



Aquatics

"Water is the driving force of all nature" ~Leonardo da Vinci



The Water Cycle

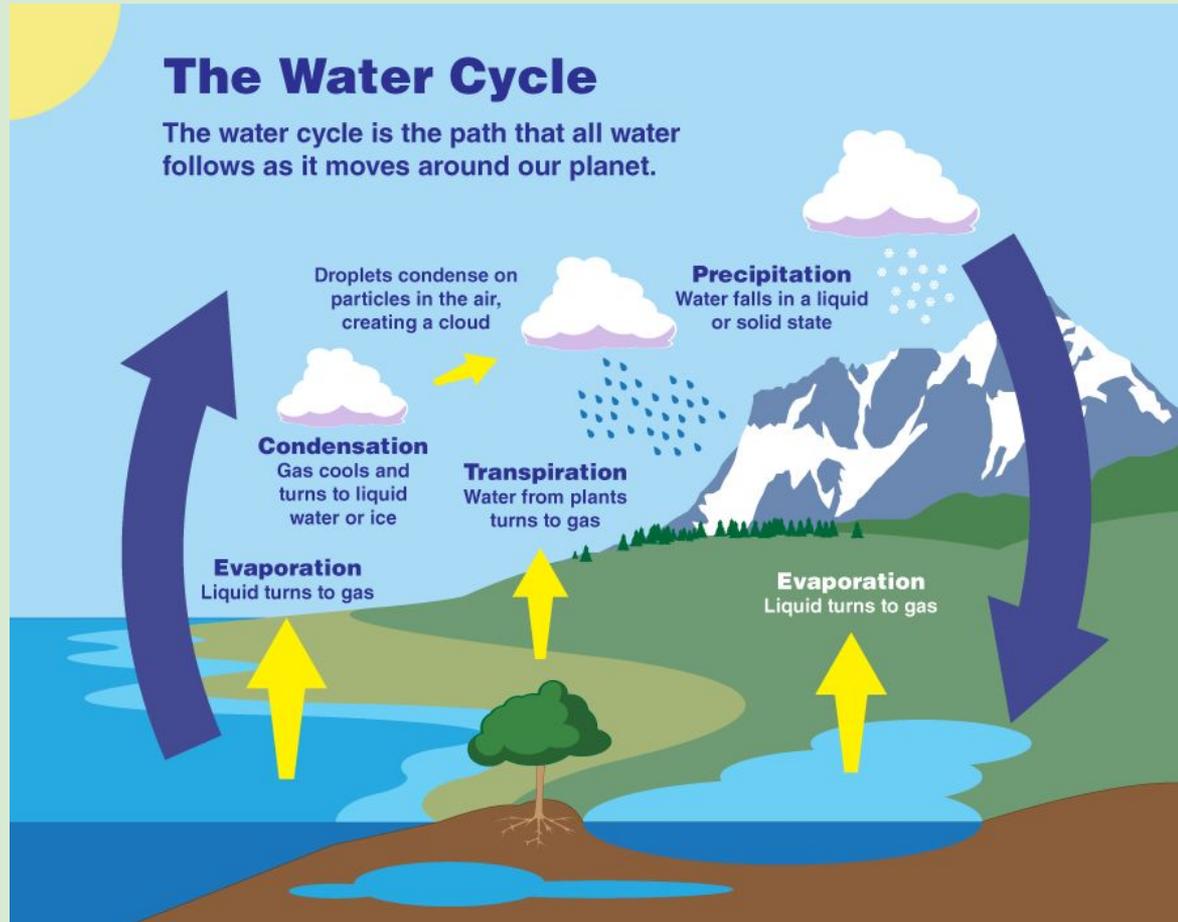


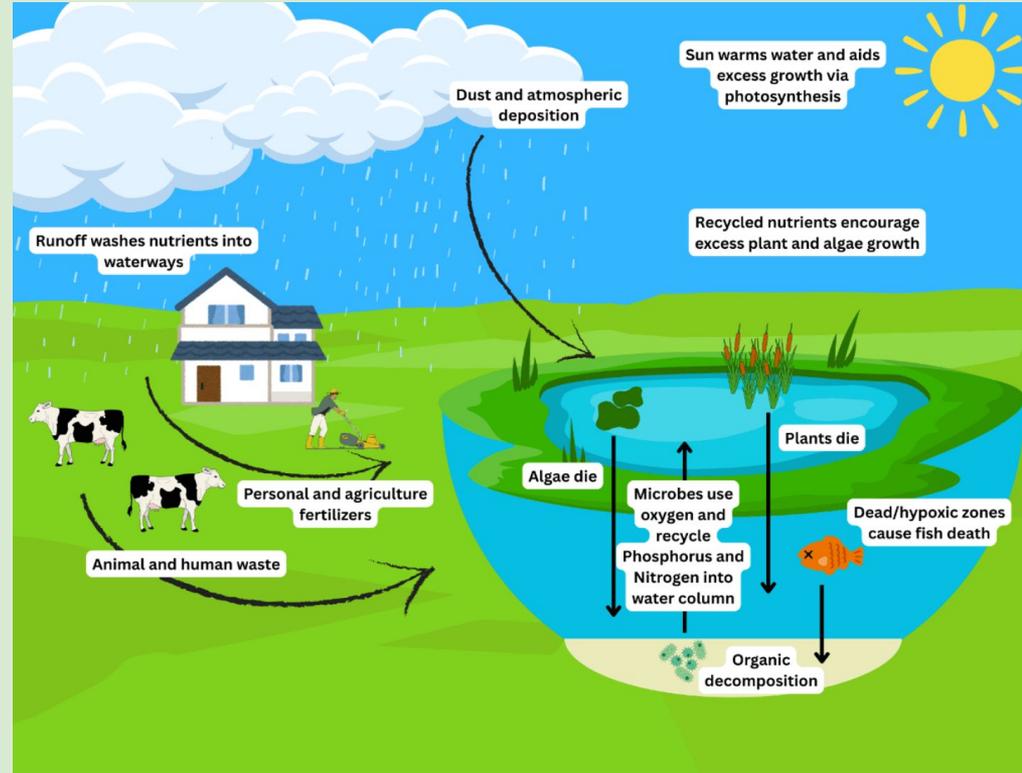
Image source - NASA

<https://assets.science.nasa.gov/dynamicimage/assets/science/cds/kids/nasa-kids-science/earth/what-is-the-water-cycle/Water-cycle-illustration.png?w=900&h=700&fit=clip&crop=faces%2Cfocalpoint>

Eutrophication

In a healthy pond, there is a daily phosphorus cycle. The concentration of dissolved phosphorus depends on the activities of aquatic plants, algae, and microbes.

- Daytime Photosynthesis increases pH: During the day, algae and plants take up carbon dioxide for photosynthesis, which causes the water's pH to rise. Phosphorus is locked up as pH rises, dissolved phosphorus reacts with cations like calcium to form insoluble calcium phosphate. The phosphorus becomes locked in sediment and is less available in the water column.
- Algae uptake: Algae and aquatic plants also absorb available phosphorus during the day to support their rapid growth.
- Phosphorus levels fall: These processes cause the concentration of dissolved phosphorus in the water to drop throughout the day, reaching its lowest point in the afternoon.
- Nighttime Respiration and decomposition decrease pH: When the sun goes down, photosynthesis stops, but respiration from plants, algae, and animals continues. Microbes on the pond bottom also decompose dead organic matter. This biological activity releases CO_2 , which combines with water to form carbonic acid, causing the pH to drop.
- Phosphorus is released: The drop in pH helps unlock phosphorus from the sediment, making it available again in the water column.
- Phosphorus levels rise: The concentration of dissolved phosphorus increases overnight as it is released from the sediment and from the decomposition of dying algae and plant matter.
- Peak before dawn: The highest concentration of dissolved phosphorus is typically observed just before dawn, before photosynthesis begins again.



Aquatic Habitats of Vermont

- Lakes and ponds
- Rivers and streams
- Wetlands
 - Swamps
 - Marshes
 - vernal pools
 - peatlands

Can you tell
which is which?

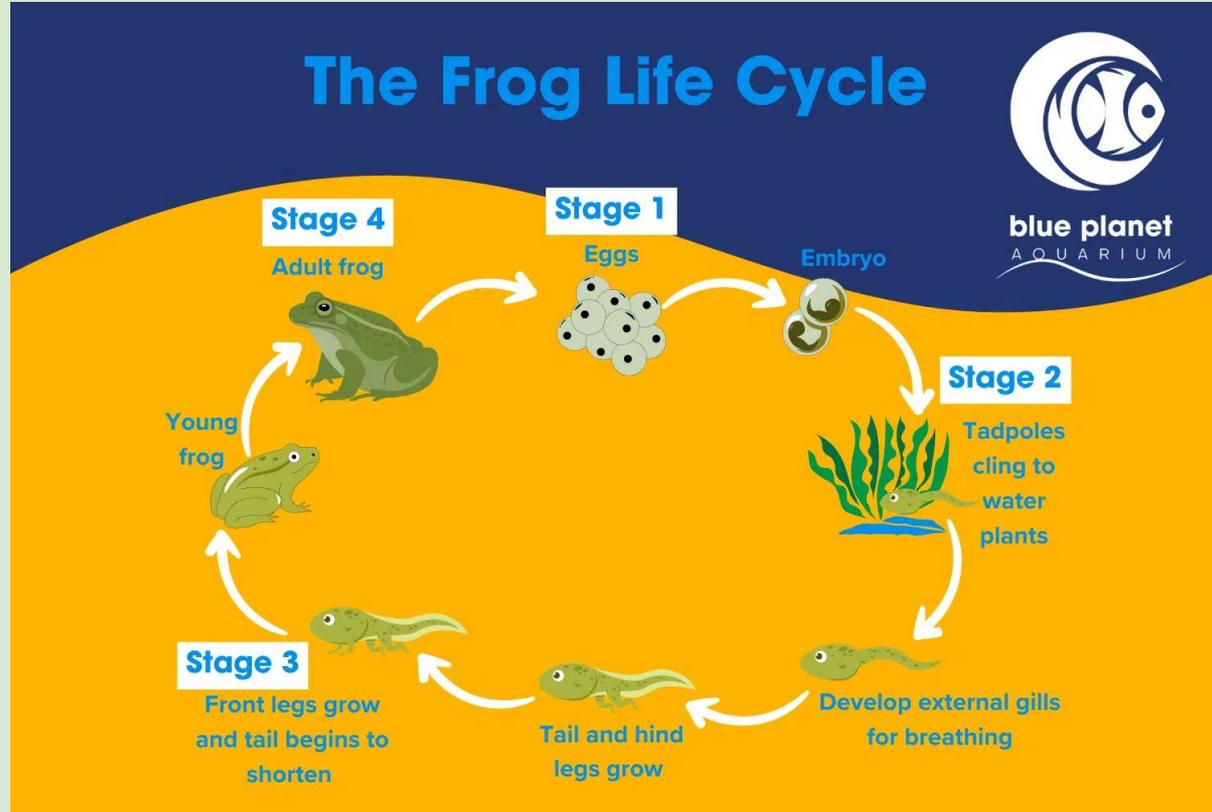


Photo: VT-DEC

VT Amphibians

American Toad
<i>anansus</i>
Fowler's Toad
Gray Treefrog
<i>lor</i>
Spring Peeper
Boreal Chorus Frog
<i>icris triseriata</i>)
North American Bullfrog
<i>ziana</i>
North American Green Frog
<i>ans</i>
Pickerel Frog
<i>is</i>
Northern Leopard Frog
Mink Frog
<i>trionalis</i>
Wood Frog
<i>ca</i>
Jefferson Salamander
Blue-spotted Salamander
Spotted Salamander
Northern Dusky Salamander
Northern Two-lined Salamander
Spring Salamander
Four-toed Salamander
Eastern Red-backed Salamander
Mudpuppy
Eastern Newt

Vermont Amphibian Life Cycle



Aquatic plants of Vermont

There are over 120 species of aquatic plants in Vermont

A slide show of common species can be found here [Slideshow](#)



Invasive Aquatic Plants of Vermont

A Few of Vermont Aquatic Invasive Species



Wetlands

- **Wetland-** A land area covered by water, either permanently or seasonally, which supports unique ecosystems of plants and animals adapted to saturated soil
- **Watch** this 6 min video on Vermont Wetlands <https://youtu.be/Y9opucrZjxc?si=hLt9-Fk9EyMaltrB>
- Wetlands have many very important functions
 - Like a sponge they soak up and hold water, reduce the velocity of the water (reduces erosion), while filtering out particulates and other pollutants
 - Habitat (especially nursery habitat) for fish, amphibians, reptiles, birds and mammals
 - Home to many sensitive and endangered species
- Vermont is home to fens, bogs, marshes, riparian wetlands, beaver ponds and the exceedingly rare alpine peatlands found only on Mt Mansfield
- Over 50% of total wetland area in Vermont is thought to have been lost with colonization resulting in poorer water quality state wide, species diversity loss, as well as completely changing the landscape of Vermont

Riparian Zone

- Riparian Zone- the area of transition between an aquatic and terrestrial ecosystem alongside a stream or river
- Healthy riparian zones stabilize banks, filter runoff, provide shade to keep water cool, and offer food sources for wildlife
- Riparian buffers refers to the protective layers of vegetation along the stream or river
 - These layers extend both from the ground to the canopy as well as from the shoreline to the buffer edge (50 meter or more)
- The riparian zone is where the terrestrial and aquatic food webs overlap so that energy can flow from the water to the land or from the land to the water

Activity- Vermont is home to a program called Stream Wise, in which assessors come to your property and inventory your riparian zone to see if it is functioning fully. Using the assessment tool from streamwise ([Field Visit Form](#) | [Stream Wise](#)), visit a riparian zone and see how well you think it is functioning.

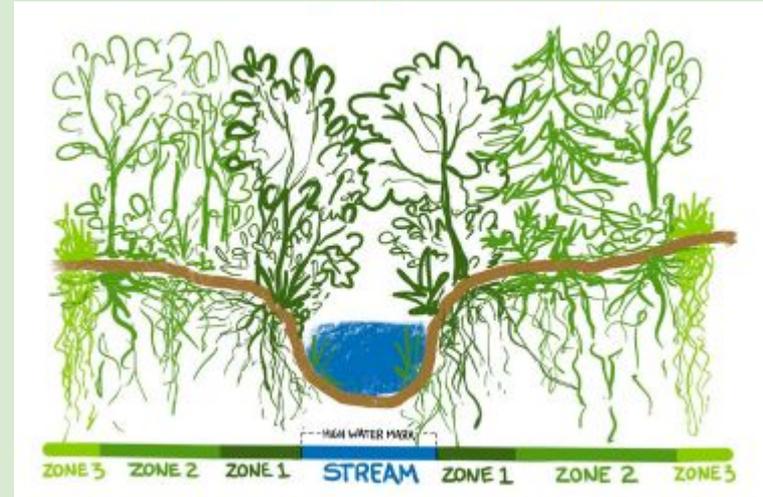


Photo: Stream Wise

Point Source or Nonpoint Source Pollution

- Point source pollution is generally released directly from an industrial plant into the water body
 - Industry
 - Sewer Treatment plants
 - Stormwater
- Nonpoint source pollution comes from all over the watershed, entering the water anywhere along its course in lower concentrations
 - Roads
 - Construction
 - Animal waste
 - Erosion



Vermont Water Pollution Sources

- Nutrient enrichment pollution in Vermont is primarily non-point source
 - With the exception of wastewater
- Chemical pollution in Vermont is typically point source
 - PFAS (forever chemicals)
 - Former mines, landfills and tanneries

Lake Champlain phosphorus sources

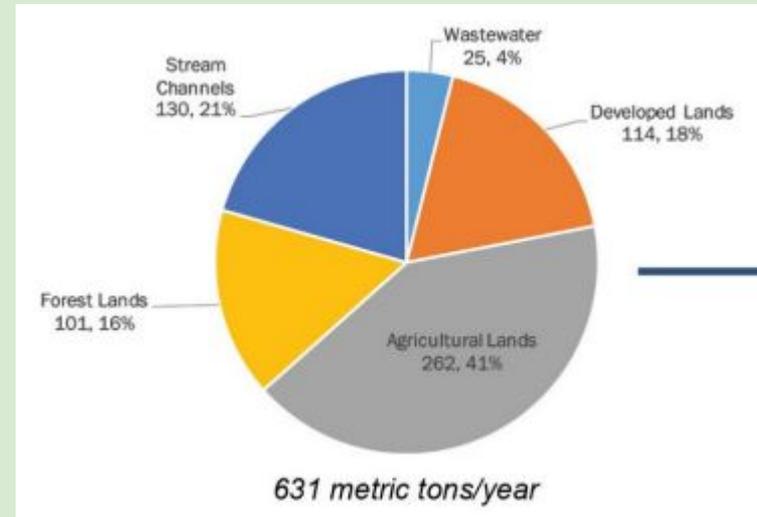


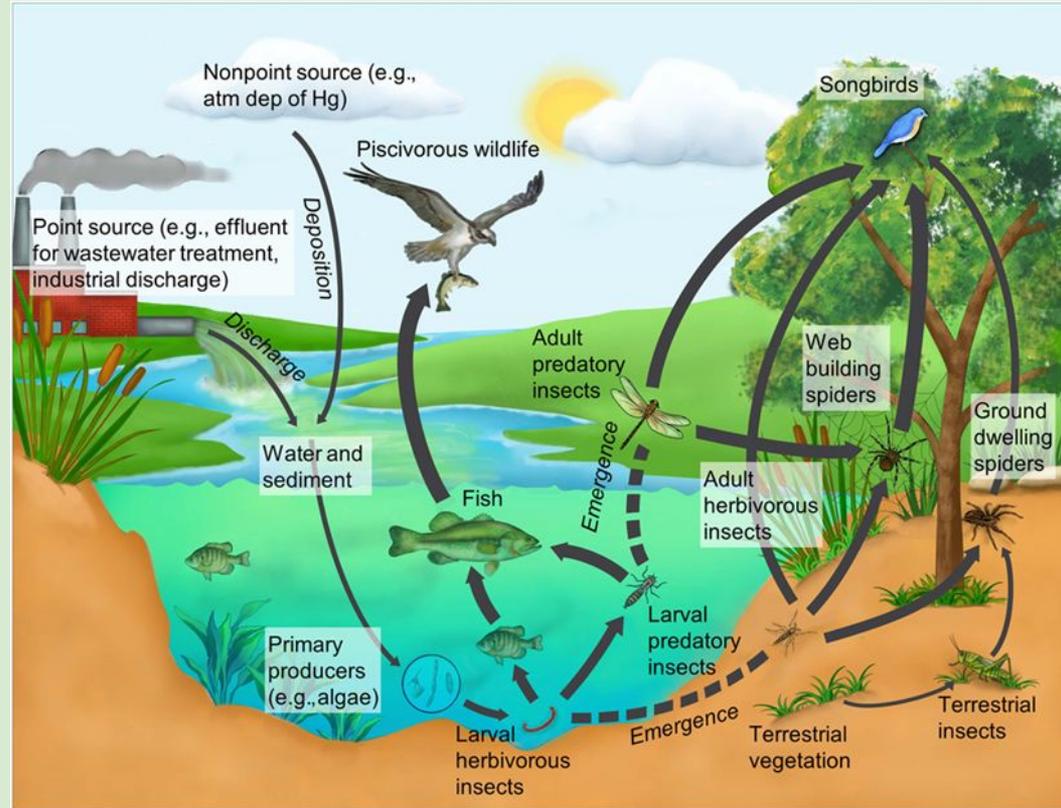
Image source- State of VT Clean Water Report
https://www.vermonttreasurer.gov/sites/treasurer/files/committees-and-reports/_FINAL_CleanWaterReport_2017.pdf

Environmental Regulations

- Water Quality & Pollution: Regulations for NPDES permits, wastewater discharge, combined sewer overflows, and water quality standards (fishing, swimming) are detailed under the Clean Water Act.
- Land Use & Development (Act 250): Vermont's landmark land-use law regulates large developments, with specific rules for sensitive areas (Tier 3).
- Stormwater Management: Rules exist for large impervious surfaces ("three-acre sites") and stormwater permitting.
- Stream & Floodplain Protection: Permits are required for altering streams (streambank stabilization, bridge work), and rules govern flood hazard areas.
- Air Quality & Climate: Includes Zero Emission Vehicle (ZEV) rules, mandates for cleaner vehicles, and efforts to combat climate change.
- Environmental Justice (EJ): Laws require meaningful engagement with communities and address disproportionate environmental burdens.
- Vermont Clean Water Act (2015): Focuses on clean water initiatives.
- Global Warming Solutions Act: Addresses climate change goals.

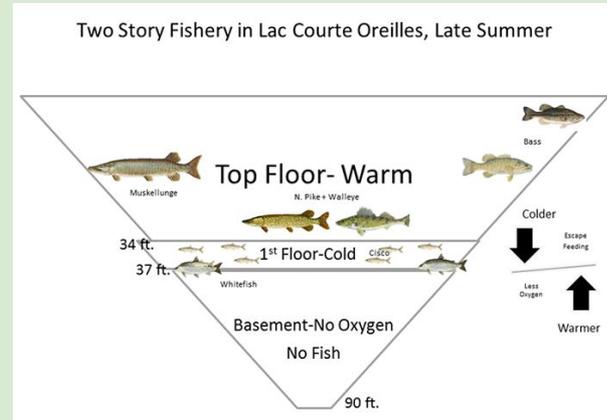
Aquatic Food Web

- The aquatic food web begins with microscopic primary producers called algae or phytoplankton
- Zooplankton are primary consumers who feed on the algae and are then eaten by bugs (macroinvertebrates), which feed the fish
- Aquatic food webs are tightly tied to the land around them
 - Nutrients required for algae growth enter the water body from runoff on the land
 - Animals such as birds, otters and beavers who are semi-aquatic feed from the water thereby removing nutrients from the aquatic cycle and adding them to the terrestrial cycle
 - Trees and plants leaving over the water drop terrestrial insects into the water making up 50% of fish diets



Cold and Warm Water Fisheries

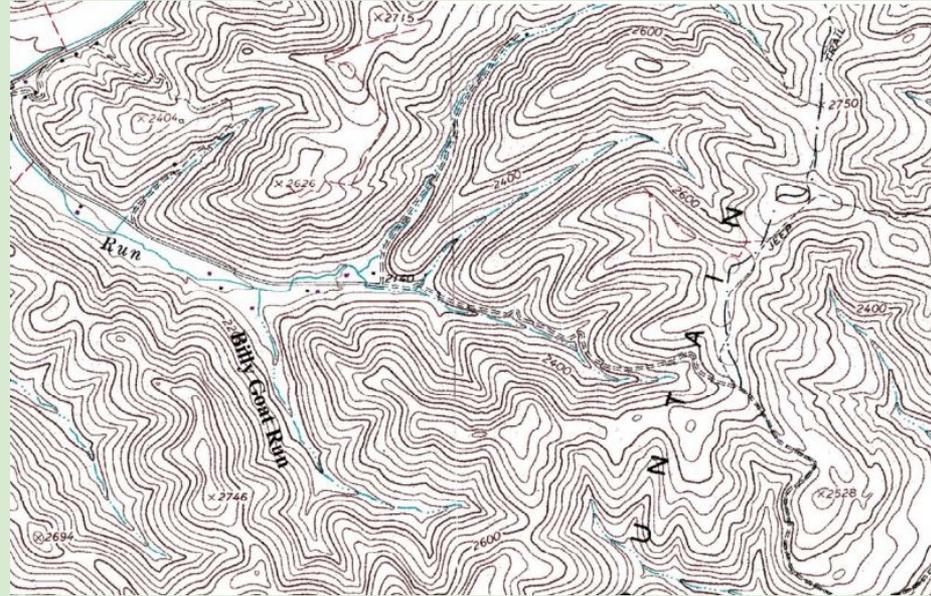
- Cold and warm bodies of water are home to different species of fish.
 - Trout and salmon are both found in cold water
 - Bass and sunfish are both found in warm water
- To fish, it is not so much about the temperature of the water, but about the amount of oxygen that can be dissolved into the water
 - Cold water can hold more oxygen than warm because warmer gas molecules have more kinetic energy and escape the water faster than cold, slower moving gas molecules
- Some deep lakes are considered 2 story lakes and can have both a warm water fishery on top and a cold water fishery on the bottom



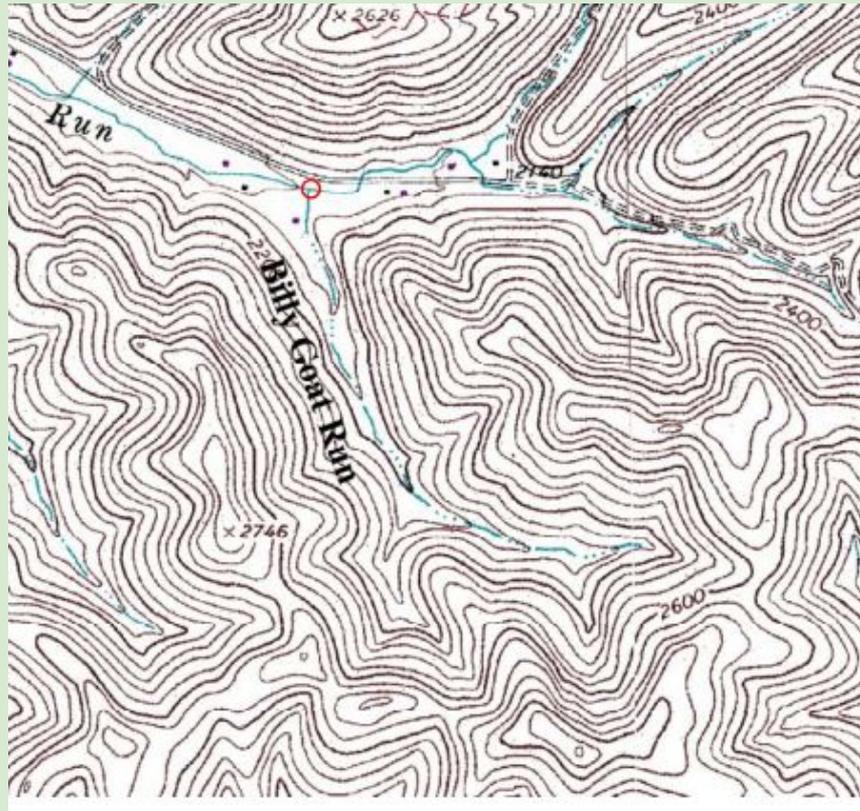
Watershed Delineation

- Watershed Delineation- identifying the boundaries of a watershed
 - This is typically done by studying the shape and slope of the land to determine where water would flow
 - Today is most often done with GIS software based on scans of the landscape
 - Historically done by hand with topographical maps
- Detailed instructions for delineating a watershed by hand with a topographical map can be found here https://www.wvca.us/envirothon/pdf/Watershed_Delineation_2.pdf

Lets Delineate the watershed of the tributary for Bitty Goat Run!



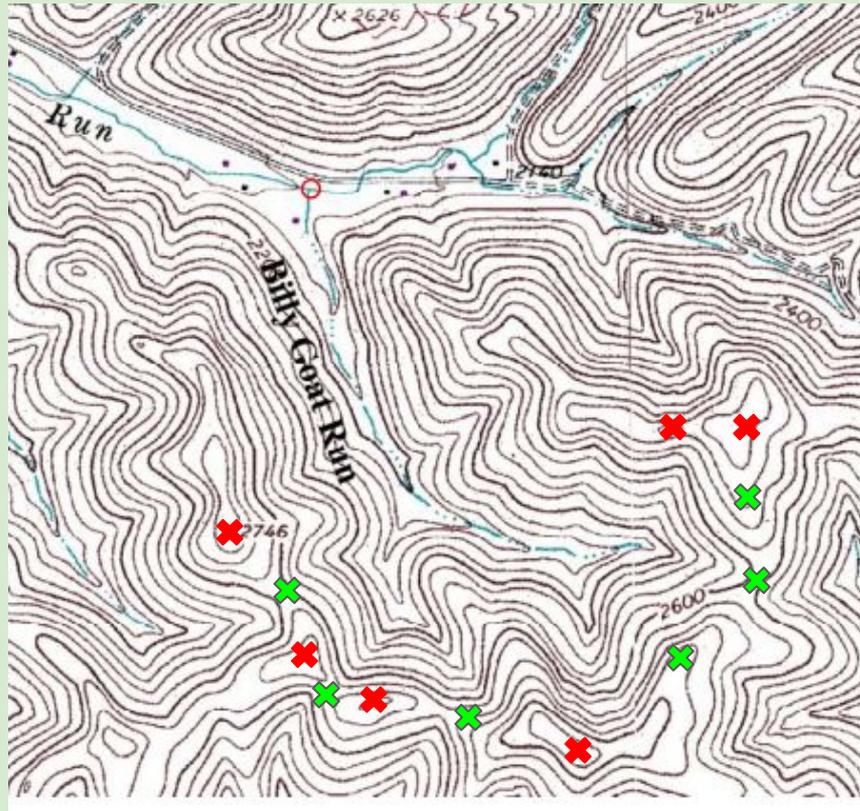
1) Let's find the point where our tributary joins the mainstem



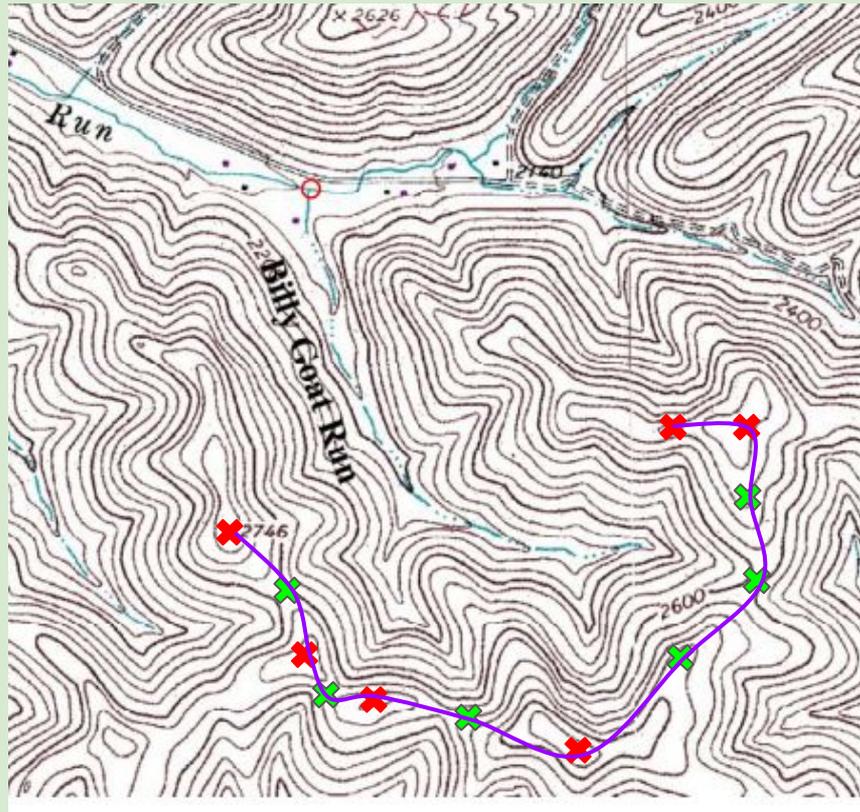
2) Put an X on the highest points of the terrain surrounding the tributary of interest. These will all have a circle for the contour line.



3) Along the ridges, you may have some flat low points where the contour lines are spaced out. Add an X at those locations.

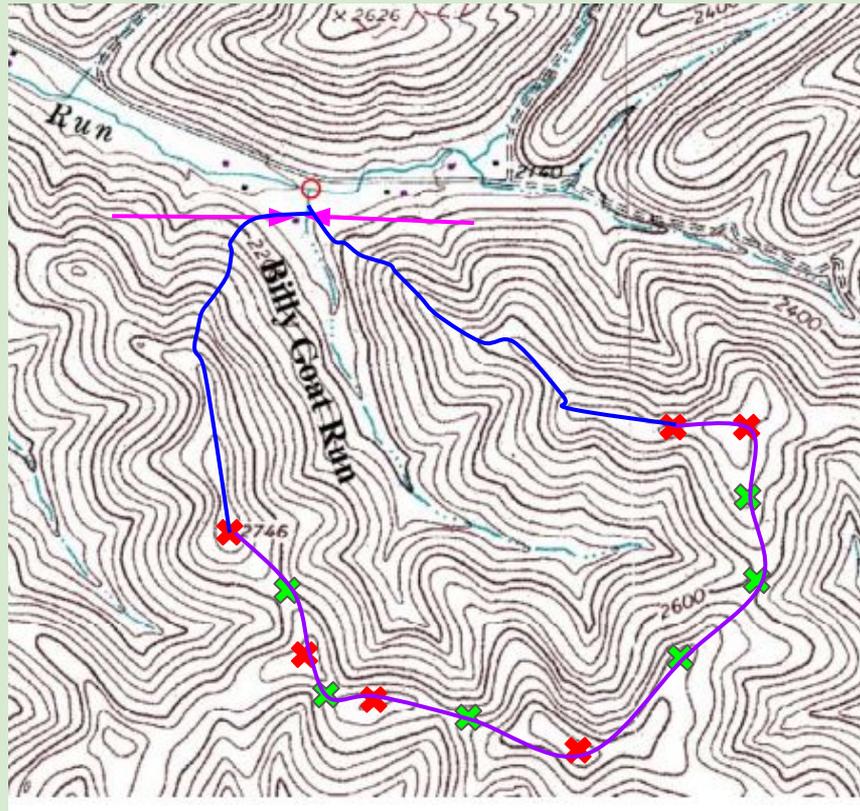


4) Connect your ridgelines. These ridges are represented on the map by the contour lines being farthest apart. The slope is gentle as you walk along a ridge, instead of straight down the face of the hill.



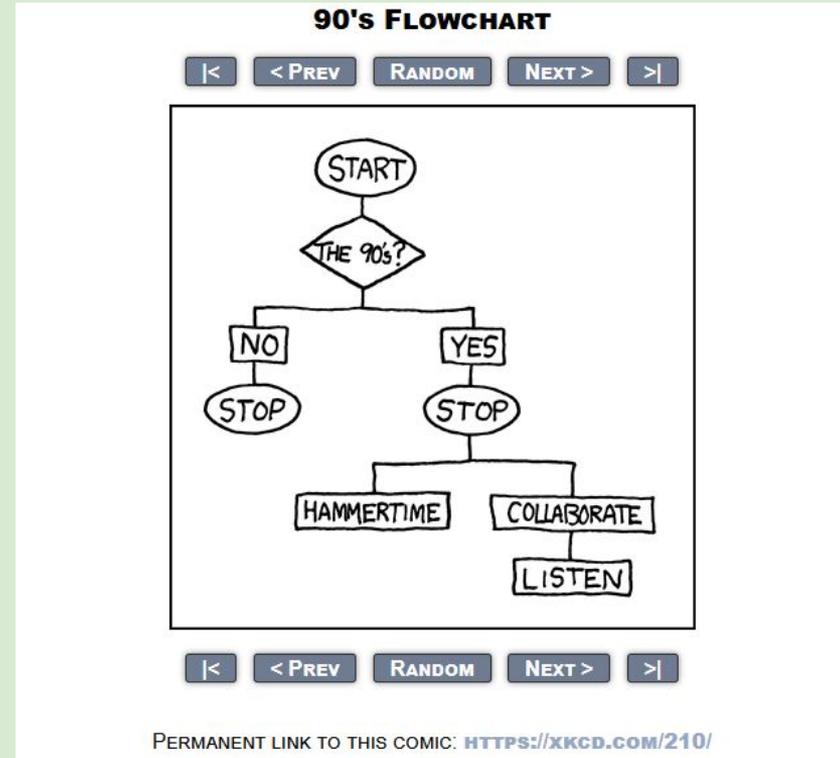
5) The watershed boundary will close just above where tributary joins the mainstem (the confluence). As water is going to flow down the steepest fall line of the hills, that means the boundary line is going to be at the least steep fall line (where the contour lines are farthest apart). This contour line will be perpendicular to the mainstem (marked with pink arrow).

You did it! You have just delineated a watershed boundary!



Dichotomous Keys

- A decision making tool used by provide two opposing choices, leading to further choices, until a single option is found.
- This is commonly used for identifying plants and animals
- The game “Guess Who” is a verbal dichotomous key
 - Your two opposing choices are yes or no for each question asked and the process continues until there is a single option remaining
- Excellent interactive dichotomous key example <https://www.macroinvertebrates.org/key#>
- Printable Ferns of Vermont dichotomous key <https://www.vtstateparks.com/sites/stateparks/files/documents/ferns.pdf>
- Aquatic plants of Vermont <https://dec.vermont.gov/sites/dec/files/wsm/lakes/AIS/GreeterPage/Key%20to%20Vermont%20Aquatic%20Species%202021.pdf>
- **Activity:** Make your own dichotomous key to identify your classmates



Water Quality Monitoring

- Vermont has 2 types of water quality standards: Drinking water and surface water, which are monitored for different components
 - Drinking Water: Bacteria, inorganic chemicals, radioactivity, PFAS, disinfection byproducts (DBPs), lead, copper
 - Surface Waters: Nutrients (phosphorus), chlorophyll-a, macroinvertebrates, fish, chemistry, habitat
- Drinking water analysis is completed by sending water samples to laboratories for analysis
- Surface water is monitored by the Department of Environmental Conservation, Lakes and Ponds Division, with a mix of laboratory analysis and field studies.
 - Lab analytes- nitrogen, phosphorus, chlorophyll *a*
 - Field measurements- conductivity, temperature, pH
 - Field assessments- electrofishing for fish abundance and species, kick net sampling for aquatic macroinvertebrates, visual habitat assessments

Aquatic Macroinvertebrates

Start with this 7 min video!
[Macroinvertebrates!](#)

- Macro= seen with the naked eye
 - Invertebrate= no spine
- Some bugs can live in a wide range of conditions
 - Others can only live in really specific conditions (maybe the need lots of O₂ or non acidic water)
 - You can infer how healthy a water body is by the kinds of bugs it supports
- Diversity- Healthy ecosystems have lots of diversity
- Species Richness- total number of different species found
- EPT Richness – Common simple test of ecosystem health
 - Number of bugs from sensitive orders
Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)
- Percent Oligochaeta – Percent of the macroinvertebrate community made up of the order Oligochaeta (worms) That are typically tolerant of most conditions
- EPT/EPT + Chironomidae – Is a measure of the ratio of intolerant EPT orders to the generally tolerant Chironomidae (midges)
- The State of VT monitors its waters with these measure to track watershed health over time

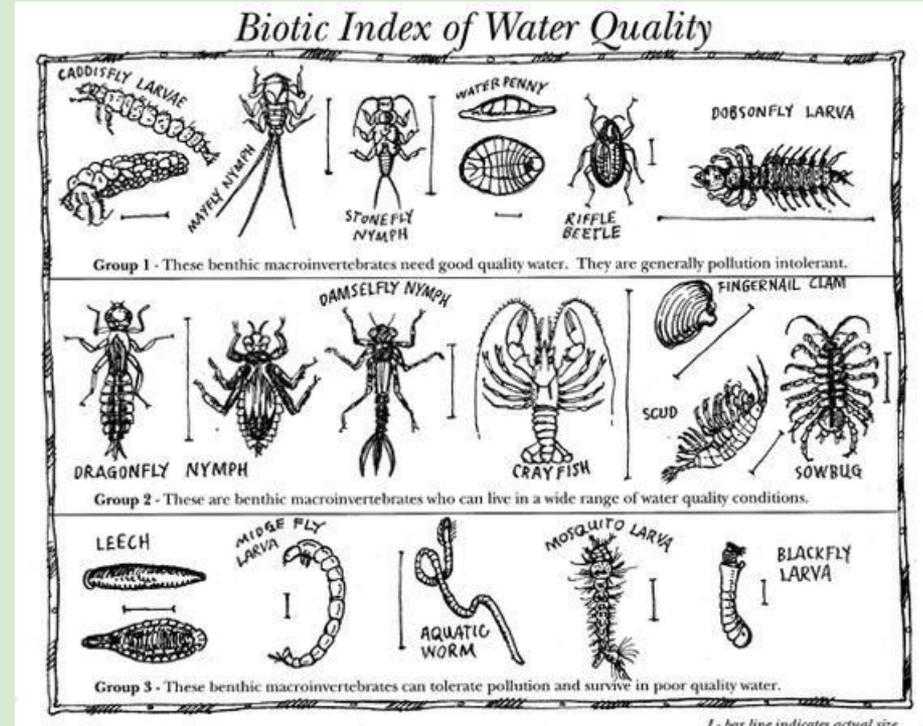
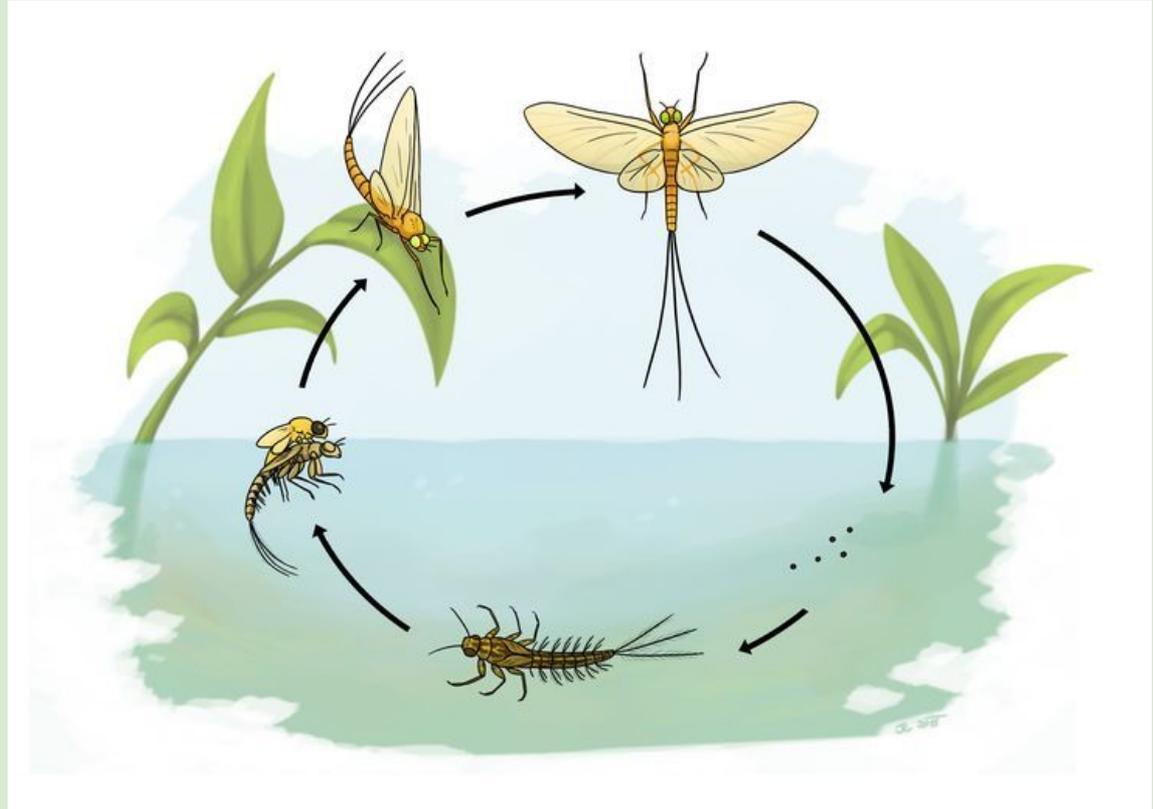


Photo: epa.gov

Life Cycle of Aquatic Macroinvertebrates

- Many Inverts cycle from:
 - Eggs
 - Nymph
 - Juvenile
 - Adult
- Each time an invertebrate molts but does not change forms is called an instar. An invertebrate can molt in nymph and juvenile stages



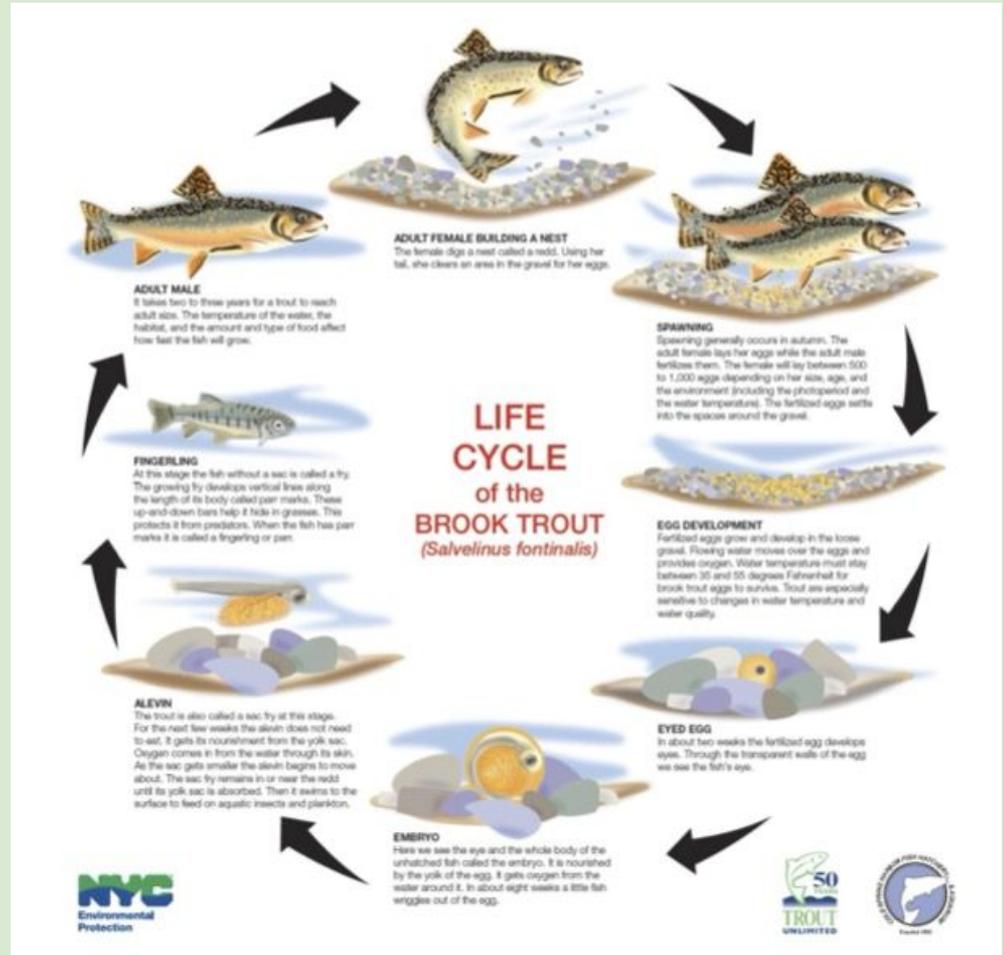
Jana Růžičková

VT Fish Species

- Vermont has at least 92 species of fish
 - At least a dozen of them are non-native sport fish added to the ecosystem
- Over 10 invasive fish have found their way to Vermont
 - Examples: Alewife, White Perch, Gizzard Shad
- Just because a fish is native to Vermont, doesn't mean it is native to every body of water within Vermont
- Vermont's fisheries contribute significantly to its economy through recreational fishing, which generated an estimated \$122.1 million in spending in 2021 from 150,900 anglers
- Use this practice quiz to learn the common fish of Vermont

Fish Life Cycle

- Egg
- Embryo
- Alevin
- Fingerling
- Adult
- Spawning



Important Takeaways

- Understanding the water cycle and its many ramifications is essential to understanding the role of water in the natural world.
- Water can be affected by many factors including temperature, dissolved organic and inorganic matter, suspended materials, and the presence of various living organisms.
- Aquatic ecosystems can be impacted by human activities such as agriculture, industry, introduction of invasive species, and others.
- Damage to wetlands and riparian areas can create profound effects on ecosystems.



www.VACD.org/Envirothon