H_2O = LIFE

FIRST FOUR DAYS

Purpose

The First Four Days are designed to accomplish three learning goals. The first is to recognize and position design-based activities and use of the informed design process as essential components of the classroom's daily routine. The second is to introduce students to the instructional format of the unit known as Knowledge and Skill Builders (KSB). Students will learn to use KSBs to inform their understanding of content before engaging in design challenges. The third is to measure students' prior knowledge on unit material through the use of a pretest.

Overview

The First Four Days allow the teacher to set the focus for the course. The routines of collaboration and using knowledge and skill builders (KSB) will be established. Students will participate in a group design challenge, practice engaging in a KSB, redesign their solution using their KSB new-found knowledge then assess their "before KSB design" and their "after KSB design". The unit pre-assessment is also administered during this time and suggested that students complete it on Day 1 or Day 4.

Big Idea:

The 21st century skills of collaborating and problem solving are essential for engineering solutions of the future.

Lesson Duration: 4-40 minute class periods

Enduring Understandings

- Collaboration means working with others to do a task and to achieve shared goals.
- Engaging in knowledge and skills builders provides simple structured learning sequences that can scaffold understanding.

Vocabulary

1. **Informed Design**- a design process where students increase their knowledge and skill base before addressing the specific design problem, done through the performance of "Knowledge and Skill Builders" (KSBs).
2. **Knowledge and Skills Builders**- (KSBs) - short, focused activities designed to help students identify the variables that affect the performance of the design

Materials / Tools Needed:

Day 1	Pre-test

Day 2-4	• 200 Straws, 20 paper clips, 2 rolls masking tape, 1 golf ball for each group, scissors, lunch bags (1 per group to hold materials)

Student Instructional Prompts
Throughout the EfA unit, students will see boxes that will look like this:

Points to Ponder This feature is intended to raise questions and cause students to think more about the subject matter.
Check Your Understanding This feature causes students to reflect on what they've learned.
Think Like an Engineer This feature helps students view the subject matter in a way similar to how an engineer might think about a question or issue.

Breakdown of First Four Days
Day 1- Pre-assessment
Day 2, 3, 4- Activity: Tallest Tower, KSB/F4D (located in F4D Student Companion and explained below), Redesign the Tallest Tower Activity, Overview of the Unit

Main Learning Activities

Have the Big Idea written on the board.

Day 1
Pre-assessment

1. Students take the pre-test.
2. Paper test: Distribute test. Have sharpened pencils on hand.
3. Electronic test: Provide instruction to retrieve the test.
4. As students are making preparation to take the test, explain that the purpose of the pre-assessment is to determine students' familiarity with the material they will be introduced to in the forth-coming unit. Assure students that they are not expected to be competent in all the objectives being tested and it will not be included in the gradebook. When students finish, if time allows, read the Big Idea and Learning Goals in the beginning of the Student Companion.
5. Continue to the remaining days activities.

Water: The World in Crisis
First Four Days
Teacher Guide

Day 2, 3, 4

The activities/ lessons for days 2, 3 and 4 are meant to be successive. Ideally, Day 2 would engage students in the initial Tallest Tower Activity, Day 3- students would engage in a practice KSB/F4D (teacher presentation of a PPT) and Day 4 would be the redesign of the Tallest Tower Activity using knowledge gained from KSB/F4D's and a short overview of the unit. This may or may not be the case in your classroom. As one part of the F4D's is completed, proceed to the next.

Both initial tower activity and final tower activity should be timed at ~25 minutes each. Teacher should be mindful of the activity allotment times, thus this should ensure time to complete the F4D's in 4 days.

Day 2 *Tallest Tower Activity*

Objective:

1. Illustrate the importance of collaboration and communication

Prior preparation: Before the activity, you need to make a packet of supplies for each group. Divide your class into groups of 3-4. The key here is to divide the supplies unevenly, but put them in a closed lunch bag or shoe box, so that students can't see that each group is getting a different set of supplies. Each group should have a lot of one supply, and only some of the other supplies. The goal is that students will realize they need to share or barter for supplies.

*Students will be "redesigning" this activity, so make 2 sets of identical supplies- 1 set for the first try, 1 set for the redesign.

For example:

Group 1 • 1 roll of masking tape • 1 scissors • 4 straws • 2 paper clips • 1 golf ball
Group 2 • 1" piece of masking tape (wound around something like a popsicle stick) • 1 scissors • 40 straws • 2 paperclips • 1 golf ball
Group 3 • A 1" strip of masking tape (wound around something like a popsicle stick) • No scissors • 35 straws • 1 golf ball

Group 4

- 1 roll of masking tape
- 1 scissors
- 6 straws
- 3 paperclips
- 1 golf ball

Directions:

Big Picture: The students work to build the tallest free-standing tower they can with the supplies given.

Engage

Quickly, assign students in groups of 3-4. Designate each group's work area within the room. Choose one representative from each group and call them up to receive their bag of materials and instructions.

Explore

Introduce the representatives to the activity by simply saying *"This is an activity to work on **communication and collaboration**, and the goal is to build the tallest free standing tower you can that can hold the weight of a golf ball for 2 minutes, using the materials in the bag. There will be prizes (or bragging rights) for the winners."*

Be careful to introduce the activity without giving too much context or answering too many questions. The key here is that each group will have a different set of supplies but the teacher should make sure this is not immediately obvious. Once it becomes more obvious, the teacher should neither discourage nor encourage collaboration and sharing. The vast majority of students when divided into groups, will assume they should be competing against the other groups but you should not specifically say it is a competition. You will address this in the debrief questions based on the groups' choice to collaborate or compete.

Explain

Answer the representatives' questions at this point. Try to be very general in answering their questions. If they have specific process questions, it may be helpful to say something like, "you have received all the instructions I can give you. You and your group will have to figure out the rest".

Then state that they are to return to the groups, and once they return, the teacher will not answer any more questions. The reasoning for this is so that the groups are forced to figure out how they want to build on their own. If the groups decide they want to collaborate, the teacher should neither encourage nor discourage them (this will come up in the debrief).

eNGINEER

Announce that students have ~25 min to build, and let the building begin.

Enrich

Some groups will spend time coming up with a detailed strategy, others will just dive right in. Some may start to notice that they don't have much tape, or that the other groups have more straws.

After a few minutes of building you have a few choices.

- You can ask for representatives to come to the center of the room and report to the other reps one thing they are doing well and one challenge they are having.
- You can have everyone stop building for a moment and walk around and see other teams' progress so far.

Again, the teacher should not answer any questions, and should not encourage or discourage collaboration! It is important to try to deflect... so if they ask, "How come they have so much more tape?" you might say "Sorry, I can't really answer any questions at this point, but it looks like you are making good progress."

As they start to see that other groups have different supplies, some will respond by questioning, some will try to beg, barter, or steal supplies, and some will just resign themselves to the fact that it's not fair and will continue to focus on working with what they have. Make notes of it all, and save it for the debrief.

Evaluate

Stop the activity after 25 minutes has passed.
Permit students to do a silent, 1 minute walk-around to view other groups' towers, then return to their seats. Students will be excited at this point and anxious to talk about the activity.

Debrief

As the discussion begins, ask students to refer to their Student Companion at the point that says, "READ, Please". As a class, read the material in the box that explains *Points to Ponder, Check Your Understanding*, and *Think Like an Engineer*. Explain that these headings/boxes will be consistent features throughout the unit and will contain content that students are expected to engage in.

Because of the unequal distribution of supplies, in order to build the tallest tower possible, the groups really have to all merge and share supplies. But because you divided them into groups, and that implies competition to most students, very few students will try to suggest that the groups collaborate or share supplies. Even if someone in the group suggests it, it is not likely that everyone will agree to it.

The teacher should ask the following question of the entire group.

- Raise your hand if you helped build a tower!

All students will likely raise their hand.

Ask students to locate the *Points to Ponder* box in their Student Companion. Teacher may also choose to have the *Points to Ponder* questions on a PPT Slide.
Ask students to answer the remaining questions in the Points to Ponder box in their Student Companion.

1. What worked well?
2. What challenges did you encounter and how did you overcome them?
3. Did you collaborate with other groups and share supplies? Explain.
4. Did you build the tallest tower you could? Why or why not?
5. Did your tower hold the weight of the golf ball for 2 minutes? Why or why not?
6. Would it have been helpful to know more about what makes structures strong?

Add the following questions if the groups did not collaborate or share supplies:

- Did you assume that you were only supposed to collaborate with those in your small group?
- What would have been possible if you had decided to share resources with the whole group?
- Would you have had a taller, stronger tower?
- Why didn't you (share resources)?
- If you had more knowledge about what makes structures strong, would that have helped your design?

Add the following questions if the groups did collaborate:

- How did you come to the decision to collaborate?
- What became possible once you made the decision to share resources?
- What was challenging?

Finally, ask this question:

- If you had more knowledge about what makes structures strong, would that have helped you be more successful with your design?

As a class, read the next paragraphs titled *Informed Design Process.* This section is meant to initiate an awareness of the *Informed Design Process* with explanation that it will be fully utilized in the Grand Design Challenge. More important at this time is that students understand *Knowledge and Skills Builders* (KSB's) and that students will be participating in KSB's as they move forward in the Unit. To clarify students' understanding of a KSB, they will engage in a *practice* KSB- **KSB/F4D** to learn about the strength of shapes- a concept that will help them to be more successful in their redesign of the tower.

Day 3 Practice- *KSB/F4D*
Objective:

1. Familiarize students with the concept of Knowledge and Skills Builders (KSB's).
2. Learn about the fundamental strength of different shapes.

Engage

Teacher explains, "Structural engineering is one of the oldest forms of engineering. The earliest buildings, roads, aqueducts and bridges all required structural design to make sure they were functional and safe. Structural engineering, though, is not unique to buildings. In fact, aerospace engineers use structural engineering when they design satellites, mechanical engineers use structural engineering when they design the frames of cars, even computer engineers use structural engineering to figure out how to best connect a video card to a motherboard! Even you- within your groups worked like structural engineers to design your tall tower."

Explore, Explain

The teacher presents the *Strength of Shapes PPT Presentation*. Give this a file name. Make sure students have a pencil handy to sketch their ideas as they follow along with the presentation. The subsequent text aligns with the *Strength of Shapes Presentation*.

(**Slide 1**) Today we will explore a fundamental structural engineering concept: the strength of shapes.

(**Slide 2**) When we look carefully at bridges, we can see how structural engineers use different shapes to make the overall design. We can see triangles and squares. We can even see parabolas.

(**Slide 3**) Structural engineers use the same types of shapes in buildings. Many building frames are simply repeating squares, as shown in the top left. The bottom left image shows how a square is reinforced by adding a diagonal cross brace in this scaffolding, which breaks the square into two triangles. The image on the right shows an Antarctic geodesic under construction. The structure of geodesic domes is similar to the structure of soccer balls and can be viewed as a group of pentagons and hexagons. But, if we break each of those shapes down, we can see that they are fundamentally composed of triangles.

(**Slide 4**) Even when we get outside the realm of civil or architectural engineering, we can see how engineers rely on the known strength of shapes. A motorcycle frame uses many triangles to support the wheels and seats. Mechanical engineers design cranes, which use triangles and squares in their frames. Even satellites use these familiar and basic regular geometries.

(**Slide 5**) If we push straight down on a shape, putting the whole shape into compression, what happens to the shape? In your Student Companion, draw, using a dashed line, how the shape would look if you pushed on it. Assume that the sides of the shape are rigid and won't change length or bend.

(**Slide 6**) Take a look at this! If you push down on top of the square, it will no longer be a square, but instead takes the shape of a rhombus, which is a type of parallelogram. This is called "racking." If we push down on the top of the diamond, it collapses down. But what about the triangle? The triangle maintains its shape! In the box labeled *Slide 6,* explain why the triangle shape won't collapse.

(**Slide 7**) The reason that the square and diamond collapse is because the angle between the structural members can change without having the length of the members change or bend. Remember back to geometry when we talked about how polygons are defined? In this case, both quadrilaterals simply require the sum of the interior angles to equal 360 degrees, but each angle can change.

(**Slide 8**) Triangles are unique in that sense. The angle between two sides of the triangle is based on the length of the opposite side of the triangle. Do you remember this from geometry? The angle "a" is fixed, based on the relative length of side "A." Just like the angle "b" is fixed based on the relative length of "B" and "c" based on "C." This is why a triangle cannot collapse!

(**Slide 9**) As we showed, other regular polygons can be deformed without changing the length of the sides. A square loses its shape as its right angles collapse, and a pentagon and hexagon can be deformed. But the shapes stay "closed" because the sum of the interior angles is kept constant. For a shape with "n" sides, the sum of the interior angles will equal 180*(n-2). So a triangle's angles sum to 180 degrees, or 180*(3-2) degrees. A square's angles sum to 360 degrees, or 180*(4-2). So what can we do to the other shapes, the squares, pentagons and hexagons, to keep them from collapsing? Draw these shapes on your paper and add what would be necessary.

(**Slide 10**) Did you break the shapes into triangles? Since we know a triangle cannot collapse, and we know that these regular polygons can always be reduced to triangles (that's how we figure out the sum of the interior angles, remember?), breaking our polygons down into triangles keeps them from collapsing!

(**Slide 11**) The same concept applies in three dimensions. As shown, a cube can collapse by "racking," just like the square we saw collapse in two dimensions. So what would we do to make a strong 3D structure?

(**Slide 12**) We make 3D triangles! Specifically, we can make rectangular or triangular pyramids! This is why structural engineers rely on triangles, both in 2D and in 3D, to make strong structures! A 3D structure made of individual structural triangles like this is called a "truss," and is used throughout engineering for a strong light-weight structure!

Students complete *Check Your Understanding* in their Student Companion.

eNGINEER

Day 4 Redesign the Tallest Tower Activity
Objective:

1. Use new knowledge from KSB/F4D (Strength of Shapes) to redesign Tallest Tower Activity

The teacher repeats the instructions given at the initial start of the Tallest Tower Challenge, giving each group representative an identical bag of supplies they received earlier.

Ask students to locate the Think Like an Engineer box in the Student Companion. This box requires students to draw a sketch of their tower idea.

The building time of 25 minutes begins as students draw their sketch.

Evaluate

Stop the activity after 25 minutes has passed. The teacher and students take a minute to walk around to see the towers of other groups, then return back to seats.
The teacher guides a discussion about the towers, using the questions located in the end section of the Think Like an Engineer- "Evaluate your Design". Students write their responses in the Student Companion. When you reach question 6, you might allow students to complete this one on their own.

Remind students of the Big Idea and Learning Goals discussed at the onset of this F4D's.

1. Did you build your tower using your "informed" KSB knowledge?
2. Did you collaborate with other groups and share materials? Explain.
3. On a scale of 1 to 5 with 5 being the tallest, rate your towers height in comparison to other groups. Circle the rating 1 2 3 4 5
4. Was your tower able to hold a golf ball for 2 minutes?
5. On a scale of 1 to 5, with 5 being the most helpful, how helpful was the knowledge from **KSB/F4D Strength and Trusses**? Circle the rating 1 2 3 4 5
6. Write a 2-3 sentence summary of what you learned from this activity.

The teacher will conclude the First Four Days with a brief overview of the unit.

Unit Overview

Water: The World in Crisis

The Water Unit is divided into two major parts: a *Student Companion* and a *Design Journal*.

Student Companion

The *Student Companion* presents a series of lessons, called Knowledge and Skill Builders (KSBs), that provides the practical experience and background knowledge that you will need to be successful with the Grand Design Challenge—to design a filtering system for a family of five in Bangladesh. The criteria and constraints of the Grand Design Challenge will be presented to you after the last KSB of the *Student Companion*. The KSB's are separate lessons and there are places in the KSB for you to write or draw.

How the unit will look: *Under construction*

	First Four Days
KSB 1	Introduction to the Water Crisis

Water: The World in Crisis
First Four Days
Teacher Guide

KSB 2	Measuring Turbidity
KSB 3	Water Contaminants
KSB 4	Filtering Media
KSB 5	Filtering Systems
	Grand Design Challenge
	Presentation

Let's begin the Unit!

Move on to KSB1.

KSB1 H2O = LIFE

Overview

When students finish this KSB, they will be able to answer the following questions:

- ✓ What is water scarcity?
- ✓ What is the difference between physical and economic water scarcity?
- ✓ What are the impacts of water scarcity on life?
- ✓ What areas of the world are affected by water scarcity?

Students first watch a video to initiate their awareness of the world's water crisis, followed by a teacher PPT presentation which details the types of water scarcity including impacts, causes and effects, and last- students design an artifact about a region affected by the water crisis and share with the class to illustrate that the water crisis affects all areas of the world.

Lesson Duration: 3-4, 40 minute class periods

Big Idea: The availability of water for drinking and other uses is a critical problem in many parts of the world.

Supporting Ideas:

- The aim of engineering should be to benefit society and the environment.
- Developing sustainable solutions to the water crisis is a great engineering challenge especially as the world's population grows.
- Sustainable development is a way to meet the needs of the present without sacrificing the needs of future generations.

Standards and Learning Goals

Performance Expectations	Learning Goals: I can
MS-ESS3-3 MS-ESS3-4 Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered	Describe impacts of population growth on natural resources like water and explain that activities and technologies can be engineered to counteract those effects.
	Identify the water crisis as both global and local.

otherwise. STL5- Students will develop an understanding of the effects of technology on the environment.	

Vocabulary

1. Economic water scarcity- there is water available, but for some economic reason it is not possible to fully utilize the source of water
2. Physical water scarcity- the demand for water is greater than the supply of water
3. Population Expansion- the increase of human population
4. Potable Water- Water that is safe for human consumption, free from harmful pollutants and bacteria
5. Urbanization- the process by which towns and cities are formed and become larger as more and more people begin living and working in central areas
6. Water scarcity- either the lack of enough water (quantity) or lack of access to safe water (quality).

   *The teacher may choose to add additional vocabulary words as needed.

Tools/Materials/Equipment (per 25 students)

KSB 1 H2o = LIFE					
Item No.	**Qty**	**Item/Description**	**Company**	**Cost per Unit**	**Total**
		Poster board, colored pencils, scissors, glue (dependent on type of artifact students create)			
Equipment/Tools (for artifact development) Teacher's choice- Google Docs, Microsoft Publisher, CorelDraw or other					
Computer with Internet Access **Suggested Websites for Pamphlet:** World Resources Institute: World's 36 Most Water-Stressed countries. http://www.wri.org/blog/2013/12/world%E2%80%99s-36-most-water-stressed-countries World Resources Institute: Baseline Water Stress Interactive Map. http://www.wri.org/applications/maps/aqueduct-country-river-basin-rankings/#x=0.00&y=-0.00&l=2&v=home&d=bws&f=0&o=139 World Resources Institute: World's 18 Most Water Stressed Rivers. http://www.wri.org/blog/2014/03/world%E2%80%99s-18-most-water-stressed-rivers Internet World Stats: Countries and World Regions.					

http://www.internetworldstats.com/list1.htm
Info Please: Countries of the World. http://www.infoplease.com/countries.html
Country Reports: Countries in the World.
http://www.countryreports.org/maps/World.htm

Learning Activities- 6E's

The Big Idea should be written on the board or elsewhere in the classroom; the teacher should begin the KSB with discussion about the Big Idea. The teacher distributes KSB1 Student Companion, reviews safety rules and expectations, then proceeds with ENGAGEMENT Activity.

ENGAGE: 15 min.

1. Students watch a short video with the premise of initiating water scarcity awareness in the world. There are many choices for a video on the Internet. The video below is just one suggestion:

- **Water_KSB1-T1_Video-Water The World Water Crisis**
  http://youtu.be/iRGZOCaD9sQ 4.02 min.

2. Prior to watching the video, ask students to be observant of surprising or interesting information
3. After the video, engage students in a Think, Pair, Share activity; students turn to the person next to them, discuss their notes and thoughts, then engage in class discussion.

EXPLORE: 10 Minutes

Points to Ponder

1. Students are directed to read the Points to Ponder in Student Companion.
2. As a class, students discuss their thoughts on the volume of water available to the volume of the Earth.

EXPLAIN: 40+ minutes

After Points to Ponder, present the PowerPoint to students **(Water_KSB1-T2_Water Crisis PPT.** Use **Water_KSB1-T3_Teacher PPT Notes** to help you explain the content.

Take time to engage students in discussion about the water crisis. There's a lot of information here and students can easily become confused.

The teacher should pay particular attention to the difference between economic and physical water scarcity, as this may be a stubborn concept for students to grasp.

When the PPT is over, direct students to the **How Serious is the Water Crisis** Section in their Student Companion. This section will add to students understanding of the world water crisis.

Move on to the next section, **A Growing Population with Not Enough Safe Water**. As class reads this paragraph, engage in discussion about the World Population graph and trends student might see in population growth.

Move on to **Think Like an Engineer** section. The purpose of this section is to reinforce the Supporting Big Ideas: Aim of Engineering and Sustainable Development.

Read this section with students then allow them to work with a partner to answer the questions.

eNGINEER: 80 min.

Activity: Design a Water Scarcity Artifact

The goal of this activity is to make students aware that water scarcity problems exist in all parts of the world, not just in developing countries but even in our own back yard. Additionally, the types of water problems can vary greatly and be the result of natural and human causes.

When assigning regions for students to research, be diverse in the choices and be sure to include locations in the US, like California and Flint Michigan.

1. Choose a reader or readers to read the info/instructions for the artifact activity from the Student Companion.
2. You may choose that your students create any type of artifact: pamphlet, poster, Google Doc, etc. A pamphlet template is included if you should choose that pathway. (**Water_KSB1-S1_Pamphlet.Template)**
3. Emphasize the importance of researching background information when working as an engineer.
4. Review the Rubric with students. **(Water_KSB1-T4_Rubric-Pamphlet)**
5. Assign students in pairs of two and assign each pair a region. Groups of two seem to work best, but the teacher can make that decision.

6. Suggested countries/regions to research: India, China, Ethiopia, Africa, Bangladesh, United States, Canada, India, and South America.
7. Students will research the following information about their country:
    - Geographical description
    - Physical scarcity or economy scarcity or both?
    - Contributing factors of the problem
    - Description of impacts of the problem

8. Define the term *impact* to ensure students give an accurately account in the pamphlet. An impact can be positive or negative and means to have a strong 'positive or negative' effect on someone or something.
9. When complete, groups give a brief presentation about their research findings.
10. The teacher prompts students to listen and ask questions as the information is presented to check for similarities and differences in the locations.
11. Initiate a whole-class discussion about water problems found around the world.
12. A few minutes before class ends, students are given an Exit Ticket to complete and submit to teacher upon leaving. Suggestions for Exit Tickets are under the **EVALUATE** section.

ENRICH: 45+ min.

Game Activity: Survive

This activity is meant to be an Enrichment Activity and suggested to be included if time permits. It is suggested to take at least one class period, maybe two.

Water_KSB1_T5-Survive Teacher Guide
Water_KSB1_T6-Survive PPT
Water_KSB1_S2-Survive Player Card

The objective of the game is to *survive*; players (students) make choices about their use of water- having only a certain amount of allotted water. Players must "balance" their water allotment throughout the game.

Each PPT slide represents a different day, scenario, etc. The teacher could lead the entire class with the PPT on the screen with the students playing the game at their seats, or students could play it independently if 'clicker' devices are available.

1. The teacher decides if Survive game is Student Navigated or Teacher Navigated.

- <u>Student Navigated</u>
    - Preferred options
    - Students navigate the presentation by themselves or in pairs.
    - Requires high numbers of computers.
    - Partnering provides good discussion opportunities.
- <u>Teacher Navigated</u>
    - Available option when computer numbers are low.
    - Best option for students who struggle with reading.
    - Provides more opportunities for class discussions.
    - May take longer than student navigated.
- The teacher uses Survive-Teacher Guide to introduce or play the game with the students.

2. The teacher reads the following rules to the students that will reference the first few slides in the presentation.

Game Directions and Rules

- *The goal of this game is to survive! You will encounter situations that will force you to make a decision about your water usage.*
- *Keep track of your water usage on the* ***Player Card*** *provided. Once you make a decision, there is no going back! You may look at the other option, but please record your first decision.*
- *To play the game, this presentation must be in "Presentation" or "Slide Show" mode.*
- *To advance through the game, only click on the clearly identified boxes or "decisions" you make.*
- *Click "****Need Water"*** *for 3 options to get more water.*
- *Click "****I cannot survive****" if you run out of options, water, and money.*
- *<u>Note</u>: Using the keyboard arrows or clicking anywhere else may disrupt the flow of the game. Left click > "End Show" to end the game early.*
- *<u>Important</u>: To get the best experience read everything!*

Scenario

1. *You start with 10 Gallons and $10.*
2. *The goal is to survive 1 week/7 days.*

3. *You will be required to use ½ gallon of water every day just to survive.*
4. *Every day you will have to make a decision about your water usage. These decisions will affect your water supply.*
5. *If you need more water before the 7 days is over, click "**Need Water**" and you will face additional decisions and 3 options to get more water.*

3. The teacher demonstrates how to navigate the presentation.
4. The teacher demonstrates how to fill in the player card by using "Day 1" as an example.
5. The Students and Teacher continue playing the game as either Student Navigated or Teacher Navigated.
6. The Teacher monitors students' progress by checking player cards for accuracy and completeness.
7. Students answer any reflection questions in the game in their Design Journal or separate piece of paper.
8. After students have finished, teacher facilitates a discussion about their experience.

   <u>Example prompt and stem questions include:</u>

   1) What did you have to do to try to survive?
   2) Which decision what the hardest to make?
   3) How much water/money did you have at the end of the 7 days?
   4) Is living a life of survival acceptable?
   5) How would this scenario have gone differently if…
   6) What techniques or events are needed to get out of a cycle of fighting to survive?

EVALUATE:

Student knowledge, skills, and attitudes are assessed through:

1. Observation and participation
2. Water Scarcity Artifact
3. Check Your Understanding: Questions-Students answer ten questions to check their understanding of the KSB content. Answer key: **Water_KSB1-T8-Key-Questions**

4. Exit Tickets

Suggestions for Exit Tickets:

*Note- The question for the exit ticket must be relative to the concepts introduced that particular day. Teacher may develop their own exit tickets if preferred.

- What factor has the greatest direct or indirect negative impact on natural resources such as water?
- Name the two types of water scarcity and briefly define each.
- Name two contributing factors of water scarcity and give a brief description of each.
- Name and describe two examples of negative impacts of physical water scarcity
- Name and describe two examples of negative impacts of economic water scarcity

Instructional Hints

- Review all KSB 1 documents to understand the goals and student expectations of the KSB.
- Prior to class time, check to be sure computer and projector are working properly.
- Download the video prior to class time. You may want to load the video on your desktop on your computer to eliminate buffering. Here is the video link- in case it won't open for you. http://youtu.be/iRGZOCaD9sQ. There are many good videos; you may choose to find a different video.
- Prior to presenting the PPT, review the Teacher PPT Notes to familiarize yourself about the PPT content and water scarcity.
- Decide how you will have students create the Water Scarcity Artifact activity; electronically or printout (pamphlet is a Microsoft Publisher document). Be prepared with materials or instructions. A list of websites is provided to help save research time.
- The vocabulary list most likely contains words unfamiliar to your students. The teacher should use their discretion as to how to best inform or teach students the meanings. Some links to sites to enhance vocabulary in fun ways are listed below:
  https://flocabulary.s3.amazonaws.com/pdfs/word-up-mini-games.pdf
  http://www.manythings.org/vocabulary/
  http://www.teach-nology.com/web_tools/materials/bingo/5/

- Upload the pamphlet template into Google Docs so both students may share and work on it at the same time.
- An alternate activity might be paper and pencil poster, an electronic poster, such as Google Docs http://www.educatorstechnology.com/2013/04/9-easy-ways-to-create-classroom-poster.html
- You may find you don't have time to do the Enrichment activity; Survive Game. You may need to do a shortened version of it.
- Review rubric with students beforehand.
- Use an Exit Ticket to assess students understanding each day. Review or reteach any material if necessary the next day

Supporting Files

Student Resources
• Water_KSB1-S1_Pamphlet-Template
• Water_KSB1-S2_Survive Player Card
Teacher Resources
• Water_KSB1-T1_Video-Water The World Water Crisis http://youtu.be/iRGZOCaD9sQ
• Water_KSB1-T2_ Water Crisis PPT
• Water_KSB1-T3_ Teacher PPT Notes
• Water_KSB1-T4_ Rubric-Pamphlet
• Water_KSB1-T5_ Survive-Teacher Guide
• Water_KSB1-T6_ Survive PPT
• Water_KSB1-T7_ End Questions

Products

- Water Scarcity Artifact

Groups develop an artifact illustrating aspects of water scarcity in various regions of the world to reinforce concepts of water scarcity and that it is a global problem.

Safety Notes:

Safety is of paramount importance to every classroom. While this guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect for and appreciation of the efforts of others.

Assessment

Assess accomplishment of learning goals

1. I can describe impacts of population growth on natural resources like water and explain that activities and technologies can be engineered to counteract those effects.
2. Identify the water crisis as both global and local.
3. Describe contributing factors as growing population, urbanization, pollution, inadequate sanitation, lack of water systems and infrastructure and climate change.

These three learning goals are attained as students watch a video, PowerPoint and engage in research that identifies the water crisis, causes, impacts and effects. Assessment includes answering questions in the Student Companion, development of an artifact, Exit Tickets and end questions.

Additional Assessment Suggestions

KSB1- H20 = Life		
Possible assessment item	**Summary of task**	**Form of assessment**
Participation in video discussion	Students respond to and ask questions about video content	No rubric included; teacher may choose to dev. rubric on own
Participation in PPT discussion	Students respond to and ask questions about PPT content	No rubric included; teacher may choose to dev. rubric on own
Think Like an Engineer	Students are asked to answer two questions about engineering and sustainable development.	No rubric included; teacher may choose to dev. rubric on own
What’s the Big Idea/	Big Idea and 3 supporting ideas; students reflect and explain what they mean to them	No right answer, no rubric, teacher discretion
Survive Game	Students play a game with the	No rubric included, informal

	goal to *survive*; players (students) make choices about their use of water	assessment

References

Chislock, M. F., Doster, E., Zitomer, R. A. & Wilson, A. E. (2013) Eutrophication: Causes, Consequences, and Controls in Aquatic Ecosystems. Nature Education Knowledge 4(4):10

Dimick, D. (2014, August 19). If You Think the Water Crisis Can't Get Worse, Wait Until the Aquifers Are Drained. Retrieved December 2, 2014, from http://news.nationalgeographic.com/news/2014/08/140819-groundwater-california-drought-aquifers-hidden-crisis/

Farming: Wasteful water use. (n.d.). Retrieved June 12, 2014, from http://wwf.panda.org/what_we_do/footprint/agriculture/impacts/water_use/

Freeman, S. (n.d.). Retrieved May 9, 2014, from http://science.howstuffworks.com/environmental/earth/geophysics/h2o3.htm

Aqueduct. World Resources Institute. Aqueduct Country and River Basin Rankings. Retrieved May 1, 2016 from http://www.wri.org/applications/maps/aqueduct-country-river-basin-rankings/#x=128.40&y=-1.34&l=2&v=home&d=dro&f=0&init=y&o=171

Home - Safe Drinking Water Foundation. (n.d.). Retrieved May 12, 2014, from http://www.safewater.org/

How Much Water Do You Need To Survive? (n.d.). Retrieved May 10, 2014, from http://wonderopolis.org/wonder/how-much-water-do-you-need-to-survive/

UNFPA - United Nations Population Fund | Population trends. (n.d.). Retrieved May 14, 2014, from http://www.unfpa.org/pds/trends.htm

United States Census Bureau. (n.d.). Retrieved May 14, 2014, from http://www.census.gov/population/international/data/idb/worldpopgraph.php

Water Basics. (n.d.). Retrieved June 12, 2014, from http://water.usgs.gov/edu/mwater.html

World Water Assessment Programme. 2014. The World Water Development Report 2014. Water and Energy. Retrieved June 2014 from http://www.unwater.org/worldwaterday/world-water-development-report/en/

KSB 2: Turbidity Matters!

Overview:

When students finish this KSB, they will be able to answer the following questions:

- ✓ What is turbidity?
- ✓ What makes water turbid?
- ✓ What are the effects of turbidity?
- ✓ What ways can turbidity be measured?
- ✓ How can I construct a device that measures turbidity?

Students first watch a video about turbidity. Further understanding about turbidity is attained as students work through the Student Companion. Students build a turbidity tube, measure the turbidity of a water sample, document their findings in graph form, then sketch a re-design of the turbidity tube.

Lesson Duration: 4- 40 minute class periods

Big Idea: Models are a powerful means for analyzing and predicting the behavior of systems.

Supporting Ideas:

- Resources for solving problems may require people, capital, energy, information, materials, time, and/or tools.
- Successful designs must be matched to human and environmental needs.

Standards and Learning Goals

Performance Expectations	Learning Goals
ESS3.C: Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise	I can explain what turbidity is, describe impacts, causes and effects, and explain ways that turbidity can be measured.
ETS1-4. - Students will develop a model to generate data for iterative testing and modification of a proposed object, tool, or	I can construct a turbidity tube to measure the clarity of a water sample.

process such that an optimal design can be achieved. STL13.F- Students will design and use instruments to gather data	

Vocabulary

1. Filtration- the process of removing something unwanted from a liquid, gas, etc., by using a filter
2. Particles- very small pieces of something
3. Pollutants- a substance that makes land, water, air, etc., dirty and not safe or suitable to use
4. Microbes- tiny microscopic organisms including bacteria, fungi, and protozoan parasites.
5. Nephelometric Turbidity Units- A unit measuring the lack of clarity of water
6. Run-off- water from rain or snow that flows over the surface of the ground into streams
7. Secchi Disk- a white disk or with alternating black and white equal quadrant device used to measure water transparency in all kinds of open waters (ponds, lakes, reservoirs, bays, oceans).
8. Sediment- material (such as stones and sand) that is carried into water by water, wind, etc.
9. Suspended- to hang freely so as to allow movement
10. Turbidity- Turbidity is the measurement of water clarity dependent on how much the suspended particles in the water decrease the passage of light through the water.
11. Turbidimeter- a device for measuring the turbidity of water or other liquids
12. Waterborne- spread or carried by water
13. Water clarity- the quality of being easily seen through

Tools/ Materials/ Equipment (per 25 students)

Item No.	**Qty**	**Item/Description**	**Company/**	**Cost per Unit**	**Total**
American PLAS-100275	12	Fluorescent bulb sleeves with end caps 48 in. - T12 - Clear - Tube	1000bulbs https://www.1000bulbs.com/category/t12-	1.72	20.64

		Guard with End Caps - Protective Lamp Sleeve - American PLAS-100275	polycarbonate-fluorescent-tube-sleeves/		
11G0075A	1	OPTIX X 4-ft x 0.08-in Clear Plexiglass or Acrylic Sheet, *optional* or scrap pieces of acrylic-approx. 3”x 3” or 4”x 4”	Lowes	25.98	25.98
ACM10431	4	Westcott Wooden Meter Stick ACM10431EA	Walmart	3.09	12.36
000357497	1	Sharpie Permanent Markers Fine Point - Black - 12 Count	Walmart	7.77	7.77
No item #	3	General Purpose Masking Tape, 1" x 60 yards, 3" Core, 3/Pack	Walmart	8.99	26.97
32833	6	32833 FUNNEL KING Funnel, Utility Funnel, Total Capacity 8 oz., Diameter 4-1/2"	Walmart	.99	5.94
550043397	1	Nestle Nesquik Chocolate Flavor Powder, 18.7 oz	Walmart	4.38	7.48

Misc. Supplies (recyclables or things teacher likely has on hand)
Scrap Plexiglas or acrylic may be used in place of purchasing a sheet of OPTIX X 4-ft x 0.08-in Clear Acrylic
Foam tray or empty plastic (white) milk jug (to draw Secchi Disk pattern on)
Glue guns/glue sticks
Secchi Disk diagram (print off Internet)
Tray , bin, buckets or similar to place beneath Turbidity Tube when measuring sample
Paper towels (to wipe spills)
Clean, empty milk jugs or other container, ½ to 1 gallon. Need 1 jug per team. To store the cocoa water samples for groups. Best if you have a lid to close the container.
Turbid/ cloudy water, ½ to 1 gal per team (make with Nestle Nesquik Chocolate Powder Flavored Milk Additive- approx. 1/2 to 1 tsp per gallon. If water is too turbid, students may not be able to take a reading.
Equipment/Tools
Scissors
Box cutter (teacher will use)

Learning Activities- 6E's

The Big Idea should be written on the board or elsewhere in the classroom; the teacher should begin the KSB with discussion about the Big Idea. The teacher distributes KSB2 Student Companion, reviews safety rules and expectations, then proceeds with ENGAGEMENT Activity.

ENGAGE: 10 min.

1. Teacher begins by explaining that some people in developing countries lack access to clean drinking water. Even when water is available, there are risks of contamination due to several factors. Turbid water, or cloudy water is one of those factors.
2. To get students thinking about effects of cloudy water, students watch a 5 min. video.
   Turbidity *https://youtu.be/EkH3jZvADTk*

EXPLORE: 10 min.

Think, Pair, Share

1. When video is over, teacher asks students to take a moment and think about a couple of questions they may have about turbidity. Students are instructed to write one of those questions in their Student Companion in the designated space in the Student Companion (SC).
2. Teacher then asks students to turn to the person next to them and tell each other their questions, then write that question in the space labeled 2.
3. Next, on teachers cue, students share their questions with the class and discuss possible answers. All questions may not be discussed- if time is a factor.

EXPLAIN: 40+ min.

PPT Presentation

1. The teacher presents a PowerPoint presentation to help clarify students' understanding and answer any additional questions students may have about turbidity.
   Water_KSB2-T1-Companion PPT
   Water_KSB2-T2 Teacher PPT Notes
2. After the presentation, students work in team of 2 to complete *Check Your Understanding*. **Water_ KSB2-T3 Key-Check Your Understanding**

3. Teacher reviews answers with students

eNGINEER: 80 min.

Activity- A. Getting Ready to Build a Turbidity Tube

1. Teacher assigns students in groups of two. Teacher explains that groups will be building a turbidity tube and will measure the clarity of a sample of water.
2. The teacher reviews Part A in the SC with students, explaining more about turbidity and describing how to take a measurement with the turbidity tube.
3. Teacher directs student groups to move on to Part B, Then Part C. Teacher remarks that groups must read all directions before they begin to build.
4. Teacher ensures that students understand procedures and that equal contribution to the project is expected of all students.
5. Teacher has all materials organized and points out the location of the materials. Teacher shows students an example of a secchi disk pattern **Water_KSB2-T4-Secchi Disk.** This can easily be drawn on the board.
6. When the turbidity tube is complete, students perform three tests on their water sample. The results are converted from centimeters to Nephelometric Turbidity Units (NTU's). The average reading is then documented in the Student Companion.

Teacher preparation:

To prepare the clear plastic sleeves for students before distributing:

1. Cut the 48" clear plastic sleeves in half; only 24" (2') is needed. The plastic cuts easily with scissors, box knife or band saw.

To prepare the water sample:

1. Empty milk jugs with lids make good containers for the water samples. You will need approx. ½ gallon per team. You can easily use a sharpie to mark each teams' sample on the jug. Ex. Team 1, Team 2, etc.
2. The water sample is a mixture of water and Nesquik. One-half to one teaspoon per gallon is usually sufficient. Each groups' sample should be a little different mixture so that students get different readings from other groups. You don't want the water to be too dark as it will be difficult for students to see the secchi disk to take the reading.

Tips!

1. Strive to have students build the turbidity tube and test for leaks on the first day, then measure turbidity the next day. Encourage students to complete the building and test it for leaks in 1 class period.
2. Reinforce that the measuring increments marked on the tube or tape should be very accurate. Begin the measurements from the point of where the bottom water level will be.
3. If your students use tape to write the measurements on, marking mistakes can easily be remedied. This allows that the tubes may be reused for another time.
4. Keep the water samples stirred or shaken; do not allow to settle.
5. Use the funnels to pour the water into the tubes.
6. Make sure students place their turbidity tubes in a catch pan of some sort to catch spills. Spills often occur when students are emptying out their tubes.
7. No need to save the water; pour water down the sink when done.
8. **Take lots of pictures and videos! Students may use these for their presentation.**

ENRICH: 20 min.
Build a Better "Turbidity Tube"

1. Student teams are asked to think about what they could do to make their turbidity tube "better".
2. "Better" can mean maximize efficiency, minimize materials, make it more portable, easier way to release water, etc. The teams then sketch out their design and write a brief description explaining their idea and describing any tradeoffs.
3. Teams discuss their ideas and designs with the class.

Think Like an Engineer

At this point- students have finished building their turbidity tube and drawing their "better" turbidity tube. Now is a perfect time to introduce systems. While a turbidity tube is not a full-out system, it can be thought of as a component of a system. With students, read the Think Like an Engineer page. You may even want to place this page on a PPT slide to go more in depth with the info and the images.

EVALUATE: 10-20 min.

Student knowledge, skills, and attitudes are assessed through:

1. Observation and participation
2. Construction of Turbidity Tube
3. Check Your Understanding: Questions-Students answer ten questions to check their understanding of the KSB content. Answer key: **Water_KSB2-T5-Key-End Questions**
4. Exit Tickets

Suggestions for Exit Tickets:

*Note- The question for the exit ticket must be relative to the concepts introduced that particular day. Teacher may develop their own exit tickets if preferred.

1. Briefly explain what turbidity is, list one example of its cause and one example of its effect on drinking water.

Instructional Hints

- Review all KSB2 documents to understand the goals and student expectations of the KSB.
- Prior to class time, check to be sure computer and projector are working properly.
- Download the video prior to class time. You may want to load the video on your desktop on your computer to eliminate buffering.
- Prior to presenting the PPT, review the Teacher PPT Notes to familiarize yourself about the PPT content and water scarcity.
- The vocabulary list most likely contains words unfamiliar to your students. The teacher should use their discretion as to how to best inform or teach students the meanings. Some links to sites to enhance vocabulary in fun ways are listed below:
  https://flocabulary.s3.amazonaws.com/pdfs/word-up-mini-games.pdf
  http://www.manythings.org/vocabulary/
  http://www.teach-nology.com/web_tools/materials/bingo/5/

- Students will be excited to build the turbidity tube. Be sure to review the tips under the ***eNGINEER*** step. Hot glue works very well to glue the base to the tube, but students must take their time to ensure even application of glue. Test it out with a small amount of water before adding larger quantities. Be sure to have plenty of paper towels on hand to wipe up spills and trays to stand the Turbidity tubes in to catch overflows.

Supporting Files

Student Resources
• Water_KSB2_S1- Rubric-TurbTube
Teacher Resources
• Water_KSB2_T1 Companion PPT
• Water_KSB2_T2 PPT Teacher Notes
• Water_KSB2_T3 Check Your Understanding
• Water_KSB2_T4 Secchi Disk Pattern
• Water_KSB2_T5- Key-End Questions

Products

- Turbidity Tube
- Groups of two construct a turbidity tube then test the clarity of a water sample.

Safety Notes:

Safety is of paramount importance to every classroom. While this guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect for and appreciation of the efforts of others.

Assessment

Assess accomplishment of learning goals

1. I can explain what turbidity is, describe impacts, causes and effects, and explain ways that turbidity can be measured.
   For students to achieve this learning goal, they must understand that there are differing levels of turbidity that affect the safety of drinking water. The more turbid water is, the more likely that bad microbes can attach to the suspended particles that are causing the turbidity. Students investigate causes and effects of turbidity then build a turbidity tube to measure turbidity (water clarity).

2. I can construct a turbidity tube to measure the clarity of a water sample.

For mastery of this learning goal, students engage in a hands-on activity where they build a turbidity tube then use it as a scientific tool to measure the clarity of water samples in Nephelometric Turbidity Units (NTU's). The turbidity tube must be leak-free, the measurement markings on the tube must be accurate, and the secchi disk and pattern must be drawn and placed correctly in the tube.

Additional Assessment Suggestions

KSB2- Turbidity Matters		
Optional assessment items	**Summary of task**	**Form of assessment**
Participation in video discussion	Students respond to and ask questions about video content	No rubric included; teacher may choose to dev. rubric on own
Check Your Understanding	Students are asked to answer 6 questions that summarize the main points of the PPT.	No rubric included; teacher may choose to dev. rubric on own
Construction of the Turbidity Tube	The turbidity tube must be leak-free, the measurement markings on the tube must be accurate, and the secchi disk and pattern must be drawn and placed correctly in the tube.	Rubric. Water_KSB2_S1- Rubric-TurbTube
Part E.- Data Collection and Results	Students complete documentation in SC pertaining to turbidity testing	No rubric included; teacher may choose to dev. rubric on own
Line Graph	Students create a simple line graph that illustrates turbidity testing results	No rubric included; teacher may choose to dev. rubric on own
Build a Better Turbidity Tube	Draw side and top views of an improved turbidity tube; include labeled parts and brief explanation of why the design is better.	Rubric is embedded in SC
What's the Big Idea?	Big Idea and 2 supporting ideas; students reflect and explain what they mean to them	No right answer, no rubric, teacher discretion

References

Dunbar, B. (2004, November 21). Retrieved December 17, 2014, from http://www.nasa.gov/centers/goddard/news/topstory/2004/0810deadzone.html

Importance of Turbidity. (n.d.). Retrieved December 17, 2014, from http://www.epa.gov/ogwdw/mdbp/pdf/turbidity/chap_07.pdf

MathinScience Index. (n.d.). Retrieved December 17, 2014, from http://mathinscience.info/

Turbidity Measurement. (n.d.). Retrieved December 17, 2014, from http://www.who.int/water_sanitation_health/hygiene/emergencies/fs2_33.pdf

Turbidity Overview:What is Turbidity and how is it measured? (n.d.). Retrieved December 17, 2014, from http://www.optek.com/Turbidity.asp

Turbidity. (n.d.). Retrieved December 17, 2014, from http://www.lenntech.com/turbidity.htm

UW Extension. (2003). Turbidity: A Water Clarity Measure. Water Action Volunteers: Volunteer Monitoring Factsheet Series. University of Wisconsin.

KSB3 Heavy Metals!

Overview:

When students finish this KSB, they will be able to answer the following questions:

- ✓ How do water contaminates enter water sources?
- ✓ What are basic categories of water contaminates?
- ✓ What effects do these contaminates have on health?

Students first examine an image to discover people participating in activities that contaminate water. Next students are informed about point and non-point source water pollution. Next, students participate in a Jigsaw Activity to learn about water contaminates, and last, students design an artifact that describes specifics about each contaminate.

Lesson Duration: 2-3 - 40 minute class periods

Big Idea:

All drinking water contains some contaminates; some are harmless and some can make the water unsafe to drink.

Supporting Idea: The aim of engineering should be to benefit society and the environment.

Standards and Learning Goals

Performance Expectations	Learning Goals
ESS3-3-C Human Impacts on Earth Systems STL.5.F. Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another.	I can name three categories of water contaminants, explain how they enter water resources and describe their impacts on human health.

Vocabulary

1. Bacteria- living organisms, such as enzymes, fungi, viruses or their products usually harmful to humans, commonly found in unsafe water
2. Biological contaminates- organisms in water- also referred to as microbes or microbiological contaminates. Examples include bacteria, viruses, protozoan, and parasites

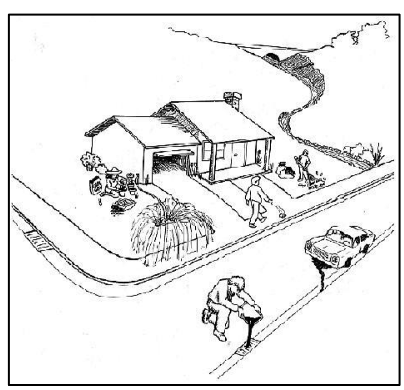
3. Chemical contaminates- elements or compounds found in water, can be natural, like arsenic or man-made like pesticides
4. Microorganism- an organism too small to be seen with naked eye but visible under a microscope
5. Parasite contaminants- parasite contaminates are organisms that live on or in a host organism and gets its food from or at the expense of its host
6. Pathogen- a bacterium, virus or other microorganism that can cause disease
7. Physical water contaminants – sediment or organic material, primarily impacting appearance or other physical properties of water
8. Radiological contaminates- a subset of Chemical contaminates, include cesium, plutonium, and uranium
9. Sediment and particulates - sand, silt and soil material that are transported- and deposited- by flowing water
10. Water contamination- Impurities in water regardless of the source
11. Water pollution- particles, chemicals or substances discharged directly or indirectly into water bodies, usually caused by humans

Tools/Materials/ Equipment (per 25 students)

KSB3 Heavy Metals					
Item No.	**Qty.**	**Item/Description**	**Company/ Address/ Phone**	**Cost per Unit**	**Total**
		No supplies needed			
Misc. Supplies					
Equipment/Tools					
Computer with Internet Access					

Learning Activities- 6E's

The Big Idea should be written on the board or elsewhere in the classroom; the teacher should begin the KSB with discussion about the Big Idea. The teacher distributes KSB1 Student Companion, reviews safety rules and expectations, then proceeds with ENGAGEMENT Activity.



ENGAGE: 10-15 min.

1. Teacher directs students to page 2 of SC and asks students to look at the picture and discuss things they see that are wrong. This image may be

copied, enlarged, and projected on a big screen so class can engage together in discussion.

Teacher asks these questions:

- What is wrong with this picture? (Answers may include: oil is spilling into street gutter, someone is dumping paint into the street gutter, someone is littering, gardener could be applying pesticides to the garden, and the sidewalk is being watered (wasting water).
- Do you think the stream is cleaner above or below the house? (Answer: The stream is cleaner above the house — that is higher into the mountains.)
- Do the community residents have a direct impact on the water quality of the stream? (Answer: yes)
- The people who live just downstream from the houses use the stream as the source of their drinking water, should they drink the water? (Answer: Knowing that the water in contaminated with oil and/or other pollution, they should not drink the water.)
- What should they do? (Answer: First, educate the people in the picture so that they stop polluting the water; next, treat the water to remove pollutants.)
- Besides drinking water, for what other purpose can streams be used? (Possible answers: recreation [boating, canoeing and swimming], fishing, crop irrigation, stock/animal water supply, education and scientific studies.)
- Can people use water that comes from polluted streams for the above purposes? (Answer: no)

EXPLORE: 10-15 min.
Teacher directs students to Points to Ponder and reads the paragraphs as a class. The paragraphs are meant to instigate discussion about water sources, how they can become contaminated and the job of engineers to help keep the water sources clean. The class moves on to next page in SC and class engages in discussion about the difference between pollution and contamination and also Point and Non-Point sources of water contamination.

EXPLAIN: 20 min.

Students move on to next page in SC, Think Like an Engineer.

Write the following statement on the board. This is one of the *integrated* Big Ideas of the unit that should be addressed and checked for understanding.
The aim of engineering should be to benefit society and the environment.

Appoint a student to read it. Ask students to think about this statement and what they think it means. Continue reading the remaining section in the SC.

There are three questions at the bottom of the page; students may work with another student as they think of how to answer these question. The class will take a few minutes to listen to the answers of some students.

ENGINEER: 2-3 40 min. Class periods

Jigsaw Activity: Missing Pieces of Water Contaminates

1. Teacher refers to Water_KSB3_T1 Jigsaw Instructions to understand how to facilitate a Jigsaw Activity.

- Teacher explains to students that they will learn about three types of water contaminants: 1) Physical, 2) Chemical, 3) and 4) Biological. Teacher assigns jigsaw Home Groups. Then assigns each member one of the topics (Physical, Chemical, or Biological contaminates). Teacher has all members with the same topic to move in one big group (or 2 smaller groups) which is called the Expert Group. Students are given a Graphic Organizer to collect their information. Water_KSB3_S1 Jigsaw Graphic Organizer

2. In Expert Groups students are given their assigned topic info sheet and are directed to read about it. (Water_KSB3_S2, S3, S4 Jigsaw Pieces). Teacher may choose to add additional water contaminate content to students "Jigsaw Pieces". There are many great web sites to add additional information.
3. When students have completed reading, they discuss what they read and determine what vital information should be taught to the team mates in their Home Group.
4. Students return to their Home Groups.
5. Upon returning to Home Group, students instruct the others about information in which they have become an "expert". Each Home Group member (now an Expert) takes turns teaching what he or she has learned to the other Home Group members.

6. When the Jigsaw Activity is complete, Home Groups will work together to complete the three "Check Your Understanding" questions. Class will discuss answers.

The teacher's role during the time students are engaged in the Jigsaw is to:

1. Circulate to ensure that groups are on task and are filling out their individual graphic organizer.
2. Ask groups to stop and think about how they are checking for classmate's understanding and ensuring that everyone's voice is heard.

3. Monitor the comprehension of the group members by asking questions and rephrasing information until it is clear that all group members understand the points.

Contaminant Artifact Activity

1. With their Home Group, students create a type of artifact to be presented to the class that illustrates their group's understanding of Physical, Chemical, and Biological Contaminates. This can be in the form of a poster, a PowerPoint, or any Web 2.0 tool. One example might be an Infographic.
2. You will decide the type of artifact according to the time you have for completion.

Information to be addressed in the artifact:

1. Provide a description of each contaminate with specific examples
2. Explain/describe how the contaminate enters the water source
3. Explain/describe the effects on health for each contaminate

Be sure to review the rubric with students beforehand. It is embedded in the SC.

What's the Big Idea?

It is important that students take away the following really important BIG IDEAS about engineering from this KSB.

1. All drinking water contains some contaminates; some are harmless and some can make the water unsafe to drink.
2. The aim of engineering should be to benefit society and the environment

Ask students to reflect on each one and explain what it means to them. There isn't an answer key for this- it is just students' opinions.

ENRICH: 10 min. **Sand, Silt, and Clay: Which settles first?**

If time allows, students engage in the "Enrich" activity below. If time is brief, an option may be a video that illustrates similar concepts. (https://youtu.be/4eUNv8pdzG0)

- In advance, the teacher prepares clear plastic water bottles filled partway with water and sediment (sand, silt, and clay), and sealed envelopes with specific questions written on the front. Each group is given a water bottle and an envelope. Groups follow the instructions on the envelope. When they are finished, they may open the envelope and read the explanation.

Envelope Front

Names

____

Shake up the bottle. Sit it down to let it settle.

When sediment is carried by water, it usually settles out according to size, just like in this bottle.

1. Can you see the sand, silt, and clay? ____________________________________
2. Which settles first? ____
3. Approximately how long does it take for each to settle to the bottom?

____

4. If the water were flowing, would they move farther? Which would move the farthest?

____

____

Explanation inside the envelope.

The finer clay will move all the way to a lake, making the lake ugly and unproductive. The silt and sand take longer to travel and because of that, they can clog creeks and streams.

Sediment is the largest single non-point source pollutant and the primary factor in the deterioration of surface water quality.

EVALUATE: 20 min.

Student knowledge, skills, and attitudes are assessed through:

1. Observation and participation
2. Water Scarcity Artifact
3. Check Your Understanding: Questions-Students answer ten questions to check their understanding of the KSB content. Answer key: **Water_KSB3_T2 Key-End Questions**
4. Exit Tickets

   Suggestions for Exit Tickets:

   *Note- The question for the exit ticket must be relative to the concepts introduced that particular day. Teacher may develop their own exit tickets if preferred.

   - In two to three sentences, describe what a biological water contaminate is. (or chemical, or physical)
   - Explain point and non-point pollution and give an example of each.
   - Describe something an engineer can do to help with a water problem.

Instructional Hints

- Review all KSB3 documents prior to the start of class to understand student goals and expectations.
- Review the Water_KSB3_T1 Jigsaw Instructions to understand how to facilitate a jigsaw activity. There are many Youtube videos that explain Jigsaw Activities; here's a suggestion: https://youtu.be/mtm5_w6JthA
- The intent of the Jigsaw Activity is for students to attain water contaminant information that they can use as they work forward in the KSB's. After they have finished the Jigsaw Activity, students should organize the information in a creative way, either as a whole class resource or a team resource. Encourage students to think about how the information can best be organized to be the most beneficial later in the unit

- The vocabulary list most likely contains words unfamiliar to your students. The teacher should use their discretion as to how to best inform or teach students the meanings. Some links to sites to enhance vocabulary in fun ways are listed below:
  https://flocabulary.s3.amazonaws.com/pdfs/word-up-mini-games.pdf
  http://www.manythings.org/vocabulary/
  http://www.teach-nology.com/web_tools/materials/bingo/5/

Supporting Files

Student Resources
• Water_KSB3_S1 Jigsaw Graphic Organizer • Water_KSB3_S2 Jigsaw Biological • Water_KSB3_S3 Jigsaw Chemical • Water_KSB3_S4 Jigsaw Physical
Teacher Resources
• Water_KSB3_T1 Jigsaw Instructions • Water_KSB3_T2 Key- End Questions • Settling Tank Experiment Video: https://youtu.be/4eUNv8pdzG0

Products

- Contaminate Artifact

Groups develop an artifact describes and explains each of the three categories of water contaminates: Physical, Chemical, and Biological. An example would be an Infographic.

Safety Notes:

Safety is of paramount importance to every classroom. While this guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect for and appreciation of the efforts of others.

Assessment

Assess Accomplishment of Learning Goals

1. I can name three categories of water contaminants, explain how they enter water resources and describe their impacts on human health.

For students to achieve this learning goal, they'll need to understand the types of water contaminates, the causes and their effects. Teacher should ensure students are attentive to their assigned topic during the Jigsaw Activity- so as to be an active participant in the "Expert Group" and then be an informative teacher in their "Home Group".

Additional Assessment Suggestions

KSB3- Heavy Metals		
Possible assessment item	**Summary of task**	**Form of assessment**
Observation and participation in KSB	Students respond to and ask questions about KSB content	No rubric included; teacher may choose to dev. rubric on own
Think Like an Engineer	Students are asked to answer three questions about how engineers can benefit society.	No rubric included; teacher may choose to dev. rubric on own
Contaminant Artifact	Development of an artifact that illustrate understanding of water contaminate concepts	Rubric is embedded in SC

What's the Big Idea/	Big Idea and 1 supporting idea; students reflect and explain what they mean to them	No right answer, no rubric, teacher discretion

References

(n.d.). Retrieved January 6, 2015, from http://impactwater.org/wp-content/uploads/2012/01/dirty-water-slider.jpgWatershed image_

(n.d.). Retrieved January 6, 2015, from http://cfpub.epa.gov/npstbx/files/ksmo_sediment.pdf

(n.d.). Retrieved January 6, 2015, from http://whatcom.wsu.edu/ipm/manual/rasp/images/hydrologic_cycle_big.jpg

(n.d.). Retrieved January 9, 2015, from http://changingplanet.files.wordpress.com/2011/10/how-parasites-infect-humans1.png

(n.d.). Retrieved January 9, 2015, from http://www.intechopen.com/source/html/44184/media/image2.jpg

(n.d.). Retrieved January 9, 2015, from http://www.northcoastlabs.com/services-analysis-testing/pic1Bacteriology.jpg

(n.d.). Retrieved January 9, 2015, from http://www.ucsf.edu/sites/default/files/legacy_files/amoeba-380-05152012_1.jpg

(n.d.). Retrieved January 9, 2015, from https://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-NWT/STAGING/images-images/hym5_1100100023417_eng.jpg

Bacteria | American Ground Water Trust. (n.d.). Retrieved January 9, 2015, from http://www.agwt.org/content/bacteria

Bacteria in Water Wells. (n.d.). Retrieved January 9, 2015, from http://www.ext.colostate.edu/pubs/natres/06703.html

British Medical Bulletin. (n.d.). Retrieved January 9, 2015, from http://bmb.oxfordjournals.org/content/68/1/167.full

Coliform Bacteria & Drinking Water. (n.d.). Retrieved January 9, 2015, from http://www.ewashtenaw.org/government/departments/environmental_health/wells_septic/well_septic_pdf/eh_coliformfactsheet.pdf

Cooperative Learning: 7 Free Jigsaw Activities for Your Students. (n.d.). Retrieved December 31, 2014, from http://www.dailyteachingtools.com/cooperative-learning-jigsaw.html#2

Drinking Water Contaminants. (2009, May 1). Retrieved June 1, 2014, from http://water.epa.gov/drink/contaminants/

Giardia and Cryptosporidium in Drinking Water. (2009, February 6). Retrieved December 22, 2014, from http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/giardia_cryptosporidium-eng.php

Giardiasis Guide: Causes, Symptoms and Treatment Options. (n.d.). Retrieved June 15, 2014, from http://www.drugs.com/health-guide/giardiasis.html

Heavy Metal Pollution Is More Common Than You Think - Fairfax County, Virginia. (n.d.). Retrieved January 9, 2015, from http://www.fairfaxcounty.gov/nvswcd/newsletter/heavymetal.htm

Heavy Metals. (2004, March 1). Retrieved January 9, 2015, from https://www.aadnc-aandc.gc.ca/eng/1100100023403/1100100023423

Heavy Metals. (n.d.). Retrieved June 2, 2014, from http://www.lenntech.com/processes/heavy/heavy-metals/heavy-metals.htm

How We Get Parasites. (n.d.). Retrieved January 9, 2015, from https://humaworm.com/How_We_Get_Parasites.html

Jarup, L. (2003). British Medical Bulletin. Retrieved January 1, 2015, from http://bmb.oxfordjournals.org/content/68/1/167.full

Metals in aquatic freshwater. (n.d.). Retrieved June 2, 2014, from http://www.lenntech.com/aquatic/metals.htm

(n.d.). Retrieved January 9, 2015, from http://globe.setac.org/2011/june/south_africa.jpg

Particulates. (n.d.). Retrieved January 6, 2015, from http://en.wikipedia.org/wiki/Particulates

Viruses, bacteria and parasites in the digestive tract. (n.d.). Retrieved January 9, 2015, from http://www.chw.org/medical-care/gastroenterology-and-hepatology-program/conditions/viruses-bacteria-and-parasites-in-the-digestive-tract/

Water Sediment and Particulates. (n.d.). Retrieved December 31, 2014, from http://www.watercenter.org/physical-water-quality-parameters/water-sediment-and-particulates/

Water. (2010, November 2). Retrieved January 9, 2015, from http://www.cdc.gov/parasites/water.html

Water. (2010, November 2). Retrieved June 2, 2014, from http://www.cdc.gov/parasites/water.html

Waterborne diseases. (n.d.). Retrieved December 22, 2014, from http://www.lenntech.com/processes/disinfection/deseases/waterborne-diseases-contagion.htm

Water-related diseases. (n.d.). Retrieved June 15, 2014, from http://www.who.int/water_sanitation_health/diseases/diarrhoea/en/

What are the various types of water pollution? (n.d.). Retrieved July 25, 2014, from http://eschooltoday.com/pollution/water-pollution/types-of-water-pollution.html

Wright, J., Gundry, S., & Conroy, R. (n.d.). Systematic Reviews-3ie: International Initiative for Impact Evaluation | Evaluating Impact, Informing Policy, Improving Lives. Retrieved July 16, 2014, from http://www.3ieimpact.org/evidence/systematic-reviews/details/303/

KSB 4: Clean Up Your Act

Overview

When students finish this KSB, they will be able to answer the following questions:

- ✓ How can I illustrate a water filtration system in a systems diagram?
- ✓ How can I detect and remediate physical, chemical, and biological contaminates in water?

The KSB begins with students watching a video to understand how water is cleaned in a traditional treatment plant. Next students complete a systems diagram activity, and last, students embark in water remediation activities that examine physical, chemical, and biological contaminates.

Lesson Duration: 6 - 40 minute class periods

Big Idea: Water sources can be improved by using engineering methods to remove contaminants.

Supporting Ideas:

- Systems have parts that work together to achieve desired results.
- Feedback involves monitoring and adjusting a system to maintain a desired output.

Standards and Learning Goals

Performance Expectations	Learning Goals
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. STL.2.M. Technological systems include input, processes, output, and at times, feedback.	I can detect and remediate physical, chemical, and biological water contaminates. I can create a systems diagram to show how water is cleaned.

Vocabulary

1. Alum-a specific chemical compound used as a coagulant to reduce the visible cloudiness (turbidity) in the water.

2. Biological Contaminates- organisms in water, also referred to as microbes or microbiological contaminants. Examples include bacteria, viruses, protozoan, and parasites.
3. Chemical Filtration-the use of specialized media to filter out organic and inorganic materials.
4. Coagulation- flocculants (chemicals) are added to the water to make dirt and dissolved particles stick together in clumps that are called flocs.
5. Detect- discover or identify the presence or existence of
6. Filter Media- A natural or synthetic material used to filter or strain undesirable solids. Filter media have porous voids that are designed, created, or manufactured to allow only desirable liquids or gasses through.
7. Remediate- to correct it or make it right.
8. Sedimentation- the tendency for particles in suspension to settle out of the fluid they are in and come to rest against a barrier or the bottom
9. Simulate- to mimic the real thing
10. Water Disinfection- the removal, deactivation or killing of pathogenic microorganisms. Microorganisms are destroyed or deactivated, resulting in termination of growth and reproduction.

Tools / Materials / Equipment (per 25 students)

Materials					
Item No.	**Qty**	**Item/Description**	**Company**	**Cost per Unit**	**Total**
No item #	1	Any inexpensive fertilizer rich in nitrogen will work 1 option: 4LB TPL Super Phosphate	Walmart	7.19	7.19
	1	KORDON Methylene Blue-General Disease Prevention Treatment for Aquarium, 4-Ounce	Amazon	5.95	5.19
551660890	1	Boardwalk Powder Free Non-Sterile Latex General Purpose Gloves, 100 Count size medium	Walmart	6.68	6.68
No item #	1	Hoosier Hill Farm Alum Powder Granulated, 1 Lb.	Amazon	10.19	10.19
009239833	1	Nestle Nesquik Chocolate Powder Flavored Milk Additive, 40.7 oz	Walmart	7.48	7.48

293189	1	Small bag all- purpose sand	Lowes	3.78	3.78
92130	1	Small bag small gravel	Lowed	3.38	3.38
No item #	1	Activated Charcoal	Walmart	4.94	4.94
551573439	1	Great Value Clear Cups, 16oz, 100 ct.	Walmart	4.98	4.98
	1	Microscope, glass slides, cover slips, eyedropper (all included in kit)	Amazon	35.00	
32833	6	FUNNEL KING Funnel, Utility Funnel, Total Capacity 8 oz.	Walmart	.99	6.00
No item #	6	Norpro 4 Cup Plastic Measuring Cup	Walmart	4.84	29.04
	1	Toothpicks	Walmart	1.50	1.50
	1	Bleach, smallest qty. available	Walmart	1.00	1.00
	1 p/ grp	¼ oz Rapid Rise or Fast Acting Baker's Yeast packet	Walmart	1.00	1.00
	1	Nitrate Test Kit http://www.amazon.com/API-LR1800-Nitrate-Test-Kit/dp/B002DVVICS/ref=sr_1_1?ie=UTF8&qid=1463674667&sr=8-1&keywords=nitrate+testing+kit	Amazon	11.99	11.99
Misc. Supplies					
Empty water bottles, 12-16 oz. (preferably 16 oz)					
1 cup sugar					
Paper towels (for spills)					
Tray to catch spills					
Additional ingredients to make dirty water; paper pieces, dirt, etc.					
Equipment/Tools					
Turbidity tube students built in KSB2					

Learning Activities- 6E's

The Big Idea should be written on the board or elsewhere in the classroom; the teacher should begin the KSB with discussion about the Big Idea. The teacher distributes KSB4 Student Companion, reviews safety rules and expectations, then proceeds with ENGAGEMENT Activity.

ENGAGE: 10 Minutes

1. The teacher begins the KSB by asking students: "Where does your water come from before it comes out of your tap?" Allow students a few minutes to share their thoughts.
2. The teacher follows the discussion with a video that illustrates how water is cleaned in a treatment facility. There are many excellent videos on YouTube that the teacher could use for this engagement.

Two suggestions are listed below:

- Water and You: The Water Treatment Process https://youtu.be/tuYB8nMFxQA
- Liquidity https://youtu.be/AeZ5Zago_co

3. After the video, teacher directs students to their Student Companion (SC). Review the Big Idea and the paragraph below the images.

EXPLORE: 20 Minutes

In the SC, students take turns reading the *Traditional Water Filtration* paragraphs. Teacher may choose to enlarge the Treatment Facility Image on a PPT slide to help students identify the different processes as they are mentioned. Stress that water treatment facilities are usually large scale and are found in populated communities in developed countries.

Group Activity: Small Scale Solutions

1. Print the five- small-scale water treatment solutions fact sheets:
   Water_KSB4_S1-Chlorination Facts
   Water_KSB4_S2-Solar Disinfection
   Water_KSB4_S3-Bio-sand Filtration
   Water_KSB4_S4-Ceramic Filtration
   Water_KSB4_S5-Solar Filtration
2. Read or have students read the paragraph under Small-scale Solutions.
3. Create five groups in the class and give each group one of fact sheets.
4. Direct groups to meet and discuss their assigned solution (approx. 5-7 minutes) then present what they learned about their topic to the class.

EXPLAIN 15-20 minutes

Think Like an Engineer- Systems

Systems are one of the five unifying engineering themes that form the basis for the Engineering for All Water and Food units. Ensure students have a clear understanding of systems and systems diagrams. The small-scale solutions students just examined are used here as examples of systems to help students make the connection between water treatment facilities and systems.

1. With students, review the information in the Think Like an Engineer- Systems section. Students will write in answers to any areas that need completed.
2. Answers for Components in the Ceramic Filtration System: Silicon seal, Glass cover, Dirty water, Distilled water collection tray, Drain tube. Students may also state that there is a container that holds all the components.
3. Engage in discussion about the components of the systems diagram: inputs, processes, outputs, and feedback, using the image in the SC as reference.

eNGINEER: 4- 40 min. class periods

Check Your Understanding

Activity- Water Treatment Systems Diagram

1. The teacher may choose this activity to be individual or pairs.
2. Students will complete the systems diagram for a water treatment plant in the Student Companion.
3. The teacher will use the teacher resource below to evaluate it: **(Water_KSB4_T1—Key-Systems Diagram and Rubric)**

Points to Ponder

The information in Points to Ponder is important for students to read and class to discuss. It’s a hint towards a possible solution in the Grand Design Challenge. Sari cloth is identified as a filtering method that is successful in reducing cholera, a waterborne disease, in developing countries.

Activity: Test Your Water- Treat Your Water

Students will detect and remediate physical, chemical, and biological water contaminants, in separate exploration activities. This activity can be implemented in two ways: 1) all groups have the opportunity to detect and remediate each contaminate- *preferred but takes more time*, or 2) groups will work on only one contaminate and will share their findings (*takes less time*). A rubric is available for student participation in this activity. (**Water_KSB4_-T2-Participation Rubric)**

Assign students in groups of 2-4 for each exploration.

Stress to students that the water samples they are working with are only simulated water contaminates; nothing in the samples is harmful to students but still be sure to tell students not to drink it.

Prior preparation:

1. The teacher prepares the three stations in advance or has materials organized in a location students can easily acquire.
2. Common materials for each station include: safety glasses, latex gloves, plastic spoons, tray to catch spills, and paper towels.
3. Review each contaminate packet for complete list of materials needed for student organization:
   Water_KSB4_S6-Physical
   Water_KSB4_S7-Chemical
   Water_KSB4_S8-Biiological
4. Prepare for each activity following instructions below:

Physical Contaminate- Teacher Preparation

The first step in water treatment is to remediate the *physical* contaminates- making the water clearer and removing visible particles. Remediate means to correct something that is wrong or improve a bad situation. Coagulation, sedimentation, and filtration are all phases of remediating physical contaminates.

Students will do two things to treat the water containing physical contaminates:

1. Make a precipitate to settle out the things in the water that make it muddy or colored.
2. Pour the clarified water through filter media to get out the smaller things that are still in the water.

Have all materials, equipment, and tools ready and organized.
All students should be wearing safety glasses and latex gloves.

Materials needed for Physical Activity:

Items	**Quantity**

Safety glasses	1 per student
Rubber/ latex/ vinyl gloves	1 pair per student
16oz water bottle of simulated “physical” contaminant	1 per group
½ teaspoon alum	1 per group
1 coffee filter	1 per group
1 cup gravel	1 per group
½ cup sand	1 per group
½ cup activated charcoal	1 per group
1 plastic spoon	1 per group
Empty water bottles with bottoms cut off	2 per group
Empty water bottles with tops cut off (to use as holders)	2 per group
Clear 16 oz cups	1-2 per group
Funnel	1 per group
Tray to catch spills	1 per group
Paper towels to wipe up spills	
Turbidity tube (students built in KSB2)	1 per group

Prepare the Physical water sample- the ingredients below will make 1-16 ounce water bottle full; each group will need 1-16 ounce water bottle full: adjust the amount you make according to amount of groups. The teacher will also need a bottle full to use as a control so students can visually compare. It may be easier to make a bucket full- then distribute into the water bottles using a funnel. The important thing is to make all the water the same. There is no exact ingredient list, except for the Nesquik. Don’t make it too dark as it will be difficult to get an initial turbidity reading.
For every16 ounces of water add:

- ½ teaspoon Nesquik
- ½ teaspoon oil
- Optional additional ingredients like dirt, small paper pieces, crushed leaves etc. to simulate dirty water

Prepare the water bottles that will hold the media and filtered water

- You need 4 empty 16 ounce water bottles per group and one for teacher “control” (5 total).

- Four bottles will be cut and one will remain intact to hold the teachers "control" water sample.
- Procedure 1: Cut two bottles in half as close to the top as possible to allow for the most amount of room possible to collect the filtered water.
- Procedure 2: Cut the other two bottles as close to the top as possible to hold the media.

For the most part, the teacher's role in this activity is explained in the students' instructions: Water_KSB4_S6-Physical.
Note: Students must take a "before" and "after" turbidity reading using the turbidity tube from KSB2 for evaluation of remediation.

Step 1- Flocculation and Sedimentation Procedure

The first process is flocculation. Students will create a precipitate, or a solid, that will attract the things floating in the water, bind them together in clumps, and make them heavier so they will fall to the bottom (this is called sedimentation). Sedimentation is when particles in suspension settle out of the fluid in which they are suspended and come to rest against the bottom.

- Provide each group with the Physical Contaminates packet.
- Provide each group with a 16oz water bottle full of a turbid water sample. Tell students to shake it so all particles are visible.
- You, as teacher will also have a bottle of the same water sample; this will be the *control*, or comparison, so students can see what the water would be like if nothing was done to it.
- As per student's instructions packet, alum will be added to clarify the water.
- After following additional instructions and specified time allotment (10-15 min), compare the newly clarified water to the teachers control water. Analyze and evaluate results.

Step 2- Filtration Procedure

The next step after flocculation is filtration. Students will filter their newly clarified water by pouring it through layers of filter media. Filter media is anything placed in a filter that changes the *quality* of water flowing through it. Students choose from four different kinds of media and conduct *two* filtration tests.
Filter media works by straining solids from the water as it passes through its pores. Pores are openings in the media. In other words, the particles are trapped by the media

as the water passes through it. The pore sizes can range from course to extra fine. Media can often be cleaned and only needs replaced when the pores become clogged.

- Groups sketch out the order of media they plan to use-for both tests.
- With a small piece of coffee filter, cover the opening of the neck of the “cut” water bottles.
- Begin to layer the media.
- Place the media-filled cut water bottles “down” inside the half-cut water bottle.
- Pour the clarified water into the media bottle and allow filtering.
- Students will follow the remaining instructions for testing and evaluation.

Explain to students that disinfection is often performed after filtration by adding chlorine to the water to kill any remaining germs.

Disposal - Once the testing is complete, the test solution can be safely poured into a sink. Don’t allow the sand, gravel, charcoal, or other to be poured in the sink as it may clog the drain. Ensure that the faucet is left open for a full minute after the solution is disposed of to ensure complete dilution of the water sample.

Chemical Contaminants Preparation

Students will simulate chemical contamination using a mix of water and fertilizer. Fertilizer contains nitrates which mimics a chemical contaminate in water. The nitrate is harmless and safe to handle.

Students will do three things in this activity:

1. Detect the contaminate using a Nitrate Test Kit.
2. Use alum to make a precipitate to settle out contaminate in the water.
3. Repeat the initial test with the Nitrate Test Kit to check for remediation.

Have all materials, equipment, and tools ready and organized.

All students should be wearing safety glasses and latex gloves.

Materials needed for Chemical Activity:

Items	Quantity

Safety glasses	1 per student
Rubber/ latex/ vinyl gloves	1 pair per student
16oz water bottle of simulated "nitrate" contaminant	1 per group
Any inexpensive fertilizer rich in nitrogen (to make the water sample)	¼ cup per group
Nitrate Test Kit	1 per class
½ teaspoon alum	1 per group
Funnel- narrow opening	1 per group
1 plastic spoon	1 per group
Tray to catch spills	1 per group
Paper towels to wipe up spills	

Prepare the Chemical water sample- Add 1 to 2 tablespoons fertilizer to 16oz water. Stir or shake well. Allow to sit for 10-15 minutes to dissolve pellets.

Step 1- <u>Detection</u> of the simulated chemical

A "purchased" Nitrate Test Kit is used to detect the nitrate before and after remediation. Follow the direction in the kit.

1. Open the test kit and lay out the contents.
2. Using the funnel, fill the test tube with 5 ml of the sample- nitrate mix (to the line on the tube).
3. Add 10 drops from Nitrate Test Solution Bottle #1, holding dropper bottle upside down in a completely vertical position to assure uniformity of drops.
4. Cap the test tube and invert tube several times to mix solution.
5. Vigorously shake the Nitrate Test Solution Bottle # 2 for at least 30 seconds. This step is extremely important to insure accuracy of test results.
6. Now add 10 drops from Nitrate Test Solution Bottle #2, holding dropper bottle upside down in a completely vertical position to assure uniformity of drops.
7. Cap the test tube and shake vigorously for 1 minute. This step is extremely important to insure accuracy of test results.
8. Wait 5 minutes for the color to develop.
9. Read the test results by comparing the color of the solution to the appropriate Nitrate Color Card (choose Fresh water).
10. The tube should be viewed in a well-lit area against the white area of the card. The closest match indicates the ppm (mg/L) of nitrate in the water sample.
11. Students are asked to explain the results?

12. Rinse the test tube with clean water after use.

Step 2- Add Alum

Students create a precipitate, or a solid, that will attract the things floating in the water, bind them together in clumps, and make them heavier so they will fall to the bottom. The same procedure was performed in the Physical activity.

1. To the 16 oz water bottle of “nitrate” water mix add ½ teaspoon of alum.
2. Replace the cap tightly, shake vigorously for 2-3 minutes, then set it aside to settle. Noticeable significant flocculation or settling of the particles in the water should be observed - after about 10 minutes.
3. After 10 minutes, repeat the Nitrate Test as performed in Step 1, Detection.
4. Students are asked to explain the results.
5. How is it different from the first test? What did the alum do that would change the test results?
6. Rinse the test tube with clean water after use and put away the contents of the test kit.

Filtering

- As an added treatment, the final solution would/should be filtered through media. If time allows, follow the steps for using filter media as applied in the Physical Contaminates Activity. Repeat the nitrate test again to check for further remediation. This step is not necessary during this activity but should be explained to students that normally media filtering would occur.

Disposal

- Once the testing is complete, the test solution can be safely poured into a sink. Ensure that the faucet is left open for a full minute after the solution is disposed of to ensure complete dilution of the test sample.

Biological Contaminants Preparation

Students will simulate biological contamination using a yeast mixture which mimics parasitic contamination when added to water. Yeast is a harmless microorganism and safe to handle.

Students will do three things in this activity:

1. Detect the contaminate using a dye solution and microscope
2. Treat the sample with a diluted bleach solution
3. Verify remediation of contaminate by repeating Step 1-Detection

Have all materials, equipment, and tools ready and organized.
All students should be wearing safety glasses and latex gloves.

Materials needed for Biological Activity:

Items	**Quantity**
Safety glasses	1 per student
Rubber/ latex/ vinyl gloves	1 pair per student
16oz water bottle of simulated “biological” contaminant	1 per group
Water	1 pint per group
¼ oz Rapid Rise or Fast Acting Baker’s Yeast packet	1 per group
Sugar	2 teaspoons per group
Unscented Clorox or equivalent	Approx. ½ cup per class
Methylene Blue	4 oz bottle
Funnel	1 per group
1 plastic spoon	1 per group
2 gallon bucket	1 per group
Teaspoon measure	1 per group
500 ml or 16 oz measuring cup	1 per group
Microscope, glass slides, cover slips	1 per class
Eye droppers	1 per group
Clear 16 oz. plastic cups or equivalent	4-6 per group
Toothpicks	3-4 per group
Tray to catch spills	1 per group
Paper towels to wipe up spills	

Prepare the Biological (parasites) water sample

Yeast is a benign organism that can simulate parasitic contamination when added to water.

Note: the solution must be prepared prior to use. This must be undertaken one to two hours before beginning the activity (the yeast will begin to deteriorate after two plus hours).

- Add a ¼ oz. packet of fast acting yeast to 500 ml (~16 oz) of warm water.

- Add 2 teaspoonful of sugar to the solution and stir till dissolved.
- Leave stand for one hour. After 2 hours, the yeast will be at its most active. After 2+ hours, the yeast potency begins to deteriorate. The ideal time to use the yeast is between one-to- hours.
- Stir the yeast solution prior to dispensing into four 125ml (~ 4oz.) samples ready for student use. If you have more than four groups, prepare double the quantity listed above to service greater number of groups.

Prepare the Treatment Solution

Chlorine is a very effective and safe disinfectant used in water treatment to kill parasites.

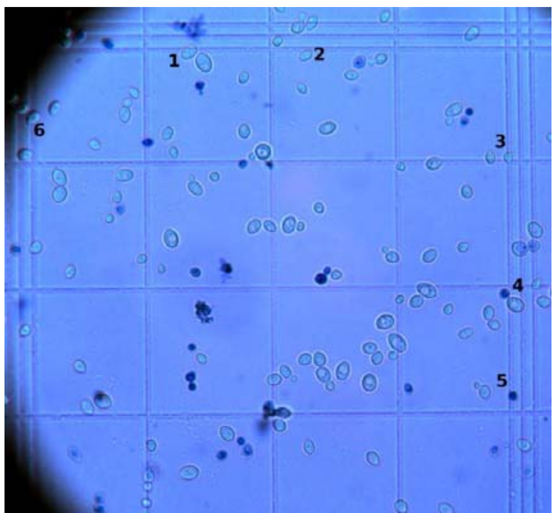
Undiluted bleach is much too concentrated for our purposes, and so it is used in a much diluted form.

** Please check on safety regulations in your school district for using a diluted bleach solution in the classroom.

- Teacher, using a clean eye dropper, will add 8 drops of bleach to 500 ml (~16oz.) of water. Stir the solution to mix the bleach. Each team of students will be provided with 125ml (~4oz.) of dilute bleach solution for use during the **Treatment** phase. The chlorine concentration of the mixture is slightly stronger than swimming pool water (approx. 18ppm of chlorine), however safety glasses and gloves should be worn when handling the dilute solution.

Step 1- Detection of the simulated parasites

1. Each group is provided with a 60ml (~2oz) of yeast solution.
2. Add the yeast solution to 250ml (~8oz) of water (clear cup). Stir the solution and let stand for 10 minutes.
3. Using a clean, dry eye dropper, take a sample of the yeast mixture from the **bottom** of container.
4. Add 1-2 drops of yeast solution to a clean, dry microscope slide.
5. Using a clean dry eye dropper, add 1-2 drops of Methylene Blue to the slide.
6. Using a toothpick, thoroughly mix the Methylene Blue solution on the slide.
7. Place the slide on a microscope set to 400x magnification. (The magnification might need to be varied to obtain the best view of the yeast cells.)



8. Observe the clear (live) yeast cells. Some dead cells might be visible: they are dark colored cells. Make sure each team member views the slide.
9. The image in Fig.1 is similar to what you should see.
10. Students are asked to sketch what they see and write notes to explain. If clear enough, students can count the number of yeast cells they see to compare to the number seen after remediation.

Fig.1 Example of Yeast Cells viewed using a Microscope (source: https://eurekabrewing.files.wordpress.com/2012/07/yeastcount.jpg)

Step 2-Treatment: Remediating the Parasites

1. One team member adds the 60ml (~2oz) of dilute bleach solution to the contaminated yeast solution.
2. Stir the yeast solution thoroughly with the spoon.
3. Leave the solution to sit for 30 minutes (to allow the bleach sufficient time to kill the yeast cells).

Step 3- Verification – Stage 1

1. Using a clean, dry eyedropper, take a sample from the bottom of the yeast contaminated solution.
2. Add 1-2 drops of yeast solution to a clean, dry microscope slide.
3. Using a clean, dry eye dropper, add 1-2 drops of Methylene Blue to the slide.
4. Using a toothpick, thoroughly mix the Methylene blue solution on the slide.
5. Place the slide on a microscope set to 400x magnification. (The magnification might need to be varied to obtain the best view of the yeast cells.)
6. Observe the slide to see if all the yeast cells have been killed by the chlorine solution. Ensure that each team member views the slide.
7. Students sketch what they see (darkening any cells that appear dead) and write notes to explain. Students can count the number of yeast cells they see and compare to the number initially seen before remediation.

Filtering

- The dead yeast cells and other debris in the contaminated solution will need to be removed using filter media.
- If time allows, follow the steps for using filter media as applied in the Physical Contaminates Activity.
- Repeat Verification procedure from Step 3

Disposal

- Once the testing is complete, the test solution can be safely poured into a sink. Ensure that the faucet is left open for a full minute after the solution is disposed of to ensure complete dilution of the test sample.

ENRICH: 80 minutes
If time allows, follow the steps for using filter media as applied in the Physical Contaminates Activity to further clean the water in the Chemical and Biological activities.

EVALUATE:
Student knowledge, skills, and attitudes are assessed through:

1. Observation and participation
2. Check Your Understanding: Questions-Students answer ten questions to check their understanding of the KSB content. Answer key: **Water_KSB4_T4-Key-Questions**
3. Exit Tickets

Suggestions for Exit Tickets:
*Note- The question for the exit ticket must be relative to the concepts introduced that particular day. Teacher may develop their own exit tickets if preferred.

- Name four processes water must go through before it comes out of our taps.
- Name a small-scale water treatment solution and describe it in words or sketch with labels.
- Name the components of a systems diagram and explain what happens in each component.
- Describe what “feedback” would mean in a system and give an example.
- What chemical is often added to make water less turbid water? Describe how it works.
- What is usually the last stage to cleaning water? Identify the chemical most often used?

Instructional Hints

- Review all KSB4 documents to understand the goals and student expectations of the KSB.
- The vocabulary list most likely contains words unfamiliar to your students. The teacher should use their discretion as to how to best inform or teach students the meanings. Some links to sites to enhance vocabulary in fun ways are listed below:
  https://flocabulary.s3.amazonaws.com/pdfs/word-up-mini-games.pdf
  http://www.manythings.org/vocabulary/

http://www.teach-nology.com/web_tools/materials/bingo/5/

- A lot of hands-on activities are packed within this KSB. Do your best to keep students on task and moving forward.
- The learning that takes place in this KSB is very important to students' success when they design and engineer their filtering system in the Grand Design Challenge. The teacher should walk around when students are exploring detection and remediation of contaminates to ensure students understand the why and how's of what they are doing.

Supporting Files

Student Resources
• Water_KSB4_S1-Chlorination Facts
• Water_KSB4_S2-Solar Disinfection
• Water_KSB4_S3-Biosand Filtration
• Water_KSB4_S4-Ceramic Filtration
• Water_KSB4_S5-Solar Filtration
• Water_KSB4_S6-Physical
• Water_KSB4_S7-Chemical
• Water_KSB4_S8-Biological
Teacher Resources
• Water_KSB4_T1-Key-Systems Diagram and Rubric
• Water_KSB4_T2-Participation Rubric
• Water_KSB4_T3-Creative Solutions Rubric
• Water_KSB4_T4-Key-Questions

Products

- Completed Student Companions
- Check Your Understanding- Water Treatment Systems Diagram
- Activity: Creative Solutions Drawing

Safety Notes:

Safety is of paramount importance to every classroom. While this guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

1. Students use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.

2. Students demonstrate respect and courtesy for the ideas expressed by others in the class.
3. Students show respect for and appreciation of the efforts of others.
4. **Students never drink the water, regardless if it is believed to be clean or contaminate free.**

Assessment
Assess accomplishment of learning goals

1. I can detect and remediate physical, chemical, and biological water contaminates.
   - For mastery of this learning goal, students must have a good understanding of the events that occurred during the detection and remediation activities, and be able to explain and answer questions accordingly.
   - The teacher observes groups as they work and checks the documentation and notes of each group making sure procedures are done correctly and students are learning. The teacher should ask students to explain what they are doing and why they get the results they get. Water_KSB4_T2-Participation Rubric
2. I can create a systems diagram to show how water is cleaned.
   - For mastery of this learning goal, students correctly complete a systems diagram. Water_KSB4_T1-Key-Systems Diagram and Rubric

Additional Assessment Suggestions

KSB4- Clean Up Your Act		
Possible assessment item	**Summary of task**	**Form of assessment**
Activity: Small Scale Solutions	Students learn about small-scale water treatment solutions and debrief info to class	No rubric included; teacher may choose to dev. rubric on own
Think Like an Eng.- Systems	Students are asked to name the components in a Ceramic Filtration System	Answers are placed in TG- no rubric
Systems Diagram	Students create a systems diagram for a water treatment plant	Ans. key and rubric *Water_KSB4_T1-Key-Systems Diagram and Rubric*
What's the Big Idea/	Big Idea and 2 supporting ideas; students reflect and explain what they mean to them	No right answer, no rubric, teacher discretion
Creative Solutions to	Students draw a small-scale water treatment system,	Rubric *Water_KSB4_T3-Creative*

Water Treatment Systems	identifying media that would be used and labeling the parts	*Solutions Rubric*
Check… End of KSB4- questions	Students answer 10 questions	Answer Key *Water_KSB4_T4-Key-Questions*

References

Biological Filtration: The Future Of Drinking Water Treatment? (n.d.). Retrieved June 18, 2014, from http://www.wateronline.com/doc/biological-filtration-the-future-of-drinking-water-treatment-0001

Colloidal Silver Filter. (n.d.). Retrieved June 18, 2014, from http://www.sswm.info/content/colloidal-silver-filter

Different water filtration methods explained. (n.d.). Retrieved June 22, 2014, from http://www.freedrinkingwater.com/water-education/quality-water-filtration method.htm

Filter Media: How Mechanical, Biological, and Chemical Filter Media Function. (n.d.). Retrieved June 20, 2014, from http://www.peteducation.com/article.cfm?c=16 2154&aid=2933

India. (n.d.). Retrieved June 22, 2014, from http://water.org/country/india/

MECHANICAL FILTRATION OF DRINKING WATER. (n.d.). Retrieved June 23, 2014, from http://www.freedrinkingwater.com/water-education2/813-mechanical-filtration-water.htm

Purification Technology. (n.d.). Retrieved June 21, 2014, from http://www.drinkmorewater.com/water-purification-methods

Teach Engineering. (n.d.) Retrieved June 6, 2016 from https://www.teachengineering.org

White Water Filters. (n.d.). Retrieved June 17, 2014, from http://www.whitewaterfilters.com/index.htm

Operation: Safe Water for Bangladesh

Overview:

In the Grand Design Challenge, student groups collaborate to design and build a multi-level water filtering device that can supply safe drinking water to a family of five living in Bangladesh. The challenge goal is to develop a device that can produce 20 liters per day of safe drinking water, using materials native to the developing country of Bangladesh. In prior KSB's, students have learned methods to test water, have learned about types of water contaminants, have learned about filter media and systems, and are now ready to develop a water filtering device specific to meet the needs of a Bangladeshi family.

Lesson Duration: 7-9 40 minute class periods

Big Idea: Water sources can be improved by using engineering methods to remove contaminants.

To demonstrate this understanding, students will:

- Identify sources of water pollution and contamination.
- Model the design of a multi-level system to filter out contaminants from a water source.
- Actively participate in a media-based group presentation to communicate their achievements.

Standards and Learning Goals

Performance Expectations	Learning Goals
MS-ETS1-1 Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. STL8.E. Design is a creative planning process that leads to useful products and	I can use a design process to develop a water filtering device for a family experiencing water scarcity problems in a developing country using only materials and tools native to that region.

systems. STL8.G. Requirements for design are made up of criteria and constraints. STL9.F. Design involves a set of steps, which can be performed in different sequences and repeated as needed.	
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. STL11.K. Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.	I can choose and justify the best solution to my problem by evaluating each of my ideas and determining how well they meet the criteria and constraints of my 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. STL13.G. Use data collected to analyze and interpret trends in order to identify the positive and negative effects of a technology.	I can analyze the data I collect from my tests to figure out which design ideas have the best characteristics most suitable for use in my solution.
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. STL9.H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.	I can make a model that I can test, evaluate and modify if needed that solves my design problem.

Vocabulary

N/A- Students should have prior knowledge of vocabulary and terminology from previous KSB's.

Tools/ Materials/ Equipment (class of 25)

*All items below are items used in prior KSB's and teacher likely will not need to repurchase.

Item No.	Qty.	Item/Description	Company/ Address/Phone	Cost per Unit	Total
551573439	1	Great Value Clear Cups, 16 fl oz, 100 count	Walmart	4.98	4.98
No item #	1	Polyform Non-Dry Modeling Clay, 5pc	Amazon	5.37	5.37
No item #	1	Hoosier Hill Farm Alum Powder Granulated, 1 Lb.	Amazon	10.19	10.19
No item #	1	New York Wire 33105 Fiberglass Screening, 36-Inch by 84-Inch, Charcoal	Amazon	4.14	4.14
No item #	6	Norpro 4 Cup Plastic Measuring Cup	Walmart	4.84	29.04
No item #	1	General Purpose Masking Tape, 1" x 60 yards, 3" Core, 3/Pack	Walmart	8.99	8.99
UNV00464	1	Universal Rubber Bands	Walmart	1.07	1.07
293189	1	Sakrete 60-lbs All-Purpose Sand, course and fine	Lowes	3.78	3.78
92125	1	Rock City 0.5-cu ft River Rock	Lowes	3.38	3.38
No item #		Plastic Bucket, Round, Capacity 1 gal.	Walmart	2.47	29.64
No item #	6	Water Dispenser Replacement Faucet White	Amazon	6.58	39.48
No item #	2	Twine, Dia. 5/64 In., Length 200 ft.	Walmart	2.00	2.00
No item #	1	Activated Carbon Filter	Walmart	4.94	4.94
32833	8	32833 FUNNEL KING Funnel, Utility Funnel,	Walmart	.99	7.92

		Total Capacity 8 oz., Diameter 4-1/2"			
551060579		White Cloud Jumbo Size Cotton Balls, 400 count	Walmart	3.68	3.68
009239833	1	Nestle Nesquik Chocolate Powder Flavored Milk Additive, 40.7 oz	Walmart	7.48	7.48
Misc. Supplies					
Empty plastic bottles, variety of types			Paper		
Scraps of material			Rubber Bands		
Scraps of wood			Tape		
Cardboard			Glue		
Grass					
Weeds					
Vines					
Equipment/Tools					
Scissors					
Craft Knives					

Learning Activities 6-E's

Teacher introduces the Water Design Journal to students explaining that students will use the Design Journal to document their work as they proceed through the process of developing a solution for the Grand Design Challenge (GDC). Teacher assigns students in groups of 2-4 and asks student groups to move together at this time. Teacher reminds students to be attentive to instructions as groups will work independently on the GDC. Teacher takes a minute for students to write their member names on the cover page of their Design Journal.

ENGAGE: 10 min.

Teacher begins with showing watch a short video clip about Bangladesh and its water problems. http://youtu.be/rGOJddHIUmI Bangladesh Overview. There are many options for videos about Bangladesh that can be found on the Internet. Teacher explains that this video provides a good overview of life in Bangladesh (water problems) but was produced by an organization called Water Aid, which students will give no reference to.

EXPLORE / EXPLAIN: 25 min.

1. The students will need to have some background information about Bangladesh in order to better relate to the conditions of that region. For this reason, the teacher provides the document **Water_GDC_S1 Bangladesh Water Problems** via paper or PPT slide, and students take turns reading it. The class then shares their thoughts.

2. The teacher now turns student's attention to the Design Journal. Explain that it's now time for students to methodically use the Informed Design Process to solve the Design Challenge and that the Design Journal is formatted with the steps of the Informed Design Process.
3. It is very important that each page is reviewed with students and the expectations for each page is explained. Take note that some steps are Group Activities and some are Individual Activities documentation. Also, be sure to review the Presentation Rubric and the Design Journal Rubric. Allow time for students to ask questions.
4. Now, direct students to the first step in the Design Journal- Clarify the Problem Criteria and Constraints. It's helpful to complete this together as a class; students will have a better understanding of the depth of completion you are expecting in terms of their documentation in the Journal.
5. Reviewing the Design Journal with students may seem time consuming, but this will help deter misunderstandings later on.
6. Remind students that although they are expected to work independently with their groups to complete the challenge, you- as teacher- will always be available to help with problems- should they run into any.
7. Remind students that all work in the Design Journal must be completed, and must be completed in the order it is in the Design Journal.
8. Explain that groups are required to present and explain their final solution to classmates and others. Others may include Principal, teachers, etc.

eNGINEER: 6- 40 minute class periods (approximate)

Grand Design Challenge

1. Once the teacher has completed the Design Journal overview, students are directed to begin discussion in their groups, perhaps do a review of the Design Journal on their own, and think about how they will proceed.
2. Groups work to develop their solution to the GDC.

ENRICH: 15 min.

Practice Presentation

1. Students decide what their presentation will look like and what role each member will play in the presentation of their solution.
2. Students practice their presentation.

EVALUATION:

Observation

Submission of Grand Design Challenge solution

Submission of Design Journal

Presentation

Supporting Files

Student Resources
• Student Design Journal • Water_GDC-S-1 Bangladesh_Water Problems
Teacher Resources
• Video- Bangladesh Overview http://youtu.be/rGOJddHIUmI • WEB 2.0 information. http://web2014.discoveryeducation.com/web20tools.cfm

Instructional Hints

- Take time to review the Design Journal with students, particularly the rubrics at the end of the Journal.
- Walk around the room; listen and observe what is happening in the groups. Remind students to be sure they are noting the criteria and constraints that must be considered.
- Take notice that each member is participating and contributing.
- Remind students to document in their Design Journal; perhaps a daily check of student's documentation will remind them of the importance of documentation.
- At the beginning of each class, ask groups what has been successful and what has been problematic.

Safety Notes:

Safety is of paramount importance to every classroom. While this guide contains some general safety guidelines, it does not address the specific tools, equipment, and working spaces found in any specific classroom. Teachers must provide comprehensive safety guidelines to students based upon individual classrooms.

Students will:

- Use tools and equipment safely, maintaining a safety level for themselves and others in the laboratory-classroom.
- Wear safety goggles when using tools and chemicals.
- Wear gloves and masks when using chemicals.
- Demonstrate respect and courtesy for the ideas expressed by others in the class.
- Students show respect for and appreciation of the efforts of others.

References

Dhaka, Bangladesh: Fastest Growing City in the World. (n.d.). Retrieved January 17, 2015, from http://www.cbsnews.com/news/dhaka-bangladesh-fastest-growing-city-in-the-world/

WaterAid America - The water story - Our approach - Delivering services. (n.d.). Retrieved January 17, 2015, from http://www.wateraid.org/us/the-water-story/our-approach/delivering-services?id=annual,G,GGL,GAW

Water Contamination in Bangladesh. (2012, April 2). Retrieved January 17, 2015, from http://www.hydratelife.org/?p=147

Average Water Use Per Person Per Day. (n.d.). Retrieved January 15, 2015, from http://www.data360.org/dsg.aspx?data_set_group_id=757

Shen, James. (2010, April 15). Retrieved January 13, 2015, from http://hdr.undp.org/en/media/HDR06-complete.pdf

Water Trivia Facts. (n.d.). Retrieved January 14, 2015, from http://water.epa.gov/learn/kids/drinkingwater/water_trivia_facts.cfm

3 - Water Supply Options. (n.d.). Retrieved January 17, 2015, from http://users.physics.harvard.edu/~wilson/arsenic/conferences/Feroze_Ahmed/Sec_3.htm

(n.d.). Retrieved January 17, 2015, from http://www.unwater.org/downloads/Water_EN.pdf

Bangladesh Water Crisis. (n.d.). Retrieved January 17, 2015, from http://www.slideshare.net/BSGeography/bangladesh-water-crisis

KSB 1

Name_______________________ Date______

H_2O = LIFE

Big Idea: The availability of safe water for drinking purposes and other uses is a critical problem in many areas of the world.

Welcome! Your class has been accepted to join our organization, Engineers across Borders. Our mission is to partner with developing countries to improve their quality of life by providing safe drinking water to the local people living in those countries. As our newest members, you'll need to know that it takes many engineering roles to build a world in which every community is able to meet their basic needs, and safe water is a basic need. Additionally, for solutions to be effective requires lots of different skills and resources from engineers and others. The first step is to learn as much about the problem as you can. When you finish this KSB you'll be able to answer the following questions:

- ✓ What is water scarcity?
- ✓ What areas of the world are affected by water scarcity?
- ✓ What is the difference between the two types of water scarcity?
- ✓ What are the impacts of water scarcity on life?

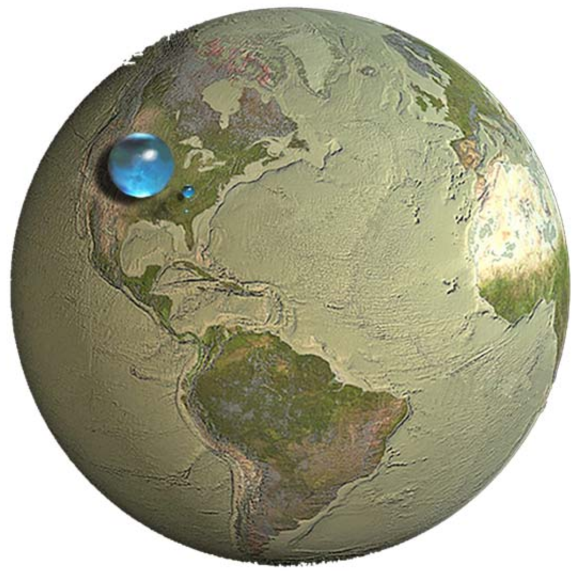
Video: Water-The World Water Crisis

After you finish watching the video your teacher shows, summarize your thoughts about it in the space below. Be prepared to participate in a video-related class discussion.

Points to Ponder

The globe below shows three blue bubbles; the smallest one is barely visible. The bubbles represent the “volume” of Earth’s water in comparison to the volume of the globe. Oceans account for only a thin film of water on the surface.

The largest bubble represents all the Earth’s water; it includes all the water in the oceans, ice caps, lakes, rivers, atmosphere water and even the water in you, your dog, and your tomato plant.



The middle-sized bubble represents liquid fresh water that is available in groundwater, lakes, swamp water and rivers.

The tiniest bubble represents fresh water in all the lakes and rivers on the planet. The water people and life need every day comes from these surface-water sources.

Does it surprise you that the bubbles are so small compared to the earth?

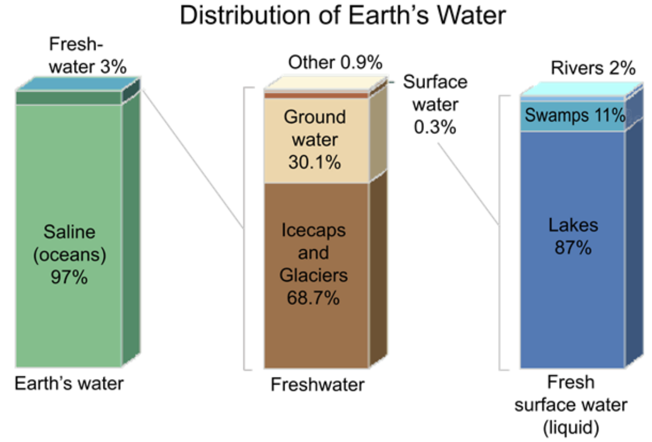
How serious is the Water Crisis?

Lack of clean water is responsible for more deaths in the world than war. About 1 in 6 people don’t have adequate access to safe water, and twice that number don’t have basic sanitation, for which water is needed. Some estimate that nearly 5000 children worldwide die from diarrhea-related disease, a number that would drastically drop if enough water was available for sanitation.

Giardia- a Microscopic parasite that causes diarrheal illness; contacted by drinking dirty water.

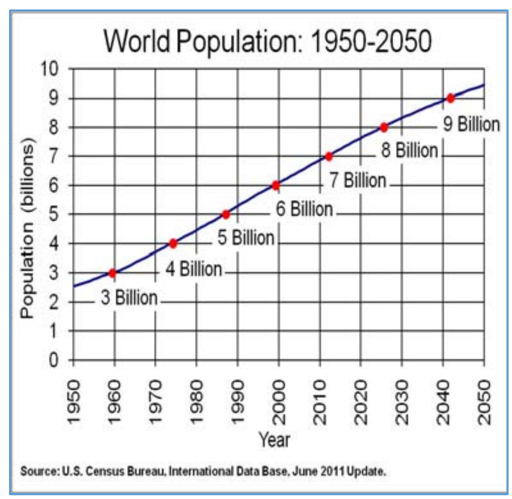
It's not that the world doesn't have enough water; the earth is abundant in water. It just isn't where it's needed.

Some countries, like Canada, have far more water than needed. But in the Middle East and Northern Africa, the water shortage is continuous. We call this Physical Water Scarcity, when the demand for water is greater than the supply.



In other cases, political and economic barriers prevent people from access to water even in areas where it is otherwise available. And in some developing countries, water supplies are contaminated not only by the people discharging toxic contaminants, but also by arsenic and other naturally occurring poisonous pollutants found in groundwater aquifers. We call this Economic Water Scarcity, there is water available but for some economic reason, it can't be accessed.

As the world's population grows, the demand for water intensifies. Growth in population means more competition for home, agricultural, industrial, and sanitation uses. To add to the problem, areas that are most water scarce or stressed are typically those with few water resources, denser populations, and high population growth rates. Population growth limits the amount of water available per person, which forces people to live in close spaces, thus placing more stress on water resources.



Overcoming the water crisis is recently reported by the United Nations to be one of the greatest human development challenges in the 21st century. Methods of ensuring safe water supplies are needed at all levels, from small communities to big industry.

A Growing Population with Not Enough Water

Think Like an Engineer

As shown in the PowerPoint and the prior paragraphs, the water crisis is a serious problem in developing countries and here in our own back yard, especially as the human population continues to grow. There are two important ideas to think about as you consider this problem.

The aim of engineering should be to benefit society and the environment.

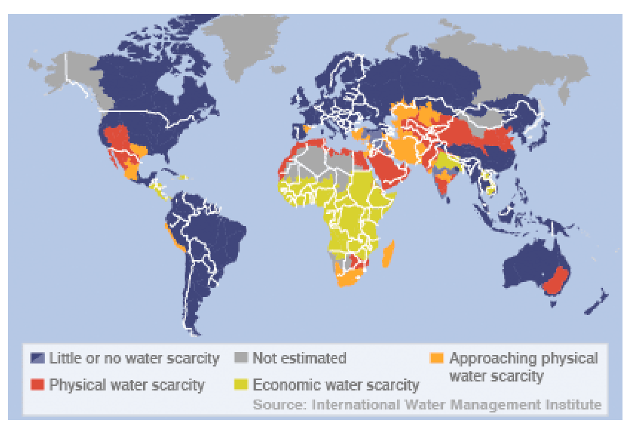
As an engineer, how could you improve current technologies, or develop new technologies to help solve this problem? Suggest one or two ideas that might help.

Sustainable development is a way to meet the needs of the present without sacrificing the needs of future generations. ***Sustainable development*** means that the same methods can continue to be used for a very long time without using up the resources that our children and grandchildren will need.

Are the ideas that you suggested above sustainable? Please explain why you think they are (or are not) sustainable?

Activity: Where in the World is the Water Crisis?

When engineers have a problem to solve, they need to find out as much information about the problem as they can. They document the information and organize it so they can see a complete picture of the problem.



In your assigned group, you will be finding out as much as you can about a water problem in some specific part of the world. Your teacher will assign the location. You'll document and organize your information in the form of a pamphlet. When all the groups have finished, you'll present your country and findings to the class.

Be sure to include the following information in your pamphlet:

- Geographical description of your assigned location
- Physical scarcity or economic scarcity or both?
- List 2-3 examples and reasons of physical and/or economic scarcity
- Description of (2-3) impacts of the problem. An impact can be a positive effect or a negative effect.
- Your teacher will provide the template for the pamphlet; it can be computer designed or hand-written. Use the websites below to get started.

Websites for your pamphlet research

World Resources Institute: World's 36 Most Water-Stressed countries.
http://www.wri.org/blog/2013/12/world%E2%80%99s-36-most-water-stressed-countries

World Resources Institute: Baseline Water Stress Interactive Map.
http://www.wri.org/applications/maps/aqueduct-country-river-basin-rankings/#x=0.00&y=-0.00&l=2&v=home&d=bws&f=0&o=139

World Resources Institute: World's 18 Most Water Stressed Rivers.
http://www.wri.org/blog/2014/03/world%E2%80%99s-18-most-water-stressed-rivers

Internet World Stats: Countries and World Regions.
http://www.internetworldstats.com/list1.htm

Info Please: Countries of the World. http://www.infoplease.com/countries.html

What's the BIG IDEA?

It is important to take away the following really important BIG IDEA about engineering from this KSB. Reflect on the Big Idea and explain what it means to you. Keep in mind that there are no right or wrong answers to the question—it's your opinion that counts.

Big Idea: The availability of safe water for drinking purposes and other uses is a critical problem in many areas of the world.

Supporting Idea #1: The aim of engineering should be to benefit society and the environment.
Supporting Idea #2: Developing sustainable solutions to the water crisis is a great engineering challenge especially as the world's population grows.
Supporting Idea #3: Sustainable development is a way to meet the needs of the present without sacrificing the needs of future generations.

	**Check Your Understanding** As a means of checking on your progress, do the best you can to answer the following questions.

1. Which statement below is an example of Physical Water Scarcity?
    a. The wealthy leaders of a small village in Bangladesh choose to supply water to big industry instead of local villages
    b. A prominent leader in a developing country has placed a price on drinking water higher than the locals can afford
    c. The community water well has ample water to supply twenty families
    d. Alijah and her mother walk almost 2 miles every day just to get water for their daily needs

e. I don't know

2. Which statement below is an example of Economic Water Scarcity?
    a. Natural arsenic contaminates ground water making the water unsafe to drink
    b. Women can get to the water source but it means walking through dangerous areas and risking physical assault
    c. The local government chooses not to invest in repairing broken water lines
    d. Water resources cannot meet the demands of the population
    e. I don't know

3. Which statement below best describes sustainable development?
    a. Continually developing new technologies to solve problems
    b. Providing sufficient funding for a project so that it can continue to completion
    c. Meeting the needs of today without sacrificing the needs of future generations
    d. Ensuring that development will continue to go on, despite setbacks
    e. I don't know

4. Pertaining to water, population growth will have the greatest negative impact on areas that
    a. have fewer water resources
    b. are sparsely populated
    c. are further distances from ocean water sources
    d. have heavy rainfall
    e. I don't know

5. Which of the region descriptions below will most likely suffer from physical water scarcity?

A region having:
    a. High annual rainfall and large population
    b. High annual rainfall and a small population
    c. Low annual rainfall and small population
    d. Low annual rainfall and large population
    e. I don't know

6. Negative impacts on natural resources such as water are the direct or indirect result of
    a. Phases of the moon
    b. Humans
    c. Natural catastrophes
    d. The water cycle
    e. I don't know

7. Describe two negative impacts of water scarcity.

____

____

____

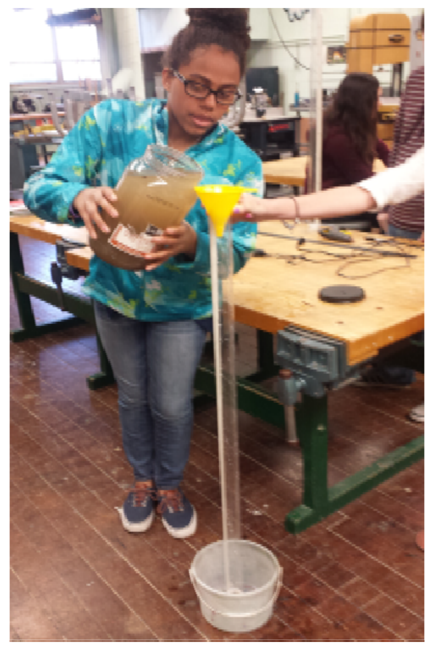
____

____ ____
8. Population growth has no effect on water resources in the world. ______ True ______ False
9. Explain sustainable development in your own words. ____ ____ ____ ____ __________________________
10. Name two reasons a region may be water stressed? a) b)

***Name*______________________ *Date*______**

Turbidity Matters!

Big Idea: The measure of turbidity is a key test of water quality.



Turbidity is the measurement of water clarity dependent on how much the suspended particles in the water decrease the passage of light through the water. In simpler terms, it is a characteristic of water and tells us how cloudy the water is.

When you finish this KSB, you'll be able to answer the following questions:

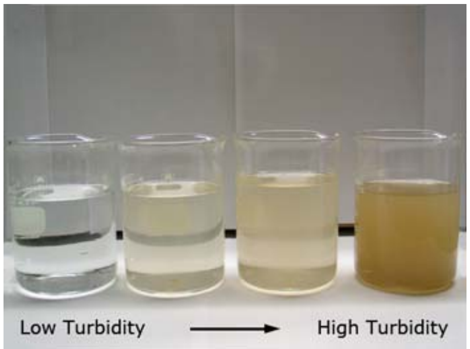
- ✓ What is turbidity?
- ✓ What makes water turbid?
- ✓ What are the effects of turbidity?
- ✓ What ways can turbidity be measured?
- ✓ How can I construct a device that measures turbidity?

Video: Turbidity

After you finish watching the video your teacher shows, write down one or two questions you have about turbidity in the space below.

Your teacher will present a PowerPoint to answer any additional questions you might have about turbidity. Be sure to listen, ask questions and take notes about what you learn in the space below.

Points to Ponder



Turbidity is an important gauge of the quality of water.

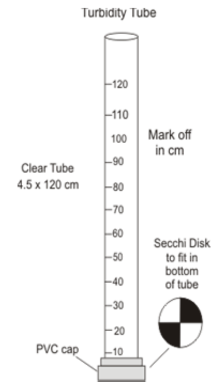
Suspended sediments that cause turbidity can interfere with disinfection and provide a means for microbial growth.
Turbidity may indicate the presence heavy metals such as lead, mercury, and arsenic and disease-causing microorganisms. These organisms include bacteria, viruses and parasites that can cause symptoms such as nausea, cramps, diarrhea and associated headaches.

Turbidity is most commonly reported in Nephelometric Turbidity Units (NTU's) and is used by government agencies and in scientific research.

Turbidity is measured by evaluating the amount of light scattered in water. This can be done with simple visual assessments, such as A) the original Jackson Candle turbidimeter, B) a turbidity tube, or C) more accurate, technological methods, such as a turbidimeter.

A

B



C

Check Your Understanding

A member of your class has been sick and missed viewing the Turbidity PowerPoint. Your teacher has asked you and a partner to summarize some of the main points from the PowerPoint so you can help that student catch up with the rest of the class.

Use the questions below as an outline for your discussion with your classmate.

1. Write your best explanation of what turbidity is.

2. Turbidity is caused by suspended particles that can be visible or invisible to our eyes. Describe the kinds of suspended particles that can cause turbidity.

3. Causes of turbidity can be both human and natural. Describe two examples of each.

4. Describe three or more things turbid water affects.

5. There are three common ways to measure turbidity. Describe them.

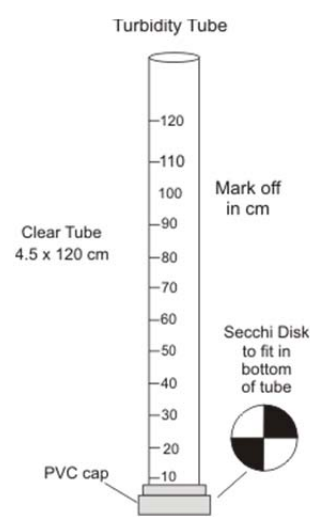
6. What is the unit of measurement for turbidity?

A. Getting Ready to Build a Turbidity Tube

As a member of Engineers across Borders, you'll be helping communities in developing countries come up with solutions for safe drinking water. Measuring turbidity and removing sources of turbidity is one of the first steps in the water treatment process.

Turbidity measures the cloudiness of water caused by the presence of suspended particles. The greater the amount of suspended particles, the murkier the water appears and the higher the measured turbidity, as can be seen in secchi disk images to the right. Since we assess water clarity visually, we don't actually measure how many suspended particles are in the water. Instead we measure the transparency of the water, which takes into account both the color and the suspended particles.

A turbidity tube is a clear tube that has a secchi disk at the bottom. Metric measurements are placed on the side of the tube in centimeter increments. The tested water is slowly poured into the tube from the top until the image of the secchi disk at the bottom can no longer be seen. This is the point that the metric measurement is taken and this measurement is converted into NTU's.



Your team will build a turbidity tube that will:

a) Have accurately marked measurements
b) Have no leaks
c) Use the materials provided

Your team will:

a) Test a water sample 3 times and calculate the average NTU measurement
b) Convert the turbidity value from centimeters to NTU's
c) Record results

B. Supplies

- Check to see if you have all these supplies
- Put a checkmark next to the name of each item as you identify it.
- If you are missing anything, ask your teacher about it.
- Tools are not shown in the list.

2' clear plastic sleeve	Black, fine permanent marker
Black plastic end cap	Secchi Disk diagram
Square of Plexiglas or acrylic for the base	Catch tray, bin or bucket
Small piece of foam tray	Masking tape wrapped around a popsicle stick (3 ft)
Meter stick, tape measure or ruler	Funnel

C. Build the Turbidity Tube

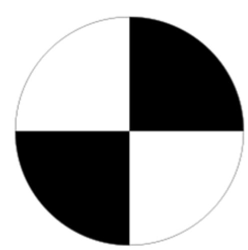
Step 1. Make the Secchi Disk

A secchi disk will be placed at the bottom of the turbidity tube.

1. What material in your supply list can you make a secchi disk out of?

2. How will you know what size to make it?

3. Make your secchi disk and set it aside.



Secchi disk

Step 2. Prepare the Plexiglas and End Cap

1. The end cap needs to be glued to the center of the Plexiglas. Draw a picture below showing how you will mark the center on the Plexiglas. Add notes to clarify your drawing.

2. Once you have the end cap placement marked on the Plexiglas, glue it to the Plexiglas with hot glue. Take your time doing this to do a good job. The end cap must not leak.
3. Once this is done, glue the secchi disk inside the end cap. Be sure to place the pattern in the "up" position.

Step 3. Prepare the Tube

1. A turbidity tube has metric measurements on it that are used to measure the level where the secchi disk can no longer be seen. You can write directly on the tube or on tape then place the tape on the sleeve. Be sure your marks are precise.

2. Hot glue the sleeve to the end cap over the secchi disk. Pay close attention so as to NOT miss any spots, yet try to glue neatly. Take your time with this step; you don't want the tube to leak.

3. Allow a few minutes to dry. Test for leaks by pouring a small amount of water into the tube. Hold the tube over a bucket or tray in case of leaks. If it leaks- dry the area and glue again.

4. Your turbidity tube is now ready to use.

D. Time to Test

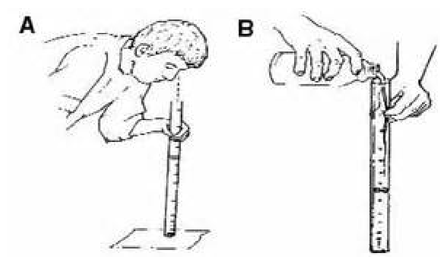
The level of the water at the point where the secchi disk can no longer be seen needs to be measured.

Test your sample 3 times, average the centimeter lengths, then convert to NTU's using the NTU Conversion Chart below.

*Note- Your test sample must be kept stirred to prevent settling to get the most accurate reading.

Directions for Testing

1. Obtain the test sample and the "catch tray". Place your turbidity tube inside the tray to catch any water spills as you test.
2. Place your head 10-20 centimeters directly above the tube opening as in Figure A to see the secchi disk.
3. Using a funnel, a team member will slowly and carefully pour water into the tube.
4. Continue adding water at a slow rate, keep looking in the tube for secchi disk visibility until the pattern on the disc becomes hard to see.
5. Stop pouring as soon as the pattern on the disc can no longer be seen.
6. Check the measurement and record it in the **Data Table.**
7. Repeat two more times.
8. Average the lengths then use the NTU Conversion Chart to convert to NTU's.
9. Write your results in the **Data Table.**



E. Data Collection and Results

Data Table	
	Centimeters
Test 1	
Test 2	
Test 3	
Average centimeter	

length	

NTU's	

NTU Conversion Chart

Centimeters		Approx. NTU Value
<6.4		>240
6.4 - 7.0		240
7.1 - 8.2		185
8.3 - 9.5		150
9.6 - 10.8		120
10.9 - 12.0		90
12.1 - 14.0		65
16.6 - 19.1		50
19.2 - 21.6		40
21.7 - 24.1		35
24.2 - 26.7		30
26.8 - 29.2		27
29.3 - 31.8		24
31.0 - 34.3		21
34.4 - 36.8		19
36.9 - 39.4		17
39.5 - 41.9		15
42.0 - 44.5		14
44.6 - 47.0		13
47.1 - 49.5		12
49.6 - 52.1		11
52.2 – 54.6		10
>54.7		<10

Engineers like to show data in different ways, making the data simpler to understand. Line graphs are good way to illustrate this. Draw a line graph in the space below that visually represents the data and results you have collected in your turbidity tests. The Y-axis would be the NTU and the X-axis would be in centimeters.

F. Build a Better Turbidity Tube

Engineers want to do get the very best results when working on problems. This might mean repeating what they have done to make sure the results are accurate and optimizing the design to make sure it is as perfect as possible. As an engineer yourself, take a few minutes to think about the turbidity tube you built, then complete the section below.
If you had a chance to optimize the design of the turbidity tube, how would you design it differently? Completing the questions below will help you answer this question. 1. What problems did you have with the turbidity tube? 2. What can you change to make the turbidity tube a better instrument?
In the space below, sketch out your idea for a better turbidity tube. **Your idea will be evaluated** so be sure to: 1. Draw the design to scale. If you're not sure how to draw to scale, watch this tutorial: How to Make a Scale Drawing- A Tutorial https://youtu.be/PgsSvBYAMJA 2. Provide side and top views of the re-designed tube 3. Label the parts of the turbidity tube. 4. Write a brief explanation of why you think this design would be better.

KSB2 Re-design Rubric- Draw a labeled and scaled sketch of the turbidity tube, and explain how it works

	1	3	5	Score
Quality of drawings	The drawings include one view that is poorly labeled and is not to scale.	The drawings include one view that is neatly drawn, is well labeled but is not to scale.	The drawings include two views, both are well labeled and at least one view is accurately scaled.	

Quality of explanation	The explanation of how the turbidity tube works is missing or incorrect.	There is a partially correct explanation of how the turbidity tube is used to assess water clarity.	There is a clear and correct explanation of how the turbidity tube is used to assess water clarity.	
			Total	

Think Like an Engineer

The turbidity tube that you just built can be thought of as a **system** for measuring the turbidity of a sample of water. A **system** is a group of components that work together to achieve desired results.

One large and very complex system that you may be aware of is a manufacturing system

that uses a group of component parts (robots, conveyors, platforms) and other resources like people, energy, materials, time, and information to produce automobiles. The desired result of a manufacturing system is to produce a product (in this case, a car.

A turbidity tube (figure 2) is a *very simple system* that uses a plastic tube, a measuring scale, a Secchi disk, and a stopper. The parts work together to achieve desired results (to determine how turbid or cloudy a liquid is).

Figure 2.
A turbidity tube.

All systems have **inputs**, **processes**, and **outputs**. The *input* is the system's *desired result*. The *process* is how the system *achieves* its results, and the *output* is the *actual* result.

Systems can be represented (modeled) as a systems diagram.

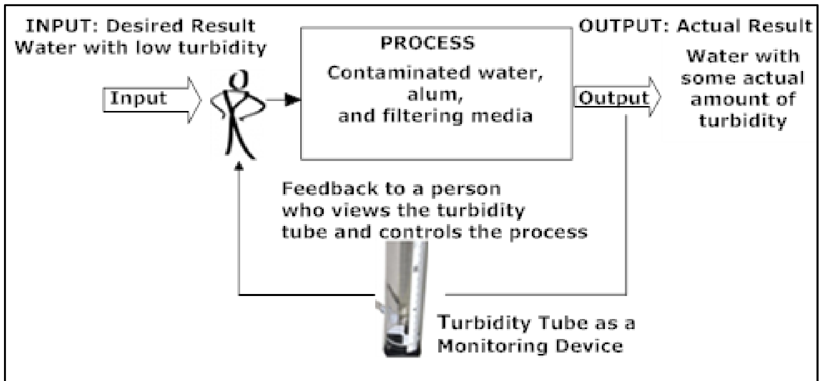


Figure 4. System to Remove Physical Contaminants From Water

Figure 3 is a diagram of what a turbidity tube might look like as a system.

A turbidity tube can also serve as a **monitoring device** in a larger system designed to remove contaminants from water as shown in figure 4. In this case, the turbidity tube gives feedback to someone who controls the process to make sure the turbidity is reduced.

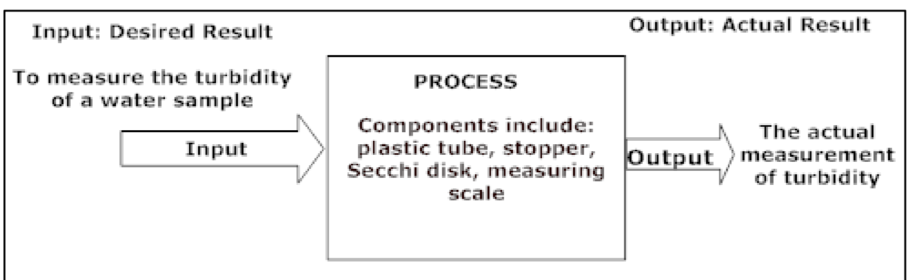


Figure 3. Turbidity Tube System Diagram

What's the BIG IDEA?

It is important to take away the following really important BIG IDEA about engineering from this KSB. Reflect on the Big Idea and explain what it means to you. Keep in mind that there are no right or wrong answers to the question—it's your opinion that counts.

Big Idea: Models are a powerful means for analyzing and predicting the behavior of systems.
Supporting Idea #1: Resources for solving problems may require people, capital, energy, information, materials, time, and/or tools.
Supporting Idea #2: Successful designs must be matched to human and environmental needs.

Check Your Understanding

As a means of checking on your progress, do the best you can to answer the following questions.

1. Which of the following is most closely related to water turbidity?
   a. The cloudiness of the water
   b. The color of the water
   c. The pH of the water
   d. The temperature of the water
   e. I don’t know

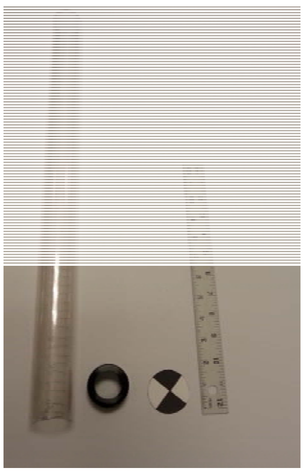
2. Which of the following statements is true?
   a. Secchi depth provides an estimate of water clarity
   b. Secchi depth is the depth of light penetration through water
   c. Secchi depth is commonly recorded in centimeters (cm)
   d. All of the above
   e. I don't know

3. When water has a high concentration of suspended particles, the particles can__________
   a. Break down the water molecules
   b. Serve as breeding grounds for bacteria
   c. Increase the population of frogs
   d. Increase photosynthesis by algae
   e. I don’t know

4. Water turbidity can be affected by various factors. Which of the following is a combination of factors due only to human activities?
   a. Fertilizer, industrial waste, sewage
   b. Industrial waste, run-off, rainfall
   c. Sewage, economy, extreme tides
   d. Sewage, rising sea levels, algae bloom
   e. I don't know

5. The best definition of a system is
    a. The operating procedure for a technology
    b. Parts that work together to achieve a desired result
    c. An engineering concept that includes steps for instruction
    d. The way a component functions when other components are added to it
    e. I don't know

6. Is the image below a system? Explain why it is or why it isn't.



7. Which statement below best describes the purpose of a turbidity tube?
    a. It measures how murky the water is
    b. It is the measure of the amount of scattered light in water
    c. It measures the amount of contaminates in the water
    d. It is the measure of algae and dirt in water
    e. I don't know

8. Which statement best describes the types of suspended particles that can cause turbidity?
    a. Clay, silt, organic and inorganic material, and microorganisms such as bacteria and viruses
    b. Industrial waste, run-off, sand
    c. Sewage, dirt, plants
    d. Rising sea levels, algae bloom, extreme microbe population
    a. I don't know

9. Water is the unit of measurement for turbidity?
    a. NTU’s
    b. UTJ’s
    c. TNU’s
    d. JTU’s
    e. I don't know

10. In 2-3 sentences, write your best explanation of what turbidity is.

KSB
3

Name______________________ Date______

Heavy Metals!

Big Idea: All drinking water contains some contaminates; some are harmless and some can make the water unsafe to drink.

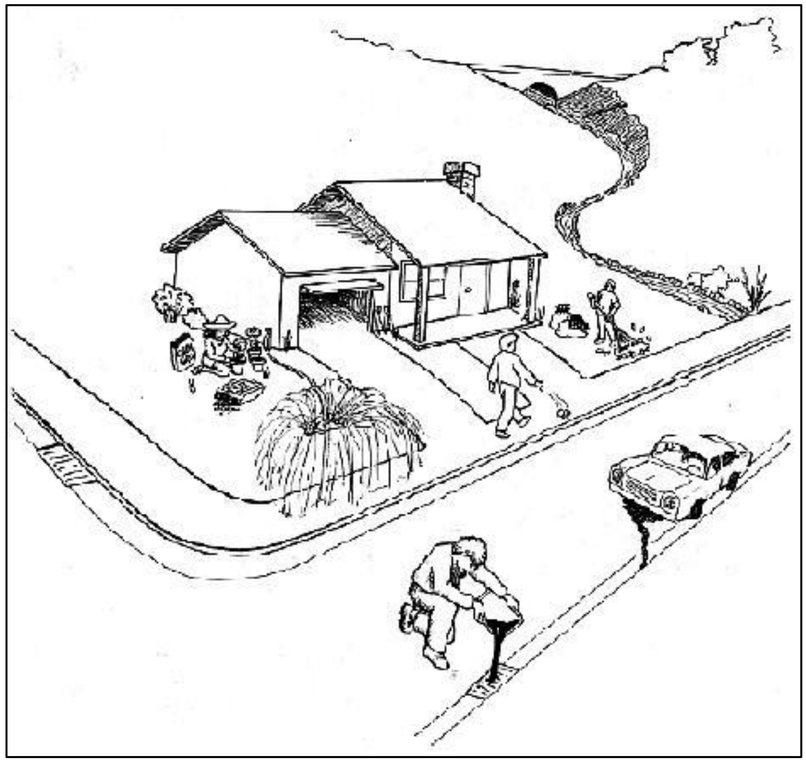
When it comes to human necessities, water is our most important resource. Without safe drinking water, the human species would be extinct in less than a week. There are many forms of water contaminates, some natural and some human-made. Water contaminant categories include physical, chemical, and biological. In this KSB, you will learn more about these types of water contaminates, how they enter water sources, and the kinds of impacts each may have on human health.

When you finish this KSB, you'll be able to answer the following questions:

- ✓ How do water contaminates enter water sources?
- ✓ What are basic categories of water contaminates?
- ✓ What effects do these contaminates have on health?

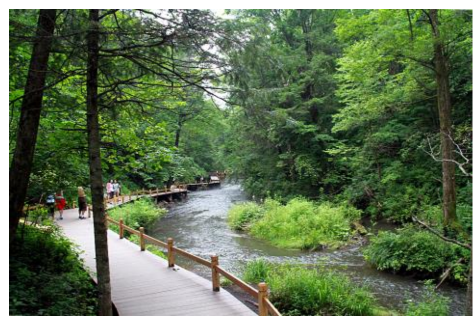
What's wrong with this picture?

Examine this picture.
Do you see anything wrong?
Write your discoveries below.



Points to Ponder

Have you been to a local stream lately and looked at the water? Have you seen fish in the stream — or insects or plants? Stream water has lots of different characteristics and many forms of aquatic life living in it. What did you see that might indicate a healthy or unhealthy stream? For example, lots of fish = healthy stream; lots of trash = unhealthy stream. Many different kinds of life benefit from healthy water, including humans and animals. We use streams and rivers for many purposes, for example, recreation, fishing, drinking water supply, agriculture, animal water supply, education and scientific studies. It's important that we keep streams other water sources healthy for all of these reasons.



When we remove water for irrigation and other reasons, it affects and changes the quality of the water habitat. Additionally, in developed countries like the US, pollution from organic wastes (such as fertilizers, human waste water) and industrial wastes have decreased over the past 20 years due to the work of engineers and legislation, but it still remains a big problem in terms of water quality in other parts of the world. These are the challenges that engineers face every day.

Water Pollution vs. Water Contamination

What's the Difference?

Water *pollution* is due to the activities of people and *contamination* may be from people or natural sources.

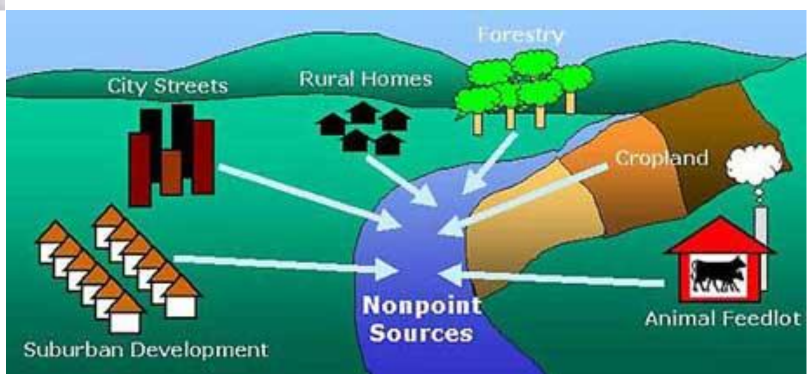
Surface waters and ground water are affected by both.

There are two ways in which contaminates and pollution occur; point-source and non-point source.

When pollution comes from a single location, such as a discharge pipe from a factory, it is point-source. Tanker oil spills or someone pouring oil from a car down a drain are other examples of point-source. In other words, we can pin-point where it came from.

Non-point source pollution comes from many sources, such as rainfall or snowmelt running over the land. As the runoff moves, it picks up and carries away natural and man-made pollutants, with the final destination being a lake, river or other water source.

Nonpoint source pollution is difficult to control because it comes from many different sources and locations.



Think Like an Engineer

The aim of engineering should be to benefit society and the environment.

Ever since people first realized that their health is related to the quality of their environment, they have tried to do things to improve it.

Archaeological digs have uncovered sewers in ancient civilization ruins. The Romans built aqueducts to prevent drought and to create a clean, safe water supply for the city of Rome. In the 15th century, Bavaria put laws in place to restrict the development and washing away of alpine country where the fresh water supply originated.

Modern environmental engineering emerged in London in the mid-19th century when Joseph Bazalgette designed the first major sewage system to reduce the rate of cholera, a waterborne disease. The engineering of water treatment and sewage treatment facilities reduced waterborne diseases from leading causes to death to rarities.

However, some engineering projects result in negative impacts on people and the environment. For example, a hydroelectric dam provides power with no pollution or greenhouse gas emissions. But the construction of the dam may require people be displaced, farmland and other sites flooded, and decrease in fish population and habitats.

1. Describe an example of an engineering project that has greatly benefitted people and society.

2. Describe an example of an engineering project that has greatly improved environmental conditions.

3. Describe an example of an engineering project that has resulted in negative impacts on people and/or the environment.

Jigsaw Activity: The Missing Pieces of Water Contaminates

Your class will learn about water contaminates using a strategy called Jigsaw. The puzzle pieces are Physical Contaminants, Biological Contaminants, and Chemical Contaminates.

Here's how it works: The teacher will place you in a *Home Group*, with a few other students. Once sitting with that group, you will be asked to *leave* that group and go to an *Expert Group*. When in the Expert Group, the teacher will give your group one of the puzzle piece topics above to learn about. You'll do some individual research about your topic, then have a discussion with the other members in your Expert Group about what you learned and come to a conclusion about what will be important to teach the members in your Home Group.

Then you'll return to your Home Group and teach your Home Group Members what you learned in the Expert Group.

Contaminant Artifact Activity- Continuing the Jigsaw:

With your Home Group, create a type of artifact to be presented to the class that illustrates your groups understanding of Physical, Chemical, and Biological Contaminates. This can be in the form of a poster, a PowerPoint, or any Web 2.0 tool. Your teacher will explain your options. Information to be addressed in the artifact include:

1. Provide a description of each contaminate with specific examples
2. Describe how the contaminate enters the water source
3. Describe the impacts on health for each contaminate

KSB3 Artifact Rubric- Create an artifact to be presented to the class that illustrates your groups understanding of Physical, Chemical, and Biological Contaminates

	1	3	5	SCORE
Description of each contaminate, Physical, Chemical, and Biological	The artifact includes a poor description of contaminates with very little information.	The artifact includes a description of the contaminates with some additional information	The artifact includes a detailed description of contaminates with excellent supporting information.	
Description of how contaminate enters the water source	The artifact vaguely describes how the contaminate enters water source	The artifact describes how the contaminate enters water source	The artifact includes a detailed description of how the contaminate enters water source	
Description of impacts of contaminates	The artifact vaguely describes the impact of the contaminates	The artifact describes the impact of the contaminates	The artifact includes a detailed description of the impacts of the contaminates	

What's the BIG IDEA?

It is important to take away the following really important BIG IDEAS about engineering from this KSB. Reflect on each one and explain what it means to you. Keep in mind that there are no right or wrong answers to the question—it's your opinion that counts.

Big Idea: All drinking water contains some contaminates; some are harmless and some can make the water unsafe to drink.
Supporting Idea: The aim of engineering should be to benefit society and the environment.

Check Your Understanding

As a means of checking on your progress, do the best you can to answer the following questions.

1. Industrial discharge and runoff of fertilizers and pesticides can be sources of
   a. Bacteriological contamination
   b. Chemical contamination
   c. Thermal contamination
   d. Physical contamination
   e. I don't know

2. This type of contaminant is usually the result of humans drinking water from water sources

contaminated with microbes from human and animal waste

a. Bacteriological contaminants
b. Parasitic contaminants
c. Metal contaminants
d. Sediment contaminants
e. I don't know

3. Which headline best describes heavy metal contamination in water

a. Volcano erupts in Hawaii
b. Explosion in Coal Mine
c. Oil Spill Takes toll on Aquatic Life
d. Tsunami in Japan
e. I don't know

4. This type of water contaminate needs a host organism to get its food. It can affect anyone, but is most dangerous to children and elderly as it can cause severe diarrhea and dehydration.

a. Metal contaminates
b. Sediment and particulates
c. Parasitic contaminants
d. Bacteriological contaminants
e. I don't know

5. This type of contaminate is caused by too much suspended particles (sand, silt and dirt) in water

a. Parasitic union
b. Industrial discharge
c. Bacteria
d. Physical Contaminates
e. I don't know

6. Toma and his family are taking their daily trek to their nearest water source. As they come into view of the pond, they see livestock wading in the water. Which contaminant is highly likely to be found in the pond water?

a. Metal contaminants
b. Algal contaminants
c. Fertilizer contaminates
d. None of the above
e. I don't know

7. The rainy season began about three weeks ago; all the villages are flooded and the water is so high it is flowing into the village water wells. Shortly after the flooding started, little Semila became sick with a stomach ache and diarrhea. What is a probable cause of Semila's sickness?

a. Semila likely has fertilizer poisoning.

b. The water Semila drank was likely contaminated with bacteria or parasites.
c. Semila likely has appendicitis.
d. None of the above
e. I don't know

8. The BP Oil Spill in 2010 was the largest oil spill in history.
Would this spill be categorized as point source or non-point source pollution?
______ Point source
______ Non-point source

9. In two to three sentences, describe an example of a *water* engineering project that has greatly benefitted people and society.

10. Describe two ways that a water source could be contaminated with chemicals.

KSB 4

Name_______________________ Date______

Clean Up Your Act!

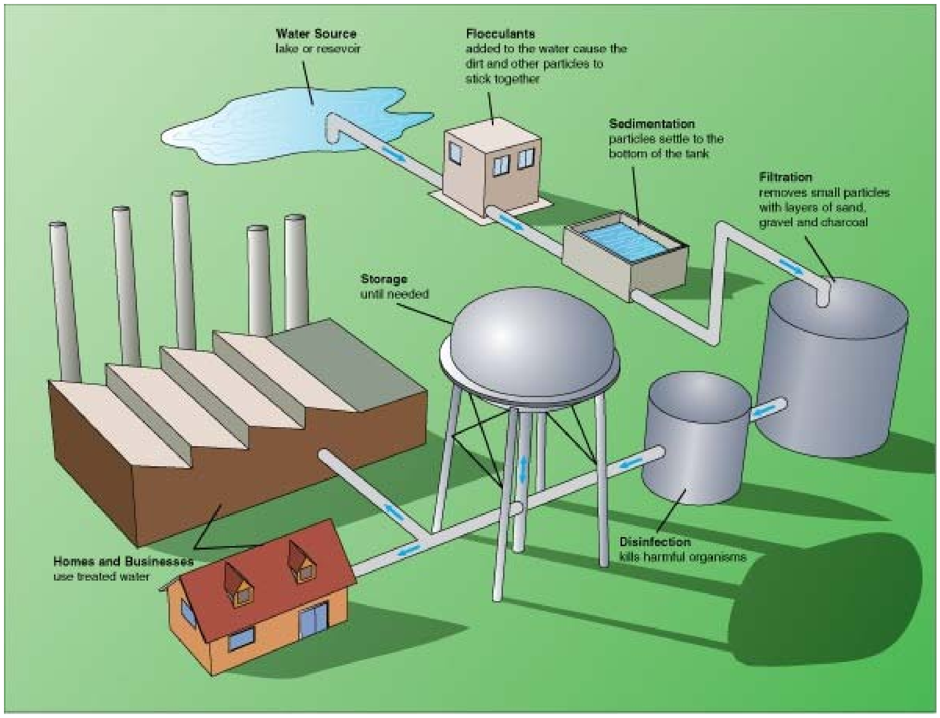
Big Idea: Water sources can be improved by using engineering methods to remove contaminants.

Living in the developed world, like the United States, we don't have to worry about how safe our drinking water is. Our communities have the means to clean and provide safe water to us. But in many parts of the world, people don't have this same luxury. Their town or village may not have a water treatment facility or nearby water well. Women and children often walk miles just to get enough water for their daily needs. Sometimes− even if there is water nearby it is contaminated and can be a source of deadly diseases. When you finish this KSB, you'll be able to answer the following questions:

- ✓ How can I detect and remediate physical, chemical, and biological contaminants in water?
- ✓ How can I illustrate a water filtration system in a systems diagram?

Traditional Water Filtration

All drinking water in the US must go through a filtering process before it comes out of our taps, like the one below.



The first step is called coagulation. During coagulation, flocculants (chemicals) are added to the water to make dirt and dissolved particles stick together in clumps that are called flocs.

In the next process, called sedimentation, the flocs get really heavy and sink to the bottom of the tank where they can be removed.

The step after this is filtration; all the water filters through layers of sand, gravel, and charcoal.

The final step in treatment is disinfection where chlorine is added. Chlorine makes sure that any dangerous microorganisms that might have gotten through all the treatment processes are killed. At this point, the clean water is placed in storage until needed.

Group Activity: Small-scale Solutions

In major cities there may be more than one water treatment plant. But these large treatment plants don't always make sense for small-scale, rural or developing communities. Engineers are always looking for new ways of designing water solutions to meet the needs of people around the world. Some examples of small-scale treatment solutions are listed below.

- Chlorination

- Solar Disinfection
- Bio-Sand Filtration
- Ceramic Filtration
- Solar Distillation

With your assigned teammates, review the fact sheet on the small-scale treatment solution your teacher gives you. Meet and discuss the concept of the solution, then share what you have learned with the class.

Think Like an Engineer- Systems

The water treatment solutions your class just examined are all ***systems.*** You may remember from KSB2 that *a system is a group of components that work together to achieve desired results.*

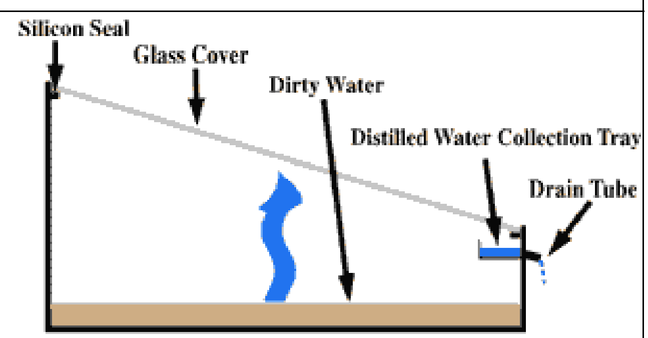
Name the components in the Ceramic Filtration System to the right. ________

____

____

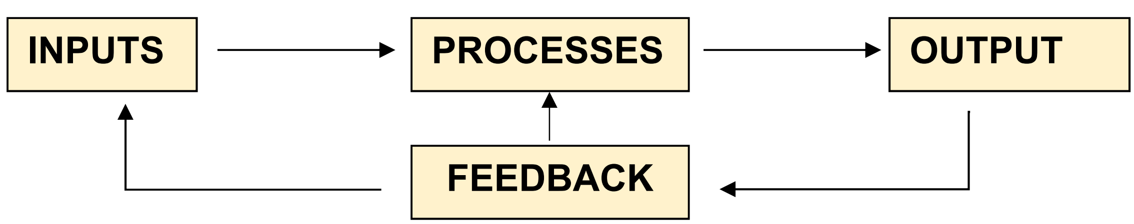
____

____

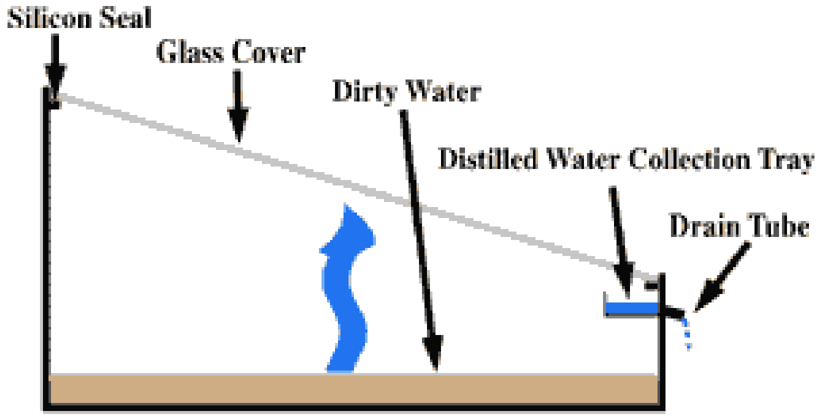


Ceramic Filtration System

Systems can be represented (modeled) as a **Systems Diagram** with *Inputs* (resources to produce the desired result), *Processes* (the activities that go on inside the system), *Outputs*(the actual results once the action or process has been completed), and sometimes *Feedback* (information can be rerouted back into the system to determine what part of the system was successful and what was not).



Example: Systems Diagram of a Solar Distillation System



INPUTS →	PROCESSES →	OUTPUT
The desired result is to produce safe drinking water	The activities that go on inside the system	The actual result
These seven general "inputs" are needed to produce the safe drinking water: 1. people 2. knowledge 3. materials 4. energy 5. tools 6. time 7. money	Sun's energy goes through a glass or Plexiglas window and evaporates the water in the pool at the bottom of the still. The evaporated water condenses on the glass and flows along the glass surface to channels at the bottom where it is collected.	Safe drinking water drains from the drain tube

FEEDBACK

Is the water safe to drink?

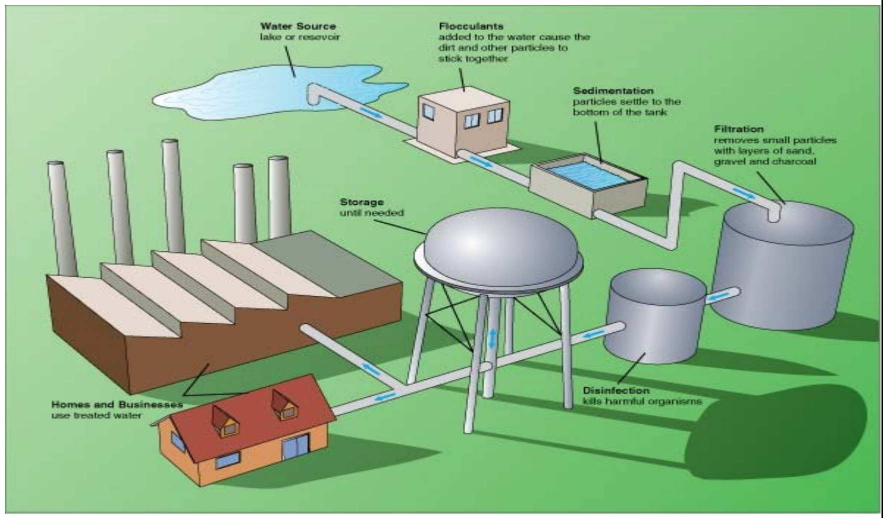
If not, any part of the system can be revisited to correct the Output.

Check Your Understanding

Water Treatment Systems Diagram

Create a Systems Diagram for the water treatment plant talked about earlier in this KSB.

1. In the *Input* area, describe the problem you are trying to solve and the resources that would most likely be needed to solve the problem.
2. In the *Process* area, describe the activities or events that are happening.
3. In the Output area, explain the result.
4. Last, describe what takes place in the Feedback area.



Systems Diagram for a Water Treatment Plant		
INPUT →	PROCESS →	OUTPUT
	← FEEDBACK	

Points to Ponder

The major cause of death of children under 5 years old in developing countries is due to cholera.

Cholera is a highly contagious, waterborne bacterial disease that causes severe diarrhea in those that drink water infested with it. Copepods, tiny crustaceans that naturally carry the cholera pathogen, have been found to be the major culprits of infestation.

There are many chemical and filtering treatments available for eliminating the pathogens, but there are many more factors such as cost, ease of use, availability and more- that prevent cholera elimination treatment in developing countries using these “modern” technologies.

A surprisingly simple, and more surprisingly successful method to reduce cholera pathogens has been found that uses readily available sari cloth to filter the water. Sari cloth is a traditional garment worn by women in South Asia. It’s been found that that filtering drinking water through four or more folds of sari cloth helps to remove the copepods, which can reduce cholera by 40 to 50 percent.

Group Activity: Test Your Water—Treat Your Water

Your team will work like environmental engineers and replicate water treatment processes on three samples of simulated contaminated water. Simulated means that the water will not really be contaminated but that something has been added to it that mimics the real contaminate. The water is safe but you still <u>should not</u> drink it!

Your team will:

- Detect the contaminant in three different water samples: physical, chemical biological.
- Follow the procedure to remediate the contaminant (Remediate means to correct it or make it right).
- Calculate the improvement of your procedure

Your teacher will assign teams and distribute the materials you will need.

What's the BIG IDEA?	It is important to take away the following really important BIG IDEA about engineering from this KSB. Reflect on the Big Idea and explain what it means to you. Keep in mind that there are no right or wrong answers to the question—it's your opinion that counts.
Big Idea: Water sources can be improved by using engineering methods to remove contaminants.	
Supporting Idea #1: Systems have parts that work together to achieve desired results.	
Supporting Idea #2: Feedback involves monitoring and adjusting a system to maintain a desired output.	

Individual Activity: Creative Solutions to Water Treatment Systems

In this KSB, you have learned about water treatment processes, filter media, and how to detect and remediate water contaminates.
Imagine you are an environmental engineer and you have a water sample that is turbid, contains sediment and particles, and also parasites and bacteria. What would your treatment system look like, in a small scale version?

In the box below draw your idea for a small scale filtration system. Identify media you would use and add labels that identify inputs, processes, output, and feedback.

Check Your Understanding

As a means of checking on your progress, do the best you can to answer the following questions.

1. Kalia and her daughters finally reached to water hole where they get their daily supply of water. They weren't surprised to find it very muddy. As they walked back to their village, Kalia thought about what she could do to make the water safer to drink. Which process below would be Kalia's most effective <u>first</u> step?
   a. Buy chlorine at the local grocers and add it to the water.
   b. Pour the water over large gravel and allow it to flow into another container.
   c. Place the container of water in the sun for ten days.
   d. Strain the water through sari cloth.
   e. I don't know
2. What happens when alum is added to dirty water?
   a. Any particles in the water will clump together, get heavy, and fall to the bottom.
   b. The water will be disinfected and therefore free of dangerous microorganisms.
   c. Any dirt particles dissolve and the water becomes clearer.
   d. The water turns white killing any contaminates, then must be filtered to remove the large particles.
   e. I don't know
3. Which scenario best describes a typical water treatment plant- in the correct order?
   a. The water is filtered through media, then goes through coagulation, then disinfected with chlorine.
   b. Adding chlorine is the first step, followed by coagulation, followed by filtration.
   c. The water is treated with a flocculent, next step is sedimentation, then filtration,

then disinfection.

d. The water is left to settle for a period of days, chlorine is added, then goes through several filtration processes.
e. I don't know

4. Biological water contaminants like parasites and viruses are best remediated with
   a. Alum
   b. Charcoal
   c. Peroxide
   d. Chlorine
   e. I don't know
5. A systems diagram is a representation of how a system works. What happens in the Process step of the systems diagram?
   a. The problem you are trying to solve is described- the desired result.
   b. The actual result.
   c. It is the cause and effect of how the system works.
   d. The activities that go on inside the system.
   e. I don't know
6. Give an example of how engineering methods can be used to remove water contaminants.
7. Cholera is a highly contagious, waterborne bacterial disease that causes severe diarrhea in those that drink water infested with it. This type of contaminate is most effectively remediated with:
   a. Coagulation
   b. Chlorine
   c. Issus
   d. Fluoride
   e. I don't know
8. A team of engineers determine the type of material, equipment, and energy sources that will be needed to create the technological solution for their challenge. Which step of a Systems Diagram would this fall under?
   a. Processes
   b. Input
   c. Feedback
   d. Output

e. I don't know
9. The thermostat in your house is set to 68 degrees. When the temperature in your house drops to 67 degrees, the furnace kicks on to heat the house. This is an example of: a. Processes b. Input c. Output d. Feedback e. I don't know
10. To remediate physical contaminates- one would: a. Use chlorine to clarify the water b. Detect first with a test kit, then use alum as a coagulate. c. First add a flocculent to settle out the suspended particles, then use filter media to remove any leftovers. d. Take a water sample to an engineer to determine treatment process. e. I don't know