Name _____ Date _____ Class Pd _____

Chloride in the Pennypack Creek

Above: The Pennypack Creek Watershed is represented by the red shaded area; Philadelphia county (PA) is outlined in red.

The Pennypack Creek is the receiving water body of the Pennypack Creek Watershed, located in Pennsylvania.

Use the information presented in *Figure 2.1 Pennypack Creek Watershed* to respond to the following prompts.

The *headwaters* (the source or beginning) of the Pennypack Creek are located in two townships in Pennsylvania. List those two townships:

1. _____
2. _____

List one Pennypack Creek *tributary* (labelled creek, brook, or run in Figure 2.1) that lies outside of the Philadelphia county boundary, and one that lies inside the Philadelphia county boundary.

1. Outside Philadelphia county boundary line _____
2. Inside Philadelphia county boundary line_____

Re-examine all of the tributaries (labelled creek, brook, or run) in Figure 2.1. In your own words, define the word *tributary*: _____

_____

_____

Into which body of water does the Pennypack Creek empty? _____

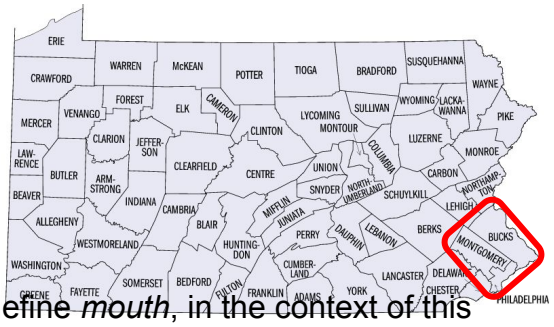
Use the information presented in *Figure 2.3 Land Use in the Pennypack Creek Watershed* to respond to the following prompts.

Observe the watershed as a whole. The most prominent color throughout the entire watershed is _____. According to the legend, this is a _____ type of land use.

In the space provided:

1. Describe the ways (if any) that the land use changes as you move from outside the boundary of Philadelphia county inward toward the southern end of the Pennypack Creek watershed.
2. How might these changes impact the Pennypack Creek Watershed?

About the Pennypack



The Pennypack Creek watershed is located in southeastern Pennsylvania, within Montgomery, Bucks, and Philadelphia counties. The Pennypack Creek watershed is a part of the Delaware River Basin; the *mouth* of the Pennypack Creek opens into the Delaware River.

Consider the maps you have been studying so far. In your own words, define *mouth*, in the context of this lesson: _____

_____

Study the Delaware River Basin map.

List the four states that have watersheds that are part of the Delaware River Basin:

1. _____ 3. _____
2. _____ 4. _____

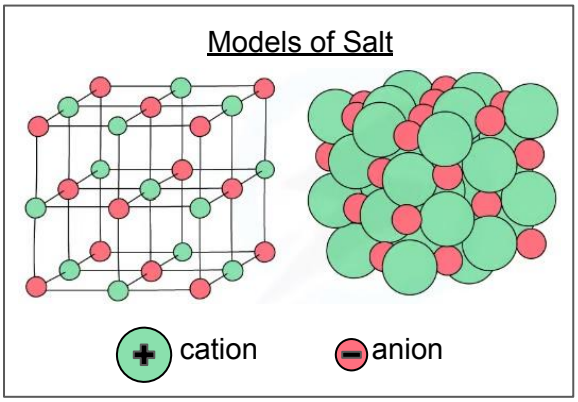
Where does the *mouth* of the Delaware River open?

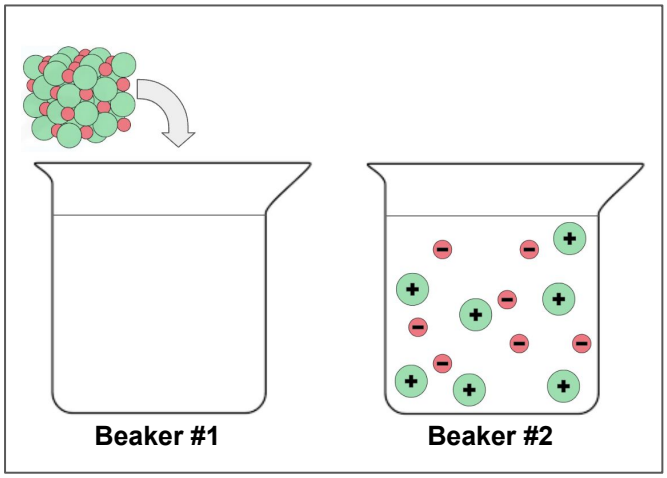
_____

Salt in Watersheds

"Salt" is a generic term that chemists use to describe *ionic compounds*. Ionic compounds are chemical compounds that form when positively charged ions (*cations*) bond with negatively charged ions (*anions*) to form a solid, neutral compound.

When dissolved in water, most salts will *dissociate*. The model (below) shows a salt before dissociation (Beaker 1) and after dissociation (Beaker 2) in water.





Based on the model (left), define dissociation in your own words:

_____

_____

_____

_____

_____

Sodium chloride (NaCl, known as "table salt") is a very common, naturally occurring mineral known to geologists as "halite." Refined (and sometimes iodized) NaCl is the same substance that you add to your french fries! Raw halite is also used in northern climates to prevent icing of roads and highways in the winter. As water flows through and over watersheds, it can dissolve NaCl from rocks (this process is known as *chemical weathering*) and other surfaces and carry them along its flow path.

Dissolved ions are essential to the health of freshwater aquatic and riparian ecosystems. Table 1 lists the most abundant ions typically found in these ecosystems. Some of the roles that these ions play in biological functions include: regulation of cell and enzyme functions, metabolic processes, pH and fluid levels; driving certain processes in photosynthesis; bone formation and growth; and many more functions.

Table 1: Most Abundant Ions Found in Freshwater Ecosystems

Cations	Anions
Calcium (Ca^{2+}) Magnesium (Mg^{2+}) Sodium (Na^{+}) Potassium (K^{+})	Bicarbonate (HCO_3^{-}) Chloride (Cl^{-}) Sulfate (SO_4^{2-})

Too high a concentration of these dissolved ions, however, can have a negative impact on the plants, animals, and microorganisms that live in aquatic and riparian ecosystems; most organisms exist within a specific range of tolerance with respect to factors such as ion concentration, temperature, and pH. In freshwater aquatic and riparian ecosystems, a Cl^- concentration of 1-150 mg/L is considered normal; this varies based on the geology of a given area.

About the Study

Critical Zone researchers at Temple University are investigating the ways in which *urban processes* influence the Pennypack Creek, including its water quality and flow. What is one example of an *urban process*:

_____

_____

In this lesson, we will analyze the results of a *synoptic sample* collected by these researchers during a three-hour period in March of 2022.

A *synoptic sample* is a collection of samples is taken from many locations over a short period of time (usually less than a few hours) as a way of capturing a "snapshot" of a stream or river at a specific time. Why do you think it is important for samples along a stream to be collected synoptically instead of, for example, over multiple days or weeks?_____

_____

_____

_____

The Data

Open the interactive ArcGIS data set using the link that your instructor has provided.

Use the Legend to answer the following questions:

1. What ion is being studied in this data set? _____
2. What are the units of measurement for this ion? _____
   a. Explain, in your own words, what this unit is describing: _____
      _____
      _____
3. What is the range of values for each of the circular and the triangular data points?
   a. Possible range of values for circular data points: _____
   b. Possible range of values for triangular data points: _____

The circular data points represent water samples taken from the Pennypack Creek during the synoptic sampling; the triangular data points represent samples taken from the Hatboro-Horsham Waste Water Treatment Plant and the Southhampton Tributary (points A and B, respectively, on the map your instructor is sharing).

Student Data Analysis

1. What trends or patterns do you see when you first look at the data?
2. Consider the numeric values next to each data point.
    a. What do these values tell us?
    b. Of the samples taken from the Pennypack Creek, what is:
        i. The highest value?
        ii. The lowest value?
    c. Do the two values listed above fall within the range of Cl^- considered "normal" for freshwater ecosystems?
3. The concentration of Cl^- in the Pennypack nearly doubles between sampling station #8 and #9 (going from 159.72 mg/L to 280.6 mg/L).
    a. With reference to the ArcGIS map and the background information provided (including Figures 2.1 and 2.3), what is one factor that could have influenced this change in Cl^- concentration?
    b. What additional data or information might you need to collect to determine whether your previous prediction is accurate?
    c. Turn this prediction into a hypothesis and outline the design of an investigation that would allow you to gather data to answer your scientific question.
4. Propose one potential explanation for the decrease and then increase in Cl^- concentration from sample stations #35 to #36 to #37.
5. Refer to the ArcGIS map and the background information provided (including Figures 2.1 and 2.3, and the map of the Delaware River Basin) to determine the validity of the following claim:

    "The relatively high Cl^- concentration at sampling site #38 is likely due to the accumulation of dissolved ions from the watersheds in New York and New Jersey polluting the Pennypack Creek as these dissolved ions move down the Delaware River and reach the mouth of the Pennypack Creek in Philadelphia."
6. The researchers who collected these samples from the Pennypack Creek are interested in the *urban processes* that influence the water quality and flow of the Pennypack Creek.
    a. What urban process(es) can you think of that could influence the concentration of Cl^- in the Pennypack Creek?
    b. Why do you think they chose to collect data about Cl^-?
    c. Why do you think they chose a synoptic sampling method?
    d. Which of the sampling stations, if any, do you think the researchers used (or could have used) as a control? Explain your reasoning.
    e. Propose a hypothesis that the researchers may have been investigating in this study.
    f. To what use might someone be able to put the results of this study?
7. This synoptic sample was collected in Philadelphia one day in March of 2022. How might the patterns and trends you observed in the data be different if this samples had instead been collected in:
    a. August of 2022? Explain your reasoning.
    b. March of 1850? Explain your reasoning.
8. Are the results of this study important to you?
    a. If yes:
        i. Explain why you say so, and
        ii. Propose one follow-up investigation that would build off of this study an help you learn more about issues that might impact Pennypack Creek.
    b. If no:
        i. Explain why not, and
        ii. Propose a different body of freshwater in which you could carry out a similar study to make the results more personal to you, include an explanation of your choice!