APPENDIX C

BEAVER BANK ROAD QUARRY HYDROLOGY

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January 8, 2003 Project No. 03025

Ms. Janice Comeau
Jacques Whitford Environmental Limited
3 Spectacle Lake Drive
Dartmouth, NS
B3B 1W8

Re: Beaverbank Quarry Hydrology

Dear Ms. Comeau:

This letter is in response to your recent request regarding the additional work on our hydrologic review for the proposed Beaverbank Quarry expansion (Hydro-Com Technologies Limited Report dated December 12, 2003). The following paragraphs summarize our findings based on a revised boundary for the proposed quarry expansion.

In our December report (Project No. 03025), the proposed quarry site was bound by Highway 354 to the west, Kimberly Clark access road to the south, a small stream (tributary to Herbert River) to the east, and a wetland to the North (W1), as presented in Figure 1. Since our submission of this report, it is our understanding that the proposed boundary has been revised as presented in Figure 2.

The two (2) small wetlands (W2-1 and W2-2) located within the southern boundary of the *originally* proposed quarry site (Figure 1), which currently drain into a larger wetland (W2) just south of the Kimberly Clark access road, are no longer contained within the proposed quarry site (Figure 2).

It should be noted that by revising the proposed site boundary; the natural drainage path for the southwestern portion of the *originally* proposed quarry site, which was in a southerly direction, has been eliminated. Therefore the natural drainage path for the *currently* proposed quarry site, in its entirety, is in a northeasterly direction towards the eastern stream (tributary of Herbert River), with drainage water making its way to a large wetland (W3) located North of the quarry site and East of Highway 354.

Flows within wetland W1, located along the northern boundary of the *currently* proposed quarry site are expected to increase as the quarry activity progresses and as the entire quarry drains in a northwesterly direction. With the revised boundary conditions of the proposed quarry site, it should be noted, that no environmental hydrological impacts on wetlands W2-1, W2-2, and W2 are expected

Based on Rational Method and HEC-1 modelling, and using a time of concentration of 22 minutes, the peak flow resulting from a 10 year return period storm event was estimated to have a magnitude of 2.87 m^3/s. All of the hydraulic control structures associated with the quarry at the currently proposed ultimate level of development should thus be designed for a peak flow magnitude of no less than 2.87 m^3/s.

Using HEC-1 modelling, the runoff volume resulting from a 6 hour duration storm event with a 25 year return period was estimated to be approximately 7,200 m^3. The flow retention/siltation treatment structures should thus have a volume of no less than 7,200 m^3 in order to accommodate the site runoff from the quarry at the currently proposed ultimate level of development.

The potential effects of the quarry development on downstream water quality include an increase in the total sediment loading and an increase in chemical parameters associated with the rock being quarried. The placement of free-draining material over all disturbed areas and the use of properly sized flow retention/siltation treatment structures is expected to fully mitigate the potential increase in downstream sediment loading. As the amount of freshly exposed rock within the quarry is likely to remain relatively constant (it should be a function of the production rate, rather than the overall quarry size), the effects of the quarry on downstream water quality are expected to be relatively minor and the downstream water quality should return to background levels following the termination of active quarrying operations.

In summary, we believe that the effects on the downstream flows and water quality associated with the currently proposed ultimate level of quarry development can be fully mitigated using the placement of free-draining material and properly sized flow retention/siltation treatment areas. Following the use of these mitigative measures, the remaining residual effects on downstream flows and water quality are expected to be minor.

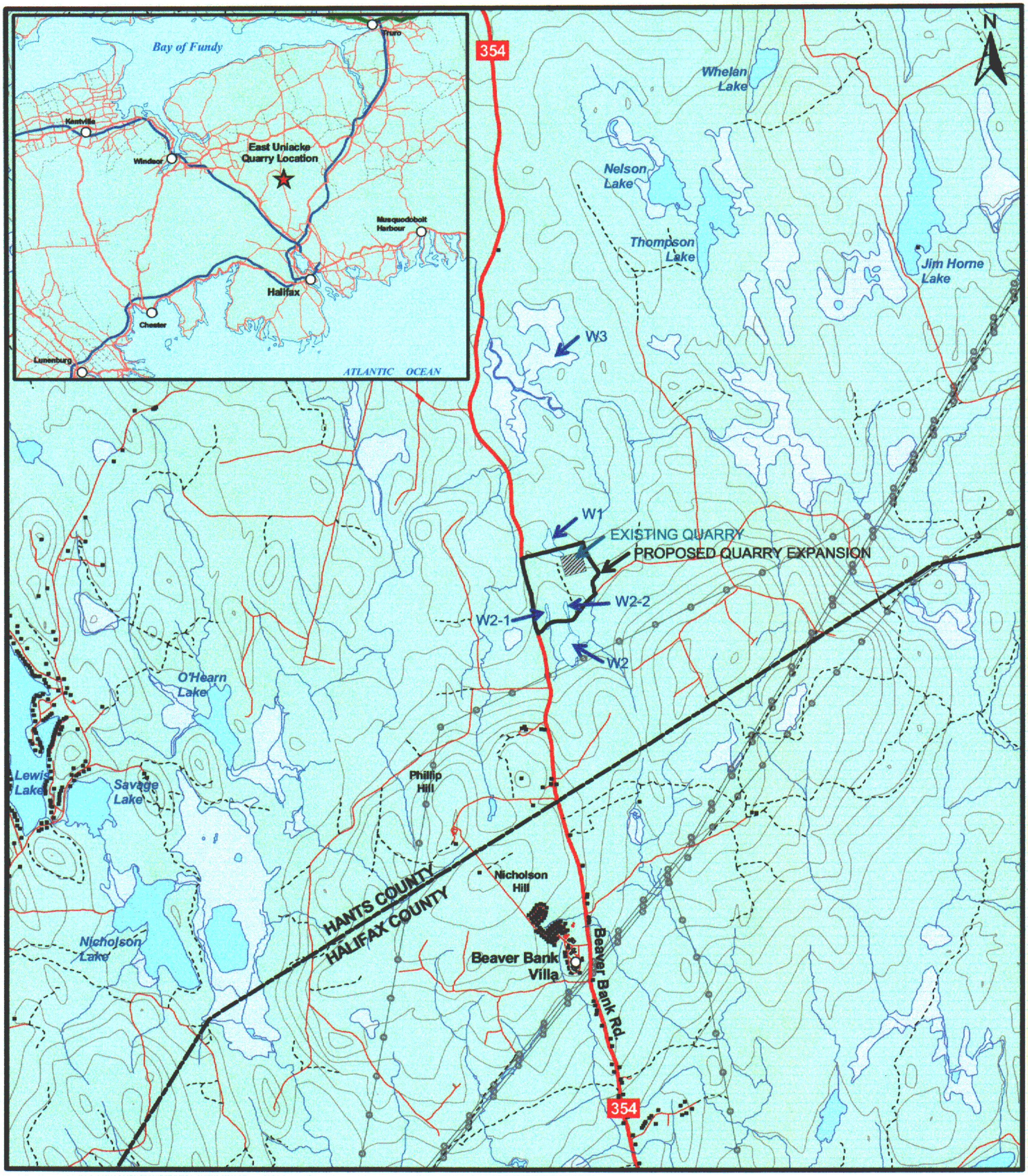
We trust that this satisfies your current requirements. If you have any questions or require additional information, please contact us at your convenience.

Yours truly,

Hydro-Com Technologies Limited

Shereen Ismail, EIT

Hans Arisz, M.Sc.E., P.Eng.



Proposed Expansion Boundary
Approximate Existing Quarry Boundary
Major Road
Minor Road
Dirt Road
Utility Line
County Line
Building/Structure
Stream
Lake
Wetland

Figure 1

East Uniacke Quarry Expansion Project Location Map

0 0.5 1 1.5 2 2.5 3
Kilometres

Map Parameters:
Projection: UTM
Datum: NAD83
Zone : 20
Date: November 2003
Project #: NSD17810

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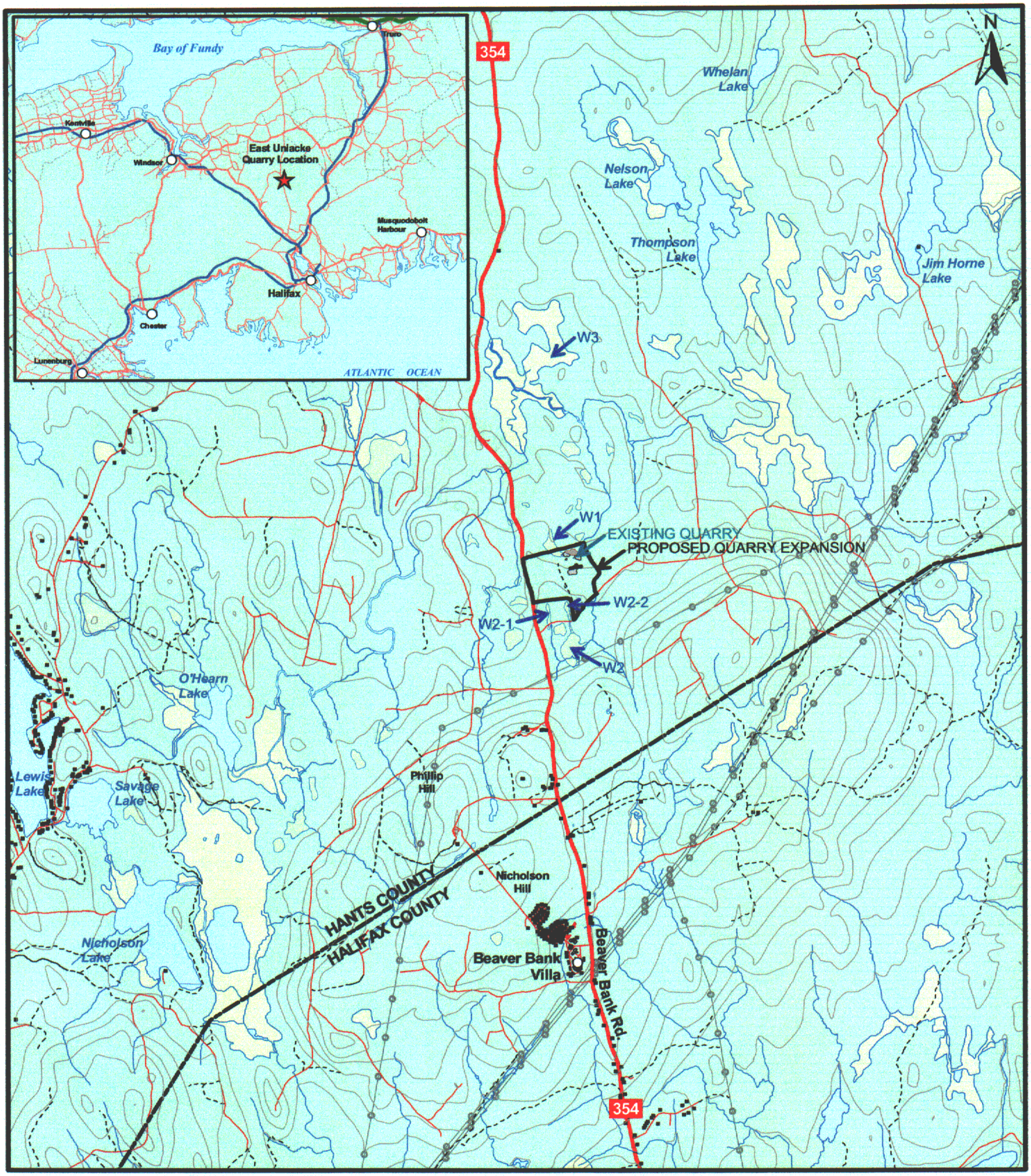

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Figure 2

East Uniacke Quarry Expansion Project Location Map

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Jacques Whitford
Consulting Engineers
Environmental Scientists
Risk Consultants

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RECEIVED
DEC 22 2003

December 12, 2003

Ms. Janice Comeau
Jacques Whitford Environmental Limited
3 Spectacle Lake Drive
Dartmouth, NS
B3B 1W8

Project 03025

Re: Beaverbank Quarry Hydrology

Dear Ms. Comeau:

This letter is in response to our recent conversations and an email dated September 25, 2003 (File NSD 17810) from Ms. Katherine Fleet of Jacques Whitford Environment Limited, regarding the performance of a hydrologic review by by Hydro-Com Technologies Limited for the above noted project. The following paragraphs present our understanding of the objectives of the hydrologic review, our methodologies, and our finding.

Site Description

The Beaverbank quarry is located just North of the Halifax Regional Municipality boundary (North of Sackville on the Beaverbank Road). The quarry entrance is located approximately 18 kilometres from the Kent building supplies intersection in Lower Sackville, and approximately 2 kilometres from the Halifax/Hants County Line. The property is bounded by Highway 354 to the west, Kimberly Clark access road to the south, a small stream (tributary to Herbert River) to the east, and a wetland to the North (W1). Figure 1 presents a plan view of the quarry site and proposed expansion area.

It should be noted that there are two (2) small wetlands (W2-1 and W2-2) located within the southern boundary of the proposed quarry site. These wetlands currently drain into a larger wetland (W2) just south of the Kimberly Clark access road, which in turn drains into the eastern stream (tributary to Herbert River).

Based on 1:50,000 mapping, the natural drainage path for the majority of the proposed quarry site is in a northeasterly direction towards the eastern stream (tributary of Herbert River), while the natural drainage path for the southwestern portion of the proposed quarry site is in a southerly direction. However, based on conversations with Jacques Whitford Environmental personnel, the existing quarry currently drains in a northwesterly direction. It is also our understanding that the quarry development will progress from north to south, and then east to west, with a 60 metre buffer zone to the eastern stream (tributary of Herbert River). For the purposes of this study, we have assumed that the quarry will continue to drain in a northwesterly direction, with drainage water making its way to a large wetland (W3) located North of the quarry site and East of Highway 354.

Objectives

Based on our discussions and the September 25, 2003 correspondence (e-mail) from Ms. Fleet, our understanding of the objectives for this project are as follows:

- estimate quantities of surface runoff from the site for the currently proposed ultimate level of quarry development,
- estimate the size and design discharge capacity of the required flow retention/siltation treatment structures for the currently proposed ultimate level of quarry development,
- determine the impact the quarry expansion will have on the various wetlands surrounding the area, in particular W1, W2-1, W2-2, and W3, and.
- assess potential effects of the quarry on downstream flows and water quality for the currently proposed ultimate level of quarry development.

Methodology

The methodologies that were used to satisfy the above objectives were as follows:

- the annual volume of runoff was estimated using a proration of mean annual flows from nearby hydrometric stations and from previous studies,
- the size and design discharge capacity of the required flow retention/siltation treatment structures were determined using the HEC-1 runoff model and the Rational Method, and
- the effects on downstream flows and water quality were assessed based on experience with similar developments.

The following physiographic parameters were obtained from the available project mapping:

- the quarry drainage area for the currently proposed ultimate level of development is approximately 0.367 km^2,
- the quarry working slope for the currently proposed ultimate level of development is approximately 3.2 %,
- time of concentration of the watershed containing the quarry is approximately 22 minutes,

- coefficient of runoff at the quarry site is equal to 0.55,
- Soil Conservation Service (SCS) land use curve number at the quarry site for average antecedent moisture conditions (AMC II) is equal to 76, and
- drainage area of the watershed within which the quarry is located at the confluence of the eastern stream and the discharge point of the larger wetland approximately 2.8 km north of the quarry is 36.7 km^2.

Mean Annual Site Runoff

Based on historic climate data at Mount Uniacke, the annual average precipitation at the site is 1,552.6 mm. If all this precipitation would be converted into surface runoff (which would represent an upper bound on the expected annual site runoff), the annual volume of runoff from the quarry site at the currently proposed ultimate level of development would be 570,000 m^3, which corresponds to a mean annual flow of 18.1 L/s.

A lower bound for the expected annual volume of site runoff could be obtained by drainage area based proration of flows from nearby hydrometric stations. Mean annual flows of 11.3 L/s and 11.8 L/s were estimated for the quarry watershed at the currently proposed ultimate level of development, by prorating the flows from hydrometric stations 01DG003 and 01DG006, respectively. The drainage area for 01DG003 (Beaverbank River near Kinsac) is 96.9 km^2, while the drainage area for 01DG006 (Shubenacadie River at Enfield) is 389 km^2. The above mean annual flows correspond to annual runoff volumes of 356,600 and 372,400 m^3, respectively.

As the removal of tree cover and topsoil from the section of watershed containing the quarry will result in a reduction of evapotranspiration and a corresponding increase in surface runoff, the expected annual volume of runoff from the quarry at the currently proposed ultimate level of development is estimated to be 467,000 m^3, which corresponds to a mean annual flow of 14.8 L/s.

Flow Retention/Siltation Treatment Structures

The criteria that was used to determine the peak design flow and the retention volume associated with the flow retention/siltation treatment structures for the quarry at the currently proposed ultimate level of development are as follows. The peak design flow for the pond consisted of the peak flow resulting from a 10 year return period storm event, while the minimum pond volume was to be equal to the runoff volume of a 6 hour duration storm event with a 25 year return period.

Based on the Rational Method and HEC-1 modelling, and using a time of concentration of 22 minutes, the peak flow resulting from a 10 year return period storm event was estimated to have a magnitude of 3.18 m^3/s. All of the hydraulic control structures associated with the quarry at the currently proposed ultimate level of development should thus be designed for a peak flow magnitude of no less than 3.18 m^3/s.

Using HEC-1 modelling, the runoff volume resulting from a 6 hour duration storm event with a 25 year return period was estimated to be approximately 7,500 m^3. The flow retention/siltation treatment structures should thus have a volume of no less than 7,500 m^3 in order to accommodate the site runoff from the quarry at the currently proposed ultimate level of development.

Effects on Downstream Flows and Water Quality

As previously mentioned, the natural drainage path for the majority of the proposed quarry site is a northeasterly direction, while the natural drainage path for the southwestern portion of the proposed quarry site is in a southerly direction. As the quarry activity progresses, it is expected that the two (2) wetlands (W2-1 and W2-1) located within the southern boundary of the ultimate level of the proposed quarry development will be de-watered, and the entire quarry will drain in a northwestern direction, as per the current drainage conditions for the existing quarry, increasing the flows within the wetland (W1) located along the northern boundary of the proposed quarry site.

The currently proposed ultimate level of quarry development is expected to reduce the amount of evapotranspiration from the quarry site and increase the volume of mean annual surface runoff. The magnitude of the above change is estimated to be approximately 102,500 m^3/year, representing an approximate increase of 30% of the mean annual flows from the quarry site. Based on a 0.367 km^2 drainage area associated with currently the proposed ultimate level of quarry development, and the 36.7 km^2 drainage area of the watershed within which the quarry is located, the above change in the volume of mean annual surface runoff from the quarry would result in an increase in the mean annual flows at the discharge point of the larger wetland to the north (W3) into the Herbert River of approximately 0.3%

Although the quarry development will result in an increase in the peak rates of surface runoff at the outlet of the quarry site and a reduction of the low flows (i.e. water will run off more quickly following additional quarry development), the placement of free-draining material over the disturbed areas and the use of properly sized flow retention structures is expected to fully mitigate the above re-distribution of flows.

The potential effects of the quarry development on downstream water quality include an increase in the total sediment loading and an increase in chemical parameters associated with the rock being quarried. The placement of free-draining material over all disturbed areas and the use of properly sized flow retention/siltation treatment structures is expected to fully mitigate the potential increase in downstream sediment loading. As the amount of freshly exposed rock within the quarry is likely to remain relatively constant (it should be a function of the production rate, rather than the overall quarry size), the effects of the quarry on downstream water quality are expected to be relatively minor and the downstream water quality should return to background levels following the termination of active quarrying operations.

In summary, we believe that the effects on the downstream flows and water quality associated with the currently proposed ultimate level of quarry development can be fully mitigated using the placement of free-draining material and properly sized flow retention/siltation treatment areas. Following the use of these mitigative measures, the remaining residual effects on downstream flows and water quality are expected to be minor.

References

Dzikowski, P.A., G. Kirby, G. Read, W.G. Richards. 1984. *The Climate for Agriculture in Atlantic Canada.* Publication No. ACA 84-2-500. Agdex No. 070. 19 pp.

MacLaren Atlantic Limited. 1980. *Regional Flood Frequency Analysis for Mainland Nova Scotia Streams.* Canada- Nova Scotia Flood Reduction Program. Figure 3.1.

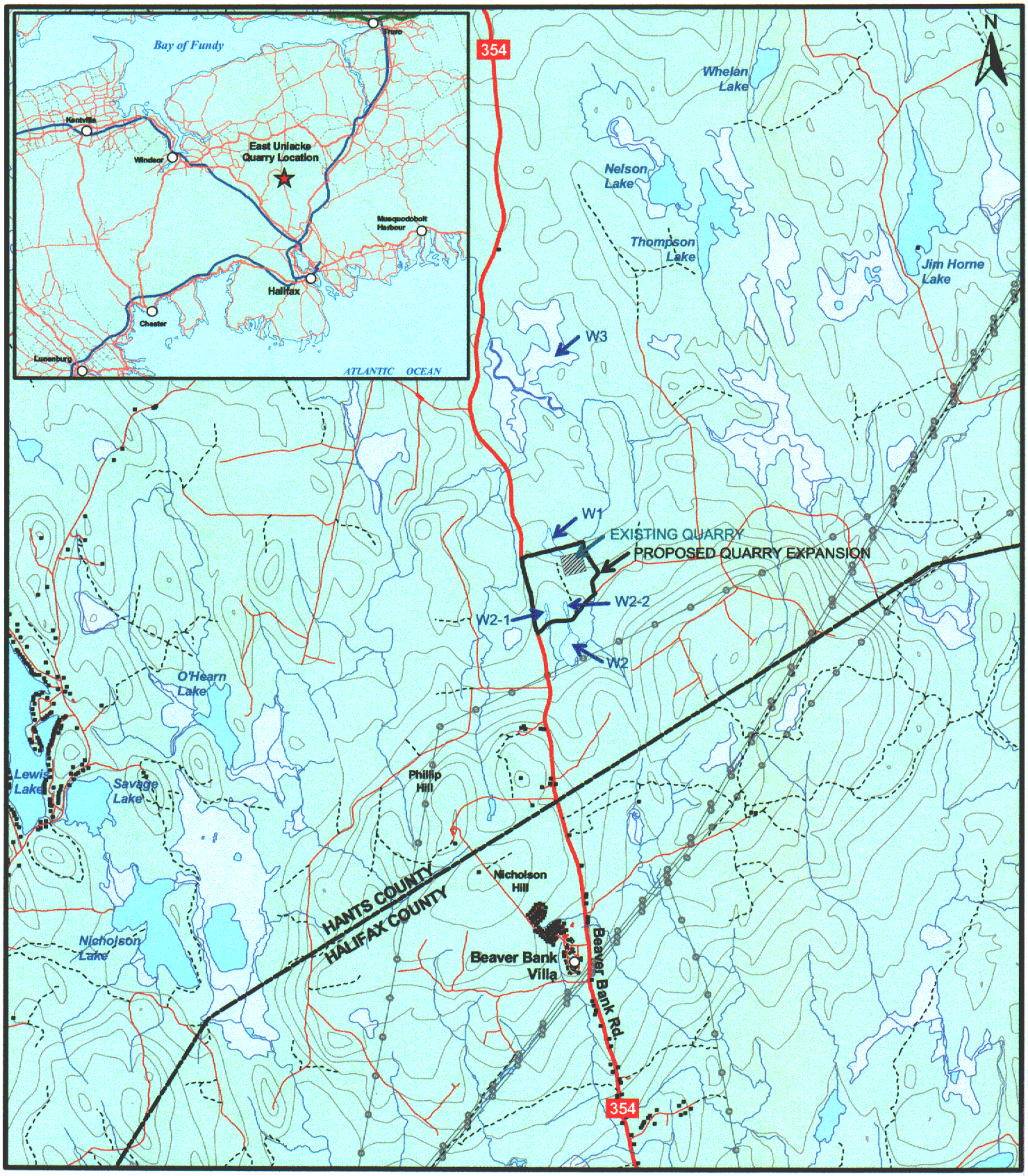
We trust that this satisfies your current requirements. If you have any questions or require additional information, please contact us at your convenience.

Yours truly,

Hydro-Com Technologies Limited

Shereen Ismail, EIT

Hans Arisz, M.Sc.E., P.Eng.



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