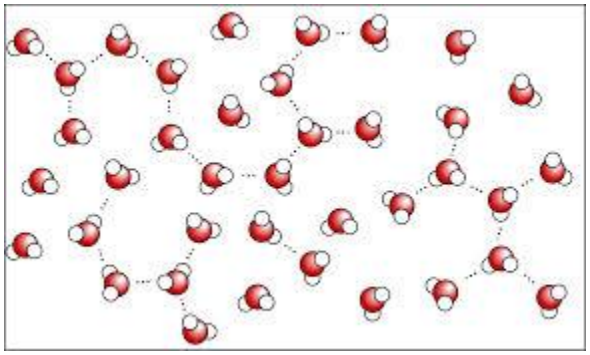
Water 101

What is water?

Chemically, it is composed of two hydrogen atoms and one oxygen atom. A water molecule forms a “V” shape, with the oxygen atom at the joint and the hydrogen atoms separated at the top. The oxygen end has a slightly negative charge and the hydrogen ends have a slightly positive charge. This makes water a polarized substance. Water can dissolve more compounds than any other common liquid and this is why water is commonly called “the universal solvent.” Water can pull apart or dissolve many polar substances, leaving negative and positive ions dissolved in the water. Water will not dissolve oils, because oils are not polarized.



The red balls represent oxygen. The white balls represent hydrogen. Note that the water molecules have an internal cohesion due to the weak polar bonds that exist among the water molecules.

Biologically, water is the essence of life. No living organism can live without water. Humans are made of approximately 97% water. Many of the essential components of the cells that make up our bodies dissolve in water. These include proteins, simple and complex sugars, DNA, salts, and many gases.

Globally, 71% of the Earth’s surface is covered by water. The ocean contains 96.5% of Earth’s water, so fresh water accounts for only 3.5%. Of that 3.5%, slightly less than half is locked up in glaciers and slightly less than half is located underground. The fresh water found in streams, rivers, ponds, lakes, and the atmosphere accounts for only 0.3% of Earth’s total water.

Physically, water has many unusual or unique properties:

- Unlike most other substances which get denser as they approach their freezing temperature, water’s density actually decreases as it begins to freeze and form ice. This is really helpful to organisms that live in water. Ice floats, leaving liquid water below to sustain life. If ice were denser than water, life at the bottom of water in cold areas would not exist.

 www.thinklink.com	Water has a high surface tension, meaning that the surface of water forms a cohesive covering or skin. This allows many insects to move on top of water without breaking the surface.

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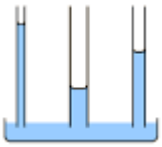 Tubes in water. Note that the water rises highest in the skinniest tube (left).	Water is capable of capillary action. If a slender tube is placed into water, the water will rise up the tube spontaneously. It will not travel all the way up the tube, but no other substance has such an internal “glue” that allows this. This characteristic is essential for vascular plants, such as trees.

- Water has a high “specific heat capacity” and a high ”heat of vaporization.” In other words, water can absorb a lot of heat and not vaporize compared to other substances. Water also holds heat better than many other substances. Areas near water tend to have more moderate temperature fluctuations than drier areas. Towns near the ocean do not have daily temperature fluctuations that are anywhere near those experienced in desert towns. Ocean currents can transport heat across oceans. The Gulf Stream, for example, carries heat from the Equator to the British Isles. This explains why, despite being more north than New England, the British Isles have a more moderate climate.
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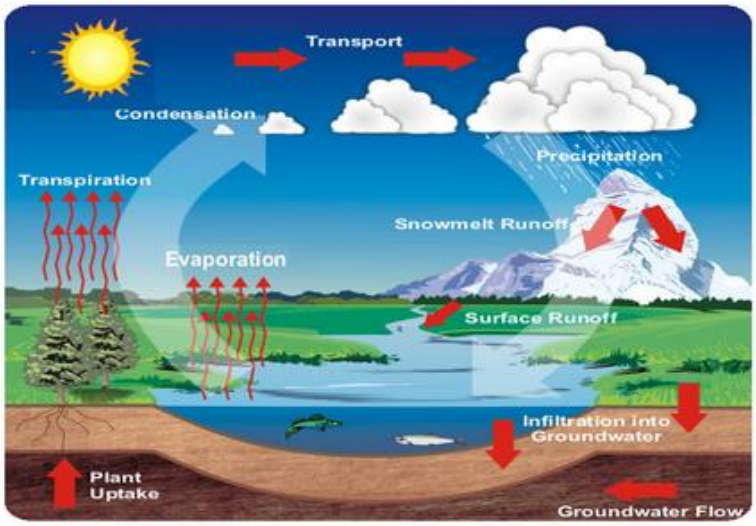
Water can exist in its gaseous state (water vapor) below its boiling temperature. Often, water vapor will not condense to its liquid state unless a site for condensation is available. In summer, that site could be a cold surface such as a cold beverage container or the tank of a toilet. In the atmosphere, dust or pollutant particles can serve as a condensation site. For example, jet planes leave trails of exhaust as they fly through the sky. These trails are invisible until water vapor condenses on the particles to form linear clouds of water droplets or ice crystals, also known as contrails.	 en.wikipedia.org

What is the “water or hydrologic cycle”?



http://www.tuzzles.com/wp-content/uploads/2013/02/F40-088.png

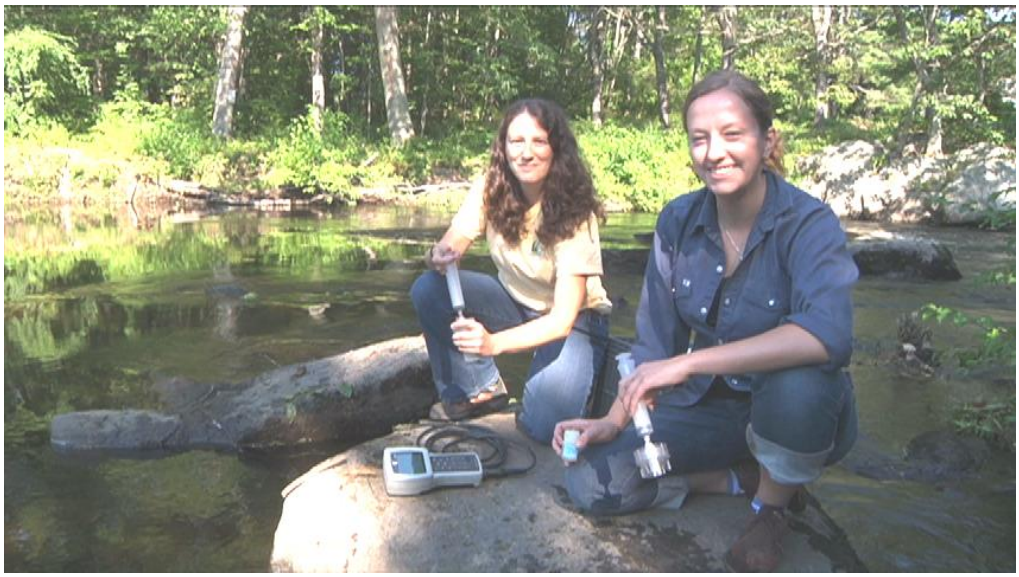
Earth’s water is always moving away from one area and to another. Some water moves quickly. Other water moves at a glacial pace, because it is locked in a glacier. Water moves through the hydrologic cycle as illustrated above. If we start with water we can see, such as in a lake or the ocean, the sun’s energy **evaporates** some of the liquid water, turning it into water vapor. The sun also fuels growth in plants, and as part of that process, plants release water vapor into the air, a process called **transpiration**. This gaseous state of water rises up into the sky. As it cools, it **condenses** into water droplets and ice particles that make up clouds. The clouds eventually release the water droplets back to Earth as **precipitation**: rain, snow, hail, sleet, or fog. Some of the falling water lands directly into surface water, such as a lake or ocean. Some flows across the land, especially across hard land such as pavement or unvegetated surfaces, and drains as **run-off** to the nearest stream or pond. Some of the falling water soaks into the soil, a process called **infiltration**. Water that is infiltrated can travel through soil to provide water to plants or streams or it can be stored for a long time in an underground reserve called an aquifer. Many towns and individuals get their drinking water from groundwater, usually pumped from bedrock. Groundwater tends to be cleaner than surface water.

What is meant by “water quality”?

Water quality is used by scientists to describe how certain chemicals or conditions in water meet criteria essential for living things. Good water quality means the water is clean and in a condition that is helpful to living things. Water quality that is poor or degraded means that living things in the water might be harmed or negatively affected by being in that water. “Impaired” water quality has a special meaning: it does not meet federal standards for being safe for swimming and/or fishing because one or more of the key criteria are not being met.

Some people mistakenly believe that “water quality” has more to do with how water tastes or looks. Unfortunately, water’s appearance can be deceptive. A river’s water might look clean, but if scientists actually test the water, they might find things that are unsafe. In nature, good water quality might mean that the water is slightly brown due to dissolved tannins from the surrounding forested landscape and that some naturally occurring minerals add certain flavors.

Water bottling companies often add to the confusion by making claims that their product has better “water quality” than public tap water. In most cases, this is not true; the companies are simply trying to justify their grossly inflated profits.

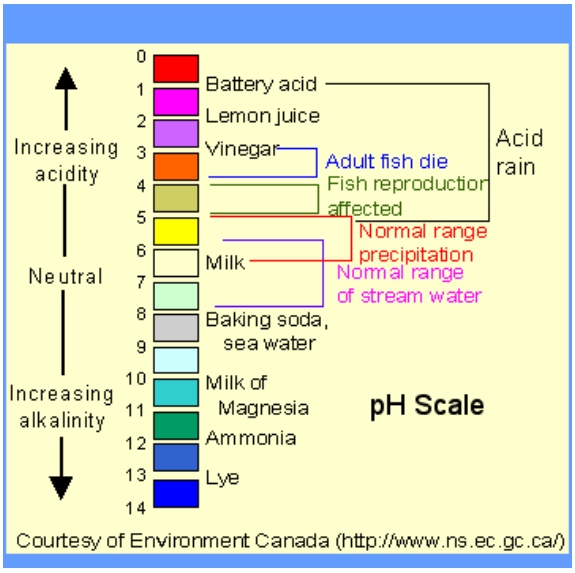


Scientists test the Lamprey River’s water. Photo by Breakaway Media.

Basic water quality measures include characteristics that have been shown to be important all over the world. More specific water quality measures can be studied to learn about more local conditions of concern.

- pH: This is a measure of acidity or alkalinity. A pH of 7 is perfectly neutral. pH is influenced by geology and soils, organic acids (decaying leaves and other matter), and human-induced acids from acid rain (which typically has a pH of 3.5 to 5.5).

In NH, pH is rated as follows:	
<5.0	high impact
5.0 – 5.9	moderate to high impact
6.0 – 6.4	normal; low impact
6.5 – 8.0	normal
6.1 – 8.0	satisfactory



- temperature: Although New Hampshire does not have a temperature range established for water quality monitoring, temperature affects what organisms can live in a certain body of water and how fast bacteria can decompose organic matter. Water temperature also has a strong effect on the amount of oxygen gas that can be dissolved in water. Cold water tends to be desirable condition for many organisms associated with high water quality, such as trout. Water temperature can be affected by the amount of shading over and near the water, rate of flow, impoundments, groundwater inputs, and the percentage of paved surfaces nearby that can shunt warm stormwater run-off into the stream.

Brook trout, the New Hampshire State Fish, needs cold, clear water and high dissolved oxygen.

www.dec.ny.gov

- dissolved oxygen:
    - As was discussed earlier, water is made of oxygen and hydrogen atoms. When fish run water over their gills, they extract oxygen from water. BUT, the oxygen they extract is NOT part of the water molecule. The oxygen they extract is oxygen gas, two oxygen atoms bonded together, and dissolved in water. It might seem odd, but gases dissolve in water. This is a trait that soda companies use to provide customers with carbonated beverages. Sodas are infused with carbon dioxide, the gas that is exhaled when animals breathe. As many people can readily attest, cold soda is full of bubbles. Warm soda is flat. Just as cold soda holds more carbon dioxide than warm soda, water in a shaded, cold stream holds more oxygen gas than water in a warm, sunny pond.
    - The total amount of dissolved oxygen is determined by more than just temperature. It is also affected by the amount of life in the water. Water that is clear and has few algae tends to have a low oxygen demand and more dissolved oxygen. Water that is full of algae and bacteria tends to have a high oxygen demand and less dissolved oxygen. Dissolved oxygen can also be affected by water movement. Water that tumbles over rocks and waterfalls has more interaction with the air and is better aerated. Water that is still tends to be less aerated.
    - Dissolved oxygen is measured by two means: concentration and percent saturation. The concentration is simply how much oxygen gas is present in a sample. Saturation is a measure of how much

oxygen gas is present compared to how much could be present under ideal circumstances at a particular temperature.

The minimum standard in New Hampshire is 5 mg/L (milligrams per liter) at any place or time or 75% average daily saturation.

- conductivity or specific conductance:
    - These two measures are slightly different, but both refer to the ability of water to pass an electric current based on the concentration of ions present in the water. Water that has more dissolved ions has a greater ability to pass a current than water that has fewer ions. Specific conductance can be used to indicate the presence of chlorides, nitrates, sulfates, phosphates, sodium, magnesium, calcium, iron, and aluminum ions. These substances occur naturally as water interacts with bedrock and soil, but in most cases, high conductivity is associated with human sources: road salt, agricultural run-off, septic systems, and wastewater treatment facilities. Conductivity tends to be highest in summer when high air temperatures increase evaporation and water inputs are diminished.

Example of a specific conductance meter.

    - New Hampshire has established the following criteria for specific conductance:

microsiemens per centimeter (uS/cm)

0 – 100	normal
101 – 200	low impact
201 – 500	moderate impact
> 501	high impact
>835	exceeding chronic chloride standard

As an indirect measure of chloride (salt) concentration, NHDES has developed a statewide [specific conductance] to [chloride ion] ratio based on simultaneous measurement of specific conductance and chloride:

freshwater chronic criterion 230 mg/l 835 uS/cm
freshwater acute criterion 860 mg/l 2755 uS/cm

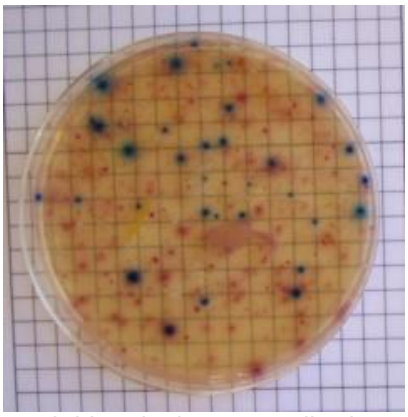
- turbidity: Turbidity is a measure of how many solid particles are suspended in water and how those particles decrease the ability of light to pass through the water. Water that is clear has low turbidity. Turbidity is caused by sediments, microscopic algae, bits of decaying material, and certain forms of pollution. Turbidity can cause more of the sun's energy to be absorbed, resulting in warmer water temperatures. The particles that

cause turbidity clog the gills of aquatic animals and can smother eggs and creatures that live on the bottom. Turbidity can be natural, such as after a rain, but often turbidity results from human activity.

- *E. coli*:

Escherichia coliform is a bacterium found in the lower digestive tract of mammals and birds. It is expelled in feces. It is a common indicator that pathogens are or might be present. The test for *E.coli* involves smearing a sample onto a Petri dish and providing optimal growing conditions in a laboratory. In a few days, the laboratory workers view the Petri dish and count how many bacterial colonies have grown.

In New Hampshire, samples shall contain not more than either a geometric mean of 126 E.coli cts/100 mL based on at least three samples obtained over a sixty-day period, or greater than 406 E.coli cts/100 mL in any one sample. Sites that exceed these limits are deemed unsafe for swimming and fishing until other samples come back within acceptable limits.



Each blue dot is an *E. coli* colony.

- chlorophyll *a*: Chlorophyll is the green pigment that allows plants to make their own food in the presence of sunlight. It provides an estimate of how many microscopic algae are present in the water. Algae are normally limited by low amounts of phosphorus and/or nitrogen in the water. When these nutrients are abundant, as in polluted waters, algae become too abundant. High chlorophyll is usually associated with low dissolved oxygen.

micrograms/liter (ug/l)	
less than 3	excellent
3 - 7	good
7 - 15	less than desirable
greater than 15	nuisance

- total nitrogen: Several soluble forms of nitrogen act as nutrients for plant growth. Nitrogen is a main ingredient of fertilizer, but it is also found in urine, feces, dead plants and animals, eroded soils, and in air particles that result from burning fossil fuels. A little bit of soluble nitrogen is necessary, but a lot of nitrogen in water causes algae and some nuisance seaweeds to grow in excess. This can make the water turbid or cloudy, lead to low dissolved oxygen, and cause undesirable changes in natural plant and animal communities. (For example, a stream might lose its clean water aquatic insects and trout. Instead, junk insects and junk fish

might become dominant, or eel grass beds in the estuary might be smothered by noxious seaweeds.)

Nitrogen is measured in milligrams per liter (mg/l).

< 0.25	ideal
0.26 - 0.40	average
0.41 - 0.50	more than desirable
> 0.51	excessive (potential nuisance concentration)

- total phosphorus: This is another essential nutrient that is helpful in small amounts, but problematic in high amounts. It is found in many formulations of lawn fertilizer and detergents, as well as human or animal waste, dead plants and animals, and eroded soil. It is especially troublesome for freshwater systems such as rivers and lakes.

  Phosporus is measured in micrograms per liter (ug/l)

< 0.010	ideal
0.011 - 0.025	average
0.026 - 0.050	more than desirable
> 0.051	excessive (potential nuisance concentration)

<u>How is the water quality in the Lamprey River?</u>

For the most part, the Lamprey River and its tributaries have good water quality. In most places, fish are healthy and people can enjoy the water for recreational activities. Sadly, a few exceptions exist:

- The mouth of the Lamprey, where the river enters Great Bay, has issues with low dissolved oxygen. Fish and shellfish can suffocate. The mud at the bottom can be dark and toxic to critters that live in or on the bottom. The number of dissolved oxygen violations is increasing, as is the severity of violations.
- The mouth of the Lamprey once had lush eelgrass beds. These beds are now degraded. The number of plants per square meter has decreased and the overall health of plants is poor. Lost eelgrass beds worsen sediment loss and also result in less habitat for estuarine animals.
- The mouth of the Lamprey also once had abundant oyster beds. Oysters are important filter feeders; they take in water, collect food particles, and discharge clean water. The loss of oyster beds seems to be the result of increased sedimentation, increased nitrogen, and possible low dissolved oxygen.

<u>What can we do to protect or improve water quality?</u>

Understand that water connects the land and us. What we do on the land has a huge effect on the water.

- Use little or no fertilizer on your lawn. Most lawns are fine without any fertilizer. Adding extra will not make your lawn better—it will run off and into a stream, fueling algae growth.
- Beware of pavement. Whatever lands on pavement usually goes straight into the nearest stream with rain or snow run-off.
    - Wash your car on the lawn or at a carwash—never on the street or driveway.
    - Make sure your car isn't leaking fluids such as oil or antifreeze.
- Always pick up your dog's poop. Even on a lawn, most of the waste will be picked up by rain and sent to the nearest stream.
- Always try to leave natural vegetation along the banks of streams, rivers, ponds, and wetlands. Vegetation helps to hold the soil against erosion, provides shade to keep the water cool, gives animals a place to live, and absorbs many potential pollutants before they can reach the water.
- Make sure your septic system is well maintained.
    - Know where the system is located. Keep trees and vehicles off the leach field.
    - Get the septic tank inspected and pumped out every 2-3 years.
    - Only put totally biodegradable substances into sinks and the toilet.
        - Do not put harsh chemicals, such as bleach or Drano, down the drain.
        - Do not put food waste down the drain. Compost it instead.
        - Keep fats out of your drains. They don't biodegrade and they can clog the septic system. Put fats in a jar and dispose with the garbage.
        - Never put anything bulkier than toilet paper down the drain. Never put paper towels, baby wipes, or feminine products down the toilet.
- Treat water as the precious resource it is. Conserve water when possible.
    - Take short showers instead of long baths.
    - Don't let the water run when you brush your teeth.
    - Do only full loads when you use the clothes washer or dishwasher.
    - Don't overwater the lawn or gardens.