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Revised July 29, 2022

Mr. Ian Scott
Ian Scott Planning Services

Dear Mr. Scott:

Re: Cortes Island Septic Drainfield Nutrient Amelioration Issue

1. Terms of Reference

I have been asked to assess the potential for migration of phosphorus and nitrogen variants which may be contained in the treated effluent from the proposed +/-24 unit housing development to be located at 965 Beasley Road. There has been concern expressed that these nutrients might move to Hague Lake and cause eutrophication and algae blooms. This study is limited to the assessment of within soil processes related to nutrient mobility in soil.

2. Qualifications and Experience

Brian French, P.Ag. is an Agrologist qualified to render opinion relevant to this project on soil survey, land capability, soil fertility and soil hydrology. Brian has over 40 years professional experience. A resume of experience is attached as Appendix A.

3. Site Visit June 3, 2022

I attended to the site on June 3, 2022 and met with Sandra Wood representing the Community Housing Project. Sandra was very helpful and she accompanied me while I did the site survey. We were able to locate most of the old test pit locations proximate to the proposed dispersal fields but all the holes had been filled in and it was not possible to re-expose them with a shovel. I exposed two representative soil pits within the bounds of the proposed field area and collected two soil samples for analysis. The soil profiles were very similar and I did not feel it was necessary to dig more holes. The ground was very hard (cemented) and stony which made shovel penetration very difficult.

4. Background Information

4.1 February 5, 2019 Report by Ron McMurtrie & Associates, Consulting Engineers (McMurtrie)[1]

The McMurtrie report considers the suitability of the site for on site sewage effluent disposal in ground. It discusses the on site conditions and estimates that the field saturated hydraulic conductivity would range between 1000mm/day and 4000mm/day (1.0 to 4.0 m/day) based on soil texture, structure and gravel content. He also quotes percolation tests carried out by EBA Engineering in 2008 which states a percolation range between 1.5 minutes/inch and 4 minutes per inch. Converting (with some licence to account for unbounded conditions with percolation tests) to a saturated hydraulic conductivity measure, this would translate to an estimated saturated conductivity of between 9.1 and 24m/day. There is more than an order of magnitude difference between the McMurtrie estimate and the EBA percolation tests which leaves a lot of room for interpretation.

McMurtrie describes each of the 31 test pits exposed on the site. Test Pits #1 to 6 are within the proposed field area. In general, the profile descriptions are consistent with what I found on the site in this area except that in our pits I encountered significant cementation at all depths below 5 to 10 cm depth. This is consistent with similar soil profiles developed on shallow lag gravel and sand veneer parent materials overlying dense, stony till found on Vancouver Island and the Gulf Islands north of Parksville. Soils with this type of stratigraphy developed in the wetter conditions of the north-central island experience prolonged periods of wetting and drying which promotes formation of hardpan layer. Unfortunately there does not appear to be any formal soil survey information covering Cortes Island and Soil Report No. 6 for Southeast Vancouver Island and Gulf Islands (1959) by Day, Farstad and Laird stops at the south half of Quadra Island.

4.2 Geology of Cortes Island and Environs, H.P Trettin, 2012[2]

Mr. Trettin, a Cortes Island resident, gives an excellent and detailed review of the geology of Cortes Island. He notes on page 12 "Most sediments are loose with two exceptions. Silty strata exposed to surface water tend to be plastic or solid, owning to cementation by clay minerals. *And sand and gravel lying in B horizons of the podzol soil profile are locally indurated by limonite." (My italics)* Limonite is a mineral formed from oxides of iron (and aluminum sesquioxides on the subject property). This induration in the Bf horizon is what I found at the site. The geologic period of the site is the Quaternary with unconsolidated deposits from the Pleistocene Epoch.

4.3 Landform and Soils

As discussed in 3.2, the landform on the subject site is a basal till blanket with a thin, water washed lag gravel veneer of coarse, gravelly and stony loamy sand to sand. The topography on the site is subdued with a NE slope at less than 5%.

The soil on the site is formed from water washed ablation till which has had almost all the fines removed. The texture is coarse sand to loamy sand with a gravel and stone content estimated to be 30%. There was an LFH layer of duff and roots 2 to 3cm thick at the surface. This was underlain by an eluviated Ae layer 2 to 3cm thick. There is an abrupt boundary to a cemented Bfc layer to the 60cm depth of our test pits. Rooting was limited to the surface 15 to 20cm. The overstorey vegetation was second growth Douglas Fir and the understorey was salal and fern. Photographs of the soil pits and surrounding landscapes are shown in Appendix C. Figure 4.3 is a map showing the site location and soil pit locations.

4.4 Testing

4.4.1 Element Laboratories

Two samples, one from each pit, were submitted to Element Laboratories for analysis of complete agricultural profile (particle size analysis, pH, E.C., CEC, N, P, K, S, Ca, Mg, Fe, Cu, Zn, B, Mn and Cl). In addition, a total metals test was carried out together with a digested total phosphorus test. The Element Report is attached as Appendix B.

The soil texture for both samples was loamy sand. As expected for a coarse textured forest soil, the nitrate nitrogen was very low in both samples at less than 2 ppm. Available phosphorus was 16 ppm in sample #1 and 31ppm in sample #2. These were rated optimum and near excess respectively for fertility. Potassium, sulfur, calcium, magnesium, zinc and chloride were deficient to marginal. Iron, copper and manganese were marginal to optimum. The pH was 5.9 to 6.2 which was higher than expected for a coarse textured forest soil. Organic matter content was low at 2.4 to 2.6%. The base saturation was 4.8 to 7.4% and the cation exchange capacity was 92 to 150meq/100g which was relatively high. The strong acid extractable phosphorus was 480 to 650 mg/kg (ppm). This is reflective of the relatively high extractable phosphorus from the Modified Kelowna Method of extraction for available phosphorus.

4.4.2 Saturated Hydraulic Conductivity

We carried out a test for saturated hydraulic conductivity by the falling head permeameter method (Methods of Soil Analysis, Part 1; Black, C.A.; American Society of Agronomy, 1965)[3] on disturbed samples taken from the two soil pits. We calculated the saturated hydraulic conductivity to be 8.8×10^{-5} metres/second or 7.6 metres/day. This is within the range of values described by McMurtrie. However, I do not believe the conductivity value we derived from the disturbed sample was representative of the field conditions we encountered on site because the cementation was no longer present. Soils which are subject to cementation by alternate wetting and drying, and formation of iron and aluminum sesquioxides, generally have restricted drainage and saturated hydraulic conductivity values much lower than uncemented soils with similar textures. The most accurate measure of the saturated hydraulic conductivity of these cemented soils is obtained by using a double ring infiltrometer in situ.

5. DISCUSSION

5.1 Soil Parameters

We found a strongly cemented soil profile within 20cm of the surface in the gravelly and stony loamy sand soil profiles we excavated by hand on site. These characteristics differ substantially from the soil profile descriptions provided by McMurtrie for TP's #3 and 4 within the proposed dispersal field area which described the limiting layer at between 90 and 100cm. Cementation in these loamy sand soils is confirmed by Trettin. Unfortunately, we were unable to penetrate to the depth of the underlying till with a shovel.

Our calculated saturated hydraulic conductivity on a disturbed sample was significantly higher than that expected on a cemented soil profile as found on site. The conductivity of a soil affects the rate at which water moves through the soil and can influence the rate at which nutrients such as phosphorus and nitrate are available for uptake by roots or immobilized in the case of phosphorus.

The level of available phosphorus was high for this coarse textured soil and this was attributable to the very high total phosphorus content of the soil. High inferred levels of iron and aluminum sesquioxides in the soil profile bind phosphorus but the site has never been cultivated or fertilized in the past, so the phosphorus must be in the parent material. Phosphorus in sewage effluent can be absorbed and effectively immobilized within the soil profile by the iron and aluminum seaquioxides or taken up by plant roots mobilized in soil water. Since the total phosphorus level in this soil is already high, uptake by plants is important and should be encouraged by applying the treated effluent at or near the highest concentration of roots which are in the surface 20cm. Most of the biological activity in these coarse textured forest soils is at or near the surface. Addition of calcium to soils raises the pH and can lead to increased immobilization of phosphorus. The pH of the subject soil is 5.9 to 6.2 which is not high considering it is under acid forming coniferous forest. Addition of lime to the dispersal field area to bring the pH up to neutral could help immobilize phosphorus. The calcium level in the soil was marginal to deficient and the cation exchange capacity and calcium saturation would be able to handle a moderate lime application.

The level of available nitrate was very low. Most of the available nitrogen supporting the coniferous forest is in the surface organic layer. Maintaining the active organic surface layer is critical to uptake by roots of the nitrate and ammonium found in sewage effluent. Once in the coarse textured subsurface layers, the nitrogen is much less available to the trees.

5.2 Potential Mobility of Phosphorus and Nitrogen

Concern has been raised about the potential for phosphorus applied to the soil by treated sewage effluent moving through the soil to a possible breakout point in a ditch or other watercourse leading to Hague Lake located downslope of the subject site and across Sutil Point Road. Despite the relatively high level of total phosphorus found in the native soil on the subject site, the cementation found in the soil profile indicates a high level of iron and aluminum sesquioxides in the soil and these minerals have a very strong affinity for phosphorus and bind it strongly in the soil profile. The high level of total phosphorus is most likely due to the native mineralogy rather than soil amendments or atmospheric deposits because the site does not appear to have been cleared or farmed in the past. The underlying till found below the surface lag sand and gravel is effectively impermeable. Water encountering this impermeable layer will mound up and form a potential gradient downslope. As the water moves horizontally through the soil profile it is exposed to the iron and aluminum sesquioxides and any soluble phosphorus would be immobilized effectively over a relatively short distance.

Nitrate and ammonium are very soluble and are not bound to soil particles. Immobilization of these nitrogen compounds relies on uptake by plant roots and use by the plant. Dead leaves, needles, bark and wood litter the ground in a coniferous forest and are slowly decomposed by forest floor flora and fauna. In these coarse textured forest soils, it is critical that nutrients are maintained as close to the surface feeder roots as possible to optimize uptake. The very low level of nitrate found in the underlying mineral B horizon indicates that most of the nitrogen is found within the surface organic matter. A close balance between mineralization of organic nitrogen and uptake by surface feeder roots is maintained under nitrogen impoverished coniferous forests. The additional nitrogen from the sewage effluent would be readily taken up by the feeder roots during the growing season but could be mobile during the winter unless absorbed by the biota in the surface litter. The effluent should be applied as close to the surface organic matter as possible to maximize plant uptake and immobilization by the soil organisms.

6. SUMMARY AND CONCLUSIONS

6.1 The proposed community housing project will employ a sewage treatment system with ground dispersal of the treated effluent. Concerns have been raised that nutrients including phosphorus and soluble nitrogen compounds could migrate through the soil profile and reach Hague Lake possibly causing eutrophication and algal blooms.

6.2 The soils within the proposed effluent dispersal field are coarse textured gravelly and stony loamy sand. We encountered strong cementation within the soil profile below 10 to 15cm depth and to the extent of the hand dug pits at 60cm. A hydraulic conductivity test on the disturbed loamy sand matrix fraction showed a value of 7.6 metres/day. However, strongly cemented soils typically have much lower conductivity as the soil pores become obstructed by the iron and aluminum sesquioxide coatings. Testing of the in-situ hydraulic conductivity of the subject soil using a double ring infiltrometer is strongly recommended. This would establish the infiltration capacity of the soil to accept effluent much more reliably than the traditional unbounded septic percolation test.

6.3 The surface soil is derived from deflated ablation till leaving a coarse textured residual of the underlying till. The basal till typically found at 60 to 100cm depth is near impervious and forms a barrier to infiltration of water. Horizontal movement of water and dissolved components which reach the till layer will occur in response to hydraulic gradients downslope.

6.4 The native soil total phosphorus content is high due to the mineralogical makeup of the constituent particles. The available phosphorus content is considered moderate to high for this coarse textured soil. However, the significant presence of iron and aluminum sesquioxides in the soil profile mitigates the mobility of the phosphorus because these minerals strongly bind phosphorus and render it largely immobile. Conversely, nitrate and ammonium are very soluble and mobile in the soil. While the cementation may slow down this migration, it will not eliminate downward and lateral movement with drainage water. Migration of phosphorus derived from the sewage effluent application for any significant distance is unlikely.

6.5 The soils on site are deficient in nitrate which is typical of coarse textured soils in coniferous forest settings. Additional nitrogen loading in the form of nitrate and ammonium in treated sewage effluent can be mobile in the soil profile, especially in the wet winter months. The proposed monitoring wells would show any abnormal presence of soluble nitrogen above background levels.

6.6 Migration of soluble phosphorus from applied sewage effluent to the land on this site is very unlikely to occur for any distance from the source due to the presence of iron and aluminum sesquioxides in the soil profile which effectively immobilize phosphorus.

6.7 Applying the effluent near the surface in close contact with the surface feeder roots of the trees will encourage and enhance uptake of nutrients, particularly nitrogen forms, by the trees.

6.8 There may exist uncertainty with the actual on-site hydraulic conductivity of the soils within the proposed effluent dispersal field area. A more rigorous determination of the hydraulic conductivity using a double ring infiltrometer is recommended to ensure that adequate infiltration capacity for the proposed effluent loading is achieved. Cemented layers near the surface can result in lateral diversion of drainage water and escape to surface downslope. If the values quoted by McMurtrie are correct, and if confirmed by the additional testing, this should not be an issue. There may be a benefit provided by the cemented soil layers through reduction of the transport potential of nitrogen ions through the soil profile and along the impervious till layer.

I trust this is sufficient evidence to allay fears of migration of phosphorus beyond the limits of the proposed effluent dispersal site. While it was not possible to accurately define the limits of soluble nitrogen compounds, it is unlikely that any significant quantities of these materials emanating from the dispersal field would migrate long distances without dilution beyond any level of concern. Ensuring enhanced contact of the effluent with the active biotic surface layer will reduce the potential for migration of these nutrients.

Yours very truly,
C&F LAND RESOURCE CONSULTANTS LTD.

per:

Brian M. French, P.Ag.

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CORTES ISLAND SEPTIC DRAINFIELD NUTRIENT AMELIORATION

EXECUTIVE SUMMARY

The Cortes Island Community Housing Project is proposing an affordable housing development on lands at 965 Beasley Road. Concern has been expressed regarding potential transport of phosphorus and nitrates to Hague Lake. The soils on the proposed septic effluent disposal field site are coarse textured sand and gravel which have been subject to chemical changes whereby iron and aluminum sesquioxides form coatings on the sand and gravel particles causing them to cement together. This cementation can cause a reduction in the hydraulic conductivity and movement of water through the soil. The hydraulic conductivity has been estimated by McMurtrie and EBA Engineering as between 1.0 and 24 metres/day. We measured the saturated hydraulic conductivity of disturbed sand at 7.6 metres/day. However, this does not represent the actual field conductivity taking into account the cemented nature of the soil profile. Testing of the conductivity in-situ is strongly recommended. Iron and aluminum sesquioxides aggressively bind and immobilize phosphorus and any movement of phosphorus beyond the immediate dispersal field is unlikely. Nitrogen ions, nitrate and ammonium, are by contrast highly soluble in water and are mobile in the soil profile. During the growing season, plants readily take up nutrients and keeping the effluent discharge point as close to the roots a possible will encourage uptake. While deep cultivation can be used to break up the cemented layers, they tend to reform over time. While the issue of soil hydraulic conductivity may be important for the design and operation of the dispersal field, it is of little importance for the issue of phosphorus movement because the phosphorus will be immobilized irrespective of the conductivity. Nitrogen ion uptake by roots may be enhanced by the lower conductivity due to prolonged contact with roots. I do not believe the installation and operation of a septic effluent disposal field would pose any risk of phosphorus migrating to Hague Lake.