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M E M O R A N D U M

May 19, 2023

TO: Phil White
Thomas Cavanagh Construction Limited
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FROM: Nick Battye
Hydrogeologist
Technical Support Section
Eastern Region

RE: MECP Hydrogeology Review Comments, Aggregate Resources Act Amendment, Highland Line Pit

Purpose

The Ministry of Northern Development, Mines, Natural Resources and Forestry (MNDMNRF) is responsible for the administration of the Aggregate Resources Act (ARA); however, overlaps with the Environmental Protection Act (EPA) and the Ontario Water Resources Act (OWRA) occur that are the purview of the Ministry of the Environment, Conservation and Parks (MECP). According to the MNDMNRF/MECP ARA Protocol, the role of the MECP hydrogeologist is to review the hydrogeological report(s) and related material to assess potential impacts from the proposed operations to water well supplies (i.e., impacts to drinking water supplies and local domestic wells as a part of the impact to the groundwater system as a whole) and nearby surface water features (i.e., wetlands, ponds, lakes, rivers). Potential impacts, if any, are assessed to ensure that adverse impacts to supplies, and the quality and flow of receiving water bodies are mitigated. With respect to this requirement, I have reviewed the report by Golder Associates Limited (Golder) titled "Level 1 and Level 2 Water Report, Proposed Highland Line Pit, Township of Lanark Highlands, Ontario." Provided below is a summary of pertinent Site information, as well as my comments related to groundwater on behalf of the MECP. An MECP surface water specialist will be providing comments related to surface water.

Background

Thomas Cavanagh Construction Limited (Cavanagh) is applying for a Class 'A' licence for a Pit Below the Groundwater Table, under the Aggregate Resources Act (ARA) and the Planning Act. The proposed Highland Line Pit is located on Part of Lot 15, Concession 10, in the Township of Lanark Highlands, Lanark County, Ontario. The proposed area to be licensed under the ARA is 50.6 ha, of which 35.1 ha would be for extraction. There is also a 1.3 ha Natural Environment Exclusion Zone. Based on the nature of the subsurface materials, the approximate base elevation of the pit will be 176

m above sea level (asl). Only unconsolidated materials (sand, gravel, etc.) will be removed from the Site. Any bedrock encountered will remain in place. It is understood that extraction operations below the groundwater table will not involve any dewatering.

Surrounding land uses include an existing sugarbush to the west, and deciduous, mixed, and coniferous forest, and wetland to the south, east and north, interspersed with small patches of active shallow rooted agriculture. A small sand extraction operation, owned by others, is located north of the Site, on the north side of Highland Line. The nearest residences are located along Highland Line, and the adjacent Leo Jay and Anderson Lanes.

Surface water features within the proposed licensed area include a single small intermittent watercourse that flows to Barbers Lake, located immediately southeast of the Site, and unevaluated wetlands. The intermittent watercourse originates from two seepage areas and is located outside of the proposed limit of extraction. There are low-moist areas throughout some of the forests at the Site, including a small pond in the mixed forest, which are associated with low topography. Barbers Lake is not within the proposed license area but is immediately adjacent to it.

The final rehabilitation plan includes a permanent pond located within the proposed limit of extraction area. Based on the groundwater level data collected at the Site, the predicted elevation of the permanent pond will be approximately 186 m asl.

Hydrogeological Study

Geology and Hydrogeology

Published surficial geology mapping indicates the presence of ice contact stratified deposits (sand and gravel, minor silt, clay, and glacial till) over the majority of the Site and Precambrian bedrock-drift complex (thin layer of overburden over bedrock and bedrock outcrops) along the southern border (western half of the Site) and in the northern corner and center of the eastern half of the Site. There is also an area identified as a coarse-grained deposit (sand and gravel) in the eastern half of the Site. The Precambrian drift complex tends to coincide with the topographic high points. The test pitting program completed at the Site confirmed the presence of sand and gravel and fine to medium sand.

Published bedrock geology mapping indicates the upper bedrock unit in the vicinity of the Site consists of carbonate metasedimentary rocks (marble) in the northern portions of the Site, and alkalic plutonic rocks (syenite) in the south. Bedrock outcrops are visible within the proposed licensed extraction area in the topographically higher areas of the Site.

Deposits of coarse-grained and permeable overburden capable of supplying enough groundwater for domestic purposes may exist locally in the area around the Site; however, most of the area is mapped as Precambrian bedrock-drift where there is only a thin layer of overburden over bedrock, which make it unlikely. This is reflected in the MECP Water Well Information System (WWIS), which shows most private water supply wells in the vicinity of the Site have been completed in the Precambrian bedrock.

Groundwater flow in the Precambrian bedrock is attributed to secondary porosity produced by fractures that have developed from tectonic processes, and the density of fractures in the bedrock tends to decrease with depth. Estimates of hydraulic conductivity in fractured igneous and metamorphic rocks ranges from 10^{-8} to 10^{-4} m/s, with actual values of hydraulic conductivity in the region being reported on the low end of this range, with marginal to adequate yields for domestic use.

Based on an air photo review, it was estimated that approximately eight private supply wells are located within 500 m of the proposed boundary of the area to be licensed; the MECP WWIS confirmed two of those, and showed them to be completed in bedrock with depths of 17 and 22 m below ground surface (bgs), and static water levels of 2 and 6 m bgs.

Test Pits and Monitoring Well Installation

An aggregate resource investigation was carried out on February 28, 2019 (TP1 to TP16) and on April 22, 2020 (TP17/MW20-1, TP18/MW20-2, TP19/MW20-3, TP20/MW20-4, TP21/MW20-5 and TP22/MW20-6). The objectives of the subsurface investigations were to determine the extent and nature of the aggregate resource in the area and install monitoring wells for the characterization of hydrogeological conditions at the site.

Hydraulic Conductivity Testing

A total of six well response tests were carried out in the monitoring wells installed in MW20-1, MW20-2, MW20-3, MW20-4, MW20-5, and MW20-6 (screened in the overburden) using the rising/falling head method. The hydraulic conductivity value from each test was calculated using either the Hvorslev (1951) or the Bouwer and Rice (1976) method. Results ranged from $3x10^{-6}$ to $1x10^{-4}$ m/s, with a geometric average of $3x10^{-5}$ m/s.

Groundwater Monitoring and Flow Direction

Groundwater monitoring was undertaken between April 29, 2020, and June 16, 2021. Pre-development groundwater elevations ranged from a low of 182.4 m asl at MW20-3 in February 2021 to a high of 195.4 m asl at MW20-6 in April 2020. Groundwater elevations in all monitoring wells show seasonal variations, with the highest elevations observed in late spring/early summer, and the lowest generally observed during summer months (July and August). Based on the groundwater elevation data, the general groundwater flow directions in the vicinity of the Site were shown to be influenced by topography and seasonal water table fluctuations; however, groundwater generally flows from southwest to east across the Site, and towards the topographic low near Barbers Lake.

Groundwater Drawdown and Radius of Influence

The proposed Highland Line Pit will not be dewatered during operations; rather, extraction will take place below the groundwater table. Based on the groundwater level data collected at the Site, the predicted elevation of the pond during operations and after rehabilitation will be approximately 186 m asl based on the lowest elevation of the

ground surface on the perimeter of the proposed extraction area (near Barbers Lake). Since the surface of the lake within the pit will be flat, there will be minor changes in the groundwater table in the area adjacent to the sides of the proposed pit. In areas where the existing groundwater table is above the estimated elevation of the lake, a drawdown will be observed during extraction operations whereas in areas where the existing groundwater table is below the estimated elevation of the lake, an increase in the groundwater table would be observed.

A radius of influence was estimated based on the groundwater levels measured in the on-Site monitoring wells (MW20-1 to MW20-5) and the hydraulic conductivity of the surficial sediments measured in the wells using the empirical formula developed by Marinelli and Niccoli (2000):

$$h = \sqrt{h_p^2 + \frac{W}{K_h}\left[r_0^2 ln\left(\frac{r}{r_p}\right) - \frac{\left(r^2 - r_p^2\right)}{2}\right]}$$

Where: h = saturated thickness above the base of the aquifer at a given radius (m), h_p = saturated thickness at the pit wall (m), W = recharge flux (m/s), K_h = horizontal hydraulic conductivity (m), r_0 = radius of influence where drawdown is zero (m), r = radius of influence (m), and r_p = effective pit radius (m).

Using a recharge flux of 200 mm/year, the geometric average of the calculated hydraulic conductivities, and the average drawdown from all the on-Site monitoring well locations (1.4 m) due to the flattening of the water table in the area immediately surrounding the pit lake, the average radius of influence based on 1 metre of water table change (increase or decrease) is estimated to be 50 m.

Hydrological Investigation and Water Balance Analysis

A water balance was completed for existing conditions, operational conditions, and rehabilitation conditions for the study area. This included the land within the property boundary of the proposed pit and contributing catchments (total area approximately 157.2 ha).

Staff gauges (SG) and a wellpoint (WP) were installed in the wetland along the northern site boundary, just south of the crossing of Highland Line Drive and Leo Jay Lane (SG2), and near the marshes along the eastern site boundary, adjacent to Barbers Lake (SG1, SG3 and WP1) to assess water levels. Data loggers were installed at each measuring point and programmed to record water levels at 15-minute intervals. Water levels in the wetland at the north end of the property (SG2) fluctuated in response to precipitation and melt events with a total daily average fluctuation of approximately 0.59 m; however, the marshland adjacent to Barbers Lake (SG1 and WP1) showed minimal response to precipitation and melt events with a daily average fluctuation ranging between 0.23 – 0.49 m. Compared to the water levels seen at the edge of Barbers Lake (SG3), the water levels recorded at the other stations remain at a higher elevation. The lowest water levels occurred in the summer and early fall. Winter water levels generally remained low, but high-water events likely caused by short melt events were observed. Water levels in the spring were moderate to high following the freshet.

Water balance calculations were based on the equation, P = S + ET + Surplus, where P = precipitation, S = change in soil water storage, ET = evapotranspiration, and Surplus = Surplus water (available for runoff or infiltration). Available data for the study area indicated a mean annual precipitation (P) of 925 mm/yr, and a mean annual potential ET of 613 mm/yr. The mean annual water surplus (Surplus) is the difference between P and the actual ET. Maximum soil storage was quantified using a water holding capacity (WHC) specific to the soil type and land use.

Results for the existing conditions water balance indicated a total average annual surplus of approximately 333 mm or 168,755 m^3/year, and the estimated infiltration 192 mm or 97,315 m^3/year. Runoff was estimated to be approximately 141 mm or 71,440 m^3/year. Results for the operational conditions water balance indicated a total average annual surplus for the proposed extraction area of approximately 299 mm or 151,180 m^3/year, and the estimated infiltration approximately 226 mm or 114,365 m^3/year. Runoff was estimated to be approximately 73 mm or 36,815 m^3/year. Results for the rehabilitated conditions water balance indicated a total average annual surplus for the proposed extraction area as approximately 295 mm or 149,340 m^3/year, and infiltration as approximately 200 mm or 101,000 m^3/year. Runoff was estimated to be approximately 95 mm or 48,340 m^3/year. Therefore, under operational conditions, surplus is anticipated to decrease by approximately 10% from 168,755 to 151,180 m^3/year. Based on the Site layout, approximately 36,815 m^3/year of runoff will be produced, which is a decrease of approximately 34,625 m^3/year (approximately 48%) from the existing conditions. Runoff will likely flow away from the pit towards Long Sault Creek, Barbers Lake, and the unevaluated Northern Wetland as the areas surrounding the proposed pit naturally flow in those directions. Under rehabilitated conditions, it is assumed the pit will remain flooded. Therefore, total surplus is anticipated to decrease by approximately 19,415 m^3/year (12%) to 149,340 m^3/year, and runoff is estimated to decrease by approximately 23,100 m^3/year (32%) compared to existing conditions.

Overall, during the operational and rehabilitated conditions, an increase in evaporative losses is expected to decrease the total annual surplus from the Site. The operational and rehabilitated conditions will also result in a decrease in total runoff and an increase in total infiltration. Due to the direction of groundwater flow (primarily from the southwest to the east), it is assumed that infiltration in the pit area will report as baseflow towards Barbers Lake, thereby increasing the surplus discharged towards Barbers Lake and decreasing the surplus toward the unnamed northern wetland and Long Sault Creek, which also discharges to Barber's Lake.

Potential Impact to Groundwater Users

Given that the aggregate extraction below the groundwater table will occur without dewatering, it was assumed that there will be no significant lowering of the groundwater table in the overburden and underlying bedrock, and thus, no potential for the proposed extraction activities to cause drawdown of the groundwater table such that it interferes with local water supply wells. As the material is extracted from below the groundwater table, there would be a localized and temporary depression of the groundwater level as the aggregate material is extracted, but this would rapidly recover given the permeable nature of the subsurface materials.

A monitoring program was proposed to measure and evaluate the actual effects on groundwater levels associated with long term pit operations, and to allow a comparison between the actual effects measured during the monitoring program with those predicted as part of this impact assessment.

Potential Impact to Existing Surface Water Features

Barbers Lake, Long Sault Creek, and the unnamed northern wetland lie outside of the Site boundaries but receive drainage from the Site. Overall, the surface water impacts associated with the proposed pit are expected to be marginal with changes in the contributing catchment to the locations discussed on the order of 2%, while infiltration is still estimated to report to two of the three adjacent waterbodies as baseflow.

Source Water Protection

The proposed Highland Line Pit falls outside of all Wellhead Protection Areas in the Mississippi-Rideau Source Protection Region; therefore, impacts to groundwater quality or quantity at those water supply wells are not predicted. The Site also lies outside of Intake Protection Zones 1 and 2, but parts of the Site do lie within Intake Protection Zone 3. However, as the Site is located greater than 35 km from the closest downstream water supply (Carleton Place), impacts to water quality or quantity there, and further downstream, are not predicted.

Portions of the Site have been identified as Significant Groundwater Recharge Areas. These areas are found both within the proposed extraction area as well as the setbacks within the licensed area. Areas within the setbacks will not be altered, except for areas along Highland Line where the extraction of aggregate in the setback above the elevation of the existing roadway to match its grade is proposed. Groundwater recharge will still occur both within the setback area and the extraction area, as the proposed pit will not be dewatered. Infiltration will take place through the overburden (in the case of the area within the setbacks) or through the bottom and sides of the pit lake.

Complaints Response Program

Nothing reported.

Monitoring Program

During pit operations, as the pit deepens below water, the water level in the pit lake will flatten out (as compared to existing conditions) thus creating areas of groundwater drawdown or areas of groundwater level increases adjacent to the pit. Given that there will not be any active dewatering of the pit and the predicted changes to groundwater levels due to pit operations are localized, no impacts to surface water features and groundwater resources are anticipated.

A monitoring program was proposed to measure and evaluate the actual effects on water resources associated with long term pit development, and to allow a comparison between the actual effects measured during the monitoring program with those predicted as part of the impact assessment. It is proposed that the groundwater monitoring program consist of the following:

- Quarterly groundwater level monitoring during pit operations, in monitoring wells MW20-1, MW20-2, MW20-3, MW20-4, MW20-5, and MW20-6 once the pit is operating below the water table.
- Quarterly surface water level monitoring during pit operations, at surface water station SG-1 once the pit is operating below the water table.

Discussion

Based on my review of the application, I require additional information on the following points:

1. I agree with WSP Golder's conclusion that groundwater quantity impacts to local water supply wells are unlikely given that aggregate extraction will be taking place below the groundwater table without dewatering; however, I do have some mild concerns regarding potential groundwater quality impacts because of this approach. To that end, I agree with the recommendation to have a monitoring program, but it wasn't clear that this program would include water quality testing. I recommend that a general chemistry suite be performed, at least to establish baseline levels before pit operations commence.

2. Notably, the area is also a SGRA, so I would like to have more detail on the standard operating procedures (SOPs) that will be followed to ensure contaminants do not end up in the water-filled pit, what the emergency spill response procedures are, and contingency measures that will go into action in the event of one.

3. Has any consideration been given to the possibility that natural, but currently immobile parameters in the soil may become mobilized because of ground disturbances (e.g., major ions, inorganics, etc., leading to issues with turbidity, total suspended solids, hardness, etc.)? Given the above, it will be important to establish a baseline geochemistry dataset for both groundwater and surface water in areas where groundwater is expected to discharge before extraction commences, and that should include some private residential wells, if consent can be acquired. Specifically, the individual well located on Anderson Lane, and at least one from the well group located along Leo Jay Lane. This data will also help in the event of a private resident complaint.

4. A complaints response program is required to address any issues brought forth by local residents.

5. As a reminder, if dewatering becomes necessary, a Permit to Take Water (PTTW) is required when a person or organization wants to take more than 50,000 litres of water in a day and doesn't qualify for an Environmental Activity and Sector Registry (EASR) water taking. Additionally, discharge of water to the environment requires an Environmental Compliance Approval (ECA).

Conclusions

Additional information is required to provide confidence on the highlighted water quality concerns as a result of working below the water table without dewatering. The points discussed in the previous section must be addressed prior to my acceptance of the quarry license proposal.

Regards,

Nick Battye, MSc, PGeo

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