

Where Did the Water Go?

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Introduction

Think globally, act locally. Great saying, and if put into practice, a very powerful agent of change. The question was how to get my students to see their role in the health of the planet when there wasn't an environmental aspect to the 6th grade Delaware state curriculum. Enter the Next Generation Science Standards and the Common Core standards for Math and ELA. Although they differ in suggested content, there is a thread that runs through all three: arguing with evidence.

The Earth Science unit under the current Delaware standards focuses on the Grand Canyon. Through examining the properties of the different rock layers, students are introduced to how weathering, erosion and deposition change the topography of the earth. By reading the fossil record and analyzing the types of rock, students can infer the changes in the prehistoric environment. In addition, plate tectonics and to a lesser extent volcanic activity are explored as the scope is widened from the Grand Canyon to worldwide topography changes. It is a unit of inference and looks at how nature works in the absence of people.

The problem is that people are here and we are making changes to the topography at a much faster rate. One of the things that amazes the students is that the Grand Canyon was carved out by the Colorado River. Two years earlier in fourth grade, they had performed experiments with stream tables investigating mostly erosion and deposition but that was with loose soils, this is with rock. As they watch a video showing white water rafters dwarfed by the canyon walls, they get a hint of the water's power. It saddens me to tell them that the river no longer reaches the Pacific. When I show them the dry cracked earth of where it had been, they always ask, "Where did the water go?"

Rationale

The purpose of this unit is to answer that question "Where did the water go?" and more importantly, what can we do to prevent it happening here in Delaware? To help students see where the water went, we will look broadly at the Colorado River and man's usage of it over the last century. We will see how damming the Colorado changed land use and

allowed the development of areas that had previously been desert to become both residential and agriculture. We will link population growth to water over-usage and examine some of the technological advances to address water shortages.

Demographics

H.B. DuPont Middle School serves approximately 900 students from 2 distinct backgrounds. Roughly 50% of the students come from middle to upper middle class, largely 2 parent families with at least one parent being college educated. The other 50% come from a lower socio-economic background, often single parent, frequently with limited education. Two additional challenges are that a subset of these students have limited English proficiency, and I will also be teaching an inclusion class that may contain students that are severely limited academically. There is also a great disparity between the two groups in both life experiences and access to technology.

For this curriculum unit, I will focus on my 6th grade Science classes. It will be incorporated in the present Earth History unit in connection with looking at the Colorado River, before and after the creation of the Hoover Dam and the resulting changes in water use.

Content

Water Cycle

The water cycle is a complex series of interactions of the land, water and the atmosphere that happens on a global scale. Water is evaporated from the ocean and land surfaces, transported as water vapor in the atmosphere and returns to the ocean and land as precipitation. It is not, however, a circular path. When precipitation falls on land, it takes a variety of paths before ultimately ending up back in the oceans. Depending on the type of precipitation and the topography of the land, the water could flow in runoff returning by a series of smaller waterways, creeks to streams, to rivers, to oceans. It could also infiltrate the soil, to be used by vegetation or percolate further down to become groundwater or even part of a larger aquifer. It could become frozen in polar and glacial ice or spend part of the time as snow in the mountains before a spring thaw returns it to the waterways. In addition, it can be stored and used by humans to meet basic needs and for industrial, agricultural, and recreational activities, its overall composition being changed pre and post human use. Key processes for students to understand include: evaporation, evapotranspiration (tree to atmosphere), condensation, surface runoff, ground water, stream flow, infiltration, percolation, and precipitation. (1)

How a Water Treatment Facility Works

There are five steps: Coagulation, Sedimentation, Filtration, Disinfection and Storage. In coagulation, alum and other chemicals are added to the raw water which causes the smaller bits of dirt to clump together (floc) and settle on the bottom of the tank. In sedimentation as the heavier particles settle, the lighter remaining water can be filtered out. The water passes through filters, some made of layers of sand, gravel, and charcoal that help remove even smaller particles. A small amount of chlorine is added or some other disinfecting method is used to kill any bacteria or microorganisms that may still be in the water. Water is then placed in a closed tank or reservoir in order for disinfection to finish taking place. The water then flows through pipes to homes and businesses in the community. (2)

How Wastewater is Created

Sewage is generated by homes, institutions, businesses and factories. It includes solids and liquids from kitchens, bathrooms, and laundry rooms that empty into sewers. In many areas, sewage also includes liquid waste from industry and commerce. Sewage may include storm water runoff. As rainfall travels over roofs and the ground, it may pick up various contaminants including sediments, fertilizers, oil, grease, animal feces, construction materials, spilled chemicals, and any other materials that are laying on the surface. Leaves and plant materials also find their way into the sewers, especially with a heavy rain. In general, gravity is used to move the debris through pipes before reaching a collection center. At this point, it is passed through a series of screens which remove the bigger pieces before the remaining sewage is treated. (3)

How a Wastewater Treatment Facility Works

Sewage treatment generally involves three stages, called primary, secondary, and tertiary treatment. In the primary stage, heavy solids sink to the bottom while oil, grease, and lighter solids float to the surface of holding tanks. The floating material is skimmed off and the settled materials are also removed. The remaining liquid contains dissolved and suspended biological matter. In the secondary treatment, locally occurring microorganisms are introduced to consume the organic waste. This stage may need a separate process to remove the microorganisms from the treated water before it's discharged or treated further. In the tertiary stage, the liquid may be further treated chemically, physically or with UV light to allow it to be discharged into a sensitive environment or used as irrigation for a non-food source area. There is a growing movement worldwide to further treat the wastewater to make it potable. (3)

Colorado River Usage

As early as 1922, the Colorado Basin States were worried about getting their share of the Colorado River. California, which contributed the least amount of runoff to the river, was making increasing demands to meet its exploding population. In addition, the Federal government had recommended building a dam at or near Boulder Canyon, which would increase California's access to the water. After much contention, a pact was reached whereby the upper basin (Wyoming, Colorado, Utah, and New Mexico) and the lower basin (California, Arizona, and Nevada) would both receive 7.5 million acre-feet per year (MAF). An acre-foot is the volume of water that it takes to cover one acre of land with one foot of water.

The dividing line on the river was set at Lee's Ferry, which is located in Arizona's canyon country near the Utah border. The lower basin states were also allowed to each increase their take by one MAF per year, if need and quantity were present. Taking into account that the river flow changes from year to year depending on snow melts and other factors, the upper basin states were actually obligated to deliver 75 MAF to Lee's Ferry during each ten year period. With an expected flow at the dividing line of 16.4 MAF, it seemed that there would be more than enough to meet the demands of the lower basin and still give water to the Navaho tribe and Mexico. The latter two were not part of the original agreement and seen as having minor claims at best, especially Mexico. Unfortunately, further scientific research, which looked at three centuries of data, revealed the average flow to be 13.5 MAF with a range of 4.4 MAF to over 22 MAF. The stage was set for further conflict.

The upper basin reached an accord in 1948 to allot 51.75% to Colorado, 23% to Utah, 14% to Wyoming, and 11.25% to New Mexico. Percentages were chosen rather than quantity as the upper basin wasn't sure of the amount available. By 1997, none of the upper basin states had used their full allocation of Colorado River water, due to slower growth rates. The lower basin hasn't fared as well.

In the lower basin, the states were not able to reach an agreement, with the dispute between California and Arizona especially contentious. As a result, the Federal government stepped in with usage being a series of ongoing legal battles. Nevada anticipated that its needs would outstrip its share of the river and available groundwater by 2015. Arizona, whose demands were less than its supply, would be using almost its full share through water banking. Hardest hit was California. Located downriver, it had

been diverting unused water earmarked for other states. In 1997, its anticipated use was 5.2 MAF but its allotment was only 4.4 MAF. (4)

Fast forward 15 years. The situation has gotten worse, not better, as states have tapped into ground water supplies to make up for shortfalls from the river due to the recent drought period. Of the 65 cubic kilometers of fresh water lost, three fourths of it has come from groundwater. Unlike reservoirs that can be replenished with increased precipitation, recovering in as little as a year or two under the right conditions, it can take hundreds of years to refill groundwater basins. It isn't that water conservation hasn't been important but rather that demand continues to outstrip supply.

About two thirds of the water flowing in the Colorado River and its tributaries is used for irrigation of crops; with the remaining third supplying urban areas, evaporating into the atmosphere, or providing water to stream-side vegetation. A series of canals carries the water even beyond the basin, supplying such diverse areas as Denver, metropolitan Los Angeles, and the Phoenix and Tucson areas. The All-American Canal provides water for the Imperial Valley of southern California, formerly desert and now the major agricultural region of the state. Without the water from the river, the area would have few crops and major cities such as Las Vegas, Nevada and Phoenix, Arizona would not have grown to their current sizes.

To better use the water, numerous dams have been built on the Colorado and its tributaries. The dams provide electricity, control floods, provide recreational and economic opportunities, and store water. The two largest, Hoover Dam, completed in 1936 on the Nevada/Arizona border (Lake Mead,) and Glen Canyon Dam, north central Arizona, (Lake Powell,) created in 1964, provide about 80% of the water storage capacity. The Morelos Diversion Dam, located on the Mexico-Arizona Border, is the southernmost dam on the Colorado River and the reason the river no longer reaches the Gulf of California, instead ending up as dry cracked earth near what was originally its mouth. (5)

The lower basin has been extremely aggressive in trying to reduce demand through technology and changes in public thinking, providing indoor water use auditing and retrofit kits to help older plumbing fixtures use water more efficiently. In addition, there is a move to xeriscaping (using native plants that require less water) and bans on excess watering. Individuals and companies are rewarded financially for decreased water usage with water-efficient fixtures and appliances earning rebates. Rainwater and gray water usage have both increased with California's Orange County having a wastewater treatment plant that recycles used water and returns it to the drinking supply at a rate of 100 million gallons per day. (3)

If people both as individuals and as corporations are doing a much better job of conserving and reusing water, then why is there a shortage? The answer is increased population. One hundred million gallons of reclaimed water sounds like a lot and is enough to meet the daily needs of 850,000 people. The problem is that the population of Orange County was 3.11 million as of 2013. (3) The figures are equally disheartening when comparing the population numbers of the seven states from 1920 to 2010 (most current census year). In 1920, population estimates for the 4 states that comprise the upper basin (Wyoming, Colorado, Utah and New Mexico) totaled was just under two million at 1,950,000. Total population estimates for the 3 lower basin states (Arizona, California, and Nevada) were almost double that at 3,972,000. Less than a hundred years later, the upper basin is supporting a combined population of 12,600,000. The situation is even worse for the lower basin states. The 2010 census puts the combined population at nearly 50,000,000 with California alone almost being 40 million. (6) Despite the recent drought that started in 2000, the area continues to grow in population at an alarming rate. In the period 2000-2010, the population of Nevada increased by more than 25%, with gains in the populations of Utah, Arizona and Colorado all being in the 15-25% range. Even the modest increases of 5-15% for California, New Mexico and Wyoming don't seem so modest in the face of the current drought. (6)

For the first time, since its creation, Lake Mead will receive less water from Lake Powell, 180 miles upstream. Lake Mead, in addition to serving as a crucial source of water for cities from Las Vegas to Los Angeles and for millions of acres of farmland, also serves as a water source for states downstream.

Lake Mead currently stands about 1,106 feet above sea level, and is expected to drop 20 feet in 2014. A continued decline would introduce a new set of problems: At 1,075 feet, rationing begins; at 1,050 feet, a more drastic rationing regime kicks in, and the uppermost water intake for Las Vegas shuts down. At 1,025 feet, rationing grows more draconian; at 1,000 feet, a second Las Vegas intake runs dry. (7)

“If Lake Mead goes below elevation 1,000” — 1,000 feet above sea level — “we lose any capacity to pump water to serve the municipal needs of seven in 10 people in the state of Nevada,” said John Entsminger, the senior deputy general manager of the Southern Nevada Water Authority. (7)

Lake Powell is another story. There, a 100-foot drop would shut down generators that supply enough electricity to power 350,000 homes.

The federal Bureau of Reclamation's 24-month forecasts of water levels at Powell and Mead do not contemplate such steep declines. But neither did they foresee the current

drought. “We can’t depend on history to project the future anymore,” Carly Jerla, a geological hydrologist and the reclamation bureau’s Colorado River expert, said in an interview. (7)

If we can’t depend on history to project the future, then where does that leave us in regard to managing our natural resources, especially fresh water? At the time of its creation, the Colorado River Authority made what was considered sound planning. Looking back, there were two areas of misinformation; the amount of available water was overestimated and the amount needed, through increased population and agricultural use, was underestimated, leading to the present drought conditions.

Where does that leave Delaware? As part of the Delaware River Basin, are we at the same risk?

Delaware’s Water Situation

Although Delaware’s overall population growth rate is considerably less for the same time period, there have been pockets of extreme growth in the state over the last 10 years. The 2010 census shows Delaware having a population of approximately 900,000 having experienced a growth rate of 5-15% in New Castle County, with more than a 25% increase in Kent and Sussex counties from 2000-2010. (6).

Delaware is also not immune to drought as the weather records show. It is the combination of the two which could cause problems for Delawareans. From a precipitation point, the drought of 1999 was less severe than that of 1964, but because of the increased population and greater demands, it had a bigger impact. (8)

Northern Delaware mainly receives its potable water from three providers: City of Wilmington, United Water, and Artesian Water. The first two focus on surface water, drawing from the Brandywine and Red and White Clay Creeks, with the latter using underground aquifers as the principal source in addition to the Christina River.

Drought Conditions in Delaware

When my students consider the immense agricultural areas irrigated by the Colorado, and the enormous number of people who rely on it for their fresh water, it is easy for them to understand why water conservation is so crucial in that area. It is actually harder for them to grasp the need to conserve in their own back yards. Although Delaware ranks 16th in precipitation with an annual average of 45.68 inches, it is not immune to droughts. There

have been several noteworthy within the last century. The first was from 1930 through 1934. A severely below average rainfall of 28.29 inches in 1930 failed to replenish local streams and the groundwater. By the end of that summer, officials had already put into place relief measures. Drought conditions would persist through 1934, resulting in low streamflow and decreased crop yields. Economic losses probably were greater than those sustained during any previous drought, as use and demand for water had increased considerably by the early 1930's. Since then, there have been 5 major drought periods in Delaware: 1953-57, 1961-71, 1979-83, 1984-88, and most recently, 1999. (8)

Drought can be defined as an extended period of time without sufficient precipitation. Yet even that definition is only partially correct as it doesn't take into account the needs of different consumers. It isn't the amount of precipitation that matters as much as whether there has been enough to recharge the system so that input matches output demands. Hydrologic drought can be defined as a period during which stream-flow is inadequate to supply established uses under a given water-management system. (9) During drought, stream-flow is affected by several factors in addition to the lack of precipitation. The most important of these are first, quantity of water in storage as surface water, groundwater, and soil moisture; secondly, rates of evaporation and transpiration; and lastly, rates of withdrawal. (9)

The drought of 1999 affected the three counties differently. Kent and Sussex suffered the most agricultural losses, losing 50% of the corn crop and 30% of the soybean crop due to the severe heat. There was never any danger of running out of water because of a substantial surplus of ground water for drinking and some irrigation. New Castle County was a different story, especially the northern end. After Pennsylvania declared a state of emergency, the 5 million gallons a day Delaware purchases from Chester, was severely reduced. Add to that dropping river levels and lack of water to recharge the underground water and other parts of the county found themselves affected by both a lack of water and a lack of quality water, due to salt encroachment.

The City of Wilmington made out the best because it wasn't limited to the amount of water it could pump from the Brandywine Creek. Both United Water and the City of Newark have limits based on stream flow. In addition, it had adequate stored water in Hoopes Reservoir. (10)

Our focus will be on the City of Wilmington's water management system. Although there have been greater increases in population in the lower two counties, the municipal water system is most applicable to my current group of students.

Curriculum

As a science teacher, my focus will be on connecting stream flow to personal water usage (withdrawal). We will move from watersheds to water treatment centers to monitoring and modifying our class water footprint. We will compare and contrast water and waste treatment centers and debate the merits of water recycling to reduce our withdrawal rate. We will look at land use from both a water demand and a water filtration standpoint.

Topic: *Colorado River*

Vocabulary: *source, mouth, irrigation, reservoir, dam*

The unit will start with a brief history of the Colorado River from the creation of Hoover Dam through the development of the Imperial Irrigation District. National Geographic has a short but powerful web video that includes actual historical photographs. (11) To help students understand the importance of fresh water, I'll model the relative scarcity of it on earth. As I move from a gallon jug which represents all the water on the planet down to a little more than an ounce, which represents the less than 1% of fresh water that is potable, I'll have students follow along, coloring in the percentages on a 10 by 10 grid. The activity will leave them with a visual reminder and reinforce the work they've done in math on decimals, fractions and percentages.

Topic: *Northern Delaware Water Sources*

Vocabulary: *potable, aquifer, ground water*

Next, our focus moves to water usage in our own backyard. We'll look at the three major potable water suppliers for our area and the sources of water from which they draw. Students will investigate watersheds to see that we all live downstream.

Topic: *What is a Watershed?*

Vocabulary: *tributary, transpiration, evaporation, condensation, participation, runoff*

To demonstrate the interconnectedness of fresh water sources, students will investigate what a watershed is. We'll start with a map of the Delaware watersheds (12), and then focus on the northern part of the state. Using geographical maps and clear plastic overlays, students will trace the various bodies of water, starting in southeastern Pennsylvania so they can see that water is not a single state issue. This will be followed

up by a review of the water cycle. In elementary school, they were presented with a simplified version that focuses on evaporation, condensation and precipitation. We'll be adding transpiration, ground water, and runoff to give a more accurate picture.

Topic: *Water Cycle*

Vocabulary: *point of view, personification, fantasy*

To reinforce both vocabulary and the concept that the water cycle is a closed system rather than a circular loop, students will perform the activity of tracing the path of a drop of water. Starting at pre-assigned stations, students follow different sets of directions that have them moving through the water cycle, recording each stage of their trip. When I've done this activity with younger students, depending on the paper they draw, they could be in the ocean, a lake, a river, a cloud, frozen as snow, being consumed by an animal, floating as mist, or held underground. For this age group, I would add house, reservoir, waste treatment facility, and water treatment facility. At the end of 10 stops, they will have the opportunity to show their individual journeys through words and/or pictures. To accommodate diverse learners, each slip will have a picture to accompany the text. Some students will then have the accommodation of using similar pictures for their story telling.

To encourage creativity, we'll look at the example from the Delaware Nature Society's web page of an anthropomorphized story of a drop of water from the Brandywine River through the water treatment plant to Rockford tower before ending up in a cup of tea. (13) From a language arts lens, this refers back to point of view, studied earlier in the year.

Topic: *What happens at a water treatment facility?*

Vocabulary: *coagulation, sedimentation, filtration, disinfecting, microorganism*

We'll take a closer look at Hoopes Reservoir (14), which isn't too far from our school, keeping local interest. Many of my students struggle with reading, but the selected article has strong picture support with much of the text chunked as captions. To align with ELA Common Core, students will work in pairs to answer text-based questions. Next, we'll investigate how water from reservoirs (and their river tributaries) are cleaned, using material taken from the Environmental Protection Agency's (EPA) downloadable activity book. (15) Most of the publication is geared to a younger audience, but it does include a very clear description of a water treatment plant.

Topic: *Engineering Solutions*

Vocabulary: *turbidity, dissolved oxygen, clumping, dilute*

Engineering solutions is a key component of the Next Generation Science Standards. Building on their previous experiences in the second grade Soils curriculum and the 4th grade Land and Water, students will design a filtration tank of their own. Having gained some background knowledge on the water treatment process, they will have the challenge of cleaning a sample of water from a local source. This will be a multiple day lesson as we first do some simple water quality tests, including checking turbidity, pH level, and dissolved oxygen. We'll also look at the sample under a microscope to check for living organisms. I will demonstrate the use of alum as a clumping agent and also very dilute chlorine as a disinfectant. Lab safety rules, including the use of eye protection, will be reviewed with students being reminded that no matter how clear their end product may look, it is not safe to drink.

Students will have the opportunity to try out the filtering properties of mesh screen, coffee filters, clay, gravel, sand, and aquarium charcoal. Based on their initial findings, they will design and create a filtration tank, using clear plastic containers, some of which have been drilled and cork stoppered. Student success will be judged on three criteria: The amount of water processed in 15 minutes, the quality of the end product, and the cost. Students may choose not to use the alum or chlorine to save money but omitting them may cause either a drop in quantity or in quality. Students will record their solutions.

Following their explorations, we will watch the Magic School House's *At the Waterworks* video (16) with students using the graphic organizer of a Venn diagram to compare their solution with the video. The video is borderline young for 6th graders, but I feel that the simpler language and comic nature are more accessible than footage of actual water treatment plants.

Topic: *Using Water Wisely*

Vocabulary: *conservation, water footprint (15)*

At this point, the focus shifts to the human impact on the environment and its resources. The average American family of four uses approximately 400 gallons of water each day between bathing, cooking, dishwashing, teeth brushing, and using the bathroom. Students will be given a list of activities and asked to put a check mark next to an activity each time it is done by any member of the family. They will also be asked to make a prediction about their own water usage. To increase its validity, the survey will include both a school day and a weekend day. Students will then convert the tally marks to gallons of water used by multiplying them by the corresponding activity value, with the total then being divided by 2. To get students to think critically, we'll discuss if our data is truly

representative. Some students may argue that it isn't valid because there are only 2 weekend days but 5 school days and so the total should be lower. The counter argument is that in the summer, there are no school days. Since controlling variables has been discussed in setting up previous investigations, I would like the students to consider what other factors could affect water use. Hopefully the list they generate will serve as the lead in to both technological solutions (like low flow shower heads and more water efficient appliances) and to changes in behavior (showers instead of baths, turning the faucet off during teeth brushing). Since we've previously discussed the value of increasing sample size to minimize individual differences, we'll pool our data to create a profile of "the average household". This allows the focus to switch to an everyman problem rather than the differences between my students who live in one bathroom apartments with no washer or dishwasher and my students living in sprawling 3 bathroom homes with Jacuzzi tubs and manicured lawns.

My initial thought was to have students go online to investigate what is considered best practices for water conservation in the home, but I discarded that idea. Access to the computer labs is limited and the laptops often run slower because of the wireless connections. Having them do it outside school was rejected because more than half don't have a computer at home or reliable transportation to get them to a library. Instead, the plan is to bring in a guest speaker from either United Water or Artesian Water. Both do educational outreach and both will bring samples of water-saving devices. As I was doing my research, I discovered that both company websites linked to the same EPA water conservation activity page. The EPA site even offers a Pac Man style game for students to test their water knowledge. I decided not to include it when I lost all three of my water wise men before answering any of the quiz questions. The site also includes some curriculum plans and worksheets that I rejected as being both too juvenile and too dependent on home involvement. Instead of having the students play their game, my thought is to have them create one of their own as one of the choices for a culminating activity, along with a print, video, or radio ad for conservation.

Topic: *After the drain, where does it go?*

Vocabulary: *penetrate, aquifer, sewer*

Students will investigate what happens to water after it has been used. We will look at how daily activities affect the water that goes to our sewers and penetrates our ground, at times seeping into our ground water. We will make a local connection by reading an article that reports on how solvents from a former Hockessin dry cleaning business have turned up in samples of well water. (17)

Topic: *Looking at Land Use*

Vocabulary: *hardscaping, erosion, rain gardens*

Using a stream table model, students will investigate how different types of land use contribute to water pollution from runoff. Students naively believe that all farms are good, all factories are bad and buildings like homes, offices, and schools are neutral. We will consider hardscaping, landscaping, and farming methods, building on the work done two years prior comparing erosion on bare earth with planted grass. Students will design a model community, incorporating green space, rain gardens, housing, schools, and businesses. We will look at what the City of Wilmington is doing to protect the quality of water before it enters the water treatment plants. (18)

Topic: *What happens at a wastewater treatment plant?*

Vocabulary: *tertiary, wastewater, micro-organisms, gray water*

Through research, students will discover what happens in a wastewater treatment plant and make comparisons between treating surface water (19) and wastewater (3). Students will debate the merits of turning wastewater into potable water, which will meet both the science standards of arguing with evidence and the common core standards for persuasive writing/oral language and using non-fiction.

Essential Questions/Outcomes

At the end of this unit, students will be able to answer the following questions:

- Why is it important to conserve water?
- How do people affect the water, which through precipitation, ends up on land?
- What are some ways that people can lower their water usage?
- How does land use affect water quality?

At the end of this unit, students will be able to:

- Describe the key parts of the water cycle including evaporation, evapotranspiration (tree to atmosphere,) condensation, surface runoff, ground water, stream flow, infiltration, percolation, and precipitation.
- Engineer a working model of a water treatment facility.
- Design a blue print for a community taking into account green space and runoff.
- Compare/Contrast a water treatment plant with a wastewater treatment plant.
- Debate the merits of turning wastewater into potable water.

Strategies

This unit utilizes a variety of instructional methods and strategies.

To address different learning styles, content is presented through text, models, video, diagrams, pictures, and a guest speaker. Most work is collaborative but students are given individual think time.

Learning is inquiry-based with students monitoring their own water use, creating their own water treatment models, and planning the land use of a community.

Assessment is ongoing and student-driven, as both formative and summative assessments have a student choice component. In describing the journey of a drop of water, students can do it from the third person (factual) or from the first person (fantasy). To share what they learned about water conservation, they can create posters, a learning game, or public service messages in either radio or video format. In presenting their arguments regarding turning wastewater into potable water, they can do it orally (through debate), or written (persuasive essay).

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"State of Delaware - Search and Services/Information". Delaware Department of Transportation. Accessed December 7, 2014. <http://www.deldot.gov/stormwater/watershed.shtml>. Color-coded watershed map of Delaware.

"Study: Colorado River Basin Drying up Faster than Previously Thought". Washington Post. Accessed December 8, 2014. <http://www.washingtonpost.com/blogs/govbeat/wp/2014/07/24/study-colorado-river-basin-drying-up-faster-than-previously-thought/>. Current article on water levels and threat to groundwater supplies 2014, excellent land use map.

"Tainted Hockessin water under scrutiny". Accessed January 11, 2015. <http://www.delawareonline.com/story/news/local/2014/10/19/hockessin-groundwater-contamination-scrutiny/17580025/>. Article on the dry cleaning chemicals found in Hockessin well water.

"Thirstin's Wacky Water Adventure". Accessed December 7, 2014. https://www.unitedwater.com/uploadedFiles/Corporate_Content/30/Thirstin-wacky_water_adventure.pdf. Excellent simple diagram of a wastewater treatment plant.

"Water Cycle - NASA Science". Water Cycle - NASA Science. Accessed December 8, 2014. <http://science.nasa.gov/earth-science/oceanography/ocean-earth-system/ocean-water-cycle/>. Science background on water cycle.

"Water Encyclopedia". Colorado River Basin. Accessed December 8, 2014. <http://www.waterencyclopedia.com/Ce-Cr/Colorado-River-Basin.html>. Information on the different dams on the Colorado River.

"The WaterSense Kids". Accessed January 11, 2015. <http://www.epa.gov/watersense/kids/index.html>. Information geared to upper elementary age students on water treatment, calculating water use footprint and ways to reduce water usage.

"Water Use in the United States". USGS. Accessed December 7, 2014. <http://water.usgs.gov/watuse/>. Excellent resource of current water usage in the country - most recent data and analysis from 2010 to be available late 2014.

“Wilmington’s Edgar Hoopes Reservoir”. Accessed December 8, 2014.
<http://www.ci.wilmington.de.us/docs/116/CoW-2005WaterQualityReport.pdf>.

Appendix

Next Generation Science Standards Addressed

MS-ESS2-4

Develop a model to describe the cycling of water through Earth’s systems driven by energy from the sun and the force of gravity.

MS-ESS3-3

Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

MS-ESS3-4

Construct an argument, supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems.

Common Core Standards Addressed

CCSS.ELA-Literacy.RST.6-8.1

Cite specific textual evidence to support analysis of science and technical texts.

CCSS.ELA-Literacy.RST.6-8.2

Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

CCSS.ELA-Literacy.RST.6-8.3

Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

CCSS.ELA-Literacy.RST.6-8.4

Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

CCSS.ELA-Literacy.RST.6-8.5

Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.

CCSS.ELA-Literacy.RST.6-8.6

Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

CCSS.ELA-Literacy.RST.6-8.7

Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

CCSS.ELA-Literacy.WHST.6-8.2

Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

CCSS.ELA-Literacy.W.6.2.d

Use precise language and domain-specific vocabulary to inform about or explain the topic.

CCSS.ELA-Literacy.W.6.3

Write narratives to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences.

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- (1) "Water Cycle - NASA Science.", last modified April 15, 2010,
<http://science.nasa.gov/earth-science/oceanography/ocean-earth-system/ocean-water-cycle/>
 - (2) "Thirstin's Wacky Water Adventure", last modified June 27, 2012,
https://www.unitedwater.com/uploadedFiles/Corporate_Content/30/Thirstin-wacky_water_adventure.pdf
 - (3) "From Toilet to Tap Water", last modified May 1, 2014,
<http://www.cnn.com/2014/05/01/world/from-toilet-to-tap-water/index.htm>
 - (4) *ibid*
 - (5) "Population Estimates", last modified December 8, 2011,
http://www.census.gov/popest/data/state/asrh/1980s/80s_st_totals.html
 - (6) "2010 Census Data", last modified October 30, 2014,
<http://www.census.gov/2010census/data/>
 - (7) "Colorado River Drought Forces a Painful Reckoning for States", last modified January 6, 2014,
<http://www.nytimes.com/2014/01/06/us/colorado-river-drought-forces-a-painful-reckoning-for-states.html? r=0>

- (8) "Delaware Annual Rainfall and Climate Data", last modified December 8, 2014, <http://coolweather.net/staterainfall/delaware.htm>
- (9) "Seasonal Streamflow Conditions and Historic Droughts in Delaware", last modified January 25, 2013, http://md.water.usgs.gov/drought/drought_de.html. *Drought conditions in Delaware from 1984-1999*.
- (10) "The Drought of 1999", accessed December 8, 2014, <http://www.dnrec.state.de.us/water2000/Sections/WatSupp/Library/Drought1999.pdf>
- (11) "The American Nile", accessed December 7, 2014, <http://www.nationalgeographic.com/americanile/#part01>
- (12) "Study: Colorado River Basin Drying up Faster than Previously Thought", last modified July 24, 2014, <http://www.washingtonpost.com/blogs/govbeat/wp/2014/07/24/study-colorado-river-basin-drying-up-faster-than-previously-thought/>
- (13) "The Nature of Delaware", last modified April 13, 2012, <http://blog.delawarenaaturesociety.org/tag/hoopes-reservoir/>
- (14) "The Edgar M. Hoopes Reservoir", last modified March 28, 2008, <http://archive.delawareonline.com/assets/pdf/BL104215327.PDF>
- (15) "The WaterSense Kids", accessed January 11, 2015, <http://www.epa.gov/watersense/kids/index.html>
- (16) *The Magic School Bus at the Waterworks*, DVD (Sundance Publishers & Distributors, Northborough, MA, 1992)
- (17) "Tainted Hockessin water under scrutiny", last modified October 19, 2014, <http://www.delawareonline.com/story/news/local/2014/10/19/hockessin-groundwater-contamination-scrutiny/17580025/>
- (18) "City of Wilmington Source Water Protection Plan", last modified November 28, 2010, http://www.ci.wilmington.de.us/docs/331/Wilmington-Source-Water-Protection-Plan_Part1.pdf
- (19) Cole, Joanna, and Bruce Degen. *The Magic School Bus at the Waterworks*. New York: Scholastic, 1986

Curriculum Unit Title

Where Did The Water Go?

Author

Terri Eros

KEY LEARNING, ENDURING UNDERSTANDING, ETC.

Water cycles through Earth's systems driven by energy from the sun and the force of gravity. Humans impact Earth's Natural Processes. There is a limited amount of potable water on the planet.

ESSENTIAL QUESTION(S) for the UNIT

Why is it important to conserve water? How do people affect the water, which through precipitation, ends up on land?
How does land use affect water quantity and quality?

CONCEPT A

Water cycles through Earth's systems.

CONCEPT B

Humans impact Earth's natural processes.

CONCEPT C

Everyone lives downstream.

ESSENTIAL QUESTIONS A

How does water move throughout Earth's systems?

ESSENTIAL QUESTIONS B

Why is it important to conserve water? How can we minimize our water usage?

ESSENTIAL QUESTIONS C

What affect does land use have on water quality?

VOCABULARY A

Hydrological cycle, : evaporation, evapotranspiration (tree to atmosphere), condensation, surface runoff, ground water, stream flow, infiltration, percolation, and precipitation.

VOCABULARY A

Flow rate, conserve,

VOCABULARY A

Hardscaping, permeable, fertilizers, pesticides,

<http://science.nasa.gov/earth-science/oceanography/ocean-earth-system/ocean-water-cycle/>

https://www.unitedwater.com/uploadedFiles/Corporate_Content/30/Thirstin-wacky_water_adventure.pdf

<http://www.cnn.com/2014/05/01/world/from-toilet-to-tap-water/index.htm>

<http://www.epa.gov/watersense/kids/index.html>

The Magic School Bus at the Waterworks, DVD (Sundance Publishers & Distributors)

<http://www.delawareonline.com/story/news/local/2014/10/19/hockessin-groundwater-contamination-scrutiny/17580025/>