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McElhanney TECHNICAL MEMORANDUM

MD of Bighorn Pigeon Mountain Backflooding Assessment	Feasibility of Lowering Heart Mountain Drive
Date:	August 10, 2015
Our Reference:	2531-24004-00

To: **Bill Luka**, Director of Operations
MD of Bighorn

From: **Kyle Gomke**, EIT, Project Engineer
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1.0 Introduction

McElhanney was retained by the MD of Bighorn to review the feasibility of lowering the grade of asphalt on Mt. McGillivary Drive and Pigeon Mountain Drive. The existing slopes on these roads are approximately 0.6% and ponding occurs on Pigeon Mountain Drive due to the low grade. These roads are connected to Heart Mountain Drive therefore the intersections with this road would be lowered as well.

The proposed road lowering would also change the cross-sloped roads to ones with centre-swales. The swales would help collect runoff from adjacent properties and direct it towards Heart Mountain Drive which would provide a higher level of service than the present conditions. Lowering these roads would also create a trap low at the south end of Pigeon Mountain Drive so the feasibility of a pumping station is discussed as well as the challenges of managing runoff in this area.

2.0 Discussion

2.1 Elevations Adjustments

To ensure positive drainage from individual lots to Heart Mountain Drive, both streets must be paved at a minimum slope of 2%. Slopes of less than 2% are not practically achievable by paving contractors except in certain situations. One of these situations is a crowned road with curb and gutter on both sides. The curb and gutter could be set at a minimum slope of 0.5% and the pavers would pave up to the concrete. Since the road is crowned, runoff would flow to the curb and gutter and down the street. Another situation is for centre-swaled roads where a concrete swale could be constructed down the middle of the road at a minimum slope of 0.5% and the road would be paved up to the edge of the swale. It should be noted that setting concrete forms at 0.5% over the length of these streets would require a high level of inspection during construction to ensure the final product drains without creating ponding issues.

ATTACHMENT #4

At the north end of Mt. McGillivary Drive, the existing concrete sidewalk is at an approximate elevation of 1289.00m. For a centre-swaled road, road elevation at the north end of McGillivary would need to be 1288.82m at the centre. This elevation would provide a 2% from the property lines at the north end of McGillivary to the centre of the road. The elevations at the ends of each street depend on the slopes used in design and the table below shows the resulting elevations at the end of Mt. McGillivary Drive and Pigeon Mountain Drive.

Location	Street Elevation @ 0.5%	Street Elevation @ 1%	Street Elevation @ 2%
North End of McGillivary	1288.82m	1288.82m	1288.82m
South End of McGillivary	1287.98m	1287.15m	1285.48m
South End of Pigeon	1287.50m	1286.18m	1283.54m
North End of Pigeon	1288.15m	1287.48m	1286.14m

In 2009, standpipes were installed in a few places around Exshaw during geotechnical testing. In March 2009, the groundwater level was 1285.59m east of the existing sanitary lift station and 1285.84m at the north end of Pigeon Mountain Drive. If the groundwater is close to these levels, it would mean that lowering the roads and their intersections with Heart Mountain Drive would lower the roads into the groundwater table. As well, March may not be the lowest month for groundwater levels as it is before the freshet and groundwater levels can be expected to raise through the spring months. Therefore groundwater levels higher than those reported here should be expected.

If it were possible to achieve 1% slopes on these roads without concrete curb & gutter, the resulting elevations should be higher than the groundwater tables, however, the resulting elevation at the south end of Pigeon Mountain Drive would be approximately 0.5m below the inverts of the culverts running under the 1A Highway which is approximately 1286.70m. Other issues with lowering the roads would involve the shallow and deep utilities in the area. All shallows would need to be exposed and potentially lowered by their respective utility company. Additionally, there are water and sanitary mains running under each of the roads. Lowering the road grades would require checking the mains to determine whether they need to be insulated. If the mains were buried at a minimum depth of cover, all water and sanitary mains may need to be retrofitted with insulation.

Using the minimum grade of 0.5% with concrete swales would also lower the roads and the elevation of the south end of Pigeon Mountain Drive would be approximately 0.70m above the inverts of the Highway 1A culverts. The resulting grade from the intersection, through the Highway 1A berm and to the 1A culverts would be approximately 0.5%. As discussed below, this option would create a trap low at the south end of Pigeon which would need to be addressed.

For the subsequent discussions, it is assumed that the roads would be lowered so that there is 0.5% or 1% slope on the roads and the elevations shown in the table above were achieved through paving alone, or with the concrete swales.

2.2 New Trap Low at Pigeon Mountain Drive

If the streets are lowered, the resulting road elevation at the intersection of Heart Mountain Drive and Pigeon Mountain Drive would be lower than the current low point in the area, which is near the existing sanitary lift station. The low point in this area is approximately 1287.25m. The Pigeon intersection would therefore become the new low point for overland runoff in the area and runoff from the lift station area would flow back to the intersection to pond, if the roads were graded at 0.5%. If the roads were graded at 1.0%, the intersection would be 0.25m above the ground elevation at the lift station. The existing culverts under Heart Mountain Drive that direct runoff to the 1A Highway ditch have an outlet invert of 1286.95m in the Highway 1A ditch. Since the Pigeon intersection would be lower than this elevation, the culverts would not provide positive drainage from this area. However, using a grade of 0.5%, the culverts would remain usable.

The new trap low at Pigeon Mountain Drive and Heart Mountain Drive would potentially create much ponding. Whereas existing conditions allow runoff to slowly flow to the Bow River, the new low area would collect all runoff at the Pigeon intersection where it would pond until it can spill to an adjacent location, or until it can be moved away from the area by another means. Since there is practically no room for a stormwater management facility in this area, the actual low point (and trap low) would have to be shifted to the east towards the sanitary lift station where the ponding can be managed. The spill location is a very important consideration and it would be designed based on ponding depths. In the City of Calgary, a maximum depth of 0.5m is specified for trap lows. At a depth of 0.5m, the spill location would likely be a notch in the existing Highway 1A berm with a maximum elevation of 1286.68m which is approximately the same as the inverts of the 1A culverts. As ponding exceeded 0.5m, the trap low should spill and slowly drain to the Bow River. In June 2015, the elevation of the Bow River was 1285.70m at the outlet of the Jura Creek culverts running under Diamond Drive. This elevation implies that the receiving water body is approximately 0.98m below the proposed spill elevation at south end of Pigeon Mountain Drive. The resulting slope from Pigeon Mountain Drive, through all the culverts and to the Bow River would be 0.3% which assumes straight channels between the culverts.

For ponding depths under 0.5m, there is no minor system to collect the runoff and one would need to be designed. A piped system is impractical in this instance because of the large cost of installation and more importantly, there is no receiving waterbody to pipe the runoff to because the groundwater table is so high in this area. There are two other options for a minor system and these are discussed in the following sections.

2.2.1 Infiltration Facility

As discussed in the Exshaw Stormwater Management Plan, an infiltration facility near the existing sanitary lift station would allow runoff in this area to infiltrate into the ground and follows with stormwater best management practices. However, if the roads are lowered then the groundwater levels in this area may be so close the ground elevation that infiltration facilities would not provide a high level of service or may not be capable of infiltrating the amount of runoff in the area. If this option is to be considered, the groundwater levels in this area need further study to determine the mean groundwater levels and whether this type of facility can be used if the local roads are lowered.

2.2.2 Pumping Station

To drain the trap low in this area, a pump station could also be considered. This option is advantageous as the pump could be sized for a very intense storm and may be able to pump faster than an infiltration facility can infiltrate runoff. However, it is possible that Exshaw experiences a storm event large enough that the system cannot pump water fast enough. In that case, the pond would reach a depth of 0.5m and then spill into the overland spill route. If the spill route cannot drain runoff from the area fast enough, the flooding may become much worse.

An important consideration with a pumping station is the location where the water will be pumped to. If runoff is pumped over the berm that separates Jura Creek, Heart Mountain Drive and the 1A right-of-way, the 1A ditch may flood. If the pumping rates are low enough, the 1A culverts and the spill route to the Bow River will drain runoff from this area. However, as noted, the spill route is approximately 0.3% which means that under intense and high-volume storms the spill route would surcharge and the ponding in the 1A ditch could travel west and up the ditch towards the Legion and spill back onto Heart Mountain Drive.

The reliability and redundancy of a pumping station is very important. A pumping station would be the first and last resort to drain runoff from this area. Although the primary system would be electrically powered, a backup diesel generator with an appropriate amount of reserve fuel would need to be stored at all times. The amount of reserve fuel may be a couple of days or longer than a week, depending on the design requirements and likelihood of a prolonged power outage.

3.0 Conclusions

Based on the discussion above, the following can be concluded regarding the feasibility of lowering Mt. McGillivary Drive and Pigeon Mountain Drive.

- Lowering the roads so there is 0.5% slope down each street and constructing concrete swales is more feasible than using steeper grades because there is less chance of encountering groundwater. However, this option would be much more expensive than using steeper grades because approximately 300m of concrete swale would need to be constructed as well as the complete removal, re-grading and paving of each of the streets. This option is considered feasible and the approximate cost to implement would be approximately $650,000.
- Lowering the roads so there is a 1% slope is not practically achievable and the resulting road elevation at the intersection of Pigeon Mountain Drive and Heart Mountain Drive would be at or near the groundwater level during part of the year. The option would be considered feasible if the 1% grades could be achieved and if there are no groundwater issues.
- Lowering the roads so there is a 2% slope would provide positive drainage, however, the intersection of Heart and Pigeon would be approximately 1283.54 which is over 2m below the level of the elevation of the Bow River in June 2015 in this area. As well, if the ground water level under Pigeon Mountain Drive is influenced by the Bow River, an artesian well may be created at the Pigeon and Heart intersection as the river level would be higher than the road elevation during part of the year. This option is not considered feasible.
- Lowering the roads would require a pump station to be constructed as no other practical solution exists to drain the trap low at Pigeon Mountain Drive and Heart Mountain Drive.

However, there is no receiving waterbody to pump runoff to, without the risk of it flowing back to the source. Pumping over the berm to the 1A highway may be effective during small storms, however, during events with large amounts of runoff, the entire 1A ditch could pond and back flood up the ditch to the Legion.

- The pumping station would need a high level of redundancy since the consequences of a system failure during a large storm may result in flooding properties. As well, constant preventative maintenance would be required all year to ensure the system is reliable. A pump station would be a feasible option if the risks of failure are acceptable, as well as the capital and maintenance costs of the system.

4.0 Summary & Closure

Lowering the street elevations of Mt. McGillivary Drive and Pigeon Mountain Drive so slopes are greater than 0.5% is not considered feasible. The resulting elevation at the intersection of Pigeon and Heart Mountain Drive could be at, or below the groundwater level, or even the level of the Bow River. As well, the lowest point in the area would be around the Pigeon and Heart intersection ensuring this area would always flood during storm events and therefore requires a spill route. Although the costs have not been fully explored, a pumping station requires maintenance and redundancy whereas a gravity system requires very little annual maintenance and does not cost money to operate under normal conditions. Lowering the roads to 0.5% and installing concrete swales would be considered feasible and the existing culverts under Heart Mountain Drive should remain usable in this option.

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