

Student Lessons – Activity 1: Where is the Watershed we will Study?

Introduction

Every location on Earth is in a watershed; therefore you could choose any place and study its watershed. However, not all watersheds have had scientists collecting data that we might use to study that watershed, so we need to choose a watershed for which data exists if we want to do a thorough study without having to collect new data. In the Baltimore area, the Baltimore Ecosystem Study has collected data on the Gwynns Falls for several years, and this will serve as an example to examine some factors that affect watersheds. Our study will show why this is a good example stream to use because it is comparable to a variety of other watersheds, probably including the one where your school or home is located. This activity doesn't have room for answers, so write them on a separate sheet of paper.

Step-by-Step Instructions

1. The regional view.

a. The watershed we will study in this lesson is that of the Gwynns Falls (In this use, Falls is another term for stream or brook). Map A shows the major watersheds in the Baltimore region, and the Gwynns Falls watershed just west of Baltimore filled by diagonal lines. What is the name of the major river whose watershed includes the Gwynns Falls?

b. All watersheds drain from the land towards the ocean. Does the watershed you found in question (a) above drain to the Chesapeake Bay? Does the Gwynns Falls drain to the Chesapeake Bay?

2. The watershed view.

a. Map B shows the Gwynns Falls watershed and its streams, and subdivides the watershed to show the watersheds of several tributaries. Besides the main stream of the Gwynns Falls, how many subwatersheds are shown on this map?

b. The line west & south of the Gwynns Falls watershed on this map is the southwestern border of Baltimore County. This border follows the flowing section of the Patapsco River, so Carroll, Howard, and Anne Arundel Counties are on the other side of the river. The flowing section of the Patapsco ends at the Chesapeake Bay after crossing briefly into southern Baltimore City, not far from the place where the boundaries of Baltimore County, Baltimore City, and Anne Arundel County meet. Does it appear that the Gwynns Falls empties into the flowing section of the Patapsco (that is, does it reach the county border), or does the Gwynns Falls simply enter the estuary of the Bay called the Patapsco River? Look at Map B1 to help with this question, and to get a different view of the watershed.

c. On Map B, there are fewer tributary streams in Baltimore City, and some of those in the city are broken up. Where might water go in the city so that there would not be a stream at the surface to draw on the map? Were there probably surface streams in these areas before the city existed?

Student Lessons –

Activity 2: What are the conditions in various parts of the Gwynns Falls watershed?

Step-by-Step Instructions

3. Using maps.

a. Map C shows the 7 stream study sites we will use, and their watersheds; list the 4 study sites that occur on the main Gwynns Falls stream in order of occurrence starting from the top (the north), then describe the location of the other 3 study sites as either on a Gwynns Falls tributary, or outside the Gwynns Falls watershed.

b. Since the water from an upper watershed flows into the next watershed below it, what happens to the size of the watershed for each of the 4 study sites on the main Gwynns Falls as we move downstream? So which of those 4 watersheds should be the largest one? Estimate a rank order of the other 3 watersheds by size, from smallest to largest. Note that the name of the study site at the bottom of the watershed becomes the name for the watershed above it.

c. Simply from where the Gwynns Falls is located, as we go downstream moving from Baltimore County into Baltimore City, how would you expect the land use to change? Would you expect that there are other similar watersheds in the Baltimore region?

d. Map D shows these study watersheds and the land use/land cover for the Gwynns Falls watershed. Use the legend to understand what the different shades or colors mean, and examine the watersheds above each study site. What are the predominant land use/land covers in each of the study areas?

e. Which study watersheds show larger amounts of impervious surfaces?

f. After you have answered these questions, your teacher will give you a table that shows the actual size and percentages of different land use/land cover classes in each watershed. For use in the rest of this exercise, make a list that shows which watersheds are best characterized by which of these 4 types: forest, agriculture, urban, or suburban. For the latter two categories, consider the 2 watersheds with the largest amount of impervious surfaces as urban, and the next 3 to be suburban; but which of those last 3 is still rather urban based on other numbers?

4. What are some other characteristics of the watershed that might affect the hydrology of the watershed?

Student Lessons –

Activity 3: How and why does the discharge vary in this watershed?

Step-by-Step Instructions

Charts 1 to 3 are hydrographs, which are graphs of the discharge for a stream for a period of time; in this case, the time period is several years. Note that on these particular graphs, one line may be graphed using the left Y-axis, while another line is graphed using the right Y-axis, so pay attention to which axis applies to which line. Also, the 0 line of the Y-axis on one side may not be the same as the Y-axis on the other side. This was done to move the discharge graph higher so it can be seen; you can ignore any negative parts of a Y-axis that result from this move. Sometimes lines are drawn with a different weight to allow us to see other lines under them.

5.
 - a. Is the discharge in these streams constant, or does it vary? If it varies, what would cause that to occur?
 - b. The amounts of change are different, but are the patterns similar - that is, do all the streams tend to rise and fall at nearly the same time? Why?
 - c. The first step in determining the amount of discharge variation is to determine what is normal, or base flow. For each stream, estimate a base flow amount.
 - d. Now for each stream, make an estimate of the peak or maximum flow. Does the amount of change from base flow to peak flow seem like a lot of variation, or a little?
 - e. What would be the effects on people, animals, and plants of these variations in flow?
 - f. Why are there 3 graphs, instead of all the streams being plotted on the same graph?

Chart 4 is for 3 of the study streams, covering a limited time in order to look at detail more clearly. This chart plots the discharge not in cfs, but in multiples of base flow, that is, how many times larger the discharge was compared to base flow. This allows us to compare streams even though their discharge amounts may be significantly different.

Some streams change their discharge quickly, and by large amounts; such streams are said to be "flashy." In a graph like Chart 4, a stream that is more flashy would have a more bumpy line in the graph than a stream which is not flashy.

6.
 - a. Rank the 3 streams shown in Chart 4 in increasing order for flashiness, with the least flashy stream first.
 - b. Looking back at the characteristics of these 3 streams (using the table you got in question 3f), what characteristic might contribute to flashiness, and do these 3 streams vary in this characteristic in a way that matches the order you found in question 6a? Make this into a general rule.
 - c. If the behavior you found in question 6b is considered usual behavior, what impact might this have for people planning the growth of a community? Do humans' choices have an effect on the streams and ecosystems around them?
7.
 - a. How is Chart 5 alike and different from Chart 4?
 - b. Rank the streams in Chart 5 by amount of impervious surfaces, and make a prediction as to how the streams would rank in flashiness of their discharge.

c. Does Chart 5 support your prediction? If not, in what way does it differ? What factors might cause this behavior?

d. How would you modify the general rule you created in question 6b above based on this new information?

Student Lessons –

Activity 4: How and why does the water chemistry vary in this watershed?

Step-by-Step Instructions

8. We will first examine how the chloride (Cl^-) ion varies.
 - a. Chart 6 shows the chloride concentrations for 3 streams. What is the range of concentrations shown? What do you notice about the timing of the concentration changes in this chart?
 - b. Chart 7 shows the chloride concentrations for 2 other streams. What is the range of concentrations shown? How does this compare with the values you found in question 8a?
 - c. Besides differences in size of the watersheds, how are the watersheds of the 3 streams in Chart 6 different from the 2 watersheds in Chart 7? The classification list you made for question 3f will help answer this question.
 - d. From your answers to questions 8a-8c, what do you hypothesize is the source of the Cl^- ions in this data? How would you determine if your hypothesis is likely to be correct?
 - e. Chart 8 plots an additional data set on the right Y-axis. Does this data back up your hypothesis from question 8d?
 - f. Discuss how this Cl^- might affect the plants and animals in the streams (both in the amounts and in the variability of the Cl^-), and the pros and cons of this Cl^- use. Do humans' choices have an effect on the streams and ecosystems around them? For comparison, the average concentration of Cl^- in the ocean is about 19,250 mg/L.

9.
 - a. Chart 9 shows nitrate concentration for 4 streams. Use the characteristics of these 4 watersheds you know from question 3f, and describe what types of land use/land cover seem to go with what levels of nitrates in the streams. The pattern seen in these watersheds is typical of the relation between nitrate and land use/cover seen elsewhere.
 - b. What are the likely major sources of nitrate in each of the types of land use/land cover discussed in question 9a?
 - c. For the 3 general watershed types in Chart 9 - agricultural, forest, and urban/suburban - which has the largest amount of impervious surfaces? What would this suggest is the expected relation between imperviousness in a watershed and its nitrate amount?

10.
 - a. Chart 10 shows nitrate concentrations for the 4 stream study sites on the Gwynns Falls; all of these can be considered urban/suburban watersheds. Do you see any seasonal trends in the nitrate levels, that is, does the nitrate concentration tend to be high during certain times of the year, and lower at another time of year? Can you think of any hypotheses on why this would occur? Hint: When would nitrate be used as a nutrient the most?
 - b. According to Chart 10, how does the nitrate concentration change as we go down the watershed & into the city - from Glyndon to Gwynnbrook to Villa Nova to Carroll Park? Also, check the impervious percentage of Dead Run and look at its nitrate levels again in Chart 9, compared to the streams in Chart 10. Do your findings for this agree with the general relation you found in question 9c above? Will knowing the imperviousness of a watershed allow you to make a good prediction of the nitrate levels, or will we need to examine other factors to fully explain nitrate levels?

c. What are some of the factors that might be causing the trend you found in question 10b?

d. Are humans' actions affecting nutrient levels in streams and the Chesapeake Bay? From the factors you have considered, what actions might be taken to reduce those nutrients? What are the pros and cons of those actions?

11. In general, the concentration of nitrate decreases as we go down the Gwynns Falls; we need to determine if this means there is less total nitrate - called the nitrate load - as we move downstream. To do that, we basically need to multiply the discharge (volume of water per unit time) times the concentration (mass of nitrate divided by a volume of water) to get the total mass of nitrate in a particular time period; the only extra steps are conversion factors to make the units of measurement useable. For example, for Glyndon (using median discharge, and median nitrate concentration):

$$\frac{0.1 \text{ cubic feet}}{\text{sec}} \times \frac{2.27 \text{ mg nitrate}}{\text{L}} \times \frac{28.32 \text{ L}}{1 \text{ cubic foot}} \times \frac{86400 \text{ seconds}}{1 \text{ day}} \times \frac{1 \text{ kg}}{1 \times 10^6 \text{ mg}} =$$

0.56 kg nitrate/day = the nitrate load at Glyndon

Calculations & questions to answer:

a. Using the median discharge and nitrate concentrations given below, calculate the nitrate load in kg of nitrate per day for each of the other watersheds in this study. The additional conversion factors will be the same as the 3 factors in the equation given above. Though the nitrate concentration often varies as the discharge changes, these calculations will give us an understanding of the order of magnitude of the nitrate load, that is, seeing if it is closer to 1 or 10 or 100, etc.

Station	Discharge - cfs	Nitrate concentration - mg/L	Total nitrate load- kg/day	Load added downstream - kg/day
Glyndon	0.1	2.27	0.56	0.56
Gwynbrook	2	2.07		
Villa Nova	22	1.33		
Carroll Park	40	1.14		
Dead Run	1.5	0.6		-----
McDonogh	0.017	4.1		-----
Pond Branch	0.09	0.02		-----

b. Then complete the above chart by finding the nitrate load added by each of the successive watersheds going downstream from Glyndon to Gwynbrook to Villa Nova to Carroll Park. Do this simply by subtracting the downstream total load from the total load immediately upstream. You don't need to do calculations for the last 3 sites because they are tributaries.

- c. What do you conclude about how the total amount of nitrate changes as we go downstream in the Gwynns Falls? By the time we get to Carroll Park, is the Gwynns Falls contributing a relatively large, or small, amount of nitrate to the Chesapeake Bay?
- d. As we go downstream on the Gwynns Falls, which watershed adds the most amount of nitrate load? Is this an urban or suburban watershed? Is this what you would expect?
- e. Does Dead Run contribute a large, or small, amount of nitrate to the Gwynns Falls?
- f. The McDonogh nitrate concentration is high due to its agricultural land use, so we might suspect it adds a lot to the Gwynns Falls; does this watershed contribute a large or small amount of nitrate to the Gwynns Falls?
- g. Based on its nitrate concentrations, we wouldn't expect Pond Branch to contribute much nitrate to the Chesapeake Bay - was that expectation verified by this calculation?

Student Lessons – Activity 5: Overall Summary

12. Some summary questions for this entire lesson:

a. Are watersheds and stream systems controlled by just a few simple factors, or are they fairly complex, with multiple interacting factors that determine their characteristics?

b. Do humans have effects on the amount and the chemistry of the water in streams?
Can these effects be changed by choices?