# The Water Chain

Most people don't think of a fairy-tale or a federal space agency when considering their tap water? Yet, contemplate how certain astronomers routinely scan the galaxies looking for planets capable of supporting life. These sky-probing scientists, while scanning the stars, subtly reveal the critical nature of water to life. If alien life exist elsewhere, consensus scientific opinion assumes that it would occupy a planet orbiting a faraway star at just the right distance, not too close but not too far, the Goldilocks zone. Planets in this zone may contain liquid water. Despite extensive searching, currently, humans have located one verifiable life-sustaining planet, a water drenched blue orb in space, Earth. Enabling the lives of all earthly species, water seemingly engulfs our planet. Yet, water, by weight, makes up only .02% of the Earth's mass. Still, compared to most other stellar locations, Earthlings luxuriate in water. Life generally needs four items to survive: water, energy, chemicals (including minerals and gases), and seed (a piece of existing life). Organisms absorb energy and use it to bind together organic chemicals suspended in water. Earthly life depends on this complex, elegant and continuous creation process. Thus, life as understood by humans depends on water. Our own lives depend on water, for most people their lives depend on tap water.

Water evaporates from the oceans driving rain and snow which falls from the sky as precipitation which permits terrestrial life. Water flows from highlands to lowlands, always seeking lower elevations. Once on land, water sometimes percolates into the ground. Water professionals call water flowing over land, surface water and water below ground, groundwater. To all people, from these two sources, does water generally flow. Most people have heard of the food chain. However, they also live from a water chain. The human water chain cleaves into two streams, groundwater, and surface water.

Ever consider where the water that fuels your life originates? It does not fall from the sky directly into your mouth. Trained industrial workers collect, purify, and deliver domestic water. These workers form a hidden subclass constantly laboring to keep the taps running. Our drinking water supplies have become a network of dams, canals and reservoirs that align to a subnetwork of treatment plants, pipelines, and energy supplies. These intertwined human-built structures obscure water sources from the masses. Water managers transport lake-sized quantities of water, sending the liquid hundreds of miles as they fancy. By weight, humans transmit more water than any other commodity. The U.S. water chain involves precipitation, collection, treatment, and delivery. Nature donates the first link on the chain. Humans sustain the last three links.

For a panoramic example of a modern water supply take California. The state boasts 1300 dams and reservoirs that provide water storage for agriculture, domestic use, and hydropower. Last century, two colossal water transportation systems were constructed in the state, the Central Valley Project, and the California State Water Project. These twin riparian aqueous machines ensnare a large share of the free-flowing water in the vast mostly dry state. Downstate, decades

ago, parched Southern California cities partnered with desert based Imperial Valley farmers to extract a large slice of the Colorado River's annual flow. Furthermore, wells permeate the state, extracting groundwater from ancient underground aquifers. Recently, still searching for supply, Golden State water managers discovered a new/old drinking water source. San Diego and Santa Clara, among others, have decided to tap their sewers to supplement their drinking water. These major cities have begun constructing towering industrial plants that scrub soured toilet water using a blur of energy, chemicals, and mechanical movement. Then the refreshed sewer water will emerge again to out the taps of citizens, toilet-to-tap etc. The industrial control of water has benefited the state. Semi-arid California ranks as the nation's most populous state and stands as the nation's largest agriculture producer. With so much effort expended in a gilded rich state, one fact may surprise. Multitudes of Californians currently lack safe drinking water in their homes, unable to drink or cook using water from their home faucets. California serves as an example, but all states suffer tap water issues. Volumes could be filled describing the wide-ranging problems that plague the country's taps. Big picture issues like population growth, large desert cities and climate change stand out. Most average people cannot dedicate themselves to an exhaustive examination of our ever-growing water problems. Still, by contemplating three fundamental subjects, people can educate themselves about the Earth's natural waters while also gaining insight into their own tap water. These three subjects are watersheds, aquifers, and infrastructure. Watersheds are paths that water follows as it runs off land. Most water follows streams, rivers, and deltas to the oceans, while a few watersheds funnel to inland terminal lakes. Prior to the twentieth century, unfettered watersheds supplied most human drinking water. When the fossil fuel/industrial age sprang forth, dam construction exploded. Dams allowed water storage for future dry periods and provided the first abundant green power, hydropower. Monolith barriers, like the Hoover Dam, spread their mass across the natural watersheds and bent nature's plan to human whim. Humans captured, stored, regulated, and moved the water to satisfy their desires. Things have limits though. With dams, the natural flow and variability of watersheds determine their utility. Yearly, on the land drained by every watershed, limited amounts of precipitation fall, and the amount varies widely by season and year. The limits of a river's flow can be calculated using observation and instrumentation. However, twentieth-century dam designers often used overly optimistic flow calculations to make dam projects more appealing to the public and politicians. Accordingly, many dams have built-in optimistic precipitation assumptions that later disappoint. Many dams were built assuming certain flows, but other dams later interrupted that flow. After Hoover dam first breached the Colorado River, dozens of other dams were later constructed upstream. Water behind dams flows out to previously dry land for farmland irrigation. The resultant irrigation-driven single species farming displaces forests and grasslands, obliterating natural flora and fauna. While providing water for irrigation, dams simultaneously starve downstream deltas. Irrigation diversion causes downstream estuaries to shrivel, killing fish, reptiles, plants, and birds alike. Wetland obliteration occurs in real time today at the mouth of the Mekong River delta, a dozen upstream dams exacting the toll on the river's mouth. Once dry, wetlands no longer form natural flood barriers. Without these barriers, human settlements

become more prone to seasonal flooding. Some dams divert water flows away from inland lakes, drying the lakes permanently. Mid-last century, Tulare Lake in California virtually disappeared after four federal dam projects redirected water from the lake to surrounding farms. Frustratingly, much dam storage is for naught since rampant evaporation constantly devours the stored water. Currently in the U.S. we have reached the limit of most natural watersheds' ability to supply water to humans. No person can ignore the immense benefits of our current dams, especially to the world's agriculture supply. Nonetheless, a sustainable water future likely requires less dams not more.

Watersheds that end at the ocean perform one additional often overlooked function, ocean feeding. For eons, watersheds inundated oceans with silt flows and nourished life in the oceans. Along the coast of continents and islands, euphotic zones exist, sunlight zones. These areas with water up to 600 feet deep host most of the ocean's underwater plants. Euphotic zone plants absorb 50% of the world's yearly CO2 production, more than all the forests on land. Natural silt flows from rivers helps fertilize these greenhouse gas gobbling water plants. Aquatic animals also benefit from silt flows. In the ocean, watershed silt sparks the formation of tiny animals like plankton and diatoms. These micro-organisms form the base of the pyramid shaped ocean food chain. The ensuing growth/consumption cycle leads from the micro animals up onto the largest fish. Watersheds also host upstream life flows which travel up rivers and streams. For example, adult salmon mass by the millions to swim up watersheds, providing feeding cycles on land when dying spawning salmon are consumed by land animals. Later, salmon fry feed downstream fish as they are consumed while returning to the ocean. One dam can interrupt this entire process. While humans starve the ocean of helpful silt, they feed the ocean a variety of undesirable substances, first and foremost being nitrogen-based fertilizers. Farming run off flows into rivers causing elevated levels of unwanted nitrates. Run-off from city streets, treated discharge from sewer plants and cities of plastic litter casually flow down watersheds. The gargantuan plasticine island swirling in the Pacific gyre floated down to the ocean along a watershed, piece by piece. Salmon ingest mercury that floated down a watershed from human polluters, bit by bit. Too long being mistaken for disposal routes, watersheds instead should be viewed as water roads that lead to the ocean, our only ocean.

Groundwater stands as the most perishable water resource. Drill holes into the earth and you can access this water. Wells have been dug on a small scale since antiquity. In the 1930s, diesel powered drill rigs and engine driven pumps began dominating groundwater extraction, unleashing a previously unfathomable assault on formerly undisturbed ancient aquifers. Natural aquifers accumulate water underground over centuries and some aquifers hold mighty underground pools of water. The Ogallala aquifer in the Midwest covers 174,000 square miles and allows multi-state farm irrigation which helps feed the world. Though taking centuries to form, aquifers can be fully depleted in decades when assaulted by engine driven pumping. In groundwater extraction the deeper in the ground that a pump resides, the better. Aquifers have depth like a pool. Competition springs up as the aquifer's top layer falls. Neighbors become competitors using well depth and

pump strength to determine who gets the precious buried fluid. The spoils go to the owner of the deepest and most powerful pump. Often the deepest and most powerful equipment belongs to large-scale farms, wineries, or businesses, not the family farmer or country commuter. Around large farming operations, household wells run dry when the top of the water table drops below their well pump inlet. Farmland irrigation is an inexact business. Once sprayed on farms, water does not disappear. Irrigation water will evaporate to air, enter plants, run off to a watershed or drain to groundwater. Farmland water runoff that drains to a watershed or percolates to groundwater often contains excessive nitrate levels that can foul both water types. Like fossil fuel, groundwater is limited and expendable. Natural groundwater can only supply a limited amount of water for human uses. Humankind exceeded that limit long ago.

In the water treatment business, water wholesalers call supplies fed from either surface water or groundwater raw water. Raw water, once located and trapped, still needs treatment and delivery. Usually, statewide, or region-wide water storage reservoirs supply pump stations which then pressurize pipelines that move water to other regions. Water capturing and transferring works so well that a water droplet falling in Wyoming can later be drank in Beverly Hills. Groundwater feeds some municipal supplies, but watersheds provide most raw water to municipalities. Treatment plants receive raw water, treat it, and then pump the water out through local pipelines and reservoirs, the plumbing systems getting progressively smaller as the water approaches the end user. The nationwide distribution system resembles a leaf pattern containing over a million miles of pipe. In the U.S., over 100,000 local water districts exist, but just 10,000 districts deliver 90% of the water. Overall, the worldwide water treatment plant and distribution system suffers from one main problem, age. Most water distribution systems in the U.S. were laid mid-last century with an expected life of 50 to 75 years. The older a city, settlement or dwelling, the more potential problems exist. Lead pipe, a common early plumbing material, remains in many early American systems throughout the country. Lead pollution in drinking water can cause stunted early childhood learning and psychosis in adults. Old plumbing solder contained lead and was used for decades longer than lead pipe. Many people know that Flint Michigan suffered water miseries, but fewer mention similarly cursed Newark New Jersey, even Washington D.C. fails to meet drinking water standards in all homes. Corroded antiquated water distribution systems regularly collapse, wasting water and causing significant flood damage to nearby structures. The City of San Diego spent over $60 million in one fiscal year repairing water main breaks. Nationally, two trillion gallons of water is lost to water main breaks each year. Though raw water is in short supply, finding new water sources does not always help. A new water supply pumped into old water systems can cause decades old internal piping corrosion to dissolve and allow formerly dormant pollutants to spoil the water systems. Flint Michigan and parts of Tucson Arizona both suffered from contaminated water after feeding new water supplies into old pipes. We invest in water improvements each year, but our investments are inadequate. Some estimates place our current water upgrade budget shortfall at $150 billion. Water districts are usually political possessions and subject to all the known political hazards. Districts also generate money, virtually all U.S. houses and businesses pay a water bill monthly. The attendant political

bureaucracy and tempting money piles often push logic aside. The political and money distractions may lead to system neglect and eventually water quality issues. Venezuela serves as a contemporaneous warning sign. Neglect, politics, and corruptions means that 89% of the Venezuelans experienced tap water quality issues last year and 11% of the population has no access to running water at all.

People say, “we are drinking the same water the Romans drank”, but it goes further back. For eons, the Earth’s water has been bound to the earth’s surface. Likewise, in the future, the water will still be bound to the Earth. Our forbearers depended on the Earth’s natural existing water supply and our future generations will also. Today’s humans will undeniably affect future water quality. What type of water will the present generation leave for future generations? Future generations may require over 500 billion gallons of water per day to meet their needs. Much of our current household water supply travels through last century water systems. The readily available natural water resources have been found and most captured. We have critical agriculture that depends on steadily shrinking aquifers. The U.S. needs a consistent decades long improvement program to meeting our future drinking and agriculture needs. Our current generation stands to leave Earth’s water much more polluted than any prior generation. What will our water legacy be? Will we be remembered as the plastic generation, the pollution generation or the generation that ran out of clean water? Stop and consider our most valuable resource, the resource that can truly limit human development, water.

The word infrastructure has once again leapt from politician’s mouths. Yet infrastructure neglect serves as a hallmark of the last few decades, an enduring Boomer legacy with projects and maintenance deferred throughout the U.S. We have magnificently and repeatedly dammed the Colorado River, but Lake Mead slowly drops most years. The titanic Oroville dam in California nearly collapsed recently and two Michigan dams did collapse in 2020. A recent canal collapse in Montana threatens the water supply for tens of thousands. Most cities east of the Mississippi need upgrades to separate their sewers and storm drains to prevent seasonal raw sewage from flowing directly into watersheds. Watersheds depletion already strains major world cities like Chennai India and Pretoria South Africa. Bottled water afficionados help drain local aquifers while feeding the ocean plastic. Pollution from PFAs and nitrites can ruin groundwater sources for years, or possibly forever. Microplastics are trapped in the ocean while the freshwater fed Aral Sea steadily withers.  At the mouth of the Mississippi, Massachusetts-sized dead zones form in the Gulf of Mexico each summer due to pollution. These oxygen-starved hypoxic zones support only limited types of sea life, such as jellyfish while spoiling formerly productive fisheries. Our problems are not insurmountable. Water conservation begins with each person. Water is not inexhaustible, changeable, or overly abundant. Does one need Kentucky bluegrass in a place like Palm Springs or irrigated bushes in highway medians. How much of our food supply should be grown in deserts? Water flattens the social structure. The same water pumps to poor and rich neighborhood alike. You hear professional water managers say, “we all touch at the tap”. The world’s taps all touch the ocean, our only true water source. Each human ultimately draws water

from the same source, the ocean. Thus, why not pool the world's knowledge and resources to make our worldwide water supply more sustainable. Please consider the water chain. Our lives may depend on it.

Respectfully submitted for you to fathom.

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