Handout 1.5 Water Resources

Water Resources (Legal definition from "Law Insider" website - A water resource is any and all water on or beneath the surface of the ground, including natural or artificial water courses, lakes, ponds, or diffused surface water and water percolating, standing, or flowing beneath the surface of the ground, and any related natural systems. However, it does not refer to treated wastewater effluent or seawater. I will not cover groundwater resources in this course.

Lake Water Resource The below is quoted from the National Geographic On-line - Lake | National Geographic Society): "Lakes are bodies of freshwater entirely surrounded by land that are generally not moving (lentic). There are millions of lakes in the world. They are found on every continent and in every kind of environment—in mountains and deserts, on plains, and near seashores. Lakes vary greatly in size. Some measure only a few square meters and are small enough to fit in your backyard. Such small lakes are often referred to as ponds.
Other lakes are so big that they are called seas. The Caspian Sea, in Europe and Asia, is the world's largest lake, with an area of more than 370,000 square kilometers (143,000 square miles). Lakes also vary greatly in depth. The world's deepest lake is Lake Baikal, in Russia. Its bottom is nearly 2 kilometers (more than 1 mile) below the surface in places.
Although Lake Baikal covers less than half the surface area of Lake Superior—one of North America's Great Lakes—it is about four times deeper and holds nearly as much water as all five of the Great Lakes combined. Other lakes are so shallow that a person could easily wade across them."

"The water in lakes comes from rain, snow, melting ice, streams, and groundwater seepage. Most lakes contain freshwater. All lakes are either open or closed. If water leaves a lake by a river or other outlet, it is said to be open. All freshwater lakes are open. If water only leaves a lake by evaporation, the lake is closed. Closed lakes usually become saline, or salty. This is because as the water evaporates, it leaves behind solids—mostly salts. The Great Salt Lake, in the U.S. state of Utah, is the largest saline lake in North America. Its water is saltier than the ocean. Surrounding the Great Salt Lake are salt flats, areas where the lake has evaporated, leaving only stretches of white salt."

How Lakes Are Formed
"All lakes fill bowl-shaped depressions in the Earth's surface, called basins. Lake basins are formed in several ways. Many lakes, especially those in the Northern Hemisphere, were formed by glaciers that covered large areas of land during the most recent ice age, about 18,000 years ago. The huge masses of ice carved out great pits and scrubbed the land as they moved slowly along. When the glaciers melted, water filled those depressions, forming lakes. Glaciers also carved deep valleys and deposited large quantities of earth, pebbles, and boulders as they melted. These materials sometimes formed dams that trapped water and created more lakes. "

"Some lake basins form where plate tectonics changed the Earth's crust, making it buckle and fold or break apart. When the crust breaks, deep cracks, called faults, may form.
These faults make natural basins that may fill with water from rainfall or from streams flowing in the basin. When these movements occur near the ocean, part of the ocean may be trapped by a new block of land thrust up from below the Earth's surface. The Caspian Sea was formed this

way. Lake Baikal was also formed by the movement of tectonic plates."

"Many lakes form as a result of volcanoes. After a volcano becomes inactive, its crater may fill with rain or melted snow. Sometimes the top of a volcano is blown off or collapses during an eruption, leaving a depression called a caldera. It, too, may fill with rainwater and become a lake. Crater Lake, in the U.S. state of Oregon, one of the deepest lakes in the world, was created when ancient Mount Mazama's volcanic cone collapsed. Not all lakes are created by basins filling with water. Some lakes are formed by rivers. Mature rivers often wind back and forth across a plain in wide loops called meanders. During periods of flooding, a swollen, rushing river may create a shortcut and bypass a meander, leaving a body of standing water. This type of small lake is called an oxbow lake, because its shape resembles the U-shaped frame that fits over an ox's neck when it is harnessed to pull a wagon or a plow. Lakes may also be created by landslides or mudslides that send soil, rock, or mud sliding down hills and mountains. The debris piles up in natural dams that can block the flow of a stream, forming a lake. Dams that beavers build out of tree branches can plug up rivers or streams and make large ponds or marshes. People make lakes by digging basins or by damming rivers or springs. These artificial lakes can become reservoirs, storing water for irrigation, hygiene, and industrial use. Artificial lakes also provide recreational use for boating, swimming, or fishing. Artificial lakes can provide electricity through hydroelectric power plants at the dam. Lake Mead, in the U.S. states of Arizona and Nevada, was formed when the Hoover Dam was built during the Great Depression. The dam was built to control the unpredictable Colorado River and provides electricity to the western United States." Watch this short video to better understand how lake are formed - https://youtu.be/cYGoDNzU_Vo

Chemical and Physical Aspects of Lakes

"Temperature, light, and wind are three of the main factors that affect the physical characteristics of a lake. Temperature and light vary from lake to lake. Depth, plant growth, dissolved materials, time of day, season, and latitude can all affect light's ability to pass through the lake's water. Light and wind affect the temperature in lakes. Sunlight warms the water, and wind cools it down. Most lakes go through a process called thermal stratification."

"Thermal stratification refers to a lake's three main layers, each with a different temperature range. A lake's shallowest layer is the epilimnion. Its middle layer is the metalimnion, or thermocline. The deepest layer is the hypolimnion. The most important chemicals in a lake are nitrogen and phosphorus. These chemicals allow nutrient-rich plants and algae to grow. Other organisms feed off these plants and algae, creating a complex, healthy ecosystem. The chemistry of a lake is affected by biological, geological, and human processes. The balance of nutrients may be altered by biological phenomena such as "algal blooms," when algae reproduces so rapidly it prevents any nutrients from reaching below the lake's surface. Natural processes such as the eruption of a nearby volcano can alter the chemical aspect of a lake by introducing new gases or minerals. Pollution, such as the introduction of toxic chemicals from industry or agriculture, can also affect a lake's chemistry. The amount of oxygen and the pH level can also affect a lake's chemistry. A lake must have a healthy amount of oxygen to sustain life. Lakes that do not have enough oxygen to sustain life are abiotic. The pH level is a chemical property of all substances. A substance's pH level

indicates whether it is an acid or a base. Substances with a pH of less than 7 are acidic; substances with a pH greater than 7 are basic. Lakes have different pH levels, with life adapting to different chemical environments. Lake Tanganyika, one of the African Great Lakes, has an extremely high pH. It is full of dissolved minerals. Fish such as cichlids thrive in Lake Tanganyika. Tilapia, a variety of cichlid, can also thrive in lakes with very low pH."

The Life Cycle of Lakes

"Once formed, lakes do not stay the same. Like people, they go through different life stages—youth, maturity, old age, and death. All lakes, even the largest, slowly disappear as their basins fill with sediment and plant material. The natural aging of a lake happens very slowly, over the course of hundreds and even thousands of years. But with human influence, it can take only decades. A lake's plants and algae slowly die. The warm, shallow water of the upper layer of the lake causes plants and algae to decompose, and eventually they sink to the basin. Dust and mineral deposits on the bottom of the lake combine with the plants to form sediment. Rain washes soil and pebbles into the basin. The remains of fish and other animals pile up on the lake's bottom. The lake becomes smaller, starting at the edges and working toward the middle. Eventually, the lake becomes a marsh, bog, or swamp. At this point, the drying-up process slows down dramatically; limnologists, people who study lakes and ponds, aren't sure why. Eventually, the lake becomes dry land. Dry lake beds are a perfect place to find and study fossils."

"Archaeologists often excavate ancient lake beds, such as Fossil Butte in the U.S. state of Wyoming. The remains of organisms, from single-celled bacteria to dinosaurs, were preserved over time as sediment on the lake bed built up around and on top of them. In fact, some scientists believe the first living organisms on Earth developed in lakes."

Lake Classification

"There are three basic ways that limnologists classify lakes: how many nutrients lakes have, how their water mixes, and what kinds of fish live in them. When lakes are classified by the amount of nutrients they have, limnologists are using the trophic system. Generally, the clearer the water in the lake, the fewer nutrients it has. Lakes that are very nutrient-rich are cloudy and hard to see through; this includes lakes that are unhealthy because they have too many nutrients. Lakes need to have a balance of nutrients. Lakes can also be classified by how the water mixes, or turns over from top (epilimnion) to bottom (hypolimnion). This is called lake turnover. Water in some lakes, mostly shallow ones, mixes all year long. These lakes have very little lake turnover.

Deep lakes experience lake turnover on a large scale. The middle layer, the thermocline, mixes and turns over throughout the year. It turns over due to climate, nutrient variations, and geologic activity such as earthquakes. However, major lake turnover happens during the fall and spring, when the lake's cold and warm waters mix and readjust. Most lakes that experience lake turnover are dimictic lakes, meaning their waters mix twice a year, usually in fall and spring.

Lake turnover changes with the seasons. During the summer, the epilimnion, or surface layer, is the warmest. It is heated by the sun. The deepest layer, the hypolimnion, is the coldest. The sun's radiation does not reach this cold, dark layer. During the fall, the warm surface water begins to cool. As water cools, it becomes more dense, causing it to sink. This cold, dense water

sinks to the bottom of the lake. It forces the water of the hypolimnion to rise. During the winter, the epilimnion is coldest because it is exposed to wind, snow, and low air temperatures."

"The hypolimnion is the warmest. It is insulated by the earth. This is why there is ice on lakes during the winter, while fish swim in slightly warmer, liquid water beneath. During the spring, the lake turns over again. The cold surface water sinks to the bottom, forcing the warmer, less dense water upward. The final way to classify lakes is by the kinds of fish they have. This helps people in the fishing industry identify what kinds of fish they might be able to catch in that lake. For example, calling a lake a cold-water lake tells a fisherman that he can probably expect to find trout, a cold-water fish. A lake that has thick, muddy sediment is more likely to have catfish.
There are other ways of classifying a lake, such as by whether it is closed or fed by a river or stream. States also divide lakes into ones that are available for public use and ones that are not. Many people refer to lakes by size."

How Animals and Plants Use Lakes

"Lakes are important in preserving wildlife. They serve as migration stops and breeding grounds for many birds and as refuges for a wide variety of other animals. They provide homes for a diversity of organisms, from microscopic plants and animals to fish that may weigh hundreds of kilograms. The largest fish found in lakes is the sturgeon, which can grow to 6 meters (20 feet) and weigh more than 680 kilograms (1,500 pounds). Plants growing along the lakeshore may include mosses, ferns, reeds, rushes, and cattails. Small animals such as snails, shrimp, crayfish, worms, frogs, and dragonflies live among the plants and lay their eggs on them both above and below the waterline. Farther from the shore, floating plants such as water lilies and water hyacinths often thrive. They have air-filled bladders, or sacs, that help keep them afloat. These plants shelter small fish that dart in and out under their leaves. Waterbugs, beetles, and spiders glide and skitter across the surface or just below it. Small islands, floating plants, or fallen logs provide sunny spots for turtles to warm themselves. Other animals live near the lake, such as bats and semi-aquatic animals, such as mink, salamanders, beavers, and turtles. Semi-aquatic animals need both water and land to survive, so both the lake and the shore are important to them. Many kinds of water birds live on lakes or gather there to breed and raise their young. Ducks are the most common lake birds. Others include swans, geese, loons, kingfishers, herons, and bald eagles. Many people think of fish when they think of lakes. Some of the most common fish found in lakes are tiny shiners, sunfish, perch, bass, crappie, muskie, walleye, perch, lake trout, pike, eels, catfish, salmon, and sturgeon. Many of these provide food for people."

How People Use Lakes

"Lakes are an important part of the water cycle; they are where all the water in an area collects. Water filters down through the watershed, which is all the streams and rivers that flow into a specific lake. Lakes are valuable resources for people in a variety of ways. Through the centuries, lakes have provided routes for travel and trade. The Great Lakes of North America, for example, are major inland routes for ships carrying grain and raw materials such as iron ore and coal. Farmers use lake water to irrigate crops. The effect of very

large lakes on climate also helps farmers. Because water does not heat or cool as rapidly as land does, winds blowing from lakes help keep the climate more even. This is the "lake effect." The city of Chicago, in the U.S. state of Illinois, benefits from the lake effect. Chicago sits on the shore of Lake Michigan. When the western part of Illinois is snowing, Chicago often remains slightly warmer. The lake effect can help farmers. In autumn, lakes blow warmer air over the land, helping the season last longer so farmers can continue to grow their crops. In spring, cool lake winds help plants not to grow too soon and avoid the danger of early-spring frosts, which can kill the young crops. Lakes supply many communities with water. Artificial lakes are used to store water for times of drought. Lakes formed by dams also provide hydroelectric energy. The water is channeled from the lake to drive generators that produce electricity. Because they are often very beautiful, lakes are popular recreation and vacation spots. People seek out their sparkling waters to enjoy boating, swimming, water-skiing, fishing, sailing, and, in winter, ice skating, ice boating, and ice fishing. Many public parks are built near lakes, allowing people to picnic, camp, hike, bike, and enjoy the wildlife and scenery the lake provides."

Virginia Peninsula Lake Example.
The value of a water resources such as a lake is defined by its use. For example, Waller Mill Lake is a 360-acre reservoir owned by the City of Williamsburg. The reservoir is located within the boundaries of Waller Mill Park. A navigable tunnel connects the upper and lower portions of the reservoir. The reservoir shoreline topography is covered by numerous points and coves. The heavily wooded shoreline with the numerous creek arms provides for a very pleasing environment in which to fish, hike, bike, bird watch or just pleasure boat. This trolling motor only resource feels larger than 360-acres due to all of the coves and creek arms. The reservoir has decent fishing opportunities for striped bass, largemouth bass, white perch, black crappie, and various sunfish species. The Waller Mill reservoir has the following uses: Drinking water; fishing, boating. From its description we can assign the following uses: Water Supply (reservoir), Recreation (fishing, boating), natural resource viewing and shoreline recreation. Waller lake would be considered an open lake under most conditions, that is water flows through the lake and over the man-made damn at its southern end and into Queens Creek which flows into the York River and then into the Chesapeake Bay."

Watch a fishing video made on Waller Mill Lake at
https://www.youtube.com/watch?v=1Q396kkd73U