Technical Review of Karst Documentation Pertaining to the Proposed Duntroon Quarry Expansion, Clearview Township, County of Simcoe (April 8, 2008)

1.0 INTRODUCTION

This review constitutes a technical review of the karst information and was prepared under retainer to The Niagara Escarpment Commission. It is based on the following reports:

1. Karst Investigation of the Duntroon Quarry Expansion Lands, Marcus J. Buck Karst Solutions and Worthington Groundwater, October 3, 2007 (and 1:20,000 scale Map – Figure 1 – provided under separate cover), and
2. Duntroon Quarry Expansion, Level 2 Hydrogeological Assessment Addendum Cumulative Assessment Proposed Expansion and Proposed MAQ Highland Quarry Computer Groundwater Modelling Response to Agency Review Comments, Jagger Hims Limited, October 2007.

In addition, a brief telephone discussion of technical karst issues was undertaken with one of the karst specialists for the project (Mr. Marcus Buck).

This review is offered as an opinion of the completeness and accuracy of the karst studies and the degree to which karst factors have been incorporated and considered in the report's analyses, conclusions and recommendations. Time has not permitted detailed discussions with the proponent or the proponent's consultants and no field observations of the karst have been undertaken.

2.0 DUNTROON QUARRY EXPANSION AREA KARST CHARACTERIZATION

The work of Buck and Worthington indicates that karst features and processes are quite common in this area but surface features tend to be concentrated in a relatively narrow zone located within a few hundred meters west of the top of the Amabel escarpment extending to the base of the Manitoulin Formation shelf. This indicates a relatively young (post-glacial) karst typical of most of the Niagara Escarpment karst in Ontario. The karst has formed in response to existing (i.e., post-glacial) hydrological conditions.

Young conduit karsts are typically characterized by having numerous springs fed by only one or two major sinkpoints. Over time competition between conduit pathways will result in one dominant conduit (cave) that carries the all or most of the recharge water but the evidence presented suggests that this has not yet occurred in the study area. However, this does not preclude the development of relatively large surface karst features such as dolines and streamsinks.

The dispersion of subsurface water via several routes restricts the size of underground passages to a few mm or cm in size, generally largest in the downstream direction. Observations reported from along the existing quarry walls, in boreholes, and from tracer characterization studies in the study area tends to confirm this situation. As such, one would not expect significant hazards typical of karst terrains (e.g., bedrock collapse) to occur from quarry operations and ancillary activities in this area. However, these operations can clearly impact the distribution of surrounding conduit flow waters and percolation waters in karst systems which could, in turn, impact flow to the headwaters of numerous surface watersheds above and below the escarpment.

3.0 KARST INVESTIGATION REPORT

The noted objectives of this work are to A) characterize the karst; B) define the role of karst in the hydrogeological setting; and C) evaluate the potential for adverse effects to groundwater and surface water resources and define mitigation needs. The descriptions, mapping and other data provided in the Karst Investigation Report (KIR), as well as the long-term surface flow monitoring undertaken by Jagger Hims Limited, appear to be very thorough and complete and, based on my understanding of Niagara Escarpment karst, appear to have fully met the first objective.

As part of this characterization, Buck and Worthington focused on three principal karst systems that they considered to have the greatest potential for significant impacts due to the expansion of the quarry – SW28 to SW27 sink/springs system; SW9 to SW11 sink/springs system; and the SW2 springs. The first two systems have potential impacts to surface waters below the escarpment (Pretty River and Batteaux Creek) and the third potentially impacts the Rob Roy Provincially Significant Wetland Complex (PSW) and Beaver River.

Based on a tracer test, water flow monitoring, and chemistry they concluded that impacts to the SW28-SW27 system from quarry operations would not be significant to either the conduit flow portion of the spring discharge or the percolation discharge. The data provided supports this conclusion in general although they did not specifically identify the source of percolation water to these springs and other nearby springs. However, given the location of these springs and their likely catchment(s) relative to the location of the proposed quarry expansion and the intent to maintain surface water features in the northeast portion of Karst Basin C (including the ANSI A and B wetlands) their conclusion appears to be reasonable.

The SW9-SW11 karst system will be more directly impacted by the proposed quarry expansion. The tracer tests conducted clearly identified the primary flow system from the ANSI B wetland drainage to at least 19 spring points below the main scarp. They concluded that only about 34% of the flow to these springs was derived from the SW9 watercourse, the remainder being percolation water (base flow). As a result, they concluded that the largest component of flow to the springs was derived from infiltration through the soil mantle overlying the Amabel aquifer “from a large area” (page 47).

They further concluded that this percolation recharge would not be significantly impacted by the proposed expansion, however no attempt to determine the likely catchment of the percolation water vis á vis the physical extent of the quarry and its surrounding draw-down zone was undertaken.

The two SW2 springs drain the uppermost part of the Amabel aquifer and, unlike the other springs studied in detail, drain into surface waters above the escarpment (Beaver River). The springs discharge at the southwestern corner of the proposed expansion and hence, will be completely eliminated as Phase 2 of the quarry expansion develops. Although not all of the drainage area to the springs will be removed by the expansion quarry and/or proposed MAQ quarry, all discharge will be intercepted by the quarry(ies), thus eliminating all flow to Rob Roy PSW Complex Unit #6. The lower spring (SW2A) flows all year and the combined flow is estimated to average about 9L/sec over the course of the year.

With regard to Objective B of the KIR, overall the report satisfactorily defines the role of karst and the hydrogeological setting in the study area. The principal failing of the study is the lack of any attempt to identify the likely catchment for the percolation water discharging to the SW11 springs and other nearby springs. Some of this water may be derived from Karst Basins C and D, both of which will be directly impacted by quarrying. Hence, the conclusion within the KIR that base flow to these springs will not be significantly impacted by quarrying is not proven by the data presented. However, it should be pointed out that water balance calculations and modelling presented in the Level 2 Hydrogeological report essentially supports the conclusion of Buck and Worthington.

The third objective of the KIR was to evaluate the potential for impacts to groundwater and surface water resources and to define mitigation needs. The most likely impacts were principally noted to be related to groundwater drawdown adjacent to the quarry(ies) which may be mitigated by the use of injection wells; the complete loss of flow to the Rob Roy PSW Unit 6 by the removal of the SW2 springs; and the loss of conduit flow water to the SW9 watercourse. The latter will be mitigated by discharging excess quarry water into this watercourse. However, they did not address the loss of water to the Rob Roy Wetland during the quarrying operation and did not provide a post-quarrying mitigation strategy. In fact they noted that once quarrying ended, the final lake levels would "not be sufficiently high to permit seasonal flow into the SW2 watercourse" (page 9). They did note that some flow into the PSW complex from the lakes may occur seasonally.

4.0 LEVEL 2 HYDROGEOLOGICAL ASSESSMENT ADDENDUM

As noted above in Section 1.0, the intent of this review is to determine the extent to which karst factors have been considered in the hyrogeological assessment and mitigation strategies and not to undertake a critical evaluation of methods, data analysis or modelling. In general, the Hydrological Assessment Addendum (HAA) does account for the major karst issues as defined in the KIR. In particular, these include the reassignment of recharge equal to the annual water surplus in the defined karst basins in the model structure (page 16) and the development of a mitigation strategy to replace recharge to the SW9 karst system during quarry operations. Also, the assignment of differential hydraulic conductivity fields in the model, although not the result of the KIR work, improved model simulations of local hydraulic heads compared to those observed in wells, which in turn provides a better fit re groundwater levels and karst (or non-karst) influence.

Given these considerations as well as the absence of reported significant conduits within drill holes in the area of the proposed expansion (note – bedrock bore hole logs were not provided in the Level 2 document), a relatively high level of confidence can be assigned to the modelling of groundwater heads and contributions to the surrounding springs. The most significant known conduits in the area include the SW9 drainage which lies east of the area proposed to be quarried and the SW2 spring complex. The latter lies within the Phase 2 quarry expansion area and will be completely removed by quarrying. There will be no karst impacts/effects off-site due to these features other than possible quarry in-flow concerns as noted in the KIR.

Model simulations of flow at nearby springs suggest only minor reductions in flow during the period of extraction (~29 years) and no reduction post-operation when the quarries will be occupied by water bodies. Given the work of Buck and Worthington and the lack of reported major karst conduits in the area of the expansion quarry, these estimations seem to be reasonable, however perennial springs should be monitored during the period of extraction.

The loss of discharge from SW2 to the Rob Roy PSW Unit 6 was specifically evaluated along with overall reductions to the entire wetland complex (Section 8.2). Specific remedial measures included the discharge of quarry water into appropriate locations (including into karst basin SW9) during quarry operations and outflow from the final lake basins once water levels reach full stage. Although these seem reasonable, there are some inconsistencies in the analyses pertaining to necessary flow requirements during operation and final lake stages following operation.

Spring SW2 discharges to only one part of the Rob Roy Complex PSW (Unit 6) from the southwest corner of the proposed expansion quarry and evidence presented in the KIA and in the HAA (page 167) indicates that the mean discharge of this source is 9L/s. However, on page 173, the cumulative reduction in flow to the entire PSW under full development was noted as only 7 L/s (pg 173). Although not significant in terms of the amount of discharge available, the wetland water budget section (Section 8.2) should be re-visited.

Once the long-term equilibrium pond levels become established in the quarries, it is expected that the PSW and other surface water features will receive passive seasonal overflow surface discharge from the ponds, some of which may need to be controlled (pg 179). The estimation of final lake levels is based on the groundwater modelling assessment of quarry inflows and outflows as well as total precipitation minus evaporative losses. The simulated lake level in the proposed expansion quarry was based on a water budget that included groundwater outflows that were double the groundwater inflows (Table 5-14). Hence, the ability to fill this quarry and reach a predicted elevation of 511.9 m depends on a significant surplus of precipitation over evaporation. Estimates of precipitation and evaporation were based on 30-year climate normals (pg 127) which may not be representative of current or future conditions. Some of the hottest and driest years on record have occurred within the past decade and these conditions may be more representative of likely conditions. Especially given that quarrying will operate for a period of at least 27 to 29 years and it will take an additional estimated 30 years to fill the quarries.

5.0 CONCLUSIONS

The KIR satisfactorily meets its objectives of characterizing the karst and karst hydrogeological conditions with the exception of fully characterizing the percolation water component (base flow) to the springs most likely to be impacted (SW11 and adjacent springs). This concern is allayed partially by the modelling work in the Jagger Hims Limited HAA as it adequately incorporated known karst drainage issues and by the apparent lack of large-scale conduits in the area underlying the proposed quarry expansion area. However, the large east-west anisotropic feature immediately north of the proposed MAQ quarry, as shown in the development scenario models (Appendix C), is of some concern and this feature should be more fully evaluated.

The mitigation strategies developed appear to be reasonable with regard to the intent to recharge into the SW9 karst drainage and Rob Roy PSW Complex using collected quarry water. Also the use of injection wells (if required) along the east and north edges of the proposed expansion quarry would allow for any observed impacts to base flow at springs. The modelling of final lake stage levels and time to fill rely heavily on the water balance calculations associated with existing 30 year normals. These may not adequately reflect conditions 60 years or more into the future when all quarrying will be finished and the lakes reach their maximum elevations.

6.0 RECOMMENDATIONS

1) Uncertainty in the actual impact to spring base flow, especially at those springs located closest to the proposed quarry expansion (including springs known to be fed by the SW9 watercourse – see Buck and Worthington's Table 8 – as well as selected other springs including SW22A, 77, 78, 80 series, 84 series, 85, 86, 137, 138, 140, 142, and 143) should result in these springs being included within the proposed comprehensive adaptive management plan for monitoring and mitigation of impacts to water resources. Spring monitoring need not involve detailed flow measurements but should be based on observable changes (dry following rainfall or snowmelt events, declining flow trends over time, etc.). If impacts are identified, then contingency planning should trigger the use of injection wells as appropriate.

2) The modelling of final lake stages (and time to fill) in each of the three quarries should be subjected to sensitivity analysis. This analysis should include the use of the most recent 10-year normals as well as projected estimates of precipitation and evaporation based on reasonable climate-warming scenarios. The lake in the proposed expansion quarry is particularly of concern due to the predicted high groundwater outflows which will likely increase over time due to on-going karstification.

3) The water budget for the Rob Roy PSW (Jagger Hims Report, Section 8.2) should be re-visited with regard to correcting estimates of existing recharge.

4) The mitigation measures for supplying water to the Rob Roy PSW during and following quarrying operations should be re-considered depending on the outcome of recommendations #2 and #3, above.

Respectfully submitted,

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