

## **2018 Nunavut Research Licence Renewal Application: Wayne Pollard**

### **Scientific Research Licence #02 030 17R-M (multiyear)**

**Project Title:** An investigation of the sensitivity of high Arctic permafrost to climate change

**Principal investigator:** Dr. Wayne Pollard, Professor, Department of Geography, McGill University, 805 Sherbrooke St. W. Montreal, Quebec. H3A 0B9

**2018 Research Team:** Wayne Pollard (PI), Chris Omelon, Dale Andersen, Denis Lacelle, Jeff Moersch, Cameron Roy (M.Sc.), Melissa Ward (Ph.D.), Frances Amyot (M.Sc.) and 4 undergraduate field assistant from McGill – This is a university-based research project.

**2018 Fieldwork Schedule:** Planned fieldwork July 1- August 30.

**2018 Field sites:** The Eureka area on the Fosheim Peninsula, Ellesmere Island (80°00'N 85°95'W), and Expedition Fiord area, Axel Heiberg Island (79°25'N; 90°45'W). We will be based at the Eureka Weather Station.

**Funding source:** Discovery Grant from the Natural Science and Engineering Research Council (NSERC). Logistical support is provided by the Polar Continental Shelf Program

#### **Project Overview:**

Over the next 2 years I will be winding down a long-term project that examines how global warming, in particular warmer summer temperatures, is effecting the stability of high Arctic permafrost conditions, landscapes and infrastructure. This timeline corresponds with my NSERC funding awarded for this research. Project aims include: (1) to identify and measure changes (and rates of change) occurring in tundra and polar desert landscapes related to increased active layer thickness and thermokarst, (2) to determine ground ice and permafrost characteristics and assess their vulnerability to climate change, and (3) to assess local climate variability. A secondary aim is to evaluate the effectiveness of shallow geophysical techniques, dGPS and UAVs to detect and monitor changing permafrost conditions. The importance of this research is highlighted by the dramatic increase in thawing permafrost observed in the extremely warm summers in 2011 and 2012. The information collected in this study will improve our understanding of how climate and permafrost interact, and the potential resiliency of the permafrost systems to unusual summer conditions, both of which will allow for the better prediction of future changes. This research also has a significant training component involving students on several levels.

#### **Progress Report – 2017 Scientific Research Licence #02 030 17R-M (multiyear)**

In 2017 fieldwork continued in the Eureka Sound area on Ellesmere Island and Expedition Fiord area on Axel Heiberg Island. My research team was based at the Eureka weather station for most of July during which we repeated on going measurements of thaw slump retreat and ice wedge subsidence around the Environment Canada weather station, runway and DND base. Fieldwork at Expedition Fiord area of Axel Heiberg Island was limited to only a few days due to limited logistical support. At Eureka work included dGPS, GPR and vegetation surveys in areas where thermokarst and erosion appear to be increasing (PhD. Research of M. Ward). Ice and soil samples were collected for chemical, organic carbon and ice content analyses (MSc Research of C. Roy). Results to date are interesting, we found that Total Soil Carbon (TSC) contents in the active layer for most of the area are extremely variable and seem to increase with depth. TSC in wetlands is much higher (2-5%) as expected. Since wetlands cover less than 3 % of the land area they represent a small potential carbon source. In 2016-17 the trends in active layer development and thermokarst were consistent with the period prior to and immediately following the unusually warm summers in 2011 and 2012 (Ward PhD). The Eureka area contains extensive massive ground ice deposits (massive ground ice refers to thick (3-10m) layers of nearly pure ice) beneath 1-4 m of marine sediments. The presence of massive ice makes this area extremely vulnerable to thaw subsidence

and erosion. My work in the Eureka Sound Lowlands over the past 2 decades has identified a series of “hotspots” where ground ice represents a significant part of the near surface permafrost. Since 2011 we have mapped thaw and changing landscape conditions related to ground ice almost everywhere below 150m asl. In 2012 we reported an unprecedented level of thermokarst (250+ retrogressive thaw slumps) but in 2017 (like 2015 and 2016) the pattern of thermokarst was more typical. BSc student C. Bernard Grand'Maison completed her research on ice wedge volumes and found that they are a significant source of ground ice and potential source of landscape change. The monitoring of retrogressive thaw slump retreat is part of the PhD research by M. Ward. In addition to field mapping areas of thermokarst Ward is using satellite imagery to map and monitor landscape scale changes. Other fieldwork included ground penetrating radar surveys of ice wedges and massive ice deposits, sampling of ground ice and aerial surveys.

### **2018 Field Program.**

This project is entering its final stages corresponding to my funding cycle by NSERC and will be completed by 2020. The aim of my 2018 field program is to continue investigations on how climate change is affecting ice-rich permafrost and in particular rates of thermokarst. My 2018 field program will address 3 topics: (1) the analysis of changes in the active layer depth and its impact on surface topography, (2) analysis of changes in ice wedge morphology and (3) analysis of the chemistry of ground ice and active layer ice. The latter includes the final year of fieldwork for MSc student C. Roy. The measurement of changes occurring in the active layer remains a key focus as well as identifying connections between the atmosphere, active layer and permafrost. Fieldwork is planned for the Expedition Fiord area on Axel Heiberg Island (79°25'N; 90°43'W) and the Eureka area on Ellesmere Island (79°59'N; 85°49'W). Our study sites were selected in 2012 and are representative of the most common ecosystems in this part of the Arctic. These sites were chosen because of their accessibility, availability of baseline data, and existing research facilities. This research will assess the sensitivity of key permafrost systems to warming by defining how surface temperature fluctuations influence the depth of the active layer and changes at the active layer permafrost interface. In this study we hope to identify critical thresholds of non-recoverable change known as tipping points, and potential feedbacks (main focus of my NSERC grant). In 2018 we will address 3 key questions: (1) does the active layer buffer the permafrost system? (2) do ice wedge polygons respond differently than other permafrost systems, and (3) is there more moisture in active layer due to increased thaw? Activities planned for 2018 include the measurement of changes in the ground surface using a high resolution gps system coupled with ground penetrating radar. These data will be included in a geographic information system and will be used to geo-reference satellite images, (b) monitoring active layer processes and the measurement of temperature and moisture changes in mid-summer. This will involve the collection of sediment and ice samples from the active layer and top of permafrost, and (c) continued aerial surveys of changes throughout the Fosheim Peninsula. A new component of this research is the utilization of a UAV to map spatial patterns of small scale surface change as well as thermokarst.

### **Significance:**

This research is making a significant contribution to the understanding of permafrost and ground ice conditions in the high Arctic. It has contributed new insights into the origin and age of permafrost systems, rates of change and the potential vulnerability of ice cored landforms and ice wedge polygons. The magnitude of warming projected for the high Arctic will have significant effects on both the ecology and geomorphology of the region. This work is even more important given the increased level of mineral exploration interests in this area.

Wayne Pollard

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