of an ignorant time.

What Do We Pay for It?

The average American household spends, on average, only $523 per year on water and sewer charges, in contrast to an average of $707 per year on soft drinks and other noncarbonated refreshment beverages.[23] Compared with other developed countries, the United States has the lowest burden for water and wastewater bills when measured as a percentage of household income. Where water is concerned, price does not indicate value to Americans.

Many studies have shown that water demand is responsive to price changes. An attack on the consumers' wallets is the surest way to get their attention, and to encourage consumers to conserve water, prices need to be increased. State utility commissions must allow utilities to use a rate structure that reflects a consumer's water usage. Consider these examples of price structures for water use:

- Most of the 60,000 water systems in the United States charge uniform rates; consumers pay the same rate per gallon no matter how much they use each month. One-third of municipalities do the opposite: the more water you use, the less you pay. Only one-fifth of utilities charge higher rates for those who use more. In Israel, where water shortages are common, a system of block rates or tiered pricing is used: the per-unit charge for water increases as the amount used increases. The first block of water (gallons) is relatively cheap, recognizing that everyone needs a basic amount of water for sanitation, cooking, and cleaning. But the price increases rapidly for each succeeding block; those who take fifteen-minute showers, fill swimming pools, wash their cars using a running hose, and regularly water large lawns have exceptionally large water bills. According to an EPA study in 2000, only 9 percent of utilities in the United States use block rates.[24]
- Utilities can charge seasonal rates, in which prices rise or fall depending on water demands and weather conditions. Water should be more expensive when demand is high. Only 2 percent of American water companies charge more during summer months.

• A corollary to seasonal pricing is time-of-day pricing, in which prices are higher during a utility's peak demand periods.
• A relatively new method for encouraging lower water use is a digital water meter.[25] Its heart is an electronic device called a water manager. The water user buys a smart card at a local convenience store that, like a long-distance telephone card, is programmed for a certain number of credits. At home, the purchaser punches the card's code into a small keyboard and pushes the LOAD key. The water manager automatically sends a signal to the water company to supply water. When the user runs out of credits, he or she pushes the LOAN key, and the utility gives the user a bridge loan until he or she purchases another card. Studies in the United Kingdom revealed that households using the water manager reduced water use by 21 percent.[26] The UK Environment Agency said that a shift to widespread metering is essential for the long-term sustainability of water resources.

More than 100 studies of the relationship between residential water use and pricing indicate that a 10 percent increase in price lowers use by 2 to 4 percent. In industry, a 10 percent increase in price lowers demand by 5 to 8 percent. In economic terms, water demand is said to be inelastic, meaning that when price increases, consumption decreases at a smaller amount than the increase in price.[27]

Reusing Dirty Water

Through the natural water cycle, the earth has recycled and reused water for billions of years. However, when used in discussions of water availability to consumers, *recycling* generally refers to projects that use technology to speed up natural processes. The number of such projects is increasing dramatically in the United States because of increasing pressure on freshwater resources. Recycled water can satisfy water demands for irrigating crops, cooling water in power plants, mixing concrete in construction work, watering a lawn, mopping a floor, or flushing a toilet. Hundreds of American cities now use recycled water for nondrinking purposes. Most irrigation of fruits and vegetables in California and Florida is accomplished with recycled wastewater. In Israel, about one-third of water needs is met by reclaimed and recycled municipal wastewater, or sewage water. Water reuse and recycling is second only to conservation as a means of boosting water supplies.

Water recycling is a three-step filtration process. When water enters the treatment facility, solids are settled out, and the wastewater is sucked up into thousands of tiny straws less than three-hundredths the thickness of a human hair, which help separate out bacteria. This is followed by reverse osmosis, a process where intense pressure is used to force the water molecules through a sheet of plastic. Dissolved salts cannot pass through the membrane. Biological processes may also be used to remove contaminants. Microorganisms consume the organic matter as food. After the bugs do their work, chlorine, ultraviolet light, hydrogen peroxide, and radiation may used to kill the organisms before the water is released from the purification plant into streams and the ocean. The entire process ensures that not even the tiniest bacterium, virus, chemical, or hormone can survive. According to California's Department of Health Services, water from such a modern plant is purer than expensive mountain spring water but is piped into streams and the ocean because current state regulations do not permit the water to be fed directly into homes.

Instead of being fed into streams after leaving the purification plant, the water may be injected underground to replenish depleted groundwater supplies that supply drinking water to millions of humans above ground. Underground injection adds another step, and perhaps an unnecessary one, to the decontamination process. A new half-billion-dollar purification plant in Orange County, California, processes 70 million gallons of sewage per day that is pumped underground but will eventually stream out of faucets in people's homes.

Only about a dozen water agencies in the United States recycle treated sewage to replenish drinking water supplies, but none steers the water directly into household taps. The concept of toilet-to-tap drinking water is hard for many people to swallow. Many Americans have a psychological barrier to imbibing water that at one stage had fecal matter floating in it. But with education, and as water shortages become more severe, their fecophobia will be overcome.

Israeli scientists have developed a system that instantly purifies contaminated water, removing organic, biological, and chemical contaminants.[28] The technology has been miniaturized to fit into the top of a cork that can be plugged into virtually any size bottle, container, or tap. One cork can purify 250 gallons of water before being replaced, and, according to the developers, it costs no more than a large coffee and pastry at an upscale coffee shop. The device is ideal for hikers, soldiers in the field, or victims of disasters and can prevent the deaths of the 1.6 million children under the age of five who die each year in the undeveloped world from drinking untreated water. Impure water is the major killer of people in the Third World.

Taking Out the Salt

The ocean holds 97 percent of the earth's water, but its salinity renders it unusable for drinking and for most other uses. It contains about 35,000 parts per million (ppm) of dissolved materials (3.5 percent). The EPA's guideline for drinking water recommends a maximum of 500 ppm; most drinking water in the United States contains 100 ppm or less. Expensive technology is required to make seawater potable, but the benefit is incalculable: an unending supply of freshwater. As one water specialist has said, "When you're running out of water, you don't care about what the energy bill is." The world's largest desalination plant opened in Ashkelon, Israel, on the Mediterranean Sea coast in 2005; it supplies 5 to 6 percent of the nation's demand and 13 percent of domestic consumer needs.[29]

Freshwater produced by desalination of seawater costs two to three times more than water obtained by conventional water treatment, but water is so cheap in the United States that doubling or even tripling the cost is something most Americans can easily bear. At present, desalination's contribution to the total U.S. water supply is negligible. There were about 250 desalination plants in the United States in 2005 and every state has at least one, but they have the capacity to provide less than 0.4 percent of the water used in the United States, and most of this water is used by industries, not municipalities.[30] Florida has nearly half of the plants, with Texas and California in second and third place.

Most of the existing plants are designed to handle brackish water (1,000–10,000 ppm) rather than seawater, and cost about half as much money to build. Brackish water is present at depths of less than 500 feet over about half of the conterminous United States (figure 1.6) and is a large potential source of water that has not been tapped.

The Bureau of Reclamation forecasts that by 2020, desalination technologies will contribute significantly to ensuring a safe, sustainable, affordable, and adequate water supply for the nation.[31] The ability to make ocean water potable guarantees an inexhaustible water supply, albeit at prices higher than Americans are used to paying. Desalination is an inevitable part of America's water future.

Poisoning Our Water

Americans are making a two-pronged attack on their water supply. Not only do they use it extravagantly and wastefully, but they pour harmful chemicals in it as well.[32] In 2007, 232 million pounds of toxic chemicals

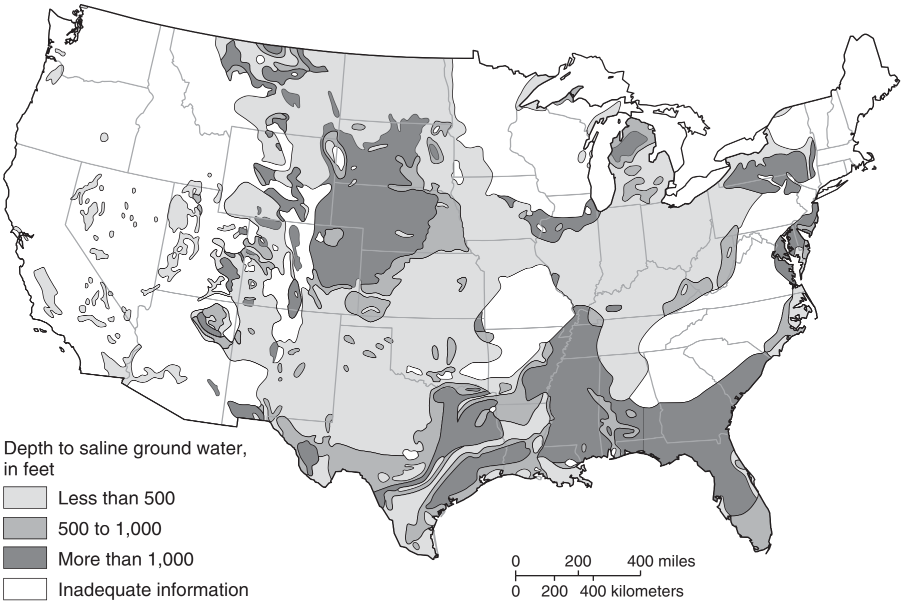


Figure 1.6
Depth to saline groundwater in the United States. (U.S. Geological Survey. Hydrologic Investigations. Atlas HA-199)

were dumped into 1,900 waterways. Indiana and Virginia were the leading dumpers. The top three waterways in the nation for the most total toxic chemicals discharged in 2007 were the Ohio River, New River (which flows through North Carolina, Virginia, and West Virginia), and the Mississippi River. The Ohio River also was number one for toxic chemicals that are cancer causing and chemicals that cause reproductive disorders.

In a Gallup Poll in 2007, pollution of drinking water, rivers, lakes, and reservoirs was named by Americans as their greatest environmental concern (60–68 percent of Democrats, 41–46 percent of Republicans).[33] Large numbers of industrial chemicals are present in our blood, although in very small amounts. Whether they affect our health and longevity is uncertain, but there are reasons to be concerned. Basic toxicity data are not publicly available for about three-quarters of the 3,000 chemicals produced in the highest volume each year, excluding pesticides. And 1.2 trillion gallons of untreated industrial waste, sewage, and storm water are discharged into U.S. waters annually.[34] To this noxious cocktail is added runoff from the animal manure in the monstrous livestock feedlots that increasingly cover the landscape (chapter 5).

The effect of these feedlots on water purity was brought home in 2009 to residents of Brown County, Wisconsin.[35] One cow produces as much waste as 18 people. The 41,000 dairy cows in the county produce more than 260 million gallons of manure each year. In measured amount, that waste acts as a fertilizer, but the cows produce far more manure than the land can absorb. Because the amounts are excessive, bacteria and chemicals flow into the ground and contaminate residents' tap water. In the town of Morrison in Brown County, more than 100 wells were polluted by agricultural runoff within a few months. As parasites and bacteria seeped into drinking water, residents suffered from diarrhea, stomach illnesses, and severe ear infections. A resident in a town a few miles away commented that "sometimes it smells like a barn coming out of the faucet." At an elementary school a few miles from a large dairy, signs above drinking fountains warn that the water may be dangerous for infants.

Rivers and aquifers are not the only casualty of pollutants. In any given year, about 25 percent of beaches in the U.S. are under advisories or are closed at least once because of water pollution.[36]

Pharmaceutical companies are among the industries that are major sources of drug pollution. Wastewater treatment plants downstream of pharmaceutical factories have exceptionally high levels of antibiotic drugs, opiates, barbiturates, and tranquilizers.

Another pollution source is the storm water that runs off lawns, streets, and driveways. It contains motor oil, fertilizers, and pesticides that will eventually end up in the nation's waterways. Impermeable surfaces like concrete prevent storm waters from soaking into the ground, which can trap potential pollutants.

Many organizations, federal, state, and private, have examined our surface waters and groundwater, and their results are consistent and scary: half of America's rivers and lakes are too polluted to safely swim in. In 2001 the U.S. Geological Survey examined 139 streams in thirty states and looked for ninety-five industrial chemicals. At least one was present in each of the 139 streams, and a mixture of seven or more were present in half the streams.[37] Groundwaters were less contaminated but also commonly contained multiple pollutants.

In 2002 the H. John Heinz III Center for Science, Economics, and the Environment published the results of a five-year study of the nation's streams and groundwaters. It determined that 13 percent of the streams and 26 percent of the groundwaters were seriously polluted.[38]

A study published in 2004 reported on the results testing thousands of rivers, aquifers, wells, fish, and sediments across the country over a ten-year period. More than 400 scientists analyzed 11 million samples for more than 600 chemicals. They detected pesticides in 94 percent of all water samples (and in 90 percent of fish samples).[39] Many of the pesticides have not been used for decades, but they continue to persist in the environment. Persistent toxins do not break down and go away; they keep polluting the water they are in. Clearly, ending the application of chemical pollutants into the environment does not immediately end their presence in our water.

In a study published in November 2009, the EPA reported that mercury, a pollutant released primarily from coal-fired power plants, was present in all fish samples it collected from 500 lakes and reservoirs. At half the lakes and reservoirs, mercury concentrations exceeded levels the EPA deems safe for people eating average amounts of fish (figure 1.7). And a person does not need to eat much fish for a seafood meal to raise mercury levels. In an experiment in 2006, David Duncan of National Geographic ate some halibut and swordfish in San Francisco and the next day had his blood drawn and tested for mercury content. The level of mercury had more than doubled from an earlier blood test—from 5 micrograms per liter of blood to 12 micrograms. There is no way to

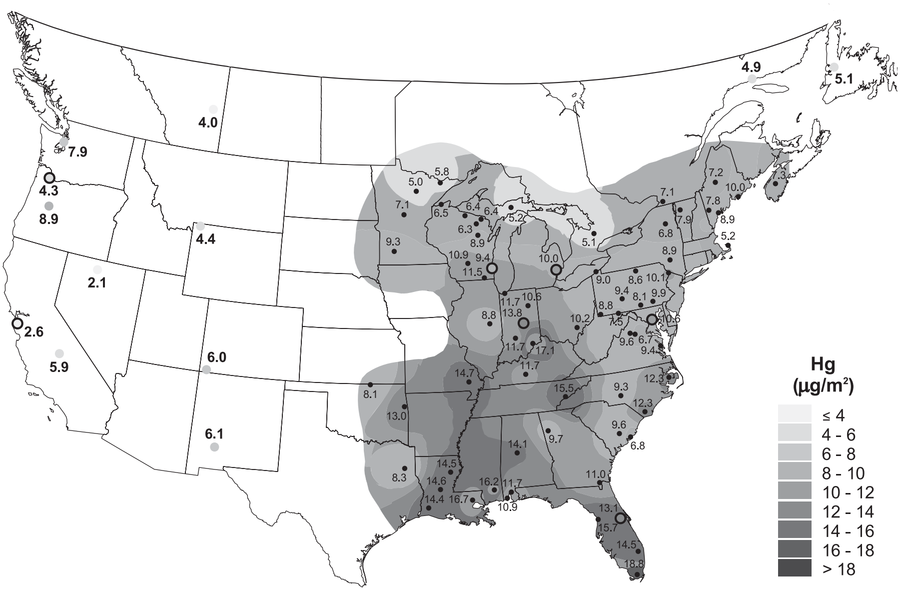


Figure 1.7
Wet deposition of mercury from the atmosphere, 2006. (Environmental Protection Agency)

know whether Duncan suffered permanent damage from the higher mercury level, but children have suffered losses in IQ at concentrations of only 5.8 milligrams.

Mercury was not the only contaminant in the lakes and reservoirs analyzed by the EPA. Polychlorinated biphenyls (PCBs), banned in the late 1970s but still present in the environment, were present in 17 percent of the water bodies. PCBs have been linked to cancer and other health effects.

A ray of hope surfaced in 2009 with the EPA's announcement in its annual Toxics Release Inventory that water pollution decreased by 5 percent between 2006 and 2007. However, releases of PCBs into the environment increased by 40 percent due to disposal of supplies manufactured before the substances were banned in 1979. Mercury releases, mostly due to mining, increased by 38 percent. Dioxin releases increased by 11 percent, and lead releases increased by 1 percent. Releases of all persistent, bioaccumulative, and toxic chemicals or metals increased by 1 percent. These increases will likely be reflected in water analyses over the next few years.

That chemicals in combination can be more deadly than either chemical alone and in lower concentrations was recently demonstrated in a study of salmon by federal scientists.[40] Five of the most common pesticides used in California and the Pacific Northwest acted in deadly synergy by suppressing an enzyme that affects the nervous system of salmon. Some fish died immediately. Exposures to a single chemical, however, did no harm. As expected, harmful effects on the salmon were observed at lower pesticide levels when chemicals were applied in combinations. Earlier studies had found that three of the pesticides can be lethal to salmon and can inhibit their growth by impairing their ability to smell prey, impair their ability to swim, and make it difficult to spawn and avoid predators.

More than 2,300 chemicals that can cause cancer have been detected in U.S. drinking water. Although the amounts are usually small and considered safe by the EPA, the surgeon general has stated, "No level of exposure to a chemical carcinogen should be considered toxicologically insignificant to humans."[41]

Seventy years ago in the United States, one person in fifty could expect to get cancer in his or her lifetime. Today one in three people and one in two males can expect to get cancer. The risk that a fifty-year-old white woman will develop breast cancer soared to 12 percent from 1 percent in 1975. Studies reveal that 90 percent of breast cancer cases are not caused by "bad" genes. Synthetic chemicals are a likely cause. The sharp increase in cases of autism since 1990 is increasingly thought to have environmental rather than genetic causes.[42] Between 1979 and 1997 cases of Alzheimer's disease and other dementias more than tripled in men and rose by nearly 90 percent in women in England and Wales, with similar results in other countries.[43]

Some of the enormous increase in cancer and Alzheimer's occurrence can probably be attributed to increased longevity. In 1940 the average American lived sixty-four years; in 2006 it was seventy-eight years, and the immune system of humans is known to deteriorate with age. But it seems unlikely that a fourteen-year increased life span could by itself be responsible for the enormous increases in catastrophic bodily diseases that have occurred. It is much more likely that increased body burdens of industrial chemicals are largely responsible for the sharp increases in some cancers and brain diseases. People are exposed to carcinogenic chemicals in pesticides, deodorants, shampoos, hair dyes, makeup, foods, cleaning products, sunscreens, electronics, furniture, walls, paints, carpeting, and a host of other common commercial products. A study in the United Kingdom found that the average woman applies 515 chemicals to her face each day in makeup, perfumes, lotions, mascara, and other beauty products. Pollution is built into the modern world.

Television personality Bill Moyers discovered that his blood contains eighty-four synthetic chemicals. Tests commissioned by the Environmental Working Group found that the blood or urine of all of the subjects they studied was contaminated with an average of thirty-five consumer product ingredients, including flame retardants, plasticizers, and stainproof coatings. These mixtures of compounds, found in furniture, cosmetics, fabrics, and other consumer goods, have never been tested for safety.[44] In another study, the group tested umbilical cord blood collected by the American Red Cross. This blood of unborn babies contained an average of 287 different industrial chemicals and pollutants per sample. Most of these compounds detected are believed to cause cancer or birth defects, or are neurotoxins.[45]

In 2005 the Centers for Disease Control and Prevention published the results of a study of blood and urine in Americans.[46] In testing volunteers for 148 industrial chemicals and harmful pollutant elements, they found mercury, pesticides, hydrocarbons, dioxins, PCBs, phthalates (plasticizers), DDT (banned since 1973 in the United States but still used in countries from where we import food), insect repellent, and other harmful chemicals. There can be no question that our bodies are heavily contaminated with the products we have manufactured that make our everyday lives more comfortable.

A study in 2009 found up to forty-eight toxic chemicals in blood and urine samples of five prominent female environmental activists from various parts of the country.[47] The chemicals found are present in everyday consumer products. Each of the women's samples contained fire retardants, Teflon chemicals, fragrances, bisphenol A (BPA), and perchlorate. Flame retardants are found in foam furniture, televisions, and computers. Teflon is used in nonstick coatings and grease-resistant food packaging. BPA is a plastics chemical; perchlorate, an ingredient in rocket fuel, can contaminate tap water and food. Fragrances have been associated with hormone disruption in animal studies. A physician with the Environmental Working Group noted that animal studies show that the chemicals can be potent at very low levels of exposure. Although the rising number of chronic diseases has many roots, increased exposure to chemicals is one likely cause.

In an incredibly detailed blood test in 2009, David Duncan, author of *Experimental Man*, underwent several hundred scientific and medical tests costing $25,000, in which he was tested for 320 chemical toxins.[48] The tests revealed he had 185 of these known toxins in his body. There are about 80,000 industrial chemicals in existence, so testing for "only" 320, much less than 1 percent of them, barely scratches the surface of our probable bodily pollution. The average person's bloodstream may well contain thousands or tens of thousands of industrial chemicals. It is noteworthy that the body is known to hide its poisons in its fat, cells, and other areas of the body to keep them out of the bloodstream, so even an analysis for all 80,000 industrial chemicals might not uncover all of the ones in the body.

Not only is our drinking water much less than pure, 40 percent of our rivers and 46 percent of our lakes are too polluted for fishing, swimming, or aquatic life.[49] Two-thirds of U.S. estuaries and bays are either moderately or severely degraded from eutrophication (nitrogen and phosphorous pollution). Chesapeake Bay and the Gulf of Mexico near-shore waters have become notorious for the level of their pollution.[50]

Even the reservoir that holds 90 percent of America's fresh drinking water is polluted.[51] More than a century of industrial dumping has spread pollution throughout the Great Lakes. Fish caught from this largest source of drinking water are often unsafe to eat.

Americans are often told by their government that no nation has better-quality drinking water than the United States. This is certainly true when only short-term effects are considered. Water-borne diseases are uncommon, and parasites and disease-causing microorganisms have been largely eliminated from the water that pours from taps. However, the statement about water purity fails to consider the long-term effects of chemical pollutants in the water. Certainly the small amounts of pesticides and other industrial chemicals in the water are not lethal in the short run, but their effect during a lifetime of ingesting them cannot be benign. And it is not necessary. There is no necessity for agriculture to use pesticides that end up in rivers (chapter 5) or for industry to pour its poisonous liquid waste into rivers and inject them underground into aquifers. Industry does it because it is an inexpensive way to dispose of stuff they do not want, and thanks to decades of lobbying of our elected representatives, it is perfectly legal.

The Hudson River

One of the most notorious examples of river pollution is the PCB contamination in the Hudson River, an important source of drinking water for a high percentage of the people in New York State.[52] In 1947, General Electric started using PCBs in one of its manufacturing plants on the eastern shore of the river. It was not illegal at the time, although major health and safety problems with PCBs had been detected eleven years earlier. The chemicals are suspected human carcinogens and increase the risk of birth defects in children born to women who eat fish from the polluted Hudson River. They cause damage to the nervous system, immune system, and reproductive system in adults. GE legally dumped more than 1 million pounds of the chemicals into the Hudson River over a thirty-year period.

In 1974 the EPA established that there were high levels of PCBs in Hudson River fish and set the safety threshold at 5 ppm PCBs in fish for human consumption. Two years later, Congress passed the Toxic Substance Control Act banning the manufacture of PCBs and prohibiting their use except in totally enclosed systems, and the public was warned about the dangers of eating fish from contaminated parts of the Hudson River. All commercial fisheries were closed. It was determined that GE had caused the pollution. In 1983, 193 miles of the upper Hudson River were added to the Superfund National Priority List. A year later the EPA reduced the acceptable safety limit for PCBs from 5 ppm to 2 ppm.

In 1993, sediment in the river adjacent to a GE plant was found to contain 20,000 ppm of PCBs. Blood tests of Hudson Valley residents in 1996 revealed elevated levels of PCBs in non–fish eaters, who presumably ingested the chemicals in drinking water. Tree swallows and bald eagles in the area were found to have 55 to 71 ppm of PCBs in their body fat, qualifying them as hazardous waste.

Under Superfund law, polluters are responsible for cleaning up the messes that they make. GE spent millions of dollars on an ultimately unsuccessful campaign to persuade the federal government not to implement a dredging and cleanup plan to rid the river of PCBs. The thirty-year economic and environmental struggle between GE and the government lasted until 2009, when GE finally began dredging the river bottom sediment. Two-and-a-half million cubic yards of toxic sludge will be dredged and transported to a landfill in Texas. The project is expected to cost $750 million and take at least six years. GE is still fighting to reduce the amount of dredging it must do.

Two-and-a-half million cubic yards of Hudson River toxic sludge will be wrapped in heavy plastic, like a burrito, loaded into open railcars, and shipped to the Texas landfill in trains at least eighty cars long. By the third year of the EPA-approved plan, two to three trains a week will arrive at the dump site. At the landfill, excavators on platforms will rip open the bags and transfer the sludge to 110-ton mining trucks. The trucks will haul and deposit the sludge into a pit 75 feet deep into red clay and lined with two layers of heavy polyethylene. Then it will be covered with 3 feet of clay.

Chesapeake Bay

Maryland's Chesapeake Bay has had pollution problems for a hundred years with no cleansing solution in sight. Nitrogen and phosphorus runoff from widespread agriculture in the bay's watershed is the cause. Oyster harvests declined from 53,000 tons in 1880 to 10,000 tons in 1980 to 100 tons in 2003. Oysters cleanse the water by filtering up to 5 quarts of water per hour, a task they can no longer perform adequately. In 1880 there were enough oysters to filter all the water in the bay in three days; by 1988 it took more than a year. The bivalve population has been decimated, and a dead zone now covers up to a third of the bay. A *dead zone* is a volume of water that lacks enough oxygen for aerobic animal life to exist.

Fish contain high levels of mercury, and there are algal blooms and voracious bacteria that threaten the health of people who fish, boat, and swim in the estuary.[53] Health authorities advise against swimming until two days after a significant rain because the rain can sweep in animal manure and human waste from older sewage systems and leaky septic tanks. A spokesman for Maryland's health department warned that people should not let cuts or open wounds contact the water.

Other Dead Zones

Pesticides and artificial fertilizers are used in massive amounts on America's farms, and most of it washes off the farms, into local streams, and eventually into the Mississippi River. In addition to making about half the streams and rivers in the watershed unsafe for drinking, swimming, or recreational contact, the pollution has created a dead zone in the nearshore Gulf of Mexico near the mouth of the river. It covers about 8,000 square miles, the size of Massachusetts, and has been growing since measurements began in 1985.

The hypoxia—very low levels of dissolved oxygen—is caused mainly by excess nitrogen from fertilizer used on crops, with corn using the most. The dissolved nitrogen flows into the Gulf and spurs the growth of excess algae. The algae cause an oversupply of organic matter that decays on the Gulf floor, depleting the water of oxygen. There are no fish, shrimp, or crabs in the dead zone and little marine life of any kind. Fish that survive in areas with slightly higher levels of oxygen have reproductive problems.

Numerous dead zones can be found around the coastline of the United States and at 405 locations worldwide. In most cases, the cause is the same: runoff of artificial fertilizer into nearshore waters.

A piece of hopeful news arrived in 2007 when North America's first full-scale commercial water treatment facility capable of removing phosphorous began operating in Edmonton, Canada. It is also possible to remove nitrogen but the process is not yet widespread.

Endocrine Disrupters

Among the many well-publicized concerns about specific pollutants such as lead and mercury in water is a group of chemicals that affect our sexual characteristics.[54] Apprehension is growing among scientists that the cause of these maladies may be a class of chemicals called endocrine disrupters, widely used in agriculture, industry, and consumer products. Some also enter the water supply when estrogens in human urine pass through sewer systems and then through water treatment plants.

These chemicals interfere with the endocrine system in our bodies, a system that regulates many functions such as growth, development and maturation, and the way various organs operate.[55] There are 966 known or suspected endocrine-disrupting chemicals in existence, and often they are found in the environment. They are ubiquitous in modern life, found in plastic bottles, cosmetics, some toys, hair conditioners, and fragrances. At least forty chemical compounds used in pesticides, and many in prescription medications, are known to be endocrine disrupters. Among the harmful effects these chemicals are known to cause are sexual and reproductive anomalies, which have been documented in studies of rats, toads, mice, fish, dogs, panthers, reptiles, polar bears, and birds. In the Potomac River watershed near the nation's capital, more than 80 percent of male smallmouth bass are producing eggs.

In 2008, research showed that humans are affected as well.[56] Among the most common endocrine disrupters are chemicals called phthalates, which suppress male hormones and sometimes mimic female hormones. Boys born to women exposed to widespread chemicals in pregnancy have smaller and imperfect penises and feminized genitals. They also have a shorter distance between their anus and genitalia, a classic sign of feminization. A study in Holland showed that boys whose mothers had been exposed to PCBs grew up wanting to play with dolls and tea sets rather than with traditionally male toys. As expressed by Gwynne Lyons, an advisor to the British government on the health effects of chemicals, "The basic male tool kit is under threat." If terrorists were putting phthalates in our drinking water, we would be galvanized to defend ourselves, but we seem less concerned when we are poisoning ourselves.

Sperm counts are dropping precipitously. Studies in more than twenty countries have shown that they have dropped by 60 percent over fifty years.[57]

There is also some evidence that endometriosis, a gynecological disorder, is linked to exposure to endocrine disrupters. Researchers also suspect that the disrupters can cause early puberty in girls.

Women in communities heavily polluted with gender benders in Canada, Russia, and Italy have given birth to twice as many girls as boys, which may offer a clue to the reason for a mysterious shift in sex ratios worldwide. Normally 106 boys are born for every 100 girls, but the ratio is slipping. It has been calculated that over the years, 250,000 babies who would have been boys have been born as girls instead in the United States and Japan alone.

In June 2009, the Endocrine Society, an organization of scientists specializing in this field, issued a landmark fifty-page warning to Americans.[58] "We present evidence that endocrine disrupters have effects on male and female reproduction, breast development and cancer, prostate cancer, neuroendocrinology, thyroid metabolism and obesity, and cardiovascular endocrinology." The effects of endocrine disruption can be subtle. For example, a number of animal studies have linked early puberty to exposure to pesticides, PCBs, and other chemicals. It is well known that women with more lifetime menstrual cycles are at greater risk for breast cancer, because they are exposed to more estrogen. A woman who began menstruating before age twelve has a 30 percent greater risk of breast cancer than one who began at age fifteen or later. American girls in 1800 had their first period, on average, at about age seventeen. By 1900 that had dropped to fourteen. Now it is twelve, and endocrine disruption is probably at least partly responsible.

In the United States, the EPA has shown little interest in studying endocrine-disrupting chemicals, and no legislation pending in the U.S. Congress addresses these.

As a Native American chief once said, "Only when the last tree has been felled, the last river poisoned and the last fish caught, man will know, that he cannot eat money."

Ocean Pollution

The world ocean is not immune from the onslaught of water pollution, although it may be one of the ugliest when oil pollution is involved. Contrary to the impression one gets from media reports, oil spills from beached tankers are only a minor part of the problem.[59] Large oil spills contribute only 5 percent to the ocean's oil pollution, and by 2015, when all oil tankers in U.S. waters will be required to be double-hulled, large oil spills may be a thing of the past because the United States is the biggest importer of oil. There are 706 million gallons of oil pollution per year, most of which can, in principle, be controlled (table 1.6).

Control in principle does not necessarily mean control in practice, as illustrated by the BP disaster in the Gulf of Mexico in April 2010, where a blowout preventer failed on a well, causing the worst oil spill that has ever occurred in U. S. waters. Petroleum from 18,000 feet below the sea floor spewed into Gulf waters for three months, perhaps 200 million gallons. The cause of the blowout was human error. There were multiple warning signs, and safety procedures were not followed.

All major oil companies have intensive safety programs and processes to prevent spills. But every human enterprise has a failure potential, as the 2010 Gulf disaster clearly demonstrates. Since 1946 50,000 oil wells have been drilled in the Gulf, and 3,858 of them are currently producing 11 percent of America's domestic supply. The BP disaster is the first

Table 1.6
Sources of oceanic oil pollution

Source	Percentage
Storm drains in cities	51.4
Routine maintenance of ships	19.4
Power plants and motor vehicles	13.0
Natural seeps	8.8
Large oil spills	5.2
Offshore drilling	2.1

Source: OceanLink, n.d. "World Oil Pollution: Causes, Prevention and Clean-Up."

major spill, nevertheless, and this safety record is incomparably better than other commercial and noncommercial activities in the United States such as driving cars, flying, slaughtering animals for human consumption, or accidents at home.

Probably the easiest source to control is the largest: the oil that drains into the ocean from America's cities. Its origin is from people dumping motor oil down storm drains after driveway oil changes, supplemented by road and urban street runoff. Motor oil produced by car owners' oil changes should be brought to garages for appropriate disposal.

The contribution from power plants and automobiles will decrease as renewable and nonpolluting energy sources gradually replace fossil fuels.

Water as a Human Right

The U.S. Constitution says that Americans are entitled to life, liberty, and the pursuit of happiness. Implied in these entitlements are access to adequate food and water. Thus, freshwater is a legal entitlement rather than a commodity or service provided on a charitable basis. Few people would quarrel with this. Access to fresh, clean water is a joint responsibility of federal, state, and local governments. Of course, the term *access* does not mean that individuals are not responsible for their own welfare, only that governments must be concerned about the essential needs of their citizens.

Until the past few decades, access to clean water has been taken for granted by nearly everyone in the United States, a situation made possible by our geographical location and the circumstance that all of the country's major rivers and their tributaries have their headwaters within national borders—the Mississippi, Ohio, Missouri, Colorado, Columbia, and Rio Grande. In addition, entirely contained within our borders is the world's largest underground water resource, the Ogallala aquifer. The amount of water used in the United States is staggering: on a per capita basis, we use far more water than any other nation does.

But all good things must come to an end. Many areas of the United States have begun to experience water problems related to population distribution (too many people in southern Arizona); inadequate or deteriorating infrastructure (old and very leaky underground water pipes); profligate use on lawns (average 10,000 gallons per year per lawn in suburbia), flower gardens, and golf courses (753 billion gallons per year); and willful pollution of both surface and subsurface water supplies (agricultural runoff and injection of pollutants into the subsurface). It almost seems as though Americans have a death wish as far as water is concerned.

What are the responsibilities of governments and individuals to ensure water supplies and avoid a water catastrophe? Some things are the responsibility of governments at various levels. Only governments have the resources to rebuild and upgrade the infrastructure and the legislative ability to stop the injection of pollutants into the subsurface, which poisons our aquifers. At the federal level, ensuring that water is clean is the responsibility of the EPA, and President Obama's EPA head, Lisa Jackson, has begun cracking down on public and private polluters. In September 2009, an investigation found that companies and other workplaces had violated the Clean Water Act more than 500,000 times in the past five years alone, but fewer than 3 percent of polluters had ever been fined or otherwise punished. The water provided to more than 49 million people has contained illegal concentrations of chemicals such as arsenic or radioactive substances like uranium.[60] Jackson has ordered an assessment of the agency's shortcomings, promised stronger enforcement, and added new chemicals to the long list of contaminants.

As with most other environmental laws, responsibility is shared. Washington sets the health standards, but the states write and enforce the permits, which tell polluters what can and cannot be discharged into the water. The EPA has the authority to crack down on polluters if a state fails to enforce the laws. However, some consistent polluters are unregulated, such as large animal-feeding operations (chapter 5). Power plant emissions into the air are regulated, but the toxics they discharge into the water, such as cadmium, lead, and arsenic, are not (chapter 6).

The EPA needs additional money and staff to accomplish its legislatively required goals.

Individuals can design the cared-for property around their houses to reduce water use. Agricultural use, the main consumer of water, can be reduced by eliminating water wasters such as above-ground irrigation sprayers and adopting water-saving devices such as drip irrigation. Population distribution will adjust automatically. If water is not available, people will relocate to areas where it is.

A right to water cannot imply a right to an unlimited amount of water. Resource limitations, ecological constraints, and economic and political factors limit water availability and human use. Given such constraints, how much water is necessary to satisfy this right? Enough solely to sustain life? Enough to grow all food sufficient to sustain a life? Enough to sustain a certain economic standard of living? International discussions among experts in water use lead to the conclusion that a human right to water should apply only to basic needs for drinking, cooking, and fundamental domestic uses such as sanitation and bathing. Water for swimming pools, golf courses, flower gardens, and so on cannot be accepted as a human right. Not pricing water correctly is at the root of many problems with water.

The United Nations and many private and governmental organizations have determined that each person needs a minimum of about 12 gallons of water per day for drinking, cooking, sanitation, and personal and household hygiene. Amounts above this are not necessary, only desirable. And of course we all desire it. But it is becoming apparent that some limitations must exist if we are to live harmoniously with our fellow citizens. Comprehensive discussions about water management among America's political leaders are sorely lacking.