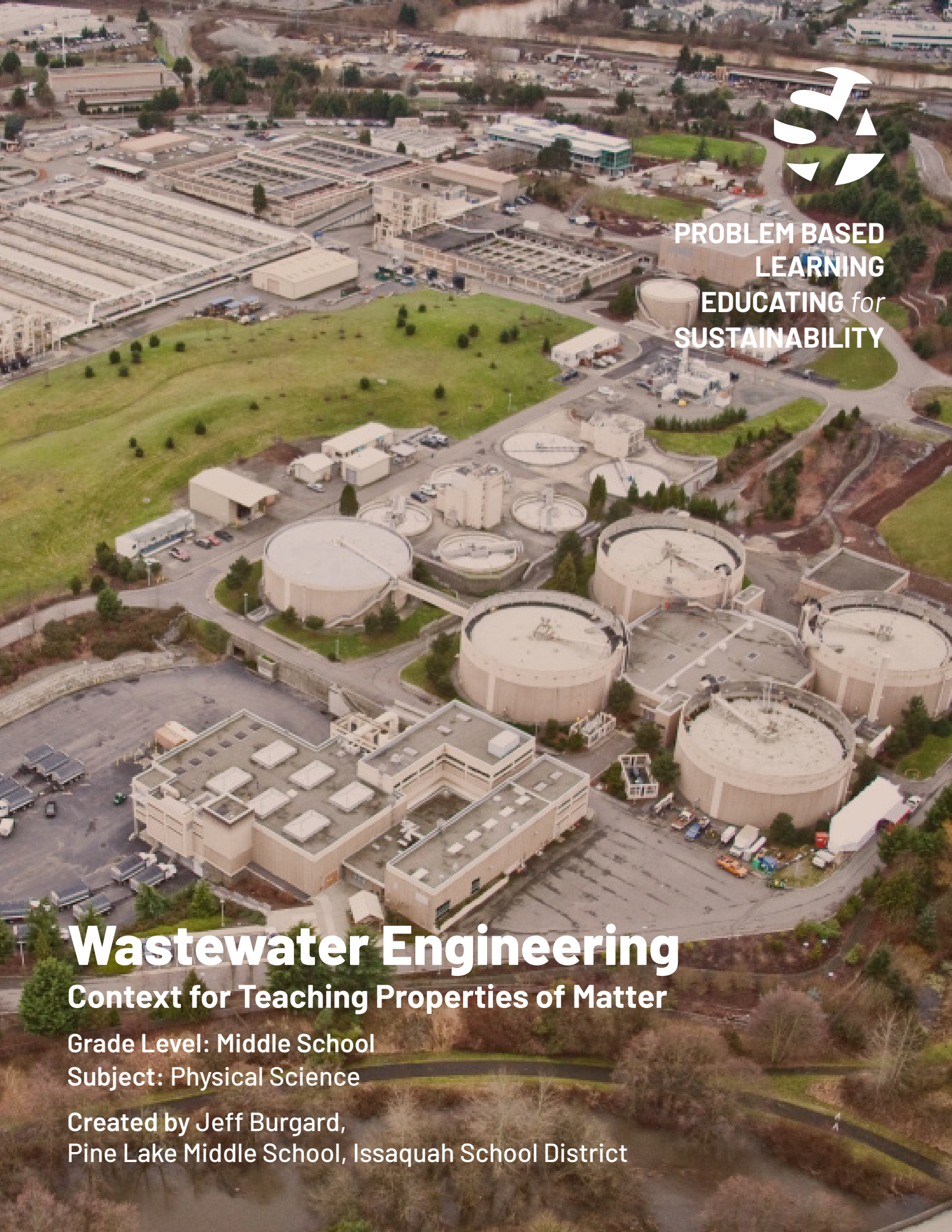


PROBLEM BASED
LEARNING
EDUCATING *for*
SUSTAINABILITY

Wastewater Engineering

Context for Teaching Properties of Matter

Grade Level: Middle School
Subject: Physical Science

Created by Jeff Burgard,
Pine Lake Middle School, Issaquah School District

PROBLEM STATEMENT

What can we do to make sure that our wastewater is not harmful to Puget Sound?

SUMMARY

Students learn that the way they use water in their homes and at school affects the health of the Puget Sound ecosystem. The water they consume in their homes is diverted from the natural water cycle and used for many purposes such as drinking, cooking, showering, dishes, laundry and toilet flushing.

In the process, it is mixed with sewage, soap, cleaners, food scraps, fats, oils, grease, medicines, and chemicals. This "wastewater" needs to be treated before it re-enters the ecosystem and becomes part of the water cycle again.

"I understand that chemistry helps us treat wastewater whether it is density or chemical reactions."

- Student

Treating wastewater uses knowledge of the properties of matter to separate the mixtures created in our homes to return clean water to Puget Sound. Using knowledge and skills gained through NGSS standards in Matter and its Interactions, students come to understand the treatment of wastewater and what they can do to ensure that the system works as effectively as possible.

"The most significant part of the learning for me was connecting what we learned in the classroom to the real world, and how we could help it."

- Student

Learning Objectives / Student Outcomes

1. **I understand how knowledge of the properties of matter and related interactions enables the wastewater treatment process to send clean water back into the water cycle.**
2. **I understand the basic science for why treating wastewater to the highest level possible is critical to the health of the Puget Sound ecosystem.**
3. **I can take personal action to make sure that our wastewater is not harmful to Puget Sound.**

Formative Assessment

Menu of possibilities...

1. An initial personal reflection, mind map or video-self-interview on how local wastewater is impacting Puget Sound.
2. Review and prioritization of possible impact projects for helping the wastewater treatment system work effectively.
3. A draft impact project plan.
4. Pre/Post Assesment

Summative Assessment

1. **Implement a final impact project that demonstrates a clear connection between key learning, personal action, and one or more policy frameworks or performance measures valued by a local stakeholder.**
2. Pre/Post Assesment

ACADEMIC STANDARDS

Washington Sustainability Standards

WA-ESE-2:

Students engage in inquiry and systems thinking and use information gained through learning experiences in, about, and for the environment to understand the structure, components, and processes of natural and human-built environments

WA-ESE-3:

Students develop and apply the knowledge, perspective, vision, skills, and habits of mind necessary to make personal and collective decisions and take actions that promote sustainability

NGSS Standards

MS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics

Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations

MS-PS1-1

Develop models to describe the atomic composition of simple molecules and extended structures

MS-PS1-2

Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred

MS-PS1-4

Develop models to describe the atomic composition of simple molecules and extended structures

MS-PS1-5

Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved

MS-PS1-6

Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes

MS-PS3-4

Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample

MS-ETS1-1 Define the criteria and constraints of a design problem

Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem

MS-ETS1-3

Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success

MS-ETS1-4

Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved

BIG PICTURE

NGSS Global Climate Change

NGSS Human Sustainability Standards

OSPI Environmental Sustainability Standards

OSPI Social Studies Standards

College, Career, and Civic Life (C3)

Common Core State Standards

COMMUNITY CONTEXT

My family's sustainable practices

My Neighborhood Association

Nonprofits focused on this issue

My School and School District

My City Wastewater Utility

My County Wastewater Utility

My Watershed Salmon Recovery Plan

Puget Sound Vital Signs

Washington Department of Ecology

Washington Department of Health

Environmental Protection Agency

Tribal Treaty Rights

West Point Wastewater Treatment Facility

Breaking Down the Problem Statement

What can we do to ensure that our wastewater is not harmful to the Puget Sound ecosystem?

What can we do...

- As a student, do I have a role in this? What's my responsibility?
- What about my family? What if every student and family in our school took action?
- Who are the other stakeholders? Who is already working on this?
- What actions need "doing?"

to ensure...

- How would we know that the actions we take have an impact?
- What kind of data do we need to gather?
- Who is already tracking this data? How can we access it? How can we analyze it?
- What are the policy frameworks and regulatory requirements for "ensuring" success?
- What is the role of my city, King County, the EPA? Dept of Ecology? Dept of Health?

that our wastewater...

- Do we really "waste" water? Or do we borrow it from the water cycle?
- What are all of the sources of wastewater? In my house? At school? In a factory?
- Make a list of what goes down the drain
- What should never go down the drain or the toilet?
- Can stormwater or groundwater get into the sewer system?
- What engineered systems are needed to convey wastewater to the treatment plant?
- What engineered systems are needed to treat it once it's at the treatment plant?
- What engineered systems are needed to return clean water to Puget Sound?
- If it's "clean", why are salmon on the same drugs that we pee?
- Can we recycle the water that we clean?
- How does the International Space Station recycle its wastewater?
- Can we use the solid organic matter that is produced?
- Can we produce heat energy from burning methane produced in the digestion process?
- How does a septic system work for a home that is not connected to the main wastewater treatment system?
- How fast do we need to move the water through the system? What happens if we fall behind?
- What do you predict happens to the system at halftime during the Super Bowl?

is not harmful...

- How do we measure "harm?" What is the threshold? Can humans be harmed?
- What can we remove in the treatment process? What can we not remove?
- What happens to the system when it rains?
- What would happen to the system in an earthquake? How do we plan for this?
- What happened in 2015 at the West Point Treatment Plant? What did we learn?

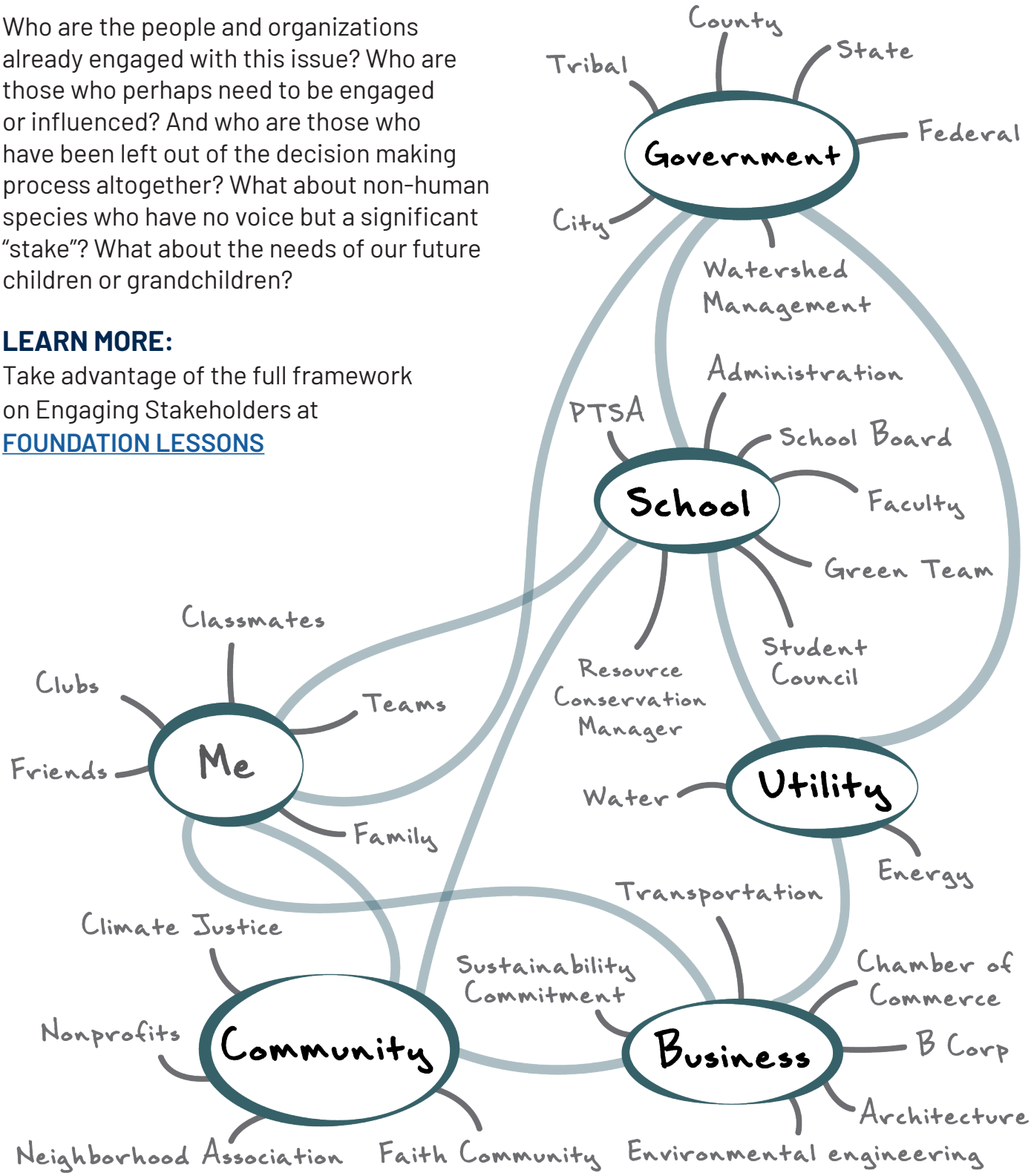
to the Puget Sound Ecosystem?

- How does the Puget Sound ecosystem function?
- What is the current status of its health? How has this changed over time?
- How does our wastewater treatment process here in King County impact it?
- Which species are affected? In what way? Does this ripple through the food web?
- What about the wastewater treatment process in Victoria BC?

Stakeholder Brainstorming

Who are the people and organizations already engaged with this issue? Who are those who perhaps need to be engaged or influenced? And who are those who have been left out of the decision making process altogether? What about non-human species who have no voice but a significant "stake"? What about the needs of our future children or grandchildren?

LEARN MORE:
Take advantage of the full framework on Engaging Stakeholders at
FOUNDATION LESSONS



Stakeholder Perspectives

As students identify specific stakeholders relevant to this topic, they will want to consider each point of view with integrity. This practice provides a critical opportunity to develop social-emotional learning skills and cultural competency by building an awareness of our own internalized biases and expanding our capacity for empathizing with stakeholder perspectives different than our own.

EXAMPLE: Stakeholder Engagement Table

STAKEHOLDERS	INTERESTS	GOALS	APPROACH
Name of stakeholder group	**What motivates them? What do they care about? What are they responsible for?**	**Do they have specific action plans, goals, or projects they are pursuing?**	**What is the best message, platform, and timing to engage with this group?**
My family	Confidence that their wastewater will be taken away from their living space.	Health and safety in their living space.	Word of mouth, informal conversations.
School (Green Team, RCM, PTA, ASB)	Maintaining functioning wastewater systems that carry wastewater away from school buildings safely.	Health and safety of all people in school buildings.	Green Team group chat or social media. PTA and school e-news.
My City	Ensuring residents have safe, functioning wastewater systems in place.	Functioning wastewater infrastructure.	Presenting at City Council meetings. Proposing resolutions. Contacting city staff and elected representatives.
Local Water Utility	Ensuring rate-payers have domestic and commercial wastewater treatment.	Meeting needs for wastewater management. Maintain and update infrastructure as needed.	Email or call utility staff responsible for community engagement. Speak at public hearings.
Tribal Governments	Access to healthy fishing grounds for salmon, shellfish, plants, as guaranteed by treaty rights.	Maintain natural resources for current and future livelihoods as well as cultural connections.	Email or call district school tribal liaison or State Office of Native Education.
Farmers	Using recycled wastewater for crops when possible.	Continue growing and maintaining crops as a source of income. Efficient water use.	Communication at agriculturally focused community meetings or meetings of farmers.

BACKGROUND

When wastewater leaves your home, it travels through a series of pipes on its way to the **wastewater treatment plant**. There are a number of issues that arise in the transportation of the sewage through the pipe. First, all the water from a home goes into the same pipe, whether it is from the shower, kitchen sink, or toilet. This includes some solids, but it is mostly water. The stuff that is put in is only a small percentage of the total flow but some of that small percentage can cause big problems over time. If people put warm **insoluble** fats, oils, and grease down the kitchen sink, those fats often cool and **solidify** on the walls of the pipes. This can eventually **clog the pipes and block the flow**.

Gravity is what moves water through the pipes and when gravity is not enough, **large pumps have been installed** to help move the wastewater over hills.

This system worked well for a long time, but recently, **"flushable" wipes** became a common item flushed down the toilet. Even though it is *technically* correct that the wipes are "flushable" - meaning that they can move through the toilet - they have **properties** that are much stronger than toilet paper so they **do not fall apart or tear easily**. Because of these **stronger properties**, they tangle in the pumps and prevent them from working. Stopping the flow to detangle the wipes from the pumps costs a lot of money and time every year.

Some other contaminants that enter the flow as the wastewater moves through the pipes are **dirt and gravel**. As the pipes age, they crack. These cracks allow some **leakage from stormwater** that is percolating into the groundwater which then causes dirt and gravel to enter the pipe. These materials, once they arrive at the wastewater treatment facility, must be taken out.

When the water reaches the treatment plant, **primary treatment** begins immediately. The water is put through a **screen filter** which removes trash larger than hole size in the screen. Then, the water moves rapidly through a deep tank where dirt and gravel, which are more **dense** than water, **are separated from the water by falling to the bottom** of the tank. Next, the water is slowed down to allow more settling and **separation through density**. The **more dense** organic solids settle to the bottom of the tank and the **less dense** fats and oils rise to the top. The water is continually and slowly moved through the tank as a **conveyor scrapes the sludge off the bottom** and a **skimmer scrapes the fats and oils off the top**, removing both substances from the water.

Secondary treatment uses natural processes to clean the water. The water is pumped into huge **aeration** tanks, warmed, **filled with bacteria** and pumped up with oxygen. The bacteria used are the **same bacteria that would break down the organic solids in nature** and the warmth and the oxygen help them to function at their best. These bacteria eat the organic waste that was not dense enough to fall out in primary treatment.

After a period of time, the water is drained and sent to **clarifying tanks** where it is cooled and allowed to move extremely slowly. Cooling the water slows bacterial activity and their **density** causes them to settle to the bottom of the slowly moving water. A **bottom scraper gently collects the bacteria** and sends them back to the aeration tanks. This leaves the water incredibly clear.

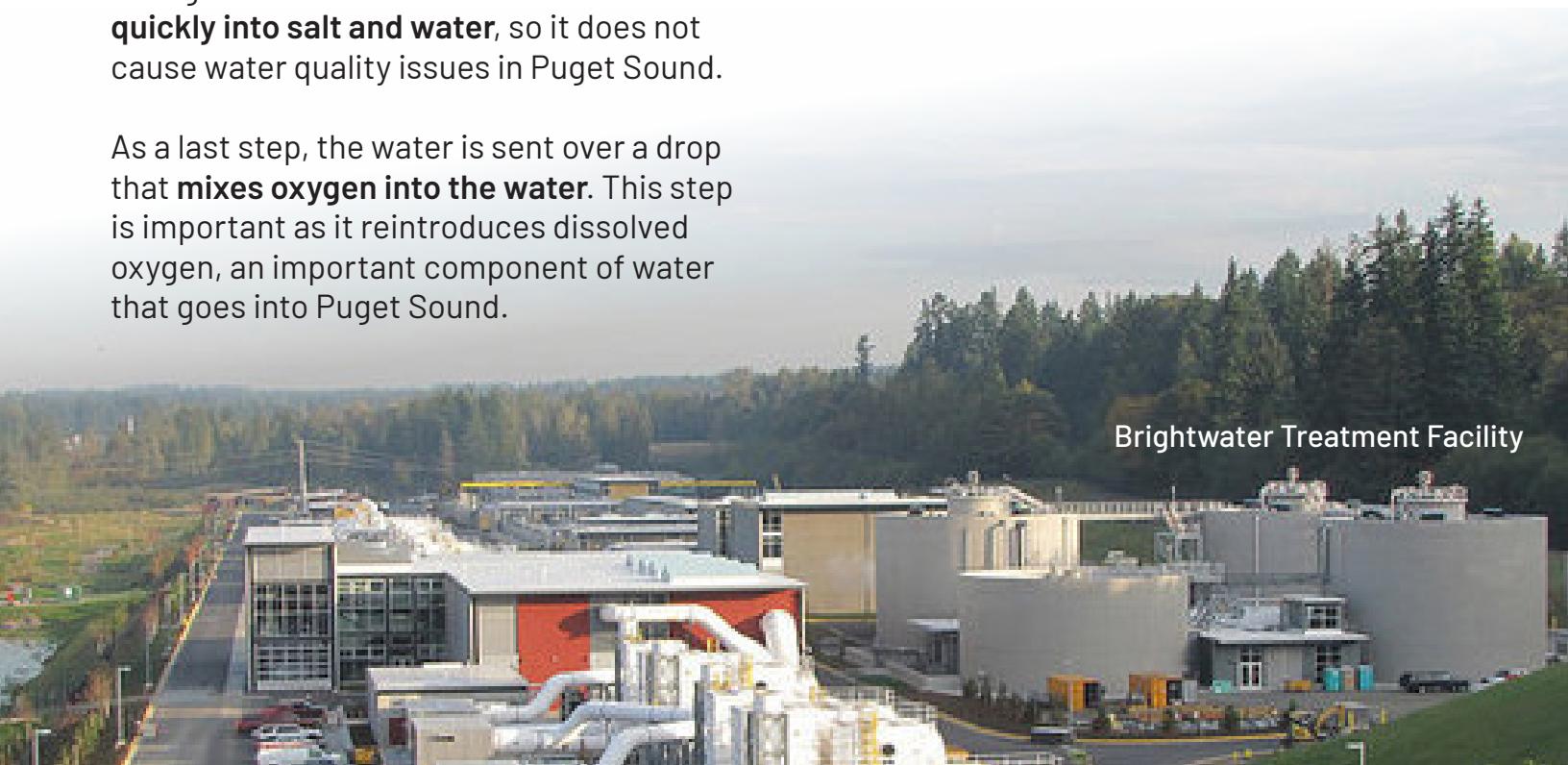
The final stage for most wastewater treatment plants in King County is **adding sodium hypochlorite (bleach)** to the water to kill any **pathogens** before it's sent through diffusion pipes deep under water in Puget Sound. **Bleach will break down quickly into salt and water**, so it does not cause water quality issues in Puget Sound.

As a last step, the water is sent over a drop that **mixes oxygen into the water**. This step is important as it reintroduces dissolved oxygen, an important component of water that goes into Puget Sound.

One of the treatment plants in King County, called Brightwater Treatment Plant, has **tertiary treatment** as well. This treatment moves the water through **membrane filters**, which mimics a cell membrane. These membrane filters have extremely small pores, so *small* that they **only allow things the size of water molecules through**.

However, even **tertiary treatment** can not capture every substance. Some **chemicals and medications** that remain in the cleaned water can be harmful to the Puget Sound ecosystem. dibly clear.

The only real way to keep them out of the water, is to never put them into the water in the first place. The two ways to do this are **mitigating source pollution** and **recycling the water**. To mitigate source pollution, there are products available to filter things like microplastics out of washing machine water and other products that clean the body or home with natural, biodegradable ingredients. There are websites that can help consumers find these products.



Brightwater Treatment Facility

Recycling Wastewater

Another option is **recycling the treated wastewater**. This recycled water meets clean water standards for many applications including **agriculture, recharging groundwater, irrigating sports fields, supplying fire hydrants, and filling up the tanks of street sweeping trucks**. Recycling the water allows a second use for the water. In addition, plants and soils that receive recycled water can process any of the chemicals still present.

There is another waste stream that happens at the treatment plant for the **organic solids** taken out of the water. Organic solids are actually a valuable resource. All the solids that settle out of water, are collected in a **digester** - a huge tank where the waste will spend the next 30 days.

In the tank, the organic solids are contained in an oxygen-free environment, warmed to human body temperature, and mixed with **anaerobic bacteria**. These bacteria eat the organic solids and digest them via **chemical reactions** inside their bodies that produce two products. One is a nutrient rich **biosolid** and the second is **methane gas**. The nutrient rich biosolid is a great fertilizer and methane gas is burned to harness **energy from a reaction** in an on-site **co-generation plant** that produces electricity to help run the wastewater treatment facility.

Biosolids, methane gas, and recycled wastewater are byproducts of wastewater treatment which can serve environmental and economic benefits. King County Wastewater names three uses for recycled wastewater:

Irrigate sports fields, golf courses, and farms.

Save companies money when they can use recycled water for things like toilet flushing.

Use recycled water in specific habitat restoration projects.

Outside of these uses for recycled wastewater, there is a market and long-term plan for biosolids. Called Loop Biosolids, the King County Wastewater services biosolids can be used as a soil amendment in certain environments. They have been used in forest and agriculture programs throughout Washington state. To learn more about how Loop is made, watch this video.

"The water treatment we learned about is happening to the water that I drink and use every day so learning about it can help me help the environment"

- Student

LESSON OUTLINE

Materials Needed:

Internet Access

Other PDFs and websites are linked in the activities

Lab supplies listed in Activity 6

See Foundation Lessons

Impact project Design

Engaging Stakeholders

VOCAB AND KEY SEARCH WORDS

Water Infrastructure

Nonpoint Source Pollution

Insoluble Fats (Fats, Oils, Grease)

Solubility

Density

Wastewater Treatment

Primary Treatment

Secondary Treatment

Tertiary Treatment

Methane Digester

Biosolids

Recycled Wastewater

Integrated Water Management

ENTRY EVENT

Students are introduced to wastewater issues by doing a jigsaw reading of the issues faced with wastewater pollution in Puget Sound. Students read and share information from four articles to discover the extent of the problem.

Students read and share information from four articles to discover the extent of the problem. Provide each student in a group of four with a different article and a finite amount of time to read and gather information about their article on this page.

Articles:

Salmon on Drugs Article

Shellfish Cannot say "no" to drugs

How your clothes are poisoning our oceans and food supply

Polluting the water with toothpaste and household chemicals

"I used to think that whatever I flush down the toilet will be cleaned, and the water will be pure again but now I know that it is very difficult to make wastewater pure again.

Also, I used to think anything can go down the drain as long as it fits but now I know that only certain things are allowed down the drain without clogging the wastewater treatment plant."

- Student

After their initial read, group students by article - two groups per article- for them to confirm and solidify their information.

Students will report back to their original group and share their information with the rest of the group. Students should record information about each article on their page as it is shared by other group members

Facilitate a class discussion where representatives from each group share information about their article. In the discussion, let students know that drugs get into the water by people dumping them into toilets and simply peeing after they are taken.

Reassure students that take medications, because some will feel guilty because they have to take medication. Tell them that human health is important, we just have to find a way to get the substances out cheaply and easily. Maybe they will be the person that figures it out.

The result of the discussion should be that although we do treat and clean the water, it still has contaminants that are harmful to Puget Sound. Share that throughout this lesson, they will learn how the wastewater is treated, why treatment plants cannot get some things out, and what they can do each day to make sure that wastewater they interact with causes as little harm as possible.

ACTIVITY 1
Initial Model of Wastewater Treatment

Students imagine the design of a water treatment plant based upon what they know at the beginning of the unit. Then, share their ideas with their classmates.

To begin, brainstorm with students all the things that go down the drain and use the white board or easel to write down the things that they say.

Show students this image from King County WasteWater Division that shows the main sewage pipes and treatment plants in the region. Show them where their school and neighborhood are on the map and which treatment plant their wastewater goes to get treated. Click here to see information about each plant.

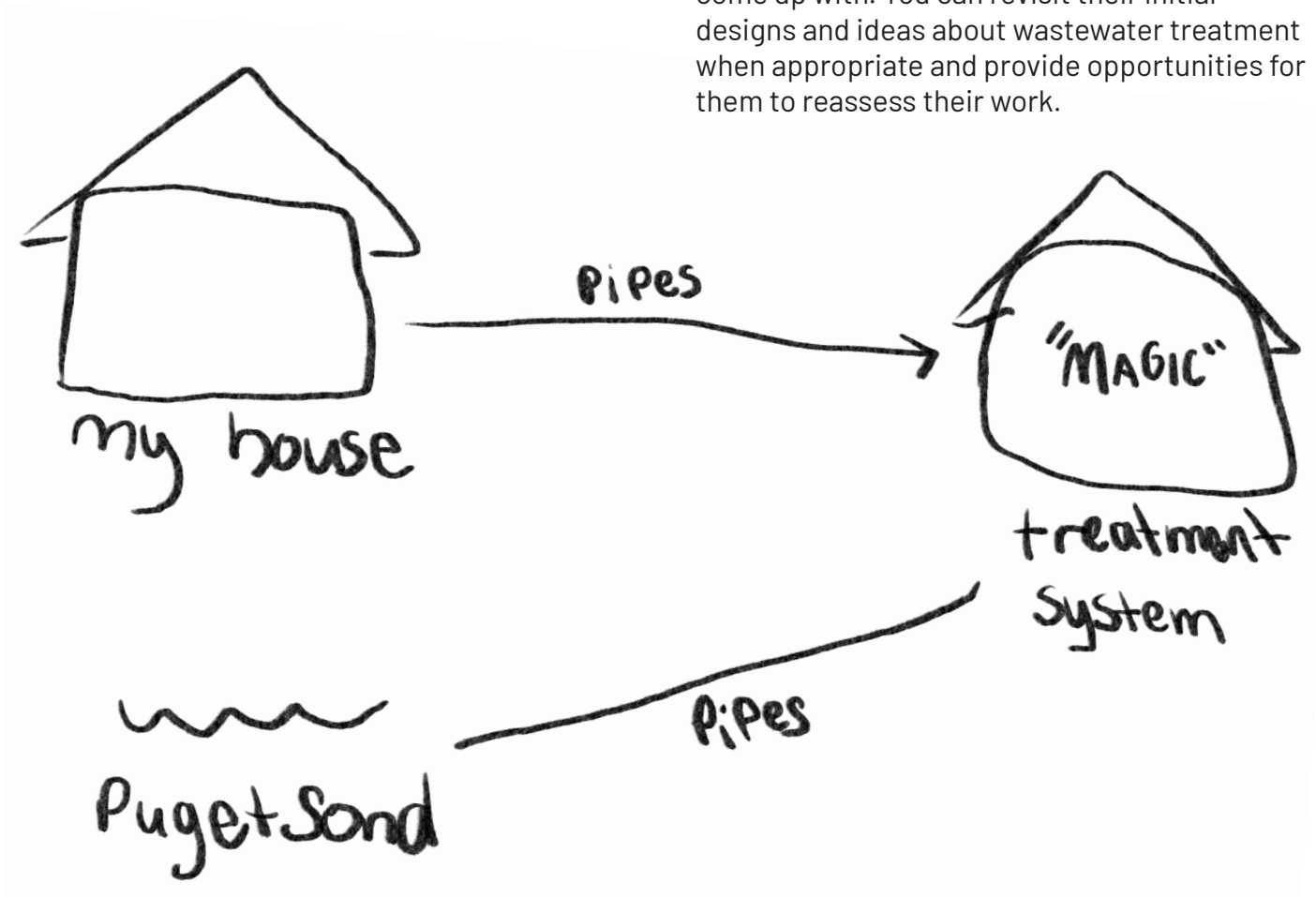
Use the picture provided on the page, or get an aerial view from your favorite map application to show the students what the treatment plant looks like. Ask students, what happens here to make the water clean?

Give each student a blank piece of paper and encourage students to put their best effort into designing what they believe happens at the treatment plant. Emphasize that they do not have to be artists, just draw boxes with a label of what would happen in each box for each stage in the process - from the time the wastewater enters the treatment facility until it goes into Puget Sound.

Here are some sample drawings

Example 1, Example 2, Example 3.

When students have finished, invite them to share their ideas. Ask for clarification, question their thinking, and take note of the ideas they come up with. You can revisit their initial designs and ideas about wastewater treatment when appropriate and provide opportunities for them to reassess their work.



ACTIVITY 2
The Problem with Wipes

After students are introduced to properties as a way of describing and differentiating matter, students are shown that properties of substances in wastewater really matter. The wastewater context emphasizes that only the **"four P's"** should go down the toilet.

Poo, Pee, Puke, and Toilet Paper

Learn more about this simple but critical responsibility we all share by studying the **infographics and videos** at King County's webpage Don't Flush Trash. The page features the same information in several different languages.

Do a demonstration for the students

Fill two screw top containers with water. Containers should hold one cup to one quart of liquid and be clear. Remind students that many people put wipes and toilet paper down the toilet and flush.

Place the same size sample of toilet paper and flushable bathroom wipe - each in their own container, seal the lids, and shake each container vigorously. The toilet paper should break into many pieces and the wipe should stay whole.

Share with students that because the two have different properties only one of them should actually go down the toilet. Even though most bathroom wipes say they are flushable they are bad for the sewer system and tangle in the pumps. People have to shut down the system and take them out by hand.

Suggested inquiries after the demonstration

Dig deeper into the properties of toilet paper and flushable wipes. What is it about their materials that makes toilet paper okay to flush and flushable wipes not okay to flush?

Do an image search for "wipes in pipes". What do you find? Where are the images from? What do the stories say about wipes in pipes? How is this relevant to wastewater treatment where you live? What was done to get the wipes out of the pipes or to solve the problem they created?

Read "Everybody wipes, so what is the best method?" either as a "jigsaw" or independent reading. Consider how companies may address the public's changing ideas about what is flushable. Facilitate a discussion with students about the article and what they can do to stop the problem.

ACTIVITY 3
Density Separates Mixtures

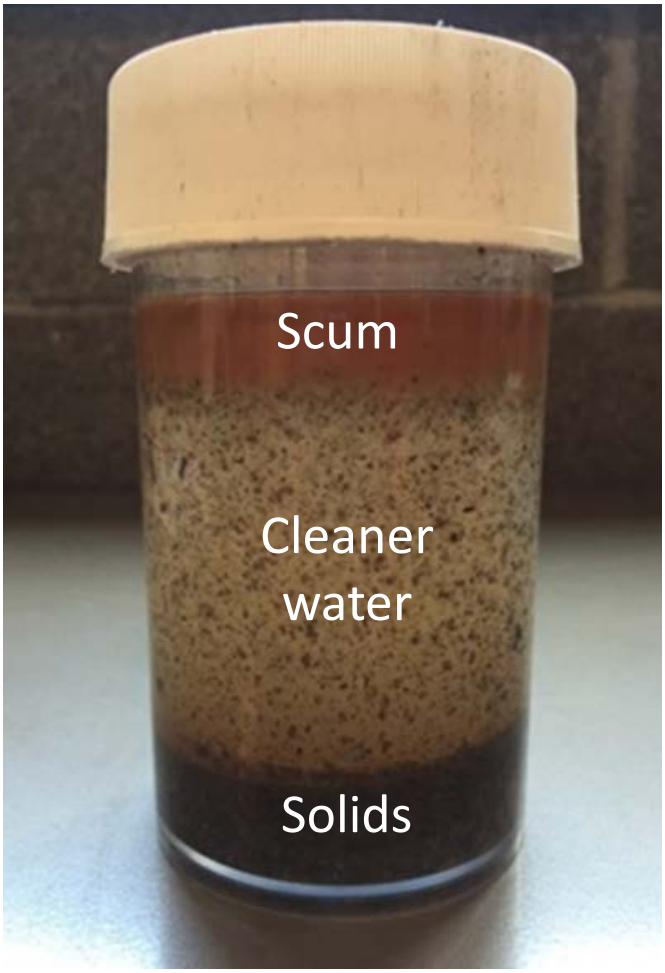
After students finish lessons on density, they watch a video from King County Wastewater and complete a drawing of the primary treatment process which uses density as the primary separation technique.

Show students the King County Wastewater Treatment Video and have a discussion about primary treatment. Show only up to the 6:00 minute mark.

Find your wastewater facility's wastewater treatment diagram by clicking here.

Share only the steps related to Primary Treatment or use this example drawing.

Guide the students through a drawing of the wastewater treatment system, so far...



ACTIVITY 4
Solubility and F.O.G

After students complete activities related to solubility, students learn the importance of not dumping insoluble fats, oils, and grease down the drain.

Invite students to read the "Fatberg" article and respond with the following three questions. After students work individually or in small groups to answer these questions, conduct a discussion around student curiosities.

What surprised you in the article?
What did the author assume you knew?
What does this make you curious about?

Additional inquiries

Students may also read this article from Clemson University about F.O.G. The article covers the effects of F.O.G.s on the environment, what is being done by restaurants to control the problem, and what students can do to help.

Conduct an image search for "F.O.G. in pipes" for some great and gross picture of clogs. Encourage students to find levity here - making memes, collages, or writing short stories about great and gross clogs.

Show this video to help students learn the proper way to dispose of fats, oils and grease.

"I wasn't really aware of where my bath/toilet water was going, and after learning about wastewater, I'll probably use/flush different things or products."

- Student

ACTIVITY 5

Boiling is not an Option!

After students have done activities related to boiling and freezing points, students will learn that even though boiling can kill some bacteria and pathogens, it is not feasible for wastewater treatment.

Talk with students about the practicality of boiling water for municipal water treatment. Since many students probably included boiling as a step in their initial design for wastewater treatment, have them share the purpose of boiling in the process. Some will say to kill bacteria, while others may describe water distillation.

Share that although boiling will kill bacteria, it does not separate anything out of the wastewater. And, although distilling is a separation technique, it is not feasible for large, community level wastewater treatment.

The wastewater treatment facility will process 90-150 million gallons a day.

Since it takes about 20 minutes to go from ice to steam in a 250 ml beaker, it would take way too much time and energy to boil the water in a large facility.

However, it can be used on a small scale. Share the Janike Omniprocessor video. Discuss the benefits to the villages where it is being used.

ACTIVITY 6

It's a LAB!

Design a Wastewater Cleaning System

After students have done activities related to pure substances and mixtures, students will use their knowledge of properties, boiling points and separation to clean a small sample of contaminated water to produce pure water. Students should understand that mixtures are two or more substances that are combined, but keep their individual properties.

This is the key to primary treatment and secondary treatment of wastewater. If you have the equipment to do simple distillations, the students can separate the soluble substances from the water to get pure water. If not, it is a good lesson related to the challenges of real water treatment, where few soluble substances can be removed.

Students are challenged to separate six substances, each with unique properties, from contaminated water. Each substance in the water represents substances commonly found in municipal wastewater.

Amounts of the following do not not have to be precise:

Sand (represents insoluble inorganics such as dirt and rock)

Salt (represents soluble substances)

Plastic beads (represents plastics)

Paper towels (represents wipes)

BB's (represents metals)

Rice (represents insoluble organics)

They should use a different technique for each substance based on the unique property. Each substance has to come out clean and clear of the others, so it takes experimentation to find the best order to accomplish this. That means they cannot not just use the spoon to bring out a mixer of sand, rice and paper, they each need to come out on their own. The following is a list of the contaminants, the property used to separate them, the best way to separate it and it is in the order to use.

Plastic beads - (Density) They float, so a spoon can be used to scoop them off the top of the water.

BB's - (Magnetism) A magnet is swirled through water until all have been attached and removed.

Pieces of paper towel - (Density) Stir water, raising the paper off the bottom into the water and then caught by the spoon.

Rice - (Large particle size) Rice, sand and water are poured onto the screen. Sand that does not fall through can be rinsed through cleaning the rice.

Sand - (Small particle size) A coffee filter removes the sand from the water.

Salt - (Boiling point and solubility, if possible in your classroom) distillation separates the salt from the water.

"Since wastewater is a mixture, the substances keep their properties. We can use those properties to develop ways to get the crap out of the water and make it pure."

- Student

Resources needed:

Teacher tools:
1 pipette
1 small aluminum pan (or similar to test a sample of the water)

Equipment for each group:
2 250 ml beaker
1 5x5 square of window screen (large debris filtration)
1 coffee filter (small debris filtration)
1 magnet
1 spoon

Tools if distillation is possible:
1 10 ml beaker
1 50 ml graduated cylinder
1 hot plate
1 large rubber stopper
1 3x3 piece of aluminum foil
1 pair of test tube tongs

Lab instructions:

Prepare the beakers of contaminated water with approximately 100ml of water and some of each contamination in each beaker.

Introduce the project to students, helping them understand the criteria and constraints of the project.

Let the students experiment with the order and the techniques until they can produce clean water.

The project can be made into a competition to see who can separate all the substances and produce the greatest amount of water in 30 minutes. The more efficient students make the process the more time they will have to distill the greatest amount of water.

If the water is distilled, use the pipette and aluminum pan to test a small sample. If a few drops of student-cleaned water can boil away and leave no residue, students were successful in removing the added contaminants.

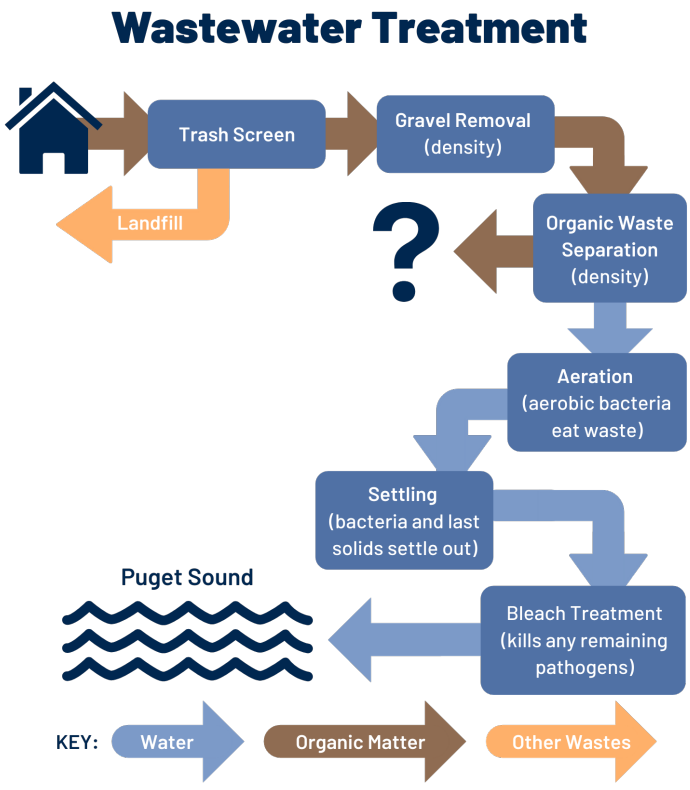
ACTIVITY 7
Secondary Treatment

After the students have completed their understanding of primary treatment, students watch a video to understand secondary treatment. It does not involve any new properties and they will also be exposed to tertiary treatment, advanced filtering, that happens at the Brightwater Treatment Facility.

Show students the next part of the King County Wastewater Treatment video. Begin the video at the 6:00 minute mark and show only up to the 19:10 minute mark.

Facilitate a discussion about the video.

Add the next steps in the process to the first drawing. Example Drawing



TEACHER NOTE: See this webpage to view a series of excellent diagrams for King County's five treatment facilities.

ACTIVITY 8
Stop Source Pollution

After students have completed activities related to synthetic substances,they learn about synthetic and harmful substances that end up in our wastewater from the cleaning products we use everyday. Then, they look for those ingredients in the products in their household. Students also look up alternative, natural cleaning options.

Distribute the harmful ingredients found in our products and provide students with the harmful ingredients student sheet.

Divide up the students into eight groups and have each group be responsible for a different ingredient and for creating a poster (or other visual) of information covering the four columns on the student sheet

Have students read the information and fill out the table for their ingredient - individually first, then in small groups.

Let students work on their visuals. Have all students move around the room on a gallery walk to collect all information.

As a closing, have students share "what surprised them", "what were some common natural products to use instead".

Possible follow up activity

Invite students to examine the cleaning products they use regularly and look at the ingredients discussed.Refer students to the Environmental Working Group website for product ratings and for seeking out cleaning product alternatives.

Additional teacher resources:

[Article] An Intro to Polymers
[Video] Cleaning products and air quality
[Video] Harmful cleaners
[Website] Principles of green Chemistry
[Curriculum] Hazards on the Home Front

ACTIVITY 9

Power from Poop!

After students have completed activities related to the release of thermal energy through chemical processes, students are shown a series of videos on how the methane gas released in the digestion of organic solids can be used as a fuel to power the treatment facility itself.

Show the first video about a 17 year boy in Kenya who designed and built a bioreactor to produce gas for burning in his village. Show the video: Students in Kenya make energy from waste

Continue the King County Wastewater Treatment video from the 19:10 minute mark and show only up to the 21:20 mark.

Engage students in discussion about how they produce and utilize the methane produced in the treatment of the organic solids. Focus on the chemical reactions involved and how thermal energy is derived from the reactions which then can be used to generate electricity in the on-site co-generation facility.

"The most significant part of the learning for me was where did all the waste that sunk go. I had no idea and thought it just went to the landfill, but the fact that we are able to turn something not so great into an amazing fertilizer is astonishing."

- Student

ACTIVITY 10

Where does the organic waste go?

After students learn what happens in a chemical reaction, they will extend their knowledge to learn that the wastewater sludge, the organics removed from the water, are processed by bacteria. When these bacteria digest the sludge, they produce two products - biosolids, nutrient rich fertilizer, and methane gas.

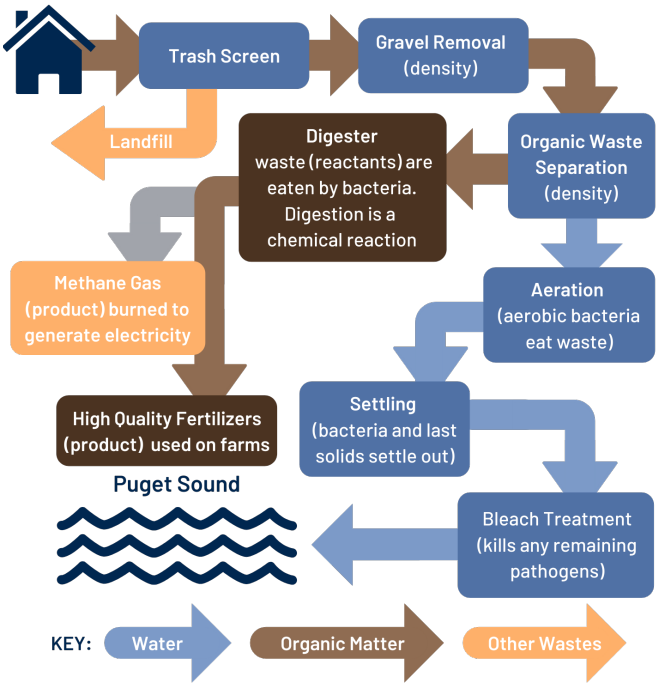
Continue to show students the King County Wastewater Treatment video. Begin the video at the 21:20 mark and go to the 23:12 minute mark and show the rest of the video.

Another variation on where does organic waste go? Here is another more detailed video about the making of Loop if needed.

After the video(s) and have a discussion about the breaking down of the waste. Emphasize the idea that **digestion is a chemical reaction**, so the products have different properties than the reactants. It is not human poop anymore.

Finish Treatment drawing. Example drawing

Wastewater Treatment



TEACHER NOTE: See this webpage to view a series of excellent diagrams for King County's five treatment facilities.

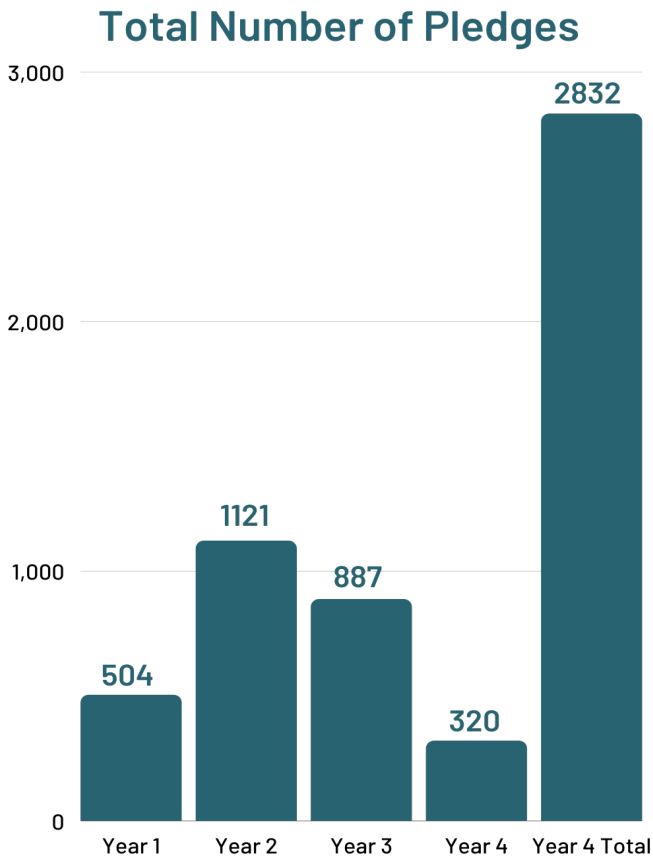
ACTIVITY 11
Recycled Wastewater

After students have completed activities related to conservation of mass, they are introduced to the idea of recycled - or reclaimed - water. This fascinating topic is fully covered in a separate lesson. See the full **Reclaiming Wastewater for Water Supply Lesson** in the SNOWPACK COLLECTION.

A possible extension... As the climate changes, some parts of the country, like the Phoenix area, have no choice but to use recycled water. This is a great time to facilitate a debate in the classroom on the pros and cons of recycling wastewater based on environmental, economic, and political conditions in our region.

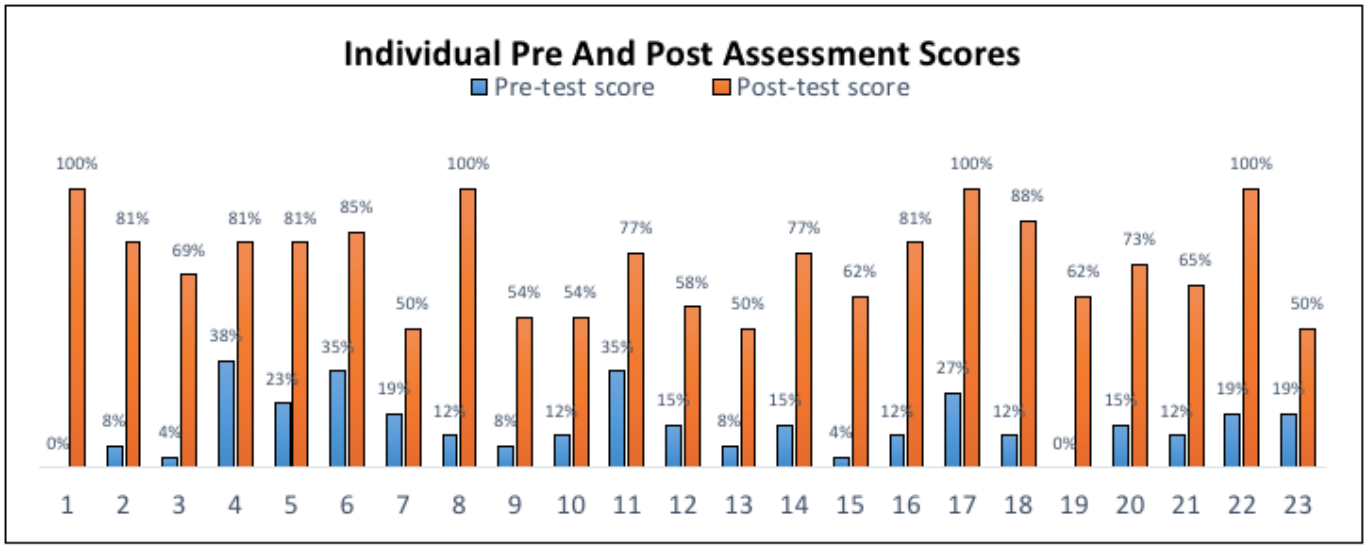
ACTIVITY 12
What can we do?
This is the most important part!

Students are given a "call to action" by filling out this Take Action Pledge about changing their current actions or maintaining their good ones. Invite the students to commit to make changes and share what they know with others. Encourage students to share what they have learned and the pledge, or link to the pledge, with as many people outside of their schoolmates that they know. The goal is to have as many people take the pledge as possible.



It all adds up!

Over the past few years, learning about wastewater treatment has impacted a large part of the community. Students took the pledge and encouraged their family members and friends outside of school to join them. The total number of pledges has fluctuated depending on participation within the department and with the effects of COVID-19 (year 4).



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CASCADE
WATER ALLIANCE

Thank you **King County WaterWorks Grant Program** for supporting additional partnership building and curriculum design related to water quality.

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About Sustainability Ambassadors

Sustainability Ambassadors is a professional development program for student leaders, teacher leaders and community leaders committed to rapidly advance a sustainable future by aligning classroom rigor with community relevance for real world impact.

We support a year-round training program for over 60 highly motivated youth, a paid Equity Advocacy Internship, a Green Jobs Youth Pathways Portal, and a Teacher Fellows Program, working with hundreds of educators to design new models of problem-based, place-based learning around a shared vision of ***educating for sustainability.***

We focus on middle school and high school youth, the teachers and school districts that guide their learning, and the community stakeholders, local government and business leaders who are relying on the next generation to be engaged voters, informed taxpayers, conscious consumers, and employees who can create and lead sustainability initiatives.

Visit: https://www.sustainabilityambassadors.org/