

Clean Air and Water

Navajo Nation: Water for Life in the Southwest

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Introduction

I was raised in an isolated area in rural Kansas. It was so quiet that you could hear ringing in your ears from the silence. The only people I have ever mentioned this to that recognized that level of quietness in nature were Navajo people that had been raised on the Navajo Reservation. My parents were glad to have seven children. We lived in a house much too small for our family. There was not enough space to stand up to leave the kitchen table after we sat down to eat until everyone finished their food. The kids closest to the next room stood up first so those of us pinned in by the table could push it outward and get out as well. We raised our own food. We had fruit trees and a huge garden, so we always had enough to eat.

We lived across a dirt road from the railroad tracks. The train would pass by once and on occasion twice a day. It was a great adventure to run along the road as the train went by and wave to the men in the caboose who would watch for us every day and wave back. My family was poor, and we had few toys other than sticks and clay that we formed into pottery shapes and paper that we drew on. I owned a doll once. My brother had a bicycle. My mother made our clothes. We spent a lot of time exploring the outdoors and inventing activities. We were happy, and it didn't occur to me until years later how poor our family had been. This state of satisfaction existed because all of those experiences were rich, full and supported by loving family. I learned our family's value system by listening to their words and by watching their living example.

There was a dry sort of gully behind our house. It was small because it seldom rained in west central Kansas. My father worried about rain and worked to protect our subsistence crops from early frosts, because without them it was uncertain how we would eat. The memories of those rich, fine growing up years have stayed with me always and have shaped and formed who I am even today. This is the case, even as it is for many young people, past and present, who have experienced childhood growing up on the Navajo Nation.

Context

Flagstaff, Arizona, lies in Coconino County just south of Arizona's San Francisco Peaks. These peaks are held sacred by several Native American tribes, including the Navajo Nation (Sacred Land Film Project, 2009). These are the tallest mountains in the state, the tallest cresting at 12,633 feet. The city lies on the Colorado Plateau. Flagstaff is a small, friendly city with a population of 74,000 people, 5,500 of whom are of Navajo ancestry ("Flagstaff Diversity," 2019). It is one of the fastest growing cities in the United States with a 25% growth occurring between 2000 to 2010, mainly due to the growth of Northern Arizona University ("Flagstaff Population Growth," 2019.) Flagstaff is surrounded by Ponderosa Pine forest and is generally considered a desirable place to live. The high school graduation rate is highest for whites at 97.5% followed by Native Americans at 89.2% and then Hispanics at 77.9%. ("Flagstaff Educational Attainment by Race," 2019) Efforts have been made by Flagstaff Unified School District to effect higher graduation rates for both Native American and Hispanic students. They have placed Native American counselors in many of the schools, even if only for a few days a week. Flagstaff's cost of living is 15% higher than the national average, and its housing cost of living is 42.5% higher than the national average. ("Flagstaff Cost of Living," 2019) However, the

average salary for a high school graduate is only \$26,389 (“Flagstaff Earnings by Educational Attainment,” 2019), so that numerous low-income families must hold two or more jobs to survive economically.

I work at a low-income, Title I school within the city limits of Flagstaff. I teach both 5th grade and Structured English Immersion in the same classroom together. Marshall Elementary School is an FUSD public magnet school with an emphasis on arts and science. It is known for its diverse student population. In 2017, the enrollment reflected this diversity. The student make-up was 211 white, 202 Hispanic and 92 Native American students. The rest of the population were varied ethnicities (Eva Marshall Elementary School,” 2018). Marshall Elementary is located in a low-income housing area. A number of students go home each evening to an empty house. Some are expected to babysit siblings until their parent or parents come home from work. For some, their parents have a high school education or less and either both parents work or there is a single parent who works more than one job. According to the Arizona Department of Education, the total number of students at Marshall Elementary with chronic absenteeism in 2016 was 168 (“Civil Rights Data Collection Reporting,” n.d.). I work to encourage parents to keep in communication with the school. I sometimes do home visits to connect with the families, and I frequently refer students’ families to various government or non-profit organizations so they can obtain basic resources such as food or clothing. Students often come into my classroom educationally behind.

Marshall Elementary has a school grade of C as assigned by the Department of Education (“State Accountability A-F Letter Grades,” n.d.). AZ Merit English Language Arts testing for the school resulted in 47% of the entire student body being minimally proficient or not passing, and 15% were highly proficient. Breaking this down further, 69% of our Native American student population was minimally proficient (not passing) in 2018 and 0% were highly proficient (excelling). In math, the entire student body tested 39% minimally proficient and 13% highly proficient, while the Native American population was 47% minimally proficient, and 6% were highly proficient. Our Structured English Immersion students have even lower passing rates (“Student Achievement in State Academic Assessment Detailed Results” 2018). Since I have a highly integrated classroom, I must use highly engaging, experiential and real-life materials when I teach.

Rationale

There are a number of factors that could affect the water availability and quality on the Navajo Nation, but one well known component is the mining of uranium and other materials. This curriculum is designed to examine those everyday water issues, including those caused by mining, that are daily affecting the living conditions of Navajo children. Its intent is to help them understand water information in a connected way by providing the parts needed for understanding the whole.

In a low-income school where students need high interest materials in order to fully engage in learning, using cultural information that students recognize and that is treated with respect gives them an advantage in the ability to share, guide and lead discussions. They become an authority

whose input is needed by the entire class. At the same time that Navajo students are the specialists, second language students, generally Hispanic, in the same classroom, have strong connections through personal experiences to conditions similar to those on the Navajo Nation. Students who visit rural areas of Mexico to spend time with their relatives always seem to have information to add about similarities between information the Native American students share with the class and their own cultural experiences. This often includes raising their own livestock and processing the meat themselves as well having a scarcity of water availability in their communities. This desire to communicate similar information to their peers gives the Hispanic students the opportunity to practice their speaking and listening skills and build their fluency in the English language. During the school year, I often share some words of Spanish or some other languages, such as Navajo with the entire class and it raises their interest and curiosity. Having Navajo students help their classmates pronounce Diné Bizaad words related to water and help their classmates interpret them will instill confidence and provide the classroom with an atmosphere of cooperative teamwork. The identification of objects in male and female terms is common in Diné culture and also in the Hispanic culture. This idea is present in the Spanish language. This is another connection that the students can share.

The Arizona Department of Education has introduced its new History and Social Science Standards 2018. Fifth grade teachers are now charged with helping students to explain how events of the past affect the students' lives today. This unit on water includes historic information about both the Diné and the United States governments, which will enable making connections between the past and present for many Navajo students as well as other affected students living on the edge of the Navajo Reservation. The new standards require that diversity of groups and differing perspectives be included in lessons. The concept of self-determination for Native American as sovereigns versus the historic view held by the United States government that tribes were wards to be managed is a good example of differing perspectives. The curriculum also shows how those differing perspectives are beginning to be resolved in some areas, such as within the EPA with the Treatment as States policy. ["Treatment as a State (TAS)," 2018]. Students can learn that change takes time, but with increased social awareness and input by groups that all government decisions continue to change over time. Another standard addressing civic duty indicates students should learn to take part in the process to influence change. This will be accomplished by the students working to come up with possible and workable solutions to provide clean water to residents of the Navajo Nation. Geology and map reading are also important standards that give students a sense of place within themselves and location between landmarks or areas. Students will be working with maps of hydrologic information to build models. Using maps and understanding their interpretations, are key components of this curriculum.

This curriculum covers a number of Fifth Grade Life Science standards from Arizona State Science Standards 2018. Students will be learning how both naturally present minerals and non-natural human activities such as uranium mining have caused changes to habitats on Navajo Nation land, (Hoover, Gonzales, Shuey, Barney & Lewis, 2017) and have affected water for Navajo people. They will understand what the consequences of changed habitats via increased uranium and arsenic contamination in the water have been on living organisms, including death,

diabetes, liver and kidney disease, changed genetics, cancer and autoimmune deficiencies (Hoover, Gonzales, Shuey, Barney & Lewis, 2017).

The engineering and technologies focus of science is a good fit for students building models of a three-layer stacked aquifer system. Students who are working to produce possible solutions to these water problems will be working with engineering and technology as well. Appendix 4 of the new Arizona Science Standards specifically states that for indigenous students, the learning should be land and place-based with cultural connections. Meeting those requirements strengthens student learning.

It will be necessary to use math skills when looking at tables of numbers to determine how levels of contaminants in actual Navajo Nation water samples compare to the standards listed by the EPA to be safe for human consumption. This mathematical analysis will encourage critical thinking skills and analysis similar to putting a puzzle together. The Environmental Protection Agency is responsible for guardianship of the Safe Drinking Water Act (SDWA) that allows these standards to be set and monitored. Understanding the function and limitations of this act will help the students to understand the causes of the continuing need for uncontaminated drinking water access on the Navajo Nation.

Thematic units, combining several different content areas to teach a central set of information, strengthens the learning process by increasing the connections the students make within the material. It provides greater depth of learning and makes learning a positive, meaningful experience.

Using the standards in contexts that match the interests and experiences of the students increases their understanding and makes learning more accessible. They are able to think more critically, produce work with greater confidence and remember what they have learned with greater accuracy. It is always a challenge to raise the test scores of low socio-economic students, but it can be done using this type of curriculum unit.

Content Objectives

Hydrology

Water availability and location must be addressed before tribal water quality can be understood by students. Water comes from numerous sources on the Navajo Reservation. First of all, it comes from minimal amounts of rain with most areas receiving less than ten inches annually (Bureau of Reclamation, 2018, p. 5.5-9). There are three main watersheds: The Upper Colorado River Basin, the Little Colorado River Basin and the San Juan River Basin. Each basin is made up of washes, tributaries and rivers that work together. A wash is an intermittent stream in an arid area. It is a low area that is often dry, but sometimes floods occur in a wash when rain comes down faster than the ground can absorb it. A wash generally flows into a tributary. A tributary is a smaller stream or river that flows into a larger stream, river or lake. A river is a large stream that begins in a higher elevation and moves toward a lower elevation with tributaries adding water to it as it continues downhill.

Another type of water on the Navajo Nation is groundwater found in aquifers. The smallest aquifers on the Navajo Nation are alluvial aquifers. They are closer to the surface than the larger aquifers and therefore more susceptible to contamination from pollutants or mining. They occur where sedimentary materials were moved over long periods of time from a higher location and deposited into a lower location. Water permeates these sediments, but there is no outlet because the surrounding geology blocks all exits. These alluvial aquifers are not usually connected to other small alluvial aquifers, so they stand somewhat alone. There are numerous artesian wells that occur when water moving downward from a higher elevation creates pressure upon a lower area of a small alluvial aquifer. That pressure causes the water to rise upward, sometimes to the surface of the ground without using pumps.

The last type of aquifers are the deeper groundwater aquifers. There are three major aquifers of interest for us on the Navajo Reservation. The Dakota group aquifer (D aquifer) is actually made up of multiple semi-connected aquifers that have varying water quality depending on the location being tested. Parts of it are somewhat salty, or also referred to as brackish. It reaches far outside of the Navajo Nation, but it does not contribute much water to the Navajo Nation itself. It is the shallowest of the three non-alluvial aquifers, provides less water, and is located above the N aquifer, particularly in the Black Mesa area. The Navajo aquifer (N aquifer) is completely within the boundaries of the Navajo and Hopi tribal lands (Bureau of Land Management, Colorado River Basin-Ten Tribes Partnership Tribal Water Study, 2018). It exists in Utah and Arizona, but it does not extend into New Mexico. Part of the N aquifer is contained, or confined, by geologic blocking, but a second part of it is unconfined. The N aquifer has higher water quality, but has limited recharging, meaning the water level can lower under unfavorable circumstances, such as industrial overuse (“Hydrology of the Eastern Plateau Planning Area – Groundwater,” 2014). One example of this overuse is Peabody Coal’s use of water to move slurry through pipelines. (Kelly, S. 2019). The third major aquifer is the Coconino aquifer (C aquifer). This is considerably larger than the N aquifer and underlies all of the Navajo Reservation, excluding only a small portion of the western edge of the reservation. It also extends a considerable distance outside of the Navajo reservation, especially northward. It is below both the D and N aquifers. (Bureau of Reclamation, 2018, p. 5.5-9). It is important to note that in the Black Mesa area, these three aquifers are stacked one on top of the other with a containment layer between each. They also are located within the geologic layers of the same names; Dakota Sandstone layer, Navajo Sandstone layer and Coconino Sandstone layer (“Hydrology of the Eastern Plateau Planning Area – Groundwater,” 2014).

Historic Water Quality

Nature influenced the quality of water on the Navajo Reservation during the late 1800s to early 1900s. If areas flooded, the water contained debris and particulates. Water carried sand away while building sandbars and creating washes. Regular floods occurred. Groundwater held some low-level uranium, radon and arsenic contamination, but it was from natural sources only and man had little influence on water quality (Bureau of Land Management, 2018). The Bureau of Indian Affairs did try to build a few earthen dams, but they were not very successful. The aquifers held a natural amount of contamination and both the Dakota aquifer and the Coconino

Aquifer were brackish in some areas even as they are today, having acquired some dissolved salt from the ground. Brackish groundwater contains more than 1g/L salinity and today is not considered safe for people to drink (Ravisankar, Seaman, Mirchandani, Arnold & Ela, 2016). The aquifers were recharging normally.

The History of Uranium Mining

The story of major mining contamination to Navajo water begins just before the second World War. During World War II, the United States government required supplies of uranium for building the Atomic Bomb. The government began a search for uranium deposits, but they did it covertly (Pasternak, 2011). They had been alerted that the German government was working on trying to produce an Atomic bomb, and the United States was determined to beat them to it. Secrecy was of the utmost importance. As a result of this hidden search, rich uranium deposits were discovered to exist on Navajo Nation land. Consequently, a number of companies and individual prospectors signed leases with the U.S. government, who acted as the guardian of the tribal lands. These companies opened mines on the land of the Navajo, hiring Navajo miners. At first, the miners thought that they were mining vanadium, a metal that, when mixed with steel, made much stronger ship hulls (Alvarez, 2013). It was seen by the tribal council as patriotic for the Navajo Nation to assist the U.S. Government in protecting the troops, a number of whom were Navajo. There was little known at that time about the effects of radiation, and what information was known was kept from the miners by representatives of the U.S. government and the mining companies in order not to frighten them away from working in the mines (Brugge and Goble, 2002). As a result, the Navajo miners were not appropriately informed of the health hazards involved or even what the true use of the uranium would be until after the first Atomic Bomb was dropped and it became clear that the uranium was the true mining product. (Pasternak, 2011). The Navajo miners' focus for employment in the mines was two-fold, both patriotism and the opportunity to provide for their families.

According to the Environmental Protection Agency (EPA), companies mined 30 million tons of uranium on the Navajo Reservation between 1944 and 1986, using Navajo workers (EPA(a) 2019). In 1967, Department of Labor Secretary Wirtz enacted safety regulations that resulted in the shutdown of numerous Navajo mines. Previous to that, there had been a lack of enforced safety regulations and high exposure by miners to contaminants. (Panikkar & Brugge, 2007). Although the mining companies' leases with the tribe had stated that the land was to be returned "in as good condition as received," the U.S. government representative responsible for overseeing the closings signed off on them, relieving the mining companies of the responsibility to restore the land and environmentally clean up the mining-related sites. (Pasternak, 2011). The United States Government continued purchasing uranium until 1971, at which time the government determined it owned more uranium than it could put to use (Brugge & Goble, 2002). The end of government purchases caused the shutdown of more Navajo uranium mines within the next few years. However, some of the closed above ground mines eventually turned into deep pits of uranium tainted water, while other closed mines had huge tailings piles leeching uranium and heavy metals into the ground, contaminating the groundwater (Pasternak, 2011).

Mining Methods

In some areas, such as near Cameron, Arizona, pit mining was used if the ore was close to the surface. In other areas such as near Monument Valley, and Cove, Arizona, tunnels were dug into land formations or underground. Sometimes further mineral extraction was done on old tailings piles using chemicals to extract even more uranium as it was in the Monument Valley area (Pasternak, 2011). One example of mining methods was a uranium mine in the Church Rock Mining District of New Mexico just outside the boundaries of the Navajo Nation that pumped water (termed dewatering) that had seeped into the uranium mine tunnels and directly released it into Pipeline Arroyo, a wash which runs into the Puerco River, which then flows into the Little Colorado River and eventually the Colorado River. This mine had pumped 75 gallons per second of uranium contaminated water from 1977 until 1982 into Pipeline Arroyo. In 1979, an earthen dam collapsed at the mine releasing uranium tailings and wastewater. It was the largest spill of this type in U.S. history, and it flowed directly through the Navajo Nation (Wirt, Geological Survey, & United States. 1994).

Environmental Protection Agency

In 1970, the Environmental Protection Agency was formed (“EPA History,” 2018). This was in response to a growing national awareness of the dangers of environmental pollutants. The Clean Air Act of 1970 was their first responsibility, and the EPA established National Ambient Air Quality Standards to protect the public from polluted air. This was in response to acid rain, smog and ozone layer damage. (“Clean Air Act Requirements and History,” 2017). In 1972, the Clean Water Act became EPA’s responsibility as well. EPA then set wastewater standards and added national water quality criteria. (“Summary of the Clean Water Act,” 2019). The power to enforce the acts were originally given to the states, who could determine the level of pollutants allowed statewide as long as they did not exceed EPA’s maximum standards. However, this caused problems for indigenous nations, including the Navajo Nation, whom the states originally set standards for if they were within that state’s boundaries. Policy changed, and EPA took the guardianship position to operate EPA standards in behalf of the tribes. However, rented or leased lands that were tribal trust lands created a checkerboard pattern on which the states still had water quality control. Then, in 1990, EPA enacted Tribal Authority Rule (TAR), giving tribes authority over their own air quality and eliminating the checkerboard control problem. (“Tribal Authority Rule (TAR),” 2017). Next, in 1997, Congress made amendments that allowed tribes to operate under Treatment As States (TAS) for water quality and the native nations were allowed to open their own EPA branches, set their own clean air and water standards and administer their own granting of permits. They had to show that they had the governmental structure in place and the ability to administer the EPA program before they were allowed to administer the program themselves. (“Revised Interpretation of Clean Water Act Tribal Provision,” 2016). The Navajo Nation met these requirements and opened their own EPA branch in 2006. (“EPA approves Clean Water Act authority for Navajo Nation,” 2016). Since then, they have been working on behalf of the Navajo Nation to produce clean air and water for the tribe.

The national EPA was given Superfund hazardous waste site cleanup funds when it was created. The problem was that the population density on the Navajo Nation was very sparse, so EPA prioritized other areas for superfund cleanups that were located in higher population areas, and

very few complete cleanups were conducted on Navajo land. (“Introduction to the Hazard Ranking System (HRS),” 2018) Thus, the cleanup of uranium mines, tailings piles and processing sites are still in the process more than 60 years after the beginning of the World War II uranium mining boom on the Navajo reservation. (“Cleaning Up Abandoned Uranium Mines,” 2019).

The Safe Drinking Water Act is the key in the slow but steady progress being made to eventually provide safe and clean drinking water to every Navajo Nation residence and drinking water source. It is a law passed by Congress in 1972 and administered by the national EPA. It protects public drinking water sources in the United States. The Navajo Nation EPA provides the same service on the Navajo Reservation under the national EPA. They are treated as a state in their ability to set their own drinking water standards and oversee the implementation of those standards on tribal lands. The federal government works collaboratively with tribal EPAs in efforts to increase access to safe drinking water on tribal lands. The national EPA helps with some technical and funding assistance, some infrastructure support and otherwise holds the same relationship with tribal EPA's as they do with each state. (Safe Drinking Water on Tribal Lands," 2018). One of the challenges of providing safe drinking water to Navajo Nation homes is that the homes are widely spread apart and the infrastructure does not exist to provide piped in water from a regulated source to many homes, meaning these residents have to haul their water from whatever sources they are able to acquire it from with whatever resources they have. In many cases, these are unregulated sources with water that does not meet Safe Drinking Water Act standards. (“Cleaning Up Abandoned Uranium Mines,” 2019).

Water Quality World War II through 1980's

The immediate negative effects of the start of uranium mining on the reservation were to the miners and their families, whom they often brought along with them to live at the mining sites. The miners inhaled the mine dust because they did not wear masks, got it on their skin through bare hands and dusty clothes, ate it as it settled onto their lunches, and as they sometimes drank the cold water that seeped into the mine tunnels through the walls (Alvarez, 2013). As the dust from the tailing piles blew across the mining camps, and also leached into the water, the families of the miners were exposed. (Pasternak, 2011). As time went by and the ore was mined from the inner earth and the tailing piles grew, then were eventually abandoned, many more people, as well as livestock, were affected by the leaching of the products of uranium into the drinking water and uranium tainted dust blowing across the earth. Despite the efforts of many to later clean up the tailings piles, the pits and to close off the mines, there is still a substantial amount of uranium, arsenic and heavy metals contamination left in the water supply. (Pasternak, 2011). In numerous instances, the water coming from alluvial aquifers is still not safe to drink on the Navajo Nation. (“Abandoned Uranium Mines and the Navajo Nation,” 2007). There are currently over 500 un-reclaimed abandoned uranium mines on the Navajo Nation. ("Cleaning Up Abandoned Uranium Mines," 2019)

According to the Navajo EPA (2018), 30 percent of the population of the tribe does not have access to running water today. Navajo people still haul water from both regulated and

unregulated sources. Some haul water from as far away as from Flagstaff or regulated sources on the reservation. Others haul from unregulated sources or from untested wells. Some of these unregulated sources contain unsafe contaminants. The reasons for using unregulated water can be lack of transportation, lack of dependable transportation, the distance they live from regulated hauling stations, or lack of funds to support hauling. Uranium does not have a taste, so the water can taste clean and pure while still having contaminants.

Other Causes of Clean Water Scarcity

In the 1950s, the Navajo Nation recognized that developing their coal resources could create an industry to provide jobs for their people. Because of this, the Navajo traded some land near Page, Arizona, with the United States government for other land so that the Glen Canyon Dam could be built. (Boren, 1997). Water from this dam was slated for water storage and the production of hydroelectric power. Navajo Nation coal was used to produce energy to power the pumps for the Central Arizona Project that moved the dam water south toward the Phoenix area. Construction on the Glen Canyon Dam began in 1956 and was completed in 1966, but it did not finish filling with water until 1980 ("Park History," n.d.). Following the start of the dam construction, Peabody Coal opened in the 1960's allowing the Navajo Generating Station (NGS) to open in 1974. (Kelly, 2019). Peabody Coal used water from the N aquifer for many years to create coal slurry to transport the coal via pipeline, causing the water in the N Aquifer to drop substantially. (Kelly, S. 2019). Emissions from the NGS caused both air particulate pollution and water pollution, increasing the amount of mercury in the waterways (Thompson, 2017). The EPA stringent clean air standards and the expense of producing energy from coal when cheaper energy was available eventually caused the decision to shut down the NGS. At this time, it is slated to close in 2019. (Thompson, 2017).

Effects of Pollutants

At one time, cancer was almost non-existent on the Navajo reservation. Nearly ten years after uranium mining began, some miners began to die from cancer due to exposure to uranium. People on the reservation today are still being exposed to uranium from former uranium mining. Arsenic is often found in high concentrations in water where high levels of uranium are already present. Health problems caused by these agents include: Navajo neuropathy, autoimmune deficiencies, developmental disabilities, hypertension, cardiovascular disease and cancer of the skin, lungs, kidneys and bladder. The incidences of these diseases are statistically higher on the Navajo reservation than for the rest of the nation. (Hoover, Gonzales, Shuey, Barney, & Lewis, 2017)

Efforts to control pollutants in drinking Water

Colleges often get grant money to start projects on the Navajo Nation to work toward water purification systems. A few examples of these are: Star charter school was given a bus with a working water purification system. (Gillden, 2017). A solar powered membrane water purification system was installed in the Leupp area. (Ravisankar, Seaman, Mirchandani, Arnold

& Ela, 2016) Research has been done on the possibility of using small personal water filtration systems for individual residences, but the expense to upkeep them would prevent many households from their continued use. (Hoover, Gonzales, Shuey, Barney, & Lewis, 2017.) Government grant money provided water trucks to the tribe to deliver water to remote rural areas (Horoshko, 2011). However, the main problem with these solutions is that grant money runs out and grant people that assist leave and the systems fall into disrepair and are unable to be up kept by the tribe due to financial or technical restraints. EPA has explored pulling water out of contaminated aquifers and running that water through ion exchange and distillation systems before returning it to the aquifer. It is estimated this could reduce contaminants in small aquifers after 20 years of purifying, and would cost millions of dollars for each system. This system is in place in Tuba City at the former milling site (“LM Sites on Navajo Nation Navajo Nation Land,” 2018). This solution may actually work, but the cost is prohibitive and would take a huge commitment from the U.S. government.

Cultural information

Language

A Navajo word for water is “tó.” It can also be spelled “tóh.” This word is used to form words that are specific bodies of water. “tó dah siyí” is a lake or pond. “Tó siyínígí” is a body of water that is sitting in one place, such as a lake. “tó biníhíyí” is an inlet along the shore of a body of water. “tó dah néigeeh” is a periodically dry body of water used to water livestock. “Tó adah ’iilí” is a waterfall (Mark, Stea, & Topaha, 2019). “Tó hahadleeh” is a water well and “tó háálí” is a spring (Yazzie & Speas, 2007).

Place Names

Place names also often refer to water. Examples are Kayenta, whose Navajo language name is “Tódinéeshzhee’.” In this case, “tó” is water and “dinéeshzhee” is similar to rivulets, or fingers of water. It was explained to me that this can be visualized by thinking of it like cooked spaghetti noodles laying the same general direction, but a little wavy. This place name is related to the way crops are planted near Kayenta. In the Kayenta area, different family groups have been given different “finger” areas determined by the stream beds in which that family group can grow their crops. Tuba City is another example of a place name based on water. Its name in Navajo is “Tó naneesdizí,” the “tó” again meaning water and “naneesdizí” being fingers. However, in the meaning this time, the fingers are straight. The water is not wavy. This idea also relates to the planting of crops in the Tuba area. Crops there are grown more like they would be on a plantation, not based along streambeds because the groundwater is higher in that area and water has historically been available to the crops without irrigation. Not only many town names, but other geographical names refer to water. One of the four sacred mountains, the San Francisco Peaks, is named “Dook’o’óóslid,” in Navajo. This doesn’t have the word “tó” in it, but it is water connected because its name refers to the reflection of sunlight off of the snow on the peaks. (C.Singer, personal communication, June 27, 2019)

Women's hair

There are numerous conditions that can either affect or show what the coming rainfall will be like. One of these is the direction a crescent moon is turned. If it is turned with the tips vertical to the Earth, then moisture will be on its way shortly. Another is the condition of the women's and girls' hair. Rain sometimes appears to be coming downward in dark strands. This relates to the vertical strands in the weaving loom, which also represent hair. When a woman or girl lets her hair down out of the traditional Navajo bun, called *tsiiyéél*, its long strands represent rain. Elders of the tribe say that if the women and girls continue in not cutting their hair, that the rain will continue to come. The obvious connection is that if droughts occur or rainfall is sparse, then female haircuts have influenced that as well. (Yazzie & Speas 2007)

Spiritual Balance

In 2002, the Navajo Nation Council passed a resolution to update the Fundamental Laws of the Diné. It clarifies the cultural values of the Diné so that Navajo Nation law can be administered correctly. In Section 5A they named the four sacred elements. "The four sacred elements of life, air, light/fire, water and earth/pollen in all their forms must be respected, honored and protected for they sustain life..." In Section 5B, it says, "The rights and freedoms of the people to the use of the sacred elements of life as mentioned above and to the use of the land, natural resources, sacred sites and other living beings must be accomplished through the proper protocol of respect and offering and these practices must be protected and preserved for they are the foundation of our spiritual ceremonies and the Diné life way..." ("Transcript of the Fundamental Laws of the Diné," 2002). According to Navajo medicine man Lorenzo Max, it is important to understand that the four sacred elements as well as all other natural objects are traditionally considered to be alive and that Indigenous persons can speak to anything in nature and ask them for protection or help. People are not 'connected' to nature. They 'are' nature. All parts of nature interact. It is all one. If man digs around in the earth and creates pollution, then the balance or harmony is damaged, and the energy of *Hózhó* is affected, affecting the ability of man to Walk in Beauty, or balance. This creates imbalance, or illness. This is the basic reason that air and water pollution are very important to Navajo people. To pollute the four sacred elements creates imbalance and illness. (L. Max, personal communication, June 25, 2019). You will sometimes hear an older Navajo person say that that life is in the water. Water is critical to sustain human life since our bodies are made mostly of water. Clean, safe water is critical for humans to have. Plants also need water for survival.

Navajo author and artist Shonto Begay

Shonto Begay was born in Shonto, Arizona, on the Navajo reservation. He is named after his great grandmother, Shonto, and his name has the word "tóh" in it. His name means "sun sparkle off the water". In his book *Navajo – Visions and Voices Across the Mesa*, he writes about experiences and impressions relating to aspects of his traditional Navajo upbringing. His poem

"Reflections After the Rain" speaks about his experiences sitting at the water's edge as the sheep were watered. Shonto was a quiet, meditative boy and found shepherding a perfect place for himself to be. He could smell nature, sense the nuances of his surroundings, look at the sky and see by this information provided by nature what a day would bring. The poem has a peaceful, meditative quality in which the balance of Hózhó is sensed. (S. Begay, personal communication, August 5, 2019).

His poem "Into the New World" was written as a reflection of his grandfather's feelings as the heavy coal mining machinery in later years disturbed the stillness and the quality of Hózhó on the mesa. It speaks about the lack of rain and disturbed prayers. The reader can't help but wonder if the lack of rain is related to the disturbance of the earth and the interrupted natural cycle of nature. The disturbed prayers show a need to return to balance, to Hózhó. The poem shows the reality of the mining situation, but also the disturbance it had caused. There is always the decision that has to be made of how to provide for family needs along with the need to balance the existence of man with the living environment. That is filled with difficult choices.

I heard Shonto speak at a meeting concerning global climate change and the need to let people know the importance of doing what they personally can to correct their own actions to help reverse the climate change trend. He read the poem "Into the New World" to the gathering and I knew it belonged in this unit. Allowing his poetry to be used in this curriculum is one of his many contributions toward helping the children to become more aware.

Teaching Strategies

Foldable

Students fold an 11"x17" sheet of white paper into half using a "hamburger" fold. They open the paper back up with the fold vertically in the center and fold both the left and right outside edges to touch the center line, creasing those down on the outside edge. Next, fold the paper into thirds by folding the bottom upward approximately 3 ½ inches, until it appears that what is left on the top of the paper is about the same length as the paper you folded upwards. Crease the bottom edge of the fold. Fold the top edge downward over the last fold, resulting in the paper being folded into thirds. Crease the upper edge of the fold. Open the horizontal folds. If you cut on the horizontal lines to only one folded square in, you will have what appears to be a flap over one square. Cut the other top flaps so that they look the same. There are several pictures of the finished foldable attached.

Hydrology Model

Students will be given maps that show where the Mesa Verde group alluvial aquifers, Dakota Aquifer, Navajo Aquifer and Coconino Aquifers are located on the Navajo Reservation. They will identify that all of the types of aquifers are present in the Black Mesa area. They will be given a Black Mesa diagram showing the aquifers' horizontal layering. Students will build a

three dimensional model of the aquifers in the Black Mesa area only because they stack on top of each other in this geographical area. They will use printouts of the layers placed inside sheet protectors. The students would use clay or playdough to build the aquifers on the correct areas and stack them, using rolled strips of paper with the end glued to hold the edges of the models up. One source of the aquifer maps is located at the United States Bureau of Reclamation site <https://www.usbr.gov/lc/region/programs/crbstudy/tws/chapter5.html> Choose chapter 5.5 for the Navajo Nation. There is also a good cross section map found on the USGS site pubs.usgs.gov/ha/ha730/ch_c/jpeg/?C=N;O=D Choose the 14th slide, C122.jpeg.

Fishbowl Discussion

Students are presented with controversial or conflicting information, usually in written articles. They use the information to fill in a Pros/Cons chart for each side of the issue and can take notes on the back. The entire class is divided evenly into two teams. One team must represent one viewpoint and the other team must represent the opposite view. Enough chairs for half of the class are put into an inner circle. Enough chairs for the other half of the class are put into an outer circle. Half of each team is seated in the inner circle. One of their teammates is seated directly behind them close enough to consult with. The teacher is the moderator. Each student in the inner circle is given two “tickets.” They must contribute speaking two times, handing the “ticket” to the teacher or placing it in a container in the center each time they speak. They must use both tickets and they are not allowed to speak more times than they have tickets. This assures no students dominate the conversation and all students participate. They are not allowed to interrupt other students and they are required to always be respectful. No students in the outside circle may speak. The students in the outside circle do not have tickets. The teacher has created a list of controversial questions. The teacher starts the discussion by asking the first controversial question. Either team may give an answer first, but the speaker must be the first to stand to their feet. If more than one student stands to their feet, then whoever was not first sits down. If they stood at the same time, one student silently volunteers to sit down and wait for another turn. Students go back and forth in this manner until they have covered the topic well or until they get stuck. If they have difficulty thinking of what they could say, give the entire group one minute to consult with their teammates seated in the chairs behind them, then resume. A new controversial question can be presented by the teacher anytime it seems appropriate. When the inner group is out of tickets, have the inner and outer circle change seats, hand the new inner circle two tickets and proceed as before. A variation to this would be to have the students sit in an inner and outer circle on the floor and pass a talking stick between those who want to speak. However, each student should orally participate and no student should dominate the discussion.

Classroom Activities

Foldable

Use this foldable by having each student make their own to gain the vocabulary and knowledge about hydrology needed for this unit. The teacher models each step of making the foldable. Then they model each section under a document camera or projector. Start by labeling the Watersheds flap. Open the flap and write the definition on the inside of the flap. Next to the definition, use an easy model of the Navaho Nation in the four states to show where the major watersheds are. I had to create my own map. Students should color and label these aquifers. You have finished one section. Now you are ready for the Washes, Tributaries and Rivers flap. Label it. Write the definitions on the inside of the flap. Next to the definitions, glue in or draw an easy map showing this system. I used a map from https://en.wikipedia.org/wiki/Little_Colorado_River but you could use a different one. Proceed with the Alluvial Aquifers, Artesian Wells, Deeper Groundwater Aquifers and Deep aquifers on the Navajo Nation sections. The sandstone strata cross section picture showing that the sandstone layers match the aquifer layers and names, I found on an Arizona Department of Water Resources site: <http://www.azwater.gov/AzDWR/StatewidePlanning/WaterAtlas/EasternPlateau/PlanningAreaOverview/Hydrology.htm> There are photographs attached to show you what we did for the foldable.

Hydrology models

Build these as shown in the Teaching Strategies section to help the students understand how the aquifers are situated in layers. Attached are sample hydrology models that can be placed inside sheet protectors to accomplish these models.

Fishbowl Discussion

The Fishbowl Discussion should be about the Clean Water Act and the Clean Drinking Water Act and how it has been applied to tribes who do not have high infrastructure to provide regulated water to individual homes, the EPA's handling of its relationship to tribes over history, superfund monies and their application to abandoned uranium mines in low density population areas. Should more have been done? What should be done now?

Navajo Language

For a language activity, build a small word wall with Navajo words for water, using the base word “tó” or “tóh.” The word wall can contain the word, the definition and a picture. The word wall can contain the place names for Kayenta and Tuba City as well. Pair this activity into the same time period as building of hydrology models.

Visiting Artist

Shonto Begay is both a well-known author and artist. He will come to visit Navajo Nation schools for “whatever the school can afford.” Before his visit, the students will be given very basic background information about Shonto. The teacher will converse with Shonto about the

approach both of them believe to be most effective for him to take during his presentation. In my case, he will come to the classroom, explain the Navajo world of his childhood and read his first poem "Reflections After the Rain." Following that, he will describe the changes to the earth and its water availability that he perceives have occurred and read his second poem, "Into the New World." He will talk to the students about how he develops the poems he writes. After his visit, the students will attempt to write a poem using the guidance he gave them. A form is attached for the poetry writing.

Annotation

The students will work with a partner to annotate the reading material. The main point is to have them read the text so closely that they remember what it says. They will highlight the main idea, circle relevant vocabulary words, circle words that are defined within the text and underline the definition. They will put an exclamation point next to important information and put a question mark beside text they are unsure about. They will write personal notes about their own thoughts in the margins. Afterward, the teacher will re-read the material out loud to the whole class and discuss the markings the students chose to make. This will help all of the students to have a deeper understanding of the materials.

Cause and Effect

Students take a scientific approach to a chain or group of events. They determine what the problem is and the multiple causes and effects that created the problem. Small groups of students design their own posters to show their thinking, using arrows to indicate the connection between the causes and effects. They view each other's group products and use sticky notes to write notes about things they would add or change, or to give positive comments. This would be effective to use after the History of Uranium Mining section.

Compare and Contrast

Students will learn to find similarities and differences between multiple texts and be able to distinguish the difference between writing a comparison or contrast without mixing the two into the same paragraph. This process is made much easier by first annotating the text and then working as a whole class to put the information into a Venn Diagram before beginning to write full paragraphs. Students should use appropriate transition words to make their writing flow smoothly and increase readability. One good text to use is the attached interview with Harvey Riggs. This can be coupled with a recent newspaper article or research article found by Google search about water issues on the Navajo Reservation such as this example: Quality of Unregulated Rural Water Supplies in the Northern Navajo Nation found at https://cals.arizona.edu/region9wq/pdf/Quality_of_Unregulated3.pdf

Problem/Solution

Small groups of students brainstorm possible partial or full solutions to the problem of the need to supply clean water to every person and livestock on the reservation. They do research as needed and choose or create their own best solution. They form a group presentation using technology such as a Power point, video, or other available app to present that solution to the class. This would be the ending project for the students.

Timeline/Sequential Order

Students use lesson information to create a timeline to show the relationship of time to events. This increases their spatial reasoning and helps them with sequential order. Afterwards, they write a short essay explaining the timeline using transition words of sequential order. A good subject for this would be the EPA timeline in the attachment to this curriculum.

Political Cartoon

Students are shown current or historic political cartoons. They are given a subject and are asked to produce their own political cartoon. The theme of political cartoons is to make a point about a controversial issue and to make the reader consider the issues. Political cartoons are easy to find as samples with an internet search. Most of the material starting with The History of Uranium Mining section and continuing through the Effects of Pollutants section is appropriate for political cartooning.

Model Drawing

Students can draw a model of mine dewatering to go with the section on Mining Methods. Drawing or building models clarifies scientific and mathematical principles. A clear mental picture can be difficult for many students without visual assistance and personal experience. Students can do the concept drawing in two dimensional form into a science notebook and labeling the processes and parts. A sample of one of these is in the attachments to this curriculum.

Data Table Analysis

It is a valuable skill for students to understand the meaning of data tables and be able to use those tables to draw conclusions. Working in small groups for support, students determine how much difference between numbers is significant and why. They draw conclusions as a group and then enter into class discussion to compare their thinking with others and to clarify each other's misconceptions. Use the website <https://www.navajopublicwater.navajo-nsn.gov/NNPDWA> under section 200 - Maximum Contaminant Level to see the Navajo Nation Primary Drinking Water Regulations (NNPDWR).that have been adopted by the Navajo Nation EPA. Page 25 of that section shows Uranium maximum contaminant levels. Compare that regulation to Table 2. Navajo Nation Contaminated Unregulated Water Sources to see the uranium levels represented in a number of Navajo Nation unregulated wells. Find Table to at website <https://www.epa.gov/navajo-nation-uranium-cleanup/water-sampling-results-navajo-nation> and click on Contaminated Unregulated Water Sources (PDF). A valuable tie-in to this Data Table

Analysis activity is to look at the website https://www.navajopublicwater.navajonnsn.gov/Portals/0/PWSSP%20FOLDERS/2015%20NNPDWR/NNPDWR_Appendix-F.pdf?ver=2015-10-29-110136-123 This is a Navajo Nation Primary Drinking Water Regulations (NNPDWA) document as well. This has the complete list of Drinking water standards and the consequences if not followed. It mentions uranium, and that over intake may "over many years cause cancer or kidney toxicity." MCL means "Maximum Contaminant Level."

Field trip

There are a number of places that a teacher located on or near the Navajo Nation can take their students for a relevant field trip related to these materials. I have chosen to take mine to Tuba City because on the drive there, we will pass a large section of un-remediated tailings piles alongside the highway that are very visible, but in the same way, not obvious. Just outside of Tuba City there is a tailings pile that was re-mediated not far from town where the students can see what has been done in an actual remediation effort. As a bonus not taught in this curriculum, Tuba City is the location of dinosaur tracks, the Navajo Museum and the Navajo Interactive Museum, all of which are valuable for students to experience. A very good resource for any area you are studying specifically is the website <https://www.epa.gov/navajo-nation-uranium-cleanup/screening-assessment-report-and-atlas-geospatial-data> There is a very good explanation about how they rank the AUM's (Abandoned Uranium Mines) for need for cleanup and show excellent maps of every AUM section and how far its effects go into the surrounding land. It also has some tables with the uranium levels of water contamination.

Video

The video "Four Stories About Water can be searched for online or found at the website <https://www.cultureunplugged.com/documentary/watch-online/play/53797/Four-Stories-About-Water>

Four Stories About Water from: Deborah Begel. It is an excellent video for the students to watch to solidify what they learned about uranium contamination and its effect on the Navajo people.

Personal Reflection

Students will end this unit with a self-reflection about what they have learned, how it has changed their perspectives and any actions they could personally take concerning water pollution.

Student Assessment Plan

Pre-assessment/Post-assessment

The students will do a pre-assessment before beginning the unit in which they will draw a model of where they think the water on the Navajo Nation comes from, where they think it goes and things that might pollute it. They will need to both draw a diagram and label it for this assessment. Save this assessment for the students to compare to their post-assessment.

Given a pre-assessment in which students are asked to draw a model of how they think something works prepares them to watch for specific information during the unit. Often added to this are some questions to answer to the best of their ability that are also designed to help them predict what they will need to learn. This structure provides them with curiosity to know and allows them to identify what their misconceptions are as the unit progresses. This also allows the teacher insight into common misconceptions before the end of the unit. The post assessment would be the exact same as the pre-assessment. When handed back at the same time, the students can see their growth and identify more effective ways to demonstrate their learning.

The students will also be producing gradable work at many other points. A list of these would be: the Foldable, the Hydrology Model, the Fishbowl Discussions, Poetry Writing, Cause and Effect Posters, Chronological Order Timelines, the group Problem and Solution work, Political Cartoon, Model Drawing, Data Table Analysis.

Alignment with Standards

State of Arizona Fifth Grade Social Studies Standards

- 5.SP1.2 Explain how events of the past affect students' lives and society.
- 5.SP1.3 Generate questions about individuals and groups who have shaped significant historical changes and continuities.
- 5.SP2.1 Explain why individuals and groups during the same historical period differed in their perspectives.
- 5.SP3.1 Develop compelling and supporting questions about the United States that are open to different interpretations
- 5.SP3.6 Construct and present arguments using claims and evidence from multiple sources.
- 5.SP4.2 Use evidence to develop a claim about the past.
- 5.G1.1 Use and construct maps and graphs to represent changes in the United States.
- 5.G2.1 Describe how natural and human caused changes to habitats or climate can impact our world.
- 5.G3.1 Use key historical events with geographic tools to analyze the causes and effects of environmental and technological events on human settlements and migration.
- 5.G4.1 Describe how economic activities, natural phenomena, and human-made events in one place or region are impacted by interactions with nearby and distant places or regions.
- 5.H2.1 Use primary and secondary sources to summarize the causes and effects of conflicts, resolutions, and social movements throughout the historical timeframe.

5.H\$.1 Use primary and secondary sources to describe how diverse groups shaped the United States” multicultural society within the historical timeframe.

State of Arizona Science Standards 2018

5.L3U1.10 Construct an explanation based on evidence that the changes in an environment can affect the development of the traits in a population of organisms.

5.L4U3.11 Obtain, evaluate, and communicate evidence about how natural and human-caused changes to habitats or climate can impact populations.

5.L4U3.12 Construct an argument based on evidence that inherited characteristics can be affected by behavior and/or environmental conditions.

State of Arizona English Standards

5.RI.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

5.RI.3 Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.

5.RI.5 Compare and contrast the overall structure of events, ideas, concepts, or information in two or more texts.

5.RI.6 Analyze multiple accounts of the same event or topic, noting important similarities and differences in the point of view they represent.

5.RI.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

5.RI.8 Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s).

5.W.4 Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.

AZ.5.W.4 Produce clear and coherent functional writing (labels, timelines, graphs/tables, etc.) in which the development and organization are appropriate to task and purpose.

5.W.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

5.W.9 Apply grade 5 reading standards to informational texts

5.W.10 Write routinely over extended time frames and shorter time frames (a single sitting or a day or two) for a range of discipline- specific tasks, purposes, and audiences.

5.SL.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others’ ideas and expressing their own clearly.

5.SL.5 Include multimedia components and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

5.L.6 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal contrast, addition, and other logical relationships.

Department of Dine Education Standards

SIC-F2.PO2 Identify and describe how location, ethnic and national cultures influence individual's daily life.

SIC-F2.PO6 Explain why individuals and groups respond differently to physical and social environmental changes that are basis of shared assumptions, values and beliefs.

SIC-F3.PO6 Design a system for decision making and a plan for action-taking on public issues and concerns by exemplifying an understanding for factual cultural knowledge and concepts drawn from historical inquiries.

S2C-F1.PO7 Identify and describe influences of perceptions, attitudes, values and beliefs on personal identity; understand the significance of the Protection Way Teachings: (display respect for spiritual concepts).

S2C-F3.PO2 Locate and discuss the importance of tribal economic activities that make use of natural resources on the reservation (e.g., mining)

S2C-F3.PO7 Identify and describe types of territorial units; describe the characteristic of political units; explain how and why people compete for control of earth's surface and resources as exemplified by being able to research, write and Illustrate a geographic history of a state; identifying Indian control and occupation of the land.

S3C-F2.PO4 Research, identify, and describe the cultural values and practices associated with utilizing earth's surface and substance: minerals and other natural resources (ore) and tell how they have become economically valuable to the traditional way of life.

S3C-F2.PO5 Compare and contrast on the current uses of the natural resources and minerals by the Indian people and by the western culture.

S3C-F2.PO6 Explain how cultural information and experiences may be interpreted by people of diverse cultures, their perspectives and frame of references; describe how Indian people relate to their environment through a cultural perception; Mother Earth provides and nurtures all things, therefore life is fulfilling a purpose, a sacred spirit and must be respected.

S3C-F4.PO1 Examine persistent issues involving the rights, roles and status of individuals in relation to the general welfare of a community and growth; and share information with community.

S4C-F1.PO7 Identify and describe examples of tension between individual beliefs and governmental policies.

S4C-F2.PO1 Acquire information on traditional values and principals stressed in living in harmony with nature; recount the early Traditional oral history (hane') associated earth (vegetation and wildlife), air, water and light; understand stories (hane') defining purposes and roles of the fire, sun, moon, constellations relative to life on earth.

S4C-F3.PO1 Demonstrate an ability to use correct vocabulary associated with time such as past, present, future and long ago; read and construct simple time lines; identify examples of change; and recognize examples of cause and effect relationships.

S4C-F3.PO2 Identify and use various resources for constructing the past, such as documents, maps, textbooks, interviews with elders and photos.

S4C-F3.PO6 Evaluate different viewpoints regarding resources, assess the varying attitudes of people regarding the use and misuse of resources on native lands (e.g., how do traditional attitudes regarding the use and care of the land reconcile with the need for economic availability).

S4C-F3.PO8 Research both the Indian point of view and the non-Indian perception of a controversial social, economic, political and environmental issue that has a geographic dimension (e.g., Indian water rights, eminent domain, allotted land, reservation boundaries).

S5C-F1.PO3 Prepare and deliver information by generating topics; identifying the audience; organize ideas, facts or opinions for a variety of speaking purposes.

S5C-F9. Prepare and deliver an oral report in a content area and effectively convey the information through verbal and nonverbal communications with a specific audience.

S7C-F3 Participate in group discussions.

S7C-F5 Prepare and deliver information on generated topics; identify the audience; organized ideas, facts or opinions for a variety of speaking purposes such as giving directions, relating personal experiences, telling a story or presenting a report.

S7C-F8 Pan, develop and produce a visual presentation, using a variety of media such as video, films, newspapers, magazines and computer images.

Resources

Teacher Background Reading

Hydrology of the Eastern Plateau Planning Area - Groundwater. (2014, March 27). Retrieved July 7, 2019, from <http://www.azwater.gov/AzDWR/StatewidePlanning/WaterAtlas/EasternPlateau/PlanningAreaOverview/Hydrology.htm>

The cross-section diagram shows the aquifers labeled in relationship to the geologic sandstone layers of the same names.

Mark, D., Stea, D., & Topaha, C. (2019). An illustrated dictionary of Navajo landscape terms
This book gives Navajo language examples and explanations for words concerning water.

Yazzie, E. P., ED.D., & Speas, M., PH.D. (2007). *Dine Bizaad Binahoo' aah Rediscovering the Navajo Language* (First ed.). Flagstaff, AZ: Salina Bookshelf.

This classroom textbook has multiple pages about water. It is present in clan names p.69-71, the reason for long hair p. 244 and words with water meanings p. 289.

About EPA: Our Mission and What We Do (2018, Feb. 7) Retrieved on August 2, 2019, from <https://www.epa.gov/aboutepa/our-mission-and-what-we-do>

This website explains what the mission and limitations of the Environmental Protection Agency are.

Mark, D., Stea, D., & Topaha, C. (2019). An illustrated dictionary of Navajo landscape terms.

Student Reading/Resources

Water Science School Aquifers and Groundwater. (n.d.). Retrieved July 7, 2019, from https://www.usgs.gov/special-topic/water-science-school/science/aquifers-and-groundwater?qt-science_center_objects=0#qt-science_center_objects

This website by USGS shows illustrations of how groundwater creates aquifers. It shows different types of aquifers and wells and explains how pumping affects aquifers.

Materials for Classroom Use

These are in the attachments.

Works Cited

Bureau of Land Management (2018). The Colorado River basin ten Tribes partnership Tribal water study. Retrieved from <https://www.usbr.gov/lc/region/programs/crbstudy/tws/docs/Ch.%205.5%20Navajo%20Current-Future%20Water%20Use%202012-13-2018.pdf> October 15, 2019.

Environmental Protection Agency (2019 a). The Navajo Nation cleaning up abandoned uranium mines. Retrieved from pa.gov/navajo-nation-uranium-cleanup#:~:text=From%201944%20to%201986%2C%20nearly,resulting%20from%20the%20abandoned%20mines. Accessed November 19, 2019.

World Population Review 2019 (2019). Flagstaff Population Growth. Retrieved from <http://worldpopulationreview.com/us-cities/flagstaff-population/>

World Population Review 2019 (2019) Flagstaff Diversity. Retrieved from <http://worldpopulationreview.com/us-cities/flagstaff-population/>

World Population Review 2019 (2019). Flagstaff Educational Attainment by Race. Retrieved from <http://worldpopulationreview.com/us-cities/flagstaff-population/>

Greater Flagstaff Chamber of Commerce (2019). Flagstaff Cost of Living. Retrieved from <https://www.flagstaffchamber.com/economic-development/cost-of-living/>

World Population Review 2019 (2019). Flagstaff Earnings by Educational Attainment. Retrieved from <http://worldpopulationreview.com/us-cities/flagstaff-population/>

National Center for Education Statistics (2018). Eva Marshall Elementary School. Retrieved from https://nces.ed.gov/globallocator/sch_info_popup.asp?Type=Public&ID=040286000220

Eva Marshall Elementary School. (n.d.). Civil Rights Data Collection Reporting. Retrieved from <https://azreportcards.azed.gov/schools/detail/4807>

AZ School Report Cards. (2018). Student Achievement in State Academic Assessment Detailed Results. Retrieved from <https://azreportcards.azed.gov/schools/detail/4807>

AZ School Report Cards. (n.d.). State Accountability A-F Letter Grades. Retrieved from <https://azreportcards.azed.gov/schools/detail/4807>

Tribal Assumption of Federal Laws (2018). Treatment as a State (TAS). Retrieved from <https://www.epa.gov/tribal/tribal-assumption-federal-laws-treatment-state-tas>

Hoover, J., Gonzales, M., Shuey, C., Barney, Y., & Lewis, J. (2017). Elevated Arsenic and Uranium Concentrations in Unregulated Water Sources on the Navajo Nation, USA. *Exposure and Health*, 9(2), 113-124.

Bureau of Reclamation. (2018, December 13). Lower Colorado Region. Retrieved June 30, 2019, from <https://www.usbr.gov/lc/region/programs/crbstudy/tws/chapter5.html>

Hydrology of the Eastern Plateau Planning Area - Groundwater. (2014, March 27). Retrieved July 7, 2019, from <http://www.azwater.gov/AzDWR/StatewidePlanning/WaterAtlas/EasternPlateau/PlanningAreaOverview/Hydrology.htm>

The cross-section diagram shows the aquifers labeled in relationship to the geologic sandstone layers of the same names.

Ravisankar, V., Seaman, R., Mirchandani, S., Arnold, R., & Ela, W. (2016). Solar-driven membrane distillation demonstration in Leupp, Arizona. *Reviews on Environmental Health*, 31(1), 79-83. (APA style)

Transcript of the Fundamental Laws of the Diné (2002, November 8) Section 5 – Diné Natural Law. Retrieved July 15, 2019, from http://www.nativeweb.org/pages/legal/navajo_law.html

Mark, D., Stea, D., & Topaha, C. (2019). *An illustrated dictionary of Navajo landscape terms*.

Yazzie, E., & Speas, M. (2007). *Diné bizaad bináhoo'aah. Rediscovering the Navajo Language: an Introduction to the Navajo Language*. J. R. Yazzie & B. Yazzie (Ed.). Flagstaff, AZ: Salina Bookshelf, Inc.

Pasternak, J. (2011). *Yellow Dirt: A Poisoned Land and the Betrayal of the Navajos*. New York, NY: Free Press.

EPA History (2018, May 3). Retrieved July 22, 2019, from <https://www.epa.gov/history>

Navajo Nation: Cleaning up Abandoned Uranium Mines (2019, July 12). Retrieved July 22, 2019, from <https://www.epa.gov/navajo-nation-uranium-cleanup>

Panikkar, B., & Brugge, D. (2007). The Ethical Issues in Uranium Mining Research in the Navajo Nation, *Accountability in Research*, 14:2, 121-153. Retrieved July 26, 2019, from <https://pdfs.semanticscholar.org/851b/825f7c05bc99a1ee5838e5c90ea044f9a97e.pdf>

Wirt, L., Geological Survey, & United States. (1994). Radioactivity in the environment: A case study of the Puerco and Little Colorado River Basins, Arizona and New Mexico. U.S. Dept. of the Interior, U.S. Geological Survey ;--U.S. Geological Survey, Earth Science Information Center, Open-File Reports Section distributor.

Alvarez, R. (2013, Nov.14). Uranium Mining and the U.S. Nuclear Weapons Program Retrieved July 25, 2019, from <https://fas.org/pir-pubs/uranium-mining-u-s-nuclear-weapons-program-3/>

Brugge, D., & Goble, R. (2002). The history of uranium mining and the Navajo people. *American journal of public health*, 92(9), 1410–1419. doi:10.2105/ajph.92.9.1410

Clean Air Act Requirements and History (2017, Jan. 10). Retrieved August 2, 2019, from <https://www.epa.gov/clean-air-act-overview/clean-air-act-requirements-and-history>

Summary of the Clean Water Act (2019, March 11). Retrieved August 2, 2019, from <https://www.epa.gov/laws-regulations/summary-clean-water-act>

Tribal Authority Rule (TAR) (2017, Oct. 3). Retrieved August 2, 2019 from <https://www.epa.gov/sites/production/files/2017-10/documents/tar-factsheet.pdf>

Revised Interpretation of Clean Water Act Tribal Provision (2016, May 16). Retrieved August 2, 2019, from <https://www.federalregister.gov/documents/2016/05/16/2016-11511/revised-interpretation-of-clean-water-act-tribal-provision>

EPA approves Clean Water Act authority for Navajo Nation (2016, December 16). Retrieved August 2, 2019, from https://archive.epa.gov/epapages/newsroom_archive/newsreleases/2130488408d1bf8d8525710000713242.html

Introduction to the Hazard Ranking System (HRS) (2018, June 4). Retrieved on August 2, 2019, from <https://www.epa.gov/superfund/introduction-hazard-ranking-system-hrs>

Cleaning Up Abandoned Uranium Mines (2019, July 19). Retrieved August 2, 2019, from <https://www.epa.gov/navajo-nation-uranium-cleanup/cleaning-abandoned-uranium-mines>

Abandoned Uranium Mines and the Navajo Nation (2007, August). Retrieved on August 2, 2019, from https://www.epa.gov/sites/production/files/2017-01/documents/navajo_nation_aum_screening_assess_report_atlas_geospatial_data-2007-08.pdf

Safe Drinking Water on Tribal Lands (2018, May). Retrieved on October 7, 2019, from <https://www.epa.gov/tribaldrinkingwater>

Park History (n.d.) Retrieved on August 2, 2019, from <https://www.lakepowell.com/discover/park-history/>

Kelly, S. (2019, Feb. 21). As Cleanup Dispute Looms, Peabody-Linked Group Pushes Navajo Nation to Buy West's Largest Coal Plant. Retrieved on August 4, 2019, from <https://www.desmogblog.com/2019/02/21/cleanup-peabody-coal-texas-public-policy-foundation-navajo-generating-station>

Boren, R. (1997, Sept. 20). Lake Powell fight makes waves. Retrieved on August 4, 2019, from <https://www.deseretnews.com/article/584207/Lake-Powell-fight-makes-waves.html>

Thompson, J. (2017, Feb. 14). 7 things you need to know about Navajo Generating Station's 2019 closure. Retrieved on August 4, 2019, from <https://www.hcn.org/articles/the-west-s-coal-giant-is-going-down>

Revisions to the Source-Specific Federal Implementation Plan for Navajo Generating Station, Navajo Nation (2018, Nov. 9) Retrieved on August 4, 2019 from <https://www.federalregister.gov/documents/2018/11/09/2018-24482/revisions-to-the-source-specific-federal-implementation-plan-for-navajo-generating-station-navajo>

Hoover, J., Gonzales, M., Shuey, C., Barney, Y., & Lewis, J. (2017). Elevated Arsenic and Uranium Concentrations in Unregulated Water Sources on the Navajo Nation, USA. *Exposure & health*, 9(2), 113–124. doi:10.1007/s12403-016-0226-6

Gildden, Z. (2017, Oct. 5). Science, service and a STAR school bus. Retrieved on August 5, 2019, from http://www.jackcentral.org/features/science-service-and-a-star-school-bus/article_64a7110c-a886-11e7-b005-871deb5592ec.html

Ravisankar, V., Seaman, R., Mirchandani, S., Arnold, R., & Ela, W. (2016). Solar-driven membrane distillation demonstration in Leupp, Arizona. *Reviews on Environmental Health*, 31(1), 79-83.

Horoshko, S. (2011, June 1) Living with the legacy of uranium on the Navajo Nation. Retrieved August 5, 2019, from <https://fourcornersfreepress.com/living-with-the-legacy-of-uranium-on-the-navajo-nation/>

LM Sites on Navajo Nation Navajo Nation Land (2018). Retrieved August 5, 2019, from <https://www.energy.gov/sites/prod/files/2019/05/f62/2018NavajoNationBrochure20180619.pdf>

Sacred Land Film Project. San Francisco peaks. Retrieved October 10, 2019, from <https://sacredland.org/san-francisco-peaks-united-states/#:~:text=The%20San%20Francisco%20Peaks%20are,collect%20herbs%20for%20healing%20ceremonies.>

Appendix: Interview with H R, July 2019

J.A. You work for the Navajo Nation covering what areas?

H.R. I work for the Navajo Nation Department of Water Resources. We have a field office in Leupp, Arizona. We cover four chapter areas in the Western Agency. The Chapters we cover are Leupp, Birdsprings, Tolani Lake and Coalmine. We work all the way north to Navajo Mountain and west over toward the Cameron area, South to the reservation border and east to Dilkon. We are under the Executive branch of the Navajo Tribal Government, so the President of the Navajo Nation is our boss and he can send us to work wherever he needs us to go.

We only work on water for livestock and irrigation water for farms. We don't work with public drinking water anymore. In the past we had several domestic water systems, but they have been upgraded and then turned over to Navajo Tribal Utility Authority (N.T.U.A.). N.T.U.A has their laboratory in Fort Defiance, Arizona, and they do all of the water sample testing for drinking water. We take our water samples over to them for testing.

J.A. Do you test the water used for livestock?

H.R. We only test it one time when they first drill a new well on trust land. We don't test water on private wells.

J.A. Are there drinking water standards for livestock?

H.R. Yes. The standards for water for livestock have higher parts per million (P.P.M.) than the standards for human drinking water. Animals can handle higher P.P.M. in particulates.

J.A. I understand sometimes people on the reservation drink water from the livestock wells, or even unregulated wells. Are there any signs to warn them that they do not meet human drinking standards?

H.R. People drank and still drink water from windmills and dug wells or from natural springs. There are signs on water tanks, springs and dug wells that usually say "Livestock water only. Do not drink." In Grand Falls, Cameron, Tuba City and towards Page there are some wells that are contaminated with uranium. These wells were tested by the Indian Health Service and they posted signs on them to warn people not to drink water from those wells.

There are wells that people dug themselves, or they developed natural springs to obtain water. We don't test any of those wells. People can drill their own wells on their home site lease, but we also don't test water on those private wells. In the Eastern Agency in New Mexico, people live on checkerboard lands and we don't work on those lands either. Some of that is leased out as private land.

J.A. Do the livestock ever get sick from the livestock wells?

H.R. There are hardly any cases where livestock has gotten sick from drinking windmill or natural spring water. If a water source is suspected to be bad, the Indian Health Service comes out and takes a water sample to test.

J.A. How is the Department of Water Resource changing how they are providing water for the Navajo Nation?

H.R. The Navajo Nation has their own drilling department, but we have a lack of funds. Due to budget constraints, we have started to cost share with Natural Resources Conservation Services (NRCS), Bureau of Indian Affairs (BIA), Bureau of Reclamation (BOR) Indian Health Services (IHS), local Chapters and local ranchers and farmers. With these partners, we have been able to drill more wells, extend waterlines and convert windmills to solar pumping systems. The Navajo Nation has over 900 windmills on the reservation and over 1,300 natural springs and dug wells.

J.A. I've heard that there are experimental programs by Northern Arizona University (NAU) and University of Arizona (U of A) that are trying to help find ways the Navajo Nation can produce more clean water for their populace.

H.R. Another way the nation is changing is that we do experiments with outside companies and universities to work toward providing more water on the reservation with less PPM's. For example, the U of A and the Bureau of Reclamation chose a windmill north of Leupp to experiment to remove salt and lower the metal content from the well water. They were taking water from the windmill and then using long mirrors to provide heat to distill the water. Then they ran that distilled water back into a tank and mixed it with other water to put minerals back in. It was designed to provide a large amount of human drinking water.

After two years of experimenting there, they discontinued the project. We had already put in about twelve miles of waterlines from well 5T-529 going towards Gray Mountain to a 24,000 gallon tank in anticipation of water from the experiment, but well 5T-529 did not produce enough water for the waterline, so a year from now we are going to drill another well at 5T-529 instead. A recurring problem with grant money is that it runs out and the projects are discontinued.

J.A. People haul water now, don't they, either from regulated wells, unregulated wells or from nearby towns? That can be a hardship, can't it?

H.R. People haul water for drinking, for their animals and domestic use from unregulated wells all the time. People drive to towns, such as Flagstaff or Winslow to buy drinking water and a round trip can be over a hundred miles. Hauling water on washboard rez roads causes vehicles to take a beating.

Three years ago a pilot project was implemented by the U.S. Environmental Protection Agency under the Safe Drinking Water Act. They gave the Navajo Nation five 4,000 gallon water trucks. One of those trucks was assigned to the offices for the Navajo Western Agency. The water truck was hauling drinking water out of Tuba City to designated places where people met the truck and could obtain their drinking water. Twice a week they would load it up and it was taken to the

Grand Falls area where it was parked by the side of the road. The project went on for three years and then was phased out due to loss of funds for continued operation.

J.A. What is the water situation in Cameron like? They had a number of uranium mines at one time and their water was not safe to drink, but I understand they have a public water system now that is safe. Does anyone still drink the unregulated water out there?

H.R. The water in Cameron has uranium in it due to a lot of mining that went on in the past and due to just a lot of uranium present in the ground. A lot of iron is also present in the water. It makes the water red and corrosive to metal tanks and livestock water troughs. Cameron has safe drinking water now, but some people still drink unregulated water. The water can taste good even if it is not safe. People will say to you, "I've been drinking water from this windmill or spring all of my life and never got sick from it." There are signs on wells that are contaminated by uranium saying not to drink from these wells and springs.

J. A. Thank you for your insightful interview. The students will greatly appreciate the information.

H.R. I was glad to share that knowledge with our next generation.