April 19, 2021

Dear Peter,

Thank you for carefully reviewing our manuscript. The following document indicates how we have implemented the minor revisions that you have suggested. Our track changed documents, and PDF versions are attached. We feel that the Manuscript has been improved and that is now grammatically consistent.

Please let us know if you require further information. We look forward to hearing from you in due course.

Best wishes,

Steve

Author Reply to Editor's Minor Revisions.

Minor track change edits were implemented throughout the text. The suggested edits were not implemented in only one instance where the change would have modified the intended meaning of the sentence. Serial commas were added throughout the manuscript and to the supplementary material text.

The narrative has been clarified to indicate that the study area includes both continuous and discontinuous permafrost terrain. The source of the NHN data and Watershed areas are briefly described and the Supplementary Methods are specifically referenced to direct readers to the sources of the NHN data and to explanation of how study "watersheds" and study "area" were constructed.

P4 L 119-120. We have adjusted the text to address the Editor's comment that the study area includes continuous and discontinuous permafrost areas.

Revised text:

"Here we present a suite of spatially nested case-studies bounded by Arctic drainage from permafrost terrain of northwestern Canada (Fig. 1). The study area is predominantly in the zone of continuous permafrost however, we also include the Great Bear River drainage and a few other Mackenzie River tributaries that drain northern margins of the extensive discontinuous permafrost zone."

P5 L145-146. In this study, we defined the broadest area of investigation as "Arctic drainage from permafrost terrain of northwestern Canada" which is the 10^6 km^2 scale. The second scale of inquiry is at the 10^5 km^2 area, which we refer to as "watersheds" so that a reader can distinguish analyses and

results pertaining to different scales of inquiry. Regarding the Editor's comment, we have modified the text slightly at line 148, to clarify that these "watersheds" are composite drainage areas. We also provide brief elaboration in the methods and would note that definitions and the NHN work units (sub sub drainage areas) are explicitly defined for the 3 scales of inquiry in supplementary methods 1-3. Supplementary methods are also referenced now early in the Manuscript to direct a reader there for more information.

Revised text:

"To assess the potential propagation of watershed-scale slope thermokarst effects (10^4 to 10^5 km2) (goal C), disturbance distribution was analyzed within a Strahler-order framework for composite drainage areas characterized by contrasting terrain and permafrost conditions that we defined for this study as the Banks Island, Amundson Gulf, Peel River and Keele-Redstone watersheds (Fig. 1, Table S1)."

Figure 1. We have changed the label Keele/Redstone Watershed to "Keele-Redstone Watersheds" and the legend title "Discontinuous permafrost extent" to "Southern limit of continuous permafrost". The source of the catchment, watershed and drainage boundaries is now indicated in the caption.

In multiple locations, including the caption, we now clarify that the Watershed scale of inquiry was defined by compositing sub-sub drainage areas in the NHN dataset, including earlier reference to the Supplementary Methods.

Figure.1. Study region map showing the distribution and dominant geomorphic environments affected by thaw-driven mass wasting, and the locations and scales of investigation constrained by the 994,860 km^2 area of Arctic drainage from permafrost terrain of northwestern Canada. Fine-scale thaw slump mapping utilizing high-resolution UAV and LiDAR terrain models is indicated by the orange corridors (Peel Plateau; Tuktoyaktuk Coastlands and Anderson Plain); small to medium scale catchments including Willow River, Peel Plateau and southeastern Banks Island areas are indicated by red polygons; focal watersheds are outlined in blue, and the Arctic drainage study area is shaded in grey. The disturbance data on the map are adapted from Segal et al., 2016b and Kokelj et al., 2017a. Late-glacial limit is from Dyke and Prest, 1987, bedrock geology is from Fulton, 1995, and the permafrost boundary is from Brown et al., 1997. The Willow River Catchment is part of a sub-sub-drainage, and the Watershed and Study area boundaries are composites of several sub-sub-drainage areas (Methods S1-3) from the National Hydro Network (NHN) geodatabase (Natural Resources Canada, 2016). The base map is from ESRI ArcGIS.

P7L172. We have adjusted the narrative to clarify that our study area also comprises some drainages from the northern zone of extensive discontinuous permafrost. We hope this adjustment is sufficient to address the editor's concerns.

"This broadest scale of inquiry is defined as the Arctic drainage networks of northwestern Canada, primarily from continuous permafrost and the northern limits of extensive discontinuous permafrost

(Fig. 1). The 994,860 km^2 Arctic drainage area of northwestern Canada is comprised of 68 sub sub drainage areas defined in the National Hydro Network geodatabase (Natural Resources Canada, 2016). This study area is characterized by a diversity of permafrost, geological, climate, and ecosystem conditions (Fig. 1)."

P10L280-282. To address Editor's comments, we have made changes to section 2.1 and to the caption in Figure 1 to define our study area. We have also adjusted the text in this location to read:

"Here we summarize methods to identify individual segments of the hydrological network affected by active thaw-driven mass wasting and the framework to map the propagation pathways of effects through watersheds for Arctic drainage from permafrost terrain of northwestern Canada (Fig. 1)."

P11L321-322. Text was modified to again clarify that the "watershed study areas" are composed of several sub-sub-drainage areas.

"To summarize information on the distribution of watershed effects, Strahler Order was computed (Methods S3) for the 4 major watershed-scale study areas of Banks Island (70,794 km2), Amundsen Gulf (90,288 km2), Peel River (76,506 km2), and Keele-Redstone (39,957 km2) (Fig. 1). For each major watershed, the respective Work Units (sub-sub-drainage areas) and PDNLF Shapefiles were merged and the 'Strahler Order Tool' in RivEx 10.25 was used to compute Strahler Order for each PDNLF polyline. For each major watershed study area, directly and indirectly affected streams and lakes were summarized by Strahler Order."

Figure 8. Editorial suggestions to adjust labels to "Keele-Redstone Watersheds" and "Southern limit of continuous permafrost extent" were implemented.

The Figure 8 caption was adjusted to address the Editors comments to indicate what the NHN abbreviation stands for, and to cite the source of the NHN Database.

"Figure 8. Thaw-driven landslide density and downstream accumulation of effects through Arctic drainage from permafrost terrain of northwestern Canada. Heat map depicts all directly affected stream, lake, and coastal National Hydro Network (NHN) segments mapped. All upstream accumulation values shown within the fluvial network are >2, and at the coast are >9. Accumulated effect contributions of the Mackenzie and Peel Rivers to the Beaufort Sea are routed separately for comparison. (a) Counts of direct and accumulated thaw-driven mass wasting effects to fluvial systems partitioned by Strahler order and hydrological feature type for the four major watersheds outlined in blue. (b) Table showing lengths of directly affected hydrological network and accumulated effects, count of directly and indirectly affected lakes and total directly affected coastline for western Arctic drainage from permafrost terrain. Remote sensing examples of thaw-driven downstream sedimentation provided in Fig. S4 for: i) Sachs River and Fish Lake, ii) Miner River inflow to the Husky Lakes estuary and iii) massive deep-seated permafrost failure on Johnson River. Late glacial limit is from Dyke and Prest, 1987, bedrock geology is from Fulton, 1995, the permafrost boundary is from Brown et al., 1997, and the National Hydro Network (NHN) base data is from Natural Resources Canada, 2016. Base map is from ESRI ArcGIS Online."