Exploring Stream Turbidity and Excess Sediment

The goal of this activity is to understand what turbidity is, what causes increased turbidity, when it is a problem, and what we can do to help fix the problem. Then we will estimate how much sediment is being carried by the water at different locations in a stream. This will help you explore the quality of the water in the stream and evaluate how sediment impacts aquatic life.

What is Turbidity?

Turbidity measures the clarity of a liquid. Scientists can use turbidity as one way to evaluate how clear the water appears in a lake or stream. Turbidity is measured by determining the amount of light scattered by suspended or dissolved particles in the water. These particles often make the water look cloudy or murky. Several types of particles can cause turbidity, including clay, silt, algae, plankton, and fine organic and inorganic compounds. The color of the murkiness will depend on the types of substances suspended or dissolved in the water.

Many of the substances that cause turbidity are naturally present in lakes and streams and an important part of the ecosystem. For example, naturally occurring erosion contributes sediment (soil) to the water column. Sediment obviously occurs naturally in aquatic environments – soil is a vital part of nature. Erosion also is necessary in natural systems, including for stream channel formation and function. However, human activities can accelerate erosion and disrupt these natural systems and processes.

For more information about turbidity, visit: http://water.usgs.gov/edu/turbidity.html

For more information about water color, visit: http://water.usgs.gov/edu/color.html

What Causes Increased Turbidity?

In the Lower Grand River Watershed (LGRW), increased turbidity in lakes and streams frequently is caused by excess sediment erosion due to human activities. Other factors, such as algae growth, also can contribute to increased turbidity. However, the remainder of this document will focus on the impacts of excess sediment because it is a major cause of water quality impairments in the watershed.

The main sources of sediment in the LGRW are agriculture, urban areas, and streambanks. On farms, sediment can come from cropland that is intensively plowed or lacking vegetation. Rain picks up the top layer of soil and carries it into nearby streams or ditches. Intensive drainage systems installed to keep farm fields dry also can increase erosion in streams and ditches from the force of the drainage water. Sediment erosion also can occur where livestock are able to cross and wade into streams. Constant trampling from the animal's hooves prevents vegetation from growing and leaves bare soil that is easily eroded by rain. The animals also break down streambanks when entering and exiting the stream, causing sediment to be carried away by the stream.

In urban areas, stormwater erodes soil and carries it – along with other substances, including fertilizer, motor oil, and animal waste – as it flows over the ground. The sediment and other substances are carried by the runoff down storm drains and into lakes, rivers, and streams. Construction sites are a large source of sediment erosion in urban areas. Construction activities disturb the soil and often leave soil exposed and at high risk of erosion.

Urban areas also can contribute to excess sediment erosion by altering the natural hydrology. Under natural conditions, rain can soak into the soil, where it slowly seeps into groundwater or is taken up by plants and other organisms. However, urban development replaced large areas of vegetation with "impervious surfaces" – hard surfaces like roofs, roads, and sidewalks – that prevent rain from soaking through into the soil.

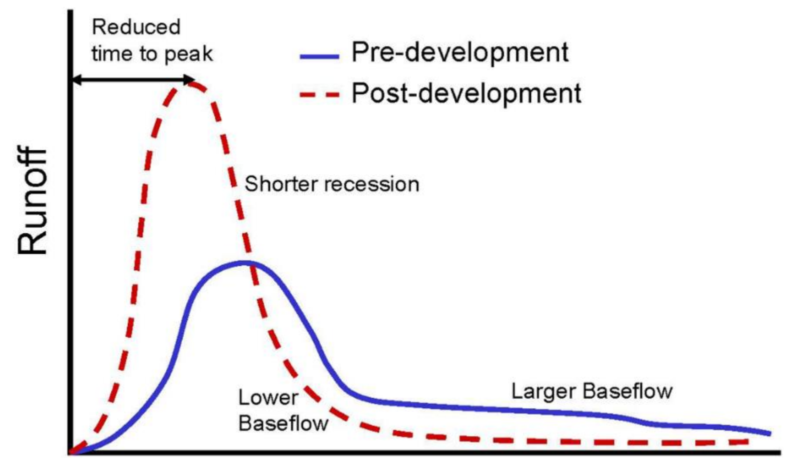


Figure 1. Hydrograph illustrating the difference in stream flow in an urban, developed setting and pre-urban development condition. Source: Liu, J.; Sample, D.J.; Bell, C.; and Guan, Y. (2014) Review and Research Needs of Bioretention Used for the Treatment of Urban Stormwater. Water 6(4), 1069-1099. Available online at: http://www.mdpi.com/2073-4441/6/4/1069/htm

Blocking the rain from following its natural pathway through the soil disrupts the hydrologic cycle and leads to "flashiness" in streams – sudden surges in the volume and velocity of water flowing in a stream (see Figure 1). If it hasn't rained for several days, an urban stream might not have much water flowing through it at all. But shortly after a storm hits, the volume of water will increase substantially and that water will be flowing very fast. This is because urban areas have been designed with systems of pipes designed to remove stormwater runoff from developed areas as quickly as possible to prevent flooding. These systems are designed so runoff flows into catch basins and through underground pipes that ultimately empty into a nearby water body.

By the time the pipe reaches a stream or river, it is carrying stormwater runoff from a fairly large area of the city – resulting in a large volume of water moving at a high velocity. The water from the pipe (called an "outfall") hits the stream or river with a lot of erosive force – like opening up a fire hose. This will scour the banks and stream bed, eroding soil, stirring up sediments, and carrying it downstream.

For more information about streamflow and hydrology, visit:
http://water.usgs.gov/edu/watercyclestreamflow.html

For more information about stormwater runoff in urban areas, visit:
http://water.usgs.gov/edu/stormflow.html

Why is Excess Sediment a Problem?

Figure 2. Stormwater flowing down a steep hill eroded the soil, carrying it down to the stream in the valley below. The soil filled in the stream, covering the habitat where aquatic organisms lived.

Excess sediment is a type of nonpoint source pollution and is one of the leading causes for impaired waters in the United States. Excess sediment in lakes and streams can reduce habitat quality, increase turbidity, disrupt stream channel processes, and increase economic costs. Sediment particles also can carry other substances, such as nutrients, that adsorb to the particle surface. If these nutrients dissolve in the water, they can contribute to algae blooms, which can reduce the amount of oxygen in the water and potentially release toxins.

Increased sediment can harm aquatic ecosystems by damaging habitat and impacting the food web. Many fish and aquatic insects rely on gravel stream beds for habitat and to lay eggs. Too much soil can cover up these gravel beds, eliminating habitat and spawning sites (see Figure 2). Sediment suspended in the water also can clog fish gills, harming the health of the fish.

Increased turbidity from excess sediment can reduce the amount of sunlight shining through the water. Reduced sunlight can impair plant growth if plants cannot receive enough sunlight for photosynthesis. This can have negative impacts throughout the food web. The population of organisms that rely on plants for food might decline and/or becomes less diverse. This can, in turn, have cascading impacts on organisms that consume herbivores. Increased turbidity also can make it harder for organisms to find food if the murky water reduces visibility.

Excess sediment erosion also can cause substantial economic costs. On land, erosion can reduce the quality of farm fields by causing fertile topsoil to be carried away by storm runoff. Erosion also can cause gullies that can damage farm equipment. In water, excess sediment can build up behind dams, reducing the depth of reservoirs, clogging hydropower equipment, and causing stress to the structure of the dam. If excess sediment deposits in rivers, it can reduce navigability, making it more difficult for boats to travel. Dredging, a very expensive process, might be necessary to keep the river channel open for transportation. Excess sediment in lakes and rivers also can increase the cost of treating water for drinking. Impacts on habitat quality that reduce fish populations can lead to economic losses for commercial fishing or areas that rely on recreational fishing as part of tourism. Increased sediment also can reduce recreational enjoyment for swimming.

For more information about sediment, visit: http://water.usgs.gov/edu/sediment.html

What can we do to Solve the Problem?

There are two main approaches to reduce the amount of excess sediment entering lakes and streams. One approach is to reduce the volume of stormwater runoff and prevent erosion. The second approach is to capture eroded sediment before it enters a water body.

Figure 3. Students from East Rockford Middle School, a Groundswell school, plant a native garden along the White Pine Trail in downtown Rockford. This native garden will capture rain water from a nearby road and parking lot, keeping it out of the Rogue River.

Several types of projects can reduce the volume of stormwater runoff. These projects attempt to restore the natural hydrology by reducing impervious surfaces and increasing vegetation. Often called green infrastructure or low impact development, these practices increase infiltration so rain water soaks into the soil instead of flowing down storm drains. Example projects include installing a rain barrel to capture rain water from roofs, planting a rain garden to capture stormwater runoff and increase infiltration into the soil, installing porous pavers, and replacing turf grass with native vegetation to increase infiltration (see Figure 3).

Maintaining vegetative cover and covering bare soil also can help prevent erosion. Plants help hold the soil in place and prevent runoff from carrying it away. Stabilizing eroded streambanks with vegetation and improving floodplain access for streams in downcut channels also will help prevent excess sediment in water bodies.

Where excess erosion still occurs, best management practices can help capture the sediment runoff before it enters lakes and streams. Vegetative buffers are one example of this type of practice. These are wide strips of vegetation that water must flow through before it enters a lake, stream, or storm drain. The buffers filter runoff, remove sediment, and protect the lake or stream. Construction sites or other sites with soil disturbance also can install silt fences. These fences are used to prevent soil from leaving the site. Silt fences should be installed around storm drains on the site, as well, to keep eroded soil from flowing down the drain.

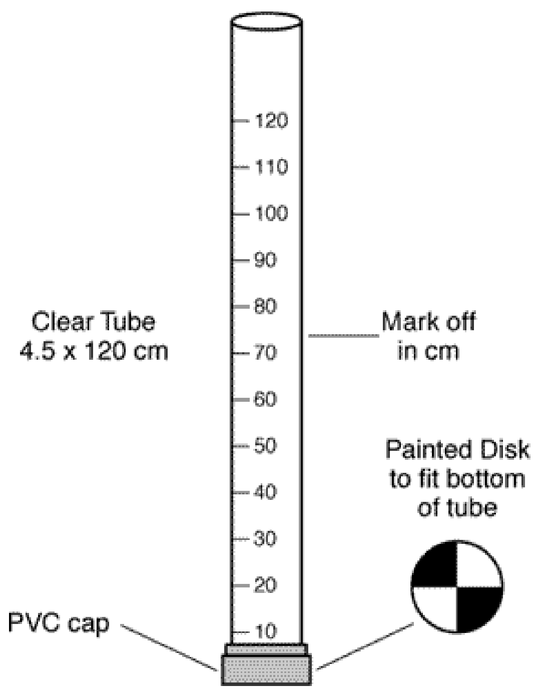
Remember and share this key phrase: “Slow it down, spread it out, soak it up”.

What do we need to Measure Stream Turbidity?

- Bucket
- Turbidity tubes – you will need one turbidity tube for each sampling spot (see instructions for making your own turbidity tube)
- Stake or marker ribbon to identify the locations where you will collect a water sample
- Stream turbidity data sheet to record your data

Make your own Turbidity Tube

1. Put a PVC cap over one end of a 3-4 foot clear tube, such as a fluorescent light protector. The cap should fit tightly so water cannot leak out.
2. Cut a disk from wood, plastic, or cardboard the same size as the tube diameter.
3. Divide the disk into fourths. Paint alternating quadrants black and white. Seal the disk by laminating or painting with varnish to make it waterproof.
4. Glue the disk in the bottom of the tube, painted side facing up (toward the end of the tube).
5. Use a marker and meter stick to make a scale on the side of the tube, beginning with 0 cm at the top of the disk.



Source: Global Learning and Observations to Benefit the Environment (GLOBE)
(https://www.gvsu.edu/wri/education/instructors-manual-turbidity-10.htm)

How do we Measure Stream Turbidity?

Select your Sample Spots

1. Identify multiple locations where you will collect water samples

   Ideally, you should collect water samples from at least three locations. If you want to evaluate the benefits of a project, select at least one location upstream of the project, one location next to the project, and one location downstream of the project.

2. Mark these locations using a stake or marker ribbon

   You'll want to come back to the same location several times, so put the stake or ribbon some place where you can leave it and it won't be disturbed or removed.

Collect the Water Sample

3. Stand at your sample location

4. Be careful where you stand

   You want to collect your water sample from an **undisturbed** area. Walking around in the stream kicks up sediment and makes the water cloudy. This makes our data unreliable because we want to know what's happening in the stream under typical conditions, when humans aren't walking around in it.

   If you stand in the stream to collect the water, face upstream (so you can see the water flowing toward you instead of away from you). Reach upstream from where you are standing to collect the water.

   If you stand on the stream bank to collect the water, make sure you aren't kicking dirt into the stream. Reach as far as you can toward the middle of the stream without falling in.

5. Dip your bucket in the water and let the stream current fill it

Evaluate the Water Sample

6. Have one person slowly pour water from the bucket into the turbidity tube

7. Have a second person look directly into the tube (looking down from the top of the tube so they can see the image on the bottom of the tube). This person will watch the bottom of the tube while the water is being poured.
8. Keep pouring water until the second person can no longer see image on the bottom of the tube

9. Stop pouring when the image on the bottom of the tube is no longer visible

10. Observe how much water was poured into the tube

11. Record this measurement (to the nearest centimeter) on your datasheet

12. If the tube was filled completely and the image was still visible, record the amount of water as greater than (>) the depth of the tube.

Repeat at the Same Spot

13. Repeat steps 3 through 12 at this spot. (Measure the turbidity at least **three times** at each spot along the stream.)

14. The third time you fill the turbidity tube, leave the water sample in the tube. Let the sample sit over night. The next day, analyze the sample to see how much of the solids have settled out. Record the depth of settled solids and describe the characteristics of the solids on the data sheet.

Collect and Evaluate Water Samples from your Other Spots

15. Repeat steps 3 through 14 at the other sample locations you identified and marked.

Come Back Later to Sample Again

16. Return to the **same spot** to measure turbidity again during different weather conditions (when it first starts raining, after it has been raining for several hours, when it has not rained for at least three days).

Name________________________________

Stream Turbidity Data Sheet

Date________________________________ Time________________________________

Location____

Current Weather Conditions____

Past Weather Conditions (last 3 days) ____

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Measuring Stream Turbidity

Follow the directions in the Stream Turbidity Procedure workbook. Collect turbidity measurements from the same spots during different weather conditions.

Spot ID	Turbidity
	1st measurement ___________________________ 2nd measurement __________________________ 3rd measurement __________________________ Depth of solids that settled out over night _____________________ Description of settled solids (soil type, texture, color, etc.):
	1st measurement ___________________________ 2nd measurement __________________________ 3rd measurement __________________________ Depth of solids that settled out over night _____________________ Description of settled solids (soil type, texture, color, etc.):
	1st measurement ___________________________ 2nd measurement __________________________ 3rd measurement __________________________ Depth of solids that settled out over night _____________________ Description of settled solids (soil type, texture, color, etc.):

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