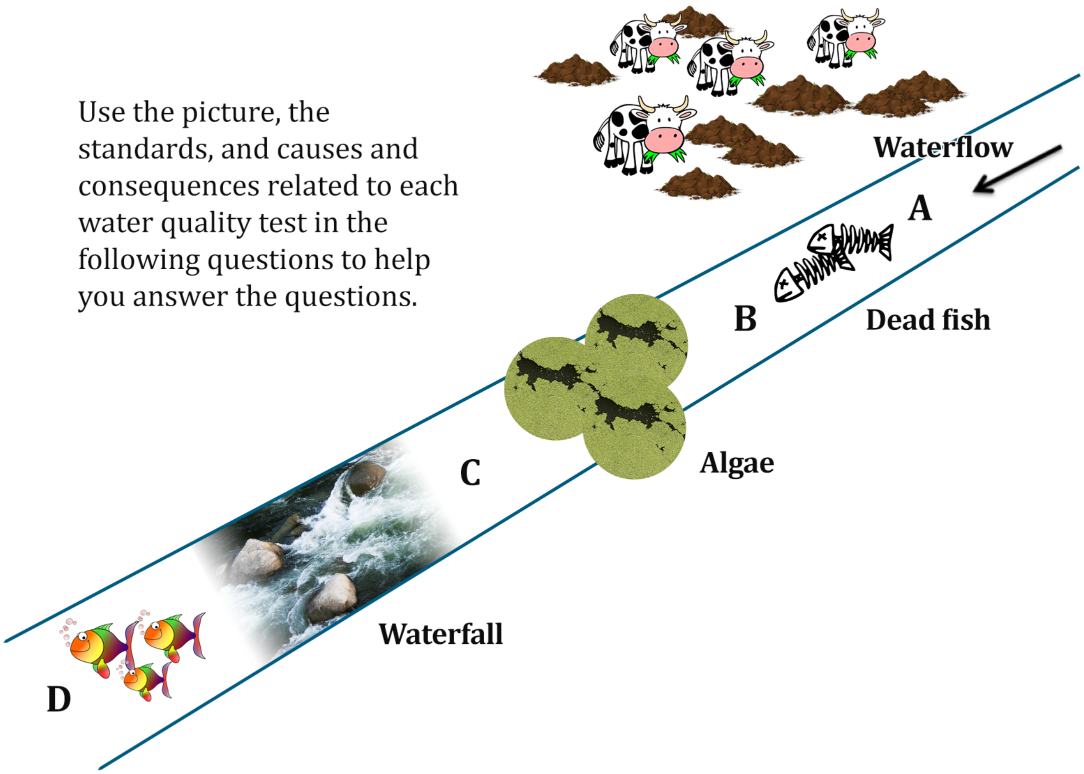
Name:____

Use the picture, the standards, and causes and consequences related to each water quality test in the following questions to help you answer the questions.



1a. A dairy farm is located in the watershed of the Beauty River. Large amounts of floating particles are seen between Points A and B. Based on this water quality measure, what would you say about the water quality between Point A and B? (2pts.)

There are too many floating particles between Points A and B with poor water quality standards for turbidity.

1b. What is the reason (**the cause**) for these results? Explain this cause thoroughly. What is the **consequence** of these results? Explain the consequence completely. (4pts.)

Cow manure from the dairy farm is the cause of turbidity. It has run off into the river. These floating particles clog fish gills and cause fish to die. That is why there are dead fish in the river.

1c. What ACTION STEP could people take to make sure this doesn't continue to happen? (2pts.)

The dairy farmer could build silt fences around the dairy farm to capture the manure so it doesn't flow into the river when it rains. Another option is for the dairy farmer to somehow dispose of the manure.

2a. Large amounts of algae are seen between Points B and C with conductivity readings of 880mg/L. Based on this water quality measure, what would you say about the water quality between Point B and C? (2pts.)

There are too many dissolved solids in the water between Points B and C, which results in poor conductivity levels according to water quality standards.

2b. What is the reason (**the cause**) for these results? Explain this cause thoroughly. What is the **consequence** of these results? Explain the consequence completely. (8pts.)

The high conductivity numbers are from decomposing manure. They add excess nitrates and phosphates from decomposing cow manure from the dairy farm. They flow downstream and are essential nutrients for growth so they cause an algal bloom. The consequence is a possible death cycle. Those excess algae have a short lifespan and when they die they become excess organic waste. Excess organic waste is excess food for decomposers like bacteria. The bacteria population then explodes. Bacteria use up all of the oxygen so there could be an oxygen depletion cycle.

3a. The dissolved oxygen level at Point D is 95%. Based on this water quality measure, what would you say about the water quality at Point D? (2pts.)

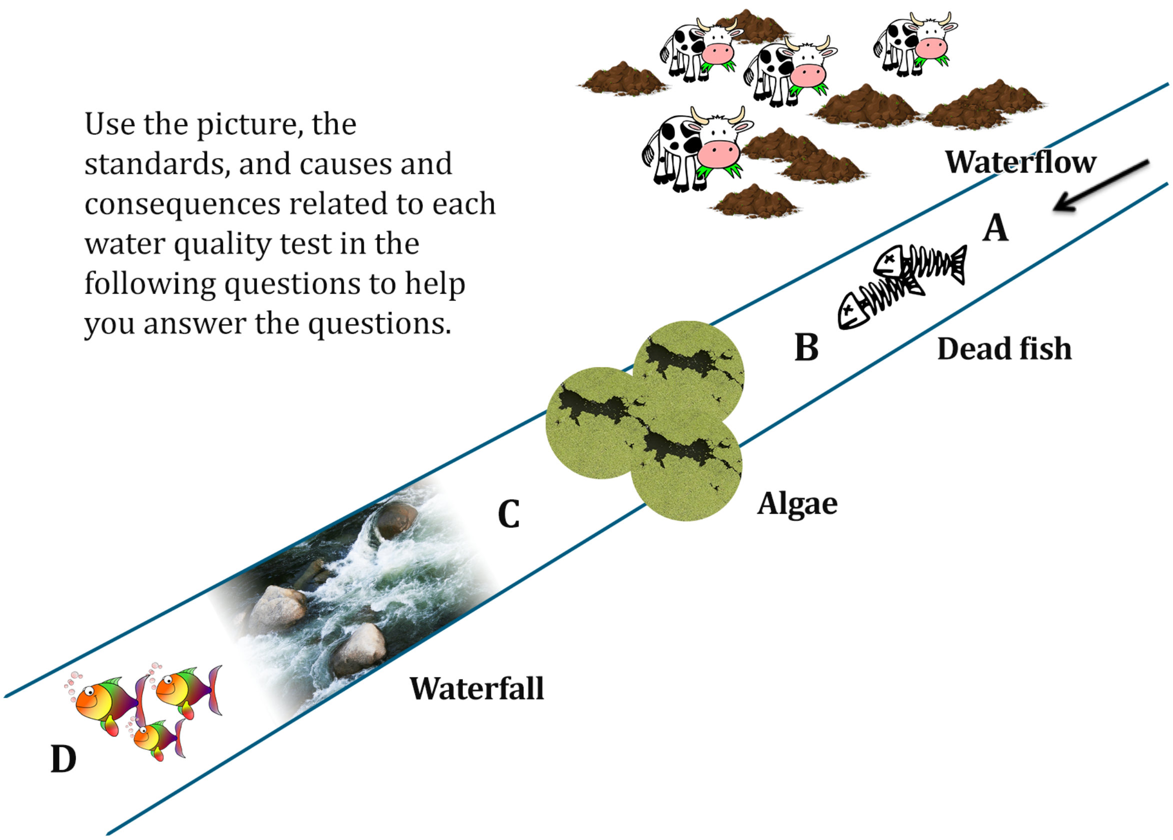
95% oxygen falls into the excellent range for water quality standards. It means there is enough oxygen in the water at Point D for fish and other aquatic organisms

3b. What is the reason (**the cause**) for these results? Explain this cause thoroughly. What is the **consequence** of these results? Explain the consequence completely. (2pts.)

The reason oxygen levels are so high is there is a waterfall and rapids. These are fast moving water that causes turbulence that can capture lots of oxygen from the atmosphere. The consequence is plenty of oxygen and since that is what fish need to live. We see happy, healthy fish at Point D.

Name: ____

Use the picture, the standards, and causes and consequences related to each water quality test in the following questions to help you answer the questions.



1a. A dairy farm is located in the watershed of the Beauty River. Large amounts of floating particles are seen between Points A and B. Based on this water quality measure, what would you say about the water quality between Point A and B? (2pts.)

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1b. What is the reason (**the cause**) for these results? Explain this cause thoroughly. What is the **consequence** of these results? Explain the consequence completely. (4pts.)

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1c. What ACTION STEP could people take to make sure this doesn't continue to happen? (2pts.)

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2a. Large amounts of algae are seen between Points B and C with conductivity readings of 880 mg/L. Based on this water quality measure, what would you say about the water quality between Point B and C? (2pts.)

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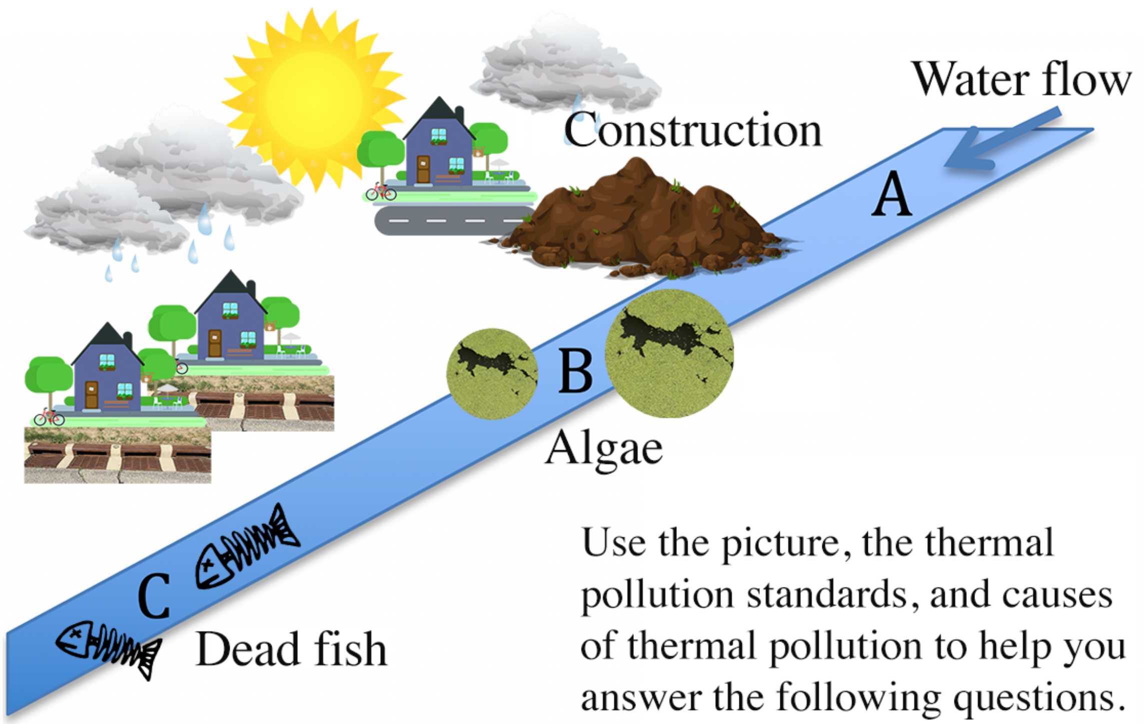
2b. What is the reason (**the cause**) for these results? Explain this cause thoroughly. What is the **consequence** of these results? Explain the consequence completely. (8pts.)

3a. The dissolved oxygen level at Point D is 95%. Based on this water quality measure, what would you say about the water quality at Point D? (2pts.)

3b. What is the reason (**the cause**) for these results? Explain this cause thoroughly. What is the **consequence** of these results? Explain the consequence completely. (2pts.)

Analyze the picture to answer each of the following questions.



1a. The temperature at Point A of a stream is 6.0 degrees C. The temperature at Point B, one mile downstream, is 13 degrees C. Based on temperature as a measure of water quality, what conclusions would you make about the water quality at Point B? How did you arrive at this conclusion? Show all of your work. (3pts.)

$13^{O}C - 6.0^{O}C = 7.0^{O}$ difference. According to water quality standards for temperature this means there is thermal pollution with a fair standard.

1b. What is the reason (the cause) for these results? Explain this cause thoroughly. What is the consequence of these results? Explain the consequence completely. (4pts.)

There is a dirt pile from a construction site between Points A and B. You can see in the picture that some of the dirt has gotten in the river because of run-off. There is also a sun in the picture. The dirt particles are probably heating up because particles absorb heat in the water and the result is thermal pollution. We also see algae at Point B. One consequence of abnormally warm water is an algal bloom.

1c. What ACTION STEP could people take to make sure this doesn't continue to happen?

Construction sites should put up detention fences (or silt fencing) to capture dirt particles so that when it rains they don't get carried downhill into waterways.

2a. The temperature at Point B of a stream is 13.0 degrees C. The temperature at Point C, one mile downstream, is 25 degrees C. Based on temperature as a measure of water quality, what conclusions would you make about the water quality at Point C? How did you arrive at this conclusion? Show all of your work. (3pts.)

$25^{O}C - 13.0^{O}C = 12.0^{O}$ difference. According to water quality standards for temperature this means there is thermal pollution with a poor standard.

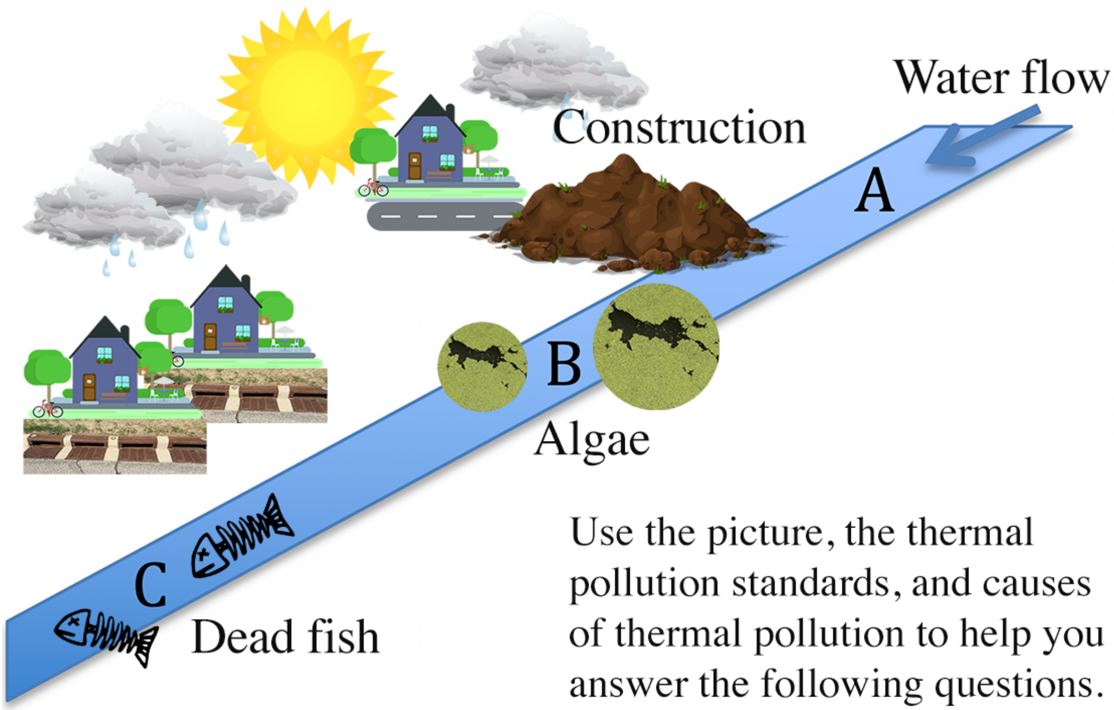
2b. What is the reason (the cause) for these results? Explain this cause thoroughly. What is the consequence of these results? Explain the consequence completely. (4pts.)

In the picture we can see rain clouds and rain and also a sun showing it's a hot day. There are many surfaces – rooftops and roads. The rain is hitting those surfaces and heating up. Then the hot rain is running downhill into the storm drains. Storm drains are connected to the river. The hot water is running into the river and causing it to heat up.
The consequence of thermal pollution is that fish die because they can only live in certain temperature ranges. If it's too hot then they die. We see dead fish at Point C.

2c. What ACTION STEP could people take to make sure this doesn't continue to happen?

People and/or communities can first connect roof gutters or roads to rain gardens. The water could soak into the ground and not flow into the river. Or, if the water does flow into a storm drain to a river it would have to cool down before it got to a river.

Analyze the picture to answer each of the following questions.



1a. The temperature at Point A of a stream is 6.0 degrees C. The temperature at Point B, one mile downstream, is 13 degrees C. Based on temperature as a measure of water quality, what conclusions would you make about the water quality at Point B? How did you arrive at this conclusion? Show all of your work. (3pts.)

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1b. What is the reason (the cause) for these results? Explain this cause thoroughly. What is the consequence of these results? Explain the consequence completely. (4pts.)

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1c. What ACTION STEP could people take to make sure this doesn't continue to happen? (2pts)

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2a. The temperature at Point B of a stream is 13.0 degrees C. The temperature at Point C, one mile downstream, is 25 degrees C. Based on temperature as a measure of water quality, what conclusions would you make about the water quality at Point C? How did you arrive at this conclusion? Show all of your work. (3pts.)

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2b. What is the reason (the cause) for these results? Explain this cause thoroughly. What is the consequence of these results? Explain the consequence completely. (4pts.)

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2c. What ACTION STEP could people take to make sure this doesn't continue to happen? (2pts)

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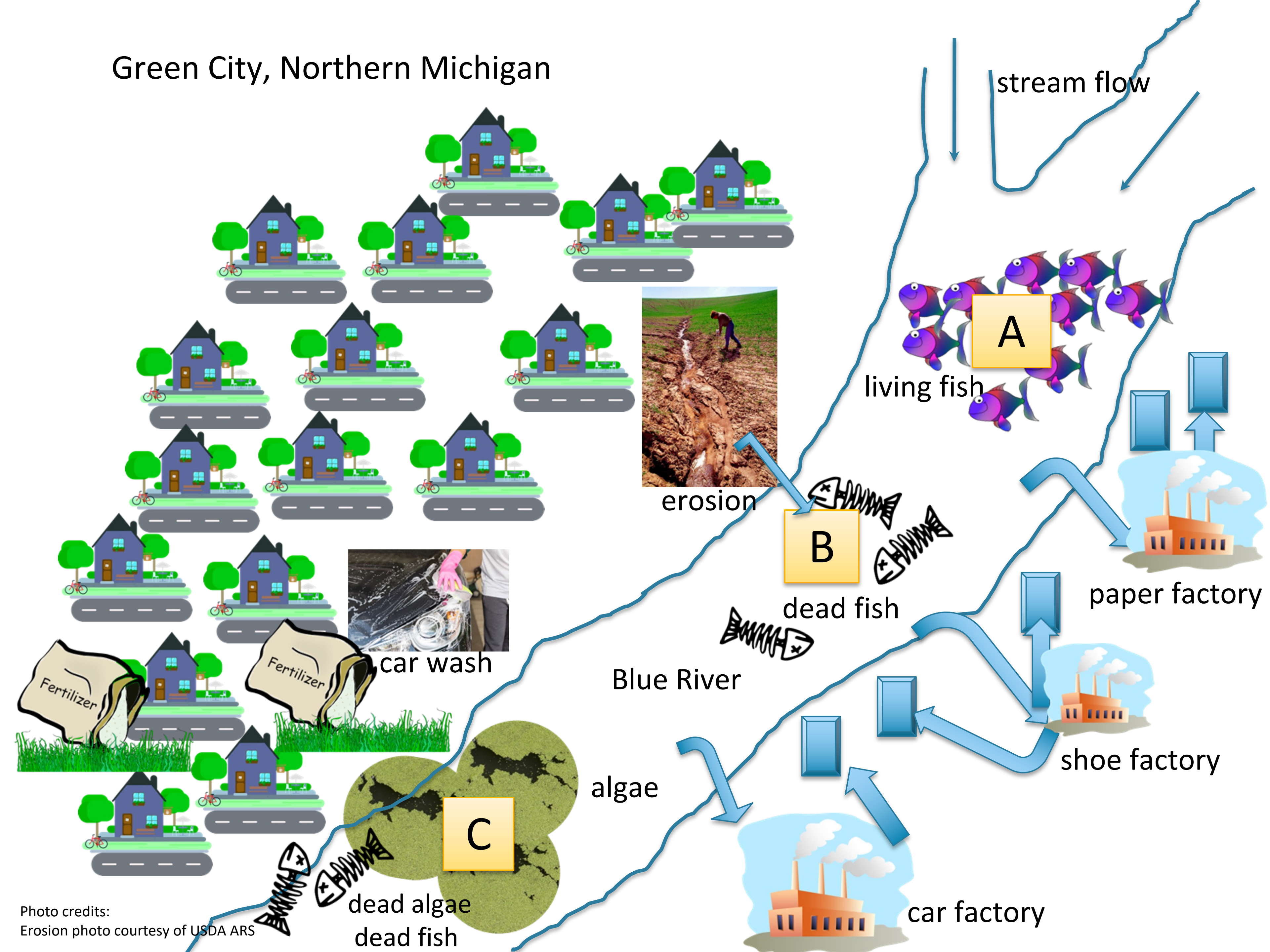


Photo credits:
Erosion photo courtesy of USDA ARS

How do I contextualize learning?

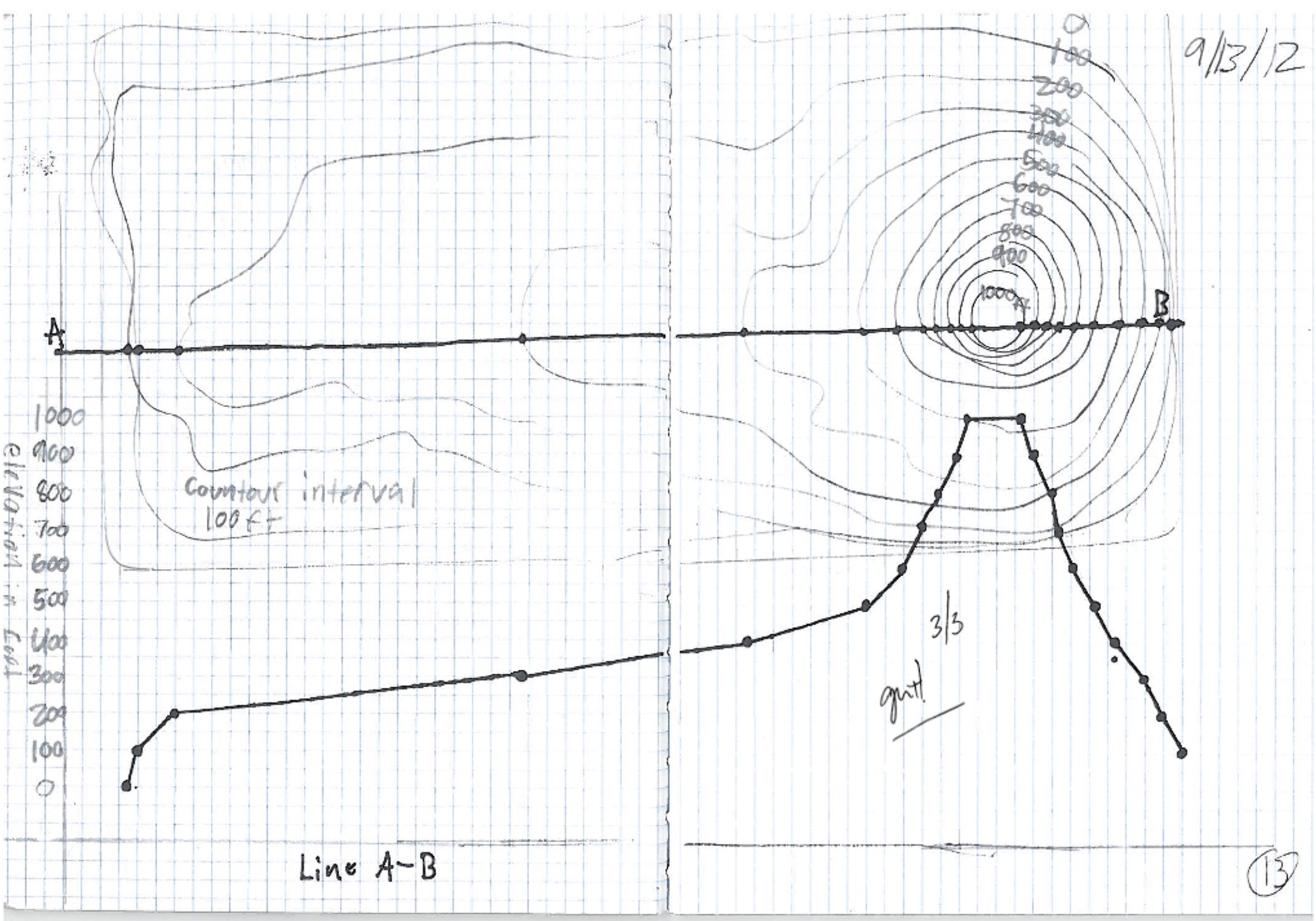
Goal: to motivate, to create interest, need to know, groundwork to situate the driving question – phenomenon that we'll be exploring/explaining through 3-D learning – make learning meaningful

- What are students ideas right now?
- The importance of assessing students prior knowledge

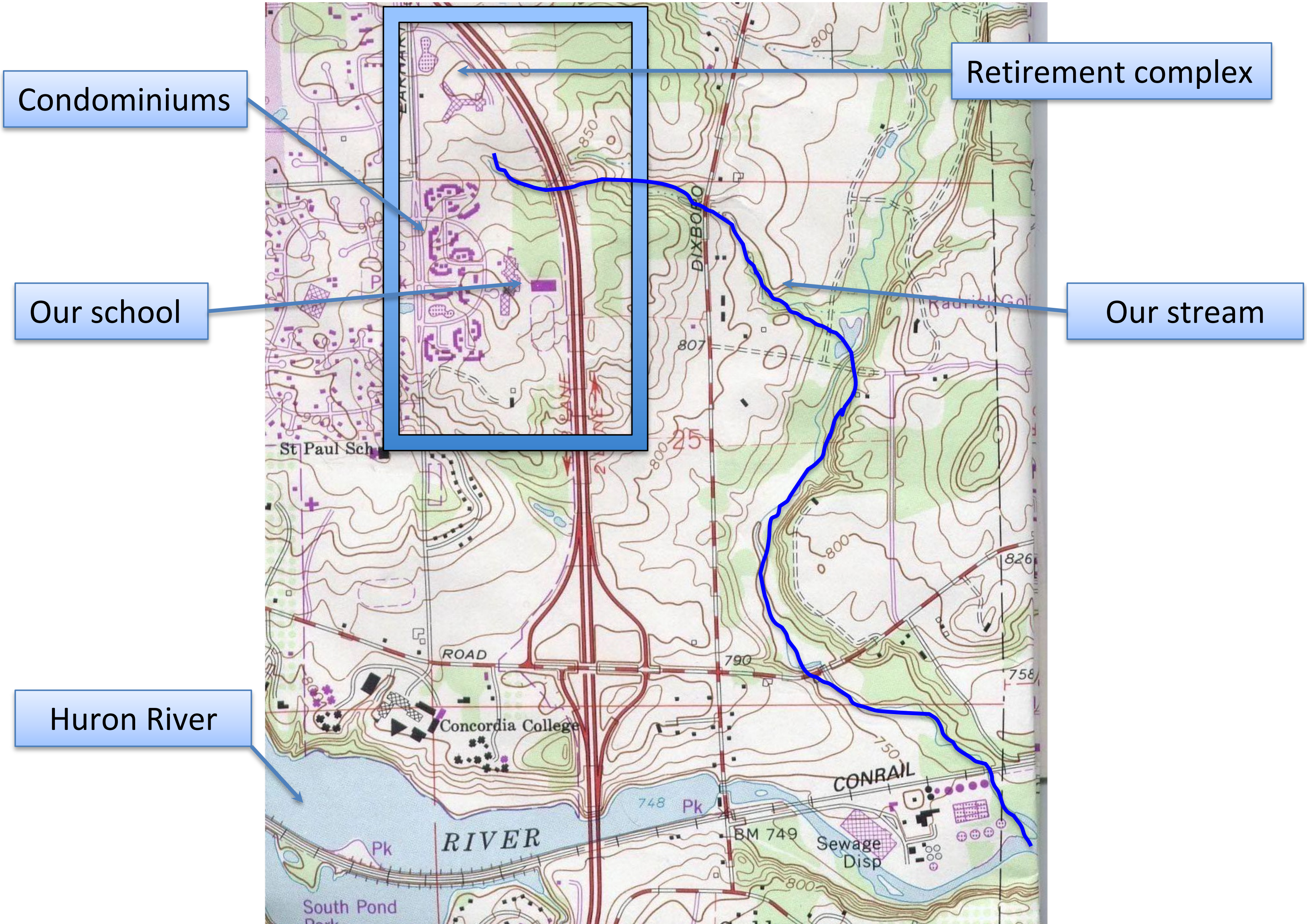
- Watersheds
    physical models
- Point and
- Non-point source pollution

- How much water is on earth and how much is useable for our everyday activities?

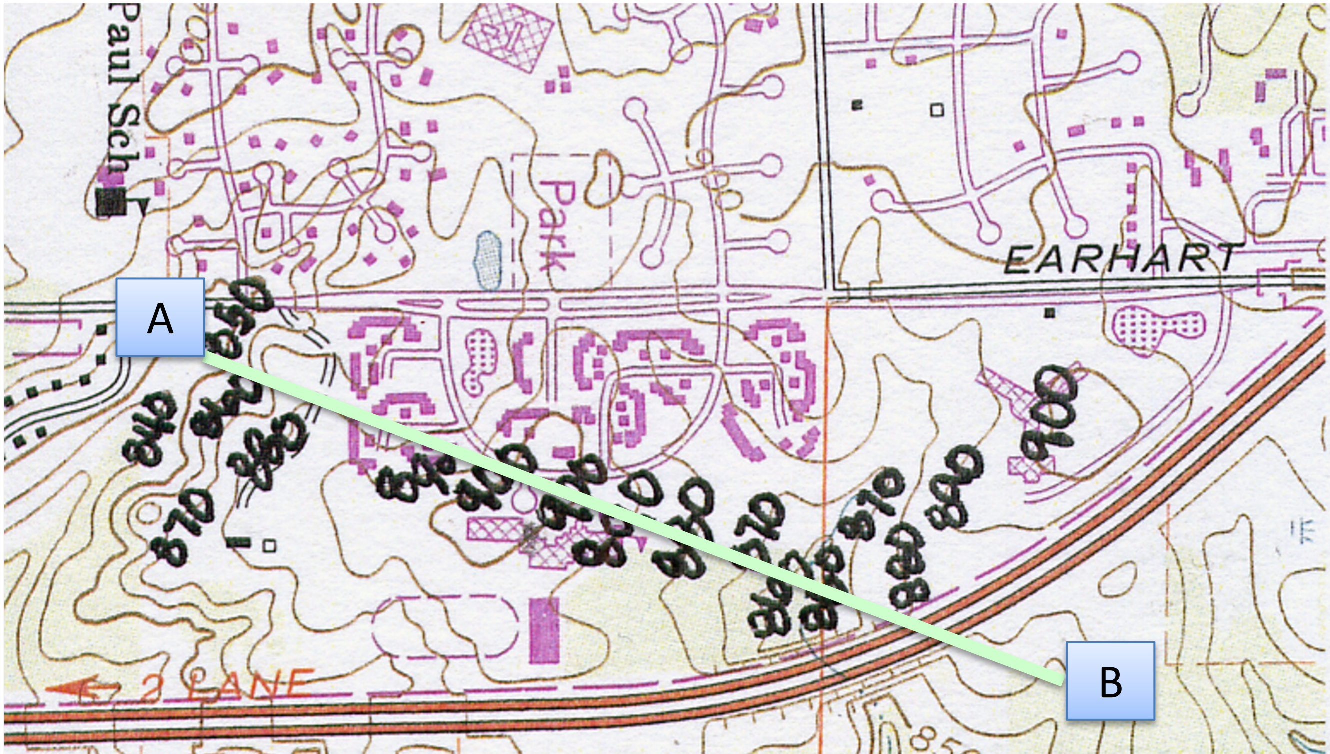
Investigating Watersheds



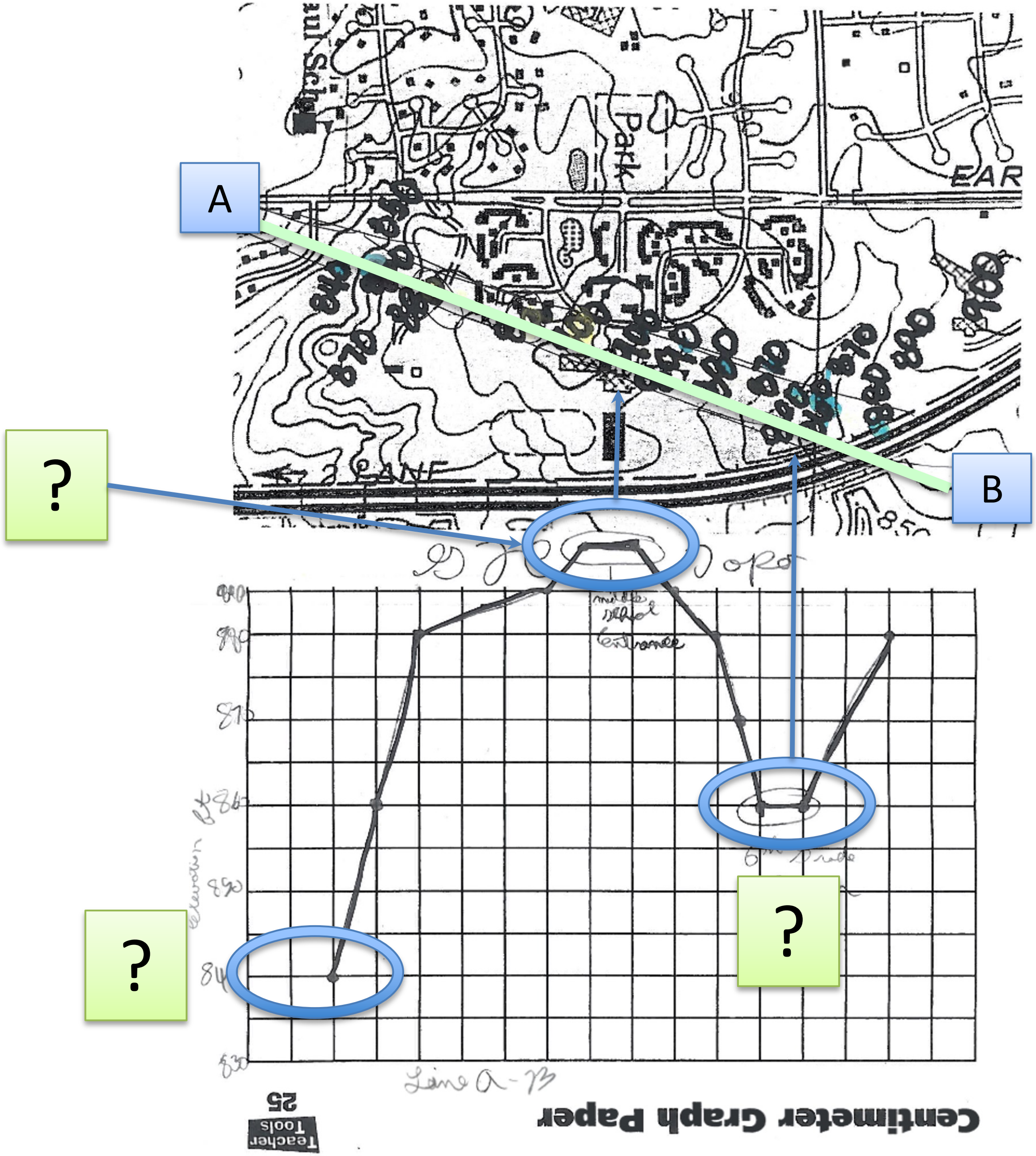
Ann Arbor Topographical Map: East



Graphing our Greenhills' Watershed



Topographical Map of our Mini-watershed



Greenhills "mini" Watershed

What’s in a bucket of water?

You go to a lake, river, or stream and scoop a bucket of water. What might you find?

- The Biological world: The world of living and recently living
- The Geological World: The world of the never living from the earth’s crust and atmosphere
- The Social World: The world of people and our impact on waterways

Water Issues in Michigan

Recent Michigan water quality issues and threats (link)

What are some questions that we can ask related to water quality of freshwaters and people?

- Generate questions and put on sticky notes (~5 min)
- Share questions

Introducing the Driving Question

Options

If waterway is close:
Go for a stream walk and intro the DQ

If not close by, but you have regular access:
Pull up picture, video, etc. of waterway and then intro the DQ

If not access and you will bring in water samples:
Pull up picture, video, etc. of waterway and then intro the DQ

How Healthy is our Stream for Freshwater Organisms? How do our activities on the land potentially impact the stream and the organisms that live in it?

Introduction of the Driving question and the Driving Question Board

The United States of America

The Great Lakes
20% of the world's fresh water

1/3 of southeast Michigan is in the Huron River Watershed

The Huron River supplies 80% of Ann Arbor's drinking water

Storm drains represented by a yellow dot

Making science relevant

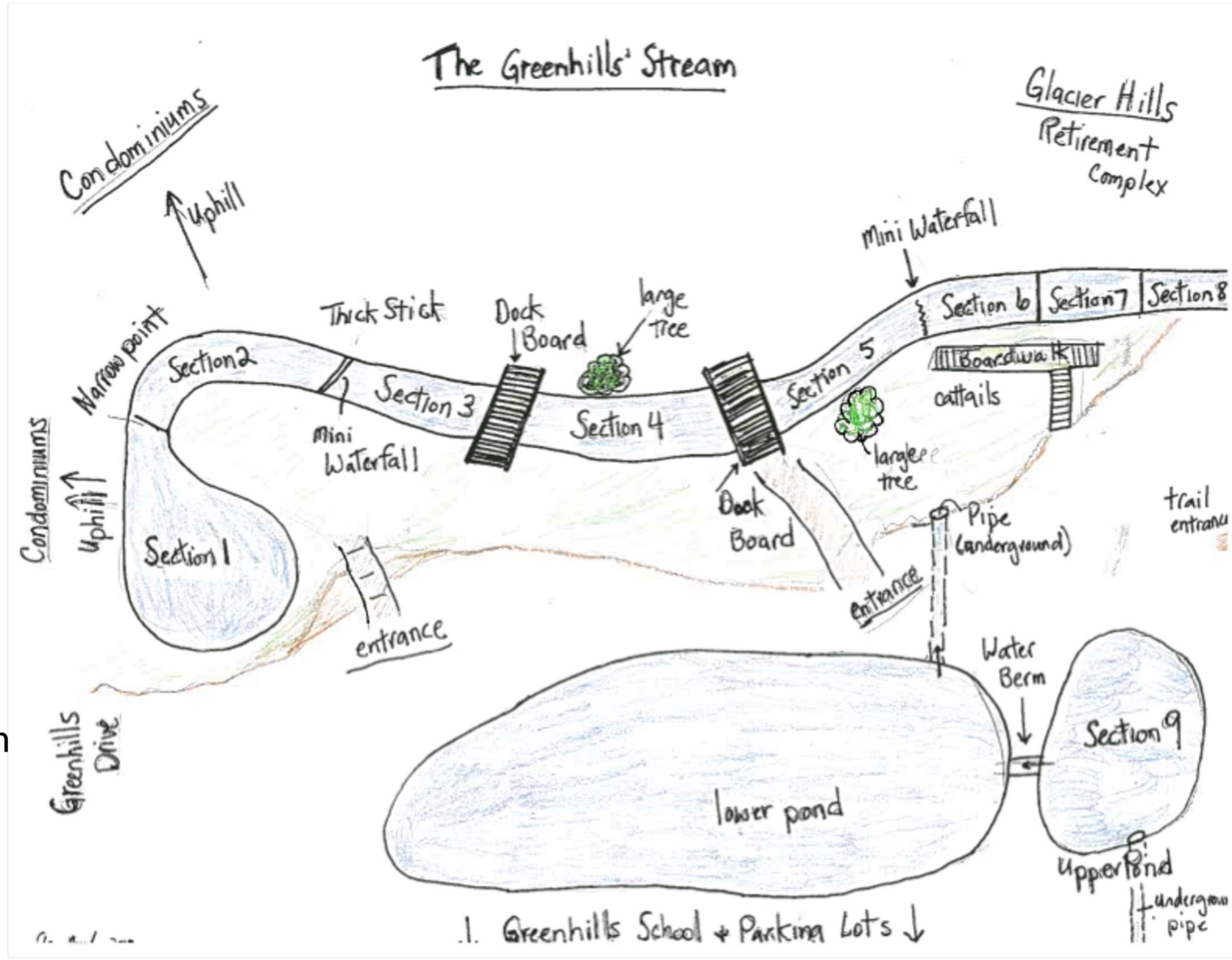
- Our school and our neighbors (condominium and a retirement complex) comprise the mini “Greenhills” watershed
- Anything we do outside at school or outside at our homes can end up in our stream
- Our stream flows into the Huron River that provides 80% of our drinking water
- The Huron River flows into one of the Great Lakes

The natural questions are…..

How healthy is our stream?

Do our actions outside on the land negatively impact the stream and the organisms that live in it?

How healthy is our stream for freshwater organisms and how do our actions on land potentially impact the stream and organisms that live in it?



Eight storm drains pipes to stream

Each stream section is unique, data can vary from team to team.

Students placed in teams, assigned to one of nine sections of the stream

Done with Lesson 1

What context will YOU create to anchor instruction?

Search, find ideas, and share (20 minutes?)

Wikiwatershed: Watershed Mapping Tool

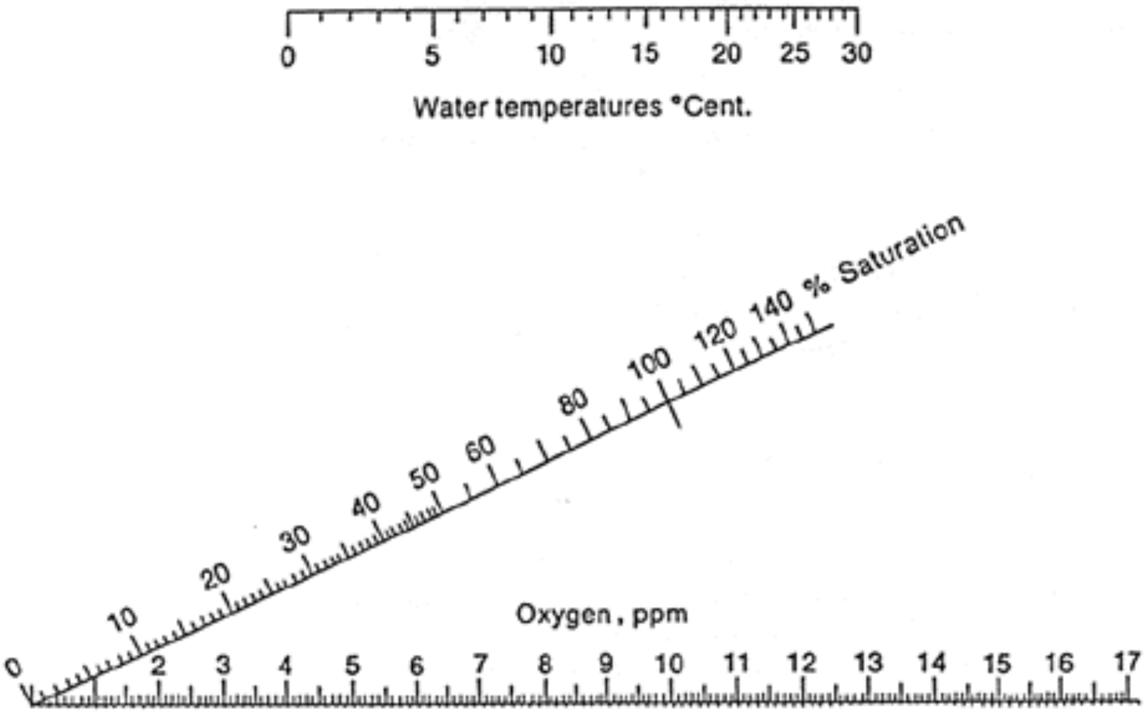
- Alter inputs to calculate outputs
- National land coverage database

Saginaw Bay Watershed Initiative Network

Flint River GREEN

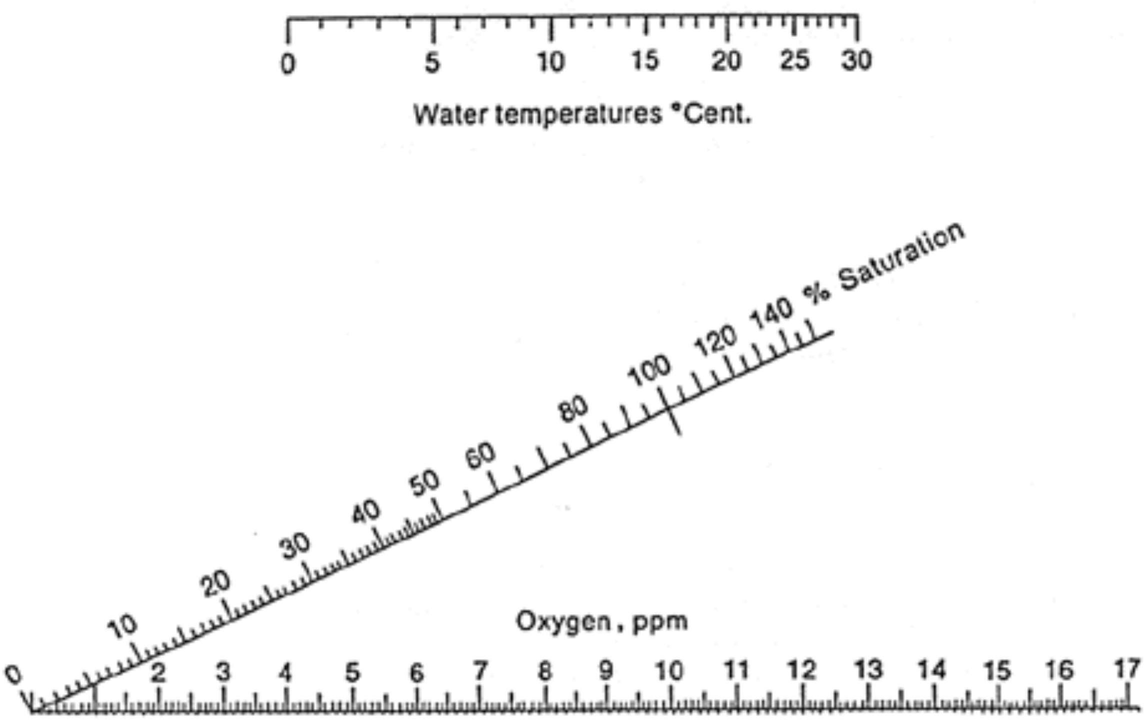
- Links: ELUCID – MSU Watershed Mapping Tool
- Materials>GREEN Notebook> Appendix has resources
- Watershed Map by School District

Dissolved Oxygen (ppm) conversion to % Saturation



Source: http://www.waterontheweb.org/under/waterquality/oxygen.html

Dissolved Oxygen (ppm) conversion to % Saturation



Source: http://www.waterontheweb.org/under/waterquality/oxygen.html

Range of pH that different organisms can tolerate

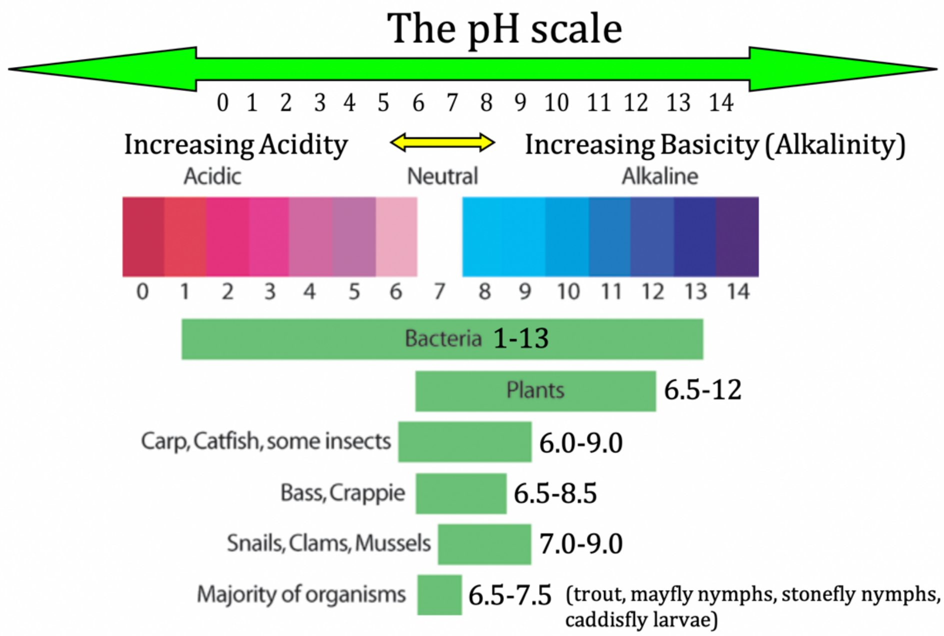


Chart modified from GREEN (Global Environmental Education Network), 1992

Range of pH that different organisms can tolerate

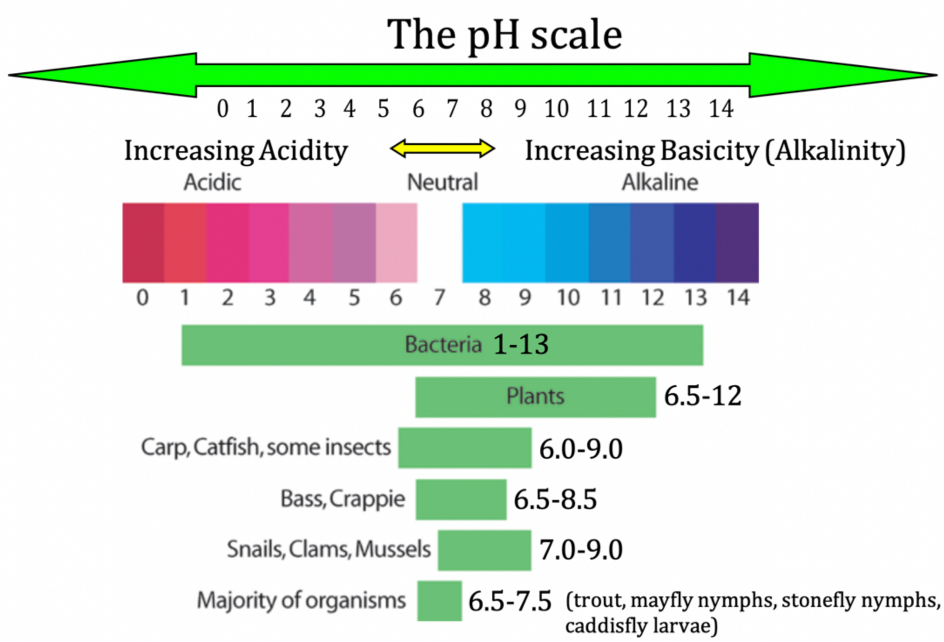


Chart modified from GREEN (Global Environmental Education Network), 1992

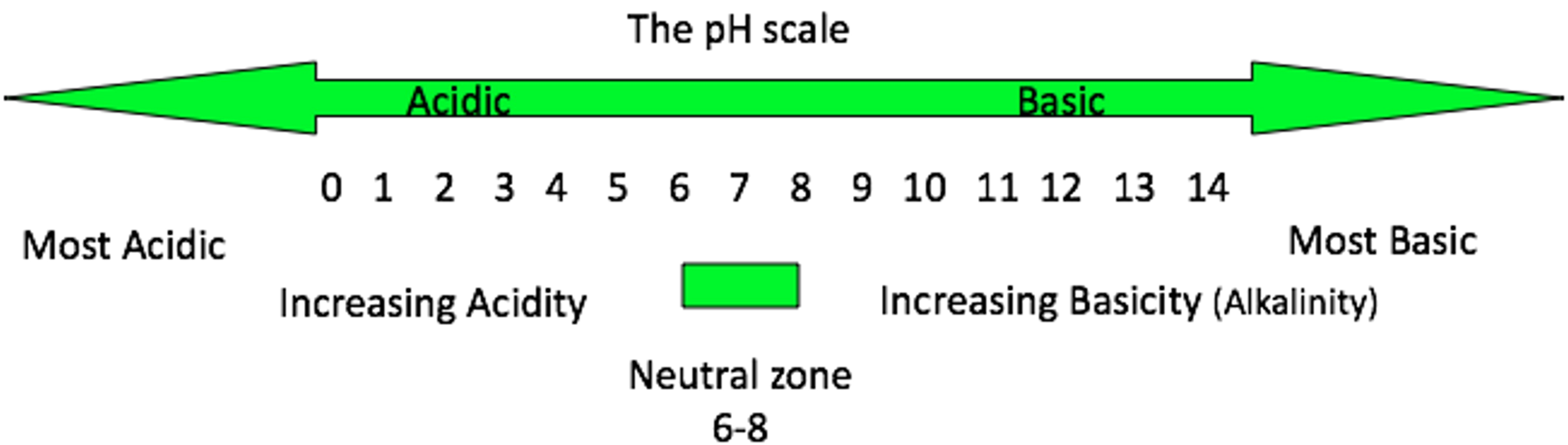
pH: A water quality measure to see if a waterway is acidic, basic, or neutral

- People use products on land and do various activities outside
  - Fertilize lawns
  - Wash cars
  - Use soaps for cleaning windows/garbage cans,
  - Windshield wiper fluid, antifreeze

- When it rains or during snowmelt, these products get washed downhill
- Products get carried with water to storm drains
- Storm drains flow into creeks, stream, rivers – untreated!

- Rainwater that hits the earth, our lawns, gardens, and natural areas can either soak into the land or flows downhill and eventually gets into waterway.
- Acid rain can be produced from factory and car emissions
- If large quantities of pollutants enter a waterway the pH can change.

pH - Is the pH of the water acid, base or neutral?

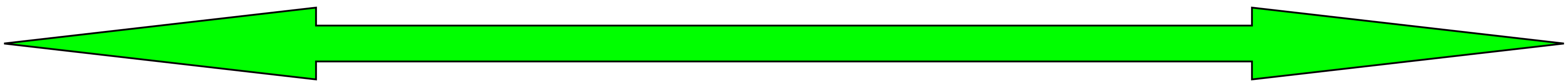


The largest variety of aquatic animals need a neutral pH range between 6.5 to 7.5 to live. Many organisms can live in a pH range between 6-8.

As the water becomes more acidic or basic more and more organisms die off.

The pH scale is logarithmic

The pH scale



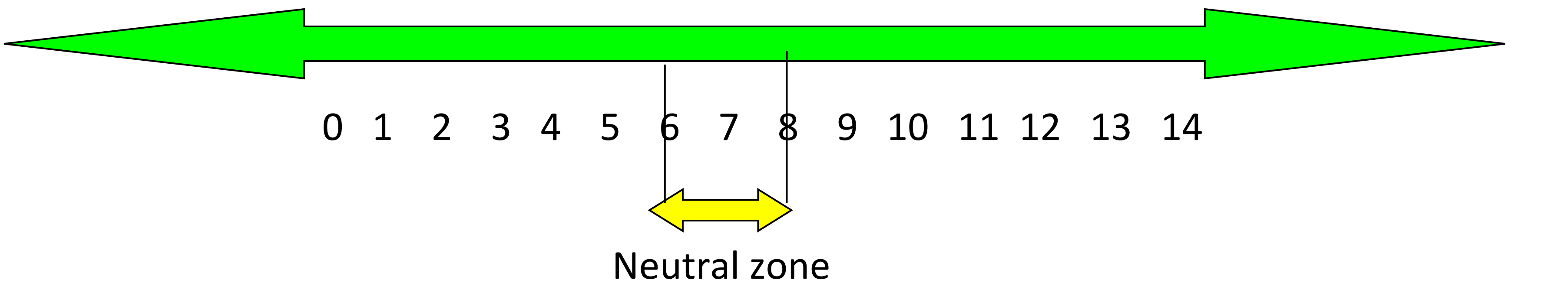
When the pH of a substance changes by one number on the scale, the level of acidity changes by a factor of ten.

A substance with a pH of 5 is 10 times more acidic than a substance with a pH of 6.

- A substance with a pH of 3 is 100 times more acidic than a substance with a pH of 5.

pH and water quality

The pH scale



pH: 7 = excellent water quality
pH: 6 or 8 = good water quality

pH less than 6 or greater than 9 = fair/poor water quality

Ranges of pH that different organisms can tolerate

pH water quality standard	pH range
excellent	6.5-7.5
good	6.0-6.4 7.6-8.0
fair	5.5-5.9 8.1-8.5
poor	Below 5.5 Above 8.6

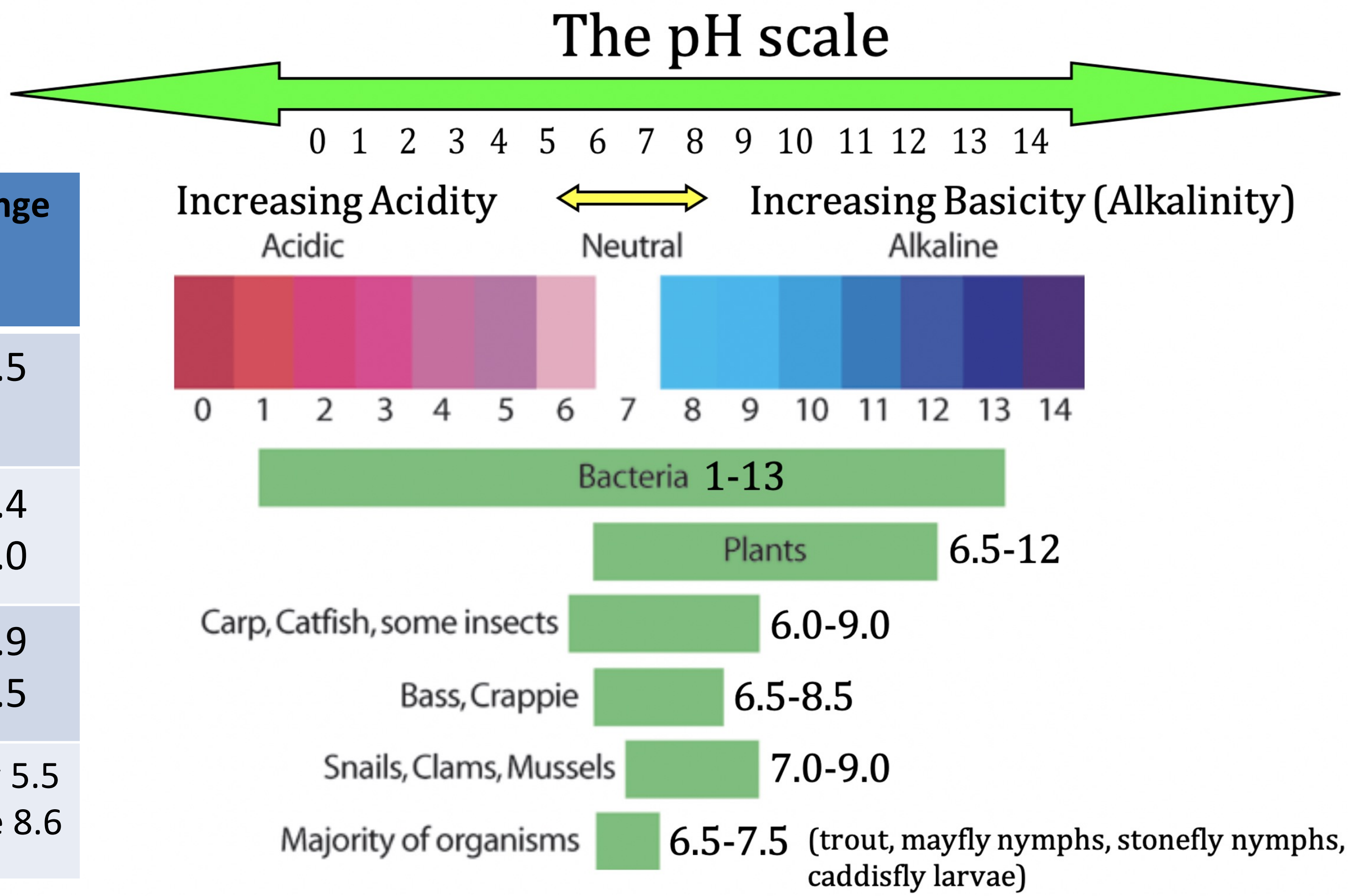


Chart modified from GREEN (Global Environmental Education Network), 1992

How many dissolved solids are in our stream?
Dissolved Solids as a measure of Water Quality

Why do we measure for dissolved solids of streams? Where do they come from?

People use products outside on land that can get washed into storm drains or simply run downhill during rain or snowmelt and then flow into streams, rivers, and lakes. Some of these products contain substances that dissolve. Three of the major dissolved solids that impact water quality are road salt, nitrates, and phosphates. High amounts of these can cause problems for organisms in the water.

Road Salt – What is its source and how does it Impact Water Quality?

If you live in a northern climate you probably have experienced snowy winters. In addition to snow covered roads, ice and freezing rain can cause po y rds. Road salt is put on surfaces - roads, sidewalks, and parking lots - to help a cciden le safe.

Organisms in lakes, rivers, and stream are freshwater organisms not saltwater organisms. Although adding salt to slippery roads is important for safety reasons, too much salt can be a problem for freshwater organisms.

Nitrates and Phosphates – What are they and where do they come from?

Compounds that contain nitrates and phosphates can dissolve. For instance, sodium nitrate can dissolve in water. But what are they? Nitrogen and Phosphorus are both elements. In nature, nitrogen and phosphorous can be found in various compounds like sodium nitrate and potassium phosphates. Nitrates and phosphates are essential nutrients; all organisms need them for growth and repair. However, they are only needed in very small amounts. So where are nitrates and phosphates found? Well, if all living organisms need them, then all living organisms have nitrates and phosphates. But so do products that come from them, like animal waste. All dead or s, then, have nitrates and phosphates. Another name for dead organisms is organic w s includes dead animals and plants. If you live in a climate where leaves change colors a ff trees every year you are very familiar with dead leaves!

Dirt can hold nitrates and phosphates. So far, all of these sources are from nature.

Nitrates and phosphates are essential components of the life cycle. When there is organic waste (dead plants and animals), decomposers such as bacteria break down the dead matter. During this process, nitrates and phosphates are released. On land, the nutrients go into the soil and are then used by plants for growth. In the water, water plants use nitrates and phosphates that are released from decomposition. Whether on land or in the water, animals eat plants and other animals. That's how they get nitrates and phosphates. Both the plants and animals eventually die and become organic waste and the cycle starts all over again. This cycle is important. Without it, new plants and animals would not be able to grow!

Too many nitrates and phosphates in water, however, can cause significant problems for aquatic environments. A major source of excess nutrients (nitrates and phosphates) in waterways is fertilizer. Think about it – farmers use fertilizer to help their crops grow. People use fertilizer to have nice lawns and gardens.

When it rains, runoff from agriculture, lawns, and home gardens can flow downhill and into various waterways, contributing excess nutrients. Dairy farms have cows that produce waste. Cow manure and manure from other animal farms can also runoff into waterways. In addition, nutrients can come from leaking septic tanks and from wastewater treatment plants. Finally, some cleaners contain phosphates. These sources – fertilizer, human waste, animal waste from farms, and cleaners – come from people and result in excess nitrates and phosphates.

What is the effect (consequence) of excess nitrates and phosphates in waterways?

When there are too many nitrates and phosphates it can lead to a disruption of the life cycle that can eventually result in a **dead zone**. Dead zones are areas in water that cannot support life. A chain-reaction cycle occurs. First, excess nitrates and phosphates in water, often from fertilizer runoff, can result in excess algae growth causing algal blooms (remember that both nitrates and phosphates are nutrients for growth). Algae have a short life span. When all the excess algae die, there is an excess amount of organic waste. Do you remember what happens to organic waste? It is decomposed, broken down, by bacteria and other decomposers. If there is an excess amount of organic waste, there is an excess food source for bacteria. The bacteria population dramatically rises. Bacteria need oxygen. These excess bacteria use up all of the oxygen. Fish and other aquatic organisms need oxygen. Without it, they die. This results in more organic waste and the cycle starts again. Eventually, the oxygen is depleted (this cycle is also known as the oxygen depletion cycle) and the area becomes a dead zone.

How do we measure dissolved solids?

There are different ways to measure the amount of dissolved solids in water. One method is to use a conductivity probe. Dissolved solids can conduct electricity. For example, when put in water, sodium chloride (salt) breaks apart into sodium and chloride and can conduct electricity. Sodium nitrate breaks down in water to sodium and nitrate and potassium phosphate breaks down in water to potassium and phosphate and can conduct electricity. Though a conductivity probe can measure the ***amount*** of dissolved solids in a lake, river, or stream, it will not identify which solids are dissolved. Qualitative observations are used to help determine which solids might be dissolved in the water.

What would you look for **in** water that might indicate the possibility of nitrates and phosphates?

Dead, decaying leaves, water plants or other plants in the water could indicate nitrates and phosphates. Algal blooms could indicate excess nitrates and phosphates. Soap bubbles could indicate phosphates.

What **area** observations might indicate that people are using products on land that might contain phosphates and nitrates that could have entered water through runoff?

Nice lawns and/or gardens could indicate fertilizer. Windows, cars, etc. could indicate cleaners. Farms or golf courses in the area could indicate fertilizer use.

If you live in a northern climate, winter weather could result in snow. High readings from a conductivity probe could be the result of road salt that has entered a waterway through run-off.

Road salt, Calcium chloride, can break down and conduct electricity. In addition to conductivity probes, nitrate and phosphate kits are sometimes used.

Here are water quality standards for different ways of measuring the amount of dissolved solids:

Dissolved Solids Water Quality Standards	**Conductivity probe**	**Total Phosphate**	**Nitrates**
Excellent – not too many dissolved solids	0-100 mg/L	0-1 mg/L	0-1 mg/L
Good - not too many dissolved solids	100-250	1.1-4	1.1-3
Fair - too many dissolved solids	250-400	4.1-9.9	3.1-5
Poor - too many dissolved solids	> 400	> 10	> 5

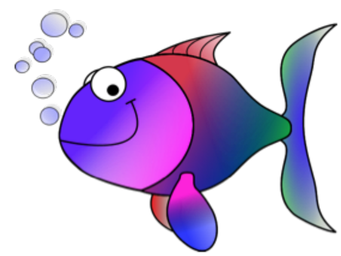
Whether due to road salt, nitrates, or phosphates, too many dissolved solids are not healthy for streams and organisms that live in streams. People's actions on the land can significantly impact the amount of these dissolved solids. Are there some action steps that you can think of that people can take to minimize the amount of dissolved solids that may enter waterways?

People can use less fertilizer and road salt. Don't use fertilizer at all. Instead, cut your grass and leave it on the lawn to naturally decompose and put nitrates and phosphates back into the soil. Rake leaves away from storm drains.

Is there enough oxygen for fish and other aquatic animals in the stream?
Dissolved Oxygen as a measure of water quality

What is dissolved oxygen (D.O.) and why is it important to measure?

Can you imagine what would happen if you didn't have enough air to breathe? Just like people, fish and other aquatic organisms need oxygen to live. Dissolved oxygen is oxygen gas that is in the water. Unlike many other water quality measures high amounts of oxygen are positive for organisms in the stream! Fish don't have lungs, like people. Instead, fish have gills that allow them to breathe in the oxygen that is in water. If there isn't enough oxygen in the water, fish and other organisms die. Trout is a type of fish that needs very high amounts of oxygen to live. That means that trout is an indicator fish. Carp, on the other hand, is a type of fish that can live in high and low oxygen levels.



If trout are spotted in a stream, what does it mean?

Trout need lots of oxygen so if there are trout in the stream that is in indication that there is plenty of oxygen in the water

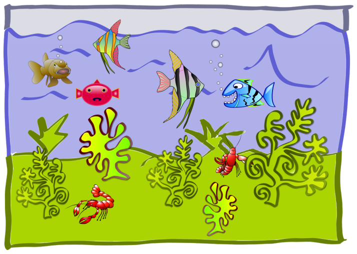
Do you remember other water quality measures and the results that trout need to make the water hospitable?

Trout need a very neutral pH, 6.5-7.5, which is an excellent standard for pH. Trout also could die if there was thermal pollution.

What are the sources of dissolved oxygen – where does it come from?

Have you ever seen water crashing against rocks as it flows downstream? At the bottom of a waterfall, have you observed the water as it hits the water below? The crashing water below a waterfall or against rocks causes turbulence.

Turbulent water can capture oxygen from the air. It traps the oxygen and pulls it into the water. The atmosphere, therefore, is one source of oxygen for streams. Any fast moving water that causes turbulence can capture oxygen from the air.



Another source of oxygen in stream comes from water plants. During photosynthesis plants produce oxygen. If the plants are on the land, the oxygen goes into the air. If stream, lakes, and rivers have water plants, when these plants produce oxygen, the oxygen goes into the water.

What causes oxygen levels to drop?

The main reason oxygen levels drop is due to excess organic waste. Organic waste is any decomposing waste from an organism. When plants and animals die they become organic waste. Waste from animals and raw sewage are also organic waste. When excess algae (often due to excess nitrates and phosphates) dies it becomes organic waste. Bacteria decompose organic waste.

Because there is an abundance of organic waste, the bacteria population dramatically increases. Bacteria also use oxygen. If there are excess bacteria they will use up all of the oxygen. Fish and other aquatic organisms die from lack of oxygen. This results in more organic waste. The cycle starts again. The end result may be an oxygen-depleted environment that can lead to a dead zone: a place that lacks the conditions necessary for life.

Another factor that could contribute to lower oxygen levels is thermal pollution. Warm water cannot hold as much oxygen as cold water. So if the water is abnormally hot its oxygen levels may be lower.

Water Quality Standards

Just like other water quality measures there are standards that are used to reflect if a fresh water body of water has enough oxygen.

Here are the water quality standards for dissolved oxygen:

Dissolved Oxygen Water Quality Standards	Dissolved Oxygen Percents
Excellent – plenty of oxygen	91-110%
Good – enough oxygen	71-91% or over 110%
Fair – not enough oxygen	51-70%
Poor – not enough oxygen	Below 50%

When you test your stream or river for dissolved oxygen, what results are you hoping to get? Can you explain why?

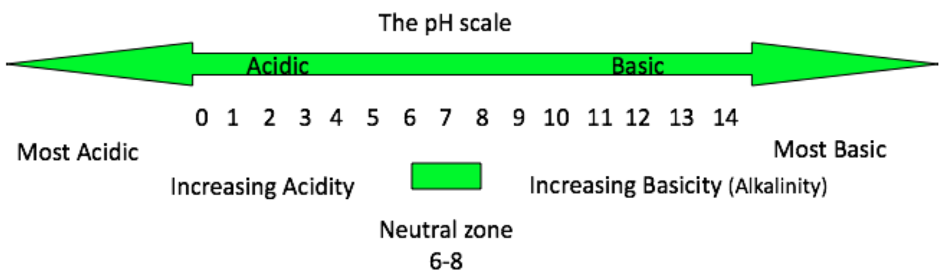
Fish and aquatic animals need oxygen to live so I'm hoping for high levels of dissolved oxygen.

Student Reader, pH

Is the stream acidic, basic, or neutral? pH as a measure of Water Quality

What does pH measure?

pH is a water quality measure that determines if a stream, river, or any body of water is acidic, basic, or neutral. Look at the pH scale below and you'll see that it runs from a value of zero, which is very acidic, to 14, which is very basic. Right in the middle is 7, which is neutral.



Credit: Ann M. Novak

What is the pH range that is the best for freshwater organisms - the pH range that is the best for the majority of organisms? To find out, look at the chart below. Read the types of organisms and line them up with the pH scale. <u>The best range of pH for organisms is 6.5-7.5</u>

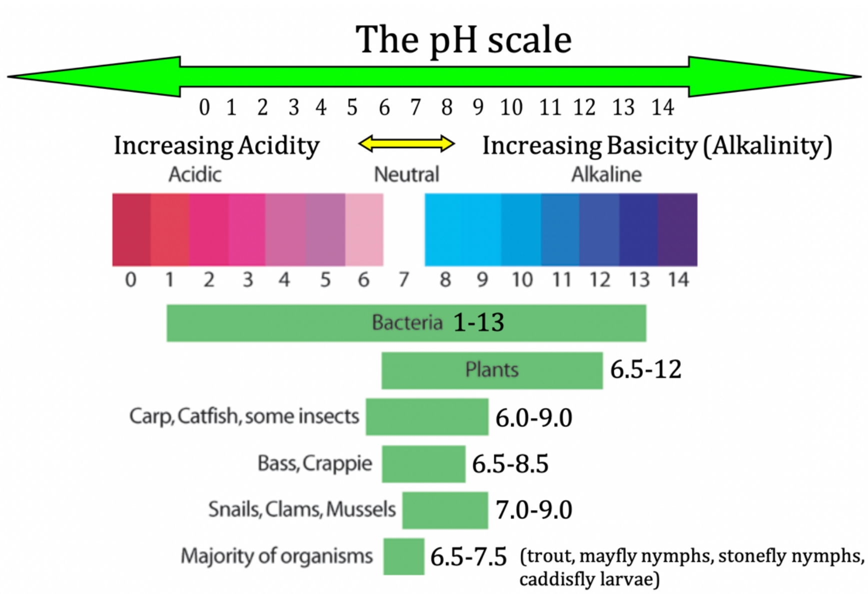
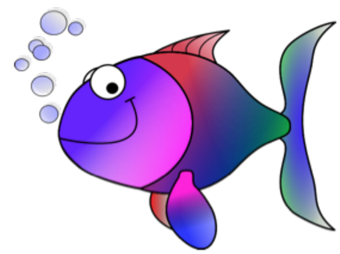


Chart modified from GREEN (Global Environmental Education Network), 1992

Student Reader, pH



Do you see that the majority of freshwater organisms need a pH between 6.5 and 7.5? This is the best pH range for freshwater organisms and would be considered excellent water quality for pH. Examples of organisms that need this pH range in order to live include trout, mayfly nymphs, stonefly nymphs, and caddisfly larvae.

Many other organisms can live in a pH range that falls between 6–8 on the pH scale. This is called the *neutral zone* for freshwater organisms. It's a pretty healthy pH for water and would be considered *good* water quality, even though 6.5-7.5 is the best. Look back at the pH scale. Do you see that 6-8 is labeled as the neutral zone? When we test the water quality of a river or stream (or any freshwater body) we hope that the pH is either excellent (pH between 6.5-7.5) or good (pH between 6.0-6.5 or 7.6-8).

What happens when the water's pH becomes more acidic or basic? Write down your guess.

Answers will vary

If something causes a stream to become either too acidic or too basic, the organisms that need a more neutral pH will die. The water is no longer healthy for them. For example, trout, mayfly nymphs and stonefly nymphs need a pH range between 6.5-7.5. Bass and Crappie would also die; they need a pH between 6-8.5. Remember, most organisms need neutral pH.

Look back at the pH chart. What organism can live in the largest range of pH? What is the pH range? What other types of organisms also have a large pH range? What is the range?

Bacteria can live in the largest pH range between 1-13. Plants can live in a large pH range – 6.5-12

Student Reader, pH

Reading the chart, you should see that bacteria can survive in a pH range from 1-13. This is a huge range - bacteria are very hearty organisms! Plants can live in a pH range between about 6-12 or 13.

Credit: Ann M. Novak

What *causes* pH to become acidic or basic?

People use products on land and do various activities outside that can end up causing a stream to change its pH. How can this happen? If someone puts fertilizer on their lawn, when it rains, the fertilizer can get picked up with the rain and then be carried by the rain downhill into the nearest water. If someone has a car wash, the car wash soap will run downhill and into a storm drain. Did you know that storm drains are connected underground to pipes that flow directly into streams, rivers and lakes? LOTS of people use fertilizer and wash their cars.

People use lots of other of products outside: soaps, windshield wiper fluid, antifreeze. We wash our driveways with a garden hose using tap water or we water our lawns with a sprinkler system. Tap water is water that is treated with chemicals to make it safe for people to drink. Those chemicals in tap water, along with products people use outside on the land can have an acidic or basic pH. If they run-off the land, either through storm drains or downhill on land, they can enter various waterways and change the pH. This can happen even if we live far away from a body of water. Many farmers also use fertilizer and pesticides that can run off into water. So do many people who take care of golf courses. Acid rain can also change the pH of water. Pollution from automobiles and coal-burning power plants can enter the air and interact with moisture and oxygen to form acid rain. The acid rain can enter the streams and lake and change the pH to be more acidic. All of these, use of fertilizer, car washes, and acid rain, and lot of other activities people do outside can cause the pH of freshwater to become either acidic or basic.

Water Quality Standards

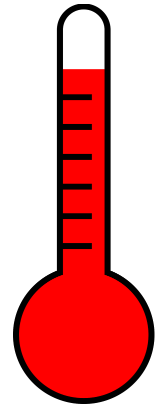
Remember earlier that we said 6.5-7.5 pH range is excellent and that just below or just above these numbers in the neutral zone are good? A group of scientists got together and developed National Water Quality Standards for freshwater lakes, rivers, and streams (Stapp, & Mitchell, 1995). They used four categories for all water quality test results. They are *excellent, good,* fair, *or* poor. If a water quality test falls into the *excellent* or *good* range for water quality standards, the stream is considered healthy for freshwater organisms with *excellent* being better than *good*. If, on the other hand, the test results match up with *fair* or *poor* water quality, the stream has problems related to supporting freshwater organisms with *poor* being the most problematic. Here are the pH water quality standards:

pH Water Quality Standards	**pH Range**
Excellent - neutral	6.5-7.5
Good - neutral zone	6.0-6.4 or 7.6-8.6
Fair - too acidic/basic	5.5-5.9 or 8.1-8.0
Poor - too acidic/basic	below 5.5 or above 8.5

When you test your stream or river for pH, what results are you hoping to get? Can you explain why? Include two or three examples of organisms and pH ranges they need in your response?

I hope we get a pH of 6.5-7.5 because that is the range where the largest variety of organisms can live. For example, trout, mayfly nymphs and stonefly nymphs all need a pH between 6.5-7.5.

Is the stream too warm for freshwater organisms?
Temperature as a measure of Water Quality



Why do we measure temperature of streams?

We are all familiar with temperature. Temperature tells us how hot or cold something is. The temperature of a stream or river can change. If you live in a northern climate, the water's temperature will be different in the summer than it will be in the winter - that's normal. At the same time of year, the temperature of rivers and streams in the south, like in Florida or Texas, will be different than temperatures in rivers and streams in the north, like in Michigan or Alaska - that's normal too. Climate or the seasons naturally affect the temperature of the water. When we measure for temperature we are trying to determine if the temperature is **abnormally warm** - we're looking for an abnormal temperature increase. For example, we would expect the temperature of waters in Canada to be cool in the winter. If we measure temperature of a river and find it to be hot we would be surprised. We might think, "something isn't right here" and need to investigate further. An abnormal temperature increase is called **thermal pollution**. It is a very different type of pollution than what we usually think of, because it isn't "stuff" that got into the water causing it to be polluted.

How do we measure for thermal pollution?

When experts test for thermal pollution, they take a temperature reading at two different locations one mile apart and then subtract to obtain a temperature difference. They look to water quality standards for temperature differences to see if there is thermal pollution.

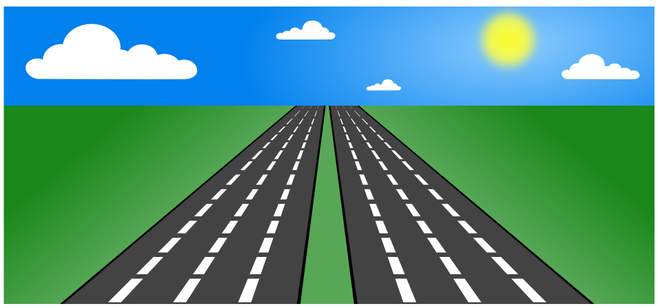
Here are the water quality standards for temperature differences, or thermal pollution:

Thermal pollution Water Quality Standards	**Temperature differences degrees Celsius**
Excellent - no thermal pollution	0-2^0 Celsius change (difference)
Good - no thermal pollution	2.1-5^0 Celsius change (difference)
Fair - thermal pollution	5.1-10^0 Celsius change (difference)
Poor - thermal pollution	above 10^0 Celsius change (difference)

What are the causes of Thermal Pollution?

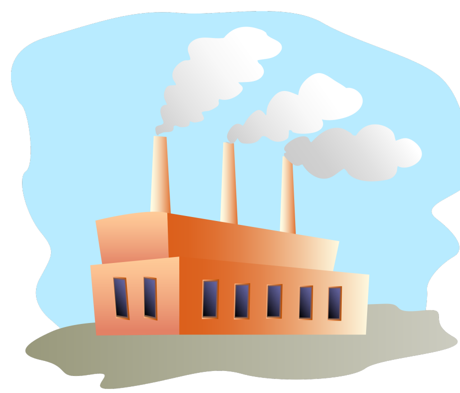
Think about this:

It's a hot summer day and you want to go swimming. You throw on your suit, grab a towel, and jump into your car and an adult takes you to the pool. You were in such a hurry that you didn't put anything on your feet. You arrive to the pool and pull into the parking lot and park. You leap from the car and, "Ouch! Ouch! Ouch!" Your feet are burning up because the parking lot is SO hot! You rush to the grass and "whew! - that feels so much better!" - the grass feels cool.



There are four causes of thermal pollution. One cause of thermal pollution is **hot surfaces**. Human-made parking lots, roads, even rooftops heat up when it's hot outside. If it rains, the rainwater hits these hot surfaces. The rainwater now also becomes hot. Do you remember where rainwater goes? It goes downhill to the nearest storm drain. Do you also remember where the water in storm drains go? It flows into nearby creeks, streams, rivers and lakes. This now **hot** rainwater then flows into the water and heats it up, causing thermal pollution, an abnormal temperature increase.

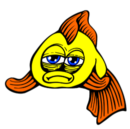
A second cause of thermal pollution is from factories that produce products we use every day, other industries, and power plants. They pull in water from a river or lake and use it to cool their machinery. The water warms up as it cools the hot machines. If this hot water is then discharged back into the river or lake then it warms up, causing thermal pollution.



A third cause of thermal pollution is soil erosion or other particles that are in the stream. Erosion can be caused when people cut down trees; the roots hold soil in place. It can be caused during construction when people dig holes in the ground and loose dirt is put in piles. Poor farming practices can result in loose dirt. All of this loose dirt can be carried into rivers and streams when it rains causing the water to become muddy (turbid). Dark water captures more heat from the sun and the water heats up. This can be a huge problem in the summer when the sun feels so hot.

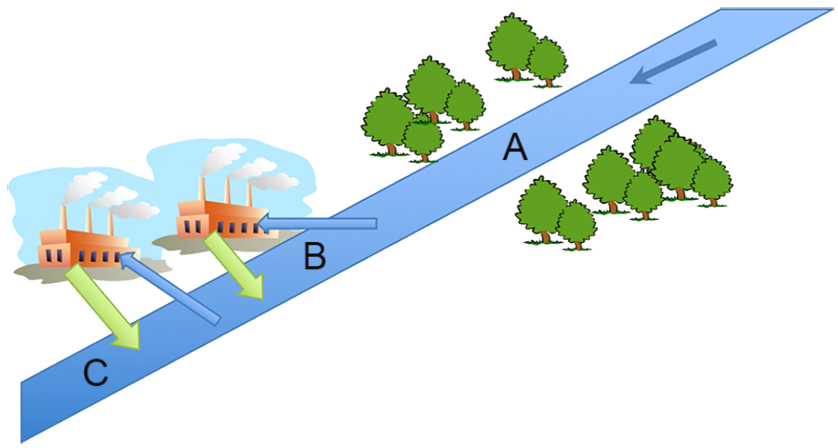
A fourth cause of thermal pollution occurs when people cut down trees along a riverbank or pond. Trees help to shade the river from the sun. Without the trees to provide shade the sun shines directly on the water and it warms up.

What are the effects (consequences) of Thermal Pollution?



Water temperature is very important for the health of a stream or river. There is a negative relationship between thermal pollution and water quality for freshwater organisms. Fish and other aquatic organisms live in certain temperature ranges. If water is too warm they die. For example, trout and stonefly nymphs need cool temperatures. Organisms' dying is one of four consequences of thermal pollution.

A second consequence of thermal pollution is that warm water can promote an algal bloom. Warm water increases the rate of plant growth and plants, like algae, can thrive. When these plants die they are decomposed by bacteria. The bacteria use up the oxygen. Third, warm water cannot hold as much oxygen as cold water so a third consequence of thermal pollution is the potential for less oxygen. Finally, thermal pollution can weaken fish and insects and make them more vulnerable to disease and toxic waste.



1. At Point A of a stream the temperature reading is 11.8 degrees Celsius. At Point B, father down the stream, the temperature reading is 12.8 degrees Celsius. What can you say about the water quality at Point B based on the temperature test? How do you know? What might be the reason for these results? Show all of your work.

Since the differences of 11.8 degrees C at Point A from 12.8 degrees C at Point B is 1.0 degrees C that means that there is no thermal pollution because a 1-degree temperature difference. That is excellent water quality according to temperature differences because if falls into the excellent range of water quality standards. The reason there is no thermal pollution, looking between Points A and B there are no causes of thermal pollution and there are lots of trees that could be providing shade.

2. At Point B of a stream the temperature reading is 12.8 degrees Celsius. At Point C, farther down the stream the temperature reading is 20.2 degrees Celsius. What can you say about the water quality at Point C based on the temperature test? How do you know? What might be the reason for these results? Show all of your work.

Since the differences of 12.8 degrees C at Point B from 20.2 degrees C at Point C is 7.4 degrees C that means that there is thermal pollution because a 7.4-degree temperature difference. According to temperature differences it falls into the fair range of water quality standards. The reason there is thermal pollution, looking between Points B and C I can see that there are factories that are taking water in from the river to cook their machinery. The water gets hot. I see pipes that show the hot water is being put back into the river. It's causing the water to be abnormally hot.

Are there too many floating particles in the stream?
Turbidity as a measure of Water Quality

What is turbidity and why is it important?

Did you ever see water that was so dirty that you couldn't see through it? Turbidity measures the amount of floating particles in water that cause the water to look murky. Floating particles, whether on top of the water, throughout the water, or sitting on the waterbed, do not dissolve. Water that is not turbid is clear. High turbidity in freshwater lakes, rivers, and streams means poor water quality.

What causes high turbidity?

There are many different types of particles that float in water. Dirt is a very common cause of high turbidity. Dirt in the water can be the result of two different activities that people do on land. One, when people build houses, apartments, or other buildings, part of the building process often includes digging a hole for a basement or for underground parking. Mounds of dirt can sit at a construction site.

When it rains, the rainwater can pick up the dirt and carry it downhill into streams, rivers, or lakes, or it can first go to storm drains that have pipes that are connected to these waterways. Preventing stormwater pollution is a component of the Clean Water Act (http://www.epa.gov/region5/water/cwa.htm) passed in the United States in 1972. Do you have any ideas of how this dirt run-off might be prevented?

Answers will vary

Did you ever see two-foot fences around a construction site? These silt fences are one solution that the construction industry came up with to help ensure that dirt would not run off from construction areas. The solid mini fences capture dirt by acting as a barrier. They work to prevent dirt runoff.

A second source of dirt is from erosion. Plants have roots that hold the soil in place. If people cut down trees or other plants the result can be loose soil. Just like from construction sites, loose dirt anywhere can be picked up by rain and carried downhill into waterways. Have you ever seen how rivers turn brown after a heavy rain? One solution to erosion is to make sure to plant grass or other plants that will hold soil in place.

There are many other particles that float in the water besides dirt. Organic waste – dead leaves or plants, animal waste from pets and dairy farms carried by runoff, and algae or other tiny plants are examples. Human waste, either from leaking septic tanks or from discharge from wastewater treatment plants, can contribute to turbidity. Floating particles also come from urban runoff including car oil, litter, etc., and from industrial waste.
Look back through the causes of turbidity and identify which ones are the result of people, and which ones are from nature?

People cause dirt piles from construction. People cut down trees or bushes and leave exposed soil. If people don't clean up after their dogs the dog waste can get into water. Farm animal waste can run downhill into water during rain. There could be loose dirt from nature. Nature also has dead matter (organic waste): dead plants and animals as well as fish and bird waste.

What are the consequences of high turbidity?

Why is high turbidity a problem? There are four consequences to the water quality of a stream if it has high turbidity. First, floating particles in the water absorb heat. This can lead to thermal pollution. Remember learning about thermal pollution in Lesson 4?

Thermal pollution can kill fish. It can also promote algal blooms. And remember, warm water cannot hold as much oxygen as cold water. Floating particles also block sunlight. Plants need the sun to photosynthesize. That means that water plants cannot undergo photosynthesis so plant growth can then be limited. This is a second consequence of high turbidity. A third consequence of high turbidity is that floating particles can clog fish gills. Can you imagine trying to breathe when the air is full of particles? Perhaps you have been some place where there is lots of smog and it was hard to breathe. Fish don't breathe with lungs; they use gills. The final consequence of high turbidity is that particles can sink and kill fish and insect eggs that are on the bottom.

Water quality standards

There are several different ways to measure turbidity. Depending on the method your class decides to use, there are also different units. Can you identify the method that you will use? Put an "X" over the column to identify the method and units.

Turbidity Standards:

Turbidity Water Quality Standards	**Turbidity probes NTU's:**	**Secchi disk or Turbidity Tube**	**Engineered filtration system**
Excellent – no (or very little) turbidity, not too many floating particles	0-10	> 3 feet > 91.5 cm	1 = none or very little turbidity
Good – low turbidity	10.1-40	1 foot to 3 feet 30.5 cm to 91.5 cm	2 = low turbidity
Fair – Medium turbidity, too many floating particles	40.1-150	2 in to 1 foot 5 cm to 30.5 cm	3 = medium turbidity
Poor – high turbidity, too many floating particles	> 150	< 2 in < 5 cm	4 = high turbidity

Are there some action steps that you can think of that people can take to minimize the amount of floating solids that may enter waterways?

Clean up after your dog when you take it for a walk. Put a fence around construction sites. If you cut down trees or bushes be sure to plant grass or other plants to hold the soil. Farmers need to make sure their animal waste doesn't get into waterways: silts fences? Collecting and removing animal waste? Spreading out manure for fertilizer?

Engagement Activity 1 (Student sheets)

Part One: How does the shape of the land determine where the water flows when it rains?

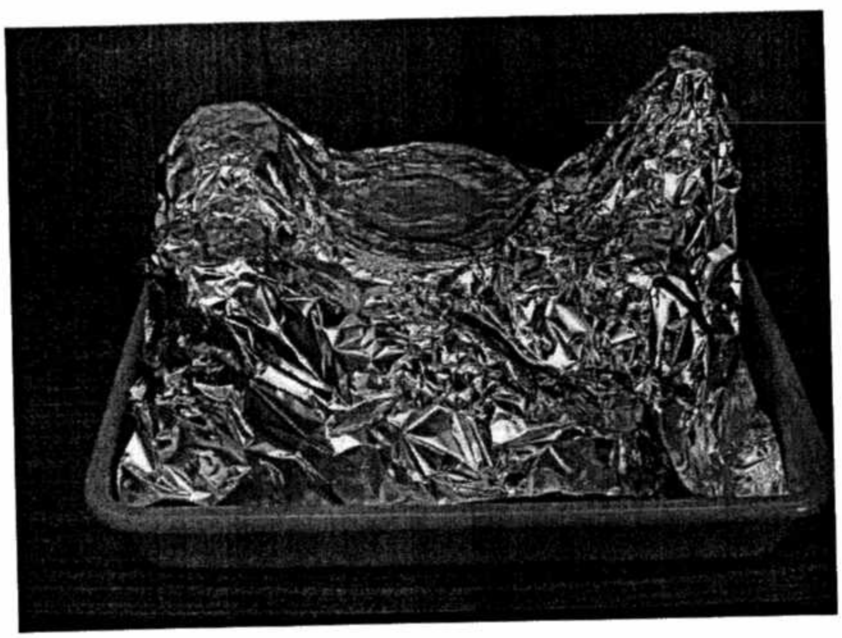
Materials per group:

- Shallow baking pan, aluminum pan or plastic container
- Plastic or metal objects from around the classroom of various shapes and sizes used as bases to add height to various areas of the watershed. For example, a tennis can might be the base of a large hill while a small cup might be a small hill.
- Aluminum foil
- Spray bottles with water
- Small amounts of soil, sand, grass, powdered drink mix, food coloring, salt, cocoa etc. to represent various substances that could enter water through run-off. For example, oregano might represent fertilizer for farms and lawns. Pancake syrup might represent car oil spilled on parking lots. Baking soda might represent pesticides.
- Towels (for clean up)

Procedure:

- Obtain a shallow baking pan, aluminum pan or plastic container from your teacher.
- Collect 8-10 plastic or metal objects from around the room (or a designated area with objects that your teacher has collected).
- Each member of the group place an object inside the container (See Photo. below) until all of the objects are in place.

- Place aluminum foil over the objects to make a topographical representation of a watershed. Crinkle the foil around the various objects beneath it to make mountains, hills and valleys - to give shape and to ensure that there are high and low spots (See Photo. Below).



Once you have finished this step let your teacher know and wait until your teacher tells you to proceed.

- Use a spray bottle filled with water to spray over the surface of the model. Keep spraying until the water flows. Observe how the water flows and where it collects.

- Record your observations in Table1 below in the column marked "Observations".

Table 1: Watershed Model

Observations: What happens to the water as it rains in the watershed? Why?	
Watershed: Our group definition	
Watershed: Our class definition	

- You've now built a watershed. As a group, create a definition of "watershed" to be shared with the entire class. Record the group's definition in the table above.

A spokesperson for each group will read your group's definition of watershed to the class discussion. Select one group member to be the spokesperson.

- In the space provided in the table above, write the definition of watershed based on your class discussion.

Part Two: What are everyday activities that people who live and work in the watershed do outside that could potentially pollute water in stream, rivers and lakes?

Generate a list of activities that people do that put substances on the land and structures which people build. Activities include putting fertilizer and pesticides on lawns, golf courses and for use on farms, putting salt on roads, sidewalks and parking lots during the winter, washing cars with soaps, cars leaking oil or antifreeze, cars using windshield wiper fluid etc. These, and other substances will represent various pollutants.

Record your ideas in Table 2 below. The first two are done for you.

Table 2: Substances people use in a watershed

Pollutant	Substance to represent the pollutant
Oil that leaks from cars onto parking lots	Pancake syrup
Road salt put on roads, parking lots etc. during winter when it snows.	Table salt

Procedure:

- Place various substances on different parts of the watershed. For example, sprinkle some oregano on a portion to represent fertilizer on a farm. Place some soil on another portion to represent loose dirt when trees were cut down for construction. Place salt on a portion to represent road salt during winter. Place pancake syrup on a portion that may be a road with cars leaking oil.

- Using the water bottle, make it "rain" on your model. What happens to the various substances that you placed in the watershed? Where do they go? What is happening to your watershed?

- Repeat using different substances.