stormwater

Teacher & Student Guide

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About This Resource

In urban and sub-urban regions, stormwater (the water that originates during precipitation) is both a stress on our ecosystems and a potential resource. With support from the City of Toronto and Toronto and Region Conservation, Citizens' Environment Watch created this guide to help teachers and students better understand stormwater, to integrate learning about stormwater into their classroom studies, and to inspire stormwater-focused action at the community level. This guide can also be used to enrich a CEW water quality monitoring project in your school. To find out more about Citizens' Environment Watch, stormwater, and water quality monitoring, please visit www.citizensenvironmentwatch.org.

Stormwater: The Good, the Bad and the Ugly

The Good

Stormwater collected in rain barrels on residential property:

- Can be rerouted to an area that is better able to soak up water than paved surfaces
- Can be reused for gardening, lawn-watering, and car and pet-washing purposes
- Reduces stormwater runoff and combined sewer overflows

Stormwater collected on a green roof on commercial property:

- Can be used to irrigate rooftop gardens while reducing stormwater runoff, especially for building owners who lack property for other stormwater management solutions

The Bad

In an urban setting such as Toronto, much of the land is covered by hard or paved surfaces, therefore stormwater does not have the opportunity to follow the natural water cycle of soaking back into the soil and groundwater. This polluted stormwater is ultimately redirected to local rivers and the waterfront.

City stormwater picks up pollutants such as:

- Oil and grease from motorized vehicles
- Bacteria from animal waste
- Pesticides from lawn and garden maintenance
- Road salt and chemicals from municipal maintenance
- Chemical waste from industrial and commercial sites and transport
- Sediment from construction activity
- Illegal disposal of household hazardous waste
- Litter

The Ugly

Heavy rainfall increases stormwater runoff in urban areas causing:

- Flooding and erosion to stream banks that can have a negative impact on local natural aquatic life
- Increased sediment into stream runnoff carries pollutants

Sewer overflow in combined sewer systems causes excess sewage to be redirected with stormwater runoff into local waterways without being treated first and contributing to:

- Excess biodegradable organic material depleting watersheds and aquatic life of oxygen
- Growth of algae in the receiving watershed from nitrogen and phosphorus compounds
- Increase in bacteria levels in the water, which results in the frequent closure of Toronto beaches
- Contamination of groundwater and potential drinking water from toxic metals, organic compounds and other contaminants
- Negative aesthetic impacts from floating litter such as grass clippings, sanitary items, etc.
- Accumulation of sewage and other pollutants in Lake Ontario

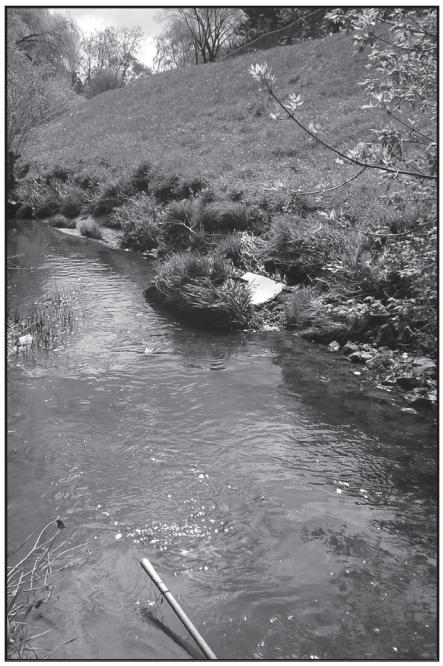
Stormwater Personal Activity Checklist

Here are some suggestions of what you can do to minimize the pollution to our local waterways caused by stormwater runoff.

Water Conservation

Using less water helps to decrease the burden on our wastewater treatment plants and the possibility of combined sewer overflows during heavy rainfall:

- ☐ Turn off the water when brushing your teeth, washing hands, shaving and soaping or shampooing in the shower.
- ☐ Install low flush, low flow and aerator fixtures to your existing toilet, showers, and sinks respectively.
- ☐ Don't let the tap run when washing dishes. Instead, partially fill up one sink with soapy water and fill up an other to rinse off dishes. If you only have one sink, rinse off dishes in a pan of hot water of spray them off in a dish rack.
- ☐ Don't let the tap run when washing fruits and vegetables. Instead, wash them in a partially filled sink and rinse them off quickly under the tap.
- ☐ Keep a refrigerated bottle of water so that tap water isn't wasted while waiting for it to run cold.
- ☐ Only wash full loads of laundry and try to use the shortest cycle possible.
- ☐ Fix leaks and drips immediately and remember to turn off faucets tightly.
- ☐ Water the lawn only when necessary and in the coolest part of the day for best results.



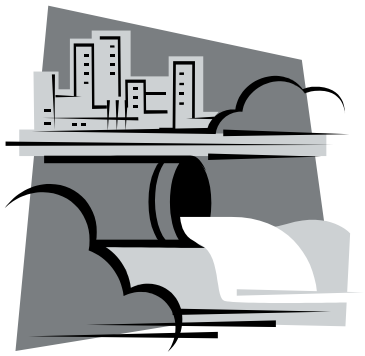
- ☐ When washing your car or pets, use a filled bucket of water instead of letting the hose run continuously.
- ☐ Disconnect your downspout and instead collect stormwater in a rain barrel for reuse when watering the lawn and/or garden and washing the car and/or pets.*
  *Check with your local municipality water department for more infmation.

Stormwater Personal Activity Checklist

Here are some suggestions of what you can do to minimize the pollution to our local waterways caused by stormwater runoff.

Pollution Prevention

Ensuring that we minimize household contributions to polluted stormwater runoff will also help to prevent further stresses on our local streams, rivers and waterfronts.



- ☐ Stop and scoop bacteria-filled animal waste.
- ☐ Ensure that your vehicles and lawnmowers are not leaking or dripping oil, grease, transmission or any other harmful fluid.
- ☐ Use alternative methods of transportation such as cycling, walking roller blading or public transit.
- ☐ Eliminate the use of pesticides on your lawn and garden. Leave grass clippings on the lawn (helps to absorb more water) and use plants and organic/alternative lawn care products for healthy garden maintenance.
- ☐ Use biodegradable cleaning agents when washing the car and pet, and phosphate-free laundry detergents.
- ☐ Never dump toxic substances such as paint, cleaners, oil, prescription medicines and batteries down the sink or sewer system. Drop these materials off at your local Hazardous Waste Depot. Each municipality should have their own Hazardous Waste Depot locations listed on their web-site.
- ☐ Replace paved surfaces with more water-absorbent materials such as gravel, woodchips, interlock and/or grass.
- ☐ Use a broom or rake to remove debris and litter from paved surfaces around your house such as driveways, sidewalks, curbs and patios.
- ☐ **Get involved in local watershed management or community restoration projects! Contact your municipality or conservation authority to find out more about programs currently in action.**

Erosion and Sediment Control

Stormwater Projects to Consider:

Erosion and sediment control is one stormwater management strategy aimed at stream rehabilitation. In urban areas, erosion is likely to occur in local waterways after heavy rainfall because stormwater is being redirected from a high concentration of impermeable surfaces to storm sewers, and finally to local creeks, streams and rivers. This sudden collection of stormwater results in powerful water flows that can severely erode stream banks, leading to sediment deposition, sedimentation or influx that blocks light necessary for aquatic life in the water system.

Erosion and sediment control include the planting of species native to the area along stream banks to increase water percolation in the soil, thereby strengthening the banks and giving the waterway a more stable flow. Rocks placed along water banks also help to reduce erosion caused by stormwater runoff. An erosion and sediment control plan should be prepared by a professional engineer or technician in both waterway restoration and construction projects, where erosion and sediment are also prevalent.

Case Study: Chaminade College School

Chaminade College Catholic Secondary School in the Lawrence Avenue West and Black Creek Drive area of Toronto continues to develop a strong track-record in environmental initiatives that are helping to provide their community with a sustainable vision for the future. One of the main projects of Chaminade's Environmental Club has been the rehabilitation of Black Creek in preparation for the restocking of Brown Trout and Atlantic Salmon into the creek. Students at Chaminade have removed in excess of 500 shopping carts from in and around the Black Creek area and continue to work with six local supermarkets develop strategies to prevent further pollution of the creek.

Additionally, students have worked on a series of environmental projects in conjunction with the Toronto and Region Conservation Authority aimed at erosion and sediment control along Black Creek, including tree planting along the banks. The dechannelization of a 200-metre concrete section of the creek has also been planned by the students to promote improved aquatic habitat.

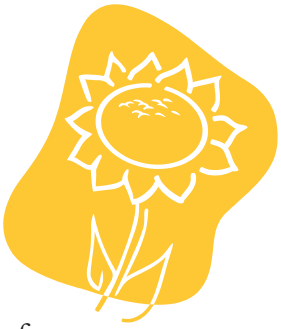
The Environmental Club at Chaminade continues to be a leader in the community through not only their Black Creek restoration projects, but also through the raising of native species of fish in their own fish hatchery, educating local elementary students at student-run workshops and canvassing the local neighbourhoods to promote environmental awareness.

Contact organizations and other helpful resources:

- Chaminade College School, Toronto Ontario: 416-393-5509
- Toronto and Region Conservation Authority: www.trca.on.ca

Green Roof Gardens

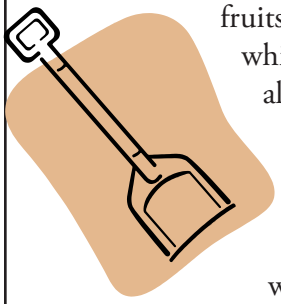
Stormwater Projects to Consider:



Green roof design is a fairly recent development towards sustainable architecture and consists of a vegetated roof designed to cover flat, impervious roof surfaces. The environmental benefits of these rooftop gardens include the reduction in building energy costs by lowering cooling and heating needs. The vegetated roof acts as an insulating barrier, air quality improvement and stormwater management. Green roofs are able to capture, absorb and store vast quantities of precipitaion that would otherwise collect in storm sewers and potentially cause combined sewer overflows, resulting in sanitary sewage and stormwater polluting local water systems. Plus green roofs with access create nice places to sit!

Factors to consider when deciding upon a green roof design are: loading capacity of the roof, municipal codes and safety standards, materials for construction, drainage system from rainfall and plant watering, plant selection, and maintenance. The design department at the school board level and environmental organization, such as Evergreen who work with schools and communities on greening projects, would be great places to start if you are interested in developing a green roof at your school.

Case Study: Jackman Avenue Public School



Jackman Avenue Public School in the Broadview and Danforth area of Toronto will soon see the fruits of their labour realized when they celebrate the completion of their green roof – a project which has been the focus of planning and fundraising for the past four years. The students, along with an extremely supportive administration, parent and community network, have been at the forefront of greening initiatives for over seven years, ever since the school decided to address the purely asphalt-covered environment of their school grounds. The ambitious green roof project began construction in October 2005, and when fully completed in June 2006, will consist of a 90-square-metre, seven-layer planting area with low maintenance plants, including 8000 wildflowers.

Although students will not be able to access the roof for safety reasons, design features have included a windowed corridor on the third floor of the school where students will be able to view the green roof on an ongoing basis. The green roof, which is expected to reduce storm water runoff by approximately 10 per cent and cool the ambient air temperature within the school during the warmer months, is also expected to be a teaching tool, supporting science, geography and social science curriculum within school classes. Jackman Avenue Public School and its students have already been nominated for a city council Green Toronto Award, and can expect many more accolades as their green roof project continues to grow.

Contact organizations and other helpful resources:

- Jackman Avenue Public School, Toronto, Ontario: (416) 393-9710
- Evergreen: http://www.evergreen.ca/en/
- Green Roofs for Healthy Cities: www.greenroofs.net

Water Conservation Projects

Stormwater Projects to Consider:

Water conservation programs are one of the most inexpensive and simple stormwater management projects to implement at the school, household and industrial level, yet can result in considerable decreases in stormwater runoff and water bills. The goal of water conservation programs is to lower the total volume of water use, which ultimately passes to the sanitary sewage systems. Water conservation reduces the risk of combined sewer overflows caused by stormwater runoff and results in less of a burden on local wastewater treatment facilities.

There are a variety of methods to conserve water at the municipal, industrial, commercial and residential levels. For schools in particular, an emphasis on repairing water leaks, reducing wasteful water habits and retrofitting older water fixtures and appliances (such as toilets) with more water-efficient devices can all contribute to conserving water and lowering water bills, as successfully demonstrated by the savings incurred by Upper Canada College after a water conservation program was implemented by the students of the school.

Case Study: Upper Canada College

Students at Upper Canada College (UCC) in the Avenue Road and St. Clair Avenue area of Toronto are demonstrating the beneficial impacts of water conservation on the environment and on the school's energy bills. After conducting a water audit of the school's water use, the UCC's Green School, a group within the school focused on educating students about environmental sustainability through the delivery of school-based greening initiatives, decided to implement a number of water-saving improvements. This water conservation program targeted wasteful water use, specifically the loss of 16,000 litres of water a day, due to the overflow of the school's swimming pool water into surface drains. The installation of waterless urinals, which saved the 500,000 litres of water per year that was used by the regular urinals, was another initiative that helped the school to reduce its water consumption by a whopping 20% and decrease its energy bills by a full quarter!

Upper Canada College's water conservation program also involved making improvements to their kitchen, showers, cafeteria and irrigation system. In the coming year, the school is prepared to add another 20 waterless urinals and more low-flush toilets, in addition to plans for recycling water from the school's boiler cooling system. All of these water conservation initiatives have not only played a part in significantly decreasing the school's contribution to stormwater runoff and reducing energy bills, but has also provided a model for Upper Canada College's students to live and learn by.

Contact organizations and other helpful resources:

- UCC Green School, Toronto Ontario: 416-488-1125, ext. 2306, GreenSchool@ucc.on.ca
- City of Toronto: TorontoWater - Water Efficiency, http://www.toronto.ca/watereff/index.htm

Lesson: Investigating Water Treatment Introductory Lesson

Time
60 min

Description
This lesson introduces students to the processes involved in water treatment. Prior knowledge of the water cycle will be reinforced and water treatment processes and terminology will be introduced. Students will have the opportunity to perform basic experiments to emphasize new ideas and concepts.

Strand(s)
Earth and Space Systems: Grade 8 – Water Systems

Expectations
- 8s5 - describe the distribution and circulation of water on the earth (e.g., oceans, glaciers, rivers, groundwater, the atmosphere);
- 8s22 - explain the different stages involved in processing water for use by humans (e.g., obtaining water from its source, treatment, distribution, disposal).

Planning Notes
1) Prepare the room by reorganizing the desks into 5 groups.
2) Prepare photocopies of student activity sheets (see Appendix A).
3) Prepare the materials for the lesson activity ahead of time. You will need:
    a) 3L of tap water mixed with 1L of carbonated soda water
    b) 2x4L of stream/river/pond/lake water
    c) 2x4L of tap water with different sized particles in it (sand, gravel, etc.)
    d) 5 beakers or small containers for clean tap water (control comparison)
    e) 8 beakers for "contaminated" water (for analysis)
    f) 250mL aluminum (potassium aluminum sulfate available in the spice isle at grocery stores)
    g) 2x10mL measuring spoon (for the alum and bleach)
    h) 2 large spoons (for stirring)
    i) 1 empty pop bottle with a closable top
    j) 3-5 devices for filtering large particles (e.g. colanders of differing hole size, a piece of window screening, coffee filter, etc.)

Prior Knowledge Required
Spend some time reviewing the water cycle with students. It would be useful to engage them in a discussion about how water picks up contaminants while moving through this cycle. For example, water can become contaminated by picking up minerals through the erosion of rocks, chemical contaminants from highway runoff, etc.

Lesson 1: Investigating Water Treatment Introductory Lesson

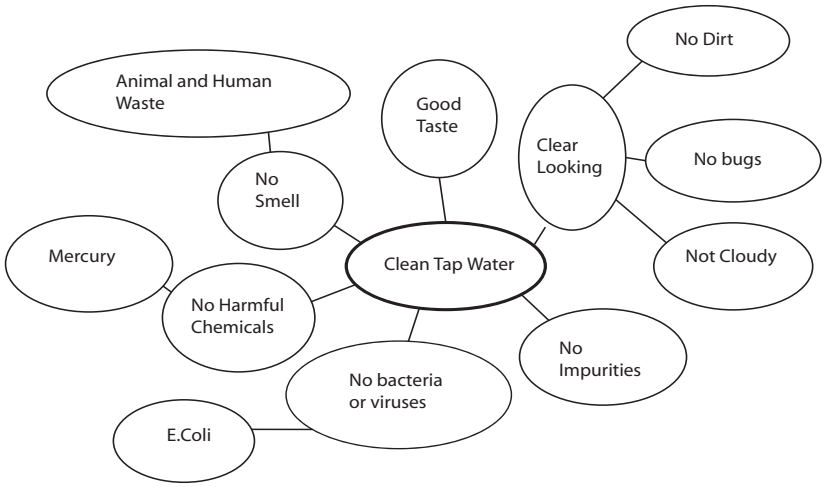
Teaching/Learning Strategies

1) Student Activity

Work out a mind map of anything relating to "Clean Tap Water." A sample mind map is drawn below.

2) Teacher Facilitation

Explain to the students that they will be learning about how to make clean water. We need to use our senses to determine if water is clean by investigating the way water looks, smells, and feels. We will not taste any water because the activity is only a simulation of water treatment and does not make the water suitable for ingestion.



3) Student Activity

Student desks will be sectioned into 5 groups. Each group will be investigating a different part of the overall process of water treatment: aeration, coagulation, sedimentation, filtration and disinfection. Instructions for each station are printed on the student worksheet (see Appendix A). Students will have a sample of contaminated water at each group. Using their senses they will compare the contaminated water with clean tap water, perform their specific process of water treatment, and compare the two water samples again to note any changes. The students will spend 5 to 10 minutes at each station learning about each stage of the water treatment process before rotating to the next station.

4) Teacher Facilitation

Different groups will require different samples of contaminated water. Have at least 4L of each contaminated sample to refill student tests after each rotation. Assign 1 student in each group to dispose of the last groups' samples and distribute new samples to their own group. This responsibility can also be shared. Circulate around the room to assist students and answer questions. Pay particular attention to the group investigating disinfection for safety reasons as they will be using diluted bleach.

5) Student Activity

After all of the groups have completed each section, perform a quick cleanup and refocus students' attention to the front of the class to debrief the activity. It may be helpful to continue filling in the mind map from the beginning of the class by asking students what else they have learned about "clean water." Students will have to copy down the new additions to the mind map into their notes so that they have the definitions accessible to them.

6) Teacher Facilitation

Explain to students that nature is capable of cleaning water by itself so that it is safe for all animals. In nature, each of the steps for water treatment happen naturally. Tomorrow's investigation will be to travel to a nearby stream and find evidence of the water treatment process happening naturally. Then, students will build a natural water treatment plant on site given nature's own supplies.

Appendix A: Student investigation sheet

Investigating Water Treatment: Aeration

Not all water is suitable for drinking. In this activity you will investigate the process of treating contaminated water. Each station represents a different stage in the water treatment process. At each station, measure out 250mL of water from your contaminated water source. Compare the contaminated water with the clean water and fill in each chart below by placing mark in either the Yes or No column of the table.

Aeration

Aeration is a process where water is rapidly disturbed in order to incorporate oxygen. Aquatic life needs the oxygen to survive in the water. Disturbing the water also allows contaminating gasses in the water to be removed.

Before Aeration

Description	Yes	No
Looks like clean water?		
Smells like clean water?		
Sounds like clean water?		
Feels like clean water?		

To aerate you water, pour the 250mL sample into the empty pop bottle. Close the lid and shake the bottle vigorously for 30 seconds. Continue the aeration process by pouring the water into another bottle or the beaker, then pouring the water back and forth between them about 10 times.

After Aeration

Description	Yes	No
Looks more like clean water?		
Smells more like clean water?		
Sounds more like clean water?		
Feels more like clean water?		

Appendix A: Student investigation sheet

Investigating Water Treatment: Coagulation

Coagulation

Coagulation is the process in which small particles in the water collectively stick to one another so they can easily be removed from the water. Adding aluminum sulfate to the water gives the small particles something to stick to.

Before Coagulation

Description	Yes	No
Looks like clean water?		
Smells like clean water?		
Sounds like clean water?		
Feels like clean water?		

To coagulate your water, add 10mL of aluminum to your water and slowly stir the mixture for 2 minutes. You will see particles in the water clinging together to make larger clumps.

After Coagulation

Description	Yes	No
Looks more like clean water?		
Smells more like clean water?		
Sounds more like clean water?		
Feels more like clean water?		

Appendix A: Student investigation sheet

Investigating Water Treatment: Sedimentation

Sedimentation

Sedimentation is the process that occurs when gravity pulls the coagulated clumps to the bottom of the container. Stir your sample so that the particles are all mixed in the water.

Before Sedimentation

Description	Yes	No
Looks like clean water?		
Smells like clean water?		
Sounds like clean water?		
Feels like clean water?		

For sedimentation, allow water to remain undisturbed for 5 minutes and write down your observations:

Which particles settle to the bottom first?_____

Which particles settle to the bottom last?_____

Is the water ever perfectly clear? Why not?_____

How would you remove the sediment from the bottom of the container?_____

_____

_____

After Sedimentation

Description	Yes	No
Looks more like clean water?		
Smells more like clean water?		
Sounds more like clean water?		
Feels more like clean water?		

Appendix A: Student investigation sheet

Investigating Water Treatment: Filtration

Filtration

Filtration is the process of passing a liquid, e.g. water through objects that only allow particles of less than a particular size to pass unobstructed.

Before Filtration

Description	Yes	No
Looks like clean water?		
Smells like clean water?		
Sounds like clean water?		
Feels like clean water?		

To filter your water, try pouring your contaminated water through the different filters provided at your table. Place another beaker underneath the filter to catch the newly filtered water.

How clean is the water if you only use a filter with big holes? _____

What happens if you pour the contaminated water into the filter with the smallest holes only?

_____

_____

How can you use multiple filters to get more particles out of the water? _____

_____

After Filtration

Description	Yes	No
Looks more like clean water?		
Smells more like clean water?		
Sounds more like clean water?		
Feels more like clean water?		

Appendix A: Student investigation sheet

Investigating Water Treatment: Disinfection

Disinfection

Disinfection is the use of chemicals and/or other means to kill potentially harmful microorganisms in the water. We are using diluted bleach to disinfect our water so you will have to be very careful handling it. Do not allow any bleach to get onto your skin or clothing.

Before Disinfection

Description	Yes	No
Looks like clean water?		
Smells like clean water?		
Sounds like clean water?		
Feels like clean water?		

To disinfect your water sample, add 10mL of bleach to the water and slowly stir.

Bleach and other disinfectants are usually very dangerous for humans to ingest. Why do you think they are still used to treat contaminated water? _____

_____

After Disinfection

Description	Yes	No
Looks more like clean water?		
Smells more like clean water?		
Sounds more like clean water?		
Feels more like clean water?		

Follow-Up Question:

The cleaning process outlined above is very similar to the steps a water treatment plant would use to clean your tap water. Nature uses similar steps to make water clean for animals and plants to use. For each of the steps above, think of ways that nature cleans water on its own, without any help from humans. Explain each step below.

Lesson 2: Investigating Water Treatment Outdoor Workshop

Time
3 hours

Description
This half-day workshop gives students the hands on experience of building their own water treatment device made from the materials provided in nature. Students will begin by analyzing water from a local source (river/stream/lake/pond) and comparing it to tap water. Next they will attempt to clean the source water using the techniques discussed in class last day and the materials supplied by nature: sand, gravel, clay, sticks leaves, etc. Students will compare their treated water with others' to determine the best possible configuration. Students will be given a worksheet to follow and fill in.

Strand(s)
Earth and Space Systems: Grade 8 – Water Systems

Expectations
- 8s5 - describe the distribution and circulation of water on the earth (e.g., oceans, glaciers, rivers, groundwater, the atmosphere);
- 8s22 - explain the different stages involved in processing water for use by humans (e.g., obtaining water from its source, treatment, distribution, disposal).

Planning Notes
1) Prepare photocopies of student activity sheets (see Appendix A).
2) Prepare the materials for the workshop ahead of time. You will need:
    a. Coffee filters (enough for every 2 students)
    b. Elastic bands (enough for every 2 students)
    c. Empty 2L plastic pop bottles (enough for every 2 students: have students bring in a pop bottle from home the day before, or collect some from the recycling bins in your neighborhood)
    d. Clear plastic cups (enough for every 2 students)
3) Location is an important consideration for this workshop. The most ideal place would be in an area where the water is visually unclean like a swamp of a dirty pond. A stream or river would also work well, however a clear lake is not ideal. In addition, it is useful (but not required) if there are visible signs of human intervention at the location.

Prior Knowledge
If students were not present for the last class on the water treatment process, make sure they have a handout from the class and are paired with someone who was present.

Lesson 2: Investigating Water Treatment Outdoor Workshop

Teaching/Learning Strategies

1) Student Activity

As a class, review the key terms from the previous lesson relating to water treatment: aeration, coagulation, sedimentation, filtration and disinfection. Have students explain in their own words how each stage of the water treatment process makes the water cleaner. Students will form small groups (3-4 people) and explore the local area around the body of water (river, lake, etc.) to find evidence of these steps occurring naturally. The groups will reconvene after 10 minutes to discuss what they have found. Students may easily find evidence of aeration and sedimentation, but it will be more difficult to see evidence of filtration, since this process happens underground.

2) Teacher Facilitation

It may be necessary to give groups extra guidance. For example, students may not know to look for undisturbed water to find evidence of sedimentation, or disturbed water to find evidence of aeration. Seek to challenge students by asking specific questions: "How can water be disinfected naturally?" or "why doesn't all of the water soak into the ground?" These questions will challenge students to think critically about water systems and encourage them to construct their own understanding.

3) Student Activity

Each pair of students will develop a device to treat water using only natural materials. Have the students wrap a coffee filter around the mouth of the pop bottle that has been cut in half using an elastic band. Students are encouraged to search the nearby water source for objects that can be used as a filter when water passes through them. Students will layer a number of different objects on top of one another to create a multi-staged filter inside their pop bottle. Remind students to think about what they learned regarding filtration during the investigation from the previous class. In many cases, students will use sticks, leaves, sand, gravel, dirt and rocks. The student worksheet provides a step-by-step procedure for assembling and testing students' filters. They will first compare the contaminated water with clean tap water brought from the class, filter the contaminated water using their design, and compare the water samples again. After students have tested their experimental filters and recorded their observations, the class will reconvene to discuss the best possible configurations by comparing observations.

4) Teacher Facilitation

Encourage students to wash their filtering objects in the nearby water source before putting them into the layered filter. This will remove some of the dirt and other contaminants that would affect the results when students filter water. Challenge students to find the best possible objects for their filter.

5) Student Activity

The final activity investigates the human impact on the natural water treatment process. In pairs, students will explore the area surrounding the water source for evidence of human impact. Students will most likely observe litter and/or garbage waste. These observations show the input of waste products into the water system that require treatment. Students may also observe human-made barriers, such as a retaining wall. Although these barriers eliminate erosion, they turn the flowing water into a straight channel, lacking any of the natural disturbances necessary for aeration. If the class is near a road, it is useful to draw their attention to the concrete pavement. Impervious surfaces such as these do not allow water to be absorbed into the ground for filtration. Instead, they channel stormwater, which contains pollutants, into sewage systems and inevitably, into local water systems. There is space on the handout for students to record their observations and suggestions of the implications of human effects on natural water treatment.

Appendix A: Student investigation sheet

Investigating Water Treatment
Outdoor Workshop

Part 1: Small Group Investigation

Recall the stages of water treatment below and find examples in nature of these stages. How is nature accomplishing this? If you cannot see visible evidence of the stages, suggest other possible ways nature is cleaning water.

Aeration is _____

_____

and can be seen _____

Coagulation is _____

and can be seen _____

Sedimentation is _____

and can be seen _____

Filtration is _____

and can be seen _____

Disinfection is _____

and can be seen _____

Part 2: Pairs Investigation

In this investigation you and a partner will build a water filter using supplies found in nature (including sand, gravel, sticks, and leaves, or anything else you find to be useful).

Before you begin, take a sample of clean tap water and compare it with a sample of untreated water. In point form, make some observations about their similarities and differences below. Use your senses in your comparisons.

	Clean Water	Untreated Water
See		
Hear		
Touch		
Smell		

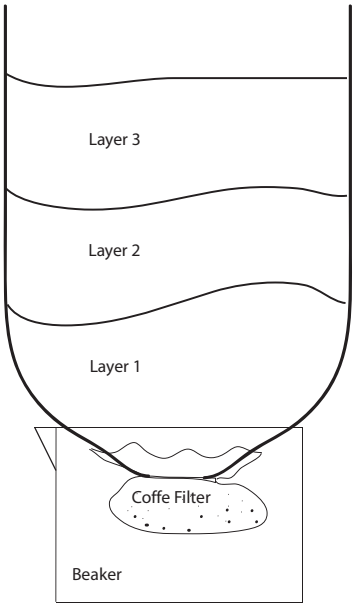
Appendix A: Student investigation sheet

Part 2: Pairs Investigation

To begin building your water filter, attach a coffee filter around the neck of your half pop bottle using the elastic band so that it covers the entire opening. You will need to start adding different components that your untreated water will have to filter through.

Why is it useful to have multiple layers with different components to filter the water?

Determine what types of natural supplies (at least 3) you will include in the layers of your filter. Try to clean any dirt off of the component parts before including them in your filter. Below, there is a space for you to draw the layers of your water filter. Indicate why you have chosen each layer in the space provided.



Before you pass your untreated water through the filter, try to aerate the water and provide some time for sediment to settle to the bottom. Slowly pour your untreated water sample through your filter. Collect the water in a clear container as it comes out of the filter. Pass the collected water through the filter 3 or 4 more times to ensure you have filtered the water fully.

Do another comparison of your naturally treated water with the clean tap water.

	Clean Water	Untreated Water
See		
Hear		
Touch		
Smell		

Appendix A: Student investigation sheet

Part 3: Human Impact on Water Quality

The natural water treatment process takes a long time, but it works. Unfortunately, humans have done many things to disrupt this natural process. Explore the area surrounding the water source looking for evidence of human impact.

What evidence do you find of human impact on the water system?	How might this affect the natural water treatment process?	How could we improve water quality?

Lesson 3: Investigating Water Treatment Concluding Lesson

Time
80 min

Description
This quiz is provided to assess students' understanding of the lessons on water treatment. An answer key is provided. (see Appendix B).

Strand(s)
Earth and Space Systems: Grade 8 – Water Systems

Expectations
- 8s5 - describe the distribution and circulation of water on the earth (e.g., oceans, glaciers, rivers, groundwater, the atmosphere);
- 8s22 - explain the different stages involved in processing water for use by humans (e.g., obtaining water from its source, treatment, distribution, disposal).

Planning Notes
1) Prepare photocopies of student quizzes (see Appendix A).
2) Remind students of quiz at least 2 to 3 days prior to quiz date.

Prior Knowledge
Students are expected to now be familiar with all the taught aspects of the wastewater treatment process, as well as be familiar with the observations made during the outdoor workshop.

Teaching/Learning Strategies
1) Student Activity
Students will have approximately 45 minutes to complete the quiz.

2) Teacher Facilitation
The teacher will be present to respond to any student questions regarding quiz questions, but will not provide any extra help with knowledge/understanding of the water treatment process.

Assessment/Evaluation Techniques

Task	Tool	Link to Achievement Chart
1 - Formative Quiz Quiz	Quiz	Knowledge/Understanding Communications Making Connections

Accommodations
Provide extra time for those students who may have literacy difficulties.

Appendix A: Student formative quiz on the water treatment process

Water Treatment Quiz

Part A – Matching
Match the appropriate term with the descriptions provided.

a. Sedimentation		Disturbing water to allow gas contaminants out and mixing the water with oxygen.
b. Coagulation		Allowing all of the sediment suspended in a liquid time to settle to the bottom of the container.
c. Aeration		Passing water through objects that stop the flow of contaminating particles from continuing to move.
d. Disinfection		Chlorinating the water to kill germs and bacteria.
e. Filtration		Adding a substance that facilitates the grouping together of contaminants within the water.

Part B – Short Answer
For each of the terms below, give one example of where the process was observed to happen in nature AND one example of how human disturbance is hindering these natural processes.

Process	Example of a natural occurrence	Example of a human disturbance
Aeration		
Sedimentation		
Filtration		

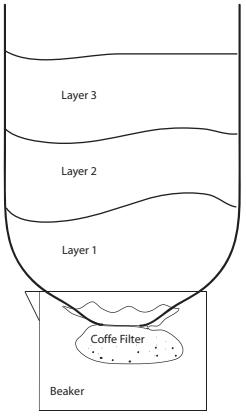
Part C – Fill in the Blank
Finish each sentence accurately and appropriately.

1. Water is filtered naturally as it passes through _____
2. Natural water treatment takes _____ than treating water in a treatment plant.
3. Depositing runoff from streets directly into streams is bad because

_____

_____

_____



Part D – Extended Response
From your lab investigation yesterday, and your comparisons with other students, what natural objects did you find to be the best for filtering the contaminated water? Briefly explain why you think they worked so well?

Appendix B: Answer Key

Part A – Matching
Match the appropriate term with the descriptions provided.

a. Sedimentation	c	Disturbing water to allow gas contaminants out and mixing the water with oxygen.
b. Coagulation	a	Allowing all of the sediment suspended in a liquid time to settle to the bottom of the container.
c. Aeration	e	Passing water through objects that stop the flow of contaminating particles from continuing to move.
d. Disinfection	d	Chlorinating the water to kill germs and bacteria.
e. Filtration	b	Adding a substance that facilitates the grouping together of contaminants within the water.

Part B – Short Answer
For each of the terms below, give one example of where the process was observed to happen in nature AND one example of how human disturbance is hindering these natural processes.

Process	Example of a natural occurrence	Example of a human disturbance
Aeration	Waterfalls; Unsmooth banks; Flowing over rocks	Water flow directed through culverts
Sedimentation	Shallow pools of standing water	Canalized banks
Filtration	Passing through gravel, sand and clay to ground water	Stormwater sewers collecting runoff and depositing directly into streams

Part C – Fill in the Blank: Finish each sentence accurately and appropriately.

1. Water is filtered naturally as it passes through varied particle sizes including gravel, sand and clay.
2. Natural water treatment takes much longer than treating water in a treatment plant.
3. Depositing runoff from streets directly into streams is bad because water is deposited directly into streams without being absorbed into the ground and a natural water treatment process.

Part D – Extended Response
From your lab investigation yesterday, and your comparisons with other students, what natural objects did you find to be the best for filtering the contaminated water? Briefly explain why you think they worked so well?
Individual answers will be judged based on the rubric below.

Communication	R – Question is unanswered	1 – Student displays a lack of understanding with no insight	2 – Student shows some understanding of water filtration but lacks significant insight	3 – Student shows good understanding of filtration and exhibits some insight	4 – Student shows excellent understanding of filtration and exhibits significant insight.

Lesson 4: Community Watershed Awareness

Time
75 min

Description
This lesson will educate students about their own community and watershed and how the two are related to one another. Students will learn about the effects of human activity on community watersheds, and distinguish between urban and rural effects on water quality.

Strand(s)
Geography of Canada, Grade 9 Academic – Human-Environment Interactions

Expectations
- CGC 1D1.01 – explain how human activities (e.g.,agricultural and urban development, waste management, parks development, forest harvesting, land reclamation) affect, or are affected by the environment;
- CGC 1D2.04 – assess how the effects of urban growth (e.g., development on former farm lands, destruction of wildlife habitats, draining of marshes) alter the natural environment;
- CGC 1D3.01 – analyze and evaluate the success, in environmental and economic terms, of local waste management methods.

Planning Notes
1) Have map of the community displaying watershed boundaries ready as large poster, overhead, or as a handout for each student.
2) Prepare chart paper and markers for group brainstorming session to list natural features in their watershed and different ways that people use these natural features.
3) Photocopy "What Matters to Me" handout for students (see Appendix A).

Prior Knowledge Required
Students should have prior knowledge of what a watershed is, the different types of freshwater ecosystems present in the Canadian and local environment and the different components of urban and rural environments, including urban sprawl.

Teaching/Learning Strategies
1) Teacher Facilitation
The teacher will review the concept of a watershed by having students study the map of their local watershed and identifying its main bodies of water.

2) Student Activity
Students will be divided into small groups of 4 or 5 and brainstorm a list of the natural features of their watershed and some of the uses humans have made from these natural features on the provided chart paper (see Appendix B for teacher prompts). Each group will then present their findings and post their lists on the wall. The teacher will use a checklist (see Appendix C) to evaluate group work.

Lesson: Community Watershed Awareness

Teaching/Learning Strategies

3) Teacher Facilitation

The teacher will consolidate all the lists into 1 master list and prompt the class make any changes or additions. The teacher will then discuss the effects of the local urban environment on the community watershed and on water quality, including such topics as water quality, urban sprawl, stormwater runoff, waste water treatment and wetland preservation. The discussion will also involve a comparison of these urban effects with rural effects on watersheds.

4) Student Activity

The student handout "What Matters to Me" (see Appendix A) will be distributed and students will have time to fill in the table. A discussion on the agreements and disagreements among which issues matter most to students will follow, with students explaining why they agree or disagree with one another.

5) Student Activity

The teacher will assign an extended research question as a 1-2 page written homework assignment: Research an event in your community or surrounding region's history when water quality was threatened or compromised and describe the measures that were taken to repair the situation. Students would have 2 to 3 days to complete this task. An evaluation rubric for this task (see Appendix D) should be distributed with the assignment of the homework.

Assessment/Evaluation Techniques

Task	**Tool**	**Link to Achievement Chart**	**Learning Skills**
2 - Group Work	Checklist	Communication Making Connection	Teamwork
3,4 - Discussion	Q&A	Communication	Presentation Skills
5 - Homework	Ruberic Knowledge/ understanding	Making Connections	Research

Accommodations

If using a large-scale poster map to display the community watershed, ensure that smaller handouts are made for those students who may have visual impairments.

Resources

- Stowe, D.P., Protecting our watersheds kit: an Earth Force GREEN action Publication, 2001.
- DesRivieres, D., et al., Experience Canada – A Geography, 2003, Oxford University Press, Toronto.

Appendix A:
Teacher checklist to evaluate group brainstorming session

Observations	**YES (=1) or NO (=0)**
All group members participating in brainstorming of ideas	
Numerous watershed features listed	
Numerous human uses of watershed listed	
List information is accurate and presented in organized manner	
All group members participating in explanation of lists to class	
TOTAL	**/5**

Appendix B
Teacher Prompts for Watershed Features and Uses

Watershed Features:

- Lakes
- Ponds
- Rivers
- Streams
- Creeks
- Wetlands
- Coastline
- Swamps
- Marshes
- Estuary
- Caves
- Hills
- Mountains
- Plains
- Forests
- Beaches
- Valleys
- Ridges
- Headwaters
- Tributaries
- Kettle Lakes

Human Impacts on a Watershed:

- Recreational: boating, fishing, swimming, water-skiing, hiking, rock climbing, camping;
- Water consumption: drinking, bathing, cooking, cleaning, gardening, irrigation;
- Agricultural;
- Industrial: thermal cooling, waste treatment;
- Extraction of natural resources: mining, refining of gas and oil, rock quarrying, logging, commercial fishing
- Housing development
- Commercial development

*Adapted from Stowe, D.P., Protecting our watersheds kit: an Earth Force GREEN action Publication, 2001.

Appendix C:
Student handout to determine student concerns and priorities on the effects human interaction on local watersheds.*

What Matters To Me!
Please rate the following watershed concerns from 0 (least) to 5 (most):

	Drinking Water Quality	Sprawl	Water Use and Waste	Stormwater Runoff	Wastewater Treatment	Wetlands Preservation
Matters to me						
I think matters to others						
I can see myself being proactive about						

*Adapted from Stowe, D.P., Protecting our watersheds kit: an Earth Force GREEN action Publication, 2001.

Appendix D:
Evaluation Rubric for Research Homework Assignment

Evaluation Rubric:

	Level 1	**Level 2**	**Level 3**
Event	Event described is outside of Canada	Event described is within the Canadian landscape	Event described is within the local or surrounding community
Research	A lack of research has been displayed in written piece	An adequate amount of research has been displayed in written piece	A thorough amount of research has been displayed in written piece
Description	Measures taken to restore water quality vaguely described or not mentioned at all	Measures taken to restore water quality adequately described	Measures taken to restore water quality described in excellent detail
References	No references cited	Only one reference cited	Two or more references cited
Spelling and Grammar	Poor spelling and grammar evident	Adequate spelling and grammar evident	Excellent spelling and grammar evident
Total			

Comments:

Lesson 5: The Effects of Water Consumption on Stormwater Runoff

Time
75 min

Description
Students will learn about the effects of urban environments on nearby freshwater ecosystems, specifically the stresses on local watersheds from stormwater runoff. Students will form groups and conduct a water audit of their daily water consumption habits to increase awareness of how their water use impacts sewer systems, and ultimately their nearby waterways. A teacher-lead discussion will end the lesson, with students sharing their findings. Students will brainstorm ways to conserve water as a method of preventing stormwater runoff as a homework assignment.

Strand(s)

- Science, Grade 10 Academic: Biology – The Sustainability of Ecosystems
- Science, Grade 10 Academic: Earth and Space Science – Weather Dynamics

Expectations

- SNC 2DB1.06 – explain why different ecosystems respond differently to short-term stresses and long-term changes (e.g., short term: the activity of tent caterpillars during a season, long-term: the effect of acid rain on maple trees);

- SNC 2DB1.07 – compare a natural and a disturbed ecosystem and suggest ways of assuring their sustain ability (e.g., compare a meadow and a lawn);

- SNC 2DB3.12 – assess the impact of technological change and natural change on an ecosystem (e.g., the introduction of fertilizer and pesticides to soil; the introduction of a genetically engineered plant or the effect of polluted water or air on plants and animals; the effect on an ecosystem of forest fire, flood, the natural infection of one species, or the movement of a species in or out of the area);

- SNC 2DB3.14 – identify and research a local issue involving an ecosystem; propose a course of action, taking into account human and environmental needs; and defend their position in oral or written form (e.g., organize and participate in a debate on converting a grass lot into a parking lot).

- SNC 2DES1.02 – describe and explain heat transfer within the water cycle and how the hydrosphere and atmosphere act as heat sinks;

- SNC 2DES3.01 – explain the role of weather dynamics in environmental phenomena and consider the consequences to humans of changes in weather (e.g., the role of weather in air pollution, acid rain, global warming, and smog; the fact that smog aggravates asthma).

Lesson 5: The Effects of Water Consumption on Stormwater Runoff

Planning Notes

1) Prepare chart paper and markers for water audit during group brainstorming session.
2) Bring an example of a 1-litre container so that students can make estimates of water use in litres.
3) Photocopy checklist to evaluate group water audit activity and student handout describing water conservation homework assignment and evaluation rubric (see Appendix A and C).
4) Photocopy Stormwater Personal Activity Checklist (see Appendix D) for following lesson as a means for students to compare their water conservation suggestions, as well as a means of identifying other ways to prevent stormwater runoff.

Prior Knowledge Required

Students should have prior knowledge of the cycling of matter within an ecosystem (e.g., water, nitrogen, carbon cycles), the components of a freshwater and marine ecosystem and the concept of sustainable development.

Teaching/Learning Strategies

1) Teacher Facilitation

The teacher will review the basic concept of the water cycle and inform students of how the water cycle is disturbed in urban areas where paved surfaces are highly concentrated. The idea of stormwater runoff as a cause of local water pollution will be discussed, with an emphasis on water conservation as a means of preventing combined sewer overflows. The teacher may also wish to describe how urban areas are more likely to surfer from smog due to the high concentration of paved surfaces which contribute to heat irradiation, and the resulting disturbed water cycle.

2) Student Activity

The teacher will form groups of 3-4 students. Each group will conduct a water audit of their average daily water consumption, using estimates in litres. Each group will be required to produce a chart, grid, or other graphic summary tool using chart paper and markers provided to display their findings. The teacher may prompt students by providing areas to concentrate the water audit on, such as bathroom water use, kitchen water use, outdoor water use, etc.

3) Teacher Facilitation

The teacher will lead a class discussion, allowing each group to post their charts on the wall and to share their findings with the rest of the class. During this discussion, other water uses that students have not suggested can then be brought up by the teacher, as well as true facts about average water consumption in Canada (actual average number of litres used by people when showering, washing laundry, etc. – see Appendix B for examples).

4) Student Activity

The teacher will then assign the homework assignment of brainstorming at least 10 ways to conserve water as a method of preventing stormwater runoff. Students will be required to present these water conservation suggestions creatively, in the format of a personal checklist that could be distributed to people in the community to inform them of how to curb their daily water consumption as a means of preventing stormwater runoff (see Appendix C).

Assessment/Evaluation Techniques

Task	Tool	Link to Achievement Chart	Learning Skills
2 - Group Work	Checklist	Communication Making Connections	Teamwork
3 - Discussion	Q & A	Communication	Presentation Skills
4 - Homework	Ruberic	Knowledge/ Understanding Making Connections	Creativity

Accommodations

Use visuals to describe water conservation methods during teacher-lead discussion.

Resources

- Melynchuk, M., Go Global With Kids – Water; Water Audit Activity Sheet, 1995.
- Grace, E., et al., SciencePower 10, 2001, McGraw-Hill Ryerson, Toronto.

Appendix A:
Teacher checklist to evaluate group water audit

Observations	**YES (=1) or NO (=0)**
All group members participating in creation of water audit graphic organizer	
Water audit comprehensive	
Water audit values reasonable	
Water audit complete and presented in organized manner	
All group members participating in explanation of water audit to class	
TOTAL	**/5**

Appendix B:
Average amount of water consumed per activity*

Activity	Average Amount of Water Used per Activity
Toilet Flushing	20 litres
Showers	100 litres
Baths	150 litres
Brushing teeth	10 litres
Shaving	20 litres
Cooking	20 litres
Dishes by hand	35 litres
Car washes	400 litres
Watering lawn/garden	35 L/min

*Water Audit: Be Water-Wise…It Makes Cents, Environment Canada.

Appendix C:
Student handout explaining water conservation homework assignment and evaluation

Educating the Public Through a Water Conservation Checklist

After completing the water audit of your water use habits in today's class, did you find any areas where you and your family are particularly wasteful? Are there any methods of decreasing the excessive use of water at the household level in order to reduce stormwater runoff, thereby, preventing local surface water pollution?

By researching water efficiency, develop a checklist of at least 10 different ways households can save water. Present this list in a creative manner that would be suitable to distribute to residents in your neighbourhood as a means of spreading awareness of what we, as citizens, can do to prevent stormwater runoff.

Some resources that may help you in the development of your checklist include:

- Municipal websites and publications that typically include information on water management
- Local conservation websites and publications, such as the Toronto and Region Conservation Authority and the Credit Valley Conservation Authority.
- Environmental groups such as Waterfront Trail, Sierra Club, Greenpeace, etc.

Evaluation Rubric:

	(Level 1)	**(Level 2)**	**(Level 3)**
Description	Description of water-saving suggestions are ambiguous.	Description of water-saving suggestions are somewhat clear.	Description of water-saving suggestions are very clear.
Research	Water-saving suggestions demonstrate lack of research.	Water-saving suggestions demonstrate adequate amount of research.	Water-saving suggestions demonstrate thorough amount of research.
Originality	A lack of varied and interesting water-saving suggestions are presented.	A good range of interesting water-saving suggestions are presented.	A wide variety of original water-saving suggestions are presented.
Creativity	Checklist presentation lacking in creativity.	Checklist presented in standard manner.	Checklist presented in very creative manner.
Presentation	Checklist is difficult to follow, unclear and disorganized.	Checklist is easy to follow, somewhat clear and organized.	Checklist is logical, clear and organized.
Total			/15

Comments:

Glossary

Aeration: the process of dissolving air in a liquid

Coagulation: the process by which a liquid thickens or clots by chemical reaction

Combined Sewer: a type of sewer which combines storm sewers and sanitary sewers. In Toronto there are 1, 301 Km of combined sewers.

Disinfection: destroying microorganisms through physical or chemical means

Green Roof: the roof of a building with is partially or completely covered with plants

Filtration: the separation of two or more substances by passing them through a permeable object

Rain Barrel: a container used to collect rainwater, usually attached to a roof downspout

Sedimentation: the deposition of suspended materials (often by settling)

Stormwater: water originating during precipitation events (i.e. rain, snow) - stormwater can either soak into the ground or become surface runoff and drain into watercourses and sewers

Watershed: the area of land that drains into a particular body of water

Notes:

Citizens' Environment Watch protects nature by investigating pollution in our air, land and water.

We mobilize people to discover the secrets of their backyards and beyond.

From hip waders to workshops, CEW is the leading organization equipping people to make a difference in their community.

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