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Contract Deliverable 3.1.1.1 – Interim Report on the Predicted Hydrological Regime: Future Discharge at Fredericton (Station 01AK003)

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DISCLAIMER

Intended use and technical limitations of the report, "Interim Report on the Predicted Hydrological Regime: Future Discharge at Fredericton". The sole purpose of this report is to provide a first prediction of discharge (flow) at the Mactaquac Generating Station site with and without a dam. It is the first step in the ongoing and longer-term Ecological Limits of Hydrologic Alteration (ELOHA) process to establish appropriate Environmental Flows for the MGS location. The predicted flow regimes are subject to change as our understanding and modelling of river discharge evolve during the course of the larger MAES project.

Planning Goal 3.1 "Examine flow management requirements for a renewed MD, 2030-80."

Project 3.1.1.1 "Report on the modelled/predicted trends for the hydrological regime of the SJR 2030-80." - *Goal is to inform the current EIA process and engineering solutions more broadly by modeling and predicting trends for the hydrological regime of the river 2030-80.*

EXECUTIVE SUMMARY

The foundation or initial working predicted future flow (discharge) regime for the Saint John River (SJR) at the current Mactaquac Generating Station (MGS) location is presented. This first examination describes the predicted regimes for the MGS location with and without the Beechwood Generating Station (BGS). Such foundation flows regimes are the first step required for building the framework for the ongoing and longer-term Ecological Limits of Hydrologic Alteration (ELOHA) process to establish appropriate Environmental Flows for the MGS location. Analyses are based on flow and level records for Environment Canada stations at Fort Kent (Environment Canada Station 01AD002) upstream of all flow control structures and the Fredericton (Station 01AK003). MGS flows were provided by NB Power. Reported are the predicted flow regime for the period 1970-2012 for (1) a natural, free-flow river at the MGS site, i.e., if both the MGS and BGS did not exist and (2) with consideration for the effects of the BGS.

INTRODUCTION

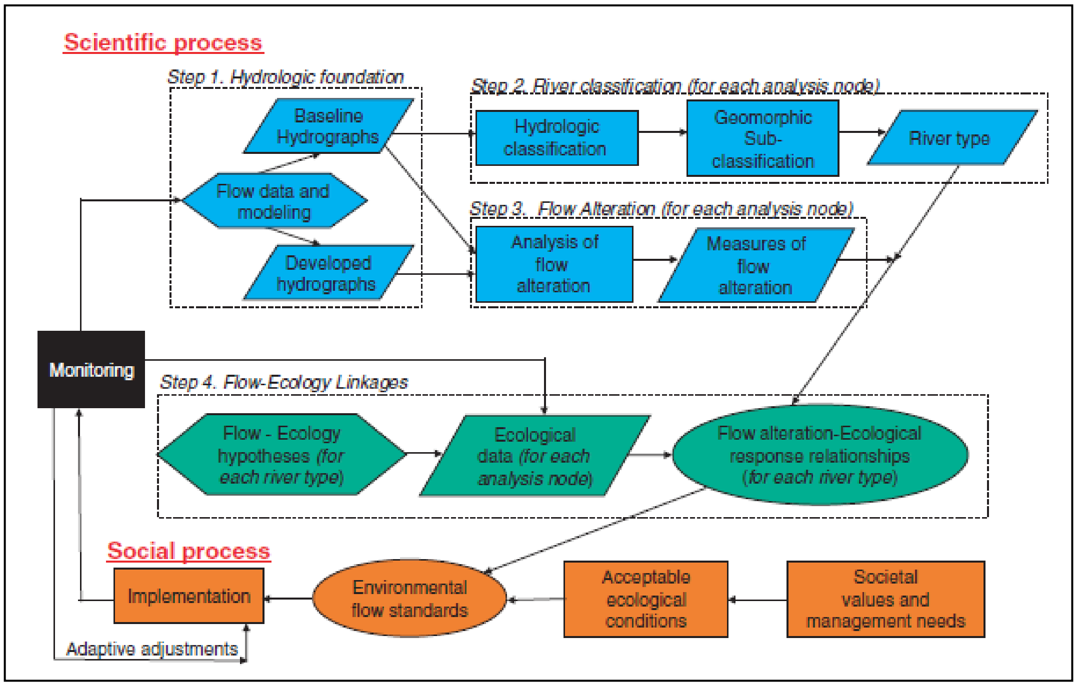
The goal of the project is to generate an appropriate environmental flow (discharge) regime for the Saint John River (SJR) at the current location of the Mactaquac Generating Station (MGS). The environmental flow is "…the quantity, quality and timing of water flows required to sustain freshwater ecosystems and the human livelihoods and well-being that depend on these ecosystems" (Brisbane Declaration 2007). Such a regime protects the natural ecosystem while addressing needs for water use among all stakeholders. The natural ecosystem is described by its ecological flow requirements, i.e., the flows and water levels required to provide for the ecological function of the flora and fauna present in a water body and its margins (New Zealand Ministry of the Environment 2008). Ecological function is sometimes referred to as the goods and services provided by the river, e.g., habitats and adequate water quality. Proper function is sustained by the natural dynamic character of the flow regime (Poff et al. 1997) or the inter- and intra-annual flow patterns of the natural hydrograph (Annear et al. 2004).

The final flow regime will be developed using the Ecological Limits of Hydrologic Alteration (ELOHA) approach (Poff et al. 2010, Arthington et al. 2006). This is a holistic environmental flow framework that has been developed and adopted worldwide during the past two decades (Tharme 2003). The framework is based on the premise that maintaining some resemblance to the natural hydrological regime in necessary to sustain healthy river ecosystems. The framework integrates the biophysical sciences, typically hydrology, geomorphology, water quality, and various disciplines of ecology, with social, cultural, and economic values to generate ecosystem protection goals specifically, the flow regimes. The method and its final consensus recommendations incorporate both the expert knowledge on river-specific data and observations, as well as input from the river's watershed stakeholders (Arthington 1998, Poff et al. 2010, Arthington et al. 2006).

The ELOHA has a framework built from scientific and social processes in five steps (Poff et al. 2010):

Step 1: Hydrologic modeling for baseline and status quo hydrographs in the region.
Step 2: Classification of rivers (or river segments) based on flow regime and geomorphic types.
Step 3: Determination of the extent of alteration.
Step 4: Development of flow-ecology relationships for the different river types.
Step 5: Establishing environmental flow standards with subsequent monitoring and adaptive management.

Figure 1. The Ecological Limits of Hydrologic Alteration (ELOHA) structure and process schematic from Poff et al. (2010).



This interim report describes the foundation flow regimes for the MGS site with and without the Beechwood Generating Station (BGS). The regimes represent the starting estimate of Environmental Flows to initiate Step 1 of the ELOHA process. For example, the ongoing ELOHA analyses will reconstruct the regime based on the Indicators of Hydrologic Alteration (IHA). The development of naturalized flows using a hydrogical budget approach is sometimes preferred in river systems with reservoirs. We will also be examining such a model in Project 1B.2.2 *Modeling predicted thermal regimes downstream during reservoir drawdown.*

Report Deliverables:
The predicted, foundation regimes required to initiate generation of appropriate Environmental Flows for the MGS site. Specifically:

1) A characterization of baseline flow hydrographs for the periods pre-Mactaquac Dam.
2) The predicted flow regime for the period 1970-2012 for a natural, free-flow river at the MGS site, i.e., if both the MGS and BGS did not exist.
3) The predicted flow regime for the period 1970-2012 with consideration for the sole effects of the BGS.

METHODOLOGY

Baseline Flows

Baseline flow (discharge) conditions were established using archived data from the Water Survey of Canada (http://wateroffice.ec.gc.ca). The flow regime at the Fort Kent, Environment Canada Station 01AD002 (reported as m^3/s) was used to calibrate and predict the natural change in flow regimes over time for the SJR. This station is upstream of all flow control structures. In the current analyses, no consideration of changes in climate (1930 to present day) or differences in climate between Fort Kent (47°15'29"N, 68°35'45" W) and the MGS (45°57'24" N, 66°51'53" W) were incorporated into the models.

The Fredericton Station (01AK003; 45°57'58" N, 66°39'5" W; ~20km downstream of the MGS) has a continuous record of daily water level (reported as m) that matches the Fort Kent station reporting period. Flow records for the MGS begin post-dam construction in 1968; three daily flows (cfs) are recorded and were provided by NB Power (1968-2012). A temporary Environment Canada monitoring station downstream of the MGS operated from 1961-95 (01AK004: 45° 57' 44'', 66° 49' 51''; daily flow reported as m^3/s).

In this report, we focus on weekly average flows, i.e., baseline data are the 7-day average of the reported daily flow (see Table 1A and Figure 1) and level (Table 1B – Fredericton station).

We examine three flow regime periods: (1) pre-Beechwood Dam (1926-50), (2) post-Beechwood/pre-Mactaquac Dam (1958 to 1962), and (3) post-Mactaquac Dam (1970-2012). The period post-Mactaquac Dam is the representation of the current state of the river's flow regimes (including the predicted flows without the MGS and BGS). The BGS factor is examined because the construction of this facility (1957) or the flow control reservoirs around the same period (Tobique Narrows, Long, Trousers, and Serpentine in the early 1950s; P. Gilks, NB Power, pers. comm.) are correlated with changes in the flow regime at Fredericton (Cunjak et al. 2011). Future flow regimes will be examined once the climate change models are developed for the watershed and river.

Table 1A. The Fort Kent, weekly average discharge (m^3/s) and 1 standard deviation (SD) for the periods: pre-Beechwood Dam = 1926-50; post-Beechwood Dam/pre-Mactaquac Dam = 1958-62; and post-Mactaquac Dam = 1970-2012.

	Pre-Beechwood Dam (1926-50)		**Post-Beechwood/Pre-Mactaquac (1958-62)**		**Post-Mactaquac Dam (197-2012)**	
Week	**Average (n = 22-24)**	**1 SD**	**Average (n = 5)**	**1 SD**	**Average (n = 42)**	**1 SD**
1	95	51	183	203	140	108
2	90	49	112	73	110	54
3	89	51	94	60	110	69
4	79	51	81	45	116	117
5	68	37	68	32	111	94
6	56	25	57	23	106	82
7	52	24	53	20	90	62
8	51	29	51	23	85	69
9	47	24	48	19	95	110
10	45	20	49	17	89	82
11	46	20	56	20	105	91
12	53	25	56	19	132	103
13	140	331	55	16	231	290
14	224	365	91	49	436	489
15	295	344	225	200	550	470
16	522	426	350	233	735	510
17	972	585	841	387	1,141	561
18	1,129	580	1,222	582	1,482	741
19	1,379	589	1,373	570	1,226	627
20	1,165	654	1,323	930	869	532
21	837	437	825	493	637	464
22	616	428	529	347	463	254
23	443	250	393	231	377	221
24	343	147	303	110	274	112
25	333	178	264	128	229	115
26	286	167	210	74	227	118
27	252	147	179	108	231	137
28	205	91	153	97	202	130
29	212	102	185	126	190	149
30	167	87	174	155	167	122
31	159	111	127	89	155	106
32	156	139	129	90	190	244
33	130	105	177	145	222	287
34	109	80	191	183	157	147
35	114	105	270	255	137	141
36	99	58	226	152	133	130
37	82	51	180	140	145	147
38	130	143	197	147	142	135

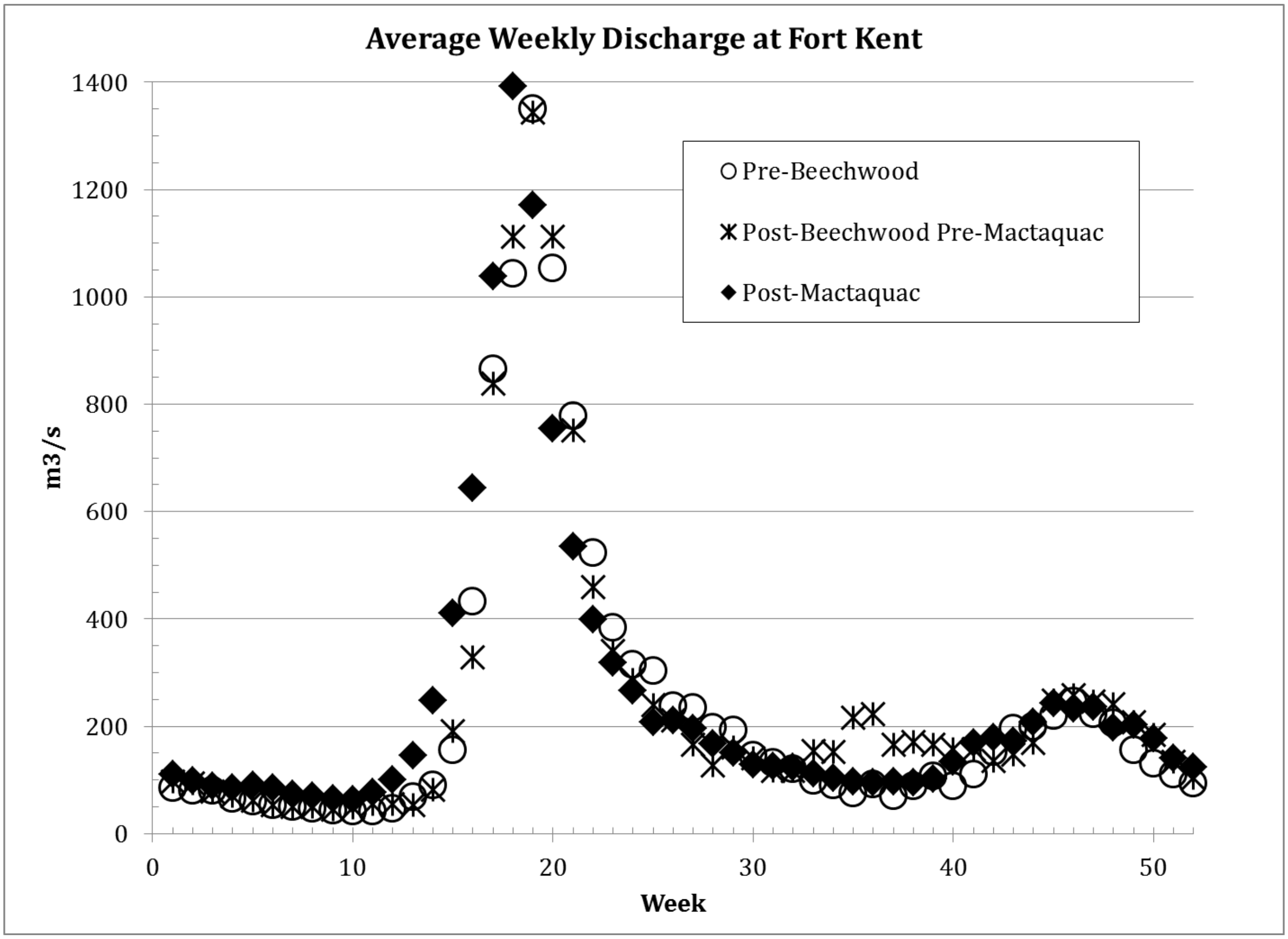
	Pre-Beechwood Dam (1926-50)		Post-Beechwood/Pre-Mactaquac (1958-62)		Post-Mactaquac Dam (197-2012)	
Week	**Average (n = 22-24)**	**1 SD**	**Average (n = 5)**	**1 SD**	**Average (n = 42)**	**1 SD**
39	151	133	173	101	137	140
40	118	83	156	91	168	136
41	140	99	159	104	202	145
42	183	124	147	104	222	187
43	218	141	150	88	243	211
44	225	149	173	60	249	196
45	255	175	255	128	282	195
46	269	169	346	362	246	126
47	283	233	287	211	274	168
48	226	140	263	182	238	152
49	209	195	232	153	242	170
50	195	192	190	95	193	105
51	149	161	138	47	165	108
52	109	67	106	22	155	110

Table 1A. The Fredericton, weekly average water level (m) and 1 standard deviation (SD) for the periods: pre-Beechwood Dam = 1926-50; post-Beechwood Dam/pre-Mactaquac Dam = 1958-62; and post-Mactaquac Dam = 1970-2012.

	Pre-Beechwood Dam (1926-50)		Post-Beechwood/Pre-Mactaquac (1958-62)		Post-Mactaquac Dam (197-2012)	
Week	**Average (n = 22-24)**	**1 SD**	**Average (n = 5)**	**1 SD**	**Average (n = 42)**	**1 SD**
1	1.4	0.6	2.4	1.2	2.0	0.7
2	1.4	0.6	2.0	0.8	1.8	0.4
3	1.4	0.5	1.8	0.6	1.8	0.5
4	1.3	0.5	1.9	0.6	1.8	0.6
5	1.2	0.4	1.7	0.5	1.9	0.6
6	1.1	0.3	1.5	0.4	1.8	0.6
7	1.1	0.3	1.5	0.4	1.7	0.5
8	1.1	0.3	1.6	0.5	1.6	0.5
9	1.1	0.3	1.5	0.5	1.7	0.6
10	1.1	0.3	1.4	0.3	1.8	0.6
11	1.1	0.4	1.4	0.3	1.9	0.7
12	1.4	0.6	1.5	0.4	2.1	0.7
13	1.7	1.2	1.6	0.4	2.5	0.9
14	2.3	1.3	2.3	0.6	3.2	1.3
15	2.7	1.2	3.6	1.1	3.5	1.2
16	3.4	1.2	3.5	0.7	3.8	1.1
17	4.2	1.2	4.3	0.9	4.6	1.0

	Pre-Beechwood Dam (1926-50)		Post-Beechwood/Pre-Mactaquac (1958-62)		Post-Mactaquac Dam (197-2012)	
Week	**Average (n = 22-24)**	**1 SD**	**Average (n = 5)**	**1 SD**	**Average (n = 42)**	**1 SD**
18	4.4	1.0	5.1	1.4	5.1	1.2
19	4.5	0.9	5.1	1.0	4.8	1.3
20	4.2	1.1	5.0	1.7	4.1	1.2
21	3.6	0.9	4.0	1.5	3.5	1.1
22	2.9	0.8	3.3	1.6	2.9	0.8
23	2.4	0.6	2.8	1.5	2.6	0.8
24	2.0	0.5	2.4	0.8	2.2	0.6
25	1.9	0.6	2.2	0.6	2.0	0.5
26	1.9	0.5	2.0	0.2	1.8	0.5
27	1.8	0.5	1.9	0.3	1.8	0.5
28	1.6	0.4	1.7	0.4	1.7	0.5
29	1.5	0.4	1.6	0.3	1.7	0.5
30	1.3	0.4	1.7	0.7	1.6	0.5
31	1.2	0.3	1.6	0.5	1.5	0.4
32	1.2	0.4	1.5	0.5	1.5	0.5
33	1.1	0.3	1.6	0.6	1.7	0.7
34	1.1	0.4	1.6	0.7	1.5	0.5
35	1.1	0.4	1.9	1.0	1.4	0.4
36	1.0	0.2	1.8	0.7	1.4	0.4
37	0.9	0.2	1.5	0.4	1.4	0.5
38	1.0	0.3	1.6	0.5	1.4	0.4
39	1.2	0.4	1.5	0.4	1.4	0.5
40	1.2	0.4	1.6	0.6	1.5	0.5
41	1.2	0.4	1.5	0.5	1.6	0.6
42	1.3	0.6	1.4	0.4	1.7	0.7
43	1.4	0.6	1.7	0.4	1.8	0.8
44	1.6	0.8	1.9	0.5	1.9	0.9
45	1.7	0.8	2.3	0.7	2.1	0.9
46	1.8	0.8	2.1	0.8	2.1	0.7
47	1.8	0.6	2.1	0.8	2.2	0.8
48	1.8	0.6	2.6	1.3	2.2	0.8
49	1.9	0.8	2.4	0.9	2.2	0.8
50	1.8	0.9	2.3	0.8	2.1	0.7
51	1.7	0.9	2.2	0.6	2.1	0.8
52	1.5	0.6	1.9	0.4	2.0	0.7

Figure 2. The Fort Kent, weekly average discharge as m^3/s for the periods: pre-Beechwood Dam = 1926-50; post-Beechwood Dam/pre-Mactaquac Dam = 1958-62; and post-Mactaquac Dam = 1970-2012.



Predicting the Changes in Flow Regimes among Periods

Step 1 – Modelling River Level at Fredericton

A probabilistic approach was selected to account for the distribution of weekly average river level (average based on a mode = 7 of daily records) for the pre-Beechwood Generating Station period. These weekly distributions were modeled in MATLAB (R2013a; n = 22 years; Table 2). One distribution per week was selected based on visual Goodness of Fit and Chi-square tests. All distributions were fitted using maximum likelihood methods when possible or method of moments when maximum likelihood methods were not deemed possible. Based on the selected weekly distribution models, e.g., a Log-normal distribution, the predicted water levels were estimated for probabilities (P) of non-exceedance at 0.05, 0.25, 0.50, 0.75 and 0.95 (Table 2). These are interpreted as: levels ≤ Level $_{P=0.05}$ have a 5% chance of occurrence, levels ≤ Level $_{P=0.25}$ have a 25% chance of occurrence, etc., and levels ≥ Level $_{P=0.95}$ have 5% chance of occurrence.

Table 2. Modelled water (river) level for probabilities of exceedance at Fredericton's Environment Canada gauging station for the pre-Beechwood Generating Station period, 1928 to 1950.

		Probability of non-Exceedance				
Week	**Modelled Distribution** (parameters in model)	**0.05**	**0.25**	**0.50**	**0.75**	**0.95**
1	Log-normal	0.69 *	1.00	1.29	1.66	2.43
2	GEV	0.75	1.03	1.25	1.47	1.79
3	Logistic	0.54	1.07	1.39	1.70	2.24
4	Logistic	0.47	0.96	1.25	1.55	2.04
5	Logistic	0.56	0.96	1.20	1.44	1.84
6	Logistic	0.71	0.91	1.08	1.30	1.74
7	Logistic	0.59	0.88	1.05	1.21	1.50
8	Gamma	0.61	0.84	1.03	1.25	1.61
9	GEV	0.73	0.89	1.02	1.17	1.46
10	Normal	0.61	0.87	1.05	1.23	1.5
11	Log-normal	0.60	0.84	1.06	1.35	1.89
12	Gamma	0.55	0.93	1.28	1.71	2.49
13	Log-normal	0.74	1.13	1.52	2.04	3.12
14	Log-normal	0.88	1.41	2.00	2.80	4.53
15	GEV	1.41	2.08	2.64	3.28	4.34
16	Logistic	1.39	2.67	3.43	4.18	5.46
17	Logistic	2.32	3.50	4.20	4.91	6.09
18	GEV	3.00	3.65	4.31	5.26	7.60
19	Log-normal	3.20	3.89	4.45	5.11	6.21
20	Log-normal	2.64	3.41	4.08	4.87	6.30
21	GEV	2.45	3.04	3.69	4.88	5.87
22	Weibull	1.49	2.55	3.35	4.16	5.29
23	Gamma	1.48	1.94	2.32	2.74	3.43
24	GEV	1.45	1.67	1.89	2.20	2.94
25	GEV	1.14	1.49	1.77	2.07	2.54
26	Fisher-Tippet (2)	0.49	1.45	1.94	2.32	2.75
27	Logistic	1.01	1.46	1.73	1.99	2.44
28	Logistic	0.89	1.30	1.54	1.78	2.19
29	Log-normal	0.88	1.18	1.42	1.70	2.15
30	Log-normal	0.84	1.08	1.09	1.55	2.00
31	GEV	0.86	1.03	1.18	1.37	1.75
32	Logistic	0.64	0.97	1.17	1.36	1.69
33	Fisher-Tippet (2)	0.26	0.68	0.90	1.07	1.26
34	GEV	0.73	0.86	0.96	1.04	1.16
35	Logistic	0.46	0.79	0.99	1.19	1.52
36	GEV	0.65	0.80	0.91	1.04	1.24
37	Log-normal	0.78	0.95	1.10	1.26	1.54
38	Logistic	0.43	0.77	0.96	1.14	1.45
39	Weibull	0.31	0.67	0.98	1.33	1.86

		Probability of non-Exceedance				
Week	**Modelled Distribution** (parameters in model)	**0.05**	**0.25**	**0.50**	**0.75**	**0.95**
40	Weibull	0.51	0.88	1.16	1.45	1.85
41	GEV	0.62	0.87	1.11	1.43	2.14
42	Weibull	0.45	0.90	1.28	1.68	2.29
43	Weibull	0.49	0.97	1.39	1.84	2.51
44	Weibull	0.5	1.06	1.56	2.12	2.97
45	Weibull	0.55	1.13	1.64	2.19	3.01
46	Normal	0.50	1.29	1.83	2.38	3.17
47	Log-normal	0.94	1.34	1.72	2.21	3.16
48	Gamma	0.88	1.31	1.69	2.14	2.90
49	Log-normal	0.97	1.37	1.75	2.24	3.18
50	GEV	1.03	1.35	1.56	1.76	2.03
51	Logistic	0.29	1.08	1.54	2.01	2.43
52	GEV	0.70	1.05	1.32	1.61	2.06

* For interpretation, Level $_{P=0.05}$ = 0.69 m

Step 2 – Predicting Fredericton Levels

The Fort Kent weekly averages for the pre-Beechwood period (Table 1A) were used to develop non-linear regression models (Table 3) to predict the Fredericton water levels at each probability of exceedance using XLSTAT (ver. 2013.05.02; Table 3).

Step 3 – Modelling the Effects of the BGS

The Fort Kent weekly averages for the post-Beechwood/pre-Mactaquac period 1958-62 (Table 1A) were used to develop a non-linear regression model to predict the Fredericton water level (Table 4). The sample size is small (n = 5), but it is the only period with BGS in place and prior to the completion of the MGS.

The percent difference between the predicted Fredericton level without the BGS, i.e., P = 0.50 from Table 3, and with the BGS (Table 4) was calculated (Table 5). These weekly effects were used to adjust Fredericton levels in the scenarios considering the effect of the BGS.

Table 3. Models predicting Fredericton water (river) level at each probability of exceedance.

Probability of Exceedance	**Observations**	**DF**	**R^2**	**SSE**	**MSE**	**RMSE (m^3/s)**
0.05	52	49	0.891	2.466	0.050	0.224
Model = 0.4082 + 1.8390 x 10^{-3} * (Fort Kent Q) + 2.0070 x 10^{-7} * (Fort Kent Q) ^{2}						
0.25	52	49	0.945	1.850	0.038	0.194
Model = 0.5625 + 3.5301 x 10^{-3} * (Fort Kent Q) - 7.6744 x 10^{-7} * (Fort Kent Q) ^{2}						
0.50	52	49	0.936	3.020	0.062	0.248
Model = 0.6754 + 4.7893 x10^{-3} * (Fort Kent Q) - 1.4416 x 10^{-6} * (Fort Kent Q) ^{2}						
0.75	52	49	0.917	5.712	0.117	0.341
Model = 0.7942 + 6.2837 x 10^{-3} * (Fort Kent Q) - 2.1986 x 10^{-6} * (Fort Kent Q) ^{2}						
0.95	52	49	0.863	16.311	0.333	0.577
Model = 1.0621 + 8.1930 x 10^{-3} * (Fort Kent Q) - 2.9639 x 10^{-6} * (Fort Kent Q) ^{2}						

Table 4. The model predicting Fredericton water (river) level during the post-Beechwood Generating Station and pre-Mactaquac Generating Station period, 1958-62.

Model Parameters	**Value**		**Parameter**	**Value**	**Standard error**
Observations	52		A (constant)	1.210	0.096
DF	49		B	0.004	0.001
R^2	0.890		C	<0.0001	<0.0001
SSE	5.277				
MSE	0.108				
RMSE (water level=m)	0.328				
Equation of the model: Fredericton Level = 1.2099 + 4.2193 x 10^{-3} * (Fort Kent Q) - 1.0870 x 10^{-6} * (Fort Kent Q)^2					

Table 5. Percent change in water level at Fredericton predicted to be the consequence of the Beechwood Generating Station.

Week	**Adjusted for Beechwood (% change in water level)**
1	35.1
2	40.2
3	40.2
4	39.1
5	39.9
6	40.9
7	44.4
8	45.5
9	43.4
10	44.6
11	41.2
12	36.4
13	24.7
14	14.2
15	11.4
16	9.0
17	8.1
18	10.2
19	8.4
20	8.2
21	10.0
22	13.4
23	16.2
24	21.5
25	24.9
26	25.1
27	24.7
28	27.4
29	28.6
30	31.2
31	32.9
32	28.6
33	25.5
34	32.6
35	35.5
36	36.1
37	34.3

Week	Adjusted for Beechwood (% change in water level)
38	34.7
39	35.6
40	31.2
41	27.4
42	25.5
43	23.8
44	23.3
45	21.0
46	23.5
47	21.5
48	24.2
49	23.8
50	28.3
51	31.5
52	32.9

Step 4 – Translating Fredericton Water Levels to Flow at the MGS

There was a large data set of daily and sub-daily levels and flows for Fredericton and the MGS (n = 14,137 days). The MGS sub-daily flows (feet^3/s [cfs] reported in the morning, afternoon, and evening) were regressed separately on Fredericton levels using non-linear approaches in search of an acceptable predictive model (XLSTAT 2013.5.02). Multiple models and transformations were unable to reduce the error in predictions, i.e., RSME were excessive (see Table 6 for an example). While the trends in river flow are consistent between the MGS and Fredericton locations, e.g., $R^2 = 0.94$, the river morphology between locations is complex, e.g., the river valley widening and complex island development. The differences between site effect doesn't appear to be a daily, electricity generation regime phenomenon because the Fredericton level was a similarly poor predictor of the discharge at the Environment Canada monitoring station downstream of the MGS that operated from 1961-95 (RMSE > 8,000).

The sub-daily flows at the MGS reflect the electricity generation regime, e.g., the average sub-daily range = 15,028 cfs and maximum daily range = 229,550 cfs. This variability created substantial errors in models and thus a smoothing transformation was used in the final predictive models: the final models use the 5-day running average of the minimum, sub-daily flow (Table 7). For reference in interpretation of predictions, the Fisheries and Oceans Canada regulated minimum flow at MGS is 2,300 cfs (P. Gilks, NB Power, pers. comm.).

An accurate non-linear model to predict the MGS flow was still not achieved using the 5-day daily minimum. Instead, a distribution analysis was used. The distribution of Fredericton levels (n = 14,137) suggested eight (8) groups or classes of levels (Table 8). Within each class, the distribution of the MGS flows was examined and these were best predicted as either a Log-normal or Normal model. Based on the distribution and its parameters (μ, δ), the probabilities of exceedance at P = 0.05, 0.50, and 0.95 were estimated for each class (Table 9).

Table 6. An example of a model to predict the daily average Mactaquac Generating Station flow (cfs) using the daily Fredericton water (river) level (m).

Model Parameters	Value		Parameter	Value	Standard error
Observations	14,043*		A (constant)	625	320
DF	14,040		B	637	237
R^2	0.940		C	4,168	36
SSE	1,005,905,799,169				
MSE	71,645,712				
RMSE (m^3/s)	8,464				

Equation of the model:

Average Daily Flow at MGS = 625 + 637 * (Fredericton Level) + 4,168 * (Fredericton Level)^2

* missing, matched data were excluded from the model

Table 7. The 5-day running average of the minimum, sub-daily flow at the Mactaquac Generating Station, 1970-2012.

Week	Average	1 SD	Minimum	Maximum
1	8,709	10,175	2,103	67,564
2	6,487	4,613	2,181	25,076
3	7,098	8,136	2,170	61,028
4	7,487	9,295	2,158	63,035
5	7,197	8,500	2,116	58,815
6	6,964	5,644	2,160	33,642
7	6,272	5,273	2,124	27,980
8	5,396	3,887	2,110	23,400
9	6,280	8,367	2,212	61,104
10	6,610	8,113	2,273	60,810
11	7,260	9,140	2,122	66,902
12	9,672	12,723	1,847	110,242
13	13,771	24,200	2,312	162,932
14	22,963	26,650	2,573	177,932
15	46,006	44,493	3,087	201,822
16	58,083	40,670	5,855	161,706
17	88,361	44,248	8,771	218,294
18	112,503	54,043	7,765	258,437
19	99,025	51,175	6,400	250,306
20	74,254	44,182	3,765	189,981
21	51,808	39,269	2,725	182,638
22	34,262	31,505	3,225	173,878
23	24,674	23,470	2,912	117,262

Week	Average	1 SD	Minimum	Maximum
24	17,432	15,603	3,050	69,226
25	12,163	10,765	2,707	61,522
26	11,520	10,403	2,386	50,480
27	10,382	10,322	2,508	54,400
28	9,794	9,399	2,490	52,830
29	9,111	8,353	2,368	59,789
30	7,200	6,776	2,409	50,932
31	6,267	3,730	2,446	21,541
32	7,523	11,263	2,331	88,073
33	10,625	14,323	2,231	76,702
34	8,989	13,090	389	88,318
35	6,647	8,211	412	57,785
36	6,420	6,960	2,076	40,912
37	6,277	7,618	2,328	66,372
38	6,455	7,398	2,349	66,722
39	6,203	6,020	2,360	36,381
40	7,779	8,255	2,508	49,930
41	9,757	10,314	2,456	50,454
42	11,033	11,512	2,462	55,631
43	14,292	18,817	2,410	104,347
44	17,429	20,713	2,286	100,004
45	14,705	13,715	2,198	63,799
46	16,529	15,134	2,228	97,628
47	17,486	18,857	2,416	107,718
48	13,517	14,246	2,156	78,860
49	15,379	17,580	1,634	92,326
50	14,519	18,183	800	120,607
51	12,101	16,546	800	127,412
52	11,575	16,522	1,348	113,297

Table 8. The class distribution of Fredericton water levels since the building of the Mactaquac Generating Station, 1970-2012.

Fredericton Level (m)	Class size
≤1.5 (min. 0.768)	4,579
>1.5 to ≤2.0	3,507
>2.0 to ≤2.5	2105
>2.5 to ≤3.0	1,226
>3.0 to ≤4.0	1,401
>4.0 to ≤5.0	698
>5.0 to ≤6.0	394
>6.0 (max. 8.286)	227

Table 9. The modeled Fredericton water (river) levels (m) based on either a Log-normal or Normal distribution for probabilities of exceedance at P = 0.05, 0.50, and 0.95.

Class Level	Statistic	Data	Parameters	µ	δ	p = 0.50	p = 0.95	p = 0.05
≤1.5 m	Mean	3,812	3,788	8.178	0.350	***3,563***	***6,338***	***2,003***
Model: Log-normal	Variance	2,607,632	1,872,433					
X^2: $p<0.0001$	Skewness	2.326	1.131					
	Kurtosis	8.228	2.357					
>1.5 to ≤2.0 m	Mean	6,689	6,659	8.688	0.481	***5,932***	***13,086***	***2,689***
Model: Log-normal	Variance	13,224,986	11,546,405					
X^2: $p<0.0001$	Skewness	2.343	1.664					
	Kurtosis	13.241	5.294					
>2.0 to ≤2.5 m	Mean	11,805	11,825	9.229	0.547	***10,184***	***25,027***	***4,144***
Model: Log-normal	Variance	46,405,062	48,701,172					
X^2: $p=0.012$	Skewness	1.762	1.976					
	Kurtosis	5.424	7.660					
>2.5 to ≤3.0 m	Mean	21,414	21,750	9.825	0.570	***18,492***	***47,200***	***7,245***
Model: Log-normal	Variance	122,654,523	181,357,831					
X^2: $p<0.0001$	Skewness	0.706	2.095					
	Kurtosis	-0.026	8.698					
>3.0 to ≤4.0 m	Mean	38,992	39,852	10.451	0.532	***34,586***	***83,027***	***14,407***
Model: Log-normal	Variance	301,085,914	520,446,524					
X^2: $p<0.0001$	Skewness	0.365	1.905					
	Kurtosis	-0.337	7.077					

Class Level	Statistic	Data	Parameters	µ	δ	p = 0.50	p = 0.95	p = 0.05
>4.0 to ≤5.0 m	Mean	76,420	76,420	76,420	23,226	***76,420***	***114,622***	***38,217***
Model: Normal	Variance	539,431,103	539,431,103					
X^2: p=0.003	Skewness	0.037	0.000					
	Kurtosis	0.089	0.000					
>5.0 to ≤6.0 m	Mean	120,805	120,805	120,805	28,108	***120,805***	***167,038***	***74,572***
Model: Normal	Variance	790,031,811	790,031,811					
X^2: p<0.0001	Skewness	-0.440	0.000					
	Kurtosis	1.059	0.000					
>6.0 m	Mean	160,333	160,614	11.958	0.239	***156,079***	***231,379***	***105,284***
Model: Log-normal	Variance	1,280,953,852	1,521,018,155					
X^2: p<0.0001	Skewness	0.055	0.743					
	Kurtosis	0.193	0.997					

Step 5 – The Predicted Scenarios

The final step was 1) the prediction of the Fredericton water (river) levels based on the models (Steps 1-3) and then 2) the application of the distribution analyses to predict the flow at the MGS (Step 4) in a No Dam Scenario (neither MGS nor BGS in place) or with the BGS in place (With BGS Scenario).

The predicted flows were the probabilities (P) of non-exceedance at 0.05, 0.25, 0.50, 0.75 and 0.95 interpreted as Flows ≤ Level $_{P=0.05}$ have a 5% chance of occurrence, Flows ≤ Level $_{P=0.25}$ have a 25% chance of occurrence, etc., and Flows ≥ Level $_{P=0.95}$ have 5% chance of occurrence. To assess variability on each prediction, the modelled distribution (log-normal or Normal; Table 9) predictions for non-exceedance at 0.05, 0.50, and 0.95 are presented (Figure 3; Appendix 1 and 2). The results are interpreted as: flows ≤ Level $_{P=0.05}$ have a 5% chance of occurrence, flows <> Level $_{P=0.50}$ have a 50% chance of occurrence, and flows > Level $_{P=0.95}$ have a 5% chance of occurrence. These are all probability-based estimates, not actual predicted absolute values.

SUMMARY

The report presents the predicted baseflows (m^3/s) for the Mactaquac Generating Station (MGS) location in the Saint John River under the scenarios of 1) No MGS and 2) No MGS or Beechwood Generating Station (BGS). The period predicted is 1970-2012, the post-MGS period. The flows are not absolute values; reported flows are probability-based estimates (probabilities of non-exceedance). The lowest flow predicted is 2,003 cfs (5% of flows <2,300 cfs) occurring in all weeks excluding Weeks 15-21 (first two weeks of April to last week of May). The greatest flow predicted was 231,379 cfs (5% of flows >231,379 cfs) occurring in the weeks between Week 17-20 (last weeks of April to middle week of May).

Figure 2(A). The observed flow at Mactaquac Generating Station (the 5-day average of the daily minimum flow; 1970-2012) and the predicted flows at this site without the MGS or BGS and with the BGS present (the Flow $_{P=0.50}$ and its P=0.50 estimate of variability; or approximately "the predicted average").

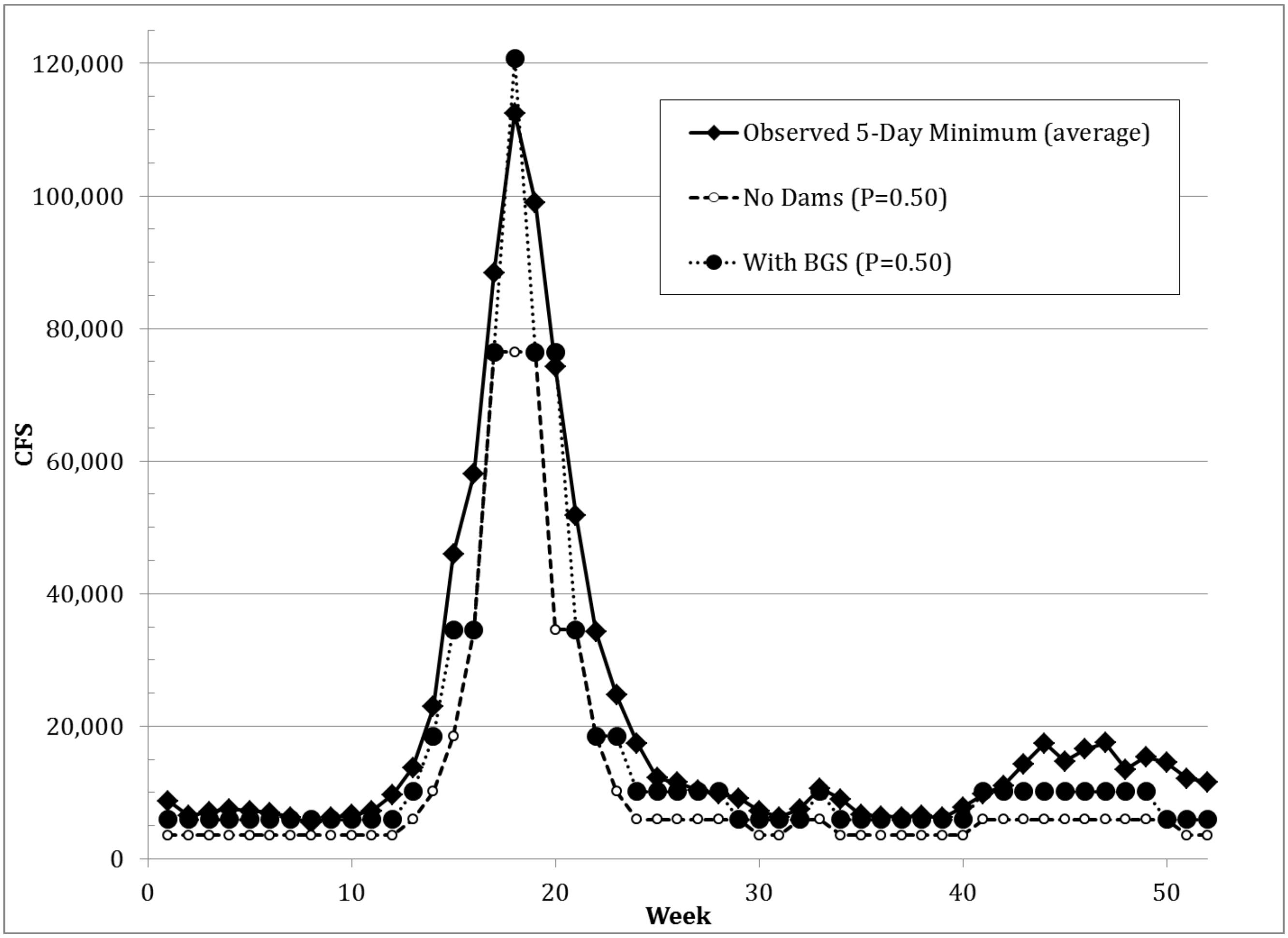


Figure 2(B). The observed minimum flow at Mactaquac Generating Station (the 5-day average of the daily minimum flow) and the predicted flows at this site without the MGS or BGS and with the BGS present (the Flow $_{P=0.05}$ and its P=0.05 estimate of variability; or approximately "the predicted minimum").

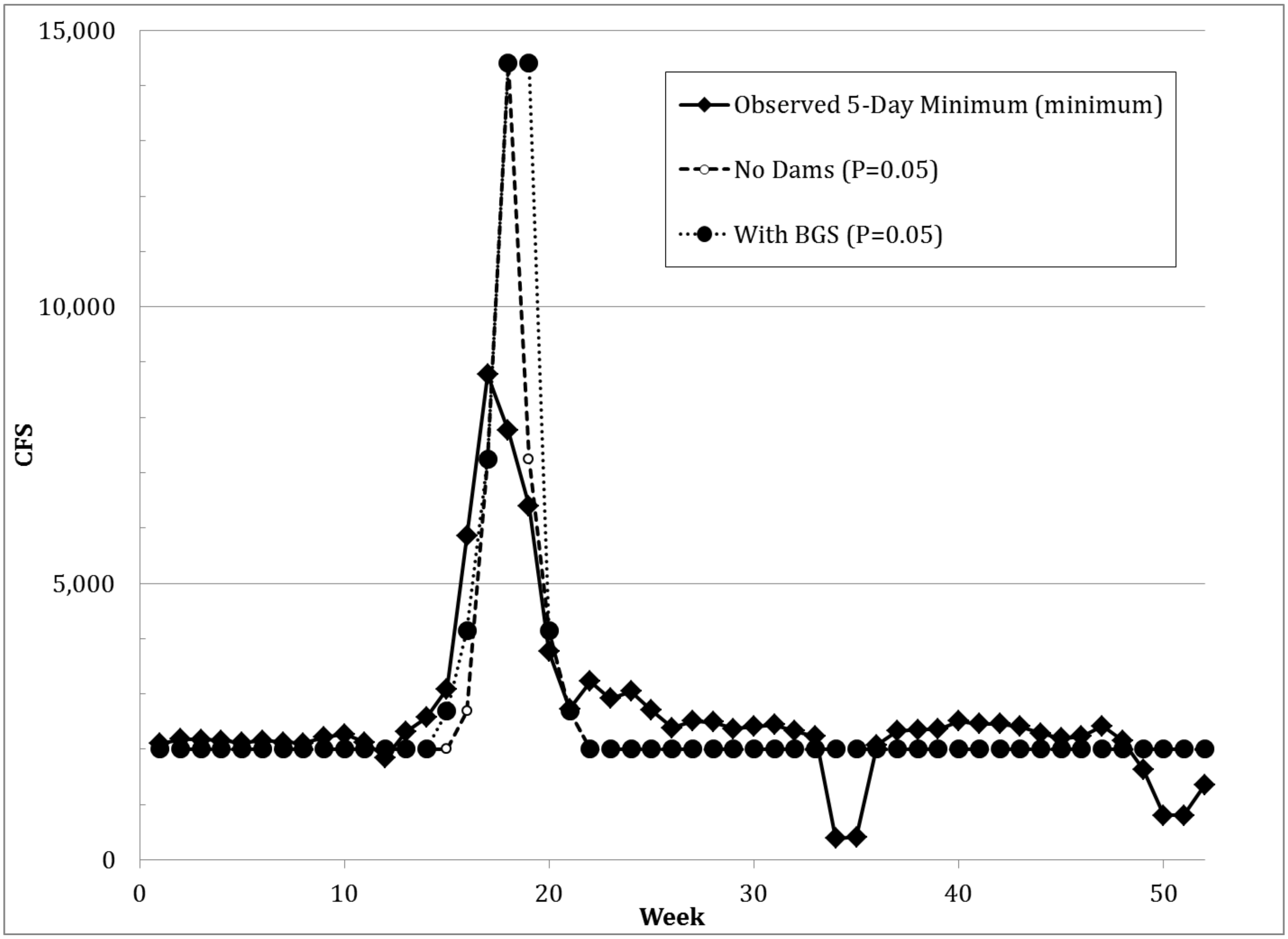
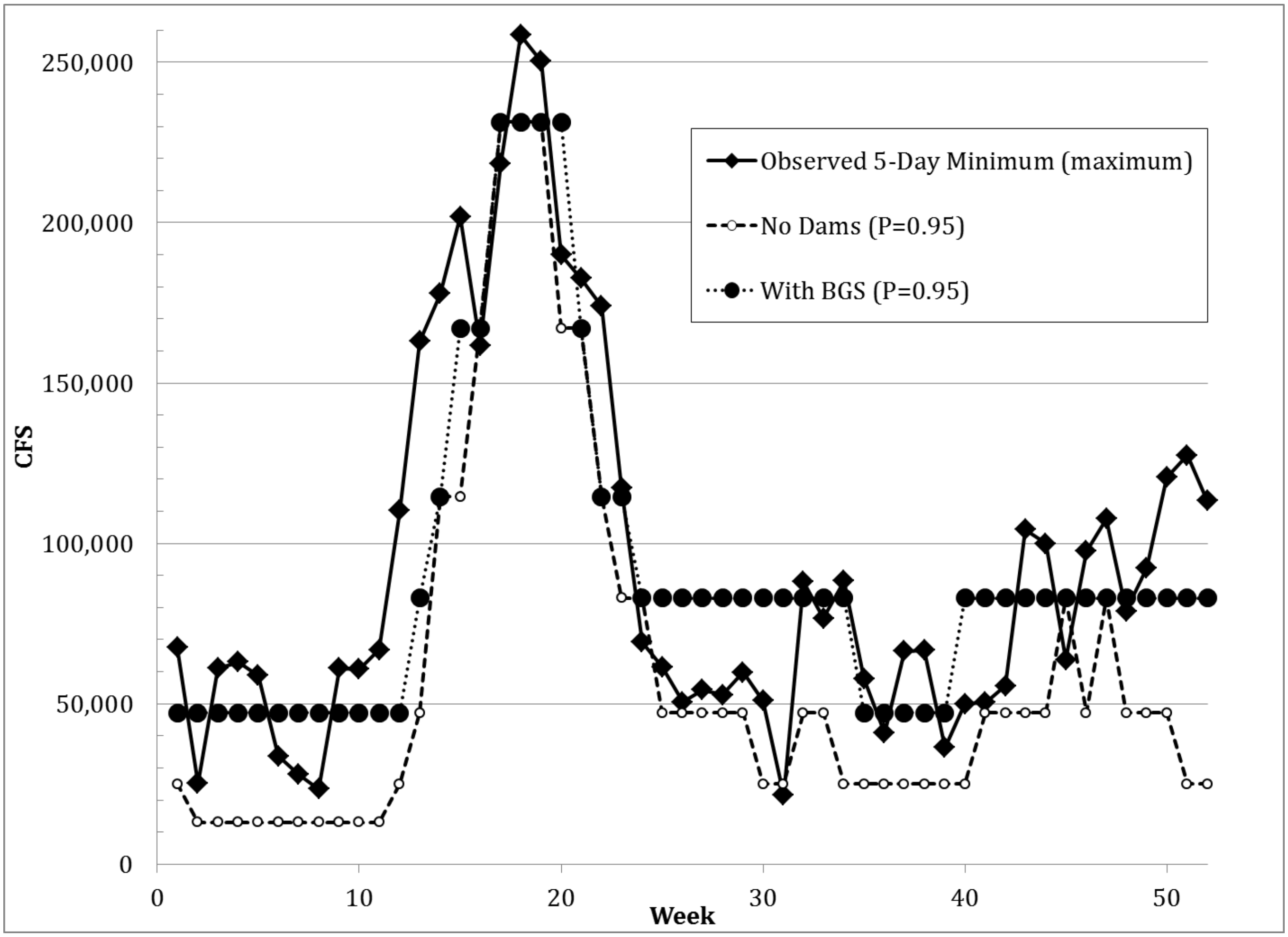


Figure 2(C). The observed maximum flow at Mactaquac Generating Station (the 5-day average of the daily minimum flow) and the predicted flows at this site without the MGS or BGS and with the BGS present (the Flow $_{P=0.95}$ and its P=0.95 estimate of variability; or approximately "the predicted maximum").



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Appendix 1. The predicted flow (cfs) at the MGS location with no dam (i.e., without the MGS) reported as probabilities of non-exceedance (0.05, 0.25, 0.50, 0.75 and 0.95) and the probabilities of non-exceedance (0.50, 0.95, and 0.05) for each of these predictions assuming no Beechwood Generating Station exists.

	5%			25%			50%			75%			95%		
Week	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**
1	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
2	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
3	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
4	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
5	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
6	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
7	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	18,492	47,199	7,245
8	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	18,492	47,199	7,245
9	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	18,492	47,199	7,245
10	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	18,492	47,199	7,245
11	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
12	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
13	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
14	3,563	6,338	2,003	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407	76,420	114,622	38,217
15	5,932	13,086	2,689	18,492	47,199	7,245	34,586	83,027	14,407	34,586	83,027	14,407	120,805	167,038	74,572
16	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407	76,420	114,622	38,217	120,805	167,038	74,572
17	18,492	47,199	7,245	34,586	83,027	14,407	76,420	114,622	38,217	120,805	167,038	74,572	156,079	231,379	105,284
18	34,586	83,027	14,407	76,420	114,622	38,217	120,805	167,038	74,572	120,805	167,038	74,572	156,079	231,379	105,284
19	34,586	83,027	14,407	76,420	114,622	38,217	76,420	114,622	38,217	120,805	167,038	74,572	156,079	231,379	105,284
20	10,184	25,027	4,144	34,586	83,027	14,407	76,420	114,622	38,217	76,420	114,622	38,217	156,079	231,379	105,284
21	5,932	13,086	2,689	18,492	47,199	7,245	34,586	83,027	14,407	76,420	114,622	38,217	120,805	167,038	74,572
22	3,563	6,338	2,003	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407	76,420	114,622	38,217
23	3,563	6,338	2,003	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407	76,420	114,622	38,217
24	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
25	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
26	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
27	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
28	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407

	5%			**25%**			**50%**			**75%**			**95%**		
Week	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**
29	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407
30	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407
31	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407
32	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407
33	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
34	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407
35	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
36	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
37	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
38	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
39	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
40	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407
41	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
42	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
43	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
44	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
45	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
46	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
47	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
48	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
49	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
50	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407
51	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407
52	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407

Appendix 2. The predicted flow (cfs) at the MGS location with no dam (i.e., without the MGS) reported as probabilities of non-exceedance (0.05, 0.25, 0.50, 0.75 and 0.95) and the probabilities of non-exceedance (0.50, 0.95, and 0.05) for each of these predictions assuming neither the Beechwood Generating Station nor the Mactaquac Generating Station exist.

	5%			**25%**			**50%**			**75%**			**95%**		
Week	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**
1	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
2	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689
3	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689
4	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689
5	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689
6	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689
7	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689
8	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689
9	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689
10	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689
11	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689
12	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
13	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
14	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407	76,420	114,622	38,217
15	3,563	6,338	2,003	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407	76,420	114,622	38,217
16	5,932	13,086	2,689	18,492	47,199	7,245	34,586	83,027	14,407	76,420	114,622	38,217	120,805	167,038	74,572
17	18,492	47,199	7,245	34,586	83,027	14,407	76,420	114,622	38,217	120,805	167,038	74,572	156,079	231,379	105,284
18	34,586	83,027	14,407	76,420	114,622	38,217	76,420	114,622	38,217	120,805	167,038	74,572	156,079	231,379	105,284
19	18,492	47,199	7,245	34,586	83,027	14,407	76,420	114,622	38,217	120,805	167,038	74,572	156,079	231,379	105,284
20	10,184	25,027	4,144	34,586	83,027	14,407	34,586	83,027	14,407	76,420	114,622	38,217	120,805	167,038	74,572
21	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407	34,586	83,027	14,407	120,805	167,038	74,572
22	3,563	6,338	2,003	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407	76,420	114,622	38,217
23	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245	34,586	83,027	14,407
24	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407
25	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
26	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245

	5%			25%			50%			75%			95%		
Week	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**
27	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
28	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	18,492	47,199	7,245
29	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	18,492	47,199	7,245
30	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
31	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
32	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	18,492	47,199	7,245
33	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
34	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
35	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
36	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
37	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
38	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
39	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
40	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
41	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	18,492	47,199	7,245
42	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
43	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
44	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
45	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407
46	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
47	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	34,586	83,027	14,407
48	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
49	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144	18,492	47,199	7,245
50	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	5,932	13,086	2,689	18,492	47,199	7,245
51	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144
52	3,563	6,338	2,003	3,563	6,338	2,003	3,563	6,338	2,003	5,932	13,086	2,689	10,184	25,027	4,144