February 2, 2015

Mr. Mike Rudkin
Senior Administrative Officer
Hamlet of Pond Inlet
Box 180
Pond Inlet, NU X0A 0S0

Re: OTT-00222042-A0 – Design Brief for the Construction of a Road to Salmon River

Dear Mr. Rudkin:

Exp Services Inc. (**exp**) was retained by the Hamlet of Pond Inlet (Hamlet) on October 28th, 2014 to provide engineering services related to the design of a road to Salmon River. The scope of services to be provided are based upon a letter from **exp** to the Hamlet dated September 26th, 2014 and the original scope of services from the Hamlet dated July 9th, 2014.

It is **exp**'s understanding that the Hamlet wishes to construct a road between the Hamlet's existing road network and the mouth of Salmon River, approximately 3.5 kms to the south west of the Hamlet. This proposed road alignment crosses one major watercourse, known as Salmon Creek, which will require specific design for the water crossing and water board approval prior to construction of the water crossing. It is our understanding that the purpose of the proposed road is to provide access to the mouth of Salmon River which the Hamlet proposes to use as a boat basin as it provides better shelter than the open water along the coast of the Hamlet.

Scope of Services

The scope of services as per the proposal letter are as follows:

1. Design of water crossing
2. Preliminary road alignment
3. Design Brief, including Class D cost estimate
4. Development of survey sketch to facilitate future legal survey

The water board application process for the water crossing will be undertaken by the Government of Nunavut on behalf of the Hamlet, and **exp**'s services are inclusive of providing the detail design information pertaining to the water crossing for use in the water licence application.

A preliminary road alignment will be researched with Hamlet staff and recorded by a handheld GPS to facilitate a preliminary road alignment and development of the survey sketch.

The design brief will include details of the rationale for the development of the road, alternative road sections and associated cost estimates, along with a recommendation regarding the proposed road section.

A survey sketch will be prepared to facilitate the future legal survey required in the next component of the project.

Preliminary Road Alignment

On November 3rd, 2014, Mr. Stephen Douglas accompanied by a surveyor mobilized into Pond Inlet to undertake the preliminary road alignment. For the site visit Hamlet staff had prepared a proposed road alignment between the Hamlet and the mouth of the Salmon River. Unfortunately, due to the timing of the site visit snow cover prevented **exp** staff from investigating alternate alignments, nor could the existing terrain be viewed to determine if there are any problematic soils or topography proposed in the Hamlet's alignment.

The proposed alignment by the Hamlet appears to be satisfactory in topographic grades and horizontal alignment. The route to the mouth of the Salmon River was driven in a half ton truck. Even though the driving surface was snow covered there were no difficulties in traversing the proposed alignment. As the snow cover prevented **exp** from viewing the existing terrain, it is anticipated that some minor adjustments to the proposed alignment may be required during the detailed topographic survey and design of the road. Therefore, it is recommended that the road allowance requested for the road includes some additional width to accommodate the realignment of the centre line of the road. It is **exp**'s recommendation that a 50 m wide road allowance be provided.

The proposed road alignment is as shown in Figure 1.

Recommended Road Section

As previously referenced, it is our understanding that the proposed road is to be used as an access to a new boat basin. Therefore it is anticipated that the road will have to be sufficient to provide two-way traffic, as well as provide a sufficient driving surface to allow for boats to be moved to and from the boat basin along the access road. It is recommended that a 7 m driving surface, comprised of two 3.5 m lanes be provided with a one metre shoulder in each side of the road for a total road width from edge of shoulder to edge of shoulder of 9 m.

The recommended road structure for the road to Salmon Creek is comprised of 100 mm of Granular A for surface course, 200 mm of Granular B for subsurface, 300 mm of Granular C and then additional engineered fill as required to meet the proposed road grades. In addition, the road structure will have a minimum side slopes of 2H:1V. Where required for drainage, roadside ditches, a minimum 0.7 m deep should be provided, and where required to allow drainage to cross the road, road culverts of a minimum 600 m diameter should be provided.

The recommended road structure for the road to Salmon Creek, is shown on Figure 2.

Proposed Road Design

The preliminary road design is based upon the alignment detailed during the site visit between **exp** and Hamlet staff. The alignment investigated during the site visit included a portion of the existing Hamlet's road network and a portion of new road. Unfortunately, at the time of the site visit snow cover prevented a visual inspection of the existing road, however, it is anticipated that the road structure will require some upgrading to meet the standards previously recommended. In total a length of 1.6 km of existing road, will require upgrading and a total length of new road of 3.0 km will be required, as shown on Figure 3.

For the purposes of this study, it is anticipated that the existing road with its approximate 7 m wide. Therefore an additional 1 m of shoulder will be required on each side of the existing road to match the proposed road section. In addition it is estimated that the additional road structure will require an average of approximate of 0.7 m of depth.

Water Crossing Design

As part of the site visit undertaken by **exp** in November 2014, a survey of the proposed location of the water crossing was undertaken. The survey information is provided in Figure 4. As part of the field investigation services we reviewed an existing water crossing located approximately 1500 m upstream of the proposed water crossing location. This existing water crossing is comprised of twin 1.0 m diameter culverts and one 1.4 m culvert.

Watershed Hydrology

The Rational Formula, shown below was used to determine the quantity of flow the culvert system will be required to handle. The Rational Formula equates the quantity of flow (Q) as a fraction (C) of the rate of water supply (i) to the entire are of the watershed area (A).

Rational Formula

$$Q = 0.0028\ CiA$$

Where:

Q = Flow
C = Runoff Coefficient
i = rainfall intensity
A = Watershed Area

The runoff coefficient is based on typical values with the main factors being soil type and land use. Typical value for gently sloped (<5%) uncultivated land would be in 0.1 to 0.4 range depending on the permeability of the soil. To account for a relatively shallow impervious layer due to rock or permafrost a coefficient of 0.4 will be used.

A total area of the watershed contributing to the flow at the location of the Salmon Creek water crossing was determined utilizing 1:50,000 contour mapping. The total area contributing to the flow was determined to be 3,900 ha as shown on Figure 5.

The rainfall intensity is obtained from Rainfall Intensity – Duration Frequency Data published by Environment Canada. As reference above, the design event is rainfall event when the entire watershed is contributing to the runoff. This event occurs when the duration of the event equals the time for runoff from the most remote part of the watershed to reach the water crossing. This is referred to as the Time of concentration (T_c). The Rainfall Intensity – Duration Frequency Data provides the corresponding rainfall intensity for the Time of concentration for different return periods.

For watersheds with a runoff coefficient of 0.4 or greater, the time of concentration is normally calculated by the Bransby Williams formula shown below. The Bransby William Formula accounts for the area, shape, length and slope of the watershed when determining the time of concentration.

Bransby William Formula

$$T_c = \frac{0.057L}{(s_w^{0.2}\ A^{0.1})}$$

Where:

T_c = Time of Concentration
L = Length of watershed = 17,600 m
s_w = Average slope of the watershed = 2.27% as calculated using the 10 - 85 approach
A = Area of the watershed = 3,900 ha

$$T_c = \frac{0.057 \times 17{,}600}{(2.27^{0.2} \times 3{,}900^{0.1})} = 372 \text{ minute}$$

Therefore the time of concentration for the water shed contributing to the flow at the water crossing is 372 minutes or 6.2 hours.

From the Rainfall Intensity – Duration Frequency Data published for the Hamlet of Pond Inlet, the rainfall intensity for a 6.2 hour storm event with a 1 in 25 year return period is 2.6 mm per hour.

Therefore the design flow from the watershed as calculated by the rational Formula is:

$$Q = 0.0028\ CiA$$

Where

C = Runoff Coefficient = 0.4
i = rainfall intensity = 2.6 mm
A = Watershed Area = 3,900 ha

$$Q = 0.0028 \times 0.4 \times 2.6 \times 3{,}900 = 11.4\ m^3/s$$

When the rainfall intensity is used in the rational Formula above, the flow from the watershed at the water crossing is equal to 11.4 m^3/s.

Culvert Hydraulic

It is our understanding that the Hamlet has pre-ordered sections of 900 mm diameter culverts. Therefore the culvert design will be based on the use of this size of culverts.

Based on the typical road section described above the culvert length will be approximately 20 m. The culverts will be installed matching the existing slope to the channel at approximately a 3.2% grade. Based on the survey information, a maximum allowable headwater for the design of the culverts of 2 m was chosen. This headwater must be provided as part of the final road design. Based on these design criteria, the hydraulic analysis of the culverts, attached, result in the culvert system requires six 900 mm diameter barrels, details of the proposed culvert design are attached on Figures 6 through 8. To account for the potential ice accumulate in the bottom of the culverts, the middle two culverts should be installed 150mm lower the remaining four culverts.

Class D Cost Estimate

Based on the preliminary design outlined above, it is estimated that the total cost of the proposed road, including upgrades to the existing Hamlet road and the proposed water crossing at Salmon Creek will be $3,357,000, inclusive of a 20% contingency. Details of the cost estimate are appended to this report.

Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Sincerely,
exp Services Inc.

Stephen A Douglas
Senior Designer
Infrastructure Services

Steven Burden, P.Eng.
Senior Manager
Infrastructure Services