Lesson: Understanding the Relationship between snowpack and water supply

Grade Levels: 3-5

Purpose:
Students will understand how and why snow pack is measured and stage experiments to forecast streamflow.

Materials:
- Videos 1-5 and worksheets on snowpack
- Graph of snow indexes on 11”x17” paper
- 6 clear water bottles
- Blue food coloring
- Tape measure or yard sticks
- Worksheet: Running A Farm

Vocabulary:
- Acre-foot
- Condensation
- Evaporation
- Infiltration
- Precipitation
- Runoff
- Terminal Lake
- Tributary

Background Agricultural Connections:
In the Western U.S. most of our precipitation falls during the winter, however, most of our water usage occurs in the summer when farmers grow crops and homeowners water lawns. In most areas of the Western U.S. snow measurements are made by the Natural Resources Conservation Service each winter. Snow measurements are made either by using snow tubes or by electronic weather stations called SNOTEL sites. These snow measurements are used to predict how much water will fill rivers in the summer. When there is little snow an area experiences too little water (drought). If more than normal snowpack exist it is more likely that rivers could flood in the springtime when the snow melts. This activity introduces two ways that snow is measured and then uses past year’s snow measurements and streamflow volumes, to predict how much water will flow in a river this year. This lesson is based on data from the Truckee River Watershed near Reno, Nevada. The same kind of lesson could be adapted to other areas. Contact your state’s snow survey staff for help picking a SNOTEL site and river near your location.
http://www.wcc.nrcs.usda.gov/contact/index.html

A refresher on the water cycle and the terms evaporation, condensation, precipitation, runoff and infiltration would be helpful prior to this lesson. At the end of water cycle refresher, discuss how the water cycle in Nevada is different from other parts of the country. There are two main differences:
1. Most of the precipitation that falls in Nevada never goes to the ocean. The Truckee River ends its flow at Pyramid Lake. In other parts of Nevada, other watersheds also go to terminal lakes or playas. Only water coming to Nevada from the Colorado River near Las Vegas has any chance of making it to the ocean.

2. The only way water leaves most of Nevada is by evaporation or transpiration from plants. That is why Pyramid Lake and Walker Lake are salty tasting. The salt is left behind when water evaporates. The salt comes from the water passing through soils and dissolving minerals. Playas also have salts on the surface for the same reason.

Interest Approach:
Show the video series on snowpack. If time is limited, videos 1, 2 and 3 are most relevant to this lesson.

In this series of five short videos, Noah interviews his father, Jeff Anderson, who is a hydrologist with the Natural Resources Conservation Service (NRCS), an agency of the United States Department of Agriculture (USDA). This video series talks about measuring snow to determine how much water will be available for us to use.

View videos online at
https://www.youtube.com/playlist?list=PLGdlCTs4dQTdFThAVQn_yZYcp_8ZMbTLf

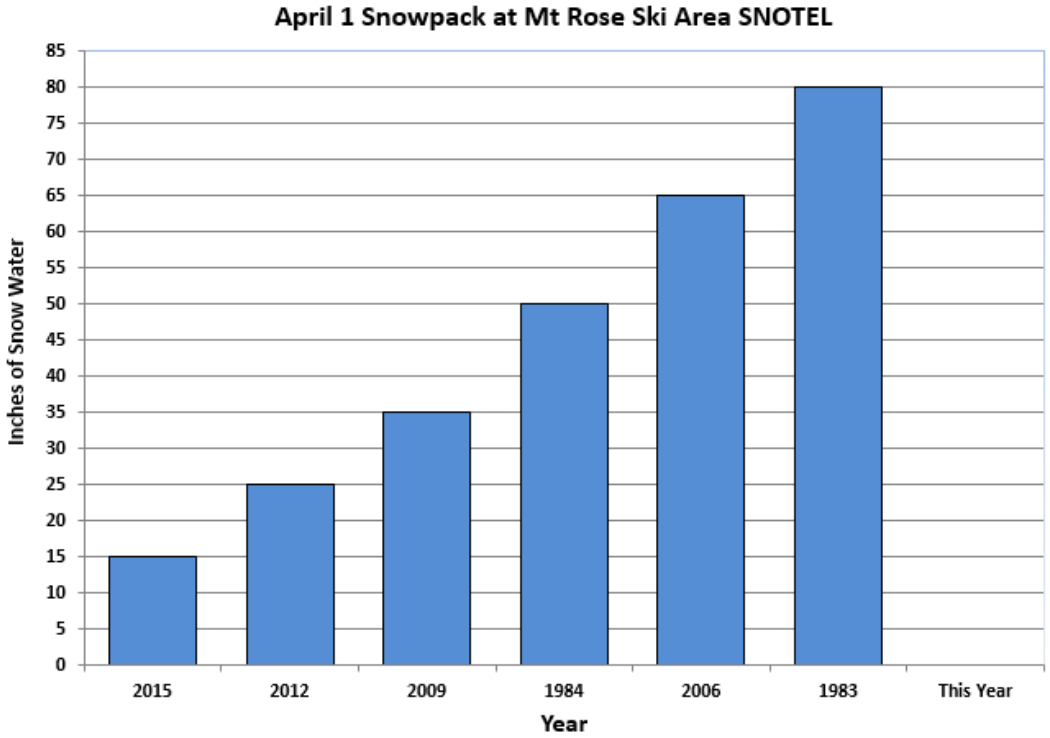
Video 1: Why we measure snow (1:50)
Video 2: How do we measure snow with snow tubes (1:42)
Video 3: How SNOTEL weather stations measure snow (1:59)
Video 4: Dr. Church, the father of snow surveying (1:34)
Video 5: What is a hydrologist? (1:58)

Procedures:

Activity 1: Measuring the Snowpack

Introduce the snowpack graph showing how much water was in the snowpack on April 1 at the Mt. Rose Ski Area SNOTEL measurement site over a period of years. The graph is distributed to show years with low snow water equivalent, which could represent a period of drought, up to years of large snow water equivalent, representing years with a big winter.

Graph 1:



Inquire what they can infer by reading the chart or graph? (shows how many inches of water that would be on the ground at this SNOTEL sites if the snow was instantaneously melted into liquid water, Data was collected on April 1 annually, the data is measured in inches, data was collected from the SNOTEL site at MT. Rose Ski area in Washoe County).
Prompting questions:

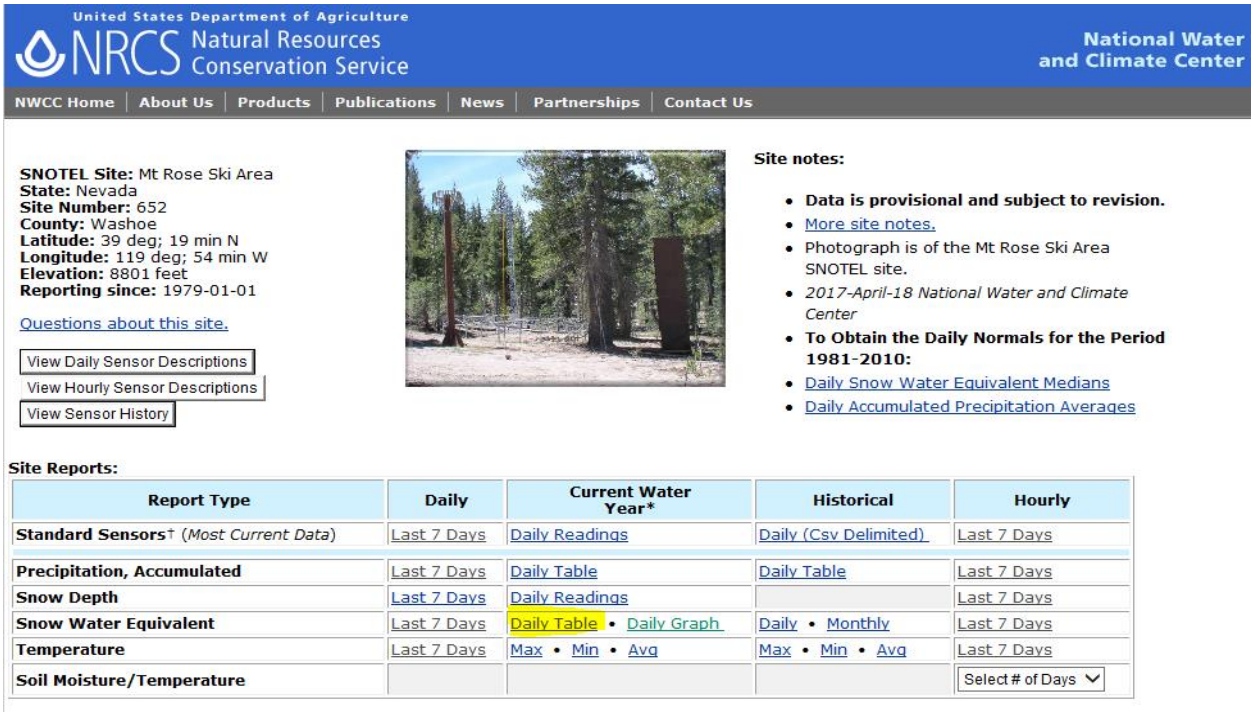
- Why would the hydrologist be interested in comparing snowpack on April 1st?
  A: The amount of water in the snowpack often reaches its peak amount near April 1 just as snow starts to melt.
- What year had the most amount of snowpack?
- What year had the least amount of snowpack?
- What was the snowpack in _____ (pick a year)?
- What year had about ___ (pick an amount) inches of snow water fall?
- Do you see any trends in the data? What do we call a number of years of low precipitation? A: Drought
- How much water is ___ (pick amounts from data) inches? (Demonstrate with tape measure or yard sticks.)

If you want to expand the data points available, use the link below for the class to look up other years.

1. Visit https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=652&state=NV

2. Click on the hyperlink "Daily Table" (highlighted in yellow below) for snow water equipvalent.
3. To expand to previous years, click on the drop-down menu "Time Period" and enter the parameters desired. Period of record provides data points starting in 1981 or enter a custom start and end date.
4. Once you have the current year or previous years data for April 1 snow water amount draw a bar of the correct height on the graph to represent the current year, compared to the other years. Discuss where this year would fit into the other years. Is this year a drought, about normal or a big snow year?

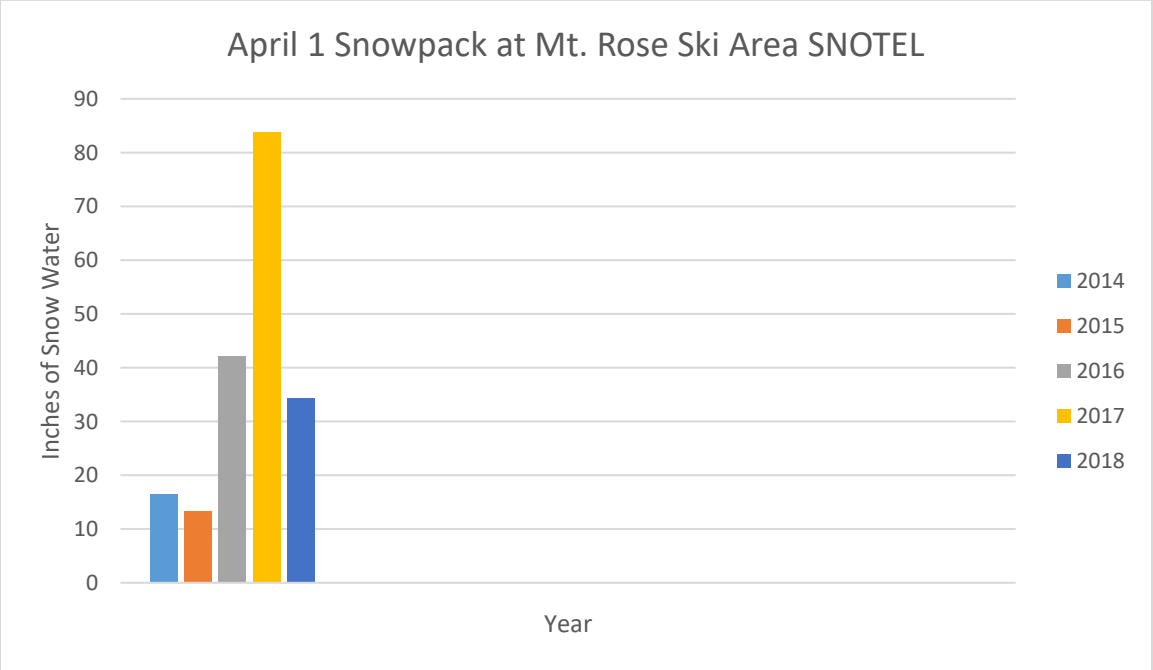
https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=652&state=NV



Examples of Resulting data charts for students to graph.

Mt Rose Ski Area (652)
Nevada SNOTEL Site - 8801 ft
Reporting Frequency: Daily; Date Range: 2012-01-01 to 2018-05-01
As of: Fri Aug 31 16:10:55 GMT-08:00 2018)
Provisional data, subject to revision

Date	Snow Water Equivalent (in) Start of Day Values
2012-04-01	24.3
2013-04-01	30.5
2014-04-01	16.5
2015-04-01	13.3
2016-04-01	42.1
2017-04-01	83.7
2018-04-01	34.3



Activity 2: Measuring stream flow

Prepare 6 bottles to represent streamflow in each of 6 years shown in the chart below. Proportionally fill bottles with the amount of water for each year based on the table. Add blue food coloring to make it easier to distinguish the levels. On the top of the bottle write the year and the streamflow volume with KAF, for thousand acre-feet, after it.

Chart 1:

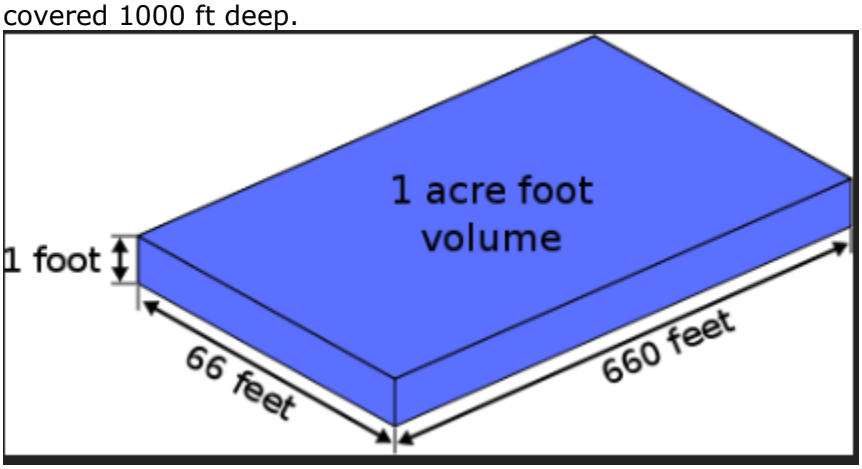
Year	Truckee River near Farad Streamflow Volume from April 1 - July 31 in thousand acre-feet (KAF)
2015	40 KAF
2012	150 KAF
2009	200 KAF
1984	300 KAF
2006	450 KAF
1983	675 KAF
This Year	

Introduce the water bottles to students.
These bottles represent how much water flowed down the Truckee River through Reno from April-July for each of the years we looked at on graph 1. Tributaries from Mt. Rose, where this SNOTEL site is located feed into Washoe Lake and Lake Tahoe.

- Why are we looking at April-July time frame? (That is when the snow is melting and directly feeding the river)
- What year had the most streamflow?
- What year had the least streamflow?

How is streamflow measured?
The bottles show an actual volume of water in thousand acre-feet abbreviated as KAF, i.e. kilo-acre-feet. The term "kilo" represents 1000. For example, a kilometer is 1000 meters.

Visualizing thousand acre-foot (KAF)
1 acre-ft = a big cube of water that is equivalent to 1 football field covered 1 ft deep with water
So, 1000 acre-ft = 1 KAF = 1000 football fields covered 1 ft deep (or) 1 football field covered 1000 ft deep.



Connecting snowpack to streamflow
Line the bottles of water up in front of the graph 1.

- Is there a relationship between snowpack and streamflow? Line the bottles up in front of snow graph 1 to show more snow equals more streamflow.
- Can we predict or forecast how much streamflow should come this year? Based on what you see with the graph and the bottles come up with a volume that fits with the other bottles.
- Why is knowing how much water will flow down the river this year helpful? (it helps water managers know if there is a drought or extra water, it helps farmers plan what crops to grow or how many acres of land they can plant, it helps people know if they need to conserve water when watering their lawns.)

Activity 3: Running A Farm

- Discuss with students what happens to the water as it continues to flow through streams and rivers (goes to the ocean, goes to terminal lakes).
- Discuss how that water is utilized as it flows downstream (recreation, wildlife, drinking water).
- Focus discussion on how some of it may be diverted for food and agriculture production. Discuss that farmers also utilize groundwater and rainwater for plant growth. In Nevada, due to our low precipitation, farmers must make choices about what crops they will plant based on the amount of water they will receive.
- Each farm has water rights. Water rights are a specified amount of water that the owner is to receive each year. In Nevada, the oldest farms have senior water rights so they are more likely to get their water, even when there is a drought. However, they still only get the amount of water their rights indicate, no more.
- Pass out **Student Worksheet: Running A Farm** to each student and task them with selecting crops/plants to grow within their water rights.

- Review Running a farm with students.
    - What crops required the most water? Would you be able to plant all 10 acres in _____(pick high water crop) with your 15-acre feet in water rights?
    - How many inches did a lawn need per acre? Where do we see lots of lawn (homes, schools, parks, etc.)? What is the purpose for lawns in all those places (a nice location to play, fields for playing sports, greenspace/beauty)? If we wanted to reduce the amount of water we use, what could we do with lawn that wasn't used for recreation? (Discuss how removing lawn and planting native plants and utilizing the space to grow small sections of food would use less water).
    - Discuss how water is only one of the things farmers have to consider when selecting which crop to plant. Farming is a business and farmers have to sell their crops or animals at a price above the production cost to make a profit. For example, if you choose a crop because it doesn't require as much water, but there's no one willing to buy the crop you will go out of business.

Enriching Activities

- The weight of water: Which weighs more, frozen or liquid water? It weighs the same. When snow exists in your area, fill a bowl. Cover with plastic wrap to prevent evaporation. Weigh bowl of snow. Let the bowl melt and reweigh the bowl. The weight should be the same. Prompt conversation around change of states, change in level of bowl filled with snow vs. liquid water and why the difference.
- Evaporation & Salt: Dissolve a teaspoon of salt into a glass of water. Pour into tin pie pan and let sit for a few days until water evaporates. Have students observe salt in the pan. In Nevada, salts are an issue for farmers because it accumulates in fields which makes it difficult to grow crops. Additionally, salty groundwater cannot be used to water crops.
- Adapt portions of the lesson plan Shaved Ice or Snow Water Equivalent for grades 6-12 from Southern Sierra Critical Zone Observatory. Have students perform their own snow measurement survey and apply some of the math skills that Mr. Anderson uses in his job. https://eng.ucmerced.edu/czo/E_O_resources/Shaved_ice_SWE.pdf

Vocabulary

Acre-foot: A unit of volume equal to the amount of water that would cover one acre (43,560 square feet) to a depth of one foot.

Condensation:

1. Water which collects as droplets on a cold surface when humid air is in contact with it.
2. The conversion of a vapor or gas to a liquid.

Evaporation: The process of turning from liquid into vapor.

Infiltration: The process by which water enters the ground. As water on the surface permeates into the ground, this is known as infiltration.

Precipitation: Rain, snow, sleet, or hail that falls to the ground.

Runoff: An overflow of rainfall or snowmelt that is not absorbed by the soil or vegetation.

Terminal Lake: A terminal lake is one in which the rivers that flow into the lake end or terminate at the lake. They do not flow out of the lake anywhere.

Tributary: A stream feeding into a larger stream, or lake.

Educational Standards Addressed

Nevada Academic Content Science Standards/Next Generation Science Standards
4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.

5-PS1-2 Measure and graph quantities to provide evidence that regardless of the type of change that
occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Nevada Academic Content Social Studies Standards
SS.4.24. Examine how and why Nevada's landscape has been impacted by humans.

SS.4.25. Analyze how technological changes have impacted the environment and economy of Nevada.

National Agricultural Literacy Outcomes
T1.3-5b Explain how the interaction of the sun, soil, water, and weather in plant and animal growth impacts agricultural production.

T1.3-5e Recognize the natural resources used in agricultural practices to produce food, feed, clothing, landscaping plants and fuel.

T4.3-5b Describe how technology helps farmers/ranchers increase their outputs (yields) with fewer inputs (less water) while using the same amount of space.

T4.3-5d Provide examples of science being applied in farming for food, clothing, and shelter products.

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