Permafrost Monitoring at Golden Horn Elementary School, Whitehorse

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Yukon Energy, Mines and Resources

Yukon Geological Survey

The Permafrost Outreach Program

A permafrost outreach program has been running in Yukon since 2007. Long-term permafrost monitoring stations and/or frost tubes have been installed near public schools in Whitehorse, Faro, Ross River, Dawson, Old Crow, Carmacks and Beaver Creek (Figure 2). The program is part of a larger network of permafrost monitoring stations that have been set up at over 100 schools throughout Alaska, Yukon, Greenland, Mongolia, China, Russia, Norway and Finland.

Shallow boreholes are drilled near the schools, and data loggers are installed to measure hourly air and ground temperatures at a variety of depths. Frost tubes were also installed in fall 2008 to start monitoring seasonal freezing and thawing trends in the active layer. School students are actively engaged with field data collection and interpretation of results posted on a central website. The program provides opportunities for elementary and high school students to participate with field research, and in doing so, allows them the opportunity to learn about the complex relationships between permafrost, the active layer, global climate and the physical environment.

The program also provides baseline data that can be used by scientists to characterize local permafrost conditions and detect long-term changes. For more information and educational resources, check out our website!
http://www.uaf.edu/permafrost/

Figure 1. Panya shows some Faro students the permafrost monitoring station.

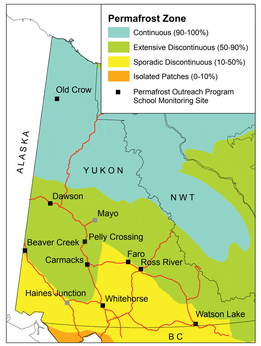


Figure 2. Map showing permafrost distribution across the Yukon, and schools participating in permafrost outreach program (black squares).

About Permafrost

What is permafrost?
Permafrost is ground that stays frozen all year round, for at least 2 years.

What is the active layer?
The active layer is the layer of soil near the ground surface that melts during summer and refreezes during winter. It lies above the permafrost and extends to the ground surface. It is usually less than 2 m thick in the Yukon.

Where is permafrost found in the Yukon?
Permafrost is not found everywhere, but it becomes more extensive in northern and western Yukon (Figure 2). It is most common on colder north-facing slopes, and beneath shady forests growing in fine silty soils. In southern and central Yukon, it is generally absent on warm southfacing slopes, in sandy soils and beneath lakes and rivers.

How thick and cold is permafrost in the Yukon?

In southern Yukon, permafrost is generally very warm (greater than -1° C) while in northern Yukon it is colder (less than -3° C).

It may be up to 10 or 20 m thick in southern Yukon, 60 m thick in central Yukon and up to 300 m thick in northern Yukon.

Why is it important to study permafrost?

Permafrost is very important for the ***ecosystem*** because it affects how water moves through the ground (water can't drain through permafrost) and therefore where certain plants and animals are found.

It is also very important for properly designing ***roads and buildings***. Construction, forest fires and flooding can cause permafrost to melt quickly which may cause the ground to settle and roads and buildings to move.

Permafrost is closely related to ***climate change*** because climate controls where permafrost can exist, and melting permafrost releases greenhouse gases (methane).

What are some local permafrost features?

There is a "drunken forest" beside Cowley Creek near the permafrost monitoring site (Figure 3). As ice in the ground melts (a process named "thermokarst"), the ground sinks and causes the trees to fall over. Flooding drowns the roots and the trees die.

Figure 3. *Drunken forest and thermokarst terrain beside Cowley Creek.*

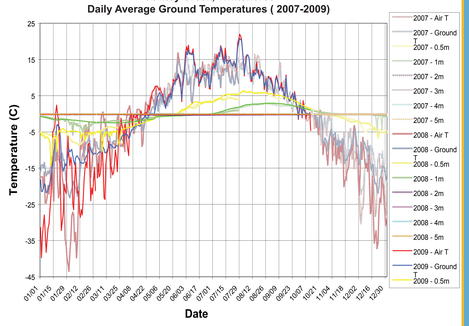
Figure 4. *Kenji drilled through ice (white material on auger) 4-5 m below the surface at the Cowley Creek monitoring site.*

Permafrost Monitoring

On May 4, 2007 a permafrost borehole was drilled in Cowley Creek subdivision, 2.2 km southwest of Golden Horn Elementary School (Figure 5). The borehole was drilled to 5 m depth approximately 40 m east of Cowley Creek and about 40 m southeast of Salmon Trail. This was the closest permafrost site to the school we could find because permafrost is very sporadic in Whitehorse.

- **location:** 60° 35' 35" N latitude, 134° 54' 18" W longitude, elevation 754 m
- **vegetation:** white spruce forest, feathermoss forest
- **soil:** 10 cm surface organic layer overlying fine-grained silt that is very ice rich from 4-5 m depth.
- **temperature sensors:** installed at 50 cm, 100 cm, 200 cm, 300 cm and 495 cm depths in the ground, as well as at the ground surface (0 m) and 100 cm above ground to monitor air temperature.

The graphs below show data collected from this site between 2007 and 2009.



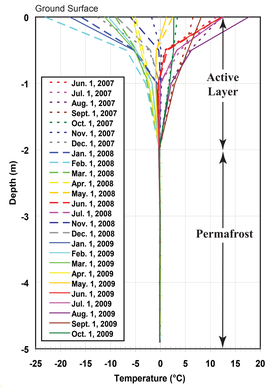


Figure 5. Cowley Creek permafrost monitoring station and results.

Active Layer Monitoring

Frost tubes are simple devices that allow us to measure how deep and how quickly the ground freezes in the active layer throughout the year. Depth of seasonal freezing depends on surface conditions such as local climate, snow depth, amount of sun exposure and shading, moss thickness, and soil moisture.

Changes in frost depth, the seasonal timing of ground freezing and thawing, and the length of the freezing period are very important for the growth of both wild and garden plants, and for building foundations and burying pipes.

A frost tube was installed approximately 100 m north of Golden Horn Elementary School on November 19, 2008. The site is located beside a mature white spruce forest, amidst willow shrubs that fringe a grassy meadow and shallow pond.

The frost tube was constructed by filling a length of 6 mm (1/4-inch) clear flexible plastic tube with water (Figure 6). The water is tinted with a small amount of food colouring to make the boundary between frozen and unfrozen liquid in the tube more obvious. The tube is inserted down a small hole in the ground that is lined with a white PVC pipe.

Graduations are marked on the tube every 5 cm below the ground surface level.

At weekly intervals, students briefly remove the clear tube from the PVC pipe and measure the depth of freezing.

This is indicated by the lowest depth of frozen water in the clear tube.

The graph below shows frost tube data collected by Goldenhorn students (Figure 7).

Figure 6. Typical frost tube installation.

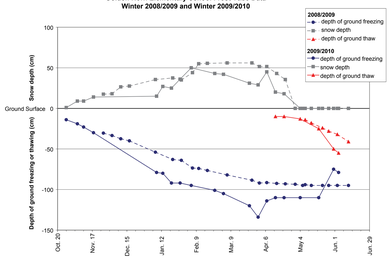


Figure 7. *Frost tube data measured by Golden Horn Elementary students since 2008.*

Highlights

- Whitehorse is in the sporadic discontinuous permafrost zone, and permafrost is only found in certain locations where soil, moisture, and climate conditions keep the ground cool enough.
- A frost tube was installed at Goldenhorn Elementary in November 2008.
- Measurements made by school students show that the ground froze down to 95 cm depth by April 2009 and 134 cm depth by April 2010.
- By early June 2010, the active layer had thawed to 55 cm depth.
- A permafrost monitoring station was installed at Cowley Creek in May 2007. Permafrost temperatures are measured once every hour at various depths in a 5 m deep borehole.
- A large amount of ice was found 4 m below the ground surface near Cowley Creek.
- Ground ice melting from the permafrost has caused "thermokarst" and created a "drunken forest" at Cowley Creek.
- The active layer at Cowley Creek is 2 m thick.
- The temperature of permafrost measured at Cowley Creek is -0.2° C, which is very close to melting!
- The average annual air temperature at Cowley Creek was -2.2° C.
- The coldest air temperature measured during winter '08/'09 was -43° C on January 7, 2009, while the warmest temperature in summer 2009 was 33° C on July 29.

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Sources of Further Information

Learn more about permafrost and climate change on these websites:

1) National Snow and Ice data center (US): http://nsidc.org/sotc/permafrost.html and http://nsidc.org/frozenground/.
2) Environment Canada: http://www.msc-smc.ec.gc.ca/crysys/education/permafrost/permafrost_edu_e.cfm
3) Northern Climate Exchange (Whitehorse): http://www.taiga.net/nce/education/resources.html and http://www.taiga.net/nce/schools/teachers.html
4) Arctic Climate Impact Assessment: http://amap.no/acia/ and check out http://www.taiga.net/acia/index.html

For more information, contact:

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http://www.uaf.edu/permafrost/

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