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March 28, 2005 Ref: 04-233-1

Friends of the Rural Communities and Environment (FORCE)
c/o Lawson Park Ltd.,
P.O. Box 15, R.R. #1
Freelton, Ontario L0R 1K0

Attention: Graham Flint, Chair, FORCE

Re: Hydrogeologic Review Report – Proposed Lowndes Dolostone Quarry, East Flamborough, City of Hamilton

Dear Mr. Flint,

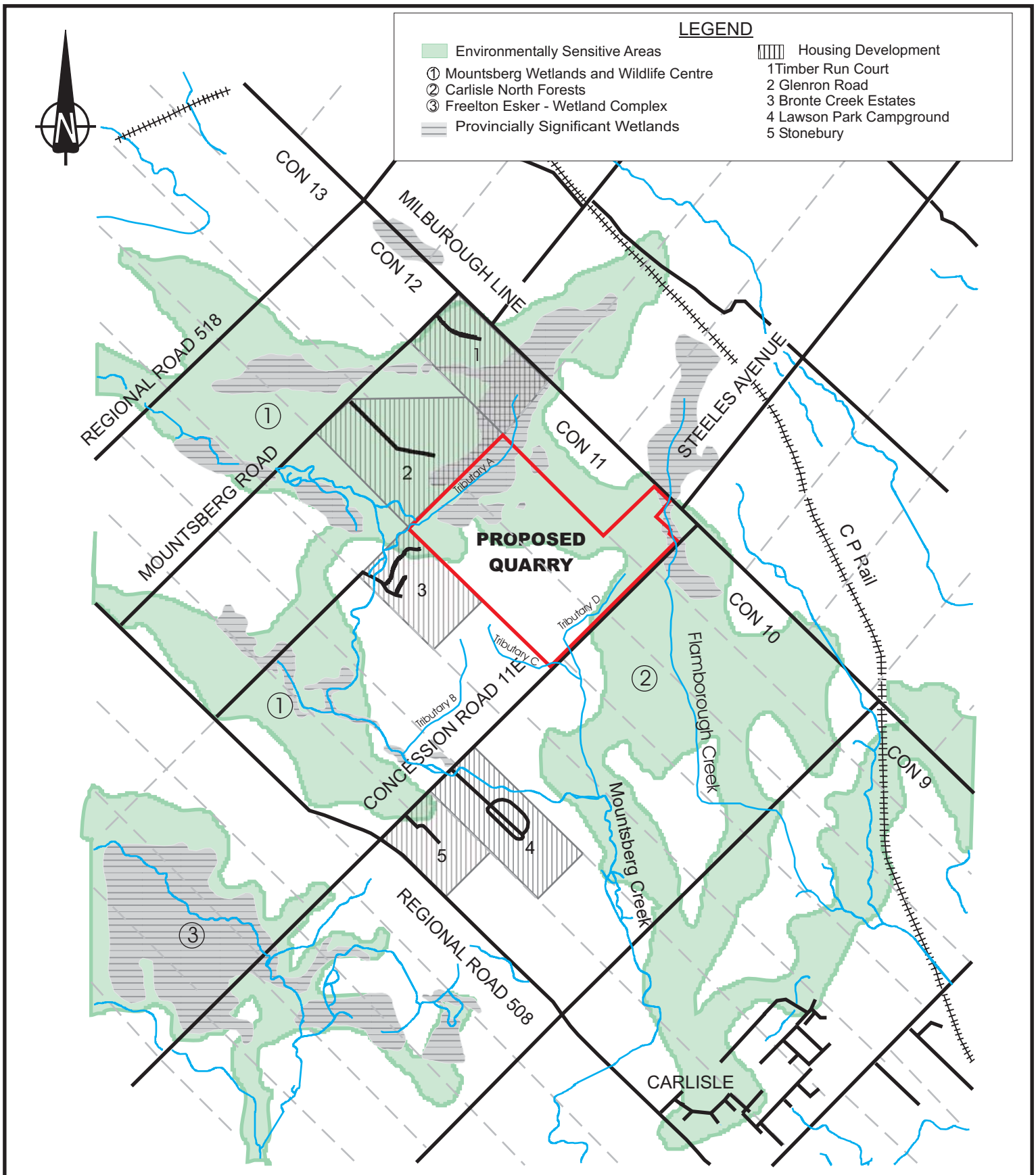
Please accept this letter as INTERA Engineering Ltd. (INTERA) report on hydrogeologic review of the proposed Lowndes Holdings Corporation dolostone Quarry. The proposed Quarry is to be developed in the Amabel Formation to depths of about 36 m in Part of Lot 1, and Lots 2 and 3, Concession 11, geographic Township of East Flamborough, now the City of Hamilton. This review and report have been undertaken and prepared in response to our e-mail correspondence of December 13, 17 and 21, 2004, review documents provided by FORCE on December 17 and 21, 2004 and January 11, 2005, my cursory review of January 10, 2005 and our consulting services agreement of January 16, 2005.

This report was prepared by Kenneth G. Raven, M.Sc., P.Eng., Principal and Senior Hydrogeologist of INTERA Engineering Ltd. This report reviews the available hydrogeologic documentation, judges the adequacy of the proponent's hydrogeologic characterization, assessment and predictions, and provides an assessment of potential adverse hydrologic and hydrogeologic impacts of the proposed Quarry operation based on my independent analysis of the data and my experience at similar sites in Ontario.

1. PRIMARY DOCUMENTS

The key documents to which I have focused my review are:

- *Watershed-Based Source Protection Planning, Science-based Decision-making for Protecting Ontario's Drinking Water Resources, A Threats Assessment Framework*, Technical Experts Committee Report to the Ontario Minister of the Environment, PIBs 4935e, November, 2004.



Surrounding ESAs and Housing Developments
Hydrogeologic Review - Proposed Lowndes Quarry

Figure 1
04-233

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JLC Quarry ESAs.cdr

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- *City of Hamilton, Application for Planning Document Amendment: Official Plan (Local and Regional), Zoning By-law*, submitted by Lowndes Holding Corp., September 16, 2004.

- *Preliminary Level 2 Natural Environment Report,* Report prepared by Stantec Consulting Ltd. for Lowndes Holdings, September 7, 2003.

- *City of Hamilton, Information Report on Proposed Quarry in Former Flamborough, 11th Concession Road East (Ward 15)*, prepared by Planning and Development Department, September 3, 2004.

- *Lowndes Holdings, Proposed Dolostone Quarry, Planning Report,* prepared by Long Environmental Consultants Inc. for Lowndes Holdings Corp., August, 2004.

- *Preliminary Hydrogeological Assessment, Proposed Dolostone Quarry, Township of Flamborough,* Report prepared by Gartner Lee Limited for Lowndes Holdings Corp, August, 2004.

- *Geological Investigation, Proposed Dolostone Quarry,* Report prepared by John Emery Geotechnical Engineering Limited for Lowndes Holdings Corp., July 16, 2004.

- *Presentation, Groundwater Resources Characterization and Wellhead Protection Partnership Study,* City of Hamilton, Public Information Centre, May 31, 2004.

- *Bronte Creek Watershed Study,* Report prepared by Conservation Halton, March, 2002.

Several other reports including those describing various hydrogeologic assessments completed in the surrounding area as well as regulatory agency documents and files were also reviewed in completion of this review report. Section 6 list these other reviewed documents and references.

2. PROPOSED QUARRY DEVELOPMENT

The proposed Lowndes Holdings Corp. Quarry is to be developed to an average depth of about 36 m within the Amabel Formation dolostone using two lifts of about equal thickness of rock excavation (i.e., 17 m). This is about 34 m below the local water table. The Amabel Formation dolostone, which is a regional groundwater supply aquifer for both municipal and private use, is overlain by an average 2.4 m of permeable sandy to silty till soil, and underlain by low permeability shales.

An application for planning document amendment is before the City of Hamilton requesting a change in Local Official Plan to allow rezoning of the site from rural and conservation management to extractive industrial for Quarry operation. Other licenses/permits and associated reviews as required

under the Ontario Aggregate Resource Act and the Ontario Water Resources Act will be necessary, prior to any Quarry development.

The proposed Quarry excavation will be large at about 96 hectare and will occupy Part of Lot 1 and all of Lots 2 and 3 of Concession 11, geographic Township of East Flamborough, now the City of Hamilton. The proponent also has entered into purchase agreements for the southern half of Lots 4 and 5, for a future/expansion phase of Quarry operations. My review assessment only considers the proposed Quarry, not a possible future expanded Quarry.

The proposed Quarry is to be operated in four phases. The 2004 *Planning Report* indicates that water table drawdowns created by the Quarry will be limited to 1 m at a distance of 250 m from the Quarry face. This report also indicates that water may be recharged through open channel infiltration trenches excavated to the bedrock surface to maintain groundwater levels in the vicinity of the Quarry.

The proponent's documentation concludes that excavation and dewatering of the Quarry could affect some nearby water wells, and also groundwater input to adjacent streams and wetlands.

3. HYDROLOGIC AND HYDROGEOLOGIC SETTING OF PROPOSED QUARRY

The proposed Lowndes Quarry is located on the Niagara Escarpment in the Flamborough Plain Physiographic Region. The area is characterized as a limestone plain with little overburden, scattered drumlins and numerous swamps. The regional and local overburden and bedrock geology are described in detail in the 2004 *Geological Investigation* Report and the 2004 *Preliminary Hydrogeological Assessment* Report, as well as numerous hydrogeological studies completed in support of subdivision development and groundwater resources management. The local hydrogeology is described based on the soil mapping, MOE water well records and drilling and hydraulic testing of communal and residential water supply wells and monitoring wells on and near the site.

Water supplies in the area of the Quarry are from private wells. Reviews of MOE water well records (W. Anderson Geologic Inc., 1997) shows that almost all wells are drilled into the bedrock. Average domestic well depth in the area of the Quarry is about 15 m.

In addition to individual residences, several subdivision developments are situated adjacent or proximate to the proposed Quarry. According to the 2004 *City of Hamilton Information Report*, there are several residential developments within 500 m of the Quarry, including an estate residential development on Glenron Road (13 lots), Timberun Court (19 lots), and a rural estate residential condominium (Bronte Creek Estates – Sierra Lane, 76 residential units draft approved with 31 units currently registered). A seasonal campground-trailer park (Lawson Park Campground - 185 sites) and housing development (Stonebury – about 14 houses) are also located about 1000 m and 1200 m, respectively, southwest of the proposed Quarry. Figure 1, appended to this letter, shows the location of these residential developments relative to the proposed Quarry site.

The overburden at and near the site consists of 0.2 to 6.5 m (2.4 m average) of sandy to silty till and some sand and gravel. The overburden is generally permeable as evidenced by the fact that the water table is usually not found with the overburden but rather is at or near the bedrock surface.

Provincially Significant Wetlands (Class 2) comprising an area of 21 hectare occupy the northern and southeastern parts of the site. The *Preliminary Level 2 Natural Environment Report* also identifies Environmentally Significant/Sensitive Area (ESAs) designated with the Hamilton-Wentworth Official Plan, including the Mountsberg East Wetlands and the Carlisle North Forest, as being on and near the Quarry property. Figure 1 also shows the locations of these Provincially Significant Wetlands and ESAs. The 2004 *Preliminary Hydrogeological Assessment* Report concludes that these wetlands could be in direct hydraulic connection with the shallow groundwater system. Consequently, lowering of shallow groundwater levels near these wetlands could result in dewatering of these wetlands.

There are also several streams and creeks within 250 m of the proposed Quarry excavation (see Figure 1). The 2004 *Preliminary Level 2 Natural Environment Report* (Section 4.1.3 and Figure 7) indicates that Tributary A, Tributary D and Flamborough Creek are all fish habitat. Tributaries B and C are not known to support fish habitat but provide baseflow to Mountsberg Creek located further west of the site. Similar to the Wetlands, the setting of these creeks suggests that they may be in direct hydraulic connection to the shallow groundwater system and hence would be susceptible to Quarry dewatering effects.

The Amabel Formation bedrock is a well known aquifer capable of providing municipal water supply needs. Detailed hydrogeological studies of this dolostone aquifer at locations south and west of the proposed Quarry, show that the aquifer permeability is provided by reefal structures, vuggy porosity, bedding plane discontinuities and fractures. The cities of Guelph and Cambridge use the Amabel Formation dolostone as a source of municipal water supply. Aquifer transmissivities of the Amabel Formation typically range from less than 10 to over 1000 m^2/day. The Amabel dolostone aquifer is underlain by low permeability shales that behave as an aquitard.

Because most of the permeable bedrock structures are horizontal, the vertical hydraulic conductivity of the Amabel Formation dolostone is much less than the horizontal hydraulic conductivity. Detailed studies of these and similar bedrock units at Smithville (Novakowski et al., 2000) and Niagara Falls (Yager, 1996), indicate that the vertical hydraulic conductivity of the Amabel Formation dolostone is likely 100s to 1000s of times less than the horizontal hydraulic conductivity. This anisotropy means that recharge of infiltrating water to deeper permeable horizons in the bedrock at the site can be limited and that drawdown in such permeable horizons can be quite laterally extensive and greater than would be estimated if the bedrock was assumed to be isotropic and fully interconnected.

The bedrock hydraulic testing completed at and near the proposed Quarry shows that the transmissivity of the Amabel dolostone aquifer is indeed very high. The 2004 *Preliminary Hydrogeological Assessment* reports an on-site aquifer transmissivity of 510 m^2/day with a range of 15 to 1520 m^2/day from a 72-hour pumping test, and that the zones of highest water production (and hence transmissivity) are from a depth of about 25 m.

The presence of higher permeability and water production at depth in the Amabel dolostone is also evident from the results of pumping tests completed at the Bronte Creek Estates (a.k.a Sundance Park, Fox Hollow Estates and Sierra Lane), located immediately southwest of the proposed Quarry. Pumping tests of supply well PW-7 completed when the well was 15.9 m deep (G. K Bell & Associates Ltd., 1992) versus 26.5 m deep (TerraProbe Limited, 2003), showed an increase in aquifer transmissivity from 36 to 80 m^2/day. These increases in transmissivity, which I independently calculated from the pumping and drawdown data, show that the bedrock is more permeable at depth than near surface.

Review of water level information from the 2004 *Preliminary Hydrogeological Assessment* Report (i.e., Appendix D and Figures 4 and 5) shows that the water levels in shallow wells are greater than levels in deeper wells. This indicates that groundwater flow directions are downward in the bedrock and that the proposed Quarry is in a groundwater recharge area.

The proposed Quarry is also located in the groundwater recharge area and wellhead protection area (WHPA) for the Carlisle municipal water supply wells. Figure 2 shows the location of the Carlisle municipal water supply wells and the 0 to 2 year time-of-travel WHPA for these wells relative to the proposed Quarry. Figure 3 schematically illustrates a hydrogeologic cross section constructed through the proposed Quarry, showing the Amabel formation dolostone, typical depths of private and communal wells and the location of the Carlisle municipal wells. The line of cross section for Figure 3 is given on Figure 2.

4. KEY HYDROGEOLOGIC ISSUES

In my judgment, the four key hydrogeologic issues for the proposed Lowndes Quarry that warrant discussion are:

1. Adequacy of hydrogeologic characterization and predictions of water table drawdown for the Quarry.
2. The potential for adverse effects to existing groundwater users (i.e., local communal and domestic wells).
3. The potential for adverse ecological effects to Provincially Significant Wetlands, Environmentally Sensitive/Susceptible Areas (ESAs) and local streams.
4. The potential for impact on the Carlisle municipal water supply wells and WHPAs.

4.1 Adequacy of Hydrogeologic Characterization and Predictions of Water Table Drawdown

The principal concerns with the existing hydrogeologic characterization and predictions of water table drawdown for the proposed Quarry are:

(1) the use of 35 m-long open on-site wells for groundwater monitoring of pumping tests and water levels;
(2) no estimation of the volume of groundwater to be pumped from the proposed Quarry; and
(3) significant underestimation of the magnitude and radial extent of drawdown to be created by Quarry dewatering.

4.1.1 Long Open Wells

The use of wells that are open over the entire length of the Amabel Formation dolostone creates significant uncertainty in the detection and estimation of the real nature and extent of drawdown that will be created by the proposed Quarry dewatering. Such wells, because they are open over long intervals, will underestimate both the magnitude and extent of drawdown created by the proposed Quarry, as the observed drawdown in a deep permeable zone (as exists as this site) in response to pumping will be obscured by water flow along the open borehole into the zone from permeable shallow bedrock horizons that otherwise are not connected to the deep permeable zone. The 2004 *Preliminary Hydrogeologic Assessment* Report acknowledges these shortcomings by stating (Section 3.1.1, page 8):

> *"water levels in the deep groundwater are approximate as they are based on open boreholes that are unsealed."*

The proposed Quarry is located in a complex fractured bedrock setting, one where the majority of groundwater flows occur within a few permeable fractures or bedding plane discontinuities. For such settings it is common practice that water level monitoring be conducted using sealed and properly constructed multi-level monitoring wells. Such multilevel monitoring wells should have been completed with sealed monitoring intervals in the deep, intermediate and shallow bedrock. Without such well completions, there is no capability to reliably predict or estimate the actual drawdowns that will occur in response to Quarry operation.

4.1.2 No Estimates of Volumes of Groundwater to be Pumped

There are no estimates of the volumes of groundwater to be pumped from the proposed Quarry in any of the proponent's documentation. While it could be argued that this information would be provided to support a later Permit to Take Water application, understanding the approximate magnitude of volumes of groundwater to be pumped is beneficial at this stage in assessing the likely hydrologic and hydrogeologic impacts of the proposed Quarry.

For a Quarry of this immense size and potentially large area of hydrogeologic influence, the preferred approach for estimation of the magnitude and extent of drawdown and the volume of groundwater removed is to use a calibrated 3-D groundwater flow model (i.e., MODFLOW or MODFLOW-type model). The use of such models is now commonplace within the hydrogeologic community, and they

are the preferred method of reliably predicting hydrogeologic impact of Quarry excavations below the water table. No such modeling has been completed or is proposed by the proponent.

Lacking such a model, I have used the simple Dupuit Forchheimer approximation (Bear, 1979, page 79) to estimate the amount of groundwater to be pumped. This is an equation commonly used by the aggregate industry to estimate Quarry pumping rates. The equation and the basis for parameter values used in the equation are as follows:

$$Q = \frac{KL(h_0^{\,2} - h_L^{\,2})}{2R} \qquad (1)$$

where:

Q = total volume of groundwater pumped (m^3/day);

K = average hydraulic conductivity of excavated bedrock (7.5 and 15 m/day based on 50% and 100% of the average aquifer transmissivity of 510 m^2/day reported in the *Preliminary Hydrogeological Assessment* Report divided by the average saturated thickness of the Amabel dolostone – 34 m);

L = perimeter length of Quarry (3800 m for maximum Quarry extent as measured from Figure 22 of the 2004 *Planning Report*);

h_0 = static water levels or saturated thickness of excavated bedrock (34 m based average thickness of Amabel dolostone);

h_L = height of seepage face on Quarry wall (assumed to be 3 m); and

R = maximum theoretical radius of influence of Quarry drawdown (conservatively assumed to be 2500 m from Quarry centre or 2000 m from the Quarry face, based on professional judgment and experience and analysis using Equation (2) below).

The calculated pumping rates of groundwater from the proposed Quarry are 16,400 m^3/day (K = 15 m/day) and 8,200 m^3/day (K = 7.5 m/day). These are large volumes of water to be pumped. Decreasing the theoretical radius of influence will result in larger Q estimates.

These estimates of groundwater pumping rates are also large relative to the maximum permitted pumping rates from the Carlisle municipal wells. Existing MOE permits to take water indicate a maximum groundwater withdrawal rate for all 4 municipal wells of 2,451 m^3/day. The predicted Quarry pumping rates are 3.3 and 6.7 times greater the maximum permitted pumping rates for the Carlisle municipal wells. Since actual municipal well pumping rates will be less than permitted pumping rates, the predicted Quarry pumping rates are greater than 3.3 and 6.7 times the actual well pumping rates.

4.1.3 Underestimation of Quarry Drawdown

The proponent estimates the drawdown that will be created by the Quarry at 1 m at a distance of 250 m from the Quarry face. This is not a credible estimate. Actual drawdowns in the groundwater water table will be much greater than this estimate.

The drawdown estimates cited in the 2004 *Planning Report* (Section 10.5, Figure 22) are based on extrapolation of the 72 hour pumping test which only created a maximum drawdown of about 12 m due to limited pumping capacity. This drawdown is significantly less than the maximum drawdown that will occur at the Quarry face of about 31 to 34 m. The actual magnitude and radial extent of Quarry drawdown will be much larger than the cited estimate due to greater drawdown at the Quarry face and the fact the Quarry will operate for many years, not 72 hours which was the duration of the pumping test.

The likely long-term or steady state magnitude and extent of Quarry drawdown can be determined assuming that the Amabel dolostone behaves as a phreatic or water table aquifer with recharge and that the Quarry can be represented as a large diameter well that pumps water from the aquifer (Bear, 1979, page 311). This analysis assumes that all of Amabel dolostone is fully interconnected, which may not be the case, particularly for some of the deeper more permeable bedrock zones identified in Section 3.

The equation and the basis for parameter values used in the equation are as follows:

$$h(r) = \left[\frac{Q}{2\pi K} \ln(r / r_w) - \frac{N}{2K}(r^2 - r_w^2) + \frac{r_w^2 N}{K} \ln(r / r_w) + h_w^2 \right]^{1/2} \qquad (2)$$

where:

h(r) = water level (m) at a radial distance r from the centre of the Quarry;

Q = Quarry pumping rate (16,400 m^3/day determined from Equation (1));

K = average hydraulic conductivity of bedrock (15 m/day as defined above);

r = radial distance from Quarry centre (assumed at 1500 m or about 1050 m from Quarry face);

r_w = radius of well (estimated at 450 m for an equivalent Quarry of circular shape);

N = recharge or infiltration rate of water into the bedrock (assumed at 50 to 150 mm/year, based on estimated water surplus of 275 mm/year (Terraprobe Limited., 2003) and professional judgment); and

h_w = water level at the Quarry face (assumed to be equal to the seepage face height of 3 m).

Equation (2) provides estimates of Quarry-induced drawdown that are most accurate within the vicinity of the Quarry. At distances greater than about 1000 m the predicted drawdowns are less accurate. The resultant water levels for the bedrock at a distance of about 1000 m from the Quarry face are calculated at 20.5 m (for N = 50 mm/year) and 21.5 m (for N = 150 mm/year). Since the static water levels in the Amabel dolostone are assumed to be about 34 m, these calculations show that drawdown created by the Quarry would be about 12.5 to 13.5 m at a distance of about 1000 m from the Quarry face.

Thus expected drawdowns would range from about 31 m at the Quarry face to about 13 m at a distance of 1000 m from the Quarry face, with essentially negligible drawdowns at distances of about 2000 m from the Quarry face. These expected drawdowns are shown in cross section in Figure 3. These

expected drawdowns are much greater than those presented by the proponent, which are essentially zero at a distance of greater than 600 m.

4.2 Potential for Adverse Effect to Existing Groundwater Users

The calculations of drawdown of about 13 m at a distance of 1000 m from the Quarry face are significant and clearly show that there is a very real potential for adverse effect to existing groundwater users in the vicinity of the proposed Quarry.

There are three subdivision developments within 500 m of the proposed Quarry, a large seasonal campground/trailer park within 1000 m of the proposed Quarry, a housing development within 1200 m of the proposed Quarry, and numerous private residences along Mountsberg Road, Milburough Line Road and Concession 11E Road. All of these properties are on private services, with most wells being only 15 m deep. With an estimated drawdown of 13 m at 1000 m distance and greater than 13 m closer to the Quarry, many of these wells may be completely dewatered by the Quarry operation. Although some wells are deeper (e.g. the Bronte Creek Estates well at 26.5 m depth), these wells are also at significant risk of being dewatered or severely affected by the proposed Quarry dewatering. Figure 3 shows in cross section, typical well depths and the expected water table drawdown that will be created by the proposed Quarry.

The proposed re-injection of groundwater through infiltration channels excavated to bedrock surface will not appreciably raise water levels and mitigate the adverse effect to existing groundwater users. As illustrated in Figure 33 of the 2004 *Planning Report,* the infiltration channels for the Phase 1 operations include two channels (200 m long by 24 m wide and 140 m long by 24 m wide). The amount of water that will infiltrate into the bedrock can be calculated from the area of the channels with Darcy's Law, using an estimate of bedrock vertical hydraulic conductivity and downward hydraulic gradient. As discussed in Section 3 of this review, the Amabel dolostone is an anisotropic material with vertical hydraulic conductivity much less than horizontal. With a vertical hydraulic conductivity of 0.015 m/day and assuming the maximum value of infiltration gradient of 1.0, the calculated infiltration rate for the channels is 120 m^3/day. This infiltration volume represents only 3% and 6%, respectively, of the estimated 2,050 and 4,100 m^3/day (i.e., one quarter of total Quarry groundwater pumping volumes of 8,100 and 16,400 m^3/day) to be pumped from Phase 1 operations and consequently is not large enough to have any appreciable mitigating effect on Quarry drawdown. Phase 1 operations represent about one quarter of the total excavation area for the Quarry.

4.3 Potential for Adverse Effect to Ecological Function

The increased bedrock drawdown to be created by the proposed Quarry and the suggestion that the nearby wetlands, and by extension the nearby streams, are hydraulic connected to the shallow bedrock groundwater system, indicates a very real potential for lowering of water levels and draining of these wetlands and creeks by Quarry dewatering during dry periods. These wetlands and streams have baseflows that are fed by shallow groundwater discharge. Such baseflows have a significant potential

to be dramatically reduced or eliminated by the proposed Quarry dewatering. This would have a major adverse effect on ecological function of these surface waters, most of which are fish habitat.

The Provincially Significant Wetlands are particularly at risk because they exist on the Quarry property. Given the magnitude and extent of drawdown to be expected within the bedrock underlying these wetlands (i.e., 31 to 13 m drawdown up to 1000 m from the Quarry face), the impacts could be widespread.

To estimate the approximate area that would be affected by reduced baseflow due to reduction in shallow groundwater discharge, I have completed a simple water balance on the amount of water pumped from the proposed Quarry and the area that would provide this water volume through shallow bedrock groundwater infiltration. For bedrock, a credible range of infiltration rate is 50 to 150 mm/year, with the higher estimate likely being more representative of shallow bedrock infiltration. For the estimated groundwater pumping rates of 8,100 and 16,400 m^3/day, infiltration over a circular area of radius 2500 to 3500 m is required to balance the pumping rate. This means that shallow groundwater discharge and baseflow to streams and wetlands over a circular area with radius of at least 2500 m centred on the Quarry would be eliminated or reduced by Quarry dewatering.

Although pumping of Quarry water to selected nearby streams will provide sustained flow in these streams, the pumped water will not be of comparable quality and temperature to that provided by shallow groundwater discharge. Impurities including suspended solids and possibly dissolved constituents imparted by quarry blasting and day to day operations make such pumped water a poor substitute for the baseflows provided by shallow groundwater discharge.

4.4 Potential for Impact to Carlisle Municipals Wells and WHPA

Figure 5.6 of the 2004 *Presentation, Groundwater Resources Characterization and Wellhead Protection Partnership Study* and Figure 40 of the 2004 *Planning Report* show that the proposed Quarry is located within and beside the 2 year reverse time-of-travel (TOT) wellhead protection area (WHPA) for the Carlisle municipal water supply wells. Figure 2 of this report shows the outline of the 2 year WHPA and the proposed Quarry.

Construction of the Quarry potentially will impact both the WHPA and the quantity and quality of water provided to the municipal wells. Pumping of large volumes of groundwater from the Quarry will significantly change the groundwater flow system in the bedrock and hence cause groundwater at the municipal wells to be drawn from other areas up-gradient of the municipal wells and away from the Quarry. This distortion of the groundwater flow system will create a different WHPA than the one currently shown in Figures 5.6 and 40. The new well capture zones may encounter potential contaminant sources and other groundwater quantity and quality issues not previously accessed by the municipal wells prior to Quarry operation.

Upon completion of Quarry operations, the re-flooded Quarry may pose water quality concerns to the Carlisle municipal wells as the re-flooded Quarry would be a potential contaminant source within the 2 year capture zone and WHPA for the wells.

The potential impact of the proposed Quarry on the Carlisle municipal wells needs to assessed in light of the new Watershed-Based Source Protection Planning initiative undertaken by the Government of Ontario in response to the recommendations of the Walkerton Inquiry. The MOE 2004 *Technical Experts Committee Report* notes the following concerns regarding quarries in Ontario (reference location in Report is given in brackets):

- Quarries are identified as a land use activity that threatens drinking water sources and are sufficiently serious to be of provincial concern (Table 3.1).
- The primary issue with quarries is one of aquifer vulnerability in that they provide a direct pathway to drinking water supplies. Any quarry found with a 25 year TOT WHPA must be assessed for risk of contaminating the drinking water supply (Table 5.1).
- The risk of new quarries and final quarry land use should be assessed according to new standards for municipal wells and/or restrict new quarries within the 5 year TOT capture zone (Table 6.2).
- The 2 year TOT is defined as Pathogen Concern Zone, where pathogens should be minimized to protect drinking water supplies (Table 6.3).

Since the proposed Quarry is located within the 2 year TOT capture zones for the Carlisle municipal wells, according to the new Watershed-Based Source Protection Planning initiative, the risk posed by the Quarry and future Quarry land use on the Carlisle drinking water supplies must be assessed and/or development of the Quarry restricted. Furthermore, as the Quarry will be allowed to flood following aggregate extraction, the resulting surface water potentially poses a bacteriological/pathogenic threat to the Carlisle wells because it will be within the 2 year TOT. Such a threat may trigger the need for upgraded treatment of this groundwater supply. None of these issues have been discussed or addressed by the proponent.

5. CONCLUSIONS

Based on this review I offer the following conclusions:

1. The proponent's hydrogeologic characterization is preliminary and uses unsealed monitoring wells to estimate hydrogeologic impacts from the proposed Quarry. These monitoring wells, which are not in accordance with industry standards, underestimate the amount of drawdown that will be created by future Quarry dewatering.

2. The preferred method for accurately predicting the magnitude and extent of the water table drawdown that will be created by the proposed Quarry is by using a calibrated 3-D groundwater flow model that is based on site-specific geologic and hydrogeologic data. No such model has been proposed, developed or used for this Quarry by the proponent.

3. The proponent estimates that drawdown of the local groundwater levels for the first Quarry excavation lift will be limited to 1 m at 250 m from the Quarry face with essentially negligible drawdown at 600 m from the Quarry face. These are not credible drawdown estimates for either the first lift or the entire Quarry operation. My independent analysis indicates that drawdown for the full Quarry operation will be close to 31 m at the Quarry face, decreasing to about 13 m at a distance of about 1000 m from the Quarry face. At full size, I estimate that the Quarry may pump about 8,200 to 16,400 m^3/day of groundwater from the Amabel Formation dolostone aquifer.

4. The proposed measures to mitigate Quarry-induced drawdown (i.e., infiltration channels excavated to bedrock) will be largely ineffective.

5. The drawdowns that will occur in response to Quarry dewatering will adversely affect water levels in nearby residential and communal water supply wells which are typically drilled to only 15 m depth. Water supply wells for nearby housing developments on Glenron Road, at Timberun Court, at Bronte Creek Estates, at the Lawson Park Campground and at private residences along Mountsberg Road, Milburough Line Road and Concession Road 11E are all at risk of being dewatered or adversely affected by the proposed Quarry dewatering.

6. The Provincially Significant Wetlands, Environmentally Significant/Sensitive Areas (Mountsberg East Wetlands) and nearby creeks and streams (that have been identified as fish habitat) are also at risk of being dewatered and adversely affected by the proposed Quarry operation. This is because these surface waters appear to be in direct hydraulic connection to the shallow bedrock that provides baseflow to these important wetlands, creeks and streams. Diminished baseflow to local surface waters is likely to occur over an area with radius of 2500 m of the Quarry centre.

7. The Carlisle municipal water supply wells that draw drinking water from the Amabel Formation dolostone aquifer, are also at risk of being adversely affected by the proposed Quarry. Pumping of large volumes of groundwater from the Quarry will change the well capture zones and WHPAs of the Carlisle wells. The new well capture zones may encounter potential contaminant sources and other groundwater quality and quantity issues not previously identified or considered prior to Quarry operation.

8. There are assessment requirements under the Province's new Watershed-Based Source Protection Planning initiative specifically directed to proposed new quarries that must be considered and completed. Under this initiative, because the proposed Quarry is located within the 2 year capture zone or WHPA for the Carlisle wells, the risk posed by the Quarry and final Quarry land use to these wells needs to assessed and/or the development of the Quarry restricted. Since the Quarry will be allowed to flood following aggregate extraction, the resulting surface water also potentially poses a bacteriological/pathogenic threat to the Carlisle

municipal wells that may necessitate upgrading of treatment requirements for these wells. None of these issues have been discussed or addressed by the proponent.

6. OTHER DOCUMENTS REVIEWED

- *Watershed Based Source Protection: Implementation Committee Report to the Minister of the Environment*, Ontario Ministry of the Environment, PIBs 4938e, November, 2004.

- *Engineer's Report for the Water Supply and Treatment System, Lawson Park Campground*, Report prepared by Frontline Environmental Management Inc., for Mr. G. Lawson, Lawson Park Campground, April 30, 2003.

- *Hydrogeologic Evaluation, Fox Hollow Estates, Lot 4, Conc. 11, Town of Flamborough East,* Report prepared by Terraprobe Limited for AWS Engineers & Planners Corp., January 30, 2003.

- *The Development of a Conceptual Model for Contaminant Transport in the Dolostone Underlying Smithville, Ontario*, Report prepared for the Ontario Ministry of the Environment, by K. Novakowski., P. Lapcevic, G. Bickerton, J. Voralek, L Zanini and C. Talbot, , December 1, 2000.

- *Hydrogeologic Study of the Hamlet of Kilbride*, Report prepared for the Regional Municipality of Halton, prepared by Terraqua Investigations Ltd., February, 1998.

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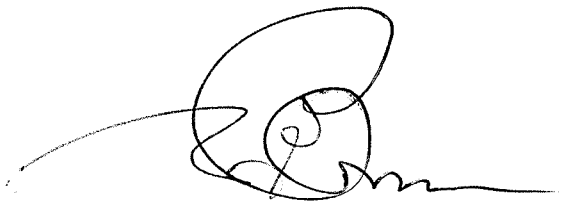
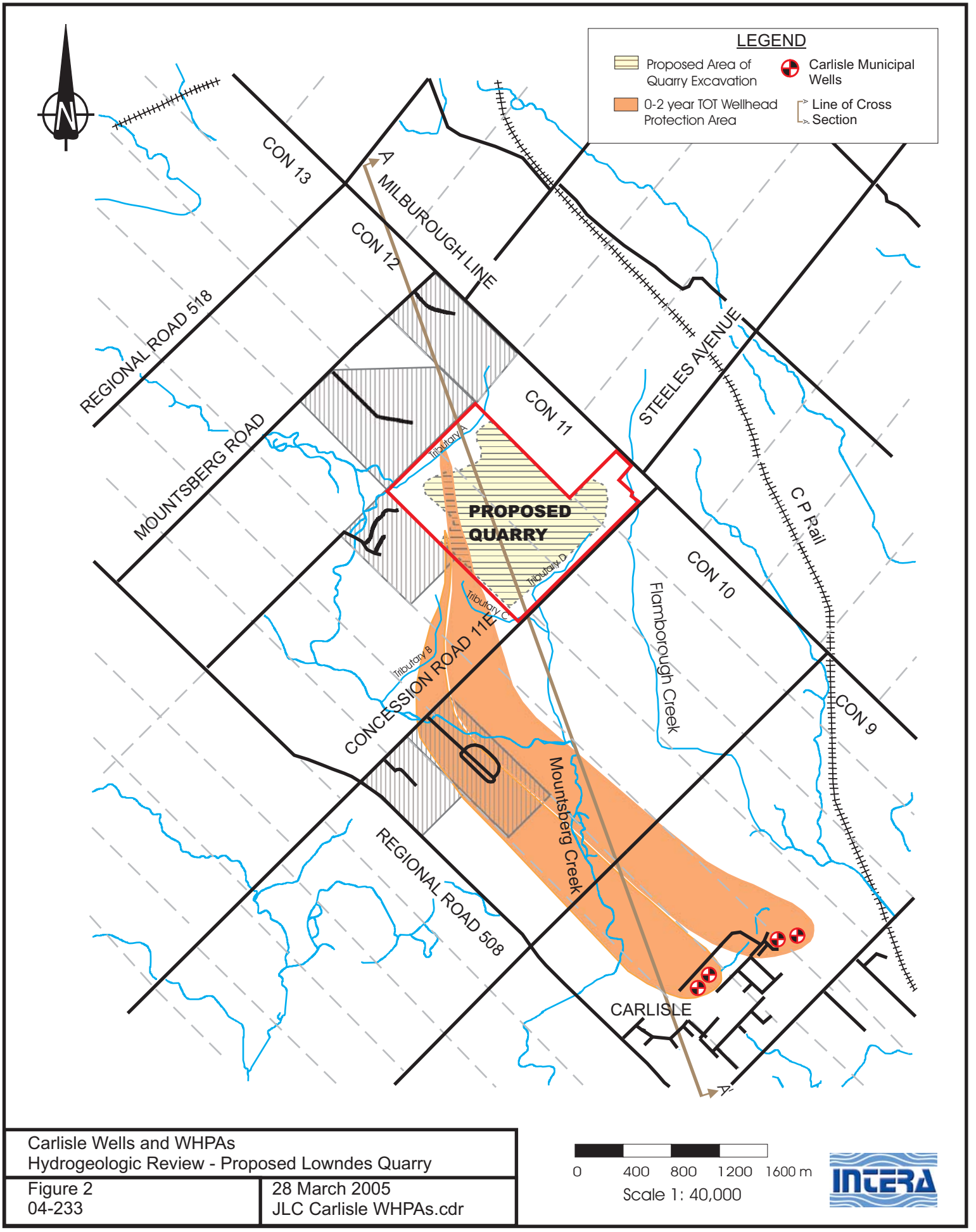
Sincerely,

INTERA Engineering Ltd.



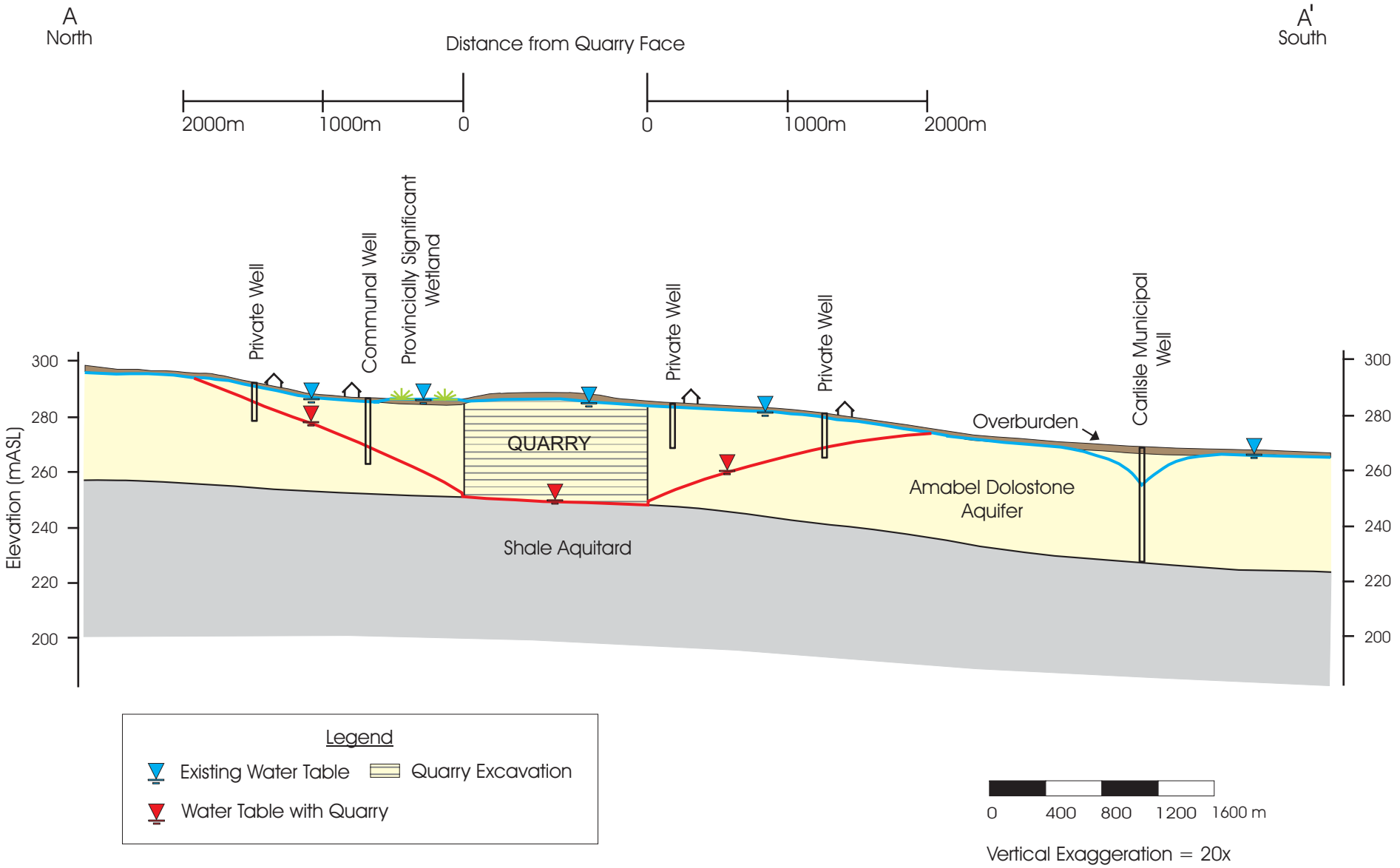
Kenneth G. Raven, M.Sc., P. Eng.
Principal

Attach.



Carlisle Wells and WHPAs
Hydrogeologic Review - Proposed Lowndes Quarry

Figure 2	28 March 2005
04-233	JLC Carlisle WHPAs.cdr



Hydrogeologic Cross Section A - A'
Hydrogeologic Review - Proposed Lowndes Quarry

Figure 3 04-233	28 March 2005 JLC Quarry X Section.cdr