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Dear Brett:

**Project No: 60160515**

**Regarding: Former Clinton Creek Asbestos Mine - Site Inspection on 23 August, 2010**

**Background**

The Clinton Creek drop structures and channel at the outlet of Hudgeon Lake were inspected as part of the Long Term Performance Monitoring program at the mine site on 20 July, 2010. At that time, the structures were found to be in good condition and no significant changes were observed in the Clinton Creek channel through the waste rock dump downstream of the structures.

Dawson District Renewable Resource Council (DDRRC) members who tried to reach the Clinton Creek area on Monday 9 August reported that streams were flowing at high levels and a slide blocked the access road. During a subsequent ground inspection along the access road, by Al von Finster on Wednesday 11 August, several slides were found and one developed during the time of the ground inspection. Based on the field observations, it was concluded that a major precipitation event had taken place in the Clinton Creek headwaters.

As a result of the reported events at the Clinton Creek access road, Brett Hartshorne of Yukon EMR Assessment and Abandoned Mines conducted a site reconnaissance by helicopter on Thursday 19 August, 2010. During the inspection it was noticed that the channel downstream of the structure had eroded significantly and Drop Structure #4 (the drop structure farthest downstream) was severely undercut. The step drop portion of the structure appeared to be reasonably intact while the downstream apron had bent down and was hanging at a steep angle. The sacrificial apron downstream of the structure apron was gone.

During a conference call in the afternoon of Thursday 19 August, the observed damages were discussed and it was decided that a formal field inspection of the structures was required. The conference call was attended by Brett Hartshorne and Frank Patch (both of Yukon EMR Assessment and Abandoned Mines) and Ken Skaftfeld, Gil Robinson, Andrew Smith and Rolf Aslund (all of AECOM).

On Monday 23 August 2010, Brett Hartshorne and David Barrett of Yukon EMR Assessment and Abandoned Mines and Andrew Smith and Rolf Aslund of AECOM (Edmonton) inspected the drop structures on Clinton Creek. The site was reached by helicopter from Dawson City. During the site inspection, Brett Hartshorne and David Barrett concentrated on the area away from the structures while Andrew Smith and Rolf Aslund concentrated on the drop structures, the channel between the structures and the channel immediately downstream of Drop Structure #4.

**Field Observations**

At the time of inspection the flow was approximately 0.2 m deep over weir crest gabions, which made it necessary to wear hip waders when crossing the structures.

**Hudgeon Lake**

- HWMs (High Water Marks) observed on the shore to the right of the lake outlet. The HWMs were in the form of duff deposits, bent grass and sediment deposition at the ford.
- The duff deposition HWM on the lake shore was surveyed and found to be at Elevation 412.54 m

**Drop Structure #1 (at lake outlet)**

- Driftwood and tree trunks have accumulated on the weir crest and have trapped a floating mat of duff.
- No significant gabion damage was seen.
- No evidence of flow by-passing the structure was seen.

**Drop Structure #2**

- Weir crest was generally free of driftwood. One larger piece of driftwood on the left side slope of the crest and one tree trunk on the steps on the right side. Minor driftwood deposited on the left apron side slope.
- No significant gabion damage was seen.
- No evidence of flow by-passing the structure was seen.

**Drop Structure #3**

- One tree trunk was seen floating in the water and stuck on the left half of the weir crest. One tree trunk caught on the right side slope of the weir crest. Minor debris deposition on the steps on the left side. Two larger pieces of driftwood caught on the steps on the right side slope. Minor driftwood deposition on the left apron side slope.
- No significant gabion damage was seen.
- No evidence of flow by-passing the structure was seen.

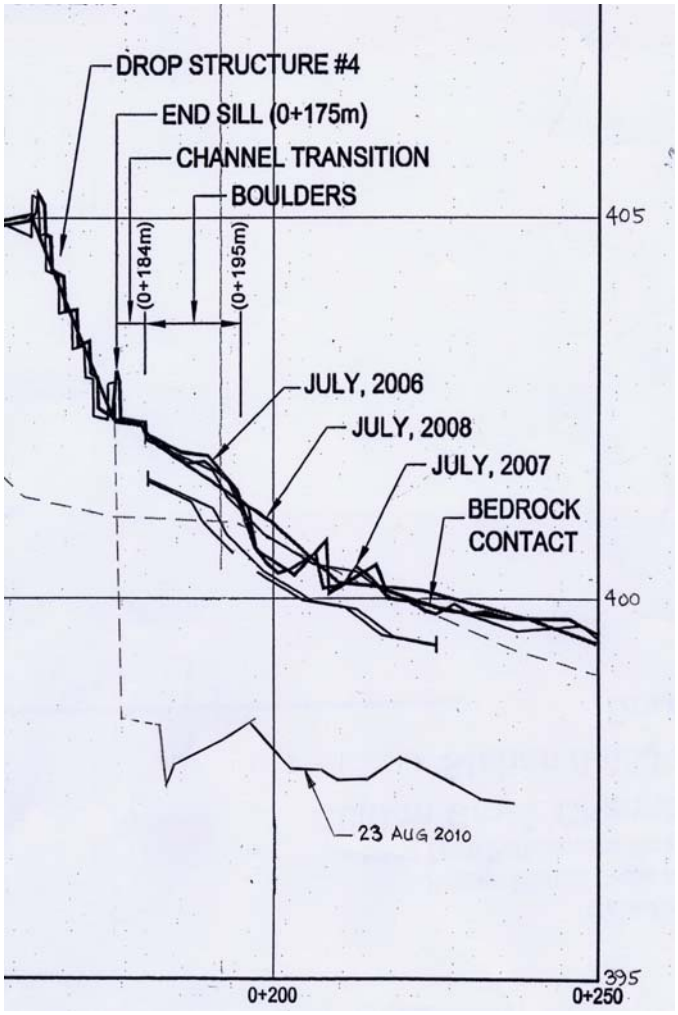
**Drop Structure #4 (farthest downstream)**

- No significant driftwood deposition on the weir crest. A couple of smaller pieces of driftwood caught on the left and right side slopes of the steps.
- No significant damage to the gabion steps was seen.
- Immediately downstream of the structure, the channel has degraded 4-5 m and undercut the structure apron. The undercutting extends to approximately 1-2 m downstream of the original lowest step. The material observed under the now hanging gabion apron appeared to consist of waste rock material that was surprisingly dry – minor seepage were observed in a few isolated spots. The 1-2 m of the apron closest to the original lowest step appeared to be supported by waste rock material.
- The water flowed over the relatively intact step drop portion of the structure and then flows down the hanging gabion apron portion to then drop down to the new creek bed level. It was suggested that this may now be the highest waterfall in Yukon.
- A plunge pool has developed where the water drops from the apron. The pool spans the full width of the original channel and the water depth was close to a metre deep.

- On the left side of the channel, a short distance downstream of the structure, the erosion has generated what appeared to be a one metre high vertical fractured rock face.
- The waste rock side slope along the right side of the Clinton Creek channel, between Drop Structure #4 and the old ford, is very steep and is currently unstable. The access road is washed out in places and, in places, tension cracks were seen in the middle of remnants of the former access road. Given that the waste rock side slope towards Clinton Creek is currently unstable in many places, I believe it is not advisable for any vehicles to travel along the existing access road across the waste rock pile during current conditions. Due to the washed out waste rock side slope, the theoretical stable slope from the current creek bed level may now extend to the top of the waste rock pile. Therefore it may not be possible to reconstruct the access road along the existing alignment of the access road and a completely new route across the top of waste rock pile may have to be selected.
- There are a large number of boulders in the channel immediately downstream of the structure. While it cannot be verified, it is believed that some of these boulders were part of the boulder field that was placed downstream of the structure in the past to (a) increase the tailwater level and (b) to reduce the risk of channel bed and bank erosion progressing up to the structure. The lack of high tailwater downstream of the structure has always been a concern.
- The bed profile of the channel immediately downstream of Drop Structure #4 was surveyed to get a better understanding of the current conditions. The surveyed profile is listed in the table below and plotted in the following figure.

| STA | Elevation (m) |
|---|---|
| STA 0+182 | 398.34 |
| STA 0+183 | 397.53 |
| STA 0+184 | 397.83 |
| STA 0+192 | 398.17 |
| STA 0+196 | 398.36 |
| STA 0+202 | 397.79 |
| STA 0+207 | 397.74 |

| STA | Elevation (m) |
|---|---|
| STA 0+210 | 397.63 |
| STA 0+214 | 397.62 |
| STA 0+219 | 397.93 |
| STA 0+222 | 397.81 |
| STA 0+227 | 397.61 |
| STA 0+232 | 397.35 |
| STA 0+237 | 397.32 |




**Channel between Structures**

- Along the left channel side slope, bank erosion has occurred along the un-armoured portions of the channel between the drop structures. The erosion is more severe downstream of Drop Structure #1, most likely due to the flow concentration along the left side that is caused by the curve in Drop Structure #1.
- Along the right channel side slope, the general bank erosion is similar to that along the left side. Immediately upstream of Drop Structure #3, the bank erosion is locally severe and resembles slumping.
- To assess the channel bed material, and attempt was made to wade across the channel with hip waders but this was not possible due to the large water depth. However, it was noticed that the channel bed was firm and rocky and no sediment deposition was detected.

**Proposed Protection of Drop Structure #4**

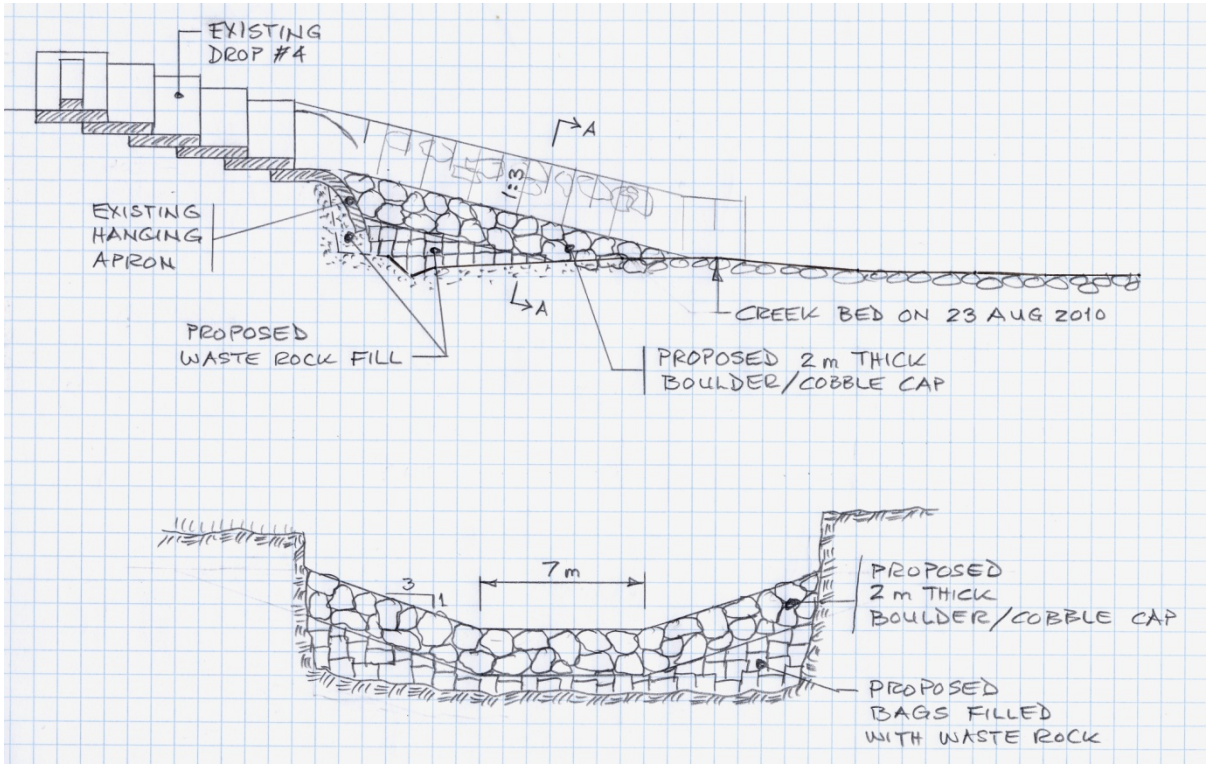
Drop Structure #4 has to be protected from total failure, to prevent a complete washout of the stabilized channel reach. At the moment, the upper portion of Drop Structure #4 is functioning well and the hanging apron protects the fill under the structure from erosion by flowing water.

Downstream of the structure, the channel bed is 4-5 m lower than before the recent flood event. There are a large number of boulders immediately downstream of the structure. The sizes of these boulders are indicative of the size of boulders that are required to resist the flood flow that occurred. As the upper portion of the structure is functioning well, that part of the structure shall be secured in place. To convey the flow from the original apron level and down to the current creek bed level, a channel transition has to be constructed. The material used in the transition has to be able to withstand the flow velocities that will occur and these velocities are a function of the channel bed slope; the steeper the slope the larger the size of the material required. In this case, the material has to be large in size to be able to have the bed slope of the transition intersect the downstream channel bed over a short length.

The proposed primary material consists of angular boulders with a diameter of approximately one metre. Concrete lock-blocks were considered as an alternative but these units are inferior to angular boulders, as they do not have the same inter-locking characteristics due to their smooth sides. To fill the voids between the boulders, it proposed that a mix of smaller boulders and cobble-sized material (such as riprap screening reject material) and waste rock material be dumped on the boulders during the construction.

The proposed transition should be constructed a steep trapezoidal channel with a bed width of 7 m, 1:3 (V:H) side slopes and a bed profile slope no steeper than 1:4 (V:H), which is the profile slope of the step drop portion of the current structure. If sufficient quantities of boulders can be secured, The eroded area was estimated to be approximately 22 m wide. Using this width and an estimated 5 m height at Drop Structure #4, the required quantity of fill was estimated for different channel profile slopes. It was found that the required volume of fill was significant and it may be difficult to find that quantity of boulders in the area.

As an alternative to using only boulders and cobbles as fill, the proposed transition was revised to have a 2 m thick lining of boulders and cobbles placed over common waste rock material. As it would be difficult to place the waste rock material in the flowing water, it is proposed to use large geosynthetic bags that are filled with waste rock material that are then placed by a crane in the water to build up a base. As the flow is slowed down by other filled bags, loose waste rock can be dumped to fill the voids between the bags before the next layer of waste rock filled bags is placed.




When the layers of waste rock filled bags are placed, the space between the upstream bags and the remnants of Drop Structure #4 will be filled with loose waste rock material. The placement of filled bags shall be placed to a level that is 2 m below the finished trapezoidal channel cross-section. To increase the stability of the stacked waste rock filled bags, it may be advisable to place geogrid between each layer of bags. The trapezoidal channel section would be capped with a 2 m thick layer of boulders and cobbles.

Using an estimated eroded channel top width of 22 m and an estimated 5 m height at Drop Structure #4, the required quantity of fill was estimated for different channel profile slopes. The estimated quantities are summarised below.

| Bed Slope (V:H) | Waste Rock ($m^3$) | 2 m Boulder Cap ($m^3$) | Total Volume ($m^3$) |
|---|---|---|---|
| 1:4 | 630 | 870 | 1500 |
| 1:5 | 790 | 1100 | 1890 |
| 1:6 | 940 | 1300 | 2240 |
| 1:7 | 1100 | 1520 | 2620 |

Large boulders may be available from the old Porcupine Waste Rock dump although an access trail may have to be constructed to reach that location. Otherwise it may be necessary to pick through the waste rock material in the Clinton dump.

The need for protection of Drop Structure #4 is urgent, as it is possible that the structure may fail during next year's freshet. That would most likely lead to a sequential failure of the channels and structures upstream of Drop Structure #4 that could cause a rapid draw-down of Hudgeon Lake.

Sincerely,
**AECOM Canada Ltd.**

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