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December 1, 2005

City of Hamilton
Planning & Development Services
Development Division
71 Main Street West, 7th Floor
Hamilton Ontario
L8P 4Y5

Attention: Stan Holiday, MCIP, RPP
Senior Planner

Dear Sirs:

Re: Geologic and Hydrogeological Peer Review
Proposed Dolostone Quarry, Hamilton
Lowndes Holding Corp.
File 501766.00

We are pleased to provide comments based on our geologic and hydrogeologic review of the documentation that was submitted in support of the Lowndes Holding Corp. Proposed Dolostone Quarry in the City of Hamilton. In particular, our review was focused on the following two key documents.

- *Geological Investigation Proposed Dolostone Quarry, Part of Lot 1 and all of Lots 2 and 3, Concession 11, Geographic Township of East Flamborough, City of Hamilton*. John Emery Geotechnical Engineering Limited (JEGEL). July 2004.
- *Hydrogeological Level 2 Report, Proposed Dolostone Quarry City of Hamilton. Volumes 1, 2 and 3.* Draft Gartner Lee Limited (GLL). June 2005 (Volumes 1 and 2) and July 2005 (Volume 3).

The following documents were also examined to provide additional background and/or operational information for the geologic and hydrogeologic peer review; however the documents were not commented upon.

- *Lowndes Holdings Corp. Proposed Dolostone Quarry, Planning Report.* Long Environmental Consultants Inc. August 2004.
- *Hamilton Groundwater Resources Characterization and Wellhead Protection Partnership Study, **Draft Report**.* SNC Lavalin and Charlesworth & Associates. November 2004.

In addition to the review of the above-noted documents, visits to the proposed quarry site were completed on June 28, 2005 and August 10, 2005. Observations from these site visits were also considered during the course of our review.

Though a preliminary review of the GLL Volume 2 - Groundwater Flow Model report and examination of the Draft Hamilton Groundwater Resources Characterization and Wellhead Protection Partnership Study was completed, a detailed review of the groundwater modelling was beyond the scope of our undertaking.

A. REVIEW SUMMARY

The following summary is provided to outline our review comments. Detailed comments are provided in Sections B to D.

1. Conceptual Setting – The conceptual setting provides a reasonable degree of detail and technical information to complete the hydrogeologic assessment. However, further rationale and discussion is required on karst features and the "production zone" within the Amabel Formation aquifer. Particularly since the production zone in the middle of the Amabel Formation is a significant component of the conceptual model put forth at this site, in terms of groundwater influence. Also, further characterization and discussion is required on groundwater interactions between the bedrock and surface watercourses and between the bedrock and wetland areas. The adaptive management plan (AMP) is only effective if the physical setting is fully understood. Thus more detailed discussion with technical support is required to permit an adequate evaluation of the AMP.

2. Hydrogeologic Impact Assessment and Mitigation – We agree that without mitigation measures, the proposed quarry will likely have a detrimental effect on adjacent water resources such as streams, wetlands and residential wells. The predictive simulations of the proposed quarry impacts are reasonable, although additional detail and/or rationale is required for some input parameters, and simulated drawdowns beyond some of the wetland/stream areas are questionable.

   It is premature to conclude that the proposed quarry will not have an affect on the Carlisle water supply. Based on report figures, the operation of the proposed quarry without mitigation will affect the capture zone of the Carlisle municipal wells. An assessment of the vulnerability of the revised capture zone to current and future contamination sources should be completed. The pre-quarry capture zone of the Carlisle municipal wells should be simulated with the GLL model for current baseline (permitted capacity) and future baseline (maximum build-out increased capacity) and compared with the City of Hamilton model. In addition, the mitigation systems and end-use condition should be simulated to predict potential effects on the Carlisle municipal wells and local water resources. In summary, it is recommended that the following additional model simulations, as a minimum, be completed with the GLL model:

- Pre-quarry capture zone of the Carlisle municipal well field using the current baseline (permitted capacity) and future baseline (maximum build-out increased capacity);
- Capture zone of the Carlisle municipal well field during the various quarry stages with an operating GRS mitigation system, using the current baseline (permitted capacity) and future baseline (maximum build-out increased capacity); and
- Capture zone of the Carlisle municipal well field during the end-use condition of the quarry (open lake without mitigation), using the current baseline (permitted capacity) and future baseline (maximum build-out increased capacity). Additional simulations are also required to predict quarry filling rates while operating the mitigation systems, and to demonstrate surrounding groundwater conditions under the end-use condition.

Insufficient information about the proposed groundwater recirculation system (GRS) is provided in the reports to effectively review whether the system would be feasible. Also, the potential effects of the quarry operation, end-use and proposed mitigation measures on groundwater quality at residential wells and the Carlisle well field are not addressed.

3. Performance Monitoring – The outline presented as part of the Adaptive Management Plan was reasonable, but no details on the performance monitoring program were provided for review. The performance monitoring program is required to evaluate the hydrogeologic assessment predictions and the effectiveness of the proposed mitigation systems, as well as to protect local groundwater and surface water resources.

4. Contingency Systems – Contingency Systems are required as part of an Adaptive Management Plan in the event of unacceptable effects on the groundwater or surface water resources. No contingency systems were provided for review.

5. There are notable errors and inconsistencies, as well as missing information in the key documents reviewed.

B. BACKGROUND AND SETTING

The Lowndes Holding Corp. Proposed Dolostone Quarry is located on Part of Lot 1 and Lots 2 and 3, Concession 11, City of Hamilton (formerly Township of Flamborough). The site covers an area of approximately 154 ha and is located approximately 3.5 km north of the community of Carlisle.

The physical setting for the Proposed Dolostone Quarry, as set out in the documents reviewed, is summarized below. Based on our review, our past experience within the area and in similar settings, as well as our observations during the site visit, the physical setting set out in the reviewed documents is reasonable.

The Proposed Dolostone Quarry is located in the Flamborough Plain physiographic region which is characterized as a limestone plain locally overlain by glacial deposits, scattered drumlins and numerous swamps. Overburden at the site varies in thickness from 0 m to 7.9 m, and is locally mapped as silt till with boulders. Organic deposits were encountered in the northern and low-lying portions of the site, while outwash gravel deposits were observed in the southern portion of the site. Overburden is underlain by dolostone bedrock of the Amabel Formation, which varies from approximately 27 m to 40 m thick at the site. The crystalline and fossiliferous dolostone from the Amabel Formation is typically considered a high quality aggregate resource. Shaley dolostone of the Reynales Formation underlies the Amabel Formation dolostone.

The northern and southeastern portions of the site are located within the Lower Mountsberg Creek Wetland Complex which is a Provincially Significant Wetland. The organic soils of the wetlands on the site are thin and directly overlie the bedrock. Surface water at the site drains either to Mountsberg Creek (northwest and southwest) or to Flamboro Creek (east and southeast). Several tributaries of the Mountsberg Creek, designated as Tributaries A to D, originate within the wetlands on or adjacent to the site. Flamboro Creek and Mountsberg Creek drain toward the south and connect to Bronte Creek over 2 km south of the site. The creeks and tributaries on and adjacent to the site are generally mapped as warmwater sportfish or potential coldwater.

The Amabel Formation dolostone is a regionally significant aquifer. Groundwater movement within the dolostone bedrock below the site is generally southerly with local variations. The water table within the wetland areas on the site is near surface.

The site is bounded by residential development to the north, and agriculture and rural residential to the east, west and south. Residents in the vicinity of the site typically use private water wells completed in the Amabel Formation dolostone for their water supply. In addition, the community of Carlisle has a municipal communal water supply which draws groundwater from the Amabel Formation dolostone. The four production wells in the communal system have a combined permitted capacity of 2,293 L/min. However, a new production well is scheduled to be brought on line in 2006 and the permitted capacity will increase. The City of Hamilton has estimated that the maximum build-out capacity for the Carlisle communal water supply will be 3,138 L/min.

The Proposed Dolostone Quarry for Lowndes Holding Corp., if approved, is intended to be developed in the Amabel Formation dolostone. If approved as proposed, the quarry will likely be developed in two lifts and will extend below the water table. As such, dewatering will be required for the quarry operation. It is understood that the proposed conceptual end-use plan includes creation of a lake and a series of shallow wetlands.

C. COMMENTS ON JEGEL REPORT

The JEGEL report documents an appropriate level of geologic investigation for a quarry site in this geological environment and presents conclusions that are reasonable, justified, and which appear properly documented. The geological information contained in the Gartner Lee Limited hydrogeological reports, which presumably is based on the JEGEL report, contains errors and discrepancies. There are several instances where the two reports are in apparent disagreement.

Following are comments on specific aspects of the JEGEL report.

- The designation of boreholes as letters B, C, D, etc. and as numbers 1, 2, 3, etc and as Hydro. 1, Hydro. 2, etc is confusing. Documentation could not be found for boreholes A, 2, and 5. Information for these boreholes should be provided.

- The report states that "No karst topography or features were detected in the rock assemblage" (JEGEL page 9, last paragraph). Information used to reach this conclusion, including a discussion of the potential that karst features might be encountered on the site should be provided. The statement appears to contradict the statement in the Gartner Lee Limited report (Volume 2, page 15, Section 2.6.2) that "The permeability of the aquifer is due primarily to the dissolution of dolomite along fractures and bedding planes."

- There are numerous references to reefs in the text of the report, particularly on pages 7 through 9, which suggests that reefs are a major component of the rock at the site. The presence of significant reef structures, and their potential affect on hydrogeological predictions, has been a concern at several recent quarry investigations. A review of the borehole logs from the site, together with the author's experience logging numerous other boreholes in the Amabel Formation suggests that the bulk of the rock mass is typically debris derived from the reefs, rather than the actual reef structure, and that the rock is relatively consistent and predictable with few actual reef structures. Information and discussion should be provided in regard to the number and size of the reef structures within the rock mass and the affect the reef structures may have on either rock quality or groundwater flow.

D. COMMENTS ON THE GLL REPORTS

Overall, a reasonable level of investigation was completed as part of the Hydrogeological Level 2 study for the proposed quarry site. However, there are some hydrogeologic issues at the site that were not fully addressed and require further analyses.

Following are comments specific to the Volume 1 report.

1) Page 9, last bullet - The report states that the borehole was cored with an HQ core barrel. However, the logs (Volume 3) indicate that the boreholes were cored with a PQ core barrel, with the exception of GLL3. Which borehole size is correct?

2) Figure 2 – Borehole 5 is shown as a production well, but there is no description or information provided for the well. Staff gauges SG1 to SG6 are shown on the east (map east) side of the site, but there is no mention of these instruments or a discussion of their results in the text.

3) Page 11, 2nd bullet – The grouting/sealing details are not provided in the monitor construction details (Table C-1) or in the borehole logs.

4) Page 12, 1st paragraph – The text indicates that piezometers were "driven into the ground to the target depth or refusal on bedrock". There is no indication in the text or in the appendices of which piezometers were driven to bedrock or what the target depths were based upon.

5) Page 14, 2nd paragraph – It is not clear to where the groundwater from the pumping wells, particularly TW13, was discharged in relation to the wetland piezometers (i.e. downstream or upstream of the monitored piezometers).

6) Section 2.2 – With the exception of Tributary D, there is no indication whether the creeks/tributaries on or adjacent to the site are intermittent or perennial. Also, the locations of the hydrological flow stations (HYDAT) for the subwatershed should be indicated and/or shown on a figure. Also, drainage features discussed in the report should be depicted on the site plans.

7) Section 2.3 – The location of the meteorological station in the City of Hamilton is not provided. Is the station located above or below the Niagara Escarpment? What is the rationale for using data from this station, particularly in light of the detailed climate data from the Kelso meteorological station provided in the Planning Report (Long Environmental Consultants Inc. August 2004)?

8) Page 18, 1st bullet – The text suggests that overburden at the site is typically sandy silt till and gravel; however the borehole logs consistently indicate clay till surficial soils. Rationale for the overburden description on a regional and site specific basis should be provided. Also, the type of overburden will influence the recharge potential in the groundwater model. Rationale for the recharge potential (infiltration) used in the model should be provided.

9) Page 18, 2nd bullet – The Amabel Formation dolostone is characterized in the text as a "fine crystalline" fossiliferous dolostone, while the borehole logs consistently describe the rock as "coarse crystalline". Rationale for the difference in interpretation should be provided.

The report states that "No obvious or visible karst topography or features were detected in the rock assemblage." Karst features have been recognized regionally on and near the Niagara Escarpment developed in the Amabel Formation, and Karrow (1987) notes the location of two karst occurrences within several kilometres of the site. The rationale and technical support for the report statement on karst should be provided, particularly since "cavities" within the bedrock are noted in the logs for borehole GLL2-I, GLL 3 and GLL 4-I.

The existence of discrete reefs in the Amabel Formation dolostone has been a concern raised during the assessment of several quarry applications in the Orangeville to Niagara Falls area. Discrete reefs within the Amabel Formation have the potential to exhibit significantly higher hydraulic conductivities than the surrounding rock, and thus may extend the effects of dewatering in a preferential direction. The potential presence of reefal features at the site should be discussed and the observations on reef structures by JEGEL considered.

10) Figure 3 – Water level elevations for the piezometers (MP1 to MP6) shown on the figure do not match those provided for that date in Table F-2. Also, the groundwater contours appear to disregard water level elevations for piezometers MP1/MP2 and MP7/MP8. The legend indicates "deep ground water contours", which is assumed to be an oversight.

11) Section 2.5.1 – Characterization of groundwater interactions between the bedrock and surface water courses and between the bedrock and wetland areas should be discussed in greater detail to establish baseline conditions for an impact assessment of the proposed quarry. For example, upward hydraulic gradients were observed at BH8 in the southern corner of the site. Can it be inferred that there is groundwater discharge to Tributary C near the southern corner of the site? Is there a southeasterly component of groundwater flow in the shallow bedrock toward Flamboro Creek? Seeps were observed within the wetland areas in the northern portion of the site. Were the seeps flowing generally toward the north from the bedrock into the wetland area?

12) Section 2.5.2, 2nd paragraph – Based on the packer testing results, conductive zones (>10^{-5} m/s) were identified at many of the boreholes between elevations 251 m ASL and 279 m ASL. However, based on borehole logs presented in Volume 3, the top of the Amabel Formation at the site is located between 277 ± m ASL and 285 ± m ASL, while the bottom is located between 250 ± m ASL and 256 ± m ASL. As such, the conductive zones identified cover most of the Amabel Formation thickness.

Additionally, some of the packer test data provided in Volume 3 exhibit poor reproducibility within the same interval, as in boreholes GLL BH4-D, JEGEL BH-B, JEGEL BH-D, and JEGEL BH-F. Results vary by up to three orders of magnitude in some intervals, but no explanation or rationale for continued use of the data is provided. A discussion should be provided to correlate the packer testing results with features identified in the core logging.

13) Section 2.5.2, 4th paragraph – The analyses and discussion provided in Appendix E indicates that the Amabel Aquifer was assumed to be confined. However there are several locations (4-S, 6-S, 7-S, 8-S and 9-S) where the groundwater table is within the upper portion of the bedrock at least seasonally. In particular, groundwater levels at GLL BH6, 7 and 9 were within the bedrock during the pumping test. The analysis of the results should consider both confined and semi confined/unconfined conditions to assess the sensitivity of the results to these assumptions.

14) Page 23, Table 1 – The average hydraulic conductivity presented in Table 1 is an arithmetic mean. Average bulk hydraulic conductivities are typically calculated using geometric means ($K_{geometric\ avg} = 7.7 \times 10^{-5}$). Rationale for using an arithmetic mean should be provided.

15) Section 2.5.3 – MOE designations for the water wells are not shown on Figure 5 (or any other site plan). Thus, the well records cannot be referenced to a location on the map and a proper review of the data could not be completed. A correlation between the domestic wells surveyed as part of the water well inventory and the MOE well records should be provided, where available. Also, it is not clear whether any Permits To Take Water (PTTWs) in the vicinity of the site, other than the Carlisle well field, were identified during the study. The influences of the proposed quarry on any existing PTTWs need to be addressed.

16) Page 27, 1st paragraph – Based on modelling from the Draft Hamilton Groundwater Resources Characterization and Wellhead Protection Partnership Study, the proposed quarry property is within the 2-year capture zone for the Carlisle municipal well field, as opposed to 25-year capture zone noted in the text.

17) Section 2.6 and Tables 2 and 3 – There are numerous errors and omissions in the tables which have a bearing on the discussion of ODWS and PWQO exceedances in the report text. Also, the November 27 Repeat result for 1869 Millbrough (Table 3) does not appear to resemble the original sample, but appears to match the results for 6 Glenron.

18) Page 33, Table 4 – The drawdown observed at JEGEL BHD is not noted on the table.

19) Section 3.1.2 - Based on a preliminary review of the pumping test data, the shallow groundwater level was not drawn down below the wetland organic soils into the underlying bedrock in the northern test. However a pumping test response for the northern test was noted in the northern wetland at MP-12, quite a distance from the pumping test discharge. In the southern test, the shallow groundwater level was drawn down below the wetland organic soils into the underlying bedrock (GLL 9-S and likely TW11), but a response in the wetland piezometers was not observed. The report notes that precipitation occurred during the pumping test, which would likely influence water level responses during the test. A discussion should be provided regarding the water level responses in the eastern wetland piezometers near the southern test and potential effects of pumping test discharge and incident precipitation.

20) Page 43, Table 6 – The pre-quarry development water balance indicates that water uptake from domestic well use and PTTWs throughout the subwatershed is approximately 890,600 m^3/yr (28.24 L/s). As noted on page 26 of the report, the permitted capacity of the Carlisle municipal wells is approximately 1,205,200 m^3/yr (38.2 L/s). As the model domain includes the Carlisle municipal wells, as well as domestic water supply wells, a discussion on the water balance error should be provided.

21) Page 44, item j – How was the productive zone (depth, thickness, etc.) determined for the model? Was the zone based only on borehole logs from the site, or were MOE well records or other sources of information used? Based on the available information, it does not appear that there are any monitoring wells screened specifically within the productive zone at the site. As such, how were the aquifer parameters for the productive zone determined?

22) Figures 12 to 15 – The figures show that a simulated drawdown extends beyond the recharge effects of the northwestern and eastern wetland/stream areas, and actually increases beyond the river boundaries. These simulation results are questionable and should be reviewed.

23) Page 55, Effect of Quarry Development on Residential Wells – As noted previously, MOE designations for the water wells are not shown or provided. Thus the well records cannot be referenced to a location on the map and a review of specific well data cannot be completed. However, given the close proximity of the residential wells to the proposed quarry development, we concur with the report's finding that the un-mitigated quarry will have a potentially significant impact on available water supplies in the nearby residential wells.

24) Page 56, Influence of Quarry on Carlisle Wells – To establish current baseline (pre-quarry) conditions and future baseline conditions for groundwater use in the model domain, it is recommended that the calibrated GLL model be used to simulate capture zones for the full permitted capacity use of the Carlisle municipal well system (2,293 L/min) as well as the estimated maximum build-out capacity of the system (3,138 L/min). A comparison with the capture zone models completed by the City of Hamilton should be completed and documented.

The text states that the particle tracking was completed based on permitted pumping rates, but Figure 16 shows Well 1 and Well 4 pumping at 0 L/min. Thus, the particle tracking appears to be based on pumping at 1,190 L/min versus the permitted capacity of 2,293 L/min. Rationale for the discrepancy should be provided.

The text also states that the quarry is not expected to be a source of contamination to the Carlisle wells because when the quarry is dewatered, groundwater will flow into the quarry rather than away from the quarry. While this is true under the un-mitigated scenario, it is not necessarily true during operation of the groundwater recirculation system proposed for the quarry. Some of the water collected from the quarry and introduced into the recirculation trench will flow away from the quarry toward the streams, wetlands, residential wells, and possibly the Carlisle wells.

25) Section 3.3.4 – The report suggests that the proposed quarry will not have an affect on the Carlisle water supply. This conclusion is premature without the simulation of current baseline (permitted capacity) and future baseline (maximum capacity) capture zones.

Based on a comparison of Figure 6 and 16, operation of the proposed quarry without mitigation will affect the capture zone of the Carlisle municipal wells by shifting the zone generally to the south. An assessment of the vulnerability of the revised capture zone to current and future contamination sources should be completed.

26) Section 4.2 – Insufficient information about the proposed groundwater recirculation system (GRS) (width of trench, location relative to quarry face, frequency of recharge conduits, etc) is provided in the reports to effectively review whether the system would be feasible. Will the GRS also mitigate for groundwater impacts in the organic overburdens of the wetlands? Have allowances been made in the water budget for evaporation losses from the trench and other losses/inefficiencies in the pipes, etc.? Are there any known examples or case studies of similar GRS systems within a similar physical setting, which are operating as designed to effectively mitigate groundwater drawdown? Please provide examples.

27) Page 61, 3rd paragraph under bullet – The report states that groundwater levels and groundwater discharge to wetlands and streams in the proximity to the property will be maintained. A discussion should be provided on the methodology, monitoring and contingency measures.

28) Section 4.3 – The adaptive management plan (AMP) is only effective if the physical setting is fully understood. A significant component of the conceptual model put forth at this site, in terms of influence, is the production zone in the middle of the Amabel Formation. However, as discussed previously, the supporting technical information (depth, thickness, hydraulic conductivity, etc.) for the simulated configuration of this production zone is not provided. Likewise, the groundwater interaction between the

bedrock and organic soils in the wetland and the groundwater/surface water interaction in the creeks was not fully characterized in this study. More detailed discussion with technical support is required to permit an adequate evaluation of the AMP.

29) Groundwater Modelling, Carlisle Municipal Wells – The GLL report does not discuss the apparent discrepancy in the Carlisle well capture zones between the City of Hamilton model and the GLL model. However, capture zones from the City of Hamilton model are based on current conditions (i.e. no quarry dewatering), while the capture zones shown on the GLL model are based on a fully developed, dewatered, and un-mitigated quarry.

One notable difference between the output of the two models is the time of travel for the capture zones. The proposed quarry site is within the 2-year capture zone in the City of Hamilton groundwater model. However, the 25-year capture zone extends south of the proposed quarry, only about half way between Concession 10 and 11 Roads in the GLL model. This difference may be a function of the effective porosity and lower permitted pumping rate used in the GLL model. Further discussion on the different capture zones is required.

To properly evaluate the quarry influence on the Carlisle wells (capture zones and on subwatershed water budgets), the full permitted use should be simulated. In addition, the maximum build-out capacity for the Carlisle communal system should be considered in the predictive groundwater models.

The GLL groundwater model does not show the Carlisle well captures zones during the mitigated conditions. Additional simulations are required to assess if the proposed quarry would fall within the wellhead protection area for the municipal wells under the current full permitted use and the maximum build-out capacity for the system.

30) Effect on Drinking Water Quality - The potential effect of the quarry on drinking water quality is not addressed in the GLL reports. The influence of the proposed GRS (an open surface water trench connected to the bedrock aquifer) on groundwater quality (temperature, microbiology, etc.) at the residential wells and the wetlands is not addressed in the report. Also, a discussion should be provided on the presence of a surface recharge trench connected directly into the bedrock that may trigger a groundwater under direct influence (GUDI) condition at the Carlisle well field. Potential measures to mitigate groundwater quality concerns should also be discussed.

31) Quarry End-Use – The quarry end-use is not discussed in the GLL reports. This aspect needs to be addressed in light of the groundwater implications. It is understood that the conceptual end-use plan includes creation of a lake and a series of shallow wetlands. The feasibility of the lake needs to be evaluated in consideration of original static groundwater level conditions, the topographic low point in the quarry perimeter, and water budget concerns related to filling of the quarry while maintaining the GRS (especially at early times), and other hydrogeologic aspects. There may also be implications for the Carlisle municipal wells in terms of a bedrock lake in the WPA (GUDI issues) and water quality concerns (temperature etc.).

32) No monitoring or contingency plan details were provided for review.

There are information limitations, as well as errors and inconsistencies in the Volume 3: Appendices document that should be corrected. A non-exhaustive list is provided as follows. It is recommended that a thorough review of the appendices be completed by GLL.

- Appendix B – There is no way to correlate the MOE water well records to their geographic location (short of plotting it oneself) as the designation is not provided on any mapping. Also, the MOE well designations should be provided for the surveyed homes (Table B-1). It is not clear which MOE well record submitted by the driller relates to which production well (TW10, TW11, BH5, etc).

- Appendix C, Table C-1 – Sealing details are not provided. Construction details for GLL 2-S are not provided. Most boreholes have an open hole diameter of 152 mm, which differs from the hole diameter used for packer testing analyses. A TW14 is noted, but is not mentioned in the text. The top of casing and ground elevations for the mini-piezometers are the same.

- Appendix C, borehole logs - The borehole logs contain numerous errors and omissions, and they are missing information which pertains to the hydrogeology of the site. The rock descriptions are generalized and there is minimal reference to visual hydrogeologic features such as fractures, staining or dissolution phenomena. “Cavities”, “vugs” and zones of lost core are noted on some of the borehole logs. The size and nature of these cavities is not consistently described, and the interpreted origin is not discussed.

  The designation of JEGEL boreholes, ‘Hydro’ boreholes, GLL boreholes, test wells and production wells is inconsistent and confusing. Data pertaining to a single borehole are filed under different borehole numbers. Are the “Hydro” boreholes in the JEGEL report the same as the “GLL” boreholes in the Gartner Lee Limited report?

Assuming that they are, there are discrepancies between survey elevations, borehole depths, and the depths and nature of features noted in the logs. Rock descriptions differ between the two sets of logs.

Recoveries graphed on most GLL borehole logs are in the order of 50 to 60 %. These are well below common recovery rates for similar drilling, and suggest a problem with the method of core drilling, a concern with the condition of the rock, or a consistent error in calculation. Core recovery rates in the JEGEL boreholes are significantly higher, and do not equate to the GLL borehole logs. Some of the core recovery values on the GLL boreholes are reported as greater than 100%. The recovery numbers noted on the GLL borehole logs do not correlate to the graphical representation on the log, or to the (assumed) same borehole in the JEGEL report.

Rock Quality Designations (RQD) graphed on the GLL boreholes are in the order of 30 to 40%. These numbers indicate poor rock quality and numerous fractures throughout the core, or an error in the determination of the RQD. The numbers do not agree with those noted in the JEGEL report, and the amount of fracturing suggested does not follow the general trend of the permeabilities presented elsewhere in the GLL report.

Monitor construction details are not consistently shown and the ground elevation provided on most logs is actually the top of casing elevation.

- Appendix E – The borehole radius (diameter of 144 mm) used in Table E-1 differs from the value provided in the monitor construction table (152 mm) and from the value provided in the text (97 mm). Which is actually the correct borehole diameter? Figures E-1-1, E-2-1 and E-3-1 are not clear in the black and white report version. Figure E-3-11 is not clear. The 168-hour pumping test water level hydrograph for GLL BH 7-S is not available.

- Appendix F – The staff gauge readings in Table F-2 are not converted to elevations. It is not clear if the SG elevations are for the top or bottom of the gauge and from where the readings are taken.

- Appendix G, Table G-2 – It is not clear what FC, MC and T refer to in the table.

- Appendix H, Tables H-1 to H-3 - The Ontario Drinking Water Standards for DOC, antimony and selenium are not provided. Shading and bolding for concentrations exceeding the standards should be reviewed. We trust that these comments are instructive and are of assistance for your purposes. Please contact us if there are any questions.

We trust that these comments are instructive and are of assistance for your purposes. Please contact us if there are any questions.

Yours truly,
JAGGER HIMS LIMITED

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DSM:jmm