Engineering Activity 6: Reuse in Action: Create a Process

Educator Preview

Activity Snapshot

Learners work in groups to plan, create, and test a water reuse process for an extreme environment.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Plan, Create, and Test	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–45 min. each

Prep Snapshot*

Prep Time 45 min.

- Space Need: Sink
- Create Filter Bases.
- Set up Materials Store.
- Print handouts.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking
- Collaboration
- Creativity

Habits of Mind

- Envision multiple solutions.

Guiding Question

Does our final water reuse process meet our water quality goals?

Learners Will Do

Create and test a water reuse process.

Learners Will Know

Engineers apply what they learn from investigations to inform their design decisions.

Connecting Across Activities

Activity 5: Investigating Reuse Process	Activity 6: Create a Process	Activity 7: Improve a Process
Last time, learners applied what they learned about water quality to reconfigure a model building to reuse as much water as possible.	**Today**, learners work in groups to plan, create, and test a water reuse process.	**Next time**, learners will improve their water reuse processes to better meet the criteria for their group's environment.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii–xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

weblink: https://hov.to/c2872316

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples & Template
- 1 bottle of scented liquid
- 1 bottle of soap
- 1 bottle of vinegar
- 1 cup of soil
- 1 roll of masking tape
- 1 roll of paper towels
- 1 safety glove
- 1 spool of thread
- 1 strainer
- 1 Tbsp detergent
- 1 teaspoon
- 1 tube of toothpaste, travel size
- 1 utility knife
- 1 vial of food coloring, yellow
- 1 learners-made water reuse process, from Activity 5
- 2 tablespoons
- 2 tea bags, black tea
- 6 two-liter bottles
- 8 containers, 1/2 gallon
- 8 sheets of copy paper
- coffee grounds
- natural materials (such as sticks, grass, sand)
- 1 roll of plastic wrap (optional)
- towels or disposable tablecloths (optional)

For each learner

- Engineering Notebook (PDF)

For the Materials Store

- 1 measuring cup, 1/4 cup
- 2 cups of activated charcoal
- 2 cups of limestone gravel
- 4 cups of sand
- 8 craft sticks
- 18 pieces of cheesecloth, 12" × 12"
- 18 half-sheets of paper towel
- 20 rubber bands
- 60 plastic cups, 8 oz.
- 80 cotton balls

For each group of 4

- 1 flashlight
- 1 foil tray, 12" × 12"
- 1 measuring cup, 1 cup
- 1 packet of pH strips
- 1 pair of scissors
- 1 permanent marker
- 1 piece of construction paper (the same color for all groups)
- 2 Filter Bases
  - Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards, pgs. 93-94

Activity 6 Materials Preparation (45 min.)

Ahead of Time

1. Watch the video Engineering How to Part 2 (1:08–2:35) to learn about what happens in this activity.
2. Review the "In-Use Example" in the *Our Ideas* Prep & Setup Guide (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
3. Follow the Preparing Filter Bases Instructions, pg. 62 to make 6 more Filter Bases (for a total of 12) if not previously assembled.
4. Make one copy of Engineering Activity 6 Choose an Environment Handout, pgs. 89-92, for each group.
5. Make one copy of Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards, pgs. 93-94, for each group, and cut out the cards. If it is useful to your learners, print these pages on swell paper or attach materials such as wiki sticks so learners can feel what is on each strip of paper.

In Your Space

6. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.
7. Prepare new water samples using the recipes on *Water Samples for Final Challenge Recipes*, pgs. 87-88, in this guide. Use the masking tape and a permanent marker to label them.
8. Using the strainer, rinse the charcoal under running water until the water runs clear (approximately 1 minute).
9. Arrange the water samples and the materials on a table to make a Materials Store. Place the tablespoons with the limestone and charcoal and the 1/4 cup with the sand on the table.

Teaching Tip

Lead this activity in a room with a sink for easy setup.

Place *Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards* in bags or envelopes for easy distribution.

Activity Guide

Get Ready & Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(We investigated how different processes allow water to be reused.)*

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs, xx-xxi) and use other engagement strategies as necessary (pgs, viii–xviii).

2. Draw learners' attention to three major concepts on the *Our Ideas* poster: water quality, filters, and reuse processes. Check for understanding of these concepts. If needed, return to these terms and have learners discuss the terms and make drawings for them. Say: **You will now use all the ideas you have explored so far: water quality, filters, and reuse processes.**
3. Say: **Today we will start the final design challenge: designing a process to reuse water, including actual filters and the order in which they are used. Last time, we thought about a building in our community. Now, you will be able to choose one of the four locations we've talked about to design for.** Share the Guiding Question with learners aloud and in writing on the *Our Ideas* poster (using multiple languages as needed): **Does our final water reuse process meet our water quality goals?**
4. Organize learners into groups of four.

Plan, Create, and Test (25 min.)

5. Give each group a copy of *Engineering Activity 6 Choose an Environment Handout*, pgs. 89-92, and have them review the environments they can choose from. Indicate the words *criteria* and *constraints* on the *Our Ideas* poster to remind them about the meaning of those terms. If needed, have learners discuss the terms and make drawings for them.
6. Give each group 5 minutes to choose one of the environments. When they make a decision, have learners write their environment, water sources, and goal on *Planning a Process*, pgs. 11-12 in their Engineering Notebooks.

Level Up!

- Have learners build a model of the environment they choose (using craft supplies, Legos, etc.) to help them think about how the parts of that environment might be connected. (30 min.)
- Have learners research a real-world context where water filtration and reuse is important. It can be a location on Earth, like a community they belong to or a community with limited or contaminated water, or another NASA mission, such as Artemis. (30 min.)

Teaching Tip

Make clear that learners cannot use their systems to create drinkable water, and they **should not** drink the water they have filtered, no matter how clean it appears to be.

7. Allow learners to examine the containers with the water samples you prepared. Explain that they will be ordering and filtering the water from up to four sources: bathroom sink, shower, laundry, and space toilet. (Groups designing for the farmhouse environment can use a fifth source: farm field.)

8. Display one of the *Engineering Activity 5 Mapping Water Reuse Handout* pages with processes on them from Activity 5. Remind learners that both the filter materials and the order of the filters matter in producing water that is clean enough to reuse.

9. Hold up *Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards,* pgs. 93-94, as you explain that learners will create a model process showing how water is used in one location, is filtered to a new level of quality, and then is reused in another location. They can arrange the water locations in any order, but their process must meet the criteria listed for their environment. Ask: **How can we test if the water is clean enough to reuse?** *(We can observe clarity, color, pH, smell, and texture.)* **How will we know where the water can be reused?** *(We can test the sample and check the* How Clean Does It Need to Be? *handout.)*

10. Remind learners that although they will have multiple water locations within their environment to think about, they will have only two Filter Bases. Learners can use multiple filter materials in each Filter Base and combine water from multiple locations to send through the Filter Bases.

Teaching Tip

A space toilet is different from a toilet on Earth because solid waste is disposed of separately, while liquid waste is collected for reuse.

Support Learner Differences

If learners have struggled with previous activities, consider starting them with the farmhouse. Once they are successful, they can select a more challenging environment. To discuss the different levels of difficulty, you can explain that sources of drinking water on Earth include rain, groundwater, lakes, rivers, and springs. Off-the-grid homes—even the ones in the driest deserts—don't have to be as efficient as NASA space missions because they can get more water from sources on Earth.

Level Up!

If learners want more information about the different environments, you can share the following:

- The surface of Mars is almost completely dry. There are reservoirs of water ice in the north and south polar caps and under the surface in some locations.
- Ocean water is not usable to sailors on most ships because it is too salty. The Navy is working with NASA to improve its ability to use and reuse ocean water for human activities. (5 min.)

11. Give each group a set of *Engineering Activity 6 Water Reuse Plan Location and Filter Base Cards,* pgs. 93-94, and let them order the cards on the table to plan their water reuse processes. Encourage them to record their ideas on *Planning a Process*, pgs. 11-12 in their Engineering Notebooks.

Support Thinking

Learners can place the Filter Bases directly on top of the Filter Base cards, if they choose.

Teaching Tip

If time is short, you can pause the activity here and finish it during another session.

12. After learners finish their plans, have them gather materials from the Materials Store and begin engineering their water reuse processes. Note that the order is not linear; in fact, sometimes two different water sources must go through the same filter. Have learners record the materials on *Planning a Process*, pgs. 11-12 in their *Engineering Notebook*.

13. When groups are ready to test their processes, have them label plastic cups with the name of each water location they will include, then come to the Materials Store. Stir the samples with a craft stick and then pour 1/2 cup of water into each labeled cup.

14. Give groups copies of *Engineering Activity 3 How Clean Does It Need to Be? Handout*, pgs. 52–53, to review the requirements for clean water, somewhat contaminated water, and very contaminated water. Have groups test their processes and record the quality of their final water sample on *Testing a Process*, pg. 14 in their Engineering Notebooks. Have them compare the result to the criteria and constraints for their environment to determine if their process has met their goals.

Teaching Tips

- The pH strips may stain the tabletop, so place used strips on a paper towel.
- Groups may want to use charcoal in their processes overnight. Label their designs, cover them with plastic wrap to prevent evaporation, and store them in an area where the water will not spill.

15. Let learners know when there are 10 and 5 minutes remaining.

Support Thinking

Learners may say that they have failed. Emphasize that engineers think about designs failing, not about people failing. Explain that failure is an important way in which engineers gather information to improve their designs. Ask: **What did you learn from the failure of this design?** *(We need to include a different material in the filter; the process needs to go in a different order.)*

Reflect (10 min.)

16. Have each group come up with an answer to the Guiding Question: **Does our final water reuse process meet our water quality goals?** Additionally, have them discuss the following questions: **How have you ordered your water locations? Is your process working like you thought it would? Are you meeting the criteria of your environment? How might you improve your process?** As needed, remind learners of terms on the *Our Ideas* poster.

17. Say: **Next time, you will improve your water reuse process. Later, you will share design recommendations for water reuse processes and demonstrate the importance of reusing water in environments on Earth and in space.**

18. Have learners clean up by

    - rinsing the charcoal and limestone with the strainer and setting them aside for use in later activities.
    - rinsing their Filter Bases and placing them in their tray with their Water Reuse Plan location cards.
    - labeling their trays for next time using a permanent marker and masking tape.

Level Up!

- Ask this story prompt question: **Can you tell a story about something you've designed in the past?** *(Possible responses include designing objects, systems, or processes.)* Have learners share with a partner (note that the sharing can take forms other than speaking aloud). Consider returning to learners' ideas at the start of the next activity. (20 min.)
- Tell learners, if anyone asks them what they did today, they can tell them "We designed a process to filter and reuse water." (5 min.)
- Invite a family or community member to come in as a special guest and share their knowledge about water-related topics. (45 min.)
- Refer to the *Engineering Design Process* poster. Ask: **What phases of the Engineering Design Process did you use today?** *(We planned, created, and tested our processes for reusing water.)* (5 min.)

After the Activity

1. Clean up:
    - Discard the remaining used filter materials.
    - Save groups' design components in a safe location so learners can improve them in the next activity.
    - Save the containers with the water samples for the Share-Out. Be sure to label them, cover them with plastic wrap to prevent evaporation, and store them in an area where the water will not spill. (If you lack storage space, you can take pictures instead.)
    - Save the *Our Ideas* poster for use in Activity 7.
    - Collect all handouts.
2. Plan for Engineering Activity 7. See Engineering Activity 7 Preparation on pg. 97.
3. Take time to reflect on the following educator prompt. **Which environments did learners choose? Why do you think they chose those environments?**

Water in Extreme Environments Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: **https://hov.to/7cb5c428**

Water Samples for Final Challenge Recipes

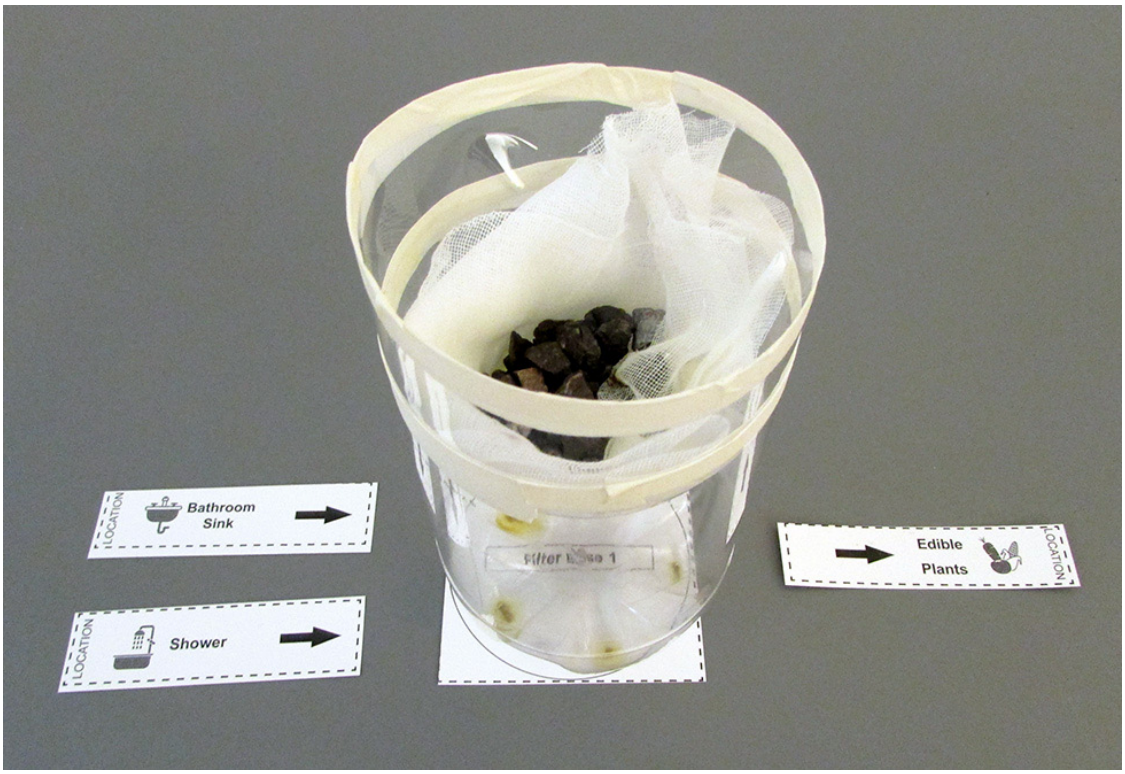
Groups will share these samples to test their water reuse process, 1/2 cup at a time.

Water Source	Mixtures
Farm Field	■ 1/2 gallon container of water ■ 1/2 tsp scented liquid ■ 1 Tbsp loose soil ■ 2 Tbsp vinegar
Space Toilet	■ 1/2 gallon of water ■ 1/2 tsp scented liquid ■ 2 drops yellow food coloring
Laundry	■ 1/2 gallon of water ■ 1/2 tsp scented liquid ■ 1 tsp soap ■ 1 tsp soil ■ 2 Tbsp vinegar ■ 30+ pieces of thread, 1–2" long
Shower	■ 1/2 gallon of water ■ 1/2 tsp scented liquid ■ 1 tsp detergent ■ 1 tsp tea leaves ■ 1 Tbsp soil
Bathroom Sink	■ 1/2 gallon water ■ 1/2 tsp scented liquid ■ 1 tsp soap ■ 2 blobs toothpaste, pea sized

1. Prepare two containers of each water mixture (or, if you are including the farm field sample, 1–2 containers of each mixture).
2. Prepare each mixture in a separate 1/2 gallon container.
3. Stir well before distributing.

Teaching Tip

There are 8 cups in a half gallon, so if several groups choose the same scenario, you may need to make an extra containers of the water samples listed in that scenario.



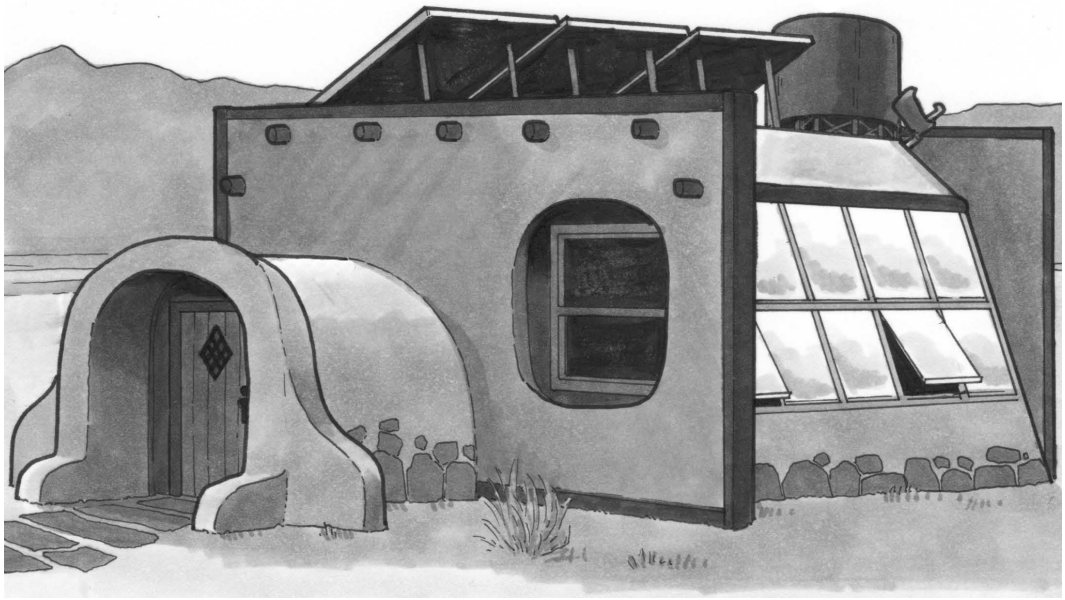
Example Water Reuse Process on Tabletop (step one of a process) with Location and Filter Base Cards.

Choose an Environment

Choose one of the four environments to design a process for.

Farmhouse

Your team is building an off-the-grid farmhouse in the American Southwest, which means all resources (water and electricity) will come from the environment. This home is specially designed to collect and reuse water. You will need to create a process that filters enough water to reuse in the vegetable garden.



Criteria

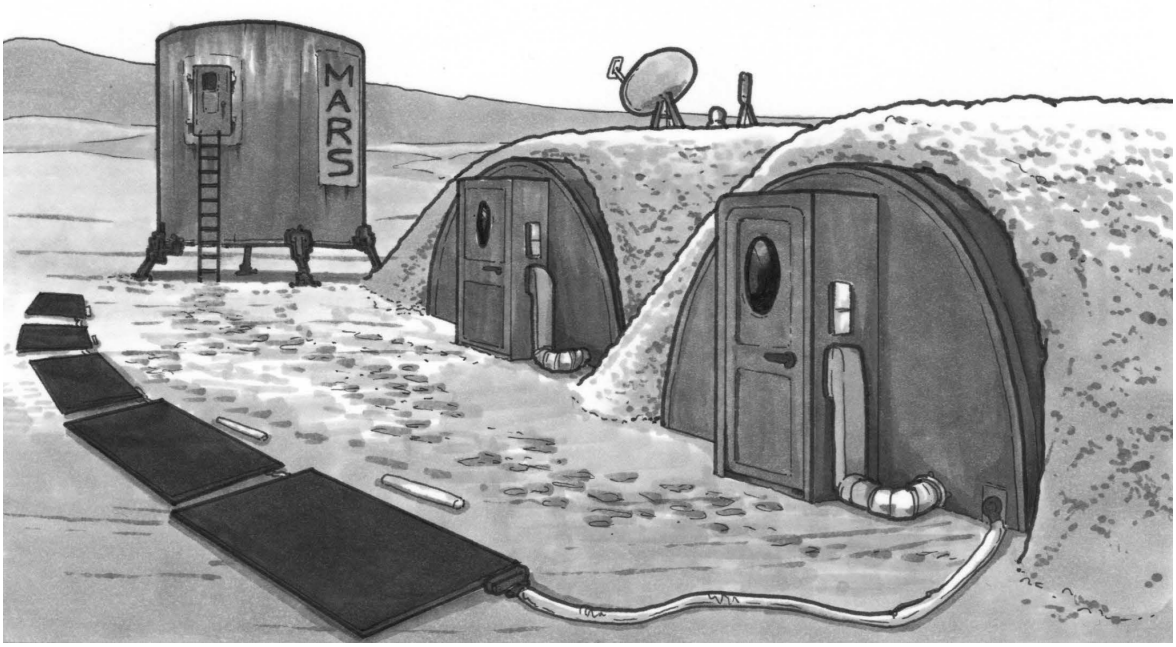
- Must filter water from each source:
  - bathroom sink
  - shower
- Must produce
  - clean or only somewhat contaminated water for watering edible plants

Constraints

- You can use two Filter Bases.

Mars Habitat

Your team is designing a process for reusing water on Mars. This process needs to reuse as much water as possible and still produce enough water for the plants in the greenhouse.



Criteria

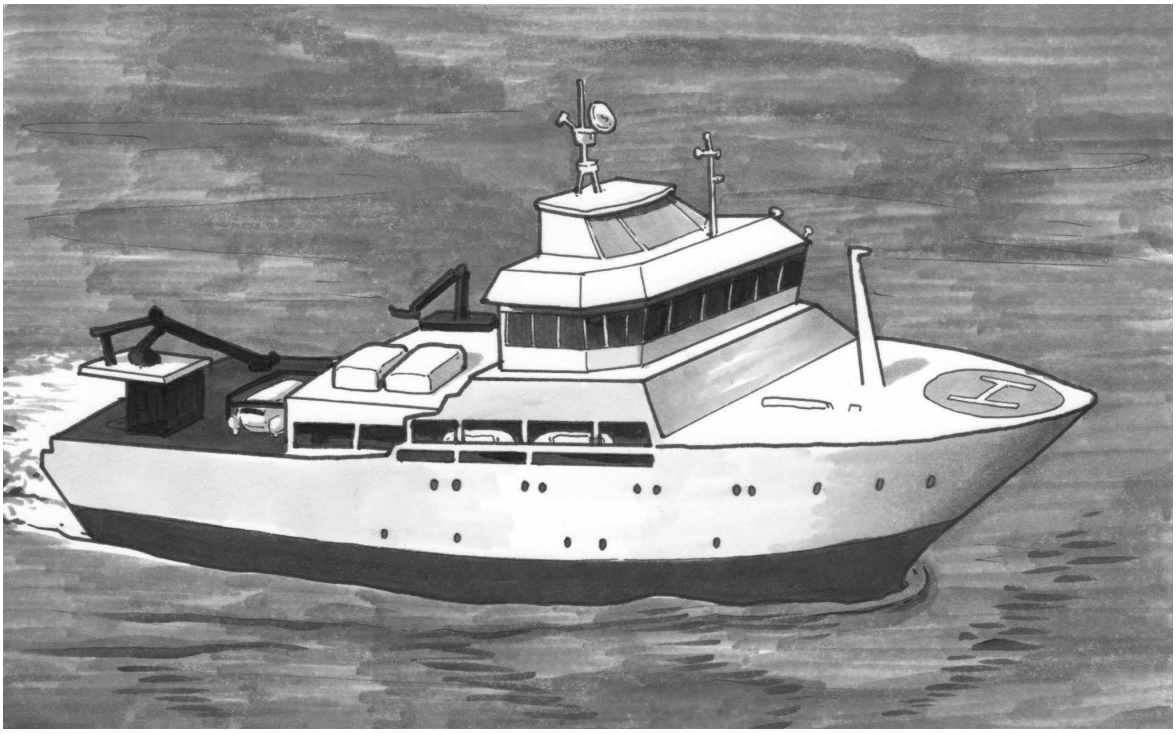
- Must filter water from each source:
  - laundry
  - shower
  - space toilet
- Must produce
  - clean or only somewhat contaminated water for watering edible plants

Constraints

- You can use two Filter Bases.

Floating Research Lab

Your team is living on a boat on the ocean, so no fresh water is available. You will have to filter and reuse as much water as you can onboard, or you'll risk polluting the surrounding waters.



Criteria

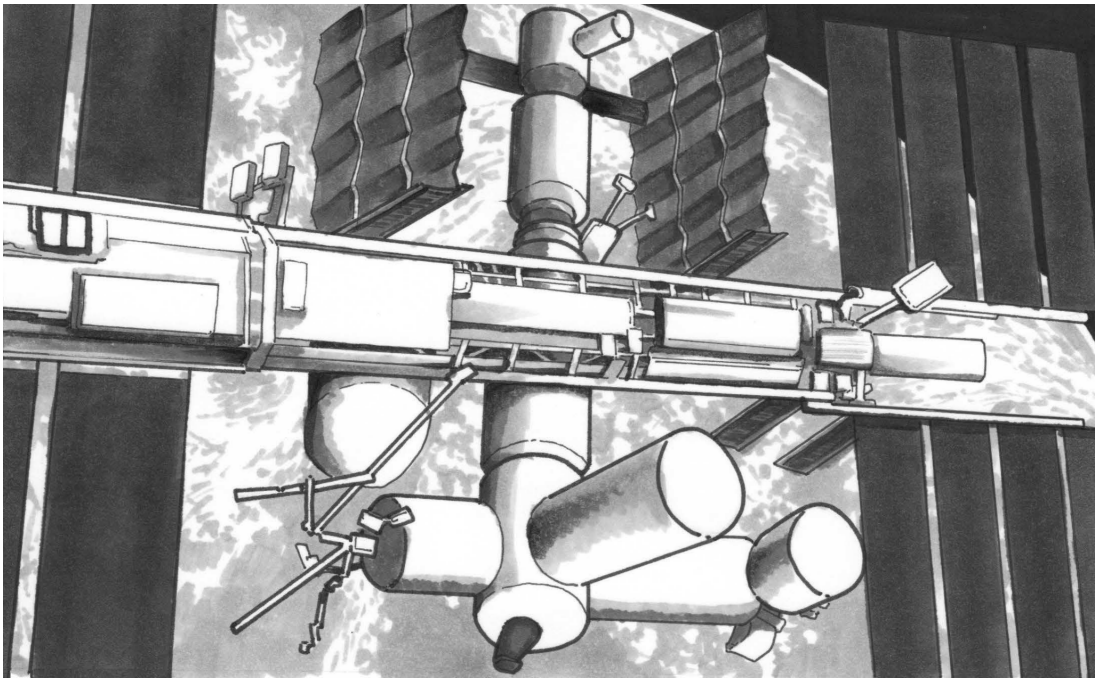
- Must filter water from each source:
  - bathroom sink
  - laundry
  - shower
- Must produce
  - clean or only somewhat contaminated water for toilet

Constraints

- You can use two Filter Bases.

International Space Station

Your team is creating a process for reusing water for the International Space Station. You need to reuse all the water you use on board. The next shipment of clean water won't arrive for another three months!



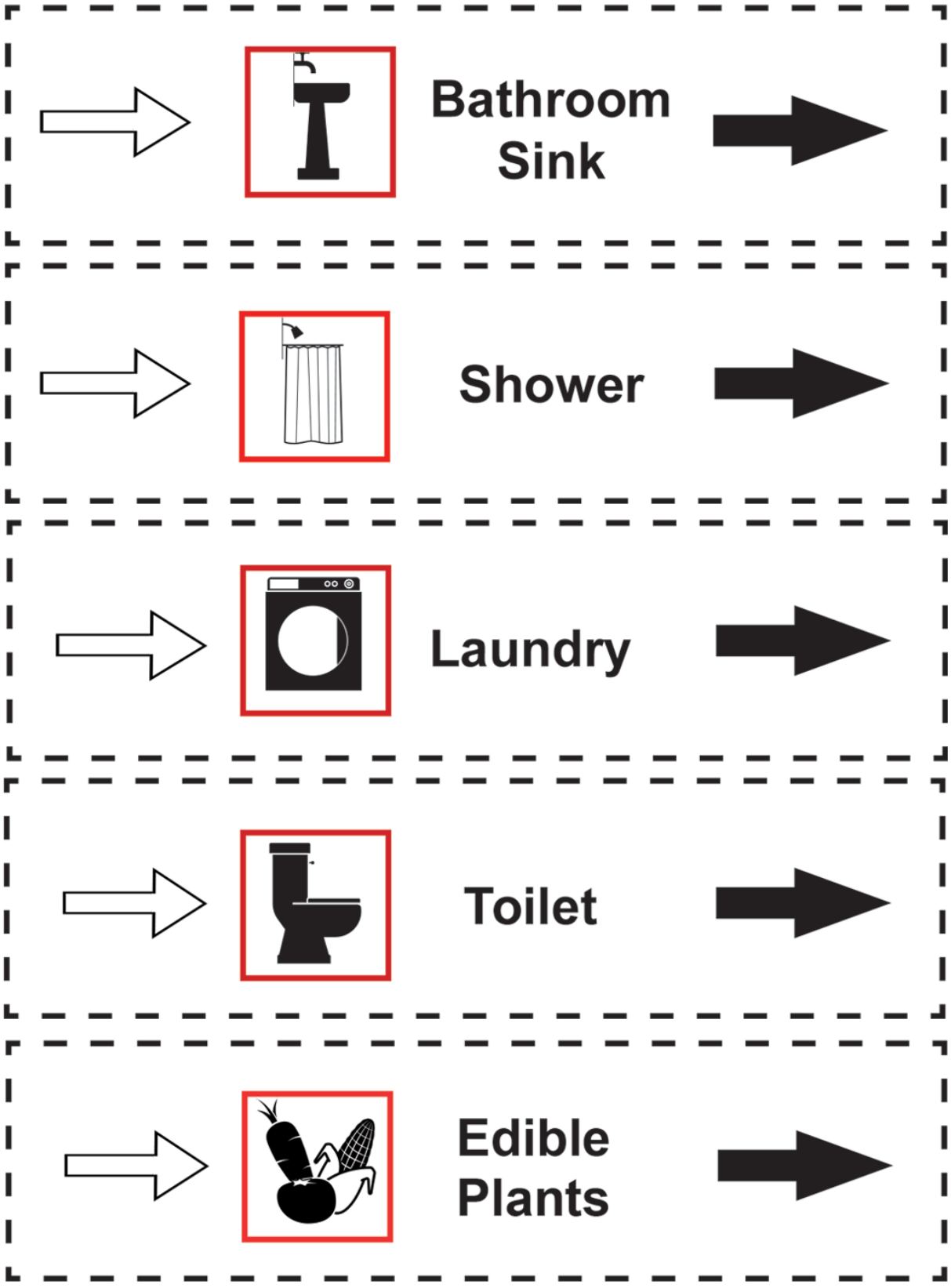
Criteria

- Must filter water from each source:
  - bathroom sink
  - laundry
  - shower
  - space toilet
- Must produce
  - somewhat contaminated water
  - clean water

Constraints

- You can use two Filter Bases.

Water Reuse Plan Location and Filter Base Cards



Cut out the boxes and arrange these cards on the table to plan your water reuse process.