Eutrophication: Tracing Nutrient Pollution Back to Penns Creek

Nutrients are substances that life depends on for growth and reproduction. However, when these nutrients enter our planet's waterways in excess, from both point and nonpoint sources, the results can be disastrous. Excess nutrients can cause eutrophication resulting in algal blooms which are detrimental to the environment. The excess of algae blocks sunlight that submerged aquatic grasses need to grow causing habitat degradation. Furthermore, as dead alga decomposes, it reduces levels of oxygen in the water. This is especially problematic in the summer months, and can result in the death of many bottom-dwelling organisms such as oysters, clams, and worms, which provide food for fish and crabs (Nutrient pollution, 2011).

The Chesapeake Bay

In 1975, the Chesapeake Bay became the United States first estuary to be targeted for protection and restoration after Congress directed EPA's Office of Research and Development to initiate a study identifying the causes of the environmental degradation observed in the Bay (The Great Waters Program). Due to the Clean Water Act Amendments of 1987, the EPA Administrator is required to continue supporting the Chesapeake Bay Program. The Chesapeake Bay Program studies, collects, and publishes information about the environmental quality of the Bay, in an effort to improve conditions in the Bay and determine the impact of human activities. Some of the environmental problems currently facing the Bay include sediment deposition, nutrient pollution, chlorine, acid precipitation, low dissolved oxygen, and toxic pollutants (The Great Waters Program).

Studies completed in the 1970s documented that increases in agricultural development, population growth, and sewage treatment plant discharges were causing the Bay to become enriched with nutrients. Currently, nutrient pollution is the most serious problem facing the Chesapeake Bay, and as a result of this pollution, the Bay suffers from massive algal blooms every summer. These algal blooms rob hundreds of square miles of adequate oxygen, and result in large sections of the Bay becoming dead zones (Waters at Risk, 2006). Currently, the total annual average ten-year loads to the Chesapeake Bay are 300 million pounds of nitrogen, and 18 million pounds of phosphorous pollution per year (Manure’s Impact on Rivers, Streams and the Chesapeake Bay, 2004).
Sources of Pollution in the Chesapeake Bay

The Bay receives this nutrient pollution from a myriad of sources, including, urban runoff, industrial activities, automobiles, human sewage, agricultural practices and manure produced by livestock (Manure’s Impact on Rivers, Streams and the Chesapeake Bay, 2004). However, recently, agricultural activities in the Chesapeake Bay Watershed have been contributing more and more nutrient pollution to the Bay. This is because meat consumption has increased in recent decades, causing the number of livestock in the watershed to grow exponentially. Specifically, livestock numbers have grown to 11 times the human population. These animal operations excrete 44 million tons of manure each year. This excess of manure is often spread over crops and used as fertilizer in agricultural practices. In fact, it is estimated that 40% of the nitrogen, and 54% of the phosphorous pollution the Bay receives can be traced back to manure (Manure’s Impact on Rivers, Streams and the Chesapeake Bay, 2004).

The Bay’s connection to the Susquehanna River

Five major tributary systems; the Potomac, Susquehanna, Rappahannock, York, and James Rivers, as well as dozens of smaller rivers supply fresh water to Chesapeake Bay (The Susquehanna and the Chesapeake Bay). A significant portion of the nutrient pollution the Bay receives comes from the Susquehanna River. The Susquehanna is the longest river on the east coast, and stretches over 444 miles through New York, Pennsylvania, and Maryland before emptying into the Chesapeake Bay (Susquehanna River Basin Commission 2006).

90% of the freshwater flow to the Chesapeake Bay comes from the Susquehanna making it the Bay’s largest tributary, and it contributes about 21% of the phosphorus, and 40% of the nitrogen pollution found in the Chesapeake Bay (The Susquehanna and the Chesapeake Bay).

Sources of Pollution in the Susquehanna River

The lower Susquehanna River Basin is located in southern Pennsylvania, and is the last portion of the river before it reaches the Bay. The soil in this area is especially good for growing crops and 47% of the land use in this region is agricultural (Bruce, 1998). Historically, farmers in the Susquehanna basin have applied a great deal of fertilizer in the form of fertilizer or manure to their crops. This has resulted in runoff which contains large amounts of nitrogen and phosphorus. To be exact, more than 60% of the phosphorus and 85% of the nitrogen pollution in the Susquehanna can be traced back to farms (The Susquehanna and the Chesapeake Bay). However, poor farming practices are not the only reason the Susquehanna suffers from nutrient pollution. Another source of nutrient pollution in the lower Susquehanna River Basin is discharge from sewer treatment plants, as well as fertilizer applied to suburban lawns. 20% of the
streams in the Lower Susquehanna River Basin exceed the U.S. Environmental Protection Agency’s maximum contaminant level of 10 mg/L of nitrogen, making it unsafe to drink (Bruce, 1998).

Nutrient pollution in the Susquehanna has a significant effect on the ecosystems of Susquehanna’s small freshwater streams and ponds (Waters at Risk, 2006). Algae thrives on phosphorus and nitrogen, leading to cloudy, oxygen starved water which cannot support aquatic life. This problem is especially prevalent during the summer months, when water temperature increases, and more algae is present.

The Susquehanna River’s Connection to Penns Creek

In Snyder County all surface water eventually flows toward the Susquehanna River, and in many places in northeastern Snyder County, streams flow into the lower sections of Penns Creek. (Watershed Protection, 2012). Penns Creek is a 67 mile long tributary of the Susquehanna, located in the Penns Creek Watershed, which covers an area of approximately 163 square miles and includes parts of Mifflin, Snyder and Union County (Bilger, 2008). Penns Creek enters the Susquehanna just below the Borough of Selinsgrove in Snyder County. Land use in this watershed is mainly categorized as agricultural and suburban/urban. The land surrounding Penns Creek has experienced large scale changes in riparian vegetative zones and the consequential impacts caused by runoff. Runoff contaminated with nutrients from agricultural practices enters Penns Creek, which then joins the Susquehanna River just below the Borough of Selinsgrove (Bilger, 2008).

Sources of Pollution in the Penns Creek

Penns Creek suffers from nutrient pollution due to various agricultural activities in the area, and is on the EPA and DEP’s list of impaired water ways. As of 5/08/2012 the total nitrogen in Penns Creek is 20.845 kg/yr/acre, the total phosphorous is 0.176 kg/yr/acre, and the total suspended solids is 0.298 kg/yr/acre. This means that currently the total measured nutrients in kg/year/acre is 10 percent above the Total Measurable Daily Load Allocation (Average Annual Nutrient
Loads on the Lower Susquehanna Basin. Land use has a large effect on what segments of Penns Creek suffer from more pollution compared to others.

In order to determine what segments of Penns Creek suffer from the most nutrient pollution, The Penns Creek Watershed Association conducted a study analyzing water quality in the area over a three year period, from August 2006 to October 2008 at 12 different sites on Penns Creek in Snyder and Union Counties. The study area began above Penns Creek’s confluence with Cherry Run, continued downstream immediately below the confluence with Middle Creek and ended 2 miles above the confluence with the Susquehanna River. This study revealed that the sites located most upstream were forested, undisturbed sites and this is where water quality was best.

This study also analyzed the presence of algal communities found at various sites on Penns Creek. Cocconeis is an alga species associated with excess nutrients in waterways, and algal blooms. The Penns Creek Watershed Association found that when high frequencies of Cocconeis were present, it was associated with a depression in diversity and richness of other species. A decrease in biodiversity is indicative of poor water quality. As you can see in the graph, sites PC10, PC09, PC08, and PC03 all have above 70% levels of Cocconeis. Sites PC10, and PC08, were located in mostly agricultural areas, with narrow riparian buffers. Site PC09, and PC03 were residential areas, with reduced riparian buffer zones. This data indicates that moving downstream, changes in land use practices, and a decreasing riparian zone width cause Lower Penns Creek to be mildly impacted by agriculture and organic pollution (Bilger, 2008).

Solutions to Nutrient Pollution

In an effort to restore water quality in Pennsylvania, and the Chesapeake Bay Watershed, is important that initiatives be undertaken which support agricultural Best Management Practices, as well as the restoration of riparian buffers. Riparian buffers are vegetated areas next to water resources that protect water resources from nonpoint source pollution and provide bank stabilization and aquatic and wildlife habitat. Every farm in Pennsylvania that applies manure to its land is required to have some type of a written plan that describes how the manure and other nutrients are managed (Snyder Country Conservation District, 2012). Here is an example of an environmentally friendly solution to decrease nutrient pollution due to agricultural activities.

By Rebecca Bub
Before: A stream bank damaged from livestock grazing

After: The same stream bank after BMP (Best Management Practice) implementation, including installed fencing, livestock crossing, and tree-planting.
Pennsylvania Curriculum Standards Meet

GRADES 3-8, 10, 12
Environment and Ecology

XL INTRODUCTION

This document includes Environment and Ecology standards that describe what students should know and be able to do in these areas:

- 4.1. Ecology
- 4.2. Watersheds and Wetlands
- 4.3. Natural Resources
- 4.4. Agriculture and Society
- 4.5. Humans and the Environment

The Declaration of Rights, Article 1 of the Pennsylvania Constitution states in Section 27: “The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and aesthetic values of the environment. Pennsylvania’s public natural resources are the common property of all people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people.” To this end it is our responsibility to develop a citizenry that is aware of and concerned about the total environment and has the knowledge and skills to work toward solutions to current problems and the prevention of new ones.

Environment and Ecology is grounded in the complexity of the world we live in and its sustainability. It examines the world's natural processes and systems. Environment and Ecology places its main emphasis in the real world. Allowing students to understand, through a sound academic content base, how their everyday lives evolve around their use of the natural world and the resources it provides.

These standards establish the essential elements of what students should know and be able to do at the end of grades four, seven, ten and twelve. The sequential nature of this document reflects the need for rigorous academic content that students will be expected to achieve. The document reinforces all areas across the grade levels with increasing degrees of difficulty as the students mature intellectually.

The study of Environment and Ecology will allow students to be active participants and problem solvers in real issues that affect them, their homes, schools and communities.

A glossary is included to assist the reader in understanding terminology contained in the standards.
### 4.1. Ecology

**Environment and Ecology**

<table>
<thead>
<tr>
<th>GRADES 3-8, 10, 12</th>
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</thead>
<tbody>
<tr>
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**The Environment**

- **4.1.3.A.** Differentiate between the living and non-living components in an environment.

**4.1.4.A.** Explain how living things are dependent upon other living and nonliving things for survival.
- Explain what happens to an organism when its food supply, access to water, shelter, or space (breeding habitat) is changed.
- Identify similarities and differences between living organisms, ranging from single-celled to multicellular organisms, through the use of microscopes, video, and other media.

**4.1.5.A.** Intentionally Blank

**4.1.6.A.** Describe the relationships between biotic and abiotic components of an ecosystem.
- Compare and contrast different biomes and their characteristics.
- Describe symbiotic and predator/prey relationships.

**4.1.7.A.** Describe the concept of carrying capacity as an ecosystem.
- Explain how organisms become classified as threatened or endangered.
- Describe how limiting factors cause organisms to become extinct.

- **4.1.8.A.** Analyze the significance of biological diversity in an ecosystem.
  - Explain how species adapt to limiting factors in an ecosystem.
  - Analyze the differences between natural causes and human causes of extinction.
  - Research wildlife management laws and their effects on biodiversity.

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**Materials Cycles**

<table>
<thead>
<tr>
<th>GRADES 3-8, 10, 12</th>
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<tbody>
<tr>
<td><strong>4.1.3.R.</strong></td>
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**4.1.3.E.** Identify sources of energy.

**4.1.4.E.** Explain how most life on earth gets energy from the sun.

**4.1.5.E.** Describe different food webs including a food web containing humans.

**4.1.6.E.** Intentionally Blank

**4.1.7.E.** Intentionally Blank

**4.1.8.E.** Intentionally Blank

**4.1.9.E.** Intentionally Blank

- **4.1.12.E.** Research how humans affect energy flow within an ecosystem.
  - Describe the impact of industrial, agricultural, and commercial development on an ecosystem.
## Community projects group - environmental education
### ENST 411 Bucknell University, Spring 2012

#### 4.1. Ecology

<table>
<thead>
<tr>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
<th>Grade 6</th>
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**Biography**

- Identify organisms that are dependent on one another in a given ecosystem. Define habitat and explain how a change in habitat affects an organism.

- Explain how specific adaptations can help organisms survive in their environment.

- Explain the differences between threatened, endangered, and extinct organisms.

- Identify reasons why organisms become threatened, endangered, and extinct.

- Explain how biogeological diversity relates to the viability of ecosystems. Compare and contrast monoculture with diverse ecosystems.

- Explain how biological diversity relates to the ability of an ecosystem to adapt to change. Explain how an adaptation is an inherited structural, functional, or behavioral characteristic that helps an organism survive and reproduce.

- Use the theory of natural selection to examine the causes and consequences of extinction.

- Research questions that impact biodiversity in specific ecosystems. Analyze the relationship between habitat changes in plant and animal population fluctuations.

- Analyze the effects of new and emerging technologies on biodiversity in specific ecosystems. Examine the impact of laws and regulations on reducing the number of threatened and endangered species.

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**Science as Inquiry**

- 4.1.3.E: Review the Introduction for grade level indicators (As indicated on page 4)

- 4.1.4.E: Review the Introduction for grade level indicators (As indicated on page 4)

- 4.1.5.E: Review the Introduction for grade level indicators (As indicated on page 4)

- 4.1.6.E: Review the Introduction for grade level indicators (As indicated on page 4)

- 4.1.7.E: Review the Introduction for grade level indicators (As indicated on page 4)

- 4.1.8.E: Review the Introduction for grade level indicators (As indicated on page 4)

- 4.1.9.E: Review the Introduction for grade level indicators (As indicated on page 4)

- 4.1.10.E: Review the Introduction for grade level indicators (As indicated on page 4)

- 4.1.11.E: Review the Introduction for grade level indicators (As indicated on page 4)
### 4.2. Watersheds and Wetlands

<table>
<thead>
<tr>
<th>GRADES 3-8, 10, 12</th>
<th>Environment and Ecology</th>
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<tbody>
<tr>
<td>4.2.3.</td>
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<td>GRADE 3</td>
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**Pennsylvania’s public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:**

#### Watersheds

- **4.2.3.A.** Define the term watershed.
  - Identify the watersheds in which you reside.
- **4.2.4.A.** Describe the physical characteristics of a watershed.
  - Identify and explain what determines the boundaries of a watershed.
  - Identify water systems and their components as either lotic or lentic.
- **4.2.5.A.** Explain the water cycle.
- **4.2.6.A.** Identify the five major watersheds of Pennsylvania.
- **4.2.7.A.** Explain how water enters, moves through, and leaves a watershed.
  - Explain the concept of stream order.
  - Describe factors that affect the flow and water quality within a watershed.
- **4.2.8.A.** Describe factors that affect the quality of ground and surface waters.
- **4.2.10.A.** Examine the interactions between abiotic and biotic factors within a watershed.
  - Describe how topography influences the flow of water in a watershed.
  - Describe how vegetation affects water quality.
  - Investigate and understand the effects of land use on the quality of water in a watershed.

**Draft June 1, 2009**

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<table>
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<th>Wetlands</th>
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<tr>
<td>4.2.3.B.</td>
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<tr>
<td>Identify plants and animals found in a wetland.</td>
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**Explain how wetland use decisions affect wetlands.**

**4.2.11.B.** Examine various wetland policies relating to wetlands.

**4.2.12.B.** Examine the intended and unintended effects of policies and regulations relating to wetlands.
### 4.2. Watersheds and Wetlands

**Environment and Ecology**

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**Aquatic Ecosystems**

- **4.2.3.C.** Identify plants and animals that live in lakes, ponds, streams, and wetlands.
- **4.2.4.C.** Explain how freshwater organisms are adapted to their environment.
  - Explain the life cycles of organisms in a freshwater environment.
- **4.2.5.C.** Identify physical, chemical, and biological factors that affect water quality.
- **4.2.6.C.** Identify natural and human-made factors that affect water quality.
- **4.2.7.C.** Use appropriate tools and techniques to analyze a freshwater environment.
  - Interpret physical, chemical, and biological data as a means of assessing the environmental quality of a freshwater environment.
- **4.2.8.C.** Describe how a diversity index is used to assess water quality.
- **4.2.10.C.** Analyze the effects of policies and regulations on various governmental levels on water quality.
  - Assess the interrelated and interdependent effects of public policies and regulations affecting water quality.

**Science as Inquiry**

- **4.2.10.D.** See Science as Inquiry in the Introduction for grade level indicators (as indicated on page 4).
### 4.5. Humans and the Environment

**Environment and Ecology**

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<td><strong>4.5.8.C</strong></td>
<td><strong>4.5.9.C</strong></td>
<td><strong>4.5.10.C</strong></td>
<td><strong>4.5.12.C</strong></td>
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<tr>
<td>Identify different types of pollution and their sources.</td>
<td>Describe how human activities affect the environment.</td>
<td>Explain the difference between point and non-point source pollution.</td>
<td>Identify key people and events that shaped the environmental history in the United States.</td>
<td>Explain how human actions affect the health of the environment.</td>
<td>Identify residential and industrial sources of pollution and their effects on environmental health.</td>
<td>Describe how humans can reduce pollution.</td>
<td>Analyze real-world data and explain how point and non-point source pollution can be detected and eliminated.</td>
<td>Research and analyze the local, state, and national laws that deal with point and non-point source pollution.</td>
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**PDF Version of State Requirements**

Lesson Plans/Additional Resources

- Earth.google.com
  - Use google earth to show the students the Chesapeake Bay, Susquehanna River, and Penns Creek.
  - Observe the locations and widths of riparian buffers lining Penns Creek, and relate it back to nutrient pollution.

- http://www.departments.bucknell.edu/environmental_center/susquehanna_river_monitoring/data_feed.html
  - Show the students up-to-date information regarding the water quality of the Susquehanna. This site provides a live data feed for sections of the Susquehanna in Milton, and Danville.

  - This lesson plan teaches students what algal blooms are, why they are harmful, and how to reduce their impact.
    - done in groups of 3-4 students
    - Requires one-two 45 minute class periods.
    - Includes links to research materials and important discussion points to be addressed.

  - This is a lab which teaches students about the importance of Riparian Buffers
  - Students form
    - hypotheses,
    - conduct an experiment
    - report findings
    - draw conclusions

- http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive0203.html
  - Examine land use in the Chesapeake Bay watershed and determine if these areas are protecting the water with vegetated buffers
    - Group activity in which students examine a different subwatersheds of the Chesapeake Bay
  - Includes discussion questions and worksheets

  - Lab activity in which Students conduct an experiment to demonstrate the impact of nutrients on algae growth.
  - Duration of activity is 2 – 45 minute classes (+2 weeks to grow algae)
Resources


