

APPENDIX C

WATER SUPPLY ASSESSMENT



GOLDBORO
LNG

February 26, 2013



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ATTENTION: Thom Dawson, VP Origination

Goldboro LNG –Assessment of Water Supply for Plant Production Requirements

Dillon Consulting Limited (Dillon) is pleased to submit the following Draft Report regarding the preliminary assessment of sources of water for the proposed Goldboro LNG plant and domestic operations. The assessment has been conducted based on an average daily flow (ADF) for plant and domestic operations of 300 m³/day and a with peak hourly flow (PHF) demand of 30 m³/hr.

The following provides a summary of the tasks completed to date:

Data Collection and Review

To determine the potential sources of water, background information regarding recent projects in the area of the proposed site were reviewed. These projects included the Sable Offshore Energy Project (SOEP), Keltic Petrochemicals (Keltic) and Maple LNG.

As outlined in the SOEP Gas Plant and Nearshore Marine Pipeline Assessment it is understood that SOEP uses groundwater as their primary source of domestic water. Based on the Natural Resources Groundwater Maps and Databases the well at the site is drilled to a depth of 91 metres with 12 metres of casing. This well reportedly yields approximately 14 lpm (0.89 m³/hr.).

Keltic was proposing to use Meadow Lake as the primary source of water for processing and domestic use. According to the environmental assessment completed for the Keltic Facility the proposed water usage was 1200 m³/hr.

Keltic contracted earth-water Concepts inc. in an effort to determine potential sources of water. As part of that work four hydrometric stations were installed in the vicinity of the proposed Keltic Plant and operated from Nov 2001 to May 2003. Through analysis of rainfall, the river gauges were determined to not be reliable to determine water availability and, therefore, rainfall modelling was used to determine the water available for use at the Keltic Facility. The analysis assumed that 10% of the available total flow could be used as a water source. The following summarizes their estimates:

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Table 1 - Flow Estimates from Keltic EA

Month	Total Flow Meadow Lake m³/month	Proposed Allowable Withdrawal m³/month	Water Withdrawal Required m³/month
January	8,869,995	887,000	892,800
February	14,553,131	1,455,313	806,400
March	16,378,389	1,637,839	892,800
April	11,170,939	1,117,094	864,000
May	8,970,270	897,027	892,800
June	1,578,400	157,840	864,000
July	4,981,735	498,174	892,800
August	9,126,733	912,673	892,800
September	3,096,361	309,636	864,000
October	6,490,466	649,047	892,800
November	11,402,344	1,140,234	864,000
December	10,065,137	1,006,514	892,800

Based on the assumption of available water for withdrawal, to obtain 1,200 m³/hr., there would be a net water deficit many months of the year (January, June, July, September, October) , but if a dam was installed, the water could be stored during the wetter months to meet the plant requirements in the drier months.

The earth-water Concepts report also included analysis of the Gold Brook Watershed which includes Goldbrook Lake and Seal Harbour Lake. No definitive analysis was provided for the watersheds of Goldbrook Lake or Seal Harbour Lake as their watersheds are significantly smaller than Meadow Lake, in the range of 10 to 30% of the size of Meadow Lake. Figure 1(attached) depicts the three lakes and their relative watersheds.

Maple LNG had begun groundwater resource investigations to determine if groundwater would be appropriate for water usage. Two potable wells were drilled and tested for yield. Geological mapping indicates that the area is underlain by the Goldenville Formation (mainly quartzite) of the Meguma Group. The bedrock typically exhibits a low hydraulic conductivity. Groundwater flow is secondary, dependant on the presence and connectivity of fractures. The approximate locations of the two water wells drilled at the site are provided in Figure 2 (attached).

The driller's logs record a well yield of less than 5 litres per minute (lpm) (0.3 m³/hr.) for both wells (estimates of 4.5 lpm (0.27 m³/hr.) and 3.4 lpm (0.20 m³/hr.), respectively). This yield was an estimate only as the tests did not include controlled flow rates or



measurement of drawdown in the wells; although, drillers' blow or air-lift, tests typically over-estimate yield.

A search of the Natural Resources – Groundwater Maps and Databases indicates that there are more than 15 wells in the immediate vicinity of the site. A search of the 15 closest wells to the site yield a range of depths from 14 to 91 metres with a range of yields from 2 lpm (0.12 m³/hr.) to 68 lpm (4.08 m³/hr.) with an average of 11 lpm (0.66 m³/hr.)

Water Quality

Surface water was sampled as part of the Maple LNG environmental approvals. Sample locations are shown on Figure 2. Sample results were compared to the Canadian Water Quality Guidelines (CWQG) for the Protection of Freshwater Aquatic Life (FWAL) and the Atlantic PIRI Guidelines for petroleum hydrocarbons.

Petroleum hydrocarbon concentrations were below applicable guidelines. Other comments on the general chemistry are as follows:

- pH was below the recommended range of 6.5 to 9.0 units and aluminium was above the guideline of 0.005 to 0.1 mg/L (pH dependant) in all samples.
- Arsenic was above the guideline of 0.005 mg/L in the majority of samples except one location (which was only sampled on one occasion).
- Cadmium was above the guideline of 10 ug/L (hardness dependant) in all samples except one in October 2007.
- Copper was above the guideline of 0.002 to 0.004 mg/L (hardness dependant) in one sample.
- Iron was above the guideline of 0.3 mg/L on several occasions.
- Zinc was above the guideline of 0.03 mg/L in one sample.

Previous samples collected in 2005 (AMEC, 2006) from Betty's Cove Brook and Crusher Brook (off-site) indicated low pH and elevated aluminium. It should be noted that the laboratory detection limit for cadmium was higher in the 2005 analysis; therefore, a direct comparison with current data could not be made.

Groundwater samples were collected from the potable water wells drilled on behalf of Maple LNG to understand the general character of the water. Because they were collected after only a short period of pumping, the results may or may not represent true groundwater quality. The following is a summary of parameter exceedances to the Canadian Council Ministers of the Environment (CCME) Drinking Water Quality Guidelines:



- Turbidity was above the guideline of 1 NCU in both samples. The concentrations were 47 and 640 NCUs. Elevated turbidity is common in newly constructed wells and likely reflects aquifer disturbances created during the drilling process.
- Manganese was above the recommended guideline of 0.05 mg/L in one sample.
- pH at a concentration of 8.6 units was slightly above the recommended guideline range of 6.5 to 8.5 units in one sample.

One of the wells was classified as calcium bicarbonate rich. The hardness concentration (76 mg/L) indicates relatively soft water. The second well was classified as sodium bicarbonate rich with a lower hardness concentration (25 mg/L).

A monitoring well network was installed on the Maple LNG site for baseline and potential construction monitoring (Figure 2). There are 10 monitoring wells constructed as five shallow/deep couplets. The shallow wells are screened through the overburden and across the water table to depths ranging from 7.6 to 8.8 metres and the deeper bedrock monitoring wells range from 15.4 metres to 42.7 metres.

The chemistry data from the deeper bedrock monitoring wells are a good indication of water quality to be expected from any potable wells drilled across the site. The following is a summary of parameter exceedances to the Canadian Council Ministers of the Environment (CCME) Drinking Water Quality Guidelines:

- Arsenic was above the guideline of 0.01 ug/L in all 5 of the bedrock monitoring wells with concentrations ranging from 0.045 ug/L to 0.480 ug/L. Elevated levels of this parameter are common in NS groundwater. The guideline is a health based limit not aesthetic.
- Manganese was above the guideline of 0.050 ug/L in 4 of the 5 bedrock monitoring wells with values ranging from 0.012 ug/L to 0.230 ug/L. Elevated levels of this parameter are common in NS groundwater. A limit is also in effect for aesthetic reasons only due to the inconvenience of staining to clothing and household fixtures.
- pH was below the recommended guideline range of 6.5 to 8.5 units in the 3 of the 5 bedrock monitoring wells with a range of 5.6 to 7.2 pH units. The recommended range for pH is also in effect for aesthetic reasons only in that high pH (alkaline) water may cause encrustations on piping and fixtures, while low pH (acidic) water tends to be corrosive.

The preliminary analytical data indicates generally good quality water with few parameter exceedances.

Definition of Potential Alternatives

The analysis conducted as part of the Keltic EA suggests that Meadow Lake could be used as a potential source of water for the Pieridae Goldboro LNG project.



Table 2 – Availability of Water from Meadow Lake

Month	Total Flow Meadow Lake m ³ /month	Proposed Allowable Withdrawal m ³ /month	Average Flow Required m ³ /month	Peak Flow Required m ³ /month
January	8,869,995	887,000	9,300	22,320
February	14,553,131	1,455,313	8,400	20,160
March	16,378,389	1,637,839	9,300	22,320
April	11,170,939	1,117,094	9,000	21,600
May	8,970,270	897,027	9,300	22,320
June	1,578,400	157,840	9,000	21,600
July	4,981,735	498,174	9,300	22,320
August	9,126,733	912,673	9,300	22,320
September	3,096,361	309,636	9,000	21,600
October	6,490,466	649,047	9,300	22,320
November	11,402,344	1,140,234	9,000	21,600
December	10,065,137	1,006,514	9,300	22,320

This demonstrates that Meadow Lake could be used as a water source without the requirement of installing a dam.

To evaluate the potential of using Gold Brook Lake and Seal Harbour Lake as water sources, the flows for these lakes were estimated using the Meadow Lake estimates and calculating a flow for each Lake based on the relative watershed size. The size of the Meadow Lake watershed is estimated to be 7,000 ha, Gold Brook Lake is 900 ha and Seal Harbour Lake is 1,900 ha. Similar to the Meadow Lake assessment, it is assumed that 10% of the flow can be withdrawn for water usage. The following table summarizes the estimated water available:

Table 3 – Availability of Water from Gold Brook and Seal Harbour Lakes

Month	Total Flow Gold Brook Lake Estimate m ³ /month	Gold Brook Proposed Allowable Withdrawal m ³ /month	Total Flow Seal Harbour Lake m ³ /month	Seal Harbour Proposed Allowable Withdrawal m ³ /month	Average Flow Required m ³ /month	Peak Flow Required m ³ /month
January	1,106,576	110,658	2,291,395	229,139	9,300	22,320
February	1,815,575	181,558	3,759,525	375,952	8,400	20,160
March	2,043,285	204,329	4,231,046	423,105	9,300	22,320
April	1,393,630	139,363	2,885,800	288,580	9,000	21,600
May	1,119,086	111,909	2,317,299	231,730	9,300	22,320
June	196,913	19,691	407,750	40,775	9,000	21,600
July	621,496	62,150	1,286,937	128,694	9,300	22,320

Month	Total Flow Gold Brook Lake Estimate m ³ /month	Gold Brook Proposed Allowable Withdrawal m ³ /month	Total Flow Seal Harbour Lake m ³ /month	Seal Harbour Proposed Allowable Withdrawal m ³ /month	Average Flow Required m ³ /month	Peak Flow Required m ³ /month
August	1,138,605	113,861	2,357,718	235,772	9,300	22,320
September	386,286	38,629	799,886	79,989	9,000	21,600
October	809,718	80,972	1,676,689	167,669	9,300	22,320
November	1,422,499	142,250	2,945,579	294,558	9,000	21,600
December	1,255,676	125,568	2,600,137	260,014	9,300	22,320

Based on this analysis any of these lakes could be used as a potential water source. The analysis suggests that in June Gold Brook Lake may not have enough water available to accommodate the peak flow. It is still expected that this lake could be used as the peak flow would not likely be sustained for an entire month.


Additional surface water sampling would be required to confirm water quality. Based on the results of surface water in the area conducted to date, it is expected that water treatment would be required for pH adjustment, arsenic and potentially other metals.

Overall the existing potable wells are not able to meet the needs of the future development (55 to 110 igpm or 250 to 500 lpm or 15 to 30 m³/hr.) as the estimated yield was limited to values less than 5 lpm (0.3 m³/hr.). It may be possible to obtain greater yield from additional wells, however the upper range of nearby wells is limited to 68 lpm (4.08 m³/hr.) with more than half of the nearby wells having similar yields to the existing wells on site (i.e., less than 5 lpm (0.3 m³/hr.)). Groundwater is unlikely to yield sufficient water to meet development needs on its own. Further drilling could be completed to confirm this, but in order to obtain sufficient water, it is likely that multiple wells (greater than ten) would need to be drilled and tested and they would require sufficient spacing so as not to dewater each other. This may not be possible given site constraints.

Groundwater quality indicates that treatment would be required for potable use (arsenic) and aesthetic reasons (turbidity, manganese, pH).

Recommendation

The above review of background data and high level analysis indicates that surface water is the most appropriate source of water for the Goldboro LNG Facility. Gold Brook Lake and Seal Harbour Lake can both provide the required water. It is recommended that Phase 2 be completed for the closest lake, Seal Harbour Lake. The closer proximity of



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this lake is expected to require less piping and, therefore, be less expensive to construct than obtaining water from Gold Brook Lake.

Closing

We trust this report is suitable to your needs. We will await your review of the Phase 1 results prior to proceeding with Phase 2. Please contact the undersigned if you have any questions or concerns.

Yours truly,

DILLON CONSULTING LIMITED



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AJB:jep
Attachment



REFERENCES:

AMEC, Keltic Petrochemicals Inc., Liquid Natural Gas Facilities and Marginal Wharf Comprehensive Study Report – Final Report, Goldboro, Nova Scotia, October 2007.

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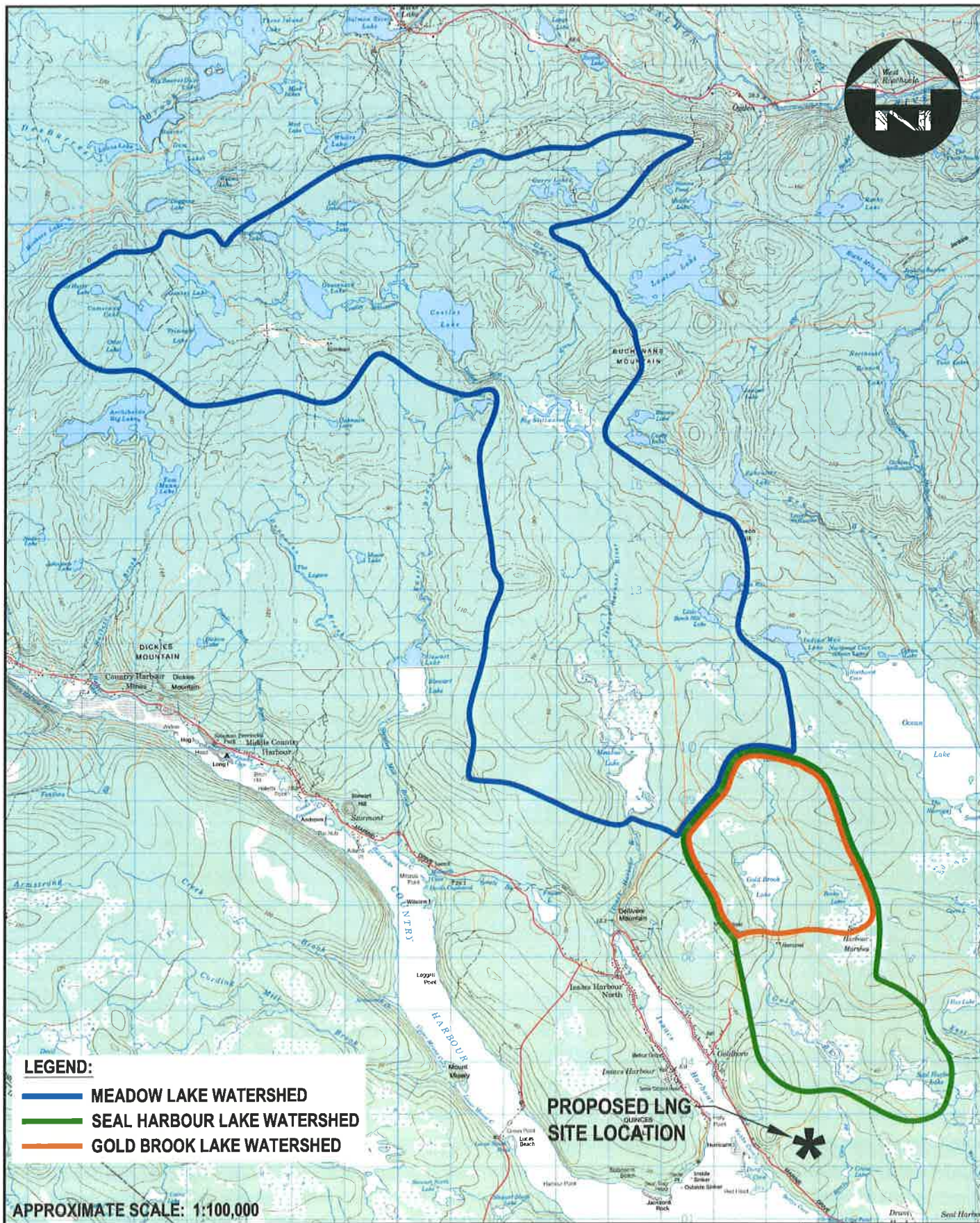
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Exxon Mobil, Sable Project Development Plan Application, <http://www.soep.com/cgi-bin/getpage?pageid=1/5/0&dpa=2/5/3/4>.

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Sable Offshore Energy Project, Gas Plant and Nearshore Pipeline Assessment, November 1996.

ATTACHMENT 1
Figure 1 – Watershed Boundaries
Figure 2 – Water Sampling Locations



 DILLON CONSULTING	PROJECT	GOLDBORO LNG	PROJECT NO.	13-7407
	TITLE	WATERSHED BOUNDARIES	FIGURE NO.	1
DATE	FEBRUARY 2013			

File name: g:\cad\137407\00-general\03-reports\fig2.dwg

