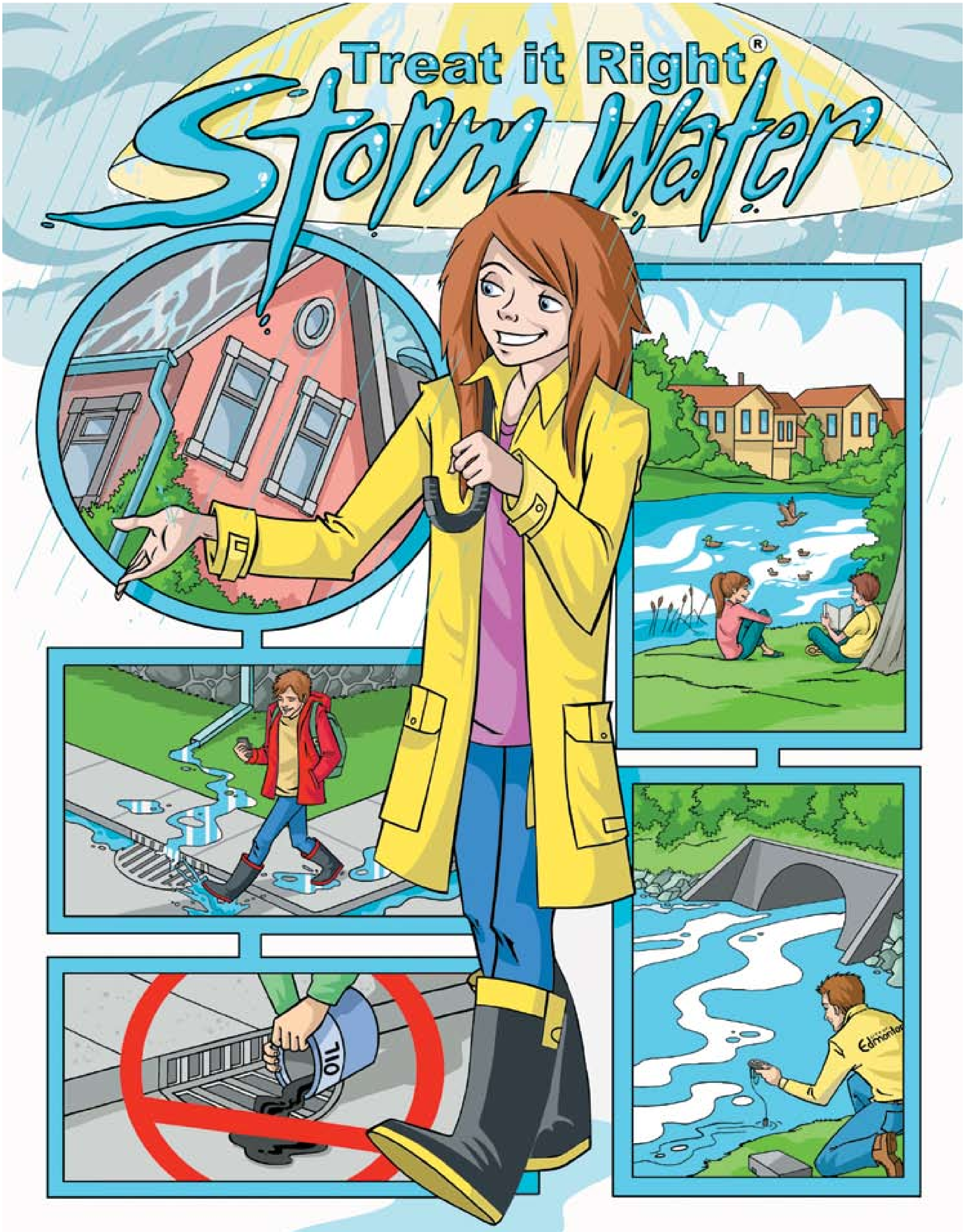

Teacher's Guide

Treat it Right!®

Storm Water (Grade 8)

Acknowledgements

The development of this resource has relied on the knowledge and expertise of many people. In particular, Louise Finlaison, the curriculum developer, whose professional expertise as a teacher and curriculum developer has been invaluable to this project.

The following staff members from the City of Edmonton have provided content review and input in the development of this program.

Ken Arychuk
Stephen Edwini-Bonsu
Andy Bowen
Steven Chan
Lyndon Gyurek
Sid Lodewyk
Albert Kwan
Liliana Malesevic
Sincy Modayil
Mike Porretta
Fayi Zhou

As well, Drainage Services, City of Edmonton wishes to recognize the cooperation of Edmonton Public and Edmonton Catholic School Boards with the distribution of this program.

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Table of Contents

Overview

The **Treat it Right!® Storm Water Teacher's Guide** addresses concepts related to the **Fresh & Saltwater Systems** unit of the Alberta Program of Studies for Grade 8 Science by exploring how storm water is managed in the City of Edmonton. Each lesson includes **Key Topics** and supporting information for the teachers to use as they proceed through each lesson. This resource addresses the following key concepts:

- water quality
- water-borne materials
- erosion and deposition
- stream characteristics
- continental drainage systems
- human impact

The **first lesson** introduces storm water and why it must be managed by looking at how the increased amount of impermeable land in urban areas affects storm water drainage. Students also explore how storm water is managed by reading about Edmonton's storm water management system and investigating evidence of this system in their own neighbourhoods, such as wet and dry ponds and catch basins.

The **second lesson** explores the nature and composition of storm water and the concept of deposition along with investigations into the chemical composition, temperature, and turbidity of storm water and their effects on animal and plant life.

In the **third lesson**, students explore the human impact on the storm water management system, in particular how substances such as detergents, herbicides, pesticides, and fertilizers are introduced into storm water through our use of water. Students are encouraged to participate in a culminating debate on whether our city's storm water management should concentrate on reducing or eliminating human impact (proactive) or addressing the effects of human impact (reactive).

The **fourth lesson** addresses the people who work in storm water management and involves student exploration of relevant career opportunities of personal interest.

Throughout this resource, students are encouraged to work both independently and cooperatively to use research and inquiry skills in initiating and planning investigations, performing investigations and recording data, analyzing and interpreting data, and communicating their findings.

Students are also encouraged to develop and demonstrate science-related attitudes related to stewardship, such as sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment, interest in science-related questions and issues, and curiosity regarding pursuing personal interests and career possibilities within science-related fields.

The **Treat it Right!® Storm Water Teacher's Guide** includes a **Lesson Guide** with overviews of each section and suggestions for introducing new concepts. There is also an **Answer Key** section that provides sample and suggested responses for the activities. Reproducible sheets for the activities can be found in the **Student Resources** section.

LESSON GUIDES

Lesson One: Storm Water

Overview

In **Lesson One** students learn that storm water refers to the water from precipitation and snow and ice melt, as well as any water used outdoors that drains into the storm water system. They also learn that urban development has necessitated the management of storm water. Because impermeable surfaces such as roads, sidewalks, rooftops, and some forms of landscaping prevent water from soaking into the ground, a considerable volume of storm water is concentrated on the available permeable surfaces when it rains or when snow melts. If it isn't managed, storm water could cause flooding that results in damage to public and private property as well as health and safety risks.

Storm water management consists of a system of catch basins (metal grids along the roadways), underground pipes, pumps, outfall pipes, constructed wetlands, and wet and dry ponds. Catch basins, pipes, and pumps are used to collect and direct storm water towards the North Saskatchewan River. In some neighbourhoods, pipes direct storm water to constructed wetlands and wet and dry ponds. Storm water undergoes a natural "cleaning" or filtering process in these environments. Only during periods of extreme precipitation or snow melt does the storm water in these neighbourhoods get directed to the river.

Key Topics

- What is storm water?
- Why must storm water be managed?
- How is storm water managed in the City of Edmonton.

Student Resources

- Alberta's Watersheds
- Impermeability Demonstration
- Calculating Impermeable Area

Reproducible sheets for the activities can be found in the **Student Resources** section. Answers are provided, as appropriate, in the **Answer Key** section.

- Flood Research and Presentation
- Edmonton’s Storm Water Management System **(Reading)**
- Comprehension Questions
- Storm Water Management Model
- Precipitation Data
- Storm Water Management in my Neighbourhood
- Storm Water Calculations

Answer Key

What is storm water?

Introduce the concept of storm water by putting the words "storm water" on the board and asking the students to generate their own definitions for the term through a **think-pair-share** activity. **Do not provide a definition or background information** previous to starting this activity**.** Draw a **Brainstorming Web** on the board, or have the students create their own **Brainstorming Web** for this activity.

Think: have the students think about what the words **storm water** refer to and jot their "rough" definition on their own for one to two minutes.

Pair: have students pair up to share their definitions and discuss how each decided on her/his definition. The students then combine their ideas to write a newly worded definition they both agree on.

Share: As a group, share the definitions jotting key words and phrases from each on the board. Whenever duplicate ideas arise, put an asterisk beside them to indicate that they are the ideas that are most strongly agreed upon by the group.

Through further discussion, lead the students to a definition of storm water that is similar to the following:

> **Storm water** refers to water that originates as precipitation, such as **rain and seasonal snow melt**. Over time, the term **storm water** has been broadened to include all of the **water that is not sanitary waste** that humans release into the environment. Water that **runs off gardens** due to overwatering and **water used to wash cars and for other cleaning tasks** combines with nature's storm water. So, when we refer to storm water in urban areas, we are referring to something that is **both a natural and a human-created phenomenon**.

Why must storm water be managed?

Introduce the concept of storm water management as the process used to control how and where storm water flows and collects, initially focusing on water quantity rather than water quality.

Divide the class into small groups, and give each group one of the following questions to discuss. These questions may be answered using background knowledge, or this could be a short research assignment using reference books and/or online sources. Have groups jot their ideas on chart paper, or be prepared to write their ideas on the board when it is time to share.

Question 1: How is storm water managed in parks and other natural, undeveloped spaces?

Question 2: How is storm water managed in urban environments?

Question 3: Why does the storm water in urban areas need to be managed, while nature takes care of water management without human intervention in rural environments, parks, and other natural, undeveloped spaces?

Question 4: Why does the amount of storm water being managed in urban environments change over time?

Question 5: What could happen if storm water wasn't managed in urban areas?

Use the **Answer Key** provided to mediate student responses in one of the following ways:

- Clarify and extend student responses through discussion.
- Provide the students with a paper copy of the **Answer Key** (as notes) and have them highlight the ideas they were able to come up with on their own, discuss why they may or may not have come up with the non-highlighted details, and add information and clarification where necessary.

Use the following activities to help students learn why storm water must be managed. Reproducible activity sheets where applicable are in the **Student Resources** section.

Alberta's Watersheds

Locating geographical locations on the larger watershed map helps to put into perspective the vastness of the North Saskatchewan River Watershed. As well, it helps students understand how activities and behaviors around the storm water system can have a huge impact on other people. (Reminder: Our storm water is not treated; therefore what is dumped or drained into the storm water system on the streets flows directly into the North Saskatchewan River.)

To obtain a free copy of the State of the Saskatchewan River Basin report and CD, contact Partners FOR the Saskatchewan River Basin email: Partners@saskriverbasin.ca

Impermeability Demonstration

Students experiment with the idea that increasing the amount of impermeable land in an area results in the need to manage storm water, both in terms of redirecting it to other areas and in terms of managing the flow of redirected water so it does not become destructive.

Calculating Impermeable Area

Students determine the percentage of impermeable land on their property and draw conclusions about the related impact on the storm water system.

Flood Research and Presentation

Students conduct research into local flooding and its possible effects on their homes. Check the FloodProof Program at: http://www.edmonton.ca/for_residents/flood-prevention-and-drainage.aspx

How is storm water managed in Edmonton?

Provide a copy of the **Reading** Edmonton's Storm Water Management System to each student. These notes summarize the parts and function of the city's storm water management system. Use the following activities to help students learn how storm water is managed in Edmonton. Reproducible activity sheets are in the **Student Resources** section.

Comprehension Questions

Students answer comprehension questions based on the content provided in the **Reading** Edmonton's Storm Water Management System.

Storm Water Management Model

Students design and build a wetland, wet pond, or dry pond and show how it works to manage storm water.

Precipitation Data (math connection)

Students read information displayed in a graph and answer questions about average precipitation in the province. They also create a graph depicting Edmonton's daily precipitation, noting the number of days in which precipitation was high. An extension activity leads students to learn about rain gauges.

Storm Water Management in Your Neighbourhood

Students engage in a fact-finding mission in which they are asked to analyze the visible storm water management systems in their neighbourhoods and draw conclusions about how the locations of catch basins are determined and how roads, curbs and other surfaces are designed around these elements of the storm water management system.

Storm Water Calculations

Students use formulas to determine the volume of storm water discharged into a pond during a storm.

Lesson Two: Water Quality Investigations

Overview

The main focus of **Lesson Two** is the physical and chemical analysis of storm water. Teachers are encouraged to order water quality testing kits (available from most science equipment suppliers) well in advance of beginning this section. Alternatively, simple water test kits are available from pet stores and other specialty stores. This lesson is largely hands-on, with the student activities serving as a guide.

Investigating the physical and chemical composition of storm water will prepare students for working through the rest of the resource and provide them with insight into the current "health" of local storm water, wet ponds, and wetlands. Water that is considered "healthy" is relatively free of contaminants and, in wetlands and wet ponds, is capable of supporting a variety of plant and animal life.

It is important to have a clear understanding of the composition and quality of storm water to be able to make informed judgments about human impact and to better understand the toll it takes on lakes, rivers, aquatic organisms, and the storm water management system.

Key Topics

- What substances are found in storm water?
- How can we monitor storm water quality?

Student Resources

- Composition Investigation
- Deposition Simulation
- Water Quality – Chemical Indicators

Reproducible sheets for the activities can be found in the **Student Resources** section. Answers are provided, as appropriate, in the **Answer Key** section.

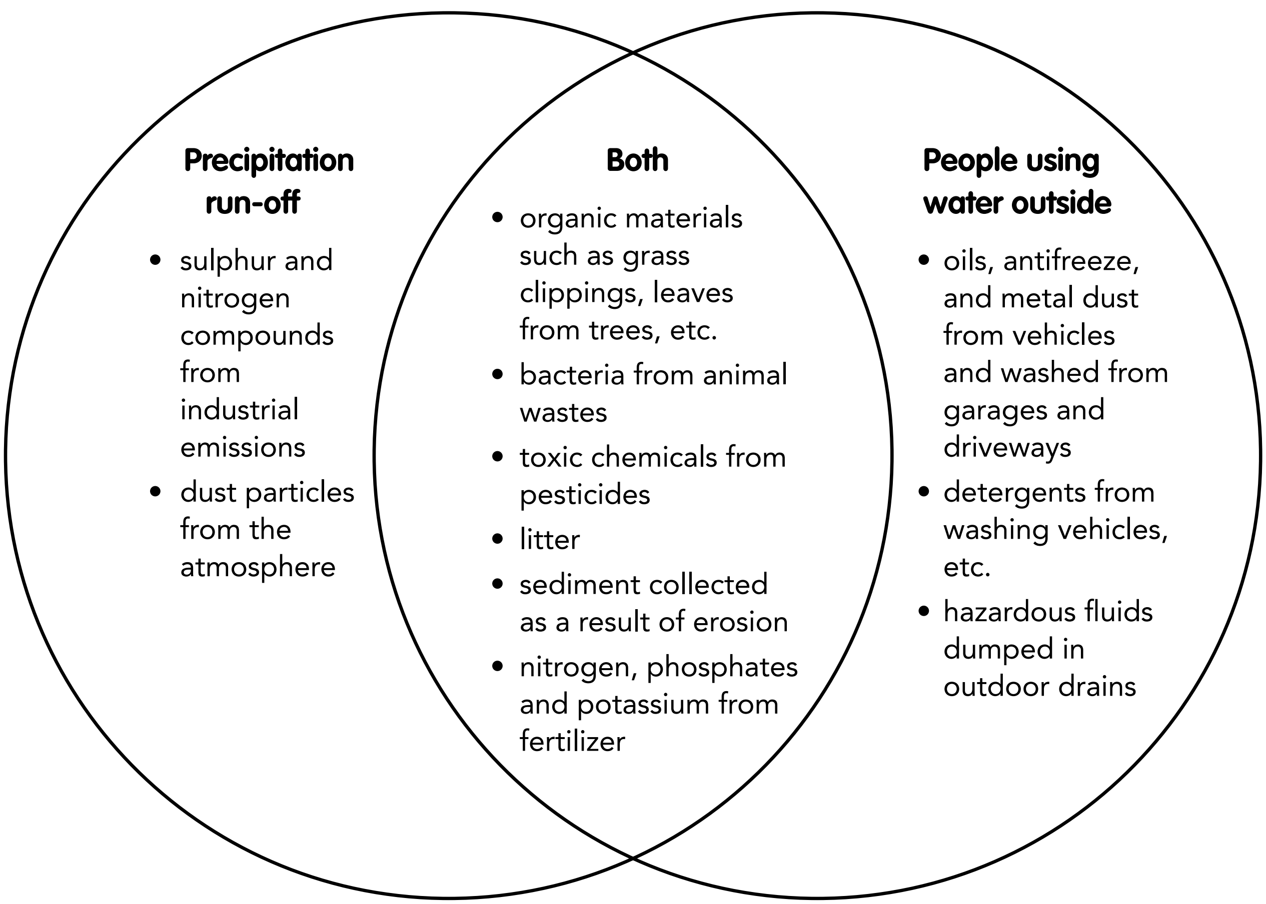
- Water Quality – Temperature
- Water Quality – Turbidity
- Water Quality – Investigation
- Water Quality Investigation – Graphs
- Water Quality Investigation – Reflection
- Case Studies – Wetlands and Ponds in Distress (three scenarios)

Answer Key

What substances are found in storm water?

Refer back to the definition of storm water and remind students that the storm water managed in urban areas has two sources: precipitation (rain and snow melt) and people using water outdoors. Regardless of the source, storm water does not go through a treatment process before it is directed to neighbourhood ponds and the North Saskatchewan River. It is important to consider how human behaviour affects the types and levels of substances found in storm water.

Randomly divide the students in your class into As and Bs. Have the As think of things other than pure water that might be found in run-off from precipitation. Have the Bs think of some things that might be found in run-off from people using water outdoors. Share student ideas through class discussion, and create a **Venn Diagram** on the board with their responses. Use the sample below as a guide.



Composition Investigation

Students collect samples of storm water from their neighbourhoods (e.g., constructed wetland or pond) and then conduct a series of investigations. First, students filter samples and examine the sediment carried by the different storm water samples. Then they use a water test kit to analyze various chemical levels in their samples. Students are encouraged to compare samples found in different neighbourhoods, as well as to compare their samples against the norm. There is a chart provided in the **Student Resources** section. Analysis and conclusion questions lead students to understand both the reasons behind and the implications of the contents of their storm water samples.

Deposition Simulation

Students create water samples with heavy sediment loads and then observe what happens when the water is allowed to flow. Analysis and conclusion questions lead the students to understand the implications of the deposition caused by the sediment load in the storm water.

How can we monitor storm water quality?

Begin the next topic with a discussion about environmental responsibility. Drainage Services is responsible for managing and monitoring the impact of storm water. Environmental monitoring is the key to ensuring that the untreated storm water that enters local ecosystems is not a threat to the organisms that live in and around the water or to the people living nearby. Have the students consider why aquatic organisms that rely on osmosis for water regulation are particularly susceptible to the effects of contaminants in the water. Distribute: Water Quality – Chemical Indicators; Water Quality – Temperature; and Water Quality – Turbidity found in the **Student Resources** section.

Water Quality Investigation

Students collect samples of water from a constructed wetland or wet pond and conduct a series of investigations in which they measure and/or observe a variety of physical and chemical indicators and form a judgment about the water quality.

Water Quality Investigation Graphs

Students graph data collected during their investigations, compare their results to those of other students, and draw conclusions. Student graphs should accurately illustrate the data collected. Conclusions may be drawn based on the relationships between the chemical levels and organism growth; e.g., in general: the higher the ammonia, the fewer the organisms; the higher the nitrates, the more abundant the organisms (to a point); the higher the phosphates, the more abundant the organisms (to a point); low pH results in fewer fish. Conclusions may also be drawn based on the relationships between the chemical levels and the nature of the neighbourhood; e.g., in general: newer, less established neighbourhoods require more fertilization to start vegetation such as lawns, trees and gardens; industry near a neighbourhood may contribute to greater chemical concentrations.

Water Quality Investigation Reflection

Students reflect on the results of their water quality investigations.

Case Studies – Wetlands and Ponds in Distress

Students are presented with three scenarios involving ponds and wetlands in ecological distress. They are asked to diagnose the problem, explain its cause, and suggest a possible solution.

Lesson Three: Human Impact on the Storm Water System

Overview

The main focus of **Lesson Three** is to analyze the day-to-day choices people make in using products that eventually end up in our storm water. Many chemicals found in products used in homes and gardens pose an ecological threat when they are washed into wetlands, wet ponds, and the river. Becoming aware of alternative products and disposal techniques is a step towards making more informed and environmentally friendly choices.

Students will conduct research, form judgments, and engage in a variety of strategies for sharing messages regarding the appropriate use of, alternatives to, and disposal of products such as detergents, fertilizers, and pesticides. The section ends with an organized debate about whether storm water management should focus on proactive or reactive solutions. Students are asked to consider whether they believe storm water should go through a treatment process (like the sewage treatment process), or whether teaching people not to contaminate storm water is the more appropriate course of action.

Key Topics

- How do our choices impact the storm water system?
- Storm water management: proactive or reactive?

Student Resources

- Detergent Detective
- Pesticide Patrol
- Friendly Fertilization
- That Doesn't Go There!
- Class Debate

Answer Key

Reproducible sheets for the activities can be found in the **Student Resources** section. Answers are provided, as appropriate, in the **Answer Key** section.

How do our choices impact the storm water system?

Introduce this topic by posing the following question:

> **Do people have a responsibility to consider what they are adding to the storm water system? If so, what is that responsibility?**

You may choose to have the students answer this question through private response and then share the results as a class. Reserve judgment on student responses to encourage diverse points of view and a spirit of debate. This will prepare students for the debate that will wrap up Lesson Three.

Some possible responses to the question may include:

- People have a responsibility to use fewer chemicals.
- People should wash fewer solids down the storm sewers.
- People have a responsibility to educate themselves.
- People should read labels and ingredients carefully and choose less harmful products.
- People should choose natural over synthetic.
- People should read the instructions and not overuse products.
- People should focus on meeting their basic needs, not luxuries.
- People should find more appropriate ways to dispose of items than washing them down outside drains.
- People should be able to wash away whatever they want.

Have the students keep in mind their ideas and opinions as they move on to the student activities in this topic. It is recommended that all four of the following projects be introduced to the class, but that students (working independently or cooperatively) only choose one to complete. Have the students present their completed projects.

Detergent Detective

Students conduct research into the products available for cleaning vehicles at home, along with the ecological threat posed by the chemical ingredients that will be washed into wetlands, ponds and the river. Students present their findings in the form of comparison charts and/or graphs, and also share their opinion(s) about which product is the best choice. Students are also encouraged to focus on guidelines for acceptable use.

Pesticide Patrol

Students conduct research into herbicide and/or pesticide use and the ecological threat posed by the chemical ingredients that will be washed into wetlands, ponds and the river. Students conduct research into biological control options, present their findings to the class, and participate in a short debate on the issue.

Friendly Fertilization

Students conduct research into fertilizer composition, focusing on comparing synthetic and organic fertilizers. Students come to conclusions about fertilizer choices and acceptable use, and then come up with advertising campaigns to educate the public. The research findings and advertisements are presented to the class.

That Doesn't Go There!

Students conduct research into the ecological threat posed by the chemical ingredients found in products that could be washed into the storm sewers. Students research local alternatives for disposing of hazardous chemicals (a focus on the Eco Station is encouraged). Findings are presented to the class.

Storm water management: proactive or reactive?

Like most cities around the world, the City of Edmonton does not treat storm water. Edmonton's storm water management system was created for the purpose of redirecting storm water to avoid flooding in heavily developed areas. In nature, storm water is managed without being processed by a treatment facility, as the water is filtered and "cleaned" through natural processes. The city's storm water management system redirects the water back to natural environments to be cleaned through the same natural processes. This system only works, however, if human products aren't allowed to contaminate the water.

As cities and industries grow, human activity has a greater effect on natural ecosystems. Some argue that it is time to consider treating storm water before it is returned to natural environments. Others feel that in doing so we are giving up on the idea that people should be responsible for their actions and the effects of their actions on the environment.

The question of whether storm water management should focus on proactive or reactive strategies is really asking whether the bulk of resources should be directed towards **preventing ecological contamination** (assuming we can control human impact and devise a self-sustaining management system) or whether resources should be directed towards **removing ecological contamination** (assuming there will always be a negative human impact and thus devising a treatment system to clean the water).

Students should have learned enough about storm water and human impacts by now to debate this topic from ideological, sociological, and scientific standpoints.

The following instructions are intended to guide the teacher in organizing a debate in which the whole class can be involved. For additional information about how to prepare for and how to conduct a debate and debate etiquette, check the internet or have students conduct some internet research on debating. A list of possible arguments as well as a related assessment tool can be found in the **Answer Key** section.

Class Debate

Students should have a clear understanding of their roles in the debate, along with expectations for debate etiquette. A formal debate usually involves an affirmative team, an opposing team, and judges.

The role of each team is as follows:

- **The affirmative team supports the idea.** In this case, the affirmative team would be arguing the "proactive" side of the storm water issue.
- **The opposing team is against the idea.** In this, case the opposing team would be arguing the "reactive" side of the storm water issue.
- **The judges assess the quality of the evidence, arguments, and performance of each team.** In this case, the teacher could choose to have a team of student judges or to be the judge him or herself, leaving the non-debating students to act as audience members and to participate in the post-debate discussion.

Tips for Whole-Class Involvement

There are a number of options for ensuring the whole class is involved in preparing for and conducting the debate. Consider the following:

- **Large-scale debate**, where the two halves of the class debating against one another, requires a lot of management and clear communication about the division of responsibilities amongst teammates.
- **Support-team concept**, where the two halves of the class are on opposite sides of the issue, requires that each group identifies speakers and the rest of the group are supporters working behind the scenes (to conduct research, assist with developing arguments, etc.).
- **Gallery concept** is when two teams of five to six members plan and conduct the debate and the other students are audience members who participate only in the follow-up discussion after the debate. Students who debate would be assessed on that task, and student audience members could be marked on a follow-up reflection paper or summary of the arguments presented.

Lesson 4: Careers in Storm Water Management

Overview

The main focus of **Lesson Four** is for students to learn about the variety of jobs involved in planning, operating and maintaining the storm water management system. Technology is widely used in this field and students will have an opportunity do some research into the careers, skills, and requirements for the people who work in this field.

Key Topics

- What tasks and technologies are involved in storm water management?

Student Resources

- People involved in Storm Water Management

Reproducible sheets for the activities can be found in the **Student Resources** section. Answers are provided, as appropriate, in the **Answer Key** section.

What tasks and technologies are involved in Storm Water management?

Have the students consider what they have learned so far about all of the things that are dissolved or suspended in storm water as it makes its way through storm water pipes and along to local wetlands, ponds, and the river.

Discuss the types of routine maintenance that would likely be required for each of the following components of the storm water system:

- **catch basins** e.g., replacement of damaged parts, clearing blockages
- **underground pipes** e.g., monitoring pipes for deterioration, clearing blockages
- **pumps** e.g., monitoring pumps for mechanical efficiency, cleaning moving parts to reduce the effects of friction
- **outfall pipes** e.g., monitoring pipes for deterioration, monitoring outfall area for signs of excessive erosion and/or concerns related to deposition
- **inlet and outlet pipes at wetlands and ponds** e.g., monitoring pipes for deterioration, clearing blockages
- **the general environment at wetlands and ponds** e.g., cutting back excessive plant growth, monitoring algae levels and water quality/cleanliness, removing litter, dredging excess sediment

Consider and discuss the need for improvements to and expansion of the existing storm water system:

- **aging hardware** e.g., repeated maintenance may be more costly than simply replacing parts
- **new technology** e.g., improved efficiency may outweigh the costs involved in replacing sections of an existing out-of-date system
- **changing living patterns** e.g., introduction of high density housing in urban centres, new suburban developments
- **changing safety regulations** e.g., incidents or accidents may prompt Drainage Services to make changes to address safety risks that were not considered during previous builds

People involved in Storm Water Management

Using the information in the **Student Resources** section, have the students review the list of some of the careers available in storm water management and the samples of just three career options. Students should then use the Alberta Learning Information Systems website (ALIS) and, after they select the job that might interest them, conduct some research into the actual position they are interested in, the responsibilities, and the qualifications required to do the job. Google **http://alis.alberta.ca**

Resume

Students write a resume (using proper resume format) for the position of their choice. Students can research resume format on the internet.


STUDENT RESOURCES
CITY OF
Edmonton

Watersheds in Alberta

A watershed, also called a basin, is an area of land that drains into a body of water such as a river, stream, lake, pond, or ocean. A watershed may be a small area or extremely large area of land. All erosion and storm water run off from that watershed flow into that body of water. For the City of Edmonton, this body of water is the North Saskatchewan River and our watershed is the North Saskatchewan River Watershed (NSRW).

The NSRW covers about 12.5 percent of Alberta's land area or about 80 000 square kilometres. You should be aware that the NSRW extends well into Saskatchewan and actually ends at the junction of the North Saskatchewan River and the South Saskatchewan River at The Forks in Saskatchewan. You should also know that the North Saskatchewan River Watershed sits within the enormous Saskatchewan River Basin (Watershed).

Compare the size and shape of the North Saskatchewan River Watershed in Alberta with the Saskatchewan River Basin (Watershed), which empties into the Hudson Bay. To locate the Saskatchewan River Basin (Watershed) map, Google:

- Partners FOR the Saskatchewan River Basin
- Click on Products and Publications
- Click on State of the Basin Report
- Click on large basin map (Note: this is a very large file)

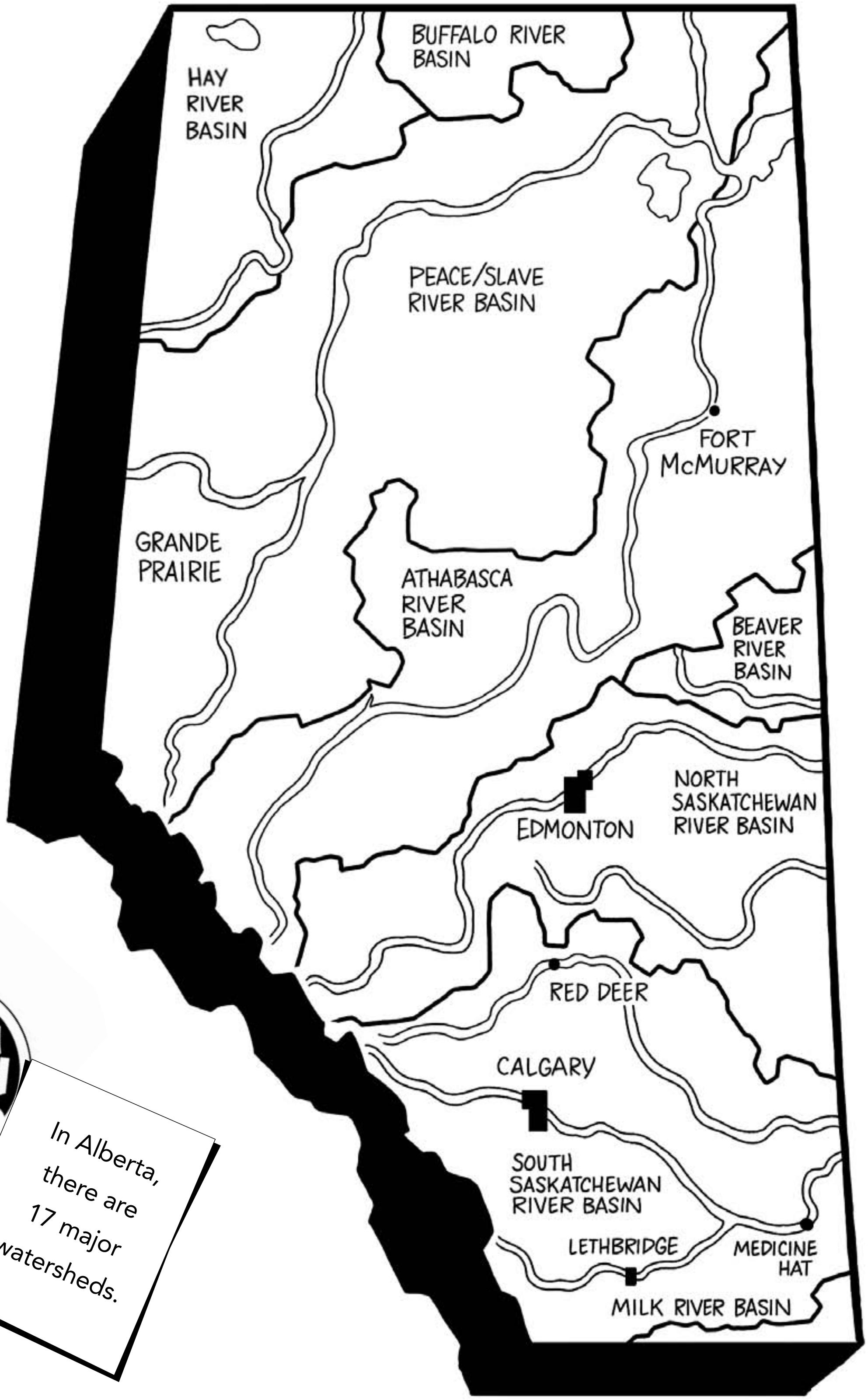
On the map of Watersheds in Alberta, shade in the North Saskatchewan River Watershed (NSRW). Complete the following exercise. Teachers may want students to work in small groups to complete this work.

1. Using the large basin map, find the shape that matches the contours of the NSRW using the Alberta Watersheds Map as your guide. List three (3) urban municipalities within the NSRW.

2. Again looking at the large basin map, list the two (2) sub-watersheds that are part of the North Saskatchewan River Watershed in Alberta.

3. Consulting the large basin map, find the Saskatchewan city that is near the end of the North Saskatchewan River Watershed.

Watersheds in Alberta



In Alberta, there are 17 major watersheds.

Impermeability Demonstration

Purpose: To demonstrate how water behaves differently on permeable surfaces than on impermeable surfaces, and draw conclusions about why this results in the need to manage storm water.

Materials:

- watering can with diffuser nozzle (many small holes instead of one large one)
- large watertight tray or tub (e.g., plastic or aluminum)
- small watertight container (e.g., Styrofoam tray with curved edges)
- sand (enough to fill large container one to two inches)
- water (in watering can)

Procedure:

1. Fill the bottom of the larger container with sand and pack it down.
2. Place the smaller container on the sand surface.
3. Use the watering can to apply water evenly across the whole surface of the larger container until the smaller container has filled up.
4. Note the condition of the sandy surface and record observations.
5. Tip the water in the smaller container out.
6. Note the changed condition of the sandy surface and record observations.

Conclusion Questions:

1. How does applying the water to the sandy surface imitate rainfall on permeable land?

2. The water that falls onto our houses is collected and transported by eaves troughs and drain spouts. How does this demonstration reflect a similar process of concentrating water? How could the release of flowing concentrated amounts of water affect nearby land surfaces?

3. How does this demonstration prove the need to manage storm water in places like your neighbourhood, where there are many impermeable surfaces?

Extension Activity: Research current trends in Low Impact Development (LID), such as the use of green roofs, permeable pavements, bioswales and rain gardens to reduce runoff from smaller storms.

Calculating Impermeable Area

Neighbourhoods in Edmonton have changed over time. The size and structure of homes, their variety, and the size and configuration of the lots have changed based on the needs and wants of homeowners, city planners and developers. These changes affect the proportion of permeable land there is in a neighbourhood. The more impermeable land there is, the more storm water management is required.

Follow these steps to calculate the amount of permeable land impermeable and on your family's property:

1. Calculate the total area of the property by measuring the length and width of the lot in metres and multiplying the two numbers to get an answer in square metres.

   Lot Size [ ]

2. Determine the area of the "footprint" of the building by measuring the length and width of the building in metres and multiplying the two numbers to get an answer in square metres.

   Building Footprint [ ]

3. Determine the area of the driveway and other impermeable surfaces on the property. Add the numbers to determine the total impermeable surface.

   Impermeable Surfaces [ ]

4. Add the area of the building footprint to the area of the impermeable surfaces.

   Total Impermeable Area [ ]

5. Use the numbers from steps 1 and 4 (lot size and total impermeable area) to calculate the percentage of the property that is impermeable as a result of property development.

   % of Impermeable Land on Property [ ]

Note: Lots or buildings that are not square or rectangular may need to be subdivided (by approximation) into rectangular shapes when calculating area. The percentage of impermeable land is used to determine the storm water utility charge on a homeowner's monthly utility bill.

Flood Research and Presentation

Did you know that many Edmontonians experience flooding every year?

Using one of the following questions, or one you generate on your own, conduct research on flooding in your area. Be prepared to present your findings to your class in a five-sentence fact-flash (explained below).

- What causes flooding?
- How might you respond to a storm water flood in your home?

Five-Sentence Fact-Flash!

1. Take notes based on your research.
2. Narrow down the key ideas and determine a logical order for presenting them.
3. Create five clearly written sentences that include all of the key ideas:
    - Your first sentence should introduce the topic in an exciting way because its purpose is to hook the audience.
    - The second, third, and fourth sentences should provide supporting details in a logical order.
    - The last sentence should be memorable. Consider including an interesting fact, thought provoking question, or a call to action.

Reading

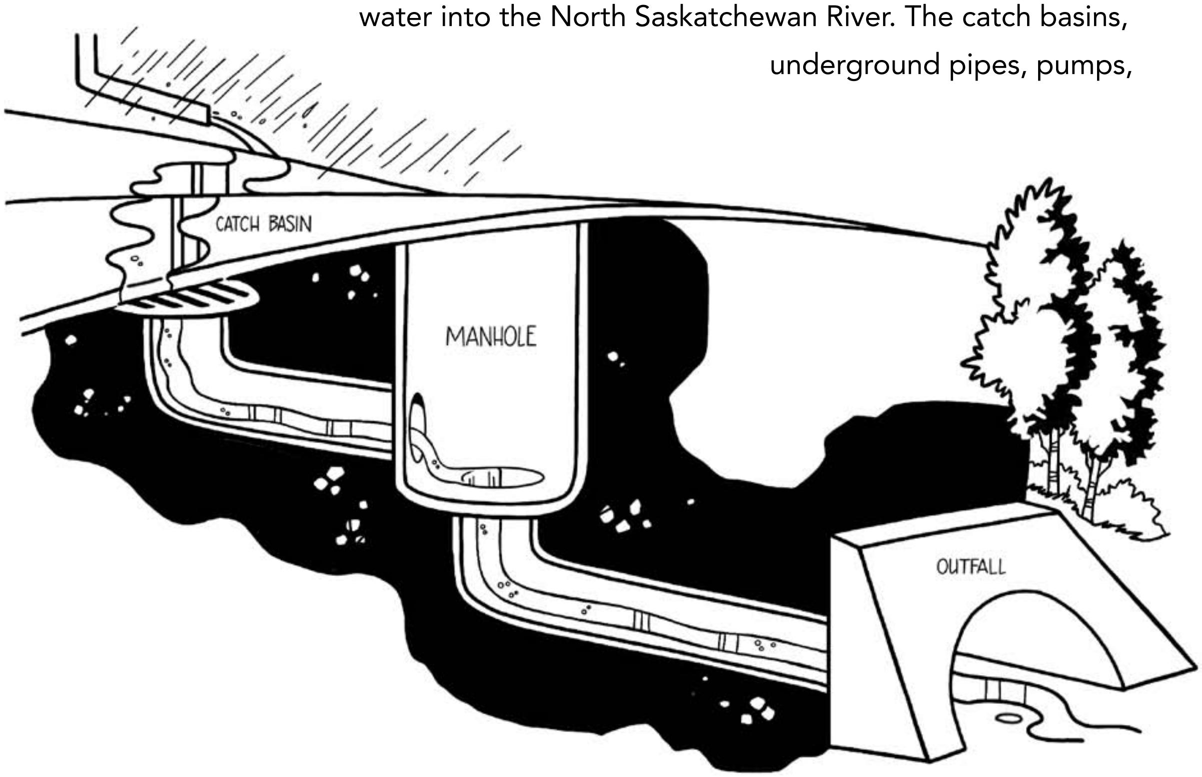
Edmonton's Storm Water Management System

In natural, undeveloped environments, storm water is managed by the permeable ground, which absorbs water, and the downward flow and collection of water through and in lakes, ponds, streams, and rivers. In urban areas such as Edmonton, a storm water management system has been developed to manage storm water and to control flooding in and around our homes.

On average, Edmonton receives about 477 mm of annual precipitation in the form of rain, snow, and everything in between. It is the job of Drainage Services to plan, build, operate, and maintain the city's storm water management system.

The storm water management system is composed of two systems – a minor system and a major system. Most years, rainfall is handled by the minor system, which is based on an estimated maximum of about 20 mm of rainfall during a 24 hour period. The major system is based on an estimated maximum of about 155 mm rainfall during a 24 hour period, which might occur once approximately every 100 years.

As of 2010, Edmonton's minor storm water management system includes 2309 km of underground storm sewer pipe and 52 442 catch basins. Other components of the minor storm water system include 74 580 manholes, which allow workers to enter the underground system to perform maintenance, and 239 outfalls that discharge storm water into the North Saskatchewan River. The catch basins, underground pipes, pumps,



manholes, and outfalls are all components of the storm water management system that we don't often see. There are, however, parts of the system that you likely see on a daily basis without even knowing it.

The major storm water system includes infrastructure such as carefully engineered roadways and swales that provide routes towards storm ponds and wetlands for water that would otherwise cause flooding.

In urban areas like Edmonton, some of the storm water soaks into the ground or runs toward bodies of water, but much of it falls onto impermeable surfaces like roads, driveways, and rooftops. Houses have eaves troughs and drain spouts that collect the rainwater and allow it to flow towards the edges of the property. Driveways, roads, and sidewalks are sloped to allow water to flow towards the gutters at the edges of the street.

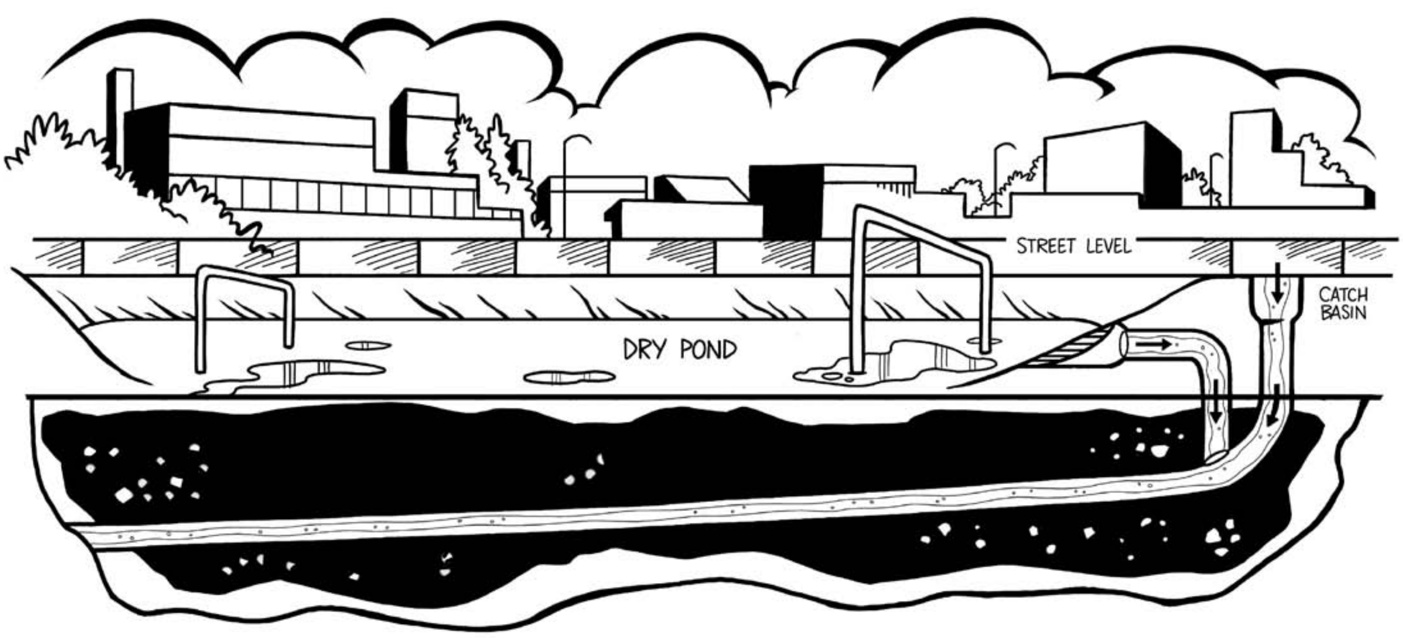
In the older neighbourhoods built close to the river, storm water pipes connect directly to the outfall pipes that drain water into the North Saskatchewan River. Today, Drainage Services also designs, builds, and maintains constructed wetlands and wet and dry ponds in new neighbourhoods. These wetlands and ponds are modelled after those found in natural, undeveloped environments, with the water levels rising and falling in relation to recent precipitation and/or melting. These newly constructed wetlands and ponds (part of the major system) reflect a change in the city's approach to storm water management.

Wetlands: Natural and Constructed

The term natural wetland refers to an area of land that is saturated with water most of the time; the water does not flow like a river, but it doesn't form in a deep basin like a lake or a pond. Wetlands are shallow, marshy areas that form where the land does not drain easily and where water-loving plants and animals thrive. The water level in a wetland changes as a result of local precipitation and snow and ice melting.

The characteristics that distinguish a constructed wetland from a wet pond are its vegetation, average depth, area, dimensions, and permeability. Wetlands have dense vegetation around the edges and are typically less than a metre deep, although they may have sections that are up to 2.5 metres deep. Wetlands are also typically long and narrow, with the length being about three times the width. Edmonton's 16 constructed wetlands are designed with low-permeable soils (such as clay) on the bottom that allow them to retain water during times of heavy flow, and then allow the water to flow out to the river through a network of pipes.

The quantity of water in a constructed wetland is controlled using a system of pipes. A wetland typically has several inlet pipes that allow storm water collected (e.g., from along our streets) to be diverted away from buildings and into the wetland. A single outlet pipe is installed at the highest level at which the wetland can contain the water without flooding. When incoming storm water causes the water in the wetland to rise above this level, it flows through the outlet pipe and down towards an outfall pipe at the North Saskatchewan River.



A lot of careful calculation goes into determining the diameter of pipe required to manage the outflow of water, keeping in mind the area of land that it is servicing.

Once the pipes are in place and the base of a constructed wetland is formed, a variety of plants are transplanted and/or a mixture of indigenous seeds and mud (pond muck) is added. Over the course of three to five years, wind, water, and the interactions of plants and animals result in the development of an ecosystem that includes a variety of thriving, water-loving plants, insects, birds, mammals, and amphibians.

Wetlands both beautify our neighbourhoods and serve a storm water management function. They not only control excess storm water but also help to filter the water. Sediment drops to the bottom of the wetlands, forming a rich layer in which aquatic plants can take root. Many aquatic plants filter chemical contaminants from the water and store them in their roots and leaves. Some plants, like bulrushes, appear to be able to perform this function without being harmed.

Ponds: Wet and Dry

Wet ponds are similar to lakes because they are standing bodies of water that have no current; however, they are smaller than lakes and usually shallower. In Edmonton, Drainage Services has constructed 104 wet ponds that range in depth from 2.5 to 3.5 metres.

The ponds have various shapes, but all have a mud bottom and rocks around the shoreline. The wet ponds are fed by rain, snow melt, and the storm water system. For the purposes of beautification and natural filtration, a variety of plants are encouraged to grow around the edges of wet ponds.

The key characteristic that distinguishes a wet pond from a wetland is how much of the water is shallow with plants growing in it: a wetland is mostly shallow water with vegetation, whereas a pond has shallow water with vegetation only around its edge. A wet pond is similar to a wetland in that it is fed by several inlet pipes and drained by an outlet pipe. These inlet and outlet pipes are designed to work the same way for both wet ponds and wetlands.

Edmonton also has 61 dry ponds, which are depressions built into parks or recreational areas. When they are dry, they are often used as sports fields in the summer and for tobogganing in the winter. Their purpose is to hold extra rainwater when the main storm water pipe becomes full. Dry ponds are gently sloped and of various sizes and shapes.

A dry pond usually has only one pipe leading in and out of it. During periods of heavy rainfall, the storm water pipe that runs under the streets may become completely filled. When the main storm water pipe is full, the water overflows from the pipe into the dry pond and the dry pond fills with water temporarily. Once the water level in the main storm water pipe goes down, the outlet pipe connecting to the dry pond allows the water to flow back out into the network of underground pipes. Dry ponds are rarely filled for longer than 24 hours and usually not at all during periods of light rainfall.

Note: All figures are as of 2009.

Comprehension Questions

1. Why is an understanding of slope important when designing the storm water management system?

____

____

____

2. What characteristic(s) of urban environments makes storm water management necessary?

____

____

____

3. How does the age of a neighbourhood determine how storm water is managed there?

____

____

____

4. What design feature prevents wetlands, wet ponds, and dry ponds from flooding?

____

____

____

____

5. Why does a dry pond only need one pipe?

____

____

____

____

Storm Water Management Model

Using the information provided in the **Reading** Edmonton's Storm Water Management System, create a three-dimensional model of a wetland, wet pond, or dry pond and demonstrate how it works.

The following materials may be useful in constructing your model:

- straws or other tubing
- modelling clay
- plastic plants
- a large, watertight tray
- watering can (to simulate precipitation)

The following checklist will be used to evaluate your model:

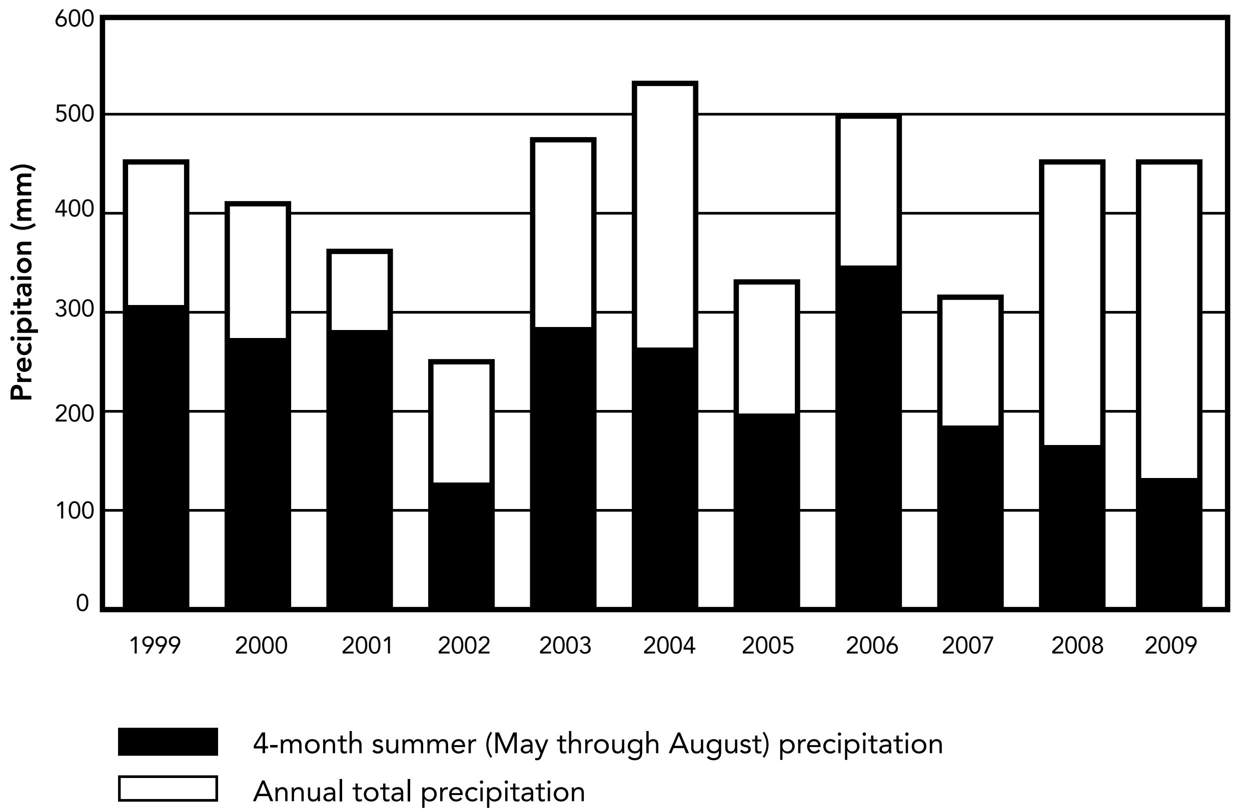
Criteria	Yes (2 points)	Somewhat (1 point)	No (0 points)
The dimensions of the model are reasonable.			
The number and placement of storm water pipes are logical.			
The model accurately reflects the process of storm water management.			

Comments:	**Total Score:**	

Precipitation Data

Much research and many calculations are involved in planning for the effective management of Edmonton's storm water. Our storm water system must be able to handle the full range of precipitation that our city experiences from year to year. One of the first steps in this process is to determine how much precipitation we can expect. The graph below shows the annual, and four-month summer precipitation in one area of Edmonton. Read the information presented in the graph, and use it to help you answer the questions that follow.

Environment Canada's Municipal Airport Rain Gauge #22
Annual and 4-Month Summer Precipitation (May through August)



1. Approximately how many millimetres of precipitation did this area of Edmonton receive during the summer of 2005?

2. During which three years did this area of Edmonton experience the wettest summer?

3. During which three years did this area of Edmonton experience the dryest summer?

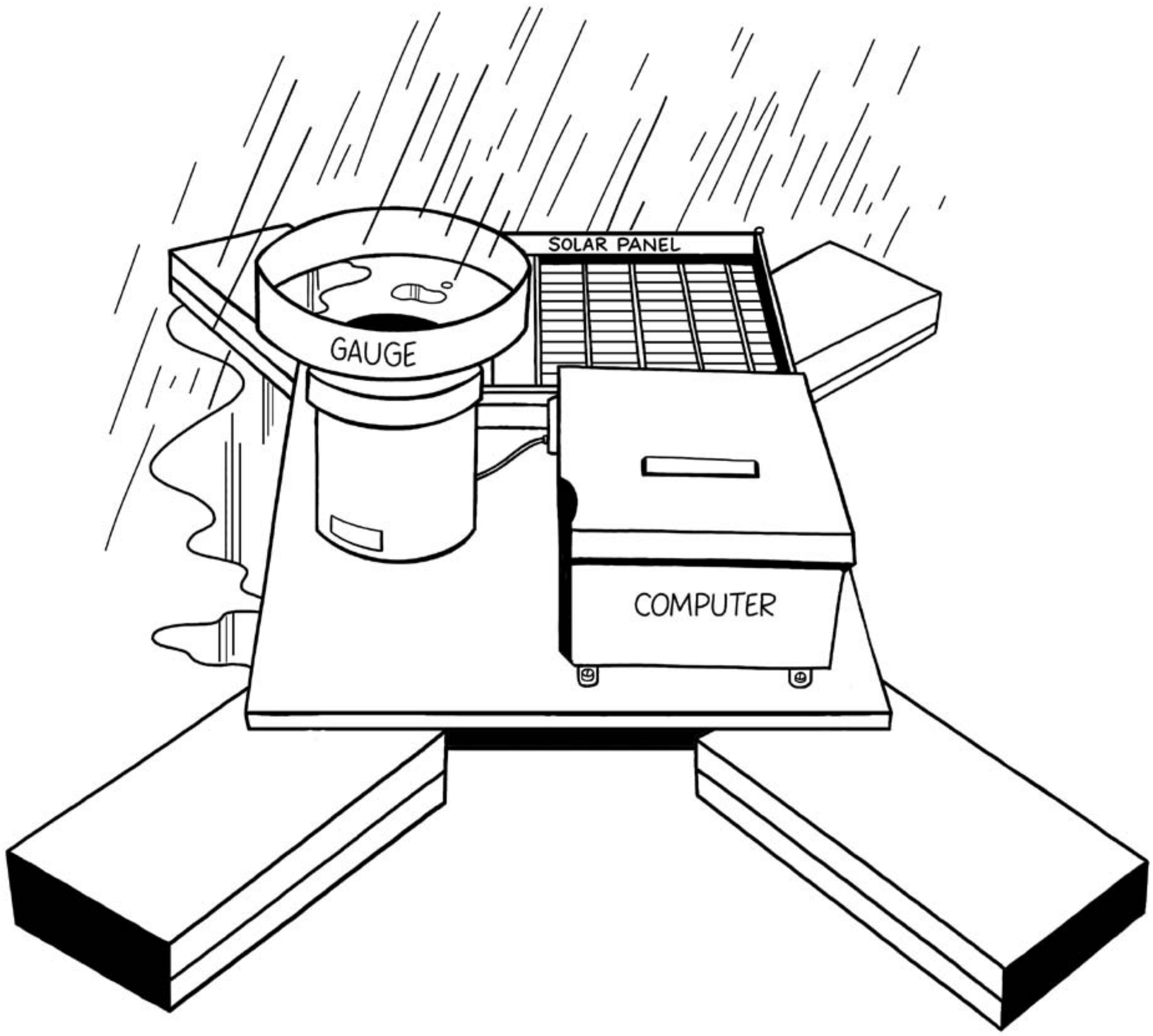
4. How much less precipitation did this area of Edmonton experience in 2009 than in 1999?

5. Why do you think the four-month summer statistics are recorded together, rather than monthly as for the other seasons?

6. Conduct research to find the precipitation statistics for the City of Edmonton and create a graph that depicts the daily precipitation over a period of time (e.g., one month). How often during the time period would storm water levels be considered very high?

Extension Activity: The information in the graph used for this activity was collected by rain gauges. Find out about rain gauges. What are they? How do they work? Where are they located? Why is the information they collect useful?

Rain Gauge



Storm Water Management in My Neighbourhood

Take a walk around your neighbourhood and, using this sheet as a guide, collect information and draw conclusions about storm water management in your area.

Name of Neighbourhood/Community: ____

Number of catch basins on your block: ____

Where do the catch basins appear to be located? (i.e., is there a pattern?) ____________

____

Have the roads, curbs and/or other surfaces been designed to direct storm water into the catch basins? How? ____

____

How effectively do the catch basins in your neighbourhood seem to be working? What evidence leads you to draw this conclusion? ______________________________

____

____

Number of manholes on your block: ____

Have the roads, curbs and/or other surfaces been designed differently around the manholes than the catch basins? How? Why might this be the case? _______________

____

____

Other evidence of storm water management I have observed in my neighbourhood:

- ❏ dry pond: ____
- ❏ wetland: ____
- ❏ wet pond: ____

Storm Water Calculations

A number of complicated formulae are used by the engineers at Drainage Services to predict and plan for the flow of water through the extensive network of underground pipes of the storm water system. The efficient functioning of the storm water management system and the safety of our neighbourhoods depends on these critical calculations.

The following calculations reflect a simplified version of the math involved in determining the quantity of water that is carried by a pipe. Use the formulae to calculate answers to the following problems.

Volume (m^3) = Discharge Rate (m^3/sec) x Time (sec)

1. Edmonton is hit by heavy rainfall that lasts ten hours. If storm water is flowing through a pipe at a discharge rate of 0.2 m^3 per second during the first hour of the storm, how much water will flow through the pipe and into the wet pond during this time?

2. If the storm water slows to a discharge rate of 0.05 m^3 per second for the next five hours, how much water will have flowed through the pipe so far?

3. If the storm water continues to flow at a rate of 0.03 m^3 per second for another four hours, how much water will have flowed through the pipe and into the wet pond in total during the storm?

Storm Water Composition Investigation

Although storm water does not go through a cleaning "treatment" process like wastewater does, Drainage Services personnel frequently test the composition of storm water as part of ongoing environmental monitoring. Since humans have an impact on storm water (e.g., garbage and chemicals we use get into the storm water system), it is important to be aware of what is entering the North Saskatchewan River and what is collecting in the city's constructed wetlands and wet ponds. The following investigation will give you some insight into the physical and chemical composition of the storm water in and around your neighbourhood.

Purpose: to determine the physical and chemical composition of local storm water

Materials:

- clean water-tight containers with lids
- filter paper (e.g., coffee filters)
- water test kit
- storm water samples

Note!

Collect water just before it reaches catch basins, not from within the catch basins.

In winter, collect and melt snow samples taken from near the catch basins and collect untouched snow.

At home:

1. Collect a sample of storm water as it runs toward a catch basin. This sample could be taken during a storm, while snow is melting, or while people are using water outside. Collect a sample of rainwater.
2. Label each container either "rainwater" or "storm water."

At school:

3. Pour half of each sample through its own piece of filter paper (do this over a sink or bucket).
4. Examine the residue on your filter papers, compare your findings with those of your classmates, and then complete the following chart.

Materials Filtered from Samples (use checkmarks to indicate presence of physical materials in each sample)			**How My Samples Compared to Others** (e.g., quantity and proportion of physical materials)
pebbles	❑ rain water	❑ storm water	
grains of sand	❑ rain water	❑ storm water	
silt	❑ rain water	❑ storm water	
organic material(s): ____________________	❑ rain water	❑ storm water	
other: ____________________	❑ rain water	❑ storm water	

5. Examine the water test kit provided by your teacher and complete the chart below to identify the substances you will be testing for in your samples.

   Water Test Kit

   ❑ detergents

   ❑ phosphate

   ❑ iron

   ❑ copper

   ❑ pH

   ❑ alkalinity

   ❑ nitrate

   ❑ nitrite

   ❑ phenol

   ❑ chlorine

   ❑ other: ____

6. Follow the instructions in the water test kit and record your findings in the chemical analysis chart.

Chemical Analysis

Chemical Levels Found in Water Samples			How My Samples Compared to:	
Tested For:	Level found in Rain Water Sample	Level found in Storm Water Sample	Other Samples	Normal Scale
			❑ lower ❑ similar ❑ higher	❑ lower ❑ similar ❑ higher
			❑ lower ❑ similar ❑ higher	❑ lower ❑ similar ❑ higher
			❑ lower ❑ similar ❑ higher	❑ lower ❑ similar ❑ higher
			❑ lower ❑ similar ❑ higher	❑ lower ❑ similar ❑ higher
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			❑ lower ❑ similar ❑ higher	❑ lower ❑ similar ❑ higher

Use the normal scales provided with the water quality testing kit to analyze your results.

Go online and find out more about the City of Edmonton's Sewers Use Bylaw 9675: Prohibited Waste and Restricted Waste Levels.

Analysis Questions

1. Based on the physical particles you found through the filtering process, how did your sample of rain water compare to your sample of storm water? Why do you think this was the case?

2. Based on the physical particles you found through the filtering process, how did your samples compare to those collected by your classmates? Why do you think this was the case?

3. How did the chemical levels found in your sample of rain water compare to those found in your sample of storm water? Why do you think this was the case?

4. In general, how did the chemical levels found in your samples compare to other samples collected?

5. In general, how did the chemical levels found in your samples compare to the normal scale?

Conclusion Questions

1. How might high levels of sediment (physical particles) cause problems for the storm water management system?

2. How might high levels of chemicals in storm water be an ecological concern?

3. Did the concentrations of contaminants you found exceed the maximum limits allowed by Edmonton's Sewers Use Bylaw 9675?

Deposition Simulation

Purpose: To demonstrate how water causes erosion and deposition and draw conclusions related to storm water management.

Materials:

- an outdoor space where dirty water can be poured
- fine natural sediment such as sand or silt
- large glass jar with lid
- water

Procedure:

1. Fill the bottle ¾ full with water.
2. Add sediment to the water and, with the lid firmly on, shake the mixture until the water is moving quickly enough to carry the sediment load for a few moments.
3. Remove the lid and tip the jar over so the water flows out (preferably along a confined pathway such as the join between two sidewalk blocks).
4. Observe how and where the sediment drops out of the water and illustrate your observations.
5. Have other students empty their samples along the same path, observe the changing patterns in deposition and illustrate your observations.

Analysis Questions:

1. Where was the sediment initially deposited?
2. How did deposition change over time?

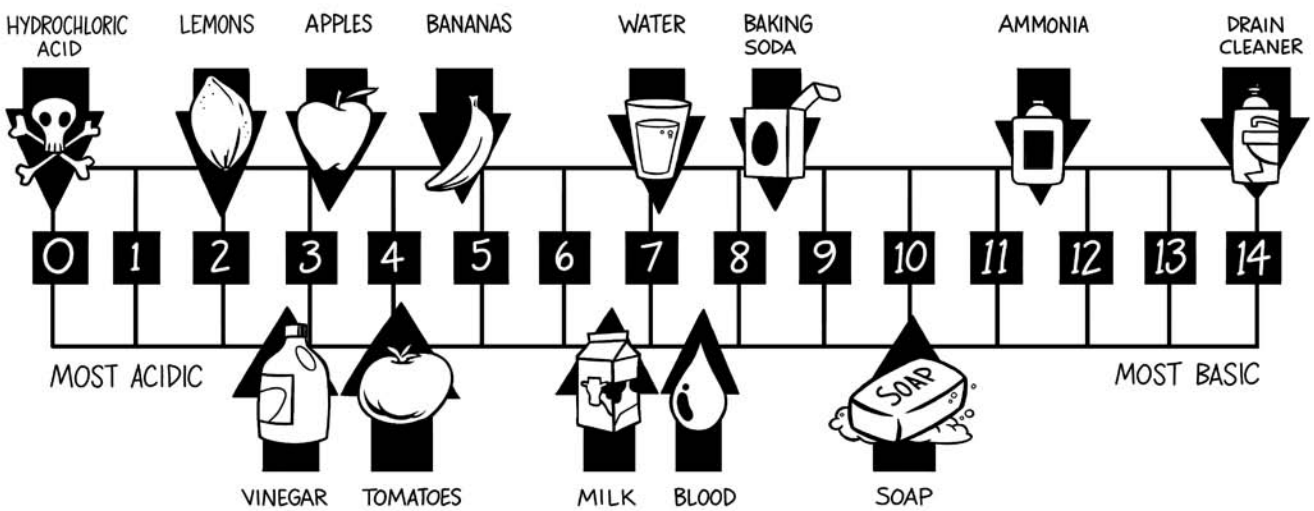
Conclusion Questions:

1. What caused deposition to occur?
2. How might deposition in a storm water wetland or wet pond need to be managed?
3. How might deposition from outfalls at the North Saskatchewan River change the natural characteristics of the river? Is this a concern? Why or why not?

Water Quality – Chemical Indicators

pH Level

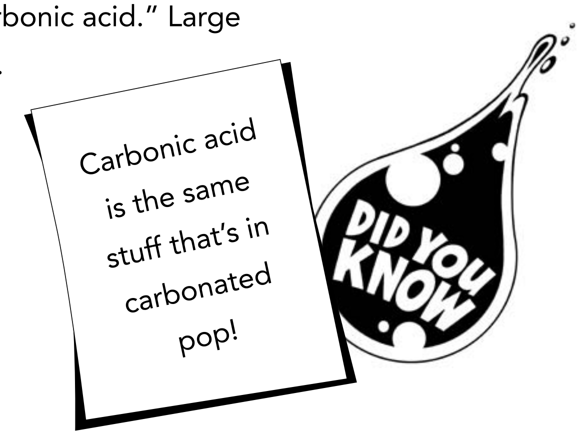
The pH level of a substance indicates how acidic or basic it is. The pH scale is used to show how acidic or basic a substance is, from zero to fourteen. For example, a zero on the pH scale means a substance is extremely acidic, whereas a fourteen means it is extremely basic. Pure water measures exactly seven on the pH scale, which means it is neither acidic nor basic.



Advanced Science

At the molecular level, pH reflects the balance of electrical charges of positive hydrogen ions (H+) compared to negative hydroxide ions (OH-). A molecule is considered to be electrically charged if it is either missing an electron (positive charge) or has an extra electron (negative charge). This might sound confusing, but it happens because each electron has a negative charge, so losing one means the molecule is missing a negative charge, so it becomes positive.

In a pond or wetland, the pH level of the water is most affected by factors such as the maturity of the environment and the chemicals brought in by storm water. Most ponds and wetlands have a basic pH when they are first formed, but they become more acidic as organic materials build up over time. As part of the natural cycle, organic substances decay and carbon dioxide (CO_2) is released into the water. The CO_2 molecules combine with water molecules to produce a weak acid, called "carbonic acid." Large amounts of carbonic acid lower the pH level of the water.



Most fish can survive in water with a pH level between 5.0 and 9.0. Most North American rivers, lakes, and streams fall within this pH range, although acid rain has altered the levels in lakes and ponds close to industrial areas.

When conducting environmental monitoring, it is important to know that pH has a synergistic effect on other substances. In this situation, a synergistic effect means that, as the water's pH level changes, other substances can suddenly become toxic. Of particular concern is that when the levels of certain metals in the water increase, aquatic life is often less able to tolerate the same pH range. For example, fish that can usually tolerate a pH as low as 4.8 will die when the pH reaches 5.5 if the water contains 0.9 mg/L of iron. Similar toxic effects occur with aluminum, lead, or mercury.

Alkalinity

Alkalinity is closely related to pH. It measures the ability of the substances in the water to neutralize the acid level, or make it less acidic and more basic. Fish and other aquatic life thrive better in environments where the pH is at a constant level that is not too acidic. Alkalinity is particularly important in areas where there is acid rain, since alkalinity helps to "fight" the acid. Rocks contain dissolvable carbonate, bicarbonate, and hydroxide compounds that increase natural alkalinity. Borates, silicates, and phosphates added to the water may also increase alkalinity.

Ammonia

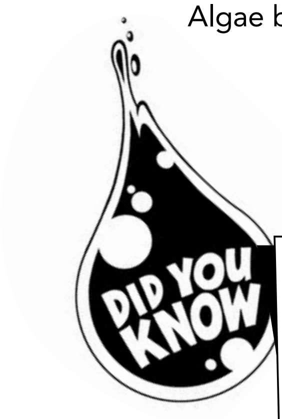
In nature, ammonia is formed when bacteria breaks down proteins and urea (a nitrogen compound in urine). Ammonia can be manufactured by combining nitrogen and hydrogen molecules, and it is also produced when coal is burned.

Ammonia is a powerful cleaning agent that is a common ingredient in industrial and household chemicals. Because ammonia is rich in nitrogen, it makes an excellent garden fertilizer.

A concentration of ammonia any greater than 0.1 mg/L usually indicates polluted waters. Even in low concentrations, ammonia is toxic to fish and other aquatic organisms. A concentration of 0.06 mg/L causes gill damage in fish, and at 0.2 mg/L sensitive fish such as trout and salmon begin to die. Some fish, such as carp, are ammonia-tolerant, but even they die when concentrations rise to 2.0 mg/L.

Temperature, pH, and the levels of dissolved oxygen and carbon dioxide all affect the toxicity of ammonia. The same concentration of ammonia becomes more toxic as pH and temperature rise. When the level of dissolved oxygen is reduced, ammonia is much more toxic to aquatic life.

Ammonia has also been known to speed up the process of eutrophication, which is an increase in nutrients in the water that disrupts the natural balance of an aquatic ecosystem. Algae bloom is a common sign of eutrophication.



Eutrophication is an aquatic condition that can be caused by many factors, but most often it is a result of chemical imbalances in the water. Eutrophication happens when too many nutrients are added to water and these nutrients cause quick-growing organisms such as algae to multiply rapidly. Too much algae on the surface of the water prevents light from getting to organisms below the surface, so other aquatic plants start to die. The rapid life cycle of the algae and the deaths of the bottom-dwelling aquatic plants leads to a lot of decomposition. The decomposition process takes oxygen out of the water (decomposers like bacteria "breathe" in oxygen and release carbon dioxide), so then the water becomes carbon-dioxide rich and oxygen poor, and the oxygen-dependent organisms like fish start to die as well. In the end it leads to a very unhealthy aquatic environment.

Nitrites and Nitrates

Nitrogen, which makes up about 80 percent of Earth's atmosphere, is essential to life and is found in the cells of all living things. Organic nitrogen combined with carbon is found in proteins. Inorganic nitrogen can exist as a gas on its own, as ammonia when it is combined with hydrogen, or as nitrite or nitrate when it is combined with oxygen. As part of the decomposition process, bacteria break down ammonia into nitrite, and then nitrite is broken down into nitrate.

Nitrites cause a serious illness in fish called brown blood disease; however, this is rare because nitrites are not usually around for long before they are converted to nitrates.

Nitrates are a main ingredient in plant fertilizer, so they get into storm water when lawn fertilizer runs off during rain storms or as a result of over-watering. Nitrates stimulate the growth of aquatic plants that provide food for fish. This may initially increase the fish population, but if algae bloom occurs, oxygen levels will fall and fish will die. Nitrate levels below 90 mg/L and nitrite levels below 0.5 mg/L have little effect on warm-water fish, but salmon and other cold-water fish are more sensitive.

Dissolved Oxygen

Oxygen becomes dissolved in water as a result of diffusion from the surrounding air and as a waste product of photosynthesis. Warmer water typically holds less oxygen because gases become less soluble as temperature rises. Bacteria decomposers and aquatic animals use up a lot of dissolved oxygen.

It is generally agreed that 9 ppm is the optimal amount of dissolved oxygen for supporting a large, diverse fish population; 4-5 ppm of dissolved oxygen is the minimum.

Because dissolved oxygen speeds up corrosion in metal water pipes, industries often use water with the least possible amount of dissolved oxygen. Water released from industry is often below the minimum levels required to support life in an aquatic environment.

Phosphates

Phosphates are chemical compounds that contain phosphorus, an element that is necessary for healthy plant and animal growth. Natural sources of phosphates include rocks and solid or liquid wastes. Organic phosphates are important in nature and can assist in the breakdown of organic pesticides.

Phosphates are a common ingredient in fertilizers, pesticides, industrial cleaning products, and household detergents. When phosphates are released into constructed wetlands and ponds, they stimulate the growth of aquatic plants that provide food for fish. This may increase the fish population and improve the quality of life in the ecosystem; however, if too much phosphate is present, aquatic plants can grow out of control, causing eutrophication and a disruption in the natural balance, and fish and aquatic organisms may die.

A typical, uncontaminated body of water will contain 0.01 to 0.03 mg/L of phosphate; a rise to 0.025 mg/L begins to accelerate the eutrophication process; 0.1 mg/L is considered to be the maximum concentration before a significant decline of the ecosystem occurs.

Water Quality – Temperature

Factors that can affect water temperature include:

Colour The sun's rays are better-absorbed by dark-coloured water, or bodies of water with dark, muddy bottoms.

Depth/Volume Deep water is usually colder than shallow water because it takes more energy to warm it up. Also, a large volume of water takes longer to heat up than a small volume of water.

Shade Shade provided by plants along the shoreline prevents water temperatures from rising too quickly on sunny days.

Season Water temperature varies with the seasons.

Supply The temperature of the water flowing into a pond or wetland affects its overall temperature.

Most aquatic organisms are cold-blooded, so their metabolisms increase when water is warmer and decrease when it is cool. Every species of aquatic organism has its own optimal water temperature, and if the water temperature moves too far from the optimal level, the organism suffers. Cold-blooded animals can not survive temperatures below 0°C, and very few fish can tolerate temperatures above 36°C. Aquatic plants also require specific temperatures to thrive.

Warm water also increases the toxic effects of chemicals such as cyanides, phenol, xylene and zinc on aquatic organisms.

Water Quality – Turbidity

Turbidity is the measurement of the cloudiness of a liquid due to the number of particles suspended (or floating) in it. Turbidity affects fish and aquatic life because it interferes with sunlight's ability to penetrate the water. If suspended particles block out light, aquatic plants cannot perform photosynthesis. Initially, this results in reduced oxygen concentrations. Over time it results in increased carbon dioxide concentrations as plants switch to respiration and the decomposition of dead organisms results in the release of this harmful gas.

Large amounts of total suspended solids (solid particles suspended in the water) can clog the gills of fish. It is also harder to find food when they can't see clearly. It is, however, easier for fish to avoid predators when they are hidden by murky water.

Eventually, large amounts of suspended solids (such as sediment, bacteria, sand, rock chips, dirt) are deposited on the bottom, and this can smother eggs in spawning beds and provide a place for harmful microorganisms to breed.

High turbidity levels in neighbourhood storm water ponds and wetlands can result in sediment begin washed or blown into the water due to such things as flooding, sand used on the streets during the winter, construction sites in new land developments, and high volumes of urban runoff on city streets.

Drainage Services personnel are responsible for ensuring the ecological health of the wetlands and ponds that are part of the storm water management system. Conduct the following investigation to provide some insight into how water quality is monitored in these environments.

Water Quality Investigation

Purpose: To analyze the water quality in a storm water wetland or pond.

Materials:

- water-tight container with lid
- water test kit
- thermometer
- flashlight
- microscope and slides
- water samples from a local storm water wetland or pond

At home:

1. Collect samples of water from a local storm water wetland or pond (you may want to collect and label samples from different locations).
2. Record the temperature of each sample as soon as you collect it.
3. Use a flashlight to help you to assess the turbidity of the water by shining the light through it and then describing how cloudy it is compared to a clear water sample.

At school:

4. Complete the plant analysis and organism analysis charts onsite and take your water samples to school and follow the instructions in the water test kit to complete the chemical analysis chart.

CAUTION!

Students of all ages must have an adult present when working near a body of water.

All posted signs should be obeyed, and under no circumstances should anyone attempt to enter the water.

Plant Analysis

PLANT ANALYSIS RESULTS Observations recorded at:	How My Observations Compared to Others

Aquatic Plants	Population Description abundant	moderate	limited	lower	similar	higher	Other Comments
Submerged: plants growing below the surface of the water (rooted or free floating)							
Floating: free floating plants with leaves that rest on the surface of the water and roots that hang down in the water							
Rooted Floating Leaf: rooted plants (deep or shallow) with leaves that float on the surface of the water (e.g., water lily)							
Emergent: non-floating rooted plants that mostly grow above the water surface and have leaves that don't float (e.g., bulrushes)							
Marginal: plants that grow at the edges of the water in very wet soil							

Terrestrial Plants	Population Description abundant	moderate	limited	lower	similar	higher	Other Comments
Conifers:							
Deciduous:							
Bushes							
Other:							

Organism Analysis

The abundance and variety of life that can be supported by an environment is an indicator of its ecological health. Environmental monitoring often involves keeping records of the organisms living in and around an area. Carefully record your biological evidence before returning your samples to the original pond or wetland.

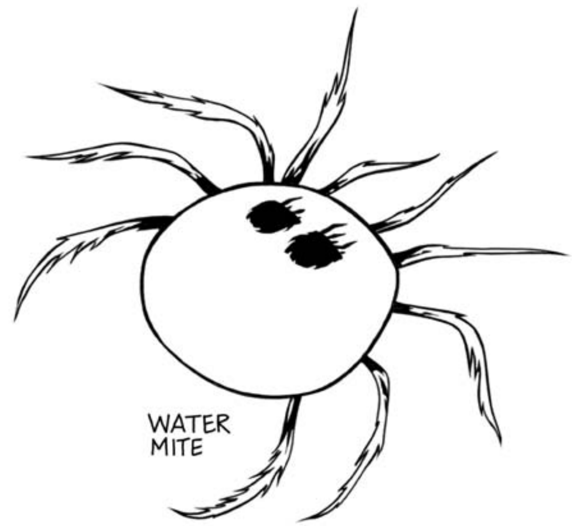
BIOLOGICAL ANALYSIS RESULTS Water sample collected from:	How Numbers in My Samples Compared to Other Samples

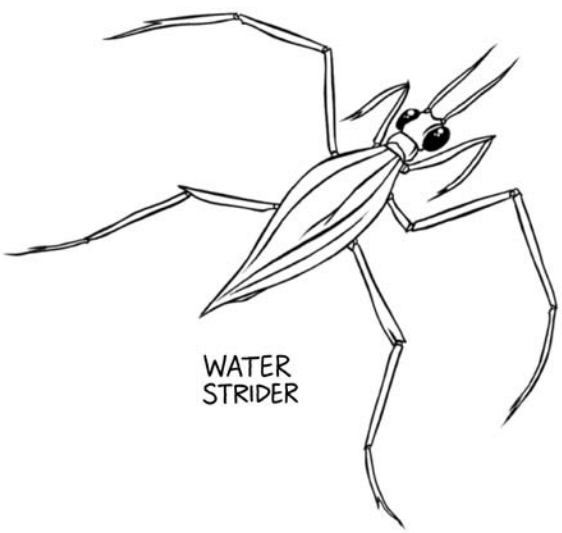
Types of Insects, Arthropods, Worms, Algae and Protozoa* Identified	Number Found	lower	similar	higher	Other Comments

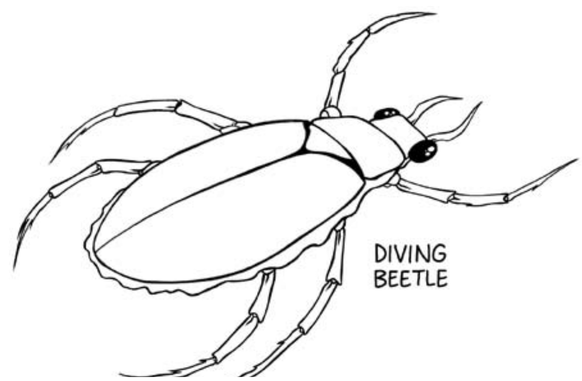
Note: Since a microscope is required to observe protozoa, this section of the chart will need to be completed at school.

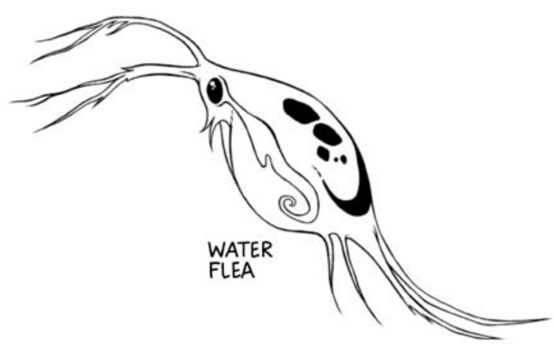
Aquatic Life Identification Key

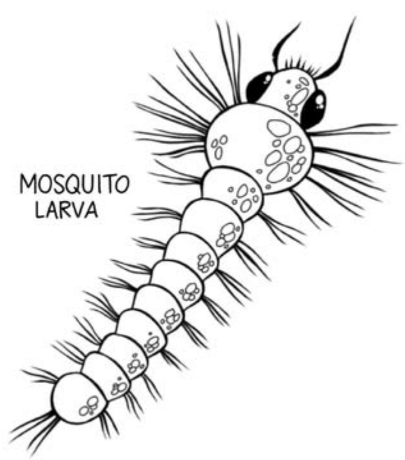
(aquatic invertebrates)

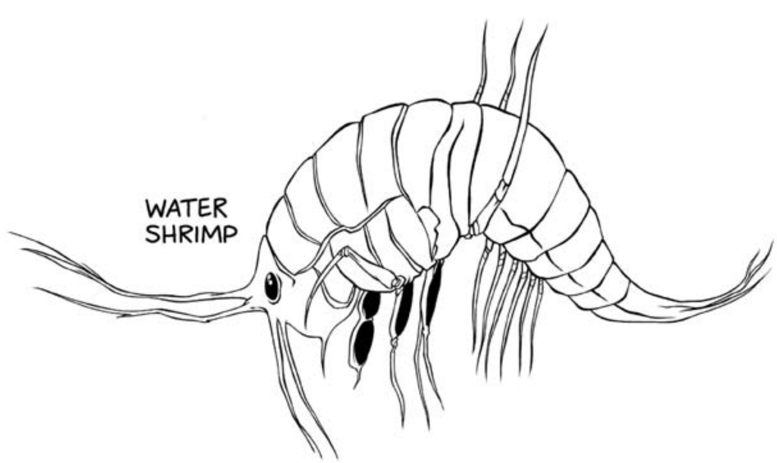






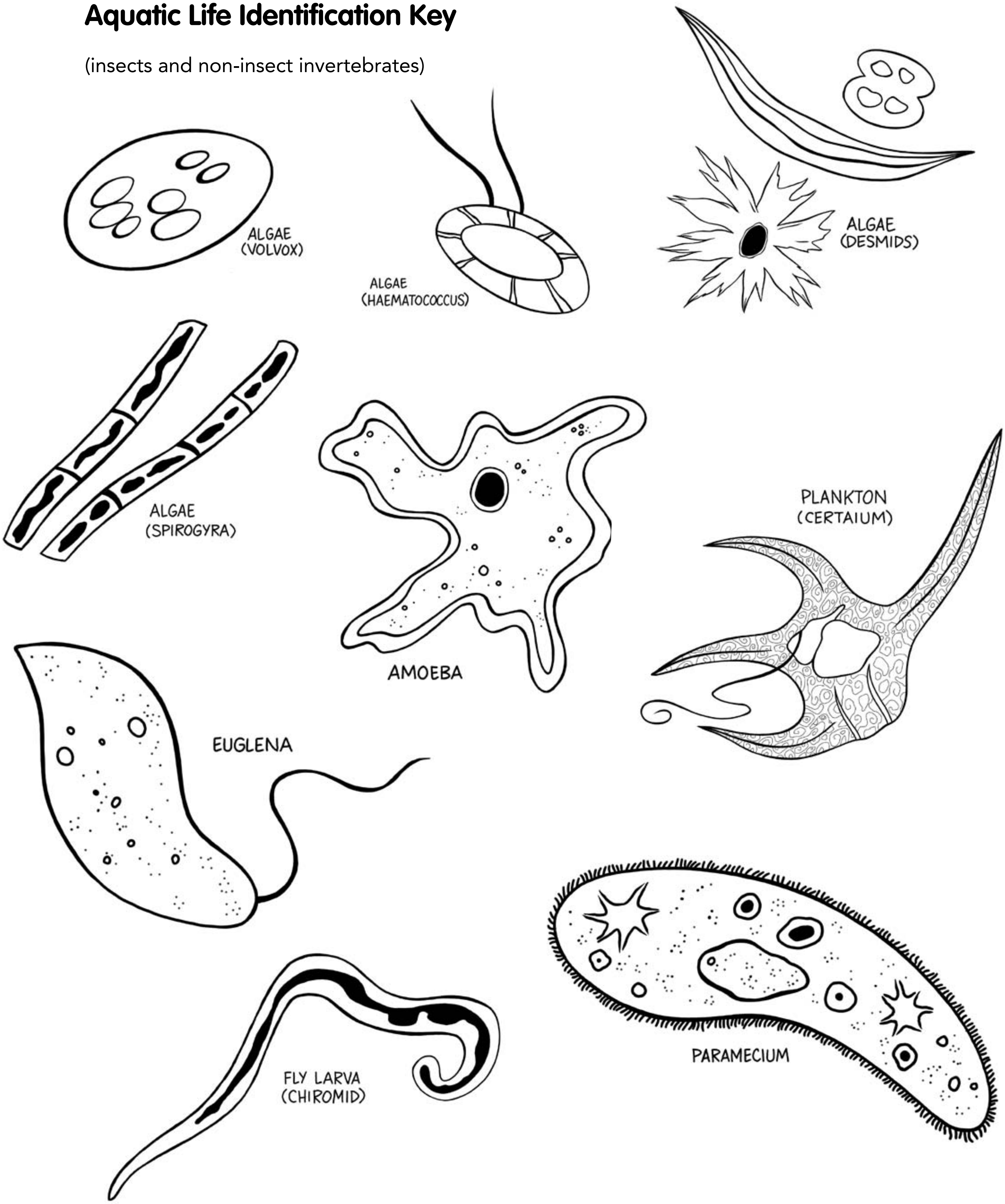






Aquatic Life Identification Key

(insects and non-insect invertebrates)



Chemical Analysis

CHEMICAL ANALYSIS RESULTS Water sample collected from:	How Numbers in My Samples Compared to:					
	Other Samples			Normal Scale		
	lower	similar	higher	lower	similar	higher
Temperature						
Turbidity						na
Chlorine						
pH						

Use the normal scales provided with the water quality testing kit to analyze your results.

Go online and find out more about Edmonton's Sewers Use Bylaw 9675: Prohibited Waste and Restricted Waste Levels.

Normal Range of Water Quality Indicators for Storm Water Management Ponds and Constructed Wetlands

Test Factor	Normal Range
chlorine	less than 0.02 ppm
oxygen	more than 5 ppm
ammonia	less than 0.3 ppm
nitrites	less than 0.1 ppm
hardness	100 to 350 ppm
salinity	0.1 to 0.3 %
phosphates	0.1 to 0.4 ppm absence of algae bloom
copper	0.002 ppm or 2 ppb
pH	7 to 9

pH at 7 is neutral

pH < 7 is acidic

pH > 7 is alkaline

The higher the pH, the higher the alkalinity.

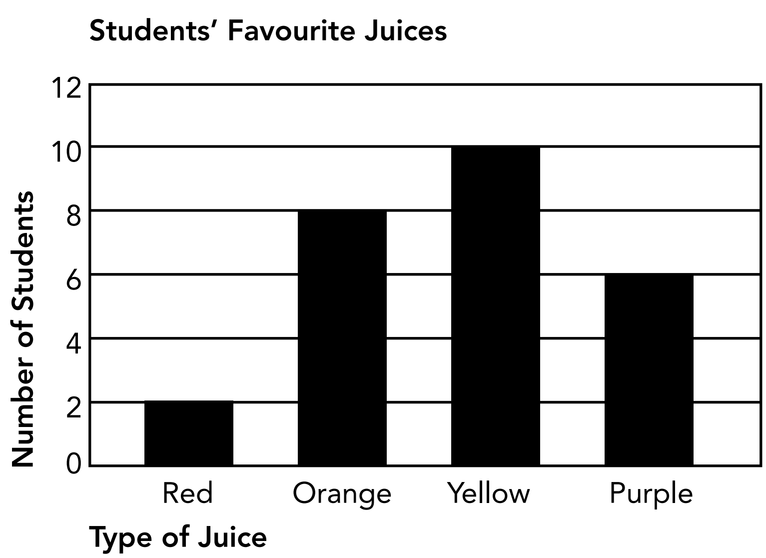
Water Quality Investigation – Graphs

Create two bar graphs: the chemicals in one graph and numbers of organisms (e.g., protozoa) in the other. Compare your graphs with those of students who took samples from other neighbourhoods. Draw a series of conclusions based on the graphs; e.g., more nitrates results in more/less organisms, one neighbourhood has higher concentrations of chemicals due to new land development.

1. Draw the x-axis and y-axis on a sheet of graph paper. Label the x-axis with the chemicals or organisms observed. Label the y-axis with numbers at appropriate intervals.
2. Decide on a width for the bars that is easy to read, and leave the same amount of space between each bar.
3. Use a pencil and a ruler to draw in each bar lightly. Double check your x-axis and y-axis, label* the bar below the x-axis, and then move on to the next bar.
4. Once you have drawn all the bars, it's a good idea to colour them differently so that they stand out and so that your legend (if you have one) is easier to use.

* If necessary, label each bar with an abbreviation and create a legend to go along with your graph.

Sample Bar Graph:



Water Quality Investigation – Reflection

Once you have compiled your information, read through the three sets of notes on water quality (chemical indicators, temperature, and turbidity), and conduct any necessary research to help you to analyze your results and answer the following questions.

1. How would you describe the water quality in the source you analyzed?

2. What key information from your observations supports your assessment of the water's quality?

3. What are the possible explanations for the water quality? Are there obvious signs of human impact?

Case Studies – Wetlands and Ponds in Distress

Read through the following scenarios and use what you have learned so far in this unit to identify the problem and its cause. Suggest a solution, and consider its pros and cons.

Scenario 1 – Pond Plummet

Dorothy and Victor enjoy a leisurely walk around the wet pond in their neighbourhood most evenings. Last week, they commented to one another on how the aquatic plants were flourishing, but this week they noticed an unpleasant smell and indications that some organisms are dying.

a. Why would life in the pond suddenly flourish and then die out? What could have caused this rapid and extreme cycle?

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b. Based on what you think the problem is, can you think of a solution?

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c. What are the pros and cons of your solution?

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Scenario 2 – Wetland Woes

A constructed wetland was recently developed in a new neighbourhood, but instead of flourishing and beginning the natural process of succession, the water has remained relatively lifeless. When walking near the wetland one evening, Emma and Abby shone a flashlight into the water and noticed that the beam hardly penetrated the water.

a. Why wouldn't the flashlight beam be able to penetrate the water, and what type of problem would this be evidence of?

b. Can you think of a solution?

c. What are the pros and cons of your solution?

Scenario 3 – Destructive Decision

A well-established storm water wet pond had been successful for many years. The water appeared to be clean and life flourished in and around the pond. The trees growing along the shoreline had reached such heights and densities that residents whose homes overlooked the pond now had an obstructed view. During a particularly warm summer when residents were spending extra time outside on their decks, they complained of missing seeing the local pond life that they had previously enjoyed. Without prior consent of the City of Edmonton, homeowners began culling the trees around the pond. They cut down the larger, overhanging trees, leaving only the young tree around the edges of the pond. Within weeks, large numbers of aquatic organisms were dying. When specialists were brought in by the City, they were dismayed to see that the large trees had been removed, especially during such a hot summer.

a. Why would the specialists be so concerned, and how had removing the overhanging trees likely affected the pond?

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b. Can you think of a solution?

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c. What are the pros and cons of your solution?

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Detergent Detective

Thinking that they are making an environmentally friendly choice or to save a few dollars, some people decide to wash their vehicles in their driveways. In doing so, they washing detergents into the streets, where they drain into catch basins and are added to the storm water. This detergent-filled water then makes its way to a local pond or wetland, or straight to the North Saskatchewan River. These bodies of water are parts of ecosystems that were never intended to contain the types and concentrations of chemicals found in detergents. The three phases of this project will lead you to understand more about detergents and the environmental consequences of washing cars, trucks, and SUVs at home.

Phase One

Conduct research at one or two businesses that carry products for washing vehicles. Take a camera with you and a means of recording written information, and collect information about the chemical ingredients and concentrations of a variety of vehicle detergents. Pay particular attention to warnings that appear on labels, tags or packaging. Record the information in detail, and then organize your findings into a chart for easy reference.

Phase Two

Continue your research online. Find out the ecological effects of each of the chemicals listed in your chart. Pay careful attention to information about chemical concentration. Make a judgment about the products you researched: if people must wash their vehicles at home, which would be the best product to use?

Phase Three

Present your findings to the class. Explain your process and provide support for the vehicle detergent you have chosen to endorse. Also include in your presentation a clear message about acceptable use (e.g., what would be considered an acceptable amount of the product to use, how often and in what circumstances is home vehicle washing acceptable). Consider enriching your presentation with a discussion of the benefits of using a car wash.

Extension Activity A: A number of cities in Canada have bans in place to prevent people from washing their cars on the street. Research and find an effective way to include this information.

Extension Activity B: Conduct research into commercial car washing facilities, the related legislation and environmental considerations and impacts.

Pesticide Patrol

Throughout this resource there has been discussion of fertilizer use and its effects on aquatic ecosystems, but what about pesticides? The word pesticides represents the family of products that are used to control weeds, insects, diseases, and rodents. The suffix "cide" from Latin means to kill, murder, cause death, slay, cut or cut down. When people use pesticides in their gardens, they are washed by rain and hose water into our ponds, wetlands, streams, and river. Check the City of Edmonton website and search for **Integrated Pest Management Policy C501**. This policy is to be followed by all City departments.

Complete the following three phases of this project to develop a greater understanding of the common chemicals used in households for pest and weed control and alternative solutions.

Phase One

Conduct research into the chemicals found in common pesticides, along with the ecological implications of allowing each of the chemicals to become part of our storm water. Pay particular attention to warnings about usage. Record your information in detail, and try to collect information in the same categories each time; e.g., active chemical ingredients, effects on pests, potential effects on humans, potential effects on animals and organisms. Organize your findings into a chart for easy reference.

Phase Two

Conduct research into biological control options for pests and weeds. Identify specific practices that can be used to control these unwanted organisms that do not involve harsh chemicals. Try to focus on solutions to local problems (i.e., unwanted organisms that we find in our gardens here in Edmonton). Include warnings about the implications of introducing one species to control another.

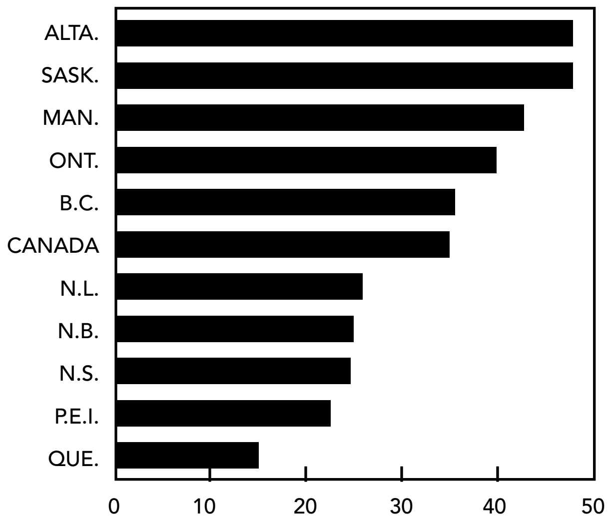
Phase Three

Present your findings to the class. Begin by informing your classmates about the contents of pesticides and herbicides and the ecological implications of their use. Introduce them to the concept of biological control with a range of locally relevant examples; be sure to address the pros and cons of using biological control. Consider enriching your presentation by encouraging a short debate about how realistic the use of biological controls is for the average homeowner.

Extension Activity: A number of cities in Canada have banned the use of garden chemicals. Research and find an effective way to include this information in your presentation.

Friendly Fertilization

Many homeowners take pride in having a lush, green lawn and a variety of plant life flourishing in their yard. Consider the following statistics about the percentage of homeowners across our country who regularly apply fertilizers to their lawns and gardens:



Source: Statistics Canada
Data Source: Statistics Canada, Households and the Environment Survey, 1994 and 2006.
Table Source: Statistics Canada, 2007, EnviroStats, volume 1, number 2, "Canadian lawns and gardens: Where are they the 'greenest'? catalogue number 16-002-XWE.
http://www.statcan.gc.ca/pub/16-002-x/2007002/c-g/4129467-eng.htm

As you have learned, excessive use of fertilizers can have a devastating effect on the local ecology. This is particularly apparent when fertilizers are washed into wetlands and ponds, and even the North Saskatchewan River. Some products that were once widely used, such as "weed and feed" chemicals that combine nutrients for the grass and broad-leaf weed herbicide are no longer approved for sale in many places because of the negative effects they can have on the environment. Efforts are being made to provide consumers with a variety of options for "feeding" their lawns. The purpose of this project is to learn more about both synthetic and organic fertilizers and to educate others about how to use these products in a responsible way.

Phase One

Conduct research into the chemicals commonly found in synthetic fertilizers and those found in organic fertilizers. Pay particular attention to information about the pros and cons of each. Record your information in detail, and try to collect information in the same categories for both types of fertilizer. Organize your findings into a chart for easy reference.

Analyze your findings and come to a decision about whether you believe there is a benefit to using organic fertilizers instead of synthetic ones, or whether it is better to simply use no fertilizers at all. Alternatively, your response might focus more on controlled use, rather than a total ban. Either way, you should be prepared to support your opinion.

Phase Two

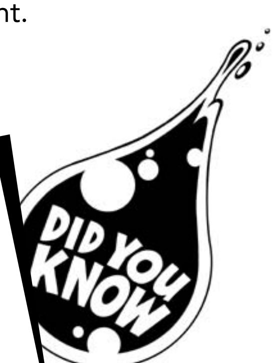
Develop an advertisement (e.g., a poster or jingle) that does one of the following:

- educates the public about acceptable fertilizer use
- encourages the public to stop using fertilizers completely

The intent of the advertisement should be clear: to think how people think and act when it comes to fertilizers. The message of the advertisement should address the need to reduce or eliminate fertilizers from storm water.

Phase Three

Present your findings to the class and then share your advertisement.



As of January 1, 2010, the province of Alberta banned the sale of granular-type lawn-care products that combine herbicide and fertilizer, known generically as weed-and-feed. Because of the nature of the product and how it is applied, it is often over-used, which can lead to the contamination of nearby water.

That Doesn't Go There!

Many people simply wash paint, oil and chemicals down the drain or throw them in the garbage. These hazardous products should be dropped off at an Eco Station so they can be properly handled. In some cases, people even rinse or dump paint, oil, and chemicals into storm water catch basins, sending them directly to wetlands, ponds, and the North Saskatchewan River. This can have an extremely harmful effect on the environment.

By working through the two phases of this project, you will learn more about the effects of rinsing certain chemicals into the storm water system.

Phase One

Conduct research into the ecological effects associated with adding the chemical ingredients of the following products (or others you can think of) to local wetlands, ponds, or the North Saskatchewan River:

- latex and oil paint and paint thinner
- antifreeze, transmission fluid and oil

Conduct research into the recommended disposal techniques (e.g., Eco Station) for each of the substances. Organize your findings in a way that will make them easy to present to your class. This might involve using visuals such as charts, diagrams and graphics.

Phase Two

Present the findings of your research to the class.

Extension Activity: Search for evidence of illegal dumping in your area and think of an effective way to incorporate this into your presentation. Evidence of illegal dumping might include staining and residue around catch basins and/or containers of hazardous materials dumped on roadsides or at the edges of neighbourhoods.

Class Debate

Like most cities around the world, the City of Edmonton does not treat storm water. Edmonton's storm water management system was created to redirect storm water and avoid flooding in heavily developed areas. In nature, storm water is managed without being processed by a treatment facility, as the water is filtered and "cleaned" through natural processes. The city's storm water management system redirects the water back to natural environments to be cleaned through the same natural processes. This system only works, however, if human waste products aren't allowed to contaminate the water.

As cities and industries grow, human activity has a greater effect on natural ecosystems. Some argue that it is time to consider treating storm water before it is returned to natural environments. Others feel that in doing so we are giving up on the idea that people should be responsible for their actions and the effects of their actions on the environment.

The question of whether storm water management should focus on proactive or reactive strategies is really asking whether the bulk of resources should be directed towards preventing ecological contamination (assuming we can control human impact) or whether resources should be directed towards removing ecological contamination (assuming there will always be a negative human impact and thus a need to clean the storm water).

People involved in Storm Water Management

There are many kinds of positions and career opportunities in storm water management. The following is a list of some of the positions that are involved in working in this area.

- Environmental Technologist
- Biologist
- Millwright/Welder
- Electrician/Instrument Technician
- Process Control Specialist
- Pumpwell Electrical Engineer
- Sewer Substructure Inspector
- Drainage System Technician
- Video Inspection Operator
- Labourer
- Industrial Waste Inspector
- Equipment Operator
- Maintenance Repairman
- Lake Drainage Leader
- Inspector
- Branch Manager or Director
- General Supervisor
- Administrative Assistant
- Business Analyst
- Bylaw Enforcement Officer
- Customer Service Staff
- Educator
- Engineers: Civil, Mechanical, Environmental, Process, Modelling, Planning, Design
- Engineering Technologist

Google http://alis.alberta.ca to learn about the kind of skills, education and experience required for these jobs. See examples on the next two pages.

Job Title: Engineering Technologists

Job Objective: Providing front line technical support for engineers by providing technical services and expertise.

Specific Responsibilities

- Develop detailed engineering and construction drawings
- Record drainage inventory based on completed construction drawings
- Map and provide schematics of existing storm water and sanitary systems
- Conduct cost estimates at design stage
- Support engineers in preparing bid and contract documents
- Inspect construction projects conduct construction surveys

Qualifications

- Engineering Technologist diploma at recognized institute of technology (NAIT)
- Eligible to be recognized as Certified Engineering Technologist with ASET

Job Title: Video Inspection Operator

Job Objective: Conducting closed circuit televising of the sanitary, combined and storm water systems.

Specific Responsibilities

- Respond to sanitary, combined and storm water pipe trouble calls
- Snake video line into and along underground pipelines and interpret images on the video monitor
- Use single or multi conductor technology to analyze and identify causes of pipe trouble and to monitor the condition of the line
- Generate reports to communicate findings

Qualifications

- High School Diploma
- Foremanship Part I
- Level I Wastewater Collection Certification
- In-house certification on single and multi conductor closed circuit TV operation
- In-house training in standardized sewer condition rating system

Job Title: Planning Engineer (Drainage)

Job Objective: Setting the guiding principles for how the City of Edmonton is to develop its urban sanitary sewerage and storm drainage to ensure that the system can handle the service requirements of land development.

Specific Responsibilities

- Develop drainage master plans
- Evaluate sanitary sewage and storm water servicing and management concepts
- Analyze performance of sanitary and storm water collection and management systems using computer models
- Identify needs to upgrade the existing systems
- Develop budgets for drainage work
- Respond to City Councillors enquiries on drainage issues
- Conduct public meetings, open houses, and workshops

Qualifications

- Bachelor of Engineering (Civil and Environmental)
- Membership in APEGGA (P. Eng)


ANSWER KEY
ASSIGNMENTS

Lesson One: Storm Water

Why must storm water be managed?

Discussion Questions:

How is storm water managed in rural environments, parks, and other natural, undeveloped spaces?

- The water cycle ensures the constant cycling of water.
- Water is stored as ground water (the water table).
- Plants absorb and store water.
- Water runs off into streams, rivers, etc.
- Water is held in lakes, ponds, and wetland areas.
- Flood plains and depressions in the land may hold water temporarily during times of heavy rain and melt.

How is storm water managed in urban environments?

- sloped roadways, roofs and other surfaces
- gutters and catch basins
- network of sewer pipes
- wetlands, wet ponds, and dry ponds
- outfall pipes to the river

Why does the storm water in urban areas need to be managed, while nature takes care of water management without human intervention in undeveloped spaces?

- Increased impermeable land (which water doesn't easily soak into) resulting from paving, houses, construction, and urban landscaping leads to decreased permeable land that becomes overloaded with water trying to soak in or run off.
- Changes to the geography that affect the natural downhill flow of water within the watershed.

- Use of water for outdoor maintenance and recreation brings additional water into the area (from the city's piped-in water supply).
- Human changes to the environment such as basements and road underpasses need to be "protected" from heavy rains.

Why does the amount of storm water being managed in urban environments change over time?

- Seasonal changes such as snow melt in the spring and heavy rainfall typical for the month of July cause changes in the amount of storm water.
- The use of water outdoors is often dictated by the seasons.
- As cities expand, more impermeable land is created.
- Drought can decrease the amount of storm water.

What could happen if storm water wasn't managed in urban areas?

- flooding in homes; e.g., basements
- unsafe roadways due to washout or flooding
- mess and unpleasant or unsanitary conditions
- damage to landscaping
- increased erosion in downstream watercourses

Watersheds in Alberta

1. Rocky Mountain House, Edmonton, Lloydminster
2. Battle River, Vermilion River
3. Prince Albert

Impermeability Demonstration

1. How does applying the water to the sandy surface imitate rainfall on permeable land?

   The water soaks in.

2. The water that falls onto our houses is collected and transported by eaves troughs and drain spouts. How does this demonstration reflect a similar process of concentrating water? How could the release of flowing concentrated amounts of water affect nearby land surfaces?

   Instead of being dispersed over a wide area, the water is concentrated and hits the surface in a rush. The force of the water causes erosion, which can wash away soil and possibly cause damage to landscaping and undermine the foundations of roads and sidewalks.

3. How does this demonstration prove the need to manage storm water in places like your neighbourhood, where there are many impermeable surfaces?

   Most of the water in our neighbourhoods falls onto impermeable surfaces, and that means there is a lot of water running off those surfaces. Storm water management needs to take into account how to channel and direct the storm water properly and how to move it away from homes where excess water can cause damage.

Calculating Impermeable Area

Answers will vary but should be calculated using formulas such as the following:

lot width m x lot length m = lot size m^2

building width m x building length m = building size m^2

driveway etc. width m x driveway etc. length m = driveway (and walkways, etc.) m^2

building size m^2 + driveway (and walkways, etc.) m^2 = impermeable area m^2

$$\frac{\textbf{impermeable area m}^2}{\textbf{lot size m}^2} = \frac{\textbf{I}}{\textbf{100}}$$

I = percent impermeable land on property

Flood Research and Presentation

What causes flooding?

Answers will vary, but should include ideas such as: In Alberta, flooding is caused by heavy rainfall and snowfall (triggered by the melting of the snow). Flooding occurs if natural (e.g., rivers, ponds, lakes) and human-made (e.g., reservoirs, wet ponds, pipes) water structures are unable to accommodate the water.

How might you respond to a storm water flood in your home?

Answers will vary but should include ideas such as: avoid contact with the water as it might be contaminated, look for and avoid electrical hazards, remove the water, dry the flooded areas, repair and clean the floor, drywall, garden or lawn.

How is storm water managed in Edmonton?

Comprehension Questions

1. Why is an understanding of slope important when designing the storm water management system?

   Impermeable surfaces need to be sloped towards collection points such as catch basins. Storm water pipes need to be sloped downwards to allow continual flow.

2. What characteristic of urban environments makes storm water management necessary?

   The lack of permeable ground (and other changes to the landscape) prevent water from being naturally managed by the environment.

3. How does the age of a neighbourhood determine how storm water is managed there?

   In older neighbourhoods, the storm water is either discharged into the same line as the sanitary system (combined system) or into separate lines discharged directly into the North Saskatchewan River. However, the newer neighbourhoods require that storm water is collected in storm water management lakes or ponds and discharged in limited amounts into the River.

4. What design feature prevents wetlands, wet ponds, and dry ponds from flooding?

   The outflow allows excess water to flow towards the outfall pipe at the North Saskatchewan River if the pond or wetland receives too much storm water. Also, ponds and wetlands are built large enough to handle big rains.

5. Why does a dry pond only need one pipe?

   The water is only being stored temporarily. The water that flows in from the main pipe is intended to flow back out of the dry pond once there is enough space to handle the water.

Storm Water Management Model

Models will vary and should be evaluated based on the following criteria:

Criteria	Yes (2 points)	Somewhat (1 point)	No (0 points)
The dimensions of the model are reasonable.			
The number and placement of storm water pipes are logical.			
The model accurately reflects the process of storm water management.			
Comments:		Total Score:	

Precipitation Data

1. Approximately how many millimetres of precipitation did this area of Edmonton receive during the summer of 2005?

   200 mm during the four-month summer

2. During which three years did this area of Edmonton experience the wettest summer?

   1993, 1994, and 1998

3. During which three years did this area of Edmonton experience the least amount of precipitation in September?

   1995, 2002, and 2009

4. How much less precipitation did this area of Edmonton experience in 2009 than in 1999?

   approximately 200 mm

5. Why do you think the four-month summer statistics are recorded together, rather than monthly as for the other seasons?

   The summer months are considered the rainy season – the time when most of the year's rain falls on the city. In what month the rain falls is not as important as understanding how much rain has fallen collectively during the rainy season.

6. Conduct research to find the precipitation statistics for the City of Edmonton and create a graph that depicts the daily precipitation over one spring or summer month. How often during the time period would storm water levels be considered very high?

   Answers will vary depending on the month and year selected, but would likely range from 0 to 4. Historical precipitation data for Edmonton is available on the Environment Canada website.

Storm Water Calculations

Volume (m^3) = Discharge Rate (m^3/sec) x Time (sec)

1. Edmonton is hit by heavy rainfall that lasts ten hours. If storm water is flowing through a pipe at a discharge rate of 0.2 m^3 per second during the first hour of the storm, how much water will flow through the pipe and into the wet pond during this time?

   60 minutes in an hour x 60 seconds in a minute = 3600 seconds total time

   V = 0.2 m^3 x 3600 sec

   V = 720 m^3

   720 m^3 of storm water would flow into the pond during the first hour.

2. If the storm water slows to a discharge rate of 0.05 m^3 per second for the next five hours, how much water will have flowed through the pipe so far?

   60 minutes in an hour x 5 hours x 60 seconds in a minute = 18 000 seconds

   V = 0.05 m^3 x 18 000 sec

   V = 900 m^3

   900 m^3 + 720 m^3 = 1620 m^3

   1620 m^3 of storm water would flow into the pond during the first six hours.

3. If the storm water continues to flow at a rate of 0.03 m^3 per second for another 4 hours, how much water will have flowed through the pipe and into the wet pond in total during the storm?

   60 minutes in an hour x 4 hours x 60 seconds in a minute = 14 400 seconds

   $V = 0.03\ m^3 \times 14\ 400$ sec

   $V = 432\ m^3$

   $1620\ m^3 + 432\ m^3 = 2052\ m^3$

   2052 m^3 of storm water would flow into the pond during the storm.

Lesson Two: Water Quality Investigation

What substances are found in storm water?

Storm Water Composition Investigation

Analysis Questions

1. Based on the physical particles you found through the filtering process, how did your sample of rain water compare to your sample of storm water? Why do you think this was the case?

   Answers will vary depending upon the nature of the neighbourhood and the types of activities resulting in the storm water. Students living in newer neighbourhoods where construction and landscaping are predominant may find more physical particles in their rainwater samples, although the natural process of erosion should result in particles being found in samples from all neighbourhoods. Activities such as watering plants may result in fewer particles than activities such as washing vehicles.

2. Based on the physical particles you found through the filtering process, how did your samples compare to those collected by your classmates? Why do you think this was the case?

   See answer to previous question.

3. How did the chemical levels found in your sample of rain water compare to those found in your sample of storm water? Why do you think this was the case?

   There should be higher levels of chemicals found in the storm water samples since they are likely to have such contaminants as oil, gas, detergents, and fertilizer.

4. In general, how did the chemical levels found in your samples compare to other samples found?

   Answers will vary depending upon the nature of neighbourhood activities. Neighbourhoods where many homeowners use fertilizers on their lawns and gardens and neighbourhoods where vehicles are washed in the driveway are more likely to have higher chemical concentrations in their storm water.

5. In general, how did the chemical levels found in your samples compare to the normal scale?

   See answer to previous question.

Conclusion Questions

1. How might high levels of sediment (physical particles) cause problems for the storm water management system?
   - In places where the flow of water slows down, the carrying capacity of the water is reduced and deposition occurs. The build up of sediment could eventually disrupt the ongoing flow of water through the system.
   - Too much sediment being deposited in wetlands and ponds could disrupt the natural balance of the ecosystem and/or prevent the necessary flow of water.
   - Deposition into creeks may affect fish habitat.
   - Pumps and valves in the storm water system could be damaged as a result of grit causing friction and/or blockage.

2. How might high levels of chemicals in storm water be an ecological concern?
   - Constructed wetlands and ponds could become contaminated or develop toxic chemical levels and this would negatively impact the ecology of the surrounding area and could also pose risks for humans and their pets.

- Chemicals flowing into the North Saskatchewan River could cause problems downstream (e.g., for other communities using it as a water source) and plant and animal populations could be affected.

3. Did the concentrations of contaminants you found exceed the maximum limits allowed by Edmonton's Sewers Use Bylaw 9675?

   Answers will vary.

Deposition Simulation

Analysis Questions

1. Where was the sediment initially deposited?

   Students will likely find that sediment is deposited at points where the water slowed abruptly (e.g., as it hit the sidewalk) and where it reaches the end of its flow (e.g., along the edges).

2. How did deposition change over time?

   Students will likely find that deposition will build into deltas and that the flow of water will change the shape and/or position of the deltas. They may also note that the increasing deposition causes changes to the rate of flow.

Conclusion Questions

1. What caused deposition to occur?

   Students should refer back to the particle theory of matter in understanding that increased motion allowed the water to hold more sediment and that more sediment is dropped when water slows down.

2. How might deposition in a storm water wetland or wet pond need to be managed?

   Since neither ponds nor wetlands have a current, the water is quite still. When sediment-laden storm water enters these bodies of water, the sediment is quickly deposited and can build up over time. Too much sediment build up could lead to the inlet pipes becoming blocked, an increase in water temperature due to the water becoming shallower, or an ecological imbalance.

3. How might deposition from outfalls at the North Saskatchewan River change the natural characteristics of the river? Is this a concern? Why or why not?

   Since the river has a strong current, it is unlikely that deposition would occur at the point of discharge from the outfall (in fact, erosion would be a bigger concern at this point if it weren't for designs that protect against erosion). Over time, as the river slows in sections, the sediment added by our storm water would increase the level of deposition in deltas and along river banks further downstream. This could be a concern if the deltas were forming in areas that blocked river traffic or changed river flow in a way that caused concern (e.g., sediment deposition could affect fish habitat). However, it could also help the river's ecology by providing pockets of calmer, protected water.

Water Quality Investigation Reflection

Answers will vary but students should demonstrate an understanding of the relationship between their results and the norms/standards.

Case Studies – Wetlands and Ponds in Distress

Scenario 1 — Pond Plummet

a. Why would life in the pond suddenly flourish and then die out? What could have caused this rapid and extreme cycle?

   Answers will vary but should lean towards:

   - Over-nutrification as a result of chemicals such as nitrogen and phosphorus washed into the pond have led to eutrophication.

b. Based on what you think the problem is, can you think of a solution?

   Answers will vary but may include:

   - campaign to encourage homeowners to change their use of fertilizers
   - flush system with clean water

c. What are the pros and cons of your solution?

Answers will vary but may include:

- people may not listen
- difficult
- costly

Scenario 2 — Wetland Woes

a. Why wouldn't the flashlight beam be able to penetrate the water, and what type of problem would this be evidence of?

Answers will vary but should lean towards:

- Excess turbidity has resulted in plants not thriving (lack of light), and this in turn has lead to animals not thriving.

b. Can you think of a solution?

Answers will vary but may include:

- Filter or allow the water to sit/settle out.
- Reduce the amount of sediment being washed in (look for source such as neighbourhood construction).

c. What are the pros and cons of your solution?

Answers will vary but may include:

- difficult and costly to filter; settling could take a long time
- some causes, such as neighbourhood construction, are "necessary evils"

Scenario 3 — Destructive Decision

a. Why would the specialists be so concerned, and how had removing the overhanging trees likely affected the pond?

Answers will vary but should lean towards:

- Cutting down trees or undertaking an environmental change around storm water ponds is both unsafe and unlawful.
- By cutting down the trees, the pond is exposed to more sunlight and its water temperature increased. The levels of chemical toxicity changed in response to temperature, so many chemicals that were not toxic at a lower temperature became toxic at the higher temperature, even though their concentrations didn't change.

b. Can you think of a solution?

Answers will vary but may include:

- replant large trees
- introduce chemical balancing components to the water
- flush with cool water

c. What are the pros and cons of your solution?

Answers will vary but may include:

- Replanting may be costly and/or impossible due to access restrictions; also, getting trees large enough may not be feasible.
- Chemical balancing is highly complex when out of laboratory conditions. It may be impossible or lead to further problems.
- Flushing with cool water could be costly and impractical (e.g., hard to find large enough quantity, hydrant water is not an option because it is chlorinated).

Lesson Three: Human Impact on the Storm Water System

Detergent Detective

Answers should include information such as: commercial car wash facilities drain their wastewater into sewer systems, so it gets treated before it is discharged back into the environment; commercial washes also use much less water due to high pressure hoses and water recycling; for home use, environmentally friendly car wash detergents are available (chlorine- and phosphate-free and non-petroleum-based), as well as waterless formulas.

Pesticide Patrol

Answers should include information such as: common herbicides (e.g., 2,4-D), how they work (e.g., uses synthetic plant hormones to kill broadleaf plants) and their safe usage (e.g., avoid direct exposure and inhalation [human and pets], wash hands) and common pesticides (e.g., pyrethrins) how they work (e.g., attack the nervous systems of pests) and their safe usage (e.g., avoid direct exposure and inhalation [human and pets], wash hands, avoid introducing to natural and storm water systems as they are toxic to fish and birds, avoid flowers as they are toxic to bees).

Friendly Fertilization

Answers should include information such as: avoiding over-fertilization, effects of fertilizer on storm water wetlands and ponds, the ban of weed-and-feed fertilizers, non-chemical fertilization products such as kelp, sewage sludge, human urine, compost, cotton seed meal, shells, and animal manure.

That Doesn't Go There!

Answers will vary.

Class Debate

PROACTIVE	REACTIVE
Stance Resources should be directed towards preventing ecological contamination (assuming we can control human impact and devise a self-sustaining management system).	**Stance** Resources should be directed towards removing ecological contamination (assuming there will always be a negative human impact and thus devising a treatment system to clean the water).
Ideological / Sociological Points • Establishing a collective consciousness draws us together as a community. Linking together in support of the environment brings us closer to being globally aware. • Allowing people to dispose of contaminants without thought could be considered "giving up" on environmental ideals.	**Ideological / Sociological Points** • Environmental ideals are unrealistic in today's world. • Anti-littering and other such campaigns have proven that a well-meaning "few" cannot exert their will over the general population. Eco-friendly storm water practices would likely fall victim to the same problems.
Scientific Points • We know it is possible to use natural means to cleanse storm water. • Some contaminants can't be removed from storm water at all. • Some contaminants would likely enter the environment before they could be removed from storm water.	**Scientific Points** • We know that there are already substances released into the environment that can't be cleansed with current methods alone. • Technology exists for removing many contaminants from the water • An established cleaning process means that we have a system already in place in case of environmental disaster.

Treat it Right!® is a public education program developed by Drainage Services, City of Edmonton. For complete information about the other teachers' guides and activities in the Treat it Right!® program, visit our website at

www.edmonton.ca/drainage/education

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