ONE

THE GLOBAL CONTEXT

> In water, two hydrogen atoms always rest against the atom of oxygen at a 104.5 degree angle. This has been called the angle of life. This is the secret of why this is not a frozen, bleak planet.
>
> —John Todd, 1990 inaugural address,
> Center for the Restoration of Waters

GOT WATER?

AS I WRITE THIS, I'm sipping a glass of water. Eight glasses a day is my goal, beginning with the first glass every morning to break the fast of sleep and pump things up enough to handle the coming slug of strong black coffee. We humans, as someone on *Star Trek* once said, "are bags of mostly water." Water makes up over 60 percent of our bodies and 70 percent of our brains. Babies are 90 percent water.

In ice or liquid form, water covers about 70 percent of the earth's surface. But for the purposes of this book I am interested in less than 1 percent of that water—the tiny portion that is fresh and readily available for human use.

The United Nations World Water Assessment Program estimates that one in six people, or a little over one billion people, currently lack access to adequate drinking water. They forecast that at least one in four people will be living in countries with serious water shortages by 2050 if the world keeps consuming water at today's rates. That outlook may be conservative since, in the 1990s alone, per capita water consumption on the planet rose at about twice the rate of population growth. This trend in increased water use is not necessarily due to you or me taking more baths. It factors in global industrialization, including massive irrigation for industrialized farming, which accounts for up to 80 percent of our planet's water use.[1]

The report also raises many questions about the *quality* of our future water. Will it pass even our most basic measures? Will it be drinkable? Fishable? Swimmable? Over half the world's lakes and estuaries are now too contaminated for fishing or swimming. Their systems for recharge and recovery have been compromised by the cutting of neighboring forests, the filling of wetlands and floodplains, and the discharge and accumulation of human and industrial wastes. Drinking from these sources may still be possible thanks to chemical treatment, primarily chlorination. But chlorination adds problems of its own, and only disinfects water for those who can get it from a pipe, which excludes a large portion of humanity and all other species that depend on raw water supplies.

MOST OF US KNOW comparatively little about the natural processes that sustain Earth's creeks, rivers, lakes, and groundwater. Most of us think someone else is minding the water. Based on my own explorations of Great Lakes waters, I'd say this is a dangerous delusion.

Within the last two decades, research on aquatic ecosystems such as that published by the Flathead Lake Biological Station at the University of Montana challenges our most basic views of how rivers work—though it remains relatively unknown to the engineers in charge of our waterways. These studies reveal that every stream is actually two interacting waterbodies: one above ground and one below. The groundwater does all the invisible housework of cleaning and providing storage, recharge, and nutrients to the waters above. Groundwater systems, called hyporheic or "below the flow" zones, also serve as a refuge for creatures during all or parts of their life cycle and assist in stream and species recovery after floods or droughts. Many previously unknown species of worms, shrimp, insects, and microscopic organisms were found below the flow, supporting a food chain that extends to the surface and beyond. Hyporheic zones have been measured as deep as 30 feet below streambeds and for miles on each side.[2]

Remember this the next time someone proposes putting your local creek or river in a concrete channel for flood control or in an underground culvert to accommodate development. Though the operation may be a success, the health of that stream and all who depend on it will suffer.

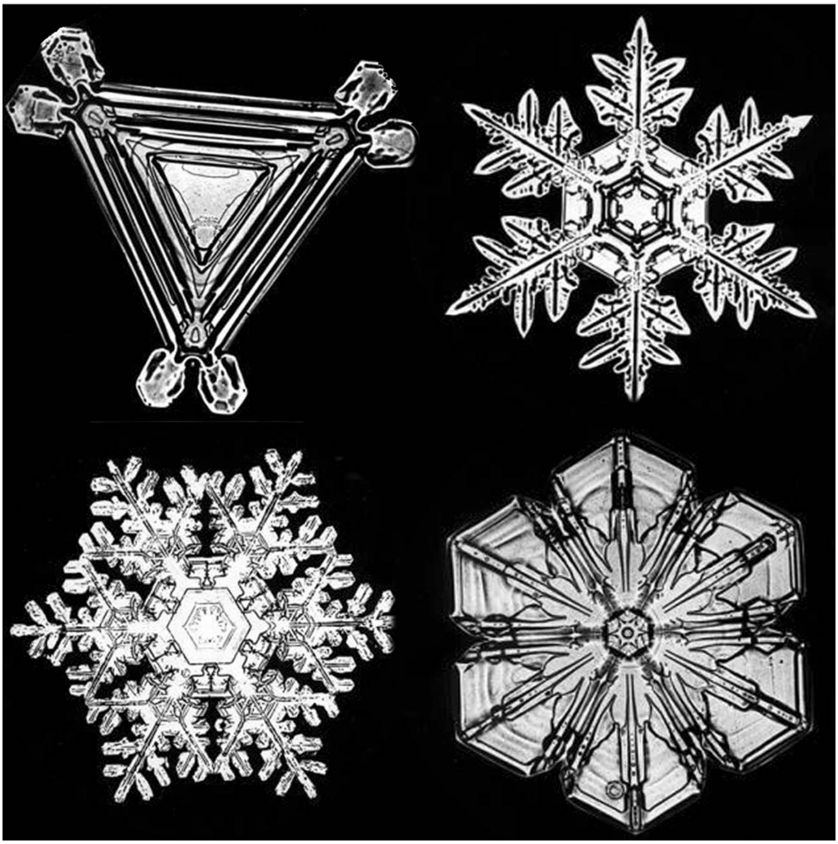
CONSIDER THE WATER that comes out of your tap. How did it cycle through its natural habitat? Where does it come from? Where does it go?

A light snow is drifting past my window this late January afternoon in Buffalo. Fallen snow is blowing down off the roofs and floating up from the driveway, big flakes up to an inch in diameter. Positioned as we are in the snow shadow of Lake Erie, we Buffalonians recognize this phenomenon as "snow flurries," meaning "intermittent snow with little or no accumulation," as opposed to "snow showers" (steady downfall), "snow squalls" (add wind), or "blizzard" (snow squalls and high winds sustained for at least—anything less is for wusses—three hours).

But what do we know about the role of snow in the water cycle? Specifically, how does the transformation to or from snow affect water?

Snowflakes are collections of individual ice crystals like the ones now stuck to my storm window. My snowflake field guide says the largest snowflake ever found was 8 by 12 inches, recorded in 1971 in Bratsk, Siberia. It must have contained millions of the tiny crystalline structures I can see clearly on my windowpane, which all look to me like variations on a six-pointed star. My guide identifies eight principal types of snow crystal: stellar dendrites, sectored plates, hollow columns, needles, spatial dendrites, capped columns, irregular crystals, and rimed crystals. Rene Descartes, sometimes called "the father of modern philosophy," began this snow crystal morphology in 1635. For some reason—perhaps it seemed a frivolous sideline to the heady enterprise of mind–body dualism—the work was not completed until over three hundred years later, when Ukichiro Nakaya published his exhaustive study, *Snow Crystals*, in 1950.

Besides being beautiful, what do these crystal structures do? Masaru Emoto, a practitioner of alternative medicine in Kyoto, Japan, studies water's variable ability to form crystals in connection with theories



1.1. Snow crystal photographs by Wilson A. Bentley. Courtesy of the Buffalo Museum of Science.

concerning the healing properties of water. His research involves freezing specimens of water from various sources, and then observing these frozen drops of water under a microscope as they first begin to liquefy, a process he has captured on film. Some water samples, like those from the springs on Mount Fuji, form simple to elaborate hexagonal crystals. Others, including samples of urban tap water from Tokyo, Paris, and other cities around the world, do not. Emoto believes that the crystal-forming power of water reveals its life energy or "hado," a centuries-old Japanese word literally meaning "vibration." The absence of crystal-forming ability indicates that the purity of that water source, and thus its ability to support life, is compromised.[3] Core to his healing practice is the belief that the life force of water can be restored through positive energy. In a lecture he has taken to cities around the world, he shows films of corrupted water samples regaining their crystal-forming ability after being exposed to music and prayer.

I may be too hopelessly Cartesian to be entirely comfortable with Emoto's conflation of mind and matter in these healing intricacies of water, but I am intrigued by his basic findings relating structural capabilities with different levels of purity. Is it possible that snow as a process in the hydrologic cycle not only reveals an atomic property of water but also helps restore it in some way, for example, by isolating or neutralizing impurities? Could the atmospheric cycling of water be as important to water's quality, its ability to support life, as the subsurface cycling through soil, sand, and rock?

If, from 5 miles up in an airplane you watch the rivers below, you might deduce that every stream is actually *three* interacting waterbodies: one working invisibly below the flow, one the glimmering flow of surface water, and one, often the only one you can see, the vapor cloud floating directly over the river, mirroring its sinuous curves, doing whatever work it is doing.

THE STATE OF THE GREAT LAKES

THOSE FORTY MILLION of us residing in the Great Lakes basin have a living laboratory in which to explore the mysteries of the water cycle. We are part of the largest freshwater ecosystem on earth, a system containing almost 20 percent of the world's fresh surface water.

Our earliest childhood lessons should lay the groundwork for appreciating this awesome fact. Where did all this freshwater come from? Why is it here?

The 5,500-cubic-mile deposit of water in the Great Lakes is a legacy of the glaciers, meltwater from the mile-thick layers of snow and ice that covered the region. The basin itself predates the glaciers by millions of years, its stratified foundation laid down by the great, shallow saltwater seas that intermittently covered much of the interior of what is now North America. Remnants of these seas and their different ecologies are everywhere to be found—from the fossilized corals and shells in the cliffs of Lake Erie, to the salt vein that is mined from a thousand feet below the Genesee River and redistributed over the ice and snow that reclaim the streets every winter.

The freshwater that now fills the Great Lakes basin is, like Saudi Arabia's oil, a limited supply. Geologists describe the Great Lakes as a relatively closed hydrologic system, with less than 1 percent of the water escaping annually through the St. Lawrence River to the sea, and less than 1 percent new water coming in from other watersheds in the form of rain or snow. That means that 99 percent of the water in the Great Lakes has been recirculating for 12,000 years through cycles of evaporation, precipitation, collection in wetlands and mountain ponds, runoff from cities, highways, farm fields, and eventual recharge back to the lakes.

This long retention capacity makes life in the Great Lakes vulnerable to contaminants that persist in the environment. In many ways, the planet's understanding of the connections between certain toxins in the environment and certain risks to organisms developed right here, in the Great Lakes region, though it took big signs—burning rivers, beaches covered with dead fish and rotting algae—to gain our attention.

I remember as a child helping my dad unload construction debris at one or another of Buffalo's waterfront dumps and I can attest to the fact that, on the industrialized shores of eastern Lake Erie and the Niagara River at least, we *expected* the waterfront to be burning and stinking and shrouded in smoke. It signaled, if not prosperity, then at least that people were working and that we belonged to some kind of economy.

But, in the 1970s, people began making the connection between human health, wildlife health, and water quality. Scientists traced the collapse of top predator wildlife populations like the bald eagle to eggshell thinning and other subtle failures in the reproductive cycle caused by DDT accumulated in Great Lakes fish. The cluster of illnesses afflicting an entire Niagara Falls neighborhood, especially the children, would soon be linked to the chemicals seeping through the groundwater at Love Canal. Something bad was happening on a major scale in the Great Lakes.

In response, in 1972, Canada and the United States signed the Great Lakes Water Quality Agreement, first to reduce phosphorous, the most obvious pollutant that had contributed to a "dead" or oxygen-poor Lake Erie, and then, as amended in 1978, to take on industrial contaminants, or "persistent toxic substances." The new objective of the federal, state, and provincial governments surrounding the Great Lakes was that "the discharge of toxic substances in toxic amounts be prohibited and the discharge of any or all persistent toxic substances be virtually eliminated."[4]

The first part of this much-examined sentence explains the regulatory regime we currently live under, as defined by the Clean Water Act in the United States and the Canadian Environmental Protection Act in Canada. States and provinces control industrial toxic releases by issuing permits whose thresholds are based, theoretically, on what the receiving water can safely dilute to some point of harmlessness.

The second part of the sentence designates the more radical approach of "virtual elimination" for *persistent* toxins, substances like mercury that live long and accumulate in animals. It commits both countries not only to eliminating discharges of the most toxic and bioaccumulative chemicals and metals (beginning with a list of the top twenty-two known to be harming Great Lakes fish and wildlife), but also to cleaning up forty-three "Areas of Concern"—highly contaminated rivers and harbors across the basin.

The International Joint Commission (IJC), created by the 1909 Boundary Waters Treaty to assist Canada and the Unites States in the protection of the lakes and rivers we hold in common, became the official watchdog to ensure the implementation of these commitments. In their 1992 *Sixth Biennial Report on Great Lakes Water Quality*, the IJC drove home the urgency for ridding the Great Lakes of persistent toxic substances:

> Because persistent toxic substances remain in the environment for long periods of time and become widely dispersed, and because they bioaccumulate in plants and animals—including humans—that make up the food web, the ecosystem cannot assimilate these substances. We conclude that persistent toxic substances are too dangerous to the biosphere and to humans to permit their release in *any* quantity . . . Zero discharge means just that: halting all inputs from human sources and pathways to prevent any opportunity for persistent toxic substances to enter

> the environment as a result of human activity. To prevent such releases completely, their manufacture, use, transport and disposal must stop; they simply must not be available.[5]

How are we doing on these commitments?

Every two years since 1994, researchers from both countries issue a report on the health of the Great Lakes. One important measure is the amount of mercury, PCBs (polychlorinated biphenyls), dioxin, and other persistent toxins found in the fish from each lake. Since sampling began, levels have dropped but remain high enough to necessitate government advisories throughout the Great Lakes and their tributaries limiting the amount of fish people can safely consume. Women and children are especially at risk due to the interference of these substances with hormones that determine fetal and child development. We owe much of our understanding of how environmental toxins threaten human and animal health to the work of Dr. Theo Colborn. Her groundbreaking collaborative research showed how PCBs and other chlorinated compounds in the fat of fish-eating mothers are transferred to the developing young (in egg or womb). There, depending on dose and timing, they can interrupt normal development to cause an array of ills, from reproductive failures and physical deformities in bald eagles and beluga whales, to long-term immune system impairments and learning deficits in humans.[6]

But haven't we had dramatic reductions in toxic discharges over the past thirty years? Why are they still showing up in Great Lakes animals?

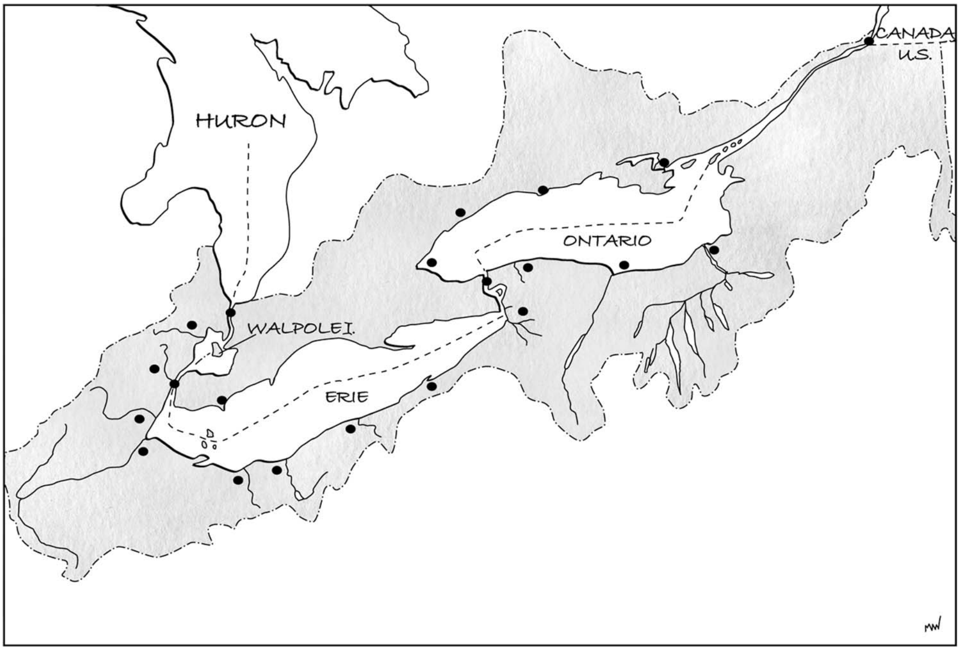
There are at least two answers to these questions.

First, although some contaminants have been greatly reduced, the Clean Water Act goal of eliminating all pollutants to all waters of the United States by 1985 remains a distant goal. For example, in 2002, the last time U.S. and Canadian toxic release inventories were compiled for the Great Lakes basin, over 4,000 facilities reported releases or transfers of over 1.3 billion pounds of pollutants. Discharges directly to water actually *increased* from the last binational reckoning four years earlier.[7] And this only accounts for the 650 substances that require reporting. According to the two governments' *State of the Great Lakes 2007* report,

> Some 70,000 commercial and industrial compounds are now in use, and an estimated 1,000 new chemicals are introduced each year. Several chemical categories have been identified as chemicals of emerging concern, including polybrominated diphenyl ethers (flame retardants), perfluorooctanyl sulfonate (PFOs) and carboxylates, chlorinated paraffins and naphthalenes, various pharmaceutical and personal care products, phenolics, and approximately 20 currently used pesticides. PBDEs, siloxanes and musks are now widespread in the Great Lakes environment. Implementation of a more systematic program for monitoring new persistent toxic substances in the Great Lakes will require significant investments in instrumentation and researchers.[8]

A second reason why we continue to find high levels of toxic substances in Great Lakes fish is the long retention capacity of the lakes, and the fact that these substances remain in the sediments of our rivers and harbors and in thousands of leaking landfills along their shores. They are a legacy common to all the Areas of Concern, including six in New York State—the Buffalo River, Niagara River, Eighteenmile Creek (Niagara County), Rochester Embayment, Oswego River, and the St. Lawrence River at Massena—none of which has been cleaned up to the point where the fish advisories could be removed. (Although the Oswego River was officially delisted in 2006, the AOC fish advisories remain. See chapter 9).

On the basis of such indicators, the lower end of the Great Lakes ecosystem appears to be in the most trouble. The *State of the Great Lakes 2007* report rated the health of Lakes Erie and Ontario as "mixed" to "poor" in terms of most of the contaminants measured in fish and waterfowl. These revealed higher levels of PCBs, DDT, and mirex in Lake Ontario than anywhere else in the Great Lakes. No real surprise, as the two lower Great Lakes are the smallest and therefore the most vulnerable to pollution, and are at the receiving end of highly industrialized rivers—the Detroit and the Niagara. Twenty-one Areas of Concern are located in the watersheds of these two lakes and their connecting channels.



1.2. Lower Lakes Areas of Concern

A WATER ETHIC

In 1998, while working for a binational Great Lakes environmental coalition, Great Lakes United, I attended a series of ten public hearings across the Great Lakes–St. Lawrence River basin to gather citizens' testimony on water quality and to present those findings to the region's representatives in Washington, D.C., and Ottawa. Listening to people talk about what was happening to the water, fish, wildlife, and human health in their communities was a deeply moving experience, especially in Detroit, where the longest, angriest, and most enlightening of all the hearings took place. The highlight was a speaker from Walpole Island First Nation, an indigenous community in Lake St. Clair, sometimes called the "sixth Great Lake," located midway between Lakes Huron and Erie. Walpole Island is just upstream from Detroit and the Detroit River, and downstream from "Chemical Valley," and Sarnia, the "chemical capital of Canada," where more than 40 percent of Canadian bulk chemicals are manufactured. Chemical spills to the river routinely threaten water quality in Lake St. Clair, causing the Walpole Island First Nation to shut down its drinking water intakes, assuming it is notified in time.

Other affected downstream communities have invested in an alternative supply, and now pipe their water down from Lake Huron. But the Walpole Island First Nation elected not to do this because, as the speaker said, "It would not have served the wildlife and the people who still consume the wildlife. It would have looked like we're giving up on the river, like we were saying, 'Okay, Chemical Valley, you can have the river between Sarnia and Imperial Chemical Industries.'"[9]

Walpole Island acted on the basis of an ethic that makes our usual ways of dealing with environmental pollution—say, leveraging a fine for a permit violation—look halfhearted at best. This was a decision more in keeping with the land ethic advocated by Wisconsin conservationist Aldo Leopold: "Examine each question in terms of what is ethically and esthetically right, as well as what is economically expedient. A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise."[10]

There are many reasons why this is not an easy ethic to live by, not the least of which is the fact that stable biotic communities are increasingly hard to find. Most of us relative newcomers to the Great Lakes region have little idea of what its native communities looked like or how they functioned before they were "improved," harvested, or otherwise appropriated. So before we can even begin to act on a Leopoldian ethic, we need to ask questions. How did this river (lake, aquifer) work before it became a drain (industrial sewer, canal, power reservoir)? What life did it support? How did precolonial residents live here and what can we learn from their knowledge and stories of the region?

My interest in such questions is not to set impossible goals for restoring some imagined "pristine" wilderness condition, but to better understand the ecosystems that coevolved here over the millennia so that we can work with rather than against them. Perhaps the most important "take-home message" from these river explorations is that the seeds and remnants of indigenous ecologies are still here, waiting to be recognized and properly valued.