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# Abstract

This report provides information on progress for three North Bear activities: (1) reconnaissance surficial geology mapping of the Rivière Grandin area, (2) ongoing compilation of mapped glaciolacustrine features associated with glacial Lake McConnell, and (3) surficial geology mapping and Holocene landscape investigations at Whitebeach Point, Northwest Territories. These activities contribute new geological knowledge and improve our understanding of the distribution and nature of the surficial geology cover and the glacial history of this region.

The Rivière Grandin map area (NTS 86-D; 1:125,000 scale) is characterized by three glacial terrains defined by different surficial sediments. Along and inland from the shores of Hottah Lake in the northeast, glacial Lake McConnell deltas, beaches and offshore sediments occur between 180-350 m elevation. Farther west, terrain near or above 500-600 m elevation is defined by hummocky glaciofluvial sediments, a few moraine ridges, abundant radial meltwater channels, and an absence of ice-flow indicators, which may indicate local cold-based glacial ice regimes. On the eastern edge of the Ortona Lake highlands, rare drumlins trend northwestward, perpendicular to the flutings at lower elevations to the north and south. The remaining and most extensive map areas are generally covered by streamlined till with interspersed minor moraines composed of ridged till. Drumlins, crag-and-tails and drumlinoids record northwestward and southwestward divergent and convergent ice flows. The area north, west, and south of Rome Lake has a greater concentration of ridged till. Late during deglaciation, a minor ice-flow shift occurred in the southwest map area, indicated by small, superimposed streamlined landforms.

Compilation of glaciolacustrine features attributed to glacial Lake McConnell is ongoing. These features are from surficial maps that conform to the Surficial Data Model of the Geological Survey of Canada. To date, two NTS map sheets have been added in 2018 (86-D, L) and 17 NTS map sheets were added in 2017. Continuing compilation will improve knowledge of previous glacial lake limits and the associated surficial geology.

The Whitebeach Point area was previously inundated by glacial Lake McConnell and more recently by ancestral Great Slave Lake. Surficial geology mapping of the area has identified a complex array of deposits, including widespread eolian sand dunes and sheets, beach ridges, and peatlands. The ongoing work will also examine the Holocene lake level history and landscape development of the area, which includes high-grade silica sand deposits.

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# Foreword

The Geo-mapping for Energy and Minerals (GEM) program is laying the foundation for sustainable economic development in the North. The Program provides modern public geoscience that will set the stage for long-term decision making related to responsible land-use and resource development. Geoscience knowledge produced by GEM supports evidence-based exploration for new energy and mineral resources and enables northern communities to make informed decisions about their land, economy and society. Building upon the success of its first five-years, GEM has been renewed until 2020 to continue producing new, publically available, regional-scale geoscience knowledge in Canada's North.

During the 2018 field season, research scientists from the GEM program successfully carried out 18 research activities, 16 of which will produce an activity report and 14 of which included fieldwork. Activities applied a variety of geological, geochemical, and geophysical methods. These activities have been undertaken in collaboration with provincial and territorial governments, Northerners and their institutions, academia and the private sector. GEM will continue to work with these key partners as the program advances.

## Project summary

The Rivière Grandin reconnaissance surficial geology map (NTS 86-D; 1:125,000 scale) depicts the glaciated landscape of a vast region of the Northwest Territories covered by glaciers until about 13,000 years ago. The surficial geology is based on the interpretation of aerial photographs and limited legacy fieldwork. This work contributes to effective drift prospecting for a variety of commodities including diamonds, precious and base metals, and supports informed decision making for resource development and land use. As part of the North Bear Surficial Geology Activity in the GEM Mackenzie Region Project, the Rivière Grandin mapping provides new geological knowledge and improves our understanding of the distribution and nature of the surficial geology cover and glacial history of this region. Surficial geology mapping and landscape development investigations at Whitebeach Point also provide new geological knowledge in the area, which includes high quality silica sand deposits.

# Introduction

The Mackenzie Corridor represents the largest unmapped (bedrock and surficial) area of Northwest Territories (Figure 1). Nearly one-half of the surficial geology of the Northwest Territories remains unmapped, and the bulk of this is within the Mackenzie Corridor. Given the high mineral potential and realized development in the Bear/Slave Geological Provinces, and the significant energy/mineral potential within the northern Shield and sedimentary basin, the lack of geologic knowledge limits the economic potential of the region. One of the remaining unmapped areas is the Rivière Grandin map area (NTS 86-D) in the North Bear activity area (Figure 1).

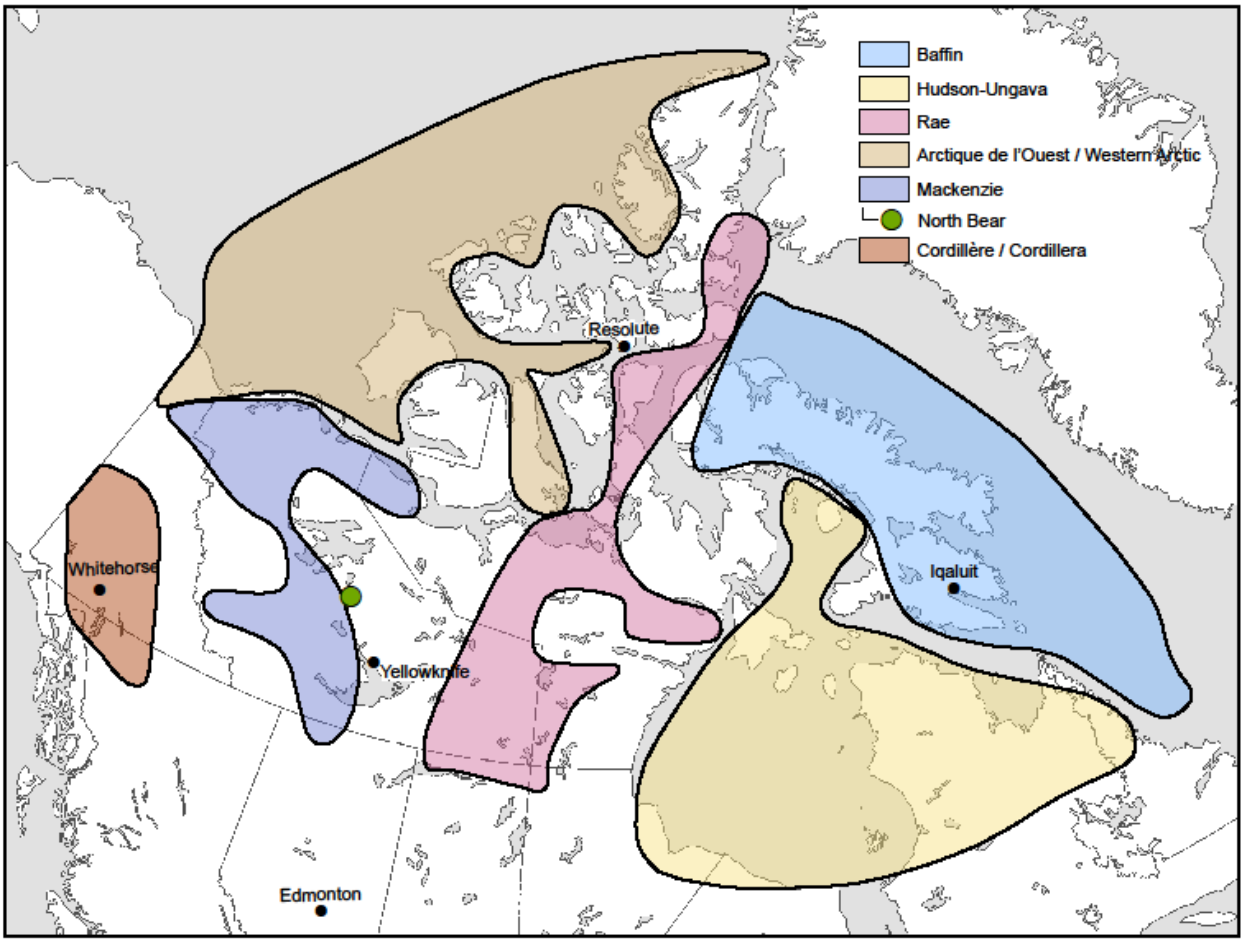


Figure 1. Location of the North Bear activity (green dot) and GEM Project areas.

# Goal & objective

This activity aims to improve our understanding of the nature and distribution of the surficial geology and glacial history of the southern Mackenzie Corridor. It fills in a major knowledge gap in the NWT, essential for the implementation of successful mineral and petroleum exploration surveys in this poorly-mapped, drift-covered region. Mapping the extent of glacial Lake McConnell sediments in the central and southern regions is of particular aid to resource and infrastructure development.

# Scientific question addressed

The regional framework scientific question being addressed by this research activity is: "what is the glacial history and sediment cover of the Mackenzie Corridor?" Improved surficial mapping and analyses will facilitate exploration, and support resource discovery and infrastructure development. (Figure 1).

# Methodology

A reconnaissance surficial geology map was produced for the Rivière Grandin area based on expert-knowledge airphoto interpretation of 1:60 000 scale National Air Photo Library (NAPL) aerial photographs acquired in 1954. The geological interpretation is based on version 2.3 of the Surficial Data Model (Deblonde et al., 2017, 2018). Airphoto interpretation includes map units/depositional genesis, texture, thickness, structure, morphology, depositional or erosional environment, ice-flow and meltwater direction, age/cross-cutting relationships, landscape evolution and associated geological features, complemented by additional overlay modifiers, points, and linear features. No fieldwork was undertaken to produce this map, however, legacy striation data recorded during an earlier till geochemistry project were added (Normandeau and McMartin, 2013). The mapping complements work carried out under the GEM Mackenzie project immediately to the east (Kerr and O'Neill, 2017a, 2018).

Glaciolacustrine features associated with glacial Lake McConnell are being compiled on an ongoing basis as new mapping and conversions become available in digital format using the Surficial Data Model (Figure 2).

A detailed surficial geology map was produced for the Whitebeach Point area using high resolution LiDAR and optical imagery to characterize surficial materials and landforms. Well-defined beach ridges at the site allow dating of past lake levels. A lake-level recession curve was developed using optically-stimulated luminescence (OSL) dates obtained from littoral sand samples collected at the site (Wolfe et al. 2018), and radiocarbon dates from the broader region (Figure 3). Other dated samples collected by Wolfe et al. (2018) from sand dunes, sand wedges, basal peat, and detrital organic matter will provide chronological control for a reconstruction of Holocene landscapes. A digital elevation model, derived from the LiDAR data, will enable flood mapping and Holocene shoreline evolution to be examined.

# Results

## *Rivière Grandin mapping*

The Rivière Grandin map area is characterized by three glacial terrains with different surficial sediments. Along and inland from the shores of Hottah Lake in the northeast, glacial Lake McConnell deltas, beaches and offshore sediments occur between 180-350 m elevation. Further west, terrain near or above 500-600 m elevation is defined by hummocky glaciofluvial sediments, a few moraine ridges, abundant radial meltwater channels, and an absence of ice-flow indicators, which may indicate local cold-based glacial ice regimes. On the eastern edge of the Ortona Lake highlands, rare drumlins trend northwestward, perpendicular to the flutings at lower elevations to the north and south. The remaining and most extensive map areas are generally covered by streamlined till with interspersed ridged till (minor moraines). Drumlins, crag-and-tails and drumlinoids record northwestward and southwestward divergent and convergent ice flows. The area north, west and south of Rome Lake has a greater concentration of ridged till. Late during deglaciation, a minor ice-flow shift occurred in the southwest map area, indicated by small, superimposed streamlined landforms.

## *Glacial Lake McConnell compilation*

During deglaciation, glacial Lake McConnell formed in the isostatically depressed land surface along the western margin of the easterly retreating ice. Glacial Lake McConnell occupied the combined basins of Great Bear, Great Slave, and Athabasca lakes (Craig, 1965, and references therein, p.18, 19). Kerr and O'Neill (2017b) summarized some of the more recent investigations in a regional context. Figure 2 illustrates the compilation of glaciolacustrine features attributed to glacial Lake McConnell identified on surficial maps that conform to the GSC Surficial Data Model. These features were compiled from 18 NTS maps in 2017 (NTS 75-K, L, M, 85-A, B, E, I, J, K, l, M, N, O, 86-B, C, N, 95-I, M) and two in 2018 (86-D, L). New data from an additional 7 NTS map sheets have yet to be compiled.

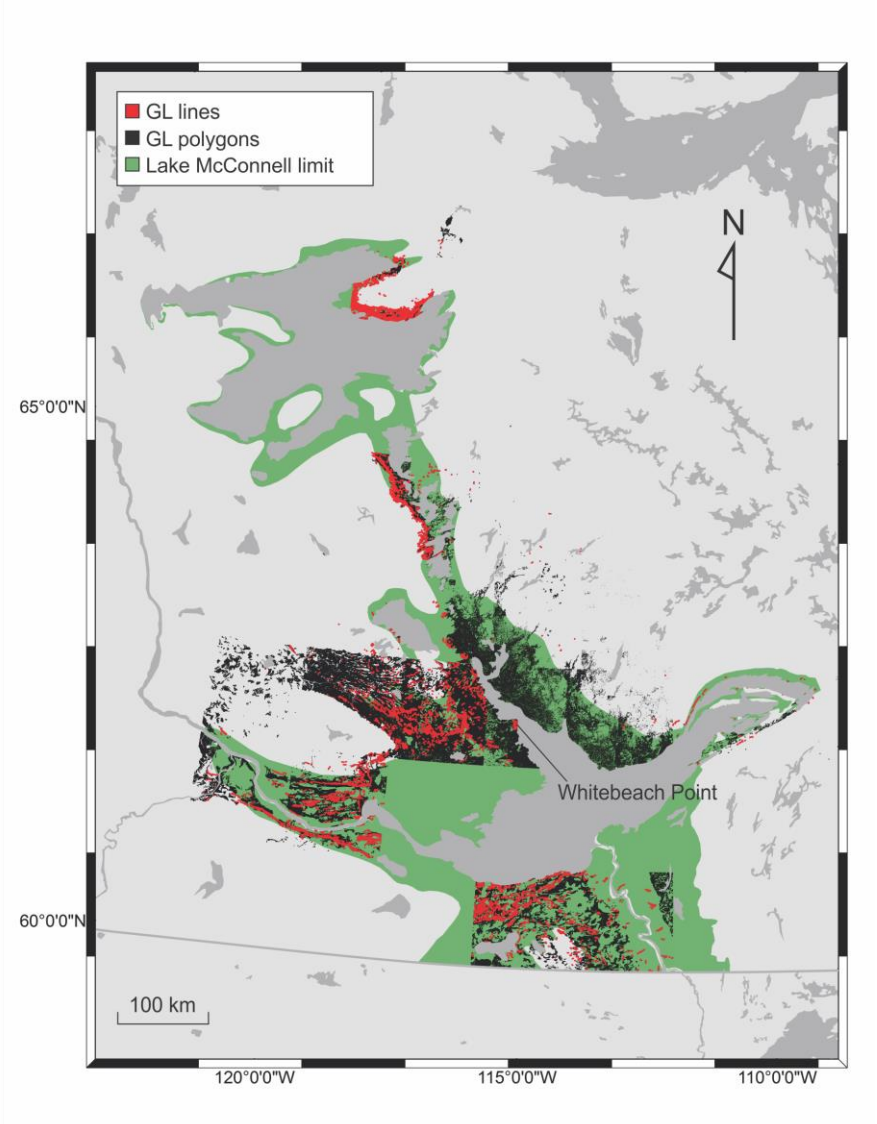


Figure 2. Mapped glaciolacustrine (GL) polygons and line features (beach ridges/limits of submergence) associated with glacial Lake McConnell around Great Bear and Great Slave lakes. The previously mapped limit of the glacial lake in Northwest Territories is shown in green (after Prest et al., 1968).

## *Whitebeach Point mapping and landscape development*

In the uplands above about 200 m elevation, surficial materials include till and glaciolacustrine sediments. Till blankets consist of poorly-sorted silt to gravel diamicton typically >2 m thick (Stevens et al., 2017). The area is also covered by littoral and nearshore glaciolacustrine sediments composed of fine sand and silt, and sandy gravel beach ridges derived from reworked sediments associated with ancestral Great Slave Lake (Stevens et al., 2017). The sediment cover includes defined beach ridges and terrace scarps; small areas of bedrock are also present (Stevens et al., 2017).

The developed recession curve indicates that the McConnell lake level was likely near the escarpment at ca. 9.5 ka (Figure 3). Below the escarpment, the current landscape is a complex mosaic of Holocene sediments and landforms (Figure 4). Active and stabilized eolian surfaces are abundant (Figure 4). Active features include sand sheets, transverse dunes, and blowouts, while stabilized areas include vegetation cover. Peatlands overlie eolian or lacustrine sediments in some areas. The escarpment slope includes coarse colluvial material weathered from the parent sandstone and overlying sediments. Beach ridge complexes are preserved inland from embayments, marking the recession of former lake shorelines (Figure 4). A series of small streams flow from the escarpment to Great Slave Lake, depositing alluvial sediments within narrow beds.

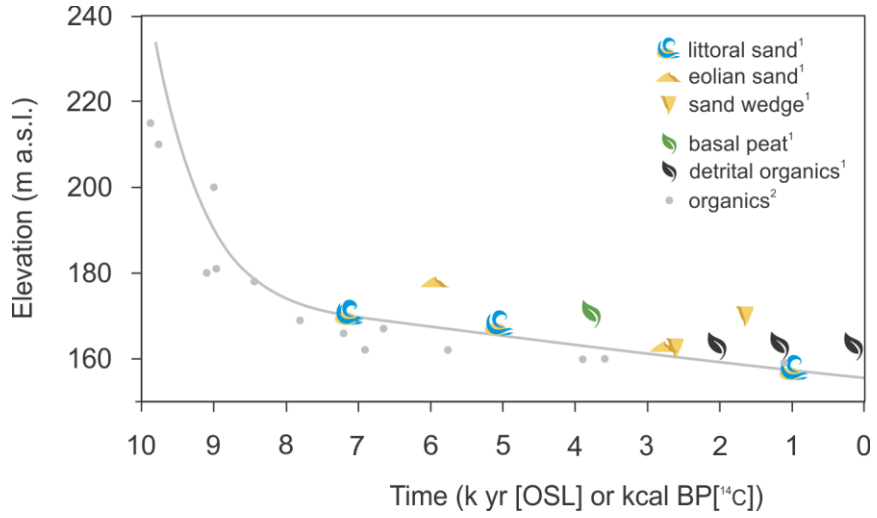


Figure 3. Optically stimulated luminescence (OSL) and calibrated radiocarbon dates ($^{14}$C) for sand and organic samples, respectively. The estimated lake-level recession curve runs through the uppermost and lowermost littoral sand sample dates, and is fitted by hand through the data points at higher elevations. [1]denotes dates from Wolfe et al. (2018) for samples collected from the study site (Figure 4). [2]indicates radiocarbon dates reported in Vanderburgh and Smith (1988) and Smith (1994) for samples from the Peace and Slave River deltas.

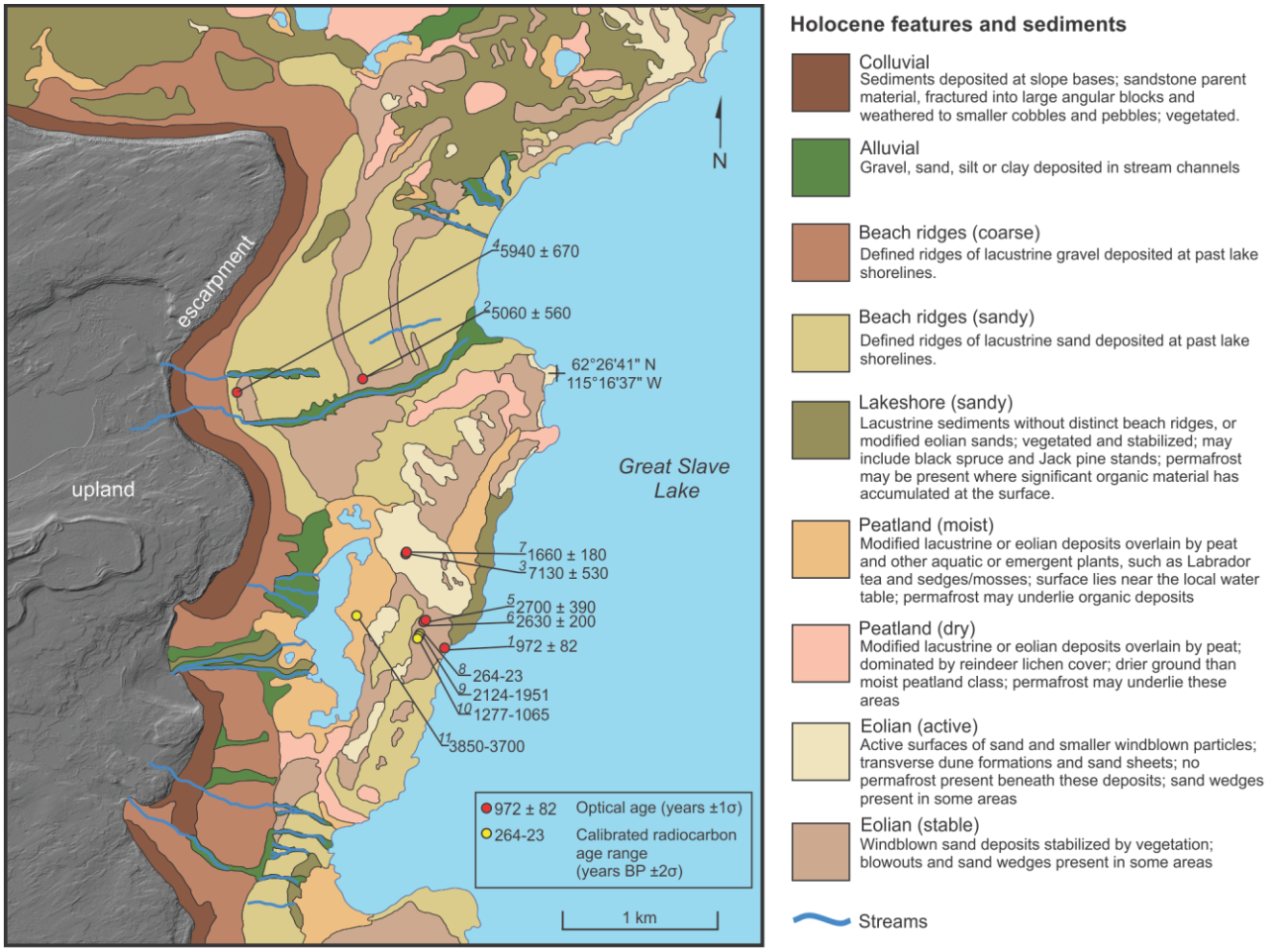

Figure 4. Present-day surficial geology and geomorphology at the Whitebeach Point study area, with locations of dated samples. The modern lake level is 156 m a.s.l.

# Conclusions

Reconnaissance surficial geology mapping of the Rivière Grandin map area identifies surficial materials and associated landforms left by the retreat of the Laurentide Ice Sheet. Mapping was completed using aerial photographs, and striations were compiled from legacy data. This work provides new geological knowledge and improves our understanding of the glacial history by depicting the nature and distribution of surficial sediments and landforms which will serve for mineral resource assessments and effective management and development of the land. Surficial geology mapping and the derivation of a lake-level recession curve for the Whitebeach Point provides new geological knowledge in an area with high-quality silica sand deposits, and continuing work will enable a better understanding of landscape development in the region below the limits of glacial Lake McConnell.

## *Future work 2018-2019*

-Production of reconnaissance surficial geology map at 1:125,000 scale for NTS 86-F in the Canadian Geoscience Map (CGM) format (in press).
-Production of reconnaissance surficial geology maps at 1:125,000 scale for NTS 86-E and NTS 86-L in the Canadian Geoscience Map (CGM) format (both are in preparation).
-Production of draft Current Research report on Holocene lake-level recession and surficial geology at Whitebeach Point.

## Acknowledgments

This surficial research activity is part of the GEM 2 Mackenzie Project, with GSC management support from Carl Ozyer and Paul Wozniak. Alain Plouffe provided helpful comments during the review process. This work is supported by the GSC through the Post-doctorate Fellowship Program for H. Brendan O'Neill.

## References

Craig, B.G. 1965. Glacial Lake McConnell, and the surficial geology of parts of the Slave River and Redstone River map-areas, District of Mackenzie; Geological Survey of Canada, Bulletin 122, 33 p.

Deblonde, C., Cocking, R.B., Kerr, D.E., Campbell, J.E., Eagles, S., Everett, D., Huntley, D.H., Inglis, E., Parent, M., Plouffe, A., Robertson, L., Smith, I.R., and Weatherston, A., 2017. Surficial Data Model, version 2.3.0: Revisions to the science language of the integrated Geological Survey of Canada data model for surficial geology maps; Geological Survey of Canada, Open File 8236, 51 p.

Deblonde, C., Cocking, R.B., Kerr, D.E., Campbell, J.E., Eagles, S., Everett, D., Huntley, D.H., Inglis, E., Parent, M., Plouffe, A., Robertson, L., Smith, I.R., and Weatherston, A., 2018. Surficial data model: the science language of the integrated Geological Survey of Canada data model for surficial geology maps Version 2.3.14; Geological Survey of Canada, Open File 8236, 1 zip file.

Kerr, D.E. and O'Neill, H.B. 2017a. Reconnaissance surficial geology, Indin Lake, Northwest Territories, NTS 86-B; Geological Survey of Canada, Canadian Geoscience Map 334, scale 1:125 000.

Kerr, D.E. and O'Neill, H.B. 2017b. Report of activities for GEM-2 reconnaissance surficial geology, Indin Lake, Northwest Territories, NTS 86-B; Geological Survey of Canada, Open File 8313, 15 p. https://doi.org/10.4095/306157.

Kerr, D.E. and O'Neill, H.B. 2018. Reconnaissance surficial geology, Hardisty Lake, Northwest Territories, NTS 86-C; Geological Survey of Canada, Canadian Geoscience Map 337, scale 1:125 000.

Normandeau, P.-X., McMartin, I. 2013. Composition of till and bedrock across the Great Bear magmatic zone: Quaternary field database and analytical results from the GEM IOCG-Great Bear Project; Geological Survey of Canada, Open File 7307, 26 p, https://doi.org/10.4095/292560.

Prest, V.K., Grant, D.R., and Rampton, V.N. 1968. Glacial map of Canada; Geological Survey of Canada, "A" Series Map 1253A, scale 1:5,000,000, https://doi.org/10.4095/108979.

Smith, D.G., 1994:Glacial lake McConnell: Paleogeography, age, duration, and associated river deltas, mackenzie river basin, western Canada Quaternary Science Reviews, v. 13, Issues 9-10, 1994, p. 829-843.

Stevens, C.W., Kerr, D.E., Wolfe, S.A., and Eagles, S. 2017. Predictive surficial geology, Yellowknife and Hearne Lake, Northwest Territories, NTS 85-J and NTS 85-I; Canadian Geoscience Map 200, Scale 1:125:000, Natural Resources Canada, Ottawa, ON, Canada.

Vanderburgh, S., and Smith, D.G., 1988. Slave River delta: geomorphology, sedimentology, and Holocene reconstruction. Canadian Journal of Earth Sciences, 25, 1990–2004.

Wolfe, S.A., Morse, P.D., Neudorf, C.M., Kokelj, S.V., Lian, O.B. and O'Neill, H.B., 2018. Contemporary sand wedge development in seasonally frozen ground and paleoenvironmental implications. Geomorphology, 308, pp.215-229.