

“Inquiry Inc. and the Case of the Missing Ducklings”



Where Does Water Go?

The Water Inquiry Story Project of Smith College creates interactive stories that encourage young readers to explore scientific questions through group discourse, field investigations and inquiry-based problem solving. Our stories:

- Invite students to ask questions, carry out investigations, and design solutions in alignment with **Next Generation Science Standards**.
- Demonstrate and support the development of **knowledge building strategies**.
- Promote collaboration between **students, characters, and the community**.
- Incorporate theoretical findings in education and narrative psychology.
- Function as traditional read-aloud texts and/or **interactive stories** that engage readers in helping story characters solve problems through **inquiry activities**.



THINK AND TALK

Interactive investigations prompt students to *think and talk, think and go, think and make*. Six inquiry activities are optional and adaptable.

Your Educator Toolkit Includes:
- Our illustrated, interactive story: <i>Inquiry Inc. and the Case of the Missing Ducklings</i>
- Inquiry Activities: handouts, student work, and suggested four class-period plan
- <i>Water Inquiry in Room 102</i> , a narrative overview of the project in a 1 st grade classroom
- Pre- and Post- Assessment suggestions and materials
- Educator resources: <i>Water in Northampton & NGSS Engineering Standards</i>



“I have too many ideas!” ~1st grade Inquiry Inc. reader

Inquiry Activities
Designed for interactive read-aloud of
Inquiry Inc. and the Case of the Missing Ducklings

Table of Contents

Lesson plan suggestions, student work samples and reflections are created by Katy Butler and First Graders at Jackson Street School. Suggested time is 4-5 class periods. Teachers are encouraged to adapt the lessons and Inquiry Activities for their students and school settings. Before reading story, see optional *Pre-Assessment: Cloud, Faucet, Drain* in teacher resources.

Inquiry Activity #1. Think and Talk.

Inquiry Activity #2. Think and Go.

- Investigate school grounds to locate storm drains.
- Map or satellite photo of school grounds to laminate (optional, if available)

Inquiry Activity #3. Think and Talk.

- Idea-building. Group chart.

Inquiry Activity #4. Think and Talk.

- Show thinking with diagrams.
- Drain and duckling photos to copy for small group work.

Optional Experiment after Inquiry Activity #4.

- Exploration of water flow and how storm drains work. See materials list.

Inquiry Activity #5. Think and Do.

- Brainstorm solution using tools on toolbelt.
- Handout of tools and toolbelt to laminate and velcro.

Inquiry Activity #6. Think and Make.

- Design and test model storm drains. See materials list.
- Photos of storm drains to copy and laminate.
- Sample photos of 1st grade storm drain models.

Teacher Resources:

- *Water Inquiry in Room 102*: Narrative by Katy Butler
- Pre-Assessment: Cloud, Faucet, Drain
- *Water in Northampton*: Overview for teachers
- Next Generation Science Standards: Engineering Design K-2 & 3-5

Day One (suggestion)

Introduce story. Optional to read character introductions at the end. Read pages 2-4.

Inquiry Activity #1. Think and Talk.

Identify Anna's problem. What would you do if you were Anna?

Options:

- You might have students share out loud.
- You might record student's ideas on an easel or chart paper as they share.
- You might have students turn and tell a partner their ideas.



Reflections on the lesson:

I found it helpful to have students think quietly to themselves, share with a partner, and then out loud to the whole group. After they shared a solution, I included follow up questions such as:

"Why would that be helpful?"

"Would you need anything else?"

"Why do you think that will work?"

Once students had all had a chance to share, I reflected back to them what I had heard the overarching themes were (ours were: more people would be better, you could use a longer arm, you will probably need a tool).

Read aloud pages 6-10.

Inquiry Activity #2. Think and Go.

Investigate your school grounds and find as many storm drains as you can.

What do you notice inside of the drains? Where are the drains located? Pick one to sketch.

Materials:

- Clipboards
- Index cards or white paper for each student
- Pencil for each student
- Flashlights (one for each group)
- *Optional: laminated pictures of the school from above, dry erase markers*

Preparation: Students could be paired up or in small groups. Adult volunteers would be helpful so that children can explore in supervised small groups.

Optional: use Google Earth to find a picture of the school grounds. Print these in color and laminate so children can use dry erase markers to mark where all of the storm drains are.

Students divide into small groups with an adult in each group to explore the school grounds. Each student has a clipboard with an index card or blank white piece of paper and a pencil. Each teacher has several flashlights.

Optional: Have students come back together as a group and share their observations.



Reflections on the lesson:

I found it helpful to have adults video or audio record what students were thinking in the different groups. It would also be helpful for adults to take notes as well.

Students were very curious about what could and couldn't (or should and shouldn't) go into a storm drain. Many of them noticed their hands couldn't fit through most storm drain covers.

Jackson Street School



100 200

400 Feet

Source: Esri, DigitalGlobe, GeoEye, Ikonos, USA, USGS, AEX, Getmapping, Aerogrid, IGN, ICP, swisstopo, and the GIS User Community

Day Two (suggestion)
Read aloud pages 12-16.

Inquiry Activity #3. Think and Talk.

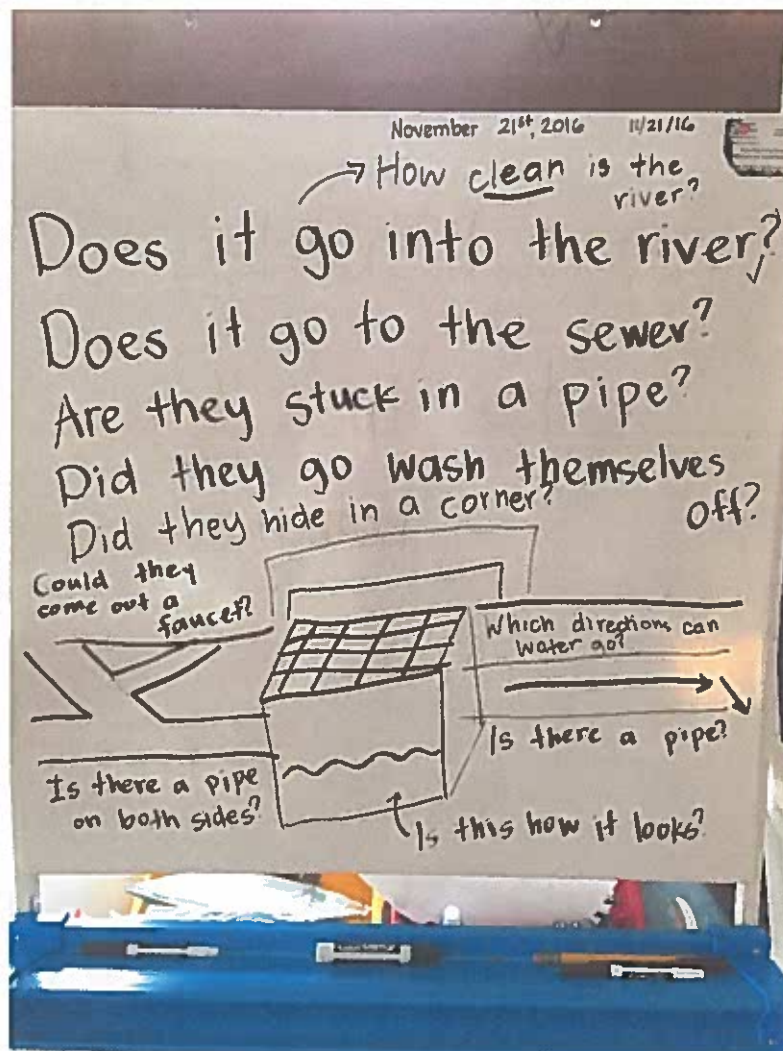
What other questions do you have for Inquiry Inc? Where do you think the water goes?

Options:

- You might have students share out loud as a whole class discussion.
- You might record student's ideas on an easel or chart paper as they share.
- You might have students turn and tell a partner their ideas.

Reflections on the lesson:

I recorded student's ideas on the easel. We ended up making a quick sketch of what we thought a storm drain might look like which prompted us to ask more questions.



Read page 18.

Inquiry Activity #4: Think and Talk.

Think about their ideas. How would you answer Anna's question: where does the water go? Where could the ducklings be? Do you have any other ideas about how the drains work?

Materials:

- Large white paper for each group with a photo of a storm drain glued on top and a black line to indicate the surface.
- Two small duckling photos for each group, paper clipped onto the poster.
- Pencils, fine lines, markers, colored pencils and glue available to partners.



Show students the prepared posters and explain that they will work with their partner to show their thinking. What is underground? What does a storm drain look like? Where does the water go?

Let them know that they will also have two small duckling pictures, and that they can indicate on their poster where they think the two missing ducklings might have gone.

Students work in partners to write and draw their thinking.

Optional: Give students a chance to come together to share their posters and their ideas.

Reflections on the lesson:

Students were immediately engaged in this lesson and very motivated by the tiny duckling pictures. It was interesting to see what they thought might be underground and definitely motivated me to think past just the story to their developing understanding of water systems.





Optional Lesson After Inquiry Activity #4 (extra class period)

The next section of the story begins with the assumptions that students know that water flows downhill and that storm drains are connected to each other through pipes underground. It also assumes that students will understand that increased rain will cause storm drains to fill and water to move quickly through the system. If these understandings are not ones that your students have grasped, or if you would like them to have hands-on experience of these phenomena, the following lesson might be appropriate for your group.

Exploration of water flow and how storm drains work underground

Materials/ Resources:

- Slope (preferably brick, concrete, asphalt)
- Bucket of water
- Chalk (draw three "storm drains". One towards the top of a hill, one in the middle, one towards the bottom.
- Two small rubber ducks (optional, purely for visuals)
- A small water pitcher for each group of students (to act as the "rain").
- A tray with raised edges to hold spills.
- On the tray: two transparent plastic cups with holes punched in them (one with a hole punched towards the middle, one with a hole punched towards the top. A hole puncher may be used, but a hot nail may be necessary to get the hole in the middle. The holes must be able to fit the straw you choose), a transparent straw that will fit through the holes, small leaves to act as the leaves at the bottom of the storm drain, 2-3 blocks (with the ability to access more from a block or math center).
- Food coloring (preferably one color for each group to help differentiate), gold/yellow glitter to symbolize the ducklings.

Procedure (Outside)

1. Begin by encouraging students to retell what has happened so far in the story. Focus on the moment the characters are in right now. "Inquiry Inc. is trying to solve a problem, and they need our help! They don't have time to stop and investigate, so we have got to do some experiments for them!"

2. Tell students they will go outside to study how water travels between drains. Have the class stand by the drain in the middle. Place the ducklings on the "storm drain" as a visual reminder of where they started. Point out the two other storm drains.

3. "Imagine we are Inquiry Inc. We are standing at the storm drain where we last saw the ducklings and trying to figure out where they might have gone. Think about what you know about water and hills. Do you predict that the ducklings might be in the drain up the hill, or down the hill? Why or why not?"

4. If students are curious, try pouring the water uphill. Share observations.

5. Now have students envision the weather in the story. To simulate the rain, tell students you will pour water on the storm drain and see where it travels. Invite students to follow the water. Bring the ducklings to place on the drain at the bottom of the hill and discuss whether inquiry Inc. might want to check a downhill drain.

Procedure (Inside)

1. Bring students inside and let them know they will create small models of storm drain to help explain to Inquiry Inc. how they work and where they might find the ducklings. Invite the students to use the items on their trays to connect the two "storm drains" (cups) with the "pipe" (straw). Have them create these storm drains on a slope (using blocks). Provide scaffolding to groups as needed as they create their models.
2. Once groups feel as though they have a model that will work, have them place the small leaves in the bottom of the upper storm drain. Sprinkle in some "ducklings" (glitter) and pour in some water from a bucket (regular water you might find in a storm drain). Next, put a couple drops of food coloring.
3. Have students use their smaller pitchers to pour in the "rain". Does the storm drain overflow? Does it travel to the next drain?
4. Let students continue experimenting with placement.
5. Optional: come together as a group to share models and discoveries.



Reflections on the lesson:

This lesson could have been improved by placing the second hole in the cup significantly lower than the first. We wouldn't have had to fill them so high, causing many spills. The colored water worked well for students to recognize their drains, many went back to them to make improvements during choice time.

Day Three (Suggestion)

Read page 20.

Inquiry Activity #5. Think and talk.

Think about the tools that Inquiry Inc. has. Brainstorm a possible solution as a class to rescue the ducklings!

Materials:

- "Toolbelt" laminated with pictures of tools velcroed to it



© Can Stock Photo - csp16238595



Options:

- You might have students share out loud as a whole class discussion.
- You might record student's ideas on an easel or chart paper as they share.
- You might have students turn and tell a partner their ideas.
- You might have students write or draw on an index card.

Reflections on the Lesson

We actually ended up using some real tools during this lesson. Young learners are so concrete, many need to see and touch the tools to come up with ideas. It was helpful for me to model their thinking by building in front of them. I did end up pushing their thinking by mentioning that they could use found objects. I had them think about things that may be nearby and they came up with branches, leaves and rocks.





wiseGEEK







Day Four (suggestion)

Read pages 22-25.

Inquiry Activity #6: Think and Make.

Why do we need drains? What else falls in a drain? What are some ways drains could be improved so that fewer objects fall through? Design your own drain using these ideas.

Materials:

- Water (small pitcher for each group)
- Laminated pictures of different drains
- Pencil and large white sheets of paper (one for every group of 3-4)
- A bucket or pail for each group
- A collection of small objects to test what falls through the drains (might include leaves, sticks, woodchips, dirt, marbles)
- Small rubber ducks (to test drain)
- A collection of other drain construction materials: Paint stirrers, paper making screen, metal rods, wooden rods, popsicle sticks, pipe cleaners, coffee filters, mesh, fly swatters, aluminum foil, parchment paper, saran wrap, scouring brush replacements
- Possible book resources: The Most Amazing Thing by Ashley Spires or Rosie Revere, Engineer by Alison Beaty

Procedure:

Lead the class to think: What DO we want to fall down a drain? What do we want to keep out? What happens if a drain gets covered/blocked? Is there a way to minimize/prevent that?

Tell students that today they will work together to create a drain that lets only water pass through and minimizes clogging from objects such as leaves.

Their drain will need to: hold two small rubber ducks up without sinking/falling for 30 seconds, and let water and some small objects pass through without causing flooding.

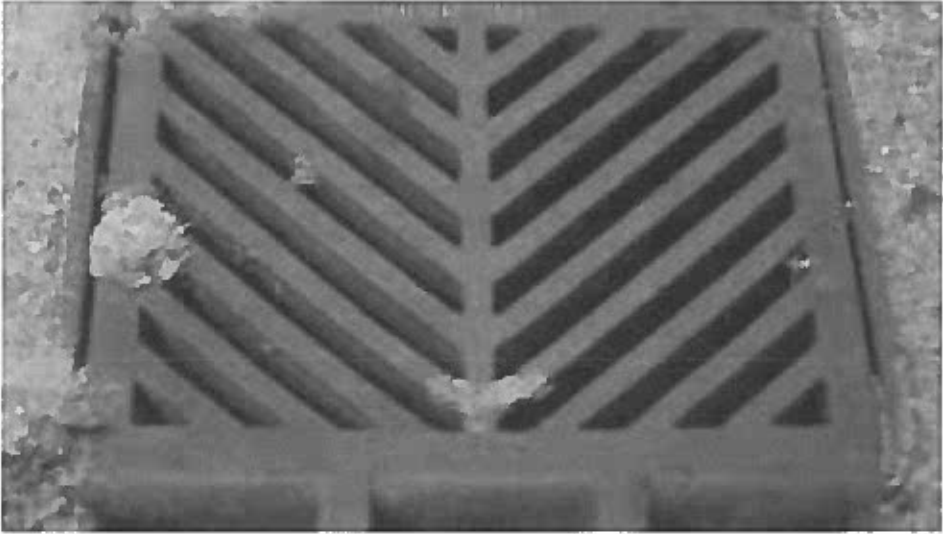
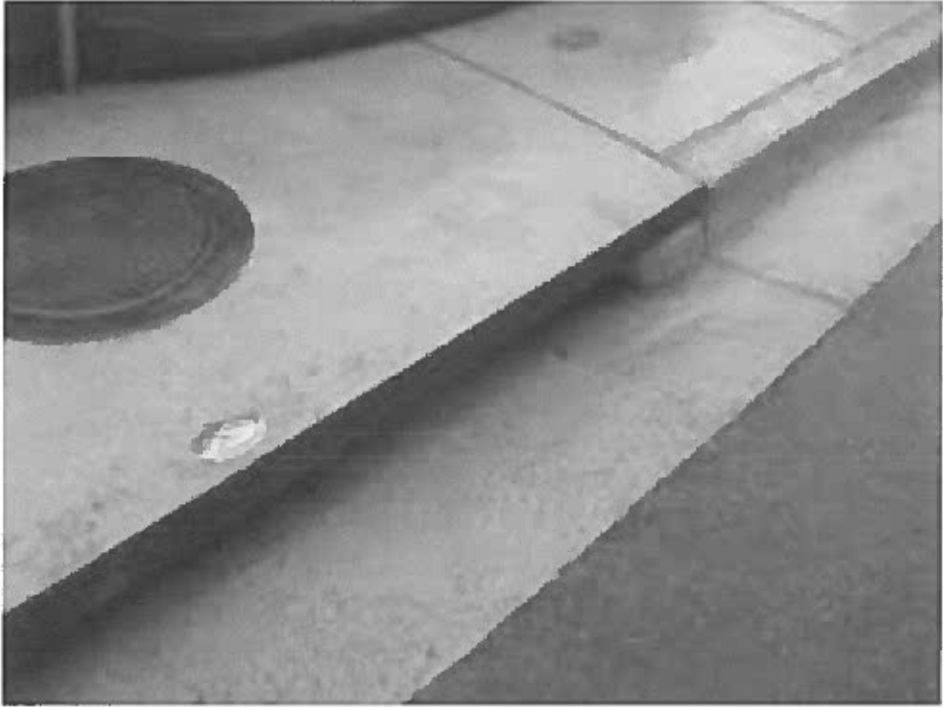
Start by looking at side by side pictures of drains.

- What is the same?
- What is different?
- Which design might work best?



1. In small groups of 3-4, have students sketch using paper and pencil how their drain cover might look.
2. Have students label the parts of their pictures and decide on their materials.
3. Students grab materials and set to work.
4. Student can periodically test their drains by pouring water and items from the collection of small objects.
5. Share out discoveries/mistakes/revelations as a class in order to improve upon designs.







Reflections on the Lesson:

We brainstormed a list of things that should and shouldn't go through a drain. Water was a unanimous decision, but it got trickier when it came to rocks, sand and leaves. Should they be able to fall through the drain? Students disagreed and decided to write that it is acceptable for a little bit of those items to fall through.

The first grade Next Generation Science Standards call for students to make a plan before they begin an engineering project. Here students had the opportunity to collaborate and incorporate many ideas into one design.

See *Water Inquiry in Room 102* for more photos, procedures and drain designs.



"Too Many Ideas"

This drain represents many group members ideas. There is a cardboard layer to catch things that fall into the drain. Above that is a filter to let only water pass through. There are sticks with round balls at the end to stir the contents of the bottom of the storm drain. Finally, sticks and aluminum foil on the sides keep it steady and secure.

Lesson plans, resources, reflections and student work created by Katy Butler and Jackson Street School First Graders. Fall, 2016.

"The Scooper"

This drain has a mesh top covered in plastic wrap. The plastic wrap is pierced with tiny holes to allow water to pass through. The small white drain catches objects before they fall through. If there is a lot on top of the drain, a sensor activates the scooper which scoops all of the leaves and debris into a hole that is directly connected to the grass.



"The Compactor"

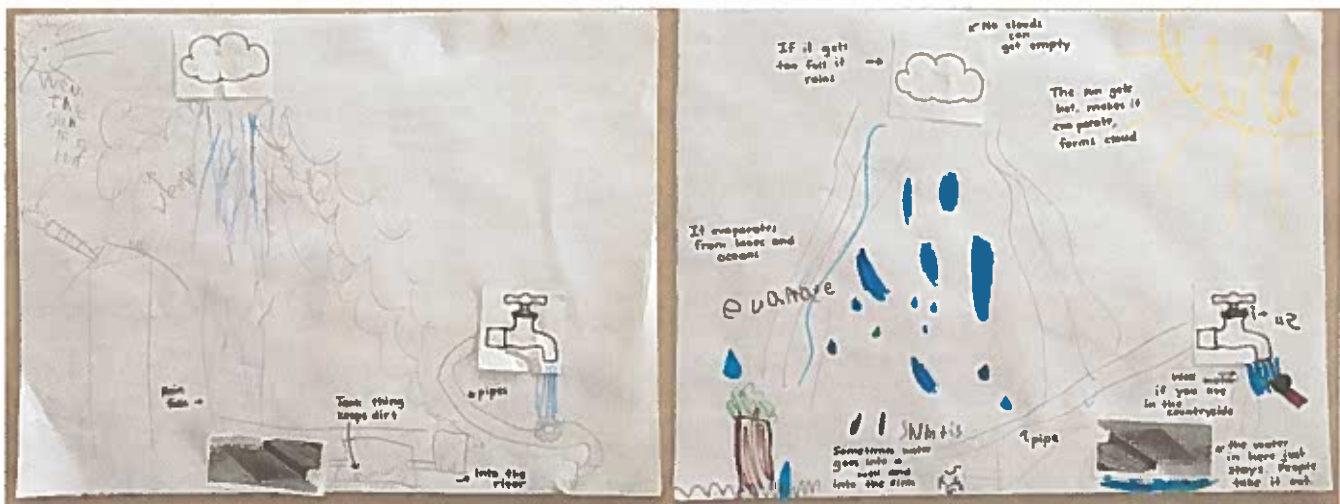
This drain is made up of paint sticks taped closely together. Only water can get through the tiny slits. On one of the far ends is some duck tape, pierced with tiny holes. On the other is a bigger hole so large objects can fall through to avoid clogging the drain. A mechanical arm presses the leaves and debris into the hole, compacting it and making space for more.

Water Inquiry in Room 102

Opening questions

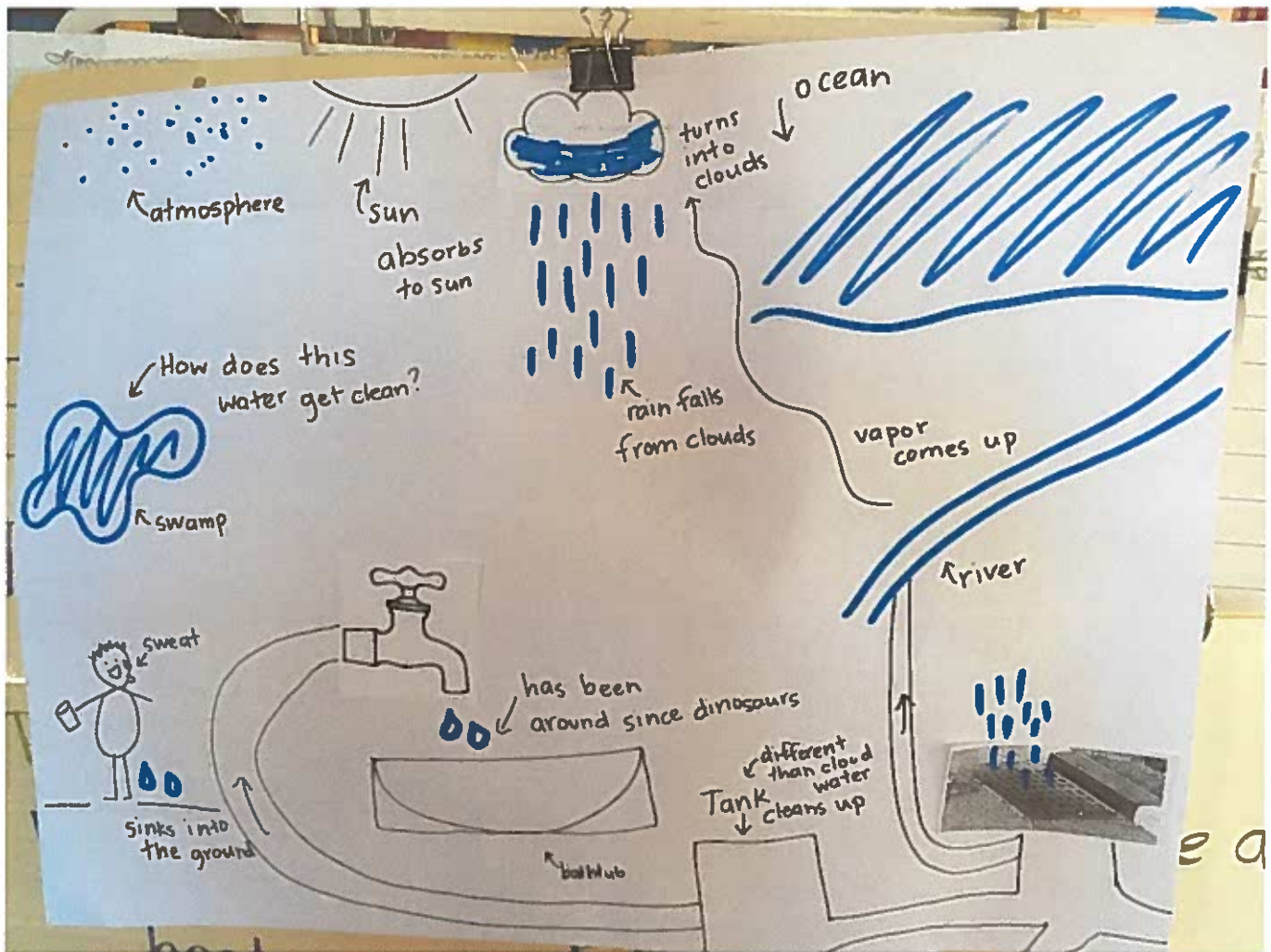
The Water Inquiry project in Room 102 began with a large sheet of white paper and three small images. As students sat in pairs at their tables, I handed out the supplies. "Where does water come from?" I asked them, "and where does water go? Use these pictures to help you tell the story of water."

Students quickly set to work. Most began by glueing the picture of the cloud somewhere near the top of the page and the storm drain near the bottom. Where to put the faucet was less clear to the students: "Why don't we wait until we draw the house" I heard one child say.



I walked around chatting with students about what they had drawn. I asked probing questions such as "Can you tell me what this is?" or "What happens after this part?". In many groups I wrote the words they told me as they pointed to the different parts of their maps. Most posters showed water falling from the clouds, a pipe connected to the faucet and some way to catch the water (swamps, oceans, catch basins).

Once students had a chance to represent their ideas on posters, we came together as a class to make a shared map. I began by asking them where to place the three images. Next, I took suggestions on how to represent the water in between.



Two interesting conversations emerged from our representation:

Can water run out?

“No, if clouds are empty rain fills them up again.”

“No, our water has been around since the dinosaurs.”

“It just keeps going around and around.”

Is all water the same?

“Sweat is not the kind of water that goes into the clouds.”

“Tank and pipe water is different than cloud water.”

“We can only drink the cleaned up kind.”

Inquiry Inc. and The Missing Ducklings

We kept our shared poster in the meeting area for several days, adding to it as necessary. It was now time for us to launch our investigations about water by piloting the interactive story: Inquiry Inc. and The Missing Ducklings. On a bright November morning, we read the first part of the story, where we meet Anna and the cast of Inquiry Inc. Immediately, the students were drawn in to the story thanks to the colorful illustrations and engaging dialogue. After identifying Anna's problem (There are five ducklings stuck in a storm drain!), students were excited to explore the storm drains on the school grounds. In small groups led by an adult holding a map and flashlights, students wandered around the school observing grates and the contents of storm drains.

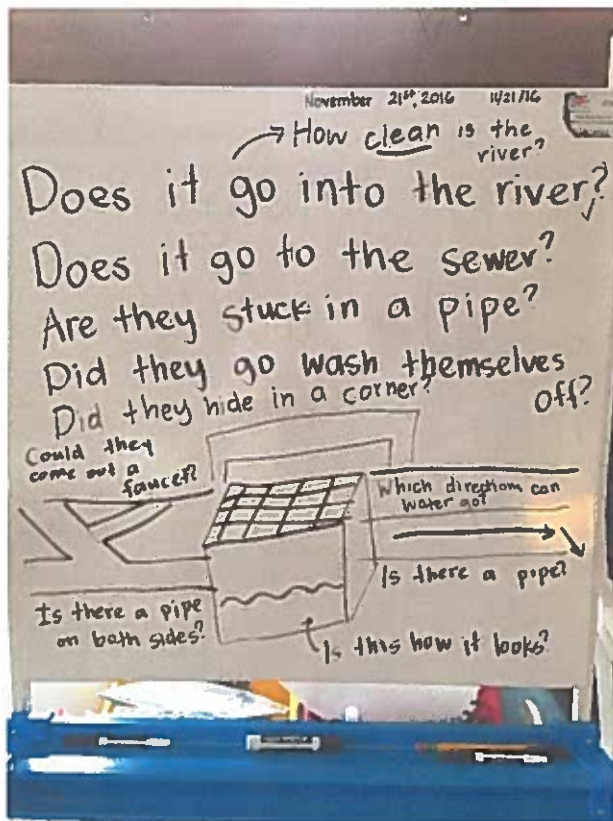


Students crowd around the “disgusting drain”, named for the strong odor of decomposing leaves found at the bottom. This is the only storm drain with a metal grate on top and an opening in the back. Students guess that the duckling must have fallen through this kind of drain. While observing closely, one student drops her pencil down into the drain. This later becomes an important twist in the Inquiry Inc. story!

Students record their words and drawings on clipboards with a simple prompt: I notice. Many students noticed the different kinds of grates covering the storm drains. Several tried to fit their hands or feet through the holes, attempting to reenact how the ducklings could have fallen through.



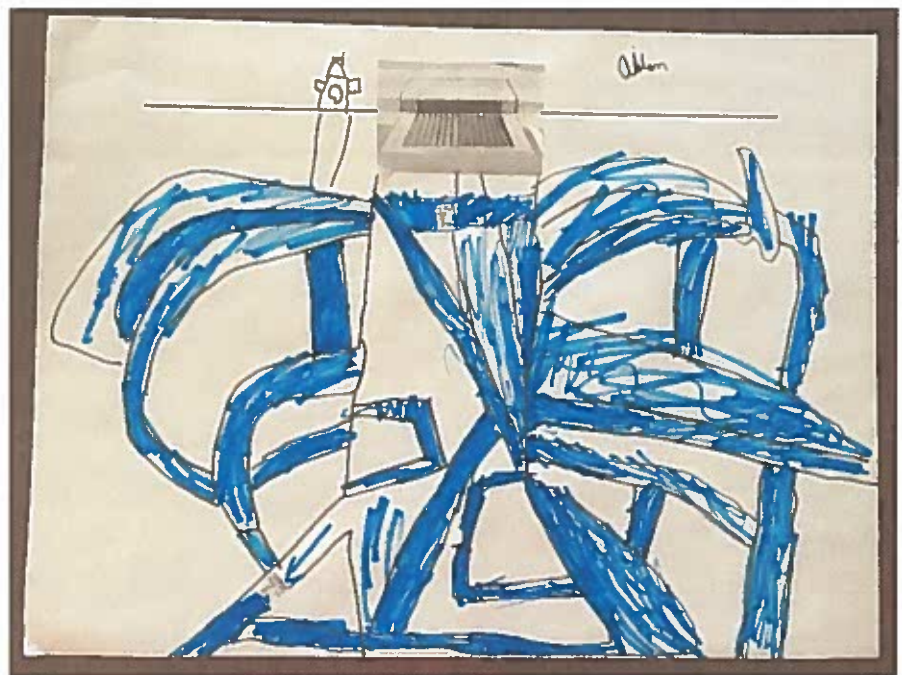
Could they come out of a faucet?



As we followed the steps for inquiry as outlined in the book, we needed to stop and ask ourselves some questions.

Students became fascinated with the idea of where the ducklings could end up. They wondered what it looked like underground, how the pipes were connected, and where they all ended up.

Students were given another large white sheet of paper, this time with a picture of a drain and of two ducklings. This is an example of their interpretation of how the drain systems work underground. The ducklings are caught in the maze of pipes.



How do drains really work?



Students were curious about the logistics of the drains. Unable to see cross-sections underground and armed only with their representations on paper, they set out to build models of storm drains.

Their discoveries included:

- Water flows downhill
- Things in the drain can transfer from one cup to the other if they are small enough to fit through the pipe
- You can siphon water by pushing the pipe (straw) down and then letting it come back up again
- The water won't go through the pipe until it is high enough to reach it
- When there is a lot of water or you pour it quickly, it rushes to the next drain

Students watch the water rushing through the pipe from one drain to the other.

“It’s raining in the story!” someone announces.

“The drains will get full!” someone else exclaims.

“Then what will happen to the ducklings?”

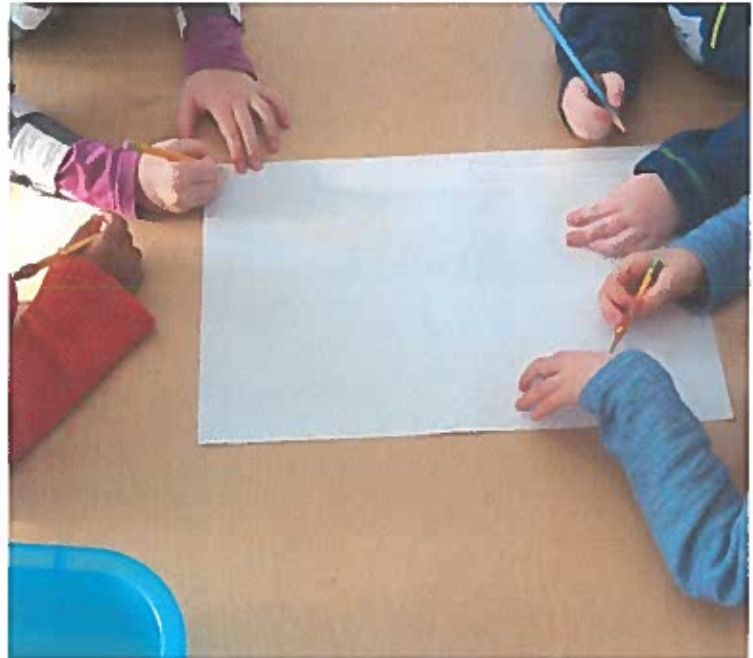
Safe and Sound – Now What?

The students were relieved to read that Inquiry Inc. “listened to their ideas” about storm drains connecting and water running downhill. They were excited that all five ducklings have been rescued by the end of the story. As we read about Inquiry Inc. walking away, we sang their cheer one more time...

Got a problem that won't go away? Inquiry Inc. will save the day!

The final handoff in the first Inquiry Inc. story was to engineer a drain that allows good things to fall through and keeps out items like ducklings. We brainstormed a list of things that should and shouldn't go through a drain. Water was a unanimous decision, but it got trickier when it came to rocks, sand and leaves. Should they be able to fall through the drain? Students disagreed and decided to write that it is acceptable for a little bit of those items to fall through. We decided that in general, trash, large leaves, sticks and branches should not fall through a drain.

Students then broke into groups of four. Led by an adult, they began designing their drains on paper.



Many designs featured a system for allowing water in (small holes, slits in between sticks), a stable upper layer (flat sticks, two layers of aluminum foil, tightly stretched saran wrap).

The first grade NGSS standards call for students to make a plan before they begin an engineering project. Here students had the opportunity to collaborate and incorporate many ideas into one design.



Once they completed their plans, I checked all of their designs.

“What if the openings between the paint stirrers are too wide and rocks can fall through?” I asked this group.

They decided the paint stirrers needed to be touching.

“What if leaves collect on top of your drain and the water can’t fall through the slits anymore?” I pushed.

They agreed to leave one end “open” for more water and larger objects to fall through without getting trapped.

Once the whole group had agreed on their design, I sent them over to grab materials. They was a wide selection, but this group already had a clear idea of what they were looking for!

The materials included:

- Saran wrap
- Aluminum foil
- Paint stirrers
- Book spines
- Fly swatters
- Mesh backpacks
- Sponges
- Filters
- Scouring brushes
- Duct tape
- Coffee filters
- Plastic straws
- Recycled materials
- Rope and twine
- Popsicle sticks



Once a group finished building their first prototype, we tested their drain. First, it had to hold a rubber duck for one minute without the duck falling through. Next, I poured dirt, sand and rocks on top to see what would fall through. Finally, I dumped water to see what would happen.



This group was not pleased with their initial results. The small slits in between the paint stirrers did cause debris to build up, making it hard for the water to flow through. The mesh helped hold the leaves, but there was nothing to move the leaves away once they had gathered. The large opening for water did work – but it worked too well! Large amounts of debris had fallen into the drain, filling it with unwanted objects.

It was back to the drawing board. This group used long dowel rods to envision a leaf removal device. They added duck tape to their wide opening and punctured it with holes to allow only water to flow through. They installed a “pusher” to compact the leaves as they built up.

Satisfied with their improvements, we did a second test. They cheered as they heard the water flow to the bottom of the drain. They demonstrated how their mechanical arm pushed away the leaves and crunched them into pieces.

Water, and our inquiry, are both a cycle

As our pilot of Inquiry Inc. and the Case of the Missing Duckling drew to a close, students had a chance to reflect on their learning. Returning back to our original water poster we had made as a class, some students still wondered if all water was the same. Enthralled by the maps of pipe systems underground, many students wanted to explore where the ducklings might have ended up if they had just kept going from drain to drain.

Armed with this question, water group writers went back to the drawing board. Using a single moment – when one of my student’s pencil fell into the “disgusting drain” – they added in a subtle detail to the story. Right as the characters are about to rescue the final ducklings, Silvia, too, drops her pencil in the drain. Carlos makes a joke that the ducklings will now have something to write with, and the story moves on. Not every group that reads this story will pick up on this small detail, but my class did. “That’s just like what happened to us!” they exclaimed. “Where will it end up?” I asked. Students’ hands shot up as they were brimming with theories. The story may be over, but our inquiry has just begun!

P.S. Where did the water go!?!?

The other morning I noticed that all of the water had disappeared from our storm drain models that have been sitting on the heater in front of the window.

“Where did the water go?” I wondered out loud.

“Oh, we were talking about it,” one student replied, “and we think maybe it sunk in.”

“Actually I think it evaporated.” Another student chimed in.

“Where does the water go when it evaporates?” I asked.

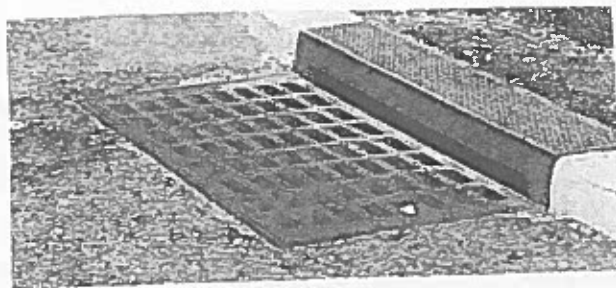
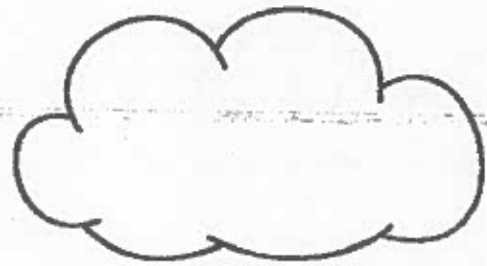
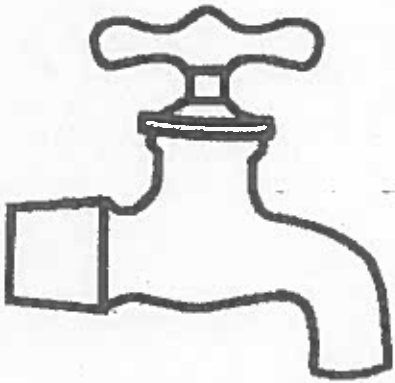
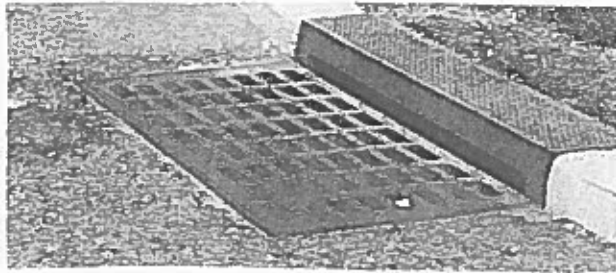
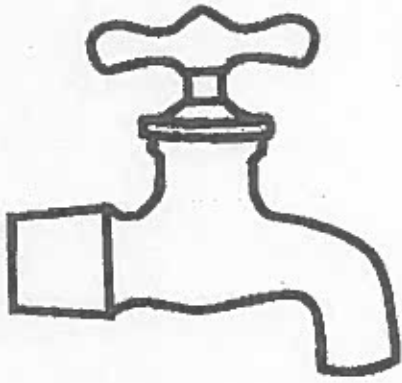
Several students who had gathered around were quiet.

“Could the water that was in these cups end up in a storm drain?” I wondered aloud.

“No!” one student laughed, “it’s not the same kind of water. It’s different, like sweat water.”

And there we were, back at the very beginning. We’ll see where these new questions take us!

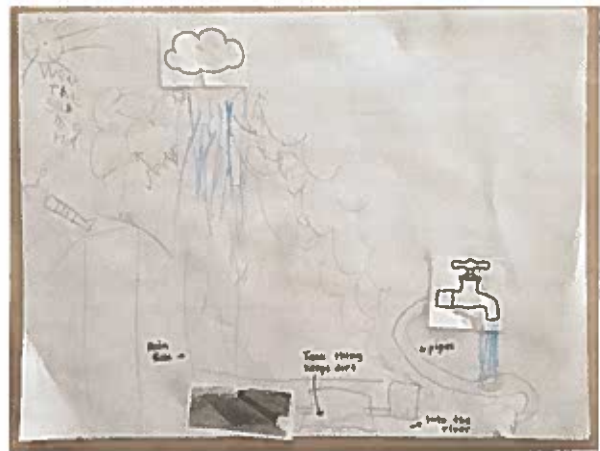
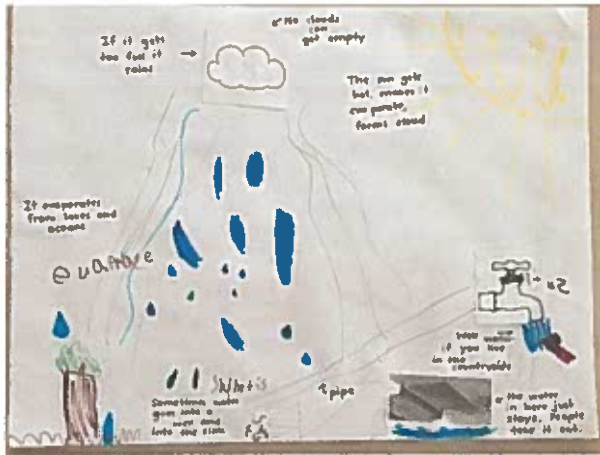




Cloud Faucet Drain: Suggestion for Pre-Assessment from Katy Butler

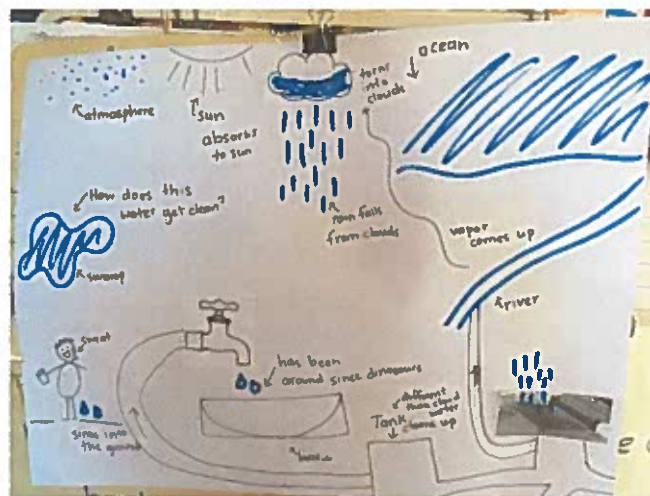
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I walked around chatting with students about what they had drawn. I asked probing questions such as “Can you tell me what this is?” or “What happens after this part?”. In many groups I wrote the words they told me as they pointed to the different parts of their maps. Most posters showed water falling from the clouds, a pipe connected to the faucet and some way to catch the water (swamps, oceans, catch basins).

Once students had a chance to represent their ideas on posters, we came together as a class to make a shared map. I began by asking them where to place the three images. Next, I took suggestions on how to represent the water in between.



Water in Northampton

Where does it go when it rains?

1. Rain soaks into the ground to help the forests and gardens grow.
2. Rain also runs off of impervious surfaces (a big word for things that cannot absorb water like roofs, roads and driveways) into grates or catch basins. This rain, also called storm water, flows through pipes underground and eventually flows into brooks that flow into the Connecticut River.



Photo of the top of a catch basin.

3. Most of the storm water in Northampton ends up in the Mill River and Connecticut River.
4. Many birds, animals and insects live in the Connecticut River and many humans swim and play in the river; therefore, it is very important that only storm water goes into grates or drains and not trash or chemicals that may pollute the water.

How does water get to our faucets?

1. Most of the water for the City of Northampton comes from three reservoirs. Reservoirs are large man-made lakes that hold water.



This is a photo of Ryan Reservoir - one of the City's largest reservoirs.

This is Mountain Street Reservoir

2. The water travels from these reservoirs in large underground pipes called water mains to the Northampton Water Treatment Plant where the water is filtered and treated for humans to use for drinking, washing, cooking, etc...



This is a photo of the Northampton Water Treatment Plant.

3. After the water leaves the water treatment plant, it travels in the water main and eventually into smaller pipes called service connections which travel from the main into smaller pipes within your house that are connected to your faucet.
4. As all living beings need water to survive, be careful not to waste water.

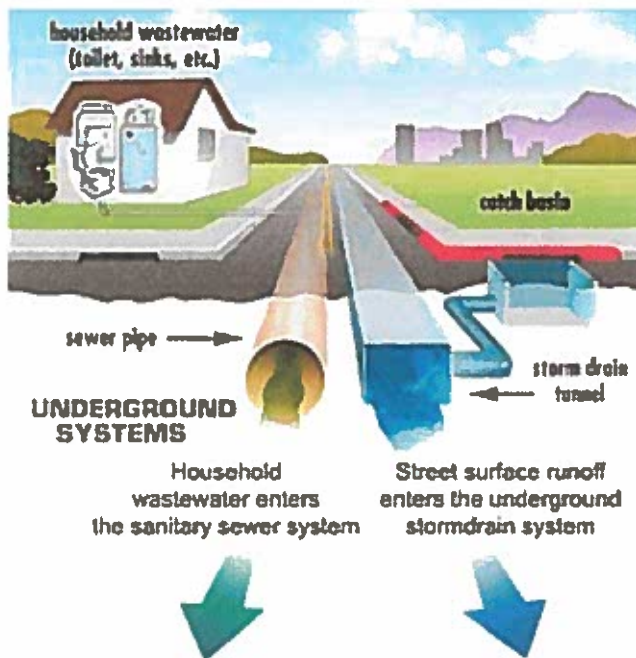
Where does it go when it goes down the drain inside our houses?

1. The dirty water or wastewater from your house that comes from the drains in your shower, tubs and sinks; your washing machine; and your toilet goes into another smaller pipe that connects to a wastewater service connection which travels from your house to a large sewer main or an underground pipe that carries wastewater.
2. Wastewater in the sewer main travels to the Northampton Wastewater Treatment Plant where the water is cleaned (contaminants are removed) so that the water can be returned to the Connecticut River.



This is a photo of the Northampton Wastewater Treatment Facility.

3. Remember used water should only go down the drain inside your house. Never pour chemicals or medicines down the drain.



Separate Sanitary Sewer System - How It Works



K-2.Engineering Design

K-2.Engineering Design

Students who demonstrate understanding can:

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>Asking Questions and Defining Problems Asking questions and defining problems in K-2 builds on prior experiences and progresses to simple descriptive questions.</p> <ul style="list-style-type: none"> Ask questions based on observations to find more information about the natural and/or designed world. (K-2-ETS1-1) Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1) <p>Developing and Using Models Modeling in K-2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.</p> <ul style="list-style-type: none"> Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2) <p>Analyzing and Interpreting Data Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations.</p> <ul style="list-style-type: none"> Analyze data from tests of an object or tool to determine if it works as intended. (K-2-ETS1-3) 	<p>ETS1.A: Defining and Delimiting Engineering Problems</p> <ul style="list-style-type: none"> A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1) <p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2) <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3) 	<p>Structure and Function</p> <ul style="list-style-type: none"> The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2)
<p><i>Connections to K-2-ETS1.A: Defining and Delimiting Engineering Problems include:</i> Kindergarten: K-PS2-2, K-ESS3-2</p> <p><i>Connections to K-2-ETS1.B: Developing Possible Solutions to Problems include:</i> Kindergarten: K-ESS3-3, First Grade: 1-PS4-4, Second Grade: 2-LS2-2</p> <p><i>Connections to K-2-ETS1.C: Optimizing the Design Solution include:</i> Second Grade: 2-ESS2-1</p>		
<p><i>Articulation of DCIs across grade-bands:</i> 3-5.ETS1.A (K-2-ETS1-1),(K-2-ETS1-2),(K-2-ETS1-3); 3-5.ETS1.B (K-2-ETS1-2),(K-2-ETS1-3); 3-5.ETS1.C (K-2-ETS1-1),(K-2-ETS1-2),(K-2-ETS1-3)</p>		
<p><i>Common Core State Standards Connections:</i></p> <p>ELA/Literacy –</p> <p>RI.2.1 Ask and answer such questions as <i>who, what, where, when, why, and how</i> to demonstrate understanding of key details in a text. (K-2-ETS1-1)</p> <p>W.2.6 With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers. (K-2-ETS1-1),(K-2-ETS1-3)</p> <p>W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1),(K-2-ETS1-3)</p> <p>SL.2.5 Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (K-2-ETS1-2)</p> <p>Mathematics –</p> <p>MP.2 Reason abstractly and quantitatively. (K-2-ETS1-1),(K-2-ETS1-3)</p> <p>MP.4 Model with mathematics. (K-2-ETS1-1),(K-2-ETS1-3)</p> <p>MP.5 Use appropriate tools strategically. (K-2-ETS1-1),(K-2-ETS1-3)</p> <p>2.MD.D.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. (K-2-ETS1-1),(K-2-ETS1-3)</p>		

3-5.Engineering Design

3-5.Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.**
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.**
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>Asking Questions and Defining Problems Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.</p> <ul style="list-style-type: none"> Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1) <p>Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.</p> <ul style="list-style-type: none"> Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3) <p>Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.</p> <ul style="list-style-type: none"> Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2) 	<p>ETS1.A: Defining and Delimiting Engineering Problems</p> <ul style="list-style-type: none"> Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1) <p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3) 	<p>Influence of Science, Engineering, and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> People’s needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1) Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)
<p>Connections to 3-5-ETS1.A: Defining and Delimiting Engineering Problems include: Fourth Grade: 4-PS3-4</p> <p>Connections to 3-5-ETS1.B: Designing Solutions to Engineering Problems include: Fourth Grade: 4-ESS3-2</p> <p>Connections to 3-5-ETS1.C: Optimizing the Design Solution include: Fourth Grade: 4-PS4-3</p>		
<p>Articulation of DCIs across grade-bands: K-2.ETS1.A (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3); K-2.ETS1.B (3-5-ETS1-2); K-2.ETS1.C (3-5-ETS1-2),(3-5-ETS1-3); MS.ETS1.A (3-5-ETS1-1); MS.ETS1.B (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3); MS.ETS1.C (3-5-ETS1-2),(3-5-ETS1-3)</p>		
<p>Common Core State Standards Connections:</p> <p>ELA/Literacy –</p> <p>RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (3-5-ETS1-2)</p> <p>RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (3-5-ETS1-2)</p> <p>RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (3-5-ETS1-2)</p> <p>W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-1),(3-5-ETS1-3)</p> <p>W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (3-5-ETS1-1),(3-5-ETS1-3)</p> <p>W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (3-5-ETS1-1),(3-5-ETS1-3)</p> <p>Mathematics –</p> <p>MP.2 Reason abstractly and quantitatively. (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3)</p> <p>MP.4 Model with mathematics. (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3)</p> <p>MP.5 Use appropriate tools strategically. (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3)</p> <p>3-5.OA Operations and Algebraic Thinking (3-5-ETS1-1),(3-5-ETS1-2)</p>		