Regional hydrologic and ecologic characterization and baseline assessment of remote northern Canadian terrain in advance of shale oil and gas development

First Annual Report to:

NWT ESRF Management Board

By:

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April, 2018

1.0 INTRODUCTION

The Year 1 work activities associated with the project have been focused on: 1). forging of collaborations and connections with the key stakeholders, researchers and local community members within the research area of interest (Sahtu Settlement Area (SSA)); 2). initial compilation of existing relevant data; 3). initial site visit; 4). the evaluation of optical remote sensing data; 5). enlisting graduate students and 6). planning for the field season for 2018. Through discussions with the research team, industrial partner Husky Oil Operations Ltd., government officials and local community member groups, the decision was made to focus the baseline monitoring activity within the Husky leases EL 462 and 463 (Figure 1, AMEC, 2014).

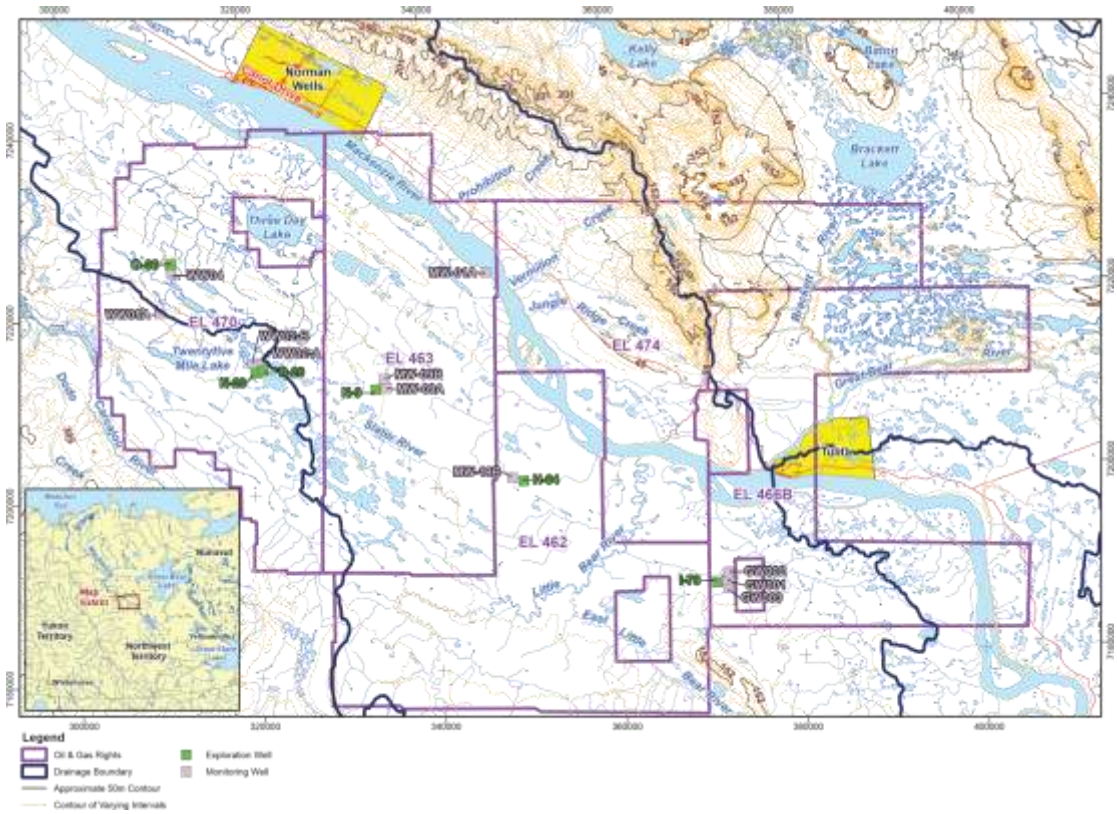

Figure 1. Regional study site plan. (from AMEC, 2014)

This region of the SSA has been the focus of initial baseline monitoring by Husky personnel since 2013. Surface water and groundwater samples have been routinely collected from a series of monitoring locations over this time period and we will maintain a subset of these initial monitoring locations moving forward. We have focused specifically on the Bogg Creek subwatershed where the all season access road constructed by Husky to support initial exploratory petroleum drilling was constructed (Figure 2 and 3).

Figure 2. Location of Bogg Creek subwatershed within the Husky lease areas in the Central Mackenzie Valley.

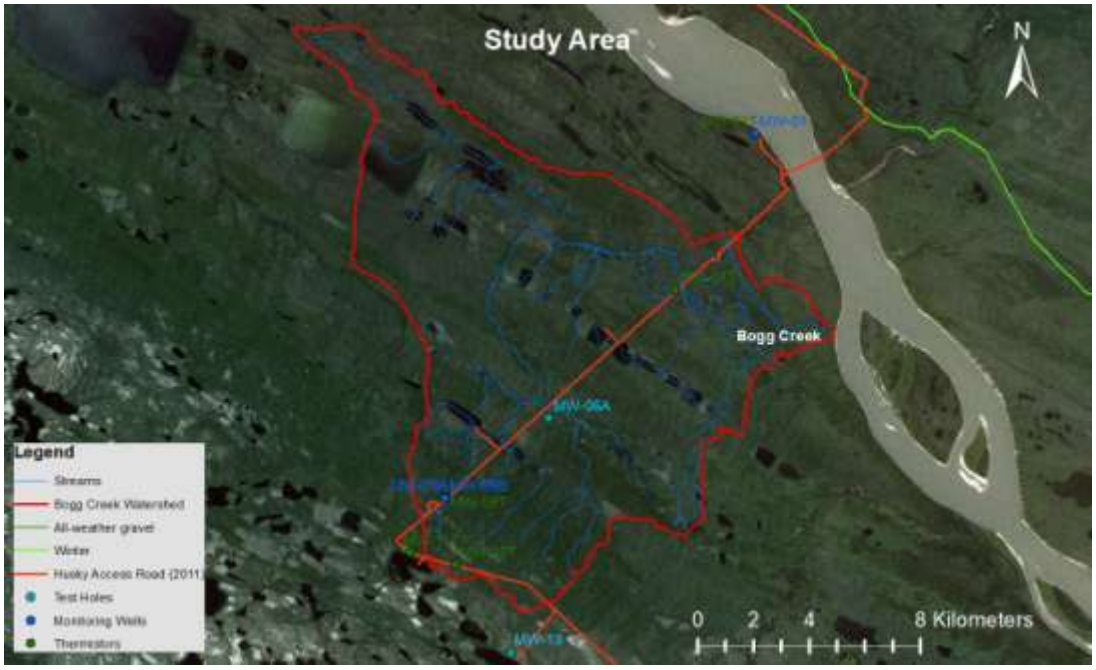

Figure 3. Detailed location of Bogg Creek subwatershed within the Husky lease areas in the Central Mackenzie Valley showing some of the historical Husky water monitoring sites and the location of the all-weather access road.

The selected study area has been the focus of exploratory activity related to shale oil and gas within the Canol Formation over the last 5 years. Currently no exploration is underway and the lease areas are in the process of being decommissioned with much of the infrastructure begin removed from the field

sites. Based on initial discussions with Husky, the intention is for the all-weather access road to remain available for use at least until 2020 and potentially longer into the future. The road is fundamental to providing access for students and research personnel to be able to complete field investigations within the study site in all seasons.

During the course of Year 1 efforts have been made to leverage the research work in the study area with other projects and researchers. We have successfully attracted support through two projects related to the Global Water Futures (GWF) program centered at the University of Saskatchewan. The first project is the Northern Water Futures study headed by Dr. Jenn Baltzer at Wilfred Laurier University. Dr. Baltzer and her students will be working as collaborative partners at the field site for at least the first 3 years of the project. In addition, Dr. Baltzer and colleague Dr. Merritt Turetsky are also working in the area through an ESRF grant focused on terrestrial ecology. This work will be collaboratively associated with the current work in the Sahtu region. Finally, personnel and resources associated with a second project related to the GWF program involving the development of Terrestrial Sensors and data fusion, headed by Dr. Claude Duguay at the University of Waterloo will be integrated into current project.

A summary of progress related to each of the research activities during Year 1 is provided in separate sections below.

2). COLLABORATIONS AND CONNECTIONS WITH THE KEY STAKEHOLDERS AND SITE VISITS

Initial communication between the research team and many of the local and government stakeholders with interest in the project was made during conference calls with the Sahtu Renewable Resources Board (SRRB). These calls provided us with the opportunity to explain the general scope of the project to many different groups and seek advice on how to coordinate field visits, existing data collection and future communication strategies.

An initial field site visit was made to Norman Wells and the Husky lease area during July, 2017. Drs. Rudolph and Baltzer met with Husky personnel, authorities from the Government of Northwest Territories and local stakeholders. During this visit, discussions were initiated on how field work would be carried out over the subsequent field seasons and how site access might be facilitated through Husky and local guides. This first meeting helped to establish a collaborative relationship between the key project partners.

During the month of February 2018, Drs. Baltzer and Rudolph, along with students and Post Doc fellows travelled to Tulita, NWT for a workshop on research activities in the region hosted by the SRRB. At this meeting, more detailed plans for the project were discussed with many different stakeholders and interested parties including community elders, leaders and youth. A brief summary of that meeting is contained in Appendix 1. During this meeting, collaborative relationships were developed with many local parties and significant support was provided by Jeff Walker, Regional Superintendent, Sahtu Region, Envir. and Natural Resources, GNWT. Initial discussions were also held with potential environmental monitors to determine availability for the initial field investigations planned for the summer of 2018.

3). DATA COMPILATION

As part of the initial site characterization phase of the study, some of the existing data available from the study site were compiled and initial interpretation completed to begin development of the geologic

and hydrogeologic conceptual model of the area. Specifically, relevant seismic shot hole data were obtained from the GSC GEOSCAN Portal (I. I. Smith, 2010, 2015) and information regarding the basic nature of the shallow subsurface was determined. Through communication with Husky Oil personnel, available airborne geophysical surveys were identified and discussions were convened to explore opportunities to obtain access to these data.

Subsurface information compiled and interpreted during the initial investigations conducted by Rudolph et al. (2015) were combined with additional subsurface information to develop a GIS representation of the Bogg Creek watershed and surrounding lands. This GIS platform will be used to present and help to interpret the physical components of the study that will be critical to the baseline monitoring program. A map of the surficial geology is shown in Figure 4 (Côté et al., 2013*;* Waterline Resources Inc., 2013a, 2013b, 2013c) and the regional bedrock geology is illustrated in Figure 5 (Fallas & MacNaughton, 2014). Initial geologic cross sections are now under construction using the regional nd local geologic information.

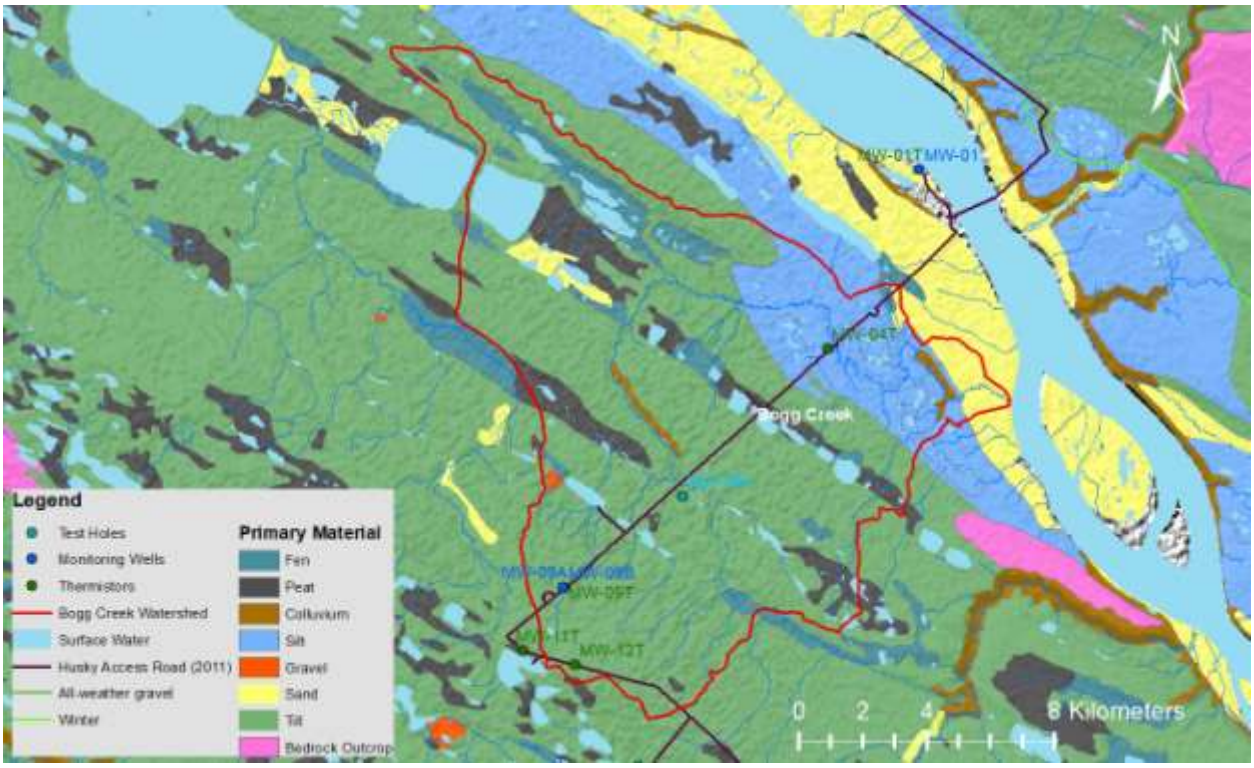

Figure 4: Map of surficial geology and present thermistor, test hole and monitoring well locations. Data obtained from GEOSCAN (Côté et al., 2013), GCODC and MVLWB (Waterline Resources Inc., 2013a, 2013b, 2013c).

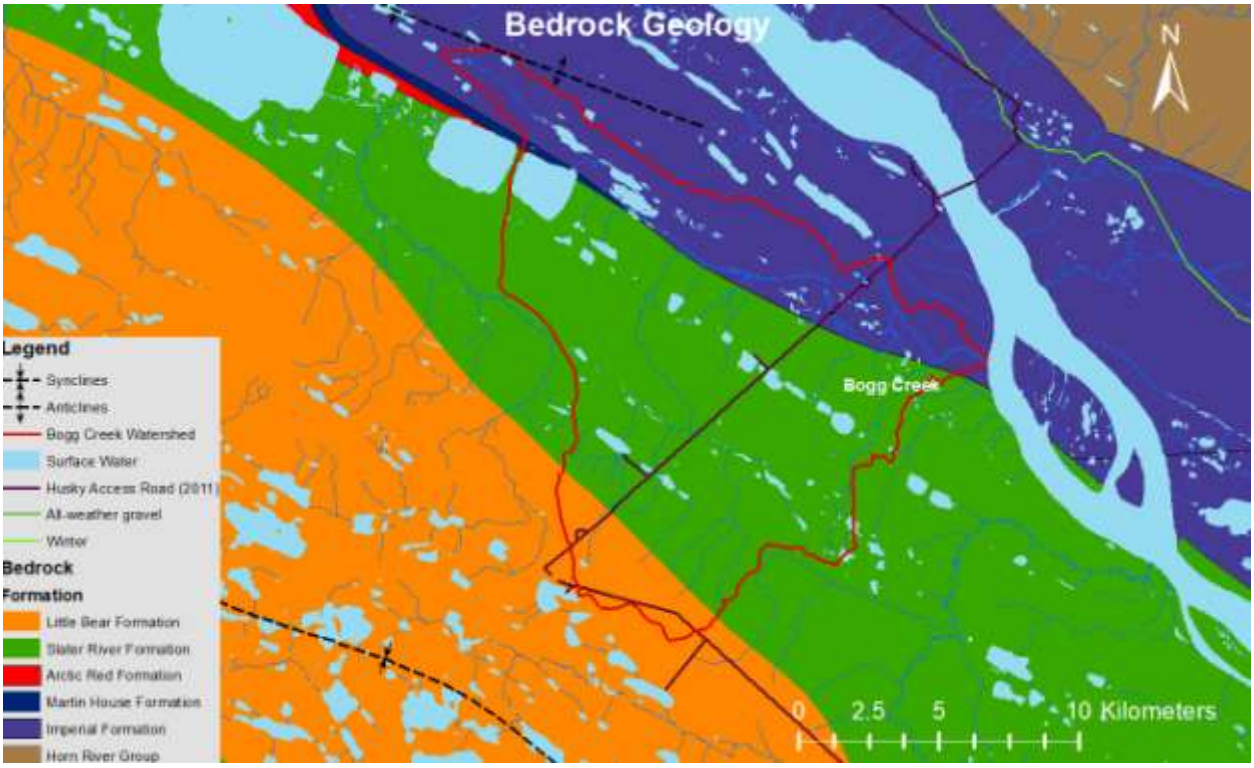

Figure 5. Bedrock geology of Bogg Creek watershed and surrounding area, including major synclines (center of Little Bear Formation) and anticline (near northwest tail of watershed). Data obtained from GCODC, MVLWB, and GEOSCAN (Fallas & MacNaughton, 2014).

Information collected by Husky Oil since 2012 on water quality in and around the Bogg Creek watershed were collected and reviewed to assist in developing a longer term baseline monitoring program for the site. The information provided an initial understanding of the nature of the surface and groundwater quality in the area, which will be used to direct subsequent water quality analyses. Detailed assessment of the geochemical data is currently underway and will inform the subsequent field monitoring programs.

4). EVALUATION OF OPTICAL REMOTE SENSING DATA

One of the critical data sets and potential sources of information related to the study site will potentially be obtained through the compilation and interpretations of the available satellite-based remote sensing. As an initial investigation into these data, multispectral and thermal band datasets obtained from Landsat-5/8 imagery were collected over and interpreted to identify the spatial and temporal occurrence of icings within the study area. The icings may indicate groundwater seepage and this information will inform subsequent field mapping and monitoring locations. For this initial mapping exercise, three Landsat images (late spring, late winter and summer) were compiled for each of three target years (2004, 2009, and 2016). The results of this work indicated that the mapping of icings in the area is possible through interpretation of the remote sensing data and that there may be benefit to utilizing higher definition optical imagery for the second stage of the process. This additional information is currently being collected for analysis. A detailed report of this work was completed by

one of the MSc students working on the project and it has been submitted as an independent document to GNWT authorities to be shared as required with the ESRB (Glass, 2017).

5). ENLISTING GRADUATE STUDENTS

Currently, three graduate students have been recruited to work on the project. Andrew Wicke is engaged in the development of the geologic and hydrogeologic conceptual model of the site. He has been working on the data compilation process and developing the GIS mapping tools. He will also be working on the water sampling and field mapping during the field work campaign during the summer of 2018. Brittney Glass is also and MSc student and she has been heavily involved with the remote sensing work and a summary of her initial work has been submitted with this Year 1 report. Finally, Max Salman has joined the project as a PhD student and he will be responsible for designing and implementing the terrestrial and low elevation (drone and helicopter or fixed wing) air borne geophysics and remote sensing.

6). PLANNING FOR THE 2018 FIELD SEASON

Through the combination of discussions with all stakeholders, review of the initial data and information obtained during the two field visit to the area, a series of field activities have been proposed for the summer 2018 field season. The entire research team is currently in the process of developing detailed plans and making arrangements to secure site access, local travel and engagement of local personnel. A summary of the proposed activities is contained below.

1). Terrestrial baseline monitoring.

- Visit and sample a selected network of surface water features chosen from sites established by Husky as part of their original baseline work.
- Field activities and measurements:
    - Electrical conductivity, temperature, pH, DO.
    - Shallow groundwater temperature and pressure. (mini piezometers)
    - Surface water and shallow groundwater sample collection (mini seepage meters)
    - Deployment of diffusion samplers at some sites.
    - Shallow groundwater sampling away from surface water features
        - Small drive probe sampler
        - Depth sounding to bottom of active layer (top of permafrost)
        - Sampling near identified icing areas and springs
- Geochemical analysis:
    - Stable isotopes, 18O and 2H
    - Major ions
    - Selected heavy metals
    - Selected organics (methane)
    - Other potentially

2). Terrestrial Geophysics

- EM31 surveys near surface water features and in different terrain settings (road)
- Potential ERT sections and profiles
- Shallow thermistor clusters near and below water features

- Hand-held IR camera imaging

3). Low elevation remote sensing (drone)

- HD optical imagery
- IR camera
- Potential use of the prototype Honeywell Hyperspectral device

4). Higher elevation remote sensing/geophysics (helicopter)

- HD optical imagery
- IR camera
- Potential use of the prototype Honeywell Hyperspectral device
- Other potential instruments (under discussion)

5). Potential sampling of Husky groundwater wells.

- To be discussed during meeting with Husky in Calgary in April, 2018

7). CONCLUSION

Due to the supportive efforts of the SRRB, GNWT, many local stakeholders and personnel, and colleagues at Husky Oil, the research team has been able to make substantial progress on the baseline monitoring strategy and site characterization during the first year of the project. We are very much looking forward to moving to the next phase of the work that will involve field activities and new data collection during the summer of 2018.

8). REFERENCES

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APPENDIX 1

Tulí t'a for the Nę K'ə Dene Ts'ıl̨ ı̨ (Living on the Land) Forum

Northern Water Futures (NWF) researchers, Jennifer Baltzer, Dave Rudolph, Kelly Skinner, Anna Coles, Mylene Ratelle and PhD student Carolyn Gibson travelled to the community of Tulí t'a for the Nę K'ə Dene Ts'ıl̨ ı̨ (Living on the Land) Forum, a workshop aimed at connecting communities within the Sahtú region with researchers to discuss research priorities in the region and for researchers to provide updates from existing projects. The Dene people of the Sahtú region have expressed deep concern about the impacts of climate change on their lands and waters. Over centuries, the Dene people of the Sahtú have developed skills and knowledge for living successfully and sustainably on the land. One of the major goals of the Nę K'ə Dene Ts'ıl̨ ı̨ Forum is to ensure co-development of research in the region and support the incorporation of both western and traditional knowledge into research planning, thereby ensuring that researchers and community members work side by side. The Forum was developed using a decolonizing approach where traditional knowledge and western science are combined to ensure that community members are actively engaged in the research decision-making process. This approach was exemplified throughout the workshop with the sharing of both types of knowledge and even a co-presentation on groundwater by NWF researcher Dave Rudolph and Leon Andrew, an elder from Tulí t'a. NWF researchers are initiating new research activities in the Sahtú region in the coming summer and Nę K'ə Dene Ts'ıl̨ ı̨ Forum workshop provided an ideal opportunity to develop these plans with the community.

Over the three-day workshop, researchers listened to stories about landscape change and its effects on ecosystems, livelihoods and safety. Through the Forum, the researchers gained a better understanding of the region and the effects climate-warming driven landscape change as experienced by the community. The researchers heard concerns about the impacts of wildfires on vital boreal caribou (tǫdzı) habitat, the impact of warming water on fish populations, and how permafrost thaw changing how much water is on the land. There was concern about how fire impacts the frozen ground below it with stories of slumping hillslopes and riverbanks following fire. Community members have observed decreasing lake and river water levels. Changes are happening fast in the Sahtú and community members want to have a better understanding of what their lands will look like in the future; data from this region is sparse making such predictions very difficult.

The need to work together to understand changes happening on the land was emphasized. The meeting involved both elders and youth and discussions revolved around two main priorities for community involvement in NWF research: 1) Working with elders to incorporate knowledge of changes on the land into sampling design; and 2) Building research capacity in the youth through direct involvement in sampling, support for on-the-land training and bringing research into the classroom.

The Nę K'ə Dene Ts'ıl̨ ı̨ Forum provided an excellent opportunity for dialogue between researchers and community members to ensure that research generated in the region is of shared value. The information gathered at the forum will help researchers finalize their research plans for the coming summer and shape new research questions moving forward. NWF researchers are looking forward to continuing to collaborate with communities in Sahtú this summer.