

Saltwater Intrusion Lesson Plan

Students learn how saline coastal groundwater can contaminate freshwater aquifers.

Lesson Summary: Students will conduct salinity investigations on different water bodies throughout Orange County, Florida. They will use the information from their investigation to write reports to Orange County Government informing them on the quality of water in the different water bodies throughout the county.

Grade Level: High School (9th–12th)

Time Allotted: Three class periods of about 50 minutes each.

Performance Objectives

References are to the Next Generation Sunshine State Standards (2007).

Language Arts

LA.910.2.2.3: The student will organize information to show understanding or relationships among facts, ideas, and events (e.g., representing key points within text through charting, mapping, paraphrasing, summarizing, comparing, contrasting, or outlining).

LA.910.4.2.2: The student will record information and ideas from primary and/or secondary sources accurately and coherently, noting the validity and reliability of these sources and attributing sources of information.

Math

MA.912.S.1.2 Determine appropriate and consistent standards of measurement for the data to be collected in a survey or experiment.

MA.912.S.3.1 Read and interpret data presented in various formats. Determine whether data is presented in appropriate format, and identify possible corrections. Formats to include: bar graphs, line graphs, stem and leaf plots, circle graphs, histograms, box and whisker plots, scatter plots, and cumulative frequency (ogive) graphs.

MA.912.S.3.2 Collect, organize, and analyze data sets, determine the best format for the data and present visual summaries from the following: bar graphs, line graphs, stem and leaf plots, circle graphs, histograms, box and whisker plots, scatter plots, and cumulative frequency (ogive) graphs.

Science

SC.912.N.1.1 Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following: 1) pose questions about the natural world; 2) conduct systematic observations; 3) examine books and other sources of information to see what is already known; 4) review what is known in light of empirical evidence; 5) plan investigations; 6) use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of

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data, including data tables and graphs); 7) pose answers, explanations, or descriptions of events; 8) generate explanations that explicate or describe natural phenomena (inferences); 9) use appropriate evidence and reasoning to justify these explanations to others; 10) communicate results of scientific investigations; and 11) evaluate the merits of the explanations produced by others.

Social Studies

- SS.912.G.1.3 Employ applicable units of measurement and scale to solve simple locational problems using maps and globes.
- SS.912.G.1.4 Analyze geographic information from a variety of sources including primary sources, atlases, computer, and digital sources, Geographic Information Systems (GIS), and a broad variety of maps.
- SS.912.G.3.3 Use geographic terms and tools to explain differing perspectives on the use of renewable and non-renewable resources in Florida, the United States, and the world.

Prior Knowledge

- Ability to graph points on a graph with x and y axes.
- Basic understanding of latitude and longitude.
- Ability to read and interpret maps.

Topic Overview: Saltwater intrusion can create many potential problems to the potable water supply of areas that are close to ocean. Saltwater intrusion occurs in coastal aquifers when saline ground water intrudes and contaminates a freshwater aquifer. Mixing occurs in the aquifer at the interface between fresh ground water and saline water. This mixing zone is referred to as the saltwater interface. The extent of saltwater intrusion, or the inland position of the saltwater interface, is highly dependent on freshwater levels within the aquifer. If water levels increase in the freshwater part of the aquifer, the interface can move seaward; however, if water levels decrease, the interface may move inland and pose a potential threat to municipal well fields. Movement of the interface is not instantaneous. Months, years, or decades may be required before the interface reaches equilibrium with surrounding water levels (Dausman and Langevin, 2005).

Students will examine hydrological data that measures the presence of chlorides in groundwater and is stored in the Water Atlas database. They will analyze that data to identify geographic patterns and temporal trends. They will investigate the source of their drinking water and use Water Atlas data to investigate its salinity. They will research the hydrogeology of the well providing their community with drinking water and investigate the types and scale of other uses of local groundwater sources.

Key Vocabulary

Aquifer

An underground geological layer (stratum), or group of layers, that holds water which can be fresh, brackish, or saline.

Climate

The long-term average of conditions in the atmosphere, ocean, and ice sheets and sea ice described by statistics, such as means and extremes.

Climate change

A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic (human-caused) changes in the composition of the atmosphere or in land use.

Confining unit

A layer of rock and clay that is impermeable to water and separates aquifers.

Floridan aquifer

One of the highest-producing aquifers in the world, the Floridan Aquifer is found throughout the state and extends into the southern portions of Alabama, Georgia, and South Carolina. The upper Floridan aquifer is the principal source of water supply in most of north and central Florida.

Hydrology

The science of the behavior of water as it occurs in the atmosphere, on the surface of the ground, and underground.

Intermediate aquifers

Layers of water between the surficial aquifer and the deeper Floridan aquifer; the depth and composition of intermediate aquifers throughout Florida is highly variable and in many places nonexistent.

Salinity

The relative concentration of salts, usually sodium chloride, in a given water sample. The salinity of surface water can be assessed by measuring its conductivity; the higher the concentration of salts in the water, the better it will conduct electricity. The salinity of groundwater is more often assessed by measuring the presence of chloride.

Saltwater intrusion

The process by which saltwater moves, laterally or vertically, into surface or groundwater. Salt water underlies all Florida's freshwater supplies, but the fresh water floats because it is lighter.

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Surficial aquifer

The layer of underground water that is closest to the surface of the earth.

Materials

- Computer with internet access
- Google Earth software (optional; free download)
- Map of Orange County with lat/long coordinates marked
- Graph paper (optional; can be used if map or Google Earth is not available)
- Spreadsheet software (Microsoft Excel or equivalent)
- Presentation software (optional)
- Science notebook

References

The following references are found in the [Digital Library](#) of the Orange County Water Atlas:

- Dausman, Alyssa and Christian D. Langevin. 2005. [Movement of the Saltwater Interface in the Surficial Aquifer System in Response to Hydrologic Stresses and Water-Management Practices, Broward County, Florida](#). U.S. Geological Survey.
- Phelps, G.G. and Donna M. Schiffer. 1996. [Geohydrology and Potential for Upward Movement of Saline Water in the Cocoa Well Field, East Orange County, Florida](#). U.S. Geological Survey.
- Schiffer, Donna M. 1998. [Hydrology of Central Florida Lakes: A Primer](#). U.S. Geological Survey.
- Barlow, Paul M. et al. 2000. [Ground-water Resources for the Future: Atlantic Coastal Zone](#). U.S. Geological Survey.
- Other references:
- Adamski, James C., and Edward R. German. 2004. [Hydrogeology and Quality of Ground Water in Orange County, Florida](#) (Water-Resources Investigations Report 03-4257). U.S. Geological Survey [Aquifer Basics: Floridan Aquifer System](#). U.S. Geology Survey.
- [Aquifers](#). Center for Aquatic and Invasive Plants, University of Florida Institute of Food and Agricultural Sciences.
- Cook, John. [Skeptical Science: Getting Skeptical About Global Warming Skepticism](#). Website. Accessed June 2011.
- [Intergovernmental Panel on Climate Change](#). Website. Accessed June 2011.
- [Power Up Florida](#) (Orlando/Orange County web portal to sites for electrical efficiency, solar usage, electric vehicles, clean technology, Climate Change Education Center, etc.). Accessed July 2011.

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Shoemaker, W. Barclay. 2003. [Important Observations and Parameters for a Salt Water Intrusion Model](#). Florida Integrated Science Center, U.S. Geological Survey.

[Source Water Assessment and Protection Program \(SWAPP\)](#). Florida Department of Environmental Protection.

Stanton, Elizabeth K., and Frank Ackerman. [Florida and Climate Change: The Cost of Inaction](#). 2007. Tufts University Global Development and Environment Institute and Stockholm Environment Institute—US Center.

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Procedure

Engage/Elicit

Engage the class in a discussion about ground water. Questions for discussion:

1. Where does most of our drinking water come from in Florida?
2. What do you know about underground water? What is an aquifer? How many aquifers does Florida have? Which is the largest?
3. Do you think we will have enough potable water in the future? What are our options for getting more water? What are the advantages and disadvantages of each option?
4. What physical features, properties and processes keep fresh and salt water separated underground?
5. How might climate change increases contribute to an increase in the salinity of our ground water?
6. What other natural processes or human activities might contribute to increases in the salinity of groundwater?
7. What kinds of tests do scientists use to determine the salinity of groundwater?

If any of the questions remain unanswered by the class, or if they have other unanswered questions, write them down for students to investigate as they complete the remainder of the lesson.

Explore

Guide students to the Orange County Water Atlas [Data Download](#) tool. Have them follow the steps below to retrieve measurements of chloride concentration in groundwater samples:

- Step 1: Select **Groundwater Water Quality**
- Step 2: Select these filters: **Water Atlas, Date Range, Parameter**
- Step 3: Filter the data to include samples of **chloride (total and dissolved)**, in **Orange County**, for the previous **10 years**.
- Step 4: Choose **Give me all station data**
- Step 5: Download the data, and save it on your computer.

Open the file you saved, using a spreadsheet program like Microsoft Excel. Sort and filter the data on different columns. What observations can you make about it? Does the amount of chloride vary significantly over time? What about from station to station? What units are used to measure chloride concentration? Can you tell at what depth each measurement was taken? Why would that be important? Which of the other columns are important? Which ones can you ignore? Which ones require further explanation?

Optional: Return to Step 4. Choose **Give me all station data**, but make a graph of the data instead of downloading it. Why is the resulting graph misleading?

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Explain

Have students collaborate in small groups (3-4 students) to analyze the data:

1. Where in Orange County is each monitoring station located? Using a map of Orange County, Google Earth, or graph paper, mark the location of each station using the coordinates in the data table.
2. Do high-salinity stations occur in groups? Plot some representative data points on your map to help you decide.
3. What might account for the high salinity measurements? How could you test your hypotheses?
4. Which monitoring stations are closest to the Atlantic Ocean? Are their salinities higher?

Extend

Divide students into groups. Assign each group one of the following questions:

1. Where does the water you drink come from? Research the question and find the geographic location of the well (or wells) that supply your drinking water.
2. Use the Data Download tool on the Orange County Water Atlas to graph the chloride level of groundwater at the nearest sampling point to “your” well. Instead of just ten years, download all available data. Is there a trend? Is salinity increasing, decreasing, or staying the same? Make a graph of the data and write a paragraph that interprets its meaning.
3. How much water is being pumped from your well? How many people/households receive water from that well? Is that more or less than average?
4. What is the hydrogeology at the site of your well? Which aquifer(s) are being tapped? Do intermediate aquifer(s) occur there?
5. Besides residential use, what other kinds of “permitted” groundwater use occur near you? Who regulates these uses? About how much water do they consume?
6. What questions remain unanswered from your original class discussion? What resources could help you find the answers?

Exchange/Evaluate

Have each group of students share the results of their investigations with the rest of the class, using maps, charts, graphs and diagrams as appropriate.

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