HIGH SCHOOL "BIOGRAPHY OF A RIVER" TABLE OF CONTENTS

BIOGRAPHY OF A RIVER
EXPLANATION

OVERALL OBJECTIVE Students will investigate and collect information to create a comprehensive description of a particular river. Students will conduct research in the following subject areas: physical and human geography, history, science, literature and current issues.

1. PHYSICAL GEOGRAPHY & CLIMATE

   Students will research and explore the geography of the river and surrounding watershed area.

2. GEOGRAPHY & HYDROLOGY

   Students will explore how water moves through the ground and how the flow patterns of rivers are affected by natural and human activities.

3. HISTORY

   Students will research the human history of a river and the affects humans have had on our waterways.

4. SCIENCE: HEALTH OF A RIVER
   BIOLOGY & CHEMISTRY

   Students will collect field data and research the topics of water quality, aquatic organisms, riparian wildlife and vegetation of the river of interest.

5. LITERATURE

   After learning some historic and scientific background, students will focus on a human perspective of the river, through reading water-related literature.

6. CURRENT ISSUES

   Students will discover current topics of interest concerning water and debate these issues in class.

CREATING THE FINAL PRODUCT

The intended final product for this unit is the completed “biography” of a chosen river. It is most useful if the chosen waterway is a prominent local river, stream, or watershed area. The final parts of the biography, representing the subject areas listed above, will be presented and shared amongst classmates.

Each of the above topics has its own lesson plan and Biography Activities. Depending upon the time the instructor has available and the subject areas they want to teach, students may complete lesson plan activities as a class and Biography Activities in groups, or instructors may assign a particular segment for a student to contribute to the final product. For example, an entire class may conduct water quality testing as part of the science portion of the river biography, and then be assigned an individual topic (in a subject such as geography or literature) to contribute to the final product. The resulting “Biography of a River” will show students how various subjects, topics of interest and viewpoints interact to illustrate a more complete picture of the whole.

GEOGRAPHY AND CLIMATE OF A WATERSHED

OBJECTIVES: Students will research the geography and geology of a watershed area, understand how these aspects affect the flow of ground and surface water and present their findings to their peers.

BACKGROUND: We all live in a watershed. It's the area that drains to a common waterway, such as a stream, lake, estuary, wetland, or ultimately the ocean. A watershed includes the entire area (both visible and invisible) that is drained by a river or creek. The visible area includes the surrounding landscape that rain and snow falls on. This water runs across the surface and collects in ponds, lakes, streams, wetlands etc; The larger and unseen part of a watershed is found within the rocks and soils underground. Water permeates the surface and moves in the porous spaces and rock fractures, following the slope of underlying rock to a stream channel. The underground flow of water will be discussed further in the Hydrology section. Stream channels lie in an area of lowest topographic relief. Therefore watershed areas are usually a series of drainage valleys separated by ridges. These ridges range in size from a small rise to a high mountain pass. The range of a watershed area depends upon what aspects you are considering. If you are concerned with local affects of a drainage area, you might define your watershed boundary according to the smaller creeks that feed a local stream. If you are concerned with actions that might affect water downstream, you may want to consider the larger basin that your watershed is a part of. Another factor affecting the flow of water in your watershed is the local climate, including the amount and type of precipitation your region receives, seasonal temperatures and vegetation. This lesson explores how the geography of the land surface and the climate of your region affect the flow of water in your area.

RESOUCES: U.S. Geological Survey, Environmental Protection Agency

keywords: watershed, groundwater, groundwater atlas, surface water, geology

GEOGRAPHY:

1. Students should define their local watershed. Where are the "boundaries?" If there are various ways to define the watershed, have students discuss their ideas.

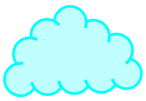
2. According to their definition of a watershed, students will draw the watershed area. See **Map of a Watershed worksheet.**

3. Students should write an explanation for why they defined the watershed area as they did.

4. Students will share and compare their maps of the watershed with the class.

CLIMATE

1. Students will answer questions about their local climate, completing the **Watershed Climate Worksheet.**
   This worksheet will introduce students to concepts in the next lesson: Geology and Hydrology.



BIOGRAPHY OF A RIVER ACTIVITIES:

GEOGRAPHY: Students will present the geography of the watershed area. Students may be assigned one or all options.

OPTION A: Students will draw a map of the local watershed, label all waterways and significant geographical points, including mountain ranges, cities, roadways etc; (This option may have already been completed in class). In addition, students should write a paragraph describing the landscape. What landforms create the watershed boundary? What kind of changing landscapes does the river flow through? Farms? Subdivisions? Mountains? Plains?

OPTION B: Students will model the local area to show three dimensional relief of the watershed landscape. Students should be creative in their 3-D mapping. They can use modeling clay, cardboard relief cutouts etc; Students should focus in on major topographic relief, using topographic maps for help. In their presentation to the class, they should explain how the water in their model will drain, where it goes and what influences this flow.

OPTION C: Students will research a watershed from another drainage area in the United States and compare and contrast the geography of that area to the local watershed.

Climate of the Watershed

Precipitation and **temperature** are the two major climatic factors that influence run-off and the flow of water in your watershed. The amount and type of precipitation represents the input of water into the watershed, while the temperature controls the type of precipitation that falls as rain or snow, and how this precipitation is stored during the seasons as snow, ice or in liquid form. Temperature also greatly affects the rate of evaporation and transpiration of water back into the atmosphere.

Annual precipitation is the major factor effecting run-off in an area. However, the amount of precipitation falling on an area versus the amount of run-off is related to the regional climate as well. Streamflow will increase quickly in arid (hot and dry) regions when rainfall is intense, while smaller storms will produce little run-off. Humid regions can increase and maintain streamflow rates with small amounts of precipitation, especially in those areas that don't lose much water to the atmosphere.

Temperature affects mainly the form of precipitation as rain or snow and how it is stored. Water stored as snow or ice diminishes streamflow in colder months, as this water is "locked up" in a frozen form. When temperatures increase, melting occurs and also increases the flow of water into local drainages. The melting of snow and ice can occur in a matter of days or months. The timing and amount of run-off from the snowpack in a basin depend upon the water content of the snow and the daily sequence of temperatures in spring and summer. The amount of run-off from a snowpack can even fluctuate with changes in temperature during a single day, from morning to afternoon and night.

Define "temperate zone"____

____

____

Locate which temperate zone your watershed is located in._____________________________

Describe each season in your region by describing the length of the season (number of weeks or months), and choosing descriptive words for temperature (cold, cool, mild, warm, hot) and amount of precipitation (arid, dry, moderately dry/wet, humid, wet)

	Length	Temperature	Precipitation
Summer			
Fall			
Winter			
Spring			

Find the average precipitation and temperature for your region:

	Average Temp	Average rainfall
Summer		
Fall		
Winter		
Spring		

Describe how your climate affects the amount of water flowing in your watershed. Consider periods of increased precipitation, temperatures and run-off events. When is the water in your local river or stream at its highest? When is it the lowest? Are these changes gradual or sudden?

MAP OF A WATERSHED

Decide where the boundary of the local watershed lies.
Label the following on your map: streams, creeks and rivers, major landforms, major highways, and cities

Please explain why you set the boundaries of the watershed as you did. (Compare this to the boundary set on USGS maps or your local watershed group).

GEOLOGY AND HYDROLOGY OF A WATERSHED

OBJECTIVES: Students will research the geology and hydrology of a watershed area, understand how these aspects affect the flow of ground and surface water, learn how to represent these flows on a hydrograph and present their findings to their peers.

BACKGROUND: As was already discussed in the last section, "Watershed Geography and Climate," precipitation and temperature, as well as topography effect the run-off patterns we see in our streams and rivers. The amount of precipitation that reaches stream channels also depends upon the geologic materials in the region. The larger and unseen part of a watershed is found within the rocks and soils underground. Water permeates the surface and moves in the porous spaces and rock fractures. Various kinds of soil and rock have varying abilities of holding and transporting water according to their porosity and permeability. Porosity is the amount of water a material can hold, while permeability is the material's ability to transmit fluid. The kind of materials found beneath the earth's surface (for example, sandstone, clay, gravels, or fractured rock) controls the amount and rate of water that can move underground. This is water that will eventually end up infiltrating into rivers and streams. We can chart the fluctuation of the amount of water flowing in our waterways using a hydrograph. Hydrographs are graphs that show the amount of water flowing through streams (runoff) for different months of the year. For example, what time of year do your local rivers and streams run the highest? The lowest? We can show this by graphing how much water there is in a stream channel for a given month. We have already discussed some reasons why surface water levels might rise and fall. This lesson will explore how surface and ground water are connected, and how geology, combined with climatic factors effect streamflow in a watershed. You will then learn how to represent and interpret this information in a hydrograph.

RESOUCES: U.S. Geological Survey, Environmental Protection Agency

keywords: watershed, groundwater, groundwater atlas, surface water, geology

GEOLOGY:

1. Students will review the **Groundwater Worksheet** as an introduction to groundwater.

2. Students will map the underground geology of the watershed area including the composition of rocks and soils and the direction of water flow underground.

3. The instructor may wish to assign the following maps:

   - underground water flow (label with arrows to show the direction of flow)
   - soil/rock composition

- cross section of soil/rock composition
- ground water table levels

RESOURCES: U.S. Geological Survey, Friends of the Teton River, Natural Resources Conservation Service

BIOGRAPHY OF A RIVER ACTIVITIES:

GEOLOGY: Students will present the geology of the watershed and basin area. Students may be assigned one or all options.

OPTION A: Students will map the underground geology of the watershed area including the composition of rocks and soils. (This option may have already been completed in class). In addition, students will write about the birth of this river. *What has happened geologically through time? For example, was this river carved by glaciers? Is it a relatively "young" river? Speculate about how it will continue to change.*

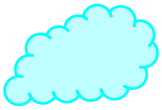
OPTION B: Students will create a three dimensional model of the watershed area's groundwater and aquifer. (Please refer to the **Build an Aquifer** activity).

OPTION C: Students will research the geology of another watershed in the United States and compare and contrast the geology to the local watershed. How are these rivers the same or different in relation to the geology of the area?

HYDROLOGY:

1. River formation—How does a river form? What is the difference between surface and stratigraphic geology? Students will complete the **River Formation Packet**.

2. Students will learn about interpreting and creating a hydrograph using the **Hydrographing Packet.**



BIOGRAPHY OF A RIVER ACTIVITIES:

HYDROLOGY: Students will present the hydrology of the watershed area. Students may be assigned one or all options.

OPTION A: Students will draw and explain hydrographs for the following scenarios.

- A spring-fed creek that includes a spring snowmelt event.
- A stream in a mountainous area that has hot summers and cold winters.
- Another
- Another

OPTION B: Students will research a watershed from another drainage area in the United States. Considering the elements of climate, precipitation, temperature, and geology, they will create a plausible hydrograph for a river in this region. Afterwards, they should compare it to an actual hydrograph for the river in a recent year. *Did they accurately predict what a typical hydrograph for this river looks like? Why or why not? Were there any unforeseen factors?*

GROUNDWATER BACKGROUND

BACKGROUND INFORMATION

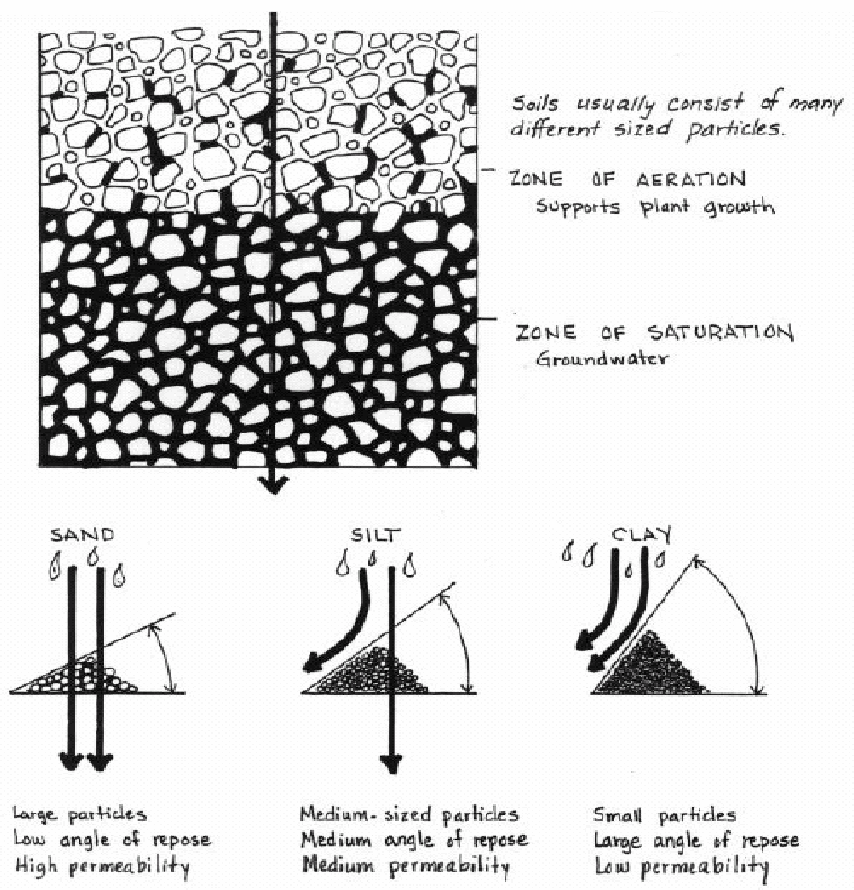
Groundwater accounts for a major portion of the world's freshwater resources. Estimates of the global water supply show groundwater as 0.6 percent of the world's total water and 60 percent of the available fresh water resources. The total volume of readily available global groundwater is about 4.2 x 10^6 km^3 as compared to 0.126 x 10^6 km^3 (kilometers cubed) stored in lakes and streams. Next to glaciers and icecaps, which do not have readily available water, groundwater reservoirs are the largest holding basins for fresh water in the world hydrologic cycle (Figure 1).

The age of groundwater may range from a few years or less to tens of thousands of years or more. For the United States, it is estimated that about 25 percent of precipitation becomes groundwater.

It is estimated that the total usable groundwater in storage is about equivalent to the total precipitation for ten years, or the total surface runoff to streams and lakes for 35 years, although all of this groundwater is not available for practical use. In the United States, groundwater storage exceeds by many times the capacity of all surface reservoirs and lakes, including the Great Lakes.

Recoverable groundwater is that water released from storage in the subsurface zone of saturation whose capacity is the total volume of the pores or openings in soil or rocks that are filled with water. The porosity values of specific materials are shown in Figure 2.

Groundwater movement is dependent on the degree of interconnection of the porous space (permeability)



Porosities

Porosities of specific materials. Approximate ranges are:

Materials	Porosity, percentage
Silts and clays (that have not been significantly compacted)	50 - 60
Fine sand	40 - 50
Medium sand	35 - 40
Coarse sand	25 - 35
Gravel	20 - 30
Sand and gravel mixes	10 - 30
Glacial till	25 - 45
Dense, solid rock	<1
Fractured and weathered igneous rock	2 - 10
Permeable, recent basalt	2 - 5
Vesicular lava	10 - 50
Tuff	30
Sandstone	5 - 30
Carbonate rock with original and secondary porosity	10 - 20

The Earth's Water Resources

SOURCE	SURFACE AREA (mi^2)	WATER VOLUME (mi^3)	% OF TOTAL WATER
Surface water freshwater lakes = ½ mi. deep	330,000	30,000	.009
Saline lakes	270,000	25,000	.008
Stream channels	---	500	.0001
Subsurface water <½ mi. deep	50,000,000	1,000,000	.31
Subsurface water >½ mi. deep	50,000,000	1,000,000	.31
Soil moisture + water in vadose zone	50,000,000	16,000	.005
Glaciers/ice caps	6,900,000	7,000,000	2.15
Atmosphere	197,000,000	3,100	.001
Oceans	139,500,000	317,000,000	97.2
TOTAL		326,000,000	

Figure 1

Terms:

carbonate aquifer: underground layer of limestone that is saturated with usable amounts of water

gradient: change of elevation, velocity, pressure, or other characteristics per unit length; slope

hydrologic cycle: the cyclical process of water's movement from the atmosphere, its inflow and temporary storage on and in land, and its outflow to the oceans; cycle of water from the atmosphere by condensation, and precipitation, then its return to the atmosphere by evaporation and transpiration.

permeability: the capacity of a porous material to transmit fluids. Permeability is a function of the sizes, shapes, and degree of connection among pore spaces, the viscosity of the fluid, and the pressure driving the fluid.

porosity: the spaces in rock or soil not occupied by solid matter.

water table: upper surface of the zone of saturation of groundwater

GROUNDWATER

About half the people in the U.S. and almost the entire rural population of this country depend upon groundwater for their drinking water. In the state of Idaho, 96% of the population depends upon it. Groundwater makes up an estimated 60 percent of the world's freshwater resources. (Useable freshwater makes up less than 1% of all water resources including salt water found in the oceans and water found in the atmosphere).Groundwater reservoirs represent the largest holdings for fresh water next to glaciers and icecaps, which are not easily accessible. Water can stay in the ground from a couple years to thousands of years, depending upon the location and movement of water underground. Groundwater is found in permeable underground layers of gravel, sand, sandstone and fractured rock known as aquifers. Many people picture groundwater as underground lakes and rivers, but it is actually water that fills up the spaces between rocks and soil particles underground—kind of like how water fills up a sponge. About one quarter of precipitation that falls to earth ends up as groundwater. It percolates from the ground surface into porous spaces in the earth. Usable and accessible amounts of groundwater are found in the zone of saturation, where all the pore spaces between particles are filled with water. The movement of water underground is directly related to the amount of porous space (permeability) and the slope of the water table.

POROSITY: the spaces in rock or soil not occupied by solid matter
PERMEABILITY: the capacity of a porous material to transmit fluids. Sometimes a very porous material is not necessarily able to *transmit* fluids very easily. Permeability depends upon the connection of pore spaces, the viscosity of fluid and fluid pressure.

USE the POROSITY TABLE to answer the following questions.

MATERIAL:	POROSITY PERCENTAGE:
Clay (not compacted)	50-60
Fine sand/silt (not compacted)	40-50
Sand	30-40
Sand and gravel mix	10-25
Fractured rock	2-10
Dense rock	<1

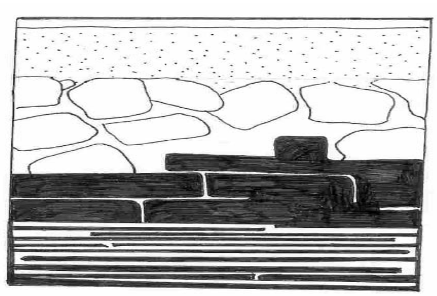
1. According to the table, which material is most porous?____

2. Which material is least porous? ____

3. Why are sand and gravel mixes less porous than sand by itself? (hint: Look at the diagram below. What would happen to the pore spaces in the gravel layer if sand is mixed in?) ____
____

4. Why does clay have a high porosity even when it often forms a "confining layer" for an aquifer? (hint: Notice the appearance of the clay layer in the diagram below).
____
____

USE THIS DIAGRAM TO VISUALIZE MATERIAL LAYERS UNDERGROUND.



Sand

Gravel

Fractured rock

Clay

FORMATION OF A RIVER

Hydrology deals with the amount and timing of water flow in your watershed. The hydrology of a river system affects the way a river looks.

The formation of a river channel depends on 3 basic elements:

1. The amount and speed (velocity) of the water flowing through the system
2. The gradient (slope) of the streambed
3. The amount and size of sediment carried by the stream

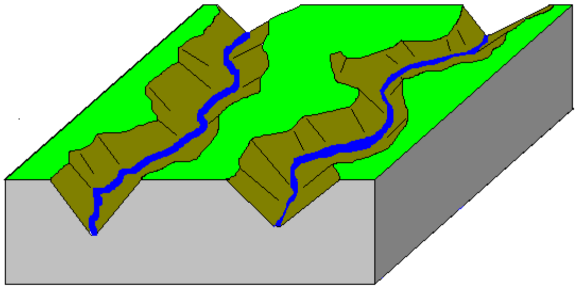
Stream velocity is a measure of the water's speed. A fast-moving stream is usually more turbulent than a slow-moving stream. The speed and extra turbulence give the water the force to scour the stream bottom and banks and pick up sediment and other material. The faster the stream is moving, the larger the materials it can pick up and carry with the current. Stream velocity changes within stream segments: in wide or deep channels velocity decreases. The outside curve of a channel is also much greater on the outside curve of a channel than the inside curve. While the force on the outside of the bank is strong enough to eroding the bank, the force on the inside is so small that material is deposited along the bank.

Streambed **gradient** measures the vertical slope of the stream over a distance. The slope of a river will determine the water speed. The best way to think of gradient is how steep the water is flowing downhill. A high mountain stream in a steep valley might have fast moving waterfalls and rapids, while a stream in a flat area may flow slowly and meander all over a valley.

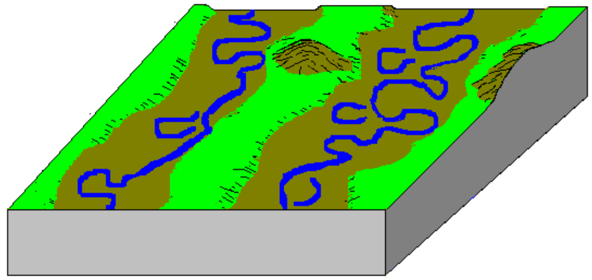
The sand, gravel and stones on the stream bottom is called **substrate** and can be filled with many different kinds and sizes of material. The substrate of slower moving streams will contain more silt, clay and mud while larger stones are found on the bottom of fast-moving streams. This is because fast-moving water picks up small particles of sand and mud and carries them downstream to settle in the slower water.

CHANNEL TYPES:

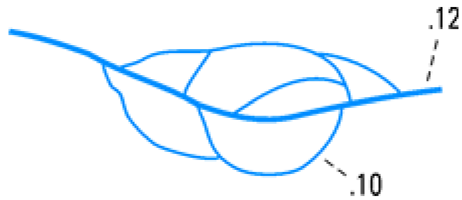
Erosional Channels—High in the mountains, headwater streams crash and tumble does steep V-shaped valleys and canyons, flowing swiftly over bedrock. A steep gradient and gravity give these streams the ability to carry large rocks and sediment farther downstream, slowly downcutting the streambed deeper into the valley. With fast moving water, these streams erode vertically, with little horizontal erosion.



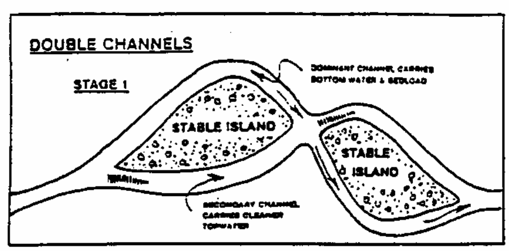
Stable—Stable, or Meadering channels are only stable vertically; they are not cutting their valleys deeper or depositing sediment on their streambeds. They move great distances horizontally across floodplains, leaving signs of their passing in oxbows and meander scars. They have broad, flat bottomed valleys, with wide, fertile floodplains.



Depositional Channels are called “braided streams” because the channel is wide with many gravel and sand bars. The channel carries so much bed load that it is constantly “plugging” itself up and changing course. Streams fed by meltwater from glaciers are often braided because they carry the course sediment turned out from the grinding of glacial ice.



Transitional Streams are streams that carry a lot of sediment, but not enough to become braided. The channels often switch back and forth like a meandering stream, as certain channels become choked with sediment. A transitional stream may have many islands and multiple channels around areas clogged with sediment.

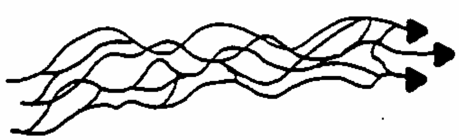


FROM REICHMUTH

Most streams vary from erosional to depositional, along their entire length, depending on what type of material they are flowing over. A stream may meander through a broad basin area and then become depositional where the gradient is steeper. It may form large islands and become braided where it spills into a gravel-filled valley.

RIVER FORMATION WORKSHEET

USING WHAT YOU KNOW ABOUT STREAM CHANNELS AND FORMATION, FILL OUT THE FOLLOWING TABLE.

STREAM PATTERN	CHANNEL TYPE	DESCRIPTION	SYSTEM CONTROLLING FACTORS
		STRUCTURALLY CONTROLLED "V" SHAPED VALLEY MEANDER SHIFTING	INCREASE WATER INCREASE ENERGY DECREASE SEDIMENT
			
			
			

from Reichmuth

REVIEW QUESTIONS:

1. List the four types of stream channels.

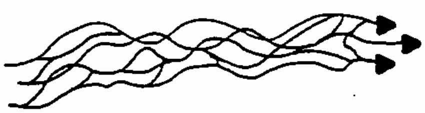
2. How would a stream channel be affected if a large amount of gravel were added to the bedload?

3. If a stream meander is cut-off (making the river channel "straighter") what happens to the velocity of the stream at this point?

4. List four different rivers that you know that are good examples of each type of stream channel.

ANSWER KEY:
RIVER FORMATION WORKSHEET

USING WHAT YOU KNOW ABOUT STREAM CHANNELS AND FORMATION, FILL OUT THE FOLLOWING TABLE.

STREAM PATTERN	VERTICAL BEHAVIOR	HORIZONTAL BEHAVIOR	SYSTEM CONTROLLING FACTORS
	EROSIONAL	STRUCTURALLY CONTROLLED "V" SHAPED VALLEY MEANDER SHIFTING	
	STABLE	MEANDERING FLAT BOTTOM VALLEY SLOWLY SHIFTING	INCREASE WATER
	TRANSITIONAL	DOUBLE CHANNEL SHORT REACH STABLE ISLANDS	INCREASE ENERGY DECREASE SEDIMENT
	DEPOSITIONAL	BRAIDED FLAT BOTTOMED VALLEY SHALLOW UNSTABLE CHANNELS	

from Reichmuth

REVIEW QUESTIONS:

1. List the four types of stream channels.
Erosional, Stable (meandering), Transitional, Depositional (braided)

2. How would a stream channel be affected if a large amount of gravel were added to the bedload? **Channels would get clogged with substrate, creating new channels and braiding the stream.**

3. If a stream meander is cut-off (making the river channel "straighter") what happens to the velocity of the stream at this point? **The velocity of this new cut-off would be greater than the old meander. The velocity of water in a meander is slowed down by the curving banks, while the straighter cut-off will run faster.**

4. List four different rivers that you know that are good examples of each type of stream channel. **Discuss the student's examples.**

HYDROGRAPHING PACKET

Hydrographs are graphs that show the amount of water flowing through streams (runoff) across time. (Hydro = water Graph = a picture that represents data) In Teton Valley, for example, what time of year do the river and streams run the highest? The lowest? We can show this by graphing how much water there is in a stream channel for a given month. We have already discussed some reasons why surface water levels might rise and fall. Remember that climatic factors including precipitation and temperature as well as the geography and geology of an area affect the amount and timing of run-off.

DIRECTIONS: READ THE GRAPH DESCRIPTIONS AND ANSWER THE QUESTIONS ABOUT EACH ONE.

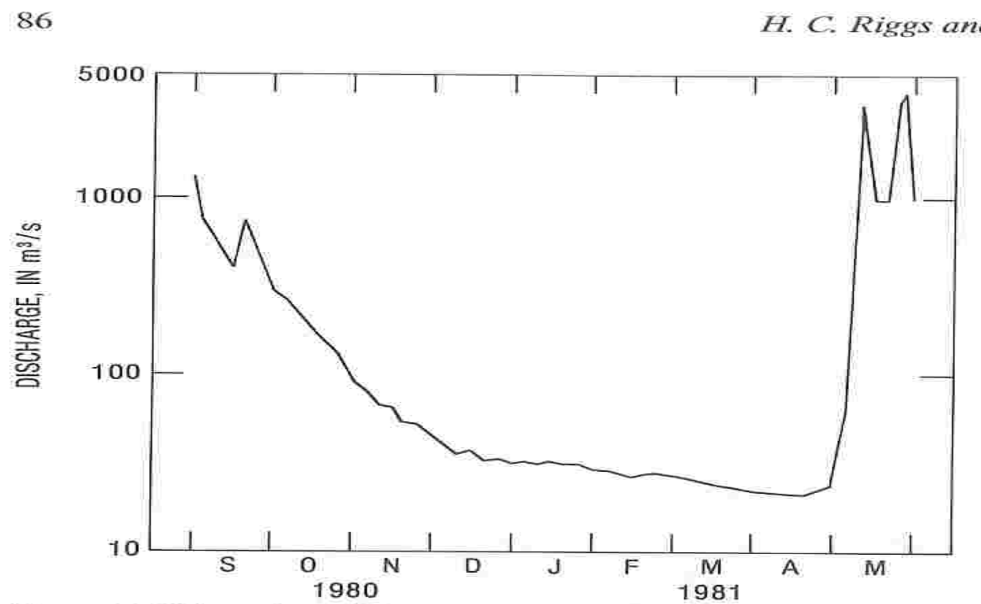


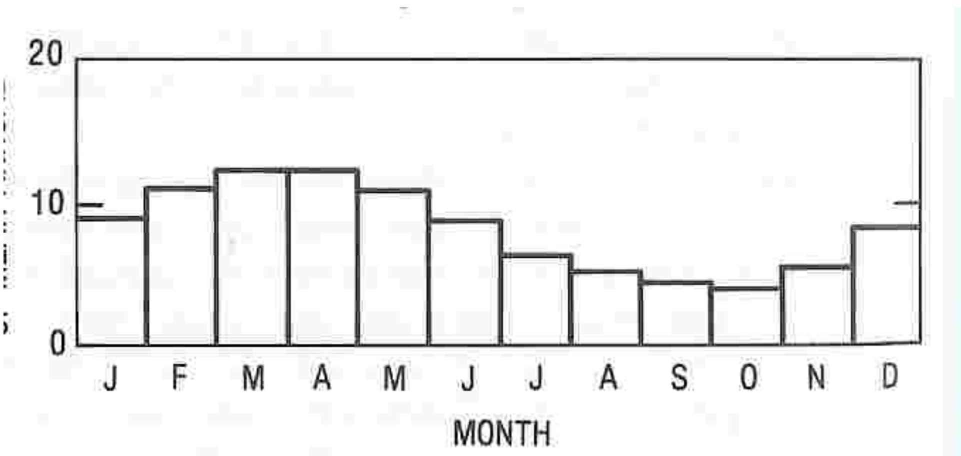
Figure 10. Winter flow of Porcupine River, Yukon Territory, showing recession during period of ice cover.

DESCRIPTION: This hydrograph represents a river in Alaska.

QUESTIONS: 1. Which months have the lowest amount of water in the stream?

2. Why? Where did this water go?

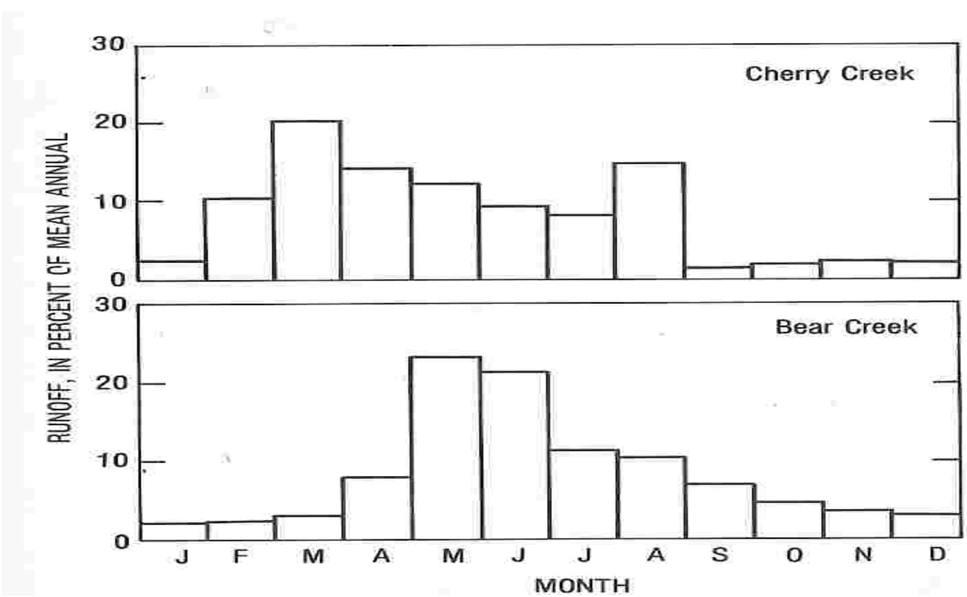
3. In which month does the water level suddenly rise? Why?



DESCRIPTION: This hydrograph represents a stream in southern Ohio, which is moderately warm all year.

QUESTIONS: 1. If melting snow and ice is not a factor, what causes this stream have more water in March and April than any other months?

2. Why does streamflow increase in December?



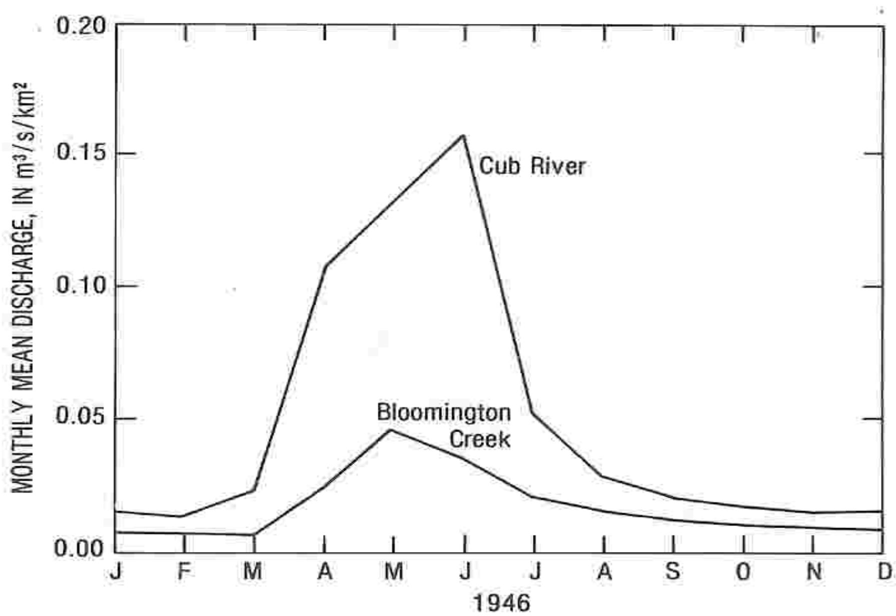
DESCRIPTION: Cherry Creek lies at the base of the Rocky Mountains where temperatures and precipitation are farily moderate year round and Bear Creek is a headwaters stream in the mountains.

QUESTIONS: 1. In what month does Cherry Creek reach peak flow? Why? Where is this water coming from?

2. Why does the Cherry Creek flow rise suddenly in August? (Hint: what kind of summer precipitation event can occur in late summer?)

3. Why does the Bear Creek flow rise sharply 2 months after the Cherry Creek flow?

4. Why do both creeks run at their lowest flows during October through January?



DESCRIPTION: Bloomington Creek has a large year-round spring in its headwaters; Cub River does not.

QUESTIONS: 1. What effects does a spring have on the flow of water into a stream?

2. Both hydrographs look similar, although the Cub River hydrograph is more pronounced, with a sharp rise in streamflow in the spring and summer months. What characteristic causes Bloomington Creek to show only a subtle rise in streamflow?

ANSWER KEY
HYDROGRAPHING PACKET

Hydrographs are graphs that show the amount of water flowing through streams (runoff) across time. (Hydro = water Graph = a picture that represents data) In Teton Valley, for example, what time of year do the river and streams run the highest? The lowest? We can show this by graphing how much water there is in a stream channel for a given month. We have already discussed some reasons why surface water levels might rise and fall. Remember that climatic factors including precipitation and temperature as well as the geography and geology of an area affect the amount and timing of run-off.

DIRECTIONS: READ THE GRAPH DESCRIPTIONS AND ANSWER THE QUESTIONS ABOUT EACH ONE.

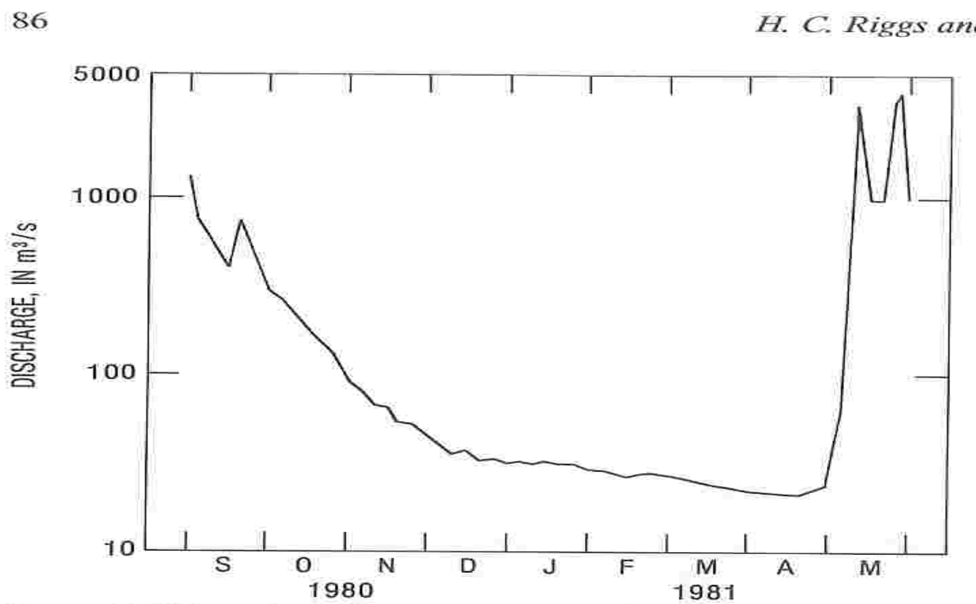


Figure 10. Winter flow of Porcupine River, Yukon Territory, showing recession during period of ice cover.

DESCRIPTION: This hydrograph represents a river in Alaska.

QUESTIONS: 1. Which months have the lowest amount of water in the stream?

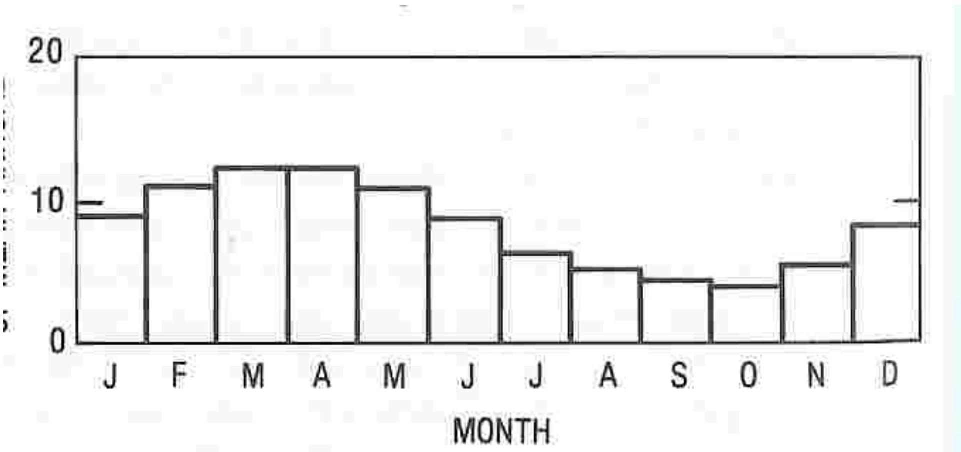
March and April

2. Why? Where did this water go?

This water has mostly been stored in a frozen form as ice and snow.

3. In which month does the water level suddenly rise? Why?

The end of April into May. Temperatures warm up and the water stored as ice and snow quickly becomes a liquid form which inundates the system as spring "run-off."



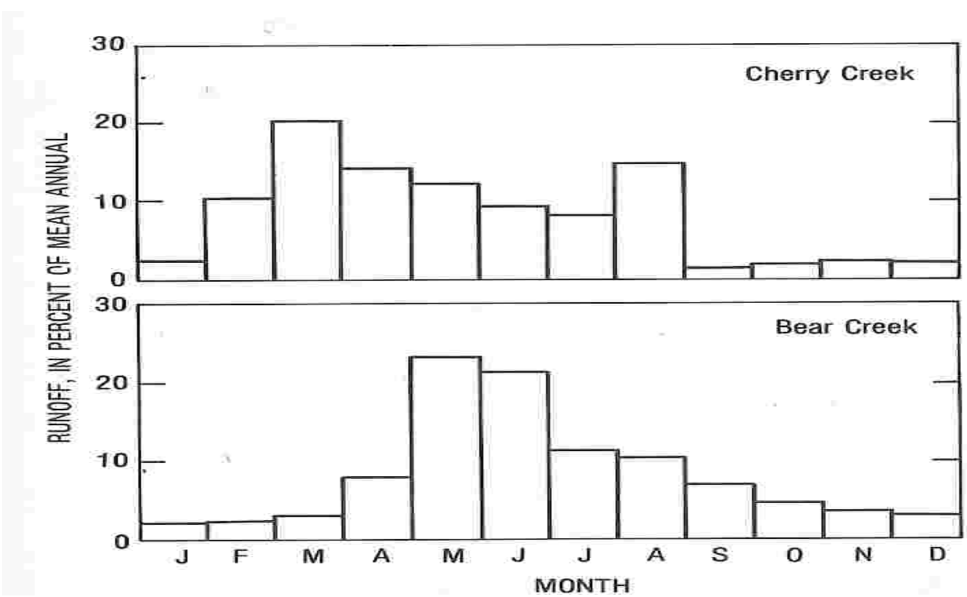
DESCRIPTION: This hydrograph represents a stream in southern Ohio, which is moderately warm all year.

QUESTIONS: 1. If melting snow and ice is not a factor, what causes this stream have more water in March and April than any other months?

These are the rainiest months of the year in this climate.

2. Why does streamflow increase in December?

This is a very snowy month. Unlike the constant frozen state in Alaska, the snow fall adds water to the stream flow in Ohio.



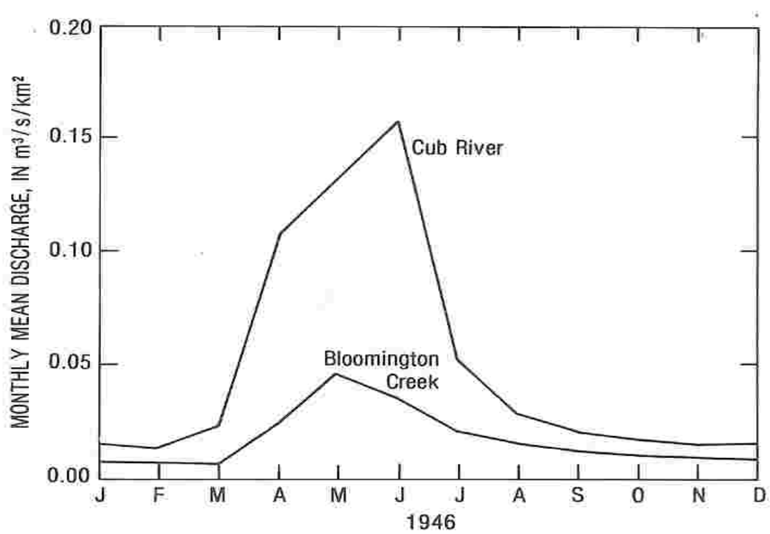
DESCRIPTION: Cherry Creek lies at the base of the Rocky Mountains where many creeks converge and temperatures and precipitation are farily moderate year round and Bear Creek is a headwaters stream in the mountains.

QUESTIONS: 1. In what month does Cherry Creek reach peak flow? Why? Where is this water coming from? May, because spring run-off from the mountain tributaries are contributing to Cherry Creek's flow at this time. Also, temperatures at this elevation are warming up rapidly in the spring.

2. Why does the Cherry Creek flow rise suddenly in August? (Hint: what kind of summer precipitation event can occur in late summer?) Because of late-summer thunderstorms.

3. Why does the Bear Creek flow rise sharply 2 months after the Cherry Creek flow? The temperatures in the mountains at high elevations don't warm up until later in the Spring (May/June).

4. Why do both creeks run at their lowest flows during October through January? Temperatures drop enough at the high elevations to store water as ice and snow for the winter months. Cherry Creek's water source in the mountain tributaries is also being stored at this time of year.



DESCRIPTION: Bloomington Creek has a large year-round spring in its headwaters; Cub River does not.

QUESTIONS: 1. What effects does a spring have on the flow of water into a stream? Peak flows are more "muted" and year-round flows are more constant. Since there is no big run-off event, the peak flow in a spring creek does not spike like a stream influenced by spring run-off or snow melt.

2. Both hydrographs look similar, although the Cub River hydrograph is more pronounced, with a sharp rise in streamflow in the spring and summer months. What characteristic causes Bloomington Creek to show only a subtle rise in streamflow? This is an example of a spring-fed creek. During the spring and summer, additional rainfall adds to the constant flow of spring water to the creek.

Build-an-Aquifer Background:

When it rains or when snow melts, water reaching the ground will infiltrate into the soil. All this water underground can move laterally (side to side) or vertically (downward movement of water through the soil). Water moving down through the soil eventually reaches the zone of saturation. This zone is where all the spaces between the rocks and soil particles are filled with water. Aquifers are storage places for usable amounts of water in the ground. They are a porous, water-bearing layer of sand, rock or gravel that is found in the zone of saturation. If about 96% of usable water in Idaho, including our drinking water, is found in aquifers, then how do we get at it? Groundwater in aquifers (or the zone of saturation) is reached by digging or drilling wells. A well is usually a pipe in the ground that fills with water and then is brought to the surface with a pump. Unfortunately, groundwater and our aquifers can become polluted through improper disposal of chemicals, pesticides and other contaminants. These wastes can percolate down through the soil and eventually end up in an aquifer—and eventually in our wells and lakes and streams. Aquifers can also be depleted by human activity if the water is not replaced.

Task:

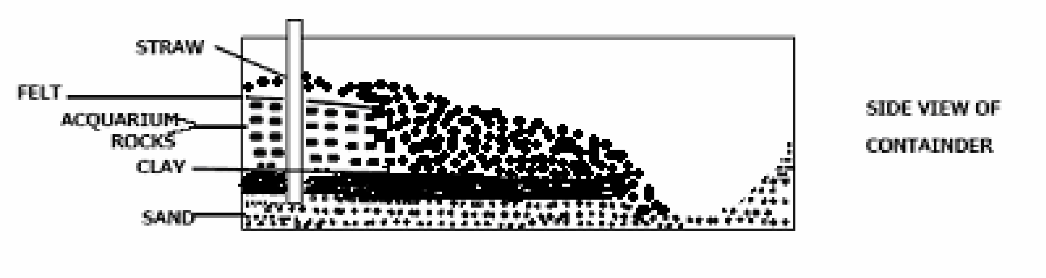
Explore how the aquifer in your area might work by building our own. Research your local aquifer and replicate a portion of it in a three dimensional model. Use the following example as a guide. You can be as creative as you want.

Materials:

A small aquarium or large clear plastic container (at least 8" deep)
modeling clay (for confining layers)
white sand (aquifer layer)
gravel or small pebbles (underground layers)
drinking water straws (wells)
plastic spray bottle (rain)
watering can or water bottle (rain)
green cloth or felt (grass or vegetation)
red and blue food coloring (pollution)
tap water
dry erase marker
tape
labels

PREPARATION:

NOTE: It is helpful to have all the supplies ready and to have experimented a little beforehand with the aquifer assembly process before creating your final aquifer. Be creative!



PROCEDURE:

1. Tape a drinking straws (representing wells) on the side of the container, allowing about 1/8” clearance with the bottom. If you wish, place another drinking straw on the other side of the container. It is essential to place the straw(s) first so they don’t get clogged with sand.

2. Pour a layers of white sand or gravel to cover the bottom of the container, about 1 ½” to 2” deep, so they can be differentiated.

3. Flatten the clay layers (to represent confining layers) over certain sections. It is best to flatten the clay “like a pancake” first and then press it tightly to three inside edges of the container.

4. Alternate gravel, rock or sand layers according to the aquifer you are modeling.. Slope aquarium rocks to one side of the container to form a high hill on that side, and subsequently, a valley on the other. This can represent where a bank meets a river channel.

5. Label features on your model including the water table, the unsaturated zone, zone of saturation, confining layers, ponds, rivers, wells, mountains, etc;

6. Fabric placed on top of the rocky layers represents a “topsoil” layer. Blue food coloring can represent improper use of chemicals like fertilizers. Fill the spray bottle with water. Make it “rain” on top of the hill and have students observe how the pollution infiltrates the ground.

7. The red food coloring can pollute the aquifer through the wells. A few drops of food coloring will represent chemicals, trash, and motor oils. To make it “rain” on the system, pour enough water to watch the pollution spread. If you need to, add more red food coloring to observe the plume spread throughout the aquifer.

8. Demonstrate your aquifer to the class. Explain why you built it as you did and it’s parts.

HISTORY OF A RIVER

OBJECTIVE: Students will learn about the cultural and historical importance of a river, and how humans have historically used and affected the waterway for use in the present day.

BACKGROUND: Just as our past life experiences shape who we are, so does the human history of a place shape what it is today. Historical accounts give us the background and a frame of reference for what happened in a particular place and time and how this background has had bearing on the location's present day condition. Water, especially in the drier Western United States, has been a cornerstone in the settlement, industry and recreation of humans. Even though many changes naturally occur within an ecosystem or river system, humans have a substantial impact in accelerating changes to their environment. The role of human history and it's effects on our waterways should not be understated. From the first settlers and users to the present day communities that line a river's banks, humans have impacted all of our waterways in some way. Without a historical frame of reference, we cannot hope to understand issues presently facing our precious water resources.

1. Students will research the cultural history of a river. (1700-present)

   Students should think about:

   - Who lived here first?
   - Who are the significant people connected to the river?
   - What was the river used for?
   - How have these uses affected the river?
   - How has use changed over time?
   - How would the history of the community be different if the river had never been used in this way?
   - What cities and towns are/were nearby and when were they settled?
   - What significant events are connected to the river?
   - What significant structures have been built in or near it?

   In a collaborative effort, the class will create a timeline of significant people, places, uses and events. Discuss how these historical uses, events, settlements, etc; have affected the current social, political and environmental situation of the river.

   RESOURCES:

   OPTION A: The instructor can assign different time periods to each student or group of students. For example, one group could focus on 1700-1800, or 1990-present.

   OPTION B: Students can create their own timeline of significant events and then collaborate with the class to produce a final timeline together.

BIOGRAPHY OF A RIVER ACTIVITY:

Option A: Recreate a larger version of the river timeline on butcher paper. Where possible, students should write an explanation of the significance of certain people, places, uses, and events. Students should explain the contributions of historical figures or why certain events have affected the river. For example, “So and so” first settled here …. Or if a farming industry began, describe the type of farming practiced and its affects on the watershed. The more historical detail that is explained, the better.

Option B: Compare and contrast the cultural history of a rural river or waterway (this can be your local river) to that of one in a highly urbanized area. Create a timeline for both. Write a paragraph making comparisons between the two. Why are they the same or different? What implications has cultural history had on the present day social, political and environmental state of the river?

HEALTH OF A RIVER

OBJECTIVE: Students will learn about the biology and chemistry of a river and how these factors interrelate and correspond to the overall health of the waterway.

BACKGROUND: The health of a river or stream may not be obvious at first glance. The physical properties of water go undetected by the human eye, fish stay hidden under snags, vegetation and cutbanks, aquatic insects cling to the bottom of rocks, and birds and mammals take cover in the surrounding streambank foliage. Upon closer investigation, we can monitor the many factors that can tell us the overall health of our rivers and streams. The biological factors that are monitored include the presence of certain fish, aquatic insects and other riparian wildlife. This lesson will focus on benthic macroinvertebrates as an indicator of stream health. These aquatic insects vary in their sensitivity to polluted water and provide information about the water quality of a stream over long periods of time. Investigating the physical properties of water, including testing water quality by chemical means, gives us a way to measure those aspects of stream health which we can't see. Water quality include tests for levels of pH, nitrates, phosphates, bacteria, clarity (turbidity), dissolved oxygen, and chemical pollutants. While testing for water for these physical properties is important, it is also useful to look at the changes that take place over time and how they affect other parts of the river ecosystem. For example, increasing levels in nitrogen can point to stream eutrophication, (the overproduction of plant life) that diminishes the oxygen available for insects and fish. Just as we are connected to our water resources in many ways, the chemistry and biology of a river are interconnected and reflective of what is happening in our rivers beyond a quick glance.

BIOLOGY:

OPTION A: Students will survey the flora and fauna of a local riparian area and collect and identify macroinvertebrates in their local river or stream to determine stream health.

- See **Macroinvertebrate Field Session**
- Students will complete the **Biosurvey: Macroinvertebrate Asessment**
- Students will complete a **Riparian Survey** of the area.

OPTION B: Students will research the aquatic life of a river using books and the internet.

- Students will complete a **Riparian Survey** of the area.

CHEMISTRY:

OPTION A: Students will test water samples from their local river or stream using a water quality testing kit.

- See **Water Quality Field Session**
- Students will complete the **Water Quality Assessment** to describe the water quality of their waterway.

OPTION B: If a water quality testing kit is unavailable, students should research aspects of water quality testing and their implications.

- pH
- nitrogen
- phosphorus
- oxygen
- suspended sediment
- choliform bacteria

Investigate any specific water quality information you can find pertaining to the river of interest. *Are there any water quality concerns (ie; high levels of bacteria)? What is the water quality "health" of this river?*

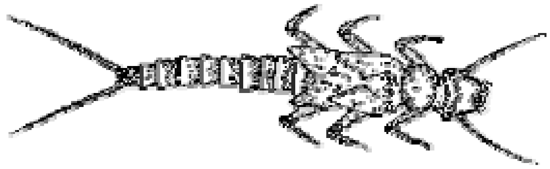
BIOGRAPHY OF A RIVER ACTIVITIES:

OPTION A: Choose to research a fish, macroinvertebrate and plant species found in your local watershed.

- Draw a detailed picture of each one and provide a short description of its characterizations. Answer questions like: *Where do you typically find this species? Why is it adapted to this area? What habitat does this species favor? What makes it unique? Where does it fit in the food chain? Is this species native or non-native to the area? Etc;*

OPTION B:

- Write a paragraph discussing the relationship between increased levels of pH, nitrogen, phosphorus, oxygen, suspended sediment, and choliform bacteria and aquatic organisms in a stream. *How are water chemistry and biology interconnected?*
- Give a real life example of a polluted waterway that is a "biological disaster." Hint: think about instances of oil spills, chemical and sewage leaks, salinization, strip mining etc; that have happened in the recent past and how they have affected a watershed. Find news reports or descriptions of the event. *Describe what happened. What were the chemical affects on the biology of the area? How could this situation have been prevented? What are the long-term affects? What has been done about it?*



What are Benthic Macroinvertebrates?

Benthic macroinvertebrates are common inhabitants of lakes and streams. The term **`benthic'** means **`bottom-living'** and indicates organisms that usually inhabit bottom substrates for at least part of their life cycle; the prefix **`macro'** indicates that these organisms are retained by mesh sizes of approx. 200-500 µm (micro-meters) and **can be seen without the aid of a microscope**; **"invertebrate"** indicates that **these creatures do not have a backbone.** The most diverse group of freshwater benthic macroinvertebrates are the aquatic insects which account for approx. 70% of known species of aquatic macroinvertebrates in North America. More than 4,000 species of aquatic insects have been reported. Thus, benthic macroinvertebrates are a highly diverse group which makes them excellent candidates for studies of changes in biodiversity.

Why Study the Stream-Bottom Macroinvertebrates?

- **Stream-bottom macroinvertebrates are an important part of the community of life found in and around a stream.**

  Stream-bottom macroinvertebrates are a link in the aquatic food chain. In most streams, the energy stored by plants is available to animal life either in the form of leaves that fall in the water or in the form of algae that grows on the stream bottom. Algae and leaves are eaten by macroinvertebrates, which in turn are a source of energy for larger animals such as fish, birds, bears, etc.

- **Different groups of macroinvertebrates have different tolerances to pollution, which means they can serve as useful indicators of water quality.**

  Some stream-bottom macroinvertebrates cannot survive in polluted water. Others can survive or even thrive in polluted water. In a healthy stream, the stream-bottom community will include a variety of pollution-sensitive macroinvertebrates. In an unhealthy stream, there may be only a few types of nonsensitve macroinvertebrates present.

- **Stream-bottom macroinvertebrates provide information about the quality of a stream over long periods of time.**

  It may be difficult to identify stream pollution with water analysis, which can only provide information for the time of sampling. Even the presence of fish may not provide information about a pollution problem because fish can move away to avoid polluted water and then return when conditions improve. However, most stream-bottom macroinvertebrates cannot move to avoid pollution. A macroinvertebrate sample may thus provide information about pollution that is not present at the time of sample collection.

- **Stream-bottom macroinvertebrates are relatively easy to collect.**

  Useful stream-bottom macroinvertebrate data are easy to collect without expensive equipment. The data obtained by macroinvertebrate sampling can serve to indicate the need for additional data collection, possibly including water analysis and fish sampling.

MACROINVERTEBRATE FIELD SESSION

OBJECTIVES: Students will learn to collect and identify macroinvertebrate species and assess the biological health of a waterway.

BACKGROUND:

Benthic macroinvertebrates are common inhabitants of lakes and streams. The term **`benthic'** means **`bottom-living'** and indicates organisms that usually inhabit bottom substrates for at least part of their life cycle; the prefix **`macro'** indicates that these organisms are retained by mesh sizes of approx. 200-500 µm (micro-meters) and **can be seen without the aid of a microscope**; **"invertebrate"** indicates that **these creatures do not have a backbone.** The most diverse group of freshwater benthic macroinvertebrates are the aquatic insects which account for approx. 70% of known species of aquatic macroinvertebrates in North America. More than 4,000 species of aquatic insects have been reported. Thus, benthic macroinvertebrates are a highly diverse group which makes them excellent candidates for studies of changes in biodiversity.

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LOCATION:

Choose a stream location for collecting macroinvertebrates. Try to choose a section that is generally quick moving, with more riffles and rapids and fewer pools. Rocky bottoms provide conditions that are a good habitat for plentiful macroinvertebrates.
Choose a stream site that is safe (no dangerous obstacles or very swift moving water) and shallow (water level is knee high or below in almost all places). Students should be well-dressed for the weather and location.

MATERIALS:

Plastic container lid
ice tray
dish bin
kick net
waders
rubber gloves
tweezers
hand lens
macroinvertebrate identification resources
Biosurvey: Macroinvertebrate Assessment
Riparian Survey

DATA:

Record data on "Macroinvertebrate Assessment."
Record additional observations on "Riparian Survey."

MACROINVERTEBRATE COLLECTION PROCEDURE:

1. Have two students help hold the **kick net** in a *riffle*, making sure the bottom edge of the screen is well sealed with the stream bottom.

2. Two more students should stand *upstream* from the **kick net** and scrape the stream bottom with the heels of their **rubber boots**, overturning substrate material. Continue scraping the bottom with your boot heels in various places directly upstream from the kick net for about 2 minutes. When finished, carefully remove the net from the stream, holding the bottom edge, so you don't lose macroinvertebrates.

3. Students standing on the bank should fill both **ice trays** and the **dish tub** ½ to ¾ full of stream water and set them in a level place on the bank.

4. Have the students holding the **kick net** transport it horizontally over to the bank. Next, place the **kick net** in the **dish tub** and rinse off as many macroinvertebrates that you can. Set the screen off to the side. The remaining macroinvertebrates can be picked off the screen during the activity.

5. Show students how to sort the macroinvertebrates into the **ice cube trays** by type. Place like types into the same partitions. Using the small **yogurt-sized containers** to remove a little bit of stream water at a time from the **dish tub** will help students catch macroinvertebrates. Students may use **surgical gloves** or **tweezers** if they prefer. Don't forget to pick clean the **kick net** screen for more bugs!

6. Once most of the macroinvertebrates are removed from the **dish tub** and sorted, pour out the stream water little by little into the **plastic container lid** to make searching easier.

7. When most of the macroinvertebrates have been sorted, help students identify them with a **Macroinvertebrate Identification Key** and record the results on the **Macroinvertebrate Assessment.**

8. Return all macroinvertebrates and water back to the stream. Rinse off all containers and the kick net in the stream.

BIOSURVEY:
MACROINVERTEBRATE ASSESSMENT

Stream name:____

County:____________________________ **State:**______________________

Investigators:____
____

Site description:____
____
____
____
____

UTM coordinates:____

Site or map number:____

Date:______________________________ **Time:**______________________

Weather in past 24 hours:

- ☐ storm (heavy rain)
- ☐ rain (steady rain)
- ☐ rain showers (intermittent)
- ☐ overcast
- ☐ clear/sunny

Weather now:

- ☐ storm (heavy rain)
- ☐ rain (steady rain)
- ☐ rain showers (intermittent)
- ☐ overcast
- ☐ clear/sunny

Type of sampling: (check one)

- ☐ rocky bottom
- ☐ sandy/silty bottom

Habitat types in this reach: (check all that apply)

- ☐ vegetated bank margins
- ☐ snags and logs
- ☐ riffles
- ☐ unvegetated bank margins/cutbanks
- ☐ pools
- ☐ glides

MACROINVERTEBRATE ASSESSMENT INSTRUCTIONS:

1. Your instructor will demonstrate how to use the kicknet to collect a macroinvertebrate sample.
2. After collecting a screen of macroinvertebrates, carefully remove the net from the stream and "rinse" it off in a dish bin about ½ full of stream water.
3. Sort macroinvertebrates from your bin and the screen into an icetray ½ full of stream water or onto your plastic lid.
4. Use the dichotomous key and other identification resources to correctly identify all the macroinvertebrates in your sample and tally the results.
5. Return your macroinvertebrates to the stream.

CONCLUDING QUESTIONS (Complete after the Macroinvertebrate Assessment Field Session)

1. What makes macroinvertebrates such a good indicator of water quality?
2. Why are certain species more tolerant of pollution? (refer to certain functional characteristics that might make them more tolerant).
3. How does water temperature and amount of dissolved oxygen determine which macroinvertebrates can survive?
4. How do bodily adaptations make it easier for tolerant macroinvertebrates like midges, rat-tailed maggots and tubifex worms to survive?
5. What might happen to a macroinvertebrate population in a stream with high levels of phosphorus and nitrogen? (hint: think about the amount of oxygen in a eutrophic system).
6. How would turbidity, or the amount of suspended material in the water, affect the kinds of macroinvertebrates found in a particular stream?

Macroinvertebrate Assessment: Fill in the blanks for the macroinvertebrates found in your sample.

ORGANISM (Order/Family)	Tolerance	Functional characteristics indicating water quality	# of Individuals
Caddisflies (Trichoptera)	S		_____
Mayflies (Ephemeroptera)	S		_____
Stoneflies (Plecoptera)	S		_____
True flies (Diptera)			
midge larva	T		_____
black fly larva	T		_____
horse fly larva	T		_____
mosquito larva	T		_____
crane fly larva	SS		_____
rat-tailed maggot	T		_____
(Megaloptera)			
dobsonflies, adult	SS		_____
alderflies, adult	SS		_____
fishflies, adult	SS		_____
hellgramite (dobsonfly larva)	S		_____
(Odonata)			
dragonfly nymph	SS		_____
damesfly nymph	SS		_____
Water Beetles (Coleoptera)			
riffle beetle, adult	S		_____
water penny (riffle beetle larva)	S		_____
whirligig beetle, adult & larva	SS		_____
diving beetle, adult & larva	SS		_____

True Bugs (Hemiptera)		
water boatmen	SS	______
backswimmer	SS	______
water strider	SS	______
giant water bug	SS	______
Non-Insect Invertebrates:		
(P. Annelida)		
leaches	T	______
worms	T	______
(P. Platyhelminthes)		
planarians & flatworms	S	______
(P. Mollusca)		
gilled snail	S	______
lunged snail	T	______
(C. Crustacea)		
sowbugs	SS	______
scuds	SS	______

TOTAL # sensitive species (S) ______
TOTAL # somewhat sensitive species (SS) ______
TOTAL # tolerant species (T) ______
(Count the # of species, not individuals)

CONCLUSION:

1. Why are benthic macroinvertebrates such a good indicator of water quality?
2. Why are certain macroinvertebrate species more tolerant of pollution?
3. How might each of the following water quality factors affect which macroinvertebrates can survive?
   a. cold water temperatures b. low amounts of dissolved oxygen c. excessive phosphorus or nitrogen
   d. excessive sediment
4. What kinds of human activities might affect overall water quality and, in turn, macroinvertebrate populations, fish populations, birds, mammals, etc?

Riparian Survey

Complete this survey in the field or with the help of research. Use a separate piece of paper to complete your answers.

1. What kinds of aquatic insects are typically found in this river? Choose one insect and tell more about it.

2. What kinds of fish and other wildlife are found here?

3. Are there any endangered or protected species found here?

4. What species are native and non-native to the area? List them.

5. What kinds of vegetation are typical of this riparian area?

6. According to your research, what is the overall biological health of this river? Give support for your answer.

WATER QUALITY FIELD SESSION

OBJECTIVES: Students will learn about what chemical tests are used to determine water quality, understand testing procedures, what the results indicate, and successfully follow the lab procedures provided. Students will then draw conclusions about the quality of their water samples based upon their lab results.

BACKGROUND:

How do we tell if a stream is healthy?

Stream health is a combination of many factors. It can fluctuate with the seasons or with use, so we must measure water quality from time to time in order to look for patterns. Water that is safe for one use may be unacceptable for another use. For our purposes, we will measure water quality as its ability to support life including fish, macroinvertebrates, and humans. As we have investigated, living organisms like macroinvertebrates can indicate the health of a stream, but there are other factors we test for that we can't see.

pH is one of the most common measures in water quality testing. pH is an indication of the sample's acidity or alkalinity, which is actually a measurement of the activity of hydrogen ions in the sample. pH value is on a scale of 1-14, with 7 being neutral. Pure deionized water contains equal numbers of $H+$ and OH^- ions and has a pH value of 7. If the sample contains more OH^- than $H+$ ions, it is considered basic with a pH greater than 7. Human-caused changes in the pH of a lake or stream begins with the release of excess nitrogen oxides and sulfur dioxides, mostly from coal-fired industry and automobile emissions. Once released in the atmosphere, these acids combine with moisture and fall to earth as acid rain. Acid rain causes many bodies of water to become too acidic, adversely affecting the plant and animal life that live there. The areas that are affected the most are those that are downwind from industrial areas and those that don't have neutralizing mineral deposits (limestone) to counteract the acidity.

NITROGEN is needed by all living plants and animals to form proteins. Nitrogen makes up 79% of the air we breathe! Aquatic animals obtain nitrogen by eating aquatic plants and converting them into useable proteins, or they feed upon other aquatic animals that eat these plants. Too much nitrogen in a stream system promotes eutrophication. Eutrophication is a condition in an aquatic ecosystem (like a stream) where high nutrient concentrations cause algae to grow very rapidly, thus choking out the other life in the water. Over time, dead plant material builds up, and combined with sediment, can fill in a body of water. Sources of nitrogen include sewage, fertilizer and animal waste. Improperly functioning household septic systems can contribute high levels of nitrogen to a system through leakage into groundwater and the surrounding surface water sources. In addition, drinking water containing high levels of nitrates can lead to methemoglobinemia, if it is used for infant formula. This is a serious condition that prevents babies from carrying enough oxygen in their blood and leads to "blue baby" syndrome.

PHOSPHOROUS is a nutrient needed for plant growth. Plant growth is limited by the amount of phosphorous available, and is thus a "growth-limiting" factor because it is only available in small amounts. However, when too much phosphorous is introduced into a stream, it is susceptible to eutrophication. Most eutrophication that takes place is human caused. Sources of excess phosphates include human, animal and industrial wastes, soil erosion, draining swamps and fertilizer run-off. Water is very sensitive to increased phosphate amounts. As eutrophication increases, algal blooms become more frequent, aquatic plants become very dense, aquatic life switches to more pollution tolerant species, and swimming and boating may become impossible.

TURBIDITY the cloudiness in water, is a measure of how much material is suspended in your stream sample. There are many possible causes. Most people think turbidity is the amount of sediment, or disturbed soil clouding the water. But microscopic plankton also contributes to high turbidity. In addition to blocking sunlight, cloudy water carries nutrients and pesticides and contributes to eutrophication. Particles in the water also collect heat from sunlight, raising the surface temperature of the water. Human causes of high turbidity are soil erosion, urban run-off and discharge of wastes into lakes and streams. Bottom feeders, such as carp, can also stir up bottom sediments. Too many suspended solids can clog fish gills, prevent development and smother fish eggs. Sediments can also settle into rocks, making an unsuitable habitat for macroinvertebrates and newly-hatched aquatic insect larvae. Turbidity is measured in Nephelometric Turbidity Units (NTU).

FECAL CHOLIFORM BACTERIA is abundant in the lower intestine of humans and other warm-blooded animals, but are rare or not found at all in unpolluted water. Presence of fecal choliform bacteria indicates sewage or fecal contamination in water. These bacteria can enter the water through direct discharge from animals, agricultural run-off from animal wastes and from the discharge of human sewage. A person swimming in water with high counts of fecal coliform is at risk for contracting an illness such as typhoid fever, hepatitis, dysentery and ear infections. Other types of bacteria can be present in water and not harm humans. Because it is a delicate health risk, your students will not be testing for fecal coliform bacteria in this lesson. Results are measured as CPU (“colony producing units”) per 100 mL.

TEMPERATURE is important in determining which species can live in an ecosystem. Temperature affects feeding, reproduction and metabolism of aquatic animals. The temperature of water also is directly related to the amount of dissolved oxygen that can be held in a stream. Colder water has the ability to hold more oxygen and is preferred by a wider range of species. Warmer water grows more plants, which uses up oxygen that other creatures rely on. Warm water can also disrupt the life cycles of insects. Water temperature is measured in degrees Celsius. (ºC)

DISSOLVED OXYGEN is essential for the survival and maintenance of healthy lakes and rivers. Just as humans need oxygen to live on land, aquatic animals need dissolved oxygen to live in water. Fish, macroinvertebrates and some bacteria all require oxygen for respiration. Oxygen dissolves into water from the atmosphere at the surface until the water holds all it can. The oxygen is then dissolved slowly and distributed throughout the water by turbulence, currents, wind and other natural forces. Oxygen is also produced by aquatic plants, algae and phytoplankton. The amount of oxygen required by aquatic life varies according to species. Species that can’t tolerate low levels of dissolved oxygen—mayfly nymphs, stonefly nymphs, caddisfly and beetle larva—will be replaced by pollutant-tolerant species like worms and fly larvae. Dissolved oxygen is measured in parts per million (ppm).

MATERIALS:

The most important component for this lab is a LaMotte Water Quality Testing Kit. This kit will contain the chemicals your class will need to conduct all the water quality tests included in the lab booklet. In addition, review the equipment requirements listed in the kits and the **Water Quality Assessment** to conduct each lab.

LOCATION:

Choose two stream or river locations for collecting water samples. Contrasting sites may provide students with two data sets from which to draw comparisons later on. Students may perform tests on-site, or follow instructions to collect samples for testing in the classroom.

IN-CLASS LAB SET-UP:

Set up the stations (pH, nitrogen, phosphorus, turbidity and additional tests) around the classroom. Prepare each station with the samples, equipment, and LaMotte water quality testing kit supplies. Divide the class into groups. Students may work at each station as a group or in pairs. It is helpful for the instructor to do a "test run" through each water quality station before the students do.

DATA:

Record data on "Water Quality Assessment" Lab Sheet

WATER QUALITY TESTING PROCEDURE:

PH:

Collect stream samples from 2 local streams in sterilized, unbreakable containers.

SIGNIFICANCE: To test the pH level of household items and 2 stream samples and understand where they fit on the pH scale.

MATERIALS: 10 mL test tube and cap, wide range indicator, eyedropper, pH comparator

HYPOTHESES: Write down a hypothesis for each sample. Where to you think it will fall on the pH scale? Will it be more acidic or basic?

PROCEDURE:

1. Rinse the test tube with the sample you are testing.
2. Fill the test tube to the 5mL line with the sample.
3. Add 8 drops of the wide range indicator to the sample.
4. Cap the tube and invert gently to mix.

5. Insert the tube into the pH comparator and identify the pH level with the most closely matching color.
6. Record results for each sample.
7. Rinse out tube with tap water in between samples. Repeat steps 1-6.

NITROGEN:

Collect stream samples for each test in sterilized, unbreakable containers. The following samples can be collected from the same location as one of the samples from the pH lab above.

SIGNIFICANCE: To test nitrogen levels in 2 samples, determine levels for healthy streams, and understand causes and consequences of excess nitrogen.

MATERIALS: 10 mL test tube and cap, nitrate #1 tablet, nitrate #2 CTA tablet, nitrate comparator, stopwatch

HYPOTHESES: Write down a hypothesis for each sample. Will it have safe or unsafe nitrogen levels? (Use the tables provided with the testing kit and lab to determine what certain nitrogen levels indicate).

PROCEDURE:

1. Fill the test tube with the sample to the 5mL line.
2. Add 1 nitrate #1 tablet to the test tube. Cap the tube and shake until disintegrated.
3. Add 1 nitrate #2 tablet to the test tube. Cap the tube and shake until disintegrated. WAIT 5 MINUTES.
4. Insert the tube into the nitrate comparator and identify the nitrate level with the most closely matching color.
5. Record results as ____ppm nitrate-nitrogen
6. Rinse out tube with tap water in between samples. Repeat steps 1-6.

PHOSPHATE:

SIGNIFICANCE: To test phosphate levels in 2 samples, determine safe levels for streams, and understand causes and consequences of excess phosphates.

MATERIALS: 10 mL test tube and cap, phosphate acid reagent, phosphate reducing reagent, .1 gram spoon, 1.0 mL pipet, phosphate comparator, stopwatch

HYPOTHESES: Write down a hypothesis for each sample. Will it have safe or unsafe phosphate levels? (Use the tables provided with the testing kit and lab to determine what certain nitrogen levels indicate).

PROCEDURE:

1. Fill the test tube with the sample (free of debris) to the 10 mL line.

2. Use the 1.0 mL pipet to add 1.0 mL of phosphate acid reagent to the test tube. Cap and mix gently by inverting.
3. Use .1 gram spoon to add phosphate reducing reagent to the test tube. Cap and mix sample until the powder dissolves.
4. WAIT 5 MINUTES for a color to develop.
5. Insert the tube into the phosphate comparator and identify the phosphate level with the most closely matching color.
6. Record results as ____ppm phosphate

   Rinse out tube with tap water in between samples. Repeat steps 1-6

TURBIDITY:

SIGNIFICANCE: To determine the amount of suspended material in 2 stream samples and understand what causes turbidity.

MATERIALS: 2 turbidity columns, tap water, standard turbidity reagent, eye dropper, stirring rod

HYPOTHESES: Write down a hypothesis for each sample. Where to you think it will fall on the turbidity scale? Would it be safe to drink? Use turbidity table included with the testing kit if you need help.

PROCEDURE:

1. Fill one column to the 50 mL line with the stream sample.
2. Fill the other column to the 50 mL line with tap water.
3. Place the two columns side by side and note the difference in clarity. How well can you see the black dot on the bottom of each tube? Describe the color of your stream sample. If the black dot appears the same in both columns, the turbidity is equal to zero.
4. Shake the standard turbidity reagent vigorously. Add 0.5 mL of standard turbidity reagent to your tap water sample and stir it to distribute the particles. Keep adding standard turbidity reagent to the tap water sample in 0.5 mL increments until both samples (your stream sample and tap water sample) have the same turbidity. This means that the black dot will appear the same through the water of both columns. Be sure to keep track of how much standard turbidity reagent you add! Don't forget to stir the sample after each addition to mix up the particles.
5. Record the total amount of standard turbidity reagent added and use the table to convert to the NTU turbidity scale.
6. Rinse out tube with tap water in between samples.

   Repeat steps 1-6 for stream sample #2.

WATER QUALITY ASSESSMENT

NITROGEN

Nitrogen is needed by all living plants and animals to form proteins. Nitrogen makes up 79% of the air we breathe! Too much nitrogen in a stream system promotes **eutrophication.** EUTROPHICATION is a condition in an aquatic ecosystem (like a stream) where high nutrient concentrations cause algae to grow very rapidly, choking out the other life in the water and robbing the water of dissolved oxygen. Over time, dead plant material and sediment builds up and can fill in a body of water. Sources of nitrogen include sewage, fertilizer and animal waste. The following table shows healthy and unhealthy levels of nitrogen, measured in ppm nitrate-nitrogen. (ppm stands for "parts per million")

NITRATE-NITROGEN TABLE

ppm nitrate-nitrogen	**Indicates:**
1 OR BELOW	UNPOLLUTED WATER IS USUALLY BELOW 1
1 TO 10	GENERALLY SAFE WATER
OVER 10	UNSAFE FOR DRINKING; CAN CAUSE "BLUE BABIES" SYNDROME

NITROGEN LAB:

SIGNIFICANCE: To test nitrogen levels in 2 samples, determine levels for healthy streams, and understand causes and consequences of excess nitrogen.

MATERIALS: 10 mL test tube and cap, nitrate #1 tablet, nitrate #2 CTA tablet, nitrate comparator, stopwatch

HYPOTHESES: Write down a hypothesis for each sample. Will it have safe or unsafe nitrogen levels? (Use the tables provided with the testing kit and lab to determine what certain nitrogen levels indicate).

PROCEDURE: Collect stream samples for each test in sterilized, unbreakable containers.

1. Fill the test tube with the sample to the 5mL line.
2. Add 1 nitrate #1 tablet to the test tube. Cap the tube and shake until disintegrated.
3. Add 1 nitrate #2 tablet to the test tube. Cap the tube and shake until disintegrated WAIT 5 MINUTES.
4. Insert the tube into the nitrate comparator and identify the nitrate level with the most closely matching color.
5. Record results as ___ ppm nitrate-nitrogen
6. Rinse out tube with tap water in between samples. Repeat steps 1-6.

	Sample #1	Sample #2
Hypothesis: What will be the nitrate level of the sample?		
Test Results:	__________PPM NITRATE	__________PPM NITRATE
According to the nitrate table, is the sample safe or unsafe for drinking?		

CONCLUSIONS:

1. WHICH SAMPLE HAD HIGHER NITRATE-NITROGEN LEVELS?

2. WERE YOUR HYPOTHESES CORRECT?

3. WHAT ARE POSSIBLE CAUSES FOR HIGH NITRATE-NITROGEN LEVELS?

4. HOW CAN THESE SOURCES BE REDUCED?

5. WHAT CAN HAPPEN TO A STREAM IF HIGH NITRATE-NITROGEN LEVELS CONTINUE?

PHOSPHOROUS

Phosphorous is a nutrient needed for plant growth. However, when too much phosphorous is introduced into a stream, it is susceptible to **eutrophication.**
Dead plant material and sediment builds up and clean water stream species are replaced with carp, midges and worms. Sources of phosphates include human, animal and industrial wastes, soil erosion, draining swamps and fertilizer run-off. The following table describes phosphate levels in ppm (parts per million) phosphate. Notice how sensitive water is to phosphate amounts!!!

PHOSPHATE TABLE

ppm phosphate	**Indicates**
BETWEEN 0-0.1	TYPICAL FOR SURFACE WATER
OVER .1	PROMOTES PLANT GROWTH FOR EUTROPHICATION

PHOSPHATE LAB:

SIGNIFICANCE: To test phosphate levels in 2 samples, determine safe levels for streams, and understand causes and consequences of excess phosphates.

MATERIALS: 10 mL test tube and cap, phosphate acid reagent, phosphate reducing reagent, .1 gram spoon, 1.0 mL pipet, phosphate comparator, stopwatch

HYPOTHESES: Write down a hypothesis for each sample. Will it have safe or unsafe phosphate levels? (Use the tables provided with the testing kit and lab to determine what certain nitrogen levels indicate).

PROCEDURE:
1. Fill the test tube with the sample (free of debris) to the 10 mL line.
2. Use the 1.0 mL pipet to add 1.0 mL of phosphate acid reagent to the test tube. Cap and mix gently by inverting.
3. Use .1 gram spoon to add phosphate reducing reagent to the test tube. Cap and mix sample until the powder dissolves.
4. WAIT 5 MINUTES for a color to develop.
5. Insert the tube into the phosphate comparator and identify the phosphate level with the most closely matching color.
6. Record results as ____ppm phosphate
   Rinse out tube with tap water in between samples. Repeat steps 1-6.

	Stream Sample #1	Stream Sample #2
Hypothesis: What will be the phosphate level of the sample?		
Test Results:	__________PPM PHOSPHATE	__________PPM PHOSPHATE
According to the phosphate table, will the sample promote eutrophication?		

CONCLUSIONS:

1. WHICH SAMPLE HAD THE HIGHER PHOSPHATE LEVELS?

2. WERE YOUR HYPOTHESES CORRECT?

3. WHAT ARE POSSIBLE CAUSES FOR HIGH PHOSPHATE LEVELS?

4. HOW CAN THESE SOURCES BE REDUCED?

5. WHAT CAN HAPPEN TO A STREAM IF HIGH PHOSPHATE LEVELS CONTINUE?

TURBIDITY:

Turbidity, the murkiness in water, is a measure of how much material is suspended in your stream sample. There are many possible causes. Most people think turbidity is the amount of sediment, or disturbed soil clouding the water. But microscopic plankton also contributes to high turbidity. In addition to blocking sunlight, cloudy water can carry nutrients and pesticides and contributes to **eutrophication**. Particles in the water also collect heat from sunlight, raising the surface temperature of the water. Turbidity is measured in Nephelometric Turbidity Units (NTU). You will investigate turbidity in your lab.

TYPICAL TURBIDITY VALUES:

ABOVE 10 NTU	MAY CAUSE HARMFUL EFFECTS TO ANIMAL LIFE, INTERFERING WITH RESPIRATION
BELOW 10 NTU	A WELL-FUNCTIONING STREAM
ABOVE 5 NTU	WATER IS NOT HEALTHY FOR HUMANS TO DRINK
0-5 NTU	HEALTHY DRINKING WATER FOR HUMANS
LESS THAN 1 NTU	TYPICAL OF MOST GROUNDWATER
.5 NTU	TYPICAL OF MOST TAP WATER

TURBIDITY LAB:

SIGNIFICANCE: To determine the amount of suspended material in 2 stream samples and understand what causes turbidity.

MATERIALS: 2 turbidity columns, tap water, standard turbidity reagent, eye dropper, stirring rod.

HYPOTHESES: Write down a hypothesis for each sample. Where to you think it will fall on the turbidity scale? Would it be safe to drink? Use turbidity if you need help.

PROCEDURE:

1. Fill one column to the 50 mL line with the stream sample.
2. Fill the other column to the 50 mL line with tap water.
3. Place the two columns side by side and note the difference in clarity. How well can you see the black dot on the bottom of each tube? Describe the color of your stream sample. If the black dot appears the same in both columns, the turbidity is equal to zero.
4. Shake the standard turbidity reagent vigorously. Add 0.5 mL of standard turbidity reagent to your tap water sample and stir it to distribute the particles. Keep adding standard turbidity reagent to the tap water sample in 0.5 mL increments until both samples (your stream sample and tap water sample) have the same turbidity. This means that the black dot will appear the same through the water of both columns. Be sure to keep track of how much standard turbidity reagent you add! Don't forget to stir the sample after each addition to mix up the particles.
5. Record the total amount of standard turbidity reagent added and use the table to convert to the NTU turbidity scale.
6. Rinse out tube with tap water in between samples.

   Repeat steps 1-6 for stream sample #2.

SAMPLE #1

<u>HYPOTHESIS:</u> IS IT A HEALTHY, WELL-FUNCTIONING STREAM? (BELOW 10 NTU) IS IT SAFE OR FOR HUMANS TO DRINK? (BELOW 5 NTU?)									
<u>OBSERVATIONS:</u> CLARITY: (USE WORDS LIKE: A LITTLE CLOUDY, VERY CLOUDY, SILTY, MUDDY, MURKY, ETC;) COLOR:									
CHECK THE BOXES FOR EACH 0.5 ML ADDITION:									

OF CHECKED BOXES X 5 = ______ NTU

SAMPLE #2

<u>HYPOTHESIS:</u> IS IT A HEALTHY, WELL-FUNCTIONING STREAM? (BELOW 10 NTU) IS IT SAFE OR FOR HUMANS TO DRINK? (BELOW 5 NTU?)									
<u>OBSERVATIONS:</u> CLARITY: (USE WORDS LIKE: A LITTLE CLOUDY, VERY CLOUDY, SILTY, MUDDY, MURKY, ETC;) COLOR:									
CHECK THE BOXES FOR EACH 0.5 ML ADDITION:									

OF CHECKED BOXES X 5 = ______ NTU

CONCLUSIONS:

1. WHICH SAMPLE HAD THE HIGHEST TURBIDITY?

2. WHICH SAMPLE(S) ARE SUITABLE FOR HUMAN DRINKING?

3. WHAT CAUSES WATER TO HAVE HIGH TURBIDITY?

IF YOU HAVE TIME, TEST YOUR SAMPLES WITH THE TURBIDITY METER. RECORD YOUR RESULTS HERE:

SAMPLE #1 READING = ________ NTU

SAMPLE #2 READING = ________ NTU

HOW DO THESE READINGS COMPARE WITH THOSE YOU GOT WITH THE TEST KIT AND EYE-DROPPER?

pH: ACIDITY VS. ALKALINITY—

pH value is on a scale of 1-14, with 7 being neutral. Pure water has a pH value of 7. If the sample has a pH *greater than* 7, it is considered alkaline (or basic). If the sample has a pH *less than* 7, it is considered acidic. It is important to remember that for every one unit of change on the pH scale, there is a ten-fold change in how acidic or basic the sample is. The following diagram shows where some household items fall on the pH scale.

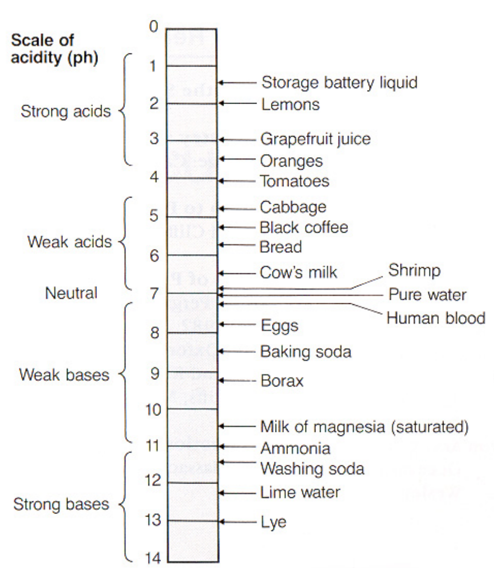


Figure 1. A scale of possible pH values and corresponding common liquids.

pH LAB

SIGNIFICANCE: To test the pH level of household items and 2 stream samples and understand where they fit on the pH scale.

MATERIALS: 10 mL test tube and cap, wide range indicator, eyedropper, pH comparator

HYPOTHESES: Write down a hypothesis for each sample. Where to you think it will fall on the pH scale? Will it be more acidic or basic?

PROCEDURE:

1. Rinse the test tube with the sample you are testing.
2. Fill the test tube to the 5mL line with the sample.
3. Add 8 drops of the wide range indicator to the sample.
4. Cap the tube and invert gently to mix.
5. Insert the tube into the pH comparator and identify the pH level with the most closely matching color.
6. Record results for each sample.
7. Rinse out tube with tap water in between samples. Repeat steps 1-6.

CONCLUSIONS:

1. WAS THE PH OF THE SAMPLE COMPLETELY NUETRAL? EXPLAIN WHY OR WHY NOT.

2. EXPLAIN WHAT MIGHT MAKE A WATER SAMPLE SLIGHTLY ACIDIC. (HINT: THINK ABOUT WHERE THE WATER IS COMING FROM AND COMING INTO CONTACT WITH).

3. EXPLAIN WHAT MIGHT MAKE A WATER SAMPLE SLIGHTLY BASIC.

4. WHAT HOUSEHOLD ITEMS HAVE THE SAME PH AS YOUR WATER SAMPLES?

LITERATURE

OBJECTIVE: Students will learn about the importance of water from a literary standpoint. Through descriptive excerpts, students will gain an appreciation for water and the environment from the author's point of view. Students will practice descriptive and creative writing skills and interview techniques.

BACKGROUND: Literature enhances our understanding of, and appreciation for, the natural environment. Books provide, perhaps better than any other medium, a descriptive reference for comprehending the places where we live, work, and visit. Books paint a picture of a place and time, according to the author's perspective. Literature offers us an intimate look at these places and conjures up emotions and memories about some of the places we hold most dear.

1. Choose excerpts from the following selections for each student to read at home. Each student should read at least 3 excerpts and complete the **Literature Review.**

   Cadillac Desert
   The River
   The Stream
   A River Runs Through It
   The River Why?
   The Snake River
   The Colorado

2. Students should choose one of the following activities to do outside of class.

   Option A: Students will write their own short (one page) essay about a local river or stream. They may write a poem, a descriptive or creative piece, about an experience they've had on the river etc;

   Option B: Students will choose their own piece of literature about water or a river. They should pick an excerpt to read to the class. The excerpt should reflect the writing or descriptive power of the author that captures the essence of the place. They will complete a **Book Report** as a final product.

BIOGRAPHY OF A RIVER ACTIVITIES:

Option A: Students will write an "epitaph" for the river. With what they know about the history, biology and current state of the river, students should speculate what might cause the river to "die out." Write a fictional (yet plausible) account of the death of the river.

Option B: Students will conduct an interview with someone who has a personal experience with the river. They will write a "personal account" of this person's story from notes they take during the interview. For example, students may speak with relatives, farmers, ranchers, business owners, land managers, anglers, boaters, etc; A well written personal account will discuss the "who, what, where, when, and why" of the individual's experience.

LITERATURE REVIEW

1. Excerpt Title:____
Author:____________________________ Point of view:_______________________________

Brief summary of the excerpt: (Where, When, Who, What?)

2. Excerpt Title:____
Author:____________________________ Point of view:_______________________________

Brief summary of the excerpt: (Where, When, Who, What?)

3. Excerpt Title:____
Author:____________________________ Point of view:_______________________________

Brief summary of the excerpt: (Where, When, Who, What?)

4. Which author did you like the best? Why? The least? Why?

5. Which excerpt was your least favorite? Why?

BOOK REPORT

Title:____
Author:________________________ **Point of view:**_____________________________

BRIEF SUMMARY OF THE BOOK: (WHERE, WHEN, WHO, WHAT?)

CHOOSE AN EXCERPT THAT IS REPRESENTATIVE OF THE AUTHOR'S "VOICE" AND THE RIVER LOCATION.

PERSONAL REVIEW: DID YOU LIKE THIS BOOK? WHY OR WHY NOT? WOULD YOU RECOMMEND IT?__________________________________

CURRENT ISSUES:

OBJECTIVES: Students will research water-related current issues, learn debate skills and strategies and practice public speaking.

BACKGROUND: Preparing for debate is an excellent way to learn about all sides of an issue. For every issue, there are many points of view to be considered and many interested parties. Individuals interested in the outcome of water related issues might include resource managers, scientists, businesses, farmers, ranchers, anglers and community members. Without an organized format to discuss their viewpoints, these various parties might not be able to effectively communicate their positions. Debate offers a way to present an argument with supportive evidence in favor of your viewpoint while arguing against the opposing viewpoint in a constructive manner.

DEBATE PREPARATION:

1. As a class, brainstorm some current issues in Teton Valley and the world.

2. Choose a well-known issue and make a statement about it. For example: “Capital punishment should be made illegal.”

3. Discuss *who* might be an interested party in the chosen issue. How might this issue be argued pro and con? As a class, make a list of these pro (affirmative) and con (negative) arguments.

4. Review **Debate Format** and **Tips for Debate**. Make student copies.

5. To get a feel for water debate topics, have students look up current water-related issues in news articles and the internet and present their findings to the class using the **Current Issues Report** worksheet. Examples of pertinent issues: damming a river, stocking fish, water restrictions in urban areas, water rights cases, etc;

6. Decide on the water issues the class would like to debate on and write a statement on about the topic for debate.

Sample topics:
Farmers should be required to irrigate using surface water instead of pumping groundwater for crops.
Non-native fish in the Teton River should be killed to make room for native species.
“First in time, first in right” is a fair way to decide questions of water rights.

7. Assign pairs to research water topics for debate (each pair will argue a pro or con for a particular debate topic. Give a deadline for debates.

DEBATE DAY:

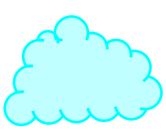
1. Set up debates for a class period and distribute **debate ballots** to students observing the debate. Observers will judge the pro and con arguments on the debate topics according to the most convincing argument and the most prepared debate team. There should be a set of ballots for each round of debates.

The teacher can time and mediate the debates or assign a student mediator following the guidelines in the **Debate Format**.

After each debate, discuss the class consensus about the arguments presented.

- What side would the student take before the debate?
- Who would they side with on this issue according to the arguments presented in the debate?
- Were they swayed in their decision?
- Why did they vote as they did?
- How did personal experience enter in to their decision?
- Are there any other points that they thought should have been brought up for pro or con?

BIOGRAPHY OF A RIVER ACTIVITY:



Option A: Students will research a current issue facing their local waterways or wetlands. They should research both the affirmative and negative points concerning the issue and present what they think is the most viable solution, giving support and reasoning for their decision. To gather information, students can use publications, the internet, local agencies, organizations, conservation groups, and community members as resources.

Option B: Students will research a historical dispute concerning their local waterways. This could include disputes over water rights, water use etc; They should present the affirmative and negative points of the historic issue from the point of view of the time period, explaining the pertinent sociopolitical framework for the thinking of the day. Then, the students should explain the issue from a current point of view. How has present thinking changed about this issue? Do we still have disputes over this issue today? Why?

DEBATE FORMAT

SEQUENCE:

1. Affirmative Constructive Speech (5-8 minutes)
2. Cross Examined by Negative Speaker (2-3 minutes)
3. Negative Constructive Speech (5-8 minutes)
4. Cross Examined by Affirmative Speaker (2-3 minutes)
5. Negative rebuttal/summary (1 minute)
6. Affirmative rebuttal/summary (1 minute)

DESCRIPTION OF SEQUENCE:

1. AFFIRMATIVE CONSTRUCTIVE SPEECH

Begin with an interesting, attention-getting introduction. Give a *brief* explanation/history of the problem. Announce the affirmative team's main points and contentions, specifically stating what the affirmative team intends to accomplish. Contentions should address the need, practicality, and advantages of the pro argument. It must be supported by evidence and reasoning. Summarize. Review the major points.

2. CROSS-EXAMINATION BY NEGATIVE SPEAKER

Analyze what the affirmative speaker has said. Point out where the Affirmative and Negative agree and where they disagree. Refute the affirmative points. Present evidence, opinion, and reasoning to deconstruct the opponent's argument. Summarize.

3. NEGATIVE CONSTRUCTIVE SPEECH

State your main points and offer further evidence and reasoning for your arguments.Your contentions should address the need, practicality, and advantages of the con argument. Offer alternate solutions for the problem and how a change could be brought into effect. Support your arguments. Summarize. Review the major points.

4. CROSS-EXAMINATION BY AFFIRMATIVE SPEAKER

Attack the negative speaker's points. Present evidence and reasoning to refute the negative point and support your own.

5. NEGATIVE REBUTTAL/SUMMARY

Negative side gives a summary. This is the last time the negative side may address the audience.

6. AFFIRMATIVE REBUTTAL/SUMMARY

Affirmative side gives a summary. This is the last time the affirmative side may address the audience.

TERMS:

DEBATE: Process whereby two or more individuals take opposing viewpoints on a proposition in an attempt to persuade others to accept or reject a solution to a problem.

RESOLUTION: A statement which presents the idea or issue which is under examination. It should be clearly worded, deal with one subject, be timely, be free of emotional or prejudicial phrases, and be phrased from an affirmative position.

PRO (Affirmative): This side tells the importance of adopting the proposition and why the change is needed.

CON (Negative): The negative side presents arguments as to why no changes should take place. They also argue against the affirimative points and present the disadvantages of the affirimative's plan.

ARGUMENT: The argument is your way of presenting evidence that helps to support your side.

MAIN POINTS: Statements or points that are offered to support your side of the case.

REFUTE: Attack the case of the opposition. The debaters seek out the weaknesses of the opponents' arguments and present a counter argument.

REBUTTAL: This is the last opportunity to argue against the opposition and to highlight your main points.

TIPS FOR DEBATE

Research both sides of your topic well. The better you understand the pro and con of an issue, the better prepared you will be anticipate points made by the other side and rebuttal their arguments.

Analyze the question. Focus on the main points of the issue to make the strongest argument for your side.

Prove your argument with strong, supportive and convincing evidence. Never falsify, create or distort evidence.

Argue with sound reasoning and logical conclusions. Do not offer emotional appeals. Concentrate on the evidence.

Respond to the opposition's arguments by refuting theirs and reinforcing your own. It is important to make references to what your opponent has said. Take notes on the oppositions argument so you remember the points you wish to attack and defend.

Organize your presentation into clear and logical points. If appropriate, use simple visual aids to illustrate your argument.

Support every argument you make. Prepare for ways the opposition will try to deconstruct your argument. Also prepare ways to deconstruct the opposition's arguments by looking for weaknesses in their case.

Speak clearly to the audience and make eye contact to deliver your argument well. Debaters should address their remarks to the judge or audience, not to the opposing side. It is important to practice your arguments before the debate and not sway or shuffle during your delivery.

Stay composed. The debater should never publicly disagree with the decision of the judge or the audience. Remember that you are arguing a point, not against the people of the opposition. Both sides are contributing to a deeper understanding of the water issues and controversies involved.

Lingo: Refer to the opposite side as "my opponent".
Use phrases like "There are three main points that prove the affirmative..."
In the rebuttal, say...."My opponent said..., however,... "

CURRENT ISSUES REPORT

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PARTIES INVOLVED (WHO)?___________________________
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DEBATE STATEMENT (STATE THE MAIN POINT OF THE ARTICLE IN THE AFFIRMATIVE)

____

PROS	CONS

DEBATE BALLOT:

NAME:______________________________

TOPIC:____

AFFIRMATIVE:						NEGATIVE:					
Names:						Names:					
Constructive Speech	**1**	**2**	**3**	**4**	**5**	Constructive Speech	**1**	**2**	**3**	**4**	**5**
Cross-Examination	**1**	**2**	**3**	**4**	**5**	Cross-Examination	**1**	**2**	**3**	**4**	**5**
Rebuttal/Summary	**1**	**2**	**3**	**4**	**5**	Rebuttal/Summary	**1**	**2**	**3**	**4**	**5**
Comments:						Comments:					
Overall score:	**1**	**2**	**3**	**4**	**5**	Overall score:	**1**	**2**	**3**	**4**	**5**

1= least convincing argument
5= most convincing argument

THE DEBATE WAS WON BY: ____

REASONS FOR MY DECISION:

DEBATE BALLOT:

NAME:______________________________

TOPIC:____

AFFIRMATIVE:						NEGATIVE:					
Names:						Names:					
Constructive Speech	**1**	**2**	**3**	**4**	**5**	Constructive Speech	**1**	**2**	**3**	**4**	**5**
Cross-Examination	**1**	**2**	**3**	**4**	**5**	Cross-Examination	**1**	**2**	**3**	**4**	**5**
Rebuttal/Summary	**1**	**2**	**3**	**4**	**5**	Rebuttal/Summary	**1**	**2**	**3**	**4**	**5**
Comments:						Comments:					
Overall score:	**1**	**2**	**3**	**4**	**5**	Overall score:	**1**	**2**	**3**	**4**	**5**

1= least convincing argument
5= most convincing argument

THE DEBATE WAS WON BY: ____

REASONS FOR MY DECISION:

HIGH SCHOOL STATE STANDARDS

BIOGRAPHY OF A RIVER

PHYSICAL GEOGRAPHY AND CLIMATE

654. Earth and Space Systems
02. Understand geo-chemical cycles and energy in the earth system.

Map of a Watershed worksheet
Watershed Climate Worksheet.

Activity **Option A: Draw a watershed map**
Option B: Model a map
Option C: Compare watersheds

GEOLOGY AND HYDROLOGY

654. Earth and Space Systems
01. Understand scientific theories of origin and subsequent changes in the universe and earth systems.
c. Know that interactions among the solid earth, the oceans, the atmosphere, and organisms have resulted in the ongoing change of the earth system.

GEOLOGY:

Groundwater Worksheet

Activity **Option A: geology map**
Option B: Build-an-aquifer activity
Option C: Compare geology

HYDROLOGY:

River Formation Packet.
Hydrographing Packet

Activity **Option A: Hydrograph scenarios**
Option B: Hydrograph predictions

HISTORY

489. Critical Thinking and Analytical Skills

01. Acquire critical thinking and analytical skills.
a. Use analytical skills for reasoning, research, and reporting including interpretation of maps, charts, graphs, timelines and works of art.
b. Evaluate and interpret points-of-view using primary and secondary sources.
c. Chronologically organize significant events and people in United States history into major eras and themes to identify and explain historical relationships.

Research the cultural history of a river (option A or B)

Activity Option A: Detailed Timeline
Option B: Compare Rural and Urban Histories

SCIENCE

648. Unifying Concepts of Science

02. Understand concepts and processes of evidence, models, and explanation.
a. Know that observations and data are evidence on which to base scientific explanations.
c. Develop scientific explanations based on scientific knowledge, logic and analysis.

03. Understand constancy, change, and measurement.
b. Recognize that change occurs in and among systems and change can be measured.
c. Measure in both the metric and U.S. customary system.

05. Understand concepts of form and function.
a. Know that form refers to function and function refers to form.

656. Science. Personal and Social Perspectives
01. Understand common environmental quality issues, both natural and human induced.
a. Identify issues, including but not limited to: - Water quality; - Air quality; - Hazardous waste; - Forest health.

652. Interdependence of Organisms and Biological Change
02. Understand the interdependence of organisms.

653. Matter, Energy and Organization in Living Systems

02. Understand the individual behavior of organisms and their interactions in populations and communities as influenced by physiological and environmental factors.

BIOLOGY:

Option A: **Macroinvertebrate Field Session**
Biosurvey: Macroinvertebrate Asessment
Riparian Survey of the area.

Option B: Research the aquatic life of a river using books and the internet.
Riparian Survey

CHEMISTRY:

Option A: **Water Quality Field Session**
Water Quality Assessment

Option B: Research aspects of water quality testing and their implications.
(pH, nitrogen, phosphorus, oxygen, suspended sediment, coliform bacteria)

Activity: Option A: Research a fish, macroinvertebrate and plant species found inyour local watershed.

Option B: Write an essay on Water Quality, research pollution

LITERATURE

752 . Reading

02. Read and respond to a variety of literature to compare and contrast the many dimensions of human experience.
b. Identify and compare own experiences to those of others in situations, events, and cultures within reading selections.
c. Interpret the social, cultural, and historical significance of a text:

03. Read a variety of traditional, technical, and electronic materials for critical analysis and evaluation.
d. Form opinions and make judgments about fiction and non-fiction.

04. Read to locate information from a variety of traditional, technical, and electronic sources.

a. Generate relevant and researchable questions.
b. Systematically organize and record information.
c. Produce research projects and reports.

753. Writing.

01. Understand and use the writing process.

02. Write and edit for correctness and clarity.

03. Write to inform and explain.
a. Incorporate facts, data, and processes from technical and non-technical materials into writing.
b. Choose appropriate format to inform and explain.

04. Write for literary response and expression.
a. Compare, contrast, and synthesize ideas and techniques from a variety of literatures and Fine Arts that represent many cultures and perspectives.

06. Write to gather, synthesize, and communicate research findings.
b. Present research findings.

Read excerpts
Complete Literature Review
Option A: Write essay or descriptive piece
Option B: Choose own piece of literature; Complete book review

Activity Option A: write a river "epitaph"
Option B: personal interview

CURRENT ISSUES

489. Critical Thinking and Analytical Skills

01. Acquire critical thinking and analytical skills.
a. Use analytical skills for reasoning, research, and reporting including interpretation of maps, charts, graphs, timelines and works of art.
b. Evaluate and interpret points-of-view using primary and secondary sources.

Brainstorm Current issues
Debate