Learning Resources

Details

Completion Time: Less than a week
Permission: Download, Share, and Remix

Water Cycling: Movement through Watersheds and Water Tracks

Overview
Students will conduct a demonstration that will help them gain a better understanding of the water cycle and runoff in a watershed. They will be able to replicate arctic and non-arctic watersheds by varying the size of the watershed. They will be able to visualize the difference in runoff by creating hydrographs of these different locations.

Objectives
- Students will understand how water moves through a watershed (and water track) and the importance of accurate measurement of this water movement.
- Students will visualize how precipitation, groundwater, and runoff are related
- Students will understand the impact of permafrost to the water cycle and water movement through watersheds

Lesson Preparation
1. Students should have a basic understanding of the water cycle and a watershed before beginning this activity.
2. Gather equipment and use the attached picture to put together a ring stand set-up for each group. It is important to run through the procedure before you perform this with students. Typical classroom balances with a max mass of 250 g make practice important. If you have access to balances with a higher max mass, use them.
3. Mix up colored water. Each group will need the following: 30 ml of red water (ground water) in the tray and 100 ml of blue water (rain) in plastic wash bottle with spout.

Procedure
1. Before jumping in to the experiment, have a brief discussion with students to about the water cycle and its

Materials
- Paper towels (multi-ply heavy duty type)
- clips
- ruler
- hanging balance
- ring stand with clamp
- tray
- table balance
- red and blue dyed water
- stopwatch
- clear plastic ~500 mL wash bottle with spout (see photos from set up)
- Optional: computers and graphing program to create hydrograph of data

importance. Water is critical for life and although it covers 75% of Earth's surface, less than 1% of that water is fresh available water. Powered by solar energy, the water cycle moves water between the atmosphere and Earth. The water cycle moves water through ecosystems and cleans the water as well. This demo will help students visualize some of the process of the water cycle. It is also important for students to understand that there is a finite amount of water on Earth.

2. If you have not already done so, introduce the concept of a watershed (the area of land that drains to a point of interest on the surface). Also introduce the idea of conservation of mass as applied to the water cycle. Introduce the following equation:

- I (inputs) – O (outputs) = change in storage
- Precipitation – (runoff + evapotranspiration) = groundwater storage

3. Ask students why it might be important to be able to accurately measure water movement through watersheds? Why do we care how much water runs off at a particular location? There are many reasons we care including the ability to create water budgets for a location. Demand for water continues to grow, especially in the arid West. It is important to be able to predict drought and implement regulation to help communities through times of water shortage.

4. Explain that you will be using a paper towel to represent the watershed during the demo. Ask students if all watersheds have the same depth or ground water storage. What might be different about the amount of storage in the Arctic as compared to where we live? Introduce the idea of permafrost (show image on PowerPoint). How will permafrost change the way water moves through a watershed? Ask them how we might be able to represent the difference between an arctic watershed and our local watershed? Solicit student responses. Ultimately you will vary the size of the paper towel. A short paper towel will simulate the Arctic with permafrost and a long paper towel will represent an area more similar to their home environment where there is much more ground water storage. Also introduce the term "Water Track", as a linear flow path of water down tundra hill slopes. Water tracks are found in permafrost areas and tend to be more linear than winding due to steep hillslope flowpaths and not much erosion. Show the images of a water track and winding river on the PowerPoint and ask students what might cause the differences in the two locations.

5. Divide students into groups and have them divvy up student roles. Student roles include the following: rainmaker, spring scale reader, table balance reader, timer, data recorder, observer and calculator. Some roles can be combined depending on the number of students in each group. It typically works best to have 5-6 students in each group.

6. Before student groups begin, orient all groups by walking though the procedure they will use.

- Hand out attached data sheet to students.
- Record the mass of the plastic bottle with the blue water before the "rain" event starts.
- Pour the red water (ground water) into the tray that is on top of the table balance. Lower the clamp on the ring stand to allow the paper towel to rest in the tray. Allow paper towel to soak up red water for a few minutes (about 1/3 the way up the towel). Discuss capillary action and how the red water represents the groundwater table.
- When done, raise towel back up and make sure water from the towel will drip into the

tray.
- Make sure to pour out the excess red water from the tray before you start your experiment.
- At time zero, record the mass on the spring scale and table balance (table balance should be zero).
- The "rainmaker" should start raining on the paper towel by carefully wetting the top of the towel with the plastic spray bottle. You can have groups rain at different speeds to represent different types of storms.
- Continue to record the mass of the spring scale and table balance every 30 seconds through out the rainstorm. Notice that at first, no water comes out of the paper towel. Next you should see red water fall into the tray. Then maybe purple water and finally blue water. Ask the students what is happening.
- Make note of the end time of the rainstorm, but continue to take data for several more minutes. Eventually, students can take measurements less frequently, such as five-minute intervals.
- Take a final mass of the rain bottle and record on data sheet.
- Finish calculations either by hand or allow students to use a spreadsheet program (such as Excel, Numbers or Google docs) to calculate change in mass and create the hydrograph for their group. If you do not have access to computers, then have students graph by hand.

7. Compare hydrographs of groups with quick or slow rainstorms and arctic (short towel) vs non-arctic locations. What differences do they notice? Use the attached image of a hydrograph to assist in conducting a discussion about phases of the hydrograph and what we can learn from a hydrograph.

Extension
- Climate change: Ask students to consider the ramifications of thawing permafrost in the Arctic in regards to the movement of water through watersheds and water tracks. How might this impact downstream ecosystems?
- Cloud Seeding: One logical extension to this lesson is to incorporate the idea of cloud seeding. Currently several states are paying Colorado to seed its clouds, without even knowing if cloud seeding really works. China has also been heavily involved in cloud seeding activities. There are several studies underway to look at cloud seeding. As students will learn from this experiment, it can be challenging to get accurate measurements for large-scale inputs and outputs to determine if cloud seeding is actually increasing the amount of precipitation and thus increasing runoff. More info can be found at: http://science.howstuffworks.com/nature/climate-weather/meteorologists/cloud-seeding1.htm or at: http://www.scientificamerican.com/article.cfm?id=cloud-seeding-china-snow
- This site has state by state water data that may allow for an interesting extension or resource for the teacher: http://waterwatch.usgs.gov/

Resources
N/A

Assessment
Students will be asked questions about the concepts covered in the activity on a unit test. Students can be given mock data and be asked to create and interpret a hydrograph.

Credits
Original experiment created by Dr. Bill Dietrich at UC-Berkeley and adapted for this lesson by Dr. Sarah Godsey, Idaho State University and Melissa Barker.

National Science Education Standards (NSES)

Content Standards, Grades 5-8

Content Standard A: Science As Inquiry
a. Abilities necessary to do scientific inquiry
b. Understandings about scientific inquiry

Content Standard B: Physical Science
a. Properties and changes of properties in matter

Content Standard D: Earth and Space Science
a. Structure of the earth system

Content Standard E: Science and Technology
b. Understandings about science and technology

Content Standard F: Science In Personal and Social Perspectives
e. Science and technology in society

Content Standard G: History and Nature of Science
a. Science as a human endeavor
b. Nature of science

Content Standards, Grades 9-12

Content Standard A: Science As Inquiry
a. Abilities necessary to do scientific inquiry
b. Understandings about scientific inquiry

Content Standard B: Physical Science
c. Chemical reactions
f. Interactions of energy and matter

Content Standard D: Earth and Space Science
b. Geochemical cycles

Content Standard E: Science and Technology
b. Understandings about science and technology

Content Standard F: Science In Personal and Social Perspectives
b. Population growth
c. Natural resources

d. Environmental quality
f. Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science
a. Science as a human endeavor
b. Nature of scientific knowledge

Other Standards
N/A

Watershed Experiment Name: ______________________________

Blue water= rain water paper towel= watershed
Red water= ground water

1) Mass of rain water (blue with bottle):
__________ (full bottle mass) - __________(empty bottle mass)= __________

Time (min)	Spring scale mass (g)	Tray mass (g)	Change in tray mass(g)	Observations (color, flow rate, rain, etc)
			0	

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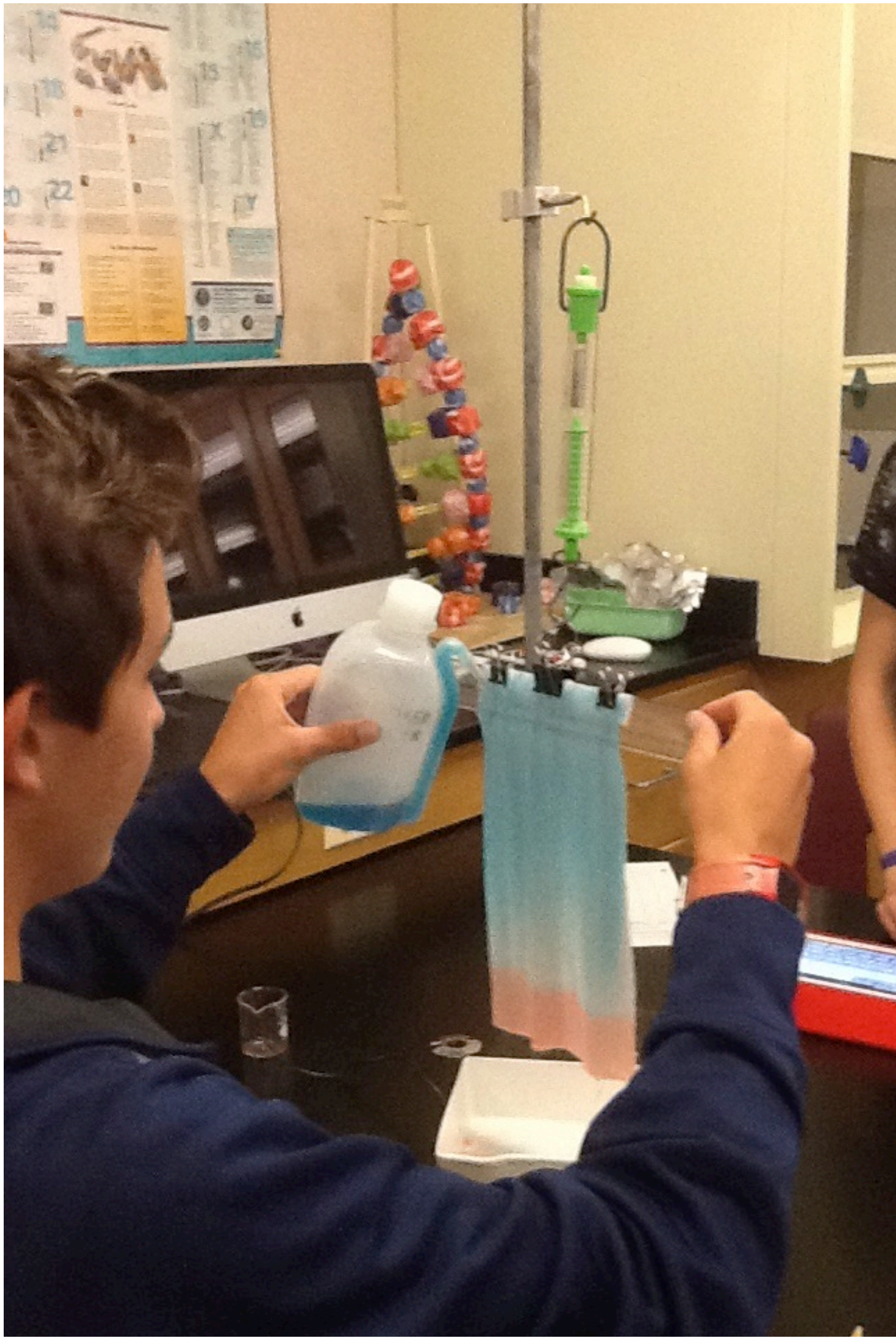
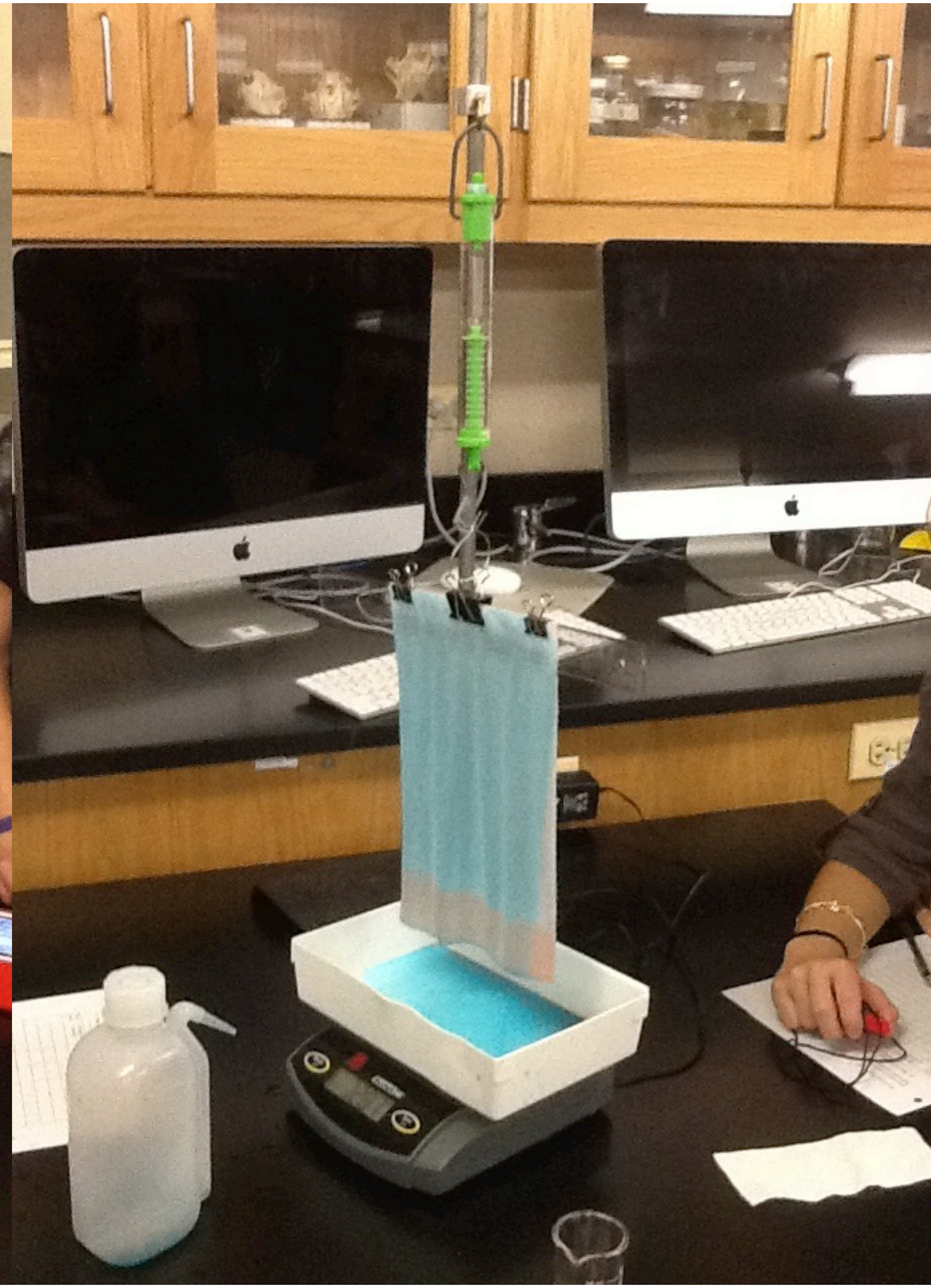
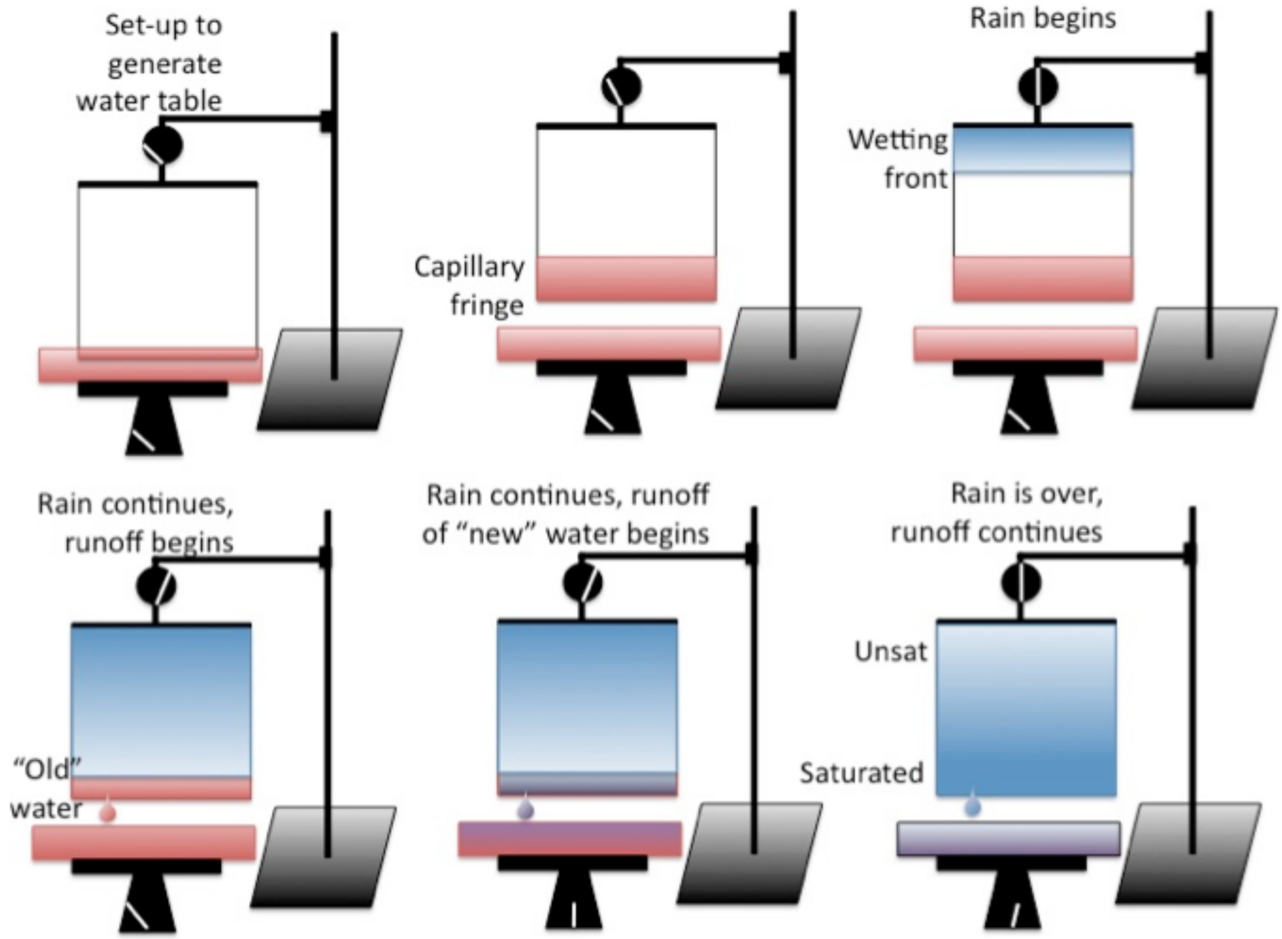
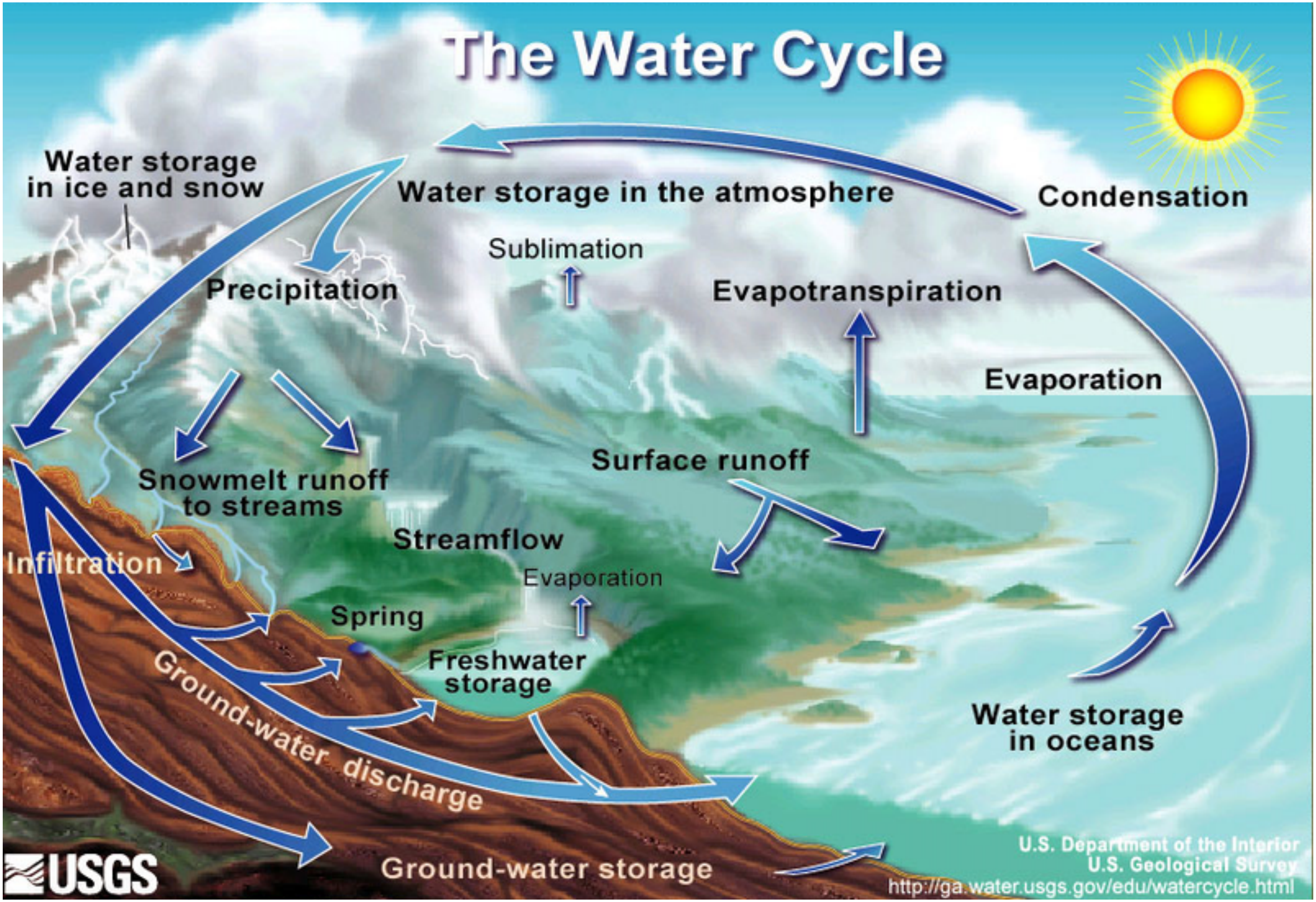
PolarTREC- supporting images

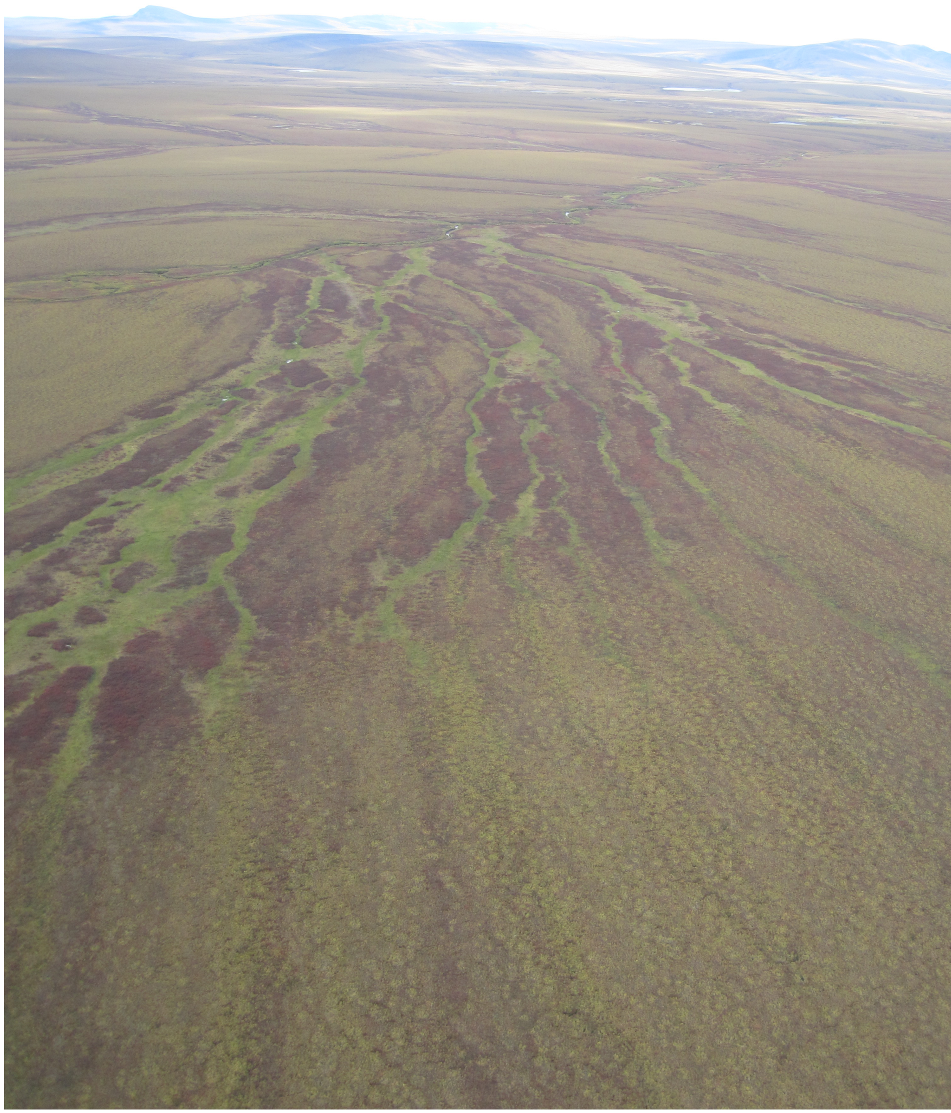



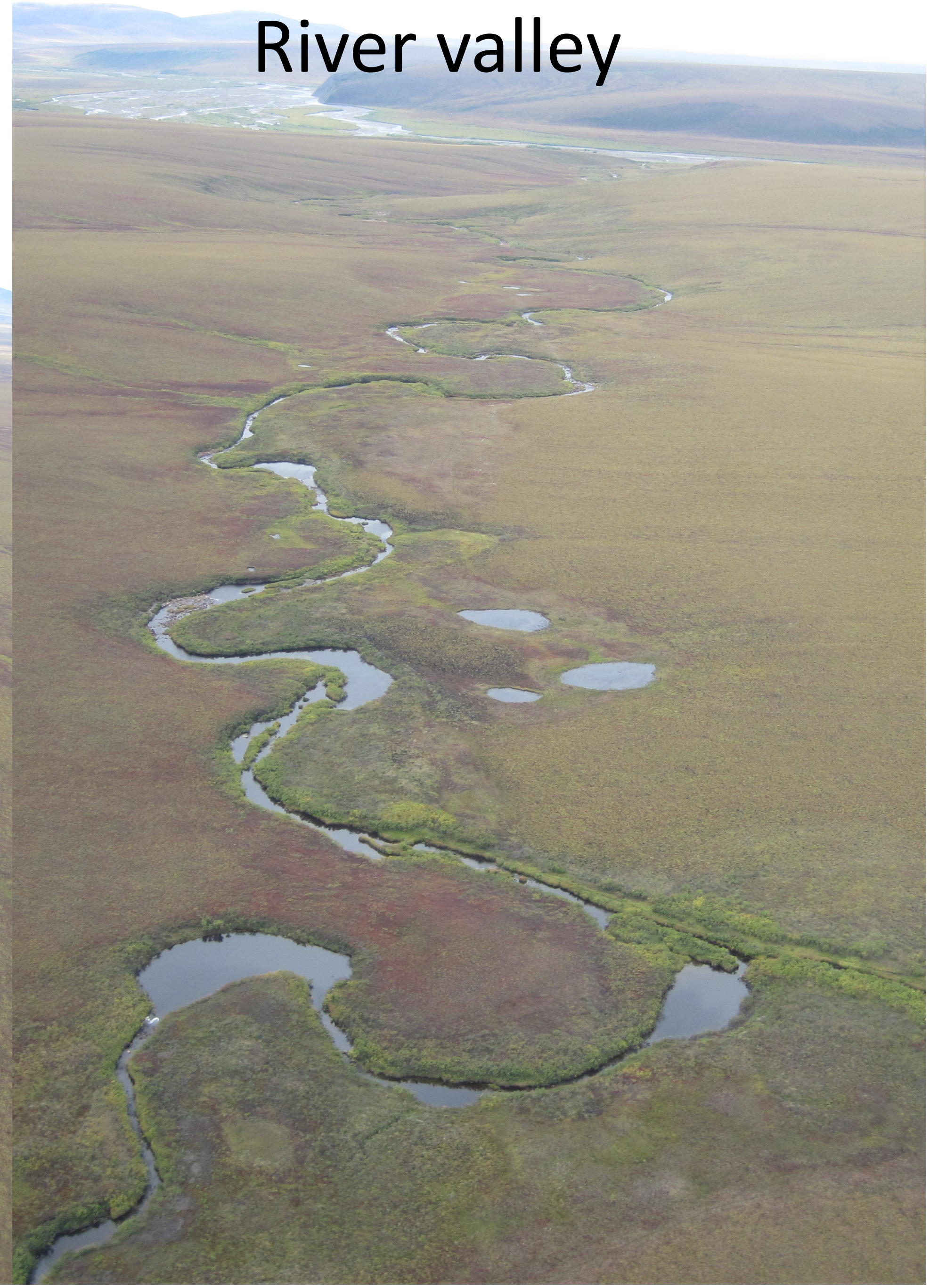
Experimental Set up

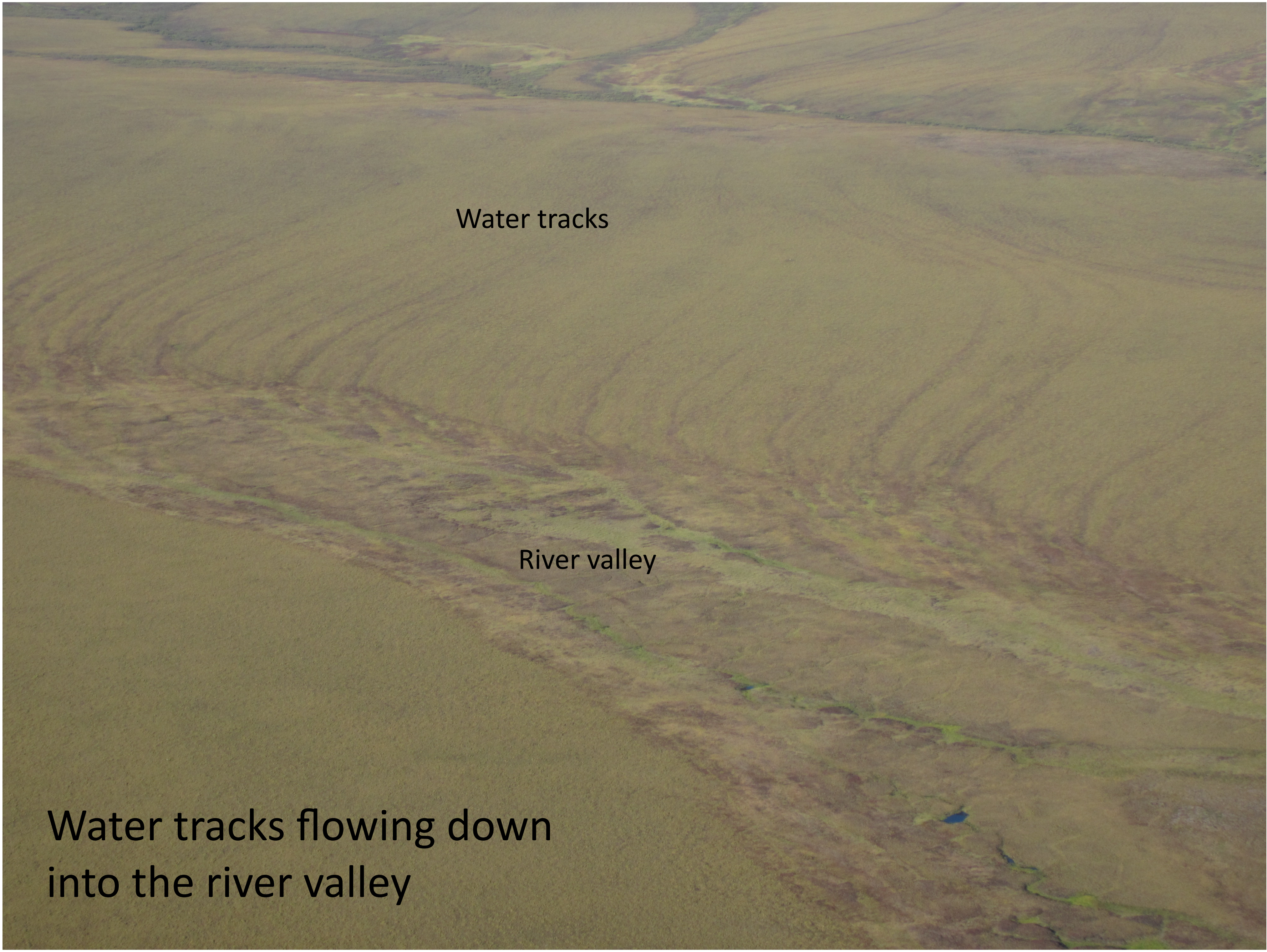


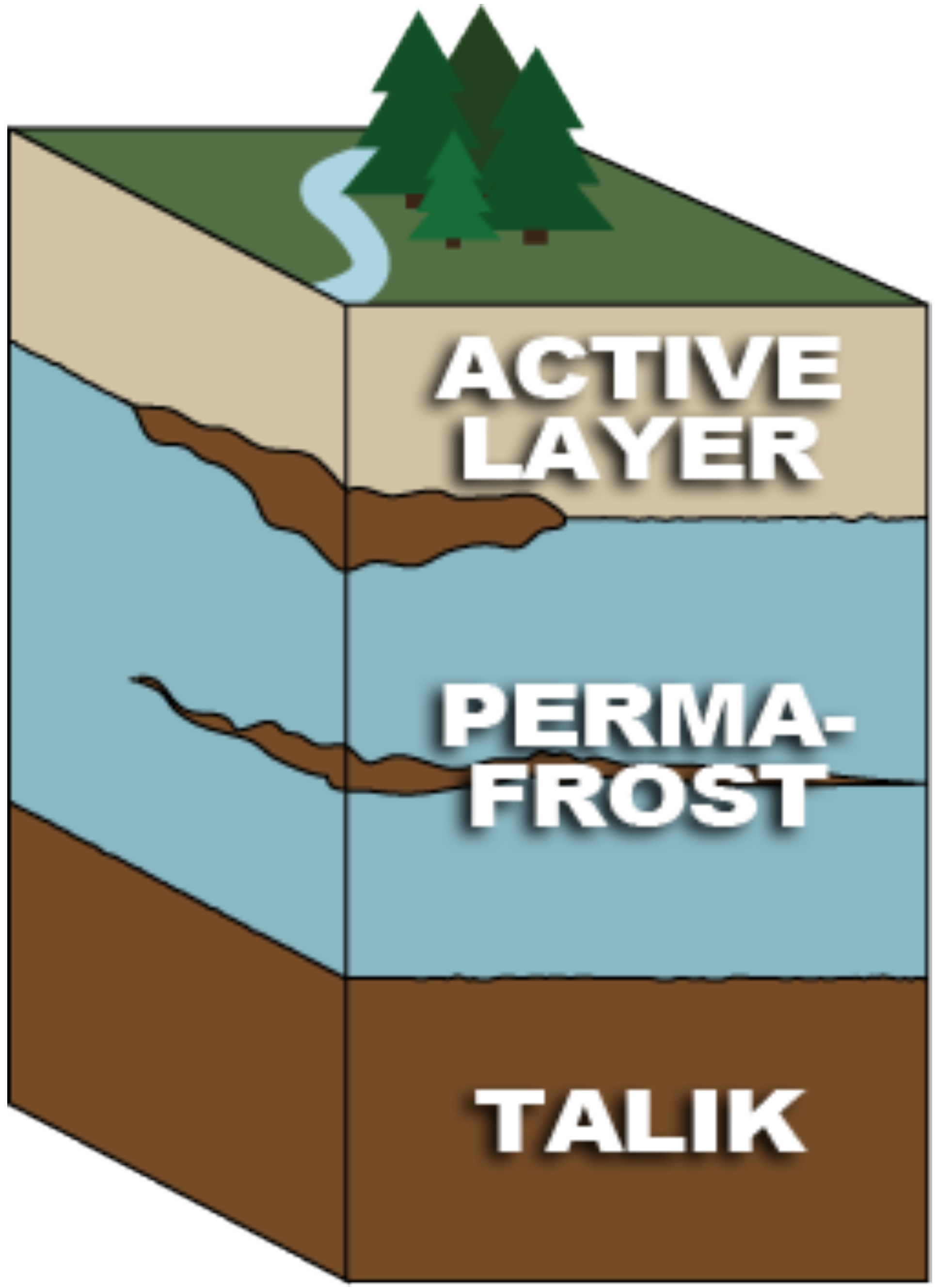

The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Precipitation
Evapotranspiration
Evaporation
Snowmelt runoff to streams
Surface runoff
Streamflow
Infiltration
Evaporation
Spring
Freshwater storage
Ground-water discharge
Water storage in oceans
USGS
Ground-water storage
U.S. Department of the Interior
U.S. Geological Survey
http://ga.water.usgs.gov/edu/watercycle.html

Water Tracks






Water tracks
River valley
Water tracks flowing down into the river valley


ACTIVE
LAYER
PERMA-
FROST
TALIK

DOES CLOUD SEEDING REALLY WORK?

Silver iodide is released in clouds to induce them to form ice crystals and consequently snow.

THE CONSERVATION OF MASS EQUATION:

$$\text{Input} - \text{Output} = \text{Change in storage}$$

or

$$I - O = \Delta S$$

To use it you must define a **boundary** to the thing of interest and you need to define a **time frame.**

capillarity: the tendency for water to cling to the surface of a solid and be pulled into pores. The capillarity force acts in all directions, and may cause water to rise and therefore pull against gravity (see reader).

capillary fringe: zone just above the water table in which pores are completely saturated with water held by capillary pull (tension).

evapotranspiration: liquid water conversion to vapor either by evaporation or by transpiration .(water loss from plants).

field capacity: maximum amount of water a soil can hold when it is freely drained.

hydrograph: a plot of runoff versus time.

macropore flow: a kind of preferential flow which follows pores of larger dimensions.

new water: water entering the ground from a precipitation event.

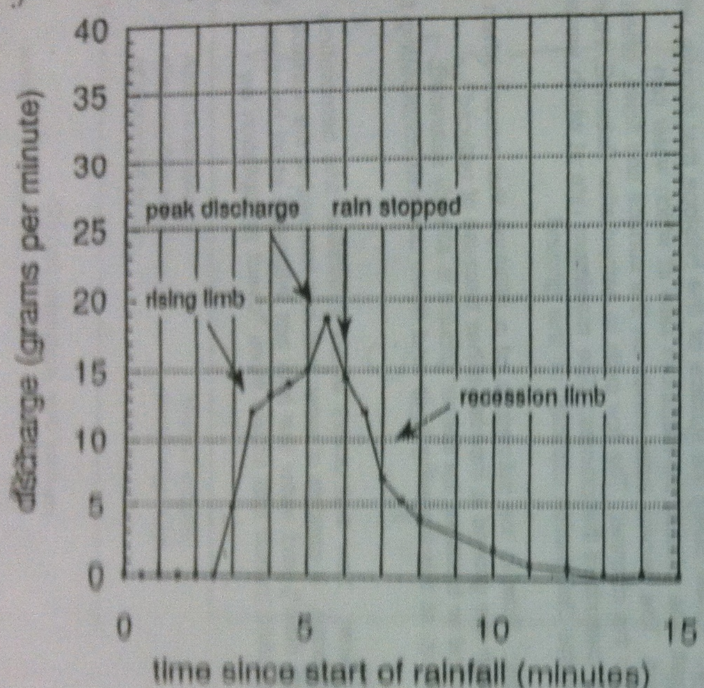
old water: water existing in the ground before the onset of precipitation.

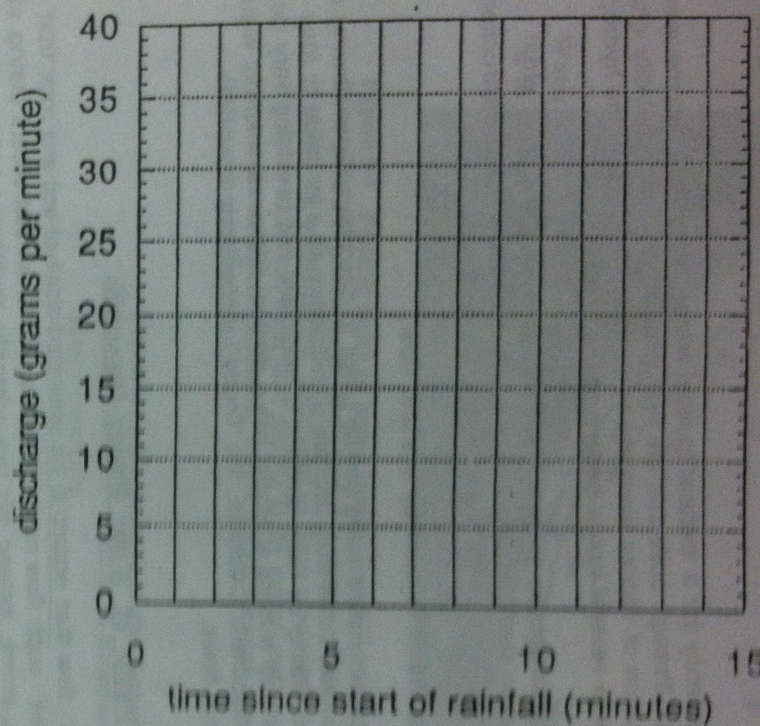
preferential flow: concentrated subsurface water movement along distinct pathways due to differences in moisture content or conductivity properties of the medium.

surface tension: liquid in contact with gas behaves as if it were covered with an elastic membrane in a constant state of tension.

wetting front: abrupt increase in water content associated with water advancing into drier soil.

Paper towel watershed hydrograph





Input	(I)	= full weight of bottle - empty weight of bottle =
Output	(O)	= weight of runoff in pan =
Change in storage	(ΔS)	= final weight of towel - starting weight of towel =