

Appendix B: Hydrogeological Assessment



**HYDROGEOLOGICAL ASSESSMENT
SOUTH CANOE WIND PROJECT**

Revised: February 17, 2012



Taking Charge™



February 17, 2012

Mr. Chris Peters
Minas Basin Pulp and Power Company Limited
53 Prince Street
Hantsport, NS B0P 1P0

Dear Mr. Peters

Re: Hydrogeological Assessment
South Canoe Wind Project

Attached is the Hydrogeological Assessment Report prepared for the South Canoe Wind Project.

This report documents our observations, findings, and environmental considerations.

We trust this report to be satisfactory at this time. Once you have had an opportunity to review this correspondence, please contact us to address any questions you may have.

Thank you,

A handwritten signature in blue ink, appearing to read "Megan Henley".

Megan Henley, BSc.
Environmental Specialist
mhenley@strum.com

A handwritten signature in blue ink, appearing to read "A. Bruce Strum".

A. Bruce Strum, P. Geo.
President
bstrum@strum.com

EXECUTIVE SUMMARY

Strum Environmental was commissioned by Minas Basin Pulp and Power Company Limited (MBPP) to conduct a Hydrogeological Assessment at the site of the South Canoe Wind Project. MBPP and Nova Scotia Power Inc. (NSPI) have proposed the development of a 100 MW wind generation facility in Central Nova Scotia between the Municipalities of the District of West Hants and District of Chester.

The Site

The Project site is near Leminster, approximately 25 km southwest of Windsor, Nova Scotia, on approximately 6,369 ha of land. The lands are currently owned and used by MBPP for logging operations. Overall, the Project site is mainly undeveloped and consists primarily of forested or recently cleared land. The Project site is accessible from New Ross Road to the North and Highway 14 to the east via several logging roads providing access throughout the site. The Project site borders several lakes including: South Canoe Lake, Mud Lake, Big Otter Lake, Little Otter Lake, Joe Long Lake, Long Bay, Card Lake, Dam Bay, Bog Lake as well as the Avon River.

Adjacent Properties

A total of 171 adjacent properties were located within the study area (500 m radius of the Project site). Land use on the adjoining properties in the study area is designated primarily as residential (43%) and undeveloped resource lands (26%), with commercial (13%) and land designated as mixed use (15%) also present. The remaining 3% of adjacent properties are unclassified according to Property Online database. Commercial properties in the area are largely forested areas owned by Bowater Mersey Paper Ltd. and Atlantic Star Forestry in addition to a few parcels owned by Nova Scotia Power (NSPI).

Overall, developed properties within the study area are provided with potable water from drilled and dug wells, and sanitary services via on-site septic systems. A total of 1 dug well and 24 drilled wells were identified in the study area, either visually during the site visit, or in the Nova Scotia Environment (NSE) Well Log Database.

Surficial Hydrogeology

The Surficial material in the study area consists of 0.3 to 35.4 m of varying material including Organic Deposits, Silty Till Plain (Ground Moraine), Silty Drumlin, Stony Till Plain, and Bedrock. The majority of the Project site is overlain by a silty, compact till material which is derived from both local and distant sources. The Silty Till Plain (Ground Moraine) creates a flat to rolling topography with a thicker till masking bedrock undulations. Silty Drumlins appear sporadically throughout the site, consisting of a siltier till with a higher percentage of distant source material including red clay (Stea et al. 1992). An area of organic deposits composed of sphagnum moss, peat, and clay occur on the western half of the Project site. A band of exposed bedrock and stony till plain overlie the central portion of the site extending from Card Lake at the southern boundary to South Canoe Lake at the northern property boundary. Dug wells in the area may experience low yields or seasonal shortages, require greater clearance distances from septic systems, and are more prone to surface/near surface contaminants than drilled wells.

Bedrock Hydrogeology

Bedrock in the vicinity of the proposed development is expected to consist of Middle to Late Devonian aged granite bedrock. Varying compositions of granite within the site include muscovite-biotite monzogranite, leucomonzogranite, muscovite leucomonzogranite, and fine grained leucomonzogranite.

Based on short term driller's estimates for the 23 drilled wells identified in the NSE Well Log Database, the average yield in the study area is approximately 32.1 Lpm (7.1 gpm) and average well depth is approximately 61 m (200.4 ft). These yields represent very short term yields estimated by the driller at the completion of well construction. It is important to note that long term well production rates are typically 25% of the drillers estimates indicating actual longer term yields may be in the 8.0 Lpm (1.8 gpm), or less range.

Longer term yields based on the NSE Pump Test Database for the two regional wells drilled through Granite bedrock and located within a 10 km radius of the site indicate long term safe yields (Q20) of 5.9 Lpm (1.3 gpm) and 50 Lpm (11 gpm), and apparent transmissivity (T) values of 0.8 and 3.7 m²/d. Storativity values were not available from the two pump tests.

An observation well is situated in Lewis Lake, Jerry Lawrence Provincial Park (No. 079) that forms part of the NSE Nova Scotia Groundwater Observation Well. This observation well was drilled through granite bedrock and a 3 hour pump test was completed on the well in 2008. Results of the pump testing indicated the well had a T value of 1.53 m²/d and a safe yield rate of 57.3 m³/day.

Groundwater quality in contact with granite bedrock will tend to have higher alkalinity, hardness, and Total Dissolved Solids (TDS). Potential health-related concerns associated with the development of groundwater supplies in the granite bedrock aquifer include elevated concentrations of arsenic (related to sulphide and base metal mineralization), as well as radionuclides such as radium, uranium, fluoride, radon, and lead-210. Water quality data from four wells drilled in granite bedrock located within 10 km of the Project site indicated exceedences of iron, fluoride, arsenic, and uranium concentrations.

The placement of turbines at the site is expected to have a negligible impact on surface water, dug wells, and drilled wells near the study area.

Environmental Considerations

The following environmental considerations are forwarded:

1. During the construction phase of development localized disturbances of surface soil and shallow bedrock may increase the risk of erosion and soil mobility. Erosion and sedimentation control measures will be required to protect surface water quality.
2. While large scale blasting is not anticipated to occur, the potential may arise as roads are being upgraded or constructed throughout the site. Turbine locations are to be situated a minimum of 1.2 km from the nearest residential property, however, if road

construction requires blasting within 1.2 km of a residential dwelling, then completion of a well survey may be recommended.

3. Although not anticipated, in the event bedrock formation of the Meguma Group bedrock (shale or slate) is closer than mapped, the potential for environmental constraint relating to acid rock drainage (ARD) should be recognized and assessed further if future disturbance or exposure of this type of bedrock is anticipated (i.e. as part of construction work). Any issues relating to ARD are governed by the NSE Sulphide Bearing Material Disposal Regulations (N.S. Reg 57/95).

The statements made in this Executive Summary are subject to the same limitations included in Section 9.0, and are to be read in conjunction with the remainder of this report.

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1.0 INTRODUCTION

Strum Environmental was commissioned by Minas Basin Pulp and Power Company Limited (MBPP) to conduct a Hydrogeological Assessment at the site of the South Canoe Wind Project. The subject properties comprising the proposed development area are herein referred to as the “site” and or “Project site”.

Given the size of the Project site, a Hydrogeological Assessment was completed to assess the potential impacts on local surface and groundwater resources in the area.

Please note that gallons and gallons per minute (gpm and igpm) in this report both refer to imperial gallons unless otherwise noted.

2.0 SITE DESCRIPTION

2.1 Definition of Study Area

For the purposes of this report, the “site” is comprised of the area within the Property boundaries as described below in Section 2.2. Reference to “adjacent properties” refers to the remaining portion of the study area, which includes all adjoining properties located within a 500 m radius of the site property boundaries.

2.2 The Site and Proposed Future Development

MBPP and Nova Scotia Power Inc. (NSPI) have proposed the development of a 100 MW wind generation facility in Central Nova Scotia between the Municipalities of the District of West Hants and District of Chester. The Project site is near Leminster, approximately 25 km southwest of Windsor, Nova Scotia, on approximately 6,369 ha of land. The lands are currently owned and used by MBPP for logging operations. .

As the Hydrogeological Assessment was initiated prior to finalizing a Project layout, the Property Boundaries were used to represent the Project site. Refer to Drawing 1 (Appendix A) for a 1:75,000 scale Site Location Map [National Topographic Survey (NTS) Map No's. 21 A/06 and 21 A/12], showing the Project site boundaries and the general location of the Project site within the region. The findings of this assessment, as they pertain to the final Project Area (i.e. area of land incorporating the turbines and access roads), are discussed within the Environmental Assessment Registration Document (see Sections 4.2 and 4.3).

The Project site includes a proposed development area of 6,369 hectares (15 738.1 acres) and consists of portions of 32 separate parcels of land. Refer to Table 1 in Appendix B for details regarding the individual properties that collectively form the Project site including PIDs, civic addresses, property owners, and land areas.

Overall, the Project site is mainly undeveloped and consists primarily of forested or recently cleared land. The site is accessible from New Ross Road to the North and Highway 14 to the east via several logging roads providing access throughout the Project site. The Project borders several lakes including: South Canoe Lake, Mud Lake, Big Otter Lake, Little Otter Lake, Joe Long Lake, Long Bay, Card Lake, Dam Bay, Bog Lake as well as the Avon River.

Representative photos of the Project site and adjacent properties are provided as Photos 1-8 (Appendix C). A summary of the property information, including Property Identification (PID) Numbers, civic addresses, property owner and land areas is provided as Table 1 (Appendix B).

A Project Site Plan depicting the boundaries and configuration of individual properties comprising the site, locations of lakes and watercourses transecting the Project site, as well as other relevant property details is included as Drawing 2 (Appendix A).

2.3 Adjacent Properties

Within a 500 m radius of the Project site boundaries, there are a total of 171 adjacent properties that were reviewed as part of this assessment. Refer to Drawings 2A and 2B (Appendix A), which show the study area including the Project site and the adjoining properties within a 500 m radius of the Project site. Drawing 2B is an inset showing the adjoining properties in concentrated areas surrounding Lake Lewis, North Canoe Lake, and Zwicker Lake.

Land use on the adjoining properties in the study area is designated primarily as residential (43%) and undeveloped resource lands (26%), with commercial (13%) and land designated as mixed use (15%) also present. The remaining 3% of adjacent properties are unclassified according to Property Online database. Commercial properties in the area are largely forested areas owned by Bowater Mersey Paper Ltd. and Atlantic Star Forestry in addition to a few parcels owned by Nova Scotia Power (NSPI).

Overall, developed properties within the study area are provided with potable water from drilled and dug wells, and sanitary services via on-site septic systems. Representative photos are provided as Photos 4-8 (Appendix C).

3.1 SCOPE AND METHODOLOGY

3.1 Scope

The purpose of the Hydrogeological Assessment was to characterize the local geology and hydrogeology, and to assess potential effects the wind power project may have on surface water and groundwater sources in the vicinity of the project and to recommend mitigation measures. The work scope for the Hydrogeological Assessment is mainly research based and consists of a detailed description of the hydrogeology and characterization of the Project site.

3.2 Methodology

This assessment involved a historic review of pertinent records and interviews with persons who have relevant knowledge of hydrogeological conditions in the area. The primary sources of information included land use documents; previous assessment reports; geologic, geochemical, and topographic maps; and the Nova Scotia Environment (NSE) Well Log and Pump Test databases. Discussions were also held with developers, local well drillers, representatives of NSE, and other experienced or qualified persons.

In order to characterize the local geology and hydrogeology, the work scope has included, but is not limited to, the following:

- Review and compile local well records from the most recent version of the Nova Scotia Provincial Well Logs Database.
- Review and compile pumping test results from the most recent version of the Provincial Pumping Test Database for the proposed aquifer source.
- Review and summarize available water quality analyses for the proposed aquifer source.
- Review of available groundwater studies and/or literature on the area.
- Consult with all appropriate provincial agencies and well contractors familiar with the area to obtain information on local groundwater resources.
- Assess local bedrock and surficial geology, including stratigraphy, depth, thickness, composition, texture, known relevant weathering/ alteration/ structural features (i.e. joints, fractures, faults, or bedding planes), water bearing potential and lateral continuity, based on existing information.
- Assess local hydrogeology, including identification of hydrostratigraphic units and the hydraulic and hydrochemical characteristics of each unit based on existing information.
- Identify primary, secondary, and tertiary sub-watersheds of the proposed development, and assess surface water features within 500 m of the Project site boundaries, including the types of surface water features and the location of the surface water features relative to the Project site. Providing the information is available, surface water features should also be assessed for water levels, flow rates, seasonal variation, surface water quality, drainage patterns, flood risk, and annual precipitation rates.
- Conduct a site visit to collect domestic well information on the adjacent properties; and, assess potential environmental concerns in the area that could negatively impact the Project site.

4.0 SITE VISIT AND ADJACENT PROPERTIES

A visit to the Project site and adjacent properties was completed in January 2012. Please note the following limitations that were encountered during the Project site visit:

- Given the Project site is large (6369 hectares) and mainly forested, the entire Project site was not walked. Instead, all access roads were driven. In addition, if relevant features were encountered while on-site that were not noted with existing photos and site plans, these features were examined further while in the field.
- Since many adjoining residences within the study area are some distance from the road or are located on well-treed lots, it was not possible to see many of the wells. In older homes, drilled wells would likely be buried as this was the standard practice prior to the early 1990s, with no requirement for casing extension at that time.

A total of 171 adjacent properties located in the study area within a 500 m radius of the Project site were examined. Property information including PID numbers, lot numbers, property owners, civic addresses, and lot areas were collected from the Service Nova Scotia and Municipal Relations Land Information Centre.

A figure depicting the configuration of the properties within the 500 m radius of the Project site has been included as Drawings 2A and 2B (Appendix A). The above-noted adjacent property data has been summarized in Table 2 (Appendix B). Please note that given the large volume of data associated with the adjacent properties, the data was not plotted on Drawings 2A and 2B. Instead, an identification number has been assigned to each adjacent property, which correlates with property data in Table 2 (Appendix B). For example, the data listed under entry number "26" in Table 2 will have a corresponding property labelled as "26" on Drawings 2A and 2B. Representative photos of adjacent properties are presented in Appendix C.

The following sections summarize land use on the adjoining properties located in the study area.

Adjacent Properties to the North

Properties in the study area to the northwest consist mainly of forested resource lands and commercial forest owned by Atlantic Star Forestry. These properties lie along New Russell Road.

Properties located directly north of the project study area consist primarily of residential properties and privately owned resource farm and forests, located along New Ross Road, Canoe Lake Cove Road, and Beaver Pond Lane. North Canoe Lake and Little Otter Lake are situated within 500 m of the Project site.

Adjacent properties to the northeast are mainly residential properties located along Wile Settlement Road and Innes Lane. Several properties are situated along Zwicker Lake located at the northeastern property boundary of the Project site.

One drilled well was identified in this area on the NSE Well Records Database. During the site visit, one drilled well and one dug well were identified.

Adjacent Properties to the East

Properties in the study area to the east of the Project site are a combination of residential, resource, and commercial forests located along Highway 14. Atlantic Star Forestry owns several parcels of commercial forest in the area. There is also a large parcel of undeveloped forest owned by NS Department of Natural Resource (NSDNR).

Based on NSE Well Records Database, one drilled well was identified in this area.

Adjacent Properties to the South

Properties in the study area to the south of the Project site are mainly forested resource lands and commercial forests located along Highway No. 14 and Sherwood Road. Commercial and resource forests in this area are primarily owned by NSDNR and Bowater Mersey Paper Company Ltd. The Municipality of the District of Chester owns resource land southeast of the Project site where the Kaizer Meadow Environmental Management Center is located.

Several water bodies lie directly adjacent to the Project site including Long Bay, Card Lake, Bog Lake, and Dam Bay.

Adjacent Properties to the West

Properties in the study area to the west of the Project site along Parklands Road and the eastern border of Lake Lewis are primarily single family residential dwellings. The remainder of the properties to the west are resource and commercial forests along Leville Road and New Russell Road. Land owners of these properties include Bowater Mersey Paper Company Ltd., NSDNR, Sidney C Hiltz Dozing & Trucking Limited, and Clifford Long & Sons Limited.

A summary of the data compiled as part of the adjacent property review, including property summary information and number of dug and drilled wells identified, is provided in Table A, below. Photos representing the adjacent properties are provided in Appendix C.

Table A: Summary of Properties Located Within a 500 Metre Radius of the Project Site

Item	Adjacent Properties				Totals
	North	East	South	West	
Total Number of Properties	77	58	14	22	171
Residential (developed or undeveloped)	40	22	-	11	73
Resource (undeveloped)	18	12	8	6	44
Commercial	8	11	1	2	22
Mixed (residential/resource/commercial etc.)	11	11	2	1	25
Other (unclassified, parks, protected, etc.)	-	2	3	2	7
Total Number of Identified Wells (NSE Database & Site Visit)	3	1	0	0	4
Dug Wells	1	0	0	0	1
Drilled Wells	2	1	0	0	3

As summarized in Table A, a total of 1 dug well and 3 drilled wells were confirmed to be located on the 171 adjacent properties located within a 500 m radius of the Project site either during the site visit or in the NSE Well Log Database. The well locations are provided on Drawings 2A and 2B, Appendix A. Additional dug and drilled wells were located on adjacent

properties during the site visit, either located outside the 500 m boundary or a civic address was not visible. A total of nine dug wells were noted on New Ross Road, Canoe Cove Road, Conrad Road, and Wile Settlement Road. Three additional drilled wells were identified on New Ross Road, Pioneer Drive, and Wilfred Hebb Road.

5.0 HYDROGEOLOGY

The hydrogeology of the Leminster area, including the Project site, will be discussed in two major sections: surficial and bedrock hydrogeology. Each section contains an overview of geology, water quantity, and water quality. Drawing 3 (Appendix A) shows a general land use overview from Hopper et al (2000) for the study area.

5.1 Surficial Hydrogeology

The following sections discuss the surficial hydrogeology of the Leminster area.

5.1.1 Surficial Geology

Information on surficial geology was obtained from Stea et al (1992), shown in Drawing 4 (Appendix A). As indicated in Drawing 4, the study area is overlain by five different types of surficial material: Organic Deposits, Silty Till Plain (Ground Moraine), Silty Drumlin, Stony Till Plain, and Bedrock.

The majority of the Project site is overlain by a silty, compact till material which is derived from both local and distant sources. The Silty Till Plain (Ground Moraine) creates a flat to rolling topography with a thicker till masking bedrock undulations. Silty Drumlins appear sporadically throughout the Project site, consisting of a siltier till with a higher percentage of distant source material including red clay (Stea et al. 1992). An area of organic deposits composed of sphagnum moss, peat, and clay occur on the western half of the Project site. A band of exposed bedrock and stony till plain overlie the central portion of the Project site extending from Card Lake at the southern boundary to South Canoe Lake at the northern property boundary. Surficial material in this area consists of a stony, sandy matrix material derived from local bedrock sources with many surface boulders. Local topography varies from flat to strongly rolling with ridges of exposed bedrock in thin till areas. Till in this area generally ranges between 3-30 m in thickness.

The predominant soils are well-drained, coarse sandy loams that have developed on granite till (Neily 2003). The majority of soils can be characterized as shallow, stony, and dry except those developed on drumlins, which tend to be deeper and less stony. Large areas of imperfectly drained soils occupy the areas between drumlins. Elevated concentrations of radon soil gas has been confirmed in the nearby Millet Brook area associated with highly evolved Middle-Lake Devonian leucomonzogranite on the eastern margin of the South Mountain Batholith (Goodwin et al. 2008).

Based on the depth to bedrock in the 24 drilled wells located within the study area, till thickness ranges from 0.3 to 35.4 m (refer to Table 3, Appendix B).

5.1.2 Water Quantity from Surficial Deposits

There were no logs for dug wells located in the study area or within 10 km of the Project site in the NSE Well Logs Database. Dug well data for wells within the same surficial unit in Lunenburg County were collected from the NSEL well log database, are summarized in Table 4 (Appendix B). Wells were completed to an average depth of 16.2 ft (4.93 m) with four of the six wells encountering bedrock 4 to 11 ft below surface (1.2 – 3.4 m). Estimated drillers yields for the dug wells ranged from 5 – 220 gpm (22.7 – 1,000 Lpm). These yields represent very short term yields estimated by the driller at the completion of well construction. It is important to note that long term well production rates are typically 25% of the drillers estimates indicating actual longer term yields may be 1.25 to 55.0 gpm (5.7 to 250 Lpm), or less range. Appendix D contains well construction details from the NSEL database for the six local dug wells. There were no original logs available for review.

One dug well located approximately 23 km south of the Project site was identified in the NSEL pump test database. The well was completed to a total depth of 20 ft (6.1 m) through clayey fill and rock. Bedrock was encountered at 14 ft (4.3 m) with water bearing fractures at 5 (1.5 m) and 20 ft. Hydraulic characteristics of the lithology encountered indicate a long term safe yield (Q20) of 72.9 Lpm (16.0 gpm), and apparent transmissivity (T) of 30.2 m²/d (2431 gpd/ft).

Dug wells completed in silty to clayey till are usually adequate for domestic use, although water shortages may occur seasonally, especially during extended dry periods. There are methods which can help to optimize well performance, such as deeper well completions (approximately 6 to 9 m or 20 to 30 feet) and large gravel reservoirs where possible. Local contractors should be aware of these and other methods applicable to the area.

5.1.3 Water Quality from Surficial Deposits

Table 5 (Appendix B) provides surficial groundwater chemistry from one dug well within 10 km of the Project site in addition to several dug wells within Lunenburg County, retrieved from DNR Groundwater Mapping database. Some median or average values and ranges from various literature sources are also provided. Water quality from dug wells is normally acceptable when compared to the Guidelines for Canadian Drinking Water Quality (GCDWQ) (Health Canada 2010). Hardness, iron, manganese, colour, turbidity, and low pH are the most common chemical parameters which may pose aesthetic issues to the user and may require point-of-entry treatment. Conventional treatment is available if necessary. Colour may be difficult to treat if it is due to humic substances.

5.2 Bedrock Hydrogeology

The following sections discuss the bedrock hydrogeology of the Leminster area.

5.2.1 Bedrock Geology

Information on bedrock geology was obtained from available geological mapping.

South Mountain Batholith - Granite Bedrock

Based on the most recent geological mapping of the area (Keppie 2000) the entire Project site has been mapped as underlain by Middle to Late Devonian aged granite bedrock. Varying compositions of granite within the Project site include muscovite-biotite monzogranite, leucomonzogranite, muscovite leucomonzogranite, and fine grained leucomonzogranite [see Drawing 5 (Appendix A)].

5.2.2 Bedrock Structure

The following sections outline the general and regional structural characteristics of the South Mountain Batholith (granite) bedrock, part of which underlies the Project site.

South Mountain Batholith

The majority of the Project site is underlain by leucomonzogranite and muscovite biotite monzogranite. The batholith is typically composed of a quartz-feldspar-biotite granite which intruded the lower metamorphic rocks. Granites have low matrix permeability and fracture systems contribute the only significant permeability in these rocks. Trescott (1968) reports that permeability in granite is found almost entirely in joints except near the surface where the release of confining pressure by erosion of the overlying rock has allowed fractures to open and where weathering has increased the aperture of many fractures (Trescott 1969).

5.2.3 Bedrock Mineralization

The Mineral Resource Land Use (MRLU) maps provided by Hopper et al from 2000 (11 D/13) were reviewed as part of this assessment. The MRLU maps provide locations where bedrock mineralization is known or suspected, such as former or active mines, quarries, gold districts, diamond drill holes mineral occurrences as well as zones containing sulphide bearing slates. A MRLU map of the study area has been compiled from map 11 D/13 and is provided as Drawing 3 (Appendix A).

Mines/Quarries

As indicated on Drawing 3, there are no abandoned mines/quarries noted within the Project site. However, abandoned mine shafts are situated in the New Ross/New Russell area, including:

- Walker Pit Tin Shaft - situated in the New Russell area, approximately 3 km west of the Project site.
- Wallaback Lake Tin Shaft - located near Wallaback Lake, approximately 3.7 km northwest of the Project site.

Diamond Drill Holes

As indicated on Drawing 3, several diamond drill holes occur approximately 3.6 km northwest of the Project site. Located to the east of Wallaback Lake, exploration took place between 1980 and 1981 for Norcen Energy Resources and Can-Lake Explorations. Detailed reports were not available for review.

Mineral Occurrences

As indicated on Drawing 3, no mineral occurrences were noted within the Project site however several metallic and non metallic mineral occurrences were noted in the surrounding region. A review of the NSDNR Mineral Occurrences Database was completed to review relevant information. The occurrence name and directional location from the Project site are listed below:

Leminster Road Fluorite Occurrence – approximately 3.3 km north
Leminster U, Cu, F Occurrence – approximately 3.4 km north
Leminster Molybdenum Occurrence – approximately 2.2 km north
Leminster Fluorite Occurrence - approximately 1 km north
Lower Canoe Lake Fluorite Occurrence – approximately 0.2 km north
Wallaback Lake Au Occurrence - approximately 4.4 km northwest
Turner Tin Prospect – approximately 5.6 km west
Harris Lake Diatomite Occurrence – approximately 6.1 km west
New Russell Mo Prospect – approximately 2.9 km west
Walker Moly Prospect – approximately 2.9 km west
Leville Cu, W Occurrence – approximately 3.5 km west
Mill Brook Pegmatite Occurrence – approximately 6.1 km west
Morleys Pegmatite Occurrence – approximately 6.1 km west
Lake Darling Mo Occurrence – approximately 9.4 km west
Lake Darling Cu Occurrence – approximately 9.6 km west

Sulfides occur in trace amounts throughout all granitic rock units, but concentrate locally near the contact with the sulphide-rich Meguma Group (Poulson et al. 1991, Samson 2005). Geological mapping indicates the Goldenville Formation of the Meguma Group lies approximately 1.4 km north of the Project site. Metallic and non-metallic mineral occurrences have been noted within this transition zone including fluorite, pyrite, chalcopyrite, and molybdenite. A large hydrothermal deposit (U-Ag) occurs approximately 10 km NE of the Project site at Millet Brook (Chatterjee and Strong 1984).

A copy of the above noted mineral occurrence reports are located in Appendix E.

5.2.4 Water Quantity from the Bedrock Aquifer

The Project site overlies granite bedrock of the South Mountain Batholith. If the development area expands to the northwest towards Mud Lake, then it will also overlie the Goldenville Formation. The bedrock aquifer is primarily used as the water supply source for homes in the region, including the proposed development area.

Well Yields in Granite Bedrock

Fracflow (2004) notes that aquifer properties in granitic rocks “have a low matrix permeability and fracture systems contribute the only significant permeability in these rocks”. That report also notes that the mean yield in granites in HRM is calculated to be 45.0 Lpm (9.9 gpm) using the NSE database. Trescott (1968) also notes an average well yield of 40.9 Lpm (9.0 gpm) in South Mountain Batholith granites. Fracflow (2004) indicated that staff at the

NSDNR believe the average yield for domestic wells in granites is closer to 15.9 Lpm (3.5 gpm). Where fracturing is well developed and interconnected, or fracture traces intersect, larger yields may be possible.

Drilled Well Data (NSEL Well Log Database)

Table 3 (Appendix B) summarizes drilled well data from the NSE Well Log Database for the domestic wells reported to be located on residential properties within the study area. A total of 23 wells were located on the DNR Digital Groundwater Map Database to be within approximately 500 m of the Project site boundary. Civic addresses were not provided on all the retrieved well logs therefore out of the 23 wells, only 2 could be confirmed to be located on the adjacent properties. For purpose of presenting local bedrock characteristics in the area all well logs are being examined as the community name has been provided.

The well logs indicate that according to the driller's interpretation of bedrock type encountered during drilling, there is reportedly granite, slate, shale and quartzite in the study area. Drawings 2A and 2B (Appendix A) notes the location of the two wells in the study area which contained civic addresses.

Based on short term driller's estimates for the 23 drilled wells identified in the NSE Well Log Database, the average yield in the study area is approximately 32.1 Lpm (7.1 gpm) and average well depth is approximately 61 m (200.4 ft). These yields represent very short term yields estimated by the driller at the completion of well construction. It is important to note that long term well production rates are typically 25% of the drillers estimates indicating actual longer term yields may be in the 8.0 Lpm (1.8 gpm), or less range.

The yield range and well depth range for the 23 wells in the study area is 0.9 Lpm (0.2 gpm) to 90.8 Lpm (20 gpm) and 23.8 m (77.9 ft) to 127.9 m (419.5 ft), respectively.

All 23 wells were drilled through varying surficial materials including clay, sand, gravel or boulders ranging from 0.3 m (1.0 ft) to 35.4 m (116.0 ft) in thickness, followed by granite, slate, shale, or quartzite bedrock. The predominant bedrock types logged in the wells are granite (19), slate/shale (1 well), quartzite (2 wells) and quartzite/granite (1 well). Within the Project site only formations of granite have been mapped, however approximately 1.4 km northwest of the Project site lies the Goldenville Formation which would account for the presence of shale/slate and quartzite.

Drilled Well Data (NSEL Pump Test Database)

Longer term or more continuous safe yields must be evaluated by pump testing. Table 6 (Appendix B) summarizes drilled well data from the NSE Pump Test Database for wells located in Granite bedrock from the two regional wells determined to be within a 10 km radius of the Project site (New Ross and Sherwood). This database provides information on aquifer properties and long term yields for wells that have been pump tested between 1971 and 1998, and for uses other than domestic.

Generally the wells tested are more successful (even if other wells on a property were of low yield) for the desired use, thus yields may be biased somewhat high. The pump test statistics in Table 6 indicate long term safe yields (Q20) of 5.9 Lpm (1.3 gpm) and 50 Lpm (11 gpm), and apparent transmissivity (T) values of 0.8 and 3.7 m²/d. Storativity values were not available from the two pump tests.

NSE Nova Scotia Groundwater Observation Well Network – Lewis Lake Well

An observation well is situated in Lewis Lake, Jerry Lawrence Provincial Park (No. 079) that forms part of the NSE Nova Scotia Groundwater Observation Well Network (see Appendix F). This observation well was selected as it was the nearest well to be constructed in granite bedrock of the South Mountain Batholith. According to the 2011 report, the Lewis Lake observation well is 77.0 m deep (6.1 m till; 70.9 m granite bedrock). Based on 3 hour pump test completed in on this well in 2008 by NSDNR (Kennedy et al., 2009), results indicated a T of 1.53 m²/d and a safe yield rate of 57.3 m³/day.

According to available data, monitoring of the Lewis Lake well started in 2008.

5.2.5 Water Quality from the Bedrock Aquifer

Trescott (1968) indicates that groundwater quality in contact with granite bedrock will tend to have higher alkalinity, hardness, and Total Dissolved Solids (TDS) than Meguma Group bedrock. Most parameters meet the GCDWQ. Those naturally present in the groundwater most likely to exceed aesthetic-based guidelines are iron and manganese, and occasionally hardness, colour, and turbidity. The pH may be higher or lower than its aesthetic range of 6.5 to 8.5 in some cases.

Heather Cross (pers comm.) and Fracflow (2004) have also indicated that potential health-related concerns associated with the development of groundwater supplies in the granite bedrock aquifer include elevated concentrations of arsenic (related to sulphide and base metal mineralization), as well as radionuclides such as radium, uranium, fluoride, radon, and lead-210. Radon occurs naturally in groundwater from the radioactive decay of uranium-238. Staff at NSDNR (Fred Boner, Bob Ryan & George O'Reilly) has concluded that, "groundwater from any drilled well in granitic rocks is at risk of being contaminated with radioelements (e.g. radium, uranium, radon, and lead-210)."

Water quality data from four wells drilled in granite bedrock located within 10 km of the Project site are shown in Table 7 (Appendix B). Iron concentrations exceeded aesthetic-based guidelines while fluoride, arsenic, and uranium concentrations exceeded health related guidelines.

6.0 SURFACE WATER DATA AND DRAINAGE

The following sections discuss surface water and drainage in the Leminster area.

6.1 Climate and Surface Water Quality Data

Climate data was obtained from the Environment Canada Climate Centre website (http://climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html) for the Windsor Martock meteorological station (44°56'00.00N, 64°10'00.00W) located approximately 20.64 km to the northeast of the Project site. For the period from 1971-2000, the mean annual temperature was 7.4°C, with a mean daily high of 12.3°C and a mean daily low of 2.4°C (EC 2011a). January and February were the coldest months (-5.2 and -4.4°C, respectively), while the warmest months were July and August (19.8 and 19.3°C, respectively) (EC 2011a).

Local precipitation data were obtained from the Avon meteorological station (44°53'00.00N, 64°13'00.00W) located approximately 13.8 km to the northeast of the Project site. This station was used for the precipitation analysis because it is situated closer to the Project site, although it did not record temperature data. For the period from 1971-2000, mean annual snowfall was 216.1 cm and rainfall was 1211.6 mm (EC 2011b). Most snowfall is received in December and January (46.5 and 52.6 cm, respectively), while the rainiest months are September, October, and November (114.7, 123.6, and 138.3 mm, respectively) (EC 2011b).

Water quality data was obtained for lakes located within and surrounding the Project site from the Lake Inventory Program. The Lake Inventory Program (formerly known as the Lake Survey Program) is a partnership initiative between Nova Scotia Fisheries and Aquaculture (NSFA) and Nova Scotia Environment (NSE) to inventory lakes throughout the province to determine baseline water quality, in support of both sport fisheries and water resource management areas.

Data from a total of 12 lakes were reviewed, from sampling events completed between 1950 and 1990. Summary data of each lake is provided below in Table B. Depth contour maps of select lakes can be viewed in Appendix G.

Table B: Summary of Lake Characteristics

Lake	Mean Depth (m)	Lake Volume (m ³)	Surface Area (ha)	Headwater Lake (y/n)	Distance from Project Site (km)
Armstrong	6.8	3512000	52	N	4 km northeast of the Project site
Lewis	2.9	2198890	74.9	Y	Borders the eastern boundary of the Project site
Little Island	2.5	467470	19	N	0.6 km north of the Project site
Mockingee	5.7	6182400	109.3	N	1.7 km northeast of the Project site

Lake	Mean Depth (m)	Lake Volume (m ³)	Surface Area (ha)	Headwater Lake (y/n)	Distance from Project Site (km)
North Canoe	2.4	2216869	87.5	N	Borders northern boundary of the Project site
Zwicker	4.9	2805100	56.9	N	Borders northeast boundary of the Project site
Card	2.9	770000	270	N	Borders southern boundary of the Project site
Little Joe Long	2.2	150220	6.7	Y	Located within Project site boundaries
Long	2	3841802	197	N	2 km north of the Project site
Nine Mile	1.2	579524	49.2	N	3.6 km south of the Project site
South Canoe	4	9444280	237.1	N	Located within Project site boundaries
Wallback	3.1	9009600	287.7	N	4.8 northeast of the Project site

Source: NS Lake Inventory Program (NSE 2012)

Table C: Water Quality Measurements for Selected Lakes

Lake	Sample Date	Temp °C		Dissolved Oxygen (mg/L)		Sechhi Disk (m)	Conductivity (umho/cm)
		Surface	Bottom	Surface	Bottom		
Armstrong	21-Jul-77	26	24	8	4	1.9	40
Lewis	9-Jul-80	19	10.5	8.4	5	1.7	22.5
Little Island	23-Aug-77	21.1	12.2	8	2	4.15	25
Mockingee	6-Aug-06	21.9	11.9	7.3	0.3	1.7	31
North Canoe	23-Aug-77	21	14.4	9	2	1.96	25
	11-Jul-89	19	10	6.4	2.3	2.75	198
Zwicker	19-Aug-77	21	5.2	7	1	3.1	26
Card	16-Aug-06	22	7.5	7.9	3.2	1.75	29.5
Little Joe Long	3-Nov-80	4.2	4.2	11	11	3	
Long	22-Aug-83	21	20.5	8	7	4.3	24.9
Nine Mile	19-Jul-89	23	22	6.8	5.6	1.5	39
South Canoe	24-Jun-80	21.9	15.5	8	5.6	1.2	17.9
Wallback	18-Jun-80	19.9	14.8	8.8	7.4	2.1	18.7

Source: NS Lake Inventory Program (NSE 2012)

Water chemistry data collected between 1977 and 2006 was obtained for 12 lakes within and near the Project site (Table C). The majority of data was collected prior to 1990 with the exception of Card Lake and Mockingee Lake which were tested in 2006. Results examined were relatively consistent among the lakes with few apparent observations. Dissolved oxygen, which is related to temperature, is a strong indicator of healthy water because it measures its ability to support fish life. Dissolved oxygen levels higher than 2 mg/L are

considered optimal and were observed in the results for all lakes with the exception of bottom readings from Mockingee and Zwicker Lake. Conductivity levels reflected dilute waters ranging from 17.9 to 40 umho/cm. Populated areas may contribute to slightly higher conductivity readings as illustrated with South Canoe (17.9 umho/cm) and Armstrong Lake (40 umho/cm). Armstrong Lake is surrounded by a residential community where the potential for pollution is greater in comparison to South Canoe Lake which is fairly isolated. All lakes surveyed reported acceptable pH levels (guideline 5.0 – 9.0), secchi disk (<1.2 m), and surface dissolved oxygen levels (>5.0) mg/L) based on water quality guidelines for the protection of aquatic life (CCME 2009) and recreational use guidelines (Health Canada 2009).

6.2 Topography, Drainage and Watersheds

Elevation data, regional drainage patterns and the locations of proximate ecological receptors were reviewed from the National Topographic Survey (NTS) map for the area (1:50,000 scale). Watershed boundaries are provided in Drawing 6 (Appendix A).

6.2.1 Regional Topography, Primary and Secondary Watersheds

The Project site lies at the eastern extent of the South Mountain Ecodistrict on a rolling till plain that overlies an extensive granitic batholith (Webb and Marshall, 1999). The Ecodistrict is a drumlinized till plain, with a rolling surface that steadily decreases in elevation to its southern, eastern, and western boundaries. Drainage is poor, and sluggish rivers and streams weave aimlessly from one shallow lake to another or lose themselves in wetlands (Webb and Marshall, 1999).

Primary Watersheds

The Project site lies within two primary watersheds, referred to as the Avon River (1DE) and Gold River (1EG) Watersheds. The central and eastern portion of the Project site lies within the Avon River Watershed. The Avon River flows northerly rising on the South Mountain, southwest of the town of Windsor. Near the rural community of Martock, the river enters a broad glacial river valley where it becomes tidal, creating an estuary for its remaining route to the Minas Basin several kilometres downriver from the town of Hantsport. Rivers flowing into the Avon include the Herbert, Cogmagun, Kennetcook, and St. Croix. Large water bodies in Avon River Primary Watershed include Card Lake, Panuke Lake, Falls Lake, Big St. Margaret's Bay Lake, and Mockingee Lake.

The Gold River Watershed occupies the eastern portion of Lunenburg County including the western Project site boundary. The Gold River Watershed is located in the Municipality of the District of Chester, Lunenburg County. Gold Brook, exiting Lake Lewis, is the first piece of the east branch of the Gold River. The river flows into Nova Scotia Lake, then Long Lake, Grassy Lake, Wallaback Lake, and Camp Lake. Below Camp Lake, and before it reaches Harris Lake, it joins the north branch of the Gold River. Past Harris Lake, the Gold River enters De Adder Lake, followed by Lake Lawson near New Ross, and then on to the ocean at the community of Gold River on Mahone Bay. The largest water body within the primary watershed is Big Mushamush Lake.

Secondary Watersheds

There are four secondary watersheds comprising the Avon River Primary Watershed. The central and eastern portion of the Project site is located entirely within one secondary watershed which spans the western half of Hants County from Upper Vaughan to Windsor.

The Gold River Primary Watershed is comprised of three secondary watersheds. All secondary watersheds generally flow in a southeasterly direction, eventually discharging into the Atlantic Ocean. The Project site is located within two inland secondary watersheds that spans from Wallaback Lake in the north to Highway 103 in the south.

6.2.2 Study Area Topography, Drainage and Tertiary Watersheds

Based on 1:10,000 topographic mapping of the area, elevation of the Project site ranges from 110 m on the eastern portion of the Project site to upwards of 250 m above sea level on the western portion of the Project site. Overall, the property undulates but generally slopes downward from west to east. Rain water and run-off on the site will primarily flow in accordance with local topographic trends. Stormwater management infrastructure, such as drainage ditches, is present along Project site access roads, which also generally mirrors the local topography. Specific flow patterns in the tertiary watersheds on the Project site are discussed in the following sections below.

Tertiary Watersheds in the Study Area

The majority of the Project site lies within the boundaries of four tertiary watersheds (see Drawing 6, Appendix A). For the purposes of this report, the four tertiary watersheds are referred to as Lake Lewis, Canoe Lake, Card Lake, and Whitney Lake. Two additional tertiary watersheds abut the Project site, however only include a very small portion of the overall area. Details of each of the four tertiary watersheds are provided in the following sections below.

Lake Lewis Tertiary Watershed

The Lake Lewis Tertiary watershed includes the northwestern corner of the Project site extending further north beyond Lake Lewis. Run-off on this portion of the Project site either discharges directly into Lake Lewis, or discharges into small faster flowing tributaries that discharge into Lake Lewis. Additional large water bodies or lakes in this watershed include Christy Lake, Nova Scotia Lake, Long Lake, Clearwater Lake, and Grassy Lake. All lakes flow south into Gold River which discharges into the Atlantic Ocean. Land and water areas for the Lake Lewis tertiary watershed are as follows (all figures approximate):

- 2681.0 hectares (ha) total area
- 2486.3 ha of land (92.7% of the total area)
- 194.7 ha of water (7.3% of the total area) – including major water bodies Lake Lewis (105.5 ha), Nova Scotia Lake (6.39 ha), Christy Lake (14.92 ha), Long Lake (24.6 ha), Clearwater Lake (29.5 ha), and Grassy Lake (13.8 ha).

Canoe Lake Tertiary Watershed

The Canoe Lake Tertiary watershed occupies a large area surrounding South Canoe Lake extending further north beyond North Canoe Lake. Surface water in the watershed flows through several watercourses discharging directly into South Canoe Lake or into smaller bodies of water such as Mud Lake which eventually discharges to South Canoe Lake. The primary receiving bodies in this watershed are South Canoe and North Canoe Lakes, located at the south-central end of the watershed.

Land and water areas for the Canoe Lake tertiary watershed are as follows (all figures approximate):

- 6335.1 ha total area
- 5678.9 ha of land (89.7% of the total area)
- 656.1 ha of water (10.3% of the total area), including major water bodies Cooney Lake (1.92 ha), Mud Lake (19.9 ha), South Canoe Lake (217.2 ha), North Canoe Lake (98.9 ha), Little Island Lake (23.5 ha), Little Otter Lake (13.3 ha), Chain Lake (17.8 ha), Upper Chain Lake (10.0 ha), Bills Lake (19 ha), Hebbs Mill Pond (3.8 ha), Upper Salter Lake (7.5 ha), Burnt Lake (3.9 ha) plus several other unnamed lakes.

Card Lake Tertiary Watershed

Over half of the Project site lies within the Card Lake Tertiary Watershed which extends from Card Lake in the south beyond Zwicker Lake in the north. Major water bodies within the watershed include Card Lake, Bog Lake, Joe Long Lake, Big Otter Lake, Zwicker Lake, and it borders Mockingee Lake.

Land and water areas for the Card Lake tertiary watershed are as follows (all figures approximate):

- 9013.5 ha total area
- 7632.6 ha of land (84.7% of the total area)
- 1381 ha of water (15.3% of the total area), including major water bodies Card Lake (390 ha), Bog Lake (12.8 ha), Joe Long Lake (8.4 ha), Big Otter Lake (23.5 ha), Zwicker Lake (79.1 ha), plus several other unnamed lakes.

Whitney Lake Tertiary Watershed

The Whitney Lake Tertiary watershed occupies a small area of the southwestern part of the Project site extending south to Hennigar Lake. Surface water in the watershed flows south via a series of several watercourses and small water bodies eventually reaching Hennigar Lake which discharges to the Chester Basin.

Land and water areas for the Whitney Lake tertiary watershed are as follows (all figures approximate):

- 3522.7 ha total area
- 3435.0 ha of land (97.5% of the total area)

- 87.7 ha of water (2.5% of the total area), including major water bodies Whitney Lake (61.4 ha), Spectacle Lake (26.3 ha), plus several other unnamed lakes or ponds.

7.0 CONCLUSIONS

The Project site is near Leminster, approximately 25 km southwest of Windsor, Nova Scotia, on approximately 6,369 ha of land. The lands are currently owned and used by MBPP for logging operations. Overall, the Project site is mainly undeveloped and consists primarily of forested or recently cleared land. The Project site is accessible from New Ross Road to the North and Highway 14 to the east via several logging roads. The Project site borders several lakes including: South Canoe Lake, Mud Lake, Big Otter Lake, Little Otter Lake, Joe Long Lake, Long Bay, Card Lake, Dam Bay, Bog Lake, as well as the Avon River.

A total of 171 adjacent properties were located within the study area (500 m radius of the Project site). Land use on the adjoining properties in the study area is designated primarily as residential (43%) and undeveloped resource lands (26%), with commercial (13%) and land designated as mixed use (15%) also present. The remaining 3% of adjacent properties are unclassified according to Property Online database. Commercial properties in the area are largely forested areas owned by Bowater Mersey Paper Ltd. and Atlantic Star Forestry in addition to a few parcels owned by Nova Scotia Power (NSPI).

Overall, developed properties within the study area are provided with potable water from drilled and dug wells, and sanitary services via on-site septic systems. A total of 1 dug well and 24 drilled wells were identified in the study area, either visually during the site visit, or in the Nova Scotia Environment (NSE) Well Log Database.

The surficial material in the study area consists of 0.3 to 35.4 m of varying material including Organic Deposits, Silty Till Plain (Ground Moraine), Silty Drumlin, Stony Till Plain, and Bedrock. The majority of the Project site is overlain by a silty, compact till material which is derived from both local and distant sources. The Silty Till Plain (Ground Moraine) creates a flat to rolling topography with a thicker till masking bedrock undulations. Silty Drumlins appear sporadically throughout the Project site, consisting of a siltier till with a higher percentage of distant source material including red clay (Stea et al. 1992). An area of organic deposits composed of sphagnum moss, peat, and clay occur on the western half of the Project site. A band of exposed bedrock and stony till plain overlie the central portion of the Project site extending from Card Lake at the southern boundary to South Canoe Lake at the northern property boundary. Dug wells in the area may experience low yields or seasonal shortages, require greater clearance distances from septic systems, and are more prone to surface/near surface contaminants than drilled wells.

Bedrock in the vicinity of the proposed development is expected to consist of Middle to Late Devonian aged granite bedrock. Varying compositions of granite within the Project site include muscovite-biotite monzogranite, leucomonzogranite, muscovite leucomonzogranite, and fine grained leucomonzogranite.

Based on short term driller's estimates for the 23 drilled wells identified in the NSE Well Log Database, the average yield in the study area is approximately 32.1 Lpm (7.1 gpm) and average well depth is approximately 61 m (200.4 ft). These yields represent very short term yields estimated by the driller at the completion of well construction. It is important to note that long term well production rates are typically 25% of the drillers estimates indicating actual longer term yields may be in the 8.0 Lpm (1.8 gpm), or less range.

Longer term yields based on the NSE Pump Test Database for the two regional wells drilled through Granite bedrock and located within a 10 km radius of the Project site indicate long term safe yields (Q20) of 5.9 Lpm (1.3 gpm) and 50 Lpm (11 gpm), and apparent transmissivity (T) values of 0.8 and 3.7 m²/d. Storativity values were not available from the two pump tests.

An observation well is situated in Lewis Lake, Jerry Lawrence Provincial Park (No. 079) that forms part of the NSE Nova Scotia Groundwater Observation Well. This observation well was drilled through granite bedrock and a 3 hour pump test was completed on the well in 2008. Results of the pump testing indicated the well had a T value of 1.53 m²/d and a safe yield rate of 57.3 m³/day.

Groundwater quality in contact with granite bedrock will tend to have higher alkalinity, hardness, and Total Dissolved Solids (TDS). Potential health-related concerns associated with the development of groundwater supplies in the granite bedrock aquifer include elevated concentrations of arsenic (related to sulphide and base metal mineralization), as well as radionuclides such as radium, uranium, fluoride, radon, and lead-210. Water quality data from four wells drilled in granite bedrock located within 10 km of the Project site indicated exceedences of iron, fluoride, arsenic, and uranium concentrations.

The placement of turbines at the Project site is expected to have a negligible impact on surface water, dug wells, and drilled wells near the study area.

8.0 ENVIRONMENTAL CONSIDERATIONS

The following environmental considerations are forwarded:

1. During the construction phase of development localized disturbances of surface soil and shallow bedrock may increase the risk of erosion and soil mobility. Erosion and sedimentation control measures will be required to protect surface water quality.
2. While large scale blasting is not anticipated to occur, the potential may arise as roads are being upgraded or constructed throughout the Project site. Turbine locations are to be located no closer than 1.2 km from the nearest residential property, however, if road construction requires blasting within 1.2 km of a residential dwelling, then completion of a well survey may be recommended.
3. Although not anticipated, in the event bedrock formation of the Meguma Group bedrock (shale or slate) is closer than mapped, the potential for environmental

constraint relating to acid rock drainage (ARD) should be recognized and assessed further if future disturbance or exposure of this type of bedrock is anticipated (i.e. as part of construction work). Any issues relating to ARD are governed by the NSE Sulphide Bearing Material Disposal Regulations (N.S. Reg 57/95).

9.0 CLOSURE

This report has been completed for the sole benefit of Minas Basin Pulp and Power Company Limited (MBPP). Any other person or entity may not rely on this report without the express written consent of Strum Environmental and MBPP.

The conclusions presented in this report represent the best judgement of the assessor based on the current regulations and standards. The assessor is unable to certify against undiscovered liabilities due to the nature of the investigation and the limited data available.

This report was prepared from information collected January 2012. The results in this report rely only on the conditions identified at this time.

Should additional information become available, Strum requests that this information be brought to our attention immediately so that we can re-assess the conclusions presented in this report. This report was prepared by Megan Henley, Environmental Specialist, and reviewed by A. Bruce Strum, P.Geo, President.

10.0 REFERENCES

Baechler, F.E. and Baechler, L. 2005 (draft). Hydrostratigraphic units, the building blocks of the waterscape. Chapter 4 in Cape Breton's Waterscape: The Blue Jewel of the East (book in preparation).

CCME (Canadian Environmental Quality Guidelines) 2009. Water Quality Guidelines for the Protection of Aquatic Life. Accessed January 2012 from:
<http://st-ts.ccme.ca/>

Chatterjee, A.K., & Strong, D.F. 1984. Discriminant and factor analysis of geochemical data from granitoid rocks hosting the Millet Brook uranium mineralization, South Mountain batholith, Nova Scotia. *Uranium*, 1, pp.289—305.

Environment Canada (a). 2011. National Climate Data and Information Archive. Accessed at http://www.climate.weatheroffice.gc.ca/climate_normals/results_e.html?stnID=6512&autofwd=1, January 13th, 2012.

Environment Canada (b). 2011. National Climate Data and Information Archive. Accessed at http://www.climate.weatheroffice.gc.ca/climate_normals/results_e.html?stnID=6294&autofwd=1, January 13th, 2012.

Fracflow Consultants Inc. 2004. Screening-level assessment of the groundwater resource potential of bedrock in HRM: a component of HRM's wastewater management options study. Report to Land Design Engineering Services. Part of Final Report #03-134 to Halifax Regional Municipality on Options for On-site and Small Scale Wastewater Management, March 2005.

Goodwin, T.A., Ford, K.L., Friske, P.W.B., and E.M. Mcisaac. 2008. Radon Soil Gas in Nova Scotia. Accessed online at <http://www.envnetwork.smu.ca/documents/RadonSoilGasinNovaScotia.pdf>

Health Canada. 2009. Guidelines for Canadian Recreational Water Quality. Prepared by the Federal-Provincial Working Group on Recreational Water Quality of the Federal-Provincial Advisory Committee on Environmental and Occupational Health.

Health Canada. 2010. Guidelines for Canadian Drinking Water Quality. Prepared by the Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment.

Hopper, D.B., Bonner, F.J., Fisher, B.E., Murphy, A.N. 2000. Map ME 2000-4, Version 2, Mineral Resource Land-Use (MRLU) Map of the Mount Uniacke area (11 D/13), Nova Scotia [1:75 000].

Keppie, J.D. (compiler) 2000: Geological map of the Province of Nova Scotia; Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Map ME 2000-1, scale 1:500 000. Available online as DP ME 43, version 2, 2006 at <http://www.gov.ns.ca/natr/meb/download/dp043.htm>.

Neily, P. D., E. Quigley, L. Benjamin, B. Stewart and T. Duke. 2003. Ecological Land Classification for Nova Scotia. Volume 1 - Mapping Nova Scotia's Terrestrial Ecosystems. Co-produced with NSDNR Renewable Resources Branch.

NSDNR 2009. Groundwater Mapping Database, Mineral Resources Branch. Accessed January 2012 from: <http://gis4.natr.gov.ns.ca/website/nsgroundwater/viewer.htm>

N.S. Reg 57/95. Sulphide Bearing Material Disposal Regulations, made under Section 66 of the Nova Scotia Environment Act, S.N.S. 1994-95, c.1.

NSE 2009. Pump Test Database. NSE Water and Wastewater Branch and NSDNR, Mineral Resources Branch. Website accessed January 2012 from: <http://gis4.natr.gov.ns.ca/website/nsgroundwater/viewer.htm>

NSE (Nova Scotia Environment). 2010. Well Logs Database – Groundwater (log data from 1966-2010). Website accessed January, 2012 from <http://www.gov.ns.ca/nse/welldatabase/wellsearch.asp>

NSE 2011. Nova Scotia Groundwater Observation Well Network 2011 Report. P.77 Accessed January 2012 from: <http://gov.ns.ca/nse/groundwater/docs/GroundwaterObservationWellNetwork2011Report.pdf>

NSE. 2012. Nova Scotia Lake Survey Program. Data available online at <http://www.gov.ns.ca/nse/surface.water/lakesurveyprogram.asp>

Poulson, S.R., Kubilius, W.P. & Ohmoto, H. (1991): Geo-chemical behaviour of sulphur in granitoids during intrusion of the South Mountain Batholith, Nova Scotia, Canada. *Geochim. Cosmochim. Acta* 55, 3809-3830.

Samson, H.R. (2005): Origin of Sulfides in the Contact Granodiorites of the South Mountain Batholith, Nova Scotia. B.Sc. Honours thesis, Dalhousie Univ., Halifax, Nova Scotia.

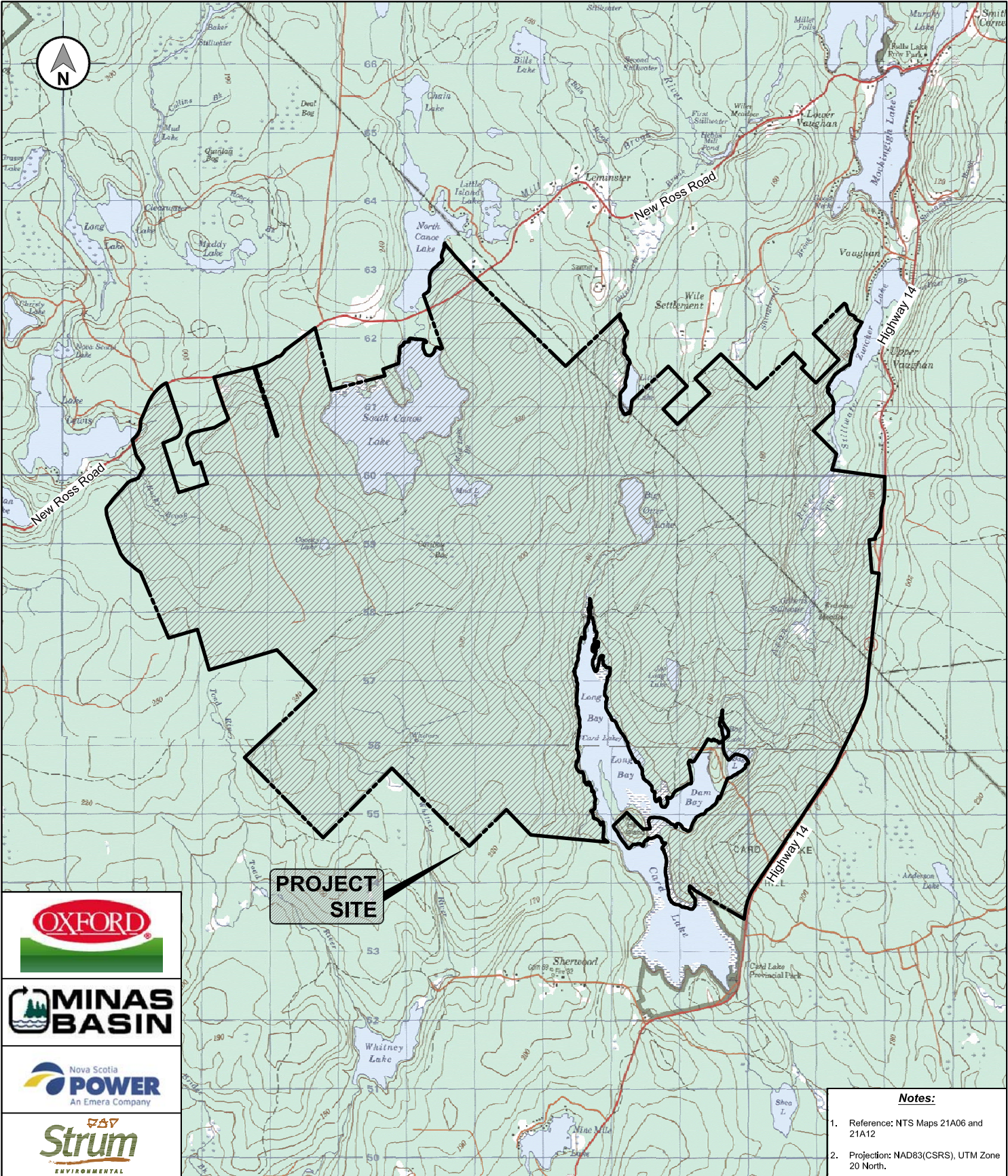
Stea, R.R., Conley, H., Brown, Y., Fisher, B.E. 1992. DP ME 36, Version 2, 2006. Digital Version of Nova Scotia Department of Natural Resources Map ME 1992-3, Surficial Geology Map of the Province of Nova Scotia, 1:500 000. Digital product compiled by B. E. Fisher. (Formerly DP ME D92-03)

Trescott, P.C. 1969. Groundwater resources and hydrogeology of the Windsor-Hantsport-Walton area, Nova Scotia. N.S. Dept. of Mines, Groundwater Sec. Report 69-2. Accessed January 2012 from: http://www.gov.ns.ca/nse/groundwater/docs/GroundwaterResourcesReport_Windsor-Hantsport-WaltonArea.pdf

Webb, K.T. and Marshall, I.B. 1999. Ecoregions and Ecodistricts of Nova Scotia. Agriculture and Agri-Food Canada Research Branch, Environment Canada. South Mountain Ecodistrict, NS. Pg. 12.

APPENDIX A
DRAWINGS

S:\Strum Project Files\2011 Files\11-4314\Drawings\CAD Drawings\Hydrological Assessment\Drawing 1 - Site Location - 4314.dwg



- Notes:**
- Reference: NTS Maps 21A06 and 21A12
 - Projection: NAD83(CSRS), UTM Zone 20 North.

DATE:	PROJECT #:
Jan. 2012	11-4314
DRAWN BY:	CHECKED BY:
H. Serhan	M. Henley
SCALE:	
1:75,000	

SOUTH CANOE WIND PROJECT
HYDROGEOLOGICAL ASSESSMENT
SOUTH CANOE LAKE, NOVA SCOTIA
SITE LOCATION - NTS MAPS 21A06 AND 21A12

DRAWING #:

1