Field Test Document

Testing the Waters

Evaluating the Condition of a Local Ecosystem

In **Beneath the Surface** you learned about the biotic and abiotic limiting factors found in aquatic ecosystems and how they impact the health of the system. Just as you have collected data and made observations about changes in temperature, dissolved oxygen, pH, and conductivity in your model ecosystem over time, scientists in Fairfax County and across America, collect similar data to assess the health of local and regional aquatic ecosystems.

In Part 1 of this activity you will use special maps to help you learn about the watershed in general and your water testing site. In Part 2 you will collect water quality and other data which you will use to assess the health of the area. You will use your data to develop an environmental stewardship plan in Part 3. From these activities you will gain a broader understanding of the ways in which humans are studying, assessing, and preserving their natural resources.

Online Resources

Chesapeake Bay Program website http://www.chesapeakebay.net/
Fieldscope website http://chesapeake.fieldscope.org

Part 1: Getting the Lay of the Land

As more people move into the Bay's watershed, land must be developed for homes, schools, shopping centers, and roadways. Removing vegetation and wetlands to make way for buildings and paved surfaces means that water flows freely and unfiltered into local streams and carries sediments, nutrients, and other pollutants to the Bay. People must rely on cars to get from their homes in the suburbs to stores, shops, and where they work. Driving from place to place increases the air pollution which enters waterways when it rains.

Scientists make use of a variety of tools to help them gather, analyze, and share data. Geographic Information Systems (GIS) allows geo-referenced data (i.e., data that was collected at a specific latitude and longitude) to be viewed in a way that makes it easier to understand. GIS technology is currently being used by federal, state, and local government agencies and services to plan and keep track of important information and resources. GIS has many applications in everyday life as well. GIS is an important tool used to assess the health of the Chesapeake Bay ecosystem and to predict the future impact of our actions – both positive and negative.

Question

What can we learn about the health of the Chesapeake Bay Watershed and other areas of interest using GIS tools?

Directions and Responses

Step 1 Using a computer with Internet access navigate to the Chesapeake Bay Program site previously bookmarked by your teacher.

Step 2 In the **Bay Resource Library,** select **Publications**. Scroll down to the **Bay Barometer 2010**. Download the electronic version.

Step 3 Read about each category in the chart below. Briefly summarize the key ideas for each category shown in the chart. Include information from relevant graphs if desired.

Step 4 In the **Bay Resource Library** select **Maps**. Find one map that illustrates the information you summarized for each of the categories. Write the name of the map and list one or more ways the map helped you better understand the Bay's health.

	Category	**Summary of Key Ideas**	**Name of Related Map(s)**
Bay Health	Water Quality		
	Habitats and Lower Food Web		
	Fish and Shellfish Abundance		
	Health of Freshwater Streams		

Restoration and Protection Efforts	Managing Fisheries		
	Protecting Watersheds		
	Fostering Stewardship		*Add to the bottom something to have the kids synthesize their learning about the summary and maps*

Step 5 Navigate to the National Geographic Fieldscope site previously bookmarked by your teacher http://chesapeake.fieldscope.us/.

Step 6 Click on the **LAYERS** tab (upper left hand side of screen) to expand the window. In the top right portion of the screen, select the **Terrain** map.

Step 7 Click in the box to the left of each of the data layers related to monitoring (i.e., Student Observations, Student Photos, CBIBS, and Shallow Water Monitoring). Uncheck each layer before moving to the next. Below, summarize the type of data to be found in each of these layers. Student Observations

- Student Photos
- CBIBS (click on the ***i*** for more information). Select “Refresh Now” to view up-to-date water quality data
- Shallow Water Monitoring

Note: You will upload the water quality data collected in Part 2 of this investigation to this site at a later date.

Step 7 Move down to the **Chesapeake History** layers. Check the boxes to the left of Chesapeake 1607 and Chesapeake Now. What is the source and what type of data is available from these layers? Uncheck each layer before moving to the next.

Step 8 Uncheck Chesapeake History or other layers selected before going further

Step 9 Under **Boundaries**, click on each of the following layers and examine the type of data displayed on the map. Uncheck each layer before moving to the next. Summarize what information these layers provide.

- Watershed Boundaries (click on the ***i*** for additional information)
- State Boundaries (click on the ***i*** for additional information)
- Physiographic Provinces

Step 10 Under **Human Geography** click on each of the following layers and examine the type of data displayed on the map. Uncheck each layer before moving to the next. Summarize what information these layers provide.

- Land Cover
- Impermeability and Impervious Surfaces
- Nutrients and Sediment
- Dissolved Oxygen (use the slider in the upper right corner of the screen to “zoom in” to the Bay; “Click and drag” the map to reposition it to see other parts of the Bay)

Step 11 Under the **Basemap** layer, click on each of the following layers and examine the type of data displayed on the map. Uncheck each layer before moving to the next. Summarize what information these layers provide.

- Wetlands
- Elevation
- Water Depth
- Boundaries and Places

Step 12 From the menu in the upper right corner of the screen, select each of the following maps and note how the map display changes. What features does each map display?

- Topographic Map
- Satellite Imagery

Step13 Click on the **SEARCH** tab (just below the LAYERS tab) and type in the address of your water testing location (e.g., Lake Accotink, VA) Be patient as this feature sometimes takes a few seconds to activate. Click **Search**.

Double click on the red needle that appears in the search window. The map display will shift to the searched address. Zoom in as close as you can and explore the area. Your teacher may have additional landmarks to help guide you to the correct location.

Switch between **Terrain Map**, **Topographic Map**, and **Satellite Map** in order to gather useful information about the site based on the following bulleted layers. Summarize what you have learned about your site in the space below. **Be creative and use a variety of maps to fully explore the site!**

- Watershed Boundaries
- Land Cover – (click on the *i* for more information)
- Impervious Surfaces
- Nutrient and Sediment Yield at this location
- Nearby wetlands
- Elevation (remember to use the topographic and the terrain map)
- Water Depth (remember to use the topographic and the terrain map)?

Step14 Click on the **FLOWPATH** button. Into which larger bodies of water does your site flow? You may need to zoom out and use the topographic, terrain, or other maps to help gather this information.

Step15 If desired, follow your teacher's directions to save a copy of the map by clicking on the Save button in the upper right corner of the screen.

Part 2: Meaningful Watershed Field Experience

Important limiting factors such as temperature, dissolved oxygen, pH, conductivity, and others are called **water quality indicators**. Their levels help to show the relative quality of the water and its ability to support life. The conditions found in a given area affect the types and number of organisms that can live there. A healthy ecosystem is one that supports a wide variety of living things. By analyzing water quality and other data, scientists try to uncover the source of environmental problems and then settle on the best way to correct a problem.

In this investigation, you will conduct **water quality monitoring** and collect other data using many of the same processes used by professionals in the field. You will then use your data to estimate the "health" of your testing site.

Question

1. How are water quality and other indicators used to evaluate the health of an aquatic ecosystem?

Key Terms

water quality monitoring
salinity
turbidity
macroinvertebrate organisms
biodiversity

Before You Begin

Think back to the lab investigations, **Watershed Walk** and **Beneath the Surface** and your own life experience.

1. What conditions would you expect to find in a "healthy" aquatic ecosystem?

2. What conditions would you expect to find in an "unhealthy" aquatic ecosystem?

Materials

pencil
Field Data Collection Sheets
clipboard or other hard surface upon which to write (with plastic sheet protector)

Safety

- ***Exercise caution near stream or pond. Do not wade into the water. Do not drink pond or stream water. Do not touch any unknown substances or objects near the stream.***
- ***Extreme care must be taken when using the probeware. Handle science equipment responsibly.***
- ***Chemicals for nitrite testing may be irritating to eyes and skin. Dispose of chemicals properly when testing is complete.***
- ***Wash hands thoroughly with soap and water upon returning to the school.***

Directions

In teams of 2-4 students, you will rotate through a series of four stations (Land Use, Water Quality & Habitat, Biodiversity, and Biology)) to collect qualitative and quantitative data on the water quality of a local waterway. From this data, you will determine the relative "health" of the waterway and make recommendations for improving the waterway or your local watershed.

- Read the information for each station found in this lab book. Be sure you understand all the terms such as habitat, streambed, sandbar, buffer, etc.

- Prepare to "test the waters" before you go to the stream by reading and discussing the directions for each of the four stations with your group. Plan how you will all work together to do all the tests and evaluations in the field.

- Follow the **Directions** you find at each station in the field. As you conduct each test or make each observation, record your findings on the Data Collection Sheets provided by your teacher.

- When you return to the classroom, complete any remaining calculations and enter your evaluation point scores on the Data sheet found in this lab investigation so that you can analyze your data.

STATION 1: LAND USE

Buffer Zone

Vegetation (trees, grass, shrubs) that separates a waterway from human activities helps to filter out pollutants that might be carried by rain into the water. This area of vegetation is known as a buffer zone. A buffer zone greater than 16 meters will filter out pollutants and sediments before they are able to enter the stream.

Shade

Streams need to maintain stable water temperatures as the temperature of the air changes from day to day. Trees and shrubs covering the water in the stream provide shade, which helps to keep the stream cool in summer. Streams with little shade may have temperatures which vary widely from day to night. This is not good for aquatic organisms – especially those that require cooler temperatures to survive.

Stream Banks

Another good way to tell if land use is affecting the stream is to look at the banks of the stream. Heavy erosion on the banks usually means that significant development directly around the waterway or in upstream areas is channeling lots of water directly into the waterway every time it rains. Banks that show little erosion are healthiest for aquatic ecosystems.

Hardness of the Soil

One way to determine whether land use is a problem for a waterway is to test the hardness of the soil. If the soil in the waterway's immediate area is very hard, then water will rush off the land carrying dirt and pollutants into the waterway and erode its banks. However, if the soil is soft, the water will soak into the ground and travel to the stream slowly, from underground.

Development

Different types of development can affect water quality. Highly developed areas tend to have a lot of paved surfaces. If you've ever walked barefoot on a hot summer day, you know that the Sun heats the pavement which feels hot to your feet. During hot weather when rain falls on pavement and runs into a stream, the water temperature can become high enough to kill all the fish and other stream inhabitants. However, if rainwater falls on soil or vegetated areas, it soaks into the ground and travels to the stream through the cool underground.

STATION 2: WATER QUALITY & HABITAT

WATER QUALITY

Temperature

The temperature of the water is very important to the fish and other organisms living in the water. Although different species of fish require different temperatures of water, all fish are stressed by rapid changes in temperature and temperatures above 32° C. In the summer, temperatures rise quickly between morning and night. Although the water temperature might be fine today, it may still become too hot during the summer.

Dissolved Oxygen

Just like you, fish and other aquatic organisms need oxygen to live. Oxygen is a key component in cellular respiration for both aquatic and land-based organisms. These organisms absorb dissolved oxygen through gills or directly through their skin by diffusion. Oxygen gas is dissolved in the water by a variety of processes – diffusion from the atmosphere, aeration as water tumbles over rocks, churning of water by waves and wind, and through photosynthesis carried out by aquatic plants. Certain species of organisms need more dissolved oxygen (DO) than others. For example, trout require at least 6.5 mg/L of DO in the water whereas carp can live with only 2.0 mg/L of DO in the water. The amount of dissolved oxygen in the water of a waterway is an important indication of which organisms can live there and if there is enough DO to support a wide variety of life.

When discussing the water quality of a stream or river, percent potential dissolved oxygen is often used to compare the measured DO with the maximum possible for a particular temperature and pressure. Percent potential dissolved oxygen is calculated by dividing the amount of dissolved oxygen measured by the maximum DO that ***could*** dissolve at a certain temperature and atmospheric pressure. Keep in mind that, unlike increasing temperature which reduces the amount of DO, a greater atmospheric pressure will increase the amount of oxygen that can dissolve in water.

Atmospheric pressure in the U.S. is usually reported in *inches* of mercury (Hg). To convert from inches of Hg to millimeters (mm) of Hg, multiply the atmospheric pressure in inches by 25.4. For example: 30.33 in Hg x 25.4 = 770 mm Hg.

pH

Old mines, certain chemicals draining into streams, or acid rain from car exhaust and factories can make streams too acidic or basic for aquatic organisms. Your stream may be too acidic or basic if the water looks very clear but you observe little life in it *and* there seem to be no other significant problems. Acidity and basicity are measured on the pH scale. The pH scale ranges from 0 – 14. Substances with a pH below 7 are considered acidic, those with a reading of 7 are neutral, and those above 7 are basic. Most organisms have a very narrow pH range that will allow them to survive.

Conductivity (Total Dissolved Solids)

Solids are found in streams in two forms, *suspended* and *dissolved*. Suspended solids include silt, stirred-up bottom sediment, decaying plant matter, or sewage-treatment runoff. Dissolved solids (TDS) can be affected by many different factors and are not always an indicator of problems in a waterway. As you may remember from the investigation, **Molecules on the Move**, a conductivity probe is used to detect the presence of dissolved substances in water. The higher the conductivity reading, the greater the number of dissolved substances there are in the water.

There are many possible manmade sources of substances that may contribute to high conductivity readings. Fertilizers from fields and lawns can add dissolved substances to a stream. Runoff from roads that have been salted in the winter and organic matter from wastewater treatment plants may also increase the amount of dissolved substances in the water. Treated wastewater may also have higher conductivity readings than surrounding streams if urban drinking water has been highly chlorinated. Irrigation water that is returned to a stream will often carry dissolved substances into the waterway as will acidic rainwater. Although you won't use them in this activity, two important terms used by water quality monitors include **turbidity** and **salinity**. Turbidity describes the relative amount of sediment in the water. Salinity refers to the percentage of salt dissolved in the water.

High conductivity is not always a bad thing! It not unusual for streams to have fairly high conductivity from dissolved minerals in the rocks and soils over which they flow. If conductivity is high, further tests should be conducted to determine exactly which substances are present and if they are a hazard to living things.

Nitrites and Other Chemicals

Nutrients, such as nitrites, phosphates, and ammonia enter the water from human and animal waste, decomposing organic matter like leaves and grass clippings, soaps, and fertilizer. Too many nutrients in the water cause algae to grow rapidly. You will investigate this phenomenon in the activity **Nutrient Nuisance**. As the algae grow and die, they block the sunlight from reaching aquatic plants. These plants die and become food for decomposers in the water. With abundant food, decomposer populations grow rapidly which decreases the dissolved oxygen in the water. This process -- excess nutrients leading to low oxygen levels -- is called eutrophication and is a major problem in many aquatic ecosystems such as the Chesapeake Bay.

HABITAT

Sediment

In a rocky bottom stream, sediment can build up behind rocks and logs. When this happens, it means that the soil around the stream is being carried into the waterway when it rains. The sediment can smother aquatic organisms and bury habitat when it settles on the bottom. In a muddy bottom stream, sediment may collect until it fills in pools and reduces the flow of water to a trickle. During storms, this heavy sediment build-up moves from one part of the stream to another, smothering aquatic organisms.

Streambed habitat

Would you rather hide in a forest or in an open field? Fish and other aquatic organisms need a variety of habitats (and places to hide) to survive in a stream.

Prime habitats for **rocky bottom stream** organisms include a mixture of different sized rocks ranging from marble to pumpkin-sized. Organisms can best hide from their predators in streams with plants growing in the water and with other areas around which to hide such as logs greater than 8 cm in diameter, fallen tree branches, clumps of roots, and “cut away” stream banks.

Prime habitats for **muddy bottom stream** organisms include fallen trees and tree branches, submerged logs, areas to hide under the stream bank, root mats, and plants growing in the water. Rocks and gravel may or may not be present in a muddy bottom stream.

Trash and Pollution

Wastewater and sewage pipes can carry harmful substances and/or excess nutrients into a waterway. Most trash looks ugly and can block the flow of water and in some cases is harmful to water quality. Other trash does not harm aquatic life and can actually provide shade and hiding places from predators.

STATION 3: BIODIVERSITY

Biodiversity refers to the variety of life in the world or in a particular habitat or ecosystem.

Knowing the types and numbers of creatures found in an area is a way to <u>indirectly measure</u> the availability of resources needed to sustain life (i.e., its “health”). Polluted areas with few resources tend to have a low diversity of organisms living there and, thus, poor ecological “health”. Areas with many resources tend to have abundant and diverse forms of life.

Humans and other creatures rely on the environment for basic needs such as food, shelter, and (for humans) medicine. It composes ecosystems that maintain oxygen in the air, enrich the soil, purify the water, protect against flood and storm damage and regulate climate.

At this station, you will be collect and analyze data on the biodiversity found in a small area of land adjacent or near the aquatic ecosystem they are investigating. Since the land is part of the watershed that drains into the water body, it will impact the aquatic ecosystem health. You will count the number of different species of animals, fungi, and plants and categorize the plants as invasive or native.

STATION 4: BIOLOGY

Macroinvertebrate organisms are normal inhabitants of aquatic ecosystems and include insect larvae, aquatic worms, and mollusks. Each species has a range of conditions needed for survival. Some organisms are very sensitive to pollution whereas others are very tolerant.

Determining the types and numbers of each type of organism that live in a waterway allows water quality monitors to make inferences about the health of the waterway. Just as you discovered by playing the game **Macromania**, finding high numbers of sensitive organisms in a waterway indicates that the water is quite clean. Finding only tolerant species indicates that the water may be polluted. For this reason, macroinvertebrate organisms are often called “bioindicators” (living indicators) of water quality.

Because collecting samples of aquatic macroinvertebrates would destroy valuable habitat, you may be asked to use data provided to you by your teacher on the type and number of macroinvertebrates found at your sampling location.

Data: Evaluation of the Water Quality of a Local Waterway

Station 1: Land Use	Points	Possible Points
buffer zone		5
ground cover vegetation		5
hardness of the soil		5
condition of the stream banks		5
stream shade cover		5
development and land use		5
Total Points for Land Use (Station 1)		30

Station 2: Water Quality	Points	Possible Points
temperature		5
percent (%) saturation of dissolved oxygen		5
pH		5
conductivity		5
nitrite content		5
Total Points for Water Quality (Station 2)		25

Station 2: Habitat	Points	Possible Points
bottom sediment		5
bottom habitat		5
amount of streambed covered by water		5
wastewater sewage pipes		5
other pipes		5
trash		5
Total Points for Habitat (Station 2)		30

Station 3 : Biodiversity	Points	Possible Points
ecosystem disturbance level		5
plant diversity		10
fungi diversity		10
animal diversity		10
native versus non-native score		5
Total Points for Biodiversity (Station 3)		40

Station 4: Biology	Points	Possible Points
macroinvertebrate data		5
Total Points for Biology (Station 4)		5

Data Analysis

1. Find the sums of all the Total Points columns in the data tables on the previous page. Copy the total points from your data table into the table below and compute the percent of the total score for each station.

Testing Station	Total Score for Station	Possible Score For Station	Percent of Total Score (Total Score / by Possible Score x 100)
1. Land Use		30	
2. Water Quality		25	
2. Habitat		30	
3. Biodiversity		40	
4. Biology		5	

2. The overall health of the study site may be evaluated by looking at all of the factors you have tested and observed at the waterway. Review the results of **each** of the categories (Land Use, Water Quality, Habitat, Biodiversity, and Biology) and indicate below whether you feel each is a “good score” or a “bad score” for this study site.

   Generally speaking, scores above 80% are considered good whereas scores below 80% are considered poor. But you will need to consider all your observations when making your decision.

Good Scores	Poor Scores

3. Why do you think your study site scored well **in the specific areas** in which it did? List three possible reasons for the high scores it received.

4. Why do you think your study site scored poorly **in the specific areas** in which it did? List three possible reasons for the low scores it received.
   Possible answers:

Conclusion

What can you infer about the **overall** health of the waterway you investigated? Give specific examples from your Data and Observations to support your conclusion.

Summary

1. What *are* water quality indicators?

2. Why did you collect data from a variety of water quality indicators - both biotic and abiotic – when evaluating the health of your study site? How would your decision be different if you had only looked at one factor when evaluating your study site's health?

Making Connections

1. Compare your model ecosystem to the study site you evaluated.
   (a) What factors affect the study site which would not affect your model ecosystem?

   (b) Overall, which do you think is healthier: the study site you investigated or your model ecosystem? Why?

Part 3: Environmental Stewardship

2. How does studying a model ecosystem help you to better understand the factors that affect a real aquatic ecosystem or the Chesapeake Bay?

Application

Whether you live in an urban, suburban, or rural area, the most important purpose of **Testing the Waters** is to provide you with the knowledge and experience needed to evaluate the general health of an aquatic ecosystem. Once problem areas are identified, possible solutions can be explored. Actions as simple as planting trees to stabilize a stream bank and produce shade, reducing erosion or pollution upstream, or reporting leaking pipes are important steps toward creating healthier aquatic environments in our community.

Since all portions of the ecosystem are interconnected, small changes in one area of the watershed can impact other areas downstream. The more we know about our waterways, and the more concerned we are about their health, the easier it will be to turn the "cumulative impact of every one of the 15 million people" in the watershed into positive action to help restore the Chesapeake Bay's ecosystem.

1. Think back to the lab activities, **Watershed Walk**, **Beneath the Surface** and this investigation.

   (a) What conditions would you expect to find in a "healthy" aquatic ecosystem?

   (b) What conditions would you expect to find in an "unhealthy" aquatic ecosystem?

Part 3: Environmental Stewardship

The Fairfax County School Board has set forth three main goals for students to achieve: (1) academic achievement, (2) essential life skills, and (3) responsibility to the community. Under Goal 3, the board has decided that Life Science students in FCPS will practice "environmental stewardship." Environmental stewardship means the responsible management and maintenance of natural resources for current and future generations. Environmental stewardship can be accomplished through small, schoolyard projects, or through larger watershed-wide projects.

Through your experiences in Parts 1 and 2 of this investigation, you have gained a better understanding of the environmental factors affecting the watershed in general and the location you visited on your MWEE. Now, in Part 3, you will develop a stewardship action plan to help promote the ecological health of your area.

Question

Which environmental stewardship activities would best help to improve the health of your local area?

Possible Stewardship Projects

Consider the location of your MWEE, or other location such as your schoolyard, for which stewardship action needs to be taken. Considering the situation, which of the following might help to remedy the situation (select all that apply)? The U.S. Environmental Protection Agency (EPA) http://www.epa.gov/stewardship/ and the Virginia Department of Environmental Quality (DEQ) http://www.dcr.virginia.gov/enviroed.shtml have stewardship ideas.

___ Growing and planting native trees or shrubs
___ Creating a schoolyard habitat or rain garden
___ Creating a manmade wetland
___ Creating and maintaining a school-wide recycling program
___ Reducing the amount of water, electricity, and/or paper used on campus
___ Growing and planting underwater grasses
___ Raising fish, such as shad or trout, in the classroom, and releasing them into a local stream
___ Other actions such as stream clean up, invasive species removal, community education, etc.

Description of Stewardship Project

Once you have decided upon the best project for your site, write a few sentences to explain your plan, what materials or partners you will need, and how your actions will improve the health of the ecosystem.