Teacher's Guide

Treat it Right!®
Wastewater (Grade 8)

Acknowledgements

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Disclaimer: Every effort has been made to ensure the accuracy of the material. Any errors or omissions should be directed to the project manager.

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Overview

This teacher's guide is intended to support Alberta's Grade 8 science program by linking to and enriching learner outcomes in the **Fresh and Salt Water Systems** and **Mix and Flow of Matter** topics. Throughout the resource, you will also find links to mathematics, language arts, social studies, and health and life skills. This resource has an **assessment section** in which tools such as answer keys, rubrics, and a quiz can be found. It includes a **student resource** section that contains all of the readings and activity sheets referred to in the lesson plans.

The intent is for students to investigate and explore how wastewater is managed and treated in the City of Edmonton through a series of four inquiry-based lessons.

Throughout the four lessons, students are encouraged to

- **share and discuss** their responses to guiding questions
- **read and consider** information provided in the student resources
- **reflect on** new ideas
- **take action** in response to new learning
- **investigate** through hands-on experiments
- **research** using the Internet or other sources
- **represent** their understanding through projects
- **integrate** with other subject areas through cross-curricular connections
- **extend** their learning through exploration of related concepts

Note: See the complete Wastewater Treatment Flow Chart at the back of this teacher's guide.

Lesson One: Introduction and personal connections

This introductory lesson provides an overview of the concept of wastewater and how its treatment has changed (globally) over time. Students identify substances added to the wastewater in their home, school, and community. They are led to consider how the composition of wastes can have far-reaching effects by researching the impact of different substances that become waste. Student learning is guided by the following inquiry questions:

1. **How has wastewater treatment changed over time?**
2. **How can the disposal choices we make on a daily basis impact today's wastewater system?**

Lesson Two: How does wastewater flow?

The second lesson focuses on the journey wastewater takes as it travels from homes, schools, and businesses through a network of underground pipes. Students explore viscosity and flow rate as they learn about the flow of wastewater through the sanitary sewer system. They conduct an experiment on flow rate and complete calculations related to pressure. They simulate the wastewater treatment process by conducting an experiment to clean and test a sample of homemade wastewater. Student learning is guided by the following inquiry question:

1. **What factors affect the flow of wastewater?**

Lesson Three: How do we treat wastewater in Edmonton?

The third lesson has students explore the wastewater treatment process. The students learn what happens at each stage of the treatment process and how the stages are connected. Student learning is guided by the following inquiry questions:

1. **How are solid and liquid wastes removed from Edmonton's wastewater?**
2. **How has Edmonton's wastewater treatment changed over time?**

Lesson Four: Where in the world does wastewater treatment need to be improved?

The final lesson has students consider wastewater treatment and sanitary conditions in other places, particularly developing countries. Students are encouraged to reflect further on previous discussions of how wastewater treatment is often a reflection of the standard of living. Students are given the opportunity to develop recommendations for a community that does not currently have an adequate wastewater treatment process. Student learning is guided by the following inquiry question:

1. **What problems are faced by communities that don't have an adequate wastewater treatment method?**


LESSONS

Lesson One

Introduction and personal connections

Focus

- Understand what wastewater is and why its treatment is important
- Consider standard of living issues associated with wastewater treatment
- Consider individual contributions to current wastewater issues

Key Vocabulary

- wastewater
- inorganic
- biodegradable
- phosphates
- carbon
- bioaccumulation
- eutrophication

Required Resources

- **Student Resource: Wastewater through Time**
- **Student Resource: Mad Mixture**
- **Student Resource: Water and Wastewater**

ACTIVITY

1. How has wastewater treatment changed over time?

This first activity leads students to understand what wastewater is and how its treatment has changed over time.

SHARE AND DISCUSS the following definition of wastewater:

> **Wastewater is water that drains from our houses into sewers; it includes all of the things that we "wash and flush away" on a daily basis.**

READ AND CONSIDER: Provide students with the **Wastewater through Time** student resource and have them consider and respond to the following question:

- **How does life without running water, drains, and sewers affect the standard of living?**

  Possible responses: health concerns related to bacteria and water-borne diseases; discomfort associated with filthy conditions; hardships related to personal hygiene tasks; and other tasks that require running water

RESEARCH AND REPRESENT: Have students work together to conduct research and create a living timeline that reflects the history of the sewer system in your area; somewhere else in Canada; or in a place related to a unit of study in social studies. For example, students could research Edmonton or Toronto's sewer system, or look at the history of the sewer system in Paris or parts of Japan.

> **A living timeline is one in which the information gathered is constantly being reconsidered and revised based on new learning. It can be as rudimentary as a line along the wall onto which students paste Post-It notes with information, or it could be a shared electronic version accessed through your Smart Board.**

A living timeline allows students to generate and organize their collectively developing knowledge on a topic. For example, each posting might need to be double-checked for accuracy and have multiple initials showing that a variety of students agree with the information as presented. As part of each research period, it is helpful to run through orally the information on the living timeline; this provides students with an overview of the information they have collected and makes the holes in their research more apparent.

To conclude, have students discuss the following questions in small groups and share their collective responses with the class:

- **How is wastewater treatment a reflection of the current level of development of a society?**

  Possible responses: reflects level of personal hygiene, technology, infrastructure, and social/economic organization

- **In order for modern wastewater treatment to be possible, what types of infrastructure need to be in place?**

  Possible responses: indoor plumbing, connected pipes, underground networks of pipes, collection stations/sites

- **What types of substances are important to treat rather than simply release into the environment? Why?**

  Possible responses: human waste, environmentally hazardous chemicals, non-biodegradable solids. To prevent/reduce environmental contamination and health concerns

EXTENSION: Where are the bathrooms in Fort Edmonton?

Conduct research to find out when and where indoor plumbing was first widely used. What was life like in our area at that same time? Why haven't wastewater treatment standards reached all areas of the globe?

ACTIVITY

2. How do the disposal choices we make on a daily basis affect the wastewater system?

This activity establishes a context in which students identify the types of substances that are disposed of through the wastewater system on a daily basis.

SHARE AND DISCUSS the following statement:

> **Human impact on the environment changes directly in proportion to our level of technology and the extent to which we focus on satisfying our wants rather than just our needs.**

Provide students with the **Mad Mixture** student resource. As a class, brainstorm a list of different substances that, as part of today's lifestyle, students "wash and flush away" on a regular basis at home and school.

Possible responses: bodily wastes, soaps and other personal cleansers, feminine hygiene and other personal care items, household cleaning products, leftover food/ drinks, chemicals used in investigations, and paint or other art media

Share with students the processes and protocols in place in the school's science lab for disposing of hazardous chemicals. Discuss the concept of mixtures and have students analyze the labels of some every-day cleansers and other products from their **Mad Mixture** list.

CONDUCT RESEARCH into the following topics and/or others related to the ideas generated on the **Mad Mixture** brainstorming sheet:

- **What types of cleansers contain triclocarbon or triclosan, and what are the environmental implications of washing this chemical down the drain?**
- **How much bodily waste is washed into the wastewater system each day? Year?**
- **How has the popularity of garburators put added strain on the wastewater system?**
- **What makes some cleaning products more environmentally friendly than others? Is there a benefit to using liquids over powders?**

- **What makes a substance biodegradable, and how are biodegradable substances easier on the wastewater system?**
- **What are phosphates, and what are the environmental implications of washing them down the drain?**
- **How can the specialized materials used in feminine hygiene products create issues for wastewater systems?**

SHARE AND DISCUSS key facts related to their research and organize them into two categories on a bulletin board: solids in the wastewater and chemicals in the wastewater. Discuss the implications of students' findings in terms of how the condition of the wastewater affects the functioning of a treatment system whose design is based on the understanding that the contents of the system will flow well. Consider, as well, the end result of wastewater treatment and how chemicals may contaminate the environment.

REFLECT on the focus question: How do the disposal choices we make on a daily basis affect the wastewater system? Have students consider which materials are reasonable to wash away and which could be disposed of in another way. Discuss realistic behavioural changes they could make that would reduce their impact on the wastewater treatment system.

TAKE ACTION: Have students work together to plan and present radio advertisements to promote wiser wastewater practices.

EXTENSION: What about business and industry?

Investigate one of the following topics related to how businesses and industries make decisions that impact the wastewater system.

- **What do car washes do with the wastewater in their systems?**
- **Why do fast food restaurants have grease bins? Do all restaurants? Should they?**

INTEGRATE: Health and Life Skills

Many commercial cleaning products can be replaced by non-toxic, natural cleaning products. Have students search for recipes for natural cleaning options that can be used on glass or other surfaces and have a competition to see which natural product outperforms the rest.

Lesson Two

How does wastewater flow?

Focus

- Calculate and draw conclusions about changes in the viscosity, flow rate, and density of wastewater
- Investigate the solubility of substances in wastewater
- Investigate how different materials can be removed from wastewater

Key Vocabulary

- sewer
- area
- flow rate
- viscosity
- force
- gravity
- kilopascals
- pressure

Required Resources

- **Student Resource: Mix and Flow**
- **Answer Key: Mix and Flow**
- **Student Resource: Fluid Flow and Properties Labs (Lab A, Lab B, and Lab C)**
- **Answer Key: Fluid Flow and Properties Labs (Lab A, Lab B, and Lab C)**

ACTIVITY

1. What factors affect the flow of wastewater?

In this activity, students investigate the process that is used to treat wastewater in the City of Edmonton. Students analyze standards that govern the wastewater treatment process.

SHARE AND DISCUSS the **Mix and Flow** student resource. Analyze how wastewater flow is maintained. Most of the wastewater flow is maintained through gravity and specially designed pipes, but occasionally the flow has to be maintained by pumps.

- **How could the following factors affect the flow of wastewater?**
  - land elevation
  - pipe size
  - pipe blockage
  - density of wastewater

INTEGRATE: Explore the concept of pressure by having students complete the mathematics problems in **Mix and Flow**.

DISCUSS the information on standards introduced in Lesson One. What standards must we adhere to in each of the phases of the wastewater treatment process?

INVESTIGATE: Fluid Flow and Properties Labs (Lab A, Lab B, and Lab C)

Before starting the labs, ensure students understand **viscosity**. Students should also understand **density**.

Viscosity is a property that describes the thickness or thinness of a fluid, particularly with respect to how this quality affects the fluid's ability to flow or the speed at which it flows (flow rate). Substances with greater viscosity are thicker and flow more slowly. Substances with lower viscosity are thinner and flow more easily/quickly.

Introduce the labs by discussing the following questions:

- **How does the viscosity of wastewater compare to the viscosity of clean water?**
- **How could flow rate and viscosity affect the functioning of the wastewater system?**

Note: Ensure that students know that the **Fluid Flow and Properties Labs** deal only with the physical removal of matter from wastewater. Students should be aware that there are also biological processes that occur, which they will learn about in the next lesson.

- **Lab A: Flow Rate and Viscosity**
- **Lab B: Solubility, Density, and Filtration**
- **Lab C: Wastewater Treatment**

EXTENSION: What are good pipes made from?

From reading **Mix and Flow**, students should know that most pipes are made from concrete or polyvinyl chloride (PVC). Have students use the Internet to research what materials should **not** be used for wastewater and why.

Density is a physical property of matter that describes its mass per unit volume. In other words, density refers to the amount of mass there is in a certain volume. Greater density means there is more packed into the same amount of space. (This is typically because of the size of the particles.) A sample of a very dense fluid will seem thicker and/or feel heavier than the same volume of a less dense fluid.

$$\text{density} = \frac{m}{v}$$

The density of fluids is typically expressed as grams per litre (g/L).

$$d = \frac{g}{L}$$

Lesson Three

How do we treat wastewater in Edmonton?

Focus

- Understand processes used in wastewater treatment plants

Key Vocabulary

- aerobic
- anaerobic
- biogas
- bioreactors
- biosolids
- concentration
- denitrification
- digesters
- effluent
- grit tank
- nutrification
- pH
- primary clarifiers
- scum
- secondary clarifiers
- sludge
- total suspended solids (TSS)

Required Resources

- **Student Resource: How Wastewater is Treated**
- **Assessment Tool: Treat it Right! Quiz**

1. How are solid and liquid wastes removed from Edmonton's wastewater?

In this activity, students will learn about the stages of the wastewater treatment process.

LEARN COOPERATIVELY: Provide students with a copy of the **How Wastewater is Treated** student resource and have them learn the information through a jigsaw approach. Divide the class into five groups and assign each group one stage of the wastewater treatment process. (Note that one group will take responsibility for stages five and six.) Have them learn their stage and prepare a summary for presentation to the class.

REFLECT AND RESPOND: After the presentations, have students work independently to complete the **Process Summary Chart** at the end of the **How Wastewater is Treated** student resource.

SHARE AND DISCUSS the following information with students:

Many years ago, people were not aware of the bacteria in human waste and the diseases that can be caused by these bacteria. Untreated human waste was often disposed of in the same place that was used to provide drinking water. This still happens in some places today. As you know, in Edmonton our drinking water comes from the North Saskatchewan River and our drinking water is treated to make it potable before it comes to your house.

- **Why is Edmonton's wastewater treatment system considered an essential service, and how is it a reflection of our standard of living?**

READ AND CONSIDER the information in the **Water and Wastewater** student resource and respond to the following questions:

- **What types of products are dependent upon water for their disposal?**
- **Why is wastewater treatment essential to healthy living?**
- **What is potable water? Is treated wastewater potable? What makes water potable? Why is clean water essential to life?**
- **How is our current wastewater system a reflection of our standard of living?**

ASSESS: Have students complete the **Treat it Right! Quiz**

EXTENSION: How can facilities reduce their burden on the wastewater treatment system?

Some facilities that would otherwise place a large burden on the wastewater system have attempted to create a self-contained system for dealing with their wastewater. Research Sidwell Friends Middle School in Washington D.C. to find out more about this topic.

Lesson Four

Where in the world does wastewater treatment need to be improved?

Focus

- Investigate wastewater treatment issues in less developed areas
- Suggest ways to improve sanitary conditions in developing areas

Required Resources

- **Student Resource: International Wastewater Statistics**
- **Assessment Tool: Wastewater Treatment Project Evaluation**

ACTIVITY

1. How is wastewater handled in developed and under-developed parts of the world?

This activity asks students to focus on the importance of wastewater treatment conditions and problems in an international context, and to consider how wastewater treatment is a reflection of the technological progress or current state of development in a society.

REFLECT AND REPRESENT: Students should reflect on what they have learned so far and complete a stream-of-consciousness graphic depiction of their responses to the following questions. Students should work with large (flip chart) paper and markers to sketch, using images and as few words as possible, their responses to the following questions:

- **Why does developed society frown on discharging untreated wastewater into rivers, lakes, and oceans?**
- **What are the health implications of releasing untreated wastewater into the body of water that supplies drinking water?**
- **What do you think life is like in communities that don't have a sewer system or proper processes for handling sanitary sewage?**
- **Do options exist for communities that do not currently have technology for treating wastewater?**

SHARE AND DISCUSS students' stream-of-consciousness graphics.

READ AND CONSIDER the specific examples of issues faced in parts of the world that exist without wastewater treatment facilities. Check the examples found on the **International Wastewater Statistics** student resource.

RESEARCH: Working independently or cooperatively, have students conduct library and Internet research into the specific wastewater conditions in an area that is less developed than the area in which they live. Brainstorm a list of questions to guide their research. Questions may include any or all of the following:

- **How does the community currently deal with wastewater? How is this reflective of the level of development of the society?**
- **Have the current wastewater treatment practices led to health-related issues? Other issues?**
- **Why is the wastewater system in the state it's in?**
- **Are the people satisfied with the current state of wastewater treatment, or are they interested in making changes?**
- **What attempts have been made to improve conditions? Successes? Failures?**
- **What options (e.g., aid organizations) does the community have for seeking assistance?**

Project Suggestions

- PowerPoint presentation
- Fan-fold display
- Essay
- Brochure

SHARE AND EXTEND: Once projects are complete, set aside time for students to enjoy and learn from one another's work. Have students choose one of their peer's projects and develop a recommendation for improving wastewater treatment in that community. Have students share and discuss their plan with the peer who conducted the original research on the area and created the project.

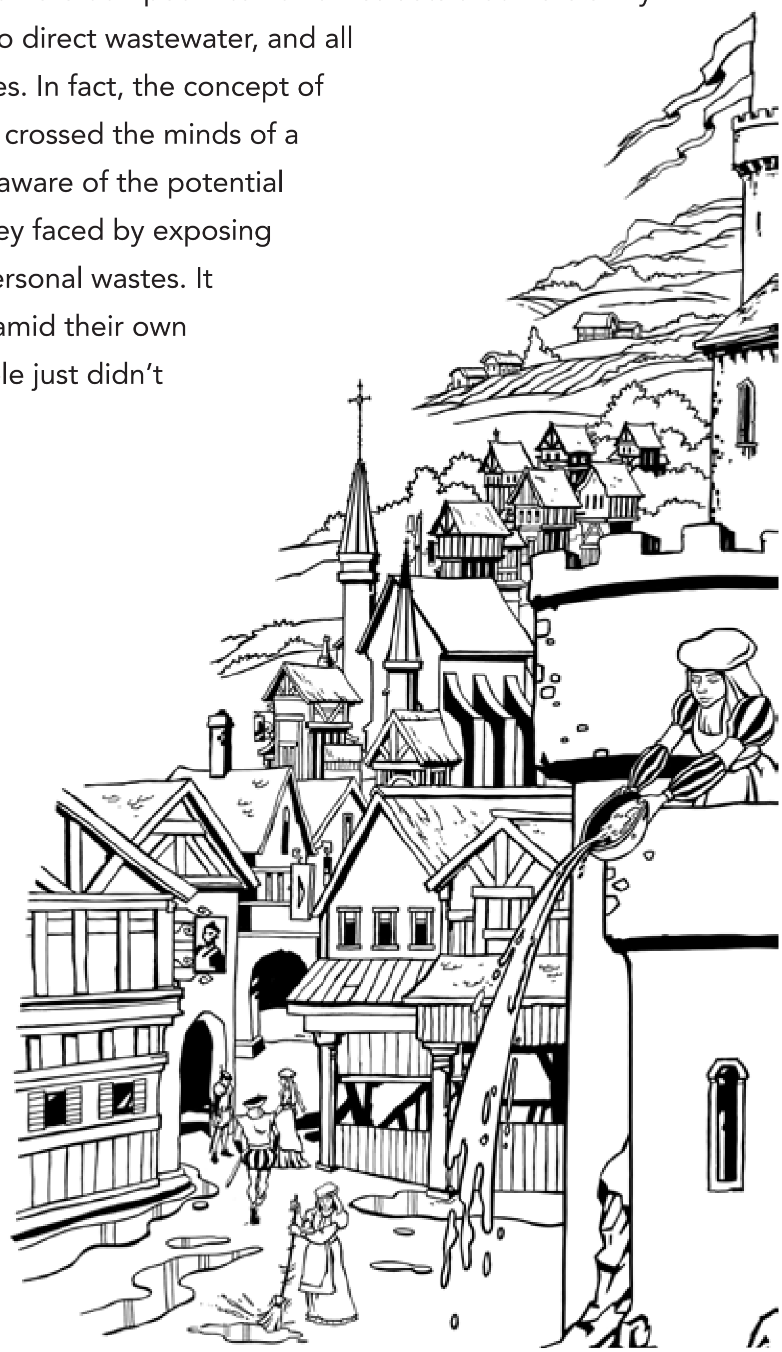
EXTENSION: What if you can't stay connected to the wastewater system?

- **What happens to the wastewater produced by astronauts when they are in space? How has this changed over time?**


RESOURCES
LAB

Wastewater through Time

Elizabethan England covered the years between 1558 and 1603. With the exception of water that flowed in rivers, English society was without running water. People relieved themselves in chamber pots that were dumped into narrow streets that were slimy with refuse. No sewers existed to direct wastewater, and all that it contains, to treatment sites. In fact, the concept of treating wastewater had not yet crossed the minds of a society that was dangerously unaware of the potential for the diseases and ill health they faced by exposing themselves to household and personal wastes. It may seem surprising that living amid their own waste was acceptable, but people just didn't know any better.



Granted, it wasn't a completely uncivilized time. Communal dung-heaps and cesspits were designated for people to dump their chamber pots and other waste. People began to construct outhouses. Castles were designed with overhangs that allowed waste to be deposited far from where the rich conducted their day-to-day affairs.

Mad Mixture

What products do you typically use and dispose of through each of the following wastewater exit/entry points?

Bathroom sink	Tub with drain, toilet
	
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________

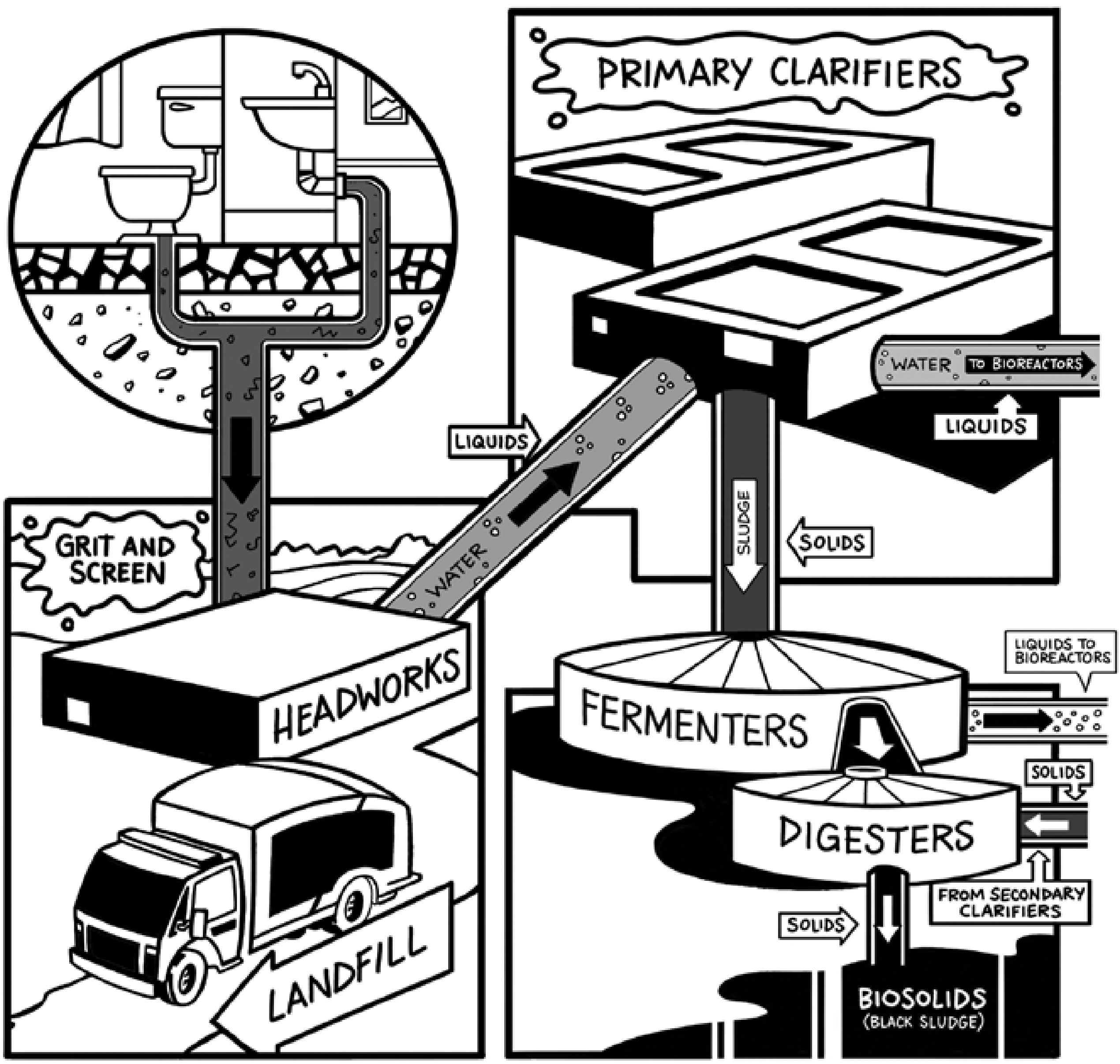
Why would we refer to these four areas as both entry and exit points for wastewater?

Kitchen sink with drain	Washing machine
	

Water and Wastewater

As you know, clean water is essential to life. Have you ever thought about how much water you use and how much wastewater you produce each day?

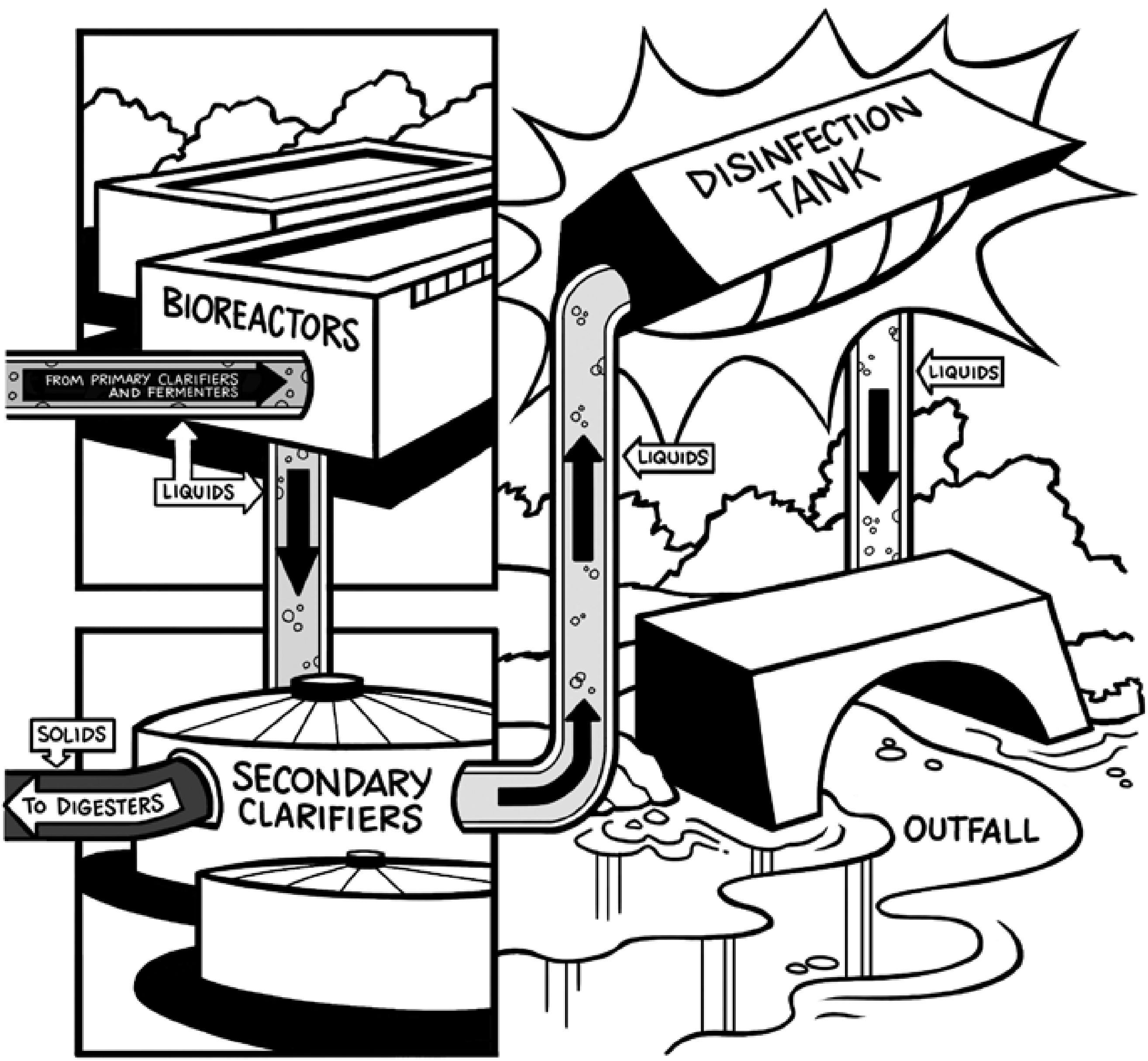
Consider the variety of products you wash down the drain each day, and then imagine that everyone else in Edmonton is using similar products. There is also the natural human waste we all produce each day. All of this wastewater runs through the city's wastewater system



and ends up at the Gold Bar Wastewater Treatment Plant (owned and operated by the EPCOR Water Services Inc. The City of Edmonton is the sole shareholder of EPCOR.). Can you imagine the amount of wastewater this system handles?

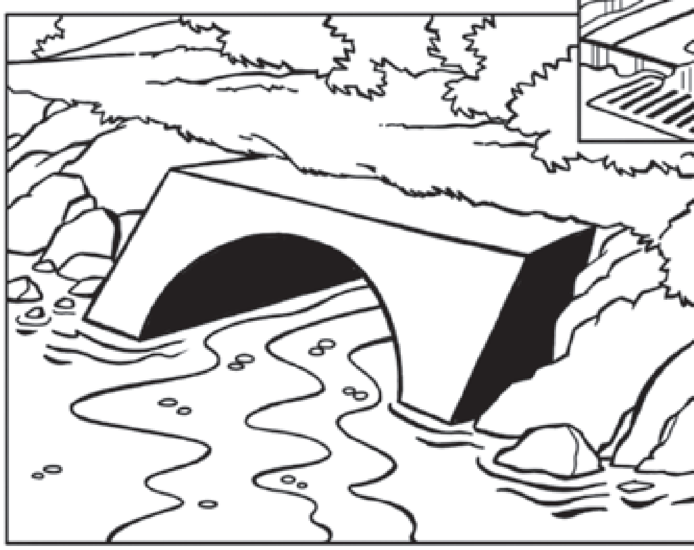
Since the end of World War II in 1945, the trend toward expanding cities has had considerable implications for wastewater treatment and storm water management. Communities like Edmonton have built wastewater treatment systems to dispose of and treat wastewater from homes and businesses.

Indeed, every drain and toilet in every house, apartment, and business in Edmonton is connected to the sanitary sewer system.



Two Major Drainage Systems in Edmonton

In sections of Edmonton built after the 1960s, there are two separate drainage systems – one for wastewater and one for storm water. However, the central core of Edmonton still has the old "combined system" which carries wastewater and storm water in the same pipe. The pipes in this old combined system carry the flow to the Gold Bar Wastewater Treatment Plant. However, when there is a huge runoff from a rain storm or heavy snow melt, the system overflows causing both sanitary sewage and storm water to flow directly into the North Saskatchewan River. That is one reason why the combined system design was changed to a separate pipe system.



Did You Know?

Storm water is not treated at Gold Bar. Rain water runoff and snow melt flows through catch basins in the street to a separate storm water system. Have you ever noticed these grates (catch basins) along the sidewalk? Storm water flows through a system of pipes directly to the North Saskatchewan River or to storm water lakes where it is stored temporarily. All storm water eventually drains into the river from outfall pipes located at several places along its banks.

Your House

Prior to 1988, all homes had foundation drainage (called weeping tile) that was connected to the sanitary sewer system. This meant that rainwater and other water from your garden was treated as if it were household or personal wastewater. In 1988, though, standards were changed so that the foundation drainage on new homes was directed to the storm water sewer system or pumped to the surface. In 2006, standards were changed again, and since then, all outdoor water drains directly into the storm water sewer system. Since this water isn't treated, it's very important to think before you wash chemicals away in outdoor drains. Detergents from washing vehicles, chemicals used to clean houses and driveways, and fertilizers and pesticides used on gardens aren't good for rivers, but that's exactly where they're headed.

Did You Know?

The City has a little over 5 000 km of sewer pipe in total consisting of:

- 2 354 km of sanitary sewage pipe that handles wastewater from homes and businesses
- 2 559 km of storm pipe that handles outdoor runoff from gardens, rain, and snow melt
- 946 km of combined sewer pipe (in "old" Edmonton) that handles both wastewater and storm water

Did You Know?

1 megalitre (ML) = 1 000 000 litres (L)

The City of Edmonton plans, builds, operates and maintains the drainage system. This includes cleaning and maintaining the storm water and sanitary sewer pipes and systems that run under our streets. Naturally, they cannot check each and every pipe every year as there are approximately 5 000 km of pipe, and this is increasing every year.

In 2015, the City cleaned approximately 617 km of underground pipes at a cost of $1.93 million. In the same year, they spent $1.5 million inspecting 123 km of pipe using specialized closed circuit television equipment. It is estimated that one of the wastewater system's worst nightmares – fats, oil, and grease (FOG) – was present in 25 percent to 50 percent of those lines.

***Figures accurate to 2015.**

What exactly is wastewater?

In Edmonton, approximately 270 megalitres (ML) (270 000 000 litres) of wastewater is produced every day. That includes all of the wastewater from 878 000 people flushing toilets, taking showers, washing dishes, cooking, and doing laundry, plus all of the wastewater from businesses and industry.

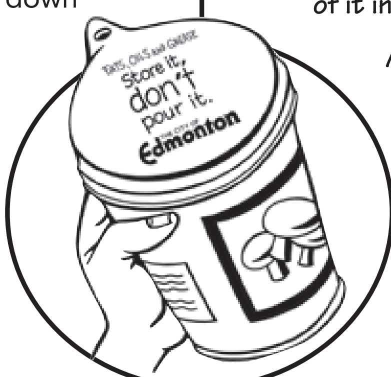
Picture this: the Kinsmen Pool holds about 2.5 ML of water. Therefore, 270 ML of wastewater is equivalent to filling the Kinsmen Pool about 108 times.

Every day, each person in Edmonton creates about 300 litres of wastewater. Each person uses about 343 litres of water every day. On average, that is equivalent to nearly 100 four-litre containers of water per person per day. (Think about emptying 100 of the four-litre jugs of milk that are in your refrigerator!)

Wastewater contains a variety of different waste products. We expect matter such as urine, feces, soap, shampoo, and detergent to be flushed or rinsed down the drain. Other products such as grease, dental floss, feminine hygiene products, and medication should NOT be put down the drain or flushed down the toilet.

Did You Know?

Fats, oils, and grease (acronym FOG) aren't just bad for your arteries and your waistline; they are bad for the sanitary sewer system as well. When FOG is poured down the kitchen sink or put in the toilet, it cools, solidifies, and starts to clog the sanitary sewage pipes. Just like cholesterol builds up and starts to clog the arteries of your body, FOG builds up in the pipes of the sanitary sewer and blocks the sewer pipes, causing sewage backup in your house. Contrary to popular belief, running hot water down the drain or adding soap to the hot water will not help to clear the FOG from your pipes. Residents are encouraged to pour used FOG into a tin and then dispose of it into the garbage.



Another problem for homeowners is caused by flushing dental floss down the toilet. Dental floss can wrap itself around the back flow valve in the sanitary sewage pipe in the basement that is wastewater's main exit from your house. This causes the flap, which is part of the mechanism, to remain open and can result in raw sewage backing up and flooding your basement.

Properties of Waste

Also in the wastewater are phosphates and other chemical ingredients found in many laundry detergents, cleansers, and soaps. Some of these ingredients cannot be completely removed by the wastewater treatment process and end up in the river. These chemicals can be toxic to fish and other living organisms in the water and often build up along the food chain through bioaccumulation. As well, when large amounts of phosphates are released into the water, they create a problem called eutrophication. **Eutrophication** is a natural process that occurs in all lakes and ponds as the amount of plant matter increases over time. However, when phosphates are released as part of wastewater, eutrophication speeds up in a body of water in an unnatural way. The excessive plant growth eventually chokes out all of the animal life in the water.

Organic and Inorganic

At the Gold Bar Wastewater Treatment Plant, records show that of all of the suspended solids in the wastewater that comes to the plant, 80 percent are organic and 20 percent are inorganic. Organic compounds are found in all carbon-based life forms (humans, plants, animals, insects, and fish) and, as a result, feces has **carbon** in its composition. Organic substances are biodegradable and most break down quite easily and can be removed during the wastewater treatment process. Organic compounds provide food for bacteria and other microorganisms, and the wastewater system takes advantage of this natural decomposition as part of its process. However, these decomposers take in oxygen and release carbon dioxide as they work; this leads to reduced oxygen levels for aquatic animals.

Did You Know?

There are non-toxic alternatives to commercial cleaning products. Baking soda and vinegar are two readily available products that are eco-friendly and inexpensive.

- Baking soda can be used as a deodorizer.
- Vinegar can be used as a window cleaner.
- Salt, baking soda, and a piece of aluminum foil placed in warm water can be used as a tarnish remover.

Inorganic compounds are generally **nonbiodegradable**, which means they cannot be easily broken down by microorganisms. Many inorganic compounds, like salt, dissolve in water and are removed in the wastewater treatment process. Some inorganic compounds, like lead and silver, can not be broken down at all and they are discharged to the North Saskatchewan River along with the treated wastewater. Urine contains ammonia, which is an inorganic substance that isn't completely removed during wastewater treatment. High levels of ammonia in water can be toxic to fish and other water organisms and, like phosphates, high ammonia levels can also lead to **eutrophication**.

Monitoring and Standards

Throughout the wastewater treatment process, wastewater samples are constantly being monitored and tested. Samples are collected from 30 different locations in the process and analyzed for suspended solids, oxygen levels, phosphorous, ammonia, harmful bacteria, oil, grease, solvents, and many other chemical compounds. To meet government standards and to protect the water in the North Saskatchewan River, the concentration of many substances must be measured. The results of these measurements are reported to the provincial government. The City of Edmonton meets and exceeds Alberta Government requirements for the quality of water that is returned to the North Saskatchewan River. The Gold Bar Wastewater Treatment Plant is one of the top wastewater treatment plants in Canada and has won many awards for its excellence in wastewater treatment.

To find out more about wastewater processes, regulations, and standards, go to the City of Edmonton's website. Also, search for the Canadian Standards Association (CSA) on the Internet. What are environmental standards? What other standards are there? Why are standards important to our quality of life?

Mix and Flow

The wastewater created in the kitchen, bathroom, and laundry room of your house goes down the sink and toilet through pipes that connect to a main pipe. This pipe extends from your house to a sanitary system main line that runs beneath the street. All of the main lines in the City of Edmonton lead to the Gold Bar Wastewater Treatment Plant. Here, wastewater is treated and then discharged to the North Saskatchewan River.

Most of the main line pipes in the sanitary sewer system are made of concrete or polyvinyl chloride (PVC). PVC is a plastic-like material that is preferred because it is stronger but lighter weight than other materials. It is non-corrosive and non-abrasive and does not readily deteriorate.

Sanitary sewer pipes vary in diameter from 20 cm where they leave your house to 2 metres where they enter the Gold Bar Wastewater Treatment Plant. They are buried at depths that vary from about 3 metres near your house to 70 metres near the Gold Bar Wastewater Treatment Plant.

All underground sewer pipes are sloped with a slight downward angle towards the Gold Bar Wastewater Treatment Plant. This allows the force of gravity to naturally move the wastewater to the plant for treatment. Gravity doesn't do all the work; of course, pipe systems are specially designed to enable wastewater to flow steadily, and assistance is provided where necessary.

Math Connection

The slope angle of a sewer pipe varies from 0.l % to 0.4 %, depending on its diameter. A 200 m long sanitary sewer pipe has a 0.4 % slope angle. Given this slope and length, use the formula below to calculate how much lower the pipe would be at one end compared to the other.

$$\text{Slope \%} = \frac{H}{L}$$

Properties of Wastewater Fluids

In determining the correct pipe diameter and slope required, engineers must consider two properties of fluids:

- viscosity
- flow rate

Wastewater moves as a **slurry** (a suspension of insoluble materials in liquid) and, as with all fluids, the density and temperature of the mixture affects its viscosity. **Viscosity** is the scientific word for the "thickness" of a fluid or its resistance to flow. Thick, more viscous, wastewater **slurry** has more resistance to flow than thin slurry.

Density compares the mass or weight of a substance to its volume. Density is calculated using the formula:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

A consistent rate of wastewater flow has to be maintained in order to prevent the suspended particles from settling and clogging the pipes. In Edmonton's wastewater system, this flow rate varies from 0.6 m/s to 3.0 m/s.

Occasionally, sewer pipes run uphill and pumps are used to move the wastewater. These pumps are often in small buildings referred to as pumping stations; there are 92 pumping stations throughout the City of Edmonton. Each station has as many as three pumps that maintain a pressure as high as 900 kilopascals (kPa) to keep the wastewater flowing steadily.

In order to maintain a pressure of 900 kPa in the pipes, the engineers must consider:

- force applied by the pump
- diameter of the sewer pipe

The pressure of the flowing fluid is calculated by dividing the force with which the fluid moves by the area against which this force is exerted. Pressure is calculated using this formula:

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Pressure and Force

How do these facts help you determine how much force is produced by the pumps in order to maintain a constant pressure of 900 kPa in the pipes?

The entire wastewater trip from your house to the Gold Bar Wastewater Treatment Plant takes from four to six hours. That means that the wastewater from the shower you had at 7:00 this morning will reach the Gold Bar Wastewater Treatment Plant around noon.

The pump at the new Transfer Station has to be designed to maintain a fluid pressure of 900 kPa in order to keep the wastewater moving uphill. The engineers have to construct a submersible pump that will exert a large force on the liquid mixture in order to maintain the pressure and keep the wastewater flowing in the pipe.

The engineers know the following facts:

- The pressure in the pipe is 900 kPa
- The diameter of the pipe is 1.2 m

1 kPa = 1 000 Pa

Pa = N/m2

1. **Use the formula to calculate the area of the pipe.**

$$\text{area} = \pi r^2$$

2. **Use the formula to calculate the force that must be exerted by the new pump.**

$$\text{Force} = \text{Pressure x Area}$$
$$F = PA$$

Using the Correct Units

- Force is expressed in Newtons (N)
- Area is often expressed in square units (e.g., m^2)
- Pressure is expressed as Newtons per square metre (N/m^2) or a Pascal (Pa)

Fluid Flow and Properties
Lab A: Flow Rate and Viscosity

Objective: Determine how adding waste affects the viscosity and flow rate of water.

Materials

- styrofoam cup
- pencil
- water
- three sources of simulated waste (e.g., soap, vegetable oil, grit, ground food, fibre supplement, etc.)

Procedure

1. Make a small hole in the centre of the bottom of a Styrofoam cup with a pencil.
2. Seal the hole with your finger as you fill the cup with 150 ml of clean water.
3. Remove your finger from the hole and record the time it takes to drain the water from the cup into the beaker.
4. Repeat the same process three more times, but each time mix some "waste" into the water, and record any changes in volume before timing its flow.

Data

Enter the data obtained from the experiment in this table.

	Clean Water	Waste Added	Waste Added	Waste Added
Volume of Water (milliliters)				
Time to Flow Through (seconds)				
Flow Rate (milliliters per second)				

Data Analysis Questions

1. How did adding waste affect viscosity and flow rate?

2. Which type of waste caused the most dramatic change in viscosity and/or flow rate?

Application Questions

1. A flow rate in the range of 0.6 m/s to 3.0 m/s has to be maintained in the sanitary sewer lines in order to prevent settling of material at the bottom of the pipes. How could engineers ensure that a consistent flow rate in the sewer lines is maintained?

2. How might changes in temperature affect flow rate and viscosity?

Fluid Flow and Properties
Lab B: Density, Solubility, and Filtration

Objective: Determine how FOG wastes (fats, oils, and grease) affect wastewater and its treatment.

Materials

- beaker
- graduated cylinder
- triple beam balance
- filter paper
- cooking oil
- water

Procedure – Part I

1. **Calculate the density of water by following these steps:**
    - Use the balance to measure the mass of the empty graduated cylinder.
    - Pour the 200 millilitres of water into the cylinder.
    - Use the balance to measure the mass of the filled cylinder.
    - Subtract the two masses to determine the mass of the water mixture.
    - Use the formula **Density = Mass ÷ Volume** to calculate the density of the water.
2. **Calculate the density of an oil-water mixture by following the steps above using a mixture of 180 millilitres of water and 20 millilitres of cooking oil.**

____

____

Analysis Questions – Part I

1. **How does adding oil affect the density of the sample?**

____

____

2. Is oil soluble in water? How do you know?

Conclusion Questions – Part I

1. How does the density of insoluble substances affect how they behave in water?

2. Consider that water is flushed through our drains to assist in transporting waste materials to the treatment plant. How might having insoluble substances in the mixture affect the system?

Procedure – Part II

1. Try to separate the oil from the mixture by passing the oil-water mixture through filter paper. Describe what happens:

Conclusion Question – Part II

1. How could oil be removed from the wastewater at the Gold Bar Wastewater Treatment Plant?

Fluid Flow and Properties
Lab C: Wastewater Treatment

Objective: Simulate wastewater treatment.

Materials

- 2 beakers
- water
- cooking oil
- strainer spoon
- filter paper
- disposal jar
- shredded toilet paper
- dental floss
- vinegar (15 mL)
- small pieces of plastic
- sand (1/2 teaspoon)
- coffee grounds or tea leaves (1/2 teaspoon)
- liquid soap (5 mL)

Procedure – Part I

1. **Make a sample of wastewater by pouring 20 mL of cooking oil into a beaker containing 180 mL of water. Add the other simulated waste matter to the oil-water mixture one at a time without stirring, and observe the properties of the mixture.**
2. **After all the substances have been added, stir the mixture to simulate the churning that happens as wastewater flows through the sanitary sewer pipes. Then, let the mixture settle for 3 minutes.**

Analysis Questions – Part I

1. **After stirring the mixture, which substances appear to be soluble in water?**

____

____

2. **Which substances in your mixture are not soluble in water?**

____

____

3. Which insoluble substances are less dense than water and float on the surface?

____

____

4. Which insoluble substances are denser than water and sink to the bottom of the container?

____

____

Procedure – Part II

1. Carefully use the strainer spoon to separate the less dense floating objects (scum) in your wastewater. Place this matter in the disposal jar.
2. Use the utensils to separate the settled matter or sludge from the wastewater. Place this matter in the disposal jar.

Analysis Questions – Part II

1. Which settled items or sludge were you able to separate and remove?

____

____

2. Which floating matter or scum were you able to separate and remove?

____

____

3. What difficulties did you encounter in attempting to remove the sludge from your sample?

____

____

Procedure – Part III

1. Pour the remaining wastewater through a filter paper and observe the results.

Analysis Question – Part III

1. Does the filtered fluid contain any evidence of waste material? If so, what evidence do you see?

Conclusion Question

1. What conclusions can be drawn from this experiment about the different processes necessary to wastewater treatment?

How Wastewater is Treated

The wastewater has just completed its four- to six-hour journey from your house to the Gold Bar Wastewater Treatment Plant. The so-called "dirty" water will spend the next 17 hours at the plant. During this time, most of the waste products in the water will be removed.

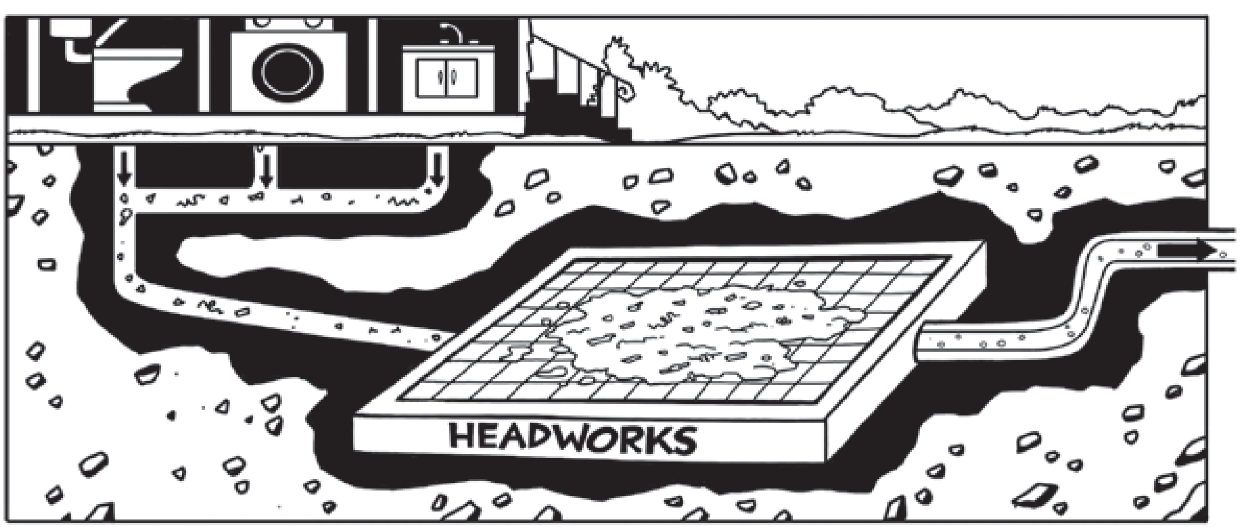
There are six stages in the treatment process, involving both mechanical and biological methods that clean our wastewater before it goes to the North Saskatchewan River.

Did You Know?

'Bio' [from Greek] means 'life' or 'living'. Biogas refers to gas produced by living organisms. The human body creates gas in a similar way. Your digestive system produces 0.5 L to 1.5 L of methane gas daily. This is expelled from the body as flatulence, or what is commonly called a 'fart'.

Stage 1: Pretreatment

Pretreatment is a **mechanical** process that prepares the wastewater for further treatment. Wastewater arrives at the Gold Bar Wastewater Treatment Plant from several trunk lines that converge at one point called the **headworks**. The wastewater entering the headworks is a **slurry** mixture of liquids and solids which has undergone some natural breakdown during its trip to the plant. The slurry still contains large items that need



to be separated from the water. These items often include things like gravel, rings, small toys, dental floss, feminine hygiene items, and pieces of wood.

First, the wastewater enters the **grit tanks**. Air is added to agitate the wastewater, helping the heavy particles to settle to the bottom of the tank. Objects like gravel, marbles, rocks, and toys all sink to the bottom and the lighter particles stay on top. These separated items are referred to as **grit**, and they are removed from the bottom and transported by truck to the Clover Bar landfill site.

The wastewater then flows to the **screens**, where any material that is 19 mm or more across is filtered out and then hauled to the landfill at Clover Bar.

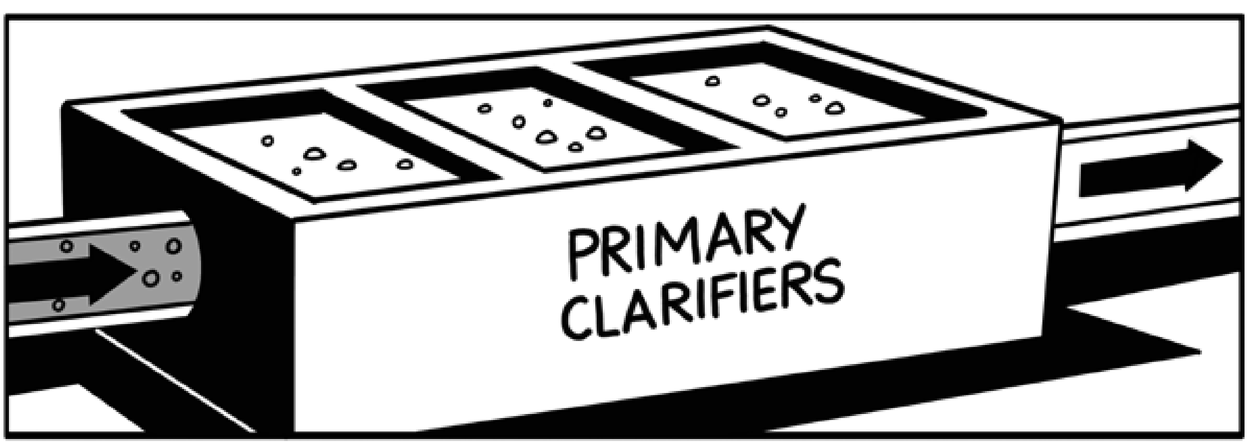
After the larger grit and debris have been removed, the wastewater flows through concrete channels to the next stage, the **Primary Clarifiers**.

Stage 2: Primary Clarifiers

Primary Clarifiers are settling tanks for **solids**. Here the denser, suspended solids settle to the bottom as sludge, while the less-dense particles float to the surface as **scum**.

What does it mean to be "more dense" or "less dense?" If you were to fill a 2 litre container with scum waste and an identical 2 litre container with sludge waste, the same volume of scum waste would weigh less than the sludge waste. Therefore, the scum is less dense than the sludge waste.

Specially designed mechanical scrapers move slowly along the bottom of the clarifier tanks,



scraping the sludge toward one end of the tank. At the same time as the lower scrapers remove the sludge, upper scrapers skim the surface of the wastewater and collect the scum.

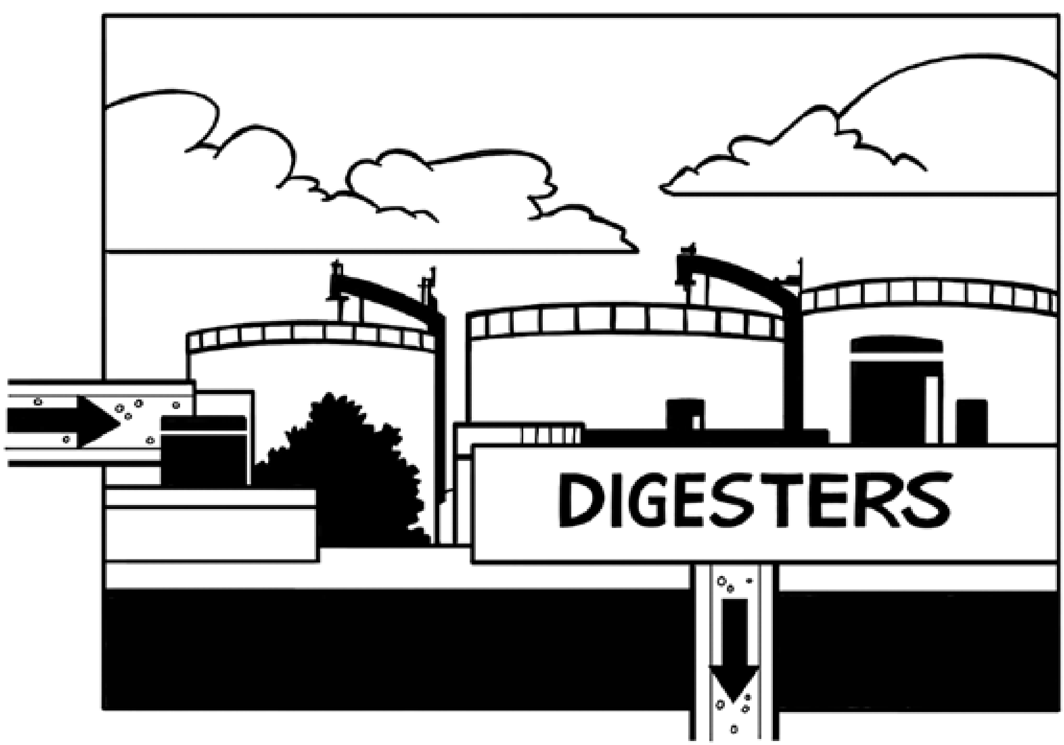
During its three-hour stay in the **Primary Clarifiers**, about 55 percent of the total suspended solids (TSS) in the wastewater are removed from the wastewater. These solids, called **primary sludge**, are then pumped from the bottom of the **Primary Clarifiers** to the **Fermenters** (see stage 3). In the meantime, the remaining wastewater, called **primary effluent**, flows into the **Bioreactors** (see stage 4).

Stage 3: Fermenters and Digesters

The **primary sludge** stays in the **Fermenters** (unheated anaerobic tanks) for three to six days where it thickens and settles to the bottom of the tanks.

In the **Fermenters**, there are anaerobic bacteria consuming some of the organic material in the primary sludge and producing volatile fatty acids (VFA). These VFAs will be used in the anaerobic zone of the Bioreactors for Bio-P bacteria (see stage 4).

The thickened, fermented sludge is pumped into large closed tanks called **Digesters** (heated anaerobic tanks) for further treatment. It stays there for decomposition for 15 to 20 days. This is where the major biological process of sludge treatment occurs.



Did You Know?

The Gold Bar Wastewater Treatment Plant has eight Digesters, with a combined capacity of 67.5 ML.

As the name suggests, the **Digesters** are not dissimilar to the human digestive system. The human digestive system contains microorganisms that work in anaerobic (without oxygen) conditions. Anaerobic bacteria break down complex organic material (such as the food you eat) into simple forms. Similarly, these **Digesters** contain microorganisms that breakdown the organic materials in the wastewater into simple compounds.

In the **Digesters**, the decomposition process breaks down the organic matter and dead bacteria and releases gas (**biogas**). The **biogas** is composed of methane (65%), carbon dioxide (30%), and hydrogen sulphide (5%).

The **biogas** is collected and 60 percent of it is used as fuel for heating the buildings and digester tanks at the plant. The remaining 40 percent of the **biogas** is flared off. Using 60 percent of the gas to heat buildings is an excellent example of recovering what otherwise would be a wasted product.

After digestion, the remaining sludge mixture is called **Biosolids**. These **Biosolids** are then transported by pipeline to the Clover Bar site, where they are discharged into huge lagoons. In the lagoons, more water is removed from the **Biosolids** to produce compost and fertilizer.

Stage 4: Bioreactors

The **primary effluent** from **Primary Clarifiers** (see stage 2) flows into the **Bioreactors**, where ammonia, phosphates, and many other substances are removed.

Ammonia, a main component of urine, is toxic to living things. Phosphates are a component of detergents and soaps that when released result in out-of-control plant growth in bodies of water.

Did You Know?

The odours emitted during the treatment process at the Gold Bar Wastewater Treatment Plant have been greatly reduced in recent years. Incoming wastewater is now treated with hydrogen peroxide, a powerful antiseptic, to suppress some of the odour at the grit tanks. The tanks in the primary treatment are covered, allowing the smelly air to be captured and "scrubbed" with a bleach compound. Much of the smelly hydrogen sulphide gas is removed in this way.

In the **Bioreactors**, the primary effluent flows through three zones: the anaerobic zones, the anoxic zones, and the aerobic zones.

Anaerobic Zone: In the anaerobic zone, special bacteria called Bio-P bacteria take in the volatile fatty acids (VFA) from the wastewater and then release phosphates into the wastewater.

Aerobic Zone: In the aerobic zone, oxygen is added to the tanks. This causes more of the same type of bacteria (Bio-P bacteria) to wake up and gobble up the released phosphates (way more than they released earlier). At the same time, there are other types of bacteria that breakdown the organics into inorganic matter in the wastewater.

Did You Know: anaerobic, anoxic and aerobic

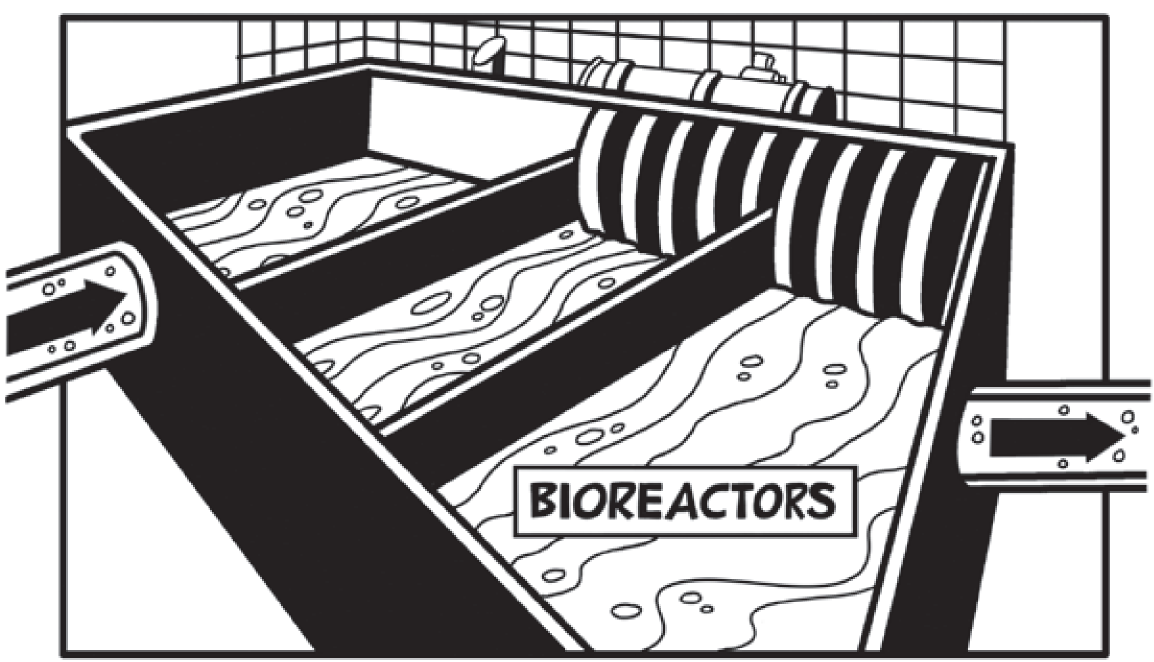
Anaerobic: living, active, and occurring without oxygen.

Anoxic: living, active, and occurring with limited oxygen.

Aerobic: living, active, and occurring only with oxygen.

Also in the aerobic zones, there are nitrifying bacteria which consume ammonia in the wastewater. The nitrifying bacteria plus oxygen convert the ammonia-nitrogen into nitrites and then convert the nitrites into nitrates.

ammonia + oxygen + bacteria produce nitrite → nitrites + oxygen + bacteria produce nitrates → nitrates are converted to nitrogen gas



Anoxic Zones: In the anoxic zones, denitrifying bacteria convert nitrates into nitrogen gas (which "bubbles" out). At this point, ammonia has been removed from the wastewater.

Nitrates + bacteria → nitrogen gas

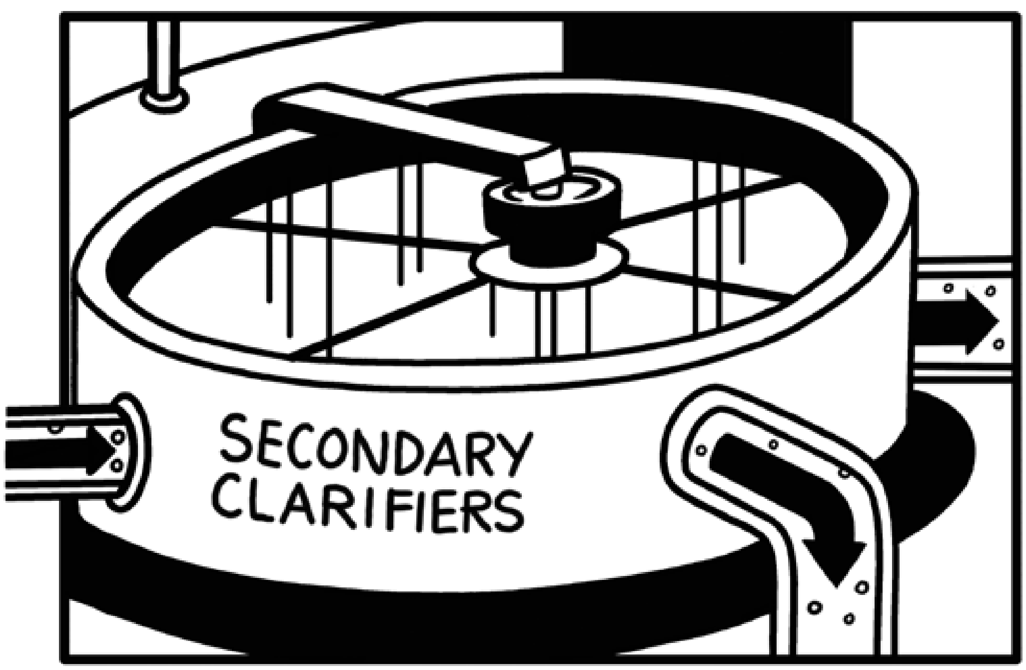
The remaining effluent in the **Bioreactor** is a mixture of water and solids. The solids are comprised of the bodies of bacteria and inorganic matter. These solids will be separated from the water at the next stage – **Secondary Clarifiers**.

Stage 5: Secondary Clarifiers

The effluent mixture in the **Bioreactors** now enters the **Secondary Clarifiers** where many of the hard-working bacteria are now dying and settling down with other solids at the bottom as part of the sludge. Mechanical rakes are used to rake the sludge into a pit at the bottom of **Secondary Clarifiers**.

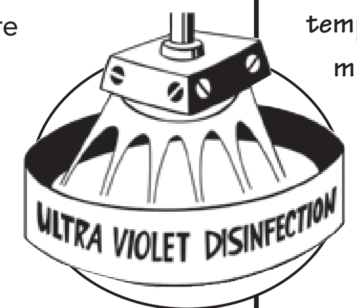
From here, the sludge is pumped into the **Digesters** (see stage 3). The remaining wastewater now flows to the next step for disinfection and discharge.

At this point, about 98.5 percent of the TSS has been removed. More than 90% phosphorus, ammonia and organics were gotten rid of from the wastewater as well. The water is now clean, but it is not potable (safe for drinking).



Stage 6: Disinfection and Discharge

In the final stage of the wastewater treatment process, wastewater passes through ultraviolet disinfection. Any harmful bacteria such as E-Coli or other microorganisms are killed by ultraviolet radiation emitted from 2800 watt ultraviolet light bulbs. These bulbs are 28 times more powerful than the standard 100 watt light bulb in your house.



The treated water, or **effluent**, is now ready to be discharged into the North Saskatchewan River. The effluent water is free of pathogenic (harmful) microorganisms. It is not potable, but it is considered safe for fish, invertebrates, plants, and birds.

Did You Know?

Biological processing takes longer in the spring than it does in the summer because the drop in temperature decreases the metabolism of the microorganisms. That means bacteria are unable to reproduce as quickly. It takes the bacteria longer to reproduce and complete the decomposition process.

Did You Also Know?

Wastewater temperature is constant throughout the year except for the few weeks of snow melt when very cold water enters the combined sewer system and lowers the temperature of the wastewater entering the Gold Bar Wastewater Treatment Plant. Bacteria then work slower because, like humans, they do not like to be cold. They conserve their energy when it is cold and do not eat or reproduce as fast as they normally do.

Revisit the Sequence

The wastewater treatment process involves a complicated series of steps that result in the removal of most of the organic wastes and some of the inorganic wastes from the wastewater.

Summarize each stage of the wastewater treatment process.

STAGE 1

STAGE 2

STAGE 3

STAGE 4	STAGE 5	STAGE 6

International Wastewater Statistics

- **884 million people** in the world do not have access to safe water. This is roughly **one in eight** of the world's population. (WHO/UNICEF)
- **2.5 billion people** in the world do not have access to adequate sanitation, this is almost **two-fifths** of the world's population. (WHO/UNICEF)
- **1.4 million children** die every year from diarrhea caused by unclean water and poor sanitation - **4,000 child deaths a day or one child every 20 seconds**. This equates to **160 infant school classrooms** lost every single day to an entirely preventable public health crisis. (WHO/WaterAid)
- **Hand-washing with soap** at critical times can reduce the incidence of diarrhea by up to 47%. (UN Water)
- The **integrated approach** of providing water, sanitation, and hygiene reduces the number of deaths caused by diarrheal diseases by an average of 65%. (WHO)
- **443 million school days are lost** each year due to water-related diseases.
- **11% more girls** attend school when sanitation is available. (UK DFID)

Source: www.wateraid.org (Click on Search for statistics)

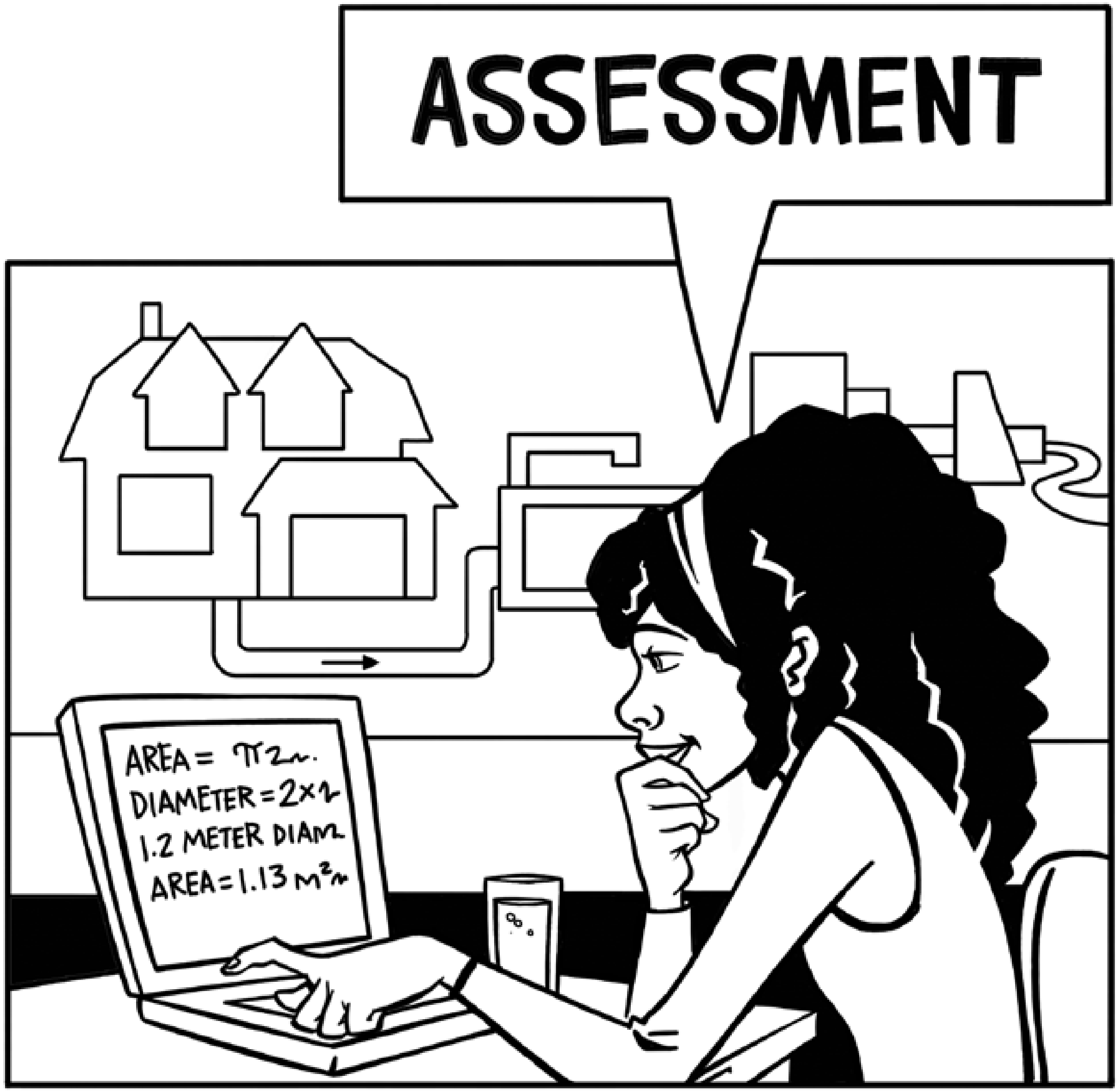
The idea of recycling wastewater is not a new one. It has been around for more than two thousand years when crops in Greece were irrigated with **effluent**, or the byproduct of wastewater. However, there are still many places in the world that aren't recycling wastewater. Developing countries often have inadequate and/or undeveloped sanitation systems. Since the 1980s, awareness of environmental and health issues related to wastewater treatment has increased and more sewage treatment facilities have been built.

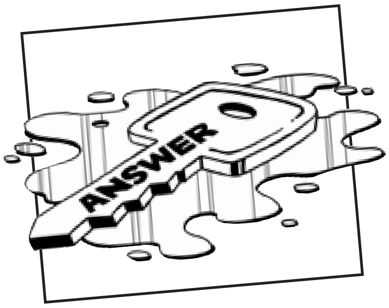
Health-related issues are an important concern when there is inadequate treatment of wastewater. For example:

- In Peru, a cholera epidemic resulted from water and sanitation that was not treated properly.
- In Shanghai, China, a major outbreak of disease was caused by sewer contamination. Water that is contaminated can cause a number of diseases, such as malaria, hepatitis, yellow fever, and dengue.

Recognizing the impact of sanitation on health, the environment, poverty, and economic and social development, the United Nations declared 2008 the International Year of Sanitation (IYS). Their five key messages were:

1. **Sanitation is vital for human health.**
2. **Sanitation generates economic benefits.**
3. **Sanitation contributes to dignity and social development.**
4. **Sanitation helps the environment.**
5. **Improving sanitation is achievable.**


ASSESSMENT
AREA = π2
DIAMETER = 2×2
1.2 METER DIAM
AREA = 1.13 M²



Lesson Two: Mix and Flow

Math Connection

The slope angle of a sewer pipe varies from 0.l % to 0.4 %, depending on its diameter. A 200 m long sanitary sewer pipe has a 0.4 % slope angle. Given this slope and length, use the formula below to calculate how much lower the pipe would be at one end compared to the other.

$$\text{Slope\%} = \frac{H}{L}$$

0.4% = H / 200 m

H = 0.004 X 200 m

H = 0.8 m

The difference is 80 centimetres.

Pressure and Force

The pump at the new Transfer Station has to be designed to maintain a fluid pressure of 900 kPa in order to keep the wastewater moving uphill. The engineers have to construct a submersible pump that will exert a large force on the liquid mixture in order to maintain the pressure and keep the wastewater flowing in the pipe.

The engineers know the following facts:

- The pressure in the pipe is 900 kPa
- The diameter of the pipe is 1.2 m

3. If the diameter of the pipe is 1.2 m, what is its area?

Area = πr^2

Diameter = 2 x radius

1.2 meter diameter = 0.6 radius

Area = 3.14 x (0.6 m x 0.6 m)

Area = 1.13 m^2

4. **What force must be exerted by the new pump?**

   Force = Pressure x Area

   $F = P \times A$

   $A = \pi r^2$

   Conversion: 900 kPa = 900 000 Pa

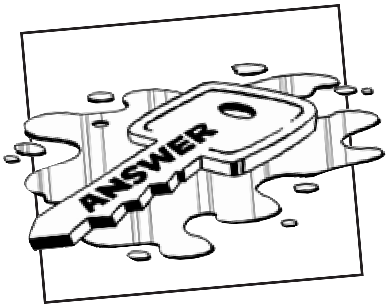
   $1 \text{ Pa} = \frac{1 \text{N}}{1 \text{ m}^2}$

   $F = 900\,000 \times 3.14 \times 0.6 \times 0.6$

   $F = 1\,017\,360 \text{ N}$

(As you recall, a Newton (N) is a measure of force.)

This is a tremendous amount of force exerted by the pumps to move the wastewater in the pipes to the wastewater treatment plant.



Fluid Flow and Properties
Lab A: Flow Rate and Viscosity

Data Analysis Questions

1. Adding waste increases viscosity and reduces flow rate.
2. Answers will vary.

Application Questions

1. Water pressure, pipe slope, pumps.
2. Decreased temperature increases the viscosity of most liquids and decreases flow rate; increased temperature does the opposite.

Fluid Flow and Properties
Lab B: Density, Solubility, and Filtration

Analysis Questions – Part I

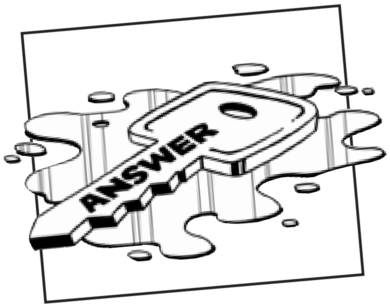
1. Oil decreases the density of the sample.
2. Oil isn't soluble in water; it separates when the mixture is left to settle.

Conclusion Questions – Part I

1. Substances that are denser than water sink to the bottom of the mixture when left to settle; substances that are less dense than water float to the top.
2. Since the insoluble particles are less attracted to the particles in the water, they are less likely to "stay" with the water as it moves. FOG materials are more likely to get left on surfaces of mechanisms along the way.

Conclusion Question – Part II

1. Oils can be removed by mixing them with denser substances and scooping them off when they float on top.



Fluid Flow and Properties
Part C: Wastewater Treatment

Analysis Questions – Part I (likely answers)

1. Vinegar and soap dissolve.
2. Toilet paper, dental floss, plastic, sand, coffee grounds, and tea leaves are insoluble.
3. Toilet paper, dental floss, coffee grounds, and tea leaves are less dense than water and float on the surface (some plastics may).
4. Sand and some plastics are insoluble substances that are denser than water and sink to the bottom of the container.

Analysis Questions – Part II (likely answers)

1. Large particles that didn't absorb water.
2. Answers will vary.
3. Answers will vary.

Analysis Question – Part III

1. Students will likely still have cloudy/murky water.

Conclusion Questions

1. Wastewater treatment involves allowing wastewater to settle. The process includes skimming and/or siphoning scum from the top of the separated water. As well, denser substances sink to the bottom.
2. Wastewater treatment will need to include physical filtration.
3. Other processes will be required after scraping and filtering in order to remove the dissolved chemicals that remain in the wastewater.

Name______________________________

Date____________________ Class ________

Treat it Right! Quiz

1. Organic compounds can be treated and removed from wastewater. T / F
2. Inorganic compounds are biodegradable. T / F
3. Reduced levels of oxygen cause eutrophication. T / F
4. Effluent is a by-product of wastewater. T / F
5. All of the main sewer lines lead to the North Saskatchewan River. T / F
6. Wastewater flow occurs entirely by the force of gravity. T / F
7. Viscosity refers to the thickness of wastewater. T / F
8. Slurry is more viscous than water. T / F
9. Density of a fluid can change with temperature fluctuations. T / F
10. Effluent water is not potable water. T / F
11. Wastewater consists of a variety of different waste products. List three products that should NOT be put down the drain or flushed down the toilet.

____

____

____

12. How is an efficient flow rate maintained in the sewer lines?

____

____

____

13. What two factors affect how pressure in sewer pipes is maintained?

____

____

____

14. What are two health risks that can result from inadequate sanitation?

____

____

____

15. Use each of the following words in a sentence that provides a fact about Edmonton's wastewater treatment process:

Slurry

____

____

Viscosity

____

____

Pressure

____

____

Sludge

____

____

Biological Treatment

____

____

16. Summarize the path that wastewater follows from your home to the Gold Bar Wastewater Treatment Plant.

____

____

____

____

____

17. Complete the matching diagram below. Indicate the correct sequence of steps by placing a number in the box on the left and match the description to each step by drawing a line from the description to the process step. An example is provided.

☐	Digesters	Larger insoluble material is removed by screening
☐	Disinfection	Scum and sludge is initially removed by scrapers
☐	Primary Clarifier	High wattage bulbs destroy harmful microorganisms
☐	Bioreactor	Methane and carbon dioxide gases are produced
☐	Grit Tanks and Screens	Microorganisms breakdown the organics and Oxygen is added
☐	Secondary Clarifier	Biosolids settle out, and TSS and Phosphates are removed

Name________________________________

Date___________________ Class ________

Wastewater Treatment Project Evaluation

You have included:	The quality of your work in this area is:	Based on this evidence:
a detailed description of current wastewater related practices linked to reasons behind the current state of wastewater treatment	outstanding........5 very good........4 fair.........3 poor........2	
issues arising from the current state of wastewater treatment standards and how the standard of living is affected by lack of wastewater treatment	outstanding........5 very good........4 fair.........3 poor........2	
examples of attempts that have been made to improve conditions and support agencies that could assist in improving conditions	outstanding........5 very good........4 fair.........3 poor........2	

Overall Score: / 15 = %
Comments:

Program Evaluation

Your participation in this evaluation will help us to further develop and improve this program. Thank you for your assistance.

School: ____

District: ____

Teacher: ____

1. The instructions to the teacher are:

- ❑ clear
- ❑ unclear
- ❑ could be improved by: ____

____

2. The learner objectives are:

- ❑ clear
- ❑ unclear
- ❑ could be improved by: ____

____

3. The information and activities connect with and enrich curricular topics:

- ❑ well
- ❑ somewhat
- ❑ could be improved by: ____

____

4. **The cross-curricular nature of the skills required to complete tasks is:**

   ❑ sufficient

   ❑ could be improved by: ______________________________

   ____

5. **In terms of age appropriateness, the activities are:**

   ❑ just right

   ❑ could be adjusted to: ______________________________

   ____

6. **The time required to work through all of the lessons is:**

   ❑ reasonable

   ❑ could be adjusted to: ______________________________

   ____

7. **The teacher's guide could be enhanced by adding the following:**

   ❑ dvd

   ❑ in-class presentations by experts

   ❑ video conferencing

   ❑ more cross-curricular activities (please be specific)

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8. I would like to have this program in another language. Please indicate:

- ❑ French
- ❑ Spanish
- ❑ German
- ❑ Chinese
- ❑ Other_______________________________

9. Other comments I have about the usefulness of this teacher's guide and/or its connection to the Alberta Education Program of Studies:

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Please print and complete this evaluation and fax or mail it to the number/address below. You can also complete this evaluation online at www.edmonton.ca/drainage/education
Thank you.

Janice Dewar, B.Ed., M.D.E.
Utility Services
City of Edmonton
2nd Floor, Century Place, 9803 - 102A Ave.
Edmonton, AB T5J 3A3
Phone: (780) 496-5431

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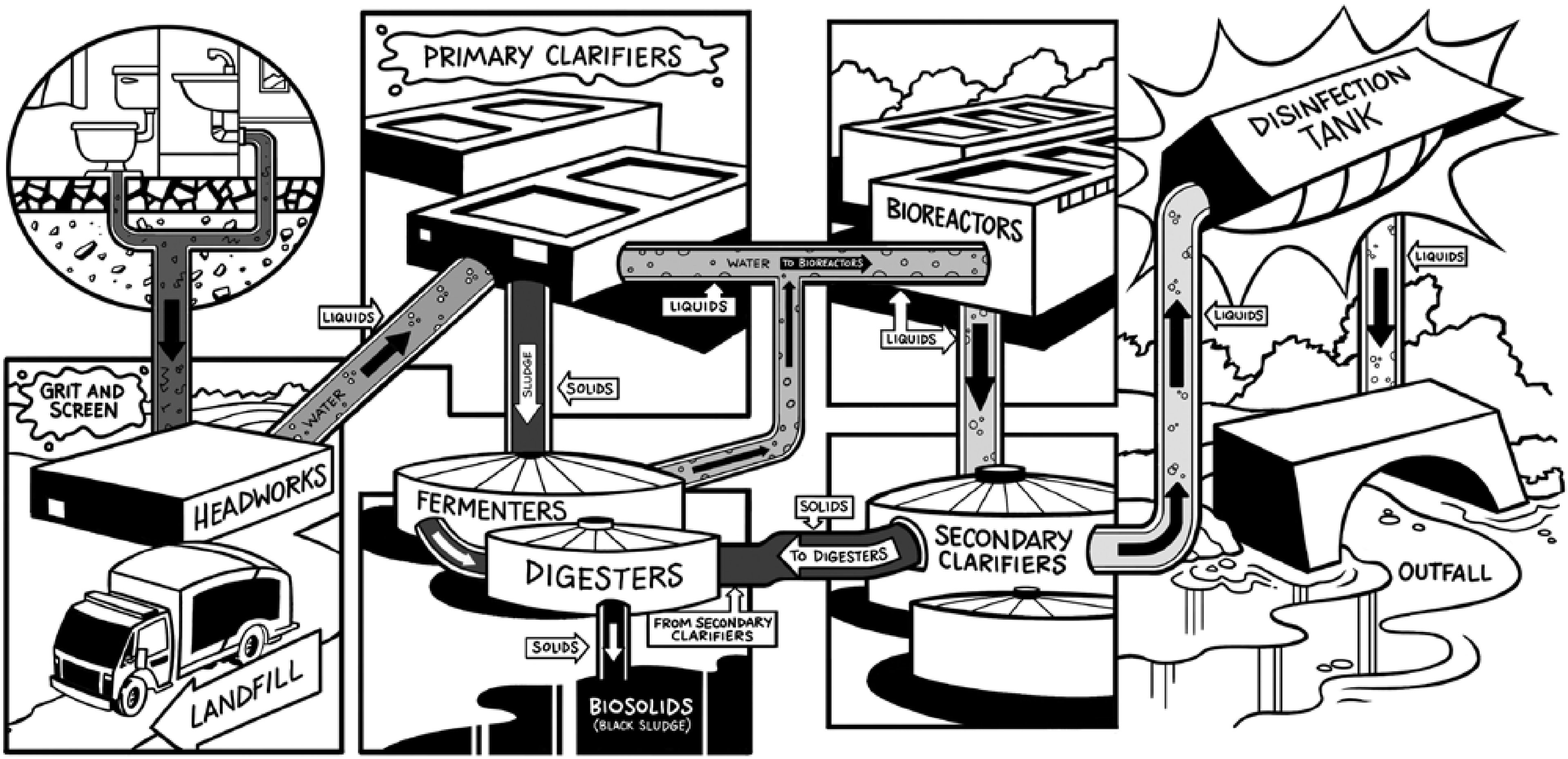
Wastewater Treatment Flow Chart



Treat it Right!®

Treat it Right!® Wastewater (Grade 4) (English and French)

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Treat it Right!® Wastewater (Grade 8)

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(Grades 2 and 4)

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