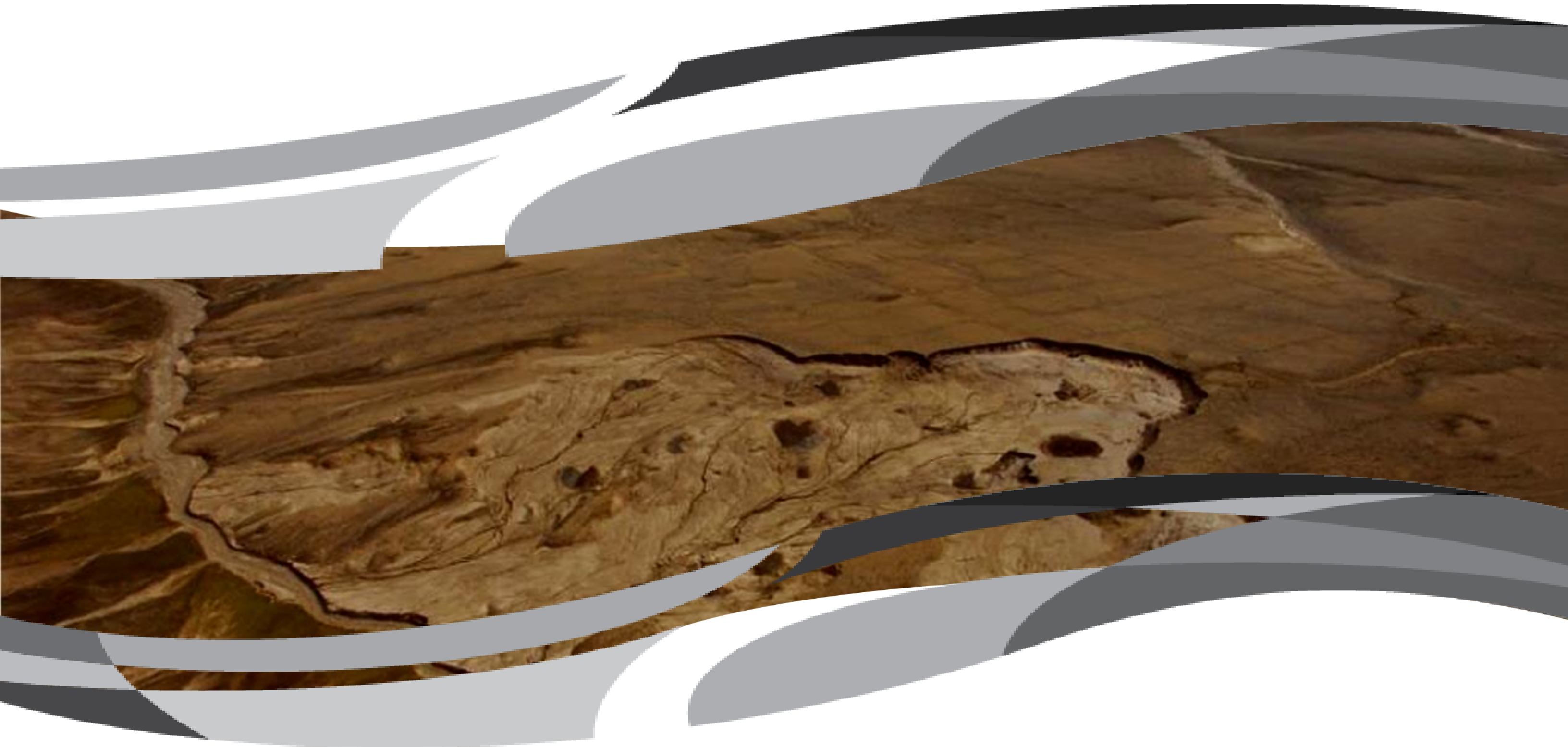
NWT Open Report 2015-021

Inventory of active retrogressive thaw slumps on eastern Banks Island, Northwest Territories



R.A. Segal, T.C. Lantz, and S.V. Kokelj

NORTHWEST TERRITORIES
GEOLOGICAL SURVEY

Government of
Northwest Territories

Cover Image:
A retrogressive thaw slump on Banks Island, Northwest Territories. Credit: Ecosystem Classification Group (2012).

NWT Open Report 2015–021

Inventory of active retrogressive thaw slumps on eastern Banks Island, Northwest Territories

R.A. Segal, T.C. Lantz, and S.V. Kokelj

Distributed by:

Northwest Territories Geological Survey
Department of Industry, Tourism and Investment
Government of Northwest Territories
P.O. Box 1320, 4601-B 52nd Avenue
Yellowknife, Northwest Territories
Canada
X1A 2L9
867-767-9211
www.nwtgeoscience.ca

Authors:

R.A. Segal
School of Environmental Studies, University of Victoria

S.V. Kokelj
Northwest Territories Geological Survey
Corresponding Author: Steve_Kokelj@gov.nt.ca

T.C. Lantz
School of Environmental Studies, University of Victoria

Recommended Citation:

Segal, R.A., Lantz, T.C., and Kokelj, S.V. 2016. Inventory of active retrogressive thaw slumps on eastern Banks Island, Northwest Territories. Northwest Territories Geological Survey, NWT Open Report 2015-021, 8 pages.

Introduction

The purpose of this report is to describe the spatial data distribution of terrain affected by active retrogressive thaw slumping on eastern Banks Island, Northwest Territories (NWT). Thawing of ice-rich permafrost can lead to significant terrain modification, alter terrestrial and aquatic ecosystems, and pose a threat to infrastructure. This remote mapping project contributes data on the distribution and density of thaw slumps across a study region (approximately 60 km by 96 km) on eastern Banks Island.

Background

Retrogressive thaw slumps are a form of thermokarst that develop in sloping terrain underlain by ice-rich permafrost (Figures 1 and 2; Lewkowicz 1987; Lantuit and Pollard 2005; Lacelle et al. 2010). These long-lived geomorphic disturbances commonly occur along coastlines, lakeshores, and river valleys. Thaw slumps can pose a threat to northern infrastructure (Kokelj and Jorgenson 2013) and can impact freshwater, marine, and terrestrial ecosystems (Lantuit and Pollard 2008; Kokelj et al. 2009; Mesquita et al. 2010; Kokelj et al. 2013; Lantz et al. 2009).

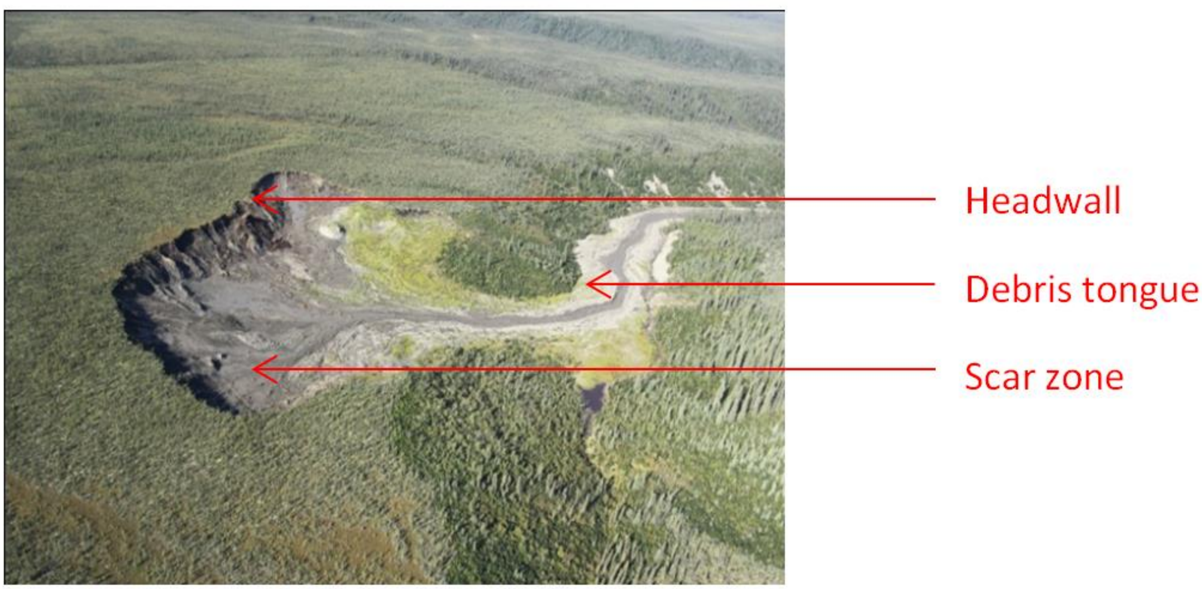


Figure 1. A retrogressive thaw slump in the Peel Plateau area (67.280°N, 135.162°W) in 2010. Arrows denote the features described in the text.

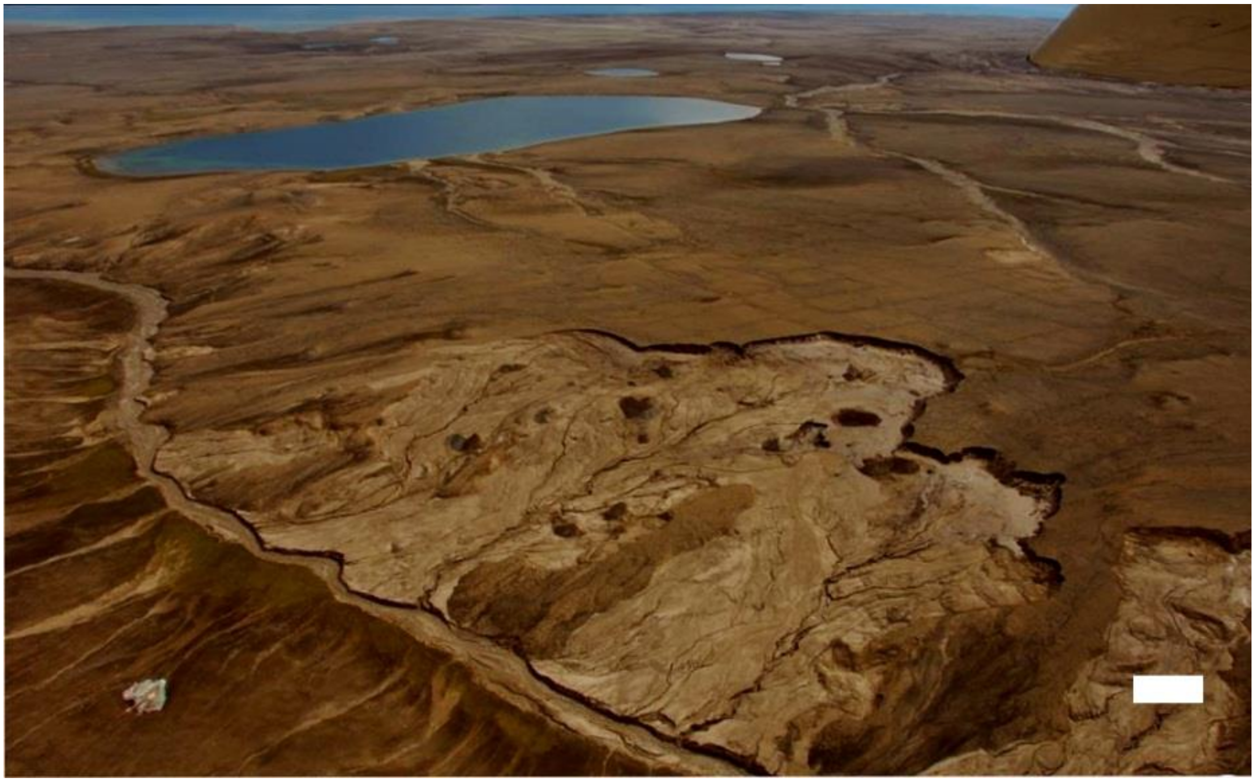


Figure 2. A retrogressive thaw slump on Banks Island. The white bar in the lower right-hand corner of the photo is ~45 m long. Image from the Ecosystem Classification Group (2012).

Active thaw slumps are characterised by an ice-rich headwall that defines the upslope boundary of the slump. Ablation of exposed ground-ice can cause retrogressive slumping and growth of the disturbance. The scar area of an active slump typically consists of saturated mineral soils and detritus, which contrasts significantly with the surrounding undisturbed forest or tundra. The headwall or upslope margins of a slump are typically crescent-shaped (Figure 1). The saturated materials in the scar zone can move downslope by a variety of processes, which can result in the development of a debris tongue (Burn and Lewkowicz 1990). Mass flows may cause the debris tongue to extend downslope and infill small valleys (Figure 1), or the materials may be transported into a lake or coastal zone. Slump stabilisation occurs when the headwall becomes covered and insulated by debris (Burn and Friele 1989; Burn and Lewkowicz 1990; Kokelj and Jorgenson 2013).

Thaw slumps are significant landscape features that impact infrastructure, and aquatic and terrestrial ecosystems (Kokelj et al. 2013; Mesquita et al. 2010; Lantuit and Pollard 2008; Kokelj et al. 2009). Sediment and solutes released by slumping can alter the chemistry of disturbed soils and surface waters. Mass movement of sediments and runoff can alter the chemistry and turbidity of adjacent rivers, lakes, and coastal environments (Kokelj et al. 2005; Lantuit and Pollard 2008; Kokelj et al. 2009; Mesquita et al. 2010; Vonk et al. 2012; Kokelj et al. 2013; Malone et al. 2013; Thienpont et al. 2013). Following slump stabilisation, vegetation communities and the underlying permafrost soils can take centuries to recover from the disturbance (Kokelj et al. 2009; Lantz et al. 2009).

Eastern Banks Island is a cold region located in the Canadian high Arctic (Fig. 3) that contains retrogressive thaw slumps. Mean annual air and ground temperatures are approximately -14 ˚C and -6 ˚C respectively NASA GISS 2014; Global Terrestrial Network for Permafrost 2010). During the Quaternary, Banks Island is thought to have been completely covered by the Laurentide Ice Sheet, which left behind a sequence of morainal deposits. In the eastern Banks Island study region, the Jesse Moraine covers all but the northwestern portion of the study region, which is characterised as undifferentiated drift (Lakeman and England 2012). Eastern Banks Island has undergone significant increases in mean annual air temperature in the past 55 years (+2.3 ˚C; (NASA GISS 2014). The topography of this region is relatively subtle, ranging from 0 m above sea level (ASL) to about 250 m ASL (Government of Canada et al. 2000). The slumps identified in this ice-rich region were generally small and slow-growing.

This report provides spatial data on the size, location, and types of active retrogressive thaw slumps on eastern Banks Island, NWT. Appendix A presents the accompanying Shapefiles, Google Earth files and metadata.

Compilation Methods

All active retrogressive thaw slumps in the eastern Banks Island study region were digitized on-screen (Figure 3) by viewing georeferenced imagery in Google Earth, ESRI ArcMap (versions 10.0 and 10.1), and the NWT Spatial Data Warehouse Geospatial Portal (http://www.geomatics.gov.nt.ca/sdw.aspx, NWT Centre for Geomatics 2013; Latitude Geographics Group Ltd.). Slumps were digitised using 2004 Quickbird imagery (0.6 m resolution) where available, as well as SPOT 5 and SPOT 4 imagery (10 m resolution, from 2006, 2009, and 2010). Slumps were identified based on the presence of exposed sediments, poorly developed vegetation, and a well-defined headwall. Thaw slump outlines were consolidated into a single shapefile using ArcMap. Waterbodies were removed from the study area using CanVec hydro features (waterbody products; 1:50 000) resolution) (Government of Canada 2016) prior to the slump density calculations.

The results of this assessment are summarised in two figures that show: A) the distribution of retrogressive thaw slumps across the eastern Banks Island study region (Figure 3), and B) the distribution of thaw slump sizes (Figure 4).

Results and Summary

The study area with the waterbodies removed was 4701 km^2. There were 832 active retrogressive thaw slumps digitised in the eastern Banks Island study region (Figure 3). These slumps ranged in size from 299 m^2 to 224 121 m^2 and had an average area of 16 917 m^2 (1.69 ha). A histogram showing the size distribution of retrogressive thaw slump areas is shown in Figure 4. This plot shows that the distribution of active slumps is roughly log-normal. There was an average of 17.7 slumps / 100 km^2. However, slumps were distributed throughout deposits of the Jesse moraine complex, but absent from the northwestern part of the study region that is underlain by undifferentiated drift (Lakeman and England 2012).

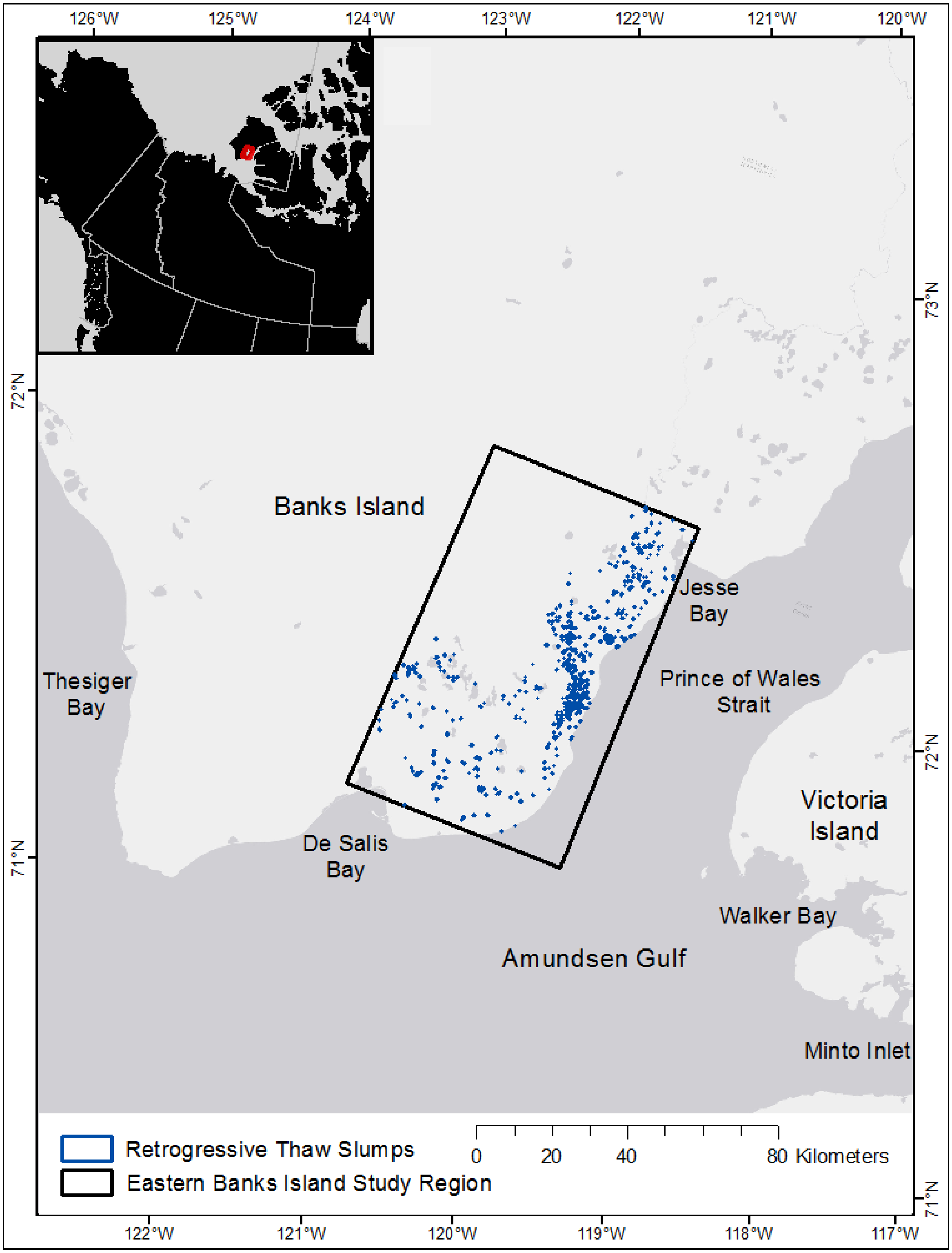


Figure 3. Map of the study region on eastern Banks Island (black outline) and active retrogressive thaw slumps (blue). The location map in the upper left corner shows the position of the study area in northwestern Canada.

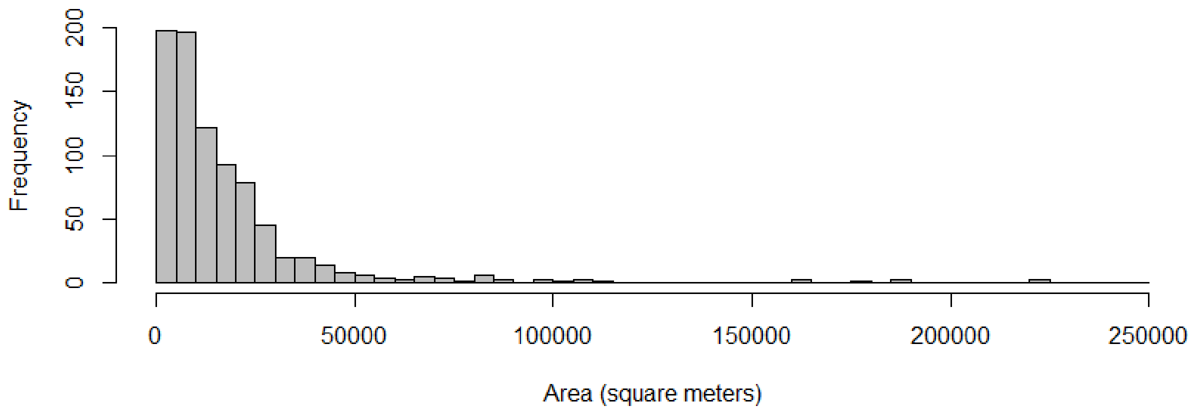


Figure 4. Histogram showing the size distribution of active retrogressive thaw slumps on eastern Banks Island.

Terms of Use

Acknowledgements

This work was supported by the Northwest Territories Cumulative Impacts Monitoring Program of the Government of Northwest Territories, the Northwest Territories Geological Survey of the Government of Northwest Territories, and the Natural Science and Engineering Research Council of Canada. The authors would like to thank Chanda Brietzke for the many and various ways she has provided assistance.

References

Burn, C.R., and Friele, P.A. 1989. Geomorphology, vegetation succession, soil characteristics and permafrost in retrogressive thaw slumps near Mayo, Yukon Territory. Arctic, 42: 31–40.

Burn, C.R., and Lewkowicz, A.G. 1990. Canadian landform examples: Retrogressive thaw slumps. 34: 273–276. doi:10.1111/j.1541-0064.1990.tb01092.x.

Commission for Environmental Cooperation. 2011. North America Climate: Mean annual temperature. Montreal, Quebec. Derived from: WorldClim (http://www.worldclim.org/), Museum of Vertebrate Zoology, University of California, Berkeley, USA.

Ecosystem Classification Group. 2012. Ecological regions of the Northwest Territories; Southern Arctic. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada.

Global Terrestrial Network for Permafrost. 2010. Inventory of candidate boreholes. Available from http://www.gtnp.org/inventory/canada_e.html [accessed 13 March 2014].

Government of Canada, Natural Resources Canada, Earth Sciences Sector, and Centre for Topographic Information. 2000. Canadian Digital Elevation Data. Sherbrooke, Quebec.

Government of Canada, Natural Resources Canada, and Earth Sciences Sector. 2016. Lakes and rivers in Canada - CanVec - Hydro Features. Natural Resources Canada. Available from http://open.canada.ca/data/en/dataset/93b9a6e6-1264-47f6-ad55-c60f842c550d [accessed 6 December 2016].

Kokelj, S.V., Jenkins, R.E., Milburn, D., Burn, C.R., and Snow, N. 2005. The influence of thermokarst disturbance on the water quality of small upland lakes, Mackenzie Delta region, Northwest Territories, Canada. Permafrost and Periglacial Processes, 16: 343–353. doi:10.1002/ppp.536.

Kokelj, S.V., and Jorgenson, M.T. 2013. Advances in thermokarst research. Permafrost and Periglacial Processes, 24: 108–119. doi:10.1002/ppp.1779.

Kokelj, S.V., Lacelle, D., Lantz, T.C., Tunnicliffe, J., Malone, L., Clark, I.D., and Chin, K.S. 2013. Thawing of massive ground ice in mega slumps drives increases in stream sediment and solute flux across a range of watershed scales. Journal of Geophysical Research: Earth Surface, 118: 1–12. doi:10.1002/jgrf.20063.

Kokelj, S.V., Zajdlik, B., and Thompson, M.S. 2009. The impacts of thawing permafrost on the chemistry of lakes across the subarctic boreal-tundra transition, Mackenzie Delta region, Canada. Permafrost and Periglacial Processes, 20: 185–199. doi:10.1002/ppp.641.

Lacelle, D., Bjornson, J., and Lauriol, B. 2010. Climatic and geomorphic factors affecting contemporary (1950–2004) activity of retrogressive thaw slumps on the Aklavik Plateau, Richardson Mountains, NWT, Canada. Permafrost and Periglacial Processes, 21: 1–15. doi:10.1002/ppp.666.

Lakeman, T.R., and England, J.H. 2012. Paleoglaciological insights from the age and morphology of the Jesse moraine belt, western Canadian Arctic. Quaternary Science Reviews, 47: 82–100. doi:10.1016/j.quascirev.2012.04.018.

Lantuit, H., and Pollard, W.H. 2005. Temporal stereophotogrammetric analysis of retrogressive thaw slumps on Herschel Island, Yukon Territory. Natural Hazards and Earth System Sciences, 5: 413–423.

Lantuit, H., and Pollard, W.H. 2008. Fifty years of coastal erosion and retrogressive thaw slump activity on Herschel Island, southern Beaufort Sea, Yukon Territory, Canada. Geomorphology, 95: 84–102. doi:10.1016/j.geomorph.2006.07.040.

Lantz, T.C., Kokelj, S.V., Gergel, S.E., and Henry, G.H.R. 2009. Relative impacts of disturbance and temperature: Persistent changes in microenvironment and vegetation in retrogressive thaw slumps. Global Change Biology, 15: 1664–1675. doi:10.1111/j.1365-2486.2009.01917.x.

Latitude Geographics Group Ltd. (n.d.). Geocortex: Do More with ArcGIS web mapping, Web GIS Mapping Software. Available from http://www.geocortex.com/ [accessed 14 April 2014].

Lewkowicz, A.G. 1987. Headwall retreat of ground-ice slumps, Banks Island, Northwest Territories. Canadian Journal of Earth Sciences, 24: 1077–1085. doi:10.1139/e87-105.

Malone, L., Lacelle, D., Kokelj, S., and Clark, I.D. 2013. Impacts of hillslope thaw slumps on the geochemistry of permafrost catchments (Stony Creek watershed, NWT, Canada). Chemical Geology, 356: 38–49. doi:10.1016/j.chemgeo.2013.07.010.

Mesquita, P.S., Wrona, F.J., and Prowse, T.D. 2010. Effects of retrogressive permafrost thaw slumping on sediment chemistry and submerged macrophytes in Arctic tundra lakes. Freshwater Biology, 55: 2347–2358.

NASA GISS. 2014. GISS Surface temperature analysis: Global maps from GHCN v3 Data. Available from http://data.giss.nasa.gov/gistemp/maps/ [accessed 4 March 2014].

NWT Centre for Geomatics. 2013. GNWT SPOT Mosaic. Available from http://apps.geomatics.gov.nt.ca/arcgis/rest/services/Mosaics/GNWT_SPOT_Mosaic/MapServer [accessed 14 April 2014].

Thienpont, J.R., Rühland, K.M., Pisaric, M.F.J., Kokelj, S.V., Kimpe, L.E., Blais, J.M., and Smol, J.P. 2013. Biological responses to permafrost thaw slumping in Canadian Arctic lakes. Freshwater Biology, 58: 337–353. doi:10.1111/fwb.12061.

Vonk, J.E., Sánchez-García, L., Dongen, B.E. van, Alling, V., Kosmach, D., Charkin, A., Semiletov, I.P., Dudarev, O.V., Shakhova, N., Roos, P., Eglinton, T.I., Andersson, A., and Gustafsson, Ö. 2012. Activation of old carbon by erosion of coastal and subsea permafrost in Arctic Siberia. Nature, 489: 137–140. doi:10.1038/nature11392.