Fracflow Consultants Inc.

Environmental, Hydrogeological and
Geotechnical Engineering Consultants

July 25, 2014

FFC File 775

Mr. Jim Taylor
Cygnet Properties Limited/Foxwood Developments Inc.
187A Bluewater Road
Bedford, NS
B4B 1H1

Dear Mr. Taylor:

RE: Level II Groundwater Assessment, Eastern Portion of PID 00513788, Old Post Road, Enfield, HRM, NS (HRM Planning Application File 19117)

Fracflow has reviewed a copy of the letter that was submitted to HRM's Planning Services department on April 21, 2014 by CBCL. That letter contains comments arising from a review of the above-noted report that was submitted by Fracflow on November 22, 2013. HRM's Planner, Erin MacIntyre, advised your planning consultant, Mr. Bill Campbell, that several conclusions will need to be addressed. Ms. MacIntyre noted in her email to Mr. Campbell, on April 23, 2014 that "...the area available for recharge, being 364 hectares (900 acres) is adequate, with certain conditions". The main condition appears to be that there would be no possibility for further development on the remainder of the lands and no potential to subdivide those lands in the future. This letter will address the planner's comments on the matter of available recharge. The other items that were raised in CBCL's letter will be addressed at a future date, pending a response from HRM to this matter.

Fracflow's Level II report noted that the area available for groundwater recharge, between the eastern boundary of your property and Black Brook, totals approximately 3.64 km^2, of which the development area represents about 8.8 percent. Using NSE's Lot Water Balance Calculator, the estimated volume of recharge available on those lands is approximately 856,000 litres per day. The estimated demand of the development, if all dwellings are developed, is 550,000 litres per day. The additional demand for water treatment processes will be addressed under separate cover, but it is our present opinion that the additional demand would not exceed ten to fifteen percent of the total water demand if standard water softening equipment were used.

In our professional opinion, the actual amount of recharge that will be available to support residential and ecological water demands will be higher than the estimate presented in our Level II report. There are four major factors to be considered, as outlined below.

1. Recharge Required for Ecological Support is Likely to be Less Than 50 Percent

The water balance calculations presented in the Level II report include a 50 percent reserve for ecological use, which is that portion of groundwater that is required to maintain ecological habitats by discharging as baseflow to surface water bodies. That percentage is the default value that Nova Scotia Environment (NSE) uses in its *Guide to Groundwater Assessments for Subdivisions Serviced by Private Wells* (NSE, 2011). The Guide states that the value can be adjusted if other information is available to indicate that the ecological water demand is less.

The International Joint Commission in its report on *Protection of the Waters of the Great Lake - Final Report to the Governments of Canada and The United States* (2000), stated that there is no comprehensive description of the role of groundwater in supporting ecological systems and that in many cases the broad estimates that are used are not a reliable reflection of the actual ecological water demand. The Council of Canadian Academies' expert panel on groundwater also addressed this issue in its report on The Sustainable Management of Groundwater in Canada (2009). Consider the following excerpt from that recent report:

"Determining instream-flow needs and acceptable nutrient loads to estuaries are two science-based problems that place groundwater science at the interface with ecology and that will ultimately bring society to some difficult sustainability questions. Management actions with regard to instream flows may need to be iterative; that is, initially allowing a partial allocation of a proposed groundwater extraction, with follow-up ecological monitoring and evaluation before making modifications to the management decision, consistent with adaptive management principles. This would better account for the slow response time for some groundwater systems and the uncertainty in isolating ecological responses."

Reserving 50 percent of the available recharge for ecological support is a prudent measure for the planning stages of this new development, given the limited amount of site-specific hydrological and hydrogeological data available. Provisions can be incorporated into the development plan to include seasonal monitoring of wetland, groundwater and streamflow responses to recharge events. The interpretation of those data, possibly aided by computer modelling, will allow a meaningful site-specific ecological water demand to be determined. In Fracflow's opinion and experience, the actual ecological water demand is likely to be less than 50 percent.

2. Groundwater Withdrawal Likely to Reduce Runoff and Increase Recharge

One of the major challenges faced by municipalities is the effect of climate change on the environment. Precipitation patterns are changing and are trending toward higher amounts falling over shorter periods of time. The net result in natural settings is increased runoff because of insufficient storage in the pore spaces above the water table. An important aspect of groundwater withdrawal that should not be overlooked is the increased storage space that is created above the drawdown cone around each pumping well. The proper placement and spacing of pumping wells can actually help to manage and utilize recharge in a more efficient manner.

3. Additional Recharge May Originate Outside the Property Boundaries

The flow system components and the aquifer boundaries that were described in the Level II report are not constrained by the physical boundaries of the property. Data that Fracflow collected to date suggest that the fractured-bedrock aquifer in the area around test wells TH2 and TH3 is behaving as a leaky-confined aquifer system, based on the shape of the drawdown curves and the low values of storativity. Further, artesian conditions that were detected at test wells TH4 and TH5 are indicative of an upward directed vertical hydraulic gradient (i.e., groundwater discharge areas). The Level II report indicates that the areas to the south of the existing drilled wells are expected to be important areas for groundwater recharge. It was not our intention to suggest that those areas to the south are constrained by the property boundaries.

Additional data to be collected during development of the groundwater supply will allow us to determine if the aquifer is truly a leaky-confined aquifer. If so, then production wells completed in that aquifer are going to harvest a combination of groundwater that is derived from the local flow systems established on the property and within the Black Brook and Beaver Brook sub-watersheds (i.e., the leaky component from local recharge), as well as from additional recharge that takes place within the more 'regional' flow system. The 'top' of that 'regional' flow system appears to originate in an area that is approximately 4 km to the southeast along a portion of Guysborough Road. The inferred groundwater flow lines are shown in **Figure 1** (see attached).

Insufficient data are currently available to quantify the actual volume of recharge that could be available to the producing aquifer from outside of the property boundaries, but one can determine the additional recharge that would be available through longer-term aquifer tests, geochemical analyses, and possibly three-dimensional flow and transport modelling.

4. Option to Develop a GUDI Groundwater Source using an Induced Infiltration Approach

Black Brook is a prominent water course that conveys a significant quantity of surface water along the eastern boundary of the property. When that brook was first inspected in August 2012, during summer baseflow conditions, the flow rate at a point closest to test well TH1 was approximately 2,400 Lpm. The brook appeared to lose water, as a result of suspected recharge to the groundwater system. Over a distance over more than 1 km, the flow diminished to an estimated rate of 840 Lpm.

While there may be some water quality issues associated with Black Brook, in light of historical mining activities in the Oldham area, the option exists to evaluate the potential for constructing wells close to the brook. The constant-head boundary condition associated with the brook has the potential to deliver a continuous supply of naturally filtered water into any nearby production wells. It may be possible to indirectly harvest 200 to 300 Lpm of water (300,000 to 400,000 litres per day) from the brook in a sustainable manner, without adversely effecting freshwater aquatic life. Groundwater extraction in this manner would classify the production wells as GUDI wells and the surface water treatment standard would apply, which is considerably more onerous

than the groundwater treatment standard. While not a preferred option, it does offer a technically feasible solution to augmenting the additional water demand.

5. Closing Comments

In Fracflow's opinion and experience, the expected impact of groundwater withdrawal on the environment, to meet the demand of the currently proposed development, is expected to be minimal provided that the additional wells required to meet total demand are properly located and spaced to take into account the various flow system components and the inherently heterogeneous nature of the fractured-bedrock aquifer. Once the Development Agreement is in place, it is our understanding that additional work will be undertaken by you to characterize the degree of groundwater/surface water interaction, including surface water quality, which will help us develop a better understanding of the available recharge.

We trust the foregoing commentary is satisfactory for your immediate purposes. Please contact the undersigned if you have any questions or require additional information.

Sincerely,
Fracflow Consultants Inc.

G. Glenn Bursey, M.Sc., P.Geo.
Vice President and Senior Hydrogeologist

cc: Dr. John Gale, P.Eng., P.Geo.
President and Senior Hydrogeologist/Engineer

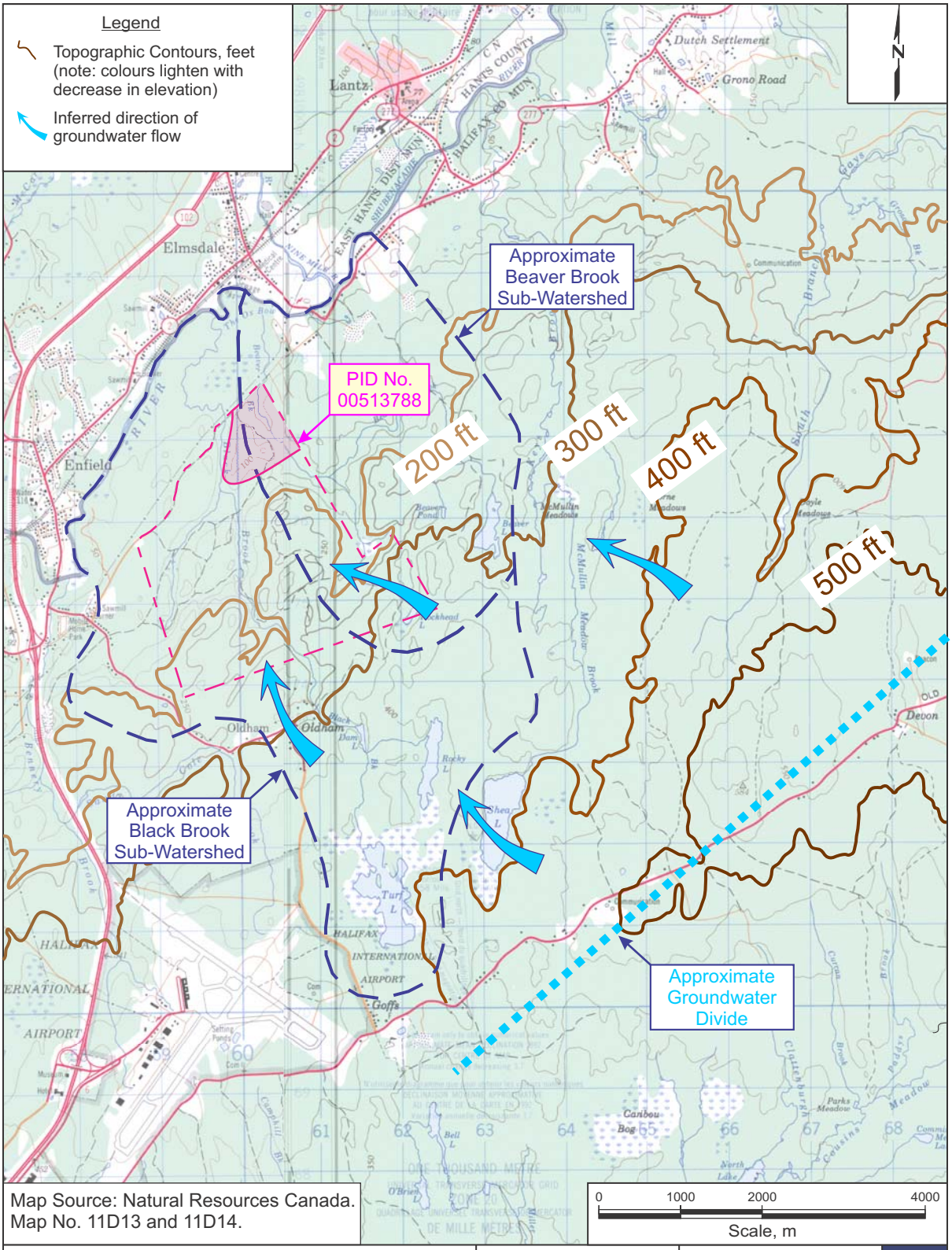

Figure 1 Inferred 'regional' groundwater flow directions.	Project No. 775	Scale As Shown
	Location Old Post Road, NS	Date July 2014

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