Land & Water Unit Revision

Pairs with STC Land and Water Kit

Grade 4

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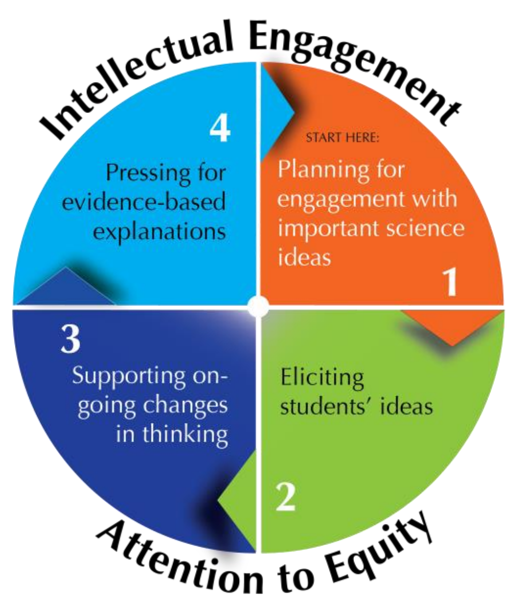
Students investigate a phenomenon of the March 2014 Oso landslide in Washington State. Readings and videos support students in making sense of data they collect during hands-on kit investigations about cause-and-effect relationships between water and land. Throughout the unit, students have multiple opportunities to create and revise their own scientific models about the Oso landslide in light of evidence they collect from activities. Ultimately, the model and explanation students create is to explain how and why the Oso landslide occurred; however, knowing the big science ideas behind this system allows students to explain multiple related events, including smaller scale events in their local community.

Ambitious Science Teaching Framework



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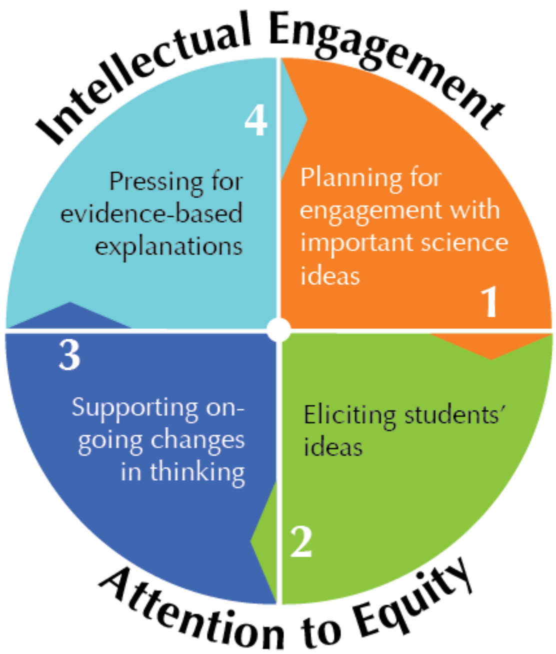
Ambitious Science Teaching

We provide here a vision of ambitious teaching—teaching that is effective, rigorous and equitable. But more than that, we provide a framework of research-based teaching practices that are consistent with this vision and a wide range of tools that can transform how students learn in your classroom. The vision, practice, and tools will furnish a common language about teaching for a group of science educators committed to the improvement of teaching. You will be able to identify "what we will get better at" and how to get started.



Ambitious teaching aims to support students of all racial, ethnic, and social class backgrounds in deeply understanding science ideas, participating in the talk of the discipline, and solving authentic problems. This teaching comes to life through four sets of teaching practices that are used together during units of instruction. These practices are powerful for several reasons. They have consistently been shown through research to support student engagement and learning. They can each be used regularly with any kind of science topic. And finally, because there are only four sets of practices, we can develop tools that help both teachers and students participate in them, anyone familiar with the practices can provide feedback to other educators working with the same basic repertoire, teachers can create productive variations of the practices, and everyone in the science education community can share a common language about the continual improvement of teaching.

The four Ambitious and Equitable Science Teaching Practices are summarized in the below.

Practices	What does it LOOK like?
Planning for engagement with important science ideas	• Planning a unit that connects a topic to a phenomena that it explains (Chemical Reactions – Bike Rusting, Photosynthesis – Seed Becoming a Tree) • Teaching a topic within a real-world context
Eliciting students' ideas	• Asking students to explain HOW and WHY they think a phenomena happens (How did the bike change? Why did it change? What is happening at the unobservable level?)
Supporting on-going changes in thinking	• Using ALL activities/lessons to explain the phenomena. • Giving students opportunities to revise their thinking based on what they're learning
Pressing for evidence-based explanations	• Allowing students to create a final model or explanation about the phenomena • Pressing students to connect evidence to their explanation

Many teachers want to know what their classrooms should look like and sound like—they want to understand how to interact with their students about science ideas and students' ideas. This is especially true now that the *Next Generation Science Standards* are being used in many states.
As a result of the last 30 years of classroom research, we know enough about effective instruction to describe in clear terms what kinds of teaching practices have been associated with student engagement and learning. This research tells us that there are many ways that teachers can design and implement effective instruction, but that there are common underlying characteristics to all these examples of teaching that can be analyzed, described, and learned by professionals. These practices embody a new form of "adaptive expertise" that EVERY science educator can work towards. Expert teaching can become the norm, not reserved for a select few. Ambitious teaching is framed in terms of practices that any teacher can learn and get better at over time. What would we see if we entered classroom of a science educator using ambitious teaching? To give you a sense of what ambitious teaching looks like, we have described below some features common to all science classrooms where ambitious teaching is being implemented (listed on right). These features address everyday problems with learning and engagement that teachers face (listed on left).

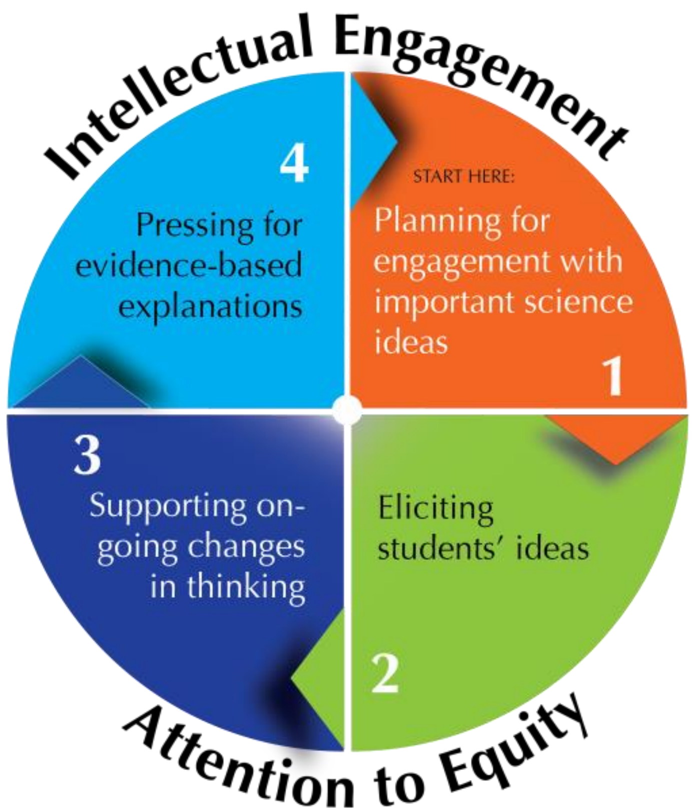
Common problems in supporting student engagement and learning	What you'd see in a science classroom where ambitious teaching is the aim
The problem: *Students don't see how science ideas fit together.* Each day is perceived by students to be the exploration of ideas that are unconnected with previous concepts and experiences.	At the beginning of the unit, students are focused on developing an evidence-based explanation for a complex event, or process. Students know that throughout unit, most of the activities, readings and conversations will contribute to this explanation.
The problem: *An oversimplified view of what it means "to know."* Science ideas perceived to be straightforward and learnable within a lesson—either you get it or you don't."	An idea is never taught once and for all, but revisited multiple times. Students' science explanations are treated as partial understandings that have to be revisited over time to become more refined and coherent.
The problem: *Lack of student engagement.* Students' experiences and interests not elicited or seen as relevant. Student ideas treated as "correct" or "incorrect."	Students' ideas and everyday experiences are elicited and treated as resources for reasoning; students' partial understandings are honored as a place to start. They are made public and built upon.
The problem: *Students reluctant to participate in science conversations.* Teachers dominate the talk, ask primarily for right answers, get brief responses from students.	Teachers use a varied repertoire of discourse moves to facilitate student talk. Guides and scaffolds for talk help students feel comfortable interacting with peers.
The problem: *Some students have little support for accomplishing tasks that would otherwise be within their grasp.* Little or no guidance for students' intellectual work. Giving "clear directions" is seen as enough to ensure participation in activities.	There is scaffolding that allows students to participate in science-specific forms of talk, in group work, and in science practices.
The problem: *Invisibility of student ideas and reasoning.* Teacher does not know what students think—their heads are a black box. Cannot then work on students' ideas. Students cannot take advantage of the ideas or ways of reasoning by their peers.	Students' thinking made visible through various public representations (tentative science models, lists of hypotheses, question they have, etc.). The teacher can see how students think and how that thinking could change over time. Students benefit from seeing and hearing the reasoning of others.
The problem: *Illusion of rigor.* Students reproduce textbook explanations, lean on vocabulary as a substitute for understanding. Talk of evidence and claims are rare.	The teacher presses for complete, gapless explanations for unique real-life events or processes, and press for the use of evidence to support claims.

As you will see, ambitious teaching is not a "method," and the teaching practices are not scripts. It is a set of principled practices that must be adapted to your classroom needs. Coaches and other teachers can work with you to do this ambitious work.

Curriculum Guide

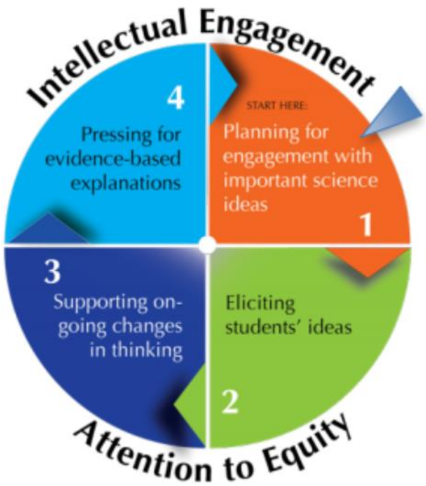
Lessons & Activity Guides

Ambitious Science Teaching Framework



This curriculum guide follows the four core teaching practices of the Ambitious Science Teaching Framework. This model-based inquiry approach to science teaching leverages students' existing personal experiences and current understanding about causal mechanisms in their world to revise their own explanations of specific, contextualized scientific phenomena.

Planning for Engagement with Important Ideas



In the Framework for Ambitious Science Teaching, the first phase in any unit of instruction is planning. Only when teachers understand where they are going in the unit can they begin to design instruction. One goal of this planning practice is to support teachers in moving from topics towards relationships between science ideas which can explain multiple real-world phenomena.

This section provides teachers with some general science background around the content goals for this unit as well as an explanation for a specific regional phenomenon for this unit — the March 2014 landslide in Oso, Washington. It also suggests ways teachers can identify related phenomenon in their local contexts explained by the same science ideas to help students see this science in their communities.

Unit Goals

This earth science unit focuses on Earth processes that change the landscape over time. Students will combine some or all of the following ideas to explain one or more real-world phenomena.

- Rainfall and water helps to shape the land found in a region; Water, ice, wind, organisms, and gravity break rocks, soils, and sediments into smaller pieces and move them around.
- Changes to Earth's physical features occur in patterns; Patterns in rock formations and layers of the earth reveal changes over time due ot earth forces and natural events. Maps and photographs can be used to locate features and determine patterns.
- Natural hazards can result from natural processes; Humans can take steps to reduce impacts of natural hazards.

Put another way:

If students understand…	Then, students can explain…
…how water, ice, wind, organisms, and gravity weather rocks into smller pieces and move them to new places.	…why earth's physical landforms are currently changinging in predictable patterns through weathering and erosion.
…why earth's physical landforms are currently changinging in predictable patterns through weathering and erosion.	…what happened long ago by interpreting layers of soil and rock formations.
…what happened long ago by interpreting layers of soil and rock formations AND why earth's physical landforms are currently changinging in predictable patterns through weathering and erosion.	…a variety of design solutions intended to reduce the impact of natural hazards related to weathering and erosion.

Next Generation Science Standards

4th Grade Land & Water Unit

The perfomance expectations and related dimensions below are from the Next Generation science standards. For more detailed descriptions of the standards visit http://nextgenscience.org.

Students who demonstrate understanding can…

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [*Assessment Boundary: Assessment is limited to a single form of weathering or erosion.*]

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features. [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

4-ESS1-1. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. [Clarification Statement: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and, a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.] [*Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.*]

4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* [Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [*Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.*]

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CC)
Planning and Carrying Out Investigations - Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1) ***Analyzing and Interpreting Data*** - Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2) ***Constructing Explanations and Designing Solutions*** • Identify the evidence that supports particular points in an explanation. (4-ESS1-1) • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2)	***ESS1.C: The History of Planet Earth*** - Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (4-ESS1-1) ***ESS2.A: Earth Materials and Systems*** - Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1) ***ESS2.B: Plate Tectonics and Large-Scale System Interactions*** - The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2) ***ESS2.E: Biogeology*** - Living things affect the physical characteristics of their regions. (4-ESS2-1) ***ESS3.B: Natural Hazards*** - A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2) ***ETS1.B: Designing Solutions to Engineering Problems*** - Testing a solution involves investigating how well it performs under a range of likely conditions.*(secondary to 4-ESS3-2)*	***Patterns*** - Patterns can be used as evidence to support an explanation. (4-ESS1-1),(4-ESS2-2) ***Cause and Effect*** - Cause and effect relationships are routinely identified, tested, and used to explain change. (4- ESS2-1),(4-ESS3-2) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Engineering, Technology, and Science on Society and the Natural World** • Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2) - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes consistent patterns in natural systems. (4-ESS1-1)

Next Generation Science Standards

Disciplinary Core Idea Progressions K-12 for DCIs featured in this unit

The performance progression for DCIs K-12 are from the Next Generation science standards. For more detailed descriptions of learning progressions and/or Diciplinary Core Ideas, visit http://nextgenscience.org.

DCI	K-2	3-5	6-8	9-12
ESS1.C The history of planet Earth	Some events on Earth occur very quickly; others can occur very slowly.	Certain features on Earth can be used to order events that have occurred in a landscape.	Rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth's history.	The rock record resulting from tectonic and other geoscience processes as well as objects from the solar system can provide evidence of Earth's early history and the relative ages of major geologic formations.
ESS2.A Earth materials and systems	Wind and water change the shape of the land.	Four major Earth systems interact. Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, organisms, and gravity break rocks, soils, and sediments into smaller pieces and move them around	Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources. Plate tectonics is one result of these processes.	Feedback effects exist within and among Earth's systems.
ESS2.B Plate tectonics and large-scale system interactions	Maps show where things are located. One can map the shapes and kinds of land and water in any area	Earth's physical features occur in patterns, as do earthquakes and volcanoes. Maps can be used to locate features and determine patterns in those events.	Plate tectonics is the unifying theory that explains movements of rocks at Earth's surface and geological history. Maps are used to display evidence of plate movement.	Radioactive decay within Earth's interior contributes to thermal convection in the mantle
ESS3.B Natural hazards	In a region, some kinds of severe weather are more likely than others. Forecasts allow communities to prepare for severe weather.	A variety of hazards result from natural processes; humans cannot eliminate hazards but can reduce their impacts	Mapping the history of natural hazards in a region and understanding related geological forces.	Natural hazards and other geological events have shaped the course of human history at local, regional, and global scales.
ESS3.C Human impacts on Earth systems	Things people do can affect the environment but they can make choices to reduce their impacts.	Societal activities have had major effects on the land, ocean, atmosphere, and even outer space. Societal activities can also help protect Earth's resources and environments.	Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things. Activities and technologies can be engineered to reduce people's impacts on Earth.	Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies.

Teacher Background Knowledge

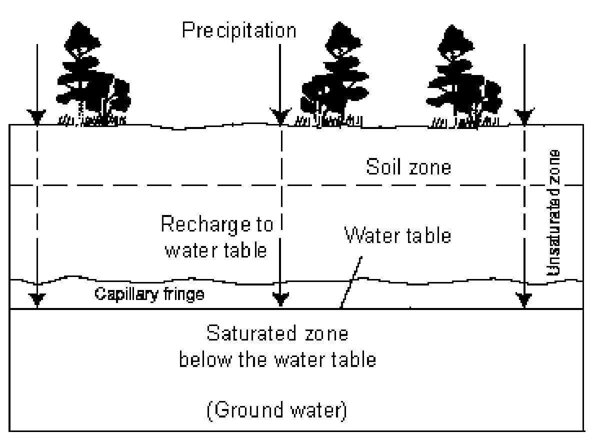
This section provides science content knowledge and explanations to explain the general phenomenon of how water affects land and explains a specific regional phenomenon: the Oso landslide, for Washington State. The last part of the section provides information from *A Framework for K-12 Science Education* describing knowledge corresponding to each Disciplinary Core Idea featured in this unit.

I. General Science Background - How water affects the land

A. *Hydrosphere – The world of water*

Information for this section from: http://www.geography4kids.com/ and http://water.usgs.gov/edu/watercyclesummary.html

Earth's water is always in movement and is always changing states, from liquid to vapor to ice and back again, cycling for billions of years. The sun heats water in the oceans and other places. Some of it evaporates as vapor into the air. Rising air currents take the vapor up into the atmosphere along with water transpired from plants and evaporated from the soil. The vapor rises into the air where cooler temperatures cause it to condense into clouds. Air currents move clouds around the globe, and cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snow packs in warmer climates often thaw and melt when spring arrives, and melted water flows overland. Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with streamflow moving water towards the oceans. Runoff, and groundwater seepage, accumulate and are stored as freshwater in lakes. Not all runoff flows into rivers, though. Much of it soaks into the ground. Some of the water infiltrates into the ground and replenishes aquifers, which store huge amounts of freshwater for long periods of time. Some groundwater stays close to the land surface and can seep back into surface-water bodies and the ocean as groundwater discharge, and some groundwater finds openings in the land surface and emerges as freshwater springs. Yet more groundwater is absorbed by plant roots. Over time, though, all of this water keeps moving.



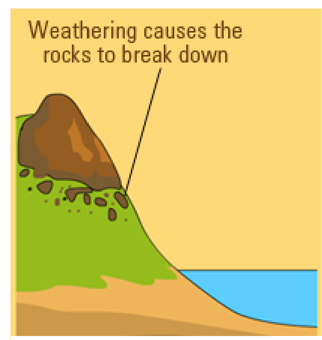
More on groundwater. Groundwater starts on the surface. When it rains and the water moves through the soil, it's called infiltration. There are spaces between the dirt and rocks that allow the water to flow through. (Different soil types have different porosities.) Eventually the water makes it to rocks where scientists say it percolates deeper into the Earth. Under the soil layer, the zone of saturation has very small spaces between the rocks. The spaces are so small they may even be the size of large molecules. When the water can go no deeper (because of impermeable rock layer), it creates an aquifer. An aquifer is an underground reservoir inside the rocks. Pollution seeps into the groundwater. Buried waste and landfills all let hazardous material seep into the groundwater. It happens naturally when water drains through the waste and seeps into the land. Eventually the groundwater will return to normal through natural filtration processes, but it will take several decades.

More on runoff. When rain hits saturated or impervious ground it begins to flow overland downhill. It is easy to see if it flows down your driveway to the curb and into a storm sewer, but it is harder to notice it flowing overland in a natural setting. During a heavy rain, water will flow along channels as it moves into larger creeks, streams, and rivers. As with all aspects of the water cycle, the interaction between precipitation and surface runoff varies according to time and geography. Similar storms occurring in the Amazon jungle and in the desert southwest of the United States will produce different surface-runoff effects. Surface runoff is affected by both meteorological factors and the physical geology and topography of the land. Only about a third of the precipitation that falls over land runs off into streams and rivers and is returned to the oceans. The other two-thirds is evaporated, transpired, or soaks into groundwater. Surface runoff can also be diverted by humans for their own uses.

- Effects of Urban Development on Floods, USGS Fact Sheet 076-03
- USGS: Surface-water data for the Nation
- USGS: Real-time streamflow data
- USGS: Surface-water information

B. *What is weathering?*

Information for this section from: www.kidsgeo.com/geology



http://pixgood.com/weathering-and-erosion-of-rocks.html

Weathering takes place as rocks are broken down into progressively smaller pieces. A large chunk of bedrock many hundreds of feet long is broken down into smaller and smaller pieces, until finally there are many tens of thousands of small rocks. Often rocks are broken down so much that they become part of the soil.

Forces of weathering. Water is an important force that greatly effects weathering, but it is not the only force. Other forces include the atmosphere, and plant and animal life. Plant roots, microscopic animals and plants, and digging animals also help to break down rocks. To better understand the different forces that cause weathering, geologists separate them into three categories. These categories are mechanical, chemical, and biotic.

a. **Mechanical Weathering**. Mechanical weathering takes place when rocks are broken down by physical force, rather than by chemical breakdown. The forces that break rocks can be numerous, and include such things as pent up energy as the Earth's crust slowly moves. When great amounts of pressure build up, the resulting mechanical effect can be that very large joints, or faults are created.

i. **Frost wedging**. In liquid form, water is able to penetrate the many holes, joints, and fissures within a rock. As the temperature drops below 32 ° F, this water freezes. As water freezes, it expands, becoming about 9-10% larger than it was in liquid form. The result is that the holes and cracks in rocks are pushed outward. Even the strongest rocks are no match for this force. As the water thaws, it is then able to penetrate further into the widened space, where it later freezes again. The expansion of holes and cracks is very slow. Month after month, year after year, water freezes and thaws over and over, creating larger holes and cracks in the rocks.

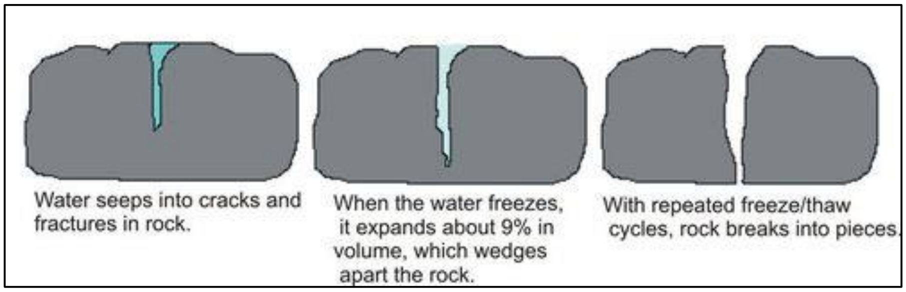


Image Source: http://www.ck12.org/user:richb/book/Earth-Science-for-St.-Marys-School-Aiken/section/5.2/

ii. **Salt wedging**. Another important type of mechanical weathering is salt wedging. As water enters the holes and cracks in the surface of rocks, it often carries salt with it. As the water later evaporates, the salt is left behind. Over time, these salt deposits build up, creating pressure that cause rocks to split.

iii. **Temperature**. As temperatures rise, rocks expand slightly. As temperatures cool, rocks contract slightly. The effect of expanding and contracting over time weakens rocks, eventually causing cracks.

b. **Chemical Weathering**. Chemical weathering takes place in almost all types of rocks. Smaller rocks are more susceptible, however, because they have a greater surface area. Chemical reactions break down the bonds holding the rocks together, causing them to fall apart into smaller and smaller pieces. Chemical weathering is more common in locations where there is a lot of water. This is because water is important to the chemical reactions that can take place. Warmer temperatures also speed up the rates of reactions. Warm and wet places have lots of chemical weathering.

c. **Biotic Weathering**. The word 'bio' means life. Thus biotic weathering is any type of weathering that is caused by living organisms. Most often the culprit of biotic weathering are plant roots. These roots can extend downward, deep into rock cracks in search of water, and nutrients. In the process they act as a wedge, widening and extending the cracks. Other causes of biotic weathering are digging animals, microscopic plants and animals, algae and fungi. Though plant roots do widen cracks and break rocks, roots are also good at holding onto soil and preventing erosion.

C. *What is erosion?*

Information for this section from: www.kidsgeo.com/geology

http://pixgood.com/weathering-and-erosion-of-rocks.html

Erosion takes place when materials in the landscape are moved from one location to another. This might happen as dust is blown off the side of a cliff face by wind, or as silt is carried downstream by a river.

Erosion due to gravity:

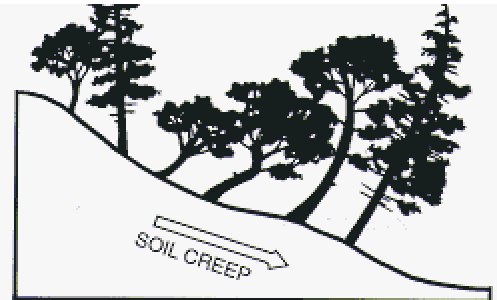
a. **Mass Wasting**. The power of gravity on Earth is inescapable. Gravity pulls a rock lower and lower towards the lowest surface possible. Rocks, dirt and soil lie on the side of a mountain or hill, apparently unmovable. For many hundreds or even thousands of years the rocks and dirt change very little. Over time, however, as small amounts of dirt and additional rocks are added to the pile, the weight and mass of the pile build up. Then, suddenly, the entire pile might move several hundred feet within only a couple of minutes or seconds, only to once again come to rest on the side of the mountain or hill, waiting for the next event.

b. **Rock falls**. The most common type of mass wasting is falling. Rocks, builders, pebbles, and dirt loosened by freezing, weathering, and other forces, simply fall downward, until they hit something that stops their descent. Often a pile of rocks forms at the bottom of a cliff or mountain. We call a pile of rocks, boulders, and dirt a talus. Often, taluses form a cone shape, as they ascend up the side of the mountain.

c. **Landslides**. Landslides take place when dirt, pebbles, rocks and boulders slide down a slope together. Sometimes these landslides are small, and hardly noticeable. Other times however, they can be substantial, involving the entire side of a mountain. These destructive slides can be triggered by a number of different causes. Often rain, which adds additional weight to the side of a slope can cause slides. Other times they might be caused by erosion, as the base of a slope is slowly removed by a stream, weakening the entire side of the mountain. As a slide progresses down a mountain slope, it can pick up tremendous speed, and energy. Some slides have been reported to travel at speeds approaching 200 miles per hour. The resulting winds can be so forceful, that they are known to strip the leaves off of surrounding trees. The momentum of falling material has been known to cause some of the materials to roll several hundred feet back up the other side of a valley. The amount of material moved in a landslide can be tremendous. In some cases this material is so substantial, that it is measured in cubic miles. This much material falling across a stream, can be the cause for the formation or a new natural lake.

d. **Flows**. Flows take place much more slowly than do slides, and usually involve great amounts of water. After a heavy rainstorm the ground can become too wet to absorb any additional water. The result is that the water is forced to run off on the surface, gathering dust, dirt, rocks, and in some cases even boulders as it builds up. The leading edge of a flow gathers the most debris, causing it to be thicker and slower moving. This acts as a slow moving dam. Eventually, such as in a wide area on a slope, the more liquid mud from behind breaks through the dam and rushes outward creating a muddy plain.

e. **Creeps**. The slowest type of mass wasting is referred to by geologists as a creep. The grass covered slope seems to ooze downhill forming little bulges in the soil. This heaving of the soil occurs in regions subjected to freeze-thaw conditions. The freeze lifts particles of soil and rocks (because water expands when it freezes) and when there is a thaw, the particles are set back down, but not in the same place as before. Gravity always causes the rocks and soil to settle just a little farther downslope than where they started from. This is the slow movement that defines creep. Creep can also be seen in areas that experience a constant alternation of wetting and drying periods which work in the same way as the freeze/thaw. Since the process is so slow, it can only be monitored in terms of flow over long periods of time. A creep takes place when the entire side of a hill or mountain moves downward under the weight of gravity, very slowly, usually much less than one inch per year. The rate of creep depends on the steepness of the slope, slope material and water absorption properties, and amount of vegetation. (Source: http://earthsci.org/flooding/unit3/u3-03-03.html)



Soil creep causes districtive curved form of tree trunks over time.

Illustration 5:
Indications of Soil Creep

: *http://www.ecy.wa.gov/programs/sea/pubs/93-31/chap2.html*

Erosion due to water

Many types of erosion described above are, at the core, caused by how water interacts with land causing the land to move. Here are ways water more directly moves soil and rocks.

a. **Rain**. As rain drops begin falling in a rain storm they are first absorbed by the landscape. As the ground becomes saturated, the drops begin moving across the landscape above the surface. As this happens, small amounts of dust and dirt are carried with the water. This is known as splash erosion. As more and more water falls, the sheet of moving water becomes larger and larger. Large amounts of rain that cannot be absorbed into the ground either because the ground is supersaturated from prior rains or the land has been altered by pavement or deforestation, this rainwater carrying particles of silt and sediment runs off downhill into streams and rivers.

b. **Streams & Rivers.** Because of their strength, streams and rivers can cause a great amount of erosion. Dirt and dust is carried away in the water of the river, leaving only pebbles and rocks. The rocks are constantly smacking into one another, as the force of the river moves them about. This causes them to be continually breaking into smaller and smaller pieces. Rivers have been known to carve deep canyons in the bedrock in only a few hundred thousand years (i.e. the Grand Canyon). As rivers carry dust, pebbles, and rocks downstream, this material is eventually deposited at some location further down. These deposits form at bends in a river, as well as in locations where rivers dump water into lakes, seas, and oceans. The effect of deposits is that new land is created using materials from other locations upstream.

D. How does land use affect infiltration and runoff?

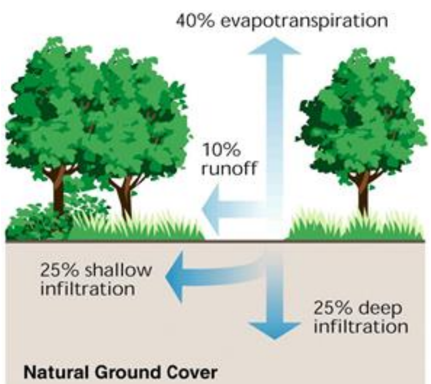
Information taken from: http://omp.gso.uri.edu/ompweb/doee/teacher/pdf/act10.pdf

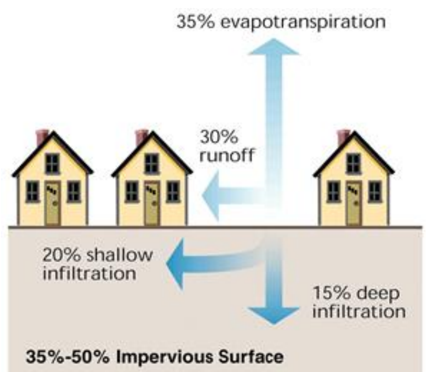
Changes how we use and change the land affects our watersheds. Water may flow in a different direction, more water reaches the rivers, lakes, and oceans, and the water gets to these bodies of water faster without sediments and pollutants being removed by slow infiltration into the soil. The amount of nutrients, sediments, and toxic materials from increased runoff and soil erosion can seriously harm ponds, streams, and groundwater resources. Infiltration is when water seeps into the soil and rock and recharges an aquifer. Currently, aquifers are being depleted due to the huge water demand of American industries, farms, and families.

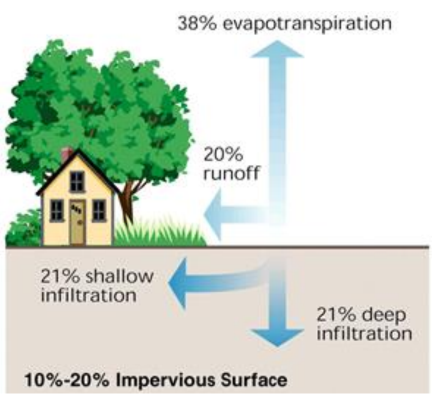
Forests have less runoff because leaves and trees slow down the rain before it hits the ground, giving plant root's time to absorb water and time for the water to soak into the earth. When land is paved or cleared for buildings, the vegetation is removed and the land is covered by blacktop or concrete. There is no longer any vegetation to slow down the rain hitting the ground and since the ground is covered, no water can soak into the soil. Instead, the water runs over the surface, often causing flooding and erosion. Our aquifers are also not being recharged with surface water as fast as they used to be.

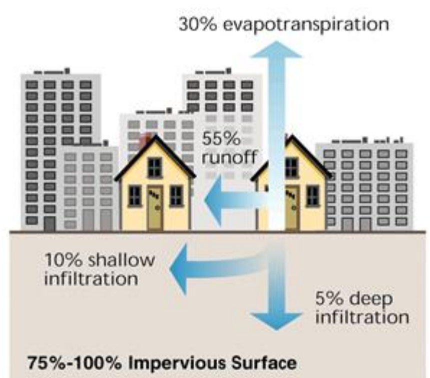
Rates of infiltration for various land uses
<---Greatest---Smallest--- >
forest > pasture > crop land > bare earth > buildings > pavement

Rates of runoff for various land uses
<-- -Greatest--Smallest--->
pavement > buildings > bare earth > crop land > pasture > forest









II. Puzzling Phenomenon – Oso Landslide, Oso, WA March 22, 2014

The scientific explanation of this regional phenomenon in Washington State requires an understanding of the key concepts for this unit identified from the Next Generation Science Standards. Though somewhat local, this landslide may or may not seem as relevant to students as something in their immediate school area or community. Other phenomena can be substituted as a focal phenomenon for the unit as long as they can be explained with the ideas targeted in the NGSS. If a different phenomenon is selected, be sure to do research and write out a scientific explanation for the phenomenon.

A. What happened?

- Watch news video clip here http://safeshare.tv/v/Cyb2sE0SUtg
- Watch a rock topple a few weeks after the major slide. This shows an insignificant amount of movement compared to the actual landslide. http://bit.ly/1o6H3eL

Slope failure occurred in the course of minutes on March 22, 2014 in the community of Steelhead Haven near Oso, Washington. The lower part of the slope gave way at 10:37am destabilizing the upper part which followed about four minutes later.

It moved an average speed of 40 miles per hour and relocated 18 million tons of sand, till, and clay (600 football fields, 10 feet deep). It crossed the North Fork Stillaguamish River. This landslide killed 43 people, destroyed 49 buildings, and closed a state highway for six months. An unusual characteristic of this landslide is that a portion of it become a debris flow (more liquified) as it crossed the river making it spread farther and faster than past landslides.

This region had higher than normal amounts of rainfall in February and March (150-200% more than normal) and the past four years was the wettest period on record. This area has historically experienced multiple landslides but none with as much mobility and liquefaction as this one.

Before & After. Top photo has yellow outline over the landslide area in the 'before' photo Bottom photo shows after the landslide.

Source: http://imgur.com/gallery/gJH9m5k

B. Why did this happen?

In general, landslides can be caused by a number of factors, in isolation or in combination. The lists below from USGS shows all the different causes of landslides; some of these likely contributed to Oso landslide, as highlighted and explained below.

Geological (rock/soil) Causes	Morphological (natural event) Causes	Human Causes
a. **Weak or sensitive materials** b. Weathered materials c. Sheared, jointed, or fissured materials d. Adversely oriented discontinuity (bedding, fault, unconformity, contact, etc.) e. **Contrast in permeability and/or stiffness of materials**	a. Tectonic or volcanic uplift b. Glacial rebound c. Fluvial, wave, or glacial erosion of slope toe or lateral margins d. Subterranean erosion (solution, piping) e. Deposition loading slope or its crest f. Vegetation removal (by fire, drought) g. Thawing h. Freeze-and-thaw weathering i. Shrink-and-swell weathering j. **Heavy rains**	a. Excavation of slope or its toe b. Loading of slope or its crest c. Drawdown (of reservoirs) d. **Deforestation** e. Irrigation f. Mining g. Artificial vibration h. Water leakage from utilities

Earthquake. The Oso landslide was the worst landslide in U.S. history not caused by and earthquake, volcano, or dam failure. There was a small earthquake (magnitude 1.1) that occurred 12 days prior but seismologists do not think it was strong enough or close enough to contribute to the destabilization. Some seismologists speculate that the earthquake happened because the area was already destabilized - so the earthquake was a symptom of the problem rather than the cause.

Soil properties & Geologic context. The interaction between properties of soil and the effects of water can have powerful consequences. This land has historic records of repeated landslides because of its geologic context. The landslide occurred at the southeastern edge of Whitman Bench, a land terrace about 800 ft (240 m) above the valley floor and consisting of gravel and sand deposited during the most recent glaciation. Sediment washed down from the higher mountains settled in the lake bottoms forming a layer of clay. As the glacial ice pressed higher against the western end of Mount Frailey, water flowing around the edge of the ice from the north was forced around the mountain, eventually pouring in through the long valley extending to the northwest and now occupied by Lake Cavanaugh. Sand and gravel carried by the flow and entering the glacial lake dropped out to form a delta, the remnant of which is now known as Whitman Bench (see map on next page). Following the glacier's retreat and allowing for the lake to be released, the river carved out most of the clay and silt deposits, leaving the former delta "hanging" approximately 650 ft (200 m) above the current valley floor. When the sand portion of a deposit has very little clay or "fines" to cement it together, it is structurally weak, leaving the area around it vulnerable.

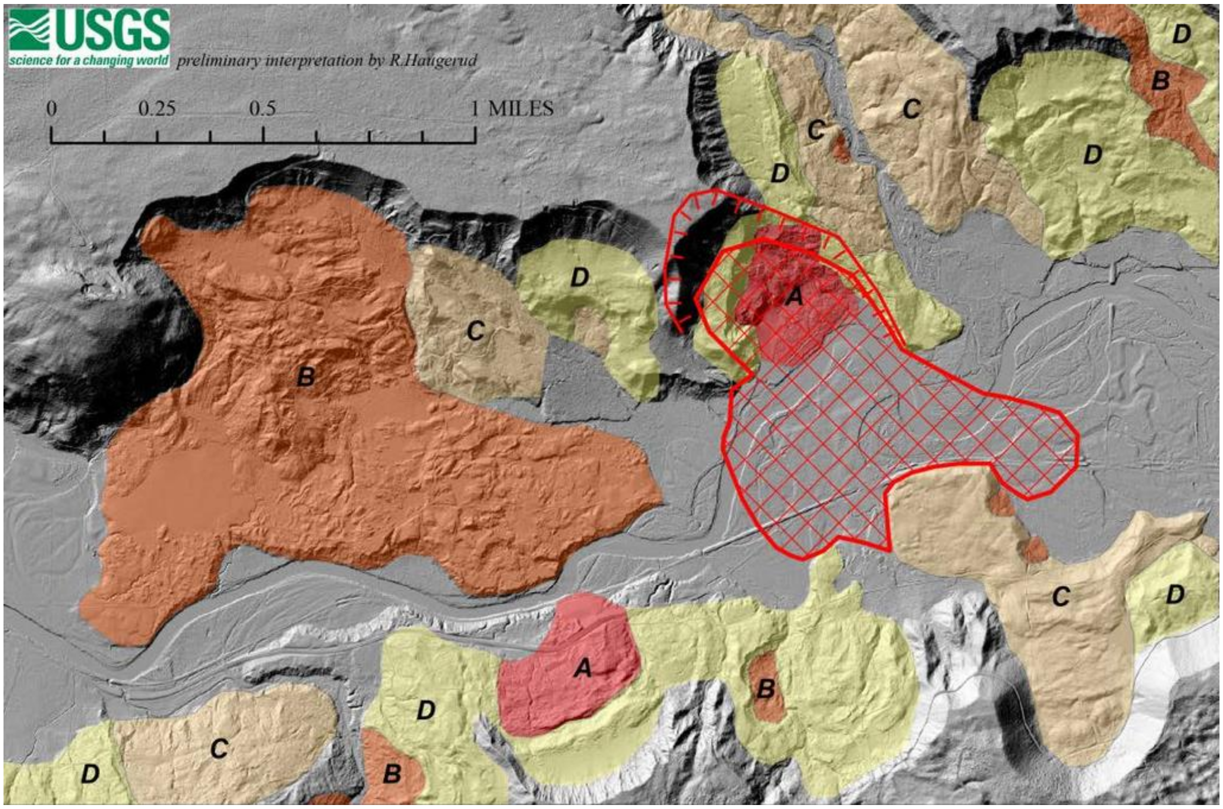
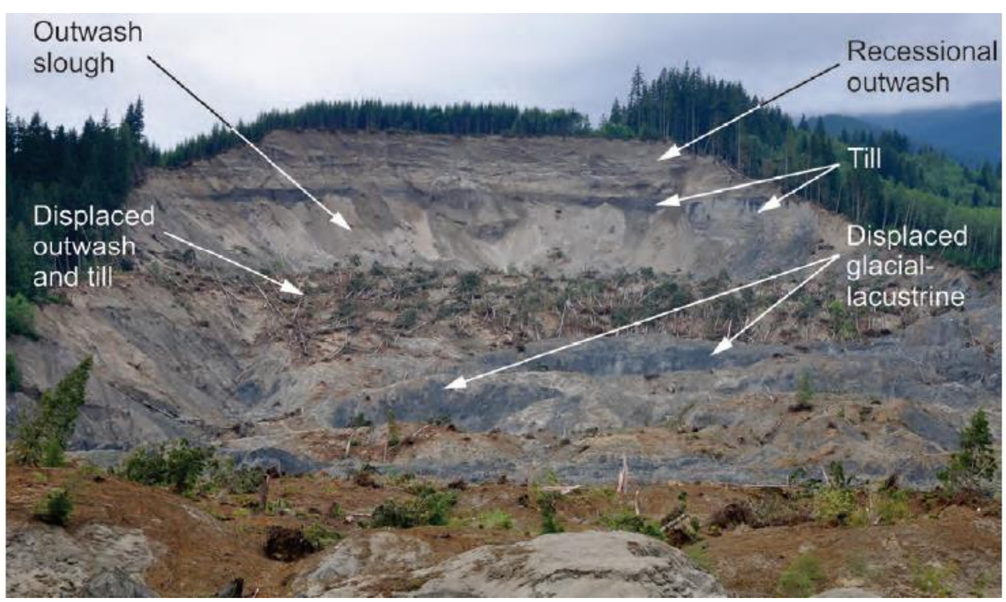
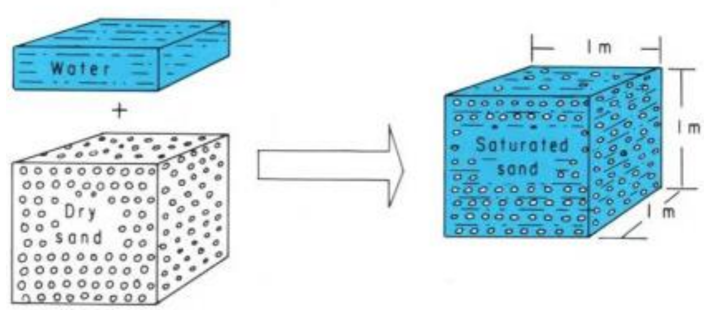


Figure 1 Shaded-relief geomorphologic map of Oso Landslide of 2014 and adjacent areas. Oso is two miles west of this map, Hazel, one mile east. Colored areas are older landslides, "D" being the oldest. Upper "A" is the March 2014 landslide, lower "A", Skaglund Hill. Topography shown is from 2006; red line is approximate location of the current head scarp. Red cross-hatching is the runout area, now buried in mud and debris. Terrace on the upper-left is Whitman Bench. Image from USGS OFR 2014-1065.

In geologist language, the area can be described as such: "The recessional outwash sand and gravel capping the local slope above the Oso Landslide and the advance outwash separating the glacial till and the glacial-lacustrine deposits are highly permeable, whereas the glacial till and glacial-lacustrine silt and clay formations are of much lower permeability. These differences in permeability create the potential for an unconfined aquifer perched on the glacial till and a confined aquifer between the till and glacial-lacustrine deposits. Evidence for local seeps along the recessional outwash/till contact was apparent on the headscarp face after the 2014 landslide during the field reconnaissance."



Rainfall & Soil Permeability. This area with clay, silt, sand, and glacial moraine is sensitive to water accumulation, increasing the internal "pore" pressure and subsequently contributing to ground failure. Water infiltrating from the surface will flow through the surface, except for contact with less permeable clay, allowing the water to accumulate and form a zone of stability weakness. Such variations in pore pressure and water flux are one of the primary factors leading to slope failure. Most rocks and soils naturally contain a certain percentage of voids that can be occupied by water. In general, unconsolidated sediments such as gravels, sands, silts and clays, which are composed of angular and rounded particles, have larger porosities than indurated, consolidated sediments such as sandstone and limestone. The size of pore space and interconnectivity of the spaces help determine permeability, so shape and arrangement of grains play a role. Permeability is a measure of a soil's or rock's ability to transmit a fluid, usually water. In coarse materials like sand, water moves through rapidly, reducing contact between the water and soil particles. However, clay has low permeability due to small grain sizes with large surface areas, which results in increased friction. Also these pore spaces are not well connected.



In case of the area of the Stillaguamish River where the March 2014 slide occurred, erosion at the base of the slope from the river flow further contributes to slope instability. Such conditions have created an extensive series of landslide complexes on both sides of the Stillaguamish valley. Additional benches on the margin of Whitman Bench are due to deep-seated slumping of large blocks, which also creates planes of weakness for future slippage and channels for water infiltration**.**

In summary, heavy rainfall in in February and March (150-200% more than before) and also across the four years prior created supersaturated conditions in the soil. Water seeps into the ground, getting between the grains of soil increasing the pore pressure and destabilizing the soil. Local soil near Oso forms a slick surface when saturated because of the interaction between sand and glacial moraine. Landslides in this area are common for these reasons but this slide in particular was devastating because of its liquid content and it "ran out" (spread out) farther and faster than any in known record.

Deforestation. Environmentalists have contended that deforestation leads to greater saturation of soil and a higher risk of catastrophic landslides. In the 1980s, timber companies heavily harvested land just north of the slide. In 2004, a timber company originally submitted a permit for 15 acres; however, it was only approved for 7.5 acres because the other acreage would encroach too much on sensitive recharge and watershed areas. This logging purportedly exceeded the permit-approved area by an acre because the state used a 1988 map instead of the updated 1997 map showing sensitive watershed areas. The state recently agreed to require additional scrutiny when logging is planned in/near groundwater recharge areas in landslide-prone areas, such as the hill above Steelhead Haven, the neighborhood that was wiped out by the Oso mudslide.

C. Finding alternate phenomena in local communities

A local phenomenon could anchor the unit instead of the Oso landslide. Or students could simultaneously explain a local phenomenon alongside the Oso landslide, identifying similarities in underlying causal mechanisms but differences in context. **Want to find another phenomenon? Or more local contexts to explore during the unit?**

- **Go on a science walk.** Similar earth science phenomena happen near and around students' school and neighborhood. Look for changes in land on or near the playground or ditches around the school. Similar science concepts of infiltration and destabilization can explain why driveways crack, mailboxes tilt, or sinkholes or potholes happen.

- **Other regional events**. It could be an event like a landslide in a more local area near the school. State websites and the USGS track and document natural hazards. For WA state, here are two links with data about landslides: http://www.ecy.wa.gov/programs/sea/landslides/ and http://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/landslides

D. Sources

Articles

- **2014 Oso Mudslide** https://en.wikipedia.org/wiki/2014_Oso_mudslide
- **NBC News Double-Barreled Blow: How the Oso Mudslide Went Down** http://www.nbcnews.com/storyline/deadly-mudslide/double-barreled-blow-how-oso-mudslide-went-down-n66511
- **NBC News Oso Mudslide: Lawsuit Blames State, Logging Company for Deadly Disaster** http://www.nbcnews.com/storyline/deadly-mudslide/oso-mudslide-lawsuit-blames-state-logging-company-deadly-disaster-n291501
- **USGS Info Landslide Types and Processes** http://pubs.usgs.gov/fs/2004/3072/fs-2004-3072.html
- **USGS article Oso Landslide Research Paves Way for Future Hazard Evaluations** http://www.usgs.gov/newsroom/article.asp?ID=4097#.VrF637IrLIV
- **USGS article on the Oso Landslide, one year later** http://www.usgs.gov/blogs/features/usgs_top_story/one-year-later-the-oso-landslide-in-washington/
- **UW Today: Oso disaster had its roots in earlier landslides** **http://www.washington.edu/news/2014/07/22/oso-disaster-had-its-roots-in-earlier-landslides/**
- **NatGeo: Causes of Deadly Washington Mudslide Revealed in Scientific Report** http://news.nationalgeographic.com/news/2014/07/140722-oso-washington-mudslide-science-logging/

Technical Reports and Scientific Studies

- Keaton, J., Wartman, J., Anderson, S., Benoit, J., deLaChapelle, J., Gilbert, R., & Montgomery, D. 2014. GEER Turning Disaster into Knowledge: The 22 March 2014 Oso Landslide, Snohomish County, Washington. http://www.geerassociation.org/administrator/components/com_geer_reports/geerfiles/GEER_Oso_Landslide_Report.pdf

- Riemer, M.F., Collins, B.D., Badger, T.C., Toth, C., and Yat Chun, Y., 2015, Geotechnical soil characterization of intact Quaternary deposits forming the March 22, 2014 SR-530 (Oso) landslide, Snohomish County, Washington: U.S. Geological Survey Open-File Report 2015-1089, 17 p., http://dx.doi.org/10.3133/ofr20151089. http://pubs.usgs.gov/of/2015/1089/pdf/ofr20151089.pdf

- Shipman, H., 2001, Coastal Landsliding on Puget Sound: A review of landslides occurring between 1996 and 1999, Publication #01-06-019, Shorelands and Environmental Assistance Program, Washington Department of Ecology, Olympia. https://fortress.wa.gov/ecy/publications/publications/0106019.pdf

III. Additional General Earth Science Background

General earth science background for teachers corresponding to the Disciplinary Core Ideas taken directly from National Academies Press *A Framework for K-12 Science Education* available in its entirety for free: http://www.nap.edu/download.php?record_id=13165

ESS1.C: THE HISTORY OF PLANET EARTH
Source: National Academies Press

How do people reconstruct and date events in Earth's planetary history?

Earth scientists use the structure, sequence, and properties of rocks, sediments, and fossils, as well as the locations of current and past ocean basins, lakes, and rivers, to reconstruct events in Earth's planetary history. For example, rock layers show the sequence of geological events, and the presence and amount of radioactive elements in rocks make it possible to determine their ages.

Analyses of rock formations and the fossil record are used to establish relative ages. In an undisturbed column of rock, the youngest rocks are at the top, and the oldest are at the bottom. Rock layers have sometimes been rearranged by tectonic forces; rearrangements can be seen or inferred, such as from inverted sequences of fossil types. Core samples obtained from drilling reveal that the continents' rocks (some as old as 4 billion years or more) are much older than rocks on the ocean floor (less than 200 million years), where tectonic processes continually generate new rocks and destroy old ones. The rock record reveals that events on Earth can be catastrophic, occurring over hours to years, or gradual, occurring over thousands to millions of years. Records of fossils and other rocks also show past periods of massive extinctions and extensive volcanic activity. Although active geological processes, such as plate tectonics (link to ESS2.B) and erosion, have destroyed or altered most of the very early rock record on Earth, some other objects in the solar system, such as asteroids and meteorites, have changed little over billions of years. Studying these objects can help scientists deduce the solar system's age and history, including the formation of planet Earth. Study of other planets and their moons, many of which exhibit such features as volcanism and meteor impacts similar to those found on Earth, also help illuminate aspects of Earth's history and changes.

The geological time scale organizes Earth's history into the increasingly long time intervals of eras, periods, and epochs. Major historical events include the formation of mountain chains and ocean basins, volcanic activity, the evolution and extinction of living organisms, periods of massive glaciation, and development of watersheds and rivers. Because many individual plant and animal species existed during known time periods (e.g., dinosaurs), the location of certain types of fossils in the rock record can reveal the age of the rocks and help geologists decipher the history of landforms.

Grade Band Endpoints for ESS1.C

By the end of grade 2. Some events on Earth occur in cycles, like day and night, and others have a beginning and an end, like a volcanic eruption. Some events, like an earthquake, happen very quickly; others, such as the formation of the Grand Canyon, occur very slowly, over a time period much longer than one can observe.

By the end of grade 5. Earth has changed over time. Understanding how landforms develop, are weathered (broken down into smaller pieces), and erode (get transported elsewhere) can help infer the history of the current landscape. Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. Patterns of tree rings and ice cores from glaciers can help reconstruct Earth's recent climate history.

ESS2.A: EARTH MATERIALS AND SYSTEMS
Edited from source: National Academies Press
How do Earth's major systems interact?

Earth is a complex system of interacting subsystems: the geosphere, hydrosphere, atmosphere, and biosphere. The geosphere includes a hot and mostly metallic inner core; a mantle of hot, soft, solid rock; and a crust of rock, soil, and sediments. The atmosphere is the envelope of gas surrounding the planet. The hydrosphere is the ice, water vapor, and liquid water in the atmosphere, ocean, lakes, streams, soils, and groundwater. The presence of living organisms of any type defines the biosphere; life can be found in many parts of the geosphere, hydrosphere, and atmosphere. Humans are of course part of the biosphere, and human activities have important impacts on all of Earth's systems.

All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems. This energy originates from the sun and from Earth's interior. Transfers of energy and the movements of matter can cause chemical and physical changes among Earth's materials and living organisms.

Solid rocks, for example, can be formed by the cooling of molten rock, the accumulation and consolidation of sediments, or the alteration of older rocks by heat, pressure, and fluids. These processes occur under different circumstances and produce different types of rock. Physical and chemical interactions among rocks, sediments, water, air, and plants and animals produce soil. In the carbon, water, and nitrogen cycles, materials cycle between living and nonliving forms and among the atmosphere, soil, rocks, and ocean. The weathering and erosion processes that break down these structures and transport the products involve interactions among the geosphere, hydrosphere, and atmosphere.

Earth's systems are dynamic; they interact over a wide range of temporal and spatial scales and continually react to changing influences, including human activities. Components of Earth's systems may appear stable, change slowly over long periods of time, or change abruptly, with significant consequences for living organisms. Changes in part of one system can cause further changes to that system or to other systems, often in surprising and complex ways.

Grade Band Endpoints for ESS2.A

By the end of grade 2. Wind and water can change the shape of the land. The resulting landforms, together with the materials on the land, provide homes for living things.

By the end of grade 5. Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. Rainfall helps shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. Human activities affect Earth's systems and their interactions at its surface.

ESS2.B: PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS
Source: [National Academies Press]
Why do the continents move, and what causes earthquakes and volcanoes?

Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. This theory is supported by multiple evidence streams—for example, the consistent patterns of earthquake locations, evidence of ocean floor spreading over time given by tracking magnetic patterns in undersea rocks and coordinating them with changes to Earth's magnetic axis data, the warping of the land under loads (such as lakes and ice sheets), which show that the solid mantle's rocks can bend and even flow.

The lighter and less dense continents are embedded in heavier and denser upper-mantle rocks, and together they make up the moving tectonic plates of the lithosphere (Earth's solid outer layer, i.e., the crust and upper mantle). Tectonic plates are the top parts of giant convection cells that bring matter from the hot inner mantle up to the cool surface. These movements are driven by the release of energy (from radioactive decay of unstable isotopes within Earth's interior) and by the cooling and gravitational downward motion of the dense material of the plates after subduction (one plate being drawn under another). The plates move across Earth's surface, carrying the continents, creating and destroying ocean basins, producing earthquakes and volcanoes, and forming mountain ranges and plateaus.

Most continental and ocean floor features are the result of geological activity and earthquakes along plate boundaries. The exact patterns depend on whether

Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. the plates are being pushed together to create mountains or deep ocean trenches, being pulled apart to form new ocean floor at mid-ocean ridges, or sliding past each other along surface faults. Most distributions of rocks within Earth's crust, including minerals, fossil fuels, and energy resources, are a direct result of the history of plate motions and collisions and the corresponding changes in the configurations of the continents and ocean basins.

This history is still being written. Continents are continually being shaped and reshaped by competing constructive and destructive geological processes. North America, for example, has gradually grown in size over the past 4 billion years through a complex set of interactions with other continents, including the addition of many new crustal segments.

Grade Band Endpoints for ESS2.B

By the end of grade 2. Rocks, soils, and sand are present in most areas where plants and animals live. There may also be rivers, streams, lakes, and ponds. Maps show where things are located. One can map the shapes and kinds of land and water in any area.

By the end of grade 5. The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features where people live and in other areas of Earth.

ESS3.B: NATURAL HAZARDS
Source: National Academies Press
How do natural hazards affect individuals and societies?

Natural processes can cause sudden or gradual changes to Earth's systems, some of which may adversely affect humans. Through observations and knowledge of historical events, people know where certain of these hazards—such as earthquakes, tsunamis, volcanic eruptions, severe weather, floods, and coastal erosion—are likely to occur. Understanding these kinds of hazards helps us prepare for and respond to them. Natural hazards and other geological events have shaped the course of human history, sometimes significantly altering the size of human populations or driving human migrations.

While humans cannot eliminate natural hazards, they can take steps to reduce their impacts. For example, loss of life and economic costs have been greatly reduced by improving construction, developing warning systems, identifying and avoiding high-risk locations, and increasing community preparedness and response capability.

Some natural hazards are preceded by geological activities that allow for reliable predictions; others occur suddenly, with no notice, and are not yet predictable. By tracking the upward movement of magma, for example, volcanic eruptions can often be predicted with enough advance warning to allow neighboring regions to be evacuated. Earthquakes, in contrast, occur suddenly; the specific time, day, or year cannot be predicted. However, the history of earthquakes in a region and the mapping of fault lines can help forecast the likelihood of future events. Finally, satellite monitoring of weather patterns, along with measurements from land, sea, and air, usually can identify developing severe weather and lead to its reliable forecast.

Natural hazards and other geological events have shaped the course of human history, sometimes significantly altering the size of human populations or driving human migrations. Natural hazards can be local, regional, or global in origin, and even local events can have distant impacts because of the interconnectedness of human societies and Earth's systems. Human activities can contribute to the frequency and intensity of some natural hazards (e.g., flooding, forest fires), and risks from natural hazards increase as populations—and population densities—increase in vulnerable locations.

Grade Band Endpoints for ESS3.B

By the end of grade 2. Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that communities can prepare for and respond to these events.

By the end of grade 5. A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions, severe weather, floods, coastal erosion). Humans cannot eliminate natural hazards but can take steps to reduce their impacts.

Unit Overview: 4th Grade Land & Water Unit

Why did the 2014 Oso Landslide happen?

This guide complements the STC Land & Water kit. It is designed to be completed in 18 forty-five minute sessions (approximate times indicated below). Based on students' questions, experiences, and ideas, teachers may change lesson order or add in activities. To clarify, track lessons 2, 3, 4, 5, and 7 on the classroom summary chart.

AST Practice	Activity Name & Suggested Time	What students observe	What students learn	Connections to Oso Landslide Phenomenon	Connection to NGSS
Eliciting students' ideas	**Lesson 1** **Eliciting students' ideas** *(added to kit)* *45-60 minutes*	Students observe the photos and news video about the Oso landslide from 2014. Students may have questions about the phenomenon which can be investigated during the unit. Students may wonder if rain caused it or if something humans did caused it. Students develop and use a model with a partner to explain their initial ideas about why this phenomenon occurs and why it might be muddier and more liquid than prior landslides in the area.			SEP – Developing & using models CCC – Cause and effect DCI - ESS3.B: Natural Hazards ESS1.C: The History of Planet Earth ESS2.A: Earth Materials and Systems ESS2.B: Plate Tectonics and Large-Scale System Interactions
Supporting on-going changes in thinking	**Lesson 2** **Modeling rain on land** *(kit lesson 3)* *Part I: 45 min* *Part II: 45-60 min** *(* reading lesson integration option)*	- Observe the effects of rain on the land - Rain splashes and moves some soil - Rain makes puddles and small rivers, carries the soil	– Rain and rivers cause erosion by picking up soil and moving it to a new place – Rain is absorbed into soil or runs across soil	It was raining a lot more than normal before the Oso landslide so it made the land muddy and wet. Soil absorbs water but too much water would make soil float away or run down the hill. Maybe the soil got heavy with water and made it slide down and/or muddy soil is more slippery and can move more easily because it's wet.	SEP Planning and Conducting Investigations (Making observations) DCI ESS2.A: Earth Materials and Systems CCC Cause & Effect
Supporting on-going changes in thinking	**Lesson 3** **Examining Earth materials** (kit lesson 5) 45 -60 min	Gravel – largest grain size; tiny rocks; gray and white colors; water goes through it easily Sand – large grain size, yellow brown color; crumbly or crunchy when wet Humus – small or medium pieces; tiny roots, dark brown color; won't clump Clay – smallest grain size; reddish color, clumps when you pinch it; soft; slippery and sticky when wet	Soil is made of amounts of various components (like ingredients in a recipe). Different soil types move differently in water – some heavy and sink, others lighter/smaller and float.	The soils in the Oso landslide might have been carried in rainwater water really well. Water could have gone into soil and got heavy – so heavy that all at once it gave way and slid down the hill. What is the Oso hill made of? (Not answered in this lesson but is likely question – answered in next lesson)	SEP Planning and Conducting Investigations (Making observations) DCI ESS2.A: Earth Materials and Systems CCC Patterns

Supporting on-going changes in thinking	**Lesson 4: Where does the water go? Looking at ground water and runoff** (kit lesson 6) Part I: 45 min Part II: 45 min	The gravel had the most water (26 ml) poured back off the soil. (Include data for each type of soil) When water mixed with gravel, water went in between spaces of gravel so it had a lower level than other soil samples. (Include sketches of data for each soil)	Components of soil have different sizes and shapes of particles. Some soils have lots of pore space between grains an can hold or move lots of water quickly. Other soils have small particles and small pore space and takes longer for water to flow through them.	There was heavy rain in the months prior to the landslide. If all the hill got saturated and filled up all the space with water maybe the hill got heavy and slippery on water so the whole thing gave way and slid down.	SEP Planning and Conducting Investigations (Making observations) DCI ESS2.A: Earth Materials and Systems CC Cause & Effect
Supporting on-going changes in thinking	**Lesson 5: Exploring Slope** (kit lesson 13) Part I: 45 min Part II: 45 min	The steeper the hill, the faster the water moves down the hill (observations) and less likely it absorbs into the soil (compared runoff in bottle). Slower motion did not move as much soil.	Gravity is the main force that causes water to move – both down as slope and into the ground. Steepness of a hill can increase the speed of flow of a river or runoff.	The Oso landslide happened on a hill. Some of the heavy rainfall probably went down the hill as runoff and maybe puddled at the bottom or went into the river. Some of it might have gone into the soil. The landside might be worse if it were steeper.	SEP Planning and Conducting Investigations (Making observations) DCI ESS2.A: Earth Materials and Systems CC: Cause & Effect
Supporting on-going changes in thinking	**Lesson 6: Looking at Maps and history of Oso** (added) Part I: 45 min Part II (OPTIONAL)	Students study maps of the Oso area, aerial photos of changes over time, and a timeline of logging and landslides. Students make inferences to hypothesize about the events that happened between photos to change the land using what they have learned so far about erosion.			SEP: Analyze and Interpret data DCI: ESS2.B Plate tectonics and large scale interactions CC: Patterns

Supporting on-going changes in thinking	**Lesson 7: How does vegetation affect soil erosion?** Part I: 45 min Part II: 45 min	The bottles of runoff from soil-only (no plants) had lots of sediments (ranking of 4-6). Runoff filtered through plants was relatively clear (ranking of 1-3).	Plant roots hold onto soil making it harder for rainwater to force the soil to be loose.	*Vegetation could help to secure the soil because roots would grow into the hill and absorb water and hold onto soil. (But if roots can also break up soil, could plants actually cause a landslide?)*	SEP: Plan and carry out investigations ESS2.A Earth materials and systems CC: Cause and Effect
Pressing for Evidence-based Explanations	**Lesson 8: Evidence-based explanations** (added) Part 1: 45 min Part II: 45 min	Students have been revising their thinking about the unit phenomenon over time in light of the new experiences, observations, and sense making talk that they have had throughout the unit activities. In this lesson, students will pull together what they have learned in this unit and identify how their thinking has changed by revising their models and supporting changes with evidence.			SEP – Developing & using models; SEP - Engaging in argument from evidence CCC – Cause and effect, patterns DCI - ESS3.B: Natural Hazards – ESS1.C: History of Planet Earth – ESS2.A: Earth Materials and Systems – ESS2.B: Plate Tectonics and Large-Scale System Interactions
Engineering Solutions using evidence-based explanations	**Lesson 9: Solutions for Reducing Landslide hazards** (added) Part I: 45 mins Part II: 45 min Part III: 45 min	In lesson 8, students worked in pairs to develop new models to explain the Oso landslide using evidence from unit activities. In this lesson, students will use that work to propose an engineering solution about how to mitigate the impact on humans from this natural hazard How might humans prevent the damage from landslides? What should we do and why?			SEP: Designing Solutions DCI: ESS3.B Natural Hazards CC: Cause and effect Influence of Engineering, Technology, and Science on Society and the Natural World

Lesson 1: Introduce the Phenomenon & Elicit Students' Ideas

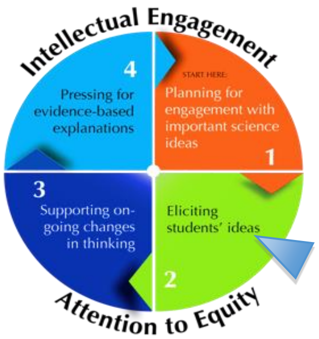
OBJECTIVES & OVERVIEW

This lesson introduces students to this unit about how water and plants change the shape of land on the Earth. Lesson 1 begins students' study of a landslide phenomenon which they will pursue throughout the unit.

In this lesson, students make observations from watching a news video, looking at photos, and examining maps to propose possible explanations as to what caused the Oso Landslide in March 2014 and why it was larger and muddier (more liquid) than past landslides in the same area.

- Students make and share observations about the Oso landslide.
- Students develop models to explain what might cause a landslide to happen in a particular area.

Ambitious Science Teaching: Eliciting students' ideas



Information gathered by eliciting all students' initial hypotheses about a scientific idea, and making a public record of these can inform instructional decisions for upcoming lessons. For more about this practice of eliciting students' ideas, visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS

Standards Note: Because this lesson is intended to elicit students' initial ideas and experiences, students will not entirely demonstrate the performance expectations (PE) listed here. Students will have additional opportunities in this unit to fully engage in the dimensions of the PEs below. However, students will use their prior experiences and their casual observations of how water affects soil (DCI) to develop models (SEP) that can explain patterns and cause-and-effect (CC) relationships to begin to explain how rainfall, vegetation, and physical characteristics of a region interact to change the landscape through slow and fast changes . Students are engaged in a three-dimensional performance.

PE 4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
PE 4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features.

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CCC)
Planning and Carrying Out Investigations - Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1) **Analyzing and Interpreting Data -** Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2) **Developing & Using Models**:** Develop a model to describe phenomena. *** This SEP is not part of the PE but was added to this lesson as part of the AST framework because students develop and use models to explain and describe the phenomenon using their initial hypotheses in this lesson.*	**ESS2.E: Biogeology.** Living things affect the physical characteristics of their regions. (4-ESS2-1) **ESS2.B: Plate Tectonics and Large-Scale System Interactions**. The locations of structures on Earth occur in patterns. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2) **ESS1.C: The History of Planet Earth**. Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes.	**Patterns -** Patterns can be used as evidence to support an explanation. (4-ESS2-2) **Cause and Effect -** Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS2-1) .

Common Core Connections: ELA/Literacy - W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

MATERIALS

For the class:

- Video clip of news about the Oso Landslide: http://safeshare.tv/v/Cyb2sE0SUtg
- Video clip of smaller rock topple weeks after the slide: http://bit.ly/1o6H3eL
- 1 color photo card per pair of students
- Chart paper and markers
- Sticky notes

Per student (or pair – see teacher decision point):

- Model scaffold sheet on 11"x17" paper
- Pencil
- Colored pencils (optional)

TEACHER DECISION POINT

Decide if students will develop models individually or in pairs.

Individually:
- can track individual progress across unit
- less student talk naturally occurs

In partners:
- more talk as they negotiate what to add
- strategic partnerships benefit English Learners or those in need of writing support
- can track pairs' understanding across unit

PROCEDURE

1. Activate prior knowledge and experiences (whole class).

Present visuals

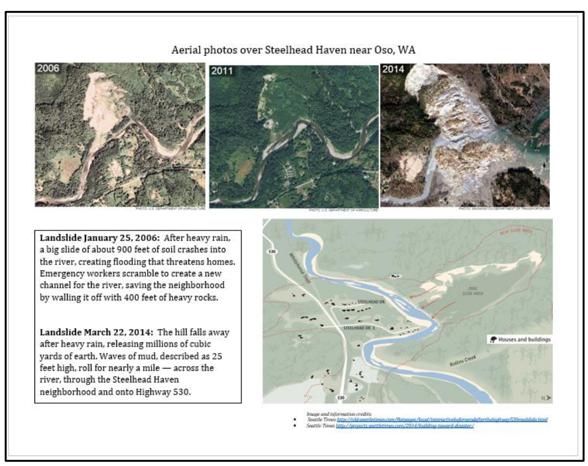
Show color photos of Oso landslide

Turn-and-Talk

What do you notice in the photos?

Introduce this unit by telling students that they will be learning about forces that shape and change land and to do this they will figure out what caused a recent landslide near Oso, WA in 2014. Show students the page of color photos from 2006, 2011, and 2014 of the Oso landslide and ask them what they notice or observe in the photos and about the information of the page.

You may also want to be responsive to students' emotional concerns. Take a moment to talk to students that landslides can be an emotional subject because they destroy homes and can injury or kill people. Some students may know friends or family who were directly affected by the March 2014 Oso landslide. Figuring out what causes landslides is important so we can engineer solutions to prevent landslides and/or lessen the damage they cause.



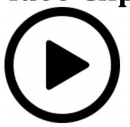
Aerial photos over Steelhead Haven near Oso, WA

Landslide January 25, 2006: After heavy rain, a big slide of about 900 feet of soil crashes into the river, creating flooding that threatens homes. Emergency workers scramble to create a new channel for the river, saving the neighborhood by walling it off with 400 feet of heavy rocks.

Landslide March 22, 2014: The hill falls away after heavy rain, releasing millions of cubic yards of earth. Waves of mud, described as 25 feet high, roll for nearly a mile — across the river, through the Steelhead Haven neighborhood and onto Highway 530.

This is the photo card to use with students to introduce the unit. Have one for each pair of students to look at together.

Video Clip



Oso Landslide News
(1 m 53 s)
http://goo.gl/TMfehX

Geologist Captures rock topple
(0m 49s)
http://bit.ly/1o6H3eL

2. Introduce the phenomenon (whole class)

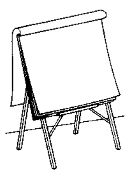
Tell students they are going to see a news video about the Oso Landslide and need to make observations as they watch to help us figure out how and why this happened. Look and listen for facts and observations about the landslide – What happened? Play the news video to hear about the landslide and observe some photos at the end of the clip.

The second clip is a few weeks after the landslide captured by a geologist. It shows at a small scale what the actual landslide would look like.

Turn-and-Talk

What observations did you make about the landslide from the news video?

Public Record



List of observations

3. Record observations about the phenomenon (whole class).

Together, as a class, make a list of observations from the news video. Start with a turn-and-talk to have students share observations about what they saw and heard with a partner.

Let table groups look at the photos and maps to add to the list of observations about this landslide.

See the chart at right for an example. It is generated with input from students so lists of observations will vary.

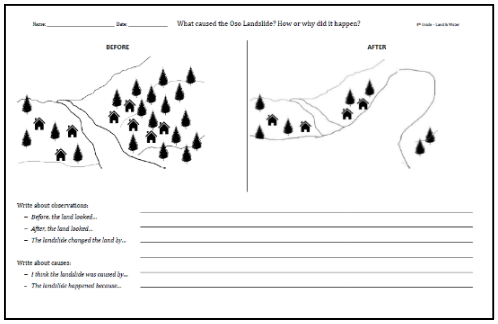
Our observations about the Oso Landslide

- a wall of mud
- entire hillside slid down
- slide went into the river
- there are victims (injuries and deaths)
- "lots of rain made the ground unstable" (news)
- knocked over trees
- really muddy
- destroyed houses

4. Develop initial models to explain the phenomenon (individually or in partners)

Show students the model scaffold page and read the directions above each panel. Tell students they are proposing some ideas to explain how and why this landslide happened. They can use arrows, lines, labels, or use colored pencils (optional) to show how or why it happened. Students should be encouraged to record their thinking, even if they disagree.

The model scaffold to use looks like this. You can edit and tailor the model to your students as long as you maintain areas for drawing and writing.



Back-Pocket Questions

After students begin working, circulate and interact with students asking them about their ideas and asking them how they could show it in a picture and/or describe it in works on their model sheet. Some possible questions are listed here:

OBSERVABLE

- What were some observations you made from the news clip?
- What do these photos show you about the landslide?
- How can you show that on your model in pictures? How could you describe it in words?

UNOBSERVABLE (OR LESS DIRECTLY OBSERVABLE)

- You said the landslide was <u>(insert students' observation</u>). What do you think made it do/like that?
- What do you think could be likely causes for this landslide?
- How can you show that on your model in pictures? How could you describe it in words?

Whole-class discussion

Compare Models

5. Summarize and select ideas to make public (whole class)

As students work on their models, circulate and observe the kinds of ideas students have. Select 2 or 3 students (or pairs) to share out one idea they have for what caused the landslide. Select students who have different ideas.

Have these students show their model under the document camera and describe their idea(s) to the class.

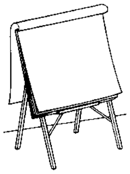
Encourage students to have a short discussion about their initial ideas to make sure we all understand each others' ideas. This is a time for clarifying and elaborating aobut ideas, not for debating or argumentation. (This can come later once students have evidence from unit activities).

Students can use prompts like:

- *Why do you think that?* (asking for evidence/experience)
- *Your idea makes me wonder if…* (posing a question)
- *I agree but I showed that idea by…* (comparing models)

Allow students to continue working on models (drawing and writing) for a few more minutes. They can incorporate some ideas they just heard if they agree and/or make sure they are showing their ideas in pictures and words.

Public Record



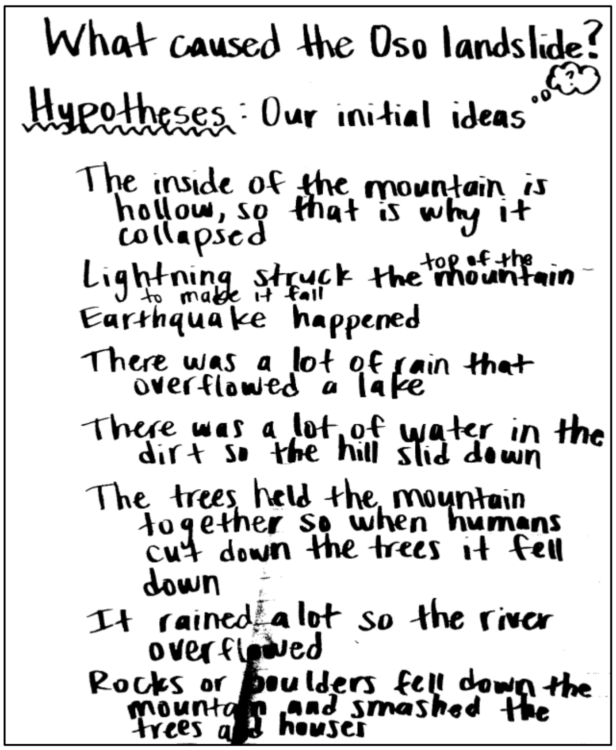
List of possible hypotheses

6. Pressing for possible explanations: Create a hypothesis list (whole class)

Have students share out their ideas with each other before writing a list to allow students to hear the different ideas.

Then, generate a list with students by having them write ideas on sticky notes. If helpful, students could use the sentence starter:

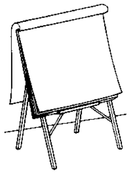
I think the Oso landslide happened because…



Here is one example of a list of initial ideas about the Oso Landslide from 4th grade students created during Lesson 1. This ideas were explored throughout the unit and revised (combined, removed, changed, etc.) based on evidence from activities, videos, and readings.

This chart is generated with input from students so list of hypotheses will vary by class.

Public Record



List of questions

7. Students generate questions (whole class)

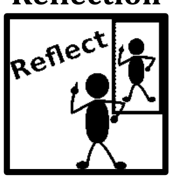
On sticky notes or on the back of the model sheet, have students write at least one question they have about the Oso landslide. These questions can be used to anchor future lessons or can be used for students' independent research. Have some students share out a few questions to make a list. Add to the list as you look over students' work.

EXAMINING STUDENT WORK

Use students' models and discussions to track students' initial understanding using the ***what-how-why level of explanation rubric***. This task is intended to help you notice what concepts students are already thinking about and which ones are new to most students. Use the what-how-why grid throughout the unit to keep track of how students' understandings change over time. Also, spend a few minutes and fill out the ***Rapid Survey of Student Thinking (RSST).*** This is another way to track students' ideas, language, and experiences which is helpful in making adjustments in future lessons to take advantage of students' funds of knowledge.

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. **TASK, TALK, & TOOLS.**

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of hypothesizing about a phenomenon helped students to/with....
The task about _______ relates to students' and/or their families' lives because...

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during (name particular parts of lesson) which allowed students to...
During turn-and-talks, I observed _______ which makes me wonder if/how...

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

The model scaffold tool allowed students to...
Creating a list of initial ideas allowed students to...

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because...
Overall, this combination of talk, task and tools, allowed most/all students to...

EQUITY.

Describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:

- *Developing relationships & forming an inclusive, trusting community*
- *Scaffolding for full participation in the culture and language of science*
- *Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs*
- *Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege*

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PLANNING NEXT STEPS

Using the ideas and questions you have heard from students during class and from their models decide what lesson(s) should come next. These lessons give students more information about ideas they shared to deepen their understanding or the lessons can help answer questions students posed. Additional lessons could be added or substituted based on the ideas and questions students have.

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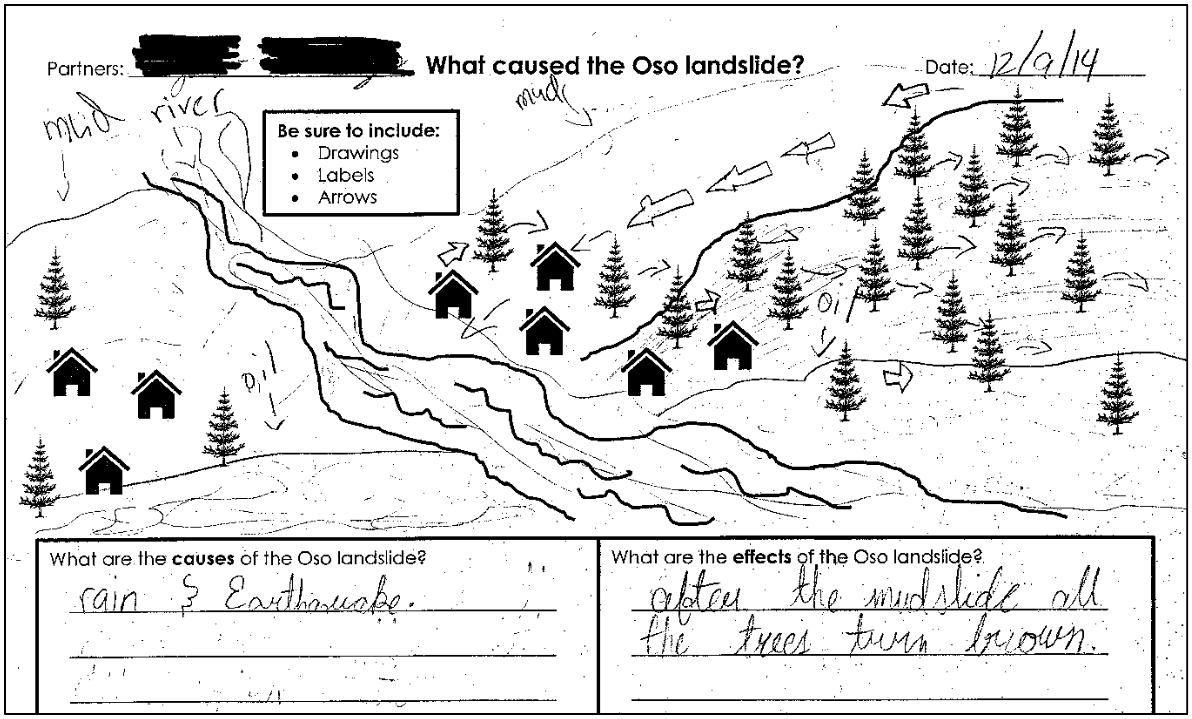
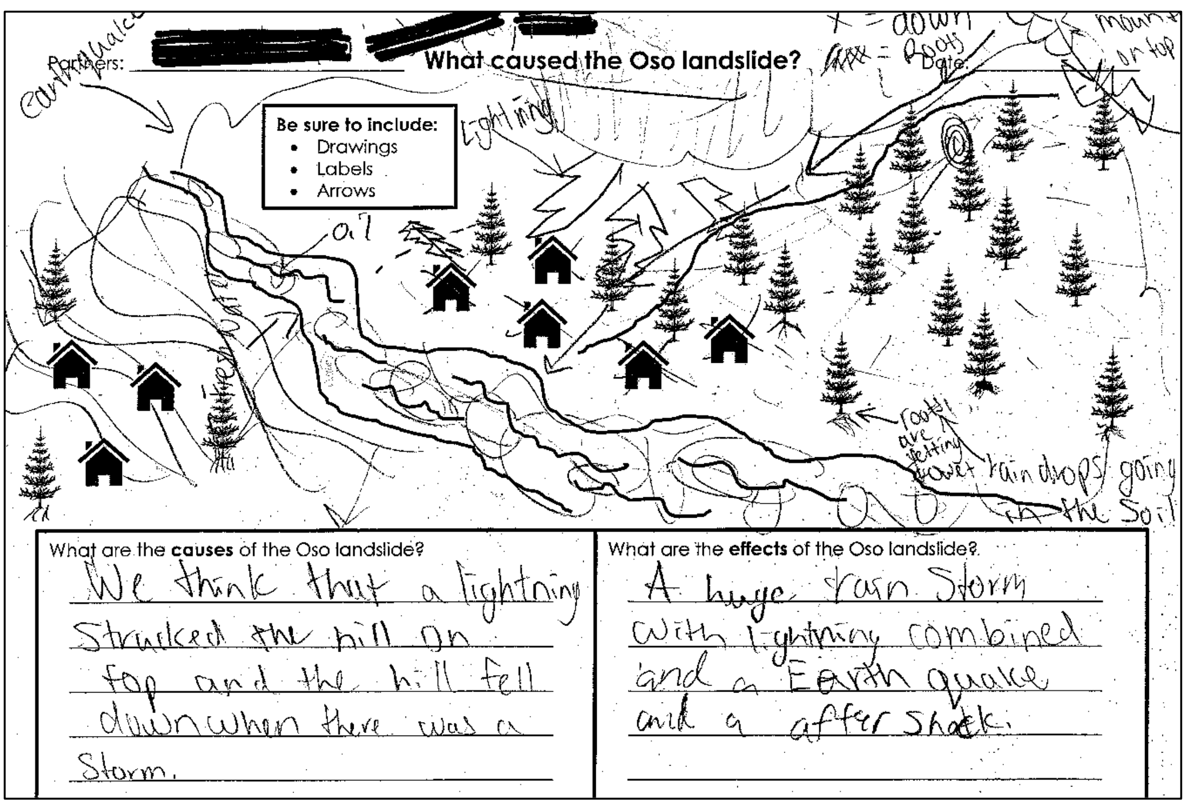
Here are two examples of 4th grade students' initial partner models from Lesson 1 using a similar model scaffold to explain how/why the Oso Landslide happened. The model scaffold used here does not feature the "before" and "after" spaces but does include room to draw and write.





Rapid Survey of Student Thinking (RSST)

Directions: Complete the RSST either during class or right after a class.

Categories	Trends in student understandings, language, experiences [sample sentence starters included below]	Instructional decisions based on the trends of student understanding
Partial understandings What facets/ fragments of understanding do students already have?	List partial understandings: What approximate % of your students have these partial understandings?	★Star the ideas on the list that need action. Instructional options: • Do further eliciting of initial hypotheses to clarify your understanding of students' partial understandings • Do 10-minute whole class whole class conversation of 2-3 key points elicited • Write multiple hypotheses on board and/or develop an initial consensus model •
Alternative understandings What ideas do students have that are inconsistent with the scientific explanation?	List alternative understandings: What, if any, experiences or knowledge bases are they using to justify these explanations?	★Star the ideas on the list that you *really* need to pay attention to based on the following criteria… 1. Which alt. conceptions seem deeply rooted (kids seem sure about)? 2. What % of kids think this? 3. Which are directly related to final explanation (not just a "side-story") Instructional options: • Do further eliciting about what experiences/frames of reference students are drawing on • Pose "what if" scenario to create conceptual conflict about validity of alt. ideas • Challenge students to think further/give them a piece of evidence to reason with • Target a round of "Discourse 2" to address this alt. conception
Everyday language What terms did you hear students use that you can connect to academic language in upcoming lessons?	Cite examples: What approximate % of your students use these terms and phrases?	★Star the ideas on the list that you can leverage in non-trivial ways. Instructional options: • Use language to reframe essential question in students' terms • Use as label in initial models that you make public. Work in academic versions of these words into public models and discussions later. •
Experiences students have had that you can leverage What familiar experiences did students describe during the elicitation activity?	What was the most common everyday or familiar experience that kids related to the essential question or task? What were the less common experiences students cited?	★Star the ideas on the list that you can leverage in non-trivial ways. Instructional options: • Re-write the essential question to be about this experience • Make their prior experiences a central part of the next set of classroom activities • If kids cannot connect science idea to familiar experiences they've had, then provide a shared experience all kids can relate to (through lab, video, etc.)

Why did the 2014 Oso Landslide happen?

Image credit: Seattle Times http://old.seattletimes.com/flatpages/local/interactivebeforeandafterthehighway530mudslide.html

Where in Washington did the 2014 Oso Landslide happen?

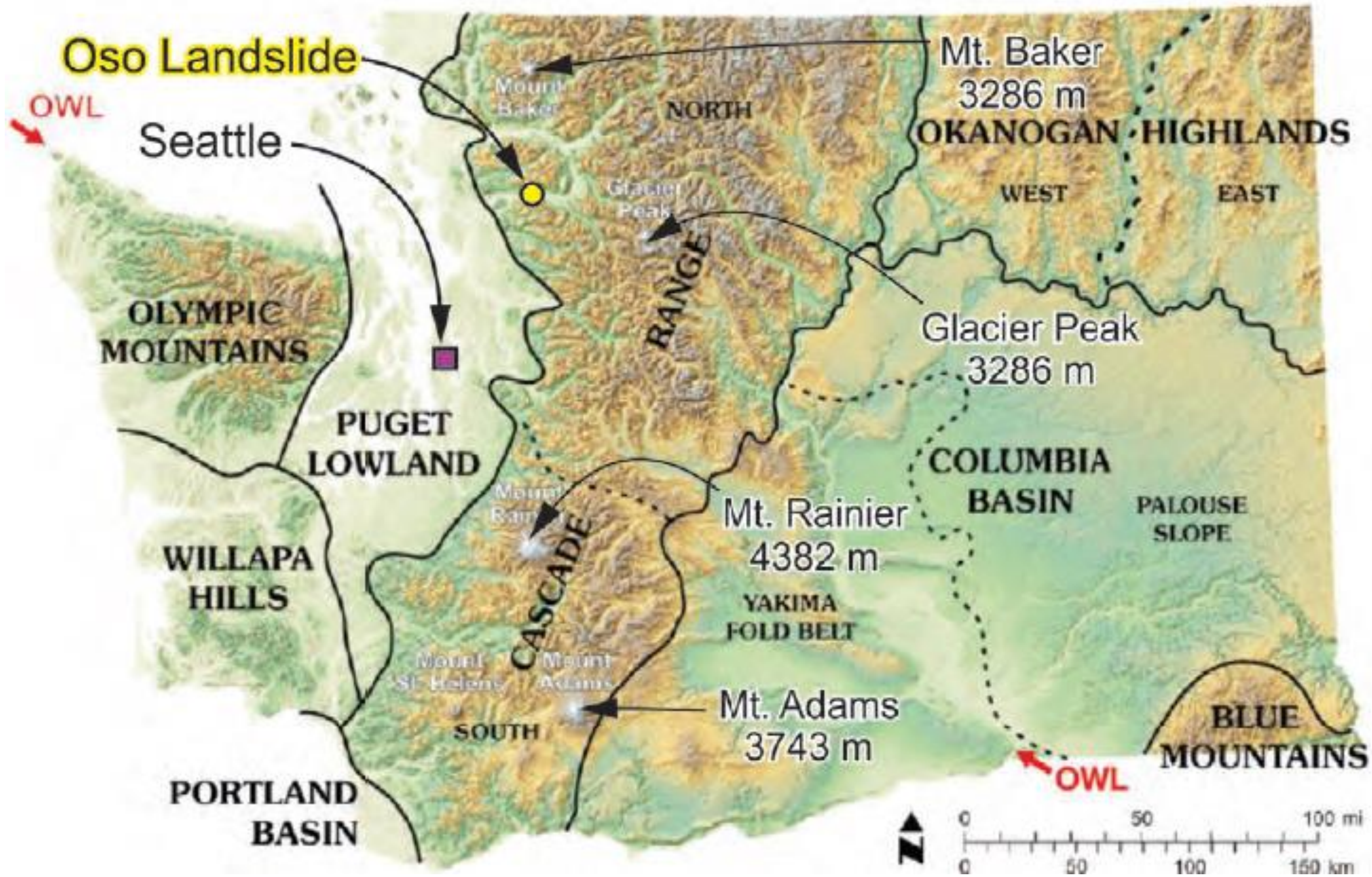


Image source: http://www.dnr.wa.gov/Publications/ger_geol_map_washington_pagesize.pdf

Aerial photos over Steelhead Haven near Oso, WA

PHOTO: U.S. DEPARTMENT OF AGRICULTURE

PHOTO: U.S. DEPARTMENT OF AGRICULTURE

PHOTO: WASHINGTON DEPARTMENT OF TRANSPORTATION

Landslide January 25, 2006: After heavy rain, a big slide of about 900 feet of soil crashes into the river, creating flooding that threatens homes. Emergency workers scramble to create a new channel for the river, saving the neighborhood by walling it off with 400 feet of heavy rocks.

Landslide March 22, 2014: The hill falls away after heavy rain, releasing millions of cubic yards of earth. Waves of mud, described as 25 feet high, roll for nearly a mile — across the river, through the Steelhead Haven neighborhood and onto Highway 530.

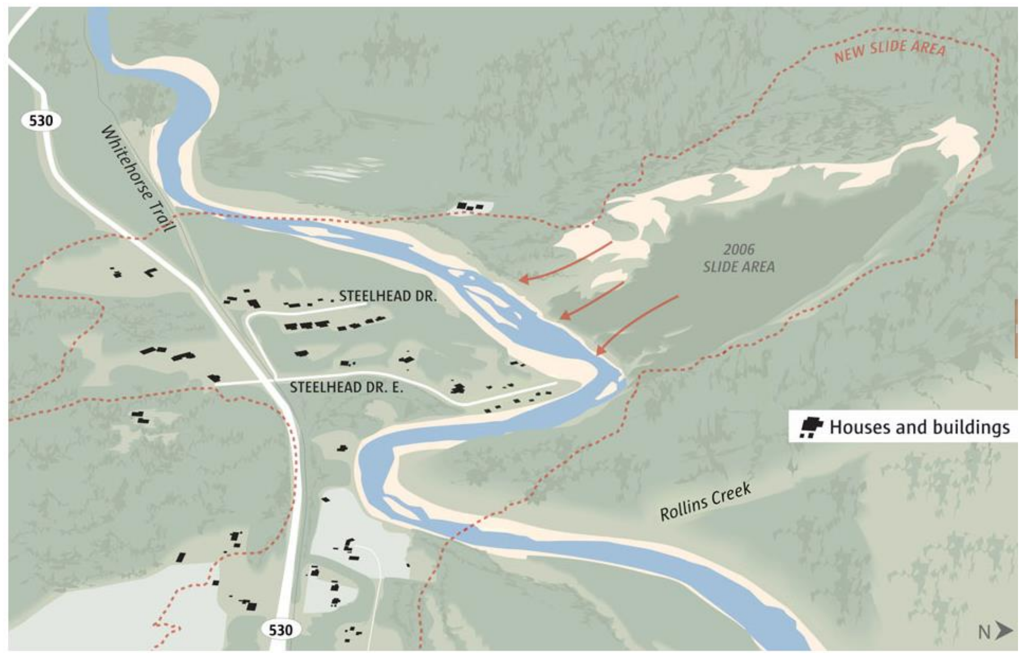


Image and information credits:
Seattle Times *http://old.seattletimes.com/flatpages/local/interactivebeforeandafterthehighway530mudslide.html*
Seattle Times *http://projects.seattletimes.com/2014/building-toward-disaster/*

Name: ______________________________ Date: _________________

What caused the Oso Landslide? How or why did it happen?

Write about observations:

- *Before, the land looked…* ______________________________
- *After, the land looked…* ______________________________
- *The landslide changed the land by…* ______________________________

____

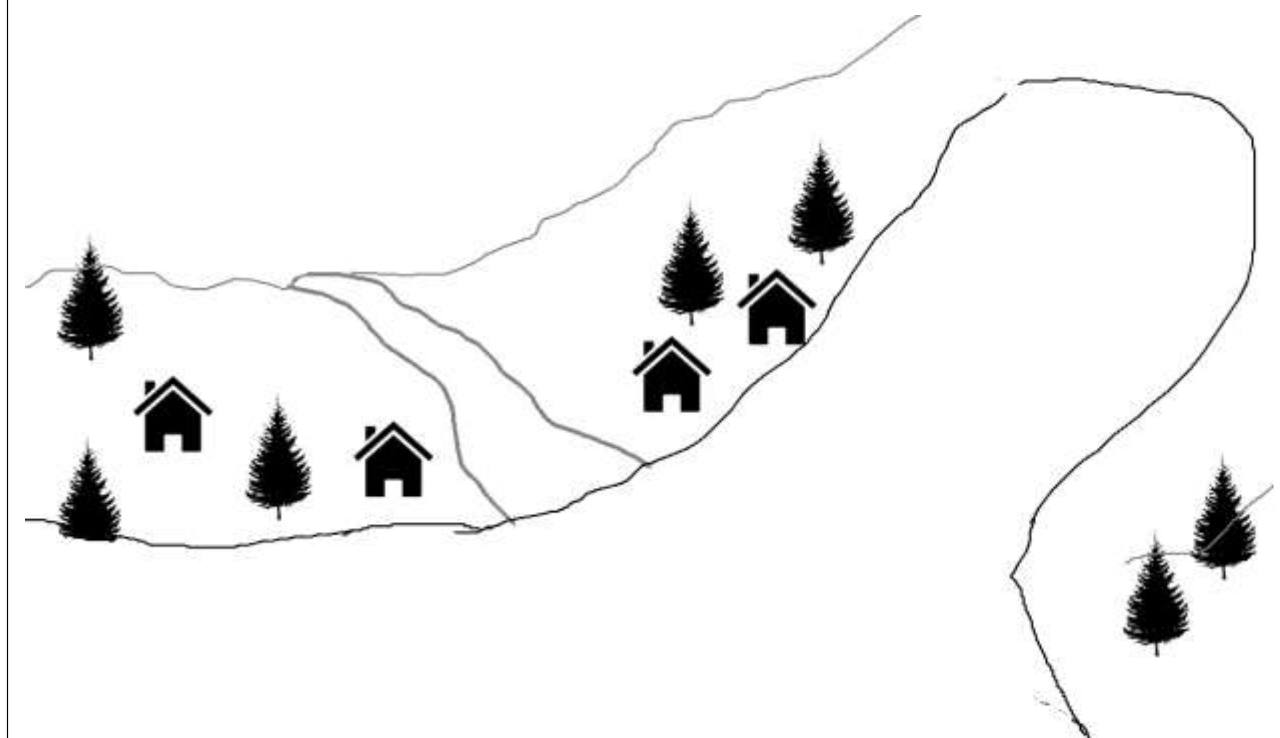
Write about causes:

- *I think the landslide was caused by…* ______________________________
- *The landslide happened because…* ______________________________

Name: ____________________ Date: __________ What caused the Oso Landslide? How or why did it happen? 4th Grade – Land & Water

BEFORE

AFTER



Write about observations:

- *Before, the land looked…*
- *After, the land looked…*
- *The landslide changed the land by…*

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Write about causes:

- *I think the landslide was caused by…*
- *The landslide happened because…*

Lesson 2: Modeling Rain on Land

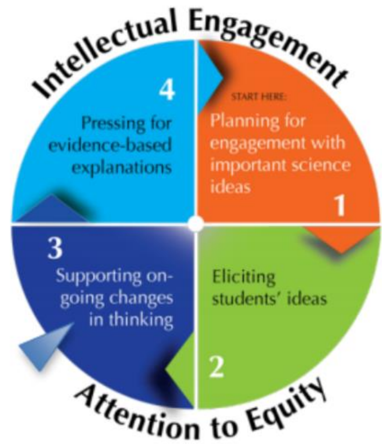
OBJECTIVES & OVERVIEW

This lesson gives students the opportunity to physically model and observe how rain affects soil. Rain is a relatively common weather event, particularly in the Pacific Northwest. Students have many experiences with rain and the effects of rain on land from their own lives (ex: playing on a muddy field after the rain; splashing in puddles; rainwater filling or flowing through drainage ditches). Besides helping to better understand this "everyday" occurrence in their lives, rainfall also plays a key part in explaining the Oso Landslide.

Focus Question: How does rain affect soil?

- Students make and share observations about the effects of rain on land.
- Students analyze rainfall data to predict or explain effects on land.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS

Standards Note: This lesson is the first time students make observations and/or measurements of how water affects land through erosion using a physical model. Students have multiple opportunities across the unit to make observations and/or measurements to gather additional evidence of the effect of water and vegetation on land.

PE 4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CCC)
Planning and Carrying Out Investigations. Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)	***ESS2.A: Earth Materials and Systems.*** Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1)	***Cause and Effect -*** Cause and effect relationships are routinely identified, tested, and used to explain changes.

Common Core Connections: ELA/Literacy
RI 4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.

MATERIALS

(For more about materials and group jobs, see STC Land & Water guide, p 30)

For the class:

- 1 graduated beaker 1 liter (1 qt)
- 1 roll of electrical tape
- Newspaper
- Cleanup supplies
- Two different readings about erosion and/or runoff, possible options:
    - 2 readings in this lesson
    - library books on water, rainfall, erosion, runoff, saturation, etc.

Per group:

- 1 directions card (in this lesson guide)
- Stream table materials:
    - clear box w/drain hole and stopper
    - sand, gravel, clay, hummus
- 1 sprinkler head
- 1 2-liter soda bottle with 0.5 liters of water
- 1 catch bucket
- 1 large & 1 small absorbent pad
- 1 gradated cylinder (for storing run off)

OPTIONAL: Digital camera or smart phone with photo capabilities

PREPARATION

30 minutes

For more about preparation, see STC Land and Water Kit guide, p13-16 & p 30

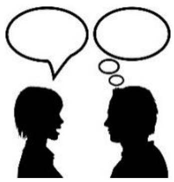
1. Materials preparation and lesson set-up takes approximately 30 minutes and can be done the day prior to the activity.
2. Prepare a materials distribution table or countertop area for the materials manager in each group to easily access (STC p14-16 for directions.) Select a location where materials can remain throughout the unit.
    a. Into each group's clear plastic tub, use an empty 1,000 ml (1L) graduated cylinder to measure out 1,500 ml of moistened all-purpose sand, 500 ml of humus, 500 ml of gravel, and 250 ml of clay. Moistening the sand helps it stick together when packed and helps students shape the soil more easily.
    b. Prepare a rain bottle for each lab group for this activity (p 30-31). Fill one 1-liter soda bottle per group with 0.5 liters of water using the graduated cylinder. Mark bottle with a black permanent marker line at 0.5L mark.
    c. Use electrical tape to wrap the cork of each sprinkler head with 15-20 revolutions of tape (to make it thicker). Push the sprinkler head into the opening of the soda bottle. Test for leakage and add more wraps of tape until it no longer leaks around the edges.
    d. If you have not done this activity yourself, take a few moments and walk through the procedure using the lab materials so you know what students are likely to do and observe (p 30-33).
3. Finally, select 2 appropriate readings about rainfall runoff and erosion that students can read and compare to the physical model they create. These readings could happen during the reading lesson or during a second science time. Students will use their observations of the physical model and what they read to make sense of how rain affects the land.

PROCEDURE — PART I: Modeling Rain on Land

1. Activate prior knowledge and experiences (whole class).

a. Introduce this lesson by revisiting ideas students had in lesson 1 about how increased rainfall possibly could cause the Oso landslide. Point to ideas related to rain on the public record (list of initial ideas from lesson 1) and tell students that today they will be observing how rain affects soil by making a physical model to see what evidence we can collect about the role of rain in the Oso landslide and more generally in how water affects soil. **Focus Question: How does rain affect soil?**

Turn-and-Talk



What have you observed when it rains on soil or dirt? How is it different comparing light rain to heavy rain?

b. Have students turn-and-talk about their experiences and prior observations of when it rains light and when it rains heavy. What happens to the soil or dirt? What does the soil look like before and after it rains? *OPTION: Have students independently write/draw about their experiences first before partner talk.*

➔ Listen in as students talk in partners for ideas about how rain splashes, creates mud, makes puddles, or soaks into soil – these are all observations students may make today using their small physical model.

2. Getting the Activity Started (whole class)

a. Show the materials: water bottle with sprinkler head, plastic tub, and soil mixture. Quickly demonstrate for students how to gather materials and set-up their simulation tub (see directions STC p 32-33 and/or student direction sheet in this guide.)

b. Show students the directions sheet and how to set-up their notebooks to record what happens at the start, midway through, and at the end. Things to remember:
- Shape the soil in the box into a cliff shape (5 cm deep x 20 cm long) opposite the side with the drain hole.
- <u>Do not squeeze the rain bottle</u> – just shake it up and down until the bottle is empty.
- <u>Do not poke or touch the soil</u> once you start the rain.
- Make a sketch of what happens before the rain, when the water is ½ gone from the bottle, and at the end (when bottle is empty).

c. Send students to get materials and set-up the simulation.

OPTIONAL: Give one group a digital camera to take photos of their rainfall simulation every minute (use classroom clock or stopwatch, if available). Students sketch a before, during, and after view but more frequent photos can be posted in the room or next to the summary table to capture just how rain water affects land.

Back-Pocket Questions

Observations & Patterns

3. **Making observations and uncovering patterns using questions (small groups).**

    a. Circulate as students set up the experiments. Redirect and help students with set-up as needed.
    b. As students make observations, circulate and ask questions to focus students on observations and patterns.
    c. Make sure students sketch how the land changes before, during, after rain.

Back-pocket Questions: Observations & Patterns

- What did you see happen to the land as it rains?
- What happens as the rainwater hits the land?
- Where did the water go?

4. **Publicly sharing observations (whole group)**

    a. Have students circulate to each table group for about 15 seconds per group to observe how each is similar or different even though each group started with the same set-up. When students return to their table group, they can write some observations they made under their sketches using the following sentence starters:
        - *Our rain model looked similar to others because they all had…*
        - *Our rain model looked different than the model in group _(name/number)_ because ours ____________ and theirs …..*

Turn-and-Talk

What was the same? What was different?

    b. Students return to their table group. Students turn-and-talk about what they observed from other groups. What was similar? Different?
    c. Share out observations about what happened in this experiment and add it to the "observation" column of the summary table. Students may have noticed things like: *Not all water drains away, some water soaks into the soil and gets trapped, the water than drains had some soil in it.*

Turn-and-Talk

Where did the water go?

    d. Have groups pour runoff from the bucket into the soda bottle. The water will be below the black line (which is the level they started with). Where do they think the rest of the water went? *Possible responses: Water got stuck in the soil. It's left in the tub because soil kept water from moving. The soil was dry at first and now it's wet so there's water in the soil.*

NOTE: KEEP 1 BOTTLE OF RUNOFF. YOU WILL NEED IT FOR LESSON 4 AND LESSON 5.

    e. Students return materials to the materials area. Stack tubs criss-crossing tubs to leave soil in tubs to dry out.

Back-pocket Questions Cause-and-Effect

- Compare the water level that rained on the soil with the amount of runoff.
- Why is there a difference?
- Where do you think the water went?

PART II: Reading about Erosion, Interpreting Data & Summary Table

TEACHER DECISION POINT

Reading Scaffolding

Decide how to best structure this reading task based on student needs.

1. **Pair of readings about how water affects land (whole grp or individual)**
   NOTE: This reading task in Step 1 could happen during reading lesson time and the data analysis during the science lesson time.

   a. Review key observations from the hands-on experiment portion of this lesson regarding how the water drained away or moved over the soil making a small stream.

   b. Students can look at their sketches and written observations as well as the contents of the soda bottles. Students may have noticed things like: *Not all the water drains away, some water soaks into the soil and gets trapped, the water than drains had some soil in it.*

   c. Have students read the readings in this lesson guide (and/or similar short reading from library books focused on runoff, saturation, and erosion.)

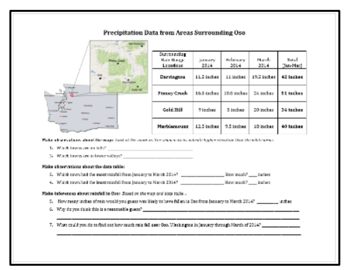
   d. Have students add what they learn from the reading to the summary table, particularly about runoff, saturation, and/or erosion. (The term erosion will come up in future lessons.) Introduce 2-3 word wall cards after reading (particularly erosion, saturation, Also, think about how this information about erosion might connect to the causes of the Oso Landside.

Investigating Data

Using maps and data

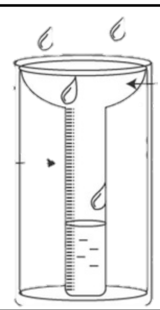
2. **Interpreting rainfall data from the Oso Landslide (pairs)**

   a. Pass out rainfall data from surrounding areas near Oso from early 2014 and the map of average rainfall for the area.



   b. Tell students that now that they have modeled rainfall on land and learned a bit about erosion, we should find out how much rain fell near Oso before the landslide in 2014 and compare it to the average rainfall.

   c. Tell students that scientists measure rainfall using a rain gauge which captures water and is read in inches. Use the box below to explain how scientists gather rainfall data.



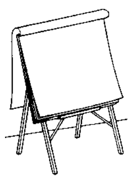
Measuring rainfall: What is a rain gauge?

Scientists use rain gauges to measure how much rain falls in a particular location. A rain gauge has a funnel and a tube. The device traps rain water. After each rain, the scientist reads the number of inches marked on the side and record it on a data table.

d. Have students answer the questions about the data table. Compare 2014 data with average rainfall in color-coded map.

e. As a class, share out the guesses students made about how much rainfall they think Oso had in January through March 2014 (the months before the landslide). *Possible estimates would likely be between 34 and 60 inches – some students may estimate higher than the data on the table because there weren't landslides reported in these towns but there was one in Oso so they probably had more rain. Let students see if they can research to find out more about the rainfall in Oso if desired.*

Public Record



Summary Table Row

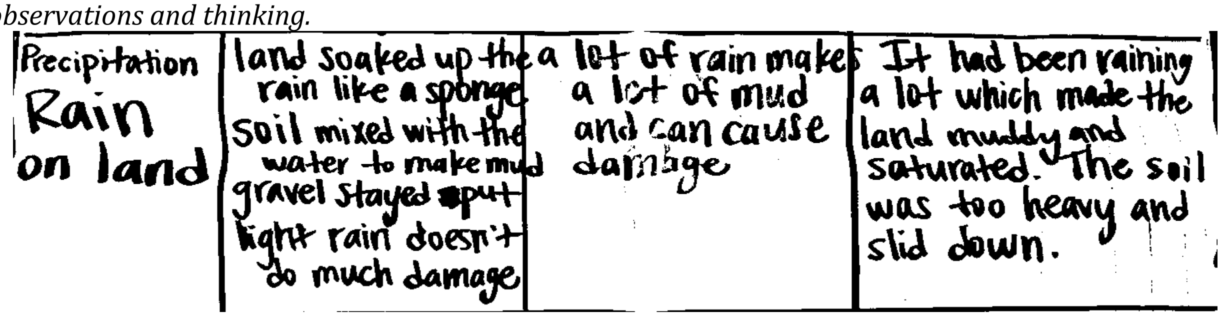
3. Connections to the phenomena (whole class)

a. Use information from the experiment, reading, data tables, and maps to complete any missing information from the 'observations' and 'learning' columns. Have students think about how this could help explain the Oso landslide. *How might higher than average rainfall be part of what caused the landslide? How does water change soil?*

b. If needed, redirect students' attention to observations from the news clip about higher than average rainfall. *How would heavy rainfall affect the land differently than light rainfall?*

Activity	***What did we observe?***	***What did we learn?***	***How does it help us explain the Oso Landslide?***
Rain on Land (Sketch activity or paste photo taken during activity here)	– Rain made the soil muddy – Rain made puddles – Rain soaked into the soil – Some water went over the land like a river and out the drain plug – Some soil came out in the bucket. – Not all the water came out, some water got trapped in the soil	From the experiment we learned that… – soil absorbs rain water – water can carry soil with it From the reading we learned … – **Erosion** = water and wind carry bits of soil to new places; plants hold onto soil and can prevent erosion – **deforestation** = cutting down trees in a forest; this can increase erosion	It was raining a lot before the Oso landslide so it made the land muddy and wet. Soil absorbs water but too much water would make soil float away or run down the hill. Maybe the soil got heavy with water and made it slide down and/or muddy soil is more slippery and can move more easily because it's wet.

Photo of the whole class summary table row from this lesson in a 4th grade class. *Notice it is different than the example provided above because it was created with students based on their observations and thinking.*



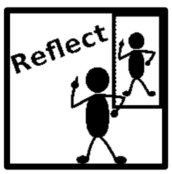
Precipitation Rain on land	land soaked up the rain like a sponge soil mixed with the water to make mud gravel stayed put light rain doesn't do much damage	a lot of rain makes a lot of mud and can cause damage	It had been raining a lot which made the land muddy and saturated. The soil was too heavy and slid down.

EXAMINING STUDENT WORK

Examine students' notebook entries that feature students' reasoning about why the water level in the runoff wasn't as much as the starting level in the soda bottle. Use this as well as evidence from science talk about the reading, maps, and data table to assess students' progress on the performance expectation for this lesson. Students will have additional opportunities related to this performance expectation in future lessons.

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. **TASK, TALK, & TOOLS.**

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of physically modeling rain on soil students to/with....
The task about ______ relates to students' and/or their families' lives because...

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during (name particular parts of lesson) which allowed students to...
During turn-and-talks, I observed _______ which makes me wonder if/how...

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

The summary table allowed students to...

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because...
Overall, this combination of talk, task and tools, allowed most/all students to...

2. **EQUITY**.

Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:

- Developing relationships & forming an inclusive, trusting community
- Scaffolding for full participation in the culture and language of science
- Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
- Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

____

____

____

____

____

PLANNING NEXT STEPS

Note: If students used digital photography during this lesson, show students photos in the next lesson and print them and add them to the summary table.

Using the ideas and questions you have heard from students during class and from their models decide what lesson(s) should come next. If students came up with a question about rainfall, these student questions should serve as a focus for what should next in the unit plan. For example, here are two options that would help students learn more about key science ideas while also learning about possible causes of the Oso landslide. Change the order of lessons or add an additional lesson to be responsive to students' questions and help them build their understanding of key concepts.

OPTION A: Effect of Soil Composition on Amount of Runoff If students had questions about what's in the soil mixture and if soil with more gravel would have more runoff, then this can anchor the next lesson. Students can learn about different kinds of soil components (kit lesson 5) and then design their own soil recipes and collect data on the amount of runoff using the bucket and soda bottle. Use a ruler to measure the height of the starting water and the height of the runoff water. Students can calculate how much water was absorbed of left in the tub.

OPTION B: Effect on speed of rainfall on visible changes in the shape of the land
If students had questions about how fast or slow the rain is and how that would affect the soil, then students can investigate that. Students could design their experiment keeping the soil the same but increasing and decreasing the rate of rainfall and do a visual comparison between groups with light rain and groups with heavy rain.

Modeling Rain on Land

Lab Group Directions

1. **Place** the large pad on the table with absorbent side up. Put the clear box on the pad on the table. Move the box so the drain hole sticks over the edge of the table.

2. **Place** the small pad on the floor with the absorbent side up. Put the bucket on the pad under the drain hole of the plastic box. The bucket will catch any water that comes out of the drain hole.

3. **Create a cliff with soil in tub.** Use the soil in the box to create a cliff that measures about 20 centimeters long and 5 centimeters deep.

4. **Remove** the drain plug from the box. Place it on the table next to the tub.

5. **Sketch** how the soil looks in your science notebook <u>before</u> adding water.

6. **Make it rain**. Have on student hold the water bottle upside down over the cliff and shake the bottle to make it rain on the soil.

7. **STOP shaking** when the water is about halfway gone from the bottle.

8. **Sketch in the "during rain" box** about halfway through the rain storm.

9. **Continue shaking** the bottle of water over the soil until the water runs out.

10. **Sketch in the "after rain" box** once the rain stops.

Making Observations

(Sketch soil before, during, and after rain and describe in your notebook.)

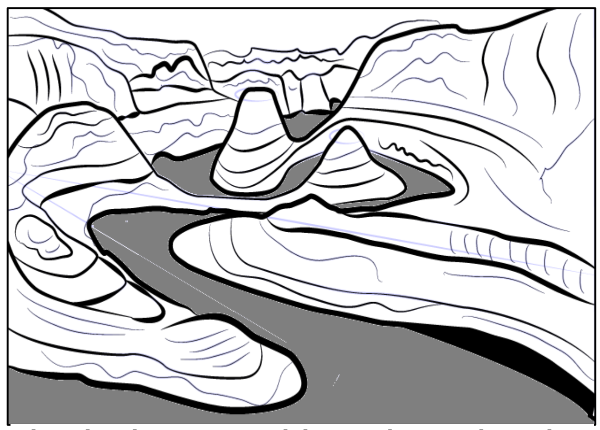
Before the rain	During the rain	After the rain

Earth Science for Kids: Erosion

Word Study:
The word erosion comes from the Latin word "erosionem" which means "a gnawing away."

erosion - noun
erode - verb
erosive - adjective

Erosion is the carrying away of land by forces such as water, wind, and ice. Erosion has formed many interesting features of the Earth's surface including mountain peaks, valleys, and coastlines. There are different forces that cause erosion. Depending on the type of force, erosion happens quickly or takes thousands of years. The major forces that cause erosion are water, wind, ice, and vegetation.



The Colorado River created the Grand Canyon by washing away bits and pieces of rock over thousands of years.

Water is the main cause of erosion. Water is one of the most powerful forces on the planet. Some ways that water causes erosion include: rainfall, rivers, waves, and flooding. Rainfall can cause erosion two ways. First, when the rain hits the ground and the drops move little bits of soil. This is called splash erosion. Second, raindrops land, roll together, and then flow like small streams carrying pieces of soil. Rivers also erode soil over time. They break up particles along the river bottom and carry them downstream. One example of river erosion is the Grand Canyon which was formed by the Colorado River. Ocean waves can cause the coastline to erode. The energy and force of waves cause pieces of rock and coastline to break off and be carried away, changing the coastline over time. Large floods cause erosion to happen very quickly, washing away loose soil and moving it to new places.

The size of earth materials that are carried away depends on how fast the water is moving. A fast-flowing river can carry large pebbles and rocks. A slow moving stream might only be able to move very small bits like clay, silt, and sand.

Other forces that cause erosion include wind, animals, vegetation, and gravity. Wind causes erosion, especially in dry areas. Wind can pick up and carrying loose particles and dust from one place to another. Small animals, insects, and worms can help erosion by breaking up the soil so it is easier for the wind and water to move pieces around. Plant roots hold onto soil which prevents erosion. In areas where trees are cut down the soil is no longer held together and can more easily be carried away by water and wind. The force of gravity can cause erosion by pulling rocks and other particles down the side of a mountain or cliff. Gravity can cause landslides which can significantly erode an area.

Additionally, humans have increased erosion in some areas. This happens through farming, ranching, cutting down forests, and the building of roads and cities. Human cause about one million acres of topsoil to erode each year. Planting trees around farmland and replacing trees that are cut down are two ways to limit the amount of erosion caused by human activity.

Erosion: Human Impacts on the Land

Erosion can cause problems that affect humans. Erosion is the process of natural forces moving rocks and soil. The natural forces that cause erosion are water, wind, ice, and gravity. Soil erosion, for example, can create problems for farmers. Soil erosion can remove nutrient-rich topsoil, leaving rocky soil behind. Erosion can also cause problems for humans by removing or weakening soil that supports buildings.

Water erosion happens when water moves the pieces of rock or soil downhill. Waves carry away small pieces of material. A wave can wash up onto the surface of rock or soil and carry away pieces of material as it flows back into the ocean or lake.

Homes built on a cliff near Pacifica, California collapse as ocean waves erode the cliff.

Ocean waves slowly erode cliffs near the beach. Many people like to live near the beach, however, this can be dangerous if they build their houses too close to the edge of the cliff. Over decades, ocean waves eat away at the soil, undercutting the cliff. Erosion destabilizes the cliff and can causes homes to fall down the cliff.

This landslide in El Salvador destroyed many homes in the valley below the hill. It happened after recent logging on the hill.

Human actions can increase the effects of water erosion. Clear-cutting trees to create farmland or to sell as timber can cause erosion problems. With no tree roots to hold soil, the topsoil easily washes away in heavy rains. Erosion caused by deforestation can lead to increased flooding because there is not as much topsoil there to absorb rain water. In hilly regions, deforestation can lead to increased likelihood of landslides.

Precipitation Data from Areas Surrounding Oso

Surrounding Rain Gauge Locations	January 2014	February 2014	March 2014	Total (Jan-Mar)
Darrington	11.5 inches	11 inches	19.5 inches	**42 inches**
Finney Creek	16.5 inches	10.5 inches	24 inches	**51 inches**
Gold Hill	9 inches	5 inches	20 inches	**34 inches**
Marblemount	12.5 inches	9.5 inches	18 inches	**40 inches**

Make observations about the map: *Look at the zoom-in. The shaded areas indicate higher elevation than the white areas.*

1. Which towns are on hills? ______________________________
2. Which towns are in lower valleys? ______________________________

Make observations about the data table:

3. Which town had the ***most*** rainfall from January to March 2014? ____________________ How much? ____ inches
4. Which town had the ***least*** rainfall from January to March 2014? ____________________ How much? ____ inches

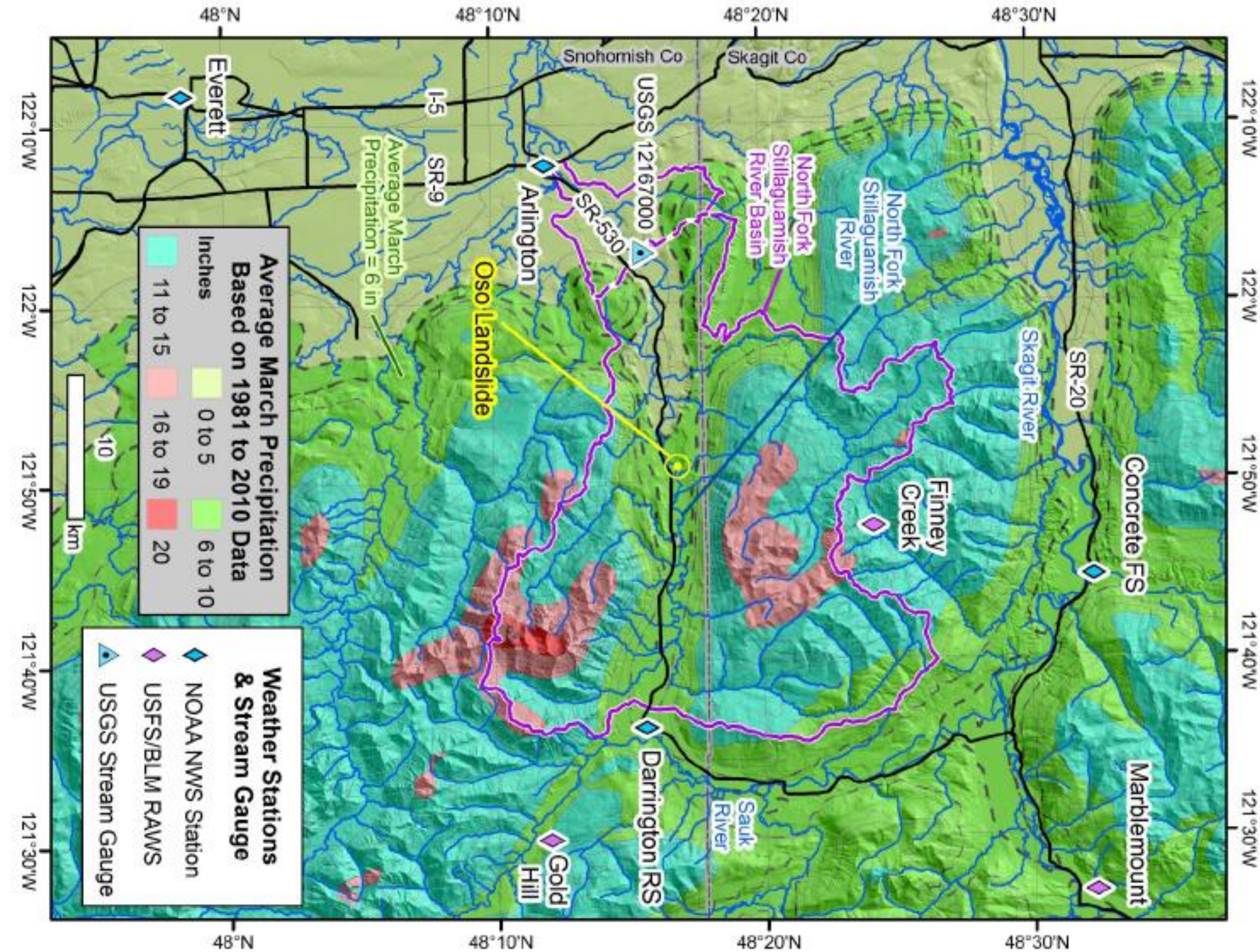
Make inferences about rainfall in Oso: *Based on the map and data table…*

5. How many inches of rain would you guess was likely to have fallen in Oso from January to March 2014? __________ inches
6. Why do you think this is a reasonable guess? ____

____

7. What could you do to find out how much rain fell near Oso, Washington in January through March of 2014? ________________

____


Average March Precipitation Based on 1981 to 2010 Data
Inches
11 to 15
0 to 5
16 to 19
6 to 10
20
Weather Stations & Stream Gauge
NOAA NWS Station
USFS/BLM RAWS
USGS Stream Gauge
Everett
Arlington
Oso Landslide
USGS 12167000
North Fork Stillaguamish River Basin
North Fork Stillaguamish River
Skagit River
Sauk River
Finney Creek
Concrete FS
Darrington RS
Gold Hill
Marblemount
Snohomish Co
Skagit Co
I-5
SR-9
SR-530
SR-20
Average March Precipitation = 6 in
10
km
48°N
48°10'N
48°20'N
48°30'N
122°10'W
122°W
121°50'W
121°40'W
121°30'W

Lesson 3: Examining Earth Materials

OBJECTIVES & OVERVIEW

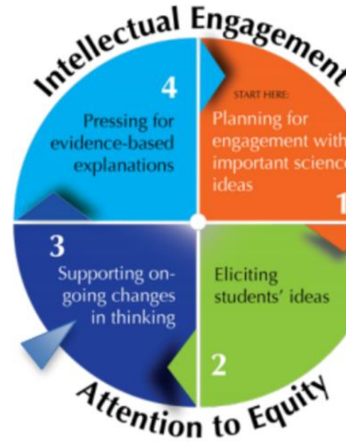
This lesson has students observe the properties of various components of soil (gravel, sand, clay, humus) in order to explain how and why each behaves differently when interacting with water. Students may have experiences digging outside in their yard or the school yard, in a sandbox, or at the beach, of using soils to build or play. These personal experiences can be leveraged in this lesson to go beyond making observations to explaining how and why different soils interact in different ways with water.

Focus Question: How are the components of soil similar and different?

- Students make and share observations about each soil component (appearance, texture, size of particles) and the effects water on these soil components.

Ambitious Science Teaching Framework:

SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS

Standards Note: This lesson focuses students on the observable properties of soil to understand why soil types behave differently in water and how water as an erosive force affects land that is composed by different soils. This lesson does not explore wind, ice, or vegetation, or slope but these will come up in future lessons.

PE 4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CCC)
Planning and Carrying Out Investigations. Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)	**ESS2.A: Earth Materials and Systems.** Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1)	**Cause and Effect -** Cause and effect relationships are routinely identified, tested, and used to explain changes.

Common Core Connections: ELA/Literacy/Writing
CCSS.ELA-LITERACY.W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
CCSS.ELA-LITERACY.W.4.2.D Use precise language and domain-specific vocabulary to inform about or explain the topic.

MATERIALS

(For more, see STC Land & Water guide, p 53)

For the class:

- Clear tape
- Video clip: What's the dirt on dirt?" (2m 50s) http://bit.ly/1WBhNcG *Note: Fast talking narrator. Can replay as needed.*
- Summary table
- Markers

Each student:

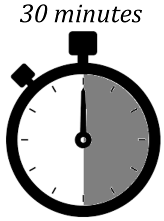
- Science notebook
- Data sheet (or make table in NB)

Per group:

- 1 directions sheet (STC p57-58)
- 1 plastic cup, half full of water
- 1 30 ml cup with 15 ml sand (½ oz)
- 1 30 ml cup with 15 ml gravel (½ oz)
- 1 30 ml cup with 15 ml humus (½ oz)
- 1 30 ml cup with 15 ml clay (½ oz)
- 1 spoon
- 2-4 hand lenses (as materials allow)
- 1 sheet white paper
- 1 stream table lid (to use as a tray)

PREPARATION

30 minutes



For more about preparation, see STC Land and Water Kit guide, p51-60

1. For each group prepare four 30-ml cups with approximately 15 ml (½ oz) of each different soil component (sand, gravel, humus, clay). Also fill 1 plastic cup halfway with water. Locate spoons and hand lenses.

2. Watch through the video clips and decide where to pause to ask students to process what they heard or saw. They could process by jotting down notes in their notebook or doing a turn-and-talk with a partner. The video clip goes fast so some parts can be re-watched.

3. Finally, make copies of directions for each group (STC p57-58) and copy data sheet per student (STC guide p 59-60 or make table in NB).

PROCEDURE

PART I: Making Observations

Turn-and-Talk

What do you notice about these different types of soil?

1. **Activate prior knowledge and experiences (whole class).**

   a. Introduce this lesson by revisiting observations students had from lesson 2 about how some of the water was absorbed or held in the soil. Show students a set of the 4 30-ml cups with individual samples of gravel, sand, clay, and humus (under document camera or place set of 4-cups at each table group). Name each type of soil for students. Then, have students turn-and-talk about what they notice about these different types of soil.

   b. Have students share out a few of their observations and introduce descriptive terms about color, texture, appearance, and particle size here – these are properties students will observe in Part I.
   Focus Question: How are the components of soil similar and different?

Video Clip

What's the dirt on dirt?
02 min 50 sec
http://bit.ly/1WBhNcG

2. Provide information to leverage during the activity (whole class)

a. Tell students that today they will be exploring each component of our soil mixture from the last lesson in more detail and learning more about soil in general.

b. Set the purpose for watching the video. What does the video say soil is made of? How can soil be different in different places? Play students the first video clip, pausing for processing time (either for note-taking or turn-and-talks). Replay video 2x.

3. Getting the Activity Started (whole class)

a. Quickly go through the directions for students so each group knows what to do with the materials and what observations to record in science notebooks (or on the data sheet, STC p59-60). The data table should be similar to the following:

	Gravel	Sand	Clay	Humus
Appearance				
Texture				
What it does in water				
What it does when stirred				
Sample or Sketch				

b. Demonstrate with one sample if needed. Students will:

Start with gravel. Then do sand, clay, then humus.

1. Dump sample on white paper.
2. Observe with hand lens. Write observations about color/look.
3. Touch sample. Write observations about clumping and texture.
4. Use piece of clear tape to get sample for your NB and tape it in the table (not gravel, unless it's a small piece).
5. Bend paper to slide sample into cup with water. Record observations of what it does in water.
6. Stir gently with spoon. Record observations.
7. Repeat with other samples in the same cup of water.

Back-Pocket Questions

4. Make observations and uncover patterns using questions (small groups)

a. Circulate as students set up the materials and make observations. Redirect and help students with set-up as needed.

b. As students make observations, circulate and ask questions about observations and patterns.

c. Make sure students are recording observations in their data tables.

Back-pocket Questions:

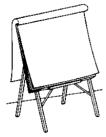
Observations & Patterns

- How are the particle sizes for each soil type?
- Which materials clumped together easily? Which didn't?

Inference & Connection

- How can studying different soils help us better understand the Oso landslide?

Public Record



Summary Table: Observations

5. Publicly sharing observations on summary table (whole group)

a. Record observations about each soil type on the summary table under "observations" column naming each type of soil and phrase and sketch beside each component taking observations from students.

b. Share color photo of "USGS Aerial Photo of Oso Landslide with Zoom ins". What do students notice about the soil in the landslide area? Does it all look the same? Do they see any gravel, sand, humus, or clay?

Quick Write

6. Quick Write (individual)

Have students spend 5 minutes to draw and write in their science notebook about the components of soil using the terms gravel, clay, sand, humus as well as grain size and texture. How are these components of soil similar? How are they different?

PART II: Reading about Soil & Summary Table

Step 1 could occur during the reading lesson and steps 2-3 in the science lesson.

Reading Integration

Read about properties of soil types.

1. Reading about grain side of soil (whole class/individual)

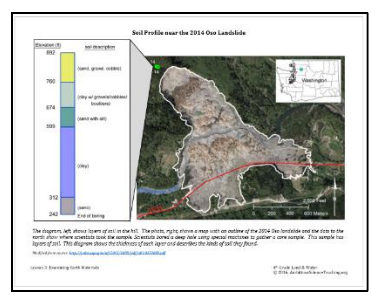
Decide if students will read independently, in partners, or using the reading as a whole-class read-aloud.

a. As students read, have them make connections to what they observed in the activity in Part I.
b. OPTIONAL: To learn more about soil, watch "Layer of Soil for Kids" (4m 08s) http://bit.ly/1T3SBfU *No narration, Have students read words aloud as video plays. It reinforces information in the reading.*
c. After reading: Students may wonder what kind of soil is in the hill that slid during the Oso landslide which moves into step 2.

Investigating Data

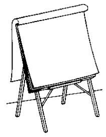
Using maps and diagrams

2. Data about Oso soil composition (whole class/individual)



a. Show the color print-out of the soil profile and map under the document camera. Explain to students how scientists collected this data (see caption).
b. Make sure students understand how to read the diagram by starting with observation questions like:
   - *What do the numbers on the left side mean?*
   - *What do the words on the right side mean?*
   - *Why is the vertical bar broken up into sections?*
   - *So, what does this diagram show?*
c. On the student sheet (in this lesson guide), students will use their observations of gravel, sand, and clay to draw the particle sizes in the blank soil profile. Then they can work with partners to answer questions 2 and 3. Question 3 sets students up for the next lesson where they investigate the interactions of water with soil.

Public Record



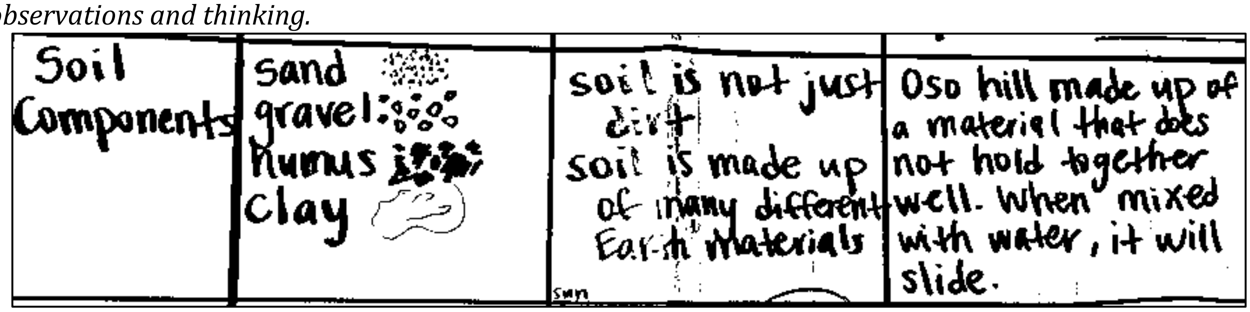
Summary Table

3. Connections to the anchoring event (whole class)

Use information from the experiment and reading to complete any missing information from the 'observations' and 'learning' columns. Have students think about how this could help explain the Oso landslide. *How might soil composition matter in what caused the landslide? Why might soil particle size matter?*

Activity	*What did we observe?*	*What did we learn?*	*How does it help us explain the Oso Landslide?*
Examining Earth Materials (Sketch activity or paste photo taken during activity here)	Gravel – largest grain size; tiny rocks; gray and white colors; water goes through it easily Sand – large grain size, yellow-brown color; crumbly or crunchy when wet Humus – small or medium pieces; tiny roots, dark brown color; won't clump – Clay – smallest grain size; reddish color, clumps when you pinch it; soft; slippery and sticky when wet	Soil is made of amounts of various components (like ingredients in a recipe). – Different soil types move differently in water – some heavy and sink, others lighter/smaller and float.	The soils in the Oso landslide might have been carried in rainwater water really well. Water could have gone into soil and got heavy – so heavy that all at once it gave way and slid down the hill. What is the Oso hill made of? (Not answered in this lesson but is likely question – answered in next lesson)

Photo of the whole class summary table row from this lesson in a 4th grade class. *Notice it is slightly different than the example provided in the lesson guide because it is created with students based on their observations and thinking.*



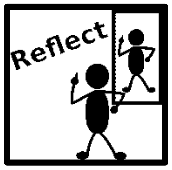
Soil Components	sand gravel humus Clay	soil is not just dirt soil is made up of many different Earth Materials	Oso hill made up of a materiel that does not hold together well. When mixed with water, it will slide.

EXAMINING STUDENT WORK

Most of student work today is at an observation level. Pay attention to the kinds of question students ask today about soil – these questions can frame tomorrow's (or a future) lesson. Also, listen in on student talk as they look at the soil profile diagram and map. How do students answer question 2 and 3? The next lesson is more about infiltration/pore space and how water filters down into soil – this idea may come up today as students observe particle size.

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.
Keep a record of these reflections for your professional portfolio.

1. TASK, TALK, & TOOLS.

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of observing individual components of soil helped students to/with….
The ____ task relates to students' and/or their families' lives or communities because…

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during (name particular parts of lesson) which allowed students to…
I observed ______ which makes me wonder if/how…

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

The summary table allowed students to…

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because…
Overall, this combination of talk, task and tools, allowed most/all students to…

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2. **EQUITY**.

Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:

- Developing relationships & forming an inclusive, trusting community
- Scaffolding for full participation in the culture and language of science
- Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
- Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

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Group Directions
Observing Properties of Soils

Start with gravel.
Then do sand, clay, and humus.

1. Dump sample on white paper.
2. Observe with hand lens. Write observations about appearance.
3. Touch sample. Write observations about clumping and texture.
4. Use small piece of clear tape to get a sample for your NB and tape it in the table.
5. Bend paper to slide sample into cup with water. Record observations of what it does in water.
6. Stir gently with spoon. Record observations.
7. Repeat with other samples in the same cup of water.

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5. Bend paper to slide sample into cup with water. Record observations of what it does in water.
6. Stir gently with spoon. Record observations.
7. Repeat with other samples in the same cup of water.

Quick Write Directions for Soil Observations
(Project under document camera or write on board)

In your science notebook…

Quick Draw & Write

How are these soil components similar? How are they different?

<u>Soil components</u>
Gravel
Sand
Clay
Humus

<u>Soil properties:</u>
Color
Texture
Particle size

Gravel and sand are similar/different because…

Clay and sand are similar/different because…

In water, ___________ was…

Looking at particle size, I observed…

One thing I'm wondering about is…

All about Soil

What is soil?

Soil is the loose upper layer of the Earth's surface where plants grow. Soil consists of a mix of decayed plants and animals and broken bits of rocks and minerals. Soil is formed over a long period of time. It can take up to 1000 years for just an inch of soil to form! Besides time, other factors help soil to form. These are:

- Living organisms - plants, fungi, animals, and bacteria
- Topography – the slope of the surface of land
- Climate and weather
- Parent material - the minerals and rocks that are slowly breaking down to form soil

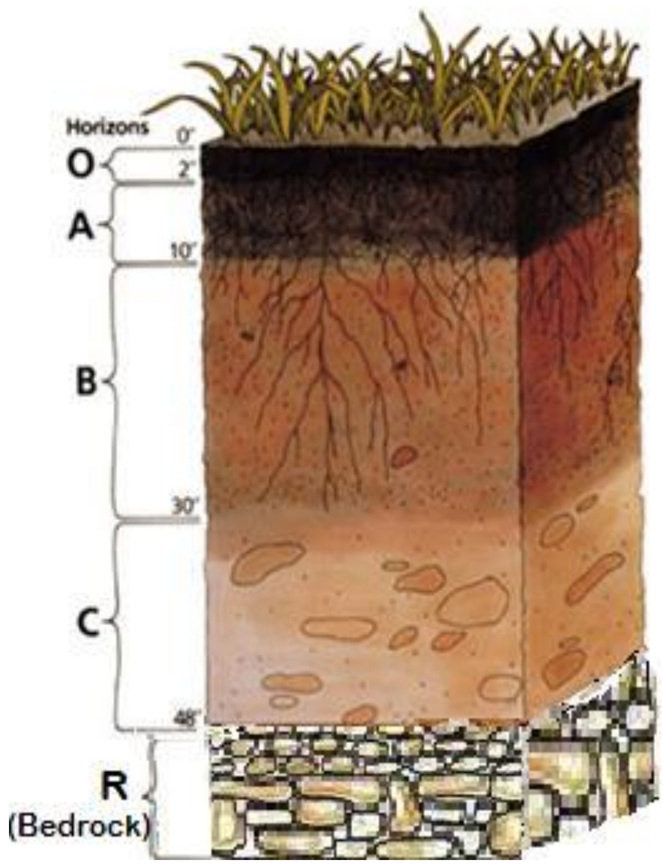
Properties of Soil

Soil is described using characteristics including texture, color, and porosity. One of the most important properties of soil is the texture. Texture is a measure of whether the soil is more like sand, silt, or clay. If a soil is sandy, the less water it can hold. On the other hand, if a soil has more clay, the more water it can hold – only after having enough time for the water to trickle into the spaces between soil particles.

Layers of Soil

Soil is made up of many layers. These layers are often called horizons. Depending on the type of soil there may be several layers. There are three main horizons (called A, B, and C) which are present in all soil.

- **Organic** - The organic layer (also called **humus**) is a thick layer of decomposed plants such as leaves and twigs.
- **Topsoil** - Topsoil is considered the "**A**" horizon. It is a thin layer (5 to 10 inches thick) composed of organic matter and minerals. This layer is where plants and organisms live.
- **Subsoil** - Subsoil is considered the "**B**" horizon. This layer is made of clay, iron, and organic matter.
- **Parent material** - The parent material layer is considered the "**C**" horizon. This layer is called the parent material because the upper layers developed from this layer. It is made up mostly of large rocks.
- **Bedrock** - The bottom layer is several feet below the surface. The bedrock is made up of a large solid mass of rock.



Text and image sources : http://www.ducksters.com/science/earth_science/soil_science.php

USGS Aerial Photo of Oso Landslide with Zoom-ins

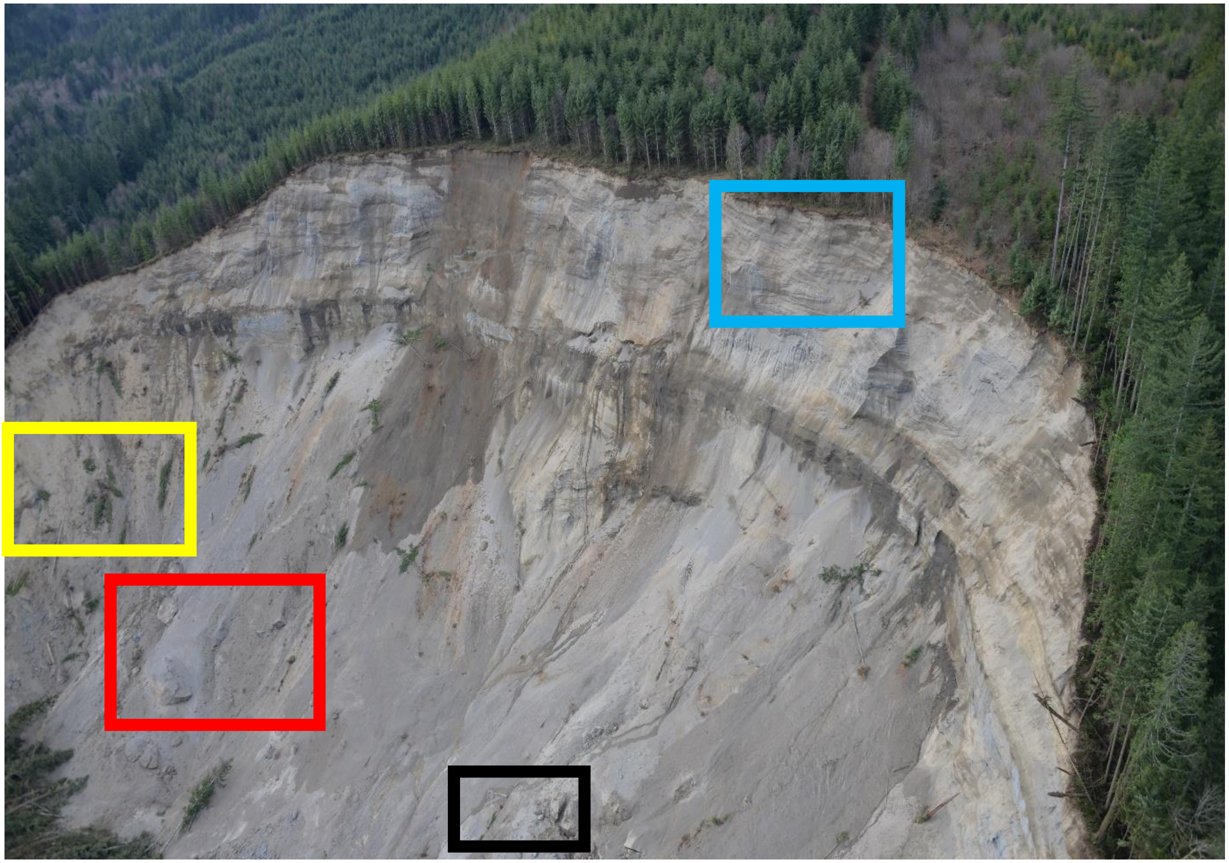
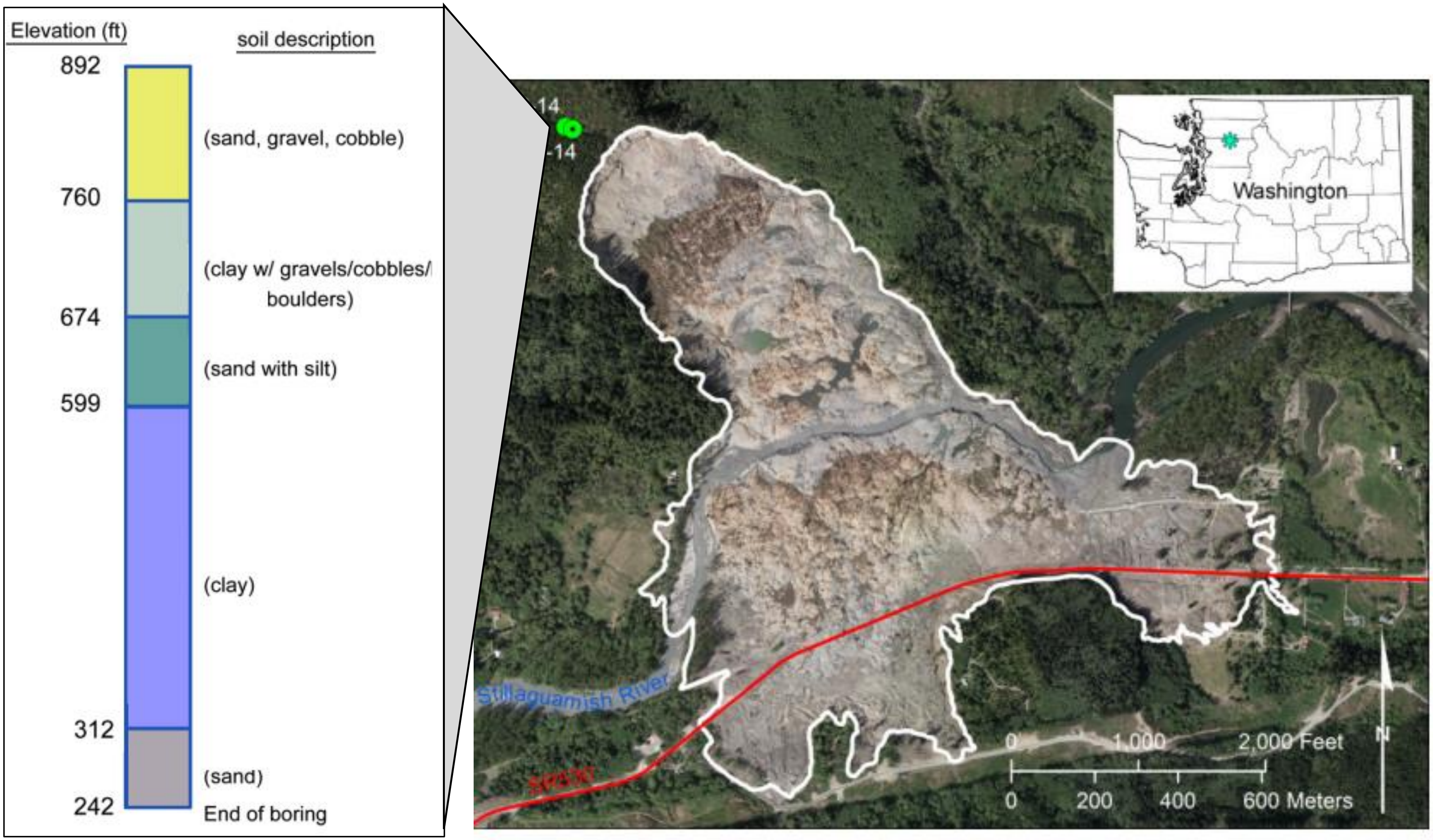


Image source: http://gallery.usgs.gov/images/03_26_2014/jne5HTs22B_03_26_2014/large/DSC_2347.JPG

How would you describe the soil?

Do you see any gravel, sand, humus, or clay?

Soil Profile near the 2014 Oso Landslide



The diagram, left, shows layers of soil in the hill. The photo, right, shows a map with an outline of the 2014 Oso landslide and the dots to the north show where scientists took the sample. Scientists bored a deep hole using special machines to gather a core sample. This sample has layers of soil. This diagram shows the thickness of each layer and describes the kinds of soil they found.

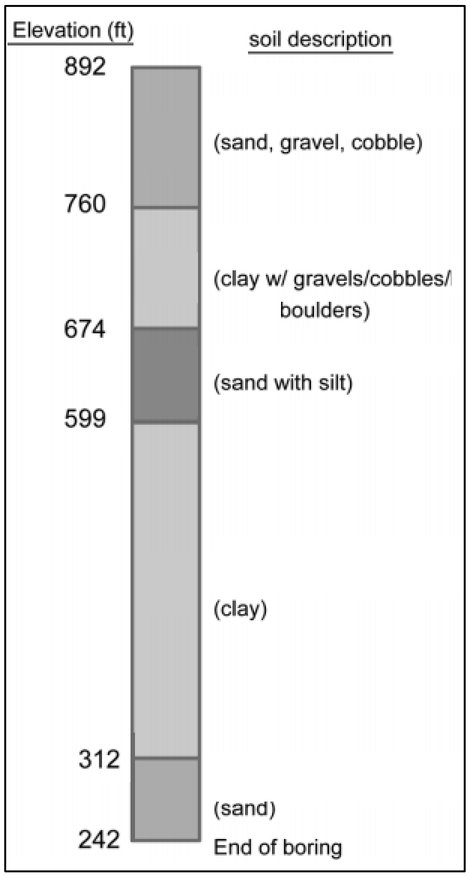
Modified from source: http://pubs.usgs.gov/of/2015/1089/pdf/ofr20151089.pdf

Name: ______________________ Date: ____________ Teacher: ____________

Soil Profile near the 2014 Oso Landslide

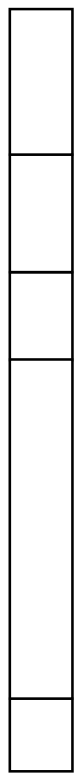
The diagram below shows layers of soil in the hill. Scientists bored a deep hole using special machines to gather a core sample. This sample has layers of soil. This diagram shows the thickness of each layer and describes the kinds of soil they found.

Modified from source:
http://pubs.usgs.gov/of/2015/1089/pdf/ofr20151089.pdf



1. Draw what each layer might look like focusing on the particle sizes of each soil type.

Use your observations of clay, gravel, and sand from the investigation and the descriptions in the soil description (left).



2. Make a connection: *Why might knowing about the soil layers help us explain the landslide?*

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3. Make a prediction: *What do you think would happen inside each soil layer after months of heavy rains?*

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Lesson 4: Groundwater & Runoff

OBJECTIVES & OVERVIEW

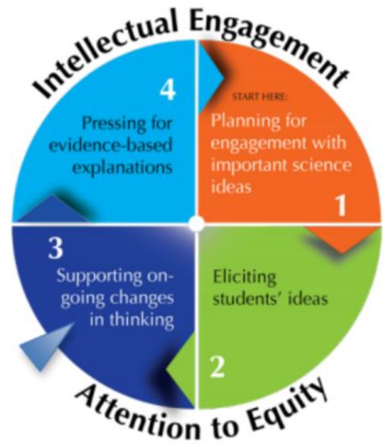
In this lesson students learn about how some rainwater is absorbed into the soil and eventually become groundwater while other rainwater runs across soil and drains into streams and rivers as surface runoff.

Understanding how water interacts with or moves through soil can help students explain a number of everyday phenomena including a muddy playground puddle, a flooded street, and how human impacts such as paving roads can influence surface runoff and infiltration.

Focus Question: How does water move through soil?

- Students make and share observations about how water moves through different soils.
- Students develop a model to explain differences in surface runoff and infiltration of each soil type.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS

Standards Note: This lesson is the first time students make observations and/or measurements of how water affects land through erosion by carrying out an investigation. Students have multiple opportunities across the unit to make observations and/or measurements to gather additional evidence of the effect of water and vegetation on land.

PE 4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CCC)
Planning and Carrying Out Investigations. Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)	**ESS2.A: Earth Materials and Systems.** Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1)	**Cause and Effect -** Cause and effect relationships are routinely identified, tested, and used to explain changes.

MATERIALS

Part I: Making Observations

For the class:

- 1 soda bottle with run off from lesson 2 (shows lower water level than black line; keep this bottle for lesson 5 as well)

For each table group:

- Clay – 30ml in small measured cup
- Humus – 30ml in small measured cup
- Sand – 30ml in small measured cup
- Gravel – 30ml in small measured cup
- 1 clear plastic cup
- 4 graduated cylinders, 50ml
- 1 chopstick
- 2 hand lenses
- 1 spoon
- Crayons (orange, black, gold, brown, blue)

Per student:

- Science notebook and pencil
- Data sheet (from this guide)

Part II: Modeling with Pore Spaces

For the class:

- Clear cup filled with marbles
- Clear cup filled with beads or beans
- Copies of reading
- Video clip: Water Movement in Soil 1 min 42 sec http://bit.ly/1VwGUz0
- Summary table
- Markers
- OPTIONAL See literacy integration section of unit guide and select relevant poem/chant

PREPARATION

30 minutes

See STC Land and Water Kit guide, 65-66

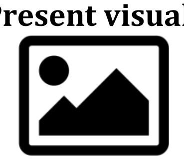
1. For each group prepare four 30-ml cups with approximately 30 ml of each different soil component (sand, gravel, humus, clay). Also fill 1 plastic cup halfway with water. Locate spoons, chopsticks, graduated cylinders, and hand lenses.

2. Make copy of group directions sheet (1 per group) and data recording sheet (1 per student).

PROCEDURE

PART I: Making Observations

Present visuals



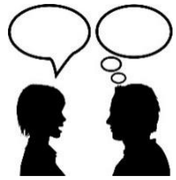
Show 2-liter bottle with black line and collected runoff from lesson 2

1. **Activate prior knowledge and experiences (whole class).**

   a. Have students open their science notebooks from their data drawings from lesson 2 (before, during, and after rain sketches and descriptions) and/or data sheet from lesson 3, question 3.

   b. Show students runoff bottle from Lesson 2. Remind students what they did, something like: *Remember when we modeled rainfall landing on soil in our tubs, we noticed that the water we collected in our bucket was less than the amount of water that we started with, which we marked with the black line. (Show bottle).*

Turn-and-Talk



Where did we think the water went?

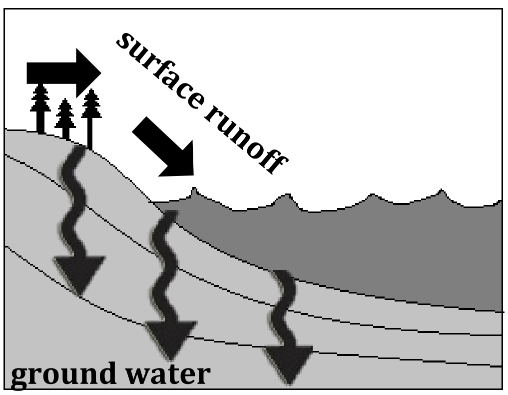
c. Have students think and then turn-and-talk about the question: **Where did we think the water went?** *Students can use their sketches and writing to support their talk if they drew/wrote I lesson 2. They talked about at the end of lesson 2.*

d. Tell students that today they will be investigating where this water goes and how it might be different with different types of soil. Remind students of the names of soil components they are working with: gravel, sand, clay, and humus. Introduce the **Focus question: How does water move through soil?**

Just-in-Time Instruction

2. **Provide information to leverage during the activity (whole class)**

Introduce two new terms for today's lesson that students can use to describe how water behaves in soil. Sometimes water moves across the top of soil and other times it moves down into the soil. Use the box below to introduce the terms. (See literacy integration section if you would like to include a GLAD chant here).



When rain falls to earth, gravity pulls it down hillsides and into soil.

Scientists use the term **surface runoff** to refer to water that flows over the top of the land.

Ground water is water that soaks into soil and seeps gradually downward, in the spaces between soil particles.

3. **Getting the Activity Started (whole class)**

Turn-and-Talk

Make a prediction: Which soil will let water run through easily? Why do you think so?

a. Tell students that today they will be investigating which soils are more likely to have runoff and which ones more easily absorb water as ground water.

b. Show students a set of 4 cups of each soil sample and remind them of their names (gravel, sand, clay, humus). Which soil type do you think will hold onto water the best? Which soil will let water run through the fastest? Why do you think so?

c. Have students share out a few responses – *likely students will talk about particle size and texture (or stickiness) since they recently observed this in the prior lesson.*

d. Quickly show students the procedure card that each group will follow. Read through each step, acting out with materials if necessary. When you get to the step about the importance of compacting the soil to get rid of air bubbles you can remind students they saw that air was a component of soil we learned about from the video in lesson 3.

e. Send students back to their table groups to gather materials and get started following the directions on the card.

Back-Pocket Questions

4. Making observations and uncovering patterns using back-pocket questions (small groups).

a. Circulate as students set up the experiments. Redirect and help students with set-up as needed.

b. As students make observations, circulate and ask questions to focus students on observations and patterns.

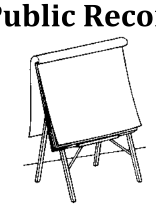
c. Make sure students sketch and collect data on the data sheet as they work. (Students need to complete the front side of the data sheet during Part I.)

Back-pocket Questions:

Observations & Patterns
- Which soils were easier to pack down? Which were harder?
- What happens when you poured the water on each sample?
- Which soil looks like it's holding onto water and absorbing it?

Inferences & Connections
- Why do you think that happened?
- Why do you think the water get into some soils more easily than others?

Public Record



Summary Table
Row: Observations

5. Publicly sharing observations (whole group)

Share out observations about what happened in this experiment and add it to the "observation" column of the summary table. *Possible observations might include:*
- *The ________ had the most water (___ ml) poured back off the soil.*
- *The ________ had the least water (___ ml) poured back off the soil.*
- *Water went in between spaces of gravel so it had a lower level than other soil samples (include numerical data).*

As time permits, have students think and turn-and-talk about these questions or they could write in their notebooks:
- Where did the water go when you poured it into each cylinder? Why?
- What does this investigation tell you about where water could when it meets land?

6. Have students clean up materials.

PART II: Modeling pore space

Just-in-Time Instruction

Turn-and-Talk

How are the jars of beads and marbles like our soil samples?

1. Provide an idea to leverage during the activity (whole class)

a. Show students the cup of marbles and a cup of beads or beans. How are these like our soil samples? Have students turn-and-talk.

b. Have students share out. Students may have trouble verbalizing their ideas so encourage them to gesture or draw on the board to show their ideas to the class, with attention to particle size.

c. Review the term 'particle size' which students used in lesson 3. Introduce the term 'pore space' if you have not already. Pore space is the space between particles of soil where water, air, and living things can exist and move through (connect to video used in lesson 3 about components that compose soils.) Use word wall card.

Video Clip

Water Movement in Soil
1 m 42 sec
http://bit.ly/1VwGUz0

d. Learn more about ground water and pore spaces by using the reading (2 pages) and a video clip. Focus students reading and discussion of video around ideas about pore space, soil composition, and how particle size explain how easily water can flow through soil (or not).

Investigating Data

Modeling to explain collected data

2. Explaining data from Part I (pairs/individuals)

a. Give students time to complete the back of the data sheet as they draw how/why water interacts with each type of soil using what they learned from the video and reading about pore space.

b. As students work, focus students on the idea of particle size and pore space. Students may use the marble or bead analogy, if they find it useful.

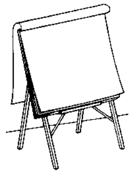
c. Circulate and look for work that shows different ways of explaining ideas related to pore space and particle size and how this affects whether rain seeps into soil to become groundwater or whether it would be more likely to be surface runoff.

Turn-and-Talk

Share your drawing and idea.

d. Once students have finished their work, have students turn-and talk to a partner about their drawing and ideas. Then, have 2-3 students come up and put their drawings and explanation under the document camera to explain their idea to the class. Encourage students to ask question to each other and compare what is similar and different about each students' work.

Public Record



Summary Table Row

3. **Connections to the anchoring event and other phenomena (whole class)**

    a. Use information from the investigation, reading and video to have students help to fill in the 'observations' and 'learning' columns.
    b. Ask students to think about how this investigation can help us understand a landslide. *We know there was heavy rain, more than usual, in the months prior to the landslide – what might happen in the pore spaces?*

Activity	*What did we observe?*	*What did we learn?*	*How does it help us explain the Oso Landslide?*
Where does the water go? Looking at ground water and runoff	The gravel had the most water (26 ml) poured back off the soil. (Include data for each type of soil) When water mixed with gravel, water went in between spaces of gravel so it had a lower level than other soil samples. (Include sketches of data)	Components of soil have different sizes and shapes of particles. Some soils have lots of pore space between grains and can hold or move lots of water quickly. Other soils have small particles and small pore space and takes longer for water to flow through them.	There was heavy rain in the months prior to the landslide. If all the hill got saturated and filled up all the space with water maybe the hill got heavy and slippery on water so the whole thing gave way and slid down.

EXAMINING STUDENT WORK

Examine students' data sheets, particularly the reverse side. How are students representing water movement through soil? How are they representing different particles sizes and pore space? How do they explain their findings? What questions or wonderings did students have today?

LESSON REFLECTION

Teacher Reflection

Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons. Keep a record of these reflections for your professional portfolio.

1. **TASK, TALK, & TOOLS.**

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of physically modeling rain on soil students to/with….
The task about ______ relates to students' and/or their families' lives because…

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during (name particular parts of lesson) which allowed students to…
During turn-and-talks, I observed _______ which makes me wonder if/how…

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

The summary table allowed students to…

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because…
Overall, this combination of talk, task and tools, allowed most/all students to…

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2. **EQUITY**.

Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:

- Developing relationships & forming an inclusive, trusting community
- Scaffolding for full participation in the culture and language of science
- Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
- Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

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PLANNING NEXT STEPS

Using the ideas and questions you have heard from students during class and from their models decide what lesson(s) should come next. What questions do students have that could anchor future lessons? What lessons might need to be added to help students build their understanding?

Group Directions: Exploring Runoff and Groundwater

Which soil holds water best? How can we find out?

A. Preparing the soil sample.

1. Pour each soil sample into its own cylinder.
2. IMPORTANT! Use the chopstick to pack down the soil to the 20-ml mark. Ask for more soil if you need it.
3. Draw how the soil looks in each graduated cylinder on your recording sheet using crayon colors.
4. Pour out any extra soil left in the small cups onto a paper towel so you have 4 empty small cups.

B. Preparing the water.

5. Fill each small cup with 30 ml of water.

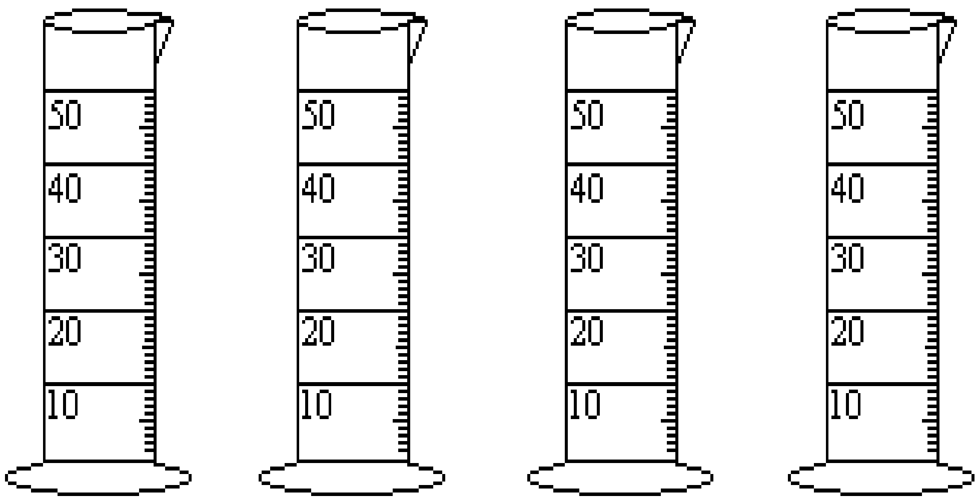
C. Testing each soil sample.

6. Pour the 30 ml of water into each cylinder over the soil.
7. Wait 5 minutes. Observe what happens. ***Where does the water go?***
8. Add to the drawing. ***How does the soil and water look in each cylinder?*** Pay attention to the total amount by reading the numbers on the side of the cylinder.
9. Pour off the water from each cylinder back into the small 30 ml cups.
10. Draw how much water is in each cup on the data sheet.
11. Answer the questions on the data sheet.

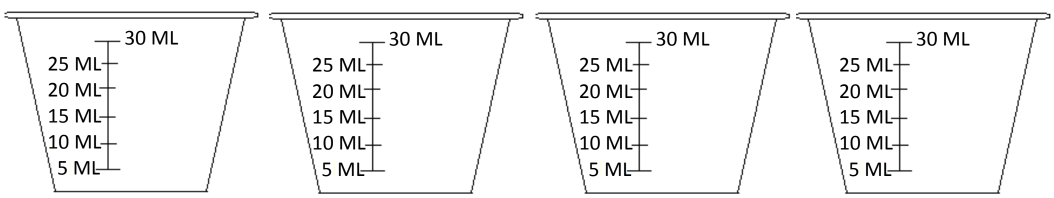
Name: ______________________________________ Date: __________ Teacher:_______________

Collecting Data: Which soil holds water best?

Sand **Clay** **Gravel** **Humus**



Water from sand | Water from clay | Water from gravel | Water from humus



	Soil Sample Amount (packed down)	**Amount of water added**	**Total volume in cylinder** (read after 5 mins)	**Volume of water poured off** (in small cup)
Sand	20 ml	30 ml		
Clay	20 ml	30 ml		
Gravel	20 ml	30 ml		
Humus	20 ml	30 ml		

Observations and Data

1. Which soil had the *most* water poured off into the cup? ___________________ How much? _______ml

2. Which soil had the *least* water poured off into the cup? ___________________ How much? _______ml

3. Which soil appeared to let water get into it easily? _____________________________

Explain the Results

4. In the boxes below, draw zoom-ins to draw the different particles sizes to explain how or why the water interacted with each soil sample.

Gravel	Sand
Clay	Humus

5. Soils with high amounts of ______________ would be good at holding ground water because ____ ____.

6. Soils with high amounts of ______________ would be good at letting water easily drain away because ____ ____.

7. How does this investigation help us figure out part of the Oso Landslide story? ____ ____

More about Groundwater and Pore Spaces

Groundwater is one of our most valuable resources—even though you probably never see it or even realize it is there. As you may have learned, most of the pore spaces in the rocks underground below the water table are filled with water. But rocks have different properties. Water can seep and flow through layers of rock and soil in different ways based on what the soil is made of.

In the diagram below, you can see how the ground below the water table is saturated or filled up with water. The "unsaturated zone" above the water table still contains some water — after all, plants' roots live in this area, but it is not saturated. You can see this in the two drawings at the bottom of the diagram, which show a close-up of how water is stored in between underground rock particles.

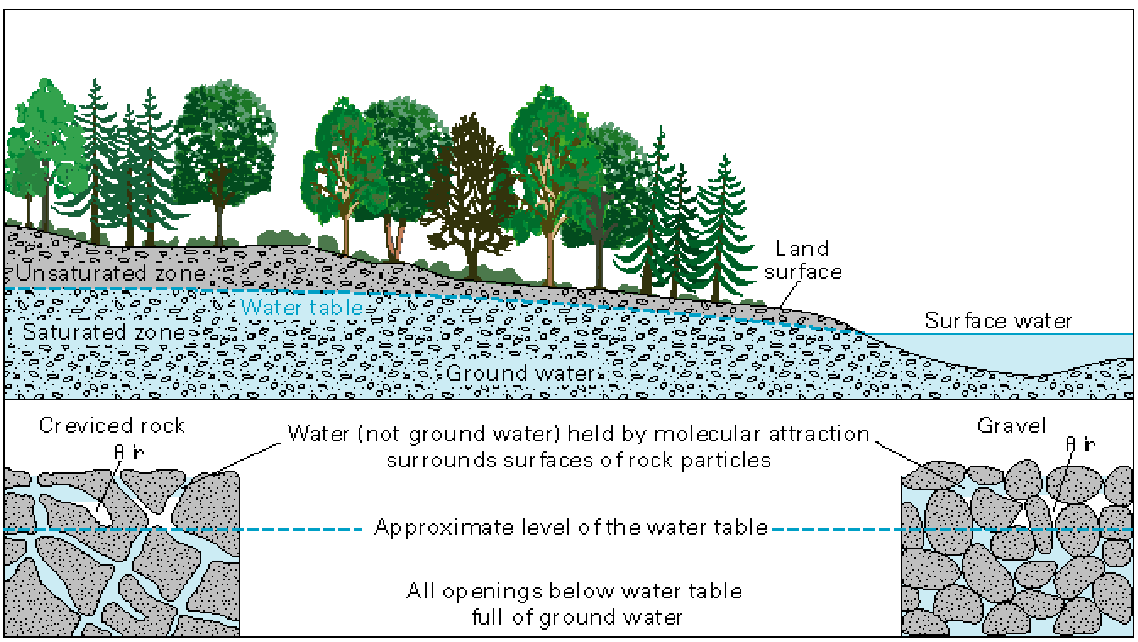


Image credit: http://water.usgs.gov/edu/earthgwaquifer.html

When a rocks and soils readily transmits water to wells and springs, it is called an aquifer. Aquifers store water underground. We drill wells into the aquifers and pump water out for drinking, bathing, and cooking. Rain adds water back into the aquifer as rain water slowly seeps into the cracks and spaces between rock particles.

Pumping too much water from a well too quickly eventually causes a well to yield less and less water and even run dry. In fact, pumping water from the well too fast can even cause your neighbor's well to run dry if you both are pumping from the same underground aquifer.

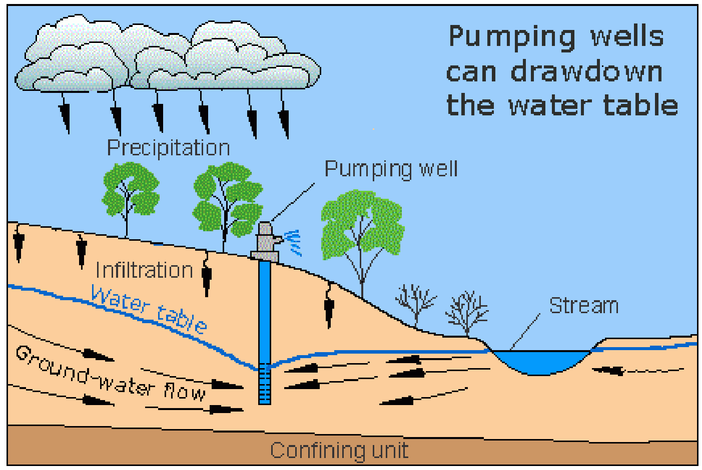


Image source: http://water.usgs.gov/edu/earthgwaquifer.html

Water movement in aquifers depends on the permeability of the material. Permeable material has interconnected cracks or spaces that are large enough to allow water to move freely. In some permeable materials groundwater may move several yards each day – through material with gravel, for example. In other places, water moves only a few inches in a hundred years! Groundwater moves very slowly through relatively impermeable materials such as clay.

Permeability = how well a material allows liquids pass through

Permeable = allow liquids to pass through

Impermeable = not allow liquids to pass through

Lesson 5: How slope affects runoff and erosion

OBJECTIVES & OVERVIEW

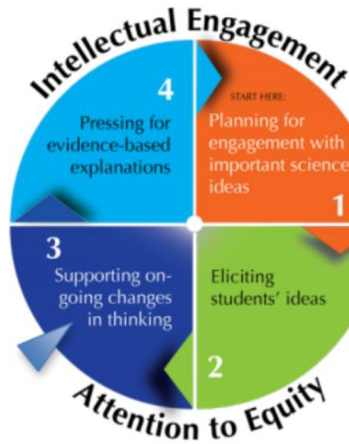
In this lesson students continue to learn about how rainwater can be either absorbed and become ground water or runs off and drains into streams and rivers as surface runoff. Understanding how slope affects runoff and erosion can help explain part of the Oso landslide story as well as related phenomena.

Students use slopes made of the soil mixture in this lesson, with no vegetation. In lesson 7, students investigate erosion and runoff of a hill with vegetation.

Focus Question: How does slope steepness affect the amount of soil erosion from rain?

- Students make predictions and share observations about how steepness of a slope affects the direction and flow of water on land.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS

Standards Note: This lesson is the first time students make observations and/or measurements of how water affects land through erosion by carrying out an investigation about the steepness of a slope. Students have had multiple opportunities across the unit to make observations and/or measurements to gather additional evidence of the effect of water on land and in future lessons will investigate how vegetation slows erosion.

PE 4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CCC)
Planning and Carrying Out Investigations. Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)	**ESS2.A: Earth Materials and Systems.** Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1)	**Cause and Effect -** Cause and effect relationships are routinely identified, tested, and used to explain changes.

MATERIALS

Part I: Making Observations

For the class:
- color photos of different sloped hills
- chart paper for class data table

For each table group:

For today's investigation:
- Directions (STC p149-150 or this guide)
- Stream tub with soil mixture from lesson 2
- 1 large plastic cup with large hole (red dot)
- 1 2-liter soda bottle with 2 liters water
- Books for stacking
- Large absorbent pad (to protect books)
- Centimeter ruler or measuring tape
- Paper towels

Cover tub at end of Part I:
- 1 sheet 3mil clear plastic sheeting
- 1 large rubber band

Part II: Data Discussion & Summary Table

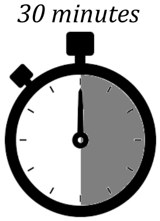
For the class:
- Copies of readings
- Color map of slope steepness at Oso
- Summary table
- Markers

Part III: Set up for lesson 7 – Why plants?

To set-up for next investigation:
- Stream tub from today's investigation
- Ryegrass seed, 30 ml (medicine cup.)
- Mustard seed, 30 ml (medicine cup.)
- Humus, 135 ml (Fill ½ large 9 oz cup)

PREPARATION

30 minutes



See STC Land & Water guide, 143-146

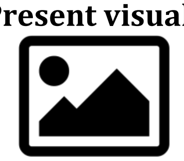
1. Part I: On each group's 2-liter bottle, use the 50 ml gradated cylinders to fill and mark 100ml from the 1L line (from lesson 2) to a 2L level (2,000 ml). Also, number each bottle by table group.

2. Part III: Measure out seeds for each group and gather materials to set up for Lesson 7. NOTE: It takes about 4 days for the seeds to germinate and grow**.** Students will plant seeds at the end of Part III. Check on growth in a day or so. Add additional seeds if necessary to make sure soil is covered in vegetation by Lesson 7.

PROCEDURE

PART I: Making Observations

Present visuals

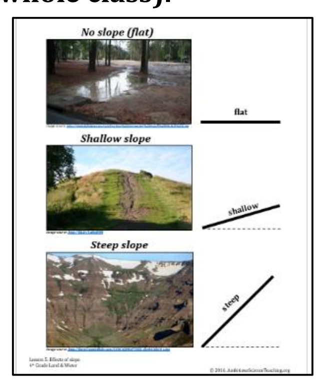


Show color photos of different slopes.

Turn-and-Talk

Where would rain water go on each slope? Why do you think so?

1. **Activate prior knowledge and experiences (whole class).**



a. Project the full-size page of photos of slopes. Ask students where they think water would go if it rained in these places.

b. Have students turn-and-talk. Press students to explain the reasoning behind their predictions. *Possible responses: ideas about speed ("running down"), absorption ("soaking up/in"), pooling at the bottom of the hill, etc.*

c. Introduce today's focus question about exploring soil erosion on different slopes. Also, refer back to students' initial ideas if any ideas were about the steepness of the slope. **Focus question: How does slope affect the amount of runoff?**

Just-in-Time Instruction

2. Provide information to leverage during the activity (whole class)

Introduce the term ‘slope’ today using the color photos so students can use this word today while communicating about their observations and results. The adjectives *flat, shallow, steep* may help as well. (Word study moment: You can also point out the –e at the end of *slope*, without it, the word would be slop. Also, the word *steep* without an *e* would be *step.*)

slope

steep shallow

Slope describes the steepness of an incline or hill. A *shallow* hill is at a lower angle than a *steep* hill. Slope is typically measured as an angle using a protractor. Sometimes people use *height* to describe slope.

3. Getting the Activity Started (whole class)

a. Tell students that they will observe different slopes to see if there is any difference in erosion of soil. Share the investigation question: *How does the <u>slope steepness</u> affect the <u>amount of runoff</u>?*

b. Explain that students will gather data as a class for 3 different slope heights (shallow, medium, and steep). Each group is only test one slope. 2-3 table groups will test the same/similar height to have multiple trials. (See student data table)
   - *Groups 1, 2, 3 = steep slope*
   - *Groups 4 & 5 = medium slope*
   - *Groups 6, 7, 8 = shallow slope*

c. The exact slopes may vary based on the size of books, just make sure the differences in slopes are different enough to show observable differences (i.e. shallow 7cm, medium 14cm, steep 21 cm).

d. Show students an example of the set up. Briefly go over the student direction card (in this lesson). Then send groups to follow direction card and begin.

4. Making observations and uncovering patterns using back-pocket questions (small groups)

a. Circulate as students set up. Redirect and help as needed.

b. As students make observations, listen and ask questions to focus students on observations and patterns.

c. Make sure students sketch and collect data on their data sheet for their group.

Back-Pocket Questions

Observations & Patterns

- What is the water doing? Where is the water going?
- How fast is the water moving?
- What do you notice in your bucket?

Inferences & Connections

- Why is there soil in your bucket? How did it get there?
- How do you think your observations will be different from another slope?
- How does this investigation help us think more about the 2014 Oso landslide?

Investigating Data

Looking for patterns and relationships

Turn-and-Talk

How is the amount of runoff different between steep and shallow slopes?

Quick Write

Write a conclusion

5. Share observations and make a class data table (whole group)

a. Have students share out data from each table group and add it to the class data table. Each student records class data on their data sheet.

b. Looking for patterns: Compare the amount of runoff from shallow slopes and steep slopes to answer the investigation question.

   i. Have students look at their class data table and compare the slope steepness with the amount of runoff.

   ii. Give students think time, then turn-and-talk with a partner about the question: ***How is the amount of runoff is different between steep and shallow slopes?***

c. Give students time to write a conclusion on the front of the data sheet (question 1) to answer the investigation question.

   By the end of Part I, students have completed the front of the student handout. Students will complete the back in Part II.

6. Clean for from Part I: IMPORTANT!!!

a. Have students cover tubs with plastic and a rubber band. (Students will plant seeds after Part III – don't want tubs to dry out.)

b. Make sure tubs are plugged and covered. Stack tubs crisscrossed on top of each other in the materials area.

c. **<u>Do NOT dump out the contents of the 2-liter bottles</u>**. Screw caps on all 2-liter bottles with the runoff from today's experiment. Label bottles steep, medium, and shallow. You need these for Part II.

PART II: Data Discussion & Summary Table

Investigating Data

Modeling to explain collected data

1. **Explaining data from Part I (pairs/individuals)**

   a. Give students time to complete question 2 on their data sheet as they draw how/why water interacts with slopes, how it affects run off and erosion using what they learned from patterns in the data and prior videos or readings.

   b. Circulate and press students to explain how/why a steeper slope might result in less retained water, more runoff, and more erosion. *Possible responses might include ideas about: the faster water doesn't have time to seep into soil and become groundwater so it's more likely to be runoff; faster water has more force and can take more soil with it; shallower slopes allow the water to sink/soak in more; on shallow slopes the water didn't move as fast so it could get into the pore spaces.*

   c. Select 2 students to share their drawings/explanation under the document camera and explain their reasoning to the class. Encourage students to ask questions to each other and compare what is similar and different about each students' explanations with their own.

2. **Looking for patterns and relationships in a data set (whole group)**

Present visuals

Show 2-liter bottles with runoff from steep, medium, and shallow slopes.

   a. Instead of looking at slope and runoff data (which they did in Part I), we turn to the relationship between slope and amount of erosion. Overnight, the eroded soil in each bottle has settled. Try not to move bottles too much and place them where all students can observe them. Make sure students can tell which bottles contain runoff from the steep, medium, or shallow slopes.

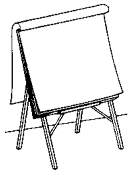
Investigating Data

Looking for patterns and relationships

   b. <u>*Compare the amount of erosion on steep and shallow slopes*</u>: Have students observe the amount of soil in each bottle of runoff. Then ask whole-group or use turn-and-talks to discuss:
   - *Which slope, steep or shallow, had the most erosion?*
   - *Which slope do you think had fastest moving water?*
   - *For slopes where water moved fast, how much water got absorbed or retained by the soil? Why might that be?*
   - *Why do you think the ______ slope had the most runoff?*
   - *(Also: If students got any contradictory data, discuss why data might not be reliable. One reason could be if students splashed or accidentally tipped over the cup.)*

   c. **IMPORTANT!** Save one of each bottle per slope (steep, medium, shallow) to use in lesson 7. Clean out the other bottles to use later. Have students bring extra bottles to class, if there are not more extra 2-liter bottles..

Public Record



Summary Table Row

3. Connections to the anchoring event (whole class)

a. **Observations**: Take a few observations from students that includes numeric data and a relationship between slope and runoff. Tape a copy of the class data table in the summary box.

b. **Learning**: Help students craft generalizable statements about what they learned from the investigation. They could also put questions or wonderings here.

c. **Connections**: Ask students to think about how this investigation can help us understand a landslide. *We know there was heavy rain, more than usual, prior to the landslide AND the photos look like it's pretty steep – what might happen to the runoff during a heavy rain?*

Activity	***What did we observe?***	***What did we learn?***	***How does it help us explain the Oso Landslide?***
How does the steepness of a slope affect runoff and erosion? *(sketch picture or post photo of investigation here)*	With a steep slope, we observed: - More runoff (___ ml) than shallow (___ml) - More erosion than shallow - Water moved faster down the hill	The steeper the slope the more likely it is that there will be more runoff, more erosion, and less infiltration or saturation of the soil. This probably happens because the water is moving too fast to get absorbed into the pore spaces.	The mountain where the landslides happen looks pretty steep. Maybe some of the heavy rain washed away the soil and some got into the soil but then got heavy and slid down. *What can humans do to prevent erosion or landslides?*

PART III: Setting up for Lesson 7 – Why vegetation?

Just-in-Time Instruction

1. Provide an idea to leverage to use in the activity (whole class)

Turn-and-Talk

What could humans do to prevent slope erosion?

a. Have students think about some ways they think they could protect a steep slope from having erosion during heavy rains, like the slope for the 2014 Oso landslide.

b. Turn-and-talk with a partner about ideas. Some students may not have ideas yet, others may have many. Tell students they will now read about one method used by people all over the world for thousands of years to lessen erosion on steep slopes.

Reading Integration

Read about one strategy to prevent slope erosion.

c. Have students read about terracing on a slope (Reading: "How do people farm in hilly regions?" in this lesson guide). This could be individually, in partners, or as a read-aloud (whole-class).

d. Possible reading comprehension questions:
- *What is one technique that slows down erosion on slopes?*
  - → *How do you know it works? What does the reading say?*
- *How does terrace farming slow down erosion?*

→ *What is the evidence from the text?*

- *What is another way to slow down erosion that the reading talks a little bit about?*

  → *Hint: The reading hinted at it. Look in the caption. (The caption mentions plants, trees, and vegetation because roots hold onto loose soil.)*

e. Explain to students that now that they have observed how erosion happens on different slopes with soil, we are going to see if vegetation really does work to prevent erosion. To do that we have to grow some plants!

2. Getting the activity started: Planting seeds (small group)

a. Give students directions for planting seeds in their tub (see directions sheet in this lesson guide).

b. Leave covered tubs in a sunny place. Check after a few days and see if you need to add more seeds or more water.

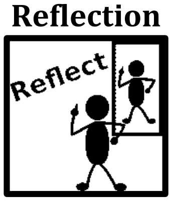
While students work on lesson 6, their ground cover will grow!

EXAMINING STUDENT WORK

Examine students' data sheets, particularly questions 1 and 2. How do they explain their findings? How do students show an understanding beyond a 'what' level and moving into explaining how or why steepness is related to runoff and erosion? What questions/wonderings did students have?

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. TASK, TALK, & TOOLS.

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of observing water moving on different slopes helped students to/with....
The task about ______ relates to students' lives or communities because...

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during (name particular parts of lesson) which allowed students to...
During turn-and-talks, I observed _______ which makes me wonder if/how...

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

The space to draw and write on question 4 allowed students to...
The summary table allowed students to...

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because...
Overall, this combination of talk, task and tools, allowed most/all students to...

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2. **EQUITY**.

Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:

- Developing relationships & forming an inclusive, trusting community
- Scaffolding for full participation in the culture and language of science
- Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
- Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

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PLANNING NEXT STEPS

Using the ideas and questions you have heard from students during class and from their explanations of the results decide what lesson(s) should come next. What questions do students have that could anchor future lessons? The next lesson (lesson 6) has some Oso-specific maps, information, and timelines that will give students more specific context for why the landslide happened in that particular location. What are other experiences students are bringing in? How can these experiences be explored in the unit?

Observing the Effects of Steepness on Erosion and Runoff

Lesson 5: Group Directions

Preparing the Materials

1. **Mix** the soil and **create** a cliff in the tub.
2. **Place** the small pad on the floor with absorbent side up. Put the bucket on the pad.
3. **Make** a stack of books and cover with a large pad absorbent side up to protect the books from any spills.
4. **Place** one end of the tub on stack of books**.**
5. **Move** the box and books to make sure the drain hole is over the bucket.
6. **Remove** the drain plug from the box. Place it on the table next to the tub.

Adding Water

7. **Place** the cup with a hole on the Velcro strip.
8. **IMPORTANT! Hold** the cup so it doesn't tip over!
9. **Pour** the water from the bottle into the cup **SLOWLY**. Make sure that any runoff goes into the bucket on the floor.

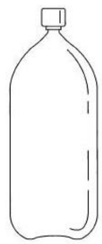
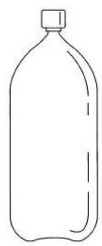
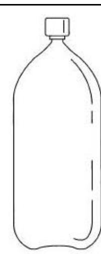
Recording Data: *Once the water has finished draining from the cup…*

10. **Sketch** the experiment set-up in your notebook. Label the drawing. Pay attention to where the water went and how it changed the soil.
11. **Write** observations and measurements in the data table.
12. **Be prepared** to share your data with the class for the class data table.

Name: ______________________________ Date: ________________ Teacher: ________________

Observing the Effects of Slope on Erosion and Runoff

Question: *How does the slope affect the amount of runoff?*

Steepness	**Amount of Runoff** (milliliters)	**What do you see in the bottle of runoff?**	**What does the soil look like AFTER?** *Sketch what the soil in one tub looks like for each hill. Visit other groups to observe and sketch.*
STEEP slope	G1: ______ml G2:______ml G3:______ml		
MEDIUM slope	G4: ______ml G5:______ml		
SHALLOW slope	G6: ______ml G7:______ml G8:______ml		

So, based on the data… *How does the slope affect the amount of runoff?*

1. **Write your conclusion:** *Look at "steepness of slope" and "amount of runoff" columns. Answer the question using a pattern from the data table.*

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2. **Explain your conclusion.** *<u>Why</u> did we get the results that we did? <u>Why</u> does slope affect erosion and runoff?* Draw and write to share your thinking. Use zoom-ins on your drawing to include ideas about pore space and particles size of the soils.

Helpful words	
erosion	runoff
gravity	saturated
particle size	pore space
speed (fast/slow)	absorb
slope (steep/shallow)	groundwater

<u>Helpful sentence stems (optional):</u>

– *We observed that on the steep slope…*
– *I think this happened because…*
– *The data shows that on the steep slope….*
– *This probably happened because…*
– *The <u>shallow/steep</u> slope retained the <u>most/least</u> water in the soil because…*

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Text source: https://simple.wikipedia.org/wiki/Terrace_farming
Modified by C. Colley

How do people farm in hilly regions?

Terrace farming is a type of farming that consists of creating different levels of "steps" or terraces. In this method of farming, people carve out steps into the side of a mountain or hill. On each level, they plant different crops.

On a steep slope, heavy rain can carry away all of the good nutrients that plants need by washing the topsoil down the slope. However, with terrace farming, the eroded soil is simply moves down to the next level where the runoff can sit for a time and absorb into the earth. Additionally, terraces slow down floods from heavy rains that, on a steep hillside, would destroy the all of the crops.

Terrace farming is still used around the world even though it is an ancient technique. The rice terraces of the Philippines dates back two thousand years. The idea was also independently developed by the Inca people in South America. The Incas built their aqueduct system so well that it is still used today to carry the water they need to water their crops. Other countries like China, Korea, and Japan use terrace farming as well.

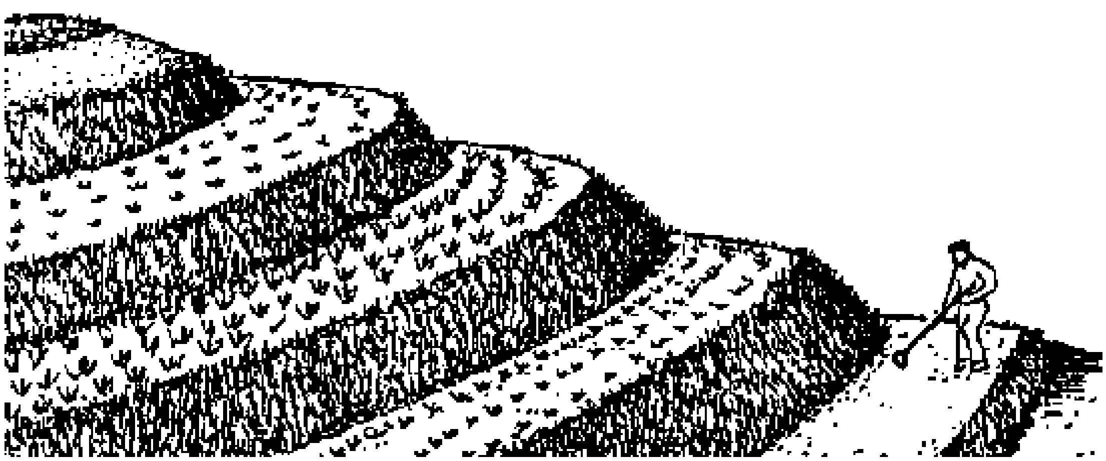

Image source: http://bit.ly/21GONBy

Terrace farming reduces erosion and runoff during heavy rains. Farmers cut into hillsides to create step-like terraces and plant crops on the flat areas. Sometimes farmers grow grasses or plant trees on the slopes between terraces. This vegetation stabilizes the soil because plant roots hold onto loose soil. Other times, terraces are reinforced with stone retaining walls.

Growing Groundcover

Lesson 7: Group Set-up Directions

Your group needs:

- 30 ml ryegrass seed
- 30 ml mustard seed
- ½ large cup humus
- spoon
- Plastic sheet
- Rubber band
- Soil tub
- Plant mister with water

Planting seeds:

1. Mix soil with the spoon.
2. Shape soil into a block about 20 cm long.
3. Sprinkle all the seeds over the half of the soil block near the cliff. Seeds should thickly cover the soil.
4. Spread *thin* layer of humus over seeds.
5. Use plant mister to dampen the seeds.
6. Cover tub with plastic and rubber band.
7. Leave in a sunny area.

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Lesson 6: About Oso – Maps, Timeline, & History

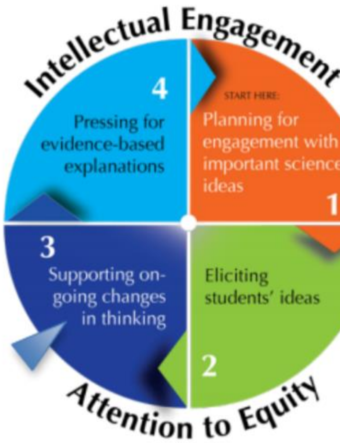
OBJECTIVES & OVERVIEW

Students gain context-specific information about the history of the 2014 Oso landslide region which will help students explain multiple possible causes of the landslide. This context-specific information is what makes the 2014 Oso landslide a puzzling phenomenon. It's not just any landslide – it's a specific one, in a particular place, under particular conditions. Learning to interpret and use maps can help students understand the natural patterns of Earth's features using the Oso region as an example.

Focus Question: How can the history of the Oso region help us better understand what could have caused the 2014 landslide?

- Students analyze and interpret data from maps to describe historical patterns of earth features in the Oso landslide region.
- Students obtain information from a timeline to draw conclusions about human impacts on increasing landslide activity.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS

Standards Note: This focus of this lesson is providing students the opportunity to engage in the performance expectation listed below. The focus is on analyzing and interpreting maps to describe patterns in Earth's features, — and that these photos and the timeline support students in constructing an explanation about the 2014 Oso landslide. Students will be able to see how the features in the area, particularly the river and hill, change shape and appearance over time in a pattern.

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features.
[Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CCC)
Analyzing and Interpreting Data - *Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2)*	**ESS2.B: Plate Tectonics and Large-Scale System Interactions -** *The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2)*	**Patterns -** *Patterns can be used as evidence to support an explanation. (4-ESS2-2)*

MATERIALS

Part I: Looking at Historical Patterns

For the class:

- Online interactive: Before/after diagram-to-photo http://bit.ly/1RgzTk0
- Video clip: "Geologist on history of mudslides near Oso" (4m 27s)
  https://www.youtube.com/watch?v=VNH5YbbVbtU

Per student:

- B&W copy of photos-over-time handout
- B&W copy of the timeline handout
- Crayons or highlighters (2 colors)

Part II: Interactive Timeline (OPTIONAL)

Per student (or pair of students):

- Computer or laptop
- interactive timeline: http://projects.seattletimes.com/2014/building-toward-disaster/
- science notebook
- research questions

PREPARATION

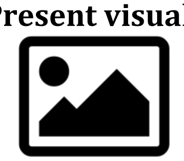
15 minutes

1. Read over lesson guide. Preview photos, timeline, websites, and videos. Make needed copies.
2. Part II is optional; however, it would fit easily during any independent work time students have as they can do it on their own with a computer and answer the questions in their science notebook.

Text

PROCEDURE PART I: Analyzing and Interpreting Data: Photos Paired with Timeline

Present visuals



Map/Photo Before-and-After http://bit.ly/1RgzTk0

Turn-and-Talk

What do you notice about the map and photo?

1. Activate prior knowledge and experiences (whole class).

a. Introduce this lesson by having students look at the before-and-after interactive site. Students have seen photos of the landslide in prior lessons. Building on this experience, start by getting students' observations about the diagram first.

   i. What do students notice? Have a students come up and point to the key features of the map.

   ii. Then slide the interactive bar over to reveal an aerial photo of the landslide. What do they notice? What does the dotted-red line mean? What happened to the houses?

b. Today students will learn more about the history of the Oso landslide area using a timeline and looking at some special maps. Remind them that the close-look they just did is the kind of observing they will need to do today to understand these documents. **Focus question: How can the history of the Oso region help us better understand what could have caused the 2014 landslide?**

2. Provide information to leverage during the activity (whole class)

Turn-and-Talk

What do you notice about how the photos change?

a. Pass out the handout with 12 black-and-white aerial photographs over the past 70 years. Have students do this to each photo:
   i. **River**: Have students use a blue crayon or highlighter and trace the river in each photo. *How has the river's shape changed over time?* Turn-and-talk to share observations.
   ii. **Hill**: Have students use a red crayon to put a circle on the hill above the river. *How does this hill seem to change over time? Why is it dark some years and lighter color other years? What might cause this?* Turn-and-Talk.

Video Clip

Geologist on history of mudslides near Oso
Watch from 0:00-2:03
http://bcove.me/ghzm5320

b. Watch the first two minutes of the video of a geologist who uses these same photos to narrate the landslide history of the area. Questions to have students consider as they watch (whole-class or partner talk):
   i. *What happened to the river over time?*
   ii. *What does the lighter-color area mean in some of the photos on the hill above the river?*
   iii. *What does the geologist say has happened in that area over time?*
   iv. *If there is such a history of landslides, why might that be a landslide prone area?*

Reading Integration

Read the time featuring logging events and landslide events

3. Analyze and Interpret: Timeline (Pairs/Individual)

a. Have students read over the timeline. Students can use the small photos from 1947-2014 to visualize the dates in the timeline.
b. Observations and Patterns:
   i. What pattern do they see between logging and landslides? There seems to be a pattern of landslides occurring after logging happens.
   ii. Do they think that logging trees is a significant or important factor? Or just coincidence?
   iii. Let students have a discussion about whether or not they think trees are important players in landslides, or in preventing them.
c. Connections:
   i. What connections do you use between the timeline events and how the photos change?
   ii. If I see a white area appear on the hill, what could I infer might have happened? Does the timeline confirm my claim?
   iii. If I see the river change shape, what could I infer might have happened? Does the timeline confirm my claim?

D. Question/Wonderings: Now that students know more about the events of the past, what questions do they have? Do they think logging is possible cause of a landslide? What about why the river changes?

Quick Write

4. Quick Write (individual)

Have students spend 5 minutes to draw and write in their science notebook about factors they think are important and might have caused the Oso landslide, either the 2014 one or past landslides, based on the geologist's video, photo series, and the timeline.

PART II: Interactive Timeline (OPTIONAL)

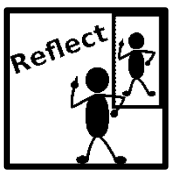
Students work individually or with a partner to answer questions about the interactive timeline found here: http://projects.seattletimes.com/2014/building-toward-disaster/ Students read about the historical engineering efforts to "fix" the hill over the last century to try to keep it from sliding. They will see photos and a history of logging and house building.

EXAMINING STUDENT WORK

This lesson is high in inferencing and asking students to predict events that would likely cause the patterns students observed in photos. The timeline and video helps students interpret the photos. Most of the work today is through talk, but some information may be gathered by going through science notebook entries from the quick write.

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons. Keep a record of these reflections for your professional portfolio.

1. **TASK, TALK, & TOOLS.**

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of analyzing photos and comparing it with a timeline helped students to/with....
The ____ task relates to students' and/or their families' lives or communities because...

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked during (name particular parts of lesson) which allowed students to...
I observed _______ which makes me wonder if/how...

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because...
Overall, this combination of talk, task and tools, allowed most/all students to...

____

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2. **EQUITY.**

Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:

- Developing relationships & forming an inclusive, trusting community
- Scaffolding for full participation in the culture and language of science
- Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
- Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

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Quick Write Directions
(Project under document camera or write on board)

In your science notebook…

Quick Draw & Write

What did you learn about the history of the Oso landslide area from the timeline and photos?

The photographs from 1947 to 2014 showed…

The timeline told us that…

Now I'm wondering if…

What do you think could explain why this area has so many landslides?

I think the area has many landslides because...

I'm not sure but I think that __________ could cause landslides because…

Photos of the Oso Landslide Area over time ***Source:*** *The Seattle Times, Building Toward Disaster timeline for the Oso 2014 landslide*

What will it look like in 5 years? 10 years?

Source: Seattle Times http://projects.seattletimes.com/2014/building-toward-disaster/
Edited and Formatted by: C.Colley

History of the Steelhead Haven area near Oso, WA

Landslide events and logging

1918 – Writer Zane Grey goes fishing at the river and observes logging. He writes, "All around me sounded the crash of the falling giants of the woods. In the sound, I heard the death knell of the magnificent cedars of Washington."

1930 – Landslide. The state's game director writes, "Many people feel that the earth movement was triggered by intensive logging of the forest cover of the land and resulting erosion."

1951 – In December, on the slide's eastern side, a mudflow partially dams the Stillaguamish river, the first of six major landslides in next seven decades.

1960 – A timber company clear-cuts about 75 acres north of the slide area. This logging takes place in what is now considered a "sensitive area." Cutting trees there could have made the slope unstable.

1967 – In January, a big slide about 800 feet long and 300 feet high collapses. The slide overwhelms a wall built to protect the town and blocks the river, flooding 48 lots in Steelhead Haven. A woman who lives there tells *The Seattle Times*: "There have been little slides going on here for years, but nothing too serious before that I know of. They've always called it 'Slide Hill.'"

1988 – A loging company named Summit Timber applies to clear-cut 400 acres near Whitman Beach above the town. Washington State approves the application for Summit Timber to begin logging in the area as long as they avoid a 48 acre "sensitive area".

1988 – In November, on Thanksgiving, a slide pushes nearly 2 acres of mud and trees into the Stillaguamish river.

1996 - A large "blowout" occurs, damming part of the river. A scientist refers to the 1996, 1988 and 1951 slides as "minor blockages," compared to the "major diversions" of 1967 and 1996.

2004 – A timber company called Gandy Lake Forest applies to log 15 acres. The Department of Natural Resources approves logging for 7.5 acres; however, due to a map error, the Department of Natural Rersources should have only approved 2.5 acres as 5 acres were part of a “sensitive area.”

2006 - Another big slide: a slice of hill about 900 feet across crashes into the river, creating flooding that threatens homes. Emergency workers scramble to create a new channel for the river, saving the neighborhood by walling it off with 400 feet of heavy rocks.

2009 – The timber company Gandy Lake Forest applies again to log in the area. They get approval and then cut down 20% of trees in a 240-acre area.

2011 – Gandy Lake is approved to cut down an additional 15% of trees in the same 240-acre area.

2014 - The catastrophic slide: The hill falls away, releasing millions of cubic yards of earth. Waves of mud, described as 25 feet high, roll for nearly a mile — across the river, through the Steelhead Haven neighborhood and onto Highway 530.

Name: ______________________________________ Date: ________________

Interactive Timeline: A History of Landslides near Oso

Directions:

1. Go to: http://projects.seattletimes.com/2014/building-toward-disaster/
2. Scroll through the timeline and click on the icons to read about different events near the Oso landslide area.
3. Select one of the icons and read each icron in the timeline.
4. Write a summary of key events for that icon.

Research Questions

1. **I'm going to read about… (circle one)**

   Homes *Logging* *Red flag warnings* *Attempted fixes*

2. **Choose 3 events for your category that you feel are important to know. Include the year and a brief description.**

Year	Event	Why do you think it's important?

Lesson 7: Effect of vegetation on soil erosion

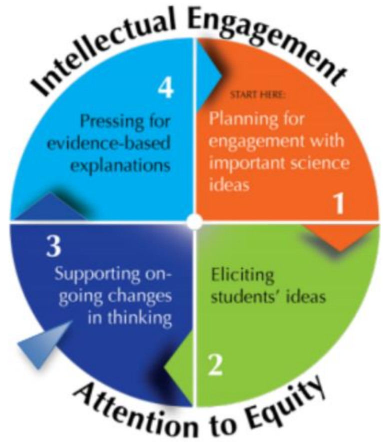
OBJECTIVES & OVERVIEW

Students observe water runoff and erosion off of slopes which are now covered with vegetation (grown from the seeds planted at the end of lesson 5). Students observe the effects of vegetation on the rate of soil erosion by collecting runoff from soil slope covered in vegetation and comparing it to the runoff from the loose soil slope in Lesson 5.

Focus Question: How does vegetation affect the amount of soil erosion on different slopes?

- Students make predictions and share observations about how vegetation affects the soil erosion on different slopes.
- Students evaluate if vegetation could be a possible solution for reducing the impact of landslides.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS

PE 4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Planning and Carrying Out Investigations. Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)	***ESS2.A: Earth Materials and Systems.*** Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1)	***Cause and Effect -*** Cause and effect relationships are routinely identified, tested, and used to explain changes.

MATERIALS

For the class:
- chart paper for class data table
- summary table
- markers

For each table group:
- Directions (this guide)
- Stream tub with soil mixture covered in vegetation from lesson 5
- 1 large plastic cup with large hole (red dot)
- 2-liter soda bottle with 2 liters water
- Runoff bucket
- Books for stacking
- Large absorbent pad (to protect books)
- Centimeter ruler or measuring tape
- Paper towels

PROCEDURE **PART I: Making Observations**

Present visuals

Show runoff bottles from lesson 5.

Turn-and-Talk

How could runoff and erosion be different on a slope with vegetation?

1. **Activate prior knowledge and experiences (whole class).**

   a. Connect to students' ideas and questions about logging and ground cover. These may have come up in lesson 6 when students were looking at changes in ground cover (dark areas on aerial photos are trees, lighter areas are exposed soil).

   b. Show students the 2-liter bottle with runoff kept form the shallow, medium, and steep slopes from lesson 5 (do not shake or agitate.) *How could runoff and erosion be different on a slope with vegetation?*

   c. Students turn-and-talk. Then, share some ideas. Use talk moves to press students explain the reasoning behind their predictions.

   d. Introduce today's focus question about exploring the erosion and runoff on different slopes. Also, refer back to students' initial ideas if any ideas were about the steepness of the slope. **Focus question: How does vegetation affect the amount of soil erosion on different slopes?**

2. **Getting the Activity Started (whole class)**

   a. Tell students that they will follow the same procedure they used in lesson 5 but this time the slope is covered with vegetation. (Introduce and briefly define term 'vegetation.')

   b. Explain that students will gather data as a class for 3 different slope heights (shallow, medium, and steep). Use the same height slopes as in lesson 5 (same books, same centimeters.)
      - *Groups 1, 2, 3 = steep slope*
      - *Groups 4 & 5 = medium slope*
      - *Groups 6, 7, 8 = shallow slope*

Back-Pocket Questions

3. Making observations and uncovering patterns using questions (small grps)

a. Circulate as students set up the experiment. Redirect and help students with set-up as needed.

b. As students make observations, circulate and ask questions to focus students on observations/patterns.

c. Make sure students sketch and collect data on their data sheet.

d. Students can complete the front side of their data sheet before the next step.

Back-pocket Questions:

Observations & Patterns

- What is the water doing? Where is the water going?
- How fast is the water moving?
- What do you notice in your bucket?
- Is there soil in your bucket? Is it more or less than our slope with soil-only?

Inferences & Connections

- How does this investigation help us think more about the 2014 Oso landslide?

Investigating Data

Looking for patterns and relationships

Turn-and-Talk

How does vegetation affect soil erosion?

Quick Write

Write a conclusion

4. Share and discuss observations (whole group)

a. Have students show their bottle of runoff to the class. Each student records class data on their data sheet by sketching the amount of sediment.

b. Looking for patterns: Compare the amount of runoff from shallow slopes and steep slopes with vegetation to the bottles from lesson 5 (with no vegetation) and answer the investigation question.

   i. Have students look at their class data table and compare the slope steepness with the amount of runoff.

   ii. Give students think time, then turn-and-talk with a partner about the question: **How does vegetation affect the appearance of the runoff and erosion on different slopes?**

c. Give students time to write a conclusion on the back of the data sheet (question 3) to answer the investigation question.

   By the end of Part I, students have completed the front of the student handout. Students will complete the back in Part II.

<u>Do NOT dump out the contents of the 2-liter bottles</u>. Screw caps on all 2-liter bottles with the runoff from today's experiment. Label bottles steep-plants, medium-plants, and shallow-plants. You need these for Part II.

Stack tubs crisscrossed in materials area. Do not clean them out yet.

PART II: Data Discussion & Summary Table

Investigating Data

Looking for patterns and relationships

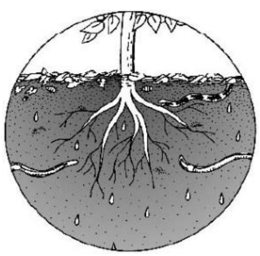
Present visuals

Show 2-liter bottles.

1. **Looking for patterns and relationships in a data set (whole group)**
   <u>*Compare the amount of erosion between slopes with vegetation and slopes without*</u>: Have students observe he amount of soil in each bottle of runoff. Compare the amount of soil in the runoff (from lesson 5) to the runoff from slopes covered in vegetation (lesson 7, part I). Then ask whole-group or use turn-and-talks to discuss:
   - *Which slope, steep or shallow, had the most erosion? How do you know? Why might that have happened?*
   - *Which slope do you think had fastest moving water? How do you know? Why might that have happened?*

2. **Provide information for students to use as leverage to explain data.**
   a. Have students pull up some of the ground cover and observe the roots and soil.
      - *What do you notice?*
      - *What do the roots look like?*
      - *Where do you see soil?*

   b. Share the information in the box below about roots.
   c. *How can knowing about roots help us explain our data?*



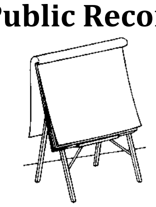
Roots anchor plants and trees into the ground. They drain water from the soil. That keeps the soil from staying too wet. And when the soil gets too dry, roots draw up water. This water has all kinds of good stuff in it that living things need to stay healthy. Roots help make soil, too. They split rocks into pieces that later become soil.

Quick Write

Explain the data

3. **Quick Write to explain results (individual)**
   a. Give students time to draw and write on the back of the data sheet about how/why plants prevent erosion.
   b. Have 2-3 students share their thinking with the class and invite questions and comparison of ideas from their peers.

Public Record



Summary Table Row

4. **Connections to the anchoring event (whole class)**

   a. **Observations**: Take a few observations from students that includes numeric data and a relationship between vegetation and amount of erosion. Tape a copy of the class data table in the summary box.
   b. **Learning**: Help students craft generalizable statements about what they learned from the investigation.
   c. **Connections**: Ask students to think about how this investigation can help us understand a landslide. *Make connections to the timeline and photos in lesson 6.*

Activity	*What did we observe?*	*What did we learn?*	*How does it help us explain the Oso Landslide?*
How does vegetation affect soil erosion?	The bottles of runoff from soil-only (no plants) had lots of sediments (ranking of 4-6). Runoff filtered through plants was relatively clear (ranking of 1-3).	Plant roots hold onto soil making it harder for rainwater to force the soil to be loose.	*Vegetation could help to secure the soil because roots would grow into the hill and absorb water and hold onto soil. (BUT roots can also break up soil, so could plants actually cause a landslide?)*

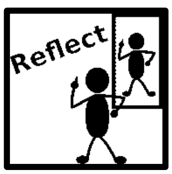
CLEAN-UP: Clean out tubs, bottles, and clean off materials.

EXAMINING STUDENT WORK

Examine students' data sheets, particularly the back of the data sheet. How do they explain their findings? How do students show an understanding beyond a 'what' level and moving into explaining how or why vegetation is related to rates of erosion?

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons. Keep a record of these reflections for your professional portfolio

1. **TASK, TALK, & TOOLS.**

   Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

   The task of observing water moving on covered slopes helped students to/with….
   The task about ______ relates to students' lives or communities because…

   Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

   The students talked to each other during (name particular parts of lesson) which allowed students to…
   During turn-and-talks, I observed _______ which makes me wonder if/how…

   Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

   The space to draw and write on question 4 allowed students to…
   The summary table allowed students to…

   Overall, reflecting on task, talk, and tools together:

   Talk, task, and tools supported students to share their thinking because…
   Overall, this combination of talk, task and tools, allowed most/all students to…

2. EQUITY

Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:

- Developing relationships & forming an inclusive, trusting community
- Scaffolding for full participation in the culture and language of science
- Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
- Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

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PLANNING NEXT STEPS

Using the ideas and questions you have heard from students during class and from their explanations of the results decide what lesson(s) should come next. Do students need an additional experience or opportunity to demonstrate an NGSS performance expectation? Do students have enough evidence to move into revising explanations and proposing solutions to prevent or lessen the impact of landslides?

Observing the Effects of Vegetation on Erosion and Runoff on Different Slopes

Lesson 7: Group Directions

Preparing the Materials

1. **Place** the small pad on the floor with absorbent side up. Put the bucket on the pad.
2. **Make** a stack of books and cover with a large pad, absorbent side up to protect the books from any spills.
3. **Place** one end of the tub on stack of books**. USE THE SAME HEIGHT AS BEFORE.**
4. **Move** the box and books to make sure the drain hole is over the bucket.
5. **Remove** the drain plug from the box. Place it on the table next to the tub.

Adding Water

6. **Place** the cup with a hole on the Velcro strip.
7. **IMPORTANT! Hold** the cup so it doesn't tip over!
8. **Pour** the water from the bottle into the cup **SLOWLY**. Make sure that any runoff goes into the bucket on the floor.

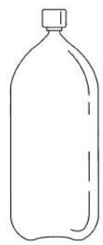
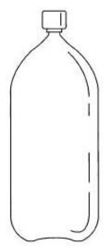
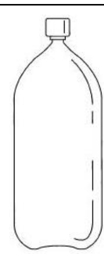
Recording Data: *Once the water has finished draining from the cup…*

9. **Sketch** the experiment set-up in your notebook. Label the drawing. Pay attention to where the water went and how it changed the soil.
10. **Write** observations and measurements in the data table.
11. **Be prepared** to share your data with the class for the class data table.

Name: ______________________________ Date: ________________ Teacher: ________________

Observing the Effects of Vegetation on Erosion

1. Use the pen marks on the side of the 2-liter bottle to measure runoff and record in the data table. The sketch what you see in the bottles and on a slope with vegetation.

Steepness	**Amount of Runoff** (milliliters)	**What do you see in the bottle of runoff?**	**What does the soil <u>with vegetation</u> looks like AFTER?** *Sketch what the soil in one tub looks like for each hill. Visit other groups to observe and sketch.*
STEEP slope	G1: ______ml G2:______ml G3:______ml		
MEDIUM slope	G4: ______ml G5:______ml		
SHALLOW slope	G6: ______ml G7:______ml G8:______ml		

How does vegetation affect the amount of soil erosion on different slopes?

1. **Write your conclusion:** *Which one had the most erosion? Why?*

____

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Explain your observations. *<u>Why</u> did we get the results that we did? <u>How</u> does vegetation affect soil erosion?* Draw and write to share your thinking. Use zoom-ins on your drawing to include ideas about plant roots, pore space, and particles size of soils.

Helpful words	
erosion	runoff
gravity	saturated
particle size	pore space
speed (fast/slow)	absorb
slope (steep/shallow)	groundwater

Helpful sentence stems (optional):

- *We observed that on the covered slope…*
- *I think this happened because…*
- *The data shows that ….*
- *The slope with/without plants absorbed the most/least water because…*

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Lesson 8: Using evidence to revise models

OBJECTIVES & OVERVIEW

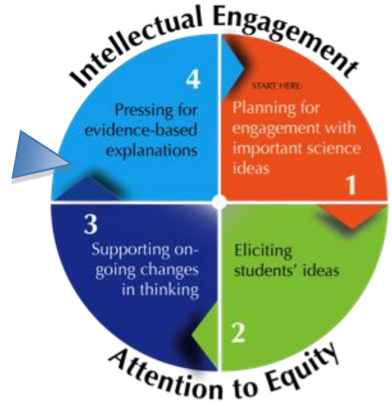
Students have been revising their thinking about the unit phenomenon over time in light of the new experiences, observations, and sense making talk that they have had throughout the unit activities. In this lesson, students will pull together what they have learned in this unit and identify how their thinking has changed by revising their models and supporting changes with evidence.

Focus Question: Why did the 2014 Oso Landslide happen? What evidence do we have?

- Students revise their models in light of evidence from unit activities to explain the phenomenon.
- Students write a short evidence-based explanation for the phenomenon.

Ambitious Science Teaching Framework:

PRESSING FOR EVIDENCE-BASED EXPLANATIONS



This practice happens near the end of a unit, but parts can be introduced at other times when students talk about evidence. This requires that several tools be available to students: 1) their current models, 2) an explanation checklist, 3) the summary table, and 4) a scaffolded guide to help students create, in writing and drawing, their final model. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features. [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CCC)
Planning and Carrying Out Investigations - Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1) **Analyzing and Interpreting Data -** Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2) **Developing & Using Models**:** Develop a model to describe phenomena. **Constructing Explanations**. ** Identify the evidence that supports particular points in an explanation. *** This SEP is not part of the PE but was added to this lesson as part of the AST framework*	**ESS2.E: Biogeology.** Living things affect the physical characteristics of their regions. (4-ESS2-1) **ESS2.B: Plate Tectonics and Large-Scale System Interactions**. The locations of structures on Earth occur in patterns. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2) **ESS1.C: The History of Planet Earth**. Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes.	**Patterns -** Patterns can be used as evidence to support an explanation. (4-ESS2-2) **Cause and Effect -** Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS2-1)

MATERIALS

For the class:
- Summary table
- Chart paper
- Markers

For each pair of student:
- sticky notes
- 1 blank model scaffold * (see preparation)
- original models (completed in pairs in Lesson 1)
- colored pencils or pens
- science notebooks (for reference)

PREPARATION

Approximate time
30 minutes

Provide a model scaffold. It can be the same or similar to the one in Lesson 1 or you can create a new template. Use clear prompts so students know what you want them to focus on and do in each part of the model. Give space to draw and write. Think about how to help students use the evidence from each activity to add to their model. Also, this lesson has students working on models in pairs. You may decide to have students work on them individually instead.

PROCEDURE — PART I. Revising Models with Evidence

Present visuals

Show photos of the before and after of the Oso landslide.

Turn-and-Talk

What ideas do we need to include in an explanation of the phenomenon?

1. GENERATE EXPLANATION CHECKLIST (WHOLE GROUP) – 10 mins

a. Remind students of the unit phenomenon using the photos of before and after the Oso landslide. **Why did the 2014 Oso Landslide happen? What evidence do we have?**

b. Ask students to think about what they have learned in this unit (refer them to look at the summary table) and identify: What are the key pieces that we have to know about in order to explain the phenomenon? Give private think time. Have students turn-and-talk.

c. Share out some ideas and generate an explanation checklist on chart paper with markers. The list might have items on it such as:

EXPLANATION CHECKLIST:
We should …
- Use our observations about water runoff and groundwater in different soils
- Include knowledge of pore space and particle size of soils
- Use data about rainfall near Oso
- Use data about role of slope and vegetation has on speed of erosion
- explain the role of gravity on water erosion
- Use timelines, maps, and other info about Oso area

2. STUDENTS UPDATE EXPLANATORY MODELS (PAIRS) – 25 mins

a. Leave the explanation checklist on the board for student reference. Tell students that they will have a chance to create a new model about the phenomenon working in pairs to show all the new ideas they have now that they have had so many experiences in this unit (point to summary table).

b. Show students the model scaffold and explain what you expect to see in each part of it. Also, remind students that both students in the pair should be talking, drawing, and writing on the sheet.

c. Give students time to work in pairs to develop a new model. Redirect students as needed to the explanation checklist, the summary table, or their notebooks to help them make progress on their models.

Back-Pocket Questions

Prompt reasoning about gaps and contradictions

As students work in pairs, prompt reasoning about gaps and contradictions in their models. These prompts or questions could help you do this:

- *"Can you tell me what role <u>[insert idea or concept]</u> has in your explanation?"*
- *"How does this part about ______ fit with the rest of your model?"*
- *"How have you included this idea about ______ from the explanation checklist?"*
- *"I see you have drawn and labeled _______. How do you know it works like that? Have we done something in class on the summary table?"*

3. PREPARE STUDENTS TO USE EVIDENCE – (15 mins)

a. Have a pair share one claim they have made on their model so far. It should be a claim that we have evidence for from an activity, video, or reading from the unit.

b. Ask the class: What evidence do we have of this idea? Where can we look to remember what evidence we have?

c. Demonstrate how to write evidence on a sticky note and put it on the model next to the claim.

d. Give students 10 minutes to identify 2 claims on their model and write sticky notes about evidence. Each student in the pair should write one sticky note and share their evidence with their partner.

e. As students work, circulate and look at how students are selecting evidence. If they are stuck, refer them to the summary table or their science notebook. If students only name the activity, put some sentence stems on the board to help get more about why this activity provided us with evidence for a certain idea or claim.

PART II. Comparing Models & Adding Evidence

Talk Norms

Remind students about talk norms.

Whole-class discussion

Collaboratively revise a model based on evidence

1. PUBLIC COMPARISON OF MODELS (whole group) – 20 mins

a. *Physically orient students towards each other*: Have students bring their model sheets to the gathering area and sit so students can see and hear each other easily and see the screen when students share work under the document camera.

b. *Set the purpose of today's discussion:* Say something like: *We are coming together to see ways to represent ideas in models and how we use evidence to support our ideas. Give each other feedback by agreeing or disagreeing and saying why you think the evidence they picked supports their idea or if you think another piece of evidence from our summary table would be stronger. After the discussion you will have time to add more evidence or clarify your ideas on your models.*

c. *Allow students to use talk norms and lead and manage the talk:* Remind students of talk norms and encourage them to call on each other and not look to the teacher.

d. Choose one pair to start the conversation and have them share one claim and the evidence they selected to support it. Encourage students to agree or disagree, in either case, saying what evidence they used or would use and how it supports their idea. Students should be sharing work under the document cameras as they have a discussion. Peers could suggest changes to either their ideas or the evidence they selected.

NGSS Note: In Appendix F: Science and Engineering Practices, one performance of developing and using models for grades 3-5 students is to Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. Students are mostly doing this in pairs this lesson but this whole group discussion is another way to collaboratively revise their partner models.

2. MAKE ADAPTATIONS TO MODELS (pairs/individuals) – 10 mins

a. Have students go back to working in their pair (or individually) and make changes to their models to clarify their ideas, add new ideas they heard during the discussion they agreed with, and to add or change the evidence they selected to support some of their claims.

b. By the end of the lesson students should have drawn and written about their ideas to explain the phenomenon and have at least two sticky notes with evidence to support two of their claims.

Quick Write

How has my thinking changed?

3. HOW HAS MY THINKING CHANGED? (individually) – 10 mins

Pass back initial models and let students look over them. As an exit ticket, have students write how their thinking has changed in this unit.

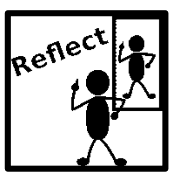
At first I thought…. Now, I think…
I used to think…. Now, I know…
Before I didn't know how… But, now, I learned that…

EXAMINING STUDENT WORK

Examine students' model revisions and see how their thinking has changed over the unit. Track changes in thinking on the What-How-Why rubric. In the next lesson students will be proposing engineering solutions and justifying their decisions with evidence.

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons. Keep a record of these reflections for your professional portfolio.

1. **TASK, TALK, & TOOLS.**

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students to communicate their ideas?

2. **EQUITY.** Describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue.

PLANNING NEXT STEPS

This lesson sets students up for the last lesson in this unit where they design an engineering solution and create a written explanation using evidence to justify their design. Consider what you've observed from student talk and seen in student models and on sticky notes to determine what support students might need in designing solutions and writing their explanations.

Name: ______________________________ Date: _________________

What caused the Oso Landslide? How or why did it happen?

Write about observations: ____

- *Before, the land looked…* ____
- *After, the land looked…* ____
- *The landslide changed the land by…* ____

____

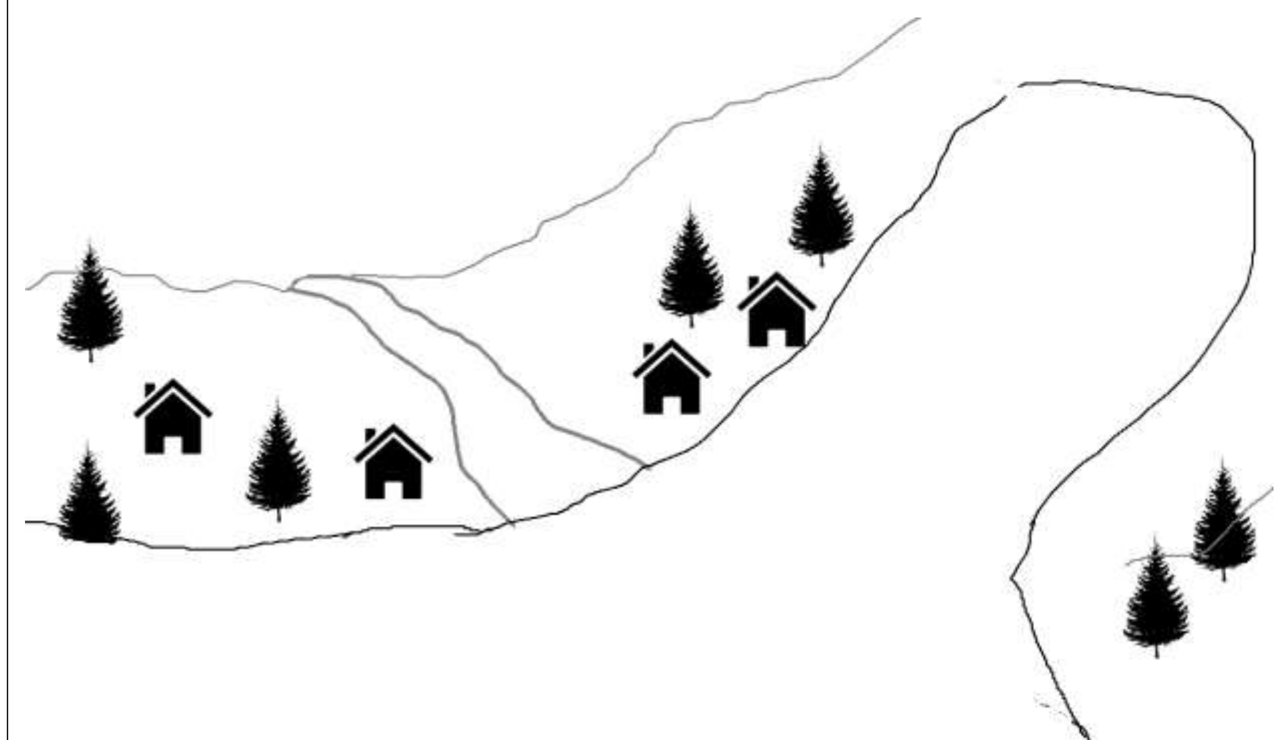
Write about causes: ____

- *I think the landslide was caused by…*
- *The landslide happened because…* ____

Name: ______________________ Date: ____________ What caused the Oso Landslide? How or why did it happen? 4th Grade – Land & Water

BEFORE

AFTER



Write about observations:

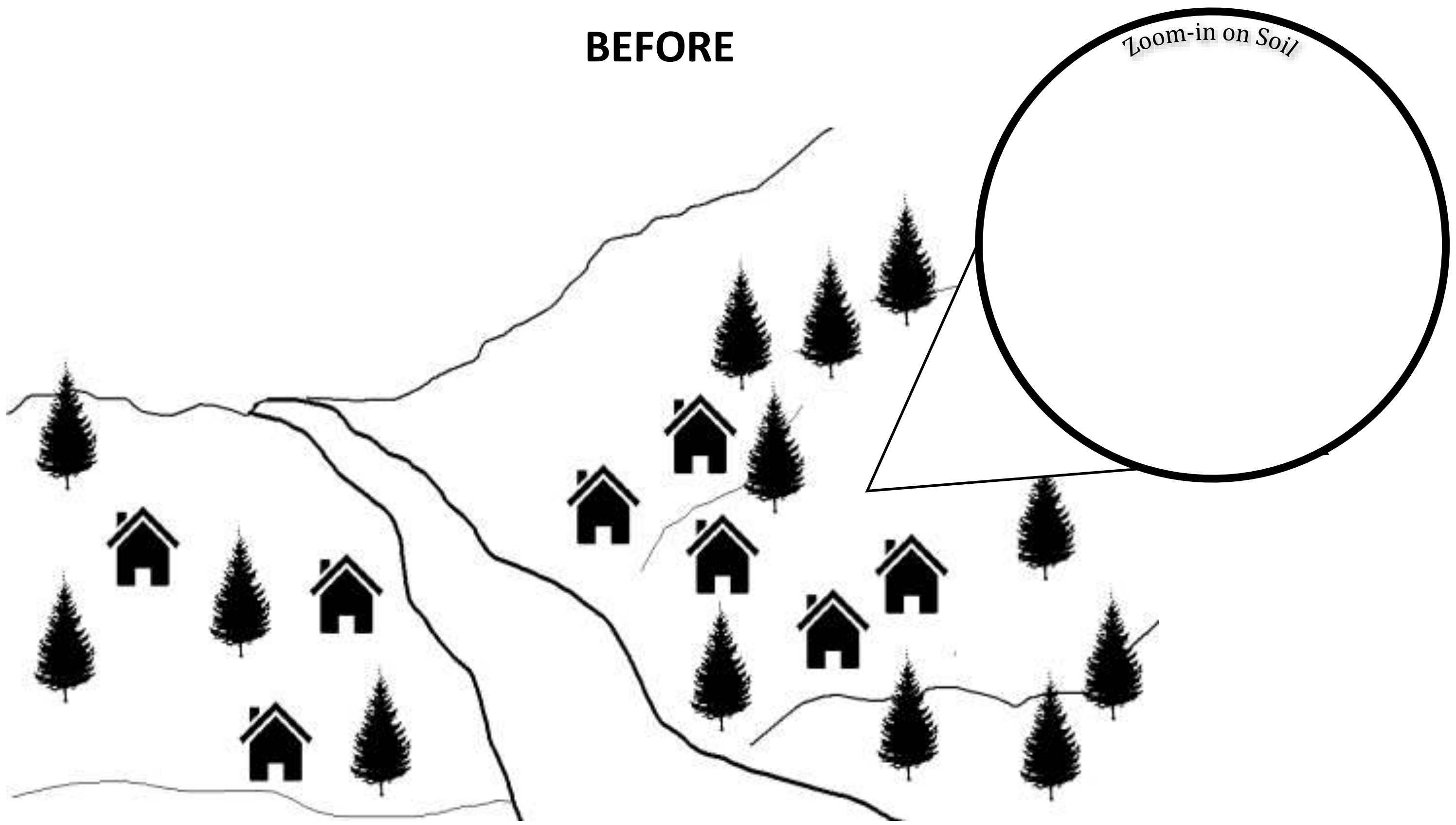
- *Before, the land looked…*
- *After, the land looked…*
- *The landslide changed the land by…*

Write about causes:

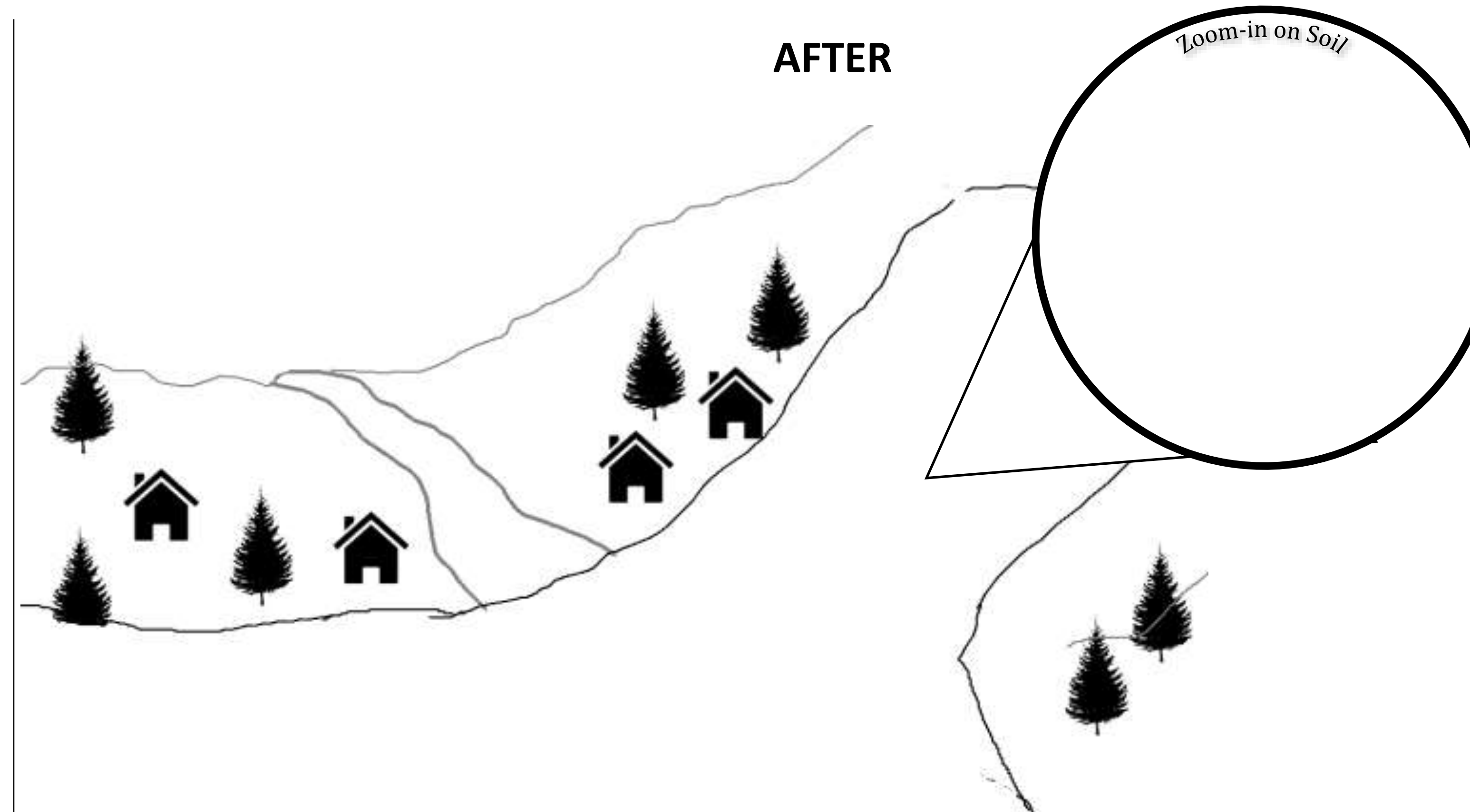
- *I think the landslide was caused by…*
- *The landslide happened because…*

Name: ______________________________ Date: _________________ What caused the Oso Landslide? How or why did it happen? 4th Grade – Land & Water

BEFORE



AFTER



Write about observations:

- *Before, the land looked…* ____
- *After, the land looked…* ____
- *The landslide changed the land by…* ____

____

Write about causes:

- *I think the landslide was caused by…* ____
- *The landslide happened because…* ____

Lesson 9: Justifying an engineering solution

OBJECTIVES & OVERVIEW

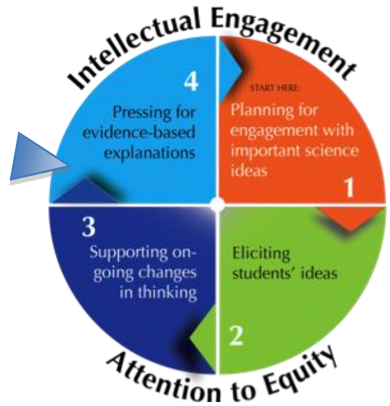
In lesson 8, students worked in pairs to develop new models to explain the Oso landslide using evidence from unit activities. In this lesson, students will use that work to propose an engineering solution about how to mitigate the impact on humans from this natural hazard

Focus Question: How might humans prevent the damage from landslides? What should we do and why?

- Students use their updated models and evidence from the unit to design and propose an engineering solution.

Ambitious Science Teaching Framework:

PRESSING FOR EVIDENCE-BASED EXPLANATIONS



This practice happens near the end of a unit, but parts can be introduced at other times when students talk about evidence. Students need: 1) their current models, 2) an explanation checklist, 3) the summary table, and 4) a scaffolded guide to help students create, in writing and drawing, their final model. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS (NGSS)

4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* [Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Constructing Explanations and Designing Solutions - *Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2)*	***ESS3.B: Natural Hazards*** *A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2)*	***Cause and effect –*** *Cause and effect relationships are routinely identified, tested, and used to explain change.* ***Influence of Engineering, Technology, and Science on Society and the Natural World*** *- Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2)*

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MATERIALS

Part I: Propose Solution
- Science notebook
- Pencil
- Colored pencils
- Sticky notes

Part II: Compare & Test Solutions
- Soil tub materials
- Any materials students need to build their prototype

Part III: Justify solution
- Science notebook
- Sentence strips

PREPARATION

Approximate time
15 minutes

Part II: Make sure students have access to the materials from this unit so they can build a slope like Oso and test their solution at a smaller scale.
Part III: If needed, prepare the sentence strips included in this guide to help students write an evidence-based justification of their design solution.

PROCEDURE

Part I: Proposing a solution to landslide disasters

Turn-and-Talk

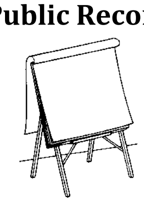
What could we do to prevent a future landslide?

1. Setting the purpose (whole group) – 8-10 minutes

a. Students may have brought up questions at the beginning of the unit in lesson 1 about why people are allowed to rebuild or why the city or town didn't do something to stop or prevent the landslide. Let students know that over the next few science sessions they will get to brainstorm possible solutions, test them using the soil tubs, and evaluate them.

b. Have students think for a few seconds then turn-and-talk about what humans could do to prevent the next landslide in the Oso area.

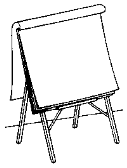
Public Record



List of Proposed Initial Solutions

c. As students share out ideas, generate a list of some strategies students propose. This list can help students who may be stuck or have trouble getting started. As students share out, press them for evidence or reasoning:
   - *Why do you think that might work?*
   - *Is there evidence from the unit to support your idea?*
   - *How would that prevent erosion?*

Public Record



Revised list of design criteria

2. Proposing a design (individually or in pairs)– 25 minutes

a. Before releasing students to work on their designs, introduce a set of criteria and ask students if they want to change or add to this list of criteria. Make revisions on the list under the document camera. Leave list projected during the lesson for student reference.

b. Have students draw and write in their science notebooks to show their ideas about what would prevent a landslide and why they think it would work.

c. As students work, circulate and redirect as needed to make sure students know what to do and where they can look for resources (i.e. list of criteria on document camera, summary table for evidence, their notebook for info about Oso).

Talk Norms

Remind students about talk norms

3. Comparing a design (pairs or small groups) – 10 minutes

a. Have students show and explain their design to a partner or table group. Some students may have similar designs and others different. Provide students with some sentence stems to help them listen and respond to each others' designs and ask questions.

b. As students share, circulate and listen in to see how many different design ideas there are. In Part II, students can build and test a prototype but there are only 8 soil tubs – so some solutions can be tested simultaneously but others may be a full-slope prototype.

PART II: Test & Compare Solutions

** Timing of this lesson may be longer depending on student progress.*

"Testing a solution involves investigating how well it performs under a range of likely conditions. Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs."

A Framework for K-12 Science Education. Washington, DC: The National Academies Press, 2012. doi:10.17226/13165..

1. Building a prototype (pairs/individuals) – 20 minutes*

a. Give time for students to craft their solution using materials available. (Teacher decision: If two students have similar designs they could work together.)

b. Once built, students can sketch and label a diagram of their design solution in their notebook while waiting for others to finish.

2. Testing prototypes (small groups) – 20 minutes

a. Have a soil tub set up at each table group. During the criteria discussion in Part I, the class decided how many books represent the slope of the Oso landslide. Set up the tub.

b. Discuss with students to make decisions about how to test their prototypes (whole group).
    i. How will we mimic heavy rainfall?
    ii. How could we mimic months of rainfall prior to the landslide?
    iii. What could we use to represent houses? Or do we need them?

c. Make adjustments to the testing set-up to respond to student concerns.

d. Place prototypes in position. Have one student per table use the rain bottle (see set-up for rain bottles from Lesson 2) and make it rain heavily on the slope (some squeezing allowed with vigorous shaking – or whatever students agreed on in Part II, step 2b).

e. Observe what happens. Make sketches in notebooks

Whole-class discussion

Identifying limitations of a model and comparing solutions

3. Comparing results (whole group) – 10 minutes

a. Having students compare solutions and prototype results. Have a few students share their design and the results with the class. Have classmates respond by using the sentence stems they used at the end of Part I.
b. As a whole class, consider these questions:
    i. What could we change about our landslide model to make it more realistic?
    ii. How were our solutions similar? Different?
    iii. Which designs seemed to work best? Why?
    iv. Would you make any modifications to your design now that you've tested it?

PART III – Explain and Justify the Solution

In this last part of the lesson, students will explain how landslides happen, why they proposed the design they did, and how it faired in the tests.

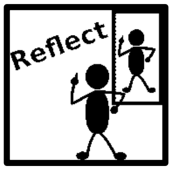
Students can use the directions and sentence starters at the end of this lesson guide to help them write in their science notebook.

EXAMINING STUDENT WORK

Track student understanding on the What-How-Why tracker. What patterns do you see on the tracker? Have most students shifted into deeper levels of reasoning (from what to how or how to why)? For students who have not displayed deeper levels of explanation were there other barriers in today's task limited that students' performance? For students who went beyond expectations, what about today's task helped students do so?

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. **TASK, TALK, & TOOLS.**

   Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

   Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

   Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students to communicate their ideas?

2. **EQUITY**. Describe one issue around equity that arose during this lesson. Consider change(s) to the next unit to help address this issue.

PLANNING NEXT STEPS

In moving into future units or lessons where students need to use evidence to support their ideas, what strengths did students show in this writing task? What areas can they improve? Consider how to plan to support students in improving how to select relevant evidence and clearly write about their ideas in a future lesson based on student performance in this lesson.

Design Criteria

Goal: Prevent the town from being demolished by a landslide.

Criteria:

- Must prevent or minimize soil erosion on a slope of ____ books
- Must withstand heavy rainfall or possible flooding
- Should include a combination of man-made and natural solutions
- Use any available materials in the classroom

Listen to Others and Compare Solutions

Can you say more about _______?

Why do you think…?

I agree with you that________, but I'm not sure about..

Your design is similar to mine because…

You design is different than mine because…

I think your design will work because…

I think the design could be improved if…

Proposing a Solution: Future Oso Landslides

What do I write?

1. Explain why the 2014 Oso landslide happened using evidence.
   - *Use your new model and the evidence sticky notes.*
   - *See the explanation checklist.*

2. Describe each part of your design using pictures and words.
   - *Describe what each part does.*
   - *Describe how the prototype worked in the soil tub.*

3. Explain how each part will help prevent a landslide.
   - *Use evidence about what causes a landslide*
   - *Say how your design will address each cause*

How could I get started writing?

- Landslides happen when…
- The Oso landslide in 2014 was caused by…
- To prevent a landslide, we have to…
- My design includes…
- My design will prevent a landslide because…
- In the prototype test…
- To prevent future landslides, I think the town near Oso should/should not __________ because…

Literacy Integration: Poems, Chants, Songs

Use these poems, songs, and chants to complement what students are learning in each lesson. A new chant or poem could be introduced each lesson or each week. Students can practice as homework and perform for the class, for another class, or on the morning school announcements. These poems, chants, and songs allow a fun way for students to practice new vocabulary and definitions.

As you introduce and read through the chant or poem to students the first time, students can circle 2-3 words they do not know, sketch pictures about what the poem or chant means in the box or in the margins. Review the words that most students are unfamiliar with – some may be Tier III science words others may be Tier I or Tier II words. Students can also invent hand gestures to act out each line or stanza as they read it – this also helps students understand and remember the meaning. Make copies for students to take home and practice and perform for family members.

GLAD Chant

Erosion by Water

By Carolyn Colley, © 2016
To the tune of: "I'm a little teapot"

I'm a little river,
I have fun.

I carry bits of soil.
It's called erosion.

When I get some rainfall,
I move fast.

Rushing and moving,
The soil I've amassed.

Saturated Soil

By Carolyn Colley, © 2016
GLAD chant Bugaboo

I'm a particle of gravel and I'm here to say,
I'm big and round, and that's okay.
There's lots of space between my buddies.
Water can pass through, like we've studied.
Doing the saturated soil BUGALOO!

I'm a particle of sand, jagged and rough
Smaller than gravel, but I'm tough.
My buddies and I fit closer together
We don't do well retaining rainy weather.
Doing the saturated soil BUGALOO!

I'm a particle of clay, much smaller than sand,
My buddies and I give water a hand.
We hold lots of water in our spaces.
It won't move easily to new places.
Doing the saturated soil BUGALOO!

When it rains really hard in one place,
Rainwater tries to get into pore space.
Some spaces are large to let water flow
But others are small — the movement is SLOW!
Doing the saturated soil BUGALOO!

GLAD Chant

Surface Runoff

By Carolyn Colley, © 2016
To the tune of: “She’ll be coming ‘round the mountain”

Water moving over soil, when it rains… Run-off!

Water moving over soil, when it rains… Run-off!

Water moving quickly over, flowing into streams and rivers.

Water moving over soil, when it rains… Run-off!

Earth’s Surface

By Carolyn Colley, © 2012
(reprinted, used with permission)

Changes on the surface of Earth
Have happened since our planet’s birth.

Weathering breaks rocks into pieces
The amount of sediment increases

Erosion moves sediment worldwide
Wind blows, water flows, glaciers slide.

Deposition drops rock to the ground
Sediments pile up into a mound

Changes on the surface of Earth
Have happened since our planet’s birth.

The Story of Rocks

By Carolyn Colley

(reprinted, used with permission)

The Earth's surface is slowly changing,
Rocks and soil are rearranging.

The layers of rock tell a tale.
The story moves forward, slower than a snail.

Sediments stay where they're dropped.
The old on bottom; then new on top.

In lots of time, these layers are made
In an order, they have stayed.

An earthquake's motion leaves a scar.
Some layers stay put, others move far.

Landslides also disrupt soil bands
Covering up with mud, clay, and sand.

Layers show what's happened in the past
The answers are there, we just have to ask.

Weathering, Erosion, Deposition

To the tune of *Jingle Bell Rock*
Lyrics by Carolyn Colley © 2012
(reprinted, used with permission)

Weathering changes the rock's condition,
Make boulders crack for demolition.
Pieces and pebbles, silt, gravel and rock,
Now it's weathering around the clock.

Sediment moving, rocks in transition,
Breaking rocks move, changing position.
Rocks move and groove on the surface of Earth
Since our planet's birth!

Weathering time is the right time,
To wear those rocks away.
Wind is blowing, water's flowing,
Erosion happens any time of day!

Weathering, erosion, deposition,
Forces that shape the Earth,
Wind and water and plants and ice,
Forces shaping our…
Forces shaping our…
Forces shaping our Earth!

Landslide Limericks

Crud by Sheila

In the cleanup that followed the flood,
We became well acquainted with mud,
But what came through the door
And was caked on the floor?
I would have to describe it as crud.

Deluge by Val

A deluge is when heavy rain
Falls in torrents, the earth cannot drain—
Which means homes built on mud
Run the risk that the flood
Will cause landslides and terrible pain.

Write your own Landslide Limerick!

Limerick Characteristics:

1. Limericks have 5 lines.
2. The last words on lines 1,2, and 5 rhyme.
3. The last words on lines 3 and 4 rhyme.
4. Lines 1 and 2 have about 8-9 syllables.
5. Lines 3 and 4 have about 6 syllables.
6. Line 5 has 8-9 syllables

Helpful words

erosion	water	runoff
landslide	flood	pore space
rain	mud	soil
rainfall	saturate	gravel
particle size	dirt	humus
sand	clay	ground water

Hint: Think about rhyming words

mud – flood – dud
stress – mess - address
rain – pain – drain - again
slide – guide – hide

Title ______________________________ Author: ____________________

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Source: http://nwpr.org/post/oso-clearcut-extended-no-logging-zone

NORTHWEST Public Radio

Oso: Clearcut Extended Into No-Logging Zone

By JOHN RYAN · MAR 28, 2014

LISTEN TO THIS ARTICLE (2 MIN 39 SEC) http://bit.ly/1ojY6Ee

State officials say they didn't approve clearcutting inside a no-logging zone directly above Saturday's deadly landslide in the town of Oso. But aerial photos show a clearcut extending into the zone where a loss of trees would heighten the risk of landslides. Removing forest cover can increase the amount of rainwater that finds its way underground. Geologists say the extra groundwater can destabilize the already unstable soils deep beneath landslide zones.

Records obtained by the Seattle Times and by KUOW show that a clearcut in 2005 did take out trees inside that zone for the Oso slide. The question that remains is whether the Department of Natural Resources approved cutting where it shouldn't have, or whether the land owner cut beyond the boundaries approved by Department of Natural Resources.

The owner, Grandy Lake Forest Associates of Mount Vernon, could not be reached for comment. Grandy Lake proposed a 15-acre clearcut at the upper edge of the Oso landslide zone in 2004. "We rejected that application," said Aaron Everett, a Washington State Forester. "The one that was approved in the end eliminated the part of the harvest that would have been inside the groundwater recharge area."

On Wednesday, Everett told KUOW that the resulting 7-acre harvest, also known as a clearcut, went right up to the edge of the groundwater danger zone. "It is right outside the area that is essentially prohibited from harvest at the head of the landslide," said Everett.

On Thursday, Everett and his boss, Washington Lands Commissioner Peter Goldmark, declined to be interviewed. But their agency did release aerial photos showing a clearcut, shaped like a seven-acre slice of pizza, crossing over the edge of the official no-cutting zone. The zone where it's officially unsafe to log might not be the same as where it's actually unsafe.

Without drilling wells deep into the earth, geologists can only make educated guesses how groundwater moves. Geologist Paul Kennard stated that nobody's drilled wells at the Oso site, so they can't say precisely which plots of land would funnel water beneath the landslide zone--and make it more prone to slumping downhill.

"I think since the groundwater recharge to the actual landslide has been changing and getting bigger over time, it's a bad idea to harvest right up to the edge of the current groundwater recharge area, especially if that is based on incomplete knowledge," says Kennard.

Kennard and fellow Seattle geologist Dan Miller have spent years studying the Oso landslide site. Miller says it's unlikely that just a seven-acre clearcut could trigger the 400-acre slide that destroyed a community on Saturday.

Much larger clearcuts were carved out of the forests above the slide in the 1980s. Geologists say it can take decades for the recovering forest to keep as much rain water out of the ground as it did before a clearcut.

Source: http://www.kplu.org/post/scientists-say-smaller-2006-landslide-set-stage-oso-disaster

KPLU 88.5

Scientists Say Smaller 2006 Landslide Set the Stage tor Oso Disaster

By GABRIEL SPITZER • JUL 22, 2014

LISTEN TO THIS ARTICLE (1 MIN 34 SEC) http://n.pr/1pyFmry

A small landslide in 2006 set the stage for the catastrophe that claimed 43 lives in Oso, Washington March 2014, say a panel of scientists in a federally-funded study. The hills above the North Fork of the Stillaguamish River had slid before, at least 15 times over the centuries, according to the study. But one slide in particular left Oso vulnerable. In 2006, that smaller slide left a loosely-packed mass of debris perched dangerously above the Steelhead Haven development.

Joseph Wartman, an associate professor of civil and environmental engineering at the University of Washington, is the lead researcher on the study. He says last spring, rains saturated the unstable ground and let loose a huge slab. Within seconds, the earth liquefied, sending a torrent more than half a mile across the valley floor. The length of its path of destruction turned out to be within the normal range for this kind of slide, Wartman says, but it still seems shocking, "You know, when we were at the site and you take a look at it, even as someone who's a trained professional in this area, it's difficult to imagine that run-out could come that far, when you look up to the slope," Wartman said.

Minutes after that slide, a second, higher mass of earth slipped, filling the bald spot left by the first. The study noted widespread timber harvests in the immediate area of the slide, but didn't analyze exactly what role forest practices might have played. Researchers say they wouldn't expect it to be a major factor, though, and note that landslides are evident in the valley for millennia before people started cutting down trees. In all, researchers say the slide moved 270 million cubic feet of earth, and was the deadliest in American history.

Source: http://www.heraldnet.com/article/20150128/NEWS01/150129048
Modified by C. Colley

HeraldNet

Lawsuit claims Oso mudslide was 'man-made'

By Noah Haglund, Herald Writer @NWHaglund
Published: Wednesday, January 28, 2015, 12:01 a.m.

OSO — A new lawsuit filed over deaths and property destruction from last year's catastrophic mudslide makes a startling claim. It blames the state of Washington, Snohomish County and a private timber company for causing, "the worst man-made landslide in the history of this nation."

Seattle attorney Karen Willie filed the suit on behalf of three families of people killed in the slide and others who lost property, "I am certain that this is a man-made landslide — I don't think it was an act of God," Willie said. The lawsuit doesn't explain how that claim agrees with the evidence geologists say exists of 15 other large slides in the valley over the past 6,000 years, occurring anywhere from 400 to 1,500 years apart. Slides on that particular stretch of hillside have been occurring at least back to the 1930s.

The suit accuses the state Department of Natural Resources of negligence for issuing a logging permit in 2004 to Grandy Lake Forest Associates of Mount Vernon. The company's 7.5-acre, pie-shaped clear-cut on top of the hillside played a major role in causing a 2006 slide that blocked the North Fork Stillaguamish River, the suit contends. A DNR investigation concluded that permitting for the clear-cut was done properly, but that the company exceeded the approved size by an acre.

While there is less agreement on what caused the 2006 slide, recent scientific studies are in general agreement that it set the stage for catastrophe in 2014. The suit draws from decades of scientific observations of 600-foot-tall Hazel hill, where the slide began. "There were studies out there and people knew so much," Willie said.

In 1947, a professor noted slumping blocks of soil on the hillside. A 1952 study suggested rerouting a stream called Headache Creek to improve the slope's stability — at a cost then calculated at $5,400. Steelhead Haven began getting built out in the 1960s, first as rudimentary fishing shacks. A large landslide destroyed vacation cabins in the area in 1967. More studies followed. Over time, more people began to settle the area as full-time residents. In 1999, a now oft-cited study warned of a 900-foot runout — similar to what happened in 1967. The damage last year — from the top of the scarp to its southernmost point — stretched 5,827 feet. That was the 10th slide to hit the same location, according to the lawsuit.

Of the two earlier lawsuits over Oso deaths, the one representing the largest bloc of victims — 10 families — was filed in October. Like the current lawsuit, it faulted the state, the county and the same timber company.

Article modified by C.Colley

December 22, 2015
[Hannah Hickey](#)
News and Information

UW TODAY

Dating historic activity at Oso site shows recurring major landslides

The large, fast-moving mudslide that buried much of Oso, Washington in March 2014 was the deadliest landslide in U.S. history. Since then it's been revealed that this area has experienced major slides before, but it's not known how long ago they occurred.

UW geologist Alison Duvall inspects a sample of wood from the Rowan Landslide. A larger section sits on the table. Samples are first dried in an oven, then inspected for purity before being sent away for radiocarbon dating. ***Dennis Wise/University of Washington***

University of Washington geologists analyzed pieces of wood buried in previous landslides and used radiocarbon dating to map the history of the site. Their findings, published online Dec. 22 in the journal Geology, show that a massive slide happened around 500 years ago, and not thousands of years ago as some had believed. "It suggests that the Oso landslide was not so much of an anomaly," Duvall said.

The study establishes a new method to figure out when all the previous landslides at a particular location occurred. The method shows that slopes in the area around Oso have collapsed on average once every 500 years, and at a higher rate of about once every 140 years over the past 2,000 years.

"This was well known as an area of hillslope instability, but the question was: 'Were the larger slides thousands of years old, or hundreds of years old?' Now we can say that many of them are hundreds of years old," said co-author Alison Duvall, a UW assistant professor of Earth and space sciences.

In late summer of 2014, the researchers began their work wading along riverbanks to look for preserved branches or trees that could be used to date previous landslides. "When you have a large, catastrophic landslide, it can often uproot living trees which kills them and also traps them in the landslide," Duvall said. "If you can find trees in the landslide, you can assume that they were killed by the landslide, and then you can date a sample to find out when the landslide occurred."

Previous UW research had shown a history of geologic activity at the Oso site, including major landslides and a recent small slide at the same slope that collapsed in 2014. But while the position of past slides and degree of surface erosion can show the order that the older slides happened, it has not been possible to give a date for the past events. Applying the method for other locations would require gathering samples for each area because each site has its own soil composition and erosion characteristics.

It's not known whether the findings for the Oso site's history would apply to other parts of the Stillaguamish River, Duvall said, or to other places in Washington state. The researchers are still studying debris from other locations. But the results do have implications for the immediate area.

Landslide Hazards in Washington State

THE HIGH COST OF LANDSLIDES

Landslides cause about $2 billion in damage and more than 25 deaths each year in the U.S. Direct costs include repair of roads and property. Indirect costs, such as loss of property value and tax revenue, and environmental effects, such as degradation of water quality, can exceed direct costs. The Washington Dept. of Transportation routinely budgets $15 million a year for cleanup of landslides on highways.

FREQUENTLY ASKED QUESTIONS

What is a landslide?
A landslide is the downward movement of soil or rock under the influence of gravity.

Where do landslides occur?
Landslides occur on unstable slopes or relatively flat areas prone to liquefaction during earthquakes.

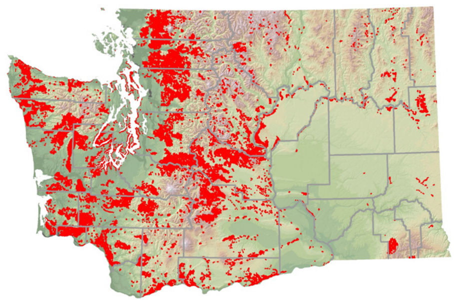
What causes landslides?
Landslides occur when the strength of earth materials on a slope becomes less than the force of gravity or when an additional load is placed on the slope. Common triggers include:

- *Rainfall* – Prolonged or intense rainfall or rain-on-snow events (Pineapple Express) can all trigger landslides.
- *Earthquakes* – Intense shaking during earthquakes can cause ground to fail.
- *Water-level change* – Rapid lowering of water levels can trigger landslides, especially along dams, coastlines, reservoirs, and rivers.
- *Human activities* – Vegetation removal, surface and underground mining, loading on a slope, excavation of the base of a slope, and leakage from pipes can all trigger landslides.
- *Geology* – Easily weathered rock types and sand and clay soils are especially susceptible to landslides.

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Peter Goldmark - Commissioner of Public Lands

Division of Geology and Earth Resources
David K. Norman - State Geologist

www.dnr.wa.gov/geology



Red dots show mapped landslides (from the landslide layer of the Washington Interactive Geologic Map, http://www.dnr.wa.gov/geologyportal).

LANDSLIDE WARNING SYSTEM

In cooperation with the National Weather Service and NOAA, we have developed a model based on recent storm and landslide data that will forecast landslide initiation thresholds to help reduce losses from landslides (https://fortress.wa.gov/dnr/landslidewarning).

The Division of Geology's mission is to collect, develop, use, distribute, and preserve geologic information to promote the safety, health, and welfare of the citizens, protect the environment, and support the economy of Washington. To this end, we conduct and maintain an assessment of landslide hazards in Washington. This assessment includes identification and mapping of landslides and an estimation of potential consequences and the likelihood of recurrence. We also provide technical assistance to state and local government agencies on the interpretation and application of this assessment. Every year, we respond to and (or) record hundreds to thousands of landslides.

Warning signs of an impending landslide

Landslides can be categorized as shallow or deep-seated. Shallow landslides are common in Washington, often forming as slumps along roadways or fast-moving debris flows down valleys or concave topography. They are commonly called "mudslides" by the news media. Deep-seated landslides are often slow moving, but can cover large areas and devastate infrastructure and housing developments. Shallow landslides typically occur in winter in Western Washington and summer in Eastern Washington, but are possible at any time.

Signs of a Shallow Landslide (generally fast-moving):

- Sudden decrease in creek water levels, especially during storms
- Sudden increase in creek water levels, often with increased sediment in the water
- Sounds of cracking wood, knocking boulders, or groaning of the surrounding ground, or unusual sounds, like the sound of an oncoming freight train, especially if the sound increases
- A hillside that has increasing springs, seeps, or saturated ground, especially if it has been dry
- Formation of cracks or tilting of trees, especially evergreens, on a hillside

Signs of a Deep-Seated Landslide (generally slow-moving):

- Newly developing cracks, mounds, or bulging on streets, sidewalks, or the ground in general
- Sagging or taut utility lines; leaning telephone poles, fences, or trees
- Sticking windows or doors; new and/or growing cracks in walls, ceilings, or foundations
- Broken or leaking underground or surface utilities, such as water, septic, or sewer lines
- Separation of foundation from sill plates; movement of soil away from foundation
- Changes in water well levels or cessation of well functioning
- Increase or changes in spring or seep activity; ground becoming soggy or wet

If you notice signs of a shallow landslide, leave the area immediately if it is safe to do so. A landslide can easily destroy or bury a car or house. Report the problem immediately to your local Emergency Management Agency. Signs of a deep-seated landslide should be reported to your local Health or Planning Department, as this type of landslide, though slower, can affect water, sewer, streets, and whole neighborhoods. *(See Resources on back page.)*

REPORT A LANDSLIDE

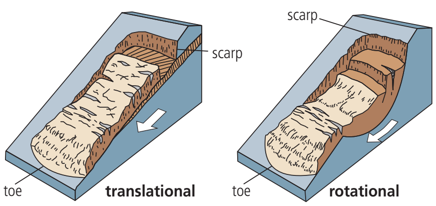
Report landslides to your local emergency management department. Find it at www.emd.wa.gov/myn/myn_contact_info.shtml.

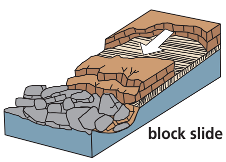
What to do if you think you are at risk

- Contact a licensed geologist or engineering geologist for a site-specific inspection.
- Listen for warnings on NOAA weather radio (recommended), TV, or local radio.
- Evacuate prior to a storm event, which can cause sudden flooding and landslides, blocking escape.
- Keep away from landslide-prone areas until you are sure it is safe to return.

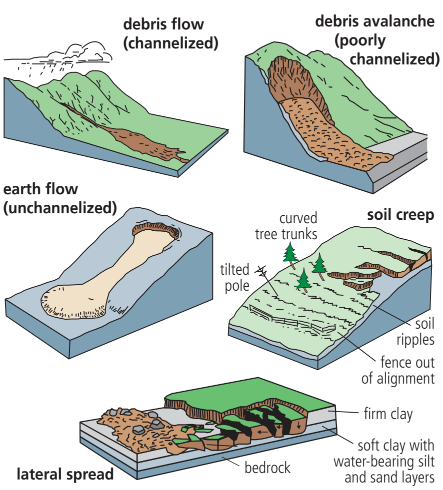
Types of Landslides

SLIDES—downslope movements of soil or rock on a surface of rupture. They commonly occur along an existing plane of weakness. The main modes are translational (along a flat plane) and rotational (along a concave surface). Slides may be deep-seated or shallow.

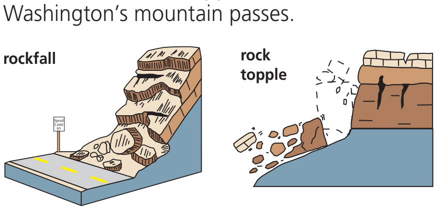




FLOWS—mixtures of water, soil rock and (or) debris that have become a slurry and commonly move rapidly downslope. The main modes of flows are channelized and unchannelized. Lahars are volcanic mudflows.



ROCKFALLS AND TOPPLES—usually rapid, downward movement of large pieces of bedrock. Sometimes a single boulder comes down, sometimes enough rocks to cover a road. Rockfalls and topples are common in Washington's mountain passes.



Slides are often slow-moving, but can move rapidly. Many of the larger landslide areas in Washington, such as the Bonneville and Aldercrest-Banyon landslides, are a complex of deep-seated, rotational slides.

Earthflows have a characteristic "hourglass" shape. The slope material liquefies and runs out, forming a bowl or depression at the head. The flow is elongate and usually occurs in fine-grained materials on moderate slopes under saturated conditions.

Mudflows are earthflows that are wet enough to flow rapidly and contain at least 50% clay, silt, and sand. Both mudflows and earthflows may be slow to rapid.

Debris Flows usually occur in steep gullies and contain more coarse material than a mudflow. They move very rapidly and can travel for many miles. Fires that denude slopes of vegetation intensify the susceptibility of slopes to debris flows.

Debris Avalanches are poorly channelized debris flows that move very rapidly to extremely rapidly. They are often large and can move like a snow avalanche at times.

Lahars are debris flows that originate on volcanoes. An eruption can melt snow and ice very rapidly, causing a deluge of rock, soil, ash, and water that accelerates down the slopes of a volcano, devastating anything in its path. Lahars can also happen spontaneously. They can travel great distances and damage structures in flat areas surrounding a volcano. The communities near rivers draining Mount Rainier and Glacier Peak are at greatest risk.

Lateral Spreads occur on very low angle slopes toward a free face. Movement is accompanied by cracking of the ground. Failure is caused by liquefaction (when soils are transformed from a solid to a liquid state), usually as a result of earthquake shaking.

Soil Creep is the slow, steady, downward movement of slope-forming soil or rock. Creep is indicated by curved tree trunks, bent fences or retaining walls, tilted poles or fences, and small soil ripples or ridges.

Landslide figures modified from U.S. Geological Survey Fact Sheet 2004-3072 and Cruden, D. M.; Varnes, D. J., 1996, Landslide types and processes. *In* Turner, A. K.; Schuster, R. L., editors, Landslides—Investigation and mitigation: National Academy Press; National Research Council Transportation Research Board Special Report 247, p. 36-75.

DEBRIS AVALANCHE
Courtesy Wash. State Dept. of Transportation

Courtesy Wash. State Emergency Management Division

TRANSLATIONAL SLIDE

RESOURCES

The frequency of landslides and their effects can be reduced by appropriate land-use planning and more stringent engineering requirements for construction on hillsides. Information about slide-prone areas is now readily available, so every homeowner should obtain this information and take necessary precautions. Links to free information are given below.

Washington Division of Geology and Earth Resources
Webpage—www.dnr.wa.gov/geology
Interactive Geologic Map—www.dnr.wa.gov/geologyportal

City/County Emergency, Health, and Planning Departments
Emergency management by county—www.emd.wa.gov/myn/myn_contact_info.shtml
Counties—www.mrsc.org/byndmrsc/counties.aspx
Cities—www.mrsc.org/byndmrsc/cities.aspx

Washington State Department of Ecology
Puget Sound Landslides; landslide mitigation—www.ecy.wa.gov/programs/sea/landslides/index.html

Washington State Department of Transportation
Road closures due to landslides; landslide mitigation—www.wsdot.wa.gov/

U.S. Geological Survey (USGS)
Landslide Hazards Program—http://landslides.usgs.gov/

Federal Emergency Management Agency (FEMA)
Landslides—www.ready.gov/landslides-debris-flow

Landslide Insurance
http://insurance.wa.gov/your-insurance/home-insurance/landslides/

Word Wall Cards

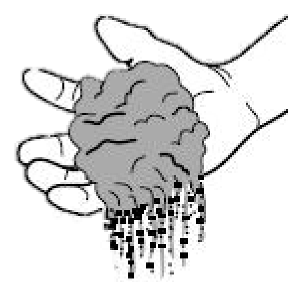
As students learn key science terms during lessons, add word wall cards 1 or 2 at a time to the science word wall. The science word wall should be a in a place students can easily reference and use in their science notebook entries and science writing when needed.

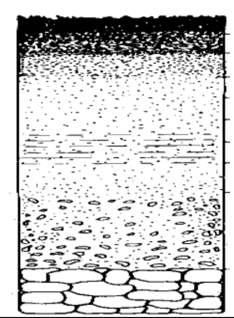
precipitation

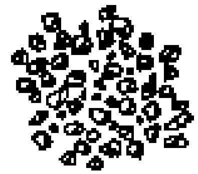
landslide

erosion

soil

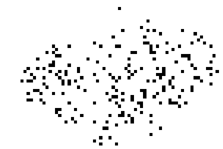


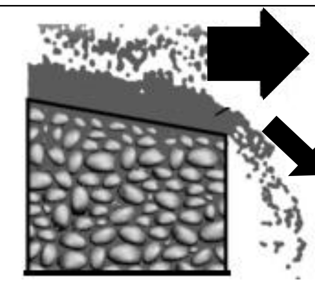


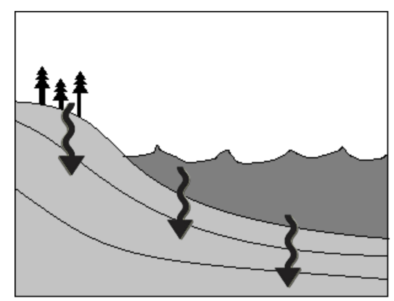
gravel 

sand 

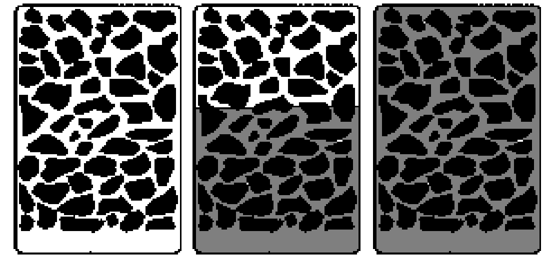
humus 

clay 

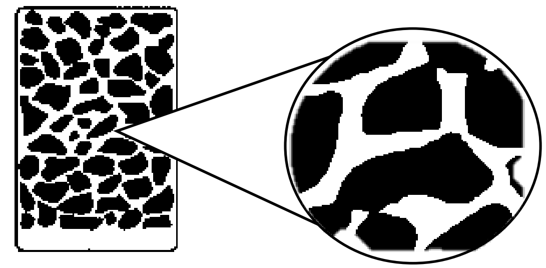
surface runoff 

ground water 

saturation



pore space



slope

vegetation