PROBLEM BASED LEARNING
EDUCATING FOR SUSTAINABILITY.

SNOWPACK COLLECTION

Harvesting Rainwater for Water Supply

Created by Jeff Burgard and Issaquah School District
Middle School Earth Science

This collection was funded through the Washington State Legislature Clime Time Proviso.

CLIME TIME
CLIMATE SCIENCE LEARNING

PHOTO SOURCE: Sustainability Ambassadors, Tom Reese, WSDOT

PROBLEM STATEMENT

With a shrinking snowpack and big changes coming in the seasonal patterns of our water cycle, what are the issues and opportunities related to harvesting rainwater from the roof design of the buildings where we live, go to school, or shop?

SUMMARY

Students will understand the pros and cons of harvesting rainwater, and apply what they learn by designing a building for net zero water use. Building types may range from a single family home, a multi-family complex, a school, or a commercial building.

Math concepts in precipitation rates, surface area, and storage capacity will be applied in assessing the balance of water demand and water availability over a 12-month period of time. This mathematical analysis will include an understanding of the changing dynamics of our local water cycle due to climate change, more rain in the winter when we don't need it but could capture and store it, less rain in the summer when we do need it but could draw on our storage systems if engineered correctly.

Students will research and analyze a range of case studies, diagrams and descriptions, and apply the engineering design process in developing their model. Using an economic lens, students will consider the cost/benefit ratio of several options including: (1) developing technologies to be more efficient with the water we do have, (2) building new regional facilities like dams, water purification plants and underground pipes, and (3) harvesting and storing rainwater at a local level, building by building. Rainwater harvesting can be part of the solution as we mitigate for snowpack losses in the coming decades.

Learning Objectives

1. **I can apply systems thinking to build connections between my personal experience and the range of current and expected local impacts from climate change.**
2. **I can explain the basic science behind projected climate impacts in our bioregion and the need for water storage.**
3. **I can use my science knowledge to develop a plan for rainwater harvesting for my home, apartment building, school, or a commercial building to address the water storage needs of its occupants.**

Formative Assessment

Menu of possibilities...

1. Discussion notes from personal or team learning. Where do we get our water? Is future water supply a problem in the Pacific Northwest?
2. An initial model of rain harvesting engineering and associated math.
3. Talking points on local climate change science and related impacts.

Summative Assessment

Students design a building with a rainwater harvesting system for net zero water use and calculations related to (1) water efficiency strategies, (2) building consumption needs, and (3) total water collected for their region based on annual rainfall.

ACADEMIC STANDARDS

NGSS: MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per capita consumption of natural resources impact Earth's systems.

Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy)

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Examples of technologies can be global or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts)

BIG PICTURE

NGSS Global Climate Change

NGSS Human Sustainability Standards

OSPI Environmental Sustainability Standards

OSPI Social Studies Standards

College, Career, and Civic Life (C3)

Common Core State Standards

COMMUNITY CONTEXT

My family's sustainable practices

My Neighborhood Association

Nonprofits focused on this issue

My School and School District

My City Climate Action Plan

My City Equity Strategy

My County Climate Action Plan

My County Equity Strategy

My Energy and Water Utility

My Waste, Recycling, Compost Company

Watershed Salmon Recovery Plan

Puget Sound Regional Council

Puget Sound Vital Signs

Washington Dept of Ecology

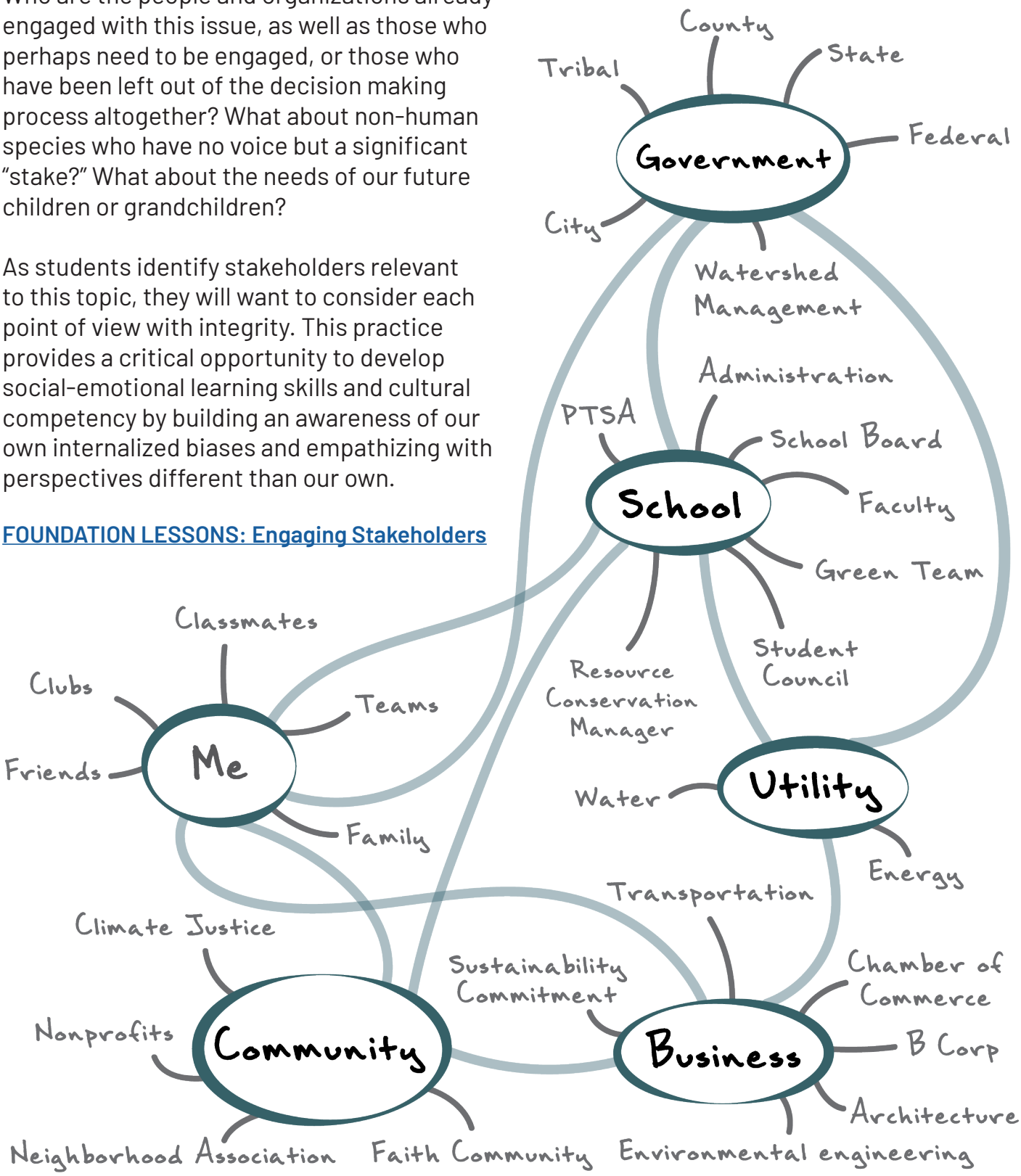
Tribal Treaty Rights

Stakeholders

Who are the people and organizations already engaged with this issue, as well as those who perhaps need to be engaged, or those who have been left out of the decision making process altogether? What about non-human species who have no voice but a significant "stake?" What about the needs of our future children or grandchildren?

As students identify stakeholders relevant to this topic, they will want to consider each point of view with integrity. This practice provides a critical opportunity to develop social-emotional learning skills and cultural competency by building an awareness of our own internalized biases and empathizing with perspectives different than our own.

FOUNDATION LESSONS: Engaging Stakeholders



BACKGROUND
We Depend on Snowpack

We have built our economy, here in the Pacifc Northwest, around the assumption of a sustained snowpack. **Our snowpack is shrinking** due to human-caused climate change.

Get the latest science from the University of Washington **Climate Impacts Group.**

Study the **Climate Change infographics series** from King County.

We depend on snowpack. Over the last hundred years, we have constructed dams across a number of our cascade alpine cannons to hold water in huge man-made reservoirs that serve the water supply needs of millions of people. In our region it rains a lot, especially at the higher elevations. This rain can be captured and held in our system of reservoirs.

What is not known by most people, is that we have been depending on a certain depth of snowpack each year to serve as a **second, natural reservoir** of water... **A frozen one**. This is important, because as we enter the summer months with little or no rainfall until October, our reservoirs would be drained by the water consumption demands of millions of people if not for our snowpack. The snow that packs down through the long winter will **slowly melt through the summer.** We count on this phenomena to supplement and sustain water levels in our reservoirs. We drink snow in August.

But with a shrinking snowpack over the next several decades, water resource managers, policy makers, and each of us within our own families, schools, and cities, need to make critical decisions about how to conserve water right now.

The same amount of precipitation. Part of this strange new reality is that we will actually have the same amount of annual precipitation. The water cycle will continue to lift vapor from Puget Sound and the Pacfic Ocean and drop it across the landscape. But the science points to a much different annual pattern.

We can expect **much more rain in the winter** (when we don't need it) along with bigger storm events, which can cause flooding and mudslides. And we can expect **much less rain in the summer** (when we do need it) which can lead to droughts, forest fires, parched streams for salmon, and dangerous heat waves for humans. We will experience the same total amount of precipitation. It's just that, as each decade continues to bring warmer temperatures, less of this precipitation will be held in the form of snow. Diminished snowpack throughout the winter means diminished water supply late in the summer.

At the same time that we are grappling with how to adapt to our shrinking snowpack, we will need a **thousand good ideas** for how to slow, stabilize, and reverse the effects of climate change. This will take a century or more. It is critical to understand the science and make wise decisions together at all scales right now. We are all stakeholders in this challenge.

SNOTEL stations. Water resource managers carefully monitor our snowpack by analyzing daily and weekly data reports from a series of remote sensing SNOTEL stations built on ridgelines throughout the Cascades. The Natural Resource Conservation Service manages a Snow Survey Program that provides "mountain snowpack data and streamflow forecasts for the western United States. Common applications of snow survey products include water supply management, flood control, climate modeling, recreation, and conservation planning."

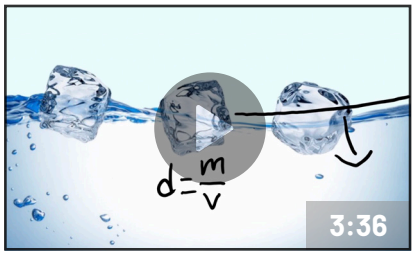
The Washington Snow Survey website includes **snow survey data, products, and reports** that students can use to understand the science and math behind the need to monitor our snowpack and make critical decisions for the current season as well as 10-30 years out.

Inquiries Across the Curriculum

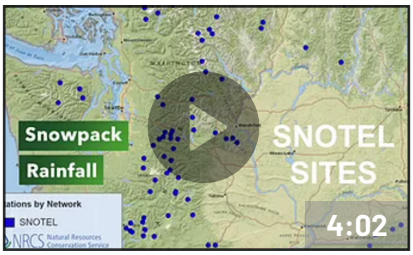
To understand more about the breadth and depth of curricular concepts using snowpack as catalyst, explore a rich set of additional inquiries.

Youth-voiced tutorials

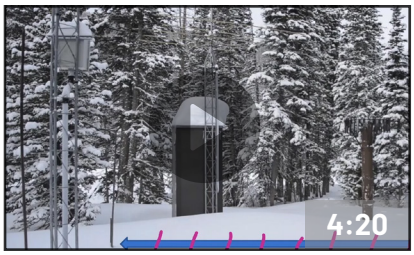
For additional support, student teams with Sustainability Ambassadors have researched and produced a series of short videos on snowpack issues. All of these videos are voiced by students.



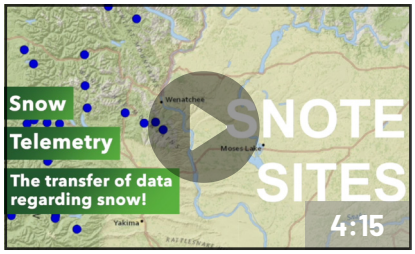
What is Snow Water Equivalent?
Harini Baskar



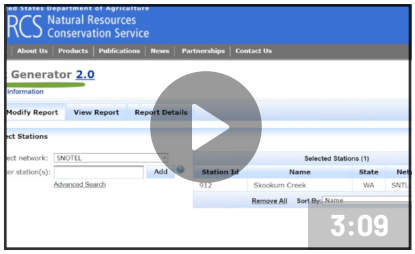
Introduction to SNOTEL
Rishi Hazra



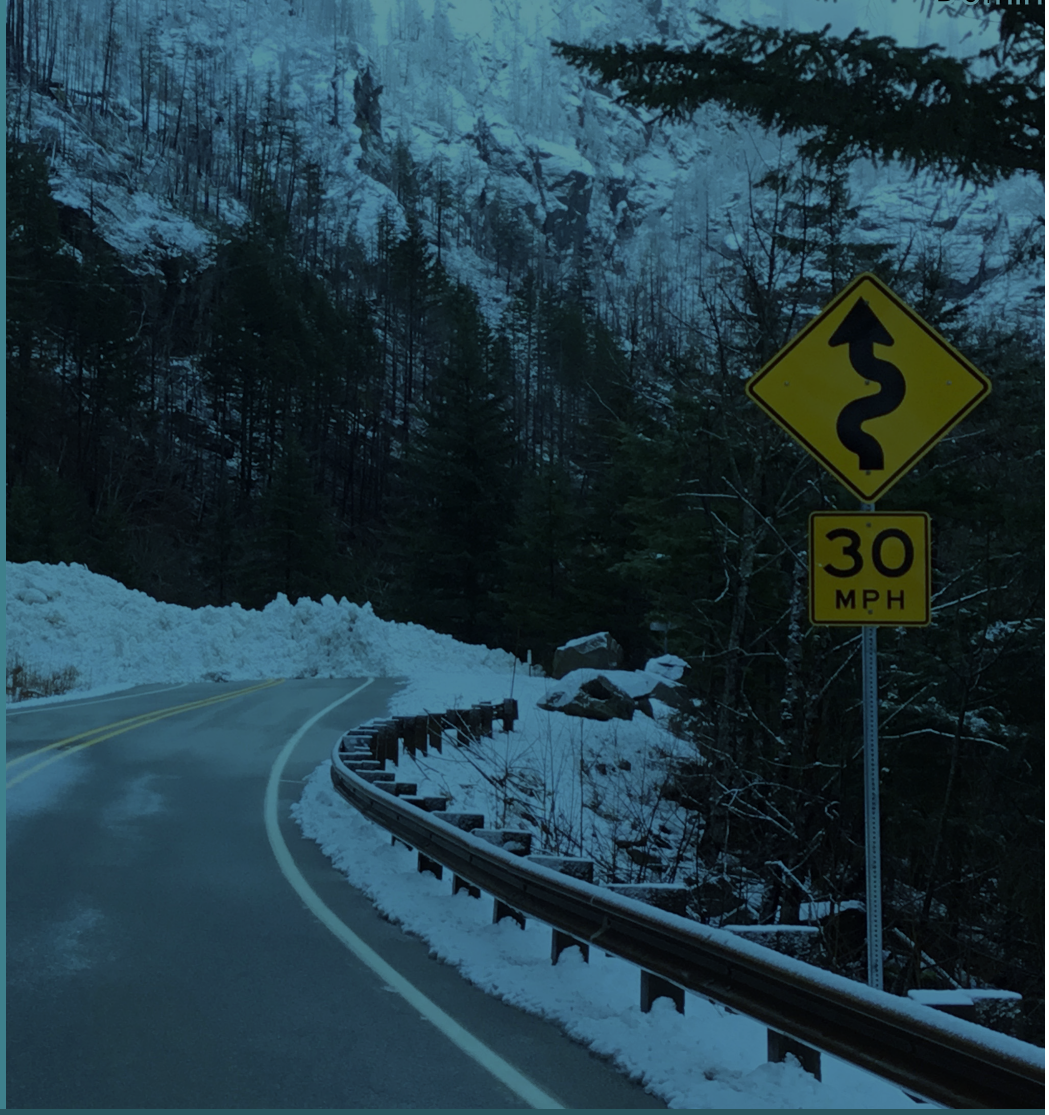
How do SNOTEL Sites Work?
Santoshi Pisupati



Locate Your SNOTEL Station
Rishi Hazra



Generating SNOTEL Data Reports
Rishi Hazra



LESSON OUTLINE

Materials Needed
Internet Access

Time Needed
1-3 class periods

ENTRY EVENT

Where do we get our water?

Organize students in groups and begin class with this question. "Where do we get most of our water?" Allow them to discuss this question for a minute or so getting ready to present their ideas.

Have one person from each group share their ideas, listening non-judgmentally and repeating back what they have said. Invite students to repeat what other groups have said if they have no other ideas.

Challenge students by asking additional questions such as "If we get our water from rain, what do we do when it stops raining in the summer" Where would we store it? Would it be clean enough to drink?

Show the image of Howard Hanson Dam and Reservoir in a normal year. Tell students that this is "one of the reservoirs that we catch water in during the winter for use during the summer, but it is not enough to get us through without another source. We need the water stored frozen in the snow (show Snowpack picture) that melts slowly to keep the reservoir full as we move into the summer. Review Snowpack Background Information in this lesson.

Activity 1

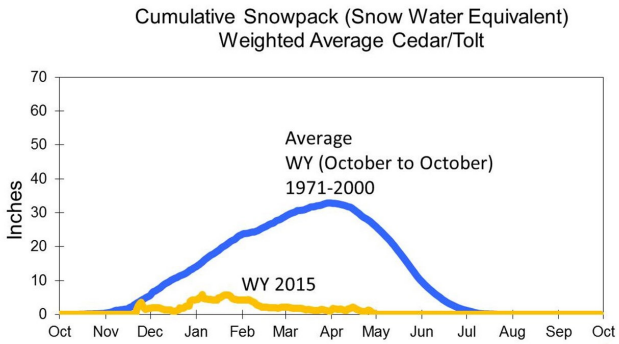
Analyzing SNOTEL Data

Go to your local SNOTEL station as a class, or share the data from the site. See youth-voiced video: How to Locate Your Local SNOTEL Station. Students can analyze comparative data on snowpack year-to-year, explore other reports, or try generating their own reports from the SNOTEL site. See youth-voiced video: Generating SNOTEL Data Reports, For further guidance see the full SNOWPACK LESSONS: How to Analyze SNOTEL Data.

Share with students that warming temperatures due to climate change is resulting in less snowpack, so our water storage capacity supply is shrinking even though we get just as much total annual precipitation.

In 2015 we had a very low snowpack year and got dangerously low on water. This graph shows the snow water equivalent data from the year 2015 compared to the 30-year average which is what climatologists use to study the longer patterns of climate versus weather.
Get the Graph

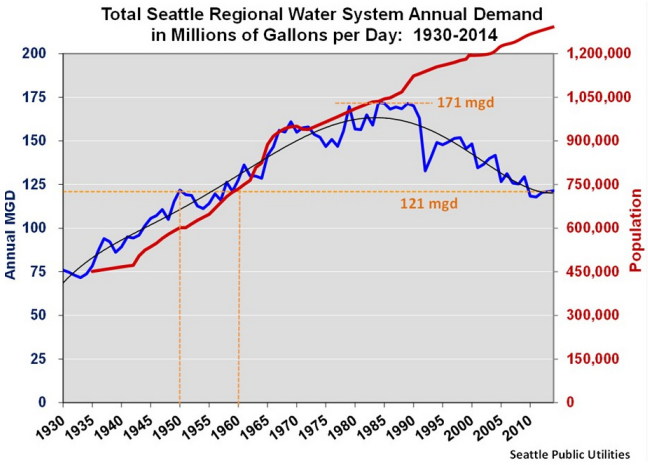
At the same time, our population is increasing. So, as a region, we need to find ways to conserve water and store more of the rain that falls where we live. More dams are ecologically and economically prohibitive, so what do we do? Have students brainstorm and share ideas.



Activity 2

Conservation efforts so far

Conservation efforts implemented have been working so far. But will our current conservation efforts be enough to deal with the future water availability with a shrinking snowpack? Will we need more storage? Show the Water use graph image and have students tell the story of the graph. See youth-voiced video: Coolest Graph Ever on Water Conservation.



Activity 3

Can we harvest the rain?

Show the video: Rainwater Harvesting. *(Although this is a promotional video for a specific technology, it is a good summary on how all rainwater harvesting works.)*

Analyze the case study presented in this video produced by Sustainability Ambassadors: Rainwater Harvesting - Stone 34 Case Study

How does this six story office building in Seattle harvest rainwater? See this youth-voiced video: Net Zero Water - Bullitt Center Case Study

A few engineering design questions:

How much water do we need?

How much can be gathered?

What size should our storage system be?

Provide students with the Website: Rain Harvesting Calculator or the following formula for calculating the number of gallons that can be collected during weather events or over rainy seasons.

Rain Harvesting Formula

Roof Area (ft2) X Precipitation Amount (in) X 0.623 = number of gallons collected)

Activity 4

Math Story Problems

Have students practice calculating the amount of water that can be collected with the following scenarios/ events and roof sizes.

A storm that drops 0.5 inches of rain on a building with a roof size of 1,700 sq ft (the average residential roof size)

If you live in an apartment try this... A storm that drops 0.5 inches of rain on a building with a roof size of 58,600 sq ft (the average roof size of an apartment complex)

A storm that drops 1 inch of rain in 24 hours on a building with a roof size of 1,430 sq ft

A storm that drops 2 inches of rain over a week-long storm on a big box store in a shopping mall near you with a roof size of 240,000 sq ft

Find your city's average rainfall and use 1,700 sq. ft for the average roof size to see what the average house in your city could collect. (You can use the Seattle weather blog if needed.)

Activity 5

Could it work at our school?

Show the specific examples of it working on schools with Rainwater Harvesting System - Valley View Middle School, Snohomish School District, and Hood River Middle School - Science and Music Building

If it is possible to find the roof size of your school and the annual water use of your school, use the Rain Harvesting Formula to determine if collecting rainwater over the course of a water year could supply your school's needs.

Tip: *Write a professional email to your school Head Custodian or School District Facilities Manager and get the actual roof size of your school.*

Activity 6

How much potential is there in our neighborhood?

Challenge students to try the same exercise for a shopping center or big box store near where they live. Combine this calculation with the potential for rain harvesting at your school, plus 500 homes (or so) in the neighborhood as students define it. Notice how much potential for rain harvesting we have in our neighborhood. Is this the future?

Activity 7

Jigsaw Case Studies

Divide students into expert groups to study the strategies used in at least two of the case studies presented below. Advanced students may also want to do an internet search using keywords such as ***"school rainwater harvesting."***

Valley View Middle School, Snohomish School District

Hood River Middle School - Science and Music Building

Rainwater Harvesting - Stone 34 Case Study

Living Building Challenge - Water Petal

Net Zero Water - Bullitt Center Case Study

Rainwater Harvesting System

Greywater System

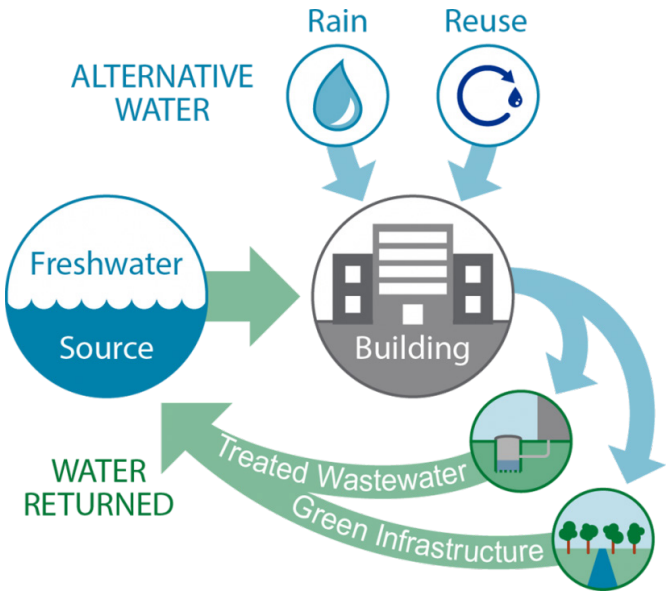
Composting Toilets

Activity 8

Design Considerations for a Net Zero Water Building

If we combine rainwater harvesting with wastewater recycling and stormwater management, how far can we go towards designing a building that uses its own "rain budget " over the course of a year? Can we design a **Net Zero Water Building?**

For excellent engineering background on this whole systems approach, have students work in small discussion groups to identify the most useful principles and design considerations for a Net Zero Water Building. Notice that this very helpful website on water conservation has been developed by the US Department of Energy. What is the relationship between **energy use and water use?**



Activity 9

Impact Project

Share with students the following Infographics for engineering a Net Zero Water Building.

DESIGN SCENARIO 1:
An Ideal Net Zero Water Building

DESIGN SCENARIO 2:
Mainstream Zero Water Building

Have them choose a building type in their community to design a rainwater harvesting system for such as a house, apartment complex, school, or commercial building.

To support students in communicating their design solutions to stakeholders who need to know, from family members to district facilities managers, see Foundation Lesson - Engaging Stakeholders.

For additional guidance see
Foundation Lesson - Impact Project Design

Additional Student Impact Project Ideas

What Impact projects could students design to **Fix Leaks at Home?**

What Impact projects could students design to improve **Direct Water Conservation?**

What Impact projects could students design to improve **Virtual Water Conservation?**

How can the classroom as a whole reduce their **Water Footprint?**

ACKNOWLEDGEMENTS

Thank you to our **Washington State Legislature for funding the ClimeTime Proviso.** Your investment in climate science education is vital for engaging the next generation in applied learning for a sustainable future that benefits everyone. We thank you for your vision and commitment.

Thank you **Cascade Water Alliance** for supporting student and teacher research on SNOTEL data analysis as a foundational understanding for water resource management decision making. And for supporting the original design of the PBL Curriculum Design Lab and Teacher Fellows Program.

Thank you **King County WaterWorks Grant Program** for supporting additional partnership building and curriculum design related to water quality.

About Sustainability Ambassadors

Sustainability Ambassadors is a professional development program for student leaders, teacher leaders and community leaders committed to rapidly advance a sustainable future by aligning classroom rigor with community relevance for real world impact.

We support a year-round training program for over 60 highly motivated youth, a paid Equity Advocacy Internship, a Green Jobs Youth Pathways Portal, and a Teacher Fellows Program, working with hundreds of educators to design new models of problem-based, place-based learning around a shared vision of ***educating for sustainability.***

We focus on middle school and high school youth, the teachers and school districts that guide their learning, and the community stakeholders, local government and business leaders who are relying on the next generation to be engaged voters, informed taxpayers, conscious consumers, and employees who can create and lead sustainability initiatives.

Visit: https://www.sustainabilityambassadors.org/