March 19, 2020
LHC File: 2003

Westbrook Consulting Ltd.
#115 – 816 Goldstream Ave.
Langford, BC
V9B 0J3

Attention: Ivana Kvartuc, B.A.

Re: Groundwater Impact of Soil Filling in Rock Quarry at 1875 Sooke Lake Road, Shawnigan Lake, B.C.

Following our e-mails January 2020 and follow-up communications we have assessed the potential impacts from soil deposition on the above described property. Our findings are presented in the following sections.

The Cowichan Valley Regional District (CVRD) has developed a bylaw to manage the deposit of soils within the region. The Bylaw (No. 4236) has established a permitting process for the deposit of soil and is intended to protect streams, groundwater resources and other sensitive features. The bylaw guards against the unauthorized importation of contaminated soils. Sites receiving more than 1000 m^3/year require a Type "C" permit.

This report is designed to assess the risk to the groundwater resource from the deposit of soils on the subject property. The report will form part of the application package for the Type "C" permit. See a property location Plan in Figure 1.

1.0 PHYSICAL SETTING

1.1 Climate

The Shawnigan Lake region is within the West Coast Temperature Zone, with an average annual precipitation of 1,247.6 mm, of which 75.5 cm falls as snow. The rainy season is generally between October to March, where precipitation averages greater than 100 mm per month. The coldest months are typically from December to February where daytime highs are lower than 5 degrees C. From June to September daytime temperatures are typically in the 15 degrees C range.

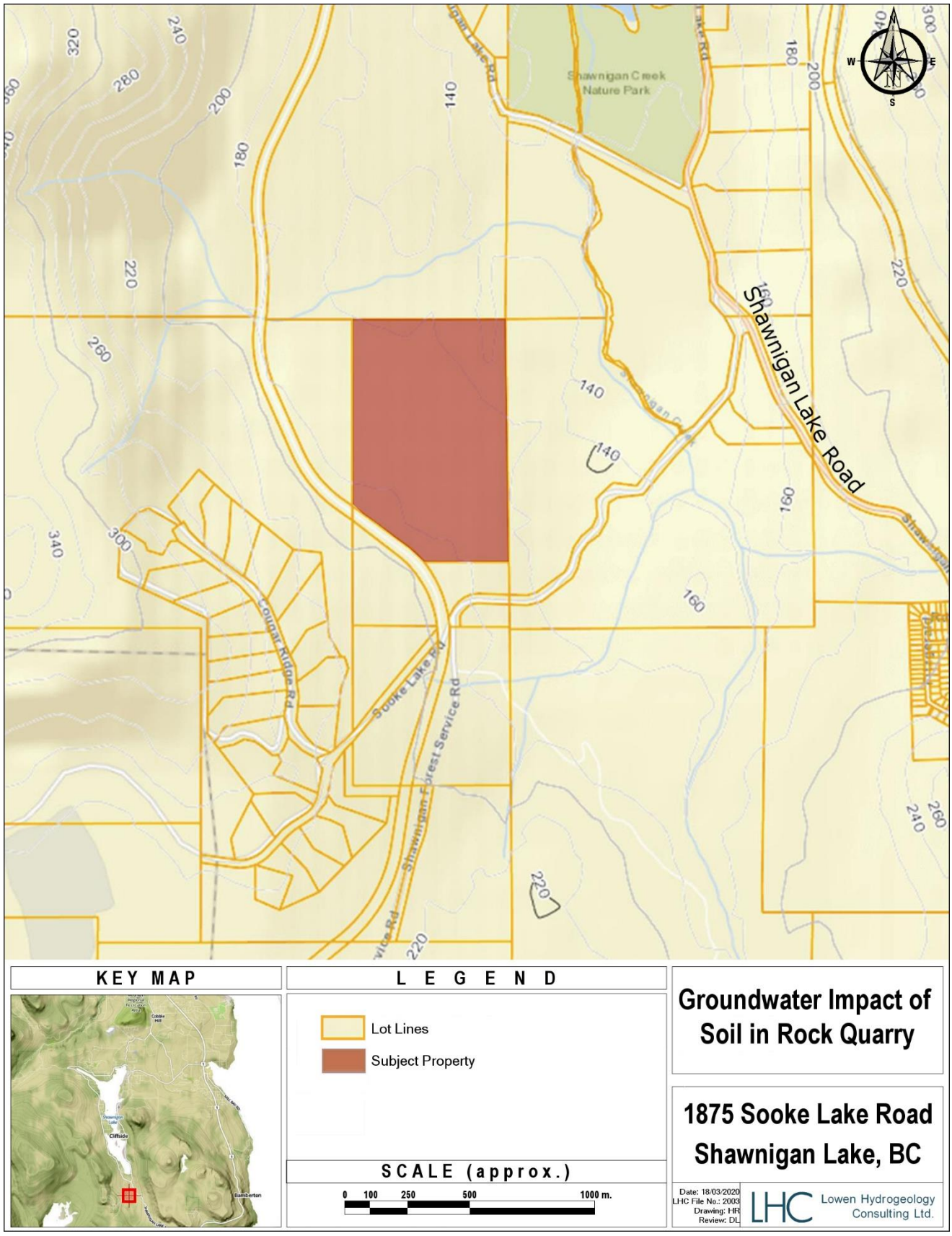
1.2 Topography and Surface Water Drainage

The subject property is located on moderately to steeply sloping terrains, with slopes ranging from 9 - 30%. The topography is complex, with multiple direction slopes and irregular surfaces. The topography slopes down to the Northeast or toward Shawnigan Creek. Surface and sub-surface drainage on the subject property follow this direction. Bedrock is not far from surface, within 2 m in this region.

1.3 Soils

The main native soils found on the subject property are the Shawnigan Moraine and the Squally Colluvium soil units, consisting of gravelly loamy sand, which is well drained. The Shawnigan unit is derivated from glacial deposition and the Squally unit from weathering of bedrock. Considering the nature of the soils, a horizontal hydraulic conductivity Kh of 2 - 5 m/day (gravelly sand) can be estimated.

Figure 1 - Location Plan



1.4 Geology

The study area is blanketed by glacial drift and colluvium deposits. Drilling records indicate permeable sand and gravel layers are thin and overly bedrock. The Geological Survey of Canada Map 1553A by J.E.Muller (1980) shows the area of study is underlain by the Wark Gneiss rock unit. The rock unit is extensively folded and faulted. There are major faults to the north in this unit but none in the immediate vicinity of the subject property. This rock units consist of metamorphosed volcanics and are generally favourable for domestic or community water supply development. Moderate yields can be obtained from these rocks (1 to 50 USgpm). The nearest existing well (200 m northeast of site) had an estimated capacity of 40 USgpm and reported depth of 200 ft (61 m).

1.5 Hydrogeology

Principally due to fractures, in addition to probable bedding plane and geologic contact zones, the bedrock is saturated at depth and the water bearing zones (aquifers) are replenished through the vertical infiltration of precipitation and/or by lateral flow from up-slope recharge zones. The bedrock wells are generally greater than 100 feet deep and completed in the Wark Gneiss bedrock unit.

The regional topography indicates the groundwater flow direction to be toward the northeast in the bedrock aquifer. The bedrock aquifer has a hydraulic conductivity ranging from 1×10^{-10} to 6×10^{-6} m/sec. (Domenico & Schwartz, 1990). A recharge rate to the bedrock aquifer of 10 percent of precipitation, or 0.10 x 1,247 mm/year = 125 mm/year, has been estimated by LHC based on these rock conductivities and the characteristics of the overlying soils. The mapped aquifer beneath the site is Aquifer No. 203. See a Summary of Aquifer data in Figure 2.

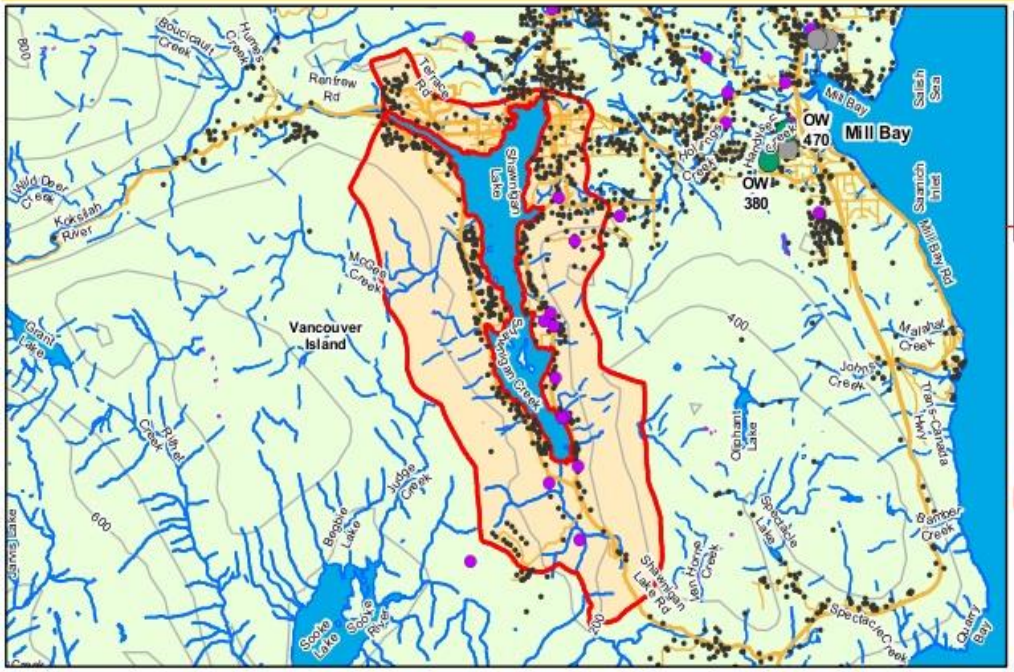
2.0 IMPACT OF SOIL DEPOSITION ON AQUIFER #203

A portion (about 50%) of the subject property will be quarried with approximately 3,000,000 m^3 of rock removed (Lawrence, R. W., 2018). The excavated rock will be replaced by clean soil fill to reclaim the site and re-establish the original topography. This quarrying and filling plan will not negatively impact the underlying aquifer. The following reasons can be cited for this conclusion:

- Only clean fill soil is being deposited at the site. All soil suppliers must fill-in and sign a “Clean Fill Approval Application”.
- Soils being deposited are primarily from Victoria region residential and commercial developments. Soils are mainly native soil that has been excavated to facilitate construction.
- A small amount of asphalt and concrete is received and is being used for on-site road construction.
- Original site drainage features are being maintained and silt traps and ponds are used to ensure clean/clear runoff from active areas.
- All creeks and ponds, inspected on March 4, 2020, exhibited clean/clear water.
- Approximate 50 m buffers are maintained around the natural water feature on the property.
- All equipment on-site is maintained in good order and leaks (hydraulic fluids) are fixed and cleaned up immediately.
- The quarried rock is <u>not</u> acid-generating (Lawrence, 2018) and runoff plus groundwater recharge will not be negatively impacted by the rock removal.
- Overall, the site is well managed, clean and neat. Best management practices are being employed. The Ministry of Mines routinely inspects the site.
- In general filling soil over rock is beneficial to bedrock aquifer recharge. The soil acts as a “sponge” soaking up wet season precipitation and slowly releasing it to the underlying rock fractures. Filled soil with about 30% porosity can store much more water than fractured rocks with less than 10% porosity.

Figure 2 - Summary of Aquifer

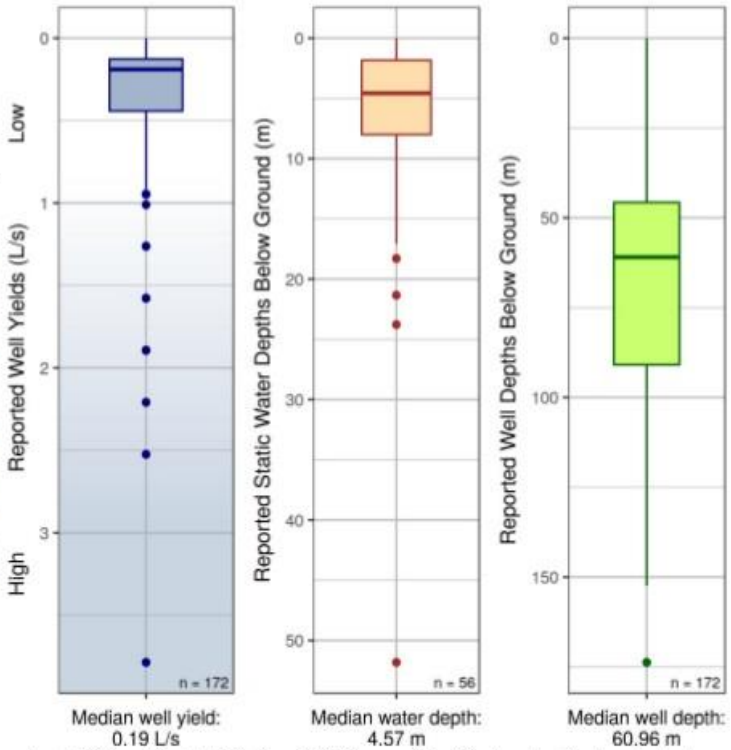
Aquifer #203



Aquifer Description (Mapping Report): Fractured crystalline (igneous intrusive or metamorphic, meta-sedimentary, meta-volcanic, volcanic) rock aquifer (subtype = 6b).

Aquifer Details	
Region	West Coast
Water District	Victoria
Aquifer Area	31 km^2
No. Wells Correlated to Aquifer	172
Vulnerability to Contamination	High
Productivity	Low
Aquifer Classification	IIA
Hydraulic Connectivity[1]	Not Likely
Aquifer Stress Index	Less stressed
No. Water Licences Issued to Wells	0
Observation Wells (**Active**, Inactive)	None

[1] Based on broad regional assessment



Detailed methods for all figures are described in the companion document (Aquifer Factsheet - Companion Document.pdf).

Factsheet generated: 2019-03-06. Available from: https://s3.ca-central-1.amazonaws.com/aquifer-docs/00000/00203_Aquifer_Factsheet.pdf.

3.0 CONCLUSION

1. Assuming current operating plans and procedures are maintained we do not consider the soil deposition on the subject property a threat to local aquifer water quality or quantity.
2. The Quarry at 1875 Sooke Lake Road can be granted a Type "C" Soil Deposit Permit from the CVRD.

4.0 CLOSURE / DISCLAIMER

This report has been prepared in accordance with generally accepted groundwater engineering practices. The opinions expressed herein are considered valid at the time of writing. Changes in site conditions can occur, however, whether due to natural events (e.g. climate change, earthquakes) or to human activities (e.g. recharge area modification or blasting on this or adjacent properties). In addition, changes in regulations and standards may occur, whether they result from legislation or the broadening of knowledge. This report is therefore subject to review and revision as changed conditions are identified.

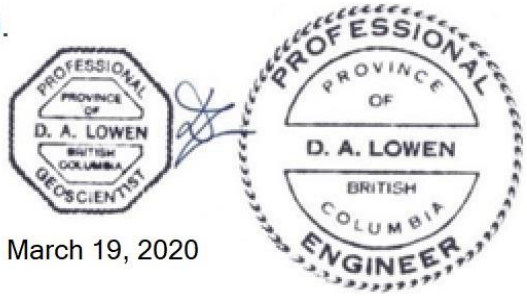
In formulating our analysis, we have relied on information provided by others; well drillers, surveyors and a Geotechnical Engineering Report (Lawrence, 2018). The information provided by others is believed to be accurate but cannot be guaranteed by Lowen Hydrogeology Consulting Ltd.

Furthermore, if the recommendations in this report are not implemented, the undersigned assumes no responsibility for any adverse consequences that may occur.

Respectfully submitted,

Yours very truly,

LOWEN HYDROGEOLOGY CONSULTING LTD.



March 19, 2020

Dennis Lowen, P. Eng., P. Geo.

DL/hr

Reference

1. Cowichan Valley Regional District (CVRD) The Bylaw (No. 4236)
2. Domenico & Schwartz, 1990; *Physical and Chemical Hydrogeology*
3. J. E. Muller, 1980, *The Geological Survey of Canada Map 1553A*
4. Lawrence, R. W., Feb. 2018; *Admirals-Mackenzie Interchange Project - Evaluation of Geotechnical Characteristics of Aggregates for Roadbed Construction*. Tech-Mem. 18-05