TECHNICAL MEMORANDUM

DATE June 13, 2014 **REFERENCE No.** 091-416-0004/4000

TO Don Chorley

CC Alan Calder

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GEOTECHNICAL ASSESSMENT
RISK OF PIPING DUE TO CHANGES IN GROUNDWATER SEEPAGE GRADIENTS
PROPOSED GRAVEL PIT, MCNAB CREEK

This memorandum presents a geotechnical engineering assessment of the potential risk of piping within the natural soils or comparable embankment fills due to existing or changes in the groundwater seepage gradients around the proposed gravel pit at McNab Creek.

1.0 GROUNDWATER SEEPAGE FLOW AND HYDRAULIC GRADIENTS

Based on the results of hydrogeology modelling and analyses considering the end of mining in Year 16, it is understood that the water level within the gravel pit will be about elevation 5.4 m, but is predicted to rise to about elevation 6.7 m during wet winter conditions. The steepest hydraulic gradient within the natural soils south of the pit is expected to occur between the pit side slopes and the portion of the constructed groundwater-fed channel (WC 2) downstream of the plug, a horizontal distance of about 66 m. For average annual pit water level conditions, the hydraulic gradient is predicted to be 0.03, increasing to 0.04 under wet-season conditions, in comparison to the current gradient of 0.01. Along the north wall of the gravel pit, the hydraulic gradient is predicted to be approximately 0.07.

The hydraulic gradient through or underlying the plug in WC 2 will depend on the detailed design and cross section of the plug, and should be reviewed as part of design.

2.0 CRITICAL GRADIENT AND POTENTIAL RISK OF PIPING

The results of numerous gradation analyses of the natural soils at the proposed gravel pit are presented in the Concrete Aggregate Assessment report 09-1416004/4000 dated April 13, 2012 and a typical plot of these gradations is attached. As illustrated, most of the soil samples consist of well graded sand and gravel to sandy gravel. A very small (approximately 1 in 20) number of the gradations indicate the presence of more uniformly graded, fine to medium sand. In addition, the gradations do not include coarser cobble and boulder sizes which are reported to constitute approximately 30 percent by weight of the overall soil mass.

The safe value of critical gradient to prevent piping based on the weighted creep values (Lane 1935) determined from assessment of 280 dams is presented in the publication "Soil Mechanics in Engineering Practice, third Edition" (Terzaghi, Peck, Mesri, 1996). Using this method, the safe critical gradient varies from 0.14 for the fine to medium uniformly graded sand to an average value of 0.25 for the sandy gravel to sand and gravel forming most of the overall soil deposit at the gravel pit.

An analytical model (Indraratna and Radampola, 2002) to determine the critical gradient is presented in the April 2002 ASCE Geotechnical and Geoenvironmental Engineering Journal. Based on the conservative assumption that the groundwater seepage flow is horizontal only, with no upward component, the critical hydraulic gradient is computed to be 0.17 for the generally well graded sandy gravel or sand and gravel, and 0.05 for the fine to medium, generally uniform sand. However, the computed critical gradient of 0.05 is based on the highly conservative and improbable assumption that the generally uniform, fine to medium sand would extend continuously over the entire groundwater flow path.

3.0 SUMMARY AND CONCLUSIONS

Based on the results of this assessment, the risk of piping under predicted maximum gradients ranging from 0.03 to 0.04 along the south perimeter and up to approximately 0.07 along the north perimeter of the gravel pit is considered to be very low and well with normal engineering practice and criteria.

We trust that this information is sufficient for your immediate requirements.

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Attachment: Aggregate Assessment

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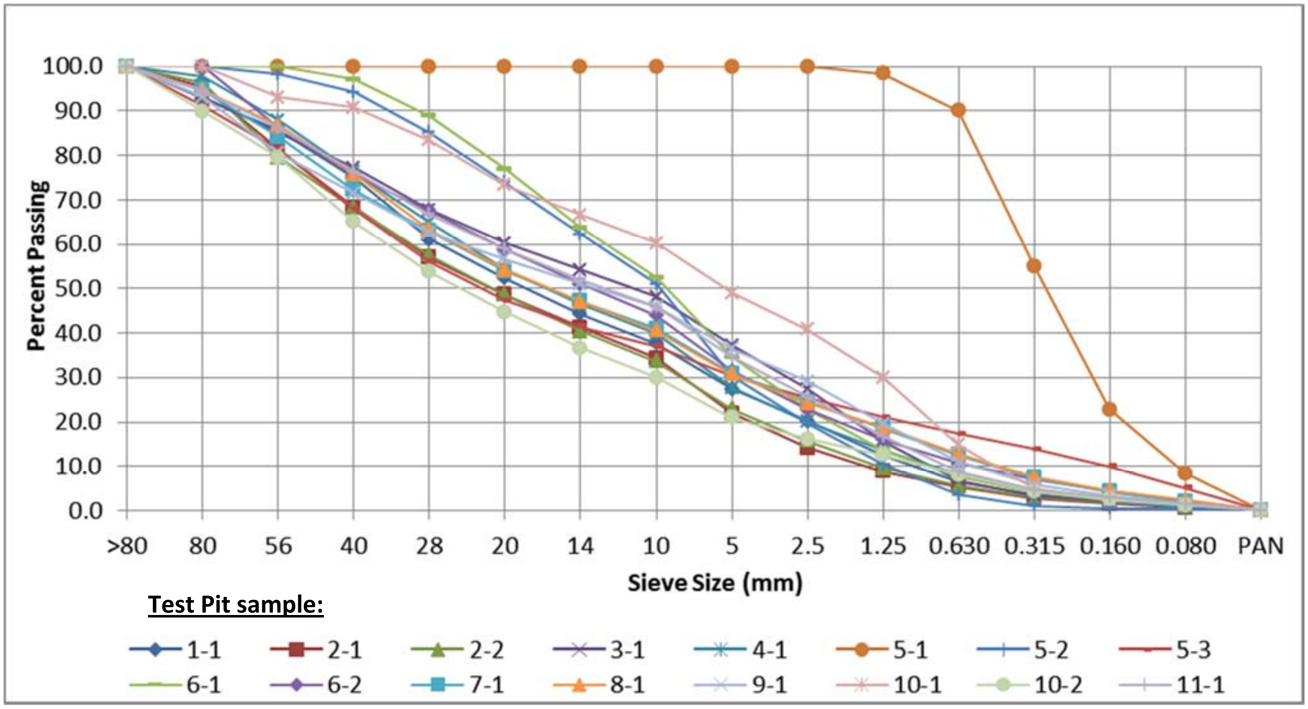

Figure 1: Summary of grain size distribution of test pit samples

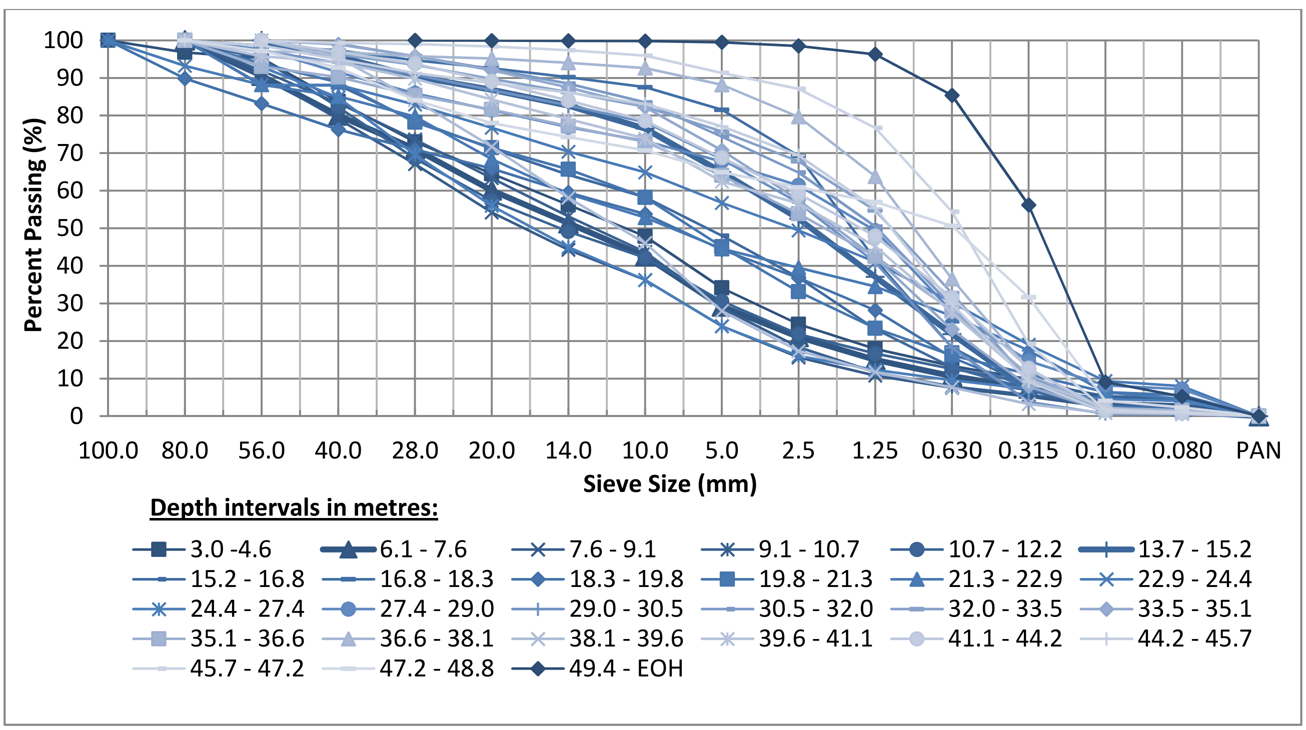

Figure 2: Grain size distribution for samples from DH 10-01

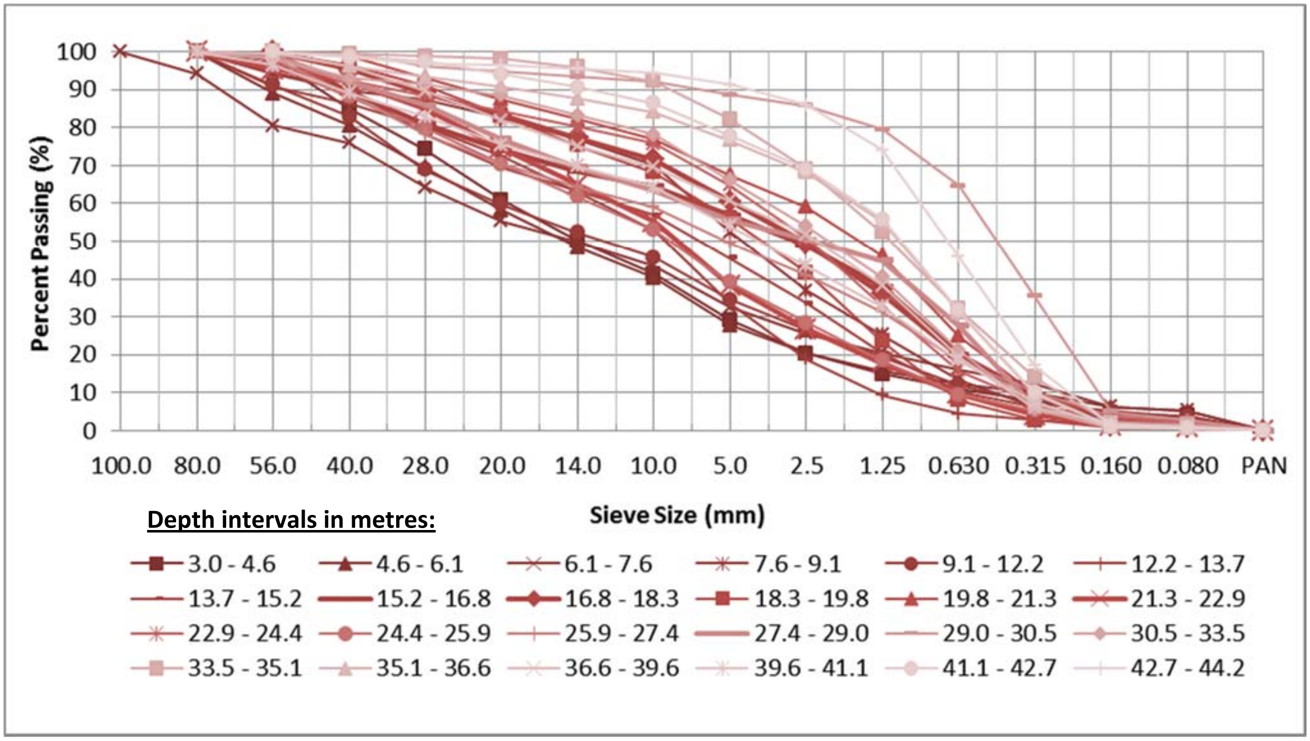

Figure 3: Grain size distribution for samples from DH 10-02

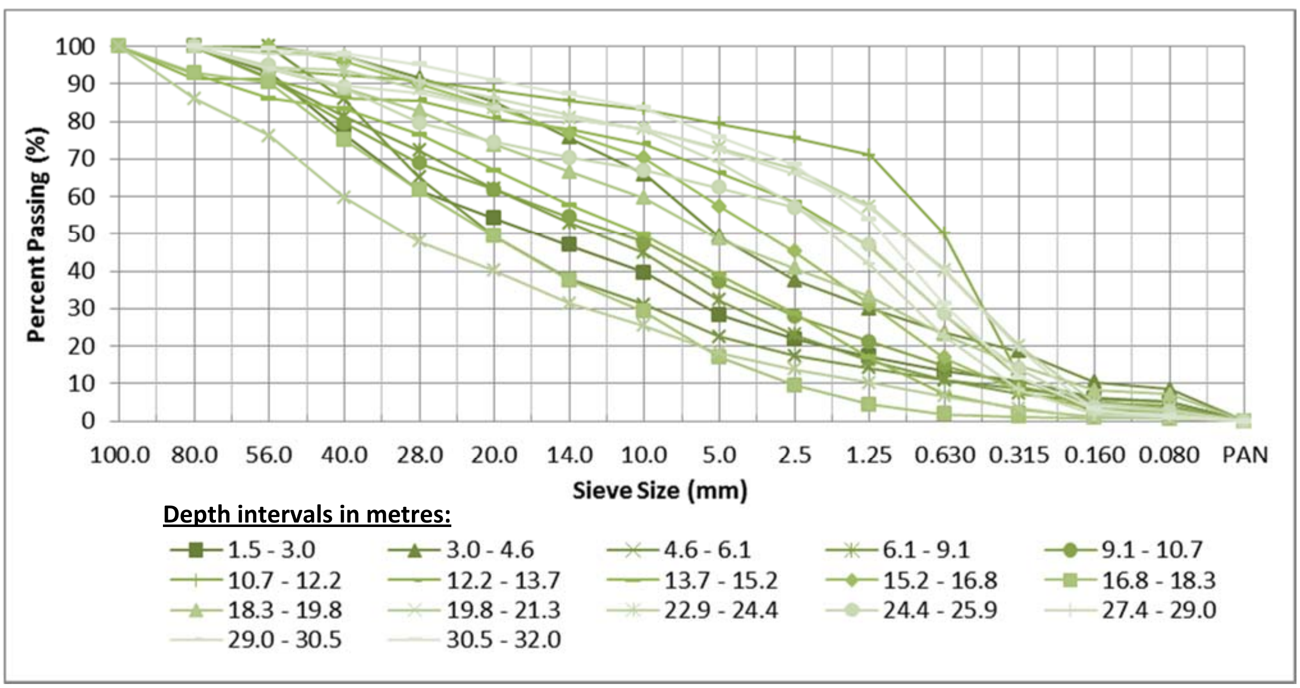

Figure 4: Grain size distribution for samples from DH 10-05

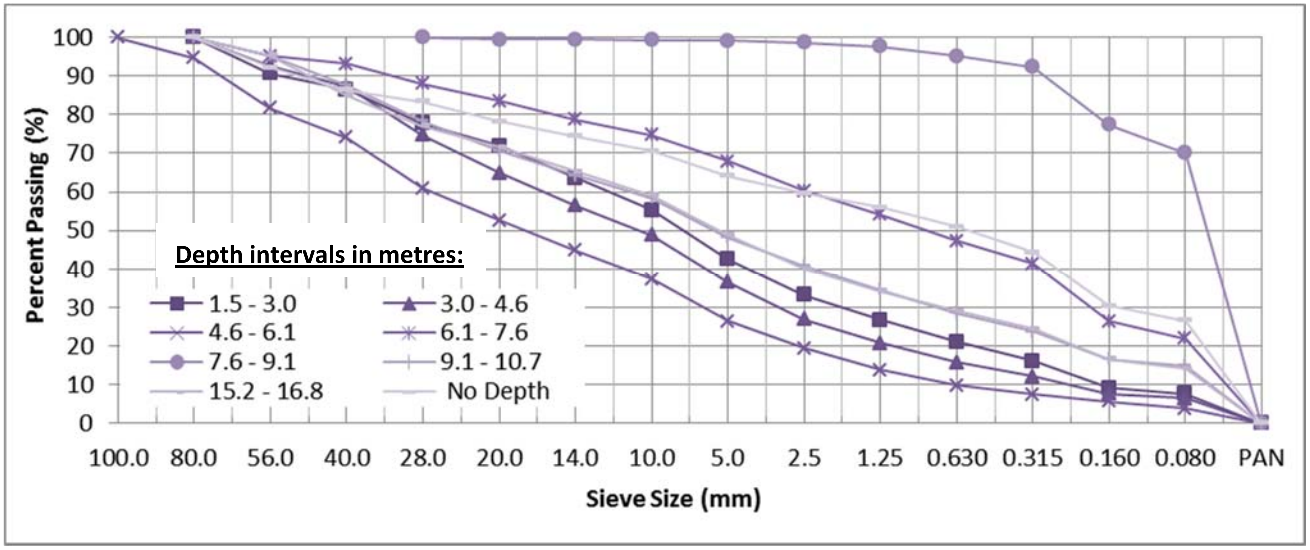

Figure 5: Grain size distribution for samples from DH 10-06

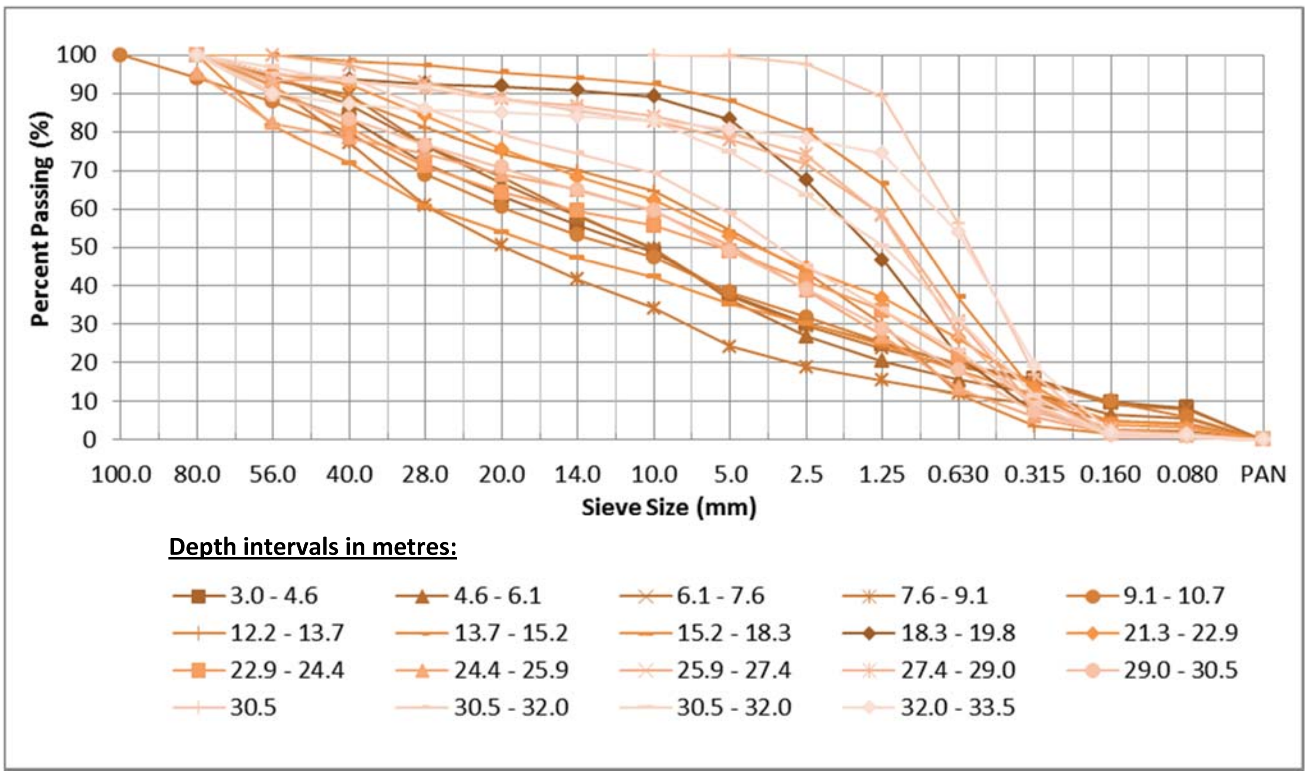

Figure 6: Grain size distribution for samples from DH 10-07