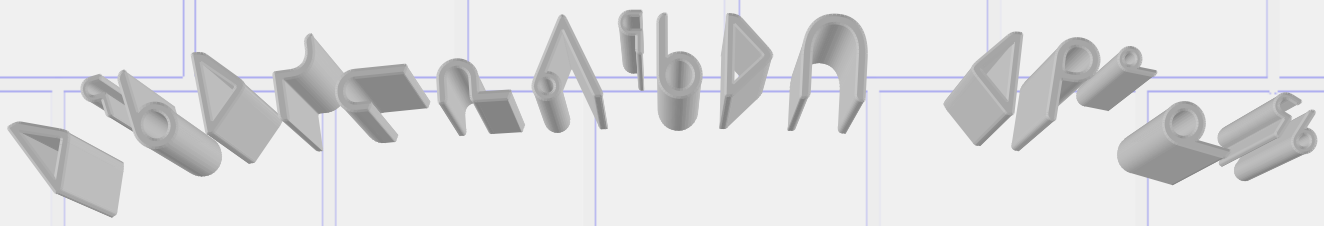
Name: _____

Date: _____

BLOCK C - 4.1

How Permanent is Permafrost?



Active layer
Clay
Climate change
Continuous permafrost
Discontinuous permafrost
Ejection block
Fractionated rock
Frost heave
Frost mound with ice-core
Gelifluction lobe
Glacial till
High centre mud boil
Hummock
Ice lenses
Ice wedge
Ice wedge polygon
Infrastructure
Intrusive ice
Landform
Low centre mud boil
Palsa
Peat
Permafrost
Pingo
Pore ice
Rock
Sand
Silt
Striped soil
Thermal conductivity

Word Wall

Active layer
Clay
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Continuous permafrost
Discontinuous permafrost
Ejection block
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Infrastructure
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Palsa
Peat
Permafrost
Pingo
Pore ice
Rock
Sand
Silt
Striped soil
Thermal conductivity

THE SITUATION

Research on permafrost in Nunavik began when new airstrips were being built between 1987 and 1992 by the Québec's Ministry of Transportation.

Studies at Raglan mine show that the permafrost goes as deep as 640 m!

The research is focused on three questions:

- How does the air temperature affect permafrost?
- How is the active layer affected by climate change? (the active layer is the ground that thaws and freezes each year)
- How does snow affect the soil temperature?

To get this information, researchers use measuring instruments, drilling, data from weather stations and knowledge of local experts.

The AVATIVUT project wants the youth of Nunavik to help observe and collect data on the permafrost in your villages!

This research is conducted in partnership with:
1) The University of Quebec at Trois-Rivières,
2) University Laval
3) The National Institute of Scientific Research and
4) The Centre for Northern Studies.

Your class has been asked to help with this long-term study in your community. As junior researchers, you will learn about permafrost, make observations of the permafrost around your community and measure soil temperature. You will use an interactive simulator to help you better understand permafrost. By the end of this activity, you will be a permafrost expert!

The information you collect will help scientists better understand how weather and climate change the active layer of permafrost and how those changes in the active layer affect the roads and buildings in your community.

For more information on the AVATIVUT project check out the following website:

Project Web portal: http://www.cen.ulaval.ca/avativut/

1. In your own words what are you being asked to do?

C1 Cr1	5	4	3	2	1	0

2. What information will you need to answer the research questions?

WHAT DO YOU KNOW?

THINK – PAIR – SHARE

- Look over the questions on this page and think of how you would answer them.
- With a partner discuss your answers. Both of you need time to share your point of view.
- Share your work with the class.

1. What is permafrost?

2. What do you know about the presence of permafrost in Nunavik?

3. What is the active layer of permafrost? What are things that could change the active layer?

4. Is the active layer of permafrost the same every year?

5. How do you think the active layer affects roads and buildings in Nunavik?

6. What temperature does water freeze at? How do you think this impacts the active layer?

7. What is the difference between heat and temperature?

CORNERS (2 x 4)

- Your teacher has posted several posters in the classroom.
- Walk around to each poster and write down as much information about the word/concept/picture as you know.
- On your teacher's signal, move to the next poster.
- Continue until you have visited all the posters.

Words for Corner activity:

PERMAFROST **ACTIVE LAYER**

TEMPERATURE **SNOW COVER**

PERMAFROST

Permafrost is the layer of soil that stays constantly frozen for at least 2 years in a row. There are different types of permafrost found throughout Nunavik.

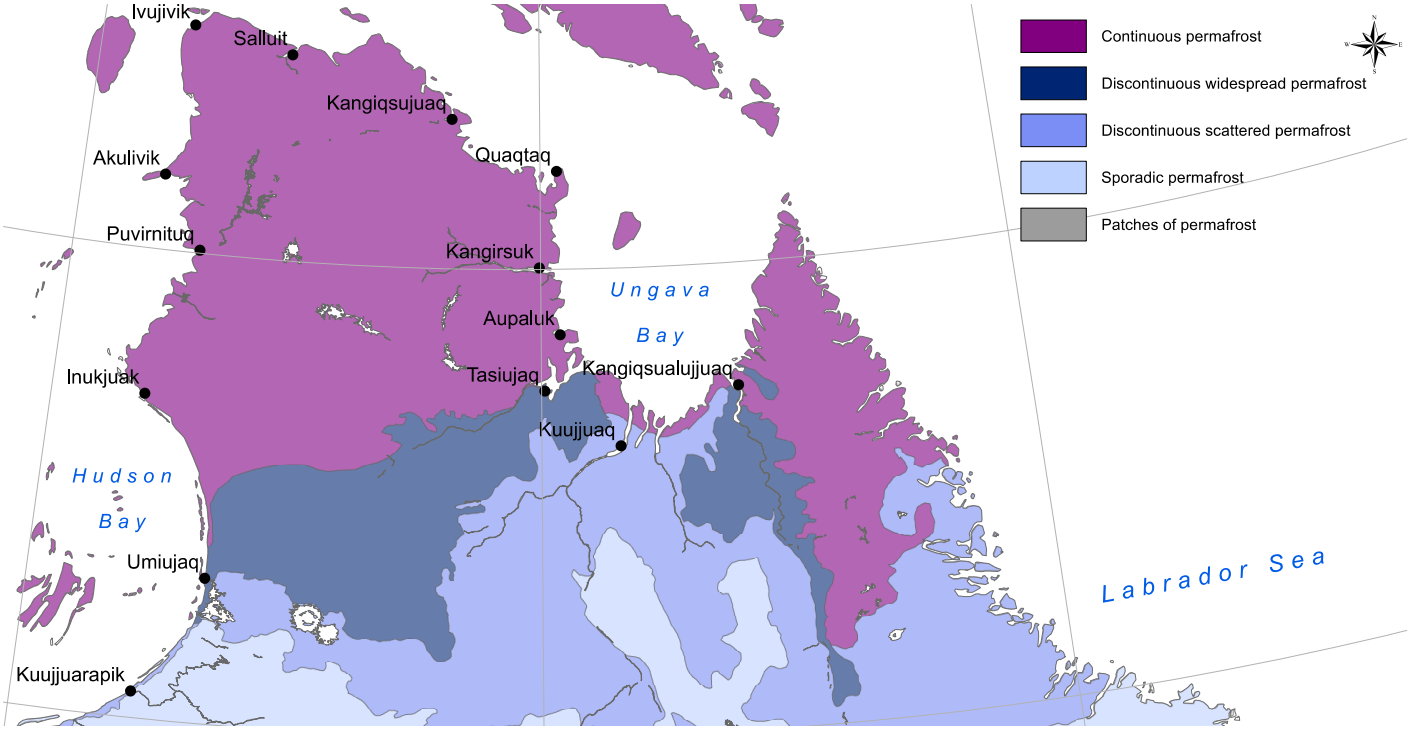
_____ happens when the ground does not stay permanently frozen for a period of at least 2 years in a row. This type of permafrost is found around Kuujjuarapik.

_____ happens in areas where unfrozen soil separates areas of permafrost. This type of permafrost is often found near the tree line, in Umiujaq, Tasiujaq, Kuujjuaq and Kangiqsualujjuaq.

_____ happens when all the soil is permanently frozen. This type of permafrost is seen in other villages like Akulivik, Ivujivik and Salluit.

NOTES

Types of Permafrost in Nunavik



NOTES

FACTORS THAT AFFECT PERMAFROST

Permafrost is affected by a number of different factors such as the _____, _____, _____ and _____.

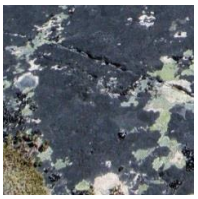
1. TYPES OF SOIL

There are many different types of soil. Your teacher will give you different soil samples. Draw a picture of each soil type and describe its characteristics (e.g. texture, colour, size of particles, weight, etc.).

Soil Type	Diagram	Characteristics
Rock		
Sand/Gravel		
Glacial till		
Clay		
Peat		




The table below shows the properties of each soil type you observed.

Soil Type	Photo	Origin	Water Content	Thermal Conductivity*
Rock		Earth's crust	0	+++
Sand/Gravel		Erosion from wind and water	+	++
Glacial Till		Deposits from glaciers	Varies based on % of clay	Variable
Clay		Marine deposits	++	+
Peat		Accumulation of decaying plant matter	+++	

***Thermal conductivity** is how fast heat can travel through a material. It is said to be the amount of heat that flows through a specified area in a specific amount of time. A material with a high conductivity number tells you that heat travels through it quickly. A material with a low conductivity number does not let heat travel through it well.

NOTES

NOTES

2. TYPES OF VEGETATION

Vegetation (plants) plays an important role in permafrost formation.

Different kinds of plants on the land affect how deep the snow is. The depth of the snow affects the temperature of the ground underneath it, which then affects the active layer of the permafrost.

Think about how an igloo keeps you warm in the winter!

The snow has an insulating (warming) effect.

The height of the plants is important because the taller the plants are the more snow collects there. For example, shrubs on the tundra trap the snow and keep it from being blown away by the wind. This means the snow is deeper near the shrub which keeps the ground beneath it warmer.

Shrubs are plants with woody stems that come in many different shapes and sizes. They can be classified based on their heights.

Shrub Type	Photo	Height (m)	Examples
Dwarf Shrub	   	< 0.2	Blueberry Crowberry Cranberry Cloudberry Willow (some species)
Low Shrub		0.2 – 0.5	Dwarf birch Willow (some species) +
Tall Shrub		≥ 0.5	Alder Birch Willow (some species)

Reference: Myers-Smith et al. 2014.

NOTES

NOTES

EVIDENCE OF PERMAFROST

Permafrost is all around us. Different soil and ice conditions are found in different _____.

1. Palsas

Do you see the dark coloured bump of ground in the photo? That is a palsa.

The soil has been pushed up by ice under the ground called frost heave.

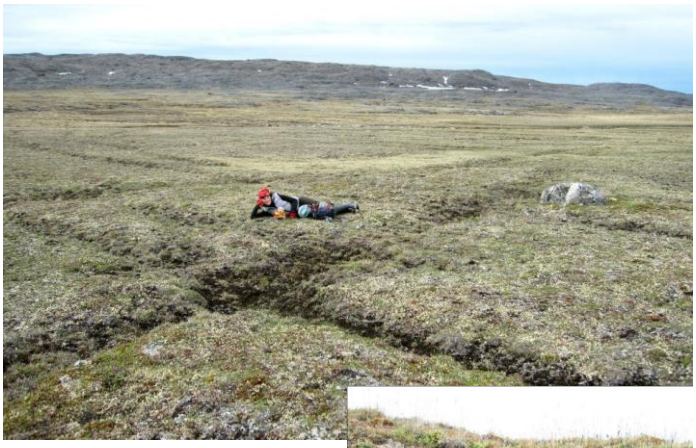
Palsas are found in peat and clay soil types.

You will find ice lenses in palsas.
An ice lens is made when water is caught in a small space or crack. When it freezes, it grows and pushes the soil or rock apart.

Peat

Clay

2. Ice-Wedge Polygons



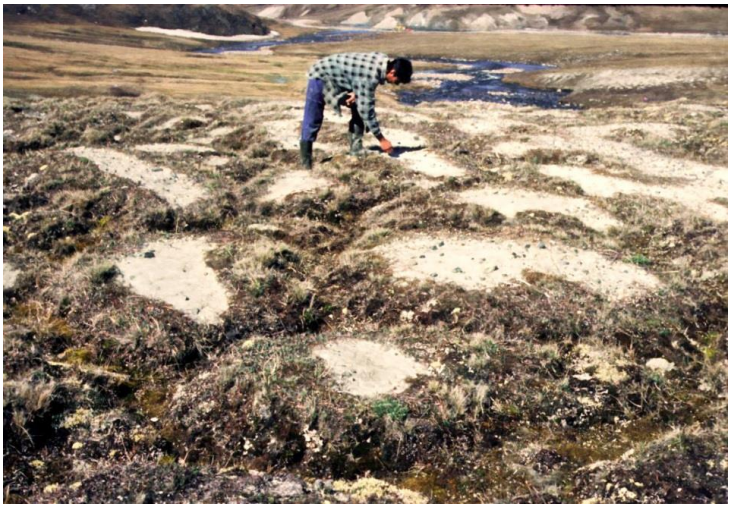
Can you see the lines in the ground in the photo?
They are ice wedge polygons.

In the winter, the cold makes the hard, frozen soil shrink and crack.
In the spring, water fills these cracks.
Then the cycle repeats itself when winter returns!

The ice you find here are ice-wedges.
An ice-wedge is a crack in the ground made by a piece of narrow ice that goes down several metres into the ground.

3. High-Centre Mud Boils

Mud boils are round bumps of mud pushed up by frost heave.



High-centre mud boils are found in clay soil.

You find ice lenses in high-centre mud boils.

NOTES

NOTES

4. Low-Centre Mud Boils

Low-centre mud boils are found in glacial till soil.

You will find ice lenses and pore ice in low-centre mud boils.
Pore ice is the ice in the little spaces between tiny soil particles.

5. Frost Mound With Ice Core

Frost mounds are ice core mounds in the active layer of permafrost. They are made by pressure deeper in the permafrost layers during the winter.

You find intrusive ice in frost mounds which is made when freezing water is pushed down into the soil or rocks under pressure.

6. Striped Soil

Striped soil happens in places where freeze and thaw cycles have made the ground slope slightly. When the fine soil sediments are very wet, gravity pulls them slowly down the slope, making the ground looked striped.

Striped soil is found in glacial till soil.

7. Gelifluction Lobes

Gelifluction is the slow movement of the thawed, super wet layer of soil on top of a frozen ground layer.

You find ice lenses and pore ice in gelifluction lobes.

Gelifluction lobes are found in glacial till soil.

NOTES

NOTES

8. Hummocks

A hummock is a rounded bump of ice pushed up on an ice field.

Hummocks are caused by slow, unequal pressure in the packed ground ice.

You find pore ice in hummocks.

Hummocks are found in glacial till soil.

9. Pingos

A pingo is a large mound of earth-covered ice.

They can be up to 70 m tall and 600 m in diameter.

You find intrusive ice in pingos.

10. Ejection Blocks

Ejection blocks start with cracks in the bedrock.

Water enters the cracks and freezes in ice lenses.

The ice lenses push up as they freeze, cracking the rocks more and more.

Ejection blocks are found in fractionated (cracked) rock.

NOTES

NOTES

CLIMATE CHANGE

1. What evidence of climate change do you see in Nunavik?

2. How do you think permafrost in Nunavik is being impacted by climate change?

Permafrost degradation

Experimental Method

- I observe.
- I develop a research question.
- I define the variables.
- I experiment.
- I collect the data.
- I analyze my results and present them.

I observe:

During the year, air temperature changes with the seasons.
Air temperature also varies from year to year.

I develop a research question:

"How does air temperature affect the frost in the ground?"

"How does soil type affect frost in the ground?"

"How do plants affect the soil temperature?"

"How does snow cover affect the soil temperature?"

"Can we reduce the impacts of climate change on infrastructure (buildings, roads, etc.)?"

EXPERIMENT

EXPERIMENT

I define the variables:

We will be looking at four variables:

1. Air temperature
2. Soil type
3. Plants
4. Snow cover

Independent Variable: _____

Dependent Variable: _____

Constants: _____

_____

_____

_____

To obtain answers for our research questions, we will use six different techniques:

 1. Interview

 2. Observation

 3. Description

 4. Sampling

 5. Measurement

 6. Analysis

INTERVIEW

EXPERIMENT

I experiment:

Material

- ✓ One elder
- ✓ Map of surficial geology around your community.
- ✓ Voice recorder (if possible)

Procedure:

1. Watch the video on how to conduct the interview.
2. Invite one or more local elders to your class to conduct the interview. Or do the interview at home with you parents or grandparents.
3. Using the questionnaire found on the following pages, ask each question to the elder you are interviewing.
4. Record their answers on their questionnaire.

5. On the surficial geology map, record the location of each landform identified by the elder you are interviewing.
6. If you have a recorder, use it so you can listen to the interview afterward and ensure that the information you recorded is accurate.
7. Compare your notes with the other students. As a class, fill out a new questionnaire, using the answers that were the most common.
8. Transfer your data from the questionnaire to the AVAT Internet portal: http://www.cen.ulaval.ca/avativut/

I collect the data (results):

INTERVIEW RESULTS

Student Name: _____

Interviewee Name: _____

Village: _____

Interview Date:_____

Question 1: Use

What is permafrost useful for? (Example: drinking water, food preservation, camps, travel, etc.)

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Question 2: History

What changes to permafrost have you observed in your lifetime?

EXPERIMENT

EXPERIMENT

Question 3: Terminology

What types of landforms related to permafrost do you know?
Look at the examples provided.
Write the names and descriptions in Inuktitut if possible.

Question 4: Locations

Have you seen any of the landforms related to permafrost around your community?

- *Locations where you have seen ice in the soil*
- *Sources of drinking water that freeze in the winter*
- *Landslides or rock falls*
- *Caves that form in the ice during the winter*
- *Locations where the soil is softer than before*
- *Damaged roads or buildings*

Use the surficial geology map of your village to identify the location of any landforms related to permafrost that you have seen around your community. Clearly mark the location and the type of landform. Record any additional information or descriptions below.

Reflection Activity

1. What did you learn about permafrost from the elder you interviewed?

2. How was the elder's knowledge of permafrost different from your own?

3. Why were you asked to interview an elder instead of a friend or your brother or sister?

4. After interviewing an elder, what do you think is the role of the elders' experience and traditional knowledge in scientific studies?

UNDERSTANDING PERMAFROST

EXPERIMENT

I experiment:

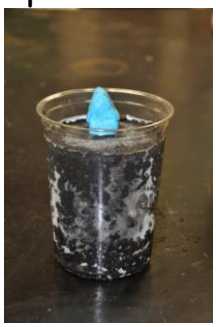
Material

- ✓ Black earth (500 mL)
- ✓ Ice cubes
- ✓ Plastic cups (500 mL) x 2
- ✓ Plasticine (modelling clay)
- ✓ Sand (500 mL)
- ✓ Water

Procedure:

1. Fill a plastic cup 1/3 full with wet sand.
2. Put ice cubes in the cup until it is 2/3 full.
3. Fill the cup with wet sand.
4. Freeze the cup for at least 24 hours.
5. Repeat steps 1 – 4 for black earth. (Be careful not to soak your black earth. It should be moist, but not drenched!)

6. Use the plasticine to make two small houses. Once your samples are frozen, place one house on top of the sand and the other house on top of the black earth.



7. Predict what will happen to the ground (the sand or black earth), the ice and the house as the samples thaw.
8. Record your observations as your samples thaw.

C1 Cr3	5	4	3	2	1	0

EXPERIMENT

I collect the data (results):

SAND		
Thawing Time From Start (h)	Drawing	Observations
0		

BLACK EARTH		
Thawing Time From Start (h)	Drawing	Observations
0		

EXPERIMENT

C1 Cr3	5	4	3	2	1	0

ANALYSIS

1. What happened to the house when the sand thawed? Explain your answer.

2. What happened to the house when the black earth thawed? Explain your answer.

3. Why did the thawing sand and black earth not have the same impact on the houses?

C1 Cr4	5	4	3	2	1	0

4. What do the results of your experiment tell you about the impact of soil type on infrastructure?

C2 Cr3	5	4	3	2	1	0

DYNAMICS OF PERMAFROST

EXPERIMENT

I experiment:

Procedure:

EXPERIMENT A

1. Select your village, sand (soil type) and low shrubs (type of vegetation cover).
2. Choose the Compare option.
3. Select sand and tall shrubs in the Compare section.
4. Set the soil depth to 0 m (surface).
5. Deselect the Show Air Temperature option.
6. Observe the effect of shrub height on soil temperature in the summer and winter.
7. Compare the differences when you select soil depths of 0.5 m, 2 m and 5 m.
8. Save or print your results.

EXPERIMENT

EXPERIMENT B

1. Select your village, a soil type and low shrubs (type of vegetation cover).

2. Choose the Compare option.

3. Select the same options except for the type of soil in the Compare section.

4. Compare the differences when you select soil depths of 0.5 m, 2 m and 5 m.

5. Save or print your results.

EXPERIMENT C

1. Select your village, a soil type and no vegetation.

2. Choose the Compare option.

3. Select the same soil option and lichens as the type of vegetation cover in the Compare section.

4. Compare the differences when you select soil depths of 0 m, 0.5 m, 1 m, 2 m and 5 m.

5. Repeat the experiment with different types of vegetation (low shrubs, tall shrubs, etc.).

6. Save or print your results.

EXPERIMENT D

1. Select your village.
2. Select clay as the soil type.
3. Select none as the type of vegetation cover.
4. Deselect the Compare option.
5. Deselect the Show Air Temperature option.
6. Set the soil depth to 5 m.
7. Save the image of your simulation to your computer as clay.png.
8. Repeat steps 1 – 6 for each soil type and save and name each image according to the soil type.
9. Use all 5 images to compare the evolution of the active layer under different soil conditions.

EXPERIMENT

I collect the data (results):

1. How does the height of the vegetation impact soil temperature?

C1 Cr4	5	4	3	2	1	0

2. How does the type of soil impact soil temperature?

3. How does the type of plants impact soil temperature?

4. Which factor do you think has the biggest impact on soil temperature? Justify your answer.

C2 Cr4	5	4	3	2	1	0

REVIEW QUESTIONS

Review Questions

1. What is the active layer of permafrost?

2. Explain why the active layer of permafrost is not the same every year.

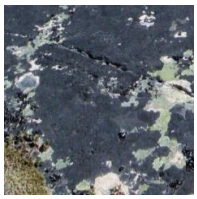
C2 Cr2	5	4	3	2	1	0

3. What are the three main factors that affect the active layer of permafrost?

C2 Cr3	5	4	3	2	1	0

4. Identify each type of soil.

_____ _____ _____



_____ _____

C2 Cr3	5	4	3	2	1	0

5. Determine if each of the following conditions would lead to freezing or thawing of the active layer of permafrost.

Condition	Freeze or Thaw
Increased air temperature	
Less snow	
Taller shrubs	
Decreased air temperature	
Smaller shrubs	
More snow	

C2 Cr2	5	4	3	2	1	0

REVIEW QUESTIONS

REVIEW QUESTIONS

6. Give at least 6 examples of evidence of changes to permafrost.

C2 Cr3	5	4	3	2	1	0

7. Describe any evidence you saw to changes in the permafrost in your community.

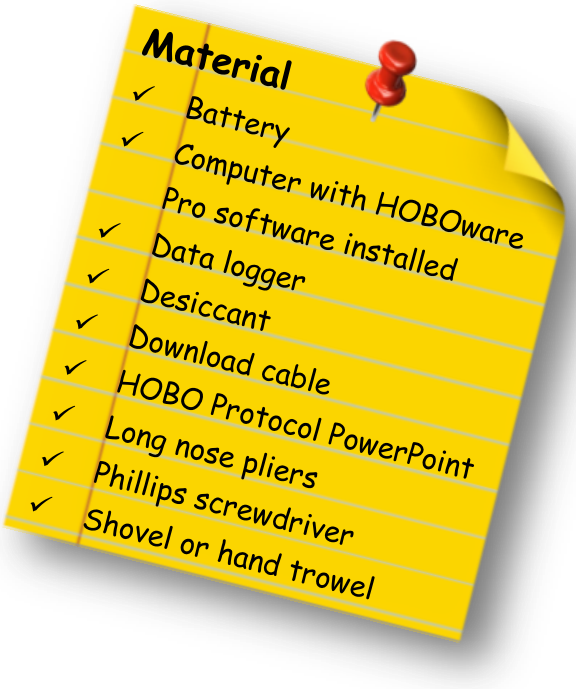
8. Describe how thawing permafrost could impact life in Nunavik.

C2 Cr2	5	4	3	2	1	0

SOIL TEMPERATURE

GOING FURTHER

I experiment:



Procedure:

1. Read through the PowerPoint presentation called HOBO Protocol Illustrated. Ensure you understand the steps before going forward!

2. Find the experiment site on Avativut internet portal.

3. Go to the monitoring plot in your village where the snow stick was installed.

4. Find the data sensor in front of the snow stick, approximately 5 cm below the surface.

5. Follow the instructions to download the data.

6. Replace the battery and the desiccant.

7. Program the data sensor. Verify that the LED indicator light is flashing.

Put the data sensor back where you found it.

OBSERVING PERMAFROST

I experiment:

Procedure:

1. Review the map of surficial geology around your community. Look for the different landforms related to permafrost around your community.

2. Walk around your community and find the landforms on the map.

3. Take a photo of the landforms you observe.

4. During your walk, look for evidence of climate change in the permafrost. Note how the thawing permafrost is affecting infrastructure. Note the GPS coordinates and take photos of any evidence of thawing permafrost you see.

5. Discuss your findings and photos with your class when you return.