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TECHNICAL MEMORANDUM

Date: February 18, 2019
To: James Kay
City of Kelowna
Re: Slope Instability - 2045 Loseth Road
Questions for Discussion with Westrek

1 Introduction

This memo answers questions raised in the teleconference on February 15, 2019 regarding the slope instability below the pump station at 2045 Loseth Road. The questions pertain to issues raised in the report by Westrek Geotechnical Services Ltd. (Westrek) titled “*Geotechnical Investigation – 2045 Loseth Road*”, dated January 24, 2019.

This memo is subject to the terms and conditions set out in the *Interpretation and Use of Study and Report and Limitations*, which is attached in Appendix A of the referenced report.

2 Answers to Questions Raised Prior to Meeting

Question 1: Can you provide a drawing showing an aerial view of the fill areas?

Answer 1: The approximate area of fill delineated by drilling and site observations is shown on the attached map.

Question 2: Further clarification on the risk to BMID Pump Station – At page 20 of the report there are statements that “the probability of a landslide affecting the pump station is high” and “[t]he pump station is at risk of settlement resulting from a slope failure”. Is the risk to the pump station from a failure of the slope(s) below a matter of settlement at worst, or is there a potential for a loss of the pump station?

Answer 2: The factor of safety of a slope failure capable of reaching the pump station is very close to 1.0, meaning a failure directly impacting on the pump station is likely. However, a more likely scenario is that the slope fails back to roughly the existing tension cracks, 2 to 2.5 m from the building, creating a near-vertical headscarp. Significant settlement and subsequent retrogressive failures would severely impact on the pump station shortly after the initial slope failure.

Question 3: With respect to the imminent hazard that is referenced as expected to develop [page 26, point ii], is it possible that the hazard will not increase to imminent probability but that there is no way of knowing at this time whether that will be the case?

Answer 3: The slope may continue to simply creep downslope, which would eventually result in an over-steepened headscarp as discussed in Answer 2. However, given the amount of movement during spring 2018, a sudden and catastrophic failure is the more likely outcome.

Question 4: Taking into account the conditions in the intervening 3 weeks since the report, can you say anything as to the timing in progression from high/very high probability to imminent risk of a landslide? In other words, is Westrek's recommendation that mitigation steps should be commenced as soon as possible, or is there an interim period where no action is required?

Answer 4: Slope stability is expected to deteriorate quickly once snow melt begins and groundwater pressures rise. Once significant movement is observed, there will likely not be sufficient time to mitigate the risks, other than evacuating the residences below and shutting down the pump station. Failure could also occur catastrophically, and without significant warning to the City of Kelowna (the City) or Black Mountain Irrigation District (the BMID).

Question 5: Is there any basis for distinguishing between the timing for initiating mitigation works on the slope above 2001 Kloppenburg Ct and the slope below the pump station on 2045 Loseth?

Answer 5: No. The slope on 2045 Loseth poses a greater hazard (i.e. failure is more likely), but the consequences of a failure above 2001 Kloppenburg Ct is greater due to the house at the toe.

Question 6: Following on the above, can the slopes be mitigated separately? Or must the mitigation work be co-ordinated?

Answer 6: No. It is better to mitigate the slopes together. Separate mitigation works could cost more and limit access to the other site.

Question 7: Given the tension cracks immediately north of the pump station and (apparently) within the statutory right of way area, does the mitigation work plan include work within the SRW area itself (and which perhaps should be directed to BMID)?

Answer 7: Yes, the toe buttress option includes either flattening the upper slope within the SRW or construction of a short GRS wall to stabilize the upper slope.

Question 8: Is there a benefit in attempting to cut off groundwater before it enters the unstable slope material? Any ideas how this might be done?

Answer 8: Yes, there would be some benefit; however, see the answer to Question 9. Source control likely requires eliminating in-ground stormwater disposal upslope. A deep drain would be very challenging because of the concentration of underground services beneath Loseth Road. Gravity drainage would be needed and the original gully is 11 m deep, requiring a very deep drain. However, this could be explored further, if required.

Question 9: What is the difference in the safety factors between the saturated and unsaturated slope?

Answer 9: The fill slope is just marginally stable when dry, and does not meet any standards for slope stability. We have not monitored the piezometers through a spring yet, so we do not know how high groundwater levels rise, but they do not have to rise much to trigger slope movement.

Question 10: BH18-06 showed quite a bit of variation in groundwater elevation and was very responsive to precipitation events. Was this observed in other boreholes as well?

Answer 10: We have not monitored through spring yet. To date, the only piezometers to measure any groundwater pressures are in BH18-01 and BH18-06. As noted, BH18-06 measured much greater fluctuations in water level than BH18-01. Some of the other piezometers may measure similar variations in the spring.

Question 11: Were groundwater levels ever shown to be higher than the potential failure surface in any of the boreholes?

Answer 11: Not to date. However, none of the instrumentation has been monitored through spring. Not only are groundwater levels expected to rise, the SI's have not all definitively measured the depth to the slip surface.

3 Additional Items Raised During Meeting

Monitoring Frequency

The monitoring frequency has been monthly over the winter but will increase gradually into spring. Weekly readings are expected by the end of April; twice weekly readings, if movement is detected, or even daily if movement is significant.

Consideration by the City could be given to establishing real-time monitoring of the vibrating wire piezometers to establish when the SI reading frequency should increase. This could be achieved by connecting the existing dataloggers to a wireless system. Westrek can assess the costs for the additional equipment.

Next Step

Pending the City's approval, Westrek will work with the City's engineers to develop a grading plan for the proposed slope buttress option. We will assess options to refine the buttress, including extending the fillslope farther downslope to eliminate the GRS wall along Cross-section A-A' and reducing the size of the level area at the crest of the slope.

4 Closure

We trust these answers will assist the City staff in their presentation to council. Please contact us if there are any other questions raised during the council meeting.

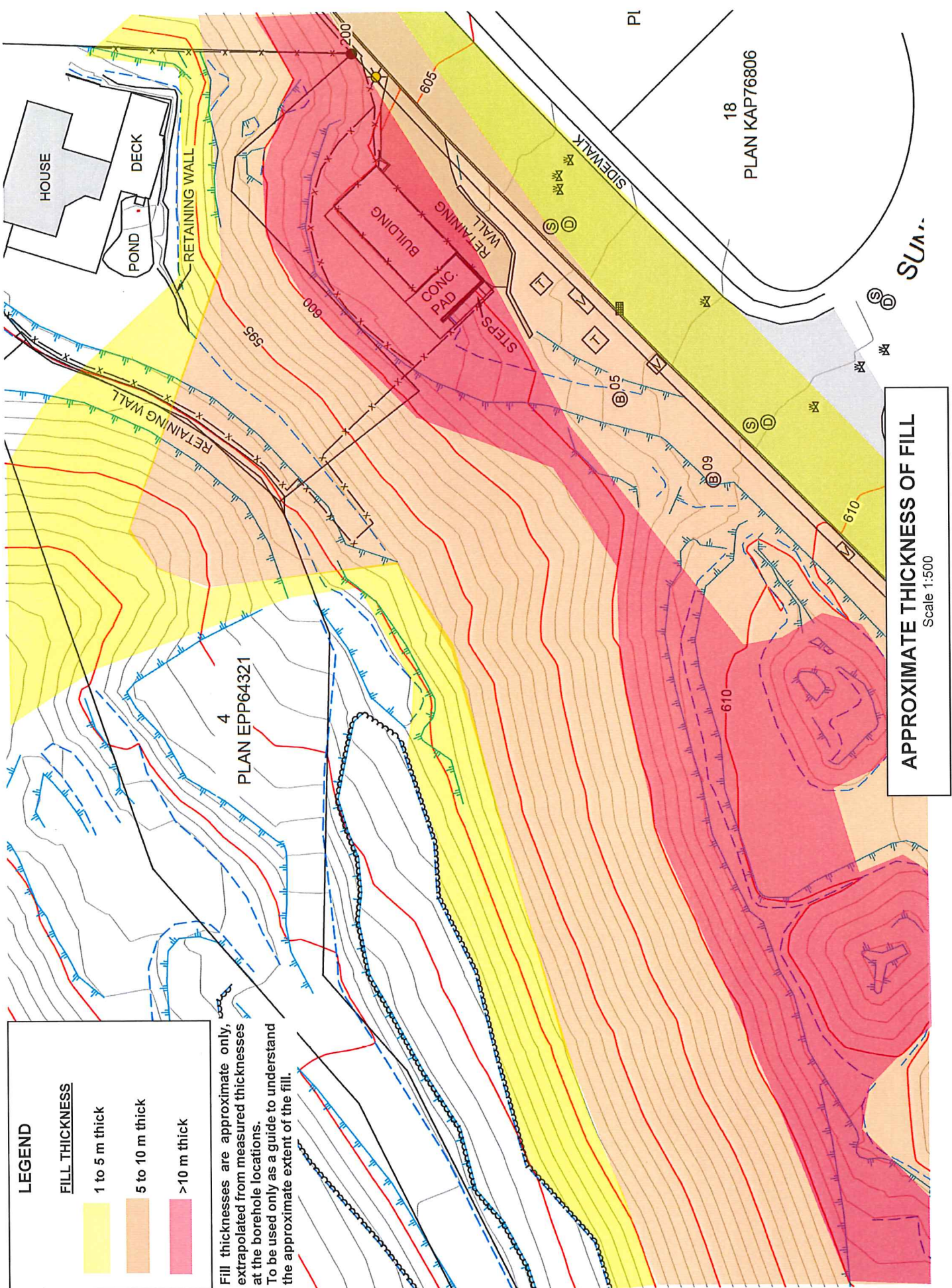
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Attachment: Map of Fill Area



LEGEND

FILL THICKNESS

- 1 to 5 m thick
- 5 to 10 m thick
- >10 m thick

Fill thicknesses are approximate only, extrapolated from measured thicknesses at the borehole locations. To be used only as a guide to understand the approximate extent of the fill.

APPROXIMATE THICKNESS OF FILL

Scale 1:500