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November 12, 2013

Via: Email/Mail

Mr. Stan Denhoed, M.Sc., P.Eng.
Harden Environmental Services Ltd.
4622 Nassagaweya-Puslinch Townline Road
RR #1
Moffatt, ON L0P 1J0

Dear Mr. Denhoed:

Re: Hydrogeological Summary Report for Township of Guelph/Eramosa
File No.: 300032475.0000

Thank you for providing R.J. Burnside & Associates Limited (Burnside) with a copy of the Harden Environmental Services Ltd. (Harden) September 5, 2013 letter to review. The Burnside comments are provided below under the same headings used in the letter.

1.0 Karst

Harden indicates that a karst environment is not present in the area proposed to be mined by Hidden Quarry.

Burnside Comment

Burnside reviewed GIS mapping generated by the OGS as part of "Brunton, F.R. and Dodge, J.E.-P, 2008. Karst of Southern Ontario and Mantoulin Island, Ontario Geological Survey, Groundwater Resources, Study 5."

The mapping indicates the presense of karst features along the Eramosa River in Rockwood and near Blue Springs Creek to the south of the proposed quarry. There is no evidence to suggest that the site is in an area of karst terrain. Some scientists now refer to the water producing fractures in the bedrock as micro-karst but this is much different that the large cavernous conditions typically associated with karst.

2.0 Water Quality

Harden indicates that the proposed Hidden Quarry will result in the mixing of groundwater from various discrete fracture sources with an overall decrease in nitrate concentrations already found in the shallow groundwater. The proposed subaqueous mining method will not result in the chemical degradation of groundwater quality.

Burnside Comment

Flow profiling indicated water in the upper 35 m of bedrock comes from three discrete zones with little flow between 19 and 36 mbgs. It appears that most of the nitrate is contributed from fractures in the upper 10 m of the bedrock. If the quarry does not encounter the deepest zone at 41 mbgs then about 30% of the water may not contribute to dilution. Although the depths and water production from fractures in the rock is heterogeneous, the water quality impacts should be calculated using the available information. Once M15 is equipped as a multi-level well, it should be purged and water quality samples collected to see if there are variations with depth. The nitrate contributed by the blasting materials should be quantified and included in the mass balance.

We concur with harden that water wells drilled in the bedrock access multiple fractures, however it is important to note that the Ontario Water Resources Act through the well Regulation 903 (Last amendment: O.Reg. 468/10) states in Section 14 that:

> "any annular space, other than annular space surrounding a well screen, is sealed to prevent any movement of water, natural gas, contaminants or other material between subsurface formations or between a subsurface formation and the ground surface"

The purpose of this section of the well regulation is to protect the good quality groundwater in the subsurface for use as potable sources. The fractures found at 36 and 41 m are currently secure sources of groundwater that are recharged over time by water moving into those formations. These deeper fractures are also the future water source for Rockwood Well 4 that will be constructed this year.

The excavation of the quarry into these fractures will cause the water in the deep fracture system to be under the influence of surface water and the associated bacteria and viruses such as Cryptospiridium and Giardia. Quarrying activities will result in constant mixing of the water in the quarry. The existing secure water quality in deep bedrock aquifer will therefore be changed to a surface water source for an unknown distance surrounding the quarry. This could result in the classification of Rockwood Well 4 as a GUDI water source.

Once the quarry is finished, there will be a large surface body directly in contact with the bedrock fracture system which may allow rapid movement of pathogens towards bedrock wells downgradient of the site.

As a result, there may be some benefit to restricting the extraction to the bedrock above 36 m in order to protect the lower fractures system.

3.0 Private Wells with Shallow Fracture Source of Water

Harden predicts a 1.6 m decline in the closest domestic well due to the quarry and indicates that testing of M15 suggests that the lack of water level response in M1, M3 and M13 is due to poor lateral shallow connectivity and poor connectivity to fractures at depth.

Burnside Comment

Analysis of the response observed at M2 indicates a total Transmissivity of 75 m^2/day. Further analysis of the data indicates a Storativity of only 0.00004. This relatively low Storativity results in the rapid (5 minutes) response at a relatively distant (125 m) location. Depressurization of the deep formation at M15 will result in rapid response over a large area. This Storativity is indicative of a confined aquifer system and is likely caused by response in the deeper fractures at 34 and 41 m.

Testing completed by Burnside on existing wells in Rockwood indicates that a well that penetrates the entire carbonate formation typically exhibits a Transmissivity in the range of 50 to 100 m^2/day. Wells that only access the fracture systems below 35 m exhibit Transmissivity of 25 to 50 m^2/day. M15 is consistent with these historical tests. It is important to note that the Transmissivity of an individual fracture or group of fractures cannot directly be converted into a hydraulic conductivity based on the entire bedrock thickness. The groundwater flow is much faster and can reach much further distances within an individual fracture than in a bulk porous media as predicted by a model. As a result, groundwater with elevated nitrate may move rapidly away from the quarry before dilution with deeper water can occur.

Currently, the total transmissivity of the fractures encountered by M15 has been estimated. Once individual monitors are installed opposite the fractures testing should be completed to assess the hydraulic properties of the individual fractures. Monitoring of water levels in this monitor well and the quarry itself can be used to predict off site impacts.

The pumping test did not continue for a period long enough for water levels to stabilize. Nearby wells (Rockwood Well 3) typically stabilize after approximately 12 hours of pumping in the deep bedrock fractures. Extrapolation of existing data to at least 12 hours allows an estimate of the actual response that will occur during quarrying activities. For example, extrapolation of the test of M15 to 12 hours would result in approximately 1.9 m of drawdown in M2. This data indicates that water levels in domestic well close to the site will be measurably impacted by onsite activities. As a result, wells with pumps set at shallow depths may experience water quantity issues. The six wells indicated on Figure 2 to be completed from 0 to 5 m below bedrock have the greatest potential to be impacted. The proposed domestic well survey plan should be combined with proactive well upgrades to ensure that no domestic water supplies are adversely impacted by the quarrying activities. Upgrades of nearby wells to include pitless adaptors and water level conduits should be included as part of the program to ease the monitoring process.

4.0 Groundwater Model Parameter – Hydraulic Conductivity

Harden indicates that the bulk hydraulic conductivity of the bedrock aquifer used by the groundwater model is 2.0×10^{-5} m/s.

Testing of M15 resulted in estimated hydraulic values ranging from 1.4×10^{-5} to 1.98×10^{-5} m/s.

Burnside Comment

Although a bulk value for hydraulic conductivity is useful in predicting the long term behaviour of water in the quarry, video flow profiling suggests that there are many metres of rock that are competent and contribute little in the way of groundwater flow. As a result, groundwater flow into the quarry may be highly variable with depth.

In-situ hydraulic conductivity of M15 when it is re-constructed as a multi-level well will help to refine the hydraulic conductivity estimates.

5.0 Brydson Spring and Blue Springs Creek

Harden indicates that there will be neither a significant quantity nor quality impact to waters discharging from the Brydson Spring and no change to groundwater quantity or groundwater quality discharging to Blue Springs Creek.

Burnside Comment

In the long term, there should be no impacts to Byrdson Spring. There may be some short term reductions in flow as the quarry fills with water following rock extraction.

6.0 Rock Extraction Water Level Change

Harden indicates that removal of rock from below the water table will simulate a pumping effect on the surrounding aquifer. Groundwater will flow into the quarry to fill the space previously occupied by rock.

The initial rock extraction will occur in a sinking cut with the dimensions of 25 x 50 m (1,250 m^2). Harden indicates the removal of this material from below the water table will cause the water levels in the quarry to decrease by 0.91 m/day. James Dick has committed to a maximum drawdown of 2.54 m in the sinking cut to be monitored daily with the rate of rock extraction moderated in the event that drawdown approaches 2.54 m.

Burnside Comment

There is significant potential for impacts from the proposed quarry activities on the groundwater resources in the surrounding area. There are several existing domestic water wells with unconfirmed pump installation depths and a municipal well that will be pumping 10 to 16 L/s when it is constructed. The combined impact of the quarry and the municipal well on the existing wells between the sites is difficult to assess in a heterogeneous carbonate aquifer.

Testing completed on M15 in 2013 showed that a pumping rate of 4.2 L/s resulted in drawdown of just under 1 m at a distance of 125 m in less than 100 minutes. This water level response was used to calculate a Transmissivity of 75 m^2/day. It was also determined that only 30% or only 1.3 L/s was derived from the bedrock above 35 m.

The description of how rock will be quarried indicates that a 25 m by 50 m strip will be mined vertically at a rate of 0.9 m/day. The daily volume of rock removed will be 1,145 m^3. If the area mined is below the water table, then removal of 1.145 m^3 of rock will require 1,145 m^3 of water to flow into the strip on a daily basis. This will necessitate a continuous flow of 13.3 L/s from the shallow bedrock fracture system 24 hours/day in order to maintain the pre-extraction water level. This will cause a measureable impact to existing domestic wells in the surrounding area during the initial days of the quarrying activities when all of the "make up" water is derived from the shallow fractures which may not be able to sustain the rate of flow into the excavation to keep if full of water. Once the first strip is quarried to the maximum depth and all of the water producing intervals are encountered, then the flow of 13.3 L/s may be sustainable. This will depend on the size and extent of the fracture system encountered.

Burnside recommends that in order to ensure that offsite impacts are minimized that:

1. The initial stages of excavation are completed at a rate that allows the water level to be maintained within 0.9 m of static conditions as predicted in the report. This would mean that at the beginning of the day removal of rock could only occur if water levels had returned to static levels. This would prevent a cumulative dewatering of the bedrock adjacent to the site.
2. All domestic wells within 500 m of the quarry site be inspected and tested to evaluate how susceptible they are to water level variations. Submersible pumps should then be set as deep as possible in the wells to ensure that they are not impacted by the quarry activities. The proposed monitoring program (Appendix A of your letter) for onsite wells and surface water stations is comprehensive, but should be expanded to include representative domestic wells.
3. Flow profiling at M15 indicated that a deeper fracture system provided about 66% of the flow. These fractures are separated from a shallow fracture system by several metres of rock which produces minimal water. If the deeper fracture set is providing water to a number of nearby domestic wells, James Dick may wish to maintain the base of the quarry above this level to ensure that an alternate water supply is available in the event that the shallow zone has water quality/quantity impacts due to quarry activities.

7.0 Aquitard

Harden indicates that the Eramosa Formation (a natural aquitard protecting the Goat Island and Gasport formation) is not present at the Hidden Quarry site.

Burnside Comment

Burnside concurs with Harden that the Eramosa Formation is not present at the Hidden Quarry site.

9.0 Monitoring Plans, Trigger Levels and Contingency Plan

Appendix A contains a revised monitoring program that was submitted to the MOE by Harden. The Burnside comments will follow the same headings as contained in the monitoring plan.

Burnside Comment

1.0 Onsite Monitoring Program

Groundwater Levels – These should be measured monthly year round (with exception of well listed below) in wells with manual levels and daily year round in wells with dataloggers.

Groundwater Levels – M2, M3, TP1, M13S10, M14SID, M15, M16. As a minimum, these should be measured hourly with the data logger during the first three months of extraction in order to ensure the maximum daily drawdown of 0.91 m is not exceeded and that any exceedance of the trigger levels can be quickly mitigated.

Surface Water Levels – SW5 and SW7 should be added to the list.

Surface Water Flow – SW5 and SW7 should be added to see if the extraction has any effect on when flow ceases in Tributary B.

Groundwater Quality – W1 should be added along with the most vulnerable wells identified in the pre-bedrock extraction water well survey (Section 4.0).

Surface Water Quality – Increase to semi-annual (spring and fall) at some time as groundwater sampling. Add northwest wetland and Tributary B (at SW4 and SW3) to confirm east and west ponds are not impacting surface water/groundwater. Add cryptosporidium and giardia to the list of parameters

2.0 Trigger Levels

The trigger levels proposed by Harden are designed to verify that water levels in the bedrock aquifer do not exceed predicted values and that the hydro-period of the northwest wetland does not change.

2.1 Trigger Levels for the Bedrock Aquifer

Harden uses the historical low levels in M1D, M2, M13D and M14D and the predicted water level change to establish conservative trigger levels.

Burnside Comment

Trigger levels should be established for M15 and M16 after monitoring begins. It is not clear how the trigger levels relate to the drawdown trigger of 2.54 m in the sinking cut. It is also not clear if the predicted change is following completion of extraction or is the maximum expected change.

2.2 Trigger Level for Northwest Wetland

The historical low value of 344.20 m AMSL at SW6 is the recommended trigger value with a warning level of 354.35 m AMSL. Harden recommends an increase in manual water level measurements to bi-weekly if the warning level is exceeded.

Burnside Comment

Burnside recommends daily water level monitoring begin 3 weeks prior to the initial overburden/bedrock extraction so pre-extraction trends can be established. Daily water level measurements should continue as long as weather conditions permit.

3.0 Contingency Measures

3.1 Groundwater Levels and Northwest Wetland

If a trigger level is breached Harden recommends the following measures be undertaken:

1. Confirmation of water levels with 24 hours.
2. Evaluation of precipitation, groundwater monitoring data and quarry activities to determine if quarry activities are responsible for the low water level observed.
3. If quarry activities are found to be responsible, the following actions will be considered and a response presented to the GRCA and the Township of Guelph/Eramosa:

- increase the length and/or width of barrier;
- decreased rate (or stopping) subaqueous extraction;
- change in configuration of mining or decrease in mining extent; and
- after timing of extraction to coincide with high seasonal groundwater levels.

Burnside Comment

Burnside recommends the following:

1. An onsite weather station be established as it can take significant time to obtain data from GRCA/Environment Canada.
2. A timeline be provided for the evaluation of data.
3. A decreased rate (or stopping) of subaqueous extraction be the initial response.
4. Increased monitoring be undertaken at other locations until the source of the trigger level exceedance is identified.

3.2 Groundwater Quality

Harden recommends semi-annual (summer) sampling for a variety of parameters. An increasing trend in the concentration of one or more elements will result in a study to determine the source of the water quality change. If the quarry is found to be responsible or there is a potential for impact to downgradient wells, James Dick Construction Ltd. will commence with the following actions:

1. Semi-annual testing of the water quality of private wells that could potentially be impacted by the quarry.
2. In the event that a water quality issue related to the quarry occurs, James Dick Construction Ltd. will remedy the issue by either providing the appropriate treatment in the home or drilling a new well and isolating the water supply to the deeper aquifer.

Burnside Comment

Burnside concurs with the proposed water quality monitoring program. It is recommended that the program begin at least a year prior to extraction so that existing conditions can be established. When a sufficient data set is available, Burnside recommends that any result above the ODWQS or above the 95th percentile result in actions 1 and 2 above. Surface water pathogens should be included in the list of quality parameters.

4.0 Pre-Bedrock Extraction Water Well Survey

Harden recommends that a detailed water well survey be completed prior to the extraction of bedrock resources.

Burnside Comment

The Harden plan is comprehensive and will provide valuable baseline information. Burnside recommends the results of the survey be used to select a number of domestic wells for inclusion in the water level monitoring program.

10.0 Well Complaint

Harden provided a proposed protocol for dealing with complaints about water well issues.

Burnside Comment

Burnside concurs with the proposed protocol. The Township of Guelph/Eramosa and the Ministry of the Environment should be advised when a complaint has been received and should be provided with the results of the independent investigation.

11.0 Next Steps (Next included in the Harden Report)

The following are the outstanding issues that need to be addressed:

- M15 should be constructed as a multilevel monitor with appropriate hydraulic conductivity and water quality testing completed. The groundwater model should be modified as necessary to incorporate the test results.
- Burnside will provide information on the construction and testing of Rockwood Well 4 to James Dick once it is available.
- The detailed domestic well survey should be completed so that pre quarrying improvements can be established.
- The potential for impacts from surface water pathogens should be quantified along with mitigation methods.
- The final depth of the quarry should be confirmed.
- Burnside comments should be addressed.

Should you have any question regarding the above, please contact the undersigned.

Yours truly,

R.J. Burnside & Associates Limited

Dave Hopkins, P.Geo.
Hydrogeologist
DH:sd

cc: Ms. J. Sheppard, Township of Guleph/Eramosa (Hand Delivery)
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