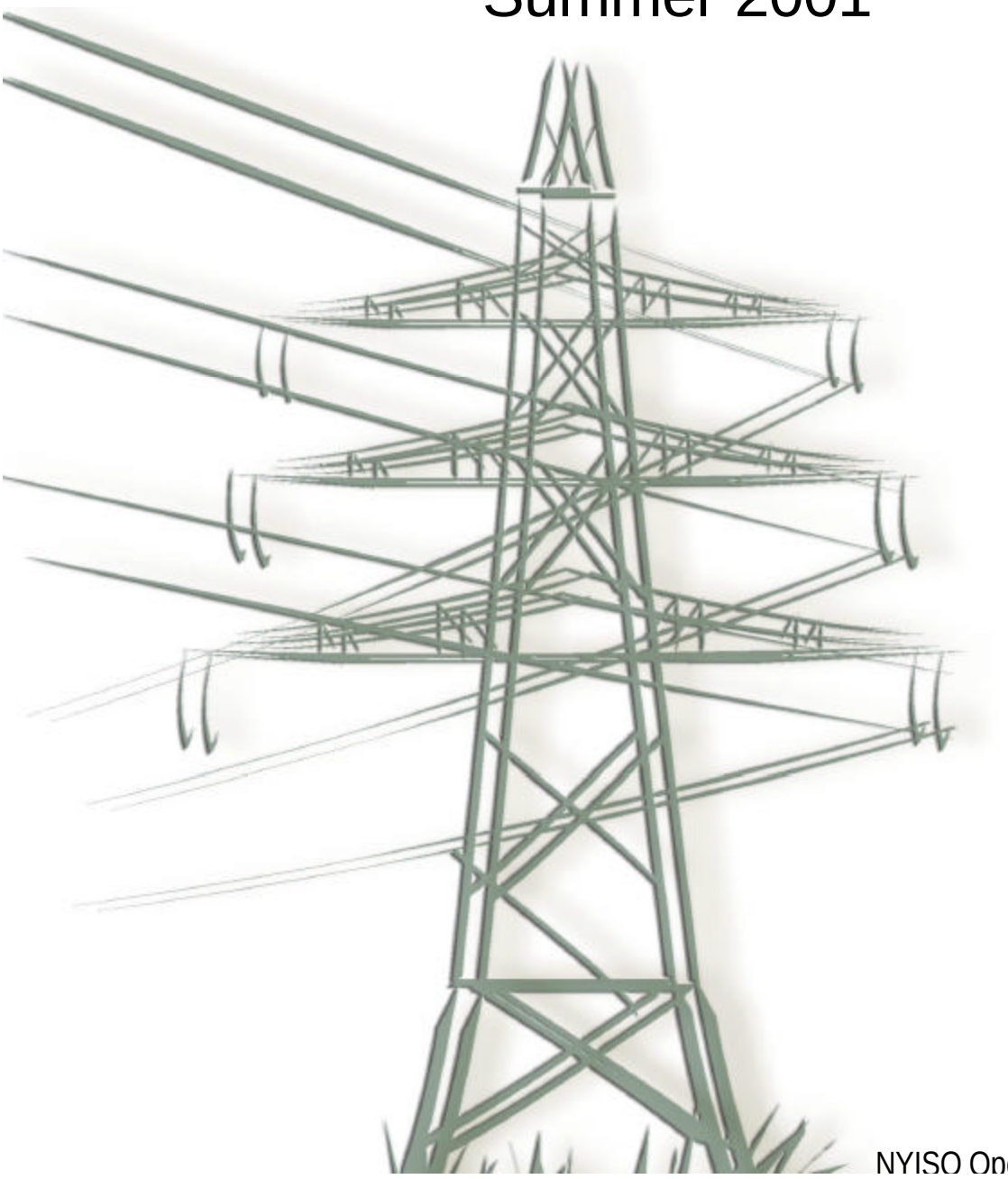
FINAL DRAFT FOR OPERATING COMMITTEE APPROVAL

Analysis of Central East Voltage for Hydro-Quebec Transfers Above 1200 MW Summer 2001



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Prepared by

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INTRODUCTION

This report summarizes the voltage analysis performed for Central East voltage limits for flows on the 7040 Chateauguay – Massena 765 kV transmission circuit above 1200 MW. This study is in response to the occurrence of low voltages in the Central New York area during conditions of increasing MW flow on the 7040 line. Powerflow cases were constructed at the 1200, 1500 and 1800 MW flow levels on the 7040 line to determine the effect this increase had on the Central East Adjusted Maximum Transfer Limits (adjusted MTL's) used for calculating the real-time Central East Operating limits.

CONCLUSIONS

The results of the voltage analysis show that as the flow on the 7040 Chateauguay – Massena line increase from 1200 to 1800 MW the Central East adjusted Maximum Transfer Limits decrease. Increasing the flow on the 7040 line cause voltage collapse to occur at lower levels of pre-contingency central east flow.

RECOMMENDATIONS

If the system is to be operated with increased flows on the 7040 line the effect of the increased flow should be taken into account when calculating the pre-contingency Central East operating limits. The calculation of the real-time operating limits should be adjusted to ensure system reliability at higher levels of flow on the 7040 line.

METHODOLOGY

The starting point for the analysis was the powerflow cases used in the Marcy FACTS Phase I analysis, in which the flow on the 7040 line is 1170 MW (all AC generation), Marcy Statcom is in-service and Oakdale 135 MVAr capacitor bank is in-service. Cases with the 7040 flow at 1500 and 1800 MW were built from this starting point using the following methods:

1500 MW 7040 flow

Both DC converters on at full (500 MW each)
500 MW Beauharnois AC generation
Two 168 MVAr harmonic filters
One full SVC
One 135 MVAr second harmonic filter

1800 MW 7040 flow

Both DC converters on at full (500 MW each)
800 MW Beauharnois AC generation
Two168 MVAr harmonic filters
One full SVC
One 135 MVAr second harmonic filter

The 1200/1500/1800 MW cases were built with increasing Central East transfers to the point of voltage collapse. The Marcy Statcom and the Leeds and Fraser SVC's were set to provide approximately 0 MVAr in the pre-contingency cases, and provide maximum voltage support in the post-contingency cases.

RESULTS

Central East adjusted Maximum Transfer limits (adjusted MTL's) were calculated for the following contingencies:

1) New Scotland #99 bus fault
2) Marcy South North tower contingency
3) Phase II HVdc (Quebec to New England)

Table 1 summarizes the adjusted MTL's for the New Scotland 99 bus fault, Marcy South North tower contingency and the loss of Phase II HVdc at 1200 MW at the three test levels on the Chateauguay – Massena 7040 line.

7040 FLOW (MW)		1200	1500	1800		1200	1500	1800		1200	1500	1800
CONTINGENCY		NS99	NS99	NS99		MSN	MSN	MSN		P II	P II	P II
MAXIMUM TRANSFER LEVELS		2720	2708	2658		4358	4349	4289		3813	3815	3762
LESS 5% SAFETY MARGIN		-136.0	-135.4	-132.9		-217.9	-217.5	-214.5		-190.7	-190.8	-188.1
POST-CONT. PV-20 FLOW		-226.9	-237.9	-243.3		-226.4	-232.5	-234.3		-244.5	-259.1	-263.5
POST-CONT. INGHAMS FLOW		-171.4	-172.1	-169.6		-190.7	-190.0	-189.1		-142.9	-141.9	-143.8
ADJUSTED M.T.L.		2185.7	2162.6	2112.2		3723.0	3709.1	3651.2		3235.0	3223.3	3166.6
(AS ROUNDED)		**2185**	**2160**	**2110**		**3720**	**3705**	**3650**		**3230**	**3220**	**3165**
SPECIFY # OF UNITS OR CAP BANKS IN SERVICE												
FITZPATRICK	1	0	0	0	1	0	0	0	1	0	0	0
OSWEGO 5	1	0	0	0	1	0	0	0	1	0	0	0
OSWEGO 6	1	0	0	0	1	0	0	0	1	0	0	0
NINE MILE 2	1	0	0	0	1	0	0	0	1	0	0	0
SITHE 1-6	6	0	0	0	6	0	0	0	6	0	0	0
MARCY STATCOM	1	-35 0	-35 0	-35 0	1	-45 0	-45 0	-45 0	1	-35 0	-35 0	-35 0
LEEDS SVC	1	-20 0	-20 0	-20 0	1	-35 0	-35 0	-35 0	1	-35 0	-35 0	-35 0
FREASER SVC	1	-20 0	-20 0	-20 0	1	-35 0	-35 0	-35 0	1	-35 0	-35 0	-35 0
MARCY CAPS	2	-35 0	-35 0	-35 0	2	-45 0	-45 0	-45 0	2	-45 0	-45 0	-45 0
N.SCOT CAPS	3	-20 0	-20 0	-20 0	3	-25 0	-25 0	-25 0	3	-25 0	-25 0	-25 0
LEEDS CAPS	2	-15 0	-15 0	-15 0	2	-20 0	-20 0	-20 0	2	-20 0	-20 0	-20 0
FRASER CAPS	2	-15 0	-15 0	-15 0	2	-20 0	-20 0	-20 0	2	-20 0	-20 0	-20 0
GILBOA CAP	1	-15 0	-15 0	-15 0	1	-20 0	-20 0	-20 0	1	-20 0	-20 0	-20 0
ROTTERDAM CAPS	2	-15 0	-15 0	-15 0	2	-20 0	-20 0	-20 0	2	-20 0	-20 0	-20 0
OAKDALE CAP	1	-15 0	-15 0	-15 0	1	-15 0	-15 0	-15 0	1	-15 0	-15 0	-15 0
MARCY REACTOR	0	-35 0	-35 0	-35 0	0	-45 0	-45 0	-45 0	0	-45 0	-45 0	-45 0
MASS. REACTORS	0	-15 0	-15 0	-15 0	0	-20 0	-20 0	-20 0	0	-20 0	-20 0	-20 0
OMS CORRECTION												
ADD POST-CONT. PV-20 FLOW		195	203	207		200	206	208		205	215	219
ADD POST-CONT. INGHAMS FLOW		160	161	162		180	180	180		137	138	139
POST-CONTINGENCY C-E OPERATING LIMITS		**2540**	**2524**	**2479**		**4100**	**4091**	**4038**		**3572**	**3573**	**3523**

Table 1: Central East Adjusted MTL's

DISCUSSION

Calculation of Adjusted MTL's

The Central East adjusted MTL is the quantity used in the determination of the real-time post-contingency operating limits. Powerflow transfer cases were built with increasing levels of MW flow on the Central East interface up to and beyond the point of voltage collapse. The three contingencies were applied to these transfer cases and the post-contingency Central East flows were recorded. The powerflow case that resulted in the highest level of post-contingency flow for a given contingency was used to calculate the adjusted MTL for that contingency.

Example: Calculate adjusted MTL for the New Scotland 99 bus fault with 7040 flow at 1500 MW.

After examining the post-contingency cases, the highest level of post-contingency flow on Central East for the loss of New Scotland #99 bus is 2708 MW. This value becomes the MTL for the NS 99 contingency with 7040 flow at 1500 MW. To calculate the adjusted MTL the following formula was used:

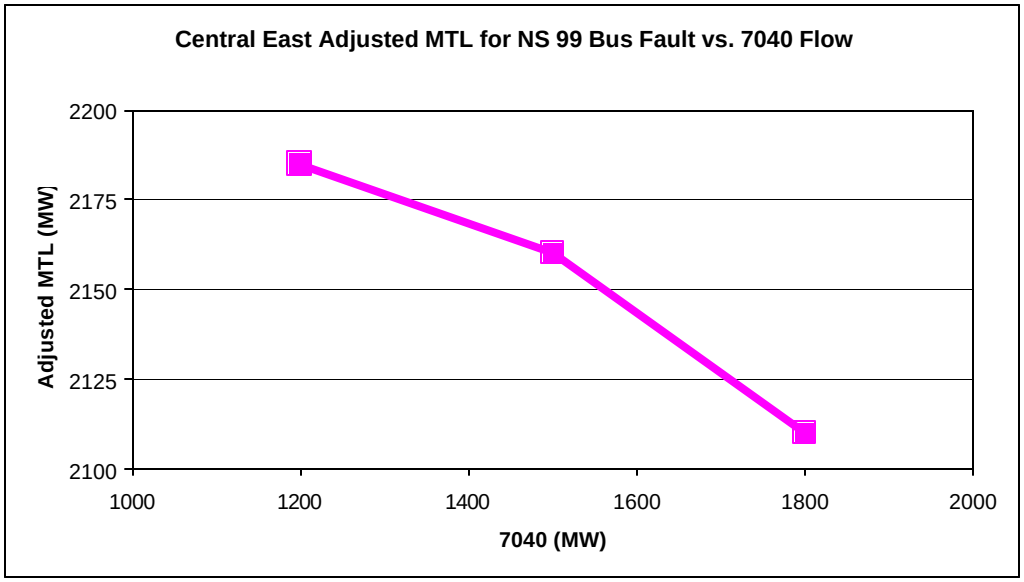
Adjusted MTL = MTL – 5% safety factor – Post-cont PV 20 flow – Post-cont Inghams flow

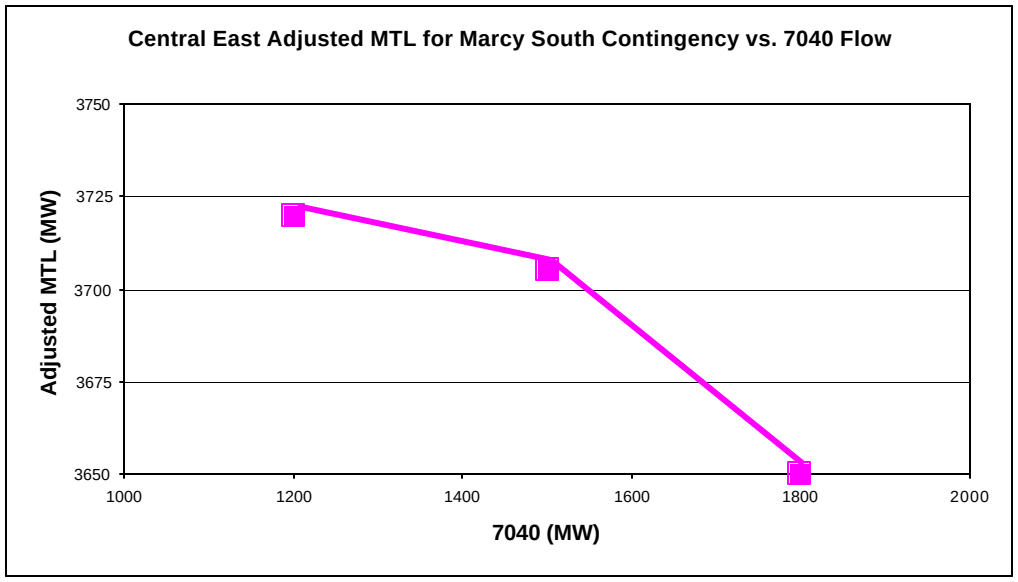
Substituting values from the powerflow case that resulted in the MTL:

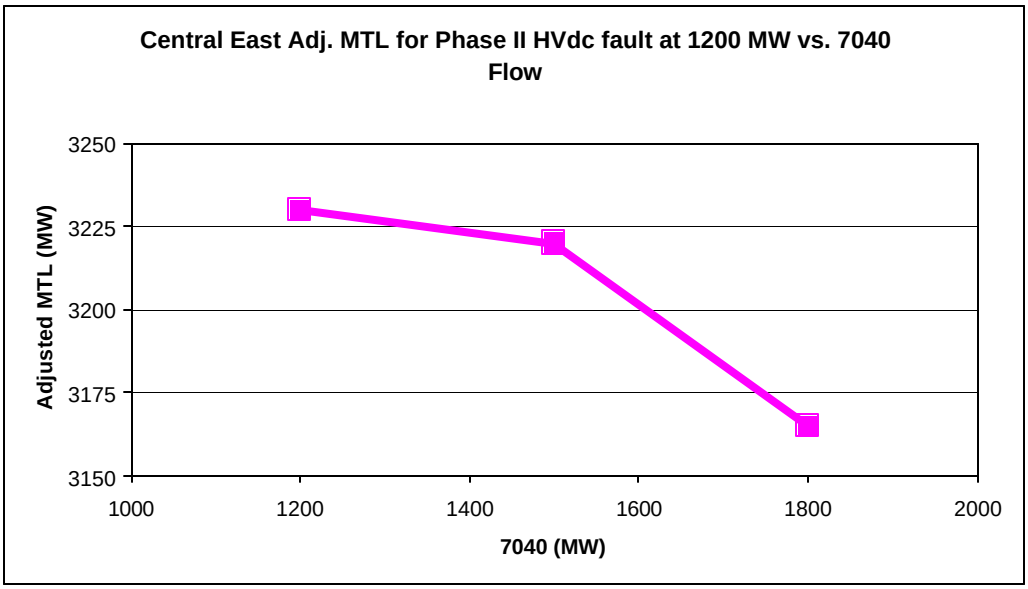
$$Adjusted\ MTL = 2708 - 135.4 - 237.9 - 172.1 = 2162.6$$

The Post-Contingency Central East Operating limits are calculated by subtracting the penalties for specific facility outages from the adjusted MTL, and adding the real-time post-contingency PV-20 and Inghams PAR flows. The values used in table 1 for the PAR flows are approximations. The various facility outage penalties are listed in the table, below the adjusted MTL values. All of the penalties are zero in the table, which reflects the configuration of the study system. For example if the Leeds SVC were out of service it would have a penalty of 20 MW for the New Scotland 99 bus fault, and 35 MW for the Marcy South and Phase II HVdc contingencies. There is no penalty subtracted since the device is modeled as in–service in the study cases.

The adjusted MTL is the constant used as the starting point for the determination of the real-time Central East operating limits. After determining the adjusted MTL values for the three levels of flow on the 7040 line. These values can be compared to determine the effect that varying 7040 flow would have on the Central East post-contingency operating limits. Using the results from Table 1, a comparison of the adjusted MTL's for the NS 99 contingency shows a decrease of 25 MW when the flow on the 7040 line is increased from 1200 to 1500 MW. A decrease of 50 MW is evident when the flow is increased from 1500 to 1800 MW. Similar reductions can be seen for the remaining contingencies. Graphically, the effect on the Central East Adjusted MTL caused by increasing the 7040 flow from 1200 to 1800 MW can be shown as follows:


Central East Adjusted MTL for NS 99 Bus Fault vs. 7040 Flow
Adjusted MTL (MW)
2200
2175
2150
2125
2100
1000
1200
1400
1600
1800
2000
7040 (MW)


Central East Adjusted MTL for Marcy South Contingency vs. 7040 Flow
Adjusted MTL (MW)
3750
3725
3700
3675
3650
1000
1200
1400
1600
1800
2000
7040 (MW)


Central East Adj. MTL for Phase II HVdc fault at 1200 MW vs. 7040 Flow
Adjusted MTL (MW)
3250
3225
3200
3175
3150
1000
1200
1400
1600
1800
2000
7040 (MW)

Contingency: Loss of Phase II HVdc

The contingency for the loss of the Phase II HVdc circuit from Quebec to New England was examined for 3 different levels: Phase II at 1200 MW, Phase II at 1600 MW and Phase II at 2000 MW. The powerflow transfer cases have Phase II modeled at 1200 MW. Therefore, to test for three different levels of Phase II transfer the contingencies were modeled as follows:

Loss of Phase II at 1200 MW

Trip Phase II HVdc lines
Trip associated filters

Loss of Phase II at 1600 MW

Trip Phase II HVdc lines
Trip associated filters
Add 400 MW load and 100 MVAr at Sandy Pond bus

Loss of Phase II at 2000 MW

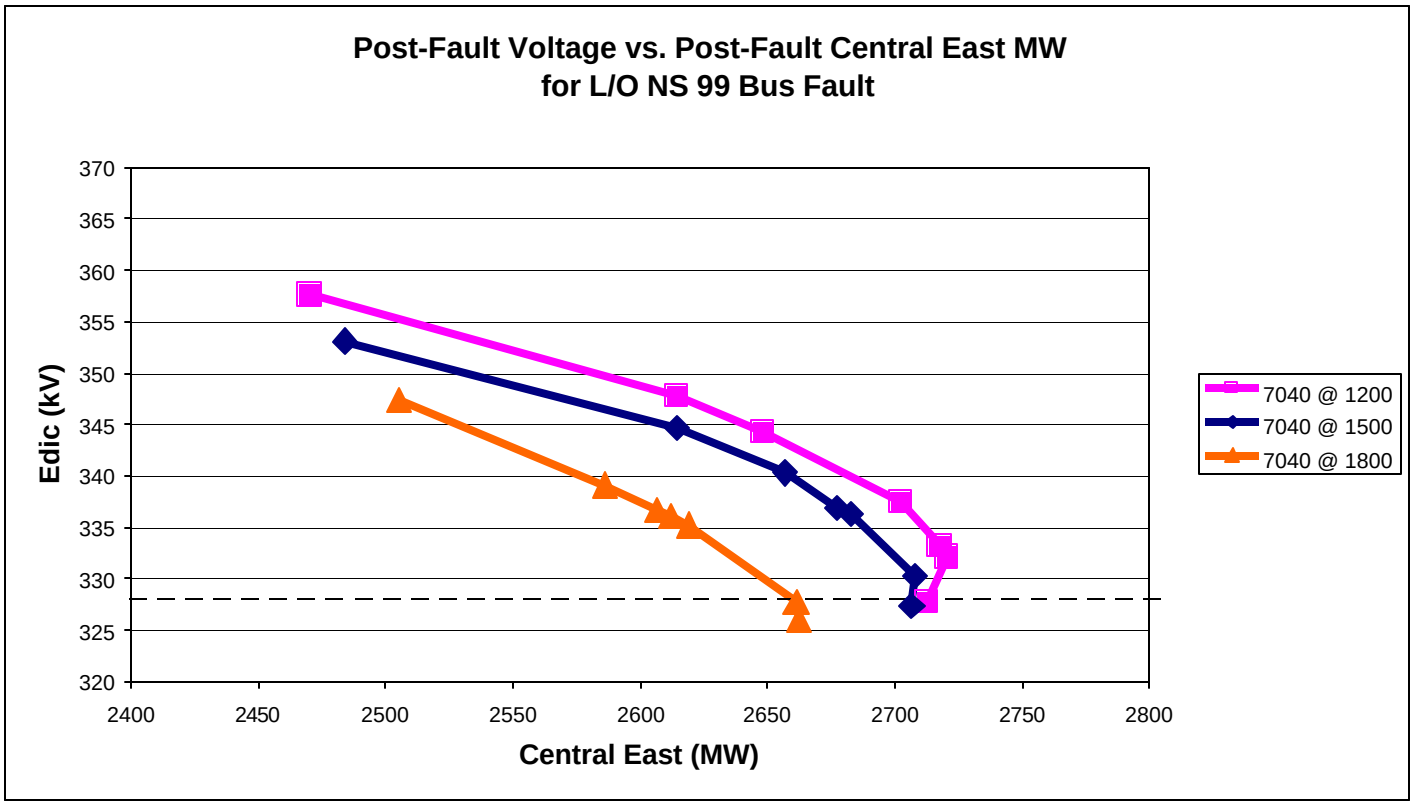
Trip Phase II HVdc lines
Trip associated filters
Add 800 MW load and 200 MVAr at Sandy Pond bus

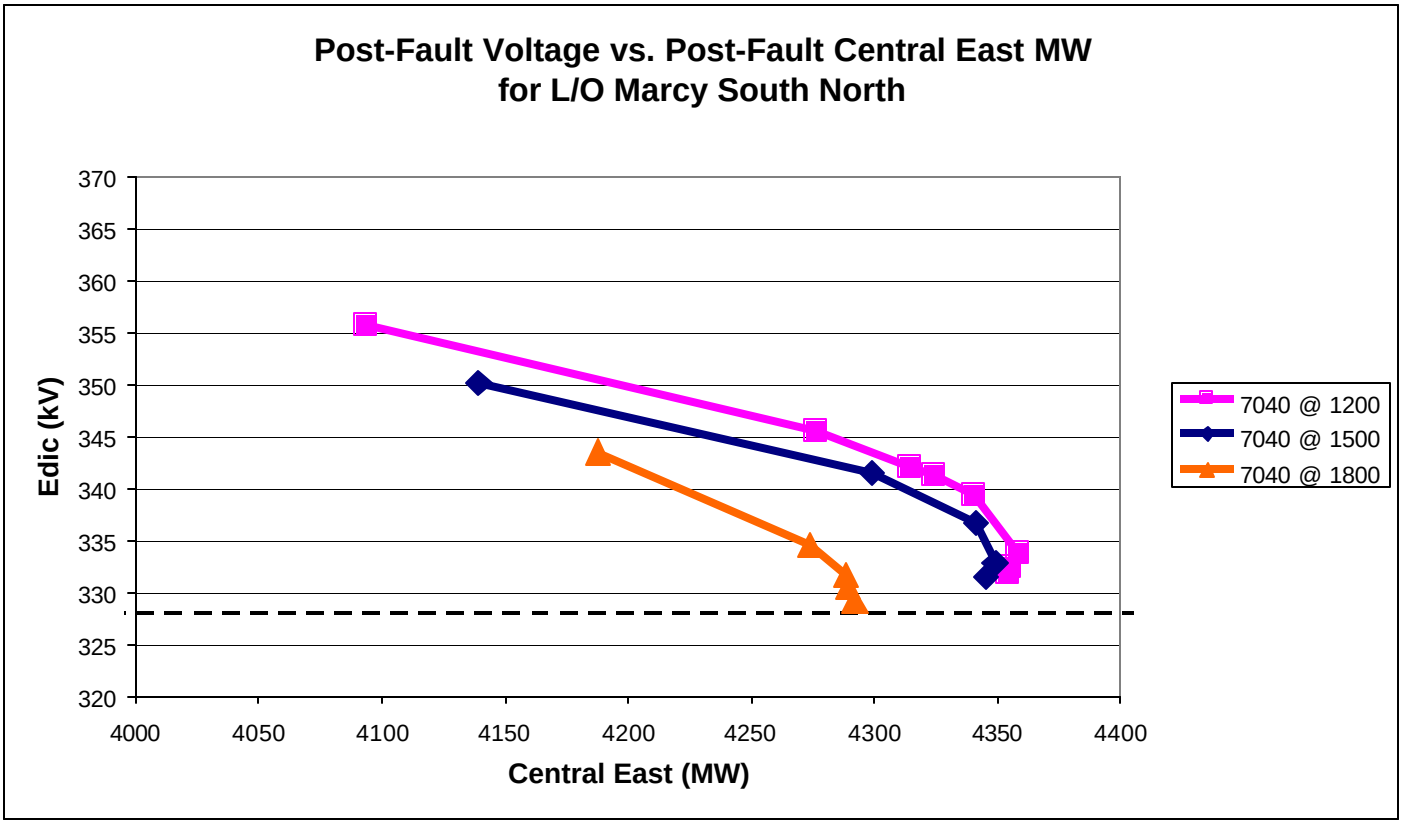
These three levels of transfer were evaluated at the 1200, 1500 and 1800 MW levels of 7040 flow.

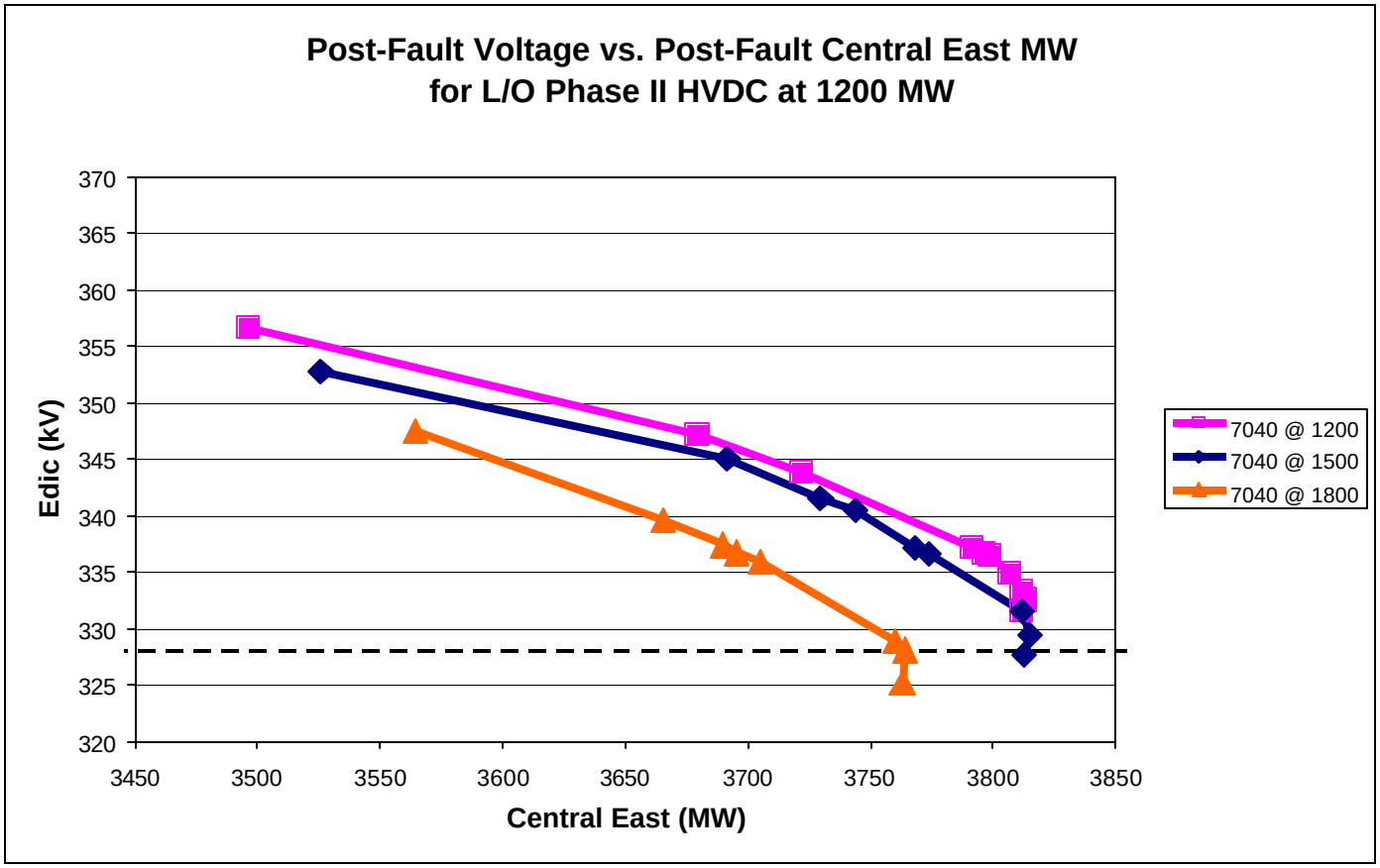
Effect of Increasing Phase II HVdc from 1200 to 2000 MW

When the Phase II HVdc flow was increased voltage collapse occurred at lower levels of pre-contingency Central East flow. This is the result of higher post-contingency flows to New England to supply the power displaced at Sandy Pond by the contingency. As the flow on the Phase II HVdc circuit was increased it became the most limiting contingency examined in this report.

The following graphs show the post-contingency Central East MTL for the three contingencies studied at the three test levels of 7040 flow.




Post-Fault Voltage vs. Post-Fault Central East MW
for L/O Marcy South North
Edic (kV)
370
365
360
355
350
345
340
335
330
325
320
4000
4050
4100
4150
4200
4250
4300
4350
4400
Central East (MW)
7040 @ 1200
7040 @ 1500
7040 @ 1800


Post-Fault Voltage vs. Post-Fault Central East MW
for L/O Phase II HVDC at 1200 MW
Edic (kV)
370
365
360
355
350
345
340
335
330
325
320
3450
3500
3550
3600
3650
3700
3750
3800
3850
Central East (MW)
7040 @ 1200
7040 @ 1500
7040 @ 1800