REPORT

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System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Issue 1.0

Project: *Windsor Area Transmission Reinforcement*

Applicant: Hydro One Networks Inc.

CAA ID 2007-263

Final Draft Report

Transmission Assessments & Performance Department

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System Impact Assessment Report

Windsor Area Transmission Reinforcement

Acknowledgement

The IESO wishes to acknowledge the assistance of Hydro One in completing this assessment.

Disclaimers

IESO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IESO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IESO should issue a notice of approval or disapproval of the proposed connection under Chapter 4, section 6 of the Market Rules.

Approval of the proposed connection is based on information provided to the IESO by the connection applicant and the transmitter(s) at the time the assessment was carried out. The IESO assumes no responsibility for the accuracy or completeness of such information, including the results of studies carried out by the transmitter(s) at the request of the IESO. Furthermore, the connection approval is subject to further consideration due to changes to this information, or to additional information that may become available after the approval has been granted. Approval of the proposed connection means that there are no significant reliability issues or concerns that would prevent connection of the proposed facility to the IESO-controlled grid. However, connection approval does not ensure that a project will meet all connection requirements. In addition, further issues or concerns may be identified by the transmitter(s) during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with physical or equipment limitations, or with the Transmission System Code, before connection can be made.

This report has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. This report has been prepared solely for use by the connection applicant and the IESO in accordance with Chapter 4, section 6 of the Market Rules. The IESO assumes no responsibility to any third party for any use, which it makes of this report. Any liability which the IESO may have to the connection applicant in respect of this report is governed by Chapter 1, section 13 of the Market Rules. In the event that the IESO provides a draft of this report to the connection applicant, you must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to you. Although the IESO will use its best efforts to advise you of any such changes, it is the responsibility of the connection applicant to ensure that it is using the most recent version of this report.

HYDRO ONE

Special Notes and Limitations of Study Results

The results reported in this study are based on the information available to Hydro One, at the time of the study, suitable for a preliminary assessment of a new generation or load connection proposal.

The short circuit and thermal loading levels have been computed based on the information available at the time of the study. These levels may be higher or lower if the connection information changes as a result

of, but not limited to, subsequent design modifications or when more accurate test measurement data is available.

This study does not assess the short circuit or thermal loading impact of the proposed connection on facilities owned by other load and generation (including OPGI) customers.

In this study, short circuit adequacy is assessed only for Hydro One breakers and does not include other Hydro One facilities. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One breakers and identifying upgrades required to incorporate the proposed connection. These results should not be used in the design and engineering of new facilities for the proposed connection. The necessary data will be provided by Hydro One and discussed with the connection proponent upon request.

The ampacity ratings of Hydro One facilities are established based on assumptions used in Hydro One for power system planning studies. The actual ampacity ratings during operations may be determined in real-time and are based on actual system conditions, including ambient temperature, wind speed and facility loading, and may be higher or lower than those stated in this study.

The additional facilities or upgrades which are required to incorporate the proposed connection have been identified to the extent permitted by a preliminary assessment under the current IESO Connection Assessment and Approval process. Additional facility studies may be necessary to confirm constructability and the time required for construction. Further studies at more advanced stages of the project development may identify additional facilities that need to be provided or that require upgrading.

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WINDSOR AREA TRANSMISSION REINFORCEMENT
IESO SYSTEM IMPACT ASSESSMENT

SIA Findings

The proposed Windsor area transmission reinforcement is a developmental project which is required to provide reliable power supply to the Windsor area loads.

Conclusions

This System Impact Assessment has examined the impact of the proposed Windsor Area Transmission Reinforcement, on the reliability of the IESO-Controlled grid. The studies concluded that:

1. The proposed project will not have a materially adverse effect on the reliability of the IESO-Controlled grid.

2. The proposed project will significantly improve the voltage profile and increase the power supply capability in Windsor area.

3. All the pre-contingency voltages, post-contingency voltages and voltage declines meet Market Rules requirements.

4. No thermal overload concerns were identified for the monitored transmission circuits in the studied scenarios. All power flows on the monitored circuits were observed to be within the continuous ratings of the circuits.

5. With the reinforcement project the frequency of using Connectivity-based LR scheme and Voltage-based LR scheme will be significantly reduced.

Notification of Approval for Connection Proposal

It is recommended that Notification of Conditional Approval for connection be issued to Hydro One, subject to IESO's Requirements for Connection listed below, and any further requirements that may be identified by Hydro One Networks Inc. in the Customer Impact Assessment.

IESO's Requirements for Windsor Area Transmission Reinforcement Connection

The IESO requirements for the connection of the proposed Windsor Area Transmission Reinforcement are as follows:

- As per Appendix 4.1 of Market Rules, all 230 kV equipment must be capable of continuously operating in the range between 220 kV and 250 kV, as per Appendix 4.1, Reference 2 of the Market Rules.

- Transmission equipment must remain in service, and not automatically trip, for the voltages up to 5% above the maximum continuous rating, in this case 262 kV, for up to 30 minutes, to allow system to be re-dispatched to return voltages within their normal range.

- Hydro One is required to install all the equipment needed to continuously monitor the information that is required by the IESO.

- Hydro One is required to provide the interrupting capability of the 230 kV circuit switchers. If the interrupting capability of the 230 kV circuit switchers is below 63 kA, Hydro One will be required to upgrade the circuit switchers at their own expense when and if the system short circuit levels exceed their interrupting capability.

IESO's Recommendations for Windsor Area Transmission Reinforcement Connection

It is recommended that Hydro One and/or the area LDCs implement a plan to alleviate the possible overloading at the existing Kingsville TS by increasing the station load capability or transferring some of the load to other transformer stations..

1. Project Description

Hydro One Networks is proposing to increase the power supply capability in Windsor area by reinforcing the local transmission system.

The Windsor area comprises the municipalities of Amherstburg, Essex, Kingsville, Lakeshore, La Salle, Leamington, Tecumseh, and Windsor, and portions of the municipality of Chatham-Kent. Electricity distribution in the area is carried out by ENWIN Powerlines Ltd., Essex Powerlines Corporation, Essex-Lakeshore-Kingsville (E.L.K.) Inc., Chatham-Kent Hydro Inc. and Hydro One.

The Windsor area is bounded by circuits C24Z and C23Z from Chatham to Lauzon, circuits C22J and C21J from Chatham to Keith and by circuit J5D from Keith to Michigan. The Windsor 115 kV area load is supplied from Lauzon 230/115 kV autotransformers T1 and T2, Keith 230/115 kV autotransformers T11 and T12, West Windsor GS G1 and G2, the Windsor TransAlta CGS G1 and G2 and Brighton Beach CGS G1A.

The Windsor Area is susceptible to a variety of operational problems including pre-contingency voltage instability, post-contingency voltage decline and thermal overload. As a result a number of special protection schemes are employed to facilitate operation of the area. The armed schemes in Windsor area include Connectivity Based L/R Scheme, Voltage Dependent L/R Scheme, Windsor Area Overload Protection Scheme, and Kingsville High-Voltage-Switching Scheme.

The proposed Windsor area transmission reinforcement will address the voltage and overload concerns and increase the area transmission supply capability by providing a new 230 kV power supply point and upgrading transmission circuits in Windsor area. The proposed project includes modifying the existing system and installing new facilities as follows:

(1) Upgrade circuits J4E and J3E.

(2) Install a new transformer station, Division TS, that will connect circuits C22J and C21J to circuits K2Z and K6Z and supply the Kingsville TS load.

(3) Upgrade the sections of circuit K2Z and K6Z between Division TS and Kingsville TS.

(4) Replace Keith transformers T11 and T12.

This connection assessment study will examine the proposed (1), (2) and (3) above and their impact on reliability of the IESO-controlled grid. Item (4), the replacement of Keith transformers, will be addressed in a separate SIA study (CAA ID: 2007 - 265).

A schematic diagram of the proposed Windsor Area Transmission Reinforcement as well as the proposed arrangement of Division TS is shown in Figure 1.

The project is scheduled for completion by April 2010.

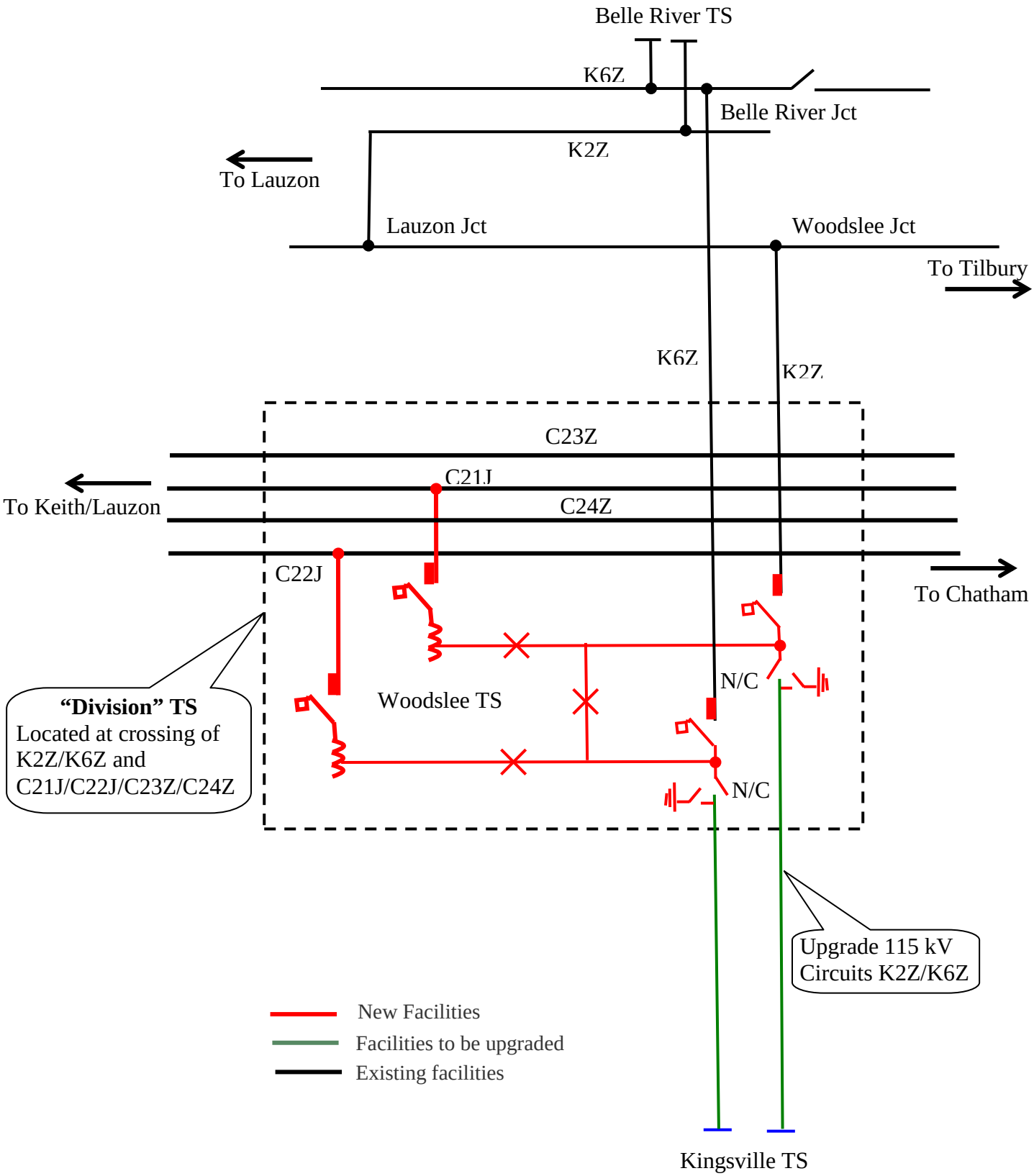

Figure 1: Windsor Area Transmission Reinforcement

2. Review of Connection Proposal

2.1 Connection Arrangement

2.1.1 115 kV circuits

The proposed Windsor Area Transmission Reinforcement project includes upgrading 115 kV circuits J3E/J4E (Keith × Essex) and L2Z/L6Z (Division × Kingsville).

The Keith × Essex 115 kV circuits J3E and J4E (12.2 km) are strung with 795 kcmil (26/7) ACSR conductor. The summer emergency ratings (127°C conductor temperature or sag limit) of the circuits are 1070 A and 1000 A, respectively. The summer continuous rating (93°C conductor temperature) of both circuits is 810 A.

After upgrading the circuits are to have the following ratings as provided by Hydro One:

- Maximum Operating Voltage: 127 kV
- Maximum Continuous Rating: 1100 A (Summer, 35 °C, 4 km/hr wind speed)
- Maximum Emergency Rating: 1600 A (Summer, 35 °C, 4 km/hr wind speed)

The section of 115 kV circuits K2Z and K6Z between the new "Division" TS and Kingsville TS (18 km) is to be upgraded. In this section, the existing K2Z and K6Z are on two single-circuit wood pole structures.

After upgrading the circuits are to have the following ratings as provided by Hydro One:

- Maximum Operating Voltage: 127 kV
- Maximum Continuous Rating: 590 A (Summer, 35 °C, 4 km/hr wind speed)
- Maximum Emergency Rating: 950 A (Summer, 35 °C, 4 km/hr wind speed)

2.1.2 Division TS

The new Division TS will be located at the crossing of 115 kV circuits K2Z/K6Z and the 230 kV Chatham SS x Keith/Lauzon circuits C21J/C22J and will be connected to C21J/C21J and K2Z/K6Z. The existing Kingsville TS, which in the current configurations are supplied from Lauzon TS, will be supplied by the new Division TS.

The proposed Division TS will be equipped with two 250 MVA, 230/115 autotransformers including delta-connected tertiary winding rated for 60 MVAr that may be used for the supply of station service or as connection point for future shunt compensation. The two autotransformers are identical and each transformer is configured with a wye winding on the high side (neutral solidly grounded). The LV windings are also wye connected and the neutral is to be solidly grounded. The delta tertiary winding is to have provision for operation with the delta open or closed.

Each transformer is equipped with under-load tap changers located on the 230 kV winding with ± 27.5 kV voltage band achieved in 21 steps.

The connection applicant indicated that the HV to LV impedance should be approximately 10% on the nameplate rating of 250 MVA. (Impedance tolerance is to be +/-7.5% of the impedance, implying a range of 9.25% to 10.75% for HV-LV Z1 impedance)

Hydro One proposes to connect each autotransformer to the IESO-controlled grid via one 230 kV circuit switchers with a continuous rating of 2000 A.

As indicated by Hydro One, the station will require the installation of three 115 kV breakers with the following ratings:

- Rated continuous current: 3000 A
- Rated short circuit current: 50 kA Symmetrical
- Rated maximum voltage: 127 kV
- Rated interrupting time: 3 cycles

Two 115 kV circuit switchers and two 115 kV disconnect switches are to be provided. Each switch should have a continuous rating of 3000 A.

2.2 On-line Monitoring

The Market Rules (Chapter 4 section 7.4) require that each transmitter shall provide the IESO on a continual basis with on-line monitored quantities as specified in Appendix 4.16. It is required that Hydro One install all the equipment needed to monitor the information required by the IESO on a continuous basis.

The IESO requires that the following quantities at Division TS be provided to the IESO on a continual basis via approved communication protocols:

1. The voltage on the 230 kV bus
2. The status of the 230 kV circuit switchers
3. The voltage on the 115 kV bus
4. The status of the transformer 115 kV breakers
5. The status of the transformer 115 kV circuit switchers and disconnect switches
6. The real and reactive power flow through both transformers
7. The transformer tap position for both transformers

Hydro One is required to install all the equipment needed to continuously monitor the information that is required by the IESO. The IESO will finalize items to be monitored during the IESO Facility Registration Process.

2.3 Protection Systems

With respect to the protection and telecommunication requirements, the connection applicant will have to follow the Transmission System Code technical requirements for tapped transformer stations supplying load.

The connection applicant indicated that standard protective relaying is to be provided for the new Division TS. The existing C21J/C22J protections at Chatham and Keith and the existing L2Z/L6Z protections at Lauzon will be reviewed and modified as required to accommodate the new proposed connections.

– End of Section –

3. Data Verification

Based on standards for supply of municipal electrical utilities the capability of a transformer station is defined as the maximum load that one transformer can carry for a predefined period of time. This value is usually computed using specific transformer data and daily loading curves, and temperature data specific to the transformer location. Hydro One has provided a 10 day summer Limited Time Rating of 400 MVA.

The system performance standards listed in the Transmission System Code require that the 230 kV and 115 kV system fault levels not exceed 63 kA and 50 kA (Sym.), respectively. This implies that 230 kV and 115 kV equipment installed should be sized to interrupt 63 kA and 50 kA (Sym.), respectively. However, lower capability equipment is allowed when the system short circuit levels are lower and no system expansion is expected.

Hydro One did not provide the interrupting capability of 230 kV circuit switchers.

Hydro One is required to provide the interrupting capability of the 230 kV circuit switchers. If the interrupting capability of the 230 kV circuit switchers is below 63 kA, Hydro One will be required to upgrade the circuit switchers at their own expense when and if the system short circuit levels exceed their interrupting capability.

The connection applicant has indicated that all new 115 kV equipment and components are capable of withstanding (interrupting) the effects of the station short circuits currents of 50 kA.

A full description of the connection arrangement of the proposed Windsor Area Transmission Reinforcement is included in Section 2.1 of this report.

– End of Section –

4. Fault Level Assessment

This project involves the reinforcement of transmission system with loads being radially connected to a new supply point. In general, radial loads do not have a large impact on the system fault levels, but a small contribution in short circuit currents can be observed due to the grounding of the transformers. In the case of Division TS the high voltage winding is grounded, hence line-to-ground faults will results in a slight increase in fault level but there is no material increase in the short circuit fault levels.

– End of Section –

5. Further Analysis

This connection assessment study concentrated on identifying the effect of the proposed Windsor Area Transmission Reinforcement on thermal loading of the transmission elements and system voltages for pre and post contingency situations.

5.1 Study Assumptions

5.1.1 Load Forecasts

The load forecasts in Windsor area before and with conservation were provided by Hydro One. The summer peak loads in 2010 are summarized in Table 1. For voltage decline studies, these loads were modeled as voltage dependant loads; P was modeled as 50% constant impedance and 50% constant current and Q was modeled as 100% constant impedance.

Table 1 – Load levels assumed in the study

Station	Before Conservation		With Conservation	
	P (MW)	Q (MVAr)	P (MW)	Q (MVAr)
Tilbury TS	1.4	0.46	1.3	0.43
Tilbury West DS	25.2	11.16	23.2	10.28
Kingsville	154.3	74.24	143.8	69.19
Walker #2	98.4	49.25	91.3	45.7
Walker	73.5	36.75	68.2	34.1
Essex	50.1	25.05	46.5	23.25
Crawford	95	47.5	88.6	44.3
Keith BY	74.8	38.84	70.3	36.5
Malden Y	69	34.5	63.8	31.9
Malden B	89.6	44.85	82.9	41.5
Lauzon EJ	97	48.48	90.1	53.39
Lauzon BQ	108.3	54.15	100.6	50.3
Ford Essex	8.5	3.98	7.6	3.56
Chrysler	36.7	16.43	32.9	14.73
GM Windsor	18.9	10.54	17	9.48
Ford Annex	12	2.81	10.8	2.53
Ford Windsor	16.7	3.92	15	3.52
Belle River	34.6	17.3	32.7	16.35
Total	1064	520.21	986.6	491.01

5.1.2 System Scenario

This system impact study was performed for 2010 summer peak area loads.

The Windsor 115 kV System was considered to be ‘closed’ in this study which means there is a continuous 115 kV transmission path between Lauzon TS and Keith TS.

There are several special protection schemes available that prevent post-contingency overloads in the Windsor area. In this SIA study, all the schemes are not used unless it is identified necessary. In particular, only Kingsville High-voltage-switching scheme is used to alleviate the overload at Kingsville TS.

Data from Kruger Wind Farm project which is ahead of the Reinforcement project was then added. The total generation assumed in this study is shown in Table 2. Depending on the scenario, Brighton Beach generation will be different from what is shown below.

Table 2 – Generation assumed in the study

Generator	Output (MW)
West Windsor GS	135.2
Windsor TransAlta	64.8
Brighton Beach	525.2
Kruger Wind Farm	100
East Windsor Cogeneration Center	95

5.1.3 Flow on J5D

The following graphs show the MW flow on J5D in one hour average samples during the period of Jan 1-Dec 31, 2007. The positive is flow out of Ontario.

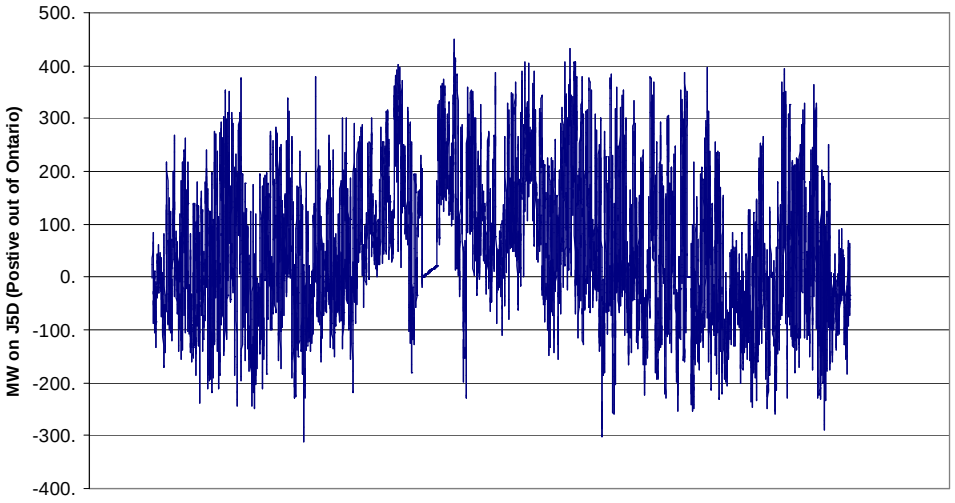

Figure 2: Flow on J5D in 2007

It can be seen that the maximum import and export on J5D could be 300 MW and 400 MW, respectively. However, the import on J5D can not exceed 150 MW when Brighton Beach is at full output, because the loss of the Brighton Beach generating station will overload J5D. Therefore, the maximum import on J5D is 150 MW while the maximum export is 400 MW in this study.

5.1.4 Cases Studied

Based on the above assumptions three cases were developed for this study - a case without Brighton Beach in service during peak load conditions, an import on J5D case and an export on J5D case. The first case stressed the 230 kV transmission lines that supply the Windsor area and the second case stressed the 115 kV transmission lines in the Windsor area. The export case stressed the autotransformers at Keith.

Three cases are described in Table 3 below.

Table 3 - Three Cases Studied

Case	Conditions	Total generation (MW)	Total Load (MW)	Status of Brighton Beach	MW Flow on J5D (positive is out of Ontario)
1	Brighton Beach out	395	986.6	Out of service	0
2	Import	920	986.6	In service	-150
3	Export	920	986.6	In service	400

For all three cases, load flow studies were completed to ensure that the pre-contingency and post-contingency flows on the transmission system and the voltage declines satisfied the IESO's requirements.

5.1.5 Recognized Contingencies

The recognized contingencies in the Windsor area which were studied in this assessment are summarized in Table 4 below.

Table 4 - Recognized Contingencies

Single Contingencies:	Double Contingencies:
1. J3E	1. C21J + C23Z
2. J4E	2. C21J + C22J
3. Z1E	3. C22J + C24Z
4. Z7E	4. C23Z + C24Z
5. C22J	5. J4E + J3E
6. C21J	
7. C23Z	
8. C24Z	
9. K2Z	
10. K6Z	

5.2 Voltage Analysis

The following IESO criteria must be satisfied before any new equipment is connected to the transmission system:

1. The pre-contingency voltage on 230 kV buses can not be less than 220 kV.
2. The post-contingency voltage on 230 kV buses can not be less than 207 kV.
3. The pre-contingency voltage on 115 kV buses can not be less than113 kV.
4. The post-contingency voltage on 115 kV buses can not be less than 108 kV.
5. The voltage drop following a contingency can not exceed 10% pre-ULTC and 10% post-ULTC.

Load flow studies have been carried out for each case to examine the voltage declines at various buses in the Windsor area for all of the recognized contingencies. The results including pre-contingency voltages, pre-ULTC voltages and post-ULTC voltages are attached in Appendix A. The pre-ULTC voltage declines are the voltage declines before the automatic taps on the transformers move and the post-ULTC voltage declines are the voltage declines after the taps move.

In order to easier identify voltage analysis results from Appendix A, a summary of the contingency results showing bus suffering the largest voltage declines is tabulated in Table 5. In case where double circuits exits, the loss of either companion circuit results in similar post-contingency voltage. Therefore, single contingency results for only one companion circuit are presented.

Table 5 - Summary of Voltage Study Results

Case 1					
Contingency	**Bus suffering greatest voltage decline**	**Voltage decline %**	**Contingency**	**Bus suffering greatest voltage decline**	**Voltage decline %**
C21J+C23Z	Malden B 27.6 kV	6.2	J3E	Chrysler 27.6 kV	0.6
C21J+C22J	Keith 220 kV	2.8	Z1E	Walker 27.6 kV	4.4
C22J+C24Z	Malden B 27.6 kV	5.8	C21J	Malden B 27.6 kV	5.3
C23Z+C24Z	Belle River 115 kV	2.6	C23Z	Lauzon 27.6 kV	4.8
J4E+J3E	Walker 115 kV	2.2	K2Z	Kingsville 27.6 kV	3.6
Case 2					
Contingency	**Bus suffering greatest voltage decline**	**voltage decline %**	**Contingency**	**Bus suffering greatest voltage decline**	**voltage decline %**
C21J+C23Z	Malden B 27.6 kV	5.3	J3E	Walker 115 kV	1.2
C21J+C22J	Keith 115 kV	0.7	Z1E	Walker 115 kV	4.4
C22J+C24Z	Malden B 27.6 kV	5.0	C21J	Malden B 27.6 kV	5.1
C23Z+C24Z	Lauzon 115 kV	2.3	C23Z	Lauzon 27.6 kV	4.5
J4E+J3E	Chrysler 27.6 kV	2.4	K2Z	Kingsville 27.6 kV	3.7
Case 3					
Contingency	**Bus suffering greatest voltage decline**	**voltage decline %**	**Contingency**	**Bus suffering greatest voltage decline**	**voltage decline %**
C21J+C23Z	Malden B 27.6 kV	5.7	J3E	Lauzon 115 kV	0.3
C21J+C22J	Keith 27.6 kV	1.0	Z1E	Walker 27.6 kV	4.5
C22J+C24Z	Malden B 27.6 kV	5.5	C21J	Malden B 27.6 kV	5.4
C23Z+C24Z	Tilbury 115 kV	3.5	C23Z	Lauzon 27.6 kV	4.5
J4E+J3E	Lauzon 220 kV	1.0	K2Z	Kingsville 27.6 kV	3.8

The study results indicate that all the pre-contingency voltages and post-contingency voltage declines meet the Market Rules requirements.

5.3 Thermal Study

This section covers an investigation of thermal capability of the 230 kV and 115 kV circuits and transformers related to the proposed project and any new thermal problems introduced by the new project.

Load flow studies have been carried out to examine the thermal loading capability for transmission elements with the proposed Windsor Area Transmission Reinforcement project. The results including circuit and transformer ratings are attached in Appendix B. The pre-contingency flow on each transmission element is expressed as a percentage of the continuous rating and the post-contingency flow on each transmission element is expressed as a percentage of either the emergency rating or the 15 min. LTR. The 15 min. LTR was used if there are post-contingency actions available that can reduce the flow on that transmission element to its emergency rating; otherwise, the emergency ratings were used.

In order to easier identify thermal analysis results from Appendix B, a summary of the pre-contingency and post-contingency results showing line with greatest % loading and magnitude of % loading is tabulated in Tables 6.

Table 6 - Summary of Thermal Study Results

Case 1					
Contingency	**Line with greatest % percentage**	**% Loading**	**Contingency**	**Line with greatest % percentage**	**% Loading**
Pre-C	K2Z	75	J3E	K6Z	38
C21J+C23Z	C24Z	62	Z1E	Z7E	62
C21J+C22J	C24Z	43	C21J	C22J	55
C22J+C24Z	C23Z	46	C23Z	C24Z	42
C23Z+C24Z	C21J	43	K2Z	K6Z	74
J4E+J3E	C24Z	38			
Case 2					
Contingency	**Line with greatest % percentage**	**% Loading**	**Contingency**	**Line with greatest % percentage**	**% Loading**
Pre-C	K2Z	75	J3E	J4E	39
C21J+C23Z	C22J	44	Z1E	Z7E	61
C21J+C22J	Z1E	30	C21J	C22J	42
C22J+C24Z	K6Z	39	C23Z	C24Z	47
C23Z+C24Z	K6Z	38	K2Z	K6Z	76
J4E+J3E	C24Z	38			
Case 3					
Contingency	**Line with greatest % percentage**	**% Loading**	**Contingency**	**Line with greatest % percentage**	**% Loading**
Pre-C	K2Z	75	J3E	J4E	74
C21J+C23Z	C22J	81	Z1E	Z7E	75
C21J+C22J	Z1E	73	C21J	C22J	76
C22J+C24Z	Z1E	51	C23Z	Z1E	51
C23Z+C24Z	C21J	52	K2Z	K6Z	75
J4E+J3E	C22J	64			

The results indicate that pre-contingency power flows are far below the circuit continuous ratings and the post-contingency power flows on the remaining circuits are well within the LTR of the circuits.

Therefore, it can be concluded that there is no thermal concern for the 230 kV and 115 kV circuits with the proposed Windsor Area Transmission Reinforcement project.

The results in Appendix B also show the percentage loading on the transformers as well as the transformer ratings in Windsor area.

It was found that for all three cases, the post- contingency loadings following the loss of K2Z or K6Z on the remaining Kingsville TS transformers are over the station loading capability. To prevent a post-contingency overload on the Kingsville transformers, a high-voltage-switching scheme was designed to switch in a third transformer either 3T1 or 3T2 in the event of a permanent line fault on either of the K2Z/K6Z. However, the study results show that the transformers were slightly overloaded even after the switching scheme was deployed. Detailed discussions on the scheme and load capability of Kingsville TS will be given in 5.4.4.

It is recommended that Hydro One and/or the area LDCs implement a plan to alleviate the possible overloading at the existing Kingsville TS by increasing the station load capability or transferring some of the load to other transformer stations..

In the export case, the flow on the Keith autotransformers following the loss of circuits C21J and C22J exceeded it short term rating. This is because the loss of C22J and C21J split the Keith 220 kV bus and put the Brighton Beach generation radial on one transformer and the 400 MW export radial on the other transformer. Hydro One has proposed to replace the autotransformers at Keith TS and the overloading problem with Keith transformers will be studied in another SIA report (CAA ID 2007- 265).

5.4 SPS in Windsor Area

As described in Project Description, the Windsor Area is susceptible to a variety of operational problems including pre-contingency voltage instability, post-contingency voltage decline and thermal overload. As a result a number of special protection schemes are employed to facilitate operation of the area such as Connectivity Based L/R Scheme, Voltage Dependent L/R Scheme, Windsor Area Overload Protection Scheme, and Kingsville High-Voltage-Switching Scheme. It should be noted the studied results showed in this report did not take account these schemes except the High-Voltage-Switching scheme.

5.4.1 Connectivity Based L/R Scheme

In the existing system a number of single and double element contingencies can result in excessive post-contingency voltage declines at Kingsville and Tilbury. The Connectivity Based L/R Scheme is intended to address the loss of the Lauzon 230/115 kV connection which may result in excessive voltage declines and/or voltage collapse at high load levels. Upon detection of the loss of the Lauzon 230/115 kV connection, the scheme trips circuits K2Z and K6Z at Lauzon, and Lauzon SC12.

The study results show that with the Windsor Area Transmission Reinforcement project the Windsor local area system performance will be significantly improved. The loss of the Lauzon 230/115 kV connection will not result in excessive voltage declines and/or voltage collapse when Kingsville TS is supplied from Division TS. However, the Connectivity Based L/R Scheme is still needed in case the Kingsville TS is supplied from Lauzon TS.

5.4.2 Voltage Dependent L/R Scheme

In the existing system, Kingsville 115 kV buses may experience an unacceptable level of voltage declines following contingencies that result in the loss of circuits C23Z and/or C24Z. The voltage dependent L/R scheme is designed to trip up to two blocks of load at the 27.6 kV Kingsville TS bus when the voltage at the 115 kV Kingsville TS buses remain below 106 kV for 7 seconds.

As the Kingsville will be radially supplied by the proposed Division TS the voltage is not a concern anymore as showed in the study results. The voltage dependent L/R scheme will be required only when the Kingsville is transferred to be supplied by Lauzon.

5.4.3 Windsor Area Overload Protection Scheme

The Windsor Area Overload Protection Scheme located at Keith TS is designed to mitigate post contingency thermal overload of Keith autotransformers and circuits emanating from Keith and Essex, and to manage possible high voltage following the splitting of Essex. The scheme provides for the rejection of the Brighton Beach units, the splitting of the Essex HV bus, the tripping of Keith autotransformers T11 and T12, and the tripping of the Keith 115 kV capacitor bank and Essex LV capacitor banks. The scheme is based on network connectivity at Keith and Essex.

Since the Windsor Area Overload Protection Scheme is related to the load capability of Keith autotransformers, it will be investigated in the SIA study for the replacement of Keith transformers (CAA ID 2007- 265).

5.4.4 Kingsville High-Voltage-Switching Scheme

The Kingsville high-voltage-switching scheme is intended to increase the load capability of Kingsville TS. As indicated in 5.3, the load capability of Kingsville is still a concern so it is necessary to keep the high-voltage-switching scheme. Except that Hydro One may alleviate the load at the existing Kingsville TS by building a new supply point or transferring some loads to other stations, there are three other options to increase the load capability at Kingsville TS: (1) physically switching T1 and T3, T2 and T4 (2) installation of circuit switchers on the incoming circuits (3) replacing T1 and T2 with transformers having higher emergency ratings.

(1) Physically switching T1 and T3, T2 and T4

The single line diagram for Kingsville TS with transformer continuous and emergency ratings is shown in Figure 3.

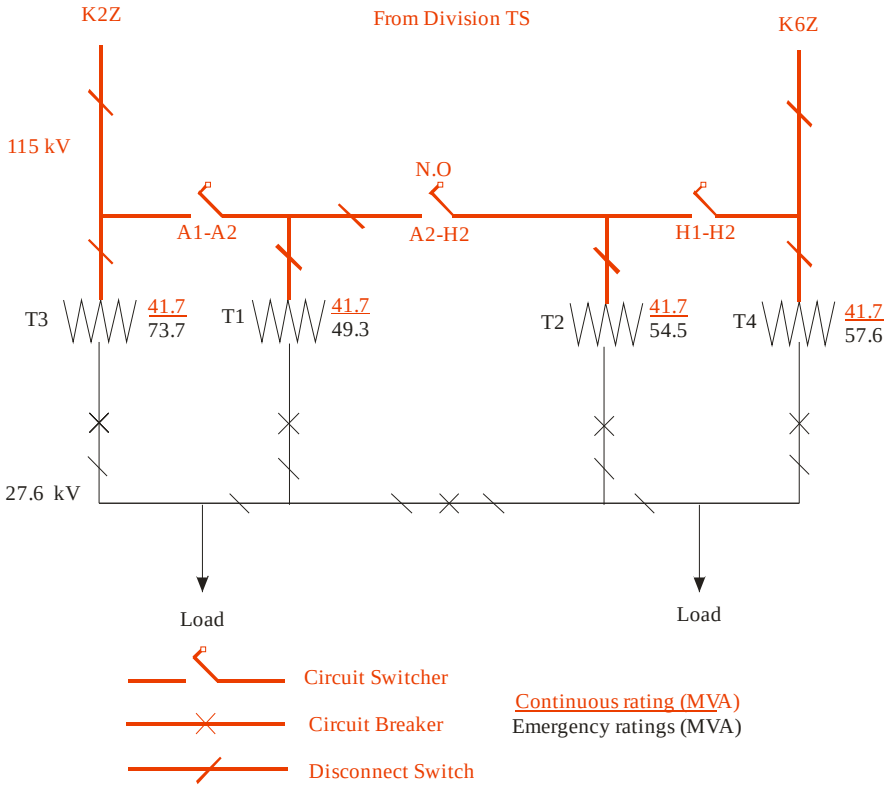

Figure 3: SLD for Kingsville TS

As shown in Figure 3 the four transformers at Kingsville TS have different emergency ratings and T1 and T2 have lower emergency ratings. Based on the existing high-voltage-switching scheme, T1, T3 and T4, which have a total emergency rating of 161.4 MVA, will be in service following the loss of K2Z while T1, T2 and T3, which have a total emergency rating of 177.5 MVA, will be on K2Z following the loss of K6Z. If T3 and T1, T2 and T4 were physically switched, as shown in Figure 4, the load capability of Kingsville TS would be 185.8 MVA following the loss of K2Z and 180.6 MVA following the loss of K6Z. The analysis results are illustrated in Table 7.

Table 7 – Load Capability with Transformer Switching

Transformer		T1	T2	T3	T4	Total
Emergency Rating (MVA)		49.3	54.5	73.7	57.6	235.1
Existing	Loss of K2Z	49.3	54.5	-	57.6	161.4
	Loss of K6Z	49.3	54.5	73.7	-	177.5
After switching	Loss of K2Z	-	54.5	73.7	57.6	185.8
	Loss of K6Z	49.3	-	73.7	57.6	180.6

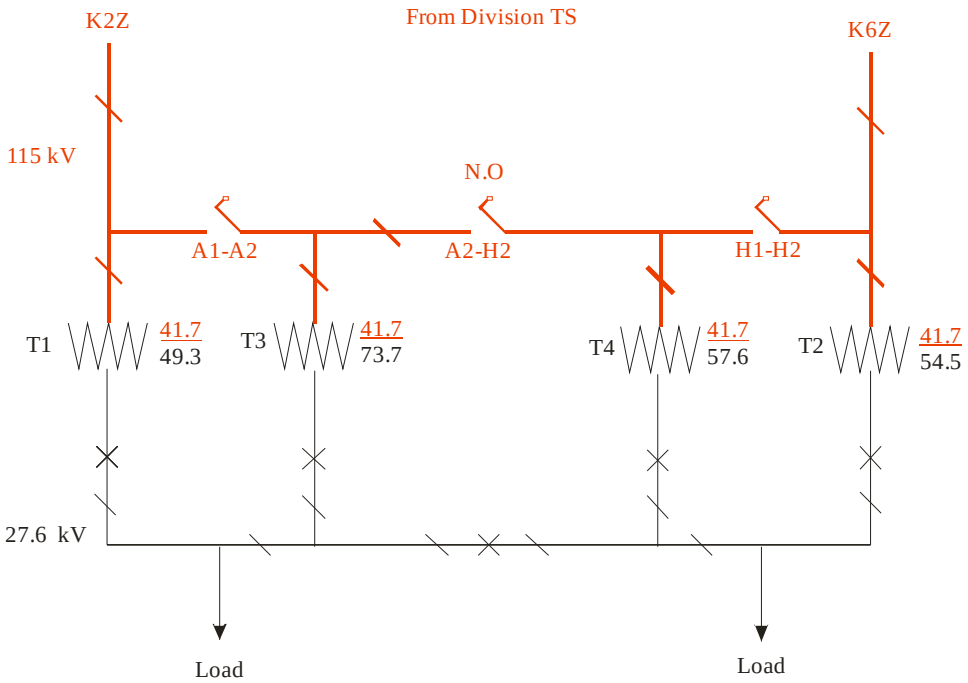

Figure 4: Kingsville TS with transformer switching

It should be noted that the effect of switching transformers is also dependent on the flow distribution on the transformers in Kingsville TS. Operation records indicated that usually T3 has a lowest flow while T4 has a highest one. The power flows on the four transformers for a period from January 10 to January 16, 2008 are shown in Figure 5.

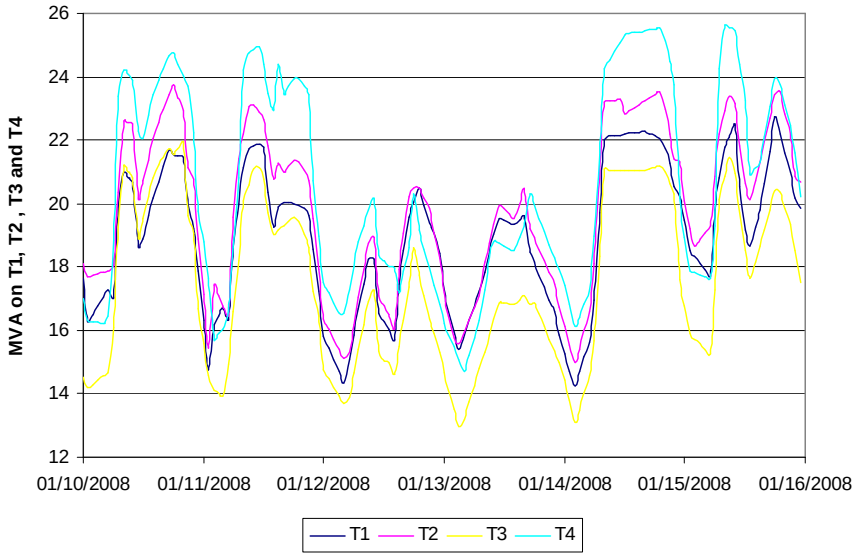

Figure 5: MVA distribution on the four transformers in Kingsville TS

(2) Installation of circuit switchers on the incoming circuits

Because of the upgrades to the K2Z/K6Z from Division TS to Kingsville TS, either of the two circuits is adequate to supply the entire load at Kingsville TS. It is not necessary to operate open the Kingsville low voltage bus tie breaker becuase in the event of a permanent fault on one of the high voltage circuits

supplying Kingsville TS the remaining circuit is capable to supply the entire Kingsville load. Installation of circuit switchers on the two circuits, K2Z/K6Z, at Kingsville TS as shown in Figure 6 will ensure all four transformers can remain in-service in the case of a permanent fault on one circuit.

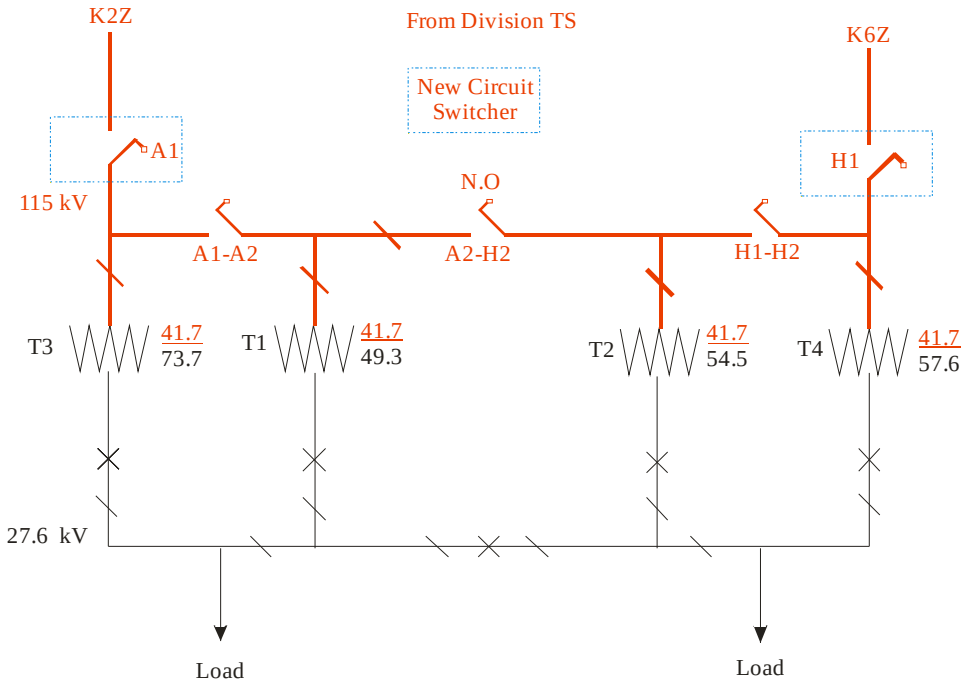

Figure 6: Kingsville TS with new breakers

In this case, the high-voltage-switching scheme can be modified as follows.

The switching logic in the case of a permanent K2Z fault will trip the A1 circuit switcher and close the A2H2 circuit switcher. This will put all four transformers on 115 kV line K6Z.
In the case of a permanent fault on the K6Z circuit, the switching logic will trip the H1 circuit switcher and close the A2H2 circuit switcher. This will put all four transformers on 115 kV circuit K2Z.

(3) Replacing T1 and T2 with transformers having higher emergency ratings.

It should be noted that the above two options work well with the loss of one of the incoming circuits but cannot improve the load capability for a contingency involved a transformer, for example, T3. So, the third option to increase the station load capability is to replace T1 and T2 with transformers having a higher emergency rating.

5.5 Summary

The findings of analysis are summarized as follows:

1. The proposed project will significantly improve the voltage profile and increase the supply capability in Windsor area.

2. Pre-contingency and post-contingency voltages in Windsor area with the proposed project meet Market Rules requirements.

3. There is no thermal overloading concern associated with the 230 kV and the 115 kV circuits with the proposed Windsor Area Transmission Reinforcement project.

4. The Connectivity-based LR scheme and Voltage-based LR scheme shold be armed when Kingsville is supplied by Lauzon TS and the frequency of using the schemes will be significantly reduced.

– **End of Report –**

Appendix A – Voltage Study Results

Table A1 – Pre-ULTC Voltage Declines – Case 1: Brighton Beach out

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	249	-0.1	1.0	0.0	0.7	0.0	0.0	-0.1	0.0	0.0	0.0	-0.2	0.0	-0.1	-0.1	0.2
Lauzon 115 kV	127	-2.6	0.7	-2.3	-2.6	0.1	0.1	0.2	0.2	-0.4	-0.5	-2.0	-1.8	-0.1	-0.1	1.6
Keith 115 kV	126	-1.7	0.9	-1.5	-1.2	-0.3	-0.2	-0.3	-0.3	-0.6	-0.7	-1.0	-0.9	-0.1	-0.1	-0.9
Essex 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Tilbury 115 kV	125	-2.6	0.7	-2.3	-2.6	0.1	0.1	0.2	0.2	-0.4	-0.5	-2.0	-1.8	-0.1	-0.1	1.6
Tilbury 27.6 kV	29	-2.6	0.7	-2.3	-2.6	0.1	0.1	0.2	0.2	-0.4	-0.5	-2.0	-1.8	-0.1	-0.1	1.6
Tilbury West 115 kV	125	-2.6	0.7	-2.3	-2.6	0.1	0.1	0.2	0.2	-0.4	-0.5	-2.0	-1.8	-0.1	-0.1	1.6
Tilbury West 27.6 kV	29	-2.6	0.7	-2.3	-2.6	0.1	0.1	0.2	0.2	-0.4	-0.5	-2.0	-1.8	-0.1	-0.1	1.6
Tilbury West 27.6 kV	29	-2.6	0.7	-2.3	-2.6	0.1	0.1	0.2	0.2	-0.4	-0.5	-2.0	-1.8	-0.1	-0.1	1.6
Kingsville K6Z 115 kV	122	-2.3	-	-1.9	-0.2	-0.1	-0.1	-0.2	-0.1	-1.5	-1.8	-0.5	-0.4	-3.0	-2.9	-0.1
Kingsville K2Z 115 kV	122	-2.3	-	-1.9	-0.2	-0.1	-0.1	-0.2	-0.1	-1.5	-1.8	-0.5	-0.4	-3.1	-3.1	-0.1
Kingsville 27.6 kV	29	-2.3	-	-1.9	-0.2	-0.1	-0.1	-0.2	-0.1	-1.5	-1.8	-0.5	-0.4	-3.2	-3.6	-0.1
Walker Z1E 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-	-0.5	-0.5	-0.5	-1.7	-1.5	-0.1	-0.1	1.9
Walker Z7E 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-	-0.5	-0.5	-1.7	-1.5	-0.1	-0.1	1.9
Walker #2 27.6 kV	29	-2.3	0.7	-2.0	-2.1	0.1	0.2	-4.4	-4.5	-0.5	-0.5	-1.7	-1.5	-0.1	-0.1	1.9
Walker 27.6 kV	29	-2.3	0.7	-2.0	-2.1	0.1	0.2	-2.0	-2.1	-0.5	-0.5	-1.7	-1.5	-0.1	-0.1	1.9
Essex 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Essex 27.6 kV	34	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Keith 220 kV	243	-1.6	2.8	-1.4	-0.6	-0.2	-0.1	-0.2	-0.2	-0.8	-0.9	-0.6	-0.5	-0.2	-0.2	-0.3
Keith 27.6 kV	29	-1.6	1.4	-1.4	-0.6	-0.2	-0.1	-0.2	-0.2	-0.8	-0.9	-0.6	-0.5	-0.2	-0.2	-0.3
Malden C21J 220 kV	243	-	-	-1.5	-0.6	-0.2	-0.1	-0.2	-0.2	-0.9	-	-0.6	-0.5	-0.1	-0.3	-0.3
Malden C22J 220 kV	243	-1.8	-	-	-0.6	-0.2	-0.1	-0.2	-0.2	-	-1.1	-0.6	-0.5	-0.3	-0.1	-0.3
Malden Y 27.6 kV	30	-4.3	-	-4.0	-0.6	-0.2	-0.1	-0.2	-0.2	-3.4	-3.6	-0.6	-0.5	-0.2	-0.2	-0.3
Malden B 27.6 kV	30	-6.2	-	-5.8	-0.6	-0.2	-0.1	-0.2	-0.2	-5.3	-5.5	-0.6	-0.5	-0.2	-0.2	-0.3
Lauzon C23Z 220 kV	239	-	0.5	-2.6	-	0.0	0.1	0.1	0.1	-0.4	-0.4	-	-2.1	-0.1	-0.1	1.0
Lauzon C24Z 220 kV	239	-3.0	0.5	-	-	0.0	0.1	0.1	0.1	-0.4	-0.4	-2.5	-	-0.1	-0.1	1.0
Lauzon EJ 27.6 kV	30	-4.9	0.5	-4.3	-	0.0	0.1	0.1	0.1	-0.4	-0.4	-4.3	-3.8	-0.1	-0.1	1.0
Lauzon BQ 27.6 kV	29	-5.4	0.5	-4.9	-	0.0	0.1	0.1	0.1	-0.4	-0.4	-4.8	-4.5	-0.1	-0.1	1.0
Ford Essex Z1E 115 kV	127	-2.5	0.7	-2.2	-2.4	0.1	0.2	-	0.0	-0.4	-0.5	-1.9	-1.7	-0.1	-0.1	1.7
Ford Essex Z7E 115 kV	127	-2.5	0.7	-2.2	-2.4	0.1	0.2	0.0	-	-0.4	-0.5	-1.9	-1.7	-0.1	-0.1	1.7
Ford Essex 13.8 kV	15	-2.5	0.7	-2.2	-2.4	0.1	0.2	-0.7	-0.7	-0.4	-0.5	-1.9	-1.7	-0.1	-0.1	1.7
Chrysler E8V 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Chrysler E9V 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Chrysler 27.6 kV	29	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
GM Windsor E8F 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
GM Windsor E9F 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
GM Windsor 27.6 kV	29	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Ford Annex E8V 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Ford Annex E9V 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Ford Annex 13.8 kV	15	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Ford Windsor E8F 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Ford Windsor E9F 115 kV	126	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Ford Windsor 27.6 kV	30	-2.3	0.7	-2.0	-2.1	0.1	0.2	-0.5	-0.5	-0.5	-0.5	-1.7	-1.4	-0.1	-0.1	1.9
Belle River K6Z 115 kV	127	-2.6	0.7	-2.3	-2.6	0.1	0.1	0.2	0.2	-0.4	-0.5	-2.0	-1.8	-0.1	-0.1	1.6
Belle River K2Z 115 kV	127	-2.6	0.7	-2.3	-2.6	0.1	0.1	0.2	0.2	-0.4	-0.5	-2.0	-1.8	-0.1	-0.1	1.6
Belle River 27.6 kV	29	-2.6	0.7	-2.3	-2.6	0.1	0.1	0.2	0.2	-0.4	-0.5	-2.0	-1.8	-0.1	-0.1	1.6

Table A2– Post-ULTC Voltage Declines – Case 1: Brighton Beach out

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	249	-0.2	1.0	0.0	0.8	0.0	0.0	-0.1	0.0	-0.1	0.0	-0.2	0.0	-0.1	-0.1	0.2
Lauzon 115 kV	127	-2.9	0.7	-2.5	-2.7	0.1	0.1	0.1	0.1	-0.5	-0.5	-2.2	-1.9	-0.1	-0.1	1.9
Keith 115 kV	126	-2.0	0.9	-1.7	-1.3	-0.2	-0.2	-0.4	-0.4	-0.6	-0.7	-1.1	-0.9	-0.2	-0.2	-0.8
Essex 115 kV	126	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
Tilbury 115 kV	125	-3.1	0.8	-2.6	-2.9	0.1	0.1	0.1	0.1	-0.5	-0.5	-2.3	-1.9	-0.1	-0.1	2.0
Tilbury 27.6 kV	29	-0.6	0.8	-1.4	-0.4	0.1	0.1	0.1	0.1	-0.5	-0.5	-1.1	-0.7	-0.1	-0.1	0.7
Tilbury West 115 kV	125	-3.1	0.8	-2.6	-2.9	0.1	0.1	0.1	0.1	-0.5	-0.5	-2.3	-1.9	-0.1	-0.1	2.0
Tilbury West 27.6 kV	29	-0.8	0.0	-1.1	-0.6	0.1	0.1	0.1	0.1	-0.5	-0.5	-0.8	-1.1	-0.1	-0.1	0.4
Tilbury West 27.6 kV	29	-0.8	0.0	-1.1	-0.6	0.1	0.1	0.1	0.1	-0.5	-0.5	-0.8	-1.1	-0.1	-0.1	0.4
Kingsville K6Z 115 kV	122	-2.6	-	-2.1	-0.2	-0.1	-0.1	-0.2	-0.1	-1.6	-1.8	-0.6	-0.4	-3.1	-3.3	-0.1
Kingsville K2Z 115 kV	122	-2.6	-	-2.1	-0.2	-0.1	-0.1	-0.2	-0.1	-1.6	-1.8	-0.6	-0.4	-3.3	-3.5	-0.1
Kingsville 27.6 kV	29	-1.3	-	-2.1	-0.2	-0.1	-0.1	-0.2	-0.1	-1.6	-1.9	-0.6	-0.4	-2.1	-1.4	-0.1
Walker Z1E 115 kV	126	-2.6	0.8	-2.2	-2.3	0.1	0.2	-	-0.6	-0.5	-0.6	-1.9	-1.6	-0.1	-0.1	2.2
Walker Z7E 115 kV	126	-2.6	0.8	-2.3	-2.3	0.1	0.2	-0.6	-	-0.5	-0.6	-1.9	-1.6	-0.1	-0.1	2.2
Walker #2 27.6 kV	29	-1.5	0.8	-1.1	-1.1	0.1	0.2	-1.4	-1.6	-0.5	-0.6	-0.7	-1.6	-0.1	-0.1	0.9
Walker 27.6 kV	29	-2.6	0.8	-2.3	-2.3	0.1	0.2	-2.1	-2.2	-0.5	-0.6	-1.9	-1.6	-0.1	-0.1	2.2
Essex 115 kV	126	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
Essex 27.6 kV	34	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
Keith 220 kV	243	-1.8	2.8	-1.5	-0.7	-0.1	-0.1	-0.2	-0.2	-0.8	-1.0	-0.7	-0.6	-0.2	-0.2	-0.3
Keith 27.6 kV	29	-0.8	0.3	-0.5	-0.7	-0.1	-0.1	-0.2	-0.2	-0.8	-1.0	-0.7	-0.6	-0.2	-0.2	-0.3
Malden C21J 220 kV	243	-	-	-1.7	-0.6	-0.1	-0.1	-0.2	-0.2	-1.0	-	-0.7	-0.6	-0.2	-0.3	-0.3
Malden C22J 220 kV	243	-2.0	-	-	-0.6	-0.1	-0.1	-0.2	-0.2	-	-1.2	-0.7	-0.6	-0.3	-0.2	-0.3
Malden Y 27.6 kV	30	0.1	-	0.4	-0.6	-0.1	-0.1	-0.2	-0.2	0.0	1.0	-0.7	-0.6	-0.2	-0.3	-0.3
Malden B 27.6 kV	30	-2.0	-	-1.5	-0.6	-0.1	-0.1	-0.2	-0.2	-1.9	-1.1	-0.7	-0.6	-0.2	-0.3	-0.3
Lauzon C23Z 220 kV	239	-	0.6	-2.9	-	0.1	0.1	0.0	0.1	-0.4	-0.4	-	-2.3	-0.1	-0.1	1.2
Lauzon C24Z 220 kV	239	-3.3	0.6	-	-	0.1	0.1	0.0	0.1	-0.4	-0.4	-2.7	-	-0.1	-0.1	1.2
Lauzon EJ 27.6 kV	30	-1.9	-0.5	-1.3	-	0.1	0.1	0.0	0.1	-0.4	-0.4	-1.2	-1.7	-0.1	-0.1	0.1
Lauzon BQ 27.6 kV	29	-0.1	0.6	-0.8	-	0.1	0.1	0.0	0.1	-0.4	-0.4	-0.6	-0.1	-0.1	-0.1	0.1
Ford Essex Z1E 115 kV	127	-2.8	0.8	-2.4	-2.6	0.1	0.1	-	-0.1	-0.5	-0.5	-2.1	-1.8	-0.1	-0.1	2.0
Ford Essex Z7E 115 kV	127	-2.8	0.8	-2.4	-2.6	0.1	0.1	-0.1	-	-0.5	-0.5	-2.1	-1.8	-0.1	-0.1	2.0
Ford Essex 13.8 kV	15	-1.6	-0.6	-2.4	-1.3	0.1	0.1	-0.8	-0.8	-0.5	-0.5	-2.1	-1.8	-0.1	-0.1	-0.7
Chrysler E8V 115 kV	126	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
Chrysler E9V 115 kV	126	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
Chrysler 27.6 kV	29	-1.1	0.0	-0.7	-0.7	-0.6	-0.6	-0.6	-0.6	-0.5	-0.6	-1.1	-0.8	-0.1	-0.1	-0.4
GM Windsor E8F 115 kV	126	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
GM Windsor E9F 115 kV	126	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
GM Windsor 27.6 kV	29	-0.7	0.1	-0.4	-0.4	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-0.6	-0.9	-0.1	-0.1	0.2
Ford Annex E8V 115 kV	126	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
Ford Annex E9V 115 kV	126	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
Ford Annex 13.8 kV	15	-0.9	-0.1	-1.4	-1.4	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.0	-1.5	-0.1	-0.1	-0.5
Ford Windsor E8F 115 kV	126	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
Ford Windsor E9F 115 kV	126	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
Ford Windsor 27.6 kV	30	-2.6	0.8	-2.2	-2.2	0.1	0.2	-0.6	-0.6	-0.5	-0.6	-1.8	-1.5	-0.1	-0.1	2.2
Belle River K6Z 115 kV	127	-2.9	0.8	-2.6	-2.8	0.1	0.1	0.1	0.1	-0.5	-0.5	-2.2	-1.9	-0.1	-0.1	1.9
Belle River K2Z 115 kV	127	-2.9	0.8	-2.6	-2.8	0.1	0.1	0.1	0.1	-0.5	-0.5	-2.2	-1.9	-0.1	-0.1	1.9
Belle River 27.6 kV	29	-1.7	-0.5	-1.3	-1.5	0.1	0.1	-1.2	-1.2	-0.5	-0.5	-1.0	-1.9	-0.1	-0.1	-0.7

Table A3 – Pre-ULTC Voltage Declines – Case 2: Export

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	248	0.3	1.1	0.4	0.9	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.1	-0.1	-0.1	0.1
Lauzon 115 kV	127	-1.9	-0.2	-1.7	-2.2	0.2	0.2	0.3	0.3	-0.1	-0.1	-1.7	-1.5	-0.1	-0.1	1.7
Keith 115 kV	125	-0.8	-0.7	-0.7	-0.7	-0.2	-0.2	-0.1	-0.2	-0.3	-0.3	-0.5	-0.5	-0.1	-0.1	-0.8
Essex 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.1	-0.1	-0.1	2.0
Tilbury 115 kV	124	-1.9	-0.2	-1.7	-2.2	0.2	0.2	0.3	0.3	-0.1	-0.1	-1.7	-1.5	-0.1	-0.1	1.7
Tilbury 27.6 kV	30	-1.9	-0.2	-1.7	-2.2	0.2	0.2	0.3	0.3	-0.1	-0.1	-1.7	-1.5	-0.1	-0.1	1.7
Tilbury West 115 kV	124	-1.9	-0.2	-1.7	-2.2	0.2	0.2	0.3	0.3	-0.1	-0.1	-1.7	-1.5	-0.1	-0.1	1.7
Tilbury West 27.6 kV	30	-1.9	-0.2	-1.7	-2.2	0.2	0.2	0.3	0.3	-0.1	-0.1	-1.7	-1.5	-0.1	-0.1	1.7
Tilbury West 27.6 kV	30	-1.9	-0.2	-1.7	-2.2	0.2	0.2	0.3	0.3	-0.1	-0.1	-1.7	-1.5	-0.1	-0.1	1.7
Kingsville K6Z 115 kV	121	-1.5	-	-1.3	0.3	0.0	0.0	0.0	0.0	-1.3	-1.4	-0.1	0.0	-3.0	-3.0	-0.1
Kingsville K2Z 115 kV	121	-1.5	-	-1.3	0.3	0.0	0.0	0.0	0.0	-1.3	-1.4	-0.1	0.0	-3.2	-3.2	-0.1
Kingsville 27.6 kV	29	-1.5	-	-1.3	0.3	0.0	0.0	0.0	0.0	-1.3	-1.4	-0.1	0.0	-3.3	-3.7	-0.1
Walker Z1E 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-	-0.5	-0.2	-0.2	-1.3	-1.2	-0.1	-0.1	2.0
Walker Z7E 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-	-0.2	-0.2	-1.3	-1.2	-0.1	-0.1	2.0
Walker #2 27.6 kV	30	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-4.3	-4.4	-0.2	-0.2	-1.3	-1.2	-0.1	-0.1	2.0
Walker 27.6 kV	30	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-1.9	-2.0	-0.2	-0.2	-1.3	-1.2	-0.1	-0.1	2.0
Essex 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.1	-0.1	-0.1	2.0
Essex 27.6 kV	34	-1.5	-0.3	-1.4	-1.7	0.2	0.3	-0.4	-0.4	-0.2	-0.2	-1.3	-1.2	-0.1	-0.1	2.0
Keith 220 kV	241	-0.6	-0.5	-0.6	-0.1	-0.1	-0.1	0.0	-0.1	-0.4	-0.5	-0.1	-0.1	-0.1	-0.1	-0.3
Keith 27.6 kV	29	-0.6	-1.6	-0.6	-0.1	-0.1	-0.1	0.0	-0.1	-0.4	-0.5	-0.1	-0.1	-0.1	-0.1	-0.3
Malden C21J 220 kV	241	-	-	-0.8	0.0	-0.1	-0.1	0.0	-0.1	-0.6	-	-0.1	-0.1	-0.1	-0.2	-0.3
Malden C22J 220 kV	241	-0.8	-	-	0.0	-0.1	-0.1	0.0	-0.1	-	-0.7	-0.1	-0.1	-0.2	-0.1	-0.3
Malden Y 27.6 kV	30	-3.3	-	-3.2	0.0	-0.1	-0.1	0.0	-0.1	-3.1	-3.1	-0.1	-0.1	-0.1	-0.1	-0.3
Malden B 27.6 kV	30	-5.3	-	-5.0	0.0	-0.1	-0.1	0.0	-0.1	-4.9	-5.1	-0.1	-0.1	-0.1	-0.1	-0.3
Lauzon C23Z 220 kV	239	-	0.3	-2.0	-	0.1	0.1	0.2	0.2	-0.1	-0.1	-	-1.8	0.0	-0.1	0.9
Lauzon C24Z 220 kV	239	-2.3	0.3	-	-	0.1	0.1	0.2	0.2	-0.1	-0.1	-2.1	-	0.0	-0.1	0.9
Lauzon EJ 27.6 kV	29	-4.1	0.3	-3.7	-	0.1	0.1	0.2	0.2	-0.1	-0.1	-4.0	-3.5	0.0	-0.1	0.9
Lauzon BQ 27.6 kV	29	-4.6	0.3	-4.4	-	0.1	0.1	0.2	0.2	-0.1	-0.1	-4.5	-4.2	0.0	-0.1	0.9
Ford Essex Z1E 115 kV	127	-1.8	-0.2	-1.6	-2.1	0.2	0.2	-	0.1	-0.1	-0.2	-1.6	-1.4	-0.1	-0.1	1.8
Ford Essex Z7E 115 kV	127	-1.8	-0.2	-1.6	-2.1	0.2	0.2	0.1	-	-0.1	-0.2	-1.6	-1.4	-0.1	-0.1	1.8
Ford Essex 13.8 kV	15	-1.8	-0.2	-1.6	-2.1	0.2	0.2	-0.6	-0.6	-0.1	-0.2	-1.6	-1.4	-0.1	-0.1	1.8
Chrysler E8V 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.1	-0.1	-0.1	2.0
Chrysler E9V 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.1	-0.1	-0.1	2.0
Chrysler 27.6 kV	29	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.2	-0.1	-0.1	2.0
GM Windsor E8F 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.1	-0.1	-0.1	2.0
GM Windsor E9F 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.1	-0.1	-0.1	2.0
GM Windsor 27.6 kV	29	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.1	-0.1	-0.1	2.0
Ford Annex E8V 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.1	-0.1	-0.1	2.0
Ford Annex E9V 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.1	-0.1	-0.1	2.0
Ford Annex 13.8 kV	15	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.2	-0.1	-0.1	2.0
Ford Windsor E8F 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.2	-0.1	-0.1	2.0
Ford Windsor E9F 115 kV	126	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.2	-0.1	-0.1	2.0
Ford Windsor 27.6 kV	30	-1.5	-0.3	-1.4	-1.7	0.2	0.2	-0.4	-0.4	-0.2	-0.2	-1.3	-1.2	-0.1	-0.1	2.0
Belle River K6Z 115 kV	126	-1.9	-0.2	-1.7	-2.2	0.2	0.2	0.3	0.3	-0.1	-0.1	-1.7	-1.5	-0.1	-0.1	1.7
Belle River K2Z 115 kV	126	-1.9	-0.2	-1.7	-2.2	0.2	0.2	0.3	0.3	-0.1	-0.1	-1.7	-1.5	-0.1	-0.1	1.7
Belle River 27.6 kV	29	-1.9	-0.2	-1.7	-2.2	0.2	0.2	0.3	0.3	-0.1	-0.1	-1.7	-1.5	-0.1	-0.1	1.7

Table A4 – Post-ULTC Voltage Declines – Case 2: Export

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	248	0.3	1.1	0.3	0.9	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.1	-0.1	-0.1	0.2
Lauzon 115 kV	127	-2.0	-0.2	-1.8	-2.3	0.2	0.2	0.3	0.2	-0.2	-0.2	-1.8	-1.6	-0.1	-0.1	2.1
Keith 115 kV	125	-0.9	-0.7	-0.8	-0.7	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.6	-0.5	-0.1	-0.1	-0.8
Essex 115 kV	126	-1.6	-0.3	-1.4	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Tilbury 115 kV	124	-2.1	-0.2	-1.8	-2.3	0.3	0.3	0.3	0.3	-0.2	-0.2	-1.8	-1.6	-0.1	-0.1	2.2
Tilbury 27.6 kV	30	-2.1	-0.2	-1.8	-2.3	-1.0	-1.0	-0.9	-1.0	-0.2	-0.2	-1.8	-1.6	-0.1	-0.1	-0.3
Tilbury West 115 kV	124	-2.1	-0.2	-1.8	-2.3	0.3	0.3	0.3	0.3	-0.2	-0.2	-1.8	-1.6	-0.1	-0.1	2.2
Tilbury West 27.6 kV	30	-1.3	-0.2	-1.1	-1.6	-0.5	-0.5	-0.5	-0.5	-0.2	-0.2	-1.1	-1.6	-0.1	-0.1	-0.2
Tilbury West 27.6 kV	30	-1.3	-0.2	-1.1	-1.6	-0.5	-0.5	-0.5	-0.5	-0.2	-0.2	-1.1	-1.6	-0.1	-0.1	-0.2
Kingsville K6Z 115 kV	121	-1.7	-	-1.5	0.3	0.0	0.0	0.0	0.0	-1.4	-1.6	-0.1	0.0	-3.4	-3.6	-0.1
Kingsville K2Z 115 kV	121	-1.7	-	-1.4	0.3	0.0	0.0	0.0	0.0	-1.4	-1.6	-0.1	0.0	-3.6	-3.7	-0.1
Kingsville 27.6 kV	29	-0.3	-	-0.1	0.3	0.0	0.0	0.0	0.0	0.0	-0.2	-0.1	0.0	-1.0	-0.4	-0.1
Walker Z1E 115 kV	126	-1.6	-0.3	-1.5	-1.8	0.3	0.3	-	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Walker Z7E 115 kV	126	-1.6	-0.3	-1.5	-1.8	0.3	0.3	-0.4	-	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Walker #2 27.6 kV	30	-1.7	-0.3	-1.5	-1.8	-0.9	-0.9	-2.3	-2.4	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	0.0
Walker 27.6 kV	30	-1.6	-0.3	-1.5	-1.8	-1.2	-1.2	-1.9	-2.0	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	0.9
Essex 115 kV	126	-1.6	-0.3	-1.4	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Essex 27.6 kV	34	-1.6	-0.3	-1.5	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Keith 220 kV	241	-0.7	-0.5	-0.6	-0.1	-0.1	-0.1	0.0	-0.1	-0.5	-0.5	-0.1	-0.1	-0.1	-0.1	-0.3
Keith 27.6 kV	29	-0.7	-0.5	-0.6	-0.1	-0.1	-0.1	0.0	-0.1	-0.5	-0.5	-0.1	-0.1	-0.1	-0.1	-0.3
Malden C21J 220 kV	241	-	-	-0.8	0.0	-0.1	-0.1	0.0	-0.1	-0.7	-	-0.1	-0.1	-0.1	-0.2	-0.3
Malden C22J 220 kV	241	-0.9	-	-	0.0	-0.1	-0.1	0.0	-0.1	-	-0.7	-0.1	-0.1	-0.2	-0.1	-0.2
Malden Y 27.6 kV	30	0.1	-	0.2	0.0	-0.1	-0.1	0.0	-0.1	0.4	0.3	-0.1	-0.1	-0.1	-0.2	-0.3
Malden B 27.6 kV	30	-1.9	-	-1.7	0.0	-0.1	-0.1	0.0	-0.1	-1.5	-1.8	-0.1	-0.1	-0.1	-0.2	-0.3
Lauzon C23Z 220 kV	239	-	0.3	-2.2	-	0.1	0.1	0.1	0.2	-0.1	-0.1	-	-1.9	-0.1	-0.1	1.2
Lauzon C24Z 220 kV	239	-2.4	0.3	-	-	0.1	0.1	0.1	0.2	-0.1	-0.1	-2.3	-	-0.1	-0.1	1.2
Lauzon EJ 27.6 kV	29	-1.0	0.3	-1.7	-	0.1	0.1	0.1	0.2	-0.1	-0.1	-0.8	-1.4	-0.1	-0.1	0.1
Lauzon BQ 27.6 kV	29	-0.4	0.3	0.0	-	0.1	0.1	0.1	0.2	-0.1	-0.1	-0.2	-1.0	-0.1	-0.1	1.2
Ford Essex Z1E 115 kV	127	-1.9	-0.2	-1.7	-2.1	0.3	0.3	-	0.0	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	2.2
Ford Essex Z7E 115 kV	127	-1.9	-0.2	-1.7	-2.1	0.3	0.3	0.1	-	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	2.2
Ford Essex 13.8 kV	15	-1.9	-0.2	-1.7	-2.1	0.3	0.3	-0.6	-0.7	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.5
Chrysler E8V 115 kV	126	-1.6	-0.3	-1.4	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Chrysler E9V 115 kV	126	-1.6	-0.3	-1.4	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Chrysler 27.6 kV	29	-0.1	-0.3	-0.7	-0.2	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-0.6	-0.4	-0.1	-0.1	-0.2
GM Windsor E8F 115 kV	126	-1.6	-0.3	-1.4	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
GM Windsor E9F 115 kV	126	-1.6	-0.3	-1.4	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
GM Windsor 27.6 kV	29	-1.0	-0.3	-0.8	-1.1	-0.4	-0.3	-0.4	-0.5	-0.2	-0.2	-0.7	-1.2	-0.1	-0.1	-0.2
Ford Annex E8V 115 kV	126	-1.6	-0.3	-1.4	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Ford Annex E9V 115 kV	126	-1.6	-0.3	-1.4	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Ford Annex 13.8 kV	15	-0.8	-0.3	-0.6	-0.9	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-0.5	-1.2	-0.1	-0.1	-0.3
Ford Windsor E8F 115 kV	126	-1.6	-0.3	-1.4	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Ford Windsor E9F 115 kV	126	-1.6	-0.3	-1.4	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Ford Windsor 27.6 kV	30	-1.6	-0.3	-1.4	-1.7	0.3	0.3	-0.4	-0.5	-0.2	-0.2	-1.4	-1.2	-0.1	-0.1	2.4
Belle River K6Z 115 kV	126	-2.0	-0.2	-1.8	-2.3	0.2	0.2	0.3	0.2	-0.2	-0.2	-1.8	-1.6	-0.1	-0.1	2.1
Belle River K2Z 115 kV	126	-2.0	-0.2	-1.8	-2.3	0.2	0.2	0.3	0.2	-0.2	-0.2	-1.8	-1.6	-0.1	-0.1	2.1
Belle River 27.6 kV	29	-0.8	-0.2	-0.5	-1.0	0.2	0.2	0.3	0.2	-0.2	-0.2	-0.5	-1.6	-0.1	-0.1	-0.5

Table A5 – Pre-ULTC Voltage Declines – Case 3: Import

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	247	0.3	0.5	0.5	1.0	-0.1	-0.1	0.0	0.0	0.1	0.1	0.1	0.2	-0.1	-0.1	-0.4
Lauzon 115 kV	125	-2.4	-0.7	-2.2	-3.1	-0.3	-0.2	0.0	0.0	-0.2	-0.2	-2.1	-1.9	-0.1	-0.1	-0.6
Keith 115 kV	125	-1.1	-0.6	-1.0	-1.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.8	-0.7	-0.1	-0.1	-0.2
Essex 115 kV	125	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.6
Tilbury 115 kV	122	-2.4	-0.7	-2.2	-3.2	-0.3	-0.2	0.0	0.0	-0.2	-0.2	-2.1	-1.9	-0.1	-0.1	-0.6
Tilbury 27.6 kV	29	-2.4	-0.7	-2.2	-3.2	-0.3	-0.2	0.0	0.0	-0.2	-0.2	-2.2	-1.9	-0.1	-0.1	-0.6
Tilbury West 115 kV	122	-2.4	-0.7	-2.2	-3.2	-0.3	-0.2	0.0	0.0	-0.2	-0.2	-2.1	-1.9	-0.1	-0.1	-0.6
Tilbury West 27.6 kV	29	-2.4	-0.7	-2.2	-3.2	-0.3	-0.2	0.0	0.0	-0.2	-0.2	-2.2	-1.9	-0.1	-0.1	-0.6
Tilbury West 27.6 kV	29	-2.4	-0.7	-2.2	-3.2	-0.3	-0.2	0.0	0.0	-0.2	-0.2	-2.2	-1.9	-0.1	-0.1	-0.6
Kingsville K6Z 115 kV	121	-1.7	-	-1.5	0.2	-0.1	-0.1	-0.1	0.0	-1.4	-1.5	-0.2	-0.1	-3.0	-3.1	-0.4
Kingsville K2Z 115 kV	121	-1.7	-	-1.5	0.2	-0.1	-0.1	-0.1	0.0	-1.4	-1.5	-0.2	-0.1	-3.1	-3.3	-0.4
Kingsville 27.6 kV	29	-1.7	-	-1.6	0.2	-0.1	-0.1	-0.1	0.0	-1.5	-1.5	-0.2	-0.1	-3.3	-3.8	-0.4
Walker Z1E 115 kV	124	-2.0	-0.7	-1.8	-2.5	-0.3	-0.3	-	-0.4	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.6
Walker Z7E 115 kV	124	-2.0	-0.7	-1.8	-2.5	-0.3	-0.3	-0.4	-	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.6
Walker #2 27.6 kV	29	-2.0	-0.7	-1.8	-2.5	-0.3	-0.3	-4.5	-4.6	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.6
Walker 27.6 kV	29	-2.0	-0.7	-1.8	-2.5	-0.3	-0.3	-2.1	-2.1	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.6
Essex 115 kV	125	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.6
Essex 27.6 kV	33	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.7
Keith 220 kV	242	-0.9	-0.8	-0.9	-0.2	-0.1	0.0	-0.1	-0.1	-0.6	-0.6	-0.3	-0.2	-0.1	-0.1	-0.2
Keith 27.6 kV	29	-0.9	-1.0	-0.9	-0.2	-0.1	0.0	-0.1	-0.1	-0.6	-0.6	-0.3	-0.2	-0.1	-0.1	-0.2
Malden C21J 220 kV	241	-	-	-1.0	-0.2	-0.1	0.0	-0.1	-0.1	-0.8	-	-0.3	-0.2	0.0	-0.2	-0.2
Malden C22J 220 kV	242	-1.1	-	-	-0.2	-0.1	0.0	-0.1	-0.1	-	-0.8	-0.3	-0.2	-0.2	0.0	-0.2
Malden Y 27.6 kV	30	-3.7	-	-3.6	-0.2	-0.1	0.0	-0.1	-0.1	-3.4	-3.4	-0.3	-0.2	-0.1	-0.1	-0.2
Malden B 27.6 kV	29	-5.7	-	-5.5	-0.2	-0.1	0.0	-0.1	-0.1	-5.3	-5.4	-0.3	-0.2	-0.1	-0.1	-0.2
Lauzon C23Z 220 kV	237	-	-0.1	-2.0	-	-0.2	-0.2	0.0	0.0	-0.1	-0.1	-	-2.0	-0.1	-0.1	-0.9
Lauzon C24Z 220 kV	237	-2.3	-0.1	-	-	-0.2	-0.2	0.0	0.0	0.0	-0.1	-2.2	-	-0.1	-0.1	-1.0
Lauzon EJ 27.6 kV	29	-4.3	-0.1	-3.9	-	-0.2	-0.2	0.0	0.0	-0.1	-0.1	-4.2	-3.8	-0.1	-0.1	-0.9
Lauzon BQ 27.6 kV	29	-4.6	-0.1	-4.3	-	-0.2	-0.2	0.0	0.0	-0.1	-0.1	-4.5	-4.3	-0.1	-0.1	-0.9
Ford Essex Z1E 115 kV	125	-2.3	-0.7	-2.1	-2.9	-0.3	-0.2	-	-0.1	-0.2	-0.2	-2.0	-1.8	-0.1	-0.1	-0.6
Ford Essex Z7E 115 kV	125	-2.3	-0.7	-2.1	-2.9	-0.3	-0.2	-0.1	-	-0.2	-0.2	-2.0	-1.8	-0.1	-0.1	-0.6
Ford Essex 13.8 kV	14	-2.3	-0.7	-2.1	-2.9	-0.3	-0.2	-0.8	-0.8	-0.2	-0.2	-2.0	-1.8	-0.1	-0.1	-0.6
Chrysler E8V 115 kV	125	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.6
Chrysler E9V 115 kV	125	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.6
Chrysler 27.6 kV	29	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.7
GM Windsor E8F 115 kV	124	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.7
GM Windsor E9F 115 kV	124	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.7
GM Windsor 27.6 kV	29	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.7
Ford Annex E8V 115 kV	124	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.7
Ford Annex E9V 115 kV	124	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.7
Ford Annex 13.8 kV	15	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.7
Ford Windsor E8F 115 kV	124	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.7
Ford Windsor E9F 115 kV	124	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.7
Ford Windsor 27.6 kV	30	-2.0	-0.7	-1.8	-2.4	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-1.7	-1.5	-0.1	-0.1	-0.7
Belle River K6Z 115 kV	124	-2.4	-0.7	-2.2	-3.2	-0.3	-0.2	0.0	0.0	-0.2	-0.2	-2.1	-1.9	-0.1	-0.1	-0.6
Belle River K2Z 115 kV	124	-2.4	-0.7	-2.2	-3.2	-0.3	-0.2	0.0	0.0	-0.2	-0.2	-2.1	-1.9	-0.1	-0.1	-0.6
Belle River 27.6 kV	29	-2.4	-0.7	-2.2	-3.2	-0.3	-0.2	0.0	0.0	-0.2	-0.2	-2.1	-1.9	-0.1	-0.1	-0.6

Table A6 – Post-ULTC Voltage Declines – Case 3: Import

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	247	0.2	0.5	0.4	1.0	-0.1	-0.1	0.0	0.0	0.1	0.1	0.1	0.2	-0.1	-0.1	-0.4
Lauzon 115 kV	125	-2.7	-0.7	-2.4	-3.3	-0.2	-0.2	-0.1	-0.1	-0.2	-0.2	-2.3	-2.1	-0.1	-0.1	-0.6
Keith 115 kV	125	-1.3	-0.6	-1.1	-1.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.9	-0.7	-0.1	-0.1	-0.2
Essex 115 kV	125	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.2	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
Tilbury 115 kV	122	-2.8	-0.7	-2.5	-3.5	-0.2	-0.2	-0.1	-0.1	-0.2	-0.2	-2.5	-2.2	-0.1	-0.1	-0.6
Tilbury 27.6 kV	29	-0.4	-0.7	-0.1	0.1	-0.2	-0.2	-0.1	-0.1	-0.2	-0.2	-0.1	0.3	-0.1	-0.1	-0.6
Tilbury West 115 kV	122	-2.8	-0.7	-2.5	-3.5	-0.2	-0.2	-0.1	-0.1	-0.2	-0.2	-2.5	-2.2	-0.1	-0.1	-0.6
Tilbury West 27.6 kV	29	-0.6	-0.7	-0.3	-0.5	-0.3	-0.2	-0.1	-0.1	-0.2	-0.2	-0.2	-0.7	-0.1	-0.1	-0.6
Tilbury West 27.6 kV	29	-0.6	-0.7	-0.3	-0.5	-0.3	-0.2	-0.1	-0.1	-0.2	-0.2	-0.2	-0.7	-0.1	-0.1	-0.6
Kingsville K6Z 115 kV	121	-1.9	-	-1.7	0.1	-0.1	-0.1	-0.1	-0.1	-1.6	-1.6	-0.2	-0.1	-3.3	-3.5	-0.5
Kingsville K2Z 115 kV	121	-1.9	-	-1.7	0.1	-0.1	-0.1	-0.1	-0.1	-1.6	-1.6	-0.2	-0.1	-3.5	-3.7	-0.5
Kingsville 27.6 kV	29	-0.5	-	-0.4	0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.3	-0.2	-0.1	-0.9	-1.3	-0.5
Walker Z1E 115 kV	124	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-	-0.5	-0.2	-0.2	-1.9	-1.7	-0.1	-0.1	-0.7
Walker Z7E 115 kV	124	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.6	-	-0.2	-0.2	-1.9	-1.7	-0.1	-0.1	-0.7
Walker #2 27.6 kV	29	-1.1	-0.7	-0.9	-0.4	-0.3	-0.3	-0.7	-0.7	-0.2	-0.3	-0.7	-0.5	-0.1	-0.1	-0.7
Walker 27.6 kV	29	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-2.3	-2.2	-0.2	-0.2	-1.9	-1.7	-0.1	-0.1	-0.7
Essex 115 kV	125	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.2	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
Essex 27.6 kV	33	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.3	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
Keith 220 kV	242	-1.0	-0.8	-0.9	-0.3	0.0	0.0	-0.1	-0.1	-0.6	-0.6	-0.3	-0.3	-0.1	-0.1	-0.2
Keith 27.6 kV	29	-1.0	-1.0	-0.9	-0.3	0.0	0.0	-0.1	-0.1	-0.6	-0.6	-0.4	-0.3	-0.1	-0.1	-0.2
Malden C21J 220 kV	241	-	-	-1.2	-0.2	-0.1	0.0	-0.1	-0.1	-0.9	-	-0.3	-0.2	-0.1	-0.2	-0.2
Malden C22J 220 kV	242	-1.3	-	-	-0.2	-0.1	0.0	-0.1	-0.1	-	-0.9	-0.3	-0.2	-0.2	-0.1	-0.2
Malden Y 27.6 kV	30	2.0	-	0.9	-0.2	-0.1	0.0	-0.1	-0.1	1.2	1.2	-0.3	-0.2	-0.1	-0.2	-0.2
Malden B 27.6 kV	29	-0.1	-	-1.1	-0.2	-0.1	0.0	-0.1	-0.1	-0.8	-0.9	-0.3	-0.2	-0.1	-0.2	-0.2
Lauzon C23Z 220 kV	237	-	-0.1	-2.2	-	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-	-2.1	-0.1	-0.1	-0.9
Lauzon C24Z 220 kV	237	-2.5	-0.1	-	-	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-2.4	-	-0.1	-0.1	-1.0
Lauzon EJ 27.6 kV	29	-0.1	-0.1	-0.8	-	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	-0.7	-0.1	-0.1	0.1
Lauzon BQ 27.6 kV	29	-0.4	-0.1	-1.2	-	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.3	-1.1	-0.1	-0.1	-1.0
Ford Essex Z1E 115 kV	125	-2.5	-0.7	-2.3	-3.1	-0.3	-0.3	-	-0.2	-0.2	-0.2	-2.2	-1.9	-0.1	-0.1	-0.6
Ford Essex Z7E 115 kV	125	-2.5	-0.7	-2.3	-3.1	-0.3	-0.3	-0.3	-	-0.2	-0.2	-2.2	-1.9	-0.1	-0.1	-0.6
Ford Essex 13.8 kV	14	0.0	-0.7	0.3	-0.6	-0.3	-0.3	0.3	0.4	-0.2	-0.2	0.3	-0.7	-0.1	-0.1	-0.6
Chrysler E8V 115 kV	125	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.2	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
Chrysler E9V 115 kV	125	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.2	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
Chrysler 27.6 kV	29	-0.3	0.1	-0.1	0.0	-0.3	-0.3	-0.5	-0.5	-0.3	-0.3	-0.3	-0.1	-0.1	-0.1	0.1
GM Windsor E8F 115 kV	124	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.2	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
GM Windsor E9F 115 kV	124	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.2	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
GM Windsor 27.6 kV	29	-0.3	-0.1	-0.1	-0.1	-0.3	-0.3	-0.5	-0.5	-0.3	-0.3	-0.6	-0.4	-0.1	-0.1	-0.1
Ford Annex E8V 115 kV	124	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.3	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
Ford Annex E9V 115 kV	124	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.3	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
Ford Annex 13.8 kV	15	-0.5	-0.7	-0.3	-0.9	-0.3	-0.3	-0.5	-0.5	-0.3	-0.3	-0.1	-0.8	-0.1	-0.1	-0.7
Ford Windsor E8F 115 kV	124	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.3	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
Ford Windsor E9F 115 kV	124	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.3	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
Ford Windsor 27.6 kV	30	-2.2	-0.7	-2.0	-2.6	-0.3	-0.3	-0.5	-0.5	-0.3	-0.3	-1.8	-1.6	-0.1	-0.1	-0.7
Belle River K6Z 115 kV	124	-2.7	-0.7	-2.4	-3.3	-0.2	-0.2	-0.1	-0.1	-0.2	-0.2	-2.3	-2.1	-0.1	-0.1	-0.6
Belle River K2Z 115 kV	124	-2.7	-0.7	-2.4	-3.3	-0.2	-0.2	-0.1	-0.1	-0.2	-0.2	-2.3	-2.1	-0.1	-0.1	-0.6
Belle River 27.6 kV	29	-0.2	-0.7	-1.2	-0.9	-0.2	-0.2	-0.1	-0.1	-0.2	-0.2	-1.1	-0.8	-0.1	-0.1	-0.6

Appendix B – Thermal Loading Study Results

Table B1 – Thermal loading – Case 1: Brighton Beach out

Circuit	From Bus	To Bus	Con't (93 degrees)	Emergency	15 min. LTR	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
C21J	CHATHAM	COMBER J	1060	1370	1590	37	-	-	41	31	25	24	26	25	36	-	26	27	21	29	21
	COMBER J	DIVISION J	1060	1370	1590	37	-	-	41	31	25	25	26	25	36	-	26	27	21	29	21
	DIVISION J	SANDWICJ	1060	1370	1590	21	-	-	19	20	14	14	15	14	15	-	16	17	21	7	11
	SANDWICJ	MALDENJ	840	1020	1130	27	-	-	27	28	19	19	21	20	21	-	22	23	30	10	15
	MALDENJ	KEITH	840	1020	1130	6	-	-	11	13	4	4	6	5	15	-	7	8	14	7	1
	MALDEN	MALDENJ	840	1020	1130	22	-	-	33	16	16	16	16	16	33	-	16	16	16	16	16
C22J	CHATHAM	COMBER J	840	1020	1130	46	55	-	-	43	34	34	36	35	-	51	37	38	40	29	29
	COMBER J	DIVISION J	840	1020	1130	46	56	-	-	43	34	34	36	35	-	51	37	38	40	29	30
	DIVISION J	SANDWICJ	840	1020	1130	27	25	-	-	28	19	19	21	20	-	21	22	23	10	29	15
	SANDWICJ	MALDENJ	840	1050	1180	26	24	-	-	27	18	18	20	19	-	20	21	22	10	28	14
	MALDENJ	KEITH	840	1020	1130	7	13	-	-	13	5	5	6	5	-	16	7	8	8	14	1
	MALDEN	MALDENJ	840	1020	1130	22	33	-	-	16	16	16	16	16	-	33	16	16	16	16	16
C23Z	CHATHAM	KRUGERJ	1060	1400	1630	12	-	8	15	-	8	8	7	8	7	7	-	12	8	8	6
	KRUGERJ	COMBER J	1060	1400	1630	20	-	17	28	-	13	13	13	12	15	15	-	24	12	12	13
	COMBER J	SANDWICJ	1060	1400	1630	45	-	34	46	-	30	30	30	29	32	32	-	41	29	29	30
	SANDWICJ	LAUZON	1060	1400	1630	45	-	34	46	-	30	30	31	29	32	32	-	42	29	29	30
C24Z	CHATHAM	COMBER J	840	1020	1130	18	37	20	-	-	14	14	15	13	17	17	31	-	14	14	14
	COMBER J	SANDWICJ	840	1020	1130	50	62	43	-	-	37	37	38	36	41	41	56	-	37	37	38
	SANDWICJ	LAUZON	1060	1590	1830	39	39	27	-	-	23	23	24	22	25	25	34	-	23	23	23
J4E	KEITH	CRAWFRDJ	1100	1600	1800	22	23	6	20	35	26	-	19	14	8	8	27	24	13	13	-
	CRAWFRDJ	ESSEX	1100	1600	1800	16	13	9	11	24	10	-	11	8	10	10	16	14	10	10	-
	CRAWFRDJ	CRAWFORD	810	1140	1260	31	20	20	20	20	33	-	20	20	20	20	20	20	20	20	-
J3E	KEITH	CRAWFRDJ	1100	1600	1800	26	24	9	21	35	-	26	20	15	12	12	27	25	16	16	-
	CRAWFRDJ	ESSEX	1100	1600	1800	4	12	6	9	24	-	10	7	2	4	4	16	13	3	3	-
	CRAWFRDJ	CRAWFORD	810	1140	1260	30	19	19	19	19	-	32	19	19	19	19	19	19	19	19	-
Z1E	ESSEX	TAWINDSJ	970	1260	1440	18	1	22	3	15	13	13	-	5	18	19	5	2	12	12	16
	TAWINDSJ	WALKERJ	970	1260	1440	16	21	5	18	36	9	10	-	20	7	7	26	23	11	11	6
	WALKERJ	JEFFERSJ	910	1190	1380	35	10	31	12	14	24	24	-	44	28	28	9	10	23	23	22
	JEFFERSJ	LAUZON	910	1190	1380	37	11	32	13	13	25	25	-	47	30	30	10	11	25	25	24
	FORDESXJ	JEFFERSJ	810	1210	1350	3	1	1	1	1	1	1	-	3	1	1	1	1	1	1	1
	WALKER	WALKERJ	870	1140	1250	43	30	31	30	30	30	30	-	62	30	30	30	30	30	30	30
Z7E	ESSEX	WALKERJ	970	1260	1440	16	21	5	18	36	9	9	11	-	7	7	26	22	11	11	5
	WALKERJ	JEFFERSJ	910	1190	1380	35	10	31	12	13	24	24	50	-	29	29	9	10	24	24	23
	JEFFERSJ	LAUZON	910	1190	1380	38	11	32	14	13	25	25	53	-	30	30	10	11	25	25	24
	FORDESXJ	JEFFERSJ	810	1210	1350	3	1	1	1	1	1	1	3	-	1	1	1	1	1	1	1
	WALKER	WALKERJ	870	1140	1250	43	30	31	30	30	31	31	62	-	30	30	31	30	30	30	30
K2Z	LAUZONJ	ROURKELJ	810	1070	1200	11	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	LAUZONJ	WOODSLEJ	590	870	930	21	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	WOODSLEJ	DIVISION J	590	800	860	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DIVISION J	GOSFIELD J	480	950	950	67	34	-	34	34	34	34	34	34	34	34	34	34	-	74	34
	GOSFIELD J	KINGSVLE	480	950	950	67	34	-	34	34	34	34	34	34	34	34	34	34	-	74	34
K6Z	LAUZON	LAUZONJ	810	1070	1200	11	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	LAUZONJ	ROURKELJ	810	1070	1200	11	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	ROURKELJ	BELRIVEJ	810	1070	1200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	BELRIVEJ	DIVISION J	480	690	720	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DIVISION J	KINGSVLE	480	950	950	75	38	-	38	38	38	38	38	38	38	38	38	38	73	-	38
Transformers	Kingsville TS	T1	41.7	49.3	68.6	93	77	-	76	78	79	79	78	78	77	77	78	78	93	**104**	79
	Kingsville TS	T2	41.7	54.5	67.4	90	68	-	67	69	69	69	69	69	68	67	69	69	86	**96**	69
	Kingsville TS	T3	41.7	73.7	84.9	72	40	-	39	40	41	41	40	41	40	39	40	40	-	54	41
	Kingsville TS	T4	41.7	57.6	74.9	93	66	-	65	67	67	67	67	67	65	65	66	67	83	-	67
	Belle River TS	T1	41.7	59.03	84.3	44	31	31	31	31	32	32	31	31	31	31	31	31	31	31	31
	Belle River TS	T2	41.7	59.03	84.3	45	31	32	31	31	32	32	31	31	32	32	31	31	32	32	31
	Keith DESN	22	83.3	109.6	109.6	43	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
	Keith DESN	23	83.3	109.6	109.6	43	32	34	32	32	32	32	32	32	32	32	32	32	32	32	32
	Lauzon	T5	83.3	112	112	63	-	47	92	-	47	47	47	47	46	46	-	93	47	47	47
	Lauzon	T6	83.3	112	112	59	93	45	-	-	44	44	44	44	44	44	92	-	44	44	44
	Lauzon	T7	83.3	114.7	165.6	52	78	38	-	-	38	38	38	38	38	38	79	-	38	38	38
	Lauzon	T8	83.3	114.7	165.6	56	-	41	79	-	41	41	41	41	41	41	-	78	41	41	41
	Keith	11	250	290	360	22	15	10	14	21	15	15	14	14	19	19	16	14	16	16	21
	Keith	12	250	290	360	22	15	27	14	21	15	15	14	14	19	19	16	14	16	16	21
	Lauzon	T1	250	280	364.2	40	-	36	31	-	28	28	30	26	32	33	-	22	27	27	29
	Lauzon	T2	250	280	364.2	32	25	30	-	-	23	23	24	21	27	27	17	-	22	22	24
	Division TS	T1	250	290	360	29	40	-	-	20	20	20	20	20	-	40	20	20	41	-	20
	Division TS	T2	250	290	360	29	-	-	40	20	20	20	20	20	40	-	20	20	-	41	20
	Malden	T1	125	195	214.5	62	-	-	80	39	39	39	39	39	80	-	39	39	40	39	39
	Malden	T2	125	195	214.5	61	80	-	-	38	39	39	39	39	-	81	38	38	38	39	39

Table B2 – Thermal loading - Case 2: Export

Circuit	From Bus	To Bus	Con't (93 degrees)	Emergency	15 min. LTR	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
C21J	CHATHAM	COMBER J	1060	1370	1590	30	-	-	32	23	19	19	21	20	30	-	20	21	16	24	14
	COMBER J	DIVISION J	1060	1370	1590	30	-	-	33	23	20	20	21	20	30	-	21	22	16	25	15
	DIVISION J	SANDWICJ	1060	1370	1590	14	-	-	11	13	9	9	10	9	8	-	10	11	16	2	6
	SANDWICJ	MALDENJ	840	1020	1130	18	-	-	15	18	13	13	14	14	11	-	14	15	23	3	9
	MALDENJ	KEITH	840	1020	1130	5	-	-	18	4	5	5	3	4	22	-	3	2	7	13	14
	MALDEN	MALDENJ	840	1020	1130	22	-	-	33	16	16	16	16	16	33	-	16	16	17	16	16
C22J	CHATHAM	COMBER J	840	1020	1130	38	43	-	-	32	27	27	29	28	-	42	28	30	34	22	20
	COMBER J	DIVISION J	840	1020	1130	38	44	-	-	32	27	27	29	28	-	42	29	30	34	23	20
	DIVISION J	SANDWICJ	840	1020	1130	17	12	-	-	17	12	12	14	13	-	11	14	15	2	23	8
	SANDWICJ	MALDENJ	840	1050	1180	18	12	-	-	17	12	12	13	13	-	10	13	14	2	22	8
	MALDENJ	KEITH	840	1020	1130	5	21	-	-	3	4	4	2	3	-	22	3	2	13	7	13
	MALDEN	MALDENJ	840	1020	1130	22	33	-	-	16	16	16	16	16	-	33	16	16	16	16	16
C23Z	CHATHAM	KRUGERJ	1060	1400	1630	17	-	15	11	-	10	10	10	11	10	10	-	10	11	11	6
	KRUGERJ	COMBER J	1060	1400	1630	15	-	11	22	-	10	10	10	9	11	11	-	19	9	9	13
	COMBER J	SANDWICJ	1060	1400	1630	38	-	22	39	-	26	26	26	25	27	27	-	35	25	25	30
	SANDWICJ	LAUZON	1060	1400	1630	38	-	23	39	-	26	26	27	25	27	27	-	36	25	25	30
C24Z	CHATHAM	COMBER J	840	1020	1130	13	27	13	-	-	10	10	11	10	12	12	23	-	10	10	14
	COMBER J	SANDWICJ	840	1020	1130	41	52	27	-	-	32	32	33	30	34	34	47	-	31	31	38
	SANDWICJ	LAUZON	1060	1590	1830	33	32	17	-	-	20	20	20	19	21	21	29	-	19	19	23
J4E	KEITH	CRAWFRDJ	1100	1600	1800	35	30	27	27	35	39	-	26	21	18	18	32	30	21	21	-
	CRAWFRDJ	ESSEX	1100	1600	1800	23	19	20	17	24	20	-	17	13	13	13	22	19	14	14	-
	CRAWFRDJ	CRAWFORD	810	1140	1260	31	20	20	20	20	33	-	20	20	20	20	20	20	20	20	-
J3E	KEITH	CRAWFRDJ	1100	1600	1800	38	30	29	27	35	-	39	27	22	20	20	33	30	23	23	-
	CRAWFRDJ	ESSEX	1100	1600	1800	16	18	16	16	24	-	20	14	9	7	7	21	18	10	10	-
	CRAWFRDJ	CRAWFORD	810	1140	1260	30	19	19	19	19	-	32	19	19	19	19	19	19	19	19	-
Z1E	ESSEX	TAWINDSJ	970	1260	1440	8	8	10	5	15	6	6	-	17	9	9	12	8	6	6	16
	TAWINDSJ	WALKERJ	970	1260	1440	30	29	28	26	36	17	17	-	37	16	16	33	29	20	20	6
	WALKERJ	JEFFERSJ	910	1190	1380	29	11	22	11	14	19	19	-	36	21	21	13	12	19	19	22
	JEFFERSJ	LAUZON	910	1190	1380	30	11	22	11	13	20	20	-	38	22	23	12	12	20	20	23
	FORDESXJ	JEFFERSJ	810	1210	1350	3	1	1	1	1	1	1	-	3	1	1	1	1	1	1	1
	WALKER	WALKERJ	870	1140	1250	43	30	30	30	30	30	30	-	61	30	30	30	30	30	30	30
Z7E	ESSEX	WALKERJ	970	1260	1440	29	29	27	26	35	17	17	29	-	16	16	32	29	20	19	5
	WALKERJ	JEFFERSJ	910	1190	1380	29	11	21	11	13	19	19	39	-	22	22	12	11	19	19	22
	JEFFERSJ	LAUZON	910	1190	1380	30	11	22	11	13	20	20	41	-	23	23	12	12	20	20	24
	FORDESXJ	JEFFERSJ	810	1210	1350	3	1	1	1	1	1	1	3	-	1	1	1	1	1	1	1
	WALKER	WALKERJ	870	1140	1250	43	30	30	30	30	30	30	61	-	30	30	30	30	31	31	30
K2Z	LAUZONJ	ROURKELJ	810	1070	1200	11	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	LAUZONJ	WOODSLEJ	590	870	930	21	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	WOODSLEJ	DIVISION J	590	800	860	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DIVISION J	GOSFIELD J	480	950	950	67	35	-	35	34	34	34	34	34	35	35	34	34	-	76	34
	GOSFIELD J	KINGSVLE	480	950	950	67	35	-	35	35	34	34	34	34	35	35	34	34	-	76	34
K6Z	LAUZON	LAUZONJ	810	1070	1200	11	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	LAUZONJ	ROURKELJ	810	1070	1200	11	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	ROURKELJ	BELRIVEJ	810	1070	1200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	BELRIVEJ	DIVISION J	480	690	720	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DIVISION J	KINGSVLE	480	950	950	75	39	-	39	38	38	38	38	38	39	39	38	38	75	-	38
Transformers	Kingsville TS	T1	41.7	49.3	68.6	93	78	-	79	79	79	79	79	79	79	79	79	79	**95**	**106**	79
	Kingsville TS	T2	41.7	54.5	67.4	90	69	-	69	70	69	69	69	69	69	69	69	69	88	**97**	69
	Kingsville TS	T3	41.7	73.7	84.9	72	40	-	41	41	41	41	41	41	41	41	41	41	-	54	41
	Kingsville TS	T4	41.7	57.6	74.9	93	67	-	67	67	67	67	67	67	67	67	67	67	85	-	67
	Belle River TS	T1	41.7	59.03	84.3	44	31	31	31	31	32	32	32	32	31	31	31	31	31	31	31
	Belle River TS	T2	41.7	59.03	84.3	45	31	32	32	31	32	32	32	32	32	32	32	31	32	32	32
	Keith DESN	22	83.3	109.6	109.6	43	32	16	32	32	32	32	32	32	32	32	32	32	32	32	32
	Keith DESN	23	83.3	109.6	109.6	43	32	80	32	32	32	32	32	32	32	32	32	32	32	32	32
	Lauzon	T5	83.3	112	112	63	-	47	93	-	47	47	47	47	47	47	-	92	47	47	48
	Lauzon	T6	83.3	112	112	59	93	44	-	-	44	44	44	44	44	44	93	-	44	44	45
	Lauzon	T7	83.3	114.7	165.6	52	80	39	-	-	38	38	38	38	38	38	80	-	38	38	38
	Lauzon	T8	83.3	114.7	165.6	56	-	41	79	-	41	41	41	41	41	41	-	79	41	41	41
	Keith	11	250	290	360	37	20	80	21	15	27	27	22	25	30	30	17	19	26	26	42
	Keith	12	250	290	360	37	20	**103**	21	15	27	27	22	25	30	30	17	19	26	26	42
	Lauzon	T1	250	280	364.2	29	-	17	18	-	22	21	23	19	24	24	-	12	20	20	29
	Lauzon	T2	250	280	364.2	22	12	14	-	-	17	16	17	14	19	19	7	-	15	15	23
	Division TS	T1	250	290	360	29	41	-	-	20	20	20	20	20	-	41	20	20	42	-	20
	Division TS	T2	250	290	360	29	-	-	41	21	20	20	20	20	41	-	20	20	-	42	20
	Malden	T1	125	195	214.5	61	-	-	80	39	39	39	39	39	80	-	39	39	40	39	39
	Malden	T2	125	195	214.5	61	80	-	-	39	39	39	39	39	-	80	39	39	38	39	39

Table B3 – Thermal loading – Case 3: Import

Circuit	From Bus	To Bus	Con't (93 degrees)	Emergency	15 min. LTR	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
C21J	CHATHAM	COMBER J	1060	1370	1590	17	-	-	16	17	13	13	11	12	13	-	13	12	14	10	25
	COMBER J	DIVISION J	1060	1370	1590	18	-	-	17	18	13	13	12	12	14	-	14	13	15	11	25
	DIVISION J	SANDWICJ	1060	1370	1590	32	-	-	34	27	23	23	21	22	32	-	23	22	15	28	35
	SANDWICJ	MALDENJ	840	1020	1130	40	-	-	48	38	32	32	30	31	46	-	33	32	22	39	50
	MALDENJ	KEITH	840	1020	1130	61	-	-	79	52	47	47	44	46	77	-	48	46	36	54	65
	MALDEN	MALDENJ	840	1020	1130	22	-	-	34	16	16	16	16	16	34	-	16	16	17	16	16
C22J	CHATHAM	COMBER J	840	1020	1130	21	23	-	-	23	18	18	15	16	-	19	18	17	13	20	34
	COMBER J	DIVISION J	840	1020	1130	22	25	-	-	24	18	19	16	17	-	20	19	18	15	21	35
	DIVISION J	SANDWICJ	840	1020	1130	40	50	-	-	37	32	32	29	30	-	45	33	31	38	21	49
	SANDWICJ	MALDENJ	840	1050	1180	40	48	-	-	36	31	31	28	29	-	43	31	30	37	20	47
	MALDENJ	KEITH	840	1020	1130	60	81	-	-	51	46	46	44	45	-	76	47	46	53	35	64
	MALDEN	MALDENJ	840	1020	1130	22	34	-	-	16	16	16	16	16	-	34	16	16	16	16	16
C23Z	CHATHAM	KRUGERJ	1060	1400	1630	33	-	35	22	-	20	20	20	21	24	24	-	19	22	22	8
	KRUGERJ	COMBER J	1060	1400	1630	17	-	23	15	-	10	10	10	11	13	13	-	13	11	11	14
	COMBER J	SANDWICJ	1060	1400	1630	24	-	11	21	-	18	18	17	16	14	14	-	23	15	15	31
	SANDWICJ	LAUZON	1060	1400	1630	25	-	12	22	-	18	18	18	16	15	15	-	24	16	16	31
C24Z	CHATHAM	COMBER J	840	1020	1130	22	20	35	-	-	14	14	14	16	19	19	17	-	17	17	15
	COMBER J	SANDWICJ	840	1020	1130	24	28	17	-	-	21	21	21	19	17	17	30	-	18	18	39
	SANDWICJ	LAUZON	1060	1590	1830	21	18	11	-	-	13	13	13	12	11	11	19	-	12	12	24
J4E	KEITH	CRAWFRDJ	1100	1600	1800	67	50	64	47	38	74	-	45	40	44	45	47	45	41	41	-
	CRAWFRDJ	ESSEX	1100	1600	1800	49	38	54	35	24	50	-	34	29	34	34	35	32	30	30	-
	CRAWFRDJ	CRAWFORD	810	1140	1260	31	20	20	20	20	34	-	20	20	20	20	20	20	20	20	-
J3E	KEITH	CRAWFRDJ	1100	1600	1800	67	49	65	47	36	-	73	45	40	45	45	47	44	41	41	-
	CRAWFRDJ	ESSEX	1100	1600	1800	48	38	53	36	27	-	51	34	29	33	33	36	33	30	30	-
	CRAWFRDJ	CRAWFORD	810	1140	1260	30	19	19	19	19	-	33	19	19	19	19	19	19	19	19	-
Z1E	ESSEX	TAWINDSJ	970	1260	1440	32	33	52	30	19	17	17	-	62	27	27	30	27	22	22	15
	TAWINDSJ	WALKERJ	970	1260	1440	64	54	73	51	39	38	38	-	83	47	48	51	48	43	43	6
	WALKERJ	JEFFERSJ	910	1190	1380	33	30	51	26	13	17	17	-	41	26	26	26	23	22	22	21
	JEFFERSJ	LAUZON	910	1190	1380	31	28	50	25	11	17	17	-	40	25	25	25	22	21	21	23
	FORDESXJ	JEFFERSJ	810	1210	1350	3	1	1	1	1	1	1	-	3	1	1	1	1	1	1	1
	WALKER	WALKERJ	870	1140	1250	45	31	31	31	31	31	31	-	63	31	31	31	31	31	31	31
Z7E	ESSEX	WALKERJ	970	1260	1440	64	54	72	50	39	37	37	75	-	47	47	50	47	43	43	6
	WALKERJ	JEFFERSJ	910	1190	1380	33	29	51	26	12	17	17	34	-	26	26	25	22	21	21	22
	JEFFERSJ	LAUZON	910	1190	1380	31	28	50	25	11	16	16	33	-	25	25	24	21	20	20	23
	FORDESXJ	JEFFERSJ	810	1210	1350	3	1	1	1	1	1	1	3	-	1	1	1	1	1	1	1
	WALKER	WALKERJ	870	1140	1250	45	31	31	31	31	31	31	63	-	31	31	31	31	31	31	31
K2Z	LAUZONJ	ROURKELJ	810	1070	1200	11	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	LAUZONJ	WOODSLEJ	590	870	930	21	14	13	14	14	13	13	13	13	13	13	14	13	13	13	13
	WOODSLEJ	DIVISION J	590	800	860	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DIVISION J	GOSFIELD J	480	950	950	67	35	-	35	34	34	34	34	34	35	35	34	34	-	75	34
	GOSFIELD J	KINGSVLE	480	950	950	67	35	-	35	34	34	34	34	34	35	35	34	34	-	75	34
K6Z	LAUZON	LAUZONJ	810	1070	1200	11	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	LAUZONJ	ROURKELJ	810	1070	1200	11	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	ROURKELJ	BELRIVEJ	810	1070	1200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	BELRIVEJ	DIVISION J	480	690	720	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DIVISION J	KINGSVLE	480	950	950	75	39	-	39	38	38	38	38	38	39	39	38	38	75	-	38
Transformers	Kingsville TS	T1	41.7	49.3	68.6	93	78	-	78	79	79	79	79	79	79	79	79	79	**95**	**104**	78
	Kingsville TS	T2	41.7	54.5	67.4	90	69	-	69	69	69	69	69	69	69	69	69	69	88	**96**	69
	Kingsville TS	T3	41.7	73.7	84.9	72	40	-	40	41	41	41	41	41	40	40	40	41	-	54	40
	Kingsville TS	T4	41.7	57.6	74.9	93	67	-	67	67	67	67	67	67	67	67	67	67	85	-	67
	Belle River TS	T1	41.7	59.03	84.3	45	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
	Belle River TS	T2	41.7	59.03	84.3	45	32	32	31	31	32	32	32	32	32	32	31	31	32	32	32
	Keith DESN	22	83.3	109.6	109.6	43	32	5	32	32	33	33	32	32	32	32	32	32	32	32	32
	Keith DESN	23	83.3	109.6	109.6	43	32	61	32	32	33	33	32	32	32	32	32	32	32	32	32
	Lauzon	T5	83.3	112	112	63	-	47	91	-	47	47	47	47	47	47	-	92	47	47	46
	Lauzon	T6	83.3	112	112	59	92	44	-	-	44	44	44	44	44	44	93	-	44	44	44
	Lauzon	T7	83.3	114.7	165.6	52	81	38	-	-	38	38	38	38	38	38	81	-	38	38	39
	Lauzon	T8	83.3	114.7	165.6	56	-	41	80	-	41	41	41	41	41	41	-	80	41	41	41
	Keith	11	250	290	360	22	18	85	16	8	14	14	16	14	19	19	15	13	16	16	42
	Keith	12	250	290	360	22	18	29	16	8	14	14	16	14	19	19	15	13	16	16	42
	Lauzon	T1	250	280	364.2	21	-	34	28	-	14	14	14	14	17	17	-	23	15	15	30
	Lauzon	T2	250	280	364.2	24	33	38	-	-	14	14	14	16	19	19	27	-	16	16	25
	Division TS	T1	250	290	360	29	41	-	-	21	21	21	20	21	-	41	20	21	42	-	20
	Division TS	T2	250	290	360	29	-	-	41	20	20	20	20	20	41	-	20	20	-	42	20
	Malden	T1	125	195	214.5	62	-	-	81	39	40	40	40	40	81	-	39	39	40	39	39
	Malden	T2	125	195	214.5	61	82	-	-	39	39	39	39	39	-	81	39	39	38	39	39