WATER QUALITY in the Ross Barnett Reservoir – The Water YOU Drink! It's Your Legacy.

Yes – believe it or not, the water you drink in Madison County, Hinds County, Rankin County and the city of Jackson comes from the Ross Barnett Reservoir. It is important that residents of the area appreciate the need to keep this water supply clean.

Below is a long term problem for your team to solve. The best solution from your school will be entered in the WaterFest competition, sponsored by the Mississippi Department of Environmental Quality in April, 2010. The team will defend their problem solution to the judges at WaterFest. Winners at WaterFest will receive prizes.

Situation

The scarcity of clean surface water was once a concern primarily of state and federal agencies. Recently it has attracted the attention of local communities. Community members are turning to environmental consulting companies such as yours for advice. Your company - Earth, Wind, and Water, Inc. - has helped many public agencies and private businesses in the towns of Brandon, Ridgeland, Madison, Jackson, Flowood and the Ross Barnett Reservoir area. Earth, Wind, and Water, Inc. monitors environmental quality. It develops practices that environmentally and economically benefit the greater Jackson Metropolitan area and neighborhoods within the Pearl River Valley Water Supply District.

Your newest client, Mr. Herrington, owns Pelahatchie Bay Trading Post. The Bay, as local area clientele call the establishment, is a business that sells fishing supplies and convenience food, offers sites to place boats into the reservoir, and has land based fishing spots near the trading post for use by the public. Mr. Herrington is upset over the fact that the fish in that stretch of the Reservoir have been become scarce. His business is suffering. He has called on your firm to figure out what is keeping the fish away from that section of the Reservoir and how to bring more fish to his area. He also wants your firm to develop a plan for monitoring the quality of the water near his business.

Examine various methods for monitoring water quality. Then prepare a creative presentation for your client in 3 formats (see below) that contains recommendations on where, when, and how to best monitor the surface water quality in the watershed near this place of business AND provides supporting scientific rationale. Include information about how to increase the fish population in this same area.

PRESENTATION: Your report can be presented to the judges in a variety of formats but **must include** one visual, one oral and one written piece. Examples are listed below. REMEMBER – the judges will be looking for original and creative presentation of your ideas.

TIME REQUIREMENTS: Your presentation must be 10 minutes long but no longer than 15 minutes. Going over or under the limit will decrease your score.

PRESENTATION FORMAT IDEAS: (*You are not limited to the following ideas but you must have one oral, one visual and one written product within your presentation.)*

ORAL

- Video or audio tapes (commercial / creative drama / editorial / documentary)
- Oral presentations (debates / games / interviews / panel discussions / plays or skits / simulations / songs or raps/ newscast)

WRITTEN

- Computer presentations (Power Point / Web page)
- Team portfolio (can include visual and written documents)
- Writings (articles for newsletters or newspapers, radio and TV scripts)

VISUAL

- Art projects (wall chart/ poster/ mural/ map/ creative art project)
- Display of scientific information (bulletin board/ memorandum to stakeholders

RUBRIC for PRESENTATION at WaterFest:

Group:

Teacher:

Title of Work:

School:

	Criteria				Points
	1	2	3	4	
Organization	Audience cannot understand presentation because there is no sequence of information.	Audience has difficulty following presentation because presenter jumps around.	Information presented in logical sequence which audience can follow.	Information presented in logical, interesting sequence which audience can follow.	____
Content Knowledge	Group does not have grasp of information; cannot answer questions about subject.	Group is uncomfortable with information and is able to answer only rudimentary questions.	Presenters are at ease with content, but fail to elaborate.	Presenters demonstrates full knowledge (more than required)with explanations and elaboration.	____
Scientific Conclusions	Analyses are not based soundly on scientific information.	Products show evidence that the group reached some valid conclusions but did not voice the analysis clearly or in a compelling way in the products.	Products show evidence that the group reached valid conclusions based on data analysis but did not voice the evidence clearly or in a compelling way in the products.	Products show evidence the group reached valid conclusions based on data analysis and displayed the results of the analysis in a clear and compelling way.	____
Problem Solution	The material presented does not address the problem statement.	Material presented addresses only one or two parts of the problem statement -- where, when and how to monitor water quality, scientific rationale to support the methodology, and how to increase fish population.	Material presented addresses most of the problem statement -- where, when and how to monitor water quality, scientific rationale to support the methodology, and how to increase fish population.	Material presented addresses where, when and how to monitor water quality, offers scientific rationale to support the methodology, and address increasing fish population.	____

Visuals	Student used no visuals.	Group had a visual but it did not fully support the purpose of the presentation.	Visuals related to the presentation.	Visuals used by presenters to reinforce the presentation in an effective manner..	____
Oral Presentation	Presentation hard to hear or follow; some terms pronounced or used incorrectly.	Presentation somewhat hard to hear and follow; pronunciation and use of terms is inaccurate at times; presentation is disjointed.	Presentation can be heard but may be hard to follow; pronunciation and use of terms is generally accurate; format of presentation is interesting.	Presentation easy to hear and follow; pronunciation and use of terms is precise; format of presentation is interesting, compelling.	____
Written Product	No written product was presented.	Written product was presented but lacked quality.	Written product was used in presentation in a manner that enhanced the overall effect.	Written product was used in presentation in a manner that enhanced the overall effect; product was well written.	____
Mechanics in all Products	Presentation materials had multiple spelling and/or grammatical errors, to the point of being distracting.	Presentation had some misspellings and/or grammatical errors.	Presentation has few misspellings and/or grammatical errors, none of which distracted from the meaning of the project.	Presentation has no misspellings or grammatical errors.	____
				Total---->	____

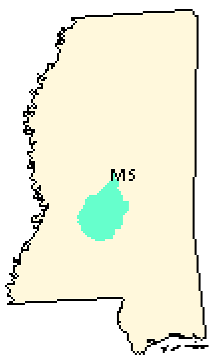
Judge Comments:

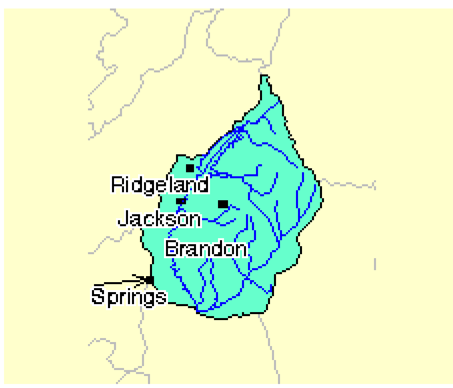
Watershed Information for Jackson Metropolitan Area

including counties: Copiah, Hinds, Leake, Madison, Rankin, Scott, Simpson, Smith

Middle Pearl-Strong Watershed -- 03180002

Middle Pearl-Strong





Watershed Profile

Watershed Name: Middle Pearl-Strong
USGS Cataloging Unit: 03180002
MS 2nd Congressional District
MS 3rd Congressional District

Citizen Based Groups at Work in this Watershed:

Ducks Unlimited – Southern Regional Office. Contact: Ross Melinchuk at 193 Business Park Drive Suite E, Ridgeland, MS 39157. Phone 601-956-1936 and Email: rmelinchuk@ducks.org and URL: http://www.ducks.org. Activity: Watershed Alliance Council.

Mississippi Wildlife Federation. Contact: Dr. Cathy Shropshire at 855 South Pear Orchard Rd. Suite 500, Ridgeland, MS 39157 and Phone: 601-206-5703 or Email cshropshire@mswf.org. and URL: htto://www.mswildlife.org. Activity: Watershed Alliance Council.

Go to Surf Your Watershed at http://cfpub.epa.gov/surf/locate/index.cfm for more information about this watershed. Information paorvided includes water quality monitoring data, environmental websites in the watershed, and National Watershed Network connection. Also at this site, access assessment of the health of the watershed (which water is impaired?)

Information provided by the United States Geological Survey (USGS)

- Stream Flow (Source: USGS)
- Science in Your Watershed
- Water use data (1985-2000): Information about the amount of water used and how it is used.
- Selected USGS Abstracts

Places Involving this Watershed

Other Watersheds Upstream:

- Upper Pearl

Other Watersheds Downstream:

- Middle Pearl-Silver

Related Links

Surf Your Watershed
Monitoring Water Quality
GLOBE Water Quality Monitoring Protocols at a Glance
U.S.G.S.: Water Resources of the United States
www.grin.hq.nasa.gov/ (great images from NASA)

References

Federal Water Pollution Control Administration. April 1, 1968. Water Quality Criteria: Report of the National Technical Advisory Committee to the Secretary of the Interior (pp. 32-34).

Merritts, D., DeWet, A., Menking, K. (1998). Environmental Geology: An Earth System Science Approach. W.H. Freeman and Company. New York, NY.

National Sanitation Foundation Water Quality (Eutrophication) Index. http://rock.geo.csuohio.edu/novp/wqi.htm

Schlesinger, W. H. (1991). Biogeochemistry: An Analysis of Global Change. Academic Press, Inc., New York, NY.

Smith, R. L. (1990). Ecology and Field Biology. HarperCollins Publishers, Inc., New York, NY.

Vannote, R. L., Minshall, G. W., Cummins, K. W., Schell, J. R., Cushing, C. E. (1980). The river continuum concept. Can. J. Fish. Aq. Sci., 37: 130-137.

http://www.cotf.edu/ete/modules/waterq3/WQintermpuzzle.html

Scientific Based Competition Problem – Teacher Materials

TEACHER:

Utilize the materials in this document as you see fit to assist your students with devising a solution to the competition problem. You may want to have student explore on the Internet and in resource materials to locate this information but if they are having difficulty finding it, you can use the attached information as a 'starter' or as teaching material. There are a list of related links in the problem statement document.

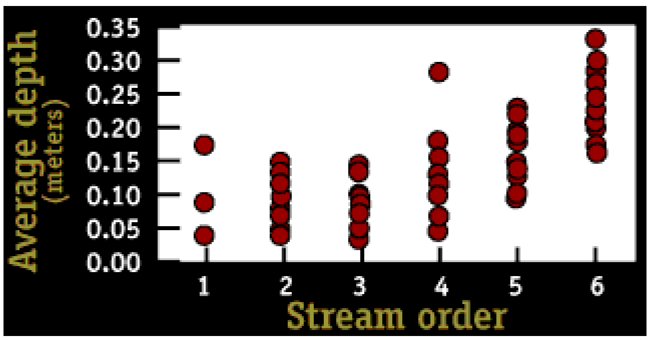
The Watershed quality charts provided below are from Wheeling, Ohio as information was not available in this format for the Reservoir and Pearl River Water Supply District. You may want to have student groups walk through this information in order to grasp the variety of information that can be gathered regarding water quality.

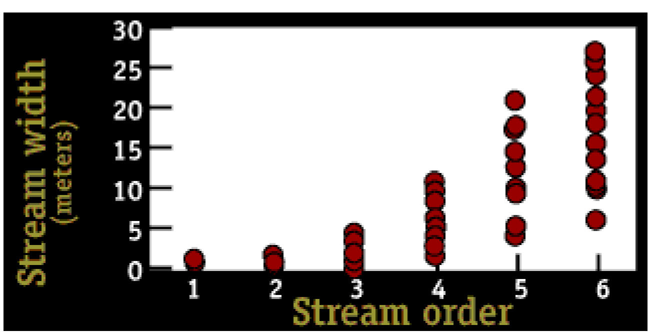
The description of problem based learning is provided to assist teachers who have not utilized this strategy in their classes. This information should be useful in organizing student groups to find solutions to the problem statement.

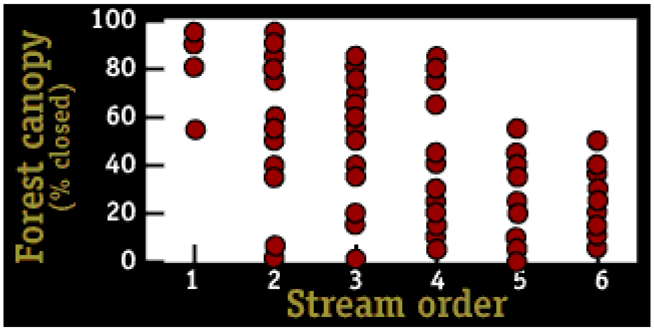
There is a glossary at the end of this document with terms that are useful in this study.

Watershed Water Quality: Physical Characteristics of Wheeling Creek Streams

**NOTE: Use this information from Wheeling, Ohio in the solution of the problems as similar information is not available for the Reservoir and Pearl River Water Supply District

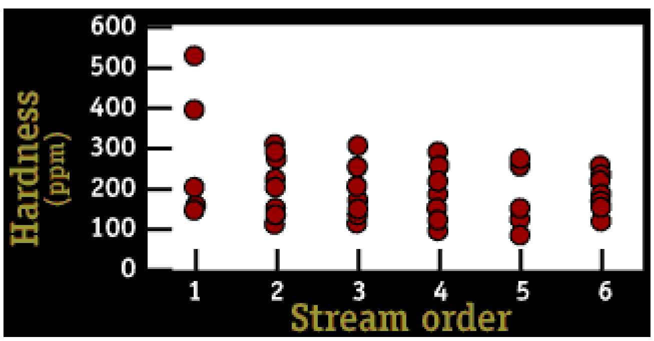






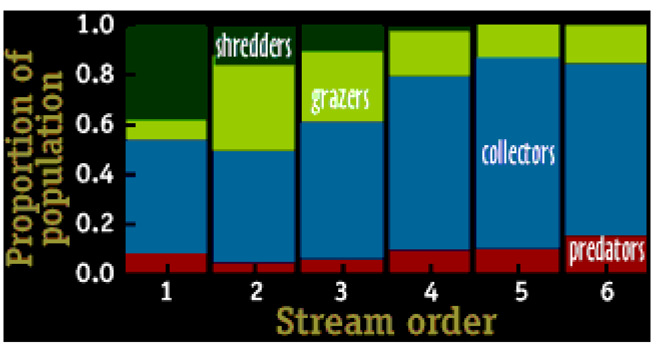
Watershed Water Quality: Chemical Characteristics of Wheeling Creek Streams

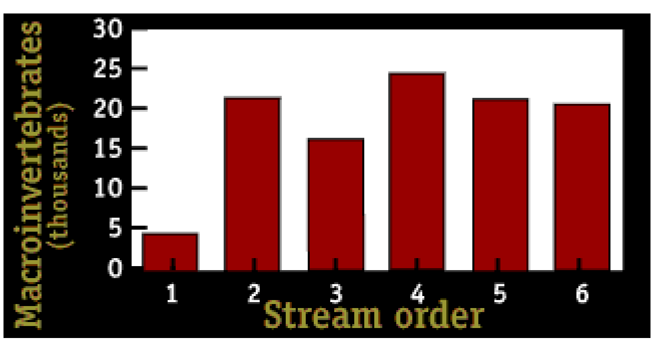
**NOTE: Use this information from Wheeling, Ohio in the solution of the problems as similar information is not available for the Reservoir and Pearl River Water Supply District

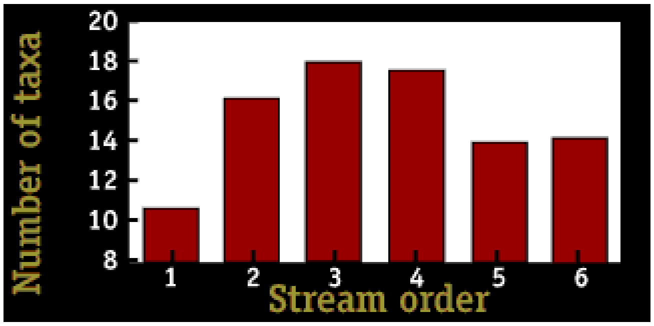


Watershed Water Quality: Biological Characteristics of Wheeling Creek Streams

**NOTE: Use this information from Wheeling, Ohio in the solution of the problems as similar information is not available for the Reservoir and Pearl River Water Supply District



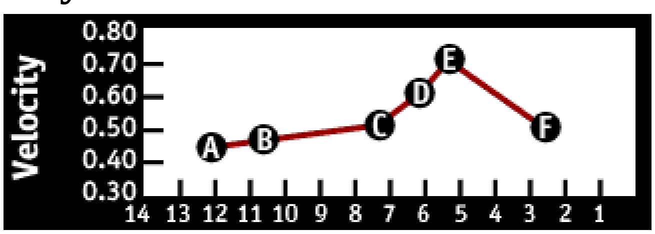


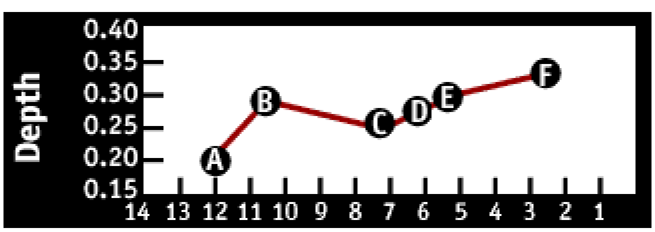


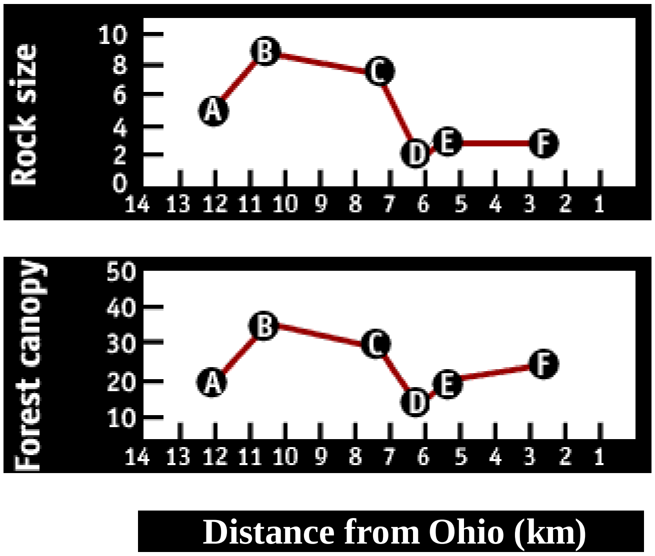
Watershed Water Quality: Water Quality Baseline

Any measure of water quality is useful if there is something to compare that value to. A group of values for the various measures of water quality in a given region is generally referred to as a baseline. The baseline water quality in Wheeling Creek was collected at over 100 sites within the Wheeling Creek watershed in Ohio.

Physical Characteristics

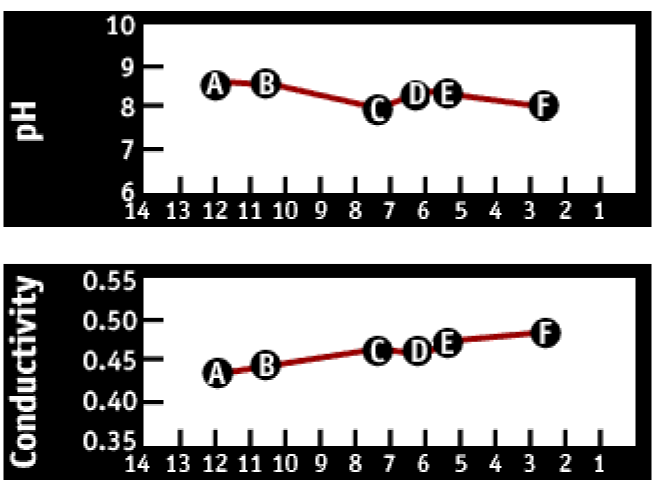


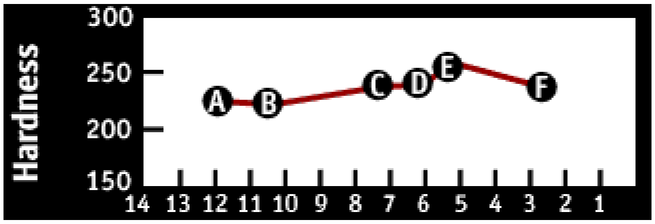


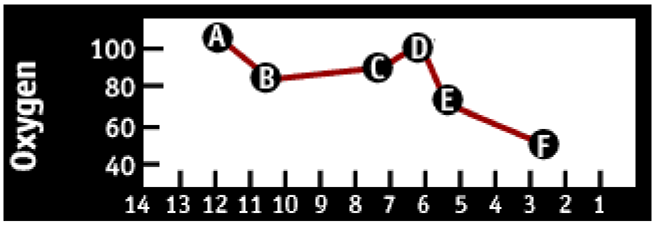


**NOTE: Use this information from Wheeling, Ohio in the solution of the problems as similar information is not available for the Reservoir and Pearl River Water Supply District

Chemical Characteristics

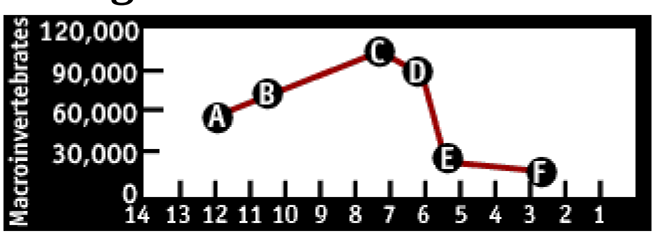


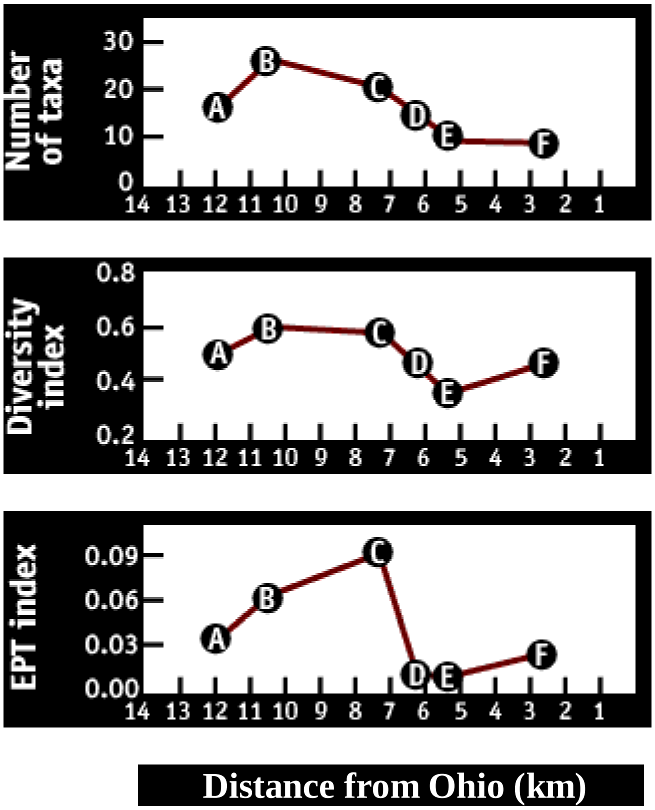




**NOTE: Use this information from Wheeling, Ohio in the solution of the problems as similar information is not available for the Reservoir and Pearl River Water Supply District

Biological Characteristics





**NOTE: Use this information from Wheeling, Ohio in the solution of the problems as similar information is not available for the Reservoir and Pearl River Water Supply District

Additional Data

Physical, chemical, and biological data for the six lower Wheeling Creek sites are provided in the following tables that may be viewed and printed. Which of the macroinvertebrates is most sensitive to water quality in lower Wheeling Creek? **NOTE: Use this information from Wheeling, Ohio in the solution of the problems as similar information is not available for the Reservoir and Pearl River Water Supply District

Physical Characteristics of Lower Wheeling Creek Sites

Site	A	B	C	D	E	F

Distance to Ohio River	meters	12024	10565	7350	6195	5361	2585
Stream order		6	6	6	6	6	6
Catchment area	square kilometers	72931	73839	74277	76259	76416	76577
Built-up area	square kilometers	1300	1376	1648	1881	1907	1926
Percent built-up	percent	1.78	1.86	2.22	2.47	2.50	2.51
Elevation	meters	214	208	214	209	212	210
Distance to source	kilometers	1083	1192	3189	2913	2446	5222
Water temperature	degrees Celcius	15.5	15.8	16.6	13.2	14.4	13.5
Air temperature	degrees Celcius	14.0	17.4	17.4	14.4	15.0	12.0
Stream width	meters	26.2	18.0	24.0	15.5	14.9	19.1
Average depth	meters	0.204	0.288	0.250	0.274	0.293	0.328
Maximum depth	meters	0.290	0.480	0.470	0.500	0.475	0.580
Minimum velocity	meters per second	0.160	0.160	0.170	0.160	0.210	0.160
Maximum velocity	meters per second	0.830	0.900	0.980	1.200	0.950	0.800
Average velocity	meters per second	0.450	0.470	0.520	0.610	0.700	0.510
Discharge (flow)	cubic meters per second	2.410	2.435	3.125	2.594	3.058	3.198
Forest canopy	percent shaded	20	35	30	15	20	25

Average rock size	diameter in centimeters	5.07	8.84	7.46	2.09	2.91	2.90
Maximum rock size	diameter in centimeters	10.16	20.29	11.36	5.56	5.48	10.02

Chemical Characteristics of Lower Wheeling Creek Sites

	Sites	A	B	C	D	E	F
pH	-log hydrogen ions	8.64	8.60	7.98	8.38	8.38	8.05
Conductivity	µmhos	0.436	0.446	0.462	0.462	0.472	0.484
Salinity	parts per million	0.2	0.2	0.2	0.2	0.2	0.2
Dissolved oxygen	percent saturation	107.30	84.60	90.60	101.90	72.70	51.40
Dissolved oxygen	parts per million	10.45	8.17	8.59	10.41	7.23	5.22
Alkalinity	parts per million	170.0	180.0	176.0	188.0	188.0	172.0
Hardness	parts per million	222.0	222.0	239.0	239.0	257.0	239.0

Macroinvertebrate Characteristics of Lower Wheeling Creek Sites

	Site	A	B	C	D	E	F
Total number of organisms	number per square meter	58,859	74,567	103,396	88,808	26,495	17,799
Mayflies (Ephemeroptera)	number per square meter	542	1,203	3,669	193	33	28
Stoneflies (Plecoptera)	number per square meter	165	443	236	189	28	66

Caddisflies (Trichoptera)	number per square meter	203	349	184	85	61	113
Beetles (Coleoptera)	number per square meter	901	575	283	556	99	42
Midges (Diptera: Chironomidae)	number per square meter	26,457	31,932	43,969	39,157	12,876	8,142
Other true flies (Diptera)	number per square meter	19	38	66	19	33	38
Dobson and Alderflies (Megaloptera)	number per square meter	0	0	5	5	0	0
Crustaceans	number per square meter	0	9	5	0	0	9
Annelid worms	number per square meter	170	193	462	217	24	344
Mollusks	number per square meter	9	42	585	24	28	5
Percent EPT index macroinvertebrate quality	(Ephem. + Plecop. + Trichop) / Total number of organisms	0.015	0.027	0.040	0.005	0.005	0.012
Shannon index of diversity	H'	0.503	0.597	0.580	0.477	0.367	0.470

Breakdown of the Earth's Fresh Water:

Earth's Fresh Water				
Nonsurface	Water	Surface	Water	
Ice	77.197	Streams & Rivers	0.004	
Ground	22.260	Lakes	0.323	

Atmosphere	0.036			
Soil	0.180			
Totals =	**99.673**	**+**	**0.3270**	**= 100% (of Earth's 1% of Freash Water)**

The portion of Earth's freshwater supply that is found in streams, rivers, and lakes is called surface water. (Ground water, and the water in the polar caps, glaciers, soil, and atmosphere, though also fresh, is not considered surface water.) It is from surface-water sources that most U.S. communities draw water for everyday use.

Clean surface water has been a concern of U. S. legislators since the 1950s and1960s, when it was observed that fish were dying in the nation's lakes. The Clean Water Act of 1972 requires that each state conduct water quality surveys to determine the overall health of its surface water supplies. Every two years the states must report their findings to the Environmental Protection Agency (EPA), which in turn prepares a biennial report to Congress. The report is a complete and up-to-date snapshot of water quality conditions throughout the country.

The states, Native American Tribes, and other jurisdictions also define appropriate uses for surface water and consider these uses when outlining water quality standards, which are then presented to the EPA for approval. One reason for these standards is to promote safe living conditions for aquatic life. These conditions, in turn, lead to fish and shellfish that are fit for human consumption and to clean water for drinking, swimming, boating, fishing, and agricultural irrigation.

Once a concern mainly of the states and federal agencies, the scarcity of clean surface water has recently attracted the attention of local communities, and more local agencies have been taking an active part in monitoring this vital commodity.

Methods for Monitoring Water Quality

Common Biological Measures

Benthic macroinvertebrates are frequently used as a biological water quality indicator because they are abundant, easier to capture than fish, and because they are easier to identify than algae or protozoans. Macroinvertebrate samples can be collected using a Hess sampler in larger (fifth and sixth-order) streams or a Surber sampler in smaller streams. Macroinvertebrates are identified and enumerated, and the number of organisms at each site is estimated from the average of three same size sample areas. Benthic macroinvertebrate densities are reported as the total number of organisms per square meter of stream bottom. In addition to the total number of those organisms, measures of diversity particularly at the taxonomic level of order such as mayflies, stoneflies, beetles, and other organisms should also be noted. The Shannon index and the EPT index measure the diversity and quality of an invertebrate community respectively.

Common Chemical Measures

Assessment of water quality by chemical measures includes measures of various elements and molecules dissolved or suspended in water. Chemical measures commonly used in water-quality field surveys can reveal an imbalance within the ecosystem. For instance, **pH** identifies acid/base balance of water. Low pH values (indicating acidity) are particularly useful for detecting acid mine drainage. However, since some streams are naturally acidic, a low pH does not necessarily indicate acid mine drainage. Conversely, in systems with high **alkalinity**--a measure of the water's ability to buffer or resist changes in pH--normal pH values may not rule out the presence of acidmine drainage.

The level of **nitrates** in a body of water is another chemical measure of water quality. Nitrogen exists in water in numerous forms, two of which are nitrate (NO_3) and nitrite (NO_2). Of these two forms, nitrate is usually the most important. Nitrate is an essential nutrient for growth of algae and other aquatic plants, and can be present at high levels due to a variety of sources. Nitrate is very difficult to measure directly. A common procedure is to first measure the level of nitrite and then reduce the nitrate to nitrite and measure the combined nitrite concentration. Subtracting the original nitrite level from the combined nitrite concentration will give you the nitrate level. Nitrate measurements are reported as nitrate nitrogen (mg/L). Nitrite measurements are reported as nitrite nitrogen (mg/L).

Some chemical indicators are specific to particular forms of pollution. For instance, low **dissolved oxygen** often results from either the presence of raw sewage or acid mine drainage.

Other "chemical" measures are actually physical measurements that indicate the presence of chemicals in the water. For instance, **conductivity**--the ability to conduct an electrical current--is a physical measurement that indicates the presence of chemical ions in the water sample. For example, when table salt (NaCl, sodium chloride) dissolves in water, it forms ions (Na+ and Cl-) that allow a current of electricity to pass through the water. Water **density** is another physical measurement that indirectly indicates the presence of chemicals. The density of water is related to salt content (salinity) and water temperature. The salinity of a body of water is one of the main factors determining what organisms will be found there.

Common Physical Measures

A variety of methods exist to determine several physical characteristics of surface water within a given watershed:

- Stream order
- Catchment area (square kilometers)
- Built-up area (square kilometers)
- Percent built-up (percent)
- Elevation (meters)
- Water temperature(degrees Celcius)
- Air temperature(degrees Celcius)
- Stream width (meters)
- Average depth (meters)
- Maximum depth (meters)
- Minimum velocity (meters per second)
- Maximum velocity (meters per second)
- Average velocity (meters per second)
- Discharge [flow] (cubic meters per second)
- Forest canopy (percent shaded)
- Average rock size (diameter in centimeters)
- Maximum rock size (diameter in centimeters)
- Water transparency (Secchi disk or turbidity tube)

Water Quality Assessment: Overview

Water quality is determined by assessing three classes of attributes: **biological, chemical,** and **physical.** There are standards of water quality set for each of these. The national standards for drinking water are developed by the federal government's Environmental Protection Agency (EPA). All municipal (public) water supplies must be measured against these standards.

Some attributes are considered of primary importance to the quality of drinking water, while others are of secondary importance. Therefore, the EPA drinking water standards are categorized as primary drinking water standards and secondary drinking water standards.

Primary drinking water standards regulate organic and inorganic chemicals, microbial pathogens, and radioactive elements that may affect the safety of drinking water. These standards set a limit--the Maximum Contaminant Level (MCL)--on the highest concentrations of certain chemicals allowed in the drinking water supplied by a public water system.

Secondary drinking water standards regulate chloride, color, copper, corrosivity, foaming agents, iron, manganese, odor, pH, sulfates, total dissolved solids, and zinc, all of which may affect qualities of drinking water like taste, odor, color, and appearance. The concentration limit of these contaminants is referred to as the Secondary Maximum Contaminant Level (SMCL).

State agencies are responsible for monitoring public water supplies and enforcing the primary and secondary drinking water standards set by the EPA. Local water districts (like the *Pearl River Valley Water Supply District*) must test and treat water and maintain the EPA standards for quality. These districts are also responsible for informing the public when any water quality standards have been violated.

Given these standards, stream- and groundwater supplies should be of high quality. Generally, one compares the values for the various measures of stream- and groundwater quality at a given time and location to the average of those values across the entire **watershed.** This "average" water quality across a watershed is referred to as the watershed's "baseline."

Water Quality Assessment: Biological

Biological attributes of a waterway can be important indicators of water quality. Biological attributes refer to the **number and types of organisms** that inhabit a waterway. The poorer the quality of water, the fewer the number and types of organisms that can live in it.

Photo: *Justicia americana* in Wheeling Creek. Photo courtesy of Dr. Ben Stout.

When assessing water quality, it is also important to look at the quality of organisms that live in a waterway. Some species are more sensitive to **chemical** and **physical** changes in their habitat than other species. If species that tend to be sensitive to pollution are present in a waterway, then that waterway most likely has good water quality.

Water Quality Assessment: Biological: Macroinvertebrates

To assess the biological attributes of water quality, scientists generally examine **benthic macroinvertebrates**. These organisms are abundant, easier to capture than fish, and easier to identify than algae or protozoa. Benthic macroinvertebrates include crustaceans, mollusks, worms, and many species of insect larva such as mayflies, stoneflies, caddisflies, and beetles. Samples of macroinvertebrates can be collected over areas of uniform size using a Hess sampler in large streams. A Surber sampler is usually used in smaller streams. Generally, three samples are collected from one **riffle** per study site.

Macroinvertebrates from each sample are identified and counted. The density of organisms per square meter of stream bottom at each site is estimated from the average of the samples collected there. A calculation of species diversity such as the **Shannon Index of Species Diversity** can be performed on this data. The Shannon Index of Species Diversity is often performed on macroinvertebrate order data rather than species data.

The abundance of macroinvertebrates belonging to the orders *Ephemeroptera*, *Plecoptera*, and *Trichoptera* should be noted. These three orders constitute the **EPT Index** of a stream. Since these orders of macroinvertebrates are highly sensitive to pollution, they are often used as water quality indicators. Their presence indicates a high quality of water, while their absence suggests water may be polluted. The EPT Index is calculated as the sum of the number of *Ephemeroptera*, *Plecoptera*, and *Trichoptera* divided by the total number of midges. Midges (*Diptera*: *Chironomidae*) are a species of fly that are present in large numbers in nearly all streams.

Students using a Hess sampler to collect benthic sample in a large stream in a watershed. Photo courtesy of Dr. Ben Stout.

Students using a Surber sampler to collect benthic sample in a small stream in awatershed. Photo courtesy of Dr. Ben Stout.

Water Quality Assessment: Chemical

Chemical attributes of a waterway can be important indicators of water quality. Chemical attributes of water can affect aesthetic qualities such as how water looks, smells, and tastes. Chemical attributes of water can also affect its toxicity and whether or not it is safe to use. The chemical quality of water is important to the health of humans as well as the plants and animals that live in and around streams. So, it is necessary to assess the chemical attributes of water.

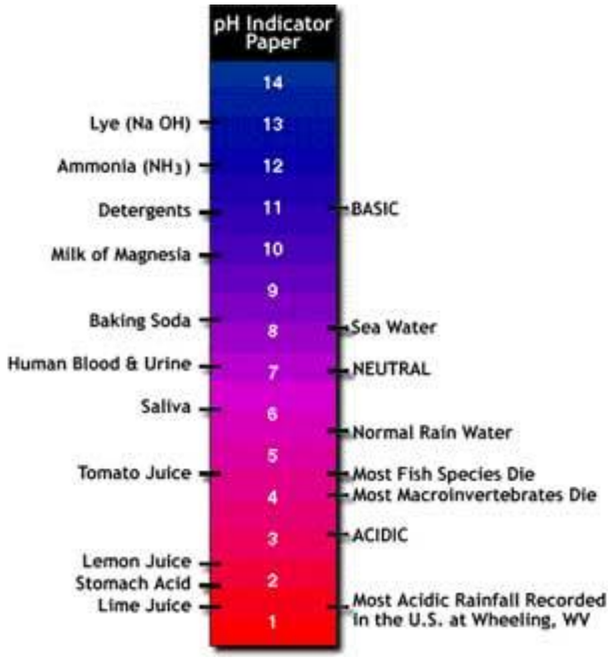
Assessment of water quality by its chemistry includes measures of many elements and molecules dissolved or suspended in the water. Chemical measures can be used to directly detect pollutants such as lead or mercury. Chemical measures can also be used to detect imbalances within the ecosystem. Such imbalances may indicate the presence of certain pollutants. For example, elevated acidity levels may indicate the presence of **acid mine drainage.**

Commonly measured chemical parameters include **pH, alkalinity, hardness, nitrates, nitrites and ammonia, ortho and total phosphates, and dissolved oxygen and biochemical oxygen demand.** The presence of **fecal coliform**, a bacteria, is also determined using a chemical test. This microscopic organism is too small to detect during the **biological assessment** of macroinvertebrate populations. In addition, some "chemical" measurements actually indicate the physical presence of pollutants in water. These include measurements such as **conductivity and density.**.

Measurements of these chemical parameters of water quality can be made one at a time using low-tech field titration kits such as Hach Kits. However, several of these parameters may be measured at once using high-tech equipment such as the YSI 3800 Water Quality Logger..

Water Quality Assessment: Chemical: pH

The most commonly measured chemical attribute of water is its acidity or pH. The pH scale ranges from 1 to 14, with 1 being the most acidic and 14 being the most basic. Most streams have a neutral to slightly basic pH of 6.5 to 8.5. If streamwater has a pH less than 5.5, it may be too acidic for fish to survive in, while streamwater with a pH greater than 8.6 may be too basic.



A change in streamwater pH can also affect aquatic life indirectly by altering other aspects of water chemistry. For example, low pH levels can increase the solubility of certain heavy metals. This allows the metals to be more easily absorbed by aquatic organisms.

A shift of pH in either direction from neutral may indicate the presence of a pollutant in the stream. However, since some streams are naturally acidic — or basic — pH may not necessarily indicate pollution. The pH of clean water depends on several factors, including the types of rock and vegetation within the **watershed**. The water that enters a stream passes through the canopy of the trees, goes through the soil, and flows through the groundwater system to eventually empty into the stream. During its travels, the water weathers the rocks and soils and picks up acidic and alkaline (high pH) compounds throughout the watershed. For example, streams draining forests and marshes are often slightly acidic due to the presence of humic acids produced by decaying vegetation in the soil. On the other hand, streams in watersheds situated on limestone ($CaCO_3$) contain high concentrations of bicarbonate ions. This results in alkaline waters.

Alkaline water can act as a weak **buffer** solution, depending on the concentrations of carbonates and bicarbonates. Therefore an acidic pollutant may be present in such water, yet not cause a change in the stream's pH. For this reason, **alkalinity** should be examined in conjunction with pH.

Water Quality Assessment: Chemical: Alkalinity

The natural **buffering capacity** of a stream may mask the presence of acidic or basic pollutants. Therefore simply measuring a stream's **pH** may not be sufficient. For a more complete assessment of water quality, most scientists also measure streamwater **alkalinity**. Alkalinity is measured to determine the ability of a stream to resist changes in **pH**. That is to say alkalinity allows scientists to determine a stream's buffering capacity.

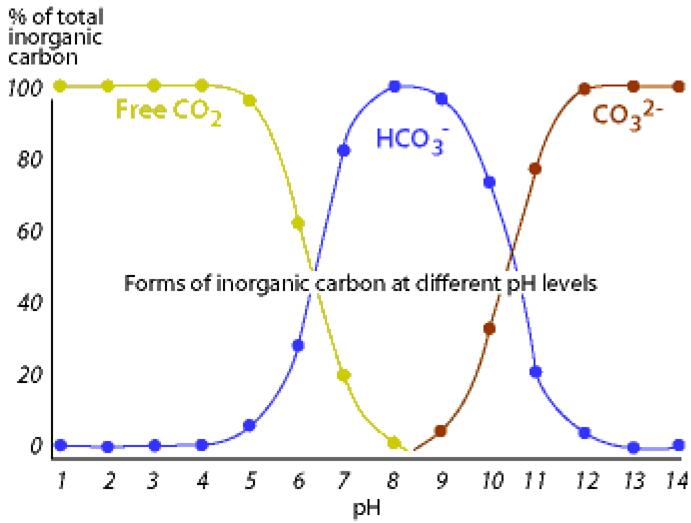
Alkalinity values of 20-200 **ppm** are common in freshwater ecosystems. Alkalinity levels below 10 ppm indicate poorly buffered streams. These streams are the least capable of resisting changes in pH, therefore they are most susceptible to problems which occur as a result of acidic pollutants.

The Chemistry of Alkalinity

Alkalinity results from the dissolution of calcium carbonate ($CaCO_3$) from limestone bedrock which is eroded during the natural processes of weathering. The carbon dioxide (CO_2) released from the calcium carbonate into the streamwater undergoes several **equilibrium reactions**. Equilibrium reactions are those that go in either direction, depending on what compounds are present in the largest concentrations. The following set of reactions is referred to as the bicarbonate **buffering** system:

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^- \leftrightarrow 2H^+ + CO_3^{2-}$$

As depicted in the above set of reactions, carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions act as hydrogen ion absorbers. This causes the reactions of the bicarbonate buffering system to shift left or right while maintaining a relatively constant pH. If hydrogen ions are added to the solution, they combine with available bicarbonate or carbonate ions, causing the reactions to shift to the left and eventually liberate carbon dioxide and water molecules. The addition of carbonate to the solution causes the hydrogen ions to be occupied and shifts the reactions to the right. In this way, an alkaline stream with a large buffering capacity is able to "hold" more acidic pollutant without displaying a significant decrease in pH.



Data courtesy of Dr. Ben Stout.

Water Quality Assessment: Chemical: Hardness

Stream water hardness is the total concentration of cations, specifically calcium (Ca^{2+}), magnesium (Mg^{2+}), iron (Fe^{2+}), and manganese (Mn^{2+}), in the water. Water rich in these cations is said to be "hard." Stream water hardness reflects the geology of the **catchment area**. Sometimes it also provides a measure of the influence of human activity in the area.

For the most part, however, hardness is a reflection of the amount of calcium and magnesium entering the stream through the weathering of rock such as limestone ($CaCO_3$). When limestone is weathered, it dissolves into calcium (Ca^{2+}) and carbonate (CO_3^{2-}). Calcium is an important nutrient that is used by plants and animals. Carbonate **buffers** the stream's **pH** . Although these two ions are beneficial to a stream, they can cause problems in a home. Foaming agents such as those in soaps and detergents do not work as well in hard water. Also, hard water tends to leave hard, scaly calcium deposits on faucets. This is why many people install water softener systems in their homes.

Water Quality Assessment: Chemical: Nitrates, Nitrites, and Ammonia

Nitrogen is an essential nutrient that is required by all plants and animals for the formation of amino acids. In its molecular form, nitrogen cannot be used by most aquatic plants, therefore it must be converted to another form. One such form is ammonia (NH_3). Ammonia may be taken up by plants or oxidized by bacteria into nitrate (NO_3^-) or nitrite (NO_2). Of these two forms, nitrate is usually the most important. However, it is very difficult to directly measure nitrate.

Although nitrogen is an essential nutrient for all aquatic plants and animals, it is possible to have too much of a good thing. Excessive concentrations of nitrogen can lead to **eutrophication** and subsequent **degradation** of stream water quality. In addition, if water containing nitrate levels greater than 10 mg NO_3^-N/L is used to prepare infant formula, it can result in methemoglobinemia. Methemoglobinemia is a condition in which red blood cells are prevented from transporting oxygen throughout the body. If the condition persists, the infant can suffocate.

Common sources of excessive nitrogen include **sewage** and **agricultural runoff**. Elevated stream water nitrogen levels may indicate the presence of one or both of these forms of pollution.

Water Quality Assessment: Chemical: Ortho- and Total Phosphate

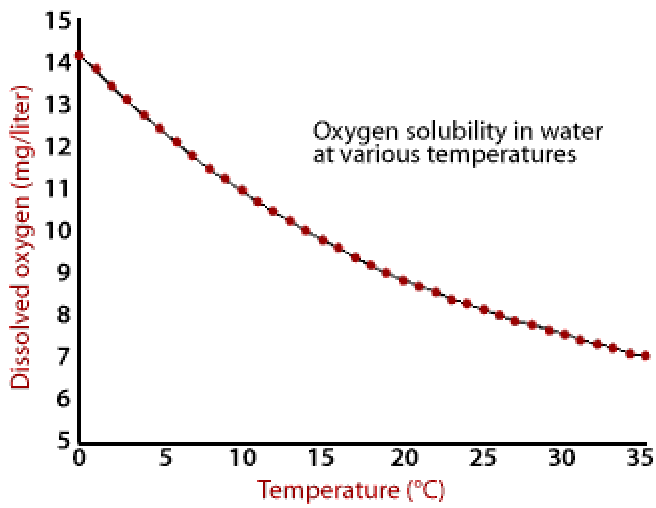
Phosphorus is a nutrient essential for the metabolic reactions of plants and animals. Once it enters the ground water or a stream, it quickly bonds to soil particles, making it temporarily unavailable to living organisms. Since it naturally occurs in low levels, phosphorus is often the "growth-limiting" factor for plants.

Phosphorus occurs in several forms—both inorganic and organic. Inorganic orthophosphate (PO_4^{3-}) is the only form available to living organisms. However, the other forms of phosphate can be transformed into orthophosphate. For this reason, total phosphate is generally measured in addition to orthophosphate. The measure of total phosphate provides an estimate of the amount of phosphorus potentially available to plants and animals.

Since the phosphorus requirements of algae are minimal, rapid algal growth occurs when excess phosphorus is present in streams. Common sources of excess phosphorus include **agricultural runoff** from feed lots and fertilized fields, and **sewage** that contains organic phosphorus as well as inorganic phosphorus in products such as detergents. The resulting algal bloom can lead to **eutrophication** and the subsequent **degradation** of stream water quality

Water Quality Assessment: Chemical: Dissolved Oxygen and Biochemical Oxygen Demand

Oxygen is essential for the survival of nearly every living thing — even those living in water. The two main sources of dissolved oxygen in stream water are the atmosphere and aquatic plants. Atmospheric oxygen is mixed into stream water as waves crash along the **riffles**. Aquatic plants introduce oxygen into stream water as a byproduct of **photosynthesis**. The amount of oxygen that can dissolve in water is limited by physical conditions such as **temperature** and atmospheric pressure.



Data courtesy of Dr. Ben Stout.

The above graph shows the maximum amount of oxygen that can be dissolved in water at various temperatures. Assuming a constant atmospheric pressure, water of low temperatures can hold more oxygen than water of high temperatures.

One unit of measure of dissolved oxygen in water is parts per million (**ppm**), which is the number of oxygen (O_2) molecules per million total molecules in a sample. Calculating the percent saturation is another way to analyze dissolved oxygen levels. Percent saturation is the measured dissolved oxygen level divided by the greatest amount of oxygen that the water can hold at that particular temperature and atmospheric pressure, then multiplied by 100.

Fish growth and activity usually require 5-6 ppm of dissolved oxygen. Dissolved oxygen levels below 3 ppm are stressful to most aquatic organisms. Levels below 2 ppm will not support fish at all.

Low dissolved oxygen levels can be the result of elevated temperature and thus the inability of the water to hold the available oxygen. Low dissolved oxygen levels can also indicate an excessive demand on the oxygen in the system. Some pollutants such as **acid mine drainage** produce direct chemical demands on oxygen in the water for certain oxidation-reduction reactions. Other pollutants such as **sewage** or **agricultural runoff** result in the build up of organic matter and the consumption of dissolved oxygen by microbial decomposers as they break down the organic matter.

The measure of the amount of oxygen used by aerobic bacteria during decomposition is called biochemical oxygen demand (BOD). Biochemical oxygen demand can be determined by collecting two water samples and immediately measuring the dissolved oxygen concentration in one of them--Sample 1. The second sample--Sample 2--is incubated at room temperature for 5 days. The incubation bottle should be in complete darkness to prevent the production of more dissolved oxygen within the sample through the process of photosynthesis. Bacteria in the incubated sample will metabolize normally, consuming dissolved oxygen in the process. After the 5 day incubation period, the dissolved oxygen concentration in Sample 2 is determined. To calculate BOD, subtract the amount of dissolved oxygen in Sample 2 from the amount of dissolved oxygen in Sample 1. This is the amount of oxygen that has been used, or demanded, by microbes during the 5-day incubation period. Unpolluted natural waters will have a BOD of 5 mg/L or less.

Water Quality Assessment: Chemical: Fecal Coliform

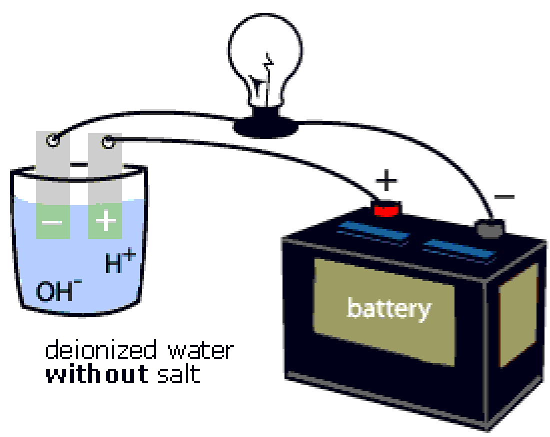
Fecal coliform is a bacteria that occurs in the digestive tracks of warm-blooded animals. It aids in the process of digestion. Fecal coliform can enter a stream by direct discharge from mammals and birds, from **agricultural runoff**, or from open or broken **sewers**. Fecal coliform is itself non-**pathogenic**. However, it is evidence of the presence of fecal wastes that may contain pathogenic microbes.

High levels of fecal coliform--greater than 200 colonies per 100 mL of water—are a good indicator that pathogenic microorganisms may be present. Disease-causing microorganisms can enter the body though cuts in the skin, or through the mouth, eyes, ears, or nose. They can result in health problems ranging from common diarrhea and ear infections to deadly diseases such as hepatitis, cholera, or even typhoid fever. Therefore, it is suggested that one does not have total body contact with water containing levels of fecal coliform greater than 200 colonies per 100 mL of water.

Water Quality Assessment: Chemical: Conductivity and Density

Conductivity is the ability of water to carry an electrical current. It indicates the physical presence of dissolved chemicals in the water. For example, when sodium chloride (NaCl, table salt) dissolves in water, it dissociates into Na^+ and Cl^- ions. The movement of these ions conducts electricity through the water. The dissociation of naturally-occurring, inorganic compounds is the main source of ions in stream water. Conductivity can also increase as a result of heavy metal ions released from pollutants such as acid mine drainage.

To "see" the electrical current being carried by Na^+ and Cl^- ions, try the following activity. First, connect the positive terminal of a battery to an electrode. Place the electrode in a glass of deionized water. Next, connect the negative terminal of the battery to a light bulb, then connect the light bulb to an electrode. Place the electrode in a glass of deionized water (see animation below). Notice that the light bulb does not glow. Add some salt (NaCl) to the deionized water (see animation below). Notice that the light bulb starts to glow. That is because the Na^+ and Cl^- ions complete the circuit between the positive and negative electrodes. They enable the electrical current to flow through the circuit.



Like conductivity, water density is an indicator of the physical presence of chemicals in water. The density of water is related to salt content and water temperature. This is a very useful parameter to measure because the salinity of a body of water is one of the main factors determining what organisms will be found there.

Water Quality Assessment: Physical

Physical attributes of a waterway can be important indicators of water quality. The most basic physical attribute of a stream is the path along which it flows. Most streams are classified as "meandering" or S-shaped. Meandering streams have many bends. The bends are characterized by deep pools of cold water along the outside banks where faster-moving water scours the bank. Meandering streams also have **riffles** along the straight stretches between pools. The riffles appear as humps in a longitudinal stream profile.

The S-shaped path of meandering streams prevents water from moving too quickly and flooding downstream ecosystems. The deep, cold pools of water provide ideal habitat for many species of fish — even when overall stream-flow is reduced. The riffles help to hold water upstream during times of low stream-flow. Also, turbulence in the riffles mixes oxygen into the water. Natural stream-channel patterns, with their bends, pools, and riffles, are essential to decreasing flooding as well as providing a suitable habitat for certain aquatic plants and animals. For these reasons, it is important to assess the physical attributes of a stream when examining its water quality.

Measurements of a stream's physical attributes are used to describe the structure of a sampling site. This allows for the comparison of the **biota** and chemistry of similarly-structured streams at different locations. Measurements of a stream's physical attributes can also serve as indicators of some forms of pollution. For example, changes in **temperature** may indicate the presence of certain **effluents**, while changes in stream **width, depth and velocity, turbidity**, and **rock size** may indicate **dredging** in the area.

Other commonly measured physical characteristics of a stream include:**elevation, catchment area, stream order, forest canopy** and **total solids.** .

Water Quality Assessment: Physical: Elevation and Catchment Area

Elevation and **catchment area** of a **watershed** can be obtained from topographic maps of the sample area. Image: Topographic map of Wheeling, WV. Image courtesy of USGS

Elevation information is printed directly on topographic maps. The investigator need only find the location of the site and read the corresponding elevation. Catchment area can be measured on a topographic map using a **planimeter**. A planimeter is a piece of clear plastic covered with evenly-spaced dots. The investigator places the planimeter on the topographic map and counts the number of dots that lie within the watershed's boundaries. Planimeters are calibrated so that one can calculate the area (km^2) of the watershed from the number of planimeter dots that cover it.

Water Quality Assessment: Physical: Stream Order

Stream order is a measure of the relative size of streams. The smallest **tributaries** are referred to as first-order streams, while the largest river in the world, the Amazon, is a twelfth-order waterway. First- through third-order streams are called **headwater** streams. Over 80% of the total length of Earth's waterways are headwater streams. Streams classified as fourth- through sixth-order are considered medium streams. A stream that is seventh-order or larger is a river.

When diagramming stream order, scientists begin by identifying the first-order streams in a watershed. First-order streams are perennial streams--streams that carry water throughout the year--that have no permanently flowing tributaries. This means no other streams "feed" them.

Once the first order streams are identified, scientists look for intersections between streams. When two first-order streams come together, they form a second-order stream. When two second-order streams come together, they form a third-order stream. And so on. However, if a first-order stream joins a second-order stream, the latter remains a second-order stream. It is not until one stream combines with another stream of the same order that the resulting stream increases by an order of magnitude..

Examining the stream network is important in determining study sites. It is best to sample a stream above and below any point at which a tributary enters it, as well as in the tributary itself. The result is 3 sample sites at each intersection of two streams. This is done in order to narrow down the location of any potential pollutants.

Stream order is also an important part of the **River Continuum Concept**. The River Continuum Concept is a model used to determine the **biotic community** expected in a stream based on the size of the stream itself. As water travels from headwater streams toward the mouths of mighty rivers, the **width, depth and velocity** of the waterways gradually increase. The amount of water they discharge also increases. These physical characteristics dictate the types of aquatic organisms that can inhabit a stream.

Water Quality Assessment: Physical: Forest Canopy

Canopy cover is the percentage of a sample area shaded by vegetation. Canopy cover plays an important role in stream water quality. For example, **headwater streams** are generally located deep within forests where canopy cover is nearly 100%. The canopy provides nutrient inputs through litter fall. It also provides shade that keeps the stream water cool.. A large canopy cover may indicate a large amount of vegetation along the stream. This results in increased stabilization of the stream bank by roots, and therefore decreased erosion.

Remote sensing is the tool most often used to examine canopy cover over large areas. Remote sensing ranges from satellite images that differentiate among soil, water and vegetation by the type of light reflected, to pictures taken from airplanes. High-level aerial photographs can show distinct landforms such as forests, pastures, and tilled lands, in addition to highways and waterways.

Canopy cover can also be estimated more economically by standing in the center of the sample area and looking at the sky directly overhead. Scientists estimate the percentage of their field of vision that appears to be covered by vegetation. This percentage is the canopy cover. A similar method entails taking a picture from this position and measuring the percentage of the picture covered with vegetation using image analysis software.

The percentage of a stream covered by canopy decreases naturally with increasing **stream order**. This is a function of stream width. However, canopy cover can also be diminished by human activities such as logging, farming and construction. For this reason, measurements of canopy cover can be useful in detecting certain polluters--either present or past.

Water Quality Assessment: Physical: Width, Depth, and Velocity

Stream width and depth affect many other characteristics of a stream. For example, a stream flowing through a wide, shallow channel will receive more sunlight throughout its water column. Increased sunlight will cause the shallow water to become warmer throughout. Also, streams that have uniform depths across their entire widths tend to flow with greater speed because there is nothing to slow them.

Velocity (speed) can be measured with a flow meter at the same time width and depth are measured. This is accomplished by stretching a meter tape across the entire width of the stream and noting the distance. At regular intervals (usually 0.5 m) across the width of the stream, depth should be measured. At these points, the flow of the stream can be measured by following the directions that accompany the flow meter. Photo: Students measuring stream width with a meter tape, depth with a meter stick, and flow with a flow meter. Photo courtesy of Ben Stout.

If a flow meter is not available, the velocity of a stream can be measured by determining the amount of time for an object such as a small film canister or a fishing bobber to float 1 m down the middle of the stream. This procedure should be repeated three times. Results from any trials in which the object gets caught on the bank, in debris, or in a whirl pool should be discarded. Velocity can then be calculated as the average of the three trials.

Uniform depths and high velocities may indicate **dredging.**

Water Quality Assessment: Physical: Rock Size

The size of rocks on the bottom of a stream is very important. It affects the flow of water through a channel. Streams with a mixture of large and small stones tend to have increased turbulence. This leads to increased **oxygenation** of the water. Rock size may also affect the species of organisms that inhabit a stream.

Typically, scientists measure the size of the rocks removed from the benthic sampler during the **biological assessment**. Scientists assume that the rocks are round and estimate their area as " πr^2", where "r" is ½ the longest distance across the rock. Another method is to photograph the rocks on a white pan and use video image analysis to calculate the exact area of each rock (see photo). Photo courtesy of Dr. Ben Stout.

A lack of variability in rock size may indicate that a stream has been **dredged** at some point in the past.

Water Quality Assessment: Physical: Turbidity

Turbidity is a measure of water clarity. It tells scientists the degree to which light entering a column of water is scattered by **suspended solids**. Suspended solids include things such as mud, algae, **detritus**, and fecal material. Factors contributing to water turbidity include soil erosion, elevated nutrient inputs that stimulate algal blooms, waste discharge, and an abundance of bottom feeders that stir up sediments.

As water becomes more turbid, less sunlight is able to penetrate its surface, therefore the amount of **photosynthesis** that can occur decreases. This results in a decrease in the amount of oxygen produced by aquatic plants. In addition, suspended materials absorb heat from sunlight and raise the water **temperature**. This also limits the amount of **dissolved oxygen** water can hold.

Turbidity can be measured in two ways. The first involves lowering a special black and white disk called a Secchi disk into the water and determining the maximum depth at which it is visible. The second method of measuring turbidity is a chemical method that involves titrating a turbidity solution into a sample until an equilibrium point is reached. The results of the Secchi disk method are reported in meters. The larger the value, the less turbid the water. The results of the chemical titration method are reported in Nephlometer Turbidity Units (NTU) or Jackson Turbidity Units (JTU), depending on the test kit. The smaller the value obtained from this method, the less turbid the water. Occasional short-term occurrences of high turbidity are common, for example after storm events or when an animal crosses a stream.

To determine whether or not there is cause for concern over a high turbidity reading, the measurement should be repeated several times over a twenty-four hour period. In general, a turbidity value of > 40 NTU for at least twenty-four hours indicates a problem. Potential causes for high turbidity include **dredging** and **acid mine drainage.**

Water Quality Assessment: Physical: Total Solids

Total solids is a measure of the suspended and dissolved solids in water. **Suspended solids** are those that can be retained on a water filter and are capable of settling out of the water column onto the stream bottom when stream velocities are low. They include silt, clay, plankton, organic wastes, and inorganic precipitates such as those from acid mine drainage. Dissolved solids are those that pass through a water filter. They include some organic materials, as well as salts, inorganic nutrients, and toxins.

The concentration of dissolved solids in stream water is important because it determines the flow of water in and out of the cells of aquatic organisms. Also, some dissolved inorganic elements such as **nitrogen, phosphorus,** and **sulfur** are nutrients essential for life. Low concentrations of total solids can result in limited growth of aquatic organisms due to nutrient deficiencies. Elevated levels of total solids, however, can lead to **eutrophication** of the stream or increased **turbidity**. Both eutrophication and increased turbidity result in a decrease in stream water quality.

Elevated concentrations of total solids may indicate the presence of **agricultural activities, dredging** or **mining** upstream from your sample site.

Water Quality Assessment: Physical: Temperature

The most common physical assessment of water quality is the measurement of temperature. Temperature impacts both the **chemical** and **biological characteristics** of surface water. It affects the **dissolved oxygen** level in the water, **photosynthesis** of aquatic plants, metabolic rates of aquatic organisms, and the sensitivity of these organisms to pollution, parasites and disease.

Thermal pollution is the introduction of water that is warmer than the body of water into which it flows. It generally occurs near power plants. These industries discharge hot water that has been used to cool equipment directly into streams.

Another source of thermal pollution is urban runoff. This is water that has been heated as it flowed over parking lots, streets and sidewalks. Plowing near streams or the removal of the forest canopy during construction also contributes to thermal pollution by decreasing shade, thereby increasing solar heating of the water's surface. In addition to increasing the amount of solar radiation reaching the water's surface, removal of vegetation near streams often results in increased erosion and increased amounts of sediments in the water. The **sediments** absorb heat from sunlight rather than reflect it. This heats the water further.

Warm water is less capable of holding dissolved oxygen. For this reason, temperature should be measured at the same place within the stream at which dissolved oxygen is measured.

The problem of low dissolved oxygen levels is magnified by the fact that the metabolic rates of aquatic plants increase as water temperature rises, thus increasing their biochemical oxygen demand. Low dissolved oxygen levels leave aquatic organisms in a weakened physical state and more susceptible to disease, parasites, and other pollutants.

Water Pollution: Overview

A water pollutant is any substance that decreases the quality of water. Water pollution is a serious problem. As mentioned in the **hydrosphere** puzzle piece, only a small portion of Earth's water is freshwater. This is the type of water we need for survival. As pollution of freshwater increases, the amount of useable freshwater decreases.

There are many types of pollutants. Common water pollutants include **acid mine drainage, agricultural runoff, sewage,** and **dredging**. Sources of pollution are classified according to the way they enter the environment. There are two major classes of pollutants: point-source and non-point-source. **Point-source pollutants** can be traced to their original source. Point-source pollutants are discharged directly from pipes or spills. Raw sewage draining from a pipe directly into a stream is an example of a point-source water pollutant. **Non-point source pollutants** cannot be traced to a specific original source. These pollutants can only be traced to a general area. Non-point sources of pollution include **runoff** from backyards, parking lots, farms, mines, construction sites, *etc*.

Water Pollution: Agriculture

Agriculture is a common contributor to non-point-source pollution. Pesticides and fertilizers from crop fields, as well as animal wastes from feed lots, are often carried in **runoff** streams. Pesticides are generally toxic and may lead to immediate health problems — even death — within the stream. Fertilizers and animal wastes, however, tend to enrich streams with large amounts of nutrients such as **nitrogen** and **phosphorus**. The immediate result of increased nutrients in a stream is increased growth of aquatic plants. While this may seem beneficial at first glance, it is actually quite harmful to the ecosystem. The overabundance of plants leads to an overabundance of plant **detritus** on the streambed at the end of the growing season. Microbes on the streambed must then use larger amounts of oxygen in order to decompose the increased amount of dead plant material. This leads to a depletion of the amount of **dissolved oxygen** in the streamwater. **Macroinvertebrates** and larger aquatic animals such as fish can die from a lack of oxygen. With the death of herbivorous (plant-eating) animals, the aquatic plant population will continue to increase. The use of oxygen by microbial decomposers will also continue to increase. This **positive feedback** process is referred to as **eutrophication**

Another indicator of agricultural pollution is the presence of the microbe **fecal coliform**. Fecal coliform is a non-pathogenic bacteria that naturally occurs in the digestive tracks of warm-blooded animals. "Non-pathogenic" means fecal coliform does not cause diseases. However, it is often found in association with pathogenic (disease-causing) organisms.

Loose dirt, or sediments, from plowed fields is also a form of agricultural pollution. Like pesticides, fertilizers, and animal wastes, dirt from plowed fields can be carried by runoff to streams. Sediments cause increased **suspended solids** in streamwater. The suspended solids decrease light penetration through the water column. When the sediments finally settle to the bottom of the stream, they suffocate life there. This movement of loose dirt into streams is called **siltation**. The murkiness of the water is referred to as turbudity.

The problem of pesticides, fertilizers, animal wastes, and sediments in runoff can be increased by livestock grazing along the stream. Vegetation that grows near streams acts as a **buffer**. This vegetation absorbs toxins and nutrients and traps sediments before they reach the stream. Livestock remove the vegetation. Without a vegetation buffer, pollutants can move freely from a field into a stream. In addition, livestock increase erosion of banks along streams, and thereby increase the occurrence of siltation.

Water Pollution: Sewage

Sewage is generally a point-source pollutant. Sewage is the waste water from residential and commercial buildings. **Degradation** of stream water quality by untreated or insufficiently treated sewage is a widespread problem in many rural areas. Home owners in these communities are often responsible for providing their own septic systems. Many times these systems are improperly installed. They leak their contents into the groundwater. Some rural home owners cannot afford to install septic systems at all, so they pipe their sewage directly into local streams.

Urban communities also face the problem of sewage in their stream water. These communities typically have water treatment plants where sewage is chemically treated then piped to nearby rivers and streams. The untreated sewage, along with stormwater runoff, is often carried to the sewage treatment plant in combined sewage outflows (CSOs).

During heavy downpours, stormwater runoff overwhelms the treatment plant. Consequently, a system of gates opens and releases the excess runoff -- along with the untreated sewage -- into nearby waterways.

Sewage carries excessive nutrients such as **nitrogen** and **phosphorus** to stream water. The excessive nutrients can lead to decreased levels of **dissolved**

oxygen as a result of the process of **eutrophication.** Sewage also contributes to increased **total solids**, including **fecal coliform**, as well as increased water **temperature.**

Water Pollution: Dredging

Dredging is a non-point-source pollutant. It is the process by which large rocks are removed from a waterway. This process changes a waterway's **substrate** composition as well as its shape. Dredging can turn a shallow, winding stream with many sizes of rocks on its bottom into a deep, straight stream with only small rocks on its bottom. In the past, rocks were often dredged from streams to provide fill material for road- and railroad-building activities. More recently, streams have been dredged as a means of flood protection. Some landowners even dredge streams to create more convenient or prettier channels.

Removal of large rocks from a stream can decrease the stream's resistance to flow. This results in an increase in the stream's **velocity**. Increased velocity can cause downstream flooding. In addition, the removal of large rocks often leaves a stream bed with small, uniform-size rocks. This destroys important habitats of aquatic plants, fish, amphibians, and **aquatic insects**. Many of these organisms require areas with **large rocks** for cover,**oxygenated water**, feeding, and even for the placement of eggs (see photo below).

Dredging is generally performed with large machinery. Large machines in small streams disrupt the stream bed and cause a short-term **siltation** event. The siltation event can be harmful to downstream aquatic communities. Siltation is observed as increased **turbidity**. Increased turbidity can lead to increased water **temperature**.

Forms of Surface Water Pollution

Water pollution is "contamination of water by undesirable foreign matter." It impacts our oceans, our surface water, and our underground water. Pollution comes in many forms--some conventional and others toxic.

Toxic Pollutants	Conventional Pollutants
Cadmium	Ammonia
Copper	BOD*
Lead	Nitrogen (and nitrate)
Mercury	Pathogens
Phenol	Phosphorus
Total residual chloride	Suspended solids

*'Biochemical Oxygen Demand'(BOD) is the term used to describe the oxygen used up as suspended solids decays.

Additional pollutant possibilities are:

- Sewage effluents
- Thermal pollution
- Eutrophication
- Petroleum
- Fecal pollution
- Acid precipitation
- Storm sewage discharges
- Urban surface water runoff
- Farm fertilizer and pesticide runoff
- Acid mine drainage
- Radioactive substances

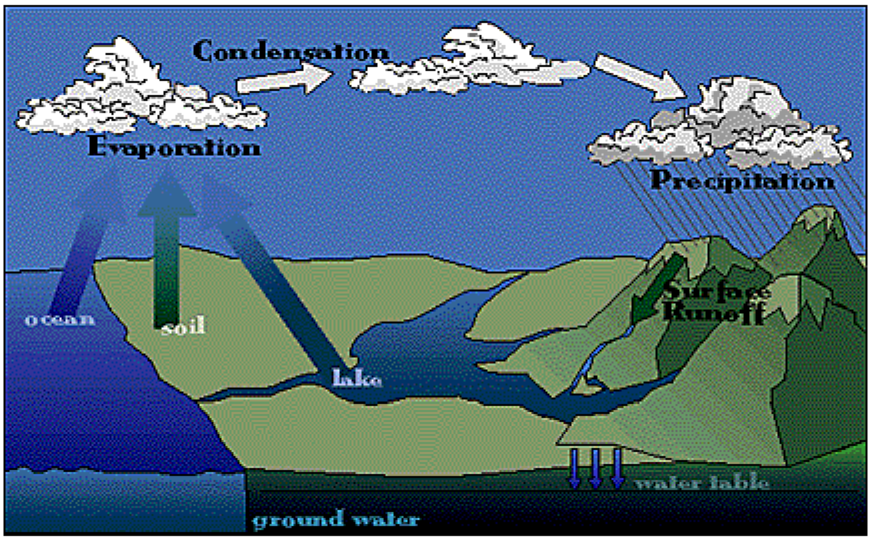
Indicators of Surface Water Pollutants:

- Suspended Sediment
- Fecal coliform
- Total phosphorus
- Nitrate
- Dissolved solids and Dissolved Oxygen

Water Cycle

Water can exist either as a solid (ice), a liquid (water), or a gas (water vapor). Water on the on surface of Earth is constantly changing between these three states. Ice can change to become water or water vapor. Water can change to become ice or water vapor. Water vapor can change to become ice or water. These continuous changes in state create a cycle of repeating events.

Water continually circulates between the surface of Earth and its atmosphere in what is called the hydrologic or water cycle. Responding to heat energy from the Sun, water in oceans, lakes, swamps, rivers, plants and even in your body can turn into water vapor. Water vapor in the atmosphere condenses as it cools to form clouds. Once the droplets of condensed water vapor are too heavy to remain in the atmosphere, they fall to Earth as precipitation. Rain, snow, sleet, fog and dew are all forms of precipitation.



After the precipitation reaches the surface of Earth, it does one of four things. It can either be absorbed by plants, percolate through the soil to become ground water, run off the surface into streams and rivers--becoming surface water and eventually flowing into the oceans, or evaporate.

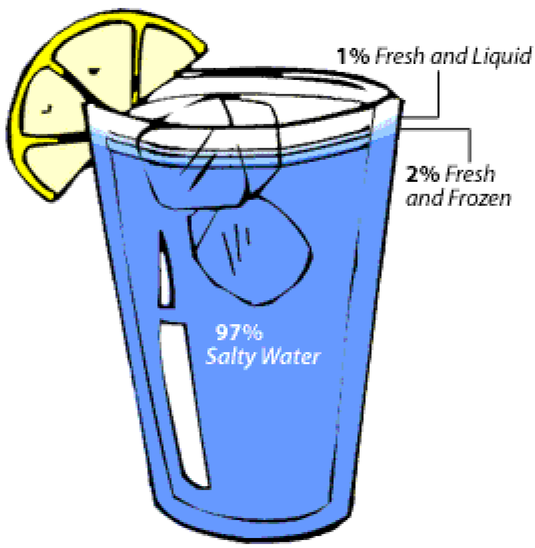
Water is a major force in the sculpting of Earth's surface and is an important means of transporting the energy that drives atmospheric circulation. Although water covers three-fourths of the surface of Earth, water represents a relatively small percentage of Earth's total volume--a 3-foot diameter model of Earth would have only one cup of water. Thus, water is actually

Importance of Water

Our Earth seems to be unique among the other known planets. It has water, which covers three-fourths of its surface and constitutes 60-70 wt % of the living world. Water regenerates and is redistributed through evaporation, making it seem endlessly renewable. So why worry?

Actually, only 1% of the world's water is usable to us. About 97% is salty sea water, and 2% is frozen in glaciers and polar ice caps. Thus that 1% of the world's water supply is a precious commodity necessary for our survival.

Dehydration (lack of water) will kill us faster than starvation (lack of food). Since the plants and animals we eat also depend on water, lack of it could cause both dehydration and starvation. The scenario gets worse. Water that looks drinkable can contain harmful elements, which could cause illness and death if ingested.

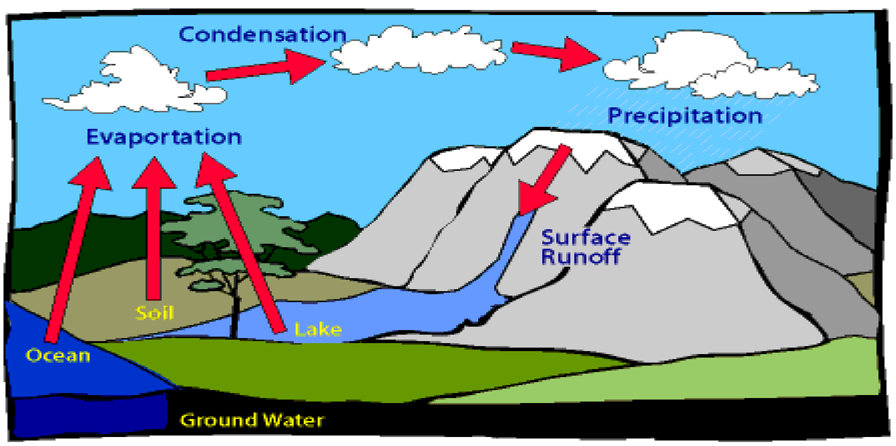


Hydrosphere: Overview

Three-quarters of Earth is covered by water. The area in which all of Earth's water exists is called the **hydrosphere**. This sphere appears to make Earth unique among bodies in the solar system. The hydrosphere enables this planet to support life.

However, not all water on Earth can support life. Ninety-seven percent of the water on Earth is salty. Most organisms cannot drink saltwater. Most living things depend on freshwater for survival. Only three percent of all Earth's water is freshwater. Sixty-seven percent of the world's freshwater is frozen in polar icecaps and glaciers. That makes it unavailable for use by most species. This leaves only thirty-three percent of the world' s freshwater--or approximately 1% of all the water on Earth--available to sustain life.

Water in the hydrosphere can exist as a solid (ice), a liquid (water), or a gas (water vapor). It is constantly changing among these three forms, or phases. Water moves around Earth as it changes form. The movement of water occurs in a group of repeating events. The group of repeating events is called the water cycle or hydrologic cycle. It is diagramed in the figure below.



Heat from the sun causes water in oceans, lakes, swamps, rivers, plants, and even our own bodies to **evaporate** into water vapor. Water vapor in the atmosphere forms clouds as it cools and **condenses**. Clouds are collections of millions of tiny droplets of water. When these tiny droplets of water cool, they form larger drops of water. When the drops of water become too heavy to stay in the cloud, they fall to the Earth as **precipitation**. Rain, snow, sleet, and hail are all forms of precipitation. The form of precipitation that falls depends on the temperature of the air. During warm temperatures, precipitation falls in the form of water (rain). During cold temperatures, precipitation falls in the form of ice (snow). Water from precipitation flows across the surface of the land into lakes, streams, and oceans. Some of the water enters the ground. Plants absorb water from the ground through their roots. The water eventually evaporates. And so the water cycle continues.

Hydrosphere: Importance of Clean Freshwater

Water is necessary for the survival of most living things. In fact, dehydration--the lack of water--will kill an organism faster than starvation--the lack of food. Since the plants and animals that many humans and other animals eat also depend upon water, a lack of it could lead to starvation as well as dehydration. In addition to sustaining life, clean freshwater is needed by humans for personal hygiene, irrigation, industry, and recreation. Humans bathe in it, brush their teeth with it, use it to make crops grow and to cool industrial reactors, and swim, boat, and fish in it.

The amount of freshwater is decreasing on Earth because of the demands humans place on the **hydropshere**, as well as climate changes which have led to **droughts.** Also,much of the available freshwater is being contaminated with harmful elements such as sulfuric acid, fertilizer, and gasoline. This happens as freshwater circulates through the **hydrologic cycle**. As **precipitation** passes through the atmosphere and flows over roads, agricultural fields, and other human-made objects, it picks up contaminants that often make it unusable. In a sense, precipitation "washes" the dirt and grime (contaminants) from the air and Earth's surfaces, just like the water washes the dirt off of you when you bathe. These contaminants are then carried to the streams, rivers, and eventually into the groundwater, lakes, and oceans of the world. Water quality may also be affected by natural causes such as volcanic eruptions.

The importance of clean water, coupled with its scarcity due to over-use, climate, and **pollution**, has resulted in increased concerns about water quality and quantity. These concerns have led to war between nations such as Namibia and Botswana. The concerns have even influenced **US legislation**.

Hydrosphere: Studying the Hydrosphere

The **watershed** approach to monitoring water quality is a systematic approach. The quality of water flowing at a particular site is compared to the quality of water flowing at sites upstream. The watershed, sometimes referred to as the **catchment area** or **drainage basin**, is defined as an area of land where all surface runoff from rain and snow eventually enters the same system of ground water and flows to common streams. The system of streams in a watershed forms an intricately linked drainage network. The major channels of this drainage network are referred to as "**trunk streams**". The finer channels that feed the trunk streams are called "**tributaries**".

Streams within a watershed are ranked by relative size and structure. The rank of a stream is referred to as stream order. **Stream order** is a very important part of the watershed approach to examining water quality. It enables one to examine the quality of streamwater at a particular site with that of a stream of similar size and structure at another point in the watershed. The image below is a computer-generated **topographic map** of Wheeling Creek Watershed. It displays the difference in size between a third-order watershed and a fifth-order watershed. A third-order watershed is a catchment area in which all the water drains into a third-order stream. A fifth-order watershed is a catchment area in which all the water drains into a fifth-order stream.

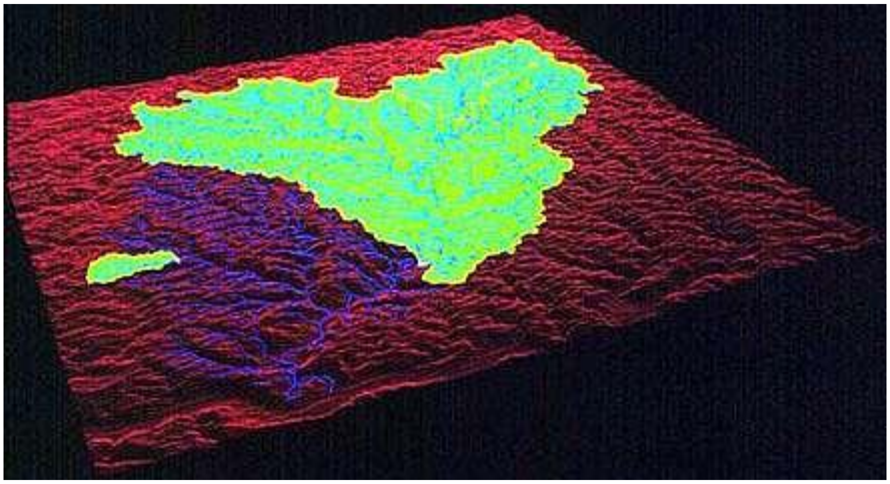


Image: Computer-generated topographic map of Wheeling Creek Watershed in Ohio. Surrounding areas are shown in red, a third-order catchment is shown in green on the left, a fifth-order catchment is shown in green on the right, and the remainder of Wheeling Creek Watershed is shown in purple. Image courtesy of Dr. Trevor Harris.

As water flows through a watershed, the size of the stream channel increases and the influence of the surrounding forest on the biotic (living) community in the stream decreases. One model for changes in biological communities that might take place as water travels from small **headwater streams** to larger rivers is referred to as the **River Continuum Concept**. It can be used to determine the biological community one could expect to find in a section of stream based on stream order, alone. This is important to the watershed approach because you can compare the expected biological community composition to what is actually observed. Differences between expected and observed biological communities may be due to pollution.

Watershed Approach

The watershed is sometimes referred to as the catchment area, or drainage basin, and is defined as the area of land over which surface runoff from rain and snow will eventually enter into a stream or river.

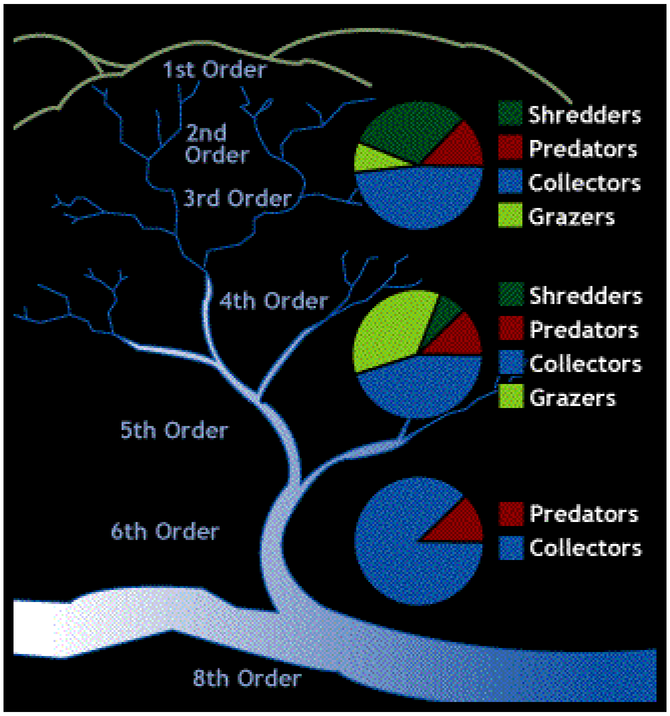
Individual water quality sampling sites in the Pearl River Valley Water Supply District watershed are representative of various sized streams from north to south and east to west. This allows comparison of water quality at one site with the water quality at other sites within the watershed. This method is called the watershed approach, which means that it is important to view water quality at any one site within the context of water quality in the overall watershed.

River as a Continuum

The river continuum concept, first proposed by Vannote and others in 1980, provides a model of changes that might take place as water travels from headwater streams to larger rivers. As stream size increases, the influence of the surrounding forest decreases. The river continuum concept provides predictions of the way that biological communities might change from headwater streams to larger rivers.

If small headwater streams depend on the surrounding forest for energy and nutrients, then leaf-shredding macroinvertebrates should constitute a large portion of the macroinvertebrate population. Grazers, those that scrape algae from rock surfaces, should be nearly absent from small streams, because these streams are well-shaded from sunlight by the surrounding forest. Collectors filter or gather fine particles from the stream and should be increasingly important in larger streams, where they take advantage of the fine fragments that are washed downstream from the headwaters. Predators should be common throughout the river system.

Compare the model below with the physical, chemical, and biological data from the Wheeling Creek watershed in Ohio. Are macroinvertebrate roles in the Wheeling Creek ecosystem organized in a manner similar to that predicted by the river continuum concept?



PBL Model

1. **Read and analyze the problem scenario.** Check your understanding of the scenario by discussing it within your group. A group effort will probably be more

effective in deciding what the key factors are in this situation. Because this is a real problem solving situation, your group will need to actively search for the information necessary to solve the problem.

2. **List what is known**. Start a list in which you write down everything you know about this situation. Begin with the information contained in the scenario. Add knowledge that group members bring. (You may want a column of things people think they know, but are not sure!)

3. **Develop a problem statement**. A problem statement should come from your analysis of what you know. In one or two sentences you should be able to describe what it is that your group is trying to solve, produce, respond to, or find out. The problem statement may have to be revised as new information is discovered and brought to bear on the situation.

4. **List what is needed**. Prepare a list of questions you think need to be answered to solve the problem. Record them under a second list titled: "What do we need to know?" Several types of questions may be appropriate. Some may address concepts or principles that need to be learned in order to address the situation. Other questions may be in the form of requests for more information. These questions will guide searches that may take place on-line, in the library, or in other out-of-class searches.

5. **List possible actions**. List recommendations, solutions, or hypotheses under the heading: "What should we do?" List actions to be taken, e.g., question an expert, get on-line data, visit library.

6. **Analyze information**. Analyze information you have gathered. You may need to revise the problem statement. You may identify more problem statements. At this point, your group will likely formulate and test hypotheses to explain the problem. Some problems may not require hypotheses, instead a recommended solution or opinion (based on your research data) may be appropriate.

7. **Present findings**. Prepare a report in which you make recommendations, predictions, inferences, or other appropriate resolution of the problem based on your data and background. Be prepared to support your recommendation.

Note: The steps in this model may have to be visited several times. Steps two through five may be conducted concurrently as new information becomes available. As more information is gathered, the problem statement may be refined or altered.

Glossary

acid mine drainage (AMD) water draining out of surface or subsurface mines that has an extremely low pH (*i.e.* high concentration of hydrogen ions) and often contains high concentrations of sulfur, aluminum, and heavy metals such as iron.

aquatic of or relating to water; living on or in water (as opposed to land or air).

alkalinity a measure of the amount of anions of weak acid in water and of the cations balanced against them.

biota living things such as plants, animals, and microorganisms.

buffer something that chemically or physically dampens changes in a system; a protective barrier.

benthic of or pertaining to the bottom, or "bed," of a body of water.

biodiversity the relationship between the number of species present in an area and the number of individuals within each of those species.

buffering capacity the ability of a solution to resist or dampen changes in pH upon the addition of acids or bases.

catchment area the area of land drained within a watershed.

composite the combined typical characteristics of several individuals within a group.

condensation the process by which a gas is cooled and converted into a liquid.

decompose to rot or decay; it is the same chemical reaction that occurs during combustion and respiration, $6\ O_2 + C_6H_{12}O_6 \rightarrow 6\ H_2O + 6\ CO_2$

degradation a decrease in quality; **degrade** (verb).

detritus fresh to partly decomposed plant or animal matter.

drainage basin see watershed.

drought a period during which there is a water shortage.

effluent anything that flows out of a source, such as sewage from a pipe.

EPT index an index of water quality based on the abundance of three pollution-sensitive orders of macroinvertebrates relative to the abundance of a hardy species of macroinvertebrate. It is calculated as the sum of the number of *Ephemeroptera*, *Plecoptera*, and

Trichoptera divided by the total number of midges (*Diptera*: *Chironomid*).

equilibrium reactions reversible chemical reactions in which the rates of reaction in both directions are the same and thus create a dynamic balance.

eutrophication the **positive feedback** process by which nutrient enrichment of aquatic systems ultimately results in the death of fish and macroinvertebrates due to suffocation. During this process, elevated nutrient levels in streams cause increased growth of aquatic plants. These plants eventually die and accumulate on the streambed. Microbes that decompose these plants use oxygen, therefore the decomposition of the excess plant material leads to an increased consumption of oxygen dissolved in the water. The decrease in available oxygen can lead to the death of plant-eating aquatic organisms like fish and macroinvertebrates. The death of plant-eating organisms results in an even greater increase in plant biomass availble for decomposition by microbes. This ultimately leads to an even greater decrease in the amount of oxygen dissolved in the stream water.

evaporation the conversion of a liquid substance into a gaseous state.

groundwater water that seeps down through the soil and is located in underground reservoirs called aquifers.

headwater streams first- through third-order streams (see stream order); these are the small streams in the upper reaches of a watershed.

hydrosphere the area in which water exists; for the purpose of this module, this sphere includes all liquid water on Earth, such as rivers, lakes, and oceans, as well as all frozen water, such as glaciers, icebergs, and polar icecaps.

landform a feature of the land such as a forest, mountain, or developed area.

macroinvertebrates small, spineless creatures that are visible with the unaided eye; they include organisms such as crustaceans, mollusks, worms, and insects.

non-point-source pollutant a pollutant that cannot be traced back to one specific source, but instead comes from a general area, such as runoff from a parking lot.

nutrient an inorganic (*i.e.* non-carbon-based) element required by an organism for normal growth and activity.

organic matter carbon-containing residues of living (or formerly living) organisms.

oxidation the loss of one or more electrons by an atom, molecule, or ion.

parameter characteristic being measured or described.

parts per million (ppm) unit of measure most often used to describe the amount of a particular gas or compound in the air or water. It is the proportion of the number of molecules of the gas or compound out of a million (1,000,000,000) molecules of air or water.

pathogenic anything that causes disease.

pH a logarithmic scale ranging from 1 to 14 that identifies the acidity of a solution as the negative logarithm of the concentration of hydrogen ions in solution: pH = - log $[H^+]$. Because the pH scale is logarithmic, each unit change represents a ten- fold change in the concentration of hydrogen ions.

photosynthesis the process by which green plants convert solar energy into chemical energy in the form of organic (carbon-containing) molecules, releasing oxygen as a by-product; $6\ CO_2 + 6\ H_2O + \text{sunlight} \rightarrow C_6H_{12}O_6 + 6\ O_2$.

planimeter a sheet of clear plastic covered with evenly-spaced dots that are calibrated to represent a unit of area. This tool is used to determine the area of a region from a map.

point-source pollutant a pollutant that can be traced back to one specific source, such as sewage from a pipe.

positive feedback the process by which the cause of a change is increased or amplified by its effect.

precipitation the process by which liquid or solid water (rain, sleet, snow, etc.) moves from the atmosphere to Earth's surface.

realistic based on or like reality, but not necessarily existing in the real world.

reduction the gain of one or more electrons by an atom, molecule, or ion.

remediation the process by which something is corrected.

remote sensing the act of collecting data about an object from a distance.

riffle portion of a stream characterized by fast-moving, turbulent, relatively shallow water flowing over a substrate of rocks of various sizes.

River Continuum Concept a model of changes that might take place in an aquatic ecosystem as water travels from headwater streams to larger rivers. As streams flow down through a watershed, their size increases and the influence of the surrounding forest decreases. The river continuum concept provides predictions of the ways in which biological communities might change in response to such habitat differences.

runoff precipitation that has drained through or over an area.

sediment small pieces of organic or inorganic material that are deposited on Earth's surface by wind, water, or ice.

sewage waste water from residential and commercial buildings.

Shannon Index of Species Diversity formula used to calculate species diversity:

$$\overset{s}{\underset{i=1}{H}} = -\sum(\rho_i)(\log \rho_i)$$

where *H* = diversity index, *s*= number of species (or orders), *i* = species (or order) number, *pI* = proportion of individuals of the total sample belonging to the *i*th species (or order) (an explicit example of the use of this equation is located in the teachers' notes). The higher the value of *H*, the greater the probability that the next individual chosen at random from a sample of species containing N individuals will NOT belong to the same species as the previous one (*i.e.* the greater *H*, the greater the diversity of species within an area).

siltation the movement of silt - tiny particles of clay and sand into streams during erosion.

species diversity a calculation that relates the density of individuals of each species (or order) present in a habitat to the total number of species (or orders) in that habitat.

stream order a measure of the relative size of a stream. Each increase in stream order is an order of magnitude increase in size. The smallest tributaries are referred to as first-order streams, while the largest river in the world is a twelfth-order waterway.

substrate the materials, such as sand, gravel, or cobble, that make up the bottom, or "bed," of a body of water.

suspended solids small pieces of organic or inorganic material floating in a column of water.

topographic map a map that displays the natural features of an area, such as elevation and bodies of water.

tributary a stream that flows into, or "feeds," another stream.

trunk stream a major artery of a stream network; for example, the Missouri and Ohio Rivers are trunk streams in the Mississippi River Basin.

watershed an area of land that drains into a common reservoir such as a stream, river, lake, or ocean; also referred to as a drainage basin or catchment area.

yellow-boy ferric hydroxide ($Fe(OH)_3$) precipitate often found in acid mine drainage; named for its yellow to red appearance.

Thirty Seconds to Spread the Word

A Waterfest Contest

Breaking News!

The water coming out of your faucet starts in the Ross Barnett Reservoir!

What will you do differently now that you know where the water coming out of your faucet originates? If more people knew they were drinking water from The Reservoir – how would they guard and nurture it more carefully?

If you had thirty seconds to enlighten people about the water they are drinking – what would you say?

Create a multi-pronged advertisement campaign that informs people about the Ross Barnett Reservoir, the water they drink from it, and what residents in Hinds, Madison, and Rankin counties can do to improve water quality! Your campaign should use radio, TV, billboards, flyers, Internet sites, and any other means of communication.

Requirements

Submissions should be appropriate for general audiences (people of all ages). Teams are limited to no more than 6 members. A minimum of 4 members MUST participate in the live presentation.

Radio Ad Length: 15 seconds – 30 seconds

Radio commercials are to be submitted in recorded format.

Television Ad Length: 15 seconds – 1 minute

TV commercials are to be submitted in video format.

Print Ads: Appropriate to the media

Total Ad Campaign Presentation: 12 minutes

You will present your entire ad campaign at Waterfest, April 17, 2010. The radio and/or television ad (team choice) will be presented LIVE by team members. Judges are looking for a combination of creativity, presentation skills, and effectiveness.

Winning entries will receive prizes.

Ideas maybe included in the official Ross Barnett Reservoir campaign.

Thirty Seconds to Spread the Word

A Waterfest Contest

Scoring Rubric

Name of Project:

	Level 4 (5 points)	Level 3 (2 points)	Level 2 (1 point)	Level 1 (0 points)
Length	Commercial is presented within the time frame.	Commercial is presented slightly outside the time frame. (+/- 5 seconds)	Commercial is presented outside the time frame. (+/- 10 seconds)	Commercial is presented significantly outside the time frame. (+/- 15 seconds)
Purpose	Campaign message clearly informs and educates audience about the drinking water from the Ross Barnett Reservoir.	Campaign message informs audience about the drinking water from the Ross Barnett Reservoir.	Campaign message vaguely informs audience about the drinking water from the Ross Barnett Reservoir.	Campaign message does not inform audience about the drinking water from the Ross Barnett Reservoir.
Creativity	Campaign demonstrated a high level of creativity. It was exciting and interesting. All ideas were unique.	Campaign demonstrated a moderate level of creativity. It was fairly interesting and most of the ideas were unique.	Campaign demonstrated some creativity. It was almost interesting and a few of the ideas were unique.	Campaign demonstrated little or no level of creativity and lacked any originality.
Presentation	All campaign elements are so clearly written, labeled, drawn, or presented that the campaign could be easily recreated if necessary.	Most campaign elements are clearly written, labeled, drawn, or presented that the campaign could be recreated with some explanation.	Some campaign elements are clearly written, labeled, drawn, or presented. The project would be difficult to recreate.	Campaign elements are not clearly written, labeled, drawn, or presented. The project would be almost impossible to recreate.

Total Points:

Glances into the Future

A Waterfest Scenario Contest

The Ross Barnett Reservoir is the center of life for the people who live near it. It provides recreation opportunities with its parks, camp grounds, boat launches, trails, baseball and soccer fields, and golf courses. Since the area is convenient to both urban and suburban areas, many business owners have chosen to make it their home, creating new jobs every day. There are also several large shopping centers in close proximity to the Ross Barnett Reservoir where you can buy anything you need or want. Even if residents choose not to take advantage of the amenities that "The Rez" offers, it is the water source for the homes and businesses in the surrounding area.

Just as the reservoir enhances the quality of life for the people who live, work, and play around it, its quality is determined by how the residents care for it in return.

Imagine yourself standing on the banks of the Ross Barnett Reservoir with your children or grandchildren. Consider these questions: How has life changed in the area? What steps have been taken to assure the reservoir has continued to be a safe place to live, work, and play? How has the Reservoir continued to provide opportunities for the people around it? Have the people taken care of the Reservoir in return? How is the quality of the water, and how does it affect life in the area? What steps have been taken to protect the reservoir environment? What problems, if any, plague the area that could have been prevented?

Compose a scenario that depicts life around the Ross Barnett Reservoir thirty to fifty years in the future. The focus of your scenario should be one of the following:

1. A concern you have about life in and around the reservoir
2. Problems that the reservoir environment faces in the future that could have been prevented
3. The progress and development of the reservoir area over the next fifty years
4. The protection of the reservoir environment as a benefit to the people that make it their home

Scenarios should be no more than 1,500 words and written in the first or third person perspective. Submissions should be typed, double spaced, in Arial or New Times Roman font size 12, and error free. The cover page of the scenario should note the title, name and age or grade of the author, and sponsoring teacher and school.

Winning entries will receive prizes.

Glances into the Future
A Waterfest Scenario Contest

Scoring Rubric

Project Title: **Student Name:**

	Level 4 (5 points)	Level 3 (2 points)	Level 2 (1 point)	Level 1 (0 points)
Purpose	Purpose is clear throughout.	Purpose is mostly clear.	Purpose is somewhat clear.	Purpose is not clear.
Content theme details	Ideas are clear and concise throughout with numerous, strong supporting details	Ideas are mostly clear and concise with some supporting details.	Ideas are somewhat clear and concise with few or weak supporting details	Ideas are vague and repetitive with no or weak supporting details.
Organization structure introduction conclusion	Writing is effectively organized in logical and creative manner, and a creative and engaging introduction and conclusion.	Writing has strong order and structure, and a satisfying introduction and conclusion.	Writing has some organization, but is confusing. Introduction and conclusion are underdeveloped.	Writing has a lack of organization, and is hard to follow. Introduction and conclusion are very weak.
Style word choice precision	Writing consistently demonstrates a variety of word choice and use of descriptive language.	Writing often demonstrates a variety of word choice and use of descriptive language.	Writing demonstrates some variety of word choice and use of descriptive language.	Writing does not demonstrate a variety of word choice and use of descriptive language.
Conventions spelling, punctuation, and grammar	Writing has no errors.	Writing has few errors.	Writing has some errors.	Writing has many errors.
Requirements	Writing meets all requirements.	Writing meets all but one requirement.	Writing meets all but two requirements.	Writing is missing three or more requirements.

Total Points: **Comments:**