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October 17, 2016

Muskrat Falls' Contribution to the Reliability of the Island Interconnected System

Expert Report
submitted to the
NL Public Utilities Board

Investigation and Hearing into Supply Issues and Power
Outages on the Island Interconnected System

on behalf of

Grand Riverkeeper (Labrador) Inc.

by

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1. INTRODUCTION AND SUMMARY

I have been asked by Grand Riverkeeper (Labrador) Inc. to examine the contribution of the Muskrat Falls Generating Station (MFGS) to the Reliability of the Island Interconnected System (IIS), in light of the Water Management Agreement (WMA) and the recent decision of the Québec Superior Court concerning the renewal provisions of the Churchill Falls Power Contract.

In Section 2, I will describe the MFGS (now under construction) and review historical flow data at Muskrat Falls. This review will show that, since Churchill Falls was commissioned in 1977, average monthly generation (based on average monthly flows) would have ranged from 470 MW in September to 761 MW in May. Winter flows are close to the annual average, and would have resulted in average monthly generation of around 580 MW during these months. However, in the driest years, daily average flows as low as 418 MW have been observed.

In Section 3, I present the banking mechanism established by the Water Management Agreement (WMA), in order to give Nalcor access to reliable capacity, regardless of the actual power generated at MFGS at a particular moment.

It is important to note that the WMA includes provisions that protect all rights under existing power contracts, including the Churchill Falls Power Contract between CF(L)Co and HQ. In its prefiled evidence, Nalcor Energy explained that the provisions of that contract would change substantially at its renewal date (Sept. 1, 2016); after that date, HQ's entitlement would be limited to fixed amounts of energy each month. HQ disputed this interpretation, and sought a declaratory judgement from the Quebec Superior Court in this regard. In a decision dated August 8, 2016, that Court declared that, under the contract, HQ has the exclusive right to all available capacity and all energy produced at Churchill Falls.

In Section 4, I explore the significance of this decision for the operation of the WMA. Using a simplified example of banking mechanism, I demonstrate that, insofar as the Quebec Superior Court decision stands, the WMA appears to resemble a bank account to which Nalcor can deposit, but from which it cannot withdraw. Thus, until such time as the decision is either

1 overturned on appeal or made irrelevant by a negotiated agreement with Hydro-Québec, the
2 power available to Nalcor from the MFGS will be limited to its actual generation capacity, which
3 varies from moment to moment, depending on the flows in the Churchill River.

4 In Section 5, I conclude that, under these circumstances, the firm capacity available to Hydro
5 from the LIL to meet IIS needs – after taking into account the obligation to deliver 167 MW to
6 Nova Scotia – is probably limited to about 211 MW – less than a third of the 673 MW of firm
7 capacity identified by Hydro for the IIS.

8 To this can perhaps be added at least some of the 110 MW of surplus Recall Power assumed by
9 Hydro to be available until interconnection.¹

10 The unavoidable implication is that the capacity balances presented by Hydro in this Reliability
11 Inquiry systematically overstate firm capacity available to the IIS, perhaps by up to 400 MW.

12 **2. THE MUSKRAT FALLS GENERATING STATION**

13 ***2.1. Physical characteristics***

14 Nalcor Energy described the Muskrat Falls powerhouse as follows:²

The Muskrat Falls powerhouse will be a surface-type, concrete structure with a
steel superstructure, 188 m long by 69 m wide. Four turbines each with a
capacity of 206 MW will provide a total installed capacity of 824 MW. In turn,
total discharge from the powerhouse will be 2,660 m³/s. The net head will be 35
m.

15

¹ NLH, Energy Supply Risk Assessment (ESRA), p. 20. This assumption applies only to the “study period”, which apparently refers to the period prior to grid connection, as per a letter from the Board dated February 8, 2016 (quoted on page 1 of the ESRA).

² Nalcor Energy, WMA Application, Appendix B, p. 4-11.

1 The expression “total discharge” presumably means “maximum discharge”, as actual discharge
2 of course depends on actual inflows. The Muskrat Falls facility will only have about 50 million
3 m³ of live storage capacity,³ equivalent to just under 5 ½ hours at full output.⁴ As, in order to
4 maximize head, the facility is most efficient when operating at full storage, I will make the
5 simplifying assumption that outflows are equal to real-time inflows. I will also make the
6 simplifying assumption that the relationship between discharge and electrical output is linear.

7 ***2.2. Inflows to Muskrat Falls***

8 Inflows to Muskrat Falls (MF) consist primarily of flows released from the Churchill Falls
9 Generating Station (CFGS), supplemented by unregulated inflows from tributaries entering the
10 Churchill River between the two dams. Daily flows at several sites along the Churchill River are
11 recorded by Environment Canada, and the historical data are readily available on its website.⁵

12 Figure 1 shows average monthly inflows at this site from 1954 to 2014, in both physical (m³/s)
13 and electrical (MW) units. (The underlying data are reproduced in Appendix A.) The horizontal
14 blue line indicates the maximum flows that can be turbined by the MF Generating Station
15 (MFGS) (and hence its maximum electrical output of 824 MW). Thus, had MFGS been in
16 service since 1954, flows above this line would have been spilled. The spills would have
17 occurred primarily in the months of June and July.

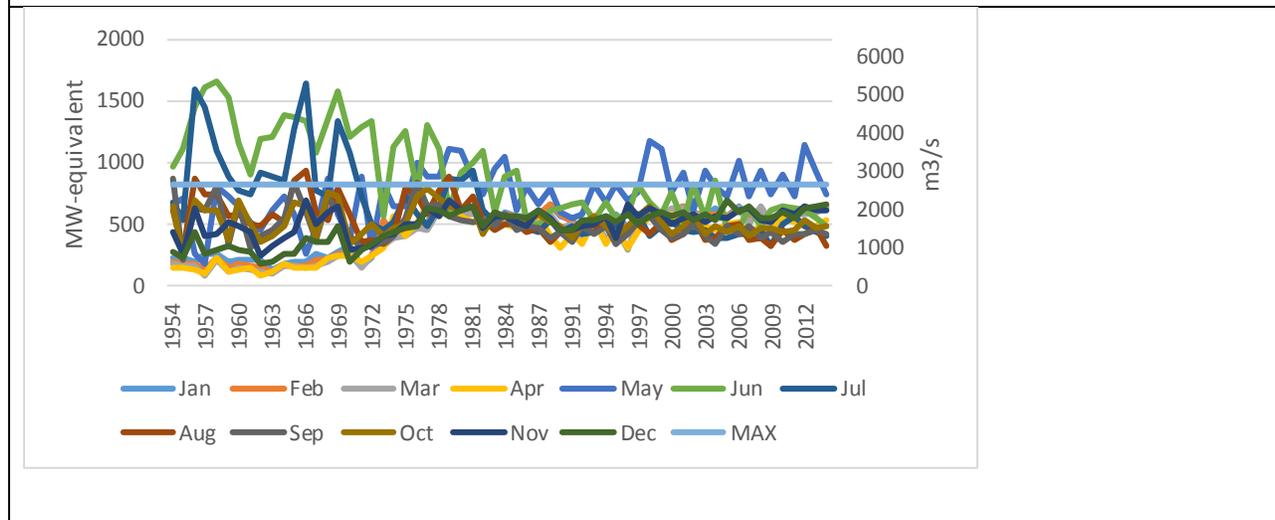
18

³ Nalcor Energy, WMA Application, Pre-filed Evidence, p. 13.

⁴ In comparison, Churchill Falls has 30 billion cubic metres of storage capacity. Nalcor Energy, Water Management Agreement Application – Prefiled Evidence, Appendix A, p. A-4.

⁵ Flows for the Churchill River above Muskrat Falls are found at http://eau.ec.gc.ca/report/report_e.html?type=h2oArc&stn=03OE001, as referenced in GRK-NLH-111.

Figure 1. Historical Flows at Muskrat Falls

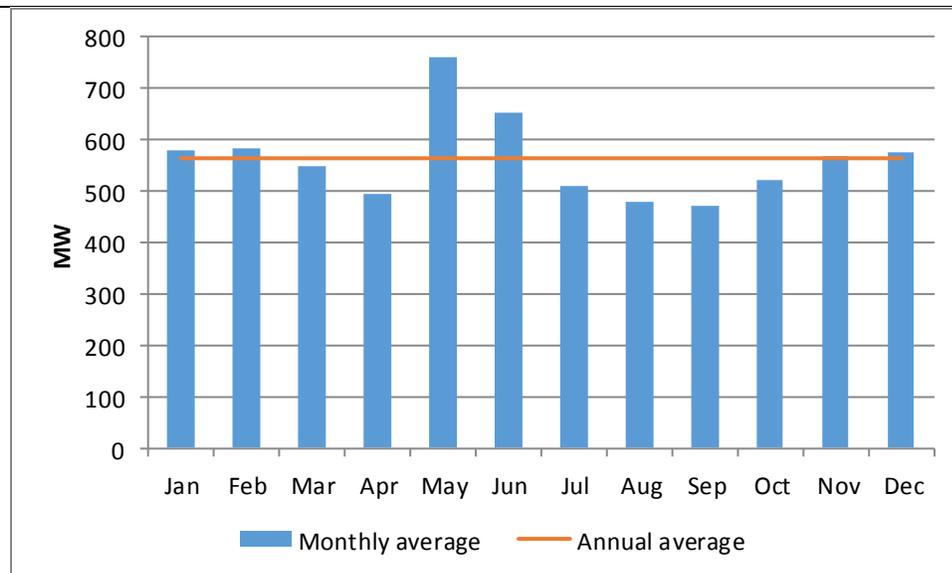


1 The Churchill Falls Generating Station (CFGS) came into service gradually from May 1973 to
2 September 1976. As CFGS has substantial inter-seasonal and inter-annual storage, the extreme
3 flows at MF observed in May and June in the 1950s and 60s have not been seen in recent
4 decades. However, in many years since 1976, the average flows during the month of May still
5 exceed the design flows of the MFGS, and so would have resulted in spills.

6 Figure 1 also clearly demonstrates that, during most months, average inflows are well below the
7 design capacity of the MFGS. As a result, average power output during these months can be
8 expected to remain well below the installed capacity of 824 MW.

9 More specifically, since 1977, average flows at Muskrat Falls would have resulted in average
10 generation at MFGS ranging from 470 MW in September to 761 MW in May, with an annual
11 average of 563 MW. Average generation in the coldest months would remain close to that
12 average level, as shown in Figure 2.

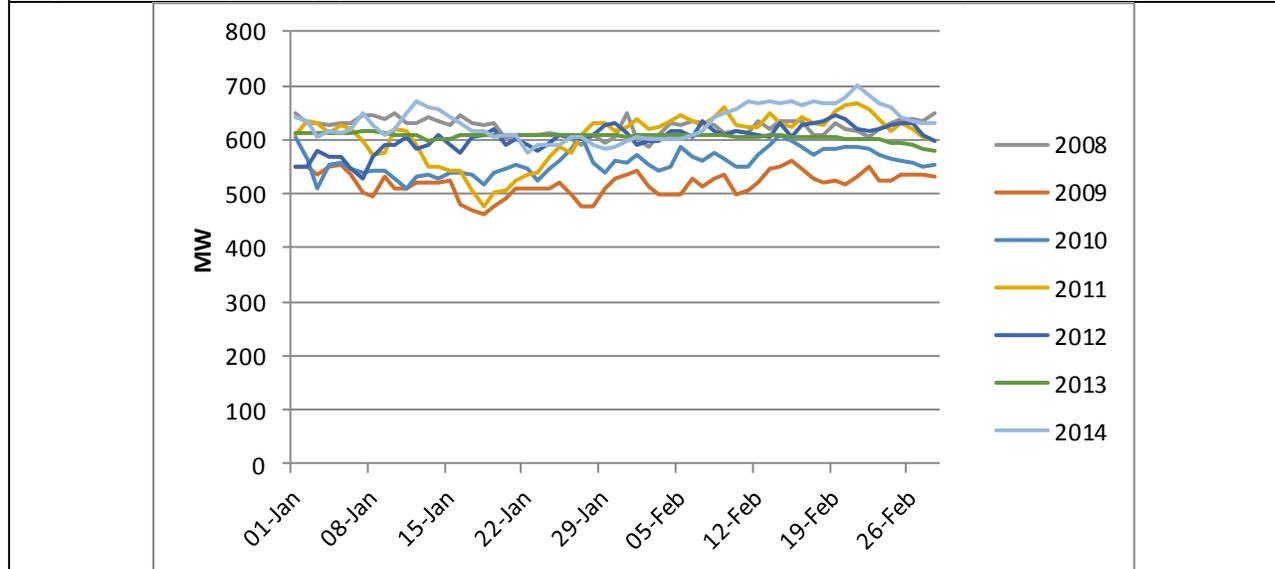
Figure 2. Average monthly generation (simulated) at Muskrat Falls (1977-2014)



1 It is important to realize that average generation in January of 581 MW does not mean that
2 MFGS would have produced 581 MW during all hours every January. In fact, flows can vary
3 considerably both from year to year and within the month, depending principally on the dispatch
4 of CFGS. Thus, insofar as reliable capacity is based on the maximum generation that can reliably
5 be expected to occur during peak hours, the reliable winter capacity of the MFGS, before
6 application of the Water Management Agreement (WMA), must be considerably lower than 581
7 MW.

8 To illustrate the range of variability in winter flows, Figure 3 shows the average daily flows
9 (converted to equivalent MW) for the months of January and February, from 2008 through 2014.

Figure 3. Average daily generation (simulated) at Muskrat Falls in January and February

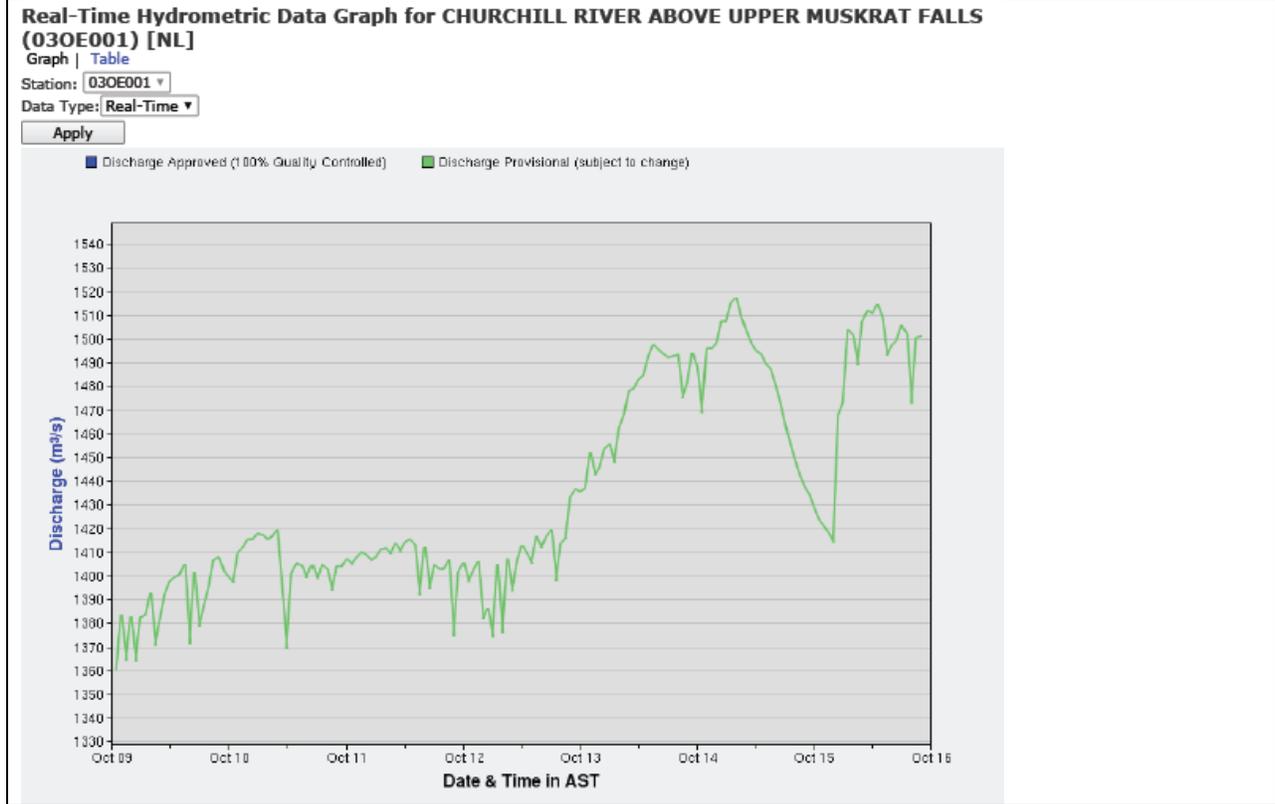


1 While the average daily generation for January and February across these seven years would
2 have been 592 MW, the minimum level (observed on January 18, 2009) would have been just
3 462 MW. That same year, the average daily generation in January and February would have been
4 just 519 MW.

5 While 2009 displayed the lowest flows of this seven-year period, it was not the driest year in the
6 relevant historical record, or the driest year since CFGS commissioning. In 1991, the average
7 flows were just 1510 m³s – 5.2% lower than the average flows in 2009. Average daily flows on
8 January 2, 1991 were just 1350 m³s, which would have resulted in average daily generation of
9 just **418 MW**.

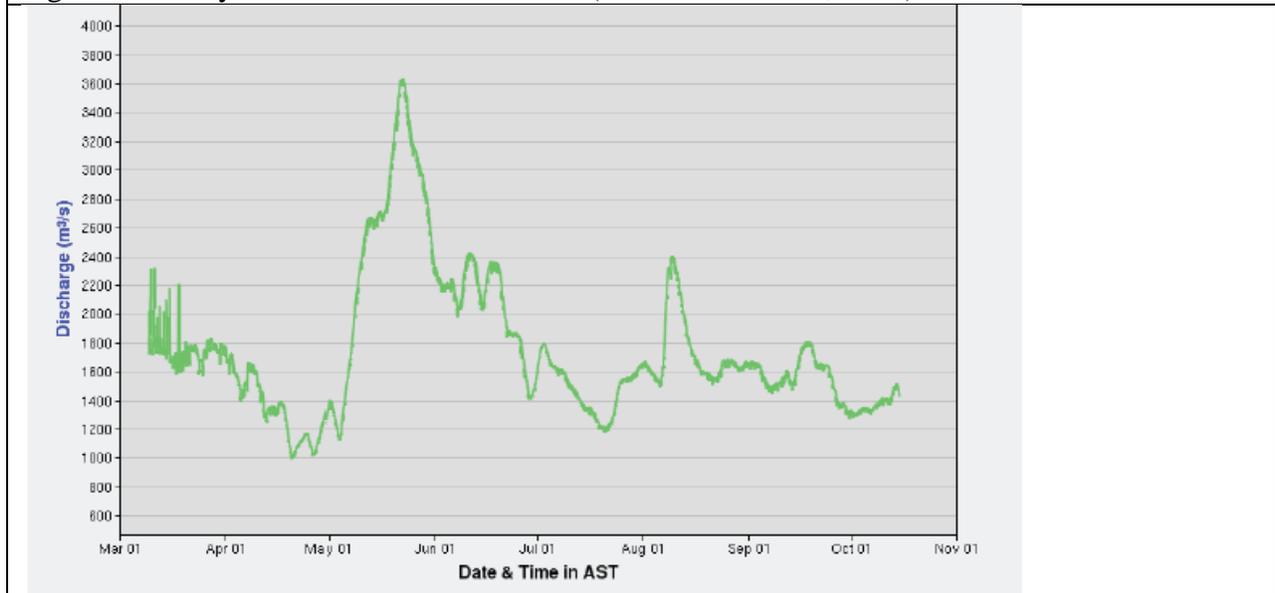
10 It must also be recognized that flows are not constant over a 24-hour period. Hourly flow data
11 are only available for certain periods, so it is unclear to what extent MFGS reliable capacity is
12 lower than these daily averages. Figures 4 and 5 show the hourly flows for the last week and for
13 the last six months, which illustrate, respectively, the substantial hourly and seasonal variability
14 of flows at MF.

Figure 4. Hourly flows above Muskrat Falls (Oct. 9-15, 2016)



1

Figure 5. Hourly flows above Muskrat Falls (March to October, 2016)



2

1 With respect to firm energy, according to Hydro, MF has a firm annual energy capability of
2 approximately 4.5 TWh.⁶ Firm energy is defined as “the maximum annual energy that can be
3 supported by MF during the critical (dry) hydrologic sequence.”⁷ It is worth noting that this 4.5
4 TWh is approximately equal to the average capacity of MFGS (estimated above at 563 MW),
5 multiplied by the 8760 hours in the year. In dry years, however, less energy would be produced.
6 In 1991, the driest year in the Churchill River since commissioning of Churchill Falls,
7 Environment Canada flow data indicate that energy production at MFGS would have been about
8 4.1 TWh (with average generation of 470 MW).⁸

9 ***2.3. Contribution of MFGS to IIS reliability, according to NLH***

10 According to Hydro, Muskrat Falls' capability is 824 MW, of which 169 MW is committed to
11 the Nova Scotia Block. Thus, “the total capacity available to Hydro once the plant is fully
12 commissioned is 655 MW”.⁹ (These figures are prior to transmission losses.)

13 The LIL capacity is 900 MW¹⁰, or 830 MW delivered to Soldiers Pond, implying a loss rate of
14 7.8%. Of these 830 MW, 157 MW are committed to the Nova Scotia Block, leaving 673 MW
15 for Island use.¹¹ (The NS Block is only delivered 16 hours a day, seven days a week.)

16 In response to an RFI, NLH wrote:

17 The total amount of generating capacity available to Hydro from the MF plant to meet
18 the peak demand in each month will be the total plant capability less the amount
19 designated to Nova Scotia. Each unit has a 206 MW capability for a total plant capability
20 of 824 MW.¹³

⁶ DD-NLH-065, page 1.

⁷ Ibid., note 2.

⁸ It is important to keep in mind that flows at MF are to a large extent determined by CF(L)Co's dispatch of the CFGS, and not only by runoff.

⁹ DD-NLH-065, page 1.

¹⁰ PUB-NLH-217, page 6.

¹¹ PUB-NLH-447.

¹³ DD-NLH-065, lines 16-19.

1 Thus it would appear that Hydro presumes, for planning purposes, that the full installed capacity
2 of the MFGS will be available as needed to meet Island demand.

3 Generally, unless otherwise characterized, “available capacity” refers to capacity that is available
4 as needed, at all times.¹⁴ For example, available capacity from the wind farms at the Fermeuse
5 and St. Lawrence wind farms is “not included in capacity planning due to the variability of
6 wind.”¹⁵

7 More specifically, in presenting its Island system capability, reproduced in Table 1, NLH takes
8 care to identify (with an asterisk) those resources that are not dispatchable. These non-
9 dispatchable resources include the two wind farms, Corner Brook Cogen, and hydraulic
10 resources belonging to NP and the CBP&P.

¹⁴ “Net (Maximum) Available Capacity Net or net maximum available capacity is the full power output of a generating unit less station service. Net available capacity is another term for busbar capacity.” Pacific Northwest Utilities Conference Committee (PNUCC), *Capabilities of Electric Power Resources*, PNUCC Planning Committee, March 2011, p. 4.

¹⁵ CA-NLH-150, Att. 1, p. 43 of 1794, Table 6.2.

Table 1. Island Interconnected System Capability, as of October 2012¹⁶

Table 3-1

Island Interconnected System Capability – As of October 2012			
* - non-dispatchable (see Section 9.1)	Net Capacity [MW]	Energy [GWh]	
		Firm	Average
<u>Newfoundland & Labrador Hydro</u>			
Bay d'Espoir	592.0	2,272	2,588
Upper Salmon	84.0	492	540
Hinds Lake	75.0	290	341
Cat Arm	127.0	678	736
Granite Canal	40.0	191	238
Paradise River	8.0	33	41
Snook's, Venam's & Roddickton Mini Hydros	<u>1.3</u>	<u>5</u>	<u>4</u>
Total Hydraulic	<u>927.3</u>	<u>3,961</u>	<u>4,488</u>
Holyrood	465.5	2,996	2,996
Combustion Turbine	100.0	-	-
Hawke's Bay & St. Anthony Diesel	<u>14.7</u>	-	-
Total Thermal	<u>580.2</u>	<u>2,996</u>	<u>2,996</u>
Total NL Hydro	<u>1,507.5</u>	<u>6,957</u>	<u>7,484</u>
<u>Newfoundland Power Inc.</u>			
Hydraulic*	96.9	324	430
Combustion Turbine	36.5	-	-
Diesel	<u>5.0</u>	-	-
Total	<u>138.4</u>	<u>324</u>	<u>430</u>
<u>Corner Brook Pulp and Paper Ltd.</u>			
Hydraulic*	121.4	793	880
<u>Star Lake and Exploits Generation</u>			
Star Lake	15.0	87	144
Exploits	<u>90.8</u>	<u>547</u>	<u>634</u>
Total	<u>105.8</u>	<u>634</u>	<u>778</u>
<u>Non-Utility Generators</u>			
Corner Brook Cogen*	15.0	52	52
Rattle Brook*	4.0	13	15
St. Lawrence Wind*	27.0	92	105
Fermeuse Wind*	<u>27.0</u>	<u>75</u>	<u>84</u>
Total	<u>73.0</u>	<u>232</u>	<u>256</u>
Total Island Interconnected System	<u>1,946.1</u>	<u>8,940</u>	<u>9,828</u>

¹⁶ PUB-NLH-047, Att. 1, page 15 of 43.

1 Hydro explains its treatment of non-dispatchable resources as follows:¹⁷

9.1 Intermittent and Non-Dispatchable Resources

Based on the island's existing plus committed generating capacity, approximately 291 MW, or 15 percent of net capacity can be characterized as non-dispatchable generation (see Table 3-1). While energy production from these resources is predictable over the long term, the generation may not be available when needed. The concern with this type of generation comes on two fronts; first in the availability of the generation to meet higher loads; and second on occasions of light load when the non-dispatchable capacity can no longer be absorbed into the system without adverse technical and economic impacts.

From a generation planning point of view, when assessing the adequacy of system resources to meet peak demands, the characteristics of non-dispatchable generation are incorporated into the unit models. Therefore, on a go-forward basis, new non-dispatchable resources are appropriately evaluated in generation capacity planning analyses.

2

3 Table 7-1 of the same document indicates the expectation that the LIL will provide 823 MW of
4 firm capability.¹⁸ No specific indication is provided as to the source of the 900 MW of available
5 capacity in Labrador required to provide these 823 MW of firm capability to the IIS.

6 Hydro's planning department presumably has a methodology it uses to evaluate the capacity
7 value of non-dispatchable resources. In order to properly evaluate IIS reliability after
8 interconnection, it will be important to apply this methodology to the Muskrat Falls Generating
9 Station.

10 Figure 1, above, showed that the inflows at MFGS are often well below the 2660 m³/s required
11 to produce its maximal output of 824 MW (except during the months of May and June). As
12 Nalcor cannot control these inflows, if 824 MW are to be "available to Hydro from the MF plant
13 to meet the peak demand in each month," it must rely on the Water Management Agreement

¹⁷ PUB-NLH-047, Att. 1, page 34 of 43.

¹⁸ Ibid., page 31 of 43.

1 (WMA), described in the next section, to ensure that the full capacity of the LIL is in fact
2 available upon demand. As we shall see, the WMA accomplishes this by providing that, insofar
3 as the power levels required by NLH are not available from the MFGS, the shortfall is provided
4 by the Churchill Falls Generating Station (CFGS), taking advantage of the WMA's banking
5 provisions.

6 ***2.4. Role of Water Management Agreement***

7 The importance of the Water Management Agreement to the operation of MF was set out clearly
8 in the WMA application presented to the Board by Nalcor Energy.

9 Irregular production at Churchill Falls will have different effects on the lower Churchill
10 facilities depending upon the uncontrolled natural inflows at various times of the year. In
11 many months, the lower Churchill facilities would have insufficient water for production
12 requirements during periods of reduced production at Churchill Falls. However, during the
13 spring runoff, there would be excess water, resulting in spillage, during periods of increased
14 production at Churchill Falls.¹⁹

15 As Hydro has noted, spillage does not in itself create reliability concerns, and does not affect
16 annual energy production.²⁰ However, the first concern raised in this citation, that the lower
17 Churchill facilities would have insufficient water for production requirements during periods of
18 reduced production at Churchill Falls, goes to the heart of this reliability inquiry. As noted
19 above, Hydro's reliability planning assumes 673 MW of reliable capacity from the LIL, whether
20 provided by the MFGS or by the CFGS (by virtue of the WMA's banking provisions), perhaps
21 supplemented by the Recall Block surplus.²¹ The reliability of the Island Interconnected System
22 is thus dependant on the proper functioning of the energy banking system put in place by the
23 WMA.

¹⁹ Nalcor Energy, Water Management Agreement Application – Prefiled Evidence, p. 13.

²⁰ GRK-NLH-111, page 2.

²¹ In its Energy Supply Risk Assessment of May 2016, Hydro makes the assumption that 110 MW of Recall Power can be made available at Soldiers Pond prior to interconnection (page 20). It does not forecast the evolution of that amount into the next decade or beyond.

1 Whether or not the WMA, as approved by this Board in P.U. 8(2010), remains capable of
2 fulfilling these functions, in light of a recent decision by the Quebec Superior Court, will be
3 addressed in the next section.

4 **3. THE WATER MANAGEMENT AGREEMENT**

5 **3.1. History**

6 The WMA was put in place by P.U. 8(2010) in response to an application filed by Nalcor, in
7 accordance with the 2007 amendments to the *Electrical Power Control Act* (EPCA). EPCA, as
8 amended, provides that where two or more entities each have rights to produce power from the
9 same river, they must enter into an agreement “for the purpose of achieving the most efficient
10 production, transmission and distribution of power” (s. 3(b)(i)). Should they fail to do so, the
11 PUB has jurisdiction to establish the terms of an agreement between them (s 5.5(1)).

12 This application was filed subsequent to the failure in October 2009 of the CF(L)Co Board of
13 Directors to approve the WMA negotiated between its management and Nalcor.²²

14 More specifically, in March 2009, Nalcor invited the Churchill Falls (Labrador) Company
15 (“CF(L)Co”) to enter into negotiations towards such an agreement. An agreement was reached
16 in September 2009.

17 Based on the CF(L)Co shareholders’ agreement, a special majority decision of the Board of
18 Directors is required for such an agreement, where at least one director appointed by both NLH
19 and Hydro-Québec must vote in favour of the decision.²³ In the vote, held in October 2009, the
20 CF(L)Co Board of Directors did not approve the agreement – probably because the Hydro-
21 Québec directors did not vote in favour of it. Furthermore, the CF(L)Co Board provided no

²² NLPUB, Nalcor Energy, Water Management Agreement Application, Pre-filed Testimony, p. 1.

²³ Ibid., p. 18.

1 direction to management as to changes that could make the agreement acceptable, nor did it
2 authorize CF(L)Co to resume negotiations.²⁴

3
4 At a meeting of the CF(L)Co Board of Directors on Friday, October 23, 2009, the Board
5 considered, for approval, the draft Water Management Agreement that was negotiated by
6 CF(L)Co and Nalcor Energy and recommended by the CF(L)Co negotiating team. The required
7 Board approval was not achieved. Neither was the Board able to provide any direction as to how
8 the agreement could be modified such that it might receive board approval. The CF(L)Co
9 negotiating team is therefore not in a position to resume negotiations at this time.

4 Consequently, Nalcor asked the Public Utilities Board to establish a Water Management
5 Agreement for the Churchill River, based on the agreement that had been submitted to the
6 CF(L)Co Board.²⁵

7 Identical proposed WMAs were submitted to the Board by CF(L)Co and Nalcor.²⁶ The WMA
8 currently in force therefore appears to be identical to the one negotiated by the two parties.

9 In December 2009, Hydro-Québec addressed a letter to the Board, indicating that it would not
10 intervene in the WMA hearing.²⁷ In this letter, signed by Christian Brousseau, HQ Vice
11 President for Wholesale Markets (and later the President of HQ Production), HQ also stated:

Hydro-Québec wishes to express to the Board its position that any water management agreement
to be established by the Board must recognize that the CF(L)Co/Hydro-Québec Power
Contracts have the benefit of Section 5.7 of the EPCA.

We note that the Nalcor Application, as well as the Nalcor and CF(L)Co submissions of
December 10, 2009, acknowledge that the CF(L)Co/Hydro-Québec Power Contracts are
protected by Section 5.7 of the EPCA, as does the water management agreement proposed by
both Suppliers to the Board.

In such circumstances, Hydro-Québec has decided not to intervene in the Nalcor Application.

²⁴ Ibid., Appendix D (email dated Oct. 27, 2009).

²⁵ NLPUB, Nalcor Energy, Water Management Agreement Application, Pre-filed Testimony, pp. 18-19.

²⁶ NLPUB, Reasons for Decision: Order No. P.U. 8(2010), p. 1.

²⁷ <http://www.pub.nf.ca/applications/Nalcor2009Water/files/submissions/HydroQuebec-WrittenSubmission-Dec15-09.pdf>

1 Section 5.7 of the EPCA states:

2 **5.7** A provision of an agreement referred to in section 5.4 or 5.5 shall not adversely
3 affect a provision of a contract for the supply of power entered into by a person bound
4 by the agreement and a third party that was entered into before the agreement
5 under section 5.4 or 5.5 was entered into or established, or a renewal of that contract.

6 The Board approved the agreement as submitted, specifying:²⁸

The Board is satisfied that the terms of the proposed Agreement ensure that existing power contracts and renewals of these contracts are not adversely affected. Existing prior contracts are expressly identified in Article 3.2. Under the terms of the proposed Agreement existing power purchasers will receive the same amount of power and energy, subject to the same limitations and contractual provisions.

7 The Board thus concluded that the WMA would not adversely affect the rights of Hydro-Québec
8 under its existing Power Contract with CF(L)Co, or under that contract's renewal, as stated in
9 s. 3.1 of the WMA:

10 **3.1 No Adverse Effect**

11 The parties acknowledge that pursuant to Section 5.7 of the Act, nothing in this
12 Agreement shall adversely affect a provision of a contract for the supply of Power and
13 Energy entered into by a Supplier and a third party prior to this Agreement, or a renewal
14 of that contract (collectively "Prior Power Contracts"), and that all provisions of this
15 Agreement and ancillary documents and agreements shall be interpreted accordingly.
16 (emphasis added)

17

18 **3.1.1. Key provisions**

19 Under the WMA, the two parties (CF(L)Co and HQ) together form a Water Management
20 Committee, which selects an Independent Coordinator to establish short- and long-term
21 production schedules for all production facilities on the Churchill River.²⁹ This would be done
22 making use of the concept of "banking." The Independent Coordinator would schedule

²⁸ NLPUB, Reasons for Decision: Order No. P.U. 8(2010), p. 15.

²⁹ NLPUB, Nalcor Energy, Water Management Agreement Application, Pre-filed Testimony, p. 21.

1 generation at both facilities in order to meet the scheduled requirements of each party in the most
2 efficient way:³⁰

10 Energy produced by Nalcor in its facilities to meet CF(L)Co's delivery requirements is
11 proposed to be credited to Nalcor in the CF(L)Co reservoir system. When the production
12 schedule calls for CF(L)Co to produce power to meet Nalcor's delivery requirements, the
13 accumulated volume banked by Nalcor in CF(L)Co's reservoirs will be reduced. The
3 14 converse is also true at lower Churchill.

4 Banking is thus central to the operation of the WMA.

5 However, the banking process is limited by the need to respect existing power contracts.
6 Nalcor's prefiled evidence states:³¹

11 The Independent Coordinator would not be able to schedule production for Nalcor where
7 12 such production would conflict with CF(L)Co's obligations under prior power contracts.

8 Along the same lines, it also states:³²

16 ***5.1. Effect of the WMA on the Parties***

17 Section 5.7 of the EPCA requires that existing power contracts not be adversely affected by
18 the provisions of a water management agreement. The WMA recognizes the existing
19 contractual obligations of CF(L)Co, and provides that the operation of the hydroelectric
20 facilities on the Churchill River under the terms of the WMA will have no effect on CF(L)Co's
9 21 ability to meet its delivery requirements.

10 In its response, CF(L)Co noted that:

³⁰ NLPUB, Nalcor Energy, Water Management Agreement Application, Pre-filed Testimony, p. 27.

³¹ Ibid., p. 22.

³² Ibid., p. 20.

1 The WMA not only recognizes existing contractual obligations, but ensures that any
2 application and interpretation of the WMA will not result in an adverse effect on a
3 provision of a Prior Power Contract (as defined in the WMA).

4 Accordingly, CF(L)Co's ability to meet its delivery requirements must be unaffected by
5 any water management agreement, as with CF(L)Co's obligations under Prior Power
6 Contracts, including availability requirements. Similarly, CF(L)Co's right to store water in
7 its reservoirs, together with its storage capacity, generating capability and transmission
8 must remain unaffected by any water management agreement.³³

9 It is thus clear that the precise nature of Hydro-Québec's rights under the Power Contract are an
10 important limitation that must be respected by both the design and the operation of the WMA.
11 These rights were the subject of recent litigation, to be discussed in s. 4, below.

12 3.1.2. Renewal provisions of HQ Power Contract

13 The initial term of the HQ contract ended on August 31, 2016. The renewal term runs for 25
14 years starting on Sept. 1 of this year. In its Pre-filed Evidence, Nalcor indicated that certain
15 important provisions of the contract – namely, “Continuous Energy” and “Annual Energy Base”
16 – had different meanings during the renewal term (as provided for by Schedule III to the
17 contract) than during the initial term. Nalcor wrote:³⁴

18 19 As a result, HQ will be entitled to essentially equal amounts of energy during each month
20 after renewal. However, HQ will remain entitled to schedule the hourly deliveries of its
21 monthly entitlement of Continuous Energy at any time during the month.

19 This interpretation of the renewal provisions of the HQ Power Contract is not shared by Hydro-
20 Québec. Indeed, HQ filed a motion in Quebec Superior Court (the forum selected by the parties
21 to the Power Contract) for a declaratory judgement with respect to the renewal provisions. As we

³³ CF(L)Co Submission, Summary of Facts and Issues in Dispute, (ii) Response to Pre-filed Evidence of Nalcor Energy, p. 7.

³⁴ NLPUB, Nalcor Energy, Water Management Agreement Application, Pre-filed Testimony, p. 6.

1 shall see in the next two sections, that Court's judgement, issued in August 2016, rejects
2 Nalcor's interpretation, with profound implications for the operation of the WMA.

3 **3.2. The Quebec Superior Court decision**

4 3.2.1. Positions of the parties

5 HQ's motion asked the Court to make a declaratory judgement with respect to five distinct
6 issues. HQ asked the Court to:

- 7 1) declare that the rights conferred on HQ by virtue of s. 4.1.1 of the Renewal Contract,
8 including its right to schedule and plan power and energy, are in no way limited,
9 circumscribed or constrained on a monthly basis to the purchase of blocks subject to a
10 ceiling of which the quantity would be established based on the notion of "Continuous
11 Energy" under the Renewal Contract., and that these rights can be exercised with respect
12 to all of the available capacity and all the energy produced by Churchill Falls, except for
13 the power and energy associated with the 300 MW Recall Block and the Twinco Block;³⁵
- 14 2) declare that, under the terms of the Renewal Contract, HQ is not constrained to limit its
15 requests for delivery of energy to blocks subject to a monthly ceiling the quantity would
16 be established based on the notion of "Continuous Energy" under the Renewal
17 Contract;³⁶
- 18 3) declare that, under the terms of the Renewal Contract, CF(L)Co is obliged to deliver to
19 HQ, on request, all the available capacity and all the energy produced by Churchill Falls,
20 except for the power and energy associated with the 300 MW Recall Block and the
21 Twinco Block;³⁷

³⁵ « DECLARER que les droits conférés à Hydro-Québec en vertu de l'article 4.1.1 du Contrat renouvelé, y compris son droit de programmation et de planification de la puissance et de l'énergie, ne sont d'aucune manière limites, circonscrits ou restreints, sur une base mensuelle, à l'achat de blocs assujettis à un plafond dont la quantité serait établie sur la base de la notion de « Continuous Energy » prévue au Contrat renouvelé, et qu'ils peuvent être exercés à l'égard de toute la puissance disponible et toute l'énergie produite à la Centrale, à l'exclusion de la puissance et de l'énergie associées au Bloc de 300 MW et au Bloc Twinco. » All translations herein are my own.

³⁶ DECLARER qu'aux termes du Contrat renouvelé, Hydro-Québec n'est pas contrainte de limiter ses demandes de livraison d'énergie a des blocs assujettis a un plafond mensuel dont la quantité serait établie sur la base de la notion de « Continuous Energy» prévue au Contrat renouvelé. »

³⁷ « DECLARER qu'aux termes du Contrat renouvelé, CF(L)Co a l'obligation de livrer a Hydro-Québec, sur demande de celle-ci, toute la puissance disponible et toute l'énergie produite à la Centrale, à l'exception de la puissance et de l'énergie associées au Bloc Twinco et le Bloc de 300 MW. »

- 1 4) declare that, as long as the Contract is in force, until August 31, 2041, CF(L)Co has no
2 right to any quantity of power or energy produced by Churchill Falls, except for the
3 power and energy associated with the 300 MW Recall Block and the Twinco Block;³⁸
4 and
- 5 5) declare that, as long as the Contract is in force, until August 31, 2041, CF(L)Co may not
6 sell to a third party, including NLH, any quantity of power and energy exceeding the
7 quantities associated with the Recall Block, regardless of whether said sales are
8 undertaken on a firm or so-called “interruptible” basis.³⁹

9 In contrast, CF(L)Co asked the court to:

10 « **DECLARE** that under the terms of the Renewal Contract, the right of Hydro-
Quebec to request and receive energy each month during the term of that
contract is limited to the amount of Continuous Energy as defined under the said
Renewal Contract, subject to the Minimum and Firm Capacity limits.

11 **DECLARE** that in addition to the 300 MW of Recapture and in addition to the
Twinco block, CF(L)Co is entitled under the Power Contract and the Renewal
Contract to use the Churchill Falls power plant's available capacity to increase
the rate of delivery of energy to third parties, provided that by so doing it
continues to make available to Hydro-Quebec its requested power and energy
scheduled in accordance with the terms and conditions of the contracts.

12 and

13 **DECLARE** that, as owner and operator of the Churchill Falls power plant and
holder of the hydraulic rights, CF(L)Co is entitled to operate the Churchill Falls
plant as it deems appropriate and is entitled to derive revenues where possible
from selling all electricity products that have not been specifically sold to Hydro-
Quebec or third parties under the terms of a contract, provided that CF(L)Co
fulfills its contractual obligations to Hydro-Quebec and third parties. »

14 The incompatibility of these two interpretations is manifest, as is their importance for the
15 operation of the WMA. The first two declarations requested by CF(L)Co are in effect those

³⁸ « DECLARER que tant que le Contrat sera en vigueur, soit jusqu'au 31 août 2041, CF(L)Co ne jouira d'aucun droit sur aucune quantité de puissance et d'énergie produite à la Centrale, à l'exception de la puissance et de l'énergie associées au Bloc de 300 MW et du Bloc Twinco. »

³⁹ « DECLARER que tant que le Contrat sera en vigueur, soit jusqu'au 31 août 2041, CF(L)Co ne pourra vendre à une tierce partie, y compris NLH, une quelconque quantité de puissance et l'énergie excédant les quantités associées au Bloc de 300 MW, et ce, sans égard au fait que lesdites ventes interviennent sur une base ferme ou prétendument « interruptible ». »

1 described in its Pre-filed testimony.⁴⁰ They are expressly contradicted by the declarations sought
2 by HQ.

3 **3.3. Holdings**

4 In a detailed, 200-page judgement issued on August 8, 2016, Justice Martin Castonguay
5 concluded without reservation in HQ's favour. After a lengthy review of the negotiations
6 leading up to the contract, the judgement concluded that "Continuous Energy" refers to all the
7 energy produced by Churchill Falls (except the reserved blocks, and including surplus energy),
8 for which HQ must pay by virtue of its "Take or Pay" obligation. Thus, it concludes that
9 CF(L)Co cannot sell to a third party what it has already sold to HQ.⁴¹

10 The Court then concludes that CF(L)Co has no right to the power or energy produced by
11 Churchill Falls, even to power and energy not used by HQ, stating that that power and energy
12 belong to HQ, because it has paid for them.⁴²

13 Consequently, the Court granted HQ's motion for a declaration judgement, stating that:

14 ... under Schedule III (Renewal Contract) of the Power Contract of May 12, 1969, HQ
15 enjoys the exclusive right to purchase all available capacity and all energy produced at
16 Churchill Falls, as defined in s. 1.1 of the Original Contract and of the Renewal Contract
17 (the definition of "Plant"), and as *entretenu* in conformity with s. 4.2.4 of the Original

⁴⁰ NLPUB, Nalcor Energy, Water Management Agreement Application, Pre-filed Testimony, p. 6.

⁴¹ « [1138] Ainsi, le Tribunal ayant conclu que « Continuous Energy » correspond a toute l'énergie produite par la Centrale (sauf les Blocs Reserves) même excédentaire telle qu'établie par une expérience de 40 ans et constatée par l'AEB final et que celle-ci doit être payé par H.Q. en vertu de son obligation «Take or Pay», la réponse a la question en litige est relativement simple.

« [1139] En effet, CF(L)Co ne peut vendre a des tiers ce qu'elle a déjà vendu a H.Q. »

⁴² « [1141] Le Tribunal conclut que CF(L)Co n'a aucun droit sur la puissance et l'énergie produite à la Centrale sauf quant a la puissance associée au Bloc de 300 MW (Rappel) et le Bloc Twinco (225 MW) et pour plus de précisions CF(L)Co ne détient aucun droit sur la puissance et l'énergie inutilisée par H.Q. mais a laquelle elle aurait droit puisque payé. »

1 Contract and s.. 4.1.4 of the Renewal Contract, except for the power and energy
2 associated with [the Twinco block and the Recall Block].⁴³

3 It then issued each one of the five declarations sought by HQ, quoted above, almost word for
4 word.

5 **4. SIGNIFICANCE OF QUEBEC SUPERIOR COURT DECISION**

6 ***4.1. Significance for operation of WMA***

7 In the week following the issuance of the Superior Court decision, Mr. Stan Marshall, CEO of
8 Nalcor Energy was reported as stating: “That court case will have no major impact on Muskrat
9 Falls whatsoever.” According to the CBC, he also “reaffirmed that a water management
10 agreement is in place on the river, meaning the power plants have to work together to coordinate
11 power production, [and] and the court decision won't change that.”⁴⁴

12 Mr. Marshall is undoubtedly correct that a water management agreement is in place on the river.
13 It was duly established by this Board under existing legislation, and clearly remains in effect.

14 However, the question remains: **What is the effect of the WMA, in light of the Quebec**
15 **Superior Court decision?**

⁴³ [1150] **DECLARE** qu'aux termes de l'Annexe III (**Contrat renouvelé**) du contrat intervenu le 12 mai 1969 entre Churchill Falls (Labrador) Corporation (**CF(L)Co**) et Hydro-Québec, Hydro-Québec jouit du droit exclusif d'acheter toute la puissance disponible et toute l'énergie produite à la centrale du Haut Churchill, telle que définie à l'article 1.1 du Contrat original et du Contrat renouvelé (à la définition de « Plant») et telle qu'entretenu conformément aux articles 4.2.4 du Contrat original et 4.1.4 du Contrat renouvelé (Centrale), à l'exception de la puissance et de l'énergie associées :

- (i) Au bloc de 225 MW qui était réservé à CF(L)Co pour satisfaire ses obligations envers Twin Falls Power Corporation Limited jusqu'au 31 décembre 2014 et qui, sous réserve des conditions énoncées dans le « Shareholders' Agreement » intervenues entre Newfoundland & Labrador Hydro (**NHL**), Hydro-Québec et CF(L)Co le 18 juin 1999, pourra être vendu par CFLCo pour distribution et consommation au Labrador Ouest à compter du 1^{er} janvier 2015 (**Bloc Twinco**); et;
- (ii) au bloc de 300 MW réserve à CF(L)Co pour vente à une tierce partie en vue d'une consommation d'énergie hors Québec (**Bloc de 300 MW**). »

⁴⁴ “Nalcor insists court loss won't impact Muskrat Falls,” CBC News, August 12, 2016.

1 In order to explore this question, it is helpful to look at the intended operation of the WMA under
2 a hypothetical and simplified sequence of transactions.

3 Table 2 shows three hours during which HQ requirements are ramping down and Nalcor
4 requirements are ramping up. In all three hours, the total requirements are 3800 MW. Assuming
5 that the maximum design flow for MFGS (824 MW) also represents the maximum output of
6 CFGS (5438 MW), MFGS output would be approximately 15% of CFGS output. Thus, the
7 optimal combination to meet combined demand in each hour would be for CFGS to generation
8 3300 MW, and for MFGS to generate 500 MW.

9

hr	HQ	Nalcor	CFGS	MFGS	banked	banking
	requirements	requirements	generation	generation	energy	account balance
1	3500	300	3300	500	200	200
2	3300	500	3300	500	0	200
3	3100	700	3300	500	-200	0

10 In Hour 1, MFGS generation is 200 MW more than Nalcor requirements, so 200 MW generated
11 by MFGS is used to meet HQ’s requirements. As a result, 200 MW is “banked” in the MFGS
12 account.

13 In Hour 2, CFGS generation is equal to HQ requirements and MFGS generation is equal to
14 Nalcor requirements, so there is no change in the banking account.

15 In Hour 3, MFGS generation is 200 MW **less than** Nalcor requirements, so 200 MW generated
16 by CFGS is used to meet Nalcor’s requirements. As a result, 200 MW is withdrawn from the
17 MFGS banking account, returning the balance to zero.

18 How would the Quebec Superior Court decision affect this sequence of transactions?

19 In Hours 1 and 2, there is of course no problem. In Hour 1, there is nothing that prevents Nalcor
20 from using MFGS to contribute to meeting HQ’s requirements, or from keeping track of the
21 energy provided in a) banking account.

1 The problem arrives in Hour 3, when Nalcor seeks to recover the banked amount from CF(L)Co.
2 In Hour 3, the WMA authorizes Nalcor to take 200 MW of the CFGS output. However,
3 according to the Superior Court decision, “HQ enjoys the exclusive right to purchase all
4 available capacity and all energy produced at Churchill Falls” (para. 1150) and “CF(L)Co has no
5 right to the power or energy not used by HQ, but to which it is entitled because it has paid for
6 them” (para. 1141). Furthermore, the Decision also states that CF(L)Co is obliged to deliver to
7 HQ, on request, all the available capacity and all the energy produced by Churchill Falls, except
8 for the power and energy associated with the 300 MW Recall Block and the Twinco Block, and
9 that CF(L)Co has no right to any quantity of power or energy produced by Churchill Falls,
10 except for the power and energy associated with these Blocks. It would thus appear that, in Hour
11 3 of our example, HQ would have the exclusive right to purchase (at the rates set out in the
12 Power Contract) the full 3300 MW produced by CFGS, and that Nalcor would have no right,
13 under the Renewal Contract, to claim the return of the 200 MW it had banked in Hour 1.

14 Thus, insofar as the WMA would give Nalcor the right to take these 200 MW in Hour 3, this
15 would appear to come in conflict with s. 5.7 of *EPCA*, and with s. 3.1 of the WMA (quoted
16 above).

17 Thus, it would appear that, given s. 3.1 and the Quebec Superior Court decision, Nalcor cannot
18 claim deliveries of banked energy without adversely affecting a provision of the HQ Power
19 Contract.

20 This suggests that, insofar as the Quebec Superior Court decision stands, the WMA is like a bank
21 account to which Nalcor can deposit, but from which it may not withdraw.

22 ***4.1. Implications for IIS reliability***

23 Nothing in the foregoing should be taken to dispute the logic underlying the Water Management
24 Agreement. It is indeed desirable that the operators of hydro plants coordinate their generation,
25 and the WMA appears to present a mutually beneficial mechanism for so doing.

1 However, the WMA was adopted without the participation or agreement of one of the key
2 players, Hydro-Québec. Instead, an agreement was imposed, relying on the force of law and on
3 Nalcor's innovative interpretation of the renewal provisions of the HQ Power Contract. Unless a
4 higher court eventually overturns the Quebec Superior Court decision (or interprets it in a way
5 inconsistent with this non-lawyer's understanding thereof), it would appear that this strategy has
6 come to nought.⁴⁵

7 In my opinion, there is no fundamental reason why HQ should not eventually agree to such an
8 arrangement, but not without a negotiated agreement.

9 In the absence of one of these developments, it would appear that the available capacity for the
10 MFGS is limited to its actual firm generation capacity during peak hours. As indicated above in
11 section 2.2, based on the flow data made available by Environment Canada, it would appear that
12 this value is likely no greater than 418 MW (at MF).

13 Taking into account line losses, this translates to about 385 MW at Soldiers Pond, of which 167
14 MW is committed to Emera (6am to 10pm, 7 days a week) in the Nova Scotia Block, leaving 218
15 MW of firm capacity from the LIL available to meet IIS capacity requirements – less than one
16 third of the 673 MW of firm capacity for Island use identified by Hydro.⁴⁶

17 To this can perhaps be added at least some of the 110 MW of surplus Recall Power assumed by
18 Hydro to be available until interconnection.⁴⁷

⁴⁵ On August 9, Nalcor issued a press release stating that the company was reviewing the decision and would provide further information once this review is complete. No subsequent news release has been issued in relation to this decision, suggesting that Nalcor has decided not to appeal.
<http://www.nalcorenergy.com/news-releases.asp>

⁴⁶ See s. 2.3. The precise value depends on the methodology used by Hydro to evaluate firm capacity from run-of-river hydro projects.

⁴⁷ ESRA, p. 20. This assumption applies only to the "study period", which apparently refers to the period prior to grid connection, as per a letter from the Board dated February 8, 2016 (quoted on page 1 of the ESRA).

1 **5. SUMMARY AND CONCLUSIONS**

2 Section 2 presented a review of historical flow data above Muskrat Falls, together with the
3 equivalent generation from the Muskrat Falls Generating Station (MFGS), now under
4 construction. This review showed that, since Churchill Falls was commissioned in 1977, average
5 monthly generation (based on average monthly flows) would range from 470 MW in September
6 to 761 MW in May. Winter flows are close to the annual average, and would have resulted in
7 average monthly generation of around 580 MW during the winter months.

8 However, flows vary on all time scales, from year to year, from day to day, and from hour to
9 hour. In the driest year⁴⁸ (1991), average daily generation during winter months would have been
10 just 522 MW, and on the driest winter day (Jan. 2, 1991), it would have been just 418 MW.

11 While long-term hourly data are not available, recent hourly data demonstrate the significant and
12 largely unpredictable variations in flows at Muskrat Falls, and hence in generation from the
13 MFGS.

14 Hydro's capacity planning relies on the Labrador-Island Link (LIL) for 900 MW of reliable
15 capacity at Muskrat Falls, which in turn provides 830 MW of reliable capacity at Soldiers Pond,
16 of which 157 MW are committed to the Nova Scotia Block (16 hours a day, 7 days a week),
17 resulting in 673 MW of available capacity for the IIS. While no precise breakdown is provided
18 of the 900 MW, it appears to rely on availability of 824 MW from the MFGS, supplemented as
19 necessary (in the near term) by up to 110 MW of unused Recall Power.⁴⁹

20 The Water Management Agreement (WMA) between Churchill Falls (Labrador) Corporation
21 (CF(L)Co) and Nalcor Energy establishes a banking mechanism which is meant to give Nalcor
22 access to reliable capacity, regardless of the actual power generated at MFGS at a particular

⁴⁸ It must be kept in mind that flows at Muskrat Falls are only partly due to runoff conditions, and largely result from dispatch by CF(L)Co of the Churchill Falls Generating Station, upstream.

⁴⁹ See note 21.

1 moment. Under its provisions, described in Section 3, energy produced at MFGS that is surplus
2 to Nalcor's needs can be used to meet the needs of Hydro-Québec (HQ), which would otherwise
3 be provided by Churchill Falls Generating Station (CFGS). This would result in the "banking"
4 of energy, which Nalcor could claim, as needed, during hours when the output of MFGS was
5 insufficient to meet its needs.

6 It is important to note that the WMA includes provisions to protect all rights under existing
7 power contracts, including the Churchill Falls Power Contract between CF(L)Co and HQ.

8 In its prefiled evidence, Nalcor Energy explained that the provisions of that contract would
9 change substantially at its renewal date (Sept. 1, 2016); after that date, HQ's entitlement would
10 be limited to fixed amounts of energy each month.

11 HQ disputes this interpretation of the renewal provisions of its Power Contract, and sought a
12 declaratory judgement in this regard from the Quebec Superior Court (the chosen forum under
13 the Power Contract). In a decision dated August 8, 2016, that Court endorsed HQ's
14 interpretation, declaring that, under the contract, HQ has the exclusive right to purchase all
15 available capacity and all energy produced at Churchill Falls.

16 A simplified analysis of the banking mechanism, presented in Section 4, demonstrates that, while
17 the WMA remains operational, there appears to be no way for Nalcor to recover any energy that
18 it has "banked" at Churchill Falls without infringing on HQ's rights under the Power Contract.
19 Thus, though the WMA remains in place, it cannot have its intended effect. Insofar as the
20 Quebec Superior Court decision stands, the WMA appears to resemble a bank account to which
21 Nalcor can deposit, but from which it may not withdraw.

22 The underlying logic of the Water Management Agreement remains valid: it is indeed desirable
23 that the operators of hydro plants coordinate their generation, and the WMA appears to present a
24 mutually beneficial mechanism for so doing. However, the WMA was adopted without the
25 participation or agreement of Hydro-Québec. Instead, an agreement was imposed, relying on the
26 force of law and on Nalcor's innovative interpretation of the renewal provisions of the HQ
27 Power Contract. Unless a higher court eventually overturns the Quebec Superior Court decision

1 – and Nalcor has not indicated that it intends to appeal the decision – or interprets it in a way
2 inconsistent with the understanding presented herein, it would appear that this strategy has come
3 to nought.

4 In my opinion, there is no fundamental reason why HQ should not eventually agree to such an
5 arrangement, but not without a negotiated agreement. Until then, the power available to Nalcor
6 from the MFGS will be limited to its actual generation capacity. As we have seen, daily average
7 winter generation at the MFGS has fallen as low as 418 MW. Depending on the methodology
8 used by Hydro to evaluate firm capacity from run-of-river hydro projects, this value may provide
9 an indication of the firm capacity of the MFGS.

10 Taking into account line losses, this translates to about 385 MW at Soldiers Pond, of which 167
11 MW is committed to Emera in the Nova Scotia Block, leaving just 218 MW of firm capacity
12 from the MFGS available to meet IIS capacity requirements – less than one third of the 673 MW
13 of firm capacity identified by Hydro for this purpose.

14 To this can perhaps be added at least some of the 110 MW of surplus Recall Power assumed by
15 Hydro to be available until interconnection.⁵⁰

16 The unavoidable implication is that the capacity balances presented by Hydro in this Reliability
17 Inquiry systematically overstate available firm capacity, by up to 400 MW.

⁵⁰ ESRA, p. 20. See note 47.

1 **QUALIFICATIONS**

2 Cofounder of the Helios Centre, Philip Raphals has extensive experience in many aspects of
3 sustainable energy policy, including least-cost energy planning, utility regulation (including
4 transmission ratemaking) and green power certification. He is the author of numerous studies
5 and reports and frequently appears as an expert witness in the regulatory arena.

6 From 1992 to 1994, Mr. Raphals was Assistant Scientific Coordinator for the Support Office of
7 the Environmental Assessment of the Great Whale hydro project, where he coauthored a study
8 on the role of integrated resource planning in assessing the project's justification.⁵¹

9 In 1997, he advised the Standing Committee on the Economy and Labour of the Quebec National
10 Assembly in its oversight hearings concerning Hydro-Québec. In 2001, he authored a major
11 study on the implications of electricity market restructuring for hydropower developments,
12 entitled *Restructured Rivers: Hydropower in the Era of Competitive Energy Markets*. In 2005,
13 he advised the Federal Review Commission studying the Eastmain 1A/Rupert Diversion hydro
14 project with respect to project justification. Later, he drafted a submission to this same panel on
15 behalf of the affected Cree communities of Nemaska, Waskaganish and Chisasibi.

16 Mr. Raphals appeared as an expert witness on behalf of Grand Riverkeeper Labrador Inc. in the
17 hearings of the Joint Review Panel (JRP) on the Lower Churchill Generation Project, which
18 retained many of his suggestions. He also presented testimony to the Newfoundland and
19 Labrador Public Utilities Board in the context of its advisory hearings concerning the Muskrat
20 Falls project.

21 In 2014, he presented expert testimony to the Nova Scotia Utility and Review Board in the
22 proceedings concerning the Maritime Link, on behalf of the Canadian Wind Energy Association

⁵¹ J. Litchfield, L. Hemmingway, and P. Raphals. 1994. *Integrated resources planning and the Great Whale Public Review*. Background paper no. 7, Great Whale Public Review Support Office, 115 pp. (also published in French).

1 and, for the compliance phase, the Low Power Rates Alliance. In 2015, he provided expert
2 testimony to this Board in its review of Hydro's Amended GRA, on behalf of the Innu Nation.

3 In British Columbia, Mr. Raphals provided expert testimony on behalf of the Treaty 8 Tribal
4 Association before the Joint Review Panel examining the proposal to build the Site C
5 Hydroelectric Project. He also provided expert testimony in two judicial proceedings in relation
6 to this project.

7 Mr. Raphals chairs the Renewable Markets Advisory Panel for the Low Impact Hydropower
8 Institute (LIHI) in the United States. He has also played a role in developing the low impact
9 renewable electricity guideline for the Canadian Ecologo programme.

10 Mr. Raphals is also a frequent expert witness before the Quebec Energy Board (the Régie de
11 l'énergie du Québec). He has appeared before the Régie as an expert witness with respect to
12 transmission tariffs (FERC), issues related to the integration of wind power, security of supply
13 with respect to hydropower, energy efficiency and avoided costs, and sustainable development
14 criteria.

**APPENDIX A —
Environment Canada Flow Data
Churchill River above Muskrat Falls
(Station 03OE001)**

**Muskrat Falls' Contribution
to the Reliability of the
Island Interconnected System**

**Philip Raphals
for Grand Riverkeeper
October 17, 2016**

ID	PARAM	TYPE	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
03OE001	1	1	1954	726	611	568	454	2140	3090	2160	1990	2800	2050	1390	876	1580
03OE001	1	1	1955	740	564	511	468	2260	3580	1700	885	681	782	831	713	1140
03OE001	1	1	1956	632	562	490	433	832	4680	5140	2780	2000	2250	2010	1390	1940
03OE001	1	1	1957	804	431	277	290	565	5220	4660	2410	1980	1960	1280	807	1730
03OE001	1	1	1958	813	724	677	736	2570	5360	3510	2410	2600	1990	1340	905	1970
03OE001	1	1	1959	622	443	361	348	2330	4910	2830	1790	1080	1200	1650	1050	1560
03OE001	1	1	1960	678	575	460	405	2070	3740	2480	1880	2150	2220	1570	942	1600
03OE001	1	1	1961	650	502	412	480	1650	2890	2410	1610	990	1600	1390	873	1290
03OE001	1	1	1962	686	487	354	280	1450	3850	2970	1580	1270	1120	770	555	1280
03OE001	1	1	1963	425	367	323	345	1990	3920	2830	1850	1470	1290	1060	642	1380
03OE001	1	1	1964	564	521	499	563	2330	4490	2740	1680	1740	1570	1240	819	1560
03OE001	1	1	1965	607	526	493	487	1880	4420	4120	2750	2710	2200	1420	842	1880
03OE001	1	1	1966	616	532	483	462	816	4300	5310	3000	1910	2050	2250	1240	1920
03OE001	1	1	1967	842	645	519	452	1520	3480	2480	1900	1170	1240	1630	1150	1420
03OE001	1	1	1968	744	662	619	701	2790	4350	2340	1720	2270	2420	1910	1160	1810
03OE001	1	1	1969	901	805	760	781	1890	5070	4300	2530	1980	2330	2070	1550	2090
03OE001	1	1	1970	1020	883	805	789	1210	3910	3480	1850	1280	1110	907	593	1490
03OE001	1	1	1971	533	499	483	608	2850	4130	2340	1120	983	1340	1000	909	1400
03OE001	1	1	1972	741	766	776	773	995	4310	1590	1170	1060	1600	1040	1100	1320
03OE001	1	1	1973	1540	1710	1020	960	2650	1820	1430	1090	1130	1280	1280	1320	1440
03OE001	1	1	1974	1240	1330	1260	1790	2100	3630	1680	1280	1290	1520	1330	1410	1650
03OE001	1	1	1975	1340	1340	1290	1280	2100	4070	2320	2560	1740	1620	1610	1520	1900
03OE001	1	1	1976	1600	1620	1480	1650	3200	2510	1880	2310	2720	2310	1600	1580	2040
03OE001	1	1	1977	1670	1530	1460	2130	2850	4220	1570	1890	2100	2530	2010	2030	2170
03OE001	1	1	1978	2050	2070	1970	1810	2880	3590	2060	2490	2110	2260	1840	1990	2260
03OE001	1	1	1979	2020	2070	2030	2060	3600	1980	2790	2830	1840	2080	2230	1840	2280
03OE001	1	1	1980	1780	1840	1850	1810	3530	2960	2730	1950	1720	1960	1990	1980	2180
03OE001	1	1	1981	2040	2050	1890	1640	2800	3240	3020	2320	1650	2070	2060	2070	2240
03OE001	1	1	1982	1980	1970	1980	1820	2400	3530	1990	1700	1730	1340	1500	1580	1960
03OE001	1	1	1983	1610	1590	1520	1710	3060	1920	1640	1440	1550	1850	1800	1910	1800
03OE001	1	1	1984	1940	1850	1810	1630	3360	2850	1890	1620	1880	1820	1840	1840	2030
03OE001	1	1	1985	1790	1830	1700	1490	1960	2990	1680	1590	1430	1750	1670	1820	1810
03OE001	1	1	1986	1800	1770	1710	1590	2600	1690	1500	1420	1570	1670	1540	1780	1720
03OE001	1	1	1986	1820	1890	1730	1870	2140	1570	1390	1510	1500	1880	1990	1990	1770
03OE001	1	1	1988	2150	2150	1880	1280	2530	1960	1720	1130	1230	1680	1760	1690	1760
03OE001	1	1	1990	1840	1870	1520	997	1920	2000	1410	1400	1420	1560	1440	1450	1570
03OE001	1	1	1991	1700	1680	1590	1340	1750	2130	1550	1190	1130	1230	1460	1450	1510
03OE001	1	1	1992	1440	1460	1290	1110	1870	2180	1340	1530	1530	1590	1550	1700	1550
03OE001	1	1	1993	1780	1800	1820	1690	2670	1730	1420	1560	1350	1800	1590	1720	1740
03OE001	1	1	1994	1770	1770	1200	1090	2200	2190	1550	1640	1530	1540	1820	1800	1680
03OE001	1	1	1995	1850	1840	1500	1500	2650	1750	1540	1080	1090	1270	1260	1650	1580
03OE001	1	1	1996	1500	1420	913	958	2240	1850	1900	1480	1370	1560	2120	1850	1600
03OE001	1	1	1997	1860	1760	1720	1400	2460	2670	1860	1590	1680	1810	1810	1590	1850
03OE001	1	1	1998	1870	1950	1920	1800	3790	2170	1320	1370	1820	2100	2030	1820	2000
03OE001	1	1	1999	1860	1850	1810	1620	3580	1860	1540	1670	1470	1650	1880	1940	1900
03OE001	1	1	2000	1960	1940	2030	1850	2460	2450	1650	1200	1220	1370	1620	1820	1800
03OE001	1	1	2001	2070	2090	2000	1470	2960	1640	1430	1360	1360	1580	1760	1910	1800
03OE001	1	1	2002	1910	1860	1870	1530	1970	2670	1380	1740	1610	1880	1870	1700	1830
03OE001	1	1	2003	1820	1860	1840	1570	3010	1760	1470	1190	1290	1360	1670	1850	1720
03OE001	1	1	2004	2020	1890	1750	1430	2580	2740	1230	1240	1070	1560	1810	1720	1750
03OE001	1	1	2005	1820	1820	1780	1600	2310	1470	1260	1540	1530	1380	1770	2220	1710
03OE001	1	1	2006	2050	2030	2000	1670	3270	1510	1360	1600	1360	1540	1970	1930	1860
03OE001	1	1	2007	1690	1740	1590	1400	2350	2030	1370	1170	1550	1300	2010	2090	1690
03OE001	1	1	2008	2010	2010	2060	1580	3020	1570	1450	1230	1250	1500	1730	1740	1760
03OE001	1	1	2009	1650	1700	1680	1460	2370	1970	1040	1030	1420	1490	1640	1750	1600
03OE001	1	1	2010	1760	1840	1680	1760	2890	2050	1590	1430	1140	1420	1980	1920	1790
03OE001	1	1	2011	1870	2040	1870	1640	2330	2020	1820	1210	1360	1430	1870	1780	1770
03OE001	1	1	2012	1900	1990	1850	1540	3680	1970	1550	1330	1340	1690	2080	2000	1910
03OE001	1	1	2013	1970	1940	1910	1540	2940	1770	1400	1510	1450	1500	1990	2070	1830
03OE001	1	1	2014	1990	2090	2040	1690	2410	1540	1310	1040	1340	1560	1970	2130	1760
03OE001	2	8	2011	16.967	17.222	16.949	16.575	17.609	17.171	16.86	15.806	16.084	16.201	16.968	16.856	16.8
03OE001	2	8	2012	17.003	17.142		16.412	19.221	17.076	16.422	16.019	16.052	16.638	17.268		
03OE001	2	8	2013				16.409	18.433	16.745	16.163	16.341	16.239	16.34	17.137	17.257	
03OE001	2	8	2014	17.139	17.286	17.221	16.639	17.625	16.395	15.988	15.436	16.047	16.43	17.103	17.344	16.7