

Unit Title: Engineering Desalinators Date Developed/Last Revised: 6-24-13 Unit Author(s): Baird Swedman/John Constantinou	Grade Level: 9-12 Time Frame: 8+ class periods (more for better observations) Primary Content Area: Marine Science and Geometry
--	--

UNIT DESCRIPTION: Student groups will construct desalinators of various sizes and shapes to determine which size and shape combination produces the largest amount of potable water and in the least amount of time.
Big Ideas (Student Insights that Will Be Developed Over the Course of the Unit): • How to convert seawater to fresh water • How surface area affects the productivity of a desalinator • How different colored materials affect the productivity of a desalinator Essential Questions (Questions that Will Prompt Students to Connect to the Big Ideas): • What will humans do when fresh drinking water becomes scarce? • Why does condensation form when water is heated up? • What are some factors that affect the rate of evaporation? • Do you think a desalination device with a black-colored bottom would be more efficient than one with a white-colored bottom? Why? Can you relate your answer to the concept of heat transfer?

	BENCHMARKS/STANDARDS/LEARNING GOALS
Science	• SC.MS.2.1: Explain how scientific advancements and emerging technology have influenced society • SC.MS.2.2: Compare the risks and benefits of potential solutions to technological issues • SC.MS.3.7: Describe the relationship between fresh bodies of water, watersheds, and the ocean • SC.MS.4.1: Differentiate freshwater, brackish, and saltwater ecosystems • SC.PS.1.2: Design and safely implement an experiment, including the appropriate use of tools and techniques to organize, analyze, and validate data • SC.PS.1.3: Defend and support conclusions, explanations, and arguments based on logic, scientific knowledge, and evidence from data • SC.PS.1.5: Communicate the components of a scientific investigation, using appropriate techniques • SC.PS.6.4: Explain that changes in thermal energy can lead to a phase change of matter

Technology	• CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
Engineering	• CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
Mathematics	• CCSS.Math.Content.HSS-ID.A.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets • CCSS.Math.Content.HSG-GPE.B.7 Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula
English Language Arts and Literacy	• CCSS.ELA-Literacy.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. • CCSS.ELA-Literacy.RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. • CCSS.ELA-Literacy.RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text. • CCSS.ELA-Literacy.SL.9-10.4 Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.
STEM Competencies	Indicator 2.2: Collaborates with, helps and encourages others in group situations An effective community contributor who is STEM-literate: • collaborates and makes positive contributions to the group toward identifying and achieving task goals. • consistently assesses the group's progress and encourages others to use scientific investigation, engineering principles, a mathematical approach, and appropriate technology towards achieving their goal. Indicator 3.3: Generates new and creative ideas and approaches to developing solutions A Complex Thinker who is STEM-literate: • examines a broad span of information, recognizes patterns, and narrows the information to reach a diagnosis of the problem. • uses creativity to generate new and innovative solutions, integrating seemingly unrelated information, and considering alternative solutions. • applies knowledge of science, technology, engineering, and mathematics to identify and solve problems using systems thinking, modeling and analysis.

LESSON SEQUENCE

	Lesson Title/Description	Learning Goals (What Students Will Know and Be Able to Do)	Assessments	Time Frame
1	Global Water Crisis: Overview/Introduction – Why we need safe drinking water	Students will understand that a shortage of clean drinking water is one of the most pressing global issues.	Exit Pass – Reflective Response	1 class period (60-70 minutes)
2	Healthy vs. Unhealthy Water	Students will develop a definition of healthy water based on student-centered classroom discussions. The students will also develop a definition of unhealthy water based on student-centered discussions.	Exit Pass – Venn Diagram or Two Column Chart Water Quality Quiz (optional)	1 class period (60-70 minutes)
3	Desalination	Students will understand the importance of desalination.	Exit Pass – Reflective response	1 class period (60 minutes)
4	Engineering Design Process (EDP): Building a Desalinator	Student groups will construct desalinators (of various shapes and surface areas) and determine their effectiveness in producing potable water.	Desalinator Evaluation	1-2 class periods (60-120 minutes)
5	EDP Continued: Improvements	Students will make variations to their desalinators to assess effectiveness.	Desalinator Evaluation	1-3 class periods (60-180 minutes)
6	EDP Continued: Comparing Results	Student groups will compare the results of their desalinators.	Group Presentations/Discussions	1 or more class periods
7	Extension: Google SketchUp	Students will use Google SketchUp to create a model of a desalinator.	Model Evaluation	2 or more class periods
8	Scientific Inquiry and Math Practice Extensions	Students develop and test hypotheses on water desalination based on their findings and wondering with the desalinators they design.	Formative- Observations and discussions during the inquiry process Summative: Completed Lab Report	1 wk - ongoing

Resources:

1. Building Desalinators:
http://www.sciencebuddies.org/science-fair-projects/project_ideas/EnvEng_p022.shtml
2. Water Secure:
http://www.watersecure.com.au/pub/images/stories/other_publications/teaching_units/2_Desalination_Grade7_Teaching_Unit.pdf
3. Interactive Virtual Tour – Follow Up Activities:
<http://www.seqwater.com.au/public/virtual-tours/>
4. Water Secure Fact Sheet: Desalination – fresh water from the sea:
http://www.upadrygully.com.au/res/FactSheets/Water_Week_Resources/factsheet-desalination.pdf
5. “Water Changes Everything”:
<http://www.charitywater.org/whywater/>
6. Safe Drinking Water Foundation:
<http://www.safewater.org/>

Unit Title: Engineering Desalinators Lesson Title: Global Water Crisis Date Developed/Last Revised: 6-24-13 Unit Author(s): Baird Swedman/John Constantinou	Lesson #: 1 Grade Level: 9-12 Primary Content Area: Marine Science/ Secondary Mathematics Time Frame: 1 class period (60 minutes)
--	---

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

- **SC.MS.2.1:** Explain how scientific advancements and emerging technology have influenced society
- **SC.MS.2.2:** Compare the risks and benefits of potential solutions to technological issues

2A. Criteria- What Students Should Know and Be Able to Do:

Students can-

- Understand that a shortage of clean drinking water is one of the most pressing global issues
- Explain the need for technology that can adequately and efficiently provide clean drinking water for global populations

2B. Assessment Tools/Evidence:

Formative:

- Observations and discussions during the lesson

Summative:

- Exit Pass – Reflective Response 1 (See below)

Reflective Response Rubric			
Criteria	Exceeds – 4	Meets – 3	Approaches - 2
Response Length (1 paragraph = 5 or more sentences)	Reflective responses are 3+ paragraphs.	Reflective responses are 2 paragraphs.	Reflective response is 1 paragraph or less.
Response Quality	Responses are detailed, relevant, and thoughtful.	Responses are relevant and thoughtful.	Responses lack detail AND/OR are irrelevant AND/OR lack thoughtfulness.
Time	Responses are turned in <u>prior</u> to the due date.	Responses are turned in <u>on</u> the due date.	Responses are turned in <u>after</u> the due date.

3. Learning Experiences (Lesson Plan)

Materials:

- Laptop/Desktop PC
- Projector
- Water Crisis PPT (attached at end of document)

Handouts/Other Resources:

- Videos:
 - “Water Changes Everything” <http://www.charitywater.org/whywater/>
 - “Water Wars” – available for instant viewing on Netflix
 - “Tapped” – available for instant viewing on Netflix
- Exit Pass – Reflective Response 1 (see below) (Questions may be written on the board to save on handouts)

Teacher Background Information:

This lesson is an introduction to the context and human need for clean drinking water. Many students in Hawaii (and the United States in general) are unaware that in several parts of the world, clean drinking water is unavailable. This introductory lesson is intended to increase students’ awareness of the problem in terms of human health and how technological advancements could possibly alleviate the pending global problem. There are many online sources about clean drinking water; familiarize yourself by doing simple online searches to provide teacher with additional background knowledge.

Procedure:

1. Hook: Show students a picture of a water catchment tank (any image found online will do) and ask how many of their families rely on catchments for their water needs.



Explain to students that not everybody relies on personal catchment tanks for water, and that many people in Hawaii (and the United States in general) rely on county water for their water needs. Then, explain that humans rely on even bigger 'catchment tanks', mainly in the forms of aquifers, and that basically, the Earth is one giant catchment tank (images found online might be useful for visual learners). Once all of the aquifers are tapped, the planet's fresh water will be gone, and we will have to rely on rainfall or other technological means to obtain fresh drinking water.

2. Introduce: Water Crisis PowerPoint - The Water Crisis PowerPoint slide set (found at end of unit) introduces facts about the global distribution of fresh water geologically. Areas of the world that do not have access to enough clean drinking water are highlighted. Per capita water usage, wealth, and access to sanitation are shown for several countries, and consequences from drinking contaminated water are highlighted.
3. Discuss: Either while presenting the PPT or afterwards, have students discuss the current global water crisis and try to brainstorm some possible solutions. Have students try to think about how technology can be used to help solve (or at least alleviate) the global water crisis.
4. Reflect: Present students with the following questions:
 - o Reflective Response 1: Why is clean drinking water a pressing global issue? What areas of the world suffer from drinking water shortages? Is your area of the world facing a water shortage? Is it necessary to develop technology that can adequately and efficiently provide clean drinking water? Explain your answers.
 - o Students are required to turn in their responses at the beginning of the next class period.

TEACHING & ASSESSMENT (Steps 4, 5, 6, &7)

Completed by teacher after instruction has taken place

4. Teaching and Collecting of Evidence of Student Learning:

Teacher Notes:

5. Analysis of Student Products/Performances-Formative:

Teacher Notes:

6. Evaluation of Student Products/Performances-Summative (Not necessary for every lesson):

Teacher Notes:

7. Teacher Reflection: Replanning, Reteaching, Next Steps:

Teacher Notes:

Unit Title: Engineering Desalinators
Lesson Title: Healthy vs. Unhealthy Water
Date Developed/Last Revised: 6-24-13
Unit Author(s): Baird Swedman/John Constantinou

Lesson #: 2
Grade Level: 9-12
Primary Content Area: Marine Science/
 Secondary Mathematics
Time Frame: 1 class period (60 minutes)

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

- **SC.MS.4.1:** Differentiate freshwater, brackish, and saltwater ecosystems

2A. Criteria- What Students Should Know and Be Able to Do:

Students can-

- Develop a definition of 'healthy drinking water' based on student-centered class discussions.

2B. Assessment Tools/Evidence:

Formative:

- Observations and discussions during the class period
- Water Concept Map

Summative:

- Venn Diagram

Venn Diagram Rubric

Criteria	Exceeds – 4	Meets – 3	Approaches - 2
Compare	4+ details	3 details	2 details or less
Contrast	4+ details	3 details	2 details or less
Time	Turned in <u>prior</u> to due date.	Turned in <u>on</u> due date.	Turned in <u>after</u> due date.

3. Learning Experiences (Lesson Plan)

Materials:

- Three 250 mL beakers
- Three empty water bottles
- Cheesecloth or a coffee filter
- Funnel
- A small amount of bleach
- Various organic substances to discolor water
- One sheet of blank paper per group

Procedure:

1. Before class begins (preferably the day before the lesson will be taught) prepare two beakers (250-500 mL) of water in the following manner:
 - a. To Beaker A add coffee, soil/compost, egg shells, or anything else that will discolor the water and give it an unpleasant smell.
 - b. To Beaker B add 1/3 cup of salt or sugar and stir to dissolve completely.
 - c. Filter the contents of each beaker (through cheesecloth) into separate, empty water bottles and replace caps.
 - d. Fill a third empty water bottle with tap water and mark the bottle to identify it from the other clear water (but do not label it).
2. Place the three bottles on the counter or in another location so that the students will notice them, but do not make direct reference to the bottles.
3. Ask the students to state a word or phrase that describes water and record their answers on the board in the form of a concept map. For example, students can create bubble maps to describe water with adjectives. <http://www.thinkingmaps.org/>
4. Ask the students to identify any words or phrases that make reference to health and underline these answers.
5. Ask the students to identify any words or phrases that make reference to unhealthy aspects and place a star beside these words.
6. Divide the class into groups of three and hand out a white piece of paper to each group. Each group must then develop a concept map of water health using the underlined and starred words or phrases. They can include other words or phrases that are not on the board in their concept maps.
7. While the groups are working, make a blank concept map of water health on the board.
8. Have one student from each group add two words or phrases to the concept map. Students should add any words or phrases that are not on their maps so that each student's map is the same.
9. Move the focus to the three bottles of water, by asking the students which bottle(s) have "healthy" or "unhealthy" water. Encourage the students to use words or phrases from their concept maps to decide.
10. Ask the students if they think that all Americans have equally safe drinking water? If so, do they think that Native communities and rural communities have equal resources (knowledge and funds) as urban areas to effectively treat their drinking water? Do they think that any of these three beakers of water might be unsafe to drink? If there is one that is unsafe to drink, what geographical area or community do they think it may have originated from?
11. Draw a blank Venn diagram on the board and label each circle "Healthy Water" and "Unhealthy Water." Instruct students that they are to create their own Venn diagram that compares/contrasts Healthy/unhealthy water and utilizes information they compiled in their group's concept map. Diagrams will be due at the beginning of the next class period.

Unit Title: Engineering Desalinators Lesson Title: Desalination Date Developed/Last Revised: 6-24-13 Unit Author(s): Baird Swedman/John Constantinou	Lesson #: 3 Grade Level: 9-12 Primary Content Area: Marine Science/ Secondary Mathematics Time Frame: 1 class period (60 minutes)
---	---

PLANNING (Steps 1, 2, & 3)			
1. Standards/Benchmarks and Process Skills Assessed in this Lesson: SC.MS.2.1: Explain how scientific advancements and emerging technology have influenced society SC.MS.2.2: Compare the risks and benefits of potential solutions to technological issues			
2A. Criteria- What Students Should Know and Be Able to Do: Students can- Understand the importance of desalination.			
2B. Assessment Tools/Evidence: Formative: - Observations and discussions during the class period - Desalination Dictionary (attached) - Desalination Flowchart (attached) Summative: - Exit Pass - Reflective Response 2 (see below)			
Reflective Response Rubric			
Criteria	Exceeds – 4	Meets – 3	Approaches - 2
Response Length (1 paragraph = 5 or more sentences)	Reflective responses are 3+ paragraphs.	Reflective responses are 2 paragraphs.	Reflective response is 1 paragraph or less.
Response Quality	Responses are detailed, relevant, and thoughtful.	Responses are relevant and thoughtful.	Responses lack detail AND/OR are irrelevant AND/OR lack thoughtfulness.
Time	Responses are turned in <u>prior</u> to the due date.	Responses are turned in <u>on</u> the due date.	Responses are turned in <u>after</u> the due date.

3. Learning Experiences (Lesson Plan)

Materials:

- Laptop/Desktop PC
- Projector
- Classroom computers/tablets

Handouts/Other Resources:

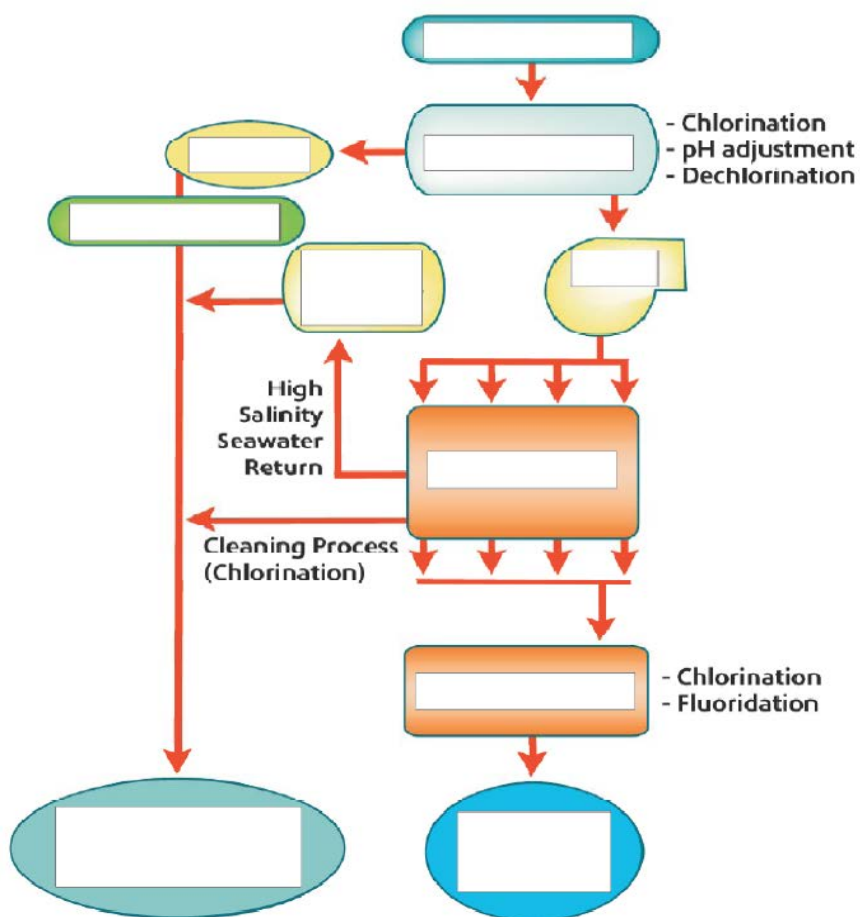
- Desalination Process Flow Chart (attached)
- Interactive Virtual Tour: Gold Coast Desalination Plant:
<http://www.segwater.com.au/public/virtual-tours/>
- Exit Pass – Reflective Response 2 (see below) (Questions may be written on the board to save on handouts)

Procedure:

1. Hook: Using the factsheet 'Desalination- fresh water from the sea' and the interactive virtual tour, students are introduced to the key stages of the desalination process.
http://www.upadrygully.com.au/res/FactSheets/Water_Week_Resources/factsheet-desalination.pdf
2. Introduce: Students will start a Desalination Dictionary (attached) to demonstrate understanding of the key terms, words and their meanings. Additional words should be added.
3. Discuss: Students will complete a flowchart (provided) that delineates the desalination process.
4. Reflect: Present students with the following questions:
 - Reflective Response 2: How can desalinating water help solve the global issue regarding safe drinking water? Explain. Do you think that this would be an effective solution? Why or why not?
 - Students are required to turn in their responses at the beginning of the next class period.

<u>Desalination Dictionary</u>		
Word	Meaning	What part of the desalination process is this associated with?
Brine	<i>Example: highly saline water</i>	<i>outlet pipe</i>
Desalination		
Diffusers		
Potable Water		
Freshwater		
Minerals		
Inlet		
Outlet		
Sea Water		
Reverse Osmosis		
Filtration		
Membrane		
Renewable Energy		

Desalination Flowchart



Unit Title: Engineering Desalinators Lesson Title: Engineering Design Process (EDP): Building a Desalinator Date Developed/Last Revised: 6-24-13 Unit Author(s): Baird Swedman/John Constantinou	Lesson #: 4 Grade Level: 9-12 Primary Content Area: Marine Science/ Secondary Mathematics Time Frame: 1-2 class periods (60 minutes each)
---	--

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

- **CTE Standard 1: TECHNOLOGICAL DESIGN:** Design, modify, and apply technology to effectively and efficiently solve problems

2A. Criteria- What Students Should Know and Be Able to Do:

Students can-

- Understand and use the Engineering Design Process (EDP) to build and improve a desalinator, incorporating the following steps.
 - o Ask
 - o Imagine
 - o Plan
 - o Create
 - o Experiment
 - o Improve

2B. Assessment Tools/Evidence:

Formative:

- Observations and discussions during the EDP
- Presentation of the final product including the initial prototype, testing and improvement to the desalinator

Prototype Rubric			
Criteria	Exceeds – 4	Meets – 3	Approaches - 2
Prototype	Students constructed a prototype following all steps of the EDP (with Improve to be addressed later).	Students constructed a prototype following most of the steps of the EDP.	Students constructed a prototype without following the steps of the EDP OR students failed to construct a prototype.
Test	Students thoroughly tested the effectiveness of their prototype.	Students adequately tested the effectiveness of their prototype.	Students inadequately tested the effectiveness of their prototype OR students failed to test their prototype.
Data	Students collected data in an easy to follow format (table, chart, etc.).	Students collected data.	Students failed to collect data OR data is disorganized.

3. Learning Experiences (Lesson Plan)

Materials:

- See building desalinators (recommended for teacher use ONLY):
http://www.sciencebuddies.org/science-fair-projects/project_ideas/EnvEng_p022.shtml
- Bottles, water, plastic, straws etc. (see above link for more extensive list)

Teacher Background Information:

Typical seawater contains dissolved salts at concentrations between 32 and 37.5 parts per thousand. That means that if you started with one kilogram of seawater (which is approximately one liter of seawater) and then you allowed all of the water to evaporate, you would be left with between 32 and 37.5 grams of salts (also called "total dissolved solids"). With all of that salt, seawater is not suitable for drinking or for watering most plants. The fluid circulating in your body (blood plasma) contains much less salt than seawater (on the order of 9 grams of total dissolved solids). If you were to drink seawater, your body would actually lose water, because the high salt concentration of the seawater causes an *osmotic pressure gradient* which drives water out of your cells. Desalination is the process of removing the dissolved salts from water, making it pure enough for drinking or irrigation.

Procedure: (a detailed list of procedures can be found at the link provided above)

Engineering Design Challenge: Build a Functioning Desalinator

1. Use supplies on your table to create a small-scale functioning model of a desalinator.
2. Start with a quick sketch of the model you will build that includes the criteria listed below.
3. Criteria: Your system should include:
 - Separate freshwater from salt water using a salinity/conductivity meter to measure salinity levels of the beginning and final water.
 - We will all start with 2L of water
 - We want to recover the most water in the least amount of time
4. Constraints:
 - Light and Temperature, which cause condensation, will be controlled (kept the same) during testing of designs.
5. When you complete the model that runs you have completed the **Create** step of the engineering design process and you can consider your system a 'prototype'. NASA engineers need to create at least 100 prototypes before they can build anything. Why?
6. We will address the **Improve** component in a future lesson (see Lesson #5).
7. Math Connections
 - Discuss with your team what measurements are needed to complete this task. Think about what you will need to measure to know if your desalinator is functioning.
 - Create a data table to record all the measurements that will be made.
 - Discuss with your team what lab tool will allow you to measure each of the variables you identified in step 1.

Unit Title: Engineering Desalinators Lesson Title: EDP Continued: Improvements Date Developed/Last Revised: 6-24-13 Unit Author(s): Baird Swedman/John Constantinou	Lesson #: 5 Grade Level: 9-12 Primary Content Area: Marine Science/ Secondary Mathematics Time Frame: 1-3 class periods (60 minutes each)
--	---

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

- **CTE Standard 1:** TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
- **CCSS.Math.Content.HSG-GPE.B.7** Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula.
- **SC.PS.6.4:** Explain that changes in thermal energy can lead to a phase change of matter

2A. Criteria- What Students Should Know and Be Able to Do:

Students can-

- Understand and use the Engineering Design Process (EDP) to build and improve a desalinator incorporating the following steps.
 - Ask
 - Imagine
 - Plan
 - Create
 - Experiment
 - Improve
- Conduct a scientific investigation that tests a hypothesis, analyze and display data, and draw inferences based on evidence.

2B. Assessment Tools/Evidence:

Formative:

- Observations of students throughout the Inquiry Process
- A completed Lab Report that uses evidence to prove or disprove a hypothesis (see attached template and rubric)

3. Learning Experiences (Lesson Plan)

Materials:

- Previous student created desalinators
- Supplies to create new or modify existing desalinators
- Vernier Probeware: Labquest 2, light probes, temperature probes, salinity probes (www.Vernier.com)
- Sun or heat lamp

Handouts/Other Resources:

- Lab Report Template
- Lab Report Rubric

Teacher Background Information:

- Surface area is a factor that affects the rate of evaporation. Think of a way to modify one of your desalination devices so that the same volume of saltwater takes up only half of the surface area of the bottom of the jug or container, such as by attaching a plastic divider to the bottom. Test the two desalination devices again, using the same volume of saltwater in each. Does the change in surface area correlate with a change in condensate yield?
- Does the volume of the desalinator (not the water, but the desalinator itself) affect the condensate yield? Utilize materials available in the class or lab to construct a desalinator with a volume different from the original prototype.
- NOTE: No two groups should make the same adaptation to their desalinator. This way, each group is conducting their own experiment, and data can be shared/presented accordingly.

Procedure:

1. Construct a second desalinator that has a different surface area and volume than other groups.
2. Measure surface area and volume of your desalinator. Record in data table 1.
3. Calculate surface area to volume ratio of your desalinator (Surface Area: Volume Ratio). Record in data table 1.
4. Operate your desalinator to measure efficiency of your desalinator. Measure light and temperature. All class groups want to operate with the same light and temperature conditions. Why? What do we call this in science? Record in data table 1.
5. Measure the volume (mL) of freshwater produced. Measure the salinity of your freshwater and record in data table 1.
6. Measure the duration of the experiment and calculate freshwater produced/hr.
7. Record your data into a class data (Table 2).

Lab Report Template

Purpose: To determine the desalinator surface area: volume ratio that produces freshwater the fastest.

Hypothesis: *I predict that desalinators with*

_____ surface area: volume ratios

will produce freshwater _____

because _____

Prior Knowledge:

Results:

Table 1: Group Desalinator Efficiency Data

Surface Area (cm ²)	Volume (cm ³)	Surface Area: Volume Ratio (cm ² / cm ³)	Freshwater Produced (mL/hr)	Temperature (°C)	Light (lux)	Salinity (ppt)

Table 2: Class Desalinator Efficiency Data

Group #	Surface Area: Volume Ratio (cm ² / cm ³)	Freshwater Produced (mL/hr)	Temperature (°C)	Light (lux)	Salinity (ppt)

Scatterplot: Graph surface area: volume ratio vs. freshwater produced

Conclusion: Look back at your hypothesis at what you *thought* would happen. Compare it to your actual data. Does your data support your prediction? Write a conclusion.

- Restate your hypothesis
- Use your data to explain if your prediction was supported
- Explain the results

Lab Report Rubric

	Excellent	Satisfactory	Getting There	Missed the Boat	Score
Title	Title is clear and descriptive of the work done.	Clarity or completeness could be improved.	Not related to purpose of the investigation.	Missing.	
Purpose/Problem <i>Why are you investigating this?</i> <i>What question(s) do you want answered?</i>	Clearly stated, complete, related to problem being investigated. (3 pts)	Clarity or completeness could be improved. (2 pts)	Not related to purpose of the investigation. (1 pts)	Missing. (0 pts)	
Hypothesis <i>Make an educated prediction using previous knowledge</i>	Clearly describes predicted outcome of investigation with justification. (4 pts)	Clarity of statement could be improved. No justification of prediction. (2-3 pts)	Not related to purpose of the investigation. (1 pts)	Missing. (0 pts)	
Procedure <i>What do you need to do this Investigation</i>	Materials list complete. Drawing of setup complete, neat, labeled and accurate. Easy to follow, logical and detailed. (4 pts)	Missing one step. Drawing of setup neat but accuracy and completeness could be improved. Most steps are easy to follow, details could be improved. (3 pts)	Missing two steps. Details, accuracy and completeness need great improvement. Sequence of steps need improvement or need more detail. (2 pts)	Missing three or more steps. Drawing of setup not labeled. (0-1 pts)	
Results Data Table/Graphs, observations <i>What data did you collect?</i> <i>How is it organized?</i>	Tables and graphs labeled correctly and completely, labels used correctly and consistently. Observations are complete, clear and accurate. (10 pts)	Tables and graphs labeled correctly but incomplete, data complete, units used but not consistent, observations not complete. (8-9 pts)	Tables and graphs labeled but incorrectly or data missing, writing hard to read, units missing, observations not complete, vague and inaccurate. (6-7 pts)	Data table and/or graph not labeled, data is missing. (5-0 pts)	
Conclusion	Restates purpose and hypothesis; supports or refutes hypothesis; uses data as powerful evidence to support statements; discuss sources of error (if any), presents a new or different way to experiment on the topic (next steps). (15 pts)	Restates purpose and hypothesis; supports or refutes hypothesis; uses data for support but explanation is vague. (10-12 pts)	Supports or refutes hypothesis; does not use data for support; explanation of findings illogical. (6-7 pts)	Hypothesis not addressed and explanation illogical. (5-0 pts)	
				Total Possible:	

Unit Title: Engineering Desalinators Lesson Title: EDP Continued: Comparing Results Date Developed/Last Revised: 6-24-13 Unit Author(s): Baird Swedman/John Constantinou	Lesson #: 6 Grade Level: 9-12 Primary Content Area: Marine Science/Secondary Mathematics Time Frame: 1 class period (60 minutes)
---	---

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

- **CTE Standard 1: TECHNOLOGICAL DESIGN:** Design, modify, and apply technology to effectively and efficiently solve problems
- **CCSS.Math.Content.HSS-ID.A.2** Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
- **CCSS.ELA-Literacy.SL.9-10.4** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

2A. Criteria- What Students Should Know and Be Able to Do:

Students can-

- Compare data sets using statistical techniques.
- Present their findings to their colleagues in a formal presentation.

2B. Assessment Tools/Evidence:

Formative:

- Observations and discussions during the class period

Summative:

- Group Presentation (see attached rubric)

3. Learning Experiences (Lesson Plan)

Materials:

- Laptop/desktop PC
- Projector

Handouts/Other Resources:

- Presentation Rubric

Procedure:

1. Student groups will present their findings to the class and compare data.
2. Students will analyze the effectiveness of each group's desalinator and choose what modification will produce the greatest amount of potable drinking water.

Presentation Rubric				
Criteria	Exceeds – 4	Meets – 3	Approaches – 2	Below - 1
Posture and Eye Contact	Student stands up straight, shows confidence. Establishes eye contact with everyone in the room during the presentation.	Student stands up straight and establishes eye contact with everyone in the room during the presentation.	Student sometimes stands up straight and establishes eye contact.	Student slouches and does not look at the audience during the presentation.
Preparedness	Student is well prepared and has obviously rehearsed. Student elaborates their notes, not just reads his/her notes.	Student seems pretty prepared but may need more rehearsals. Student elaborates their notes, not just read his/her notes.	Student is somewhat prepared, but it is clear that the student did not rehearse. Student reads his or her notes sometimes.	It is obviously that the student does not prepare at all. Student reads his or her notes through the entire presentation.
Enunciation	Student speaks clearly and uses the time well, and mispronounces no words.	Student speaks clearly and uses the time well, but mispronounces one or two words.	Student speaks clearly and wastes some time. Mispronounces more than two words.	Student often mumbles or cannot be understood OR mispronounces many words.
Volume	Volume is loud enough to be heard by all audience through the entire presentation.	Volume is loud enough to be heard by all audience at least 90% of the time.	Volume is loud enough to be heard by all audience at least 80% of the time.	Volume often too soft to be heard by all audience.
Content	Student shows a full understanding of the topic.	Student shows a good understanding of the topic.	Student shows a good understanding of parts of the topic.	Student does not seem to understand the topic very well.
Data	Data is organized and presented clearly in an easy to read format (chart, table, graph, etc.) Graphs are constructed using Microsoft Excel.	Data is organized and presented in an easy to read format (chart, table, graph, etc.). Graphs are constructed using Microsoft Excel.	Data is slightly organized and presented in a fairly easy to read format (chart, table, graph, etc.). Graphs are constructed by hand.	Data is unorganized or missing; data is not presented; no graphs.

Unit Title: Engineering Desalinators
Lesson Title: Extension: Google SketchUp
Date Developed/Last Revised: 6-24-13
Unit Author(s): Baird Swedman/John Constantinou

Lesson #: 7
Grade Level: 9-12
Primary Content Area: Technology
Time Frame: 2 class periods, 60 min each

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

- **CTE Standard 1: TECHNOLOGICAL DESIGN:** Design, modify, and apply technology to effectively and efficiently solve problems
- **GLO #6: Effective and Ethical Users of Technology:** The ability to use a variety of technologies effectively and ethically

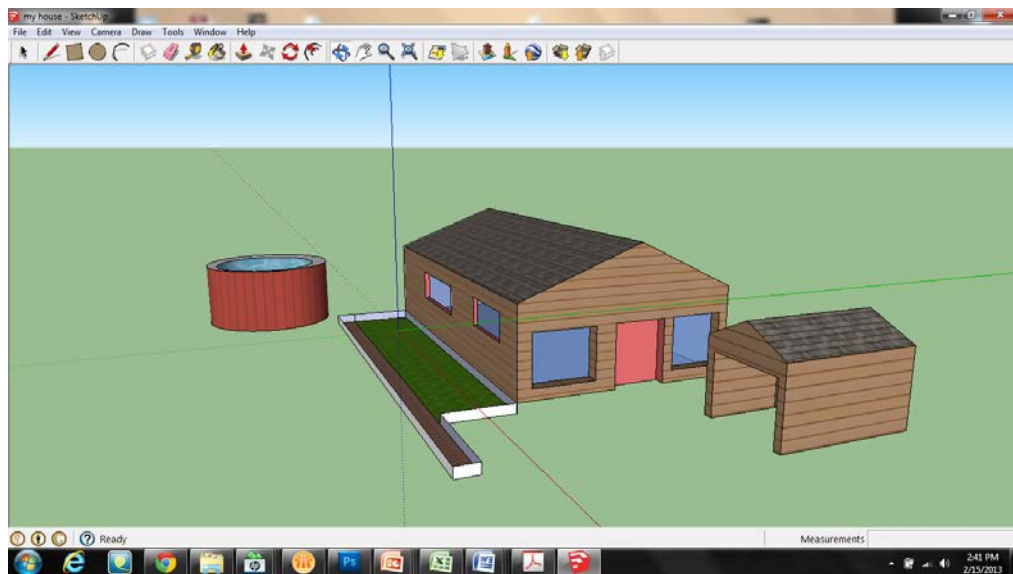
2A. Criteria- What Students Should Know and Be Able to Do:

- Students will be able to design a model of a desalinator (either mini, classroom, or large system) using Google SketchUp.
- Students will be able to describe how their desalinator model works.

2B. Assessment Tools/Evidence:

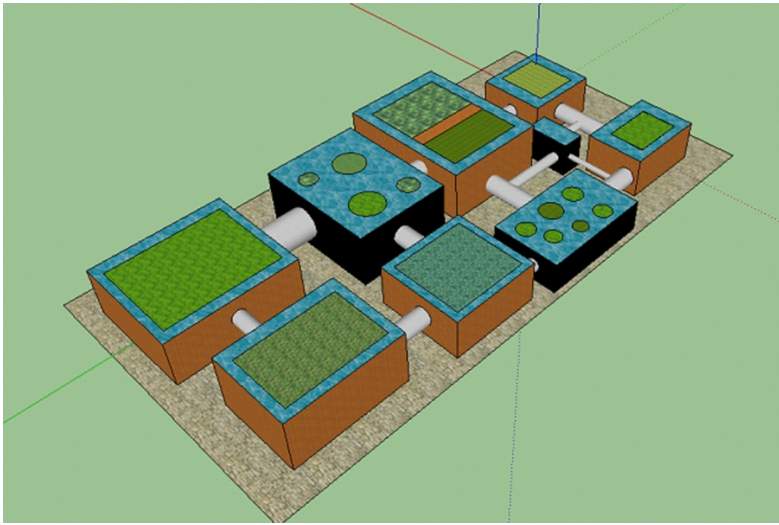
Formative:

- House model on Google SketchUp



Summative:

- Desalinator model on Google SketchUp



- Reflection (Science Journaling in Science Notebook)
Suggestions for Journal Entries:
 - o [CCSS.ELA-Literacy.RST.9-10.1](#) Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
 - o [CCSS.ELA-Literacy.RST.9-10.2](#) Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
 - o [CCSS.ELA-Literacy.RST.9-10.3](#) Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
 - o Explain how your desalination model works. Why did you design it the way you did?

3. Learning Experiences (Lesson Plan)

Materials:

- Access to Google SketchUp (free software can be downloaded at <http://www.sketchup.com/download>)
- Science journals (with finished diagram of desalinator unit)
- Projector

Handouts/Other Resources:

- There are some great Google SketchUp training videos that can be used for teacher background knowledge or shown to students:
<http://www.sketchup.com/intl/en/training/>

Teacher Background Information:

Google SketchUp is a 3D modeling program that can be used for a broad range of applications such as architectural, civil, mechanical, film and video game design. It is available in free and professional versions. Teachers should spend some time familiarizing themselves with the program and the tools (try to create a "house" as this will be the first task you have students do).

Procedure (Day 1):

1. HOOK: Show students some cool Google SketchUp designs in the gallery (these were done by students) on a projector.
<https://picasaweb.google.com/gallery.sketchup/EducationK12>
2. On a teacher computer/projector show students how to open the program and to navigate to the "home page." Show students the toolbar and that when you hover over each icon, it will tell you the name of the icon. Do a quick example of building a house with simple shapes. Show students how to use the different shape tools, the push/pull tool, the move tool and so on.
3. After giving an overview of the program, tell students that their task today is to construct their own model house and practice using the tools. Use whatever procedures you normally use when running a computer activity. The purpose of today is for students to familiarize themselves with the program and tools.
4. Monitor and assist students. If possible, it is nice to showcase student work at the end of the lesson. If you are able to have students save their work to a common folder, then you can project student work for all to see. Another idea is to have a "gallery walk" where all students leave their work open on their computer and walk around to see everyone's work. This is a great time for students to ask each other questions on how they performed certain tasks.

Homework Activity (Optional):

- Tell students that Google SketchUp can be downloaded for free and if they have parental permission, they can do this at home as well. You may want to send home a letter or a link in your weekly/monthly newsletter.

Procedure (Day 2):

1. Tell students that today's task will be to take the design that was created for the engineering a mini desalinator and improve it in Google SketchUp.
2. Show students the criteria/checklist for what it is expected to include.
3. Allow students to work on their models. When they are finished, have them print it out and glue into their science notebooks with the checklist.
4. Have students reflect in their science notebook about what they learned and the process that they went through. Make sure students check the science notebook rubric before submitting work.

Google SketchUp - Desalinator System Checklist

<u>Criteria</u>	<u>Maximum Points</u>	<u>Points Awarded</u>	<u>Comments</u>
Source of saltwater	1 point per grow bed		
Freshwater collection	3		
Piping from saltwater to freshwater	5 (subtract a point for each missing pipe)		
Must include at least 5 details (shading/coloring /texture/etc.)	5		
Followed the diagram in Science Notebook	5		

Additional Comments:

Total: _____/ 20 points

Unit Title: Engineering Desalinators Lesson Title: Scientific Inquiry and Math Practice Extensions Date Developed/Last Revised: 6-24-13 Unit Author(s): Baird Swedman/John Constantinou	Lesson #: 8 Grade Level: 9-12 Primary Content Area: Marine Science/ Secondary Mathematics Time Frame: 1+ class period
--	--

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

- **CTE Standard 1: TECHNOLOGICAL DESIGN:** Design, modify, and apply technology to effectively and efficiently solve problems

2. Learning Experiences (Lesson Plan)

Inquiry Extensions:

In this science project you created desalinators with clear bottoms. What do you think would happen if you changed the color of the bottom of the desalinator to black, or red, or blue? What do you think would happen if you used an aluminum foil reflector? How do you think you could set up such a reflector so that it heats up the water in the device as much as possible?

How does the temperature of saltwater affect the rate of evaporation? You can try this science project again but this time fill one desalination device with ice-cold water and the other with hot water. Is one device much more efficient than the other?

Saltwater has a higher boiling point than freshwater. Does this mean that you would get a higher condensation yield using freshwater than you did using saltwater? To find out, you can try this science project again but this time use saltwater in one desalination device and freshwater in the other. To make sure you are collecting "pure" water, you can add some food coloring to the initial water in each device. Are the condensate yields very different between the two devices? If you try even saltier saltwater than was used in this science project, is there a greater difference? How does the collection rate change during the course of the day? To investigate this, it would be a good idea to have your collection container marked with graduated volumes. That way you can measure collection volumes easily without disturbing the collection system.

Think about scale – All engineering projects begin with a prototype (usually dozens and dozens of prototypes) before they are adapted to serve a larger function. How would you go about adjusting the scale of a desalinator to produce water for an entire village? An entire country?

In what other ways do you think you could change your desalination device to improve its efficiency? Find out what factors affect the rate of evaporation and how other desalination devices are designed. Figure out how you can use this information to modify your device, or design a completely new device, to improve efficiency.



The Water Crisis

A lack of clean water results in poverty, disease and death

Sources: <http://truthaholics.files.wordpress.com/2012/01/water.jpg>

Clean Water is Necessary for Life

- Drinking
- Bathing
- Agriculture
- Sanitation



Sources: http://omiusajpic.org/files/2009/01/need_future14.jpg

<http://assets.inhabitat.com/wp-content/uploads/lifestraw.jpeg>

https://dpqe0zkrio0ak.cloudfront.net/pfil/5671/Clean_drinking_water_blessing_from_GOD_for_them_happy_and_asking_thanks_to_Global_Giving_Grid7.JPG

<https://yadkinriverkeeper.org/sites/default/files/Drinking-Water.jpg>

World Water Gap

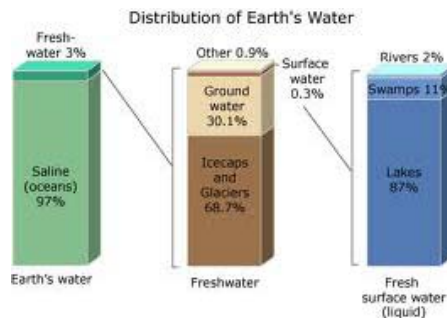
- Despite the apparent abundance of clean water in the US and most of the developed world, more than 20% of the Earth's population lacks clean, safe drinking water.



Sources: <http://www.tribuneindia.com/2004/20040718/pb3.jpg>

How is the World's Water Distributed?

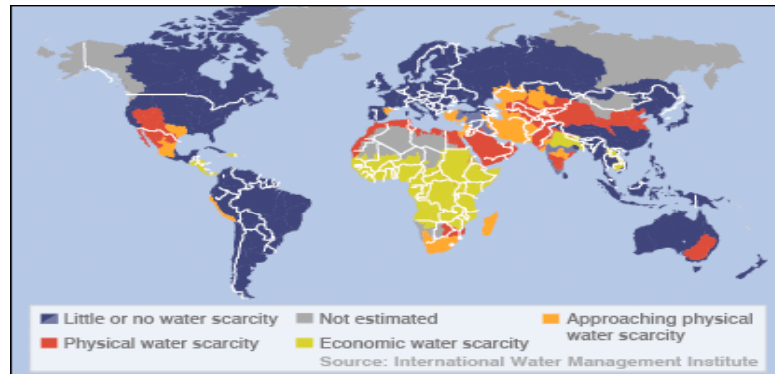
- Less than 3% of Earth's water is fresh water
- The vast majority (97%) is undrinkable salt water in the oceans



Sources: www.globaled.uconn.edu

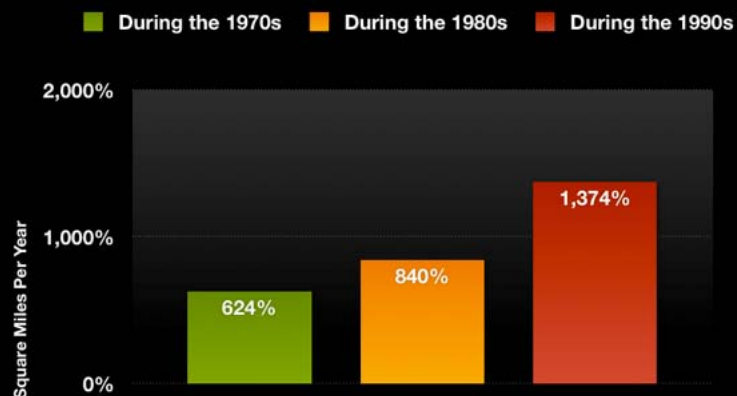
Water is Scarce in Some Regions

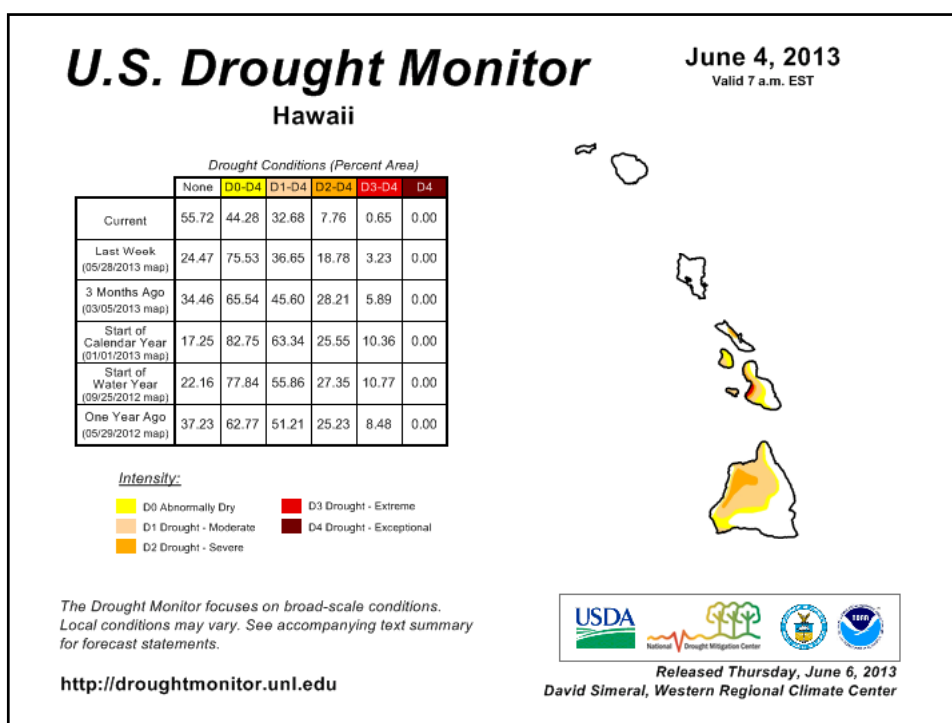
- 2.4 billion people live in highly water-stressed areas



Sources: http://newsimg.bbc.co.uk/media/images/41997000/gif/_41997832_stockholm_water_main.gif

Global Yearly Desertification





No Single Cause for the Water Crisis

- Climate and geography
- Lack of water systems and infrastructure
- Inadequate sanitation
- 2.6 billion people (40% of the world's population) lack access to sanitation systems that separate sewage from drinking water
- Inadequate sanitation and no access to clean water have been highly correlated with disease

Pollution is a Big Problem Too

Types of pollution in fresh water:

- Sewage is the most common
- Pesticides and fertilizers
- Industrial waste dumping
- High levels of arsenic and fluoride



Sources: www.thewaterq.com

http://totallycoolpix.com/wp-content/uploads/2013/20130222_china_water_pollution/china_water_pollution_003.jpg

Impact of Water Scarcity

- Health, education, and economic growth are impacted
- World Water Forum estimates:
 - 1.4 billion people lack clean drinking water
 - 2.3 billion people lack adequate sanitation
 - 7 million people die yearly from diseases linked to water
 - Half the world's rivers and lakes are badly polluted
 - Shortages could create millions of refugees seeking homes in a location accessible to water



•Sources: National Geographic, "The World Water Gap" World Water Forum, The Hague March 17-22, 2000

•http://totallycoolpix.com/wp-content/uploads/2013/20130222_china_water_pollution/china_water_pollution_019.jpg

Impact of Water Scarcity

- **World Health Organization estimates:**
 - 80% of all sickness in the world is attributable to unsafe water and sanitation
 - The leading causes of death in children under 5 are related to unclean water; there are about 5,000 child deaths every day
 - Without action, as many as 135 million people could die from water-related diseases by 2020



Sources: http://sap.einaudi.cornell.edu/sites/sap.einaudi.cornell.edu/files/India-Pollution_1.jpg

How Can We Address the Water Crisis?

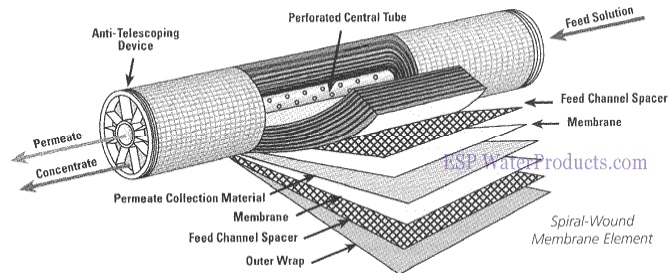
- **Use less water**
 - More efficient irrigation, like drip irrigation
 - Low-flow shower and toilets
 - Use native plants for crops and landscaping
 - Eat less meat
- **Find new sources of clean water**
 - Um... Where? On the moon?
- **Treat the undrinkable water that we have**
 - Use reverse osmosis to desalinate salt (ocean) water
 - Clean polluted water using filters, chemicals, and UV light



Sources: <http://media.treehugger.com/assets/images/2011/10/countries-global-water-crisis.jpg>

Using Filters to Clean Water

- Pebbles, sand, & charcoal filter out large particles
- Membranes filter out smaller particles
- It is efficient to use a series of membranes to filter increasingly smaller particles



Sources: http://esppwaterproducts.com/images/filter-diagrams/diagram_of_Reverse_Osmosis_Membrane.gif