GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2301 | HOW SMART IS YOUR SEWER?

SHREWD SANITATION

Image Credit: Great Lakes Now

OVERVIEW

This lesson will explore the phenomenon of **water pollution** from combined sewer systems in the Great Lakes by learning about the smart sewer technology developed at Notre Dame and implemented in South Bend, IN. Students will learn about the technology, the water pollution problem it is trying to solve, and engineer a model sewer system of their own using household materials to transport water a distance.

LESSON OBJECTIVES

- **Know** about the smart sewer technology being used in cities like South Bend, IN and Buffalo, NY
- **Understand** the water pollution problem posed by combined sewer systems
- **Be able to** engineer a gravity sewer to transport water from one location to another

WHAT YOU'LL NEED

- Computer or mobile device with Internet access to view video and online resources
- Notebooks and pencils
- Chart paper
- Sticky notes
- Markers
- Lab supplies (see individual activities for a full list)
- Copies of the Student Handouts

INTRODUCTION

Sewer systems transport water underground using a combination of gravity and technology. Combined sewer systems use the same pipes to carry rainwater and wastewater away from residential and commercial areas. That sewer style, though less common in newer cities, can cause for sanitation problems when there is heavy rainfall in an area, because if the volume of water gets too great too quickly water management systems can get overloaded and back up into basements or flood roadways unless the pressure is released through drainage. What's more is that the mixed water can contain pollutants and harmful pathogens, such as E. coli and salmonella. Some cities are using technology to help with this problem.

This lesson includes multiple activities, including lab activities, that can span the course of several sessions or be adapted to fit the needs of your group's meeting format.

Some prior knowledge* with which students should be familiar includes:

- states of matter
- pressure, force, and density
- gravity
- volume and how it is measured/calculated

Follow this QR Code or hyperlink to the Episode Landing Page!

***Check out our full collection of lessons for more activities related to topics like thes**

****The sequence of these activities is flexible, c can be rearranged to fit your teaching need**

NGSS CONNECTIONS

Phenomenon: Water Pollution

- MS-LS2-1
- MS-ESS2-1
- MS-ESS2-4
- MS-ESS3-2
- MS-ETS1-2
- SEP-2
- SEP-3
- SEP-6

During the course of the lesson, students will progress through the following sequence** of activities:

- Class discussion to elicit and activate prior knowledge about **sewers**
- Demonstration of how a siphon works
- Teacher notes on sewer systems
- Watch a segment from *Great Lakes Now*
- Class discussion to debrief the video
- Read about **water infrastructure in** Ontario
- Engineer a gravity sewer to transport wastewater a set distance
- Create a self-starting siphon and compare design styles for efficiency

The lesson progresses through three major sections: **launch, activities, and closure.** After the launch of the lesson, you are ready to begin the lesson activities. Once finished with the activities, students will synthesize their learning in the closure. You can select the activities that are best suited for your learners and teaching goals, and then sequence them in a way that makes sense within your learning progression and the scaffolds of the lesson.

If you use this lesson or any of its activities with your learners, we'd love to hear about it!

Contact us with any feedback or questions at:
GreatLakesNow@DPTV.org

TEACHER BACKGROUND INFORMATION

by Gary G. Abud, Jr., Great Lakes Now Contributor

**This information can be presented by the teacher as notes to students at the teacher's discretion.*

A **sewer system** is like a big underground river that carries away dirty water and waste from our homes, businesses, and streets. It also allows rainwater to drain off of our roads and walkways to prevent flooding.

The dirty water goes down the drain in our sinks, toilets, and showers and flows through pipes underground to a treatment plant. At the treatment plant, the water is cleaned and then released back into the environment, including into natural bodies of water or seeping into the ground—but only after it is treated.

Some cities have separate underground pipes for rainwater and wastewater, while others have **combined systems**. In either case, when there is heavy rainfall in a short amount of time, the sewers can get overwhelmed and not be able to transport water away from cities fast enough. This leads to backups and flooding. If this happens in a combined sewer system, the result can be disastrous, because wastewater can go where it is not supposed to be: backing up into homes and businesses or dumping out into natural bodies of water.

You can think of it like the flow of traffic. Whereas a freeway has multiple lanes to accommodate lots of cars, a combined sewer system has multiple pipes to allow a large volume of rainwater and sewage. But when too many cars are trying to use the same lane, traffic can get congested; similarly, a combined sewer system can become overwhelmed when too much stormwater and sewage are trying to flow through the same pipes. This can cause a "backup" in the system, similar to a traffic jam. That's why separating the stormwater and sewage systems can help alleviate backups in a combined sewer system.

Heavy rains can overload drainage systems because they produce large amounts of water in a short period of time. And since all of the pipes of a sewer system are interconnected, eventually enough water in the main line will start to push back up into the lines of the homes and businesses where the sewage came from. It is kind of like the way that the water went up the straw when it was put in the container of water in the siphon demo. Homes that are not on higher slopes of land tend to drain more slowly and are particularly susceptible to flooding or backups.

A sewer **backflow preventer** is a device that is installed in the sewer system to prevent dirty water and waste from flowing back into our homes and streets. It works by keeping a one-way flow of water in the pipes, so that dirty water can only flow away from our homes and streets, and not back into them. This is especially important in higher flood potential areas.

A **smart sewer system** is a type of sewage management system that uses advanced technology to monitor and control the flow of wastewater and rainwater through the sewer network. This technology allows for real-time monitoring of the sewer network, early detection of blockages or leaks, and proactive maintenance to prevent problems from occurring.

Smart sewer systems typically use sensors, cameras, and other devices to gather data about the condition of the sewer network. This data is then analyzed by computer systems to identify potential issues, such as blockages, leaks, or overflow events. Overall, Smart sewer systems can help to improve the efficiency of sewage management, reduce the risk of flooding, and protect the environment by reducing the amount of untreated wastewater that is released into the environment or homes.

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities. It helps students to begin thinking about the topic at the center of the lesson.

1. Ask students to list out on a piece of paper five things that come to mind when thinking of **sewer**.
2. Have students pair up with a partner to share their five ideas with each other. If any ideas appear on both lists, have students circle those.
3. Then, engage students in a whole-group discussion to ask them to share any ideas that were circled.
4. Generate a list of the circled ideas.
5. Ask for volunteers to share any ideas that were not circled that they think are really important to include in this topic.
6. Generate a separate list of those ideas.
7. At the end of making the two lists, have students copy down one single list of all the circled ideas and important ideas in their notebooks or on their paper.
8. Ask students individually to rank the ideas in the list from most to least relevant.
9. Ask for some students to share which term should be most relevant and why they think that is. Engage the whole group in discussion to arrive at consensus about the most relevant idea related to **sewer** that they already know about or that came to mind during this exercise.

Image Credit: Great Lakes Now

B. Bridge to Learning

After the warm-up activity has concluded, help students prepare for the learning that is about to come by demonstrating how a siphon works:

1. Have a tall clear plastic cup / beaker filled to the brim with water next to a shorter empty cup / beaker.
2. Take a clear plastic flex straw, without bending it, and submerge it in the water. Have students observe that the water "went up" the straw.
3. Take another clear plastic flex straw, bending it so it could hook on the side of the tall cup. Close off the opening of the short end with your finger and submerge the opening on the longer end of straw in the large cup until the straw rests on the rim of the cup.
4. Before removing your finger, hold the bendable segment of the straw in place on the edge of the container while you aim the short end of the straw down over the side pointing at the opening of the smaller cup next to the large cup.
5. Ask students to predict what will happen when you remove your finger from the opening on the short end of the straw. Have them share some ideas, or give them a few options to vote for (e.g., nothing will happen, water will flow, etc.)
6. On the count of three, take your hands off of the straw completely and back away. ***Note***: water should be flowing, but you should practice this beforehand
7. Ask students to observe what they see, and predict what will happen some time later. When it stops, have them observe the water level and discuss what significance that might hold.
8. Explain to them how a siphon works.

C. Background Information Notes

Explain that we are going to build on these ideas and learn more about **sewers** in this lesson. Then proceed to give the notes from the **Teacher Background Information**.

ACTIVITY 2: READ ABOUT WATER INFRASTRUCTURE

It's true that technology can help improve our water management systems, including dealing with stormwater and sewage, but making such improvements in a city's infrastructure can be costly. This article looks at the cost of water in Ontario.

In this activity, students will use a **Think Pair Square Protocol** for discussing what they will read about this very topic.

First, have students partner up and distribute the article **Ontario Faces Uneven Investment in Water Infrastructure** by Andrew Reeves from *Great Lakes Now*. Allow time for students to individually read the article, and have them jot down three things they took away from the article using the **Rose Thorn Bud Protocol**—in their notebook or using the handout.

Then, give students time after reading to discuss the article that they read with their partner. Have students share their rose, thorn, and bud with each other, including how those points connect to each other. The pair should come up with a statement to summarize all of their article takeaways.

Next, have two student pairs join up, standing near each other to form the four corners of a square, to discuss the article and what they talked about in their pairs. Encourage them to come to a consensus about which point they found most important or interesting in the article.

Teaching Tip:
If the reading level of the article is going to be tough for some students to read individually, have partners or small groups read the article together aloud while each follows along.

Image Credit: Great Lakes Now

Last, have each group craft a summary statement of the most important point from their discussion and ask for a volunteer in each group to share that key point with the whole group.

As student groups share their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks.

Once the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

Who do you think should pay for the upgrades to water infrastructure systems: local governments, individual residents, both, or neither?

After giving the groups some time to discuss this question, invite conversation from the whole group to see what consensus can be reached.

Be sure to encourage students to support their claims with evidence and reasoning as they discuss in the whole group.

ACTIVITY 3: ENGINEER A MODEL SEWER SYSTEM

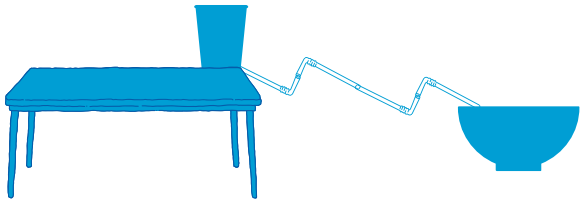

Image Credit: Gary Abud, Jr.

In this activity, students will engineer a simple gravity sewer to transport "wastewater." This will simulate how sewage is drained away from homes or businesses into a city's waterways using gravity.

Materials:

- Water
- Clear plastic cups
- Clear plastic straws (straight, flexible, or loopy)
- Sharpened pencil
- Modeling clay
- Scissors
- Tape
- Food coloring
- Poppy seeds
- Bowl or disposable aluminum 1/4 size pan

Before beginning, determine if all groups will have the same parameters, or if the level of challenge can be variable, by choosing how many straws they can/must use, what minimum distance they need the water to travel, how many turns are required, and where the starting and ending locations* will be for the "home" (e.g., the cup) and the "sewer" (e.g., the bowl).

Have students team up in pairs to make their sewers and make materials available for them to get. Explain the task and challenge ahead of them: to make a sewer that will move water a certain distance. Elaborate that they will be building a gravity-powered sewer drainage system to simulate dirty water being carried away from a home and dumped into a sewer.

The cup will represent the home; the straws the home's sewer line; food coloring and poppy seeds are waste; and the bowl will represent the city's main sewer.

***Teaching Tip*: Staircases or ramps make great locations for this challenge.**

First, have them use the sharpened pencil (or scissors) to poke a small hole close to the bottom in the side of the cup. The hole should be just smaller in diameter than the straw. Snugly insert a straw through the hole; it is up to students which end of the straw to use. They can seal around the hole using clay or tape if needed to prevent leakage.

Next, allow students to determine how they will connect and orient the angles of multiple straws to get their sewer to travel where it needs to, given any established parameters. Monitor them as they construct their sewers to remind them they can seal straws together using tape as needed and to ensure the angle of the straws generally slopes downward.

Then, allow them the opportunity to test their sewers with clean water by filling another cup and pouring into their cup to track the water as it makes its way into the bowl. Allow them to make any adjustments, add supports, or seal any leaks as needed. Encourage them to keep track in their notes of any "upgrades" they made to their sewer system before the final challenge.

Last, give students the challenge to move some "wastewater" through their sewer. They can make their own wastewater or you can provide it premade to save time. Either way, have them pour the "wastewater" into their sewer and observe it travel into the city's "main line." Ask them to consider what's happening, how it is happening, and why it is happening.

Extend their thinking by having multiple groups drain their sewers into the same bowl at the same time, and ask them to notice what's happening? As they see the bowl starting to fill, ask them to consider what would happen to the bowl if we were to also pour some additional clean water (e.g., "rainwater") into the bowl at the same time the sewers were draining?

Help them to see the need for a sewer system to have its own drainage system that goes somewhere else, like a local body of water, and why its key to keep the rainwater separate from the raw sewage.

ACTIVITY 4: CREATE A SELF-STARTING SIPHON

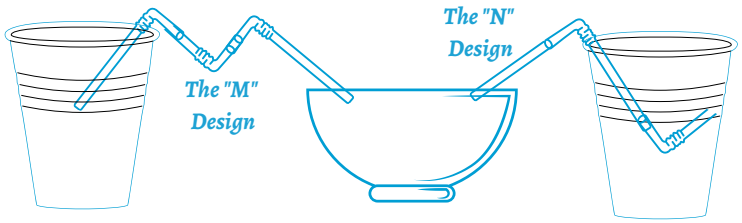

Image Credit: Gary Abud, Jr.

In this activity, students will create a self-starting siphon inspired by the siphon demonstration they observed in the launch phase of the lesson.

Materials:

- Water
- Clear plastic cups
- Clear plastic flex straws
- Scissors
- Tape
- Food coloring (optional to tint the water)
- Bowl or plastic container

There are two designs that can accomplish this. Have students work in pairs to create one of each design, so they can compare how each one works compared to the other. You may wish to create one of each design ahead of time on your own to test and demonstrate them to students before this experiment.

Ask students to recall the demonstration from the launch phase of the lesson with the siphon. Draw their recollection to how you had your finger over the hole of one end of the straw while placing the other end in the water. Discuss with them how releasing your finger allowed the water to fill the straw and rush up the one side, spilling over the flexible section of the straw (because the water rose up the straw to match the water level in the cup) and then it began to pour over and down the other side of the straw, which because of the attractive forces between the water molecules started to cause the rest of the water to follow and flow out the straw.

Explain the task and challenge ahead of them: to create a self-starting siphon. You can demonstrate how one, or both, of the designs work. Show the difference in how the self-starting siphon works when place slowly vs. quickly into the water. Ask students what they observe and why that is. Discuss their responses.

First, distribute the materials to students and have them fill their plastic cups to the brim with water and place it next to their small containers. They can add food coloring to the cup before filling with water, if they choose.

Next, give them time to create the siphon designs—"M-style" and "N-style"—based off of the models you showed them. They can use the scissors to cut slits in the ends of the straw, or to make the segments of the straws shorter. Alternatively, they can fold the ends of the straw (think folding a taco) to help them fit inside one another. They'll need three full flex straws for the "M" design and two full flex straws + one extra straight segment for the "N" design.

Note: Make sure they orient their siphons to have the flexible segment of the straw positioned to rest on the edge of the cup, and ensure that there is a height difference between the peaks of the "M" design variation (the peak touching the cup rim should be lower in height than the other peak when the "M" is on the table standing up. Once assembled, have students seal the connections between the straws with tape so they are air/water tight.

Then, allow them the opportunity to test their siphons and make any adjustments. Remember that the siphons need to be quickly put into the water in order to start flowing. But they can also check for leaks and seal those up with more tape, as needed, if water doesn't flow.

Last, once the siphons are working, have students compare the two designs to see which one is more effective at transferring water. Have them make qualitative and quantitative observations about each design to support a conclusion about which design is best.

Last, engage the whole class in discussing their findings to arrive at a consensus about which design of self-starting siphon works best and the reasons they would give to support their conclusion. You can extend student thinking by having them draw a particle diagram to represent how the siphon works in terms of forces, air pressure, and water pressure.

LESSON CLOSURE

After the conclusion of all the activities, help students to make connections* between everything they did in the lesson and what they learned overall.

A. Free Recall

Group students in pairs or triads (e.g., in groups of 2-3 partners) and distribute the **Free Recall Protocol handout**, Alternatively, you can have students do this in their notebooks. Set a 3-min timer and have students generate a list of everything they can remember learning about in this lesson related to the central topic of the lesson. This doesn't have to be in depth, just whatever each group can call to mind. Have them draw lines between any terms that relate to one another. After the timer finishes, give groups a chance to volunteer to share aloud 2-3 things from their free recall lists and any of the connections that they made with those. Jot down any ideas that come up multiple times during the shareout for the whole group to see.

B. Lesson Synthesis

Give students individual thinking and writing time in their notebooks to synthesize their learning, by jotting down their own reflections using the **Word, Phrase, Sentence Protocol.**

In the Word-Phrase-Sentence Protocol, students write:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

Image Credit: Great Lakes Now

C. Cool Down

After the individual synthesis is complete, students should share their synthesis with a partner.

After sharing their syntheses, have students complete a **3, 2, 1 Review** for the lesson with their partner, recording in their notebooks or, optionally, on exit ticket slips to submit, each of the following:

- **3 things** that they liked or learned
- **2 ideas** that make more sense now
- **1 question** that they were left with

Invite several students to share aloud what they wrote in either the synthesis or 3, 2, 1 Review.

Lastly, ask one student volunteer to summarize what has been heard from the students as a final summary of student learning.

**Optionally here, the teacher can revisit the learning objectives and make connections more explicit for students.*

Teaching Tip: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.

NAME: _____

A Word, Phrase, Sentence Protocol

What is a **word** that you thought was most important from this lesson?

What is a **phrase** that you would like to remember from this lesson?

What is a **sentence** that sums up what you learned in this lesson?

3, 2, 1 Review Protocol

What are **3 things that you liked or learned** from this lesson's activities?

-
-
-

What are **2 ideas that make more sense** now to you?

-
-

What is **1 question that you were left with** after this lesson?

-

NAME: _____

Free Recall Protocol

With 1-2 partners, generate a list of everything you can remember learning about in this lesson related to the central topic of the lesson. Draw lines between any terms that relate to one another.

NAME: _____

4 Notes Summary Protocol

OOOH!

Something that was interesting to you

AAAH!

Something that became clearer; an "ah-ha" moment

HMMM...

Something that left you wanting to learn more

HUH?

Something you questioned or wondered

Sum It Up Statement:

Summarize your group discussion about your 4 Notes Summaries below:

NAME: _____

Think Pair Square Protocol

THINK

Write down your own individual ideas

PAIR

Summarize what you and your partner discussed

SQUARE

Summarize what your group discussed

NAME: _____

Rose, Thorn, Bud Protocol

ROSE

Something that "blossomed" for you in your learning

THORN

Something that challenged your thinking or was difficult to understand

BUD

Something that's new and growing in your mind — a "budding" idea