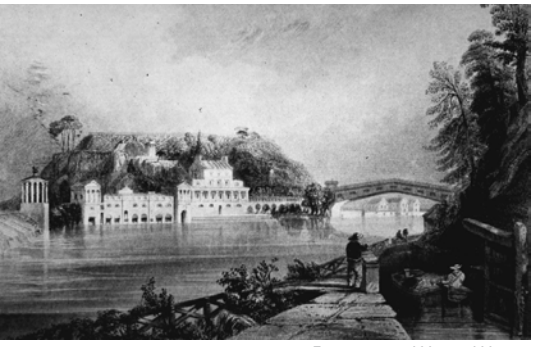
William Braham

WASTE, WORK & WORTH

For most of human history, people could be divided into two classes: those who carried their daily water, and an elite who had someone else carry it for them. Water is quite heavy; approximately 8 pounds per gallon and moving it takes work. As a result, it is little surprise that people who have to carry water use only a few gallons a day for drinking, cooking, bathing, and cleaning. When water can be supplied without human work, the amount of water used each day increases dramatically. In Rome, at the time of the empire, water was delivered to neighborhood fountains, apartment buildings, and the residences of the wealthy, so affluent citizens used up to the luxurious volume of 150 gallons per day. The correlation between work and water exemplifies the classic parable of technological innovation, in which human labor is replaced by mechanical (or hydraulic) ingenuity and the amounts of work (or water) that can be delivered are dramatically increased.



Fairmount Water Works

With abundance, however, comes waste. In 1842, Charles Dickens visited the Philadelphia Waterworks, part of the first modern water supply system, and expressed his surprise at the waste:

Philadelphia is most bountifully provided with fresh water, which is showered and jerked about, and turned on, and poured off, everywhere. … The river is dammed at this point, and forced by its own power into certain high tanks or reservoirs, whence the whole city, to the top stories of the houses, is supplied at a very trifling expense.

The Waterworks was built thirty years prior to Dickens's visit and had rapidly become a model for metropolitan water systems across the country and around the world. As the model spread, so too did increases in water use, largely due to the installation of pressured and piped supply systems. Much of that flow was lost in the leaky systems of distribution as they were extended into households and business, but since the supply was rarely metered until the twentieth century, the population was free to explore uses of water that had been unimagined by even the wealthy bathers of previous generations.

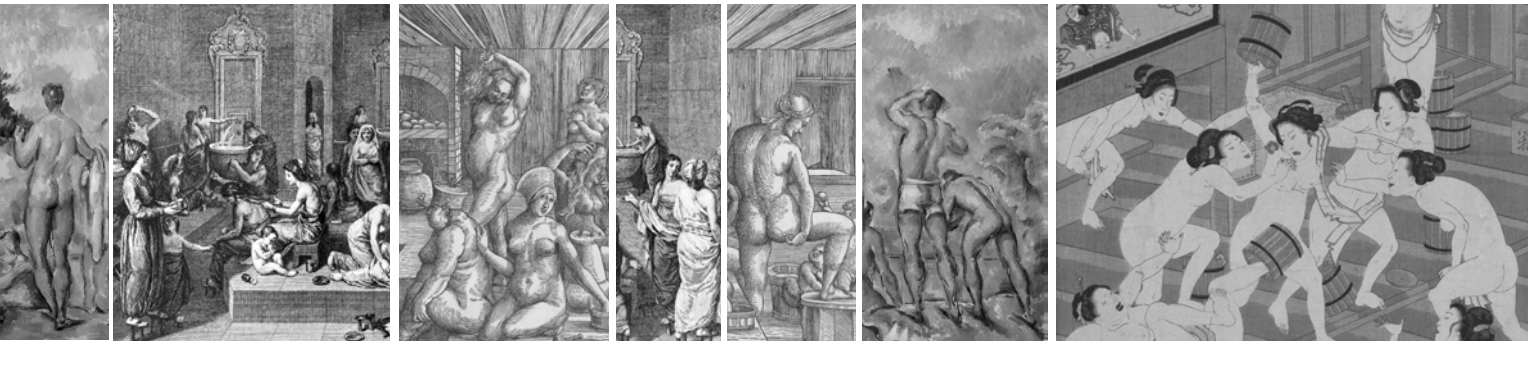
Waste

As water consumption exceeded the capacity of local ecosystems to simultaneously provide fresh water and absorb waste, water intakes were extended and distribution systems made more efficient. However, consumption continued to increase as Philadelphians began to experiment in new ways with a readily available water supply. In a report of 1900, it was noted, that "the average daily consumption in Philadelphia has risen from 36 gallons per capita in 1860, to 215 gallons in 1897." As a result, municipal engineers began seeking the installation of meters to help moderate rates of use. These dramatic increases in consumption can seem quite abstract in the engineering reports, so it is important to recognize the dramatic changes in personal habits that were accompanied by the hundreds of gallons that began flowing through households. At its most fundamental, this cultural change involved a transformed concept of cleanliness, both of the water and of those that used it.

In the final chapter of Mechanization Takes Command, Siegfried Giedion examined this change through the history of the modern bathtub, contrasting it with the public bathing habits of the ancient world and locating the shift to private cleansing in the political and corporeal anxieties of the early modern period. It can be hard to imagine a regime of cleanliness so different from our own, in which daily bathing prevails. The change in concept and degree didn't happen all at once (or everywhere at the same rate), but as we consider the subject of water use in the twenty-first century, it is imperative to understand the moist evolution of habits, habitats, and inhabitants that are involved in the new technologies of water use. An infrastructural alignment and a public health regulation illustrate this evolution.

The installation of the first water supply systems typically preceded the construction of sewage systems,

Embodied Bathing

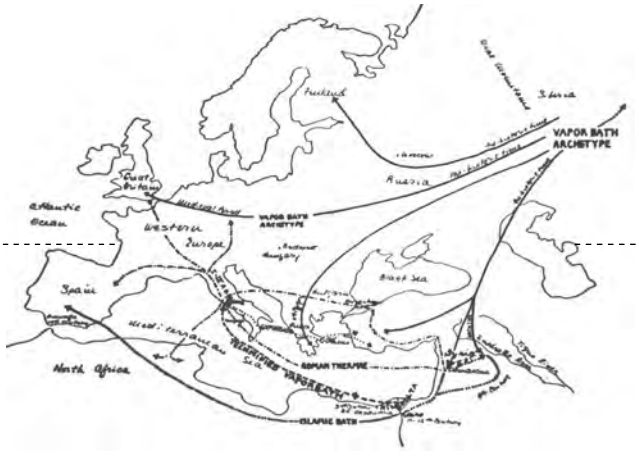


"The concise lines of this white bathtub will perhaps bear witness to later periods for the outlook of ours as much as the amphora for the outlook of fifth centry Greece. It is a luxury article, which the combinations of refined metallurgical and technical skills transformed into a democratic utensil. In its own way, this double-shell tub, which on the other side of the atlantic still smacks of luxury, numbers among the symbols of our time."
Giedion

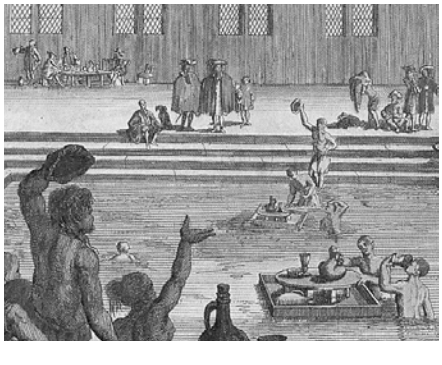
Disembodied Bathing

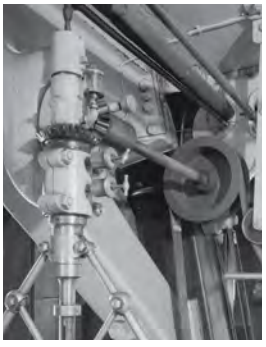
sometimes by decades. Dirty water was simply dumped into existing yards, privies, and drains until they overflowed, causing a host of problems and demanding an investment in sewage piping and closed sewers. This ultimately ushered in the armature of modern plumbing, which uses one set of pipes for clean water and another for dirty. The real acceleration in water use began once the two systems were aligned, when the drain for dirty water was located below the faucet delivering clean water. Public health officials quickly learned about the dangers of letting the systems connect, with one person's dirty water siphoning back into another person's supply pipes, and so legislated a minimum "air gap" between the bottom of a faucet and the top of a bathtub or sink. The diagram of the alignment between faucet and drain, with its hygienic gap and simple backflow prevention mechanism, describes the realization of a powerful new technology for maximizing the conversion of clean water into dirty. You don't have to touch water; all you have to do is turn on the tap.

Giedion posed the question of bathing as a choice between cleansing and leisurely regeneration, and hoped that a recovery of the more public forms of bathing might help redeem industrialized culture. However, he also recognized the power of the new technologies of the bathroom, and their luxurious appeal. To Giedion, the smooth white tub signaled much more than the fruit of advanced metallurgy; it symbolized the luxury of hot and cold running water itself ("on every floor" as hotels used to advertise). The term luxury is quite precise in this situation, meaning the willful and visible expenditure of wealth, in the form of an unnecessary expenditure of some of that massive hydraulic power. Arguably, the first gallon or so a day is a biological necessity, but the rest is a luxury to which we have become accustomed.



Migration & Evolution of Bathing in Europe: *"The manner in which a civilization integrates bathing within its life, as well as the type of bathing it prefers, yields searching insight into the inner nature of the period."*
Giedion



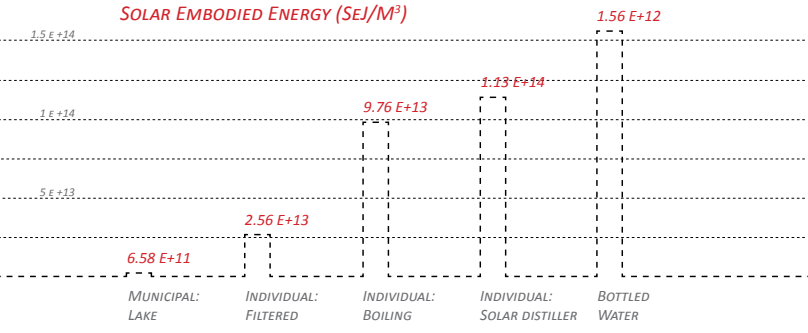
Work

The water delivered through modern pipes is luxurious in two ways. First, is freedom from the mostly physical work of lifting and conveying all that water. This entails, on the part of most municipal water systems, the moving of water that is already fresh, drawing it from lakes, rivers, and underground aquifers, filtering it for particulates, and then pumping it through the massive water supply infrastructure under pressure. The typical cost of the water supply, whether paid through taxes or individual meters, covers the work of building and operating that hydraulic enterprise, which increasingly includes some amount of chemical purification. This brings us to the second luxury, the "freshness" of water. The largely biochemical work of distilling and cleaning water adds value that becomes starkly apparent in regions where water re-use is necessary. In such cases, freshness can be achieved by distillation, boiling and condensing water using large sources of heat, or by osmotic filtration under very high pressure, using electrically powered pumps. The amount of electricity used to power the osmotic process for cleaning dirty water can be up to ten times greater than that used in facilities which start with fresh water sources. This makes evident some of the work already performed by the biosphere to make the fresh water in lakes and rivers.

Water filtration methods can also be applied to sewage, in a process called "toilet-to-tap," which according to a county official in San Diego, is "one of the most expensive kinds of water you can create." While he was referring to the economic cost, that expense also reflects the tremendous amount of work that natural waterways provide up until their biological processes are overwhelmed. Toilet-to-tap is is really just the final step of water recycling implemented to reduce the burden on local ecosystems that began when American legislators enacted the Clean Water Act of 1948. Along with the revisions of 1972, this legislation made the common practice of dumping raw sewage illegal and required effluent to meet secondary treatment standards, mostly through the elimination of biodegradable organics. Most of that treatment work is performed in sewage treatment facilities by microbes similar to those found in natural waterways, which consume the organic material as food, converting it to carbon dioxide, water, and heat. They biologically neutralize wastewater before it is returned to waterways, where some of it is simply extracted again for the water supply system. A common urban saying is that the river water of major cities is "drunk seven times between the source and the sea."

Potable Water Component Costs: 30 MGD

Disinfection	*$120*
Wastewater Reuse	*$250*
Coagulation & Filtration	*$540*
Lime Softening	*$410*
Membrane Softening	*$590*
Reverse Osmosis	*$601*

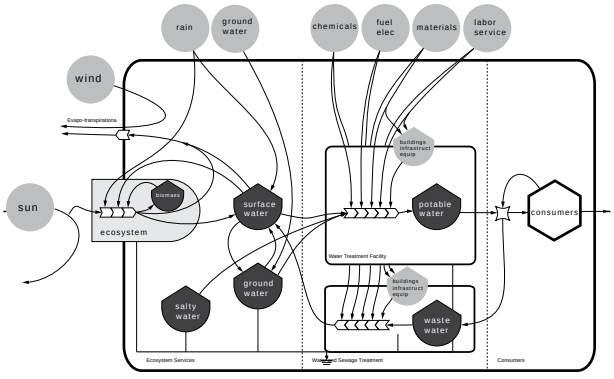


Worth

In spite of all the work that goes into water treatment, anxieties about cleanliness and the last step from sewage to drinking water are profound. San Diego ultimately decided to pump its osmotically filtered sewage water into local aquifers, where it actually became somewhat less pure before it is subsequently withdrawn again for consumption. However "laundering" water in this way more adequately satisfies public superstition about cleanliness. This is a fascinating perception, in which we trust the natural processes of the hydrologic cycle to deliver cleanliness, while counting their services as "free," but we distrust the engineered services for which we have to pay. Pristine nature versus imperfect people perhaps, but the distinction highlights the difference between common sense perceptions and the economic exchange value of natural resources. As long as the human uses of a river are within the capacity of the waterway to clean itself, the exchange value more or less reflects the work of obtaining and delivering it. But once the renewal capacity is exceeded, as consumption grows past those limits, the real price of purifying and delivering the water becomes evident, as costlier forms of work and greater quantities of energy are required to reproduce the natural supply. Municipal engineers can purify seawater and recycle sewage to augment or even replace fresh water supplies, but it requires tremendous amounts of work to do so. In other words, the luxury of abundant fresh water is purchased with work, whether through the "free" work of the biosphere or the paid work of the technosphere.

As ecological economists have demonstrated, monetary costs undervalue the contribution of the biosphere until its capacities are exceeded. An alternate approach for evaluating environmental work (and worth) is biophysical accounting. In the method developed by H. T. Odum, every form of energy transformation is tracked to provide a common evaluation of the many different kinds of work and resources required to deliver fresh water. Ultimately all the work performed in the bio-

sphere can be traced back to the sun, whether as part of the hydrologic cycle, the human conversion of fossil fuels to work, or the production of food to support human labor. Putting these many different contributions in the common terms of solar embodied energy (solaremjoules, sej) enabled Andres Buenfil to quantify the total cost of the different delivery mechanisms for fresh water in Florida. The clean water delivered to a lake involves about 250 million sej per cubic meter of water. Not surprisingly, the least expensive fresh water supply was a municipal system drawing fresh water from a lake, which required about one trillion sej per cubic meter. Using an osmotic filtration system with brackish water doubled that cost, while a system purifying seawater was over seven times as expensive. This largely confirms the conventional engineering ranking, but reinforces the contribution of ecosystem services and the value of maintaining the health of existing watersheds. Of course the most expensive method of delivering fresh water is in plastic bottles, which requires over 150 times as much total work and energy as the municipal supply from a lake, even when the water had been drawn from the same fresh water source. It turns out to be much, much more expensive to drive water in a diesel-powered delivery truck than to pump it through pipes.



ENERGY SYSTEMS: *POTABLE TAP WATER FOR CONSUMERS IS THE RESULT OF A COMPLICATED MATRIX OF ENERGETIC AND MATERIAL INPUTS STEMMING FROM INDUSTRIAL AND ECOLOGICAL SYSTEMS.*

Life unavoidable generates waste, and the ubiquitous plastic bottle of water stands as a symbol of the particularly wealthy life-style of the early twenty-first century. It is a wealth obtained by extracting work from a biosphere reaching the limits of its capacity to provide more fresh water and absorb more wastes. However there is a more human lesson to be taken from this brief history. Clean water isn't valuable because it is scarce, it becomes scarce because it is so useful. Water is a powerful agent of chemical transformation and of heat and mass transfer, which is integral to most biological activities and many social and symbolic ones as well. We simply use water to the point of scarcity, and that is what makes its abundant use so luxurious.