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Dear Ms. Vrbanac:

This review has been prepared in response to a direct request by Dr. Doug Joy, on behalf of CWRA. It provides an independent evaluation, from the perspective of an experienced pedologist, of the *Planning Summary Report*, herein after referred to as the PSR, dated *April 3 2009*, entitled *Hunsberger Pit*, prepared by *Hunder Development Ltd*. Specifically, it addresses primarily Section 5, *Soils Classifications and Rehabilitation to Agriculture*, as well as Section 7, *Proposed Extraction Design* (specifically 7.3 and 7.4, dealing with rehabilitation), with reference to other relevant sections as required. No site visit was performed, however, satellite imagery available through Google Earth was examined (Google Earth 2011). Consequently, interpretations contained within this review are based primarily on the PSR, original documents cited by the authors, as well as one extra supporting document (which has been referenced).

Section 5.1 'Soils Classifications'

As stated by the authors of the PSR, this Section based on *Report No 44 of the Ontario Soil Survey* (and associated maps), entitled *'Soils of Waterloo County'*, published by Research Branch Canada Department of Agriculture in 1971. This publication constitutes the most recent semi-detailed pedological survey of soils for Wellington County, and was produced in accordance with recognized soil survey procedures and norms of the period.

The PSR presents a tabular summary of the soils present within the 'area to be licenced', specifically denoting those found within the 'area to be extracted'. For clarification purposes, six soil series are identified, by the PSR authors, within these areas, namely: Burford, Conestogo, Floradale, Maryhill, St. Jacobs and Woolwich. It should be noted that the column entitled 'Soil Classification' is a misnomer, since what is presented are the soil series names and textures, and not a classification (taxonomic nor interpretive) of these soils per se – this is common mistake, however, by non-soil specialists, and not necessary of consequence here. A notable area of Colwood soil (denoted by the abbreviation Cd on the soil map), is found on the eastern end of the 'area to be licensed' in the land, located south of Hunsburger Road, belonging to the Ronan Hunsburger Farm – this has not been included in the summary presented in the PSR, but will be discuss in my review.

The Woolwich, Conestogo and Maryhill series comprise the Woolwich catena, which are the soils developed from loam and silt loam sediments overlying loam till (specifically, alluvial and lacustrine deposits overlying calcareous till). In the Woolwich catena, the Woolwich series is found in the well-drained, upper landscape positions; moving downslope into imperfectly-drained positions, the Conestogo series is encountered; finally, the Maryhill series represents those soils in the poorly-drained, lower landscape positions. The authors of the PSR note that the thickness of the overlying sediments ranges from 0.3 to 1 m.

The St. Jacobs and Floradale series comprise the St. Jacobs catena, which are soils developed from loam and silt-loam sediments overlying gravel (outwash sands and gravels). In this catena, the St. Jacobs series is found in the well-drained, upper landscape positions; the Floradale are located in the imperfectly-drained, lower landscape positions. Special note was made, by the authors of the PSR, that the overlying sediments associated with the Floradale series, ranged from 0.3 to 1 m in thickness.

The Burford series occupies the well-drained landscape positions within the Burford catena. Soils of the Burford catena are developed on gravelly and cobbly loam parent materials (also outwash sands and gravel deposits). The authors of the PSR specifically highlight these soils as being developed from less than 0.3m of 'loamy or sandy loam overlying gravely soil materials'

The Colwood series, not included in the PSR, are soils occupying the poorly-drained landscape positions of the Brant catena. Soils of the Brant catena are developed from loam and silt loam parent materials (lacustrine deposits).

The presence of variations of most of these soils (the Maryhill series being the exception), specifically with respect to the nature and slope of the topography, is indicated under the column of 'Soil Symbol' (see the table in Section 5.1), which is comprised by the abbreviation for the soil series (eg. Bg = Burford), followed by an upper case letter (signifying simple topography or a regular surface) to represent slope class: A = 0 to 3%, B = 3 to 6%, C = 6 to 12% and D > 12% (note that a lower case letter would have signified complex topography or an irregular surface). It must also be noted that no reference was made to an area of St. Jacobs soil, with complex topography (denoted Sjb), located at the east end of the 'area to be licensed' in the land, located north of the Hunsburger Road, belonging to the Ronan Hunsburger Farm.

While variations in local climate are assumed to be minimal, major controls on soil development in this area would be the parent material (variety of unsorted and sorted glacial sediments) and relief. Of particular significance is the relative position of land surface above the groundwater table, which influences hydromorphic conditions (redox chemistry) of the soil. Based on information provided later in the PSR (section 14.1 *Hydrogeological Assessment*, on page 60), "the groundwater elevation varies from 333masl in the northeast limit of the proposed extraction area to 322 masl at the southwest limit." It was also stated that "…due to the close proximity of the Grand River, it is likely provides a stabilizing influence on the groundwater and while there is expected to be seasonal variation, extreme variations are not expected”. Accordingly, a detailed assessment of current surface elevation, in conjunction with the current distribution of the various soil series, could provide insight to the impact of an artificial lowering of the land surface on subsequent long-term moisture regime in the ‘area to be extracted’ – it is anticipated that, in general, the proportion of imperfectly- and/or poorly-drained soil may result.

The ‘Agricultural Capability Rating’ of each of the mapped soil types (again, with the exception of the ‘Cd’ and ‘Sjb’ noted previously) are also tabulated in Section 5.1. These ratings (Canada Land Inventory -CLI) appear to have been extracted from the Table 11 in the ‘Soils of Waterloo County’ report. An error in capability class was found for the soils mapped as BgC, which are supposed to be 3 rather than 4. Unfortunately, none of the CLI subclasses were reproduced (in the PSR) for those soils rated other than 1 – the subclasses provide important insight into the specific reasons for the CLI class reduction. The BgA and BgB, were classed as 2 due to both moisture deficiency (‘m’ subclass) and low natural fertility (‘f’ subclass); these can be related to the gravelly nature of the soil. BgC and BgD were classed as 3, due to the combination of moisture deficiency (‘m’ subclass) and low natural fertility (‘f’ subclass) – jointly represent by subclass ‘s’ (adverse soil characteristics) - in combination with steeper slopes, reflected by the topographic (‘t’) subclass. The ‘m’ and ‘f’ subclasses, which downgrade the Burford soil CLI class, can be also related back to the nature of the coarse parent material, as describe previously.

The Mr soils have a CLI class of 2 due to excess water (‘w’ subclass); recall that these soils occupy the poorly-drained, lower lower slope positions of the Woolwich catena. The unreported Sjb soils are also classed as 2, but with a ‘t’ subclass, due to the nature of the complex slopes. The Cd soils are classed as 3, due to a combination of low natural fertility (‘f’ subclass) and excess water (‘w’ subclass) – as indicated above, these are found in the poorly-drained landscape positions of the Brant catena.

For interpretive reference, according to the CLI system for Agriculture:

Class 1: have no significant limitations for cropping.
Class 2: have moderate limitations that reduce choice of crop.
Class 3: have moderately severe limitations than reduce choice of crop.
Class 4: have severe limitations that restrict choice of crop.
Class 5: have very severe limitations, restricting them to perennial forage crops.
Class 6: are unsuitable for cultivation, may be used for pasture.
Class 7: no capability for arable culture or permanent pasture.

It was not explicit, within Section 5.1 of the PSR, how the values for ‘% of Each Soil Type Within Total Site’ was derived, though it is presumed that a suitable GIS system was employed. Ultimately, these values are presented to summarize the distribution of soils with the ‘area to be extracted’ (identified by an asterisk) and those within the ‘area to licensed’. It is not clear whether or not the soils mapped as ‘BgB’, amounting to 0.12%, constitute the difference between these two areas. In first regard, according to the introduction of the PSR (Section 1, page 1), the ‘total area to be extracted’ constitutes 62.0 ha (or about 70) of the 88.3 ha of ‘area to be licensed’; the difference is, then, about 30% not 0.12%. Moreover, considering that both of these areas cross several soil types, it seems unusual that the difference between the two would be restricted to only one soil type. In general, however, the authors of the PSR, observed that “Most of the soils on the site are noted as having a Canada Land Inventory rating of 1 to 3…the site is defined as prime agriculture land.” Ultimately, the values presented within this table would need to be recalculated to consider the missing soil types.

Section 5.2 ‘Rehabilitation to Agriculture’

The authors of the PSR, have indicated that, “…with the exception of the areas around the Hunsberger farm buildings and the spruce hedgerow”, all lands to be influenced by extraction are currently in agricultural production. Significantly, it has also been noted (in Section 5.1, page 13, and in Section 5.3, page 14) that this land is “prime agricultural land”. Within the context of rehabilitation to agriculture, the PSR indicates that “all these lands will progressively be returned to an agricultural use”. The PSR does not however, define what this eventual ‘agricultural use’ constitutes – this could vary from arable production of high value crops (i.e. CLI class 1) to pasture (i.e. CLI class 6). It is recommended, therefore, that clarification be sought on both current agricultural production and then nature of the envisaged post-rehabilitation agricultural use.

Section 5.3 ‘Summary of Soil Classification and Rehabilitation to Agriculture’

As was noted in the discussion of Section 5.2, there is need to provide more explicit definitions to the terms like “final agricultural land use” or “agricultural rehabilitation is maximized”. Are there specific and measurable targets in mind which can be articulated?

Section 7.3 ‘Progressive Rehabilitation’

The PSR employs the two terms ‘topsoil’ and ‘subsoil’ – it is important to be clear about this terminology and its relevance to this particular situation. These terms are used within this Section (7.3), as well as in Sections 7.4, 9.1 and 10.1.

Typically, ‘topsoil’ is used to refer to the surface A soil horizon; on an arable agricultural field (which much of the land proposed for ‘area to be extracted’ represents) this would be an ‘Ap’ horizon or plough layer, having a typical depth of 15 cm. Any lateral variations in the nature of this material would likely be in relation to texture or organic matter content.

The term ‘subsoil’ is usually employed to mean the lower portion of the solum (soil above the parent material); in the typical A-B-C profile, this would then refer to the B horizon. While the cultivated soils in the ‘area to be extracted’ are expected to have B horizons (based on the pedological descriptions available in the *‘Soils of Waterloo County’* report), there is variability in their nature and thickness. As describe previously, progressing from upper to lower landscape positions, typically increases the degree of hydromorphism or ‘gleying’ (to imperfectly then to poorly drained) in the B horizons (thus, designated as ‘Bgj’ or ‘Bg’). In the more well-drained upper landscape positions, the B horizons typically exhibit an enrichment of clay (designated as ‘Bt’), which has been translocated from the overlying soil horizons. In some soils, specifically the St. Jacobs and Burford Series, the B horizons have developed in the coarser (more gravelly) material underlying the finer texture surface deposit. The published profile descriptions suggest that the thickness of the B horizon varies from between 10 and 15 cm in the Floradale and Burford series, to about 35 cm in the Conestogo and Colwood series.

It is also important to recognize the presence of what is colloquially called a ‘subsurface soil’; from a pedological perspective, this typically corresponds with an eluvial horizon (designated ‘Ae’ or ‘Ahe’), in the more well-drained upper landscape positions. Eluvial horizons are so designated because they are depleted in clay, organic matter and/or nutrients. These horizon are typically found in all soils (considered within the context of the PSR), except the Conestogo and Maryhill series, ranging in thickness from between 5 and 10 cm in the Burford series, to between 40 and 45 cm in the Woolwich series.

The authors of the PSR state that “Generally, as each extraction phase is started, …topsoil and subsoil will be stripped…and used to immediately initiate the rehabilitation of the preceding phase.” Based on the details provided later in the PSR (page 31), this is an oversimplification, and the term ‘immediately’ not very precise – for example, material stripped from Phase 1 (and used to construct the Phase 6 Berm = parallel to the hydro easement?) will only be replaced after Phase 9 is complete. As revealed in the ‘specific steps of the progressive rehabilitation’ (page 31), the ‘topsoil’ and ‘subsoil’ will be used to construct berms, with excess being stockpiled. No details have been provided as to how these two materials will be kept separated, for subsequent replacement on the land surface. Moreover, no information has been provided as to measure that may be taken to mitigate deterioration of the quality (structure and fertility), especially of the topsoil, during storage.

Concern is raised, in the PSR, regarding the final pit floor level, with respect to the groundwater. Apparently, monitoring will be conducted to allow for necessary upward adjustments. Evidently, the authors are aware of the issue of proximity of the groundwater table. According to recent guidelines, for implementation of the CLI in Ontario (Wilson, 2004), the presence of excess water, resulting from inadequate soil drainage, a high water table, seepage or runoff from surrounding areas, could lead to a downgrading of land (for coarser-textured soils) to CLI class 2 (if artificial drainage is in place or feasible) or to at least CLI class 4 (when drainage is not feasible) – assuming no bedrock (barrier to infiltration) within 100 cm. In this regard, and referring back to earlier comments about the current distribution of hydromorphic soils, there is the possibility that a greater portion of the landscape would be downgraded to at least CLI class 2 (‘w’ subclass). Alteration of the hydrological regime of soil has a very rapid and profound impact on its behaviour and, consequently, potential agricultural productivity. It is recommended that the installation of subsurface drainage be considered, as part of any eventual rehabilitation strategy.

The PSR indicates that “the sideslopes of the extraction area will be backfilled to a final slope of 3(h) to 1(v)…” This represents a slope of 33%, which according to recent CLI guidelines (Wilson, 2004), would downgrade that specific land to 6 class (‘t’ subclass). The PSR indicates that “to create these slopes overburden or other on-site material may be utilized” – further elaboration should be provided, to determine the impact on final soil quality (to be discuss shortly). Based on the final slopes, projected for the ‘area to be excavated’ proper, illustrated on Sheet Nos. 3 of 4 and 4 of 4, no downgrading in CLI (with respect to slope) would apply for the rehabilitated pit floor area.

The issue of compaction of the pit floor is significant, especially on the ‘haul route corridors’. Without adequate mechanisms to alleviate this compaction, this surface would likely behave, at least in the short-term, similar to a bedrock contact (admittedly, this will depend heavily on the proportion of fine particles, especially clay in the material comprising the pit floor). Assuming, using projections provided in the PSR, that the replaced ‘topsoil/subsoil’ will have a combined thickness of about 50 cm, the potential downgrading due to shallowness to bedrock (‘r’ subclass) would be to CLI class 3 – *note that this is not a strict interpretation of this particular guideline, rather is being presented to suggest that may have similar reductions in agricultural potential.* Apparently, the pit floor will be ‘deep-ripped’ by bulldozer prior to replacement of ‘topsoil/subsoil’. Moreover, the use of deep rooted forages, for initial re-vegetation, will likely aid in reducing any impediment to infiltration.

According to the PSR, the rehabilitation plan calls for a final combined depth of +/- 45 to 55 cm “topsoil’ plus ‘subsoil’. This is comparable to the depth of the solum (soil above the parent material) for the various imperfectly and poorly-drained soils currently found within the area under consideration. The more well-drained St. Jacobs and Woolwich series, typically extend to depths of about 60 and 80 cm respectively. Replacement of ‘+/- 15 to 20 cm’ of ‘topsoil’, is reasonable, considering that this would correspond to the typical depth of the existing plough layer.

Of particular concern is the degree to which the so-called ‘topsoil’ and ‘subsoil’ may be contaminated with underlying (or foreign) material during the initial stripping, storage and replacement operations. While the transition from the Ap to the immediately subjacent horizon is expected to be relatively smooth and clear, the transition between any underlying horizons (i.e Ae to B, or B to C) may be much less regular and clear (considering the tonguing phenomena often encountered in these soils). The incorporation of subjacent materials could result in a reduction in agricultural potential similar to that produced by erosion; where B horizon material becomes incorporated into the plough layer the CLI class could be reduced to 2 (‘e’ subclass); where a substantial amount of non-solum material is incorporated, the reduction could be to class 3 (‘e’ subclass). Care must also be exercised in the construction of the rehabilitated ‘subsoil’, as excessive clay contents could lead to a reduction in CLI class to at least 2 ('d' subclass – undesirable structure and/or low permeability), where its clay content >35%.

With respect to the proposed 'specific steps of the progressive rehabilitation', vis-à-vis handling of 'topsoil' and 'subsoil', some ambiguities exist in the PSR. Surficial material to be stripped during Phase 3, is apparently destined for usage in both the construction of berms and rehabilitation of Phase 2 – it is not clear what proportions will be used for each purpose. No clear indication was give as to what material would be used to rehabilitate Phase 6. In general, and especially considering the variable thickness and nature of 'topsoil' and 'subsoil' material, in the soils currently covering the 'area to be excavated', there is no quantitative analysis provided to show that sufficient amounts of both would be available for construction of the berms and progressive rehabilitation during each phase.

The PSR indicates that, throughout the life of the pit, and specifically during progressive rehabilitation, the majority of the lands will be in 'agricultural production'. Once again, the term 'agricultural production' should be defined. The statement "if any vegetation dies, it will be replaced immediately (during the proper planting season)", does not seem to be internally consistent. The issue of 'proper planting season' should be elaborated upon, specifically with respect to the nature of the vegetation/crop under consideration.

Section 7.4 'Final Rehabilitation'

The various point raised by the authors of the PSR, in this section have been addressed under the previous heading. There is a need for clarification of terminology, and quantitative analysis (especially with respect to amounts and fate of stripped soil materials), to permit more comprehensive interpretation of the potential impact of the excavation operations and effectiveness of the rehabilitation strategy, with regard to the both the short-term and long-term impact of on the soil and agricultural productivity of the land.

References Cited

Wilson, E. 2004. Classifying Prime and Marginal Agricultural Soils and Landscapes: Guidelines for Application of the Canada Land Inventory in Ontario. OMAFRA.

Sincerely,

Richard J. Heck, P.Ag.