# Freshwater *Natural Inquirer* • Reflection Section Answer Guide

## GREEN MEANS CLEAN

### Introduction

Do you know where your drinking water comes from? If so, what is the source? If you are not sure of the source of your drinking water, do some research to identify the source. Your source might be a stream, river, lake, or reservoir. You may also have a spring, an individual water well at your home, or a community well.
*Students will have individual answers to these questions. The goal of these questions is to get students to think about where their drinking water comes from long before it reaches the tap.*

Look at figure 7a. Why do you think **wastewater** treatment plants are identified as a risk to safe drinking water?
*Students will have individual answers to this question. Students should be made aware that treated wastewater is clean, but not clean enough to drink. Treated wastewater is released from wastewater treatment plants into rivers. Students should also consider that wastewater, prior to treatment, is contaminated water and may cause a hazard to drinking water supplies.*

Explain in your own words why the scientists wanted to conduct a national assessment of drinking water watersheds.
*Students will have individual answers to this question. They should, however, realize that the status of the Nation's drinking water watersheds, and therefore the status of the Nation's water quality, cannot be determined by looking at smaller watersheds. The only way to understand the national picture is to standardize assessment methods across all of the Nation's watersheds.*

### Methods

Explain what kind of information the scientists compared for each of the drinking water watersheds.
*Students will have individual answers to this question. They should, however, realize that for each drinking water watershed, the scientists compared land cover change between 1992 and 2001 while considering what percentage of the watershed was protected from further urban development.*

What is the relationship between land cover change and drinking water quality?
*Students should realize that the more a watershed is developed into urban or agricultural land cover from natural land cover, the less protected is the drinking water quality.*

### Findings

What national trends in land cover change were discovered for the drinking water watersheds?
*Students should see that although the numbers were not large, the trend was for a loss of natural land and an increase in urban land in U.S. drinking water watersheds.*

Based on what you learned in this article, would you say that future threats to drinking water quality are equal across the United States? Why or why not? Provide reasons for your answer.
*Students will have individual answers to this question. However, they may conclude that water quality threats will rise across the United States due to continued development and growth. The west may be less susceptible to issues due to the large amounts of public land that can protect the water resources.*

### Discussion

The scientists discovered that 8 percent of the Nation's drinking water watersheds contain at least 20 percent urban land. Do you think these more urbanized watersheds are mostly found in the Eastern United States or the Western United States? Why?
*Students can use evidence from the article for their answers. Information from the article shows that the Western United States has more conserved public land, which is evidence that there is less urban land. The "Findings" section also notes that loss of natural vegetation as common in the Ohio and Southeast hydrologic regions which are both in the Eastern United State region.*

Based on this article, do you think that drinking water sources will face more challenges from pollution in the future? Why?
*Students will have individual answers to this question. Based on this research, however, students should reasonably conclude that unless more land is put into protective status or less urbanization occurs, drinking water watersheds will face more challenges from urbanization, including pollution. The trends uncovered in this research would lead one to conclude that challenges will increase if present trends continue.*

## WHAT'S THE NONPOINT?

### Introduction

Why might understanding the nonpoint source water pollution threat by U.S. watershed region be helpful to those trying to better understand water pollution?
*Students will have individual answers to this question. Students should reason that if pollution threat is greater in the east, for example, that something about larger population density might be contributing to water pollution. Likewise, if pollution threat is greater in agricultural areas, students might reason that something related to agricultural production might be contributing to water pollution.*

In the years since passage of the Clean Water Act of 1972, one type of threat to water quality has not been adequately addressed. Explain in your own words why it is difficult to identify and address nonpoint source pollution.
*Students will have individual answers to this question. They should be able to explain that nonpoint sources are generalized and widespread, and therefore more difficult to address through legislation or direct action. Nonpoint sources of pollution also take a longer time to address. For example, cars are polluting less today than in 1972, but it has taken decades for this improvement in pollution control to happen.*

### Methods

What are the basic sources of the three water quality problems? (Hint: Look at the contributing factors in figure 8.)
*Students will have individual answers to this question. They should, however, use figure 8 to look for clues. In general, the sources of the water-quality problems identified by the scientists are human development and activity, including housing, roads, mining, and livestock production.*

Observe the different units of measurement used for the different contributing factors in figure 8. As you can see, these different units of measurement could not be added together. Think about converting each of these measures to 1 of 5 percentiles. What is lost when this kind of standardization process is used? (Hint: Review figure 1 in "Thinking About Science" on page 27.)

*Students will have individual answers to this question. Help them think through the process of taking a wide range of measurements and collapsing those measurements into just 5 categories. The detail of each separate measure is lost in this standardization process. What is gained by this process? The ability to compare and combine measurements from different types of variables is gained from this standardization process.*

## Findings

Look closely at figure 9 and locate the area where you live. What is the nonpoint source water pollution threat level for your area? How does the threat level compare with other areas? Based on what you have read in this article and other things you know about your area, explain why the threat level is where it is.
*Students will have individual answers to this question. They should, however, be able to give a reasonable and justified explanation for why the scientists calculated the particular threat level for the area.*

Observe the locations of the Eastern United States low-threat areas. Name one difference between the Florida Everglades and the other locations.
*Students should notice that the Florida Everglades is much farther south than the other locations; and it has a much warmer climate.*

What is similar about all these eastern low-threat areas, including the Florida Everglades?
*All of these areas have lower human population density than the more populated areas across the eastern United States.*

## Discussion

Federal and State lands help to protect water resources because they limit human development. Name two other natural resources that are usually protected by Federal and State lands.
*Students will have individual answers to this question. Some possible answers include: animal and plant habitats, air quality, threatened and endangered species, and soil conservation. Students may be able to name others.*

Think about the Clean Water Act. If population continues to rise as expected, what actions might help protect Americans from a reduction in water quality?
*Students will have individual answers to this question. They should, however, realize that either modifications to the Clean Water Act or other Congressional action could be taken to reduce the amount of pollution coming from nonpoint sources. Students may also note that individuals and groups can take action to protect water resources. If students note the ability of individuals to take action, hold a class discussion about some actions they can take to protect water resources.*

# CARIBBEAN CRUISE

## Introduction

In your own words, what is the question the scientists wanted to answer in this study?
*The scientists wanted to know how the amount and type of CPOM in the watersheds changed over time.*

The scientists studied two watersheds in the experimental forest. What is one reason the

scientists wanted to study two watersheds instead of only one watershed?
*One reason is that the scientists wanted to be able to compare data between the two watersheds.*

## Methods

The scientists collected CPOM after large storms. Why do you think these collections were a good idea?
*After large storms, more debris and leaf litter would likely have fallen in the watershed areas causing more of it to get caught in the traps and potentially breaking the mesh and traps. These collections were also a form of maintenance to make sure the traps kept working well.*

The scientists had to test several different types of metal mesh traps to collect the CPOM until they found a design that worked. Think of a time that you have tried to make something or do something and it didn't work. What did you do? What are some characteristics that you think are important for scientists to have in order to overcome obstacles? (Hint: Take a look at some of the *Natural Inquirer* scientist cards at http://www.naturalinquirer.org/scientists-v-92.html. Look at the back of the cards and read about important scientist characteristics. See if you think any of those characteristics apply to this situation.)
*Students will have individual answers to these questions. However, some of the characteristics that may come up are perseverance, creativity, thoughtfulness, ability to see the big picture, critical thinking, and problem solving.*

## Findings

CPOM export was lowest during times of drought. Think about the stream and the surrounding environment during these times. Brainstorm some ideas as to why you think CPOM export could have been low. You may want to research one of your ideas to see what you can find out about it.
*Students will have individual answers to these questions. Students should support their ideas with evidence and logic. However, some things to consider are streamflow and how drought may affect trees and plants.*

December, January, and February had low CPOM export. Why do you think this low level may have occurred?
*These months are low rainfall months, and although there is some litterfall it does not reach the streams to be exported.*

## Discussion

In your own words, what did the scientists learn from their study?
*The scientists learned that CPOM export followed a seasonal pattern. This pattern loosely followed rainfall and litterfall patterns. The scientists also learned about how hurricanes and large storms influenced CPOM export. The amount of CPOM export is affected by how often the storms occur and the severity of the storm. Additionally, the age of the forest has an effect on CPOM export.*

Why are natural disasters and other large weather events important to study? What information can they provide for the future management of the natural systems?
*Students will have individual answers to this question. Natural disasters and large weather events, as evidenced by the results of this research, can cause major impacts to an ecosystem. Natural disasters and large weather events are common in certain parts of the world and in certain ecosystems. Studying these types of events can help us understand*

*how the environment reacts to the large changes. Scientists and land managers can anticipate what they need to do to protect the ecosystem in the event of a similar event.*

## SEDIMENT-AL JOURNEY

### Introduction

Concrete is used for many building projects, including bridges, sidewalks, and buildings. Concrete is made from calcium. What part of your body contains calcium? Does this body part need to be strong? Why or why not?
*Students will have individual answers to this question. They should realize that their own skeletal system contains calcium. Their bones must be strong to support their body's structure.*

Based on what you have read so far, would you expect to find more calcium and lead in riparian sediment closer to or farther away from the city center? Why?
*Students will have individual answers to this question. They should reason, however, that riparian sediment closer to the city center would likely have more calcium and lead than areas away from the city center. The reason is that the greater the urban development, the more buildings, sidewalks and roads are built, and therefore the greater the possibility of calcium and lead washing into waterways and deposited onto riparian areas. If students read "Thinking About the Environment," they should also remember that precipitation in urban areas drains into waterways more quickly than it does in vegetated environments, and this quick drainage carries more chemicals into soils and waterways.*

### Methods

Observe figure 12. Why did the scientists take samples across the entire watershed, from northwest to southeast?
*Students will have individual answers to this question. They should realize, however, that the scientists were interested in differences in sediment deposits across the urban-suburban gradient. Since the Gwynn Falls watershed follows the urban-suburban gradient, it was necessary to take soil samples across the entire watershed.*

Why did the scientists take every sample 10 meters from the water's edge?
*Students will have individual answers to this question. They should realize, however, that by standardizing the distance from the water's edge, the scientists were removing a source of variation that could affect their results.*

### Findings

Scientists prefer to use measurements to describe conditions. For example, rather than describing a day as hot, a scientist would prefer to report that the temperature is 94 °F (34 °C). Based on this study's results, what measure might one day be used to describe the amount of an area's urbanization? What is one advantage of using this measure?
*Students will have individual answers to this question. Based on the results of this study, the measured level of calcium found in riparian sediment samples might be used to describe the degree of urbanization of an area. If a calcium measurement could be used to describe how urbanized an area is, the description would be less biased.*

The scientists found a relationship between higher levels of trace chemicals in riparian

sediment and nearby artificially created land areas. If that same relationship is found in other studies, what might you conclude about one consequence of using fill dirt to create new areas of land?
*Students will have individual answers to this question. They should realize, however, that the evidence might indicate that for some reason, using fill dirt to create new land areas is associated with an increase in trace chemicals in nearby riparian sediment samples.*

### Discussion

Do you agree with the scientists that more research is needed about urban-related chemical sediment deposits? Why or why not?
*Students will have individual answers to this question. Whatever their answer, students should be prepared to back up their answer with a reasoned justification for their opinion.*

Baltimore is just one urban area among thousands of urban areas across the globe. If the findings of this study were true for all urban areas with nearby waters, what long-term change might you expect to find in these waters, such as rivers, lakes, and coastal bays around the world? What impact would this change have on global health? (Hint: Reread the first sentence of the last paragraph in the "Discussion" section).
*Students will have individual answers to this question. If most urban areas are contributing calcium, lead, copper, and zinc to waterways and to riparian areas, then eventually scientists might detect higher levels of calcium, lead, copper, and zinc worldwide in coastal bays and other waters. The impact of increasing levels of these metals on global health is unknown. As the scientists noted, little is currently known about the effects of increased metals in urban riparian areas.*

## MUSSEL MANIA

### Introduction

State in your own words and in the form of questions what the scientists wanted to learn.
*How does streamflow in bottomland hardwood forests ecosystems affect mussel growth?*

Mussels are important to the ecosystem. Name three ways mussels are important and why each function is important to the ecosystem.
*Mussels help filter water. The filtering helps ecosystems because filtered water provides cleaner water. Mussels are a source of food for other animals. The mussels are an important part of the ecosystem's food web. The old shells from mussels provide a home for other animals. Mussels are an indicator species to help people know if an ecosystem is healthy. Because the mussels depend on many different kinds of fish for reproduction, the presence of many kinds of mussels also means that there is a diverse and healthy fish fauna in the ecosystem.*

### Methods

The scientists collected data from three different rivers. Do you think it is a good idea to collect data from different areas? Why or why not?
*Gathering data from different areas is important because scientists can compare the areas and try to figure out what may be influencing the growth of mussels. It also helps them understand what kind of variation in growth is normal and what is caused by other things like dams.*

The scientists included a description of each river in the study (see figure 13). Why do you think this information is useful?
*The description of the river may lead scientists*

*to other factors that may be influencing streamflow and mussel growth.*

## Findings

How does mussel growth change in times of high and low flow? How do you know based on the data in figure 17?
*The data in figure 17 show a lot of negative numbers during high streamflow in the unregulated rivers. Eight out of nine are negative for the Sipsey River and one out of three are negative for the St. Francis River. These data suggest that mussels' growth is slower during times of high streamflow.*

What did the scientists find out about the relationship between regulated and unregulated rivers and mussel growth? (Hint: Review figures 13 and 17.)
*Unregulated rivers showed two different things. In the Sipsey River, there was faster mussel growth in times of low streamflow and slower mussel growth during times of high streamflow. In the St. Francis River, there was a strong, positive relationship between mussel growth and hydrologic reversals. In the regulated river, no relationships could be found.*

Read the descriptions of the rivers in figure 13. Do you think any of these river characteristics could influence mussel growth? What do you think the scientists might suggest as the next steps to take after this research?
*The large scale agriculture and watershed diversion projects could have an impact on the mussels. The presence of dams and reservoirs may also impact mussel growth. The scientists might suggest looking at more mussels and other rivers.*

## Discussion

Do you think it is important to study the impact of streamflow on mussels? Why or why not?
*Students will have individual answers to these questions. Students should support their answer with logic and examples from the article. Students should realize that mussels are important parts of bottomland forest ecosystems. Mussels provide a variety of benefits to the ecosystem. Therefore, it is important to understand mussel growth and the ecosystem that best supports their growth.*

What are the advantages and disadvantages of dams on our rivers? Discuss with your classmates.
*Students will have individual answers for this question. From the article, students should be able to discuss the impacts of dams on the growth and success of freshwater mussels. For other advantages or disadvantages, students may discuss recreation access (i.e., fishing, boating, swimming, etc.), flood control, drinking water access, loss of natural processes, power generation, or increased carbon emissions.*

# TIMED TRAVEL

## Introduction

Why does stream or river water temperature vary across a 24-hour period?
*Students will have individual answers to this question. They should, however, realize that nighttime water temperatures are often cooler than daytime temperatures.*

Imagine that you are going camping over the weekend. You will be sleeping in a tent. The average daily air temperature across 24 hours will be 45 °F (7.2 °C). Do you think it would be more helpful for you to know how the

air temperature will vary across the 24-hour period? Why or why not?
*Students will have individual answers to this question. They should realize, however, that knowing whether the nighttime temperature will be, for example, 25, 30, or 40 degrees Fahrenheit and knowing the minimum and maximum temperatures would help them plan for their trip.*

## Methods

Explain in your own words how the experiment was controlled so that any observed differences in fry emergence and condition would most likely be related to water temperature patterns.
*Students will have different ways to describe the experiment. They should note at least a few of the following procedures to control the experiment: Adult Chinook salmon were collected within a 2 month period and from the same area of the river; eggs were collected at the same time and under controlled conditions at the hatchery; the chambers were constructed the same and all were heated by a similar heater. The same measurements were used for each chamber. The only difference between the chambers was the temperature patterns. Therefore, any observed differences in fry emergence would most likely be related to the different temperature patterns.*

What were the scientists trying to discover in this experiment?
*Students will have different answers to this question. They should realize, however, that the scientists wanted to discover whether a variable daily temperature affected the timing of Chinook salmon fry emergence differently than a constant daily temperature.*

## Findings

Based on the scientists' results, what would you conclude about the relationship between water temperature variability and Chinook salmon development?
*Students will have individual answers to this question. Some will have more insight into the impact of temperature variability. Students should understand, however, that variability in water temperature impacted the timing of fry emergence.*

Look at figure 14. What do you notice about fry emergence from this figure?
*Students will have individual answers to this question. They should, however, notice some of the patterns evident in this figure. For example, fry in different but stable water temperature emerged at about the same accumulated temperature units. When the temperature varied to a high of 13°C, fry had accumulated many fewer TU at emergence. When exposed to seasonal variation and seasonal as well as daily variation, fry emerged after accumulating similar TU.*

## Discussion

If you were teaching young scientists how to study fish emergence, what would you teach about considering water temperature variability?
*Students will have individual answers to this question. They should, however, recognize that young scientists should be aware of and consider water temperature variability when they study fish development.*

Do you think the results of this research are convincing? Why or why not?
*Students will have individual answers to this question. They should, however, note that so*

*much of the variation was controlled in this study's design, that any changes in when fish emerged would almost have to be the result of the differences in water temperature. Therefore, students should feel that the results of this research are convincing.*

## UNDER WHERE?

### Introduction

Does water flow underground in your region? Why do you think so?
*Students may not know this answer. However, if students realize that water flows underground in a desert and emerges in some areas as an oasis, they should induce that water flows underground in the region they live.*

What is surprising about figure 5? *Students should be surprised at the extent of underground aquifers across the United States.*

Do you think other areas across the planet have aquifers? Why or why not? *Students will have individual answers to this question. They should reason, however, that if the United States has extensive underground aquifers, other regions across the planet also have extensive underground aquifers.*

If you have not read "Thinking About the Environment," do so now. Using the information in "Thinking About the Environment" and in the "Introduction" as clues, how do you think the scientists answered their first research question?
*Students should guess that the scientists used chemistry to answer their first question.*

### Methods

Why did the scientists sample catchments at two different elevations?
*Students should realize that to answer their question about the amount of snow and rain contributing to streams, the scientists had to sample from areas that had much snowfall and from areas that did not have much snowfall.*

Look at figure 14 and reread its caption. Why do you think an air line was connected to the sampler?
*Students will have individual answers to this question. Encourage them to think about trying to suck water through a straw from a jar of water that is otherwise airtight. They should realize that air is needed to pump liquid out of a closed container.*

### Findings

What force is at work in the underground movement of water? Explain how this force affects underground water movement.
*The force is gravity, which exerts a downward pull on objects. Gravity is at work when water runs downhill on the ground's surface. It is also at work when water infiltrates into the ground and percolates. Gravity causes water to run downhill, even when it is underground. Gravity causes water to move downward and fill crevices in between gravel and rocks until it hits bedrock. Gravity causes water to flow in aquifers because of the continual downward supply of water from above.*

Read the last sentence in the "Findings" section. Based on this finding, what do you think was the answer to the scientists' second research question? (Hint: See the end of the "Introduction" section, page 110.)
*Students will have individual answers to this*

*question. They should, however, realize that if the total amount of precipitation does not change, the percentage of precipitation as snow or rain should not affect groundwater's contribution to streamflow.*

## Discussion

Explain why the scientists expect that a lower percentage of snowfall and a higher percentage of rainfall in the future will not affect the flow of groundwater into streams.
*Students may need assistance answering this question. The key is to focus on the percentage of water falling as snow or rain, not the total amount of precipitation. The scientists found that the type of precipitation falling (snow or rain) did not impact the amount of underground water contributing to streamflow.*

In a changing climate, some areas might receive less precipitation. Imagine that the scientists had also considered the trend in the total amount of precipitation falling in the area over time. How might their findings change if they discovered a trend toward less total precipitation over time?
*Students will have individual answers to this question. If the scientists noted a trend toward less precipitation over time, they might conclude that although a lower percentage of snowfall would not impact streamflow, a trend toward less total precipitation would likely have an impact on the amount of groundwater from all sources contributing to streamflow.*