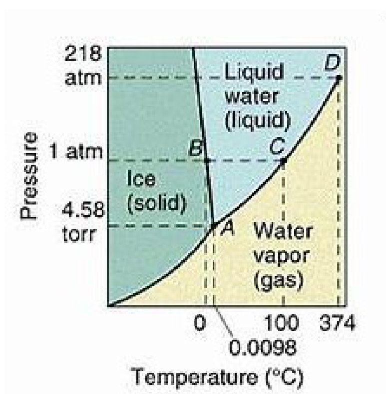
Big Bubble Circulation Pump (BBCP) and Thermoclines

Physical Properties of Water

Water has three physical states—solid, liquid, and gas—depending on factors like hydrogen bonding, temperature, and pressure. It is a polar inorganic compound that serves as a universal solvent and has a neutral pH in its pure state.

The melting point of solid water is 0 degrees Celsius, and the boiling point is 100 degrees Celsius. Depending on the temperature and atmospheric pressure, water exists in three phases: solid (ice), liquid, and gas (water vapor).



Hydrogen bonding between water molecules decides its physical state. In liquid water, hydrogen bonds form an extensive 3-D network where they constantly form and break.

The kinetic motion of water molecules breaks the hydrogen bonds. As the temperature increases, the kinetic motion of water molecules increases, causing a breakdown of hydrogen bonds and converting water into gas or vapor.

As the temperature decreases, water freezes or forms a crystalline structure supported by intermolecular hydrogen bonding, turning water into solid ice.

Stratification in Lakes

Water can form films or layers because its density changes with temperature. As the temperature decreases, water becomes heavier and denser. Two such layers are the surface layer at the water-atmosphere interface and the thermocline layer which forms deeper in the lake. The thermocline separates the warmer, sun-heated surface water from the colder, deeper water below, effectively preventing vertical mixing under normal conditions.

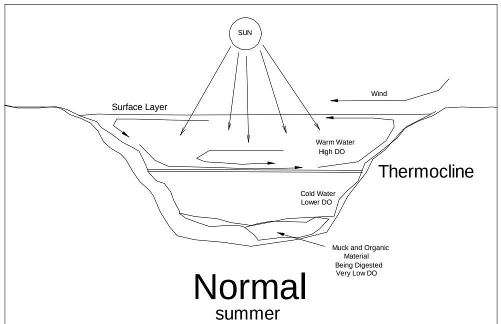


Figure 1

Thermocline

The term "thermocline" refers to a distinct layer in a body of water, like a lake, where there is a rapid change in temperature. This layer acts as a barrier, separating the warmer water above from the much colder water below. The thermocline's position and thickness can vary depending on various environmental factors such as sunlight, wind, and surrounding temperatures. The depths at which thermoclines form depend on factors such as the heat absorbed from the sun, normal wind patterns that create waves to circulate the upper layer, and the temperature of the surrounding earth and air above the lake.

Normal Fall/Spring Turnover in Colder Climates

As a lake changes from summer to winter, it will slowly experience a turnover as the upper layer of water gets heavier due to cooling. Turnover happens gradually as the atmosphere cools the upper layer of the lake to the point where it becomes heavier than the water below it. The temperature of the lower zone in the lake is supported by the surrounding earth. Cooler, heavier pockets of water from the surface start to sink, causing the thermocline to become thinner and move higher in the lake. The thermocline will eventually disappear as the warmer, lighter bottom water flows upward toward the freezing surface where it will cool further and possibly freeze. If the lake's surface freezes over completely and enough light passes through the ice, plants will supply limited oxygen for respiration and remediation until spring.

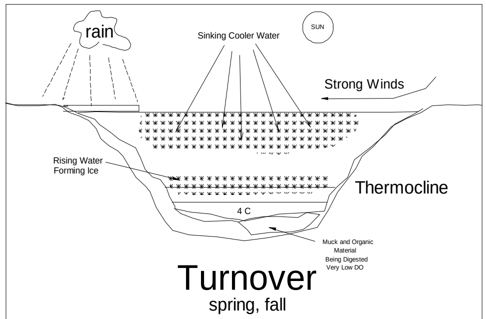


Figure 2

Rapid Turnover and Fish Kill

Once the temperature starts changing and the heavier water starts moving downward, the lake becomes unstable and will turn over quickly if disturbed by high winds making waves or a large volume of cold water from a storm entering the lake quickly.

Normal spring and fall turnovers that experience strong storms and high winds can create a rapid turnover, quickly mixing cold low-oxygen, and high-nutrient bottom water throughout the entire lake, killing marine life.

Thermoclines Do Not Exist Above Air Diffusers, Eliminating Turnover

Air diffusers release millions of small bubbles under pressure that dissolve to increase oxygen and combine to make bigger bubbles that rise faster, lifting water to the surface. Within the slow-rising column, bubbles lift water to the surface where mounding occurs, creating limited circulation across the surface.

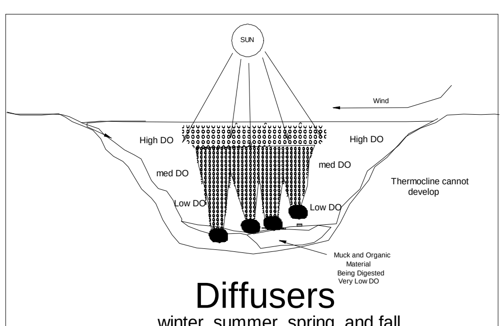


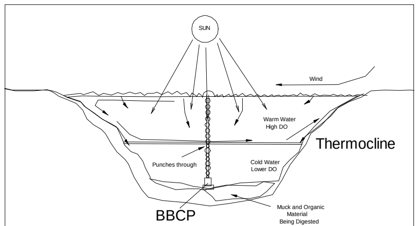
Figure 3

The rising and spreading column of bubbles created by the diffuser passes through any formed or forming thermocline, mixing waters of different temperatures. This mixing prevents thermocline from forming. The lake directly above the diffuser will continually mix from the bottom to the top via the rising columns of small bubbles. The average temperature throughout the lake would be higher with diffusers operating. The higher temperature means lower dissolved oxygen throughout the lake, especially in the summer, stressing fish. Without the thermocline, the earth surrounding the lake cannot cool the faster-moving water below where the thermocline would have formed.

In cooler climates, after most water bodies have frozen over for the winter, water bodies with installed diffusers will have a hole in the ice where warmer water from deeper in the lake is brought to the surface via the rising water column. This rising warmer water will absorb oxygen at the surface before sinking back into the lake.

BBCP and the Thermocline

The U.S. Patented BBCP uses compressed air to rapidly generate a continuous stream of 5-inch bubbles that quickly rise to the surface. The bubbles continually expand and rise faster, lifting and drafting hundreds of gallons of water each minute. The narrow stream from the BBCP passes through the thermocline on its way to the surface, where mounding occurs, forming strong harmonic ripples that move from the BBCP location toward the shore in all directions. The movement across the surface is referred to as “Visual Circulation.”



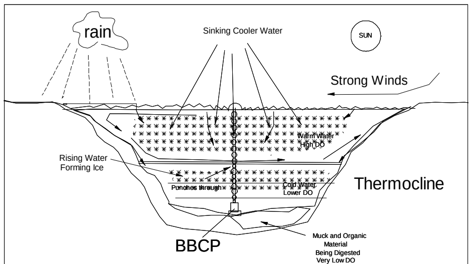
Big bubble Circulation Pump
winter, summer

Figure 4

The ripples flowing away from the boil are started by the cold, low-oxygen water vertically lifted above the surface, then collapsing below it. This process repeats over and over until ripples flow across the surface, absorbing oxygen before sinking back into the lake. Ripples over 100 feet from the BBCP are constructed from cold bottom water. The ripples travel through surface water over 100 feet and beyond, allowing gas transfer to and from the atmosphere, like a 10-mph wind blowing 24/7.

BBCP and Turnover

The fast-rising vertical movement of 5-inch bubbles from the BBCP moves cold water through the thermocline to the surface where oxygen is absorbed. This movement also creates powerful ripples that flow to the shore in all directions, transferring gases between the lake's upper water layer and the atmosphere (Visual Circulation). The ripples eventually hit the shore or another obstacle, dissipating energy and slowing down. The water within the ripples flows back into the lake, circulating the upper layer.



Big bubble Circulation Pump
during Turnover
Figure 5

During spring and summer turnovers, when the warmer water cools, becomes heavier, and begins sinking, the lake is unstable. A large storm with high winds that create large waves, and heavy cold rain can cause the slightly warmer, lighter bottom water to rise quickly to the surface, diluting the low-oxygen, high-nutrient water throughout the lake. If this change happens too quickly, fish and other aquatic life may die.

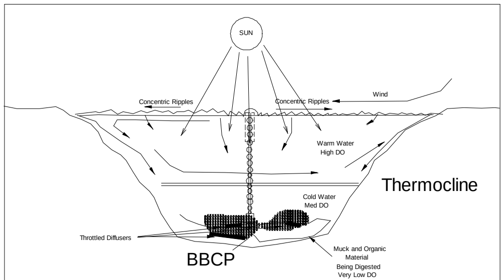
The BBCP provides two main defenses to reduce the severity of a quick turnover in spring and summer:

1. The constant 24/7 circulation can help mix cold, heavy rainwater as it enters the lake, reducing the possibility of the flowing water acting like a river and disturbing the bottom. The circulation would also ensure that the water zone above the thermocline supports as high of an oxygen level as possible.
2. The ripples on the surface lessen the effects of the winds by creating ripples in the opposite direction to dampen wave formation.

BBCP Optimal Design

The best design for a lake includes the BBCP to lift and draft colder, low-oxygen water from just above the lake's bottom to the surface, where harmonic mounding occurs, forming powerful ripples known as “Visual Circulation.” As the nearer ripples spread the colder, heavier, low-oxygen water across the surface, absorbing oxygen before slowing and sinking, farther ripples continue mixing the surface water all the way to the shore. The ripples break at the shore, with the contained water flowing up the bank and back into the lake, creating circulation in the zone above the thermocline.

Instead of installing disc or tube-type diffusers that run maximum airflow to generate bubbles for both aeration and circulation, install 20-foot straight lengths of weighted diffuser hose that will generate bubbles intended to dissolve instead of combining and rising. This adjustment will be made visually along the shore in shallow water so the bubbles form and rise slowly. Once the valves are set, the weighted diffuser hoses will be placed around the BBCP, no closer than 30 feet.



BBCP & Throttled Diffusers
winter, summer

Figure 6