The Active Layer Network

A collaborative project between the US Geological Survey, Yukon River Inter-Tribal Watershed Council, and Yukon River communities

USGS
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ONE PEOPLE-ONE RIVER
Yukon River Inter-Tribal Watershed Council
www.yritwc.org

A Four year summary report for the community of Nenana

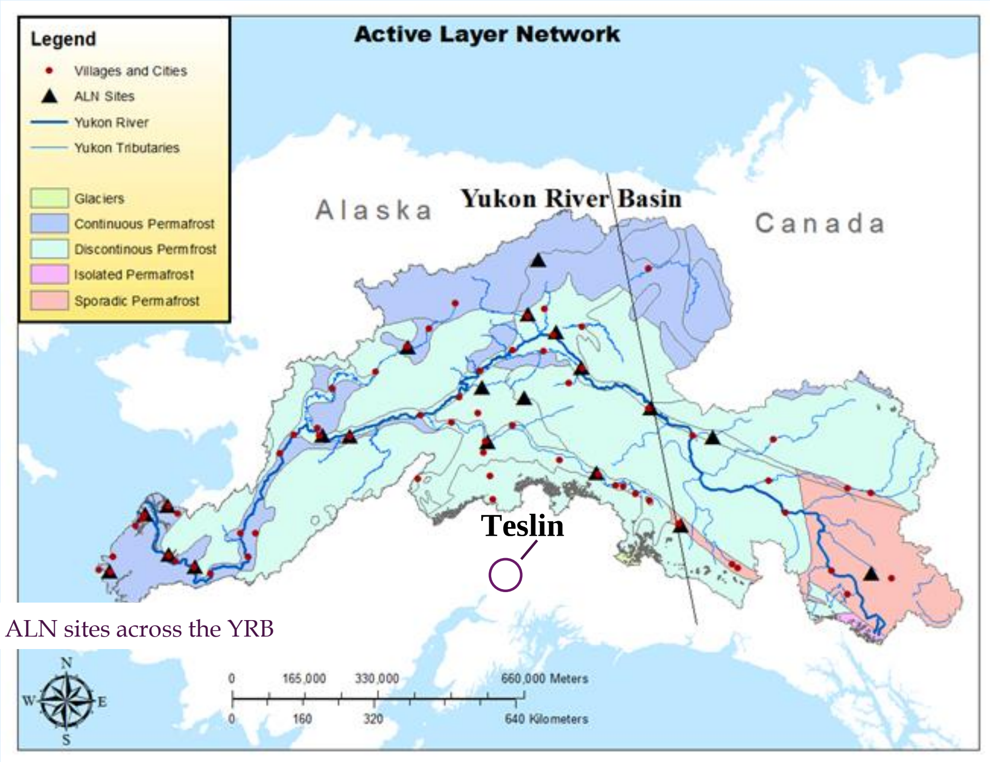
Introduction

The Active Layer Network (ALN) was launched in 2009 as a cooperative project between the United States Geological Survey (USGS), the Yukon River Inter-Tribal Watershed Council (YRITWC), and Yukon River Basin (YRB) communities. The active layer is the soil above the permanently frozen ground that thaws during the summer months and freezes again in the autumn. By measuring the depth of the active layer in late summer, at the time of maximum thaw over several years, we are able to better understand the effects of a warming climate on permafrost. Over the 2009 and 2010 field seasons twenty ALN sites were installed across the YRB.

Active Layer: layer of soil above the permafrost that freezes and thaws with the seasons.

Permafrost: soil that has been frozen for two or more years.

Talik: year round unfrozen ground in permafrost areas.



Location of ALN sites across the YRB

Problem and Need

Numerous studies indicate that permafrost is thawing and the active layer is deepening. Permafrost thaw will likely lead to changes in groundwater flows and the quantity and quality of the rivers, streams, and lakes in the YRB. Additionally, changes in the thickness of the active layer may have profound effects on human infrastructure such as houses, sewage lagoons, and water systems.

"Drunken Houses" that are falling over due to permafrost thaw

Previous Work

Faculty at the University of Alaska – Fairbanks (UAF) pioneered permafrost and active layer network studies in Alaska through the development of the global Circumpolar Active Layer Monitoring Program (CALM). The primary goal of CALM is to observe the response of the active layer and near surface permafrost to climate change over long (multi-decadal) time scales. The data collected as part of the ALN is submitted to the CALM program and available online at http://www.gwu.edu/~calm/.

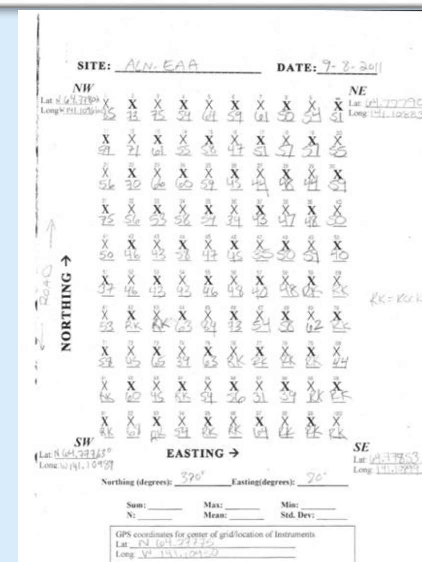
Methods

Site Locations

The location of ALN sites was based on several factors. First, locations were chosen based on the presence of generally continuous permafrost at a depth that can be measured manually with a calibrated rod. Second, distribution of sites within the YRB must represent the wide range of regions and land cover found in the YRB such us upland, lowland, un-forested, and forested areas. Third, the site must be available for community involvement. The specific location of each site within the chosen regions was selected through community participation using community member's local knowledge of permafrost distribution and depth.

Design

The general project design for the ALN follows the design of other CALM projects. All sites consist of 50 meter by 50 meter grids. The depth of the active layer is measured each year at these grid locations. Measurements are taken every 5 meters for a total of 100 measurements. Measurements are made with a calibrated 1.1 meter steel metal rod with a blunt tip and a T-handle grip. The rod is pushed into the active layer until it makes contact with the permafrost. The depth is then measured and recorded on a field sheet. The results of these measurements from your community are provided on the following pages. In addition to manual active layer measurements soil temperature, soil moisture, and air temperature data are all recorded at the ALN site in the center of the grid. Each site is equipped with two soil temperature and two soil moisture sensors. One soil temperature sensor and one soil moisture sensor is placed just above the permafrost and the others are placed just below the soil surface. The sensors collect data every 30 minutes. The air temperature sensor is placed on a tree or a wooden stake and also collects data every 30 minutes. Each year this data is downloaded onto a laptop computer from the data logger box which is also placed at the ALN grid.



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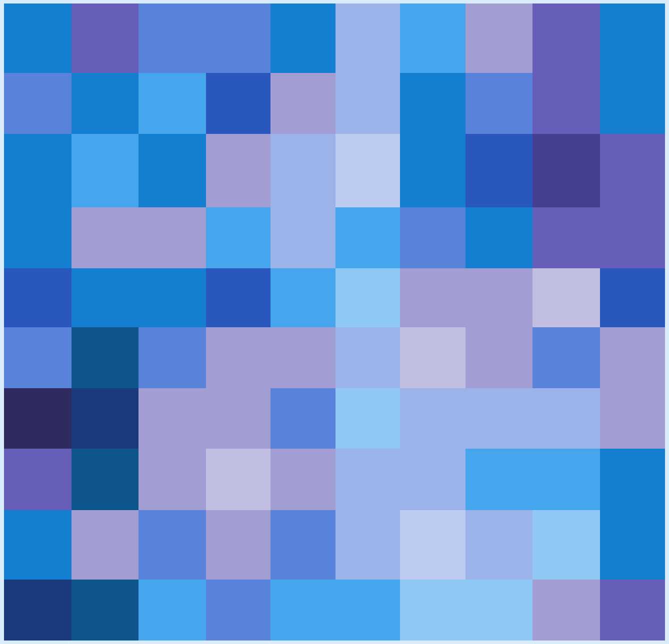
Results from manual measurements. The colors in each square represent how far from the surface the permafrost is, which is also the depth of the active layer. The darker the color the deeper the active layer.

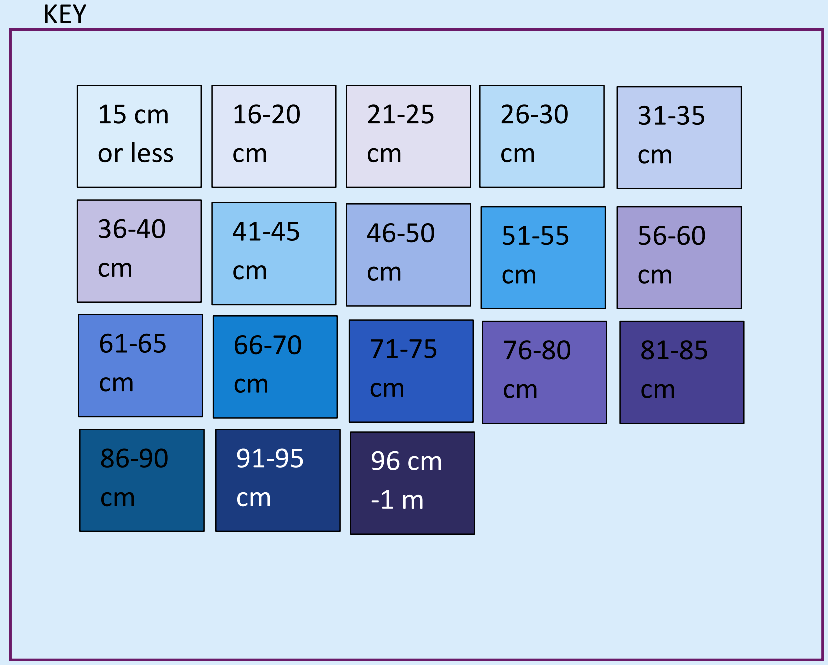
2010

Average depth = 61.3 cm

Minimum depth = 35 cm

Maximum depth = 98 cm



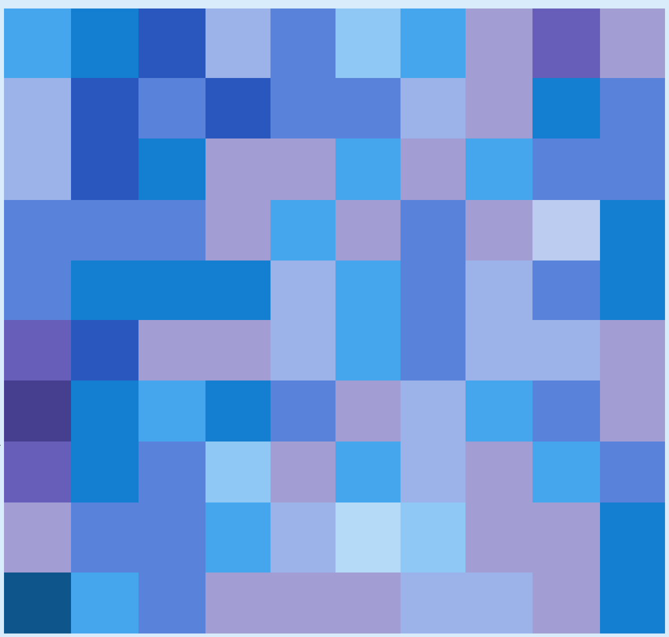


2011

Average depth = 59.4 cm

Minimum depth = 29 cm

Maximum depth = 89 cm

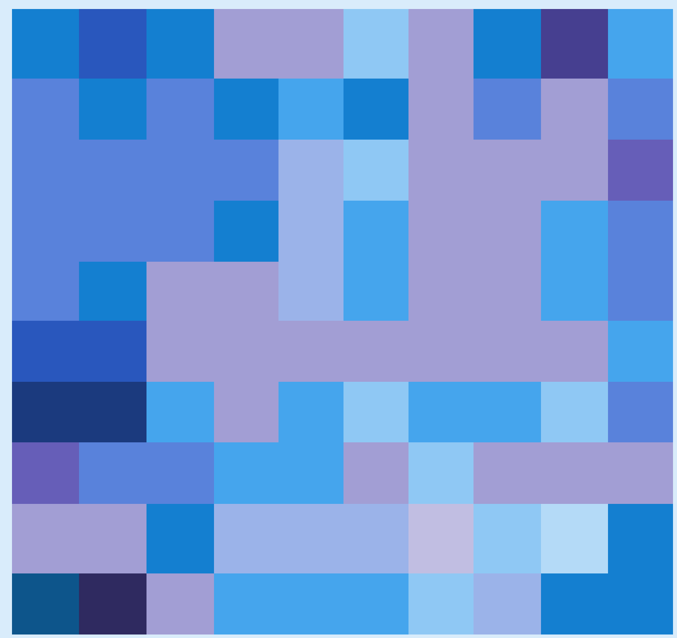


2012

Average depth = 59.6 cm

Minimum depth = 26 cm

Maximum depth = 97cm

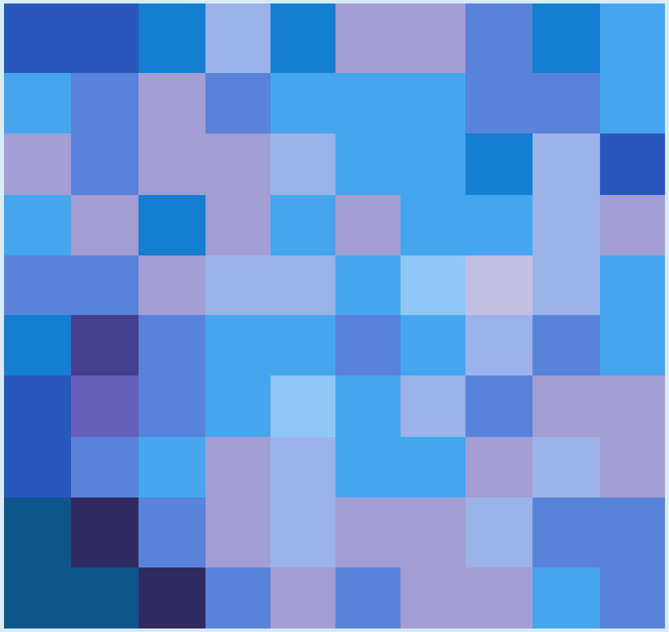


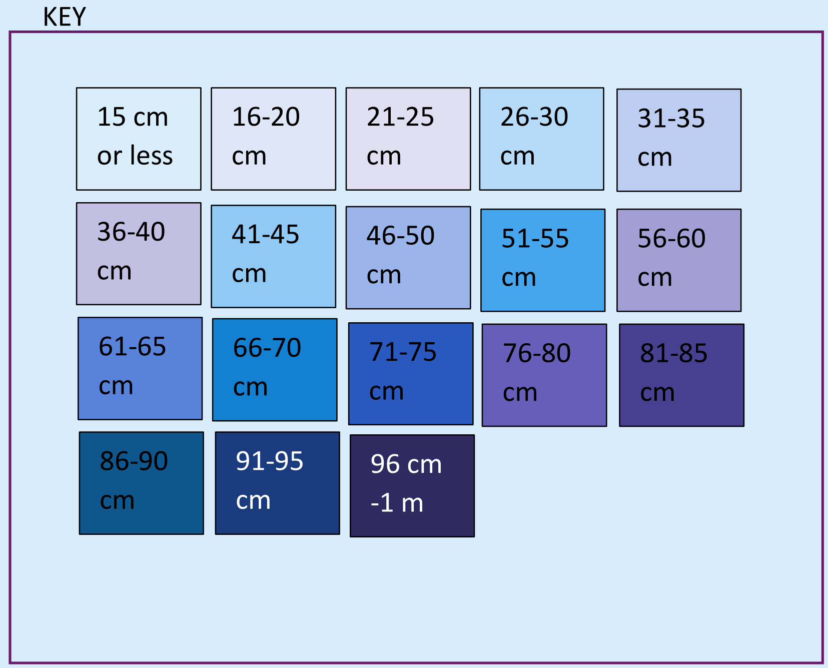
2013

Average depth = 59.5 cm

Minimum depth = 40 cm

Maximum depth = 1 meter



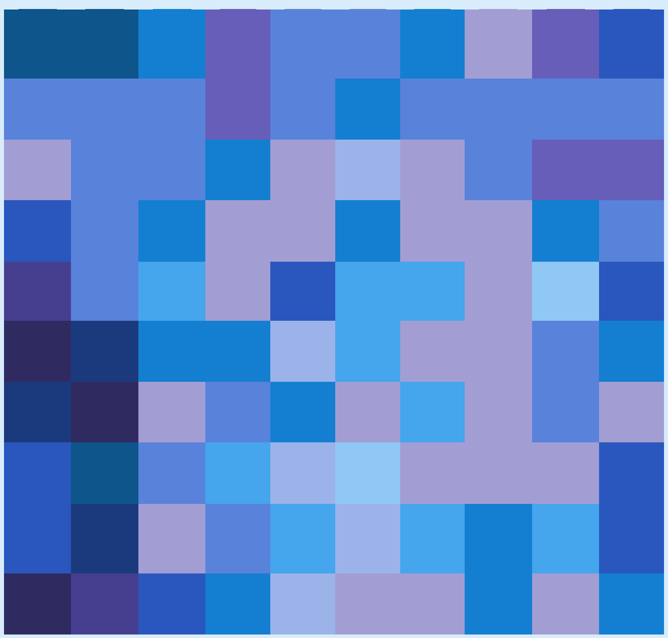


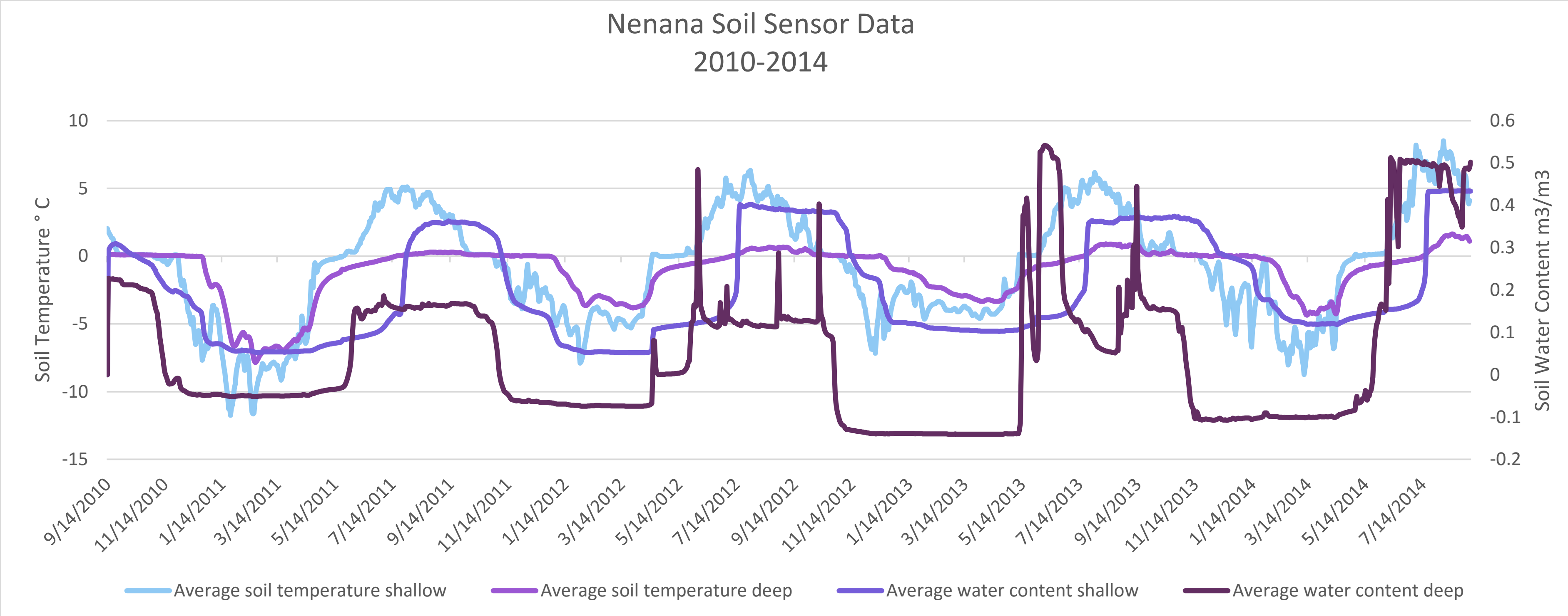
2014

Average depth = 65.3 cm

Minimum depth = 42 cm

Maximum depth = 1 meter





Soil measurements	**September**	**October**	**November**	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**
shallow soil moisture	0.304	0.277	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.093	0.164	0.346
deep soil moisture	0.224	0.206	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.149	0.162	0.162
Shallow soil temperature	0.877	0.123	-0.226	-5.042	-7.501	-8.786	-7.951	-3.942	-0.094	1.870	4.556	4.212
Deep soil temperature	0.111	0.097	0.054	-0.268	-4.004	-6.648	-6.728	-0.045	-1.330	-0.563	-0.065	0.220

Freeze Back	Frozen Ground	Thawing	Thaw peak

Average soil water content (moisture) and temperature °C Averages 2011-2012

Soil measurements	September	October	November	December	January	February	March	April	May	June	July	August
shallow soil moisture	0.360	0.347	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.130	0.293	0.393
deep soil moisture	0.166	0.140	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.156	0.127	0.126
Shallow soil temperature	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.18	0.148	0.148	0.148	0.148
Deep soil temperature	0.261	0.097	0.035	0.006	-1.549	-3.202	-3.584	-0.028	-0.713	-0.348	0.197	0.580

Freeze Back	Frozen Ground	Thawing	Thaw peak

Average soil water content (moisture) and temperature °C Averages 2012-2013

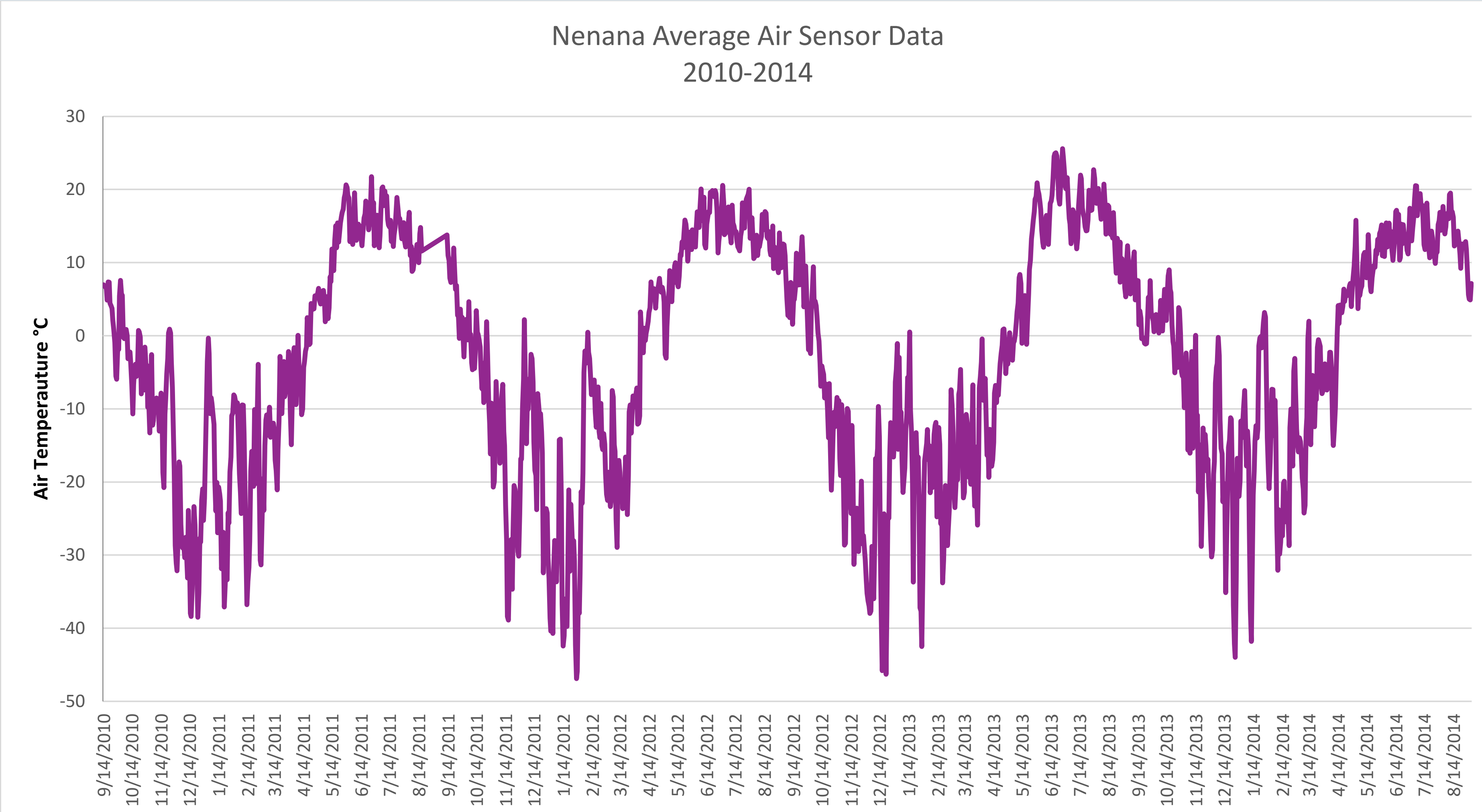
Soil measurements	September	October	November	December	January	February	March	April	May	June	July	August
shallow soil moisture	0.387	0.383	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.138	0.240	0.363
deep soil moisture	0.129	0.083	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.443	0.113	0.078
Shallow soil temperature	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148
Deep soil temperature	0.463	0.111	-0.005	-0.312	-2.374	-3.008	-3.177	-1.592	-0.546	-0.546	0.048	0.821

Freeze Back	Frozen Ground	Thawing	Thaw peak

Average soil water content (moisture) and temperature °C Averages 2013-2014

Soil measurements	September	October	November	December	January	February	March	April	May	June	July	August
shallow soil moisture	3.70	0.371	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.157	0.302	0.434
deep soil moisture	0.198	0.144	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	Frozen	0.409	0.496	0.444
Shallow soil temperature	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148
Deep soil temperature	0.508	0.280	0.052	0.008	-0.071	-1.577	-3.881	-2.984	-0.855	-0.434	0.180	1.420

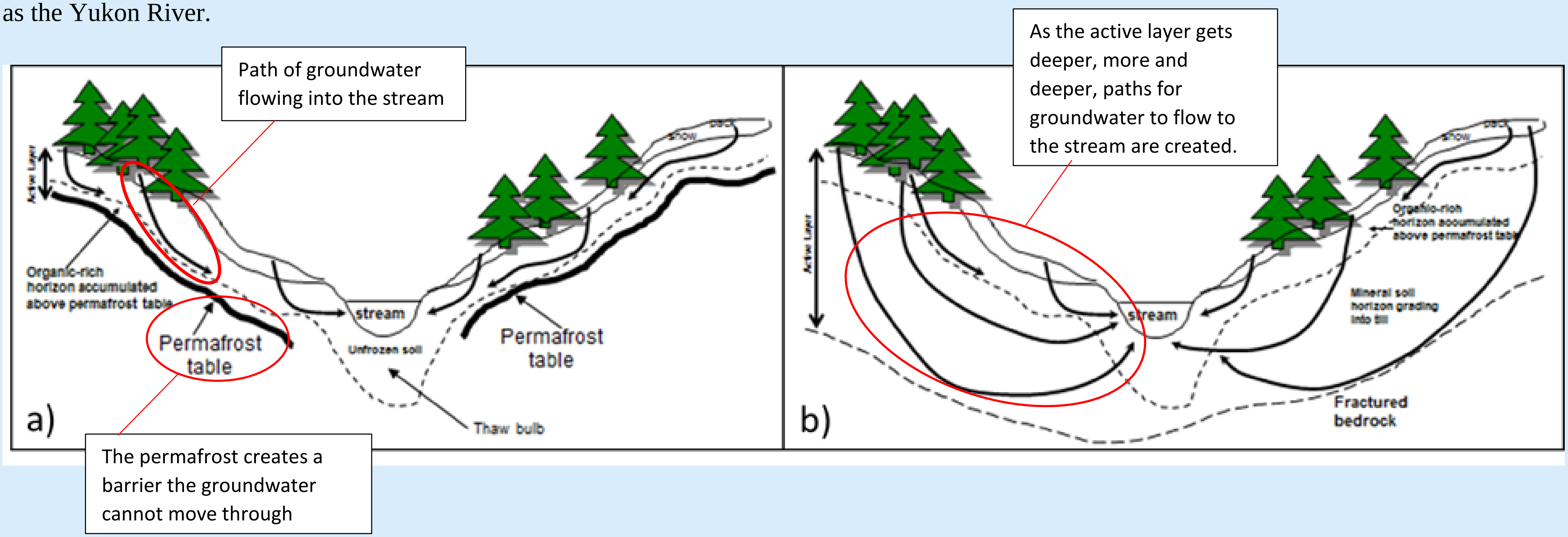
Freeze Back	Frozen Ground	Thawing	Thaw peak



Years	September	October	November	December	January	February	March	April	May	June	July	August
2009-2010	2.67	-2.40	-10.51	-28.05	-18.38	-19.14	-11.78	-1.63	10.97	15.65	15.73	12.40
2010-2011	6.27	-3.35	-21.24	-15.42	-32.81	-11.15	-17.13	1.95	9.29	16.42	15.54	12.67
2012-2013	7.01	-5.41	-21.94	-26.28	-16.92	-19.79	-15.61	-7.61	6.44	19.15	17.07	14.07
2013-2014	4.86	1.65	-13.60	-19.76	-12.91	-18.22	-10.17	-0.05	9.98	13.66	15.03	13.61
4 year average (2010-14)	5.20	-2.38	-16.82	-22.38	-20.26	-17.08	-13.67	-1.83	9.17	16.22	15.84	13.19

Next Steps

The ALN project is designed to continue for decades as it can take years to see a definitive change in the depth to the active layer and permafrost degradation. However, early analysis of the ALN and water-quality data suggests that we are seeing a relationship between a thawing active layer and ground water. As the diagram below shows as the active layer deepens new paths for groundwater to flow through are created. This means that more elements in the soil may be dissolved by the water traveling through new paths and these elements may be carried into the nearby streams such as the Yukon River.



As the figure above shows in figure a) the permafrost creates a barrier that groundwater cannot move through, this forces the groundwater to move through shallow paths into the stream; in figure b) the active layer is deeper, which means the permafrost is further down and the groundwater can move through more paths and deeper paths than before. New and deeper paths of groundwater flow can change the chemical composition of the stream this groundwater is flowing into. The results of preliminary analysis at key ALN locations across the YRB suggest that we are seeing a seasonal change in the chemical composition of the river due to seasonal changes in the depth of the active layer. In order to confirm these findings the ALN and Water-quality monitoring must continue in the future at key locations so that we can collect more data to see if this trend continues into the future.