Teacher's Guide

How Do Geology and Physical Streambed Characteristics Affect Water Quality?

Lesson Description

In this lesson, the students research a dynamic, vertical dimension of a watershed - the geological bedrock. Landscape regions, such as the Erie-Ontario Plains and the Allegany Plateau of Central New York, result from the interaction of erosional action upon various types of underlying bedrock. These rocks differ in their resistance to erosional conditions. The great variety of landscape regions in New York State is due to the diversity in and the resistance of the bedrock found throughout the State.

The Devonian and Silurian geological bedrock of Central New York are important factors affecting the conditions and physical, chemical and biological processes occurring in a watershed's streams, and in regions where climate is similar, this bedrock may be the most significant factor determining a watershed's condition. Water in its natural state is never pure, absorbing minerals and salts from the land over which it passes. Since the physical, chemical and biological conditions in a watershed are often directly or indirectly related to bedrock and underlying geologic formations, the bedrock can often provide an explanation why a stream has certain characteristics, especially the composition of the streambed.

Geological bedrock also determines the slope of a basin and its drainage patterns. The difference between the highest elevation in a region and the lowest elevation in that region is defined as topographic relief. Topographic relief of a landscape region and gravity influence: stream velocity and discharge, stream flow direction, watershed drainage, and creation of watershed divides, streambed composition; and ultimately, the water quality parameters in a stream.

A major challenge for the students in the lesson is locating Project Watershed stream sites that have not been impacted by point and nonpoint source pollution and cultural eutrophication runoff.

Science Concepts Introduced

- Geological bedrock, landscape regions and topographic relief
- Data retrieval, interpretation and analysis

Process Skills Emphasized

- Retrieval of data on the Internet
- Collecting, graphing and interpreting data
- Interpreting geological, topographic and watershed maps

Technology Used

- Internet
- MS Excel

MST Standards

- Standard 1 Key Ideas 1, 2, 3 Scientific Inquiry Performance Indicators A, K
- Standard 2 Key Idea 1, 2
- Standard 3 Key Idea 3
- Standard 4 Key Idea 1, 2 Performance Indicator 2.1
- Standard 7 Key Idea 1, 2

Learning Outcomes

Students well be able to:

- Identify and describe the geological bedrock and landscape region(s) of Central New York.
- Locate and delineate the major watersheds in Central New York and correlate them with the underlying bedrock and landscape regions.
- Select stream sites that clearly exhibit bedrock and landscape characteristics and show a low probability of human activity; and then select stream sites that are obviously impacted by human activity.
- Illustrate how topographic relief influences each of these stream sites with regard to direction of flow, velocity and discharge.
- Develop a database profile of the physical, chemical and biological water quality parameters at each natural site.
- Develop a database profile of the physical, chemical and biological water quality parameters at each human impacted site
- Compare the database profiles of the natural and human impacted stream sites.
- Identify those water quality parameters most likely generated by the underlying geological bedrock, landscape region and topographic relief at the natural stream sites.

Time Requirement

Four class periods or two double (block) periods

Instructional Strategies

- Interacting and learning through group work
- Using scientific inquiry
- Applying basic mathematics skills
- Direct instruction

Background

This is a challenging lesson for the students because they are expected to be concerned with several earth science concepts - geological bedrock, landscape region, topographic relief and hydrologic elements - stream flow, stream velocity, discharge and watershed. The teacher should assess early on the students' knowledge of earth science; some instruction by the teacher prior to the lesson may be necessary. They may need help with bedrock and topographic maps and how these can be correlated with watershed maps.

The downloading, interpretation and analysis of stream water quality data from the Project Watershed database by the students and then applying this data to their selected stream sites may be a new dimension of learning, and inquiry, for them. There are a lot of data to deal with, but the sub-watershed approach should facilitate the students[1] work. The most difficult part of this lesson will be locating stream sites in their selected sub-watersheds that have been minimally impacted by human activity. Since chloride testing had not been established until 1999, students have been advised to download <www.projectwatershed.org> water quality data from 1999 through the present.

With the exception of the topographic and watershed maps, five handouts are available to facilitate the students' work. These maps can be obtained from your County Soil and Water Conservation District, New York State Department of Environmental Conservation or the United States Geological Service.

Assessment

1. Each of the four groups submits:
- a comprehensive poster depicting their research on the selected sub-watershed stream sites.
- a log of all collected data in Excel form
- a list of parameters resulting from geological bedrock and landscape region with supportive library research.
2. Teacher's appraisal of individual student participation in group work and interpretations and conclusions made by each group

Rubric

- Participates productively with members of his/her group (30%)
- Demonstrates facility for reading and interpreting maps (10%)
- Demonstrates ability to download, manipulate and graph data (20%)
- Writes and presents observations, interpretations and conclusions in a clear and concise manner (40%)

Extensions/Options

- If available, find a water quality database for a watershed in a different bedrock region than Central New York and compare that collected data to Project Watershed data.

- Describe the water quality parameter changes that might occur as a stream flows from one landscape region to another.

- Conduct a field trip to a stream site where bedrock is evident, perform water quality testing and estimate how the bedrock may have affected the test results.

- Identify sources other than bedrock for variations in water quality parameters in a stream or watershed.

Key Terms

watershed, basin, delineate, streambed, corridor, geology, geological bedrock, landscape region, cross section, relief, slope, parameter, discharge, water quality, nonpoint source, point source, cultural eutrophication

Prerequisite Knowledge

- Basic mathematics competency
- Use of topographic and geological maps
- Watershed concept
- Basic knowledge of earth science and geology

Materials

- Computer with Microsoft Excel

- Computer access to Internet

- Earth Science Reference Tables: Generalized Landscape Regions of NYS and Generalized Bedrock Geology of NYS

- Topographic maps of Central New York region

- Maps of Oneida - Seneca - Oswego and Tioughnioga River watersheds

References/Web Sites for Teachers/Students

Bedrock Studies

http://water.usgs.gov/pubs/fs/fs-003-02/

Earth Science Reference Tables

http://www.nysedregents.org/testing/reftable/ESRTpg1and2C2.pdf

Geography of NYS

http://www.netstate.comstates/geography/ny_geography.htm

Landforms Depicted on Topographic Maps

http://www.csus.edu/indiv/s/slaymaker/Archives/Geol10L/landforms.htm#Undergrou nd%20Water

NYS Geologic Map/Legend (cross section)

http://www.albany.net/~go/newyorker/

http://geology.about.com/library/bl/maps/newyorkmapmid.jpg

http://geology.about.com/library/bl/maps/nylegend.jpg

Topographic Maps

http://www.nh.nrcs.usda.gov/technical/Publications/Topowatershed.pdf

http://ngmdb.usgs.gov/Other_Resources/rdb_topo.html

Water Quality

http://www.pacd.org/resources/downstream/downstream_sinkholes.htm

http://www.leo.lehigh.edu/projects/hydroprobe/wqdef.html

http://www.pwea.org/Images/2004StudentReseachPapers/joseph_goodwill_research_ paper.pdf

Water Quality Database

http://projectwatershed.org

Watersheds

http://web.cnyrpdb.org/extranet/cnyrpdb/oneidalake/SOLWFinal/ch2-3.pdf

http://water.usgs.gov/

http://ga.water.usgs.gov/edu/dictionary.html

United States Geologic Service

http://www.usgs.gov/

Handouts

Topographic Map(s) of Oneida - Seneca - Oswego Rivers Basin

Topographic Map(s) of Onondaga - Otisco Lakes, Oneida Lake, Seneca River and Tioughnioga River sub-watersheds

Regents Earth Science Reference Tables

Generalized Landscape Regions of NYS
Generalized Bedrock Geology of NYS

How to Delineate a Watershed

How To Locate a Watershed in a Landscape Region

How To Locate a Watershed Over Geological Bedrock

How Does Topographic Relief Affect a Watershed?

Identifying Water Quality Parameters Generated By Geological Bedrock

How to Delineate a Watershed

The following procedure will help you locate and connect all of the high points around a watershed on a topographic map.

1. Draw a circle at the outlet or downstream point of the watershed in question.
2. Put small "X's" at the high points along both sides (contour lines) of the watershed, working your way upstream toward its headwaters.
3. Starting at the circle that was made in step one, draw a line connecting the "Xs" along one side of the watershed. This line should always cross the contours at right angles (i.e. it should be perpendicular to each contour line it crosses).
4. Continue the line until it passes around the head of the watershed and down the opposite side of the watercourse. Eventually it will connect with the circle from which you started. At this point you have delineated the watershed. The delineation appears as a solid line around the watershed.

Source: NRCS Method for the Comparative Evaluation of Nontidal Wetlands in New Hampshire, 1991. Alan Ammann, PhD and Amanda Lindley Stone.

How To Locate a Watershed in a Landscape Region

Name of Sub-watershed Group ________________________________

1. Define a watershed and a landscape region.

2. Prepare a transparency of the watershed delineated on a topographic map. After adjusting for scale, apply the transparency to the Generalized Landscape Regions of NYS and identify the landscape region in which the watershed is located. Is the watershed located in the Erie-Ontario Lowlands or the Allegany Plateau?

3. Refer to the Geography of NYS reference <http://www.netstate.com/states/geography/ny_geography.htm>. Describe the terrain in which the watershed is situated.

4. Compare the topographic relief in the two landscape regions. How does the relief affect the direction of flow, velocity and the discharge of streams in the watershed?

How To Locate a Watershed Over Geological Bedrock

Name of Sub-watershed Group ___________________________

1. Prepare a transparency of the watershed delineated on a topographic map.
2. After adjusting for scale, apply the transparency to the Generalized Bedrock Geology of NYS and identify the type of bedrock over which the watershed is located.
   - Is the watershed located over the Silurian or Devonian bedrock? Describe the composition of the Silurian or Devonian bedrock that underlies the watershed. Be specific (limestone, shale, etc).
   - If a stream is flowing close to the bedrock, what effect does the bedrock have on the streambed and on the quality of the water in the stream, the watershed?
   - What effect does the stream have on the bedrock?
3. For a more vivid, detailed view of Central New York bedrock, download the NYS Geological Bedrock Map reference <http://www.albany.net/~go/newyorker/>. Repeat Steps 1 and 2 using this geological map.

How Does Topographic Relief Affect a Watershed?

Name of Sub-watershed Group _____________________________________

1. If relief is the difference between the highest elevation in a region and the lowest region in a region, which Landscape Region in Central New York has the higher relief? Which has the lower relief?
2. After delineating the watershed on the topographic map, describe how relief (elevation and slope) in the watershed determines each stream¹s direction of flow, velocity and discharge.
3. If a stream is swiftly flowing over bedrock in steep terrain, describe the erosional effect of the water. How is the stream¹s water quality changed by erosion? If a stream is flowing slowly over the land, how is the stream¹s water quality changed by erosion? What happens over time to the particle size of rock material in a streambed as the stream¹s velocity increases?
4. In consideration of the Bedrock Region that underlies the watershed, propose some chemical parameters that can be found in the water.
5. . In a fast flowing stream, are the rocks more or less embedded in the silt, sand or mud than in a slow flowing stream?
6. How does relief affect aquatic organisms in a stream?

Identifying Water Quality Parameters Generated By Geological Bedrock

Name of Sub-watershed Group________________________________

1. View and compare the MS Excel Bar Graph Profiles of the averaged physical, chemical and biological parameters for the selected bedrock impacted stream sites and human impacted stream sites researched in the sub-watershed.
2. Use the following format to compare the bedrock impacted stream sites and human impacted stream sites.
3. Identify the water quality parameters that <u>most probably</u> were generated by the geological bedrock at the selected bedrock site (s), and <u>not</u> by human cultural activities.

Bedrock Impacted Stream Site(s)	**Human Impacted Stream Site(s)**
Stream Name	Stream Name
Site Location	Site Location

<u>Observable Data: Streambed Composition</u>

<u>Physical Data</u>

Stream velocity	Stream velocity
Discharge	Discharge

<u>Chemical Data</u>

Suggested parameters in Project Watershed Database: pH, water temperature, dissolved oxygen, biochemical oxygen demand, phosphate, nitrate, chloride, total dissolved solids and turbidity

<u>Biological Data</u>

Macroinvertebrate abundance	Macroinvertebrate abundance
Diversity index	Diversity index

Student¹s Guide

How Do Geology and Physical Streambed Characteristics Affect Water Quality?

Lesson Introduction

A watershed, also called a drainage basin, is the area in which all water, sediments, and dissolved materials drain from the land into a common body of water, such as a stream, river, lake or ocean. A watershed encompasses not only the water, but also the surrounding land from which the water drains. A watershed may be either a large or small area, and its physical characteristics can greatly affect how the water flows. These characteristics affect stream flow and can be a key to evaluating the quality of water in the watershed.

Geological bedrock is an important factor affecting the conditions and physical, chemical and biological processes occurring in a watershed, and in regions where climate is similar, this bedrock may be the most significant factor determining a watershed¹s condition. Water in its natural state is never pure, absorbing minerals and salts from the land over which it passes. Since the physical and ecological conditions of a watershed are often directly or indirectly related to bedrock and underlying geologic formations, the bedrock can often provide an explanation why a stream has certain characteristics, especially the composition of the streambed. The slope of a basin and its drainage patterns are also influenced or determined by geology.

Landscape regions result from the interaction of erosional action upon various types of underlying bedrock. These rocks differ in their resistance to erosional conditions. The great variety of landscape regions in New York State is due to the diversity in and the resistance of the bedrock found throughout the State.

Streams with beds above the water table are ephemeral streams; those with beds below the water table are permanent streams. Not only are streams affected by their geologic environment, streams in turn affect their geologic environment. The nature and magnitude of the effect are influenced by the amount of water (discharge) and character of flow (turbulence).

Geological bedrock also influences the topographic relief and landscape regions in Central New York. Relief is the difference between the highest elevation in a region and the lowest elevation in that region. A landscape region is a geographic description of the land: lowlands, plateau, mountains, etc. The topographic relief of a landscape region determines: stream velocity and discharge, stream flow direction, watershed drainage, creation of watershed divides, stream bed composition; and ultimately, water quality parameters in a stream.

The main purpose of this lesson is to assess the impact of geological bedrock, landscape regions and topographic relief on the water quality of selected Central New York watershed streams. Students face a challenge in this lesson: In addition to the impact of these aforementioned natural sources, human activities leading to point and nonpoint source pollution and runoff from cultural eutrophication may also substantially impact the water quality of these streams.

Learning Outcomes

Students well be able to:

- Identify and describe the geological bedrock and landscape region(s) of Central New York.
- Locate and delineate the major watersheds in Central New York and correlate them with the underlying bedrock and landscape regions.
- Select stream sites that clearly exhibit bedrock and landscape characteristics and show a low probability of human activity; and then select stream sites that are obviously impacted by human activity.
- Illustrate how topographic relief influences each of these stream sites with regard to direction of flow, velocity and discharge.
- Develop a database profile of the physical, chemical and biological water quality parameters at each natural site.
- Develop a database profile of the physical, chemical and biological water quality parameters at each human impacted site
- Compare the database profiles of the natural and human impacted stream sites.
- Identify those water quality parameters most likely generated by the underlying geological bedrock, landscape region and topographic relief at the natural stream sites.

Skills Required

- Accessing a database on the Internet
- Collecting, graphing and interpreting data
- Interpreting topographic maps
- Delineating a watershed
- Working cooperatively

New Terms

watershed, basin, delineate, streambed, corridor, geology, geological bedrock, landscape region, cross section, relief, slope, parameter, discharge, water quality, nonpoint source, point source, cultural eutrophication

Quest

A geological hydrologist, you are asked to search for and investigate stream sites in Central New York watersheds that have not been affected by point and nonpoint source pollution and cultural eutrophication. Since these streams are relatively rare, you must employ: top of the line mapping skills, competent water quality data, and most of all, qualified and responsible personnel to conduct the research.

Materials

- Computer with Microsoft Excel
- Computer access to Internet
- Earth Science Reference Tables: Generalized Landscape Regions of NYS and Generalized Bedrock Geology of NYS
- Topographic maps of Central New York region
- Maps of Oneida - Seneca - Oswego and Tioughnioga River watersheds

Procedure

1. Using watershed and topographic maps, students identify and delineate the Oneida - Seneca - Oswego Rivers basin. Next, students locate and delineate the Onondaga - Otisco Lakes, Oneida Lake and Seneca River sub-watersheds in the Oneida - Seneca - Oswego Rivers basin. Finally, students locate and delineate the Upper Tioughnioga River sub-watershed.

2. Working in groups of four, each group selects one of the sub-watersheds for study. What streams or rivers flow in the selected sub-watershed? (Since the Seneca and Upper Tioughnioga sub-watersheds are smaller in area, and the Project Watershed collected water quality data is considerably less, it is suggested that smaller student groups work on these selections and larger groups work on the Onondaga - Otisco and Oneida sub-watersheds.)

3. Referring to the Regents Earth Science Reference Tables, overlay (transparency) the Generalized Landscape Regions of NYS map on the selected sub-watershed and identify the region(s) in which it is located.

4. Referring to the Regents Earth Science Reference Tables, overlay (transparency) the Generalized Bedrock Geology of NYS on the selected sub-watershed and name and describe in detail the subsurface bedrock material (limestone, shale, sandstone, etc) under the sub-watershed.

5. Using a topographic map(s), observe the relief that determines the elevation and slope of the streams in the selected sub-watershed, indicated by contour lines. Describe how relief determines the streams direction of flow, stream velocity and the sub-watershed's drainage. Explain the possible effects of relief on the chemical and biological conditions and processes in the sub-watershed¹s streams.

6. Referring to a topographic map depicting the selected sub-watershed and after viewing the Project Watershed database at <www.projectwatershed.org>, identify Project Watershed stream sites that exhibit bedrock and landscape characteristics, and show a low probability of point source and nonpoint source pollution and cultural eutrophication resulting from runoff. These stream sites will most likely be flowing over steep terrain and a distance from housing and development. Streambed composition descriptions in the database may be helpful.

7. Repeating Step 6, identify Project Watershed stream sites that are clearly impacted by point source and nonpoint source pollution and cultural eutrophication resulting from runoff. These stream sites will most likely be found on low terrain and flowing near or through housing and development. The contrasting sites in Steps 7 and 8 may belong to the same identified stream(s).

8. Using the Browse Data by Stream option at <www.projectwatershed.org> and Microsoft Excel, develop a bar graph profile of the averaged physical, chemical and biological water quality parameters for each bedrock impacted site. Also, develop a Microsoft Excel bar graph profile of the averaged physical, chemical and biological water quality parameters for each human impacted site. (It is suggested that each profile be based on data from 1999 through the present.)

9. Organize the data into four categories: observable (streambed composition, etc), physical (stream velocity and discharge), chemical (pH, water temperature, dissolved oxygen, biochemical oxygen demand, phosphate, nitrate, chloride, total dissolved solids and turbidity) and biological (macroinvertebrate abundance and diversity index).

10. Compare the database profiles of the natural bedrock impacted and human impacted stream sites.

11. Identify those water quality parameters most likely generated by the underlying geological bedrock and landscape region in each sub-watershed. Students should support their identifications with library and Internet research.

12. Each student group presents their sub-watershed research to the class. The teacher and the class compare all the sub-watersheds with regard to geological bedrock and landscape region generated water quality parameters.

Extensions/Options

- If available, find a water quality database for a watershed in a different bedrock region than Central New York and compare that collected data to Project Watershed data.
- Describe the water quality parameter changes that might occur as a stream flows from one landscape region to another.
- Conduct a field trip to a stream site where bedrock is evident, perform water quality testing and estimate how the bedrock may have affected the test results.
- Identify sources other than bedrock for variations in water quality parameters in a stream or watershed.

Assessment

1. Each of the four groups submits:

- a comprehensive poster depicting their research on the selected sub-watershed stream sites.
- a log of all collected data in Excel form
- a list of parameters resulting from geological bedrock and landscape region with supportive library research.

2. Teacher¹s appraisal of individual student participation in group work and interpretations and conclusions made by each group

Rubric

- Participates productively with members of his/her group (30%)
- Demonstrates facility for reading and interpreting maps (10%)
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- Writes and presents observations, interpretations and conclusions in a clear and concise manner (40%)