GNWT - DEPARTMENT OF PUBLIC WORKS

# PROPOSED ARENA SITE 2

CORAL HARBOUR ARENA

THURBER CONSULTANTS LTD., Geotechnical Engineers

| | |
|---|---|
| DRAWN | NH / JAB |
| FILE NO. | 15-22-60 |
| DATE | SEPT. 1985 |
| APPROVED | |
| SCALE | 1:5000 |
| DRAWING NO | A 2 |

# APPENDIX E
## MEETING MINUTES

**Meeting Minutes:**

Subject: Interaction with local people

Venue: Hamlet of Coral Harbour Office, Coral Harbour, Nunavut

Date: November 14, 2012 Time: 9:00 AM – 11:00 AM

Present:

Mr. Jerry Paniniuq, Mayor
Ms. Leonie Pameolik, Senior Administrative Officer
Mr. Mike Emiktort, Former Mayor
Mr. John Pameolik, Senior elders
Mr. Peter Nakoolak, Former Mayor
Mr. Bryan Perdue, P. Eng.
Mr. Jagadish Kayastha, EBA

Bryan Perdue appreciated local people and office bearers of Hamlet of Coral Harbour for participating the meeting. The following was the outcome of the meeting based on discussion with local people.

1. Spring flooding with continuous rainfall of 12 to 24 hours and snow melt has been quite common every year.
2. Spring flood occurred on June 30, 2012 was a unique as it washed out roads near culverts located in the vicinity of Fuel Storage Tank.
3. Rainfall depth of about 25 mm to 35 mm occurs during spring flooding in June.
4. The water level touched the bridge deck during the last year flooding.
5. Also, one of the previous year flooding stored water all the way up to Culvert # 12, north of the town.
6. The washout water width was about 50 m for each washout.
7. Snow cover depth during the snow melt time varies from 1 m to 1.5 m.
8. About 2 km radius is snow free during snow melt time.
9. There is no evidence of freezing floating snow pieces during flooding.
10. The Hamlet of Coral Harbour installed a 1200 mm diameter CMP culvert near the bridge to protect the bridge washout last year.
11. The road elevation near the washout areas has been raised about 1 m in the stretch of 150 m length.

# APPENDIX F

## CONSTRUCTION COST ESTIMATE – CONCEPT DESIGN ESTIMATE

**Project Name: Community Road Washout in Coral Harbour, Nunavut**
**Government of Nunavut, Department of Community & Government Services**

## Option 1 Conceptual Design - Construction Cost Estimate - Bridge at Washout #1 and 4-1500mm ϕ Culvert at Washout #2

| Item | Description | Unit | Qty. | Unit Price | Extended Amount |
|---|---|---|---|---|---|
| **PART A - GENERAL** | | | | | |
| 1 | Mobilization / Demobilization / Permits / Facilities / Bonding / Insurance / Construction Survey /Accommodation / Etc. (Assume 10%) | LS | 1 | $ 68,000.00 | $ 68,000.00 |
| **PART B - CIVIL REHABILITATION - WASHOUT # 1** | | | | | |
| 1 | Supply and Shipping of Materials for Bridge | LS | 1 | $ 230,000.00 | $ 230,000.00 |
| 2 | Labour, Material, and and Equipment for Bridge | LS | 1 | $ 350,000.00 | $ 350,000.00 |
| **PART C - CIVIL REHABILITATION - WASHOUT # 2** | | | | | |
| 1 | Common Excavation and Backfill for Culverts | m^3 | 300 | $ 40.00 | $ 12,000.00 |
| 2 | Common Excavation and Dispose Off Site | m^3 | 200 | $ 50.00 | $ 10,000.00 |
| 3 | Granular Bedding - 150mm Depth | m^3 | 20 | $ 30.00 | $ 600.00 |
| 4 | Supply, Shipping, and Installation of 4-1500mm ϕ Culvert | m | 56 | $ 1,200.00 | $ 67,200.00 |
| 5 | Supply and Place Geotextile for Rip Rap | m^2 | 220 | $ 30.00 | $ 6,600.00 |
| 6 | Place Rip Rap at Inlet and Outlet - Material Supplied Locally | m^3 | 180 | $ 40.00 | $ 7,200.00 |

| | Amount |
|---|---|
| **PART A - GENERAL** | $ 68,000.00 |
| **PART B - CIVIL REHABILITATION - WASHOUT # 1** | $ 580,000.00 |
| **PART C - CIVIL REHABILITATION - WASHOUT # 2** | $ 103,600.00 |
| UNIT PRICES SUBTOTAL | **$ 751,600.00** |
| Contingencies (35%) | **$ 263,060.00** |
| **TOTAL ESTIMATED COST** | **$ 1,014,660.00** |

Assumption:

1) This cost estimate is prepared for planning and budgetary purposes only, and does not constitute a guarantee on the project cost. The actual cost will be determined by the tendering and construction processes.
2) Bridge prices provided by Jivko Engineering and was marked up 25% for additional pricing for piles, embedment of material, etc.
3) Prices shown assume local supply of granular material on site (quarry of new material not required)
4) Assume depth from existing road surface to existing culvert bottom is 2.5m - no additional material assumed for building up road to meet minimum cover requirements.
5) Assume granular material excavated from road can be reused as backfill for new culvert.
5) All unit prices are estimated in 2012 monetary value. Taxes are not included.

**Project Name: Community Road Washout in Coral Harbour, Nunavut**
**Government of Nunavut, Department of Community & Government Services**

## Option 2 Conceptual Design - Construction Cost Estimate - 3-2400 x 1800mm Concrete Box Culvert at Washout #1 and 3-2400 x 1800mm Concrete Box Culvert at Washout #2

| Item | Description | Unit | Qty. | Unit Price | Extended Amount |
|---|---|---|---|---|---|
| **PART A - GENERAL** | | | | | |
| 1 | Mobilization / Demobilization / Permits / Facilities / Bonding / Insurance / Construction Survey /Accommodation / Etc. (Assume 10%) | LS | 1 | $ 76,000.00 | $ 76,000.00 |
| **PART B - CIVIL REHABILITATION - WASHOUT # 1** | | | | | |
| 1 | Common Excavation and Backfill for Culverts | m^3 | 190 | $ 40.00 | $ 7,600.00 |
| 2 | Common Excavation and Dispose Off Site | m^3 | 420 | $ 50.00 | $ 21,000.00 |
| 3 | Granular Bedding - 150mm Depth | m^3 | 25 | $ 30.00 | $ 750.00 |
| 4 | Supply and Shipping of 3-2400mm x 1800mm Culvert | m | 42 | $ 8,000.00 | $ 336,000.00 |
| 5 | Supply and Place Geotextile for Rip Rap | m^2 | 270 | $ 30.00 | $ 8,100.00 |
| 6 | Place Rip Rap at Inlet and Outlet - Material Supplied Locally | m^3 | 210 | $ 40.00 | $ 8,400.00 |
| **PART C - CIVIL REHABILITATION - WASHOUT # 2** | | | | | |
| 1 | Common Excavation and Backfill for Culverts | m^3 | 190 | $ 40.00 | $ 7,600.00 |
| 2 | Common Excavation and Dispose Off Site | m^3 | 420 | $ 50.00 | $ 21,000.00 |
| 3 | Granular Bedding - 150mm Depth | m^3 | 25 | $ 30.00 | $ 750.00 |
| 4 | Supply and Shipping of 3-2400mm x 1800mm Culvert | m | 42 | $ 8,000.00 | $ 336,000.00 |
| 5 | Supply and Place Geotextile for Rip Rap | m^2 | 270 | $ 30.00 | $ 8,100.00 |
| 6 | Place Rip Rap at Inlet and Outlet - Material Supplied Locally | m^3 | 210 | $ 40.00 | $ 8,400.00 |

| | Amount |
|---|---|
| **PART A - GENERAL** | $ 76,000.00 |
| **PART B - CIVIL REHABILITATION - WASHOUT # 1** | $ 381,850.00 |
| **PART C - CIVIL REHABILITATION - WASHOUT # 2** | $ 381,850.00 |
| UNIT PRICES SUBTOTAL | **$ 839,700.00** |
| Contingencies (35%) | **$ 293,895.00** |
| **TOTAL ESTIMATED COST** | **$ 1,133,595.00** |

Assumption:

1) This cost estimate is prepared for planning and budgetary purposes only, and does not constitute a guarantee on the project cost. The actual cost will be determined by the tendering and construction processes.

2) Prices shown assume local supply of granular material on site (quarry of new material not required)

3) Assume depth from existing road surface to existing culvert bottom is 2.5m - no additional material assumed for building up road to meet minimum cover requirements.

4) All unit prices are estimated in 2012 monetary value. Taxes are not included.

**Project Name: Community Road Washout in Coral Harbour, Nunavut**
**Government of Nunavut, Department of Community & Government Services**

## Option 3 Conceptual Design - Construction Cost Estimate - Bridge Plate Box Culvert 6400mm x 1800mm at Washout #1 and 6400mm x 1800mm Bridge Plate Box Culvert at Washout #2

| Item | Description | Unit | Qty. | Unit Price | Extended Amount |
|---|---|---|---|---|---|
| **PART A - GENERAL** | | | | | |
| 1 | Mobilization / Demobilization / Permits / Facilities / Bonding / Insurance / Construction Survey /Accommodation / Etc. (Assume 10%) | LS | 1 | $ 44,000.00 | $ 44,000.00 |
| **PART B - CIVIL REHABILITATION - WASHOUT # 1** | | | | | |
| 1 | Common Excavation and Backfill for Culverts | m^3 | 400 | $ 40.00 | $ 16,000.00 |
| 2 | Common Excavation and Dispose Off Site | m^3 | 260 | $ 50.00 | $ 13,000.00 |
| 3 | Granular Bedding - 300mm Depth | m^3 | 50 | $ 30.00 | $ 1,500.00 |
| 4 | Supply, Shipping, and Install 6400mm x 1800 mm Culvert | m | 14 | $ 7,100.00 | $ 99,400.00 |
| 5 | Supply, Shipping, and Install of Concrete Footing (Dimensions to be confirmed) | LS | 1 | $ 75,000.00 | $ 75,000.00 |
| 6 | Supply and Place Geotextile for Rip Rap | m^2 | 260 | $ 30.00 | $ 7,800.00 |
| 7 | Place Rip Rap at Inlet and Outlet - Material Supplied Locally | m^3 | 200 | $ 40.00 | $ 8,000.00 |
| **PART C - CIVIL REHABILITATION - WASHOUT # 2** | | | | | |
| 1 | Common Excavation and Backfill for Culverts | m^3 | 400 | $ 40.00 | $ 16,000.00 |
| 2 | Common Excavation and Dispose Off Site | m^3 | 260 | $ 50.00 | $ 13,000.00 |
| 3 | Granular Bedding - 300mm Depth | m^3 | 50 | $ 30.00 | $ 1,500.00 |
| 4 | Supply, Shipping, and Install 6400mm x 1800 mm Culvert | m | 14 | $ 7,100.00 | $ 99,400.00 |
| 5 | Supply, Shipping, and Install of Concrete Footing (Dimensions to be confirmed) | LS | 1 | $ 75,000.00 | $ 75,000.00 |
| 6 | Supply and Place Geotextile for Rip Rap | m^2 | 260 | $ 30.00 | $ 7,800.00 |
| 7 | Place Rip Rap at Inlet and Outlet - Material Supplied Locally | m^3 | 200 | $ 40.00 | $ 8,000.00 |

| | Amount |
|---|---|
| **PART A - GENERAL** | $ 44,000.00 |
| **PART B - CIVIL REHABILITATION - WASHOUT # 1** | $ 220,700.00 |
| **PART C - CIVIL REHABILITATION - WASHOUT # 2** | $ 220,700.00 |
| UNIT PRICES SUBTOTAL | **$ 485,400.00** |
| Contingencies (35%) | **$ 169,890.00** |
| **TOTAL ESTIMATED COST** | **$ 655,290.00** |

Assumption:

1) This cost estimate is prepared for planning and budgetary purposes only, and does not constitute a guarantee on the project cost. The actual cost will be determined by the tendering and construction processes.
2) Prices shown assume local supply of granular material on site (quarry of new material not required)
3) Assume depth from existing road surface to existing culvert bottom is 2.5m - no additional material assumed for building up road to meet minimum cover requirements.
4) All unit prices are estimated in 2012 monetary value. Taxes are not included.

# APPENDIX G

## MANUFACTURER INFORMATION FOR CULVERTS

# APPENDIX H

## REVIEW OF THE CULVERT CROSSINGS UNDER AIRPORT ROAD, CORAL HARBOUR, NU

EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company
Oceanic Plaza, 9th Floor, 1066 West Hastings Street
Vancouver, BC V6E 3X2 CANADA
p. 604.685.0275 f. 604.684.6241

# TECHNICAL MEMO

ISSUED FOR USE

**TO:** Bruce Johnson
**C:** Lisa Ma
**FROM:** David Moschini

**DATE:** February 14, 2012
**MEMO NO.:**
**EBA FILE:** 704-C31103058-01

**SUBJECT:** Review of the Culvert Crossings under Airport Road, Coral Harbour, NU

## 1.0 INTRODUCTION

As requested, EBA Engineering Consultants Ltd. operating as EBA, a Tetra Tech Company (EBA) has completed a detailed hydrologic analysis of the Post River watershed to confirm flows for various return periods. Included below is a summary of the analysis and subsequent findings. As part of this review, we have also developed a dynamic PCSWMM model detailing the hydraulic capacity of the system. Following our analysis, we have highlighted our initial recommendations.

## 2.0 HYDROLOGY

The Post River watershed was analysed to determine the hydrological properties of the catchment and investigate typical hydrological responses to precipitation events, including the effect of snowmelt. This watershed evaluation was then used to define the shape and duration of a typical flood hydrograph and determine peak instantaneous design flows for a variety of return periods.

The Post River is located on the eastern side of Southampton Island and is approximately 281 km$^2$ (See Figure 1). The watershed originates approximately 48 km north of Coral Harbour and drains to the south into the Hudson's Bay. The project site is defined by Airport Road, which provides access to Coral Harbour Airport.

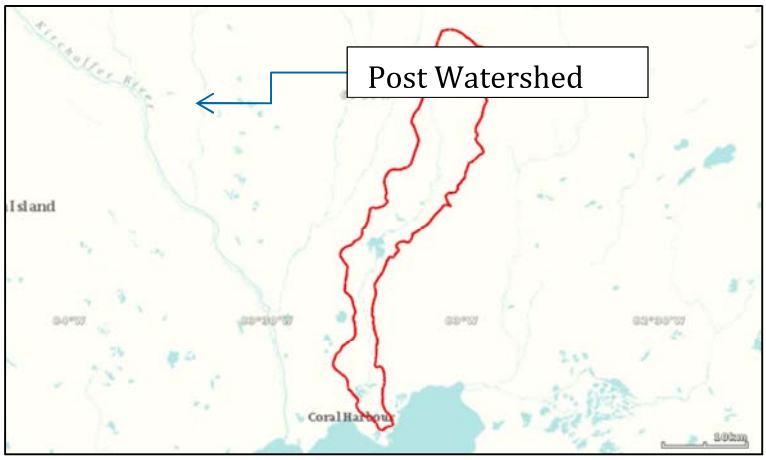


**Figure 1 – Post River Watershed**

As detailed in the report *Airport Community Road Washout Coral Harbour, Nunavut – EBA 2013,* drainage across Airport Road is routed through a series of culvert crossings and under a bridge. Aerial photographs of the site show numerous lakes and wetlands within the Post River watershed, especially at the lower elevations and near the town of Coral Harbour.

As there was no hydrometric station or flow data available for the Post River, a regional based statistical approach was used to estimate peak flows. Water Survey of Canada (WSC) hydrometric stations installed across Nunavut were reviewed to find gauged watercourses with similar watershed characteristics and sufficient data for a meaningful statistical regional analysis. Selection of the comparable watersheds was limited to regions of similar climate, topography, and watershed size.

WSC Station 06PA001, Kirchoffer River near Coral Harbour, is located approximately 13 km to the west of the Post River with a watershed area of 3,160 km$^2$ (See Figure 2). Although the close proximity of the Kirchoffer River station to the Project site is ideal for a watershed comparison, the data record for this WSC station consisted of less than five years of flow data. This was considered insufficient for statistical extrapolation purposes. However, several important conclusions were drawn from this data set:

- Peak flows on the Kirchoffer River occur in late June, shortly after average daily temperatures begin to exceed 0° Celsius. This coincides with the snowpack melt within the watershed.
- Peak river flows are governed almost entirely by snowmelt. Precipitation events seem to produce only minor responses in the Kirchoffer River.
- The shape and duration of the river flow freshet hydrograph was found to be consistent for all four years of available data.

Due to the consistency of the freshet flow responses and the proximity of the Kirchoffer River station to the project site, the shape of the freshet hydrograph was used to scale the hydrograph for the Post River.

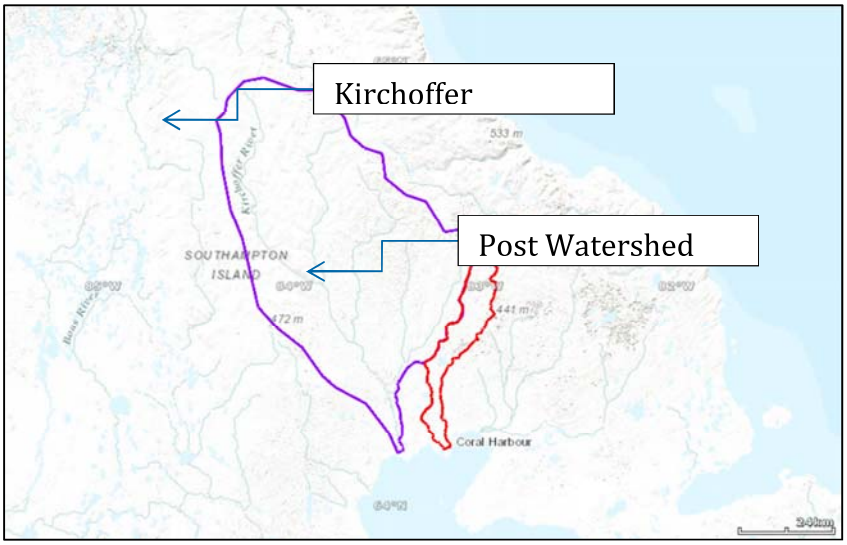


**Figure 2 – Post River and Kirchoffer River Watersheds**

Four WSC stations with ten or more years of available peak instantaneous flow data were used in a regional statistical flow evaluation to determine peak flows on the Post River for a variety of return periods. Table 1 outlines the four selected WSC stations.

**Table 1 – WSC Stations Comparison Summary**

| Station ID | Station Name | Distance from Post River | Direction from Post River | Number of Years of Peak Daily Flow Data | Number of Years of Peak Instantaneous Flows | Watershed Area |
|---|---|---|---|---|---|---|
| 06MA002 | QINGUQ CREEK NEAR BAKER LAKE | 635 km | West | 15 | 6 | 432 $km^2$ |
| 10UH001 | SYLVIA GRINNELL RIVER NEAR IQALUIT | 715 km | East | 13 | 13 | 2,980 $km^2$ |
| 10UH002 | APEX RIVER AT APEX | 722 km | East | 9 | 11 | 58.5 $km^2$ |
| 06OA001 | LORILLARD RIVER ABOVE DALY BAY | 353 km | West | 8 | 9 | 11,000 $km^2$ |

While all of the selected WSC hydrometric stations are on the same latitude as the Post River watershed, most are far from the project site. Closer WSC stations were found to be unsuitable for statistical analysis. However, there are similar flow trends and magnitudes at all four stations, supporting the conclusion that the hydrologic behavior of Nunavut watersheds is relatively similar at this latitude.

A flood frequency analysis was conducted using peak instantaneous flows for each of the four stations. In years where a station had a maximum daily flow reported, but no maximum instantaneous flow reported, a maximum instantaneous flow was synthesized by prorating the maximum daily value. Prorating factors were determined as the average ratio between the maximum instantaneous flow and the maximum daily flow in all years where both were available.

Flood frequency statistical analysis software, HYFRAN, was used to fit the flow data to selected statistical distributions. While several probability distributions were tested, the three-parameter Log Pearson distribution is the most accepted for extreme flow events. Calculated peak instantaneous watershed flows for each of the WSC stations are presented in Table 2.

**Table 2 – Return Period Summary**

| Return Period (years) | 06MA002 432 $km^2$ | 10UH001 2,980 $km^2$ | 10UH002 58.5 $km^2$ | 06OA001 11,000 $km^2$ |
|---|---|---|---|---|
| 1000 | 149 | 832 | 28.4 | 5,450 |
| 200 | 138 | 742 | 25.0 | 4,360 |
| 100 | 132 | 701 | 23.4 | 3,900 |
| 50 | 125 | 658 | 21.6 | 3,440 |
| 20 | 113 | 598 | 19.1 | 2,840 |
| 10 | 102 | 549 | 16.9 | 2,380 |
| 5 | 88.5 | 494 | 14.4 | 1,920 |
| 3 | 75.7 | 447 | 12.4 | 1,560 |
| 2 | 62.7 | 401 | 10.4 | 1,250 |

Flows were then scaled to compensate for differences in watershed area. In order to acknowledge the differences in basin geometry between large and small basins, the formula shown below was used.

$$Q_2 = Q_1 \times \left(\frac{A_2}{A_1}\right)^K$$

Where: Q = Flow ($m^3/s$)

A = Area ($km^2$)

K = Slope coefficient

Subscripts 1 and 2 denote two watersheds of differing size

A slope coefficient, K, was determined for each return period based on comparisons made between data for the four WSC stations. Figure 3 depicts a log-log plot of flow compared to watershed area for each of the WSC stations for each return period. Each set of data was fitted with a power trendline where the exponent in the trendline's equation was taken as the K coefficient. Depending on the return period, K values ranged from 0.920 to 0.956 which is indicative of a landscape with a constant slope (K value of 1.0).

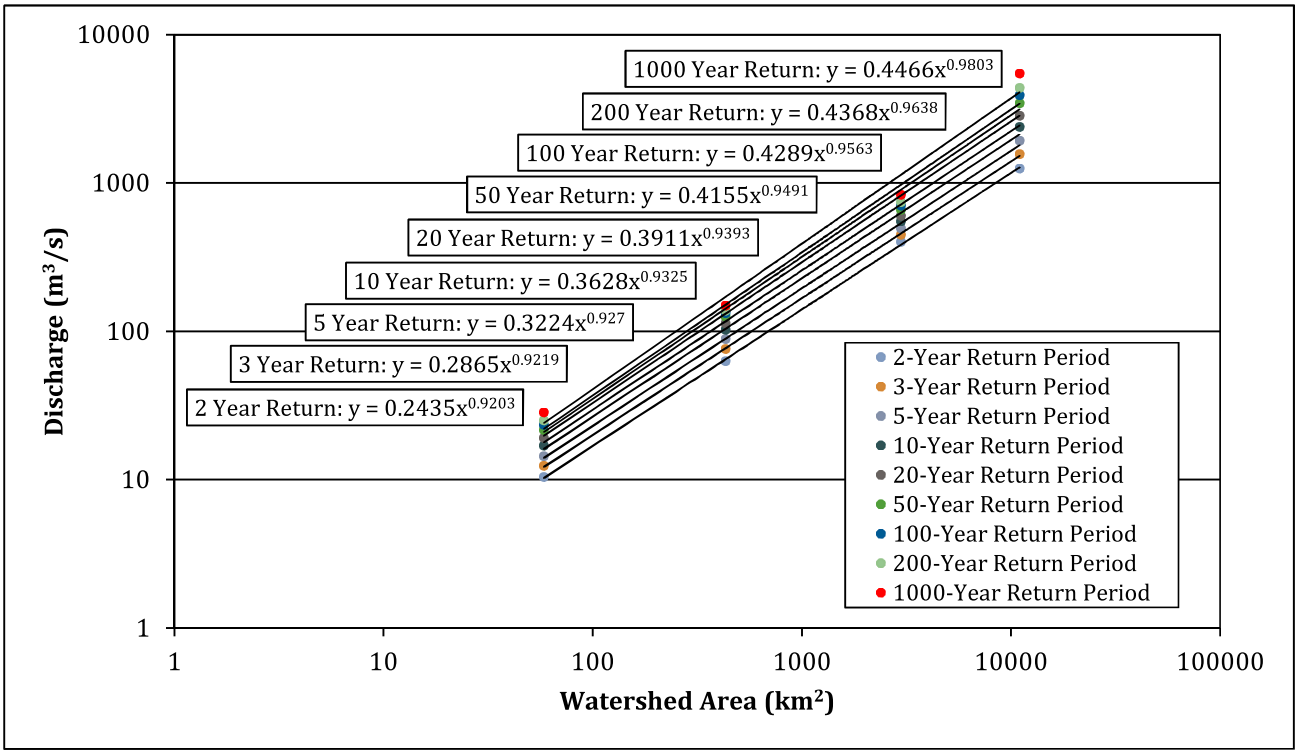


**Figure 3 – Post River at Airport Road: K Value Determination**

Using the above equation, four different estimated flows for the Post River were calculated based on the projected flows for each WSC station; this was done for each return period. The resulting flows were then averaged to obtain the final reported estimate for each return period. Table 3 summarizes the results for several flood event return periods.

**Table 3 – Flood Projection Analysis**

| Return Period | K | 06MA002 | 10UH001 | 10UH002 | 06OA001 | Post River |
|---|---|---|---|---|---|---|
| | | Flow Est. ($m^3/s$) | Flow Est. ($m^3/s$) | Flow Est. ($m^3/s$) | Flow Est. ($m^3/s$) | Average ($m^3/s$) |
| 1000 | 0.980 | 97.8 | 82.2 | 132.2 | 149.8 | 115.5 |
| 200 | 0.964 | 91.2 | 76.2 | 113.5 | 127.1 | 102.0 |
| 100 | 0.956 | 87.5 | 73.3 | 104.9 | 117.1 | 95.7 |
| 50 | 0.949 | 83.1 | 70.0 | 95.8 | 105.9 | 88.7 |
| 20 | 0.939 | 75.5 | 65.1 | 83.4 | 90.7 | 78.7 |
| 10 | 0.933 | 68.3 | 60.6 | 73.1 | 77.7 | 69.9 |
| 5 | 0.927 | 59.4 | 55.3 | 61.7 | 64.1 | 60.1 |
| 3 | 0.922 | 50.9 | 50.7 | 52.7 | 53.0 | 51.8 |
| 2 | 0.920 | 42.2 | 45.7 | 44.1 | 42.8 | 43.7 |

Once the peak flow was estimated, the Kirchoffer River hydrographs were reviewed to determine the shape and behavior of the Post River freshet hydrograph. It was noted that the Kirchoffer River freshet period spanned multiple days, often lasting more than three weeks (See Figure 4). The four years of available Kirchoffer River freshet flow data were graphed and the most critical hydrograph selected for the synthesis of the Post River freshet hydrograph. This synthetic Post River freshet hydrograph was later used in the PCSWMM hydraulic analysis of the Airport Road culvert system (See Figure 5).

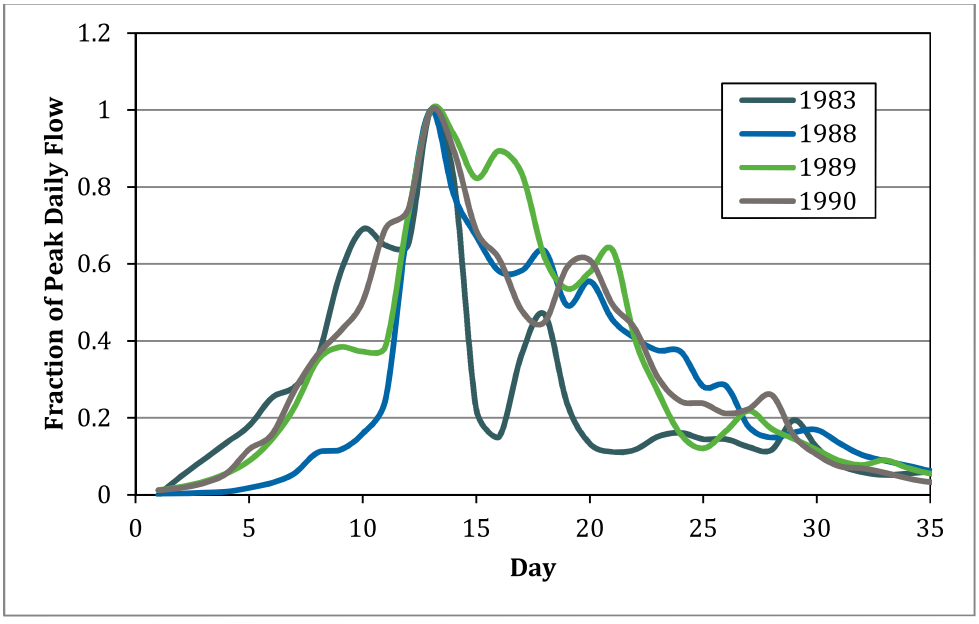


**Figure 4 – Typical Freshet Hydrograph**

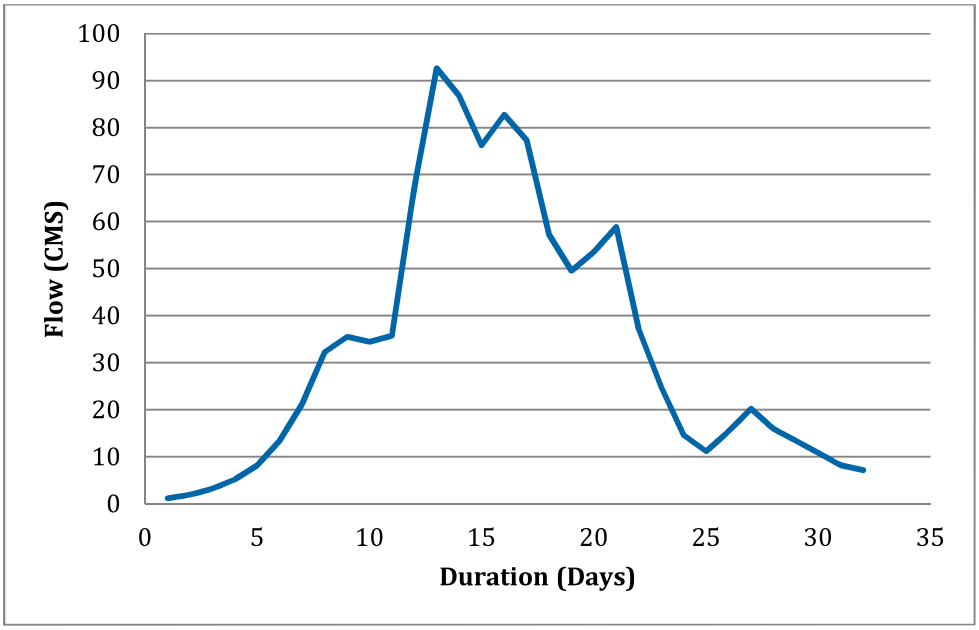


**Figure 5 – Synthesised Post River 100-Year Hydrograph**

## 3.0 HYDRAULIC ANALYSIS

For the purposes of the hydraulic analysis we reviewed the flood flow estimate of 126 $m^3/s$ developed in the report: *Airport Community Road Washout Coral Harbour, Nunavut – EBA 2013.* It is recognised that the statistical method used only estimated a peak flow of 95.7 $m^3/s$. The decision to complete the hydraulic analysis using the 126 $m^3/s$ was based on the recognition that the intent of this phase of the project is to develop conceptual options, based on limited data currently available at the construction site. In addition it is recognised that other factors have likely contributed to the washouts witnessed by the local residents. The frequency of the washouts (four in the last eight years) suggest that the flood frequency may not, in fact, be the sole source of the problem, but a component contributing to the overall issue. The more conservative estimate will inevitably help to lower the depth of water behind Airport Road, again helping the system to cope with the yearly freshet.

A schematic hydraulic model of the Airport Road outfall system was modelled using PCSWMM.

Preliminary results of the PCSWMM model conclude that the capacity of the existing culvert crossings and bridge is sufficient to meet the capacity requirements of the 100-year peak flow although it is estimated that the water depth behind Airport Road would be as deep as 2 meters. Based on the frequency of the washouts, we have again opted to propose a solution likely to lower the headwaters depths.

## 4.0 RECOMMENDATIONS

The Mayor of Coral Harbour reported that Airport Road has washed out four times in the last seven or eight years. Based on this remark, it would appear that the current infrastructure is incapable of handling even a 2-year return period flow. However, the hydrologic review of the Post River watershed predicts a 2-year flood flow of 43.7 $m^3/s$, which is only 55% of the maximum system capacity estimated in the report *Airport*

*Community Road Washout Coral Harbour, Nunavut – EBA 2013*. Although there are a number of possible reasons for this discrepancy, this review indicates that the most plausible reason may be the improper installation of the culverts during recent system repairs. It is suspected that the backfill may not have been properly graded, allowing the water ponding behind Airport Road to pipe through the backfill soils/gravels. This would have slowly weakened the structural stability of the crossings and could have eventually caused the washouts observed over the past few years. Although data collected this past June (June 2012) included significant total precipitation, this was not the case in previous years when washouts were observed (See Figure 6). Snowmelt is, typically, the major source of runoff for watersheds within this region.

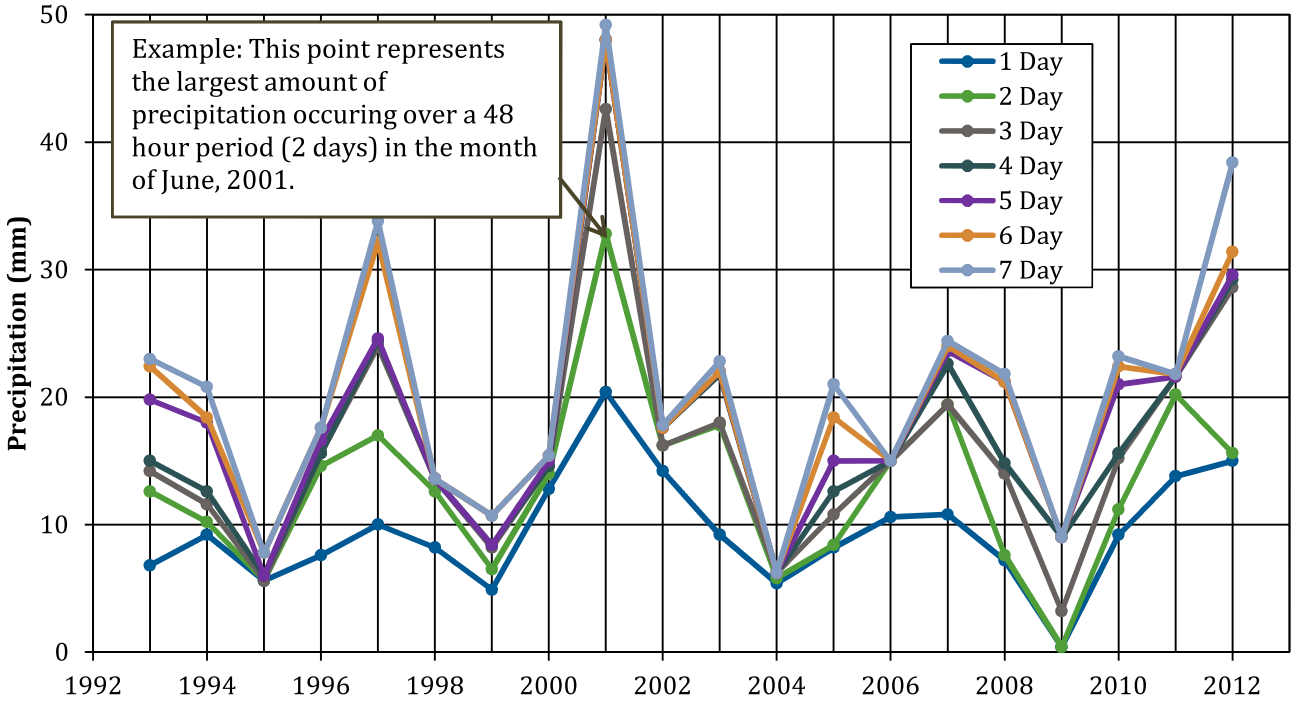


**Figure 6 – Maximum Precipitation over an X-Day Period in June, 1992 to 2012**

Although the Airport Road culvert crossings do meet the required capacity, we do agree with the recent report recommending increasing the capacity of the culvert crossings at Washout Locations 1 and 2. Increasing the culvert capacity will reduce the hydraulic head behind the road and further reduce the chances of failure.

To evaluate the potential reductions in hydraulic head three different scenarios were evaluated in PC-SWMM. The original estimate of 126 $m^3/s$ was used to develop a profile for the existing infrastructure. Again, this estimate, although high, may be warranted at this level of the assessment given the limited survey information and the absence of measurements of flows in the Post River.

Two preferred options for increasing capacity at Washouts 1 and 2 were then examined in the PC-SWMM model to estimate the headwaters depths acting on Airport Road:

- Option 4A: Install a 14 metre long Aluminum Structural Plate Box culvert, 6375 mm span x 1854 mm rise, at Washout Locations 1 and 2 (similar in design to the culvert shown in Figure 7).

- Option 4B: Install three 14 metre long Multi-Plate (Galvanized) Pipe-Arch Shape culverts, (2440 mm span x 1750 mm rise) at Washout Locations 1 and 2.

**Figure 7 – Closed Box Culvert**

It was concluded that both Option 4A and Option 4B provide similar reductions in hydraulic head of approximately 0.37 metres. The results of the modelling are presented below in Table 4.

**Table 4 – Maximum Observed Hydraulic Head**

| Option | 100-Year Flood Maximum Hydraulic Head (m) |
|---|---|
| Existing System | 2.07 |
| Option 4A | 1.69 |
| Option 4B | 1.70 |

During implementation, it is recommended that particular attention be placed on the construction methods and the material used as culvert backfill. The detailed design phase of the project should also include a detailed review of the substrate conditions and invert elevations of the remaining culvert crossings. Regular maintenance and inspection for possible ice jams should also be considered part of the long term solution to this issue.

# APPENDIX I
## CHANGE ORDER #1

EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company
Riverbend Atrium One, 115, 200 Rivercrest Drive SE
Calgary, AB T2C 2X5 CANADA
p. 403.203.3355 f. 403.203.3301

# TECHNICAL MEMO

ISSUED FOR USE

| | | | |
|---|---|---|---|
| **TO:** | Mr. Brian Duguay, P.Eng. - Acting Projects Manager<br>Department of Community and Government Services<br>Kivalliq Regional Project Management Office | **DATE:** | February 14, 2013 |
| **C:** | | **MEMO NO.:** | |
| **FROM:** | Lisa Ma, E.I.T.<br>Reviewed by: Brian Adeney, P.Eng.<br>Reviewed by: Bruce Johnson, C. Tech | **EBA FILE:** | C31103058-01 |
| **SUBJECT:** | Change Order #1 – Option IV | | |

## 1.0 INTRODUCTION

EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) prepared a report for the Airport Community Road Washout at Coral Harbour, Nunavut dated January 2013 for the Government of Nunavut, Department of Community & Government Services (DCGS). Within the Report, three options were considered.

Table 1: Three Options for Increasing Capacity of the Drainage Infrastructure at Coral Harbour

| | **Drainage Infrastructure at Washout 1 (Crossing 9)** | **Drainage Infrastructure at Washout 2 (Crossing 10)** |
|---|---|---|
| **Option 1** | Bridge With an Opening of 10m width and 2.5m Height | 4- 1500mm Diameter CMP Pipe |
| **Option 2** | 3 – 2400mm x 1800mm Concrete Box Culvert | 3 – 2400mm x 1800mm Concrete Box Culvert |
| **Option 3** | 6400mm x 1800mm Bridge Plate Box Culvert | 6400mm x 1800mm Bridge Plate Box Culvert |

In Change Order #1, DCGS requested EBA for additional engineering services to include an Option 4 for the Airport Community Road drainage rehabilitation. The work includes:

- Determining the sizing and number of metal pipe arch culverts at locations Washout #1 and Washout #2.
- Providing a Class D construction cost estimate for supply and installation of the metal pipe arch culverts.

## 2.0 HYDROLOGY

As part of this review, another method was looked at in analyzing the peak flow of the Post River Watershed (see the technical memo prepared by EBA in January 2013 in Appendix H). A flood frequency analysis was conducted using peak instantaneous flows using four existing Water Survey of Canada (WSC) hydrometric stations at the same latitude as Coral Harbour, and a correlation was completed to acknowledge the differences in basin geometry and sizing between the WSC stations and the Post River Watershed. The average of the four stations was taken and the 1:100 year flow for the Post River

Watershed was estimated to be 95.7 $m^3/s$. Typically, this type of extrapolation for different return periods is more accurate when extensive historical data is available (40 or more years). In contrast, for the 1:100 year flow, the hydrologic modelling methodology used in the EBA report *Airport Community Road Washout Coral Harbour, Nunavut – EBA 2013* calculated a peak flow of 126 $m^3/s$, and the methodology used in the *Route Location Southampton Island N.W.T. report - Airphoto Analysis Associates for the Department of Indian Affairs and Northern Development April 1971* calculated a peak flow of 99.1 $m^3/s$.

Given the uncertainties and assumptions in flow data at this point, possibility for ice impeding flow through culverts, the lack of historical data available (15 or less years), and changes since the 1971 report, the higher value of the three methods was used (126 $m^3/s$). Supporting this selection are the comments provided in the 2013 technical memo, pointing out to the frequency of the washouts suggesting that other factors may be contributing to the damages witnessed by the Coral Harbour community. Again, given the limited availability of data it was concluded that taking the more conservative approach would result in a more permanent and functional solution.

## 3.0 OPTION 4

Two proposed culvert sizes and types were offered for Option 4 within the technical memo prepared by EBA in January 2013 (see Appendix H):

- Option 4A - 6375 mm x 1854 mm aluminum structural plate box culvert at Crossing 9 and Crossing 10; and
- Option 4B - 3 – 2440 mm x 1750 mm Multi-Plate (galvanized) pipe-arch shape culverts at Crossing 9 and Crossing 10.

Both options were proposed because Option 3 had the lowest estimated Class D construction cost, but there were concerns with an open bottom culvert and concrete footings situated on permafrost ground, and potential for movement over time.

As for Option 3, Option 4A proposes a similar cross-sectional area for the crossings, but includes an aluminum invert plate spanning over the entire width of the culvert (See Figure 7 in Appendix H). The intent of "closing" the pipe along the bottom is to protect the crossing from scouring while helping to stabilize the culvert by distributing the loadings over the entire span. Additionally, it does not require concrete footings which may be difficult to source in Coral Harbour. While Option 4A proposes a more expensive all-aluminum product, the lighter weight will offset some of the constructability issues likely to arise during construction. The lighter culvert will allow the contractor to pre-assemble the entire culvert outside the trench. This in turn will help the contractor to meet quality requirements as well as expedite the installation phase.

Option 4B is the aluminized metal pipe arch option and also has a closed bottom.

Both Options will require assembly limiting the impact on the Airport Community Road. It is recommended that the contract specifications limit the closure of the road forcing the contractor to assemble the proposed culverts off-site. Each aluminum culvert for Option 4A culvert is approximately 7900 kg in total and each culvert for Option 4B is approximately 3500 kg. It is advised, at this stage, to confirm with the local contractors the capacity of the available equipment is on site, and the most efficient way of installing

the culverts to reduce the closure time of the Airport Community Road. Some of the available equipment on site includes an excavator, dozer, wheel loader, grader, and double axel tandems. Assembling the culvert in the open trench would close the Airport Community Road for a number of days.

## 4.0 CONSTRUCTION COSTS

The Class D construction costs were calculated for Option 4A and 4B after contacting a metal culvert manufacturer, Armtec (see Table 2 below).

Table 2: Proposed Option 4 for the Drainage Infrastructure at Coral Harbour

| | Drainage Infrastructure at Washout 1 (Crossing 9) | Drainage Infrastructure at Washout 2 (Crossing 10) | Estimated Construction Cost (Includes 35% Contingency) |
|---|---|---|---|
| **Option 4A** | Aluminum Structural Plate Box Culvert (6375mm span x 1854mm rise) | Aluminum Structural Plate Box Culvert (6375mm span x 1854mm rise) | $800,000 |
| **Option 4B** | 3 - Multi-Plate (Galvanized) Pipe-Arch Shape 2440 span x 1750 mm rise | 3 - Multi-Plate (Galvanized) Pipe-Arch Shape 2440 span x 1750 mm rise | $520,000 |

The preliminary construction cost assumes the following:

- This cost estimate is prepared for 2013 planning and budgetary purposes only and is based on concept designs, and does not constitute a guarantee on the project cost. The actual cost will be determined by the detailed design, tendering and construction processes.
- Preliminary material selection (See attached for manufacturer information). Material and sizing selection is preliminary and will need to be confirmed during final design. Factors that will change the material selection include traffic loading, existing soil conditions, etc. Option 4A assumes that the minimum allowable soil (foundation) bearing pressure of 4000 psf (200 kPa) can be met with existing conditions.
- Prices for supply and installation of culverts were based on a breakdown of 40% labour and 60% materials.
- Rip rap assumed for inlets and outlets. Additional cost has been assumed within the contingency cost for cut-off collars, headwalls, etc.
- Construction in permafrost conditions will need to be considered during detailed design. Piles for the culverts may be required, and should be investigated within a geotechnical study. A geotechnical study is recommended during the detailed design.
- A local supply of acceptable granular material, granular bedding, and rip rap is available on site (quarry of new material not required).
- No road build-up was assumed and the existing grades on the Airport Community Road were assumed adequate to provide a minimum depth of cover for the new pipe culverts. Topographic survey for road, adjacent area, and culvert inverts is recommended prior to initiating the detailed design.

- Option 4A includes 300mm of granular bedding material along the entire footprint of the invert plate.
- Option 4B includes a 1m separation between the culverts, and a 2 m clearance at the two ends. The culverts include 500mm of granular bedding.

# 5.0 RECOMMENDATIONS

Recommendations from the EBA report *Airport Community Road Washout Coral Harbour, Nunavut – EBA 2013* still apply. In particular:

- Since the Hamlet of Coral Harbour is in the region of continuous permafrost, specific considerations will have to be given to designing these infrastructures. The construction cost may be higher depending on the depth of embedment, sub-excavation of frost susceptible material, etc.
- A geotechnical study is recommended to better understand the in-situ conditions and types of granular material which may be available on site.
- A topographic survey of the road and pipe culverts and bridge structures is recommended to better understand the slopes of the pipe, amount of granular material required, and drainage along the road. Depending on the detail of survey required, the cost is estimated to be approximately $30,000 .
- The existing culverts on site do not have rip rap around the inlets and outlets. Consideration for this should be investigated to prevent scouring at these areas.
- Since all options discussed involve increasing the flow of water at washout areas 1 and 2 and there is a fuel pipeline downstream of the washout 2 area, an energy dissipater structure such as rip rap may be required adjacent to the fuel pipeline to control the velocity of the water.
- A real time flow monitoring system during snow melt season is recommended to be installed and the flow data should be used for model calibration prior to construction of the proposed culverts. This information would be important for a re-evaluation of the hydrological and hydraulic analysis during detailed design. EBA has a group of experts dedicated to flow monitoring, and has completed multiple projects including installations in very remote areas throughout Canada.