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# CUSTOMER IMPACT ASSESSMENT

# WOODSTOCK AREA TRANSMISSION REINFORCEMENT PLAN

# REPLACE 14KM OF 115KV LINE AND ADD AUTOTRANSFORMERS

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## Disclaimer

This Customer Impact Assessment was prepared based on information available about the Woodstock Area Transmission Reinforcement Plan. It is intended to highlight significant impacts, if any, to affected transmission customers early in the project development process and thus allow an opportunity for these parties to bring forward any concerns that they may have. Subsequent changes to the required modifications or the implementation plan may affect the impacts of the proposed connection identified in Customer Impact Assessment. The results of this Customer Impact Assessment are also subject to change to accommodate the requirements of the IESO and other regulatory or municipal authority requirements.

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# CUSTOMER IMPACT ASSESSMENT
# WOODSTOCK AREA TRANSMISSION REINFORCEMENT PLAN

## 1.0 INTRODUCTION

### 1.1 Background

Toyota is proposing to develop a new automotive assembly plant located to the East of the Town of Woodstock. This assembly plant will cause significant load growth for the Woodstock area. The HV system in the Woodstock area is at capacity. The additional load growth will result in a system that will not provide reliable supply for the connected load in the event of W7W or W12W circuit or Woodstock step-down transformer outages. It should be noted that with 2006 load levels, no voltage issue is found under normal conditions; however, the existing system at Woodstock does not meet voltage performance criteria during a loss of one of the 115kV circuits W7W or W12W. The work proposed corrects both a future thermal overload constraint and unacceptable voltage performance for the 115kV system supplying Woodstock. Hydro One proposes to connect a new autotransformer station at a site along the W7W/W12W transmission corridor between Ingersoll and Woodstock. The new autotransformer facility connects to Hydro One's 230kV transmission system through a pair of 250MVA autotransformers via 2x230kV taps onto circuit M32W and M33W at Ingersoll TS. Also, the W7W/W12W line between Ingersoll and Woodstock will be removed and rebuilt to eliminate a thermal constraint.

Hydro One is to carry out Customer Impact Assessment (CIA) studies to assess the impact of the proposed connection on facilities owned by other customers on the M32W/M33W and the W7W/W12W circuits. This is in accordance with the Market Rules (Chapter 4, Section 6) and IESO's CAA process.

### 1.2 Woodstock Area Transmission Reinforcement Plan

#### 1.2.1 230 kV Line Work

Hydro One will be constructing up to a 14km M32W/M33W 230kV tap extension to connect a new 230/115kV transformer station. The line tap will connect to M32W/M33W near Ingersoll TS near tower #I-46 (where M32W/M33W and W7W/W12W cross). If the autotransformer station site near Woodstock is made available, the 230kV line extension will require 14km of W7W/W12W line removal from tower 98 and to approximately tower 10. This line would be rebuilt as 230kV.

#### 1.2.2 Autotransformer Station

A new 230/115 kV transformer station is to be established. Two 150/200/250MVA 230kV-115kV autotransformers will be connected to extensions of the M32W/M33W 230kV circuits and the W7W/W12W circuits. The autotransformers would be equipped with under-load tap-changers. The exact location of the station has not yet been determined as it depends upon the purchase of a site. The site could be anywhere along the W7W/W12W transmission corridor between Ingersoll and Woodstock. The preferred location is a site as close as practicable to Woodstock TS.

### 1.2.3 115kV Line and Station Work

With respect to the 115kV transmission line work, the W7W/W12W line (at tower 98) from Ingersoll TS to Woodstock TS will be replaced with one of more than twice the original capacity. The line will be built to a 230kV design and operated at 115kV for the section from the autotransformer station to Woodstock TS. At the autotransformer station, the 115kV switching arrangement will be a three breaker arrangement with two autotransformer circuit breakers and a tie breaker between the W7W/W12W circuits.

## 1.3 Customer Connections

The purpose of this CIA is to assess the potential impacts on the existing transmission connected customer(s) in the vicinity of the proposed new transmission facility at their connection point to the Hydro One system. The primary focus of this study was on customers supplied by stations directly connected to circuit M32W/M33W. Table 1 summarizes the customers connected at each station:

**Table 1: Customers Connected to M32W/M33W/W7W/W12W/B8W**

| Station | Customers |
|---|---|
| Ingersoll TS | Hydro One Networks (Distribution)<br>Erie Thames Hydro |
| Woodstock TS | Woodstock Hydro<br>Hydro One Networks (Distribution) |
| Lafarge CTS | Lafarge Cement |
| Brantford TS | Brantford Hydro<br>Hydro One Networks (Distribution) |
| Toyota (Future) CTS | Toyota |

# 2.0 METHODOLOGY & CRITERIA

## 2.1 Planning Criteria

To establish the adequacy of Hydro One transmission system incorporating the proposed additional transmission facilities, the following post-fault voltage decline criteria were applied:

- The loss of a single transmission circuit should not result in a voltage decline greater than 10% for pre-transformer tap-changer action (including station loads) and 10% post-transformer tap-changer action (5% for station loads) ;
- The loss of a double transmission circuit should not result in a voltage decline greater than 10% for pre- transformer tap-changer action (including station loads) and 10% post- transformer tap-changer action (5% for station loads) ; (this is not evaluated / applicable in this CIA)
- Voltages below 50 kV shall be maintained in accordance with CSA 235.

## 2.2 Study Assumptions

- The following proposed generators are modeled in the basecase used for power flow voltage analysis:
  - St. Clair Energy Centre is connected to L25N and L27N (570MW)
  - Greenfield Energy Centre is connected to Lambton 230kV bus (1005MW)
  - GTAA is connected to LV buses at Bramalea TS and Woodbridge TS (117MW)
  - Port Burwell Wind Farm is connected to WT1T (99MW)

- Kingsbridge I Wind Farm is connected to LV bus at Goderich TS (39.6MW)
- Kingsbridge II Phase I Wind Farm is connected to B562L (160MW)
- Amaranth (Melancthon) I and II Wind Farm is connected to B4V and B5V (199MW)
- Kruger Wind Farm is connected to C23J and C24J (100MW)
- Ripley Wind Farm is connected to B22D and B23D (76MW)

- Lambton GS is assumed in-service. Nanticoke GS is assumed in-service. 6 Pickering GS units and 8 Bruce GS units are assumed in-service.
- All loads are modeled as constant MVA loads except for immediately after contingencies.
- With respect to the area loads, immediately after a contingency, 50% of the real power load value was modeled as constant MVA; the other 50% of the real power was modeled as voltage dependent load; 100% of the reactive power was assumed as voltage dependent. After tap-changer action, a constant MVA power load model is assumed.

## 2.3 Power System Analysis

Power system analysis is an integral part of the transmission and distribution planning process. It is used by Hydro One to evaluate the capability of the existing network to deliver power and energy from generating stations to provide a reliable supply to customers.

a. Load Flow Studies: The PTI PSS/E AC load flow program was used to set up detailed base cases.

b. Short-Circuit Studies: Short circuit studies are used to determine the impact of the new facilities to customers at their points of connection to Hydro One.

## 3.0 ASSESSMENT OF HYDRO ONE NETWORKS SHORT CIRCUIT LEVELS AT CUSTOMER CONNECTION

Short-circuit studies were carried out to assess the fault contribution when two new autotransformers that would ultimately be connected to support the Woodstock Area at either the Ingersoll Site or the site near Woodstock. The study area encompasses 230 kV M32W/M33W line taps and end stations; 115kV line taps and end stations. The following study assumptions were used for symmetrical short circuit studies:

- Base case assumes existing & committed generating facilities in-service.
- Pre-fault voltage of 250.00 kV at 220 kV stations is assumed.
- Pre-fault voltage of 127.00 kV at 115 kV stations is assumed.
- Pre-fault voltage of 29.00 kV at 27.6 kV stations is assumed.
- Pre-fault voltage of 14.4 kV at 14.4 kV stations is assumed.
- Pre-fault voltage of 14.2 kV at 13.8 kV stations is assumed.
- Pre-fault voltage of 4.4kV at 4.4kV stations is assumed

The following study assumptions apply to the values stated for asymmetrical short circuit studies:

- Base case assumes existing & committed generating facilities in-service.
- Pre-fault voltage of 230.00 kV at 220 kV stations is assumed.
- Pre-fault voltage of 118.05 kV at 115 kV stations is assumed.
- Pre-fault voltage of 27.6 kV at 27.6 kV stations is assumed.
- Pre-fault voltage of 14.4 kV at 14.4 kV stations is assumed.
- Pre-fault voltage of 13.8 kV at 13.8 kV stations is assumed
- Pre-fault voltage of 4.4kV at 4.4kV stations is assumed

The study results are summarized in Table 2 to Table 4 below show both symmetric and asymmetric (3-cycle) fault currents and percentage increase. The study also assumes maximum contribution from all the planned generation additions. Middleport was assumed split.

## 3.1 Present Systems

**Table 2: Present Fault Levels**

| Area Customers | Fault Levels (kA) | | | |
|---|---|---|---|---|
| | Symmetrical | | Asymmetrical | |
| | 3-Phase | L-G | 3-Phase | L-G |
| Buchanan TS 230 kV | 28.8 | 24.6 | 29.6 | 25.2 |
| Buchanan TS 115kV | 24.1 | 28.1 | 28.0 | 31.5 |
| Middleport TS 230 kV East/West | 56.4/56.4 | 54.8/54.8 | 61.4/62.2 | 57.3/56.3 |
| Brantford 230kV M32W | 13.9 | 9.66 | 14.0 | 9.02 |
| Brantford 230kV M33W | 13.9 | 9.64 | 14.0 | 9.00 |
| Ingersoll 230kV M32W | 8.35 | 5.93 | 8.43 | 5.53 |
| Ingersoll 230kV M33W | 8.35 | 5.93 | 8.43 | 5.53 |
| Lafarge CTS 115kV W7W/W12W | 4.11 | 2.44 | 3.83 | 2.28 |
| Woodstock 115kV W7W | 3.61 | 2.00 | 3.38 | 1.86 |
| Woodstock 115kV W12W | 3.61 | 2.00 | 3.38 | 1.86 |
| Toyota 115kV B8W (future) | 3.44 | 1.91 | 3.21 | 1.77 |
| Woodstock 27.6kV | 8.81 | 8.32 | 8.62 | 8.54 |
| Lafarge CTS 13.8kV | 4.02 | N/A | 4.92 | N/A |
| Lafarge CTS 4kV | 16.9 | N/A | 20.2 | N/A |
| Brantford 27.6kV Y/Z | 12.5/12.4 | 9.95/9.92 | 15.2/15.8 | 12.9/13.2 |
| Ingersoll 27.6kV E/Z | 11.9/11.9 | 9.70/9.71 | 15.2/15.2 | 12.4/12.4 |
| Toyota 13.8kV | 6.59 | 7.41 | 7.15 | 8.31 |
| | | | | |

## 3.2 The Incorporation of Woodstock Area Transmission Reinforcement Plan

**Table 3: Fault Levels with Two New Autotransformers Near Woodstock**

| Area Customers | Fault Levels (kA) | | | |
|---|---|---|---|---|
| | Symmetrical | | Asymmetrical | |
| | 3-Phase | L-G | 3-Phase | L-G |
| Buchanan TS 230 kV | 28.8 | 25.1 | 29.6 | 25.7 |
| Buchanan TS 115kV | 24.1 | 28.3 | 28.0 | 31.7 |
| Middleport TS 230 kV East/West | 56.4/56.4 | 54.9/54.9 | 61.3/62.2 | 57.4/56.4 |
| Brantford 230kV M32W | 14.0 | 9.75 | 14.1 | 9.10 |
| Brantford 230kV M33W | 14.0 | 9.73 | 14.1 | 9.09 |
| Ingersoll 230kV M32W | 8.80 | 6.82 | 8.88 | 6.45 |
| Ingersoll 230kV M33W | 8.80 | 6.82 | 8.88 | 6.44 |
| Lafarge CTS 115kV W7W/W12W | 3.65 | 2.33 | 3.39 | 2.17 |
| Woodstock 115kV W7W | 9.58 | 9.25 | 9.60 | 8.96 |
| Woodstock 115kV W12W | 9.58 | 9.24 | 9.60 | 8.96 |
| Toyota 115kV B8W (future) | 8.51 | 7.63 | 8.38 | 7.2 |
| Woodstock 27.6kV | 11.7 | 9.81 | 14.5 | 12.3 |
| Lafarge CTS 13.8kV | 3.96 | N/A | 4.71 | N/A |
| Lafarge CTS 4kV | 16.6 | N/A | 19.2 | N/A |
| Brantford 27.6kV Y/Z | 12.5/12.4 | 9.95/9.92 | 15.2/15.8 | 12.9/13.2 |
| Ingersoll 27.6kV E/Z | 11.9/11.9 | 9.70/9.71 | 15.2/15.2 | 12.4/12.4 |
| Toyota 13.8kV | 7.75 | 8.34 | 10.1 | 10.8 |
| Karn 230 | 9.02 | 7.96 | 9.43 | 8.18 |
| Karn 115kV | 12.6 | 14.5 | 14.1 | 15.7 |
| | | | | |

**Table 4: The Increase Percentages with the Woodstock Area Transmission Reinforcement Plan**

| Area Customers | Percentage Increase (%) | | | |
|---|---|---|---|---|
| | Symmetrical | | Asymmetrical | |
| | 3-Phase | L-G | 3-Phase | L-G |
| Buchanan TS 230 kV | 0.0 | 2.1 | 0.0 | 2.0 |
| Buchanan TS 115kV | 0.0 | 0.7 | 0.0 | 0.6 |
| Middleport TS 230 kV East/West | 0.0/0.0 | 0.1/0.1 | -0.2/0.0 | 0.2/0.2 |
| Brantford 230kV M32W | 0.7 | 0.9 | 0.7 | 0.9 |
| Brantford 230kV M33W | 0.7 | 0.9 | 0.7 | 1.0 |
| Ingersoll 230kV M32W | 5.4 | 15 | 5.3 | 17 |
| Ingersoll 230kV M33W | 5.4 | 15 | 5.3 | 16 |
| Lafarge CTS 115kV W7W/W12W | -11 | -4.5 | -11 | -4.8 |
| Woodstock 115kV W7W | 265 | 462 | 184 | 382 |
| Woodstock 115kV W12W | 265 | 462 | 184 | 382 |
| Toyota 115kV B8W (future) | 247 | 399 | 161 | 307 |
| Woodstock 27.6kV | 39 | 18 | 68 | 44 |
| Lafarge CTS 13.8kV | -1.5 | N/A | -4.3 | N/A |
| Lafarge CTS 4kV | -1.7 | N/A | -5.0 | N/A |
| Brantford 27.6kV Y/Z | 0.0/0.0 | 0.0/0.0 | 0.0/0.0 | 0.0/0.0 |
| Ingersoll 27.6kV E/Z | 0.0/0.0 | 0.0/0.0 | 0.0/0.0 | 0.0/0.0 |
| Toyota 13.8kV | 17.6 | 7.4 | 41 | 30 |
| | | | | |
| | | | | |

Observations made from the short-circuit study results in Table 2 & 3 above may be summarized as follows:

Table 2 study results for the present system show that existing fault levels meet maximum symmetrical three-phase and single line-to-ground faults (kA) of 230 kV, 115 kV, 27.6 kV, 14.4kV, 13.8kV and 4.4.KV systems for all equipment connected to Hydro One transmission system as set out in Appendix 2 of the *Transmission System Code* (TSC).

- The maximum symmetrical three-phase and single line-to-ground faults given in the TSC may be summarized as follows:

| *Nominal Voltage (kV)* | *Max. 3-Phase Fault (kA)* | *Max. SLG Fault (kA)* |
|---|---|---|
| 230 | 63 | 80 |
| 115 | 50 | 50 |
| 44 | 20 | 19 |
| 27.6 | 17 | 12 (4 wire)/ 0.45 (3 wire) |
| 13.8 and under | 21 | 10 |

Table 3 shows that some stations like Woodstock and Toyota see significant increases in the fault levels. Their faults levels increase; however, they are still within their respective capabilities. Lafarge sees a decrease in fault level.

Table 4 shows that there is a maximum of 462% increase in short circuit level at 115kV tap for Woodstock TS as a result of the new autotransformer connection. The fault current capability at the station is within station capability. Toyota sees increases of up to 399% at their HV connection. Toyota and Woodstock LV faults increases of up to 68% to 41% respectively; however, they will operate within their respective capabilities. Other locations have increases less than 17%. The increases are within the station capability. Lafarge sees a decrease in the fault level of up to 5% on the LV and up to an 11% decrease at their HV connection.

Overall, the increased short circuit level at all customer delivery points is below the TSC limit and the existing equipment rating.

## 4.0 ASSESSMENT OF HYDRO ONE NETWORKS VOLTAGE PERFORMANCE AT CUSTOMER CONNECTIONS

Load flow studies were carried out for the incorporation of the Woodstock Area Transmission Reinforcement Plan. The studies reviewed performance on the local 230 kV system, 115kV system and customer stations in the vicinity. The area under study encompasses stations connected to W7W/W12W/B8W/M32W/M33W. This includes the stations Ingersoll, Brantford, Woodstock, Lafarge and Toyota. Brant supply conditions were not assessed because the existing system cannot reliably support Brant load for normal operating configurations. (Back-up for Brant is only achieved with light load conditions and transfer of loads away for lines connected to B8W.)

Local voltage impact was assessed using post-contingency load flows. It should be noted that the existing system at Woodstock has no voltage issue under normal conditions but it does not meet voltage performance criteria for a loss of one of the 115kV circuits W7W or W12W. The proposed transmission work corrects both a thermal overload constraint and unacceptable voltage performance for the 115kV system.

The following condition was used to assess the local voltage impact:

Incorporation of Woodstock Area Transmission Reinforcement Plan with Autotransformers near Woodstock (2010) with 90% lagging power factor load with all existing LV shunt capacitors in-service, an extra 21.6MVAr capacitor available at Woodstock and Toyota In-service.

Tests for the voltage impact were conducted using the following contingencies:
a) A single contingency loss of M32W
b) A single contingency loss of M33W
c) A single contingency loss of W7W (Woodstock Side)
d) A single contingency loss of W12W (Woodstock Side)
e) A single contingency loss of W7W (Lafarge Side)
f) A single contingency loss of W12W (Lafarge Side)

Results for these tests are shown in Tables 5-10 and summarized below show that:

- Table 5: Maximum voltage decline is 7.50% at Brantford 27.6kV bus immediately following the contingency.

- Table 6: Maximum voltage decline is 8.75% at Brantford 27.6kV bus immediately following the contingency.

- Table 7: Maximum voltage decline is 8.24% at Woodstock 27.6kV bus immediately following the contingency.

- Table 8: Maximum voltage decline is 9.22% at Woodstock 27.6kV bus immediately following the contingency.

- Table 9: Maximum voltage change is only 0.14% at Toyota 13.8kV bus immediately following the contingency.

- Table 10: Maximum voltage decline is only 0.20% at Lafarge 4.4kV bus immediately following the contingency.

Immediately following a single contingency loss of the circuit W12W between Karn TS and Woodstock TS, Woodstock 27.6 kV bus has a voltage decline of 9.22%, which are within reach of the maximum allowable voltage decline of 10%. In 2010, Woodstock TS load is expected to increase to 110MW which is over the 10-day LTR of 92MW. One of the purposes of the Woodstock Area Transmission Reinforcement Plan is to provide sufficient transmission capacity to permit the connection of additional transmission supply stations in Woodstock to relieve the overload on the existing Woodstock TS. If Woodstock TS is assumed to only supply a load of 92MW, the voltage decline at Woodstock 27.6kV bus reduces to 5.56% immediately following a loss of the circuit W12W between Karn TS and Woodstock TS. The result of this single contingency case is summarized in Table 11 below.

Load flow studies thus confirmed that incorporation of the Woodstock Area Transmission Reinforcement Plan will not degrade the voltage performance at all customer delivery points. Following the worst single contingency, the voltage changes are well within the voltage decline guideline for customer buses of less than 10% and 5% voltage drop before- and after- transformer tap-changer operation.

## Table 5: Loss of circuit M32W

| | *Existing System* | *With Woodstock Area Plan* | *Before ULTC Post-C Voltage* | | *After ULTC Post-C Voltage* | |
|---|---|---|---|---|---|---|
| | *Pre-C Voltage (kV)* | *Pre-C Voltage (kV)* | *Voltage (kV)* | *% Change (%)* | *Voltage (kV)* | *% Change (%)* |
| Buchanan TS 230 kV | 239.1 | 239.5 | 238.9 | -0.26 | 238.2 | -0.84 |
| Middleport TS 230 kV East | 244.8 | 244.7 | 243.9 | -0.34 | 243.2 | -0.61 |
| Middleport TS 230 kV West | 244.6 | 244.5 | 245.0 | 0.20 | 244.5 | 0.00 |
| Brantford 230kV M32W | 242.1 | 242.0 | 0 | N/A | 0 | N/A |
| Brantford 230kV M33W | 243.8 | 243.8 | 241.8 | -0.84 | 240.9 | -1.19 |
| Ingersoll 230kV M32W | 238.8 | 237.6 | 0 | N/A | 0 | N/A |
| Ingersoll 230kV M33W | 239.3 | 238.5 | 233.5 | -2.11 | 232.3 | -2.60 |
| New Auto. Stn. 230kV M32W | N/A | 237.2 | 0 | N/A | 0 | N/A |
| New Auto. Stn. 230kV M33W | N/A | 238.1 | 232.8 | -2.24 | 231.6 | -2.73 |
| Buchanan TS 115 kV | 122.3 | 123.2 | 122.9 | -0.25 | 122.5 | -0.57 |
| Lafarge CTS 115kV W7W / W12W | 116.1 | 122.4 | 122.1 | -0.25 | 121.7 | -0.57 |
| Woodstock 115kV W7W | 115.0 | 119.2 | 115.3 | -3.26 | 116.8 | -2.01 |
| Woodstock 115kV W12W | 117.7 | 119.8 | 115.9 | -3.29 | 117.4 | -2.00 |
| Toyota 115kV B8W (future) | 114.0 | 118.4 | 114.5 | -3.32 | 115.9 | -2.11 |
| New Auto. Stn. 115kV W7W | N/A | 121.6 | 117.6 | -3.27 | 119.2 | -1.97 |
| New Auto. Stn. 115kV W12W | N/A | 121.6 | 117.6 | -3.27 | 119.2 | -1.97 |
| Woodstock 27.6kV | 27.7 | 27.9 | 27.0 | -3.33 | 28.4 | 1.79 |
| Lafarge CTS 14.4kV | 12.9 | 14.5 | 14.5 | -0.15 | 14.4 | -0.69 |
| Lafarge CTS 4.4kV | 4.1 | 4.4 | 4.4 | -0.43 | 4.4 | 0.00 |
| Brantford 27.6kV | 28.2 | 28.2 | 26.1 | -7.50 | 28.3 | 0.35 |
| Ingersoll 27.6kV | 27.6 | 27.9 | 26.3 | -5.58 | 27.7 | -0.72 |
| Toyota 13.8kV | 13.0 | 13.6 | 13.1 | -3.48 | 13.2 | -2.94 |

## Table 6: Loss of circuit M33W

| | *Existing System* | *With Woodstock Area Plan* | *Before ULTC Post-C Voltage* | | *After ULTC Post-C Voltage* | |
|---|---|---|---|---|---|---|
| | *Pre-C Voltage (kV)* | *Pre-C Voltage (kV)* | *Voltage (kV)* | *% Change (%)* | *Voltage (kV)* | *% Change (%)* |
| Buchanan TS 230 kV | 239.1 | 239.5 | 238.4 | -0.47 | 237.5 | -0.84 |
| Middleport TS 230 kV East | 244.8 | 244.7 | 245.4 | 0.30 | 245 | 0.12 |
| Middleport TS 230 kV West | 244.6 | 244.5 | 243.7 | -0.32 | 243.1 | -0.57 |
| Brantford 230kV M32W | 242.1 | 242.0 | 238.3 | -1.53 | 236.9 | -2.11 |
| Brantford 230kV M33W | 243.8 | 243.8 | 0 | N/A | 0 | N/A |
| Ingersoll 230kV M32W | 238.8 | 237.6 | 231.9 | -2.40 | 230.5 | -2.99 |
| Ingersoll 230kV M33W | 239.3 | 238.5 | 0 | N/A | 0 | N/A |
| New Auto. Stn. 230kV M32W | N/A | 237.2 | 231.2 | -2.53 | 229.8 | -3.12 |
| New Auto. Stn. 230kV M33W | N/A | 238.1 | 0 | N/A | 0 | N/A |
| Buchanan TS 115 kV | 122.3 | 123.2 | 122.6 | -0.46 | 122.2 | -0.81 |
| Lafarge CTS 115kV W7W / W12W | 116.1 | 122.4 | 121.9 | -0.45 | 121.4 | -0.82 |
| Woodstock 115kV W7W | 115.0 | 119.2 | 115.2 | -3.34 | 117.4 | -1.51 |
| Woodstock 115kV W12W | 117.7 | 119.8 | 115.8 | -3.37 | 118.0 | -1.50 |
| Toyota 115kV B8W (future) | 114.0 | 118.4 | 114.4 | -3.41 | 116.5 | -1.60 |
| New Auto. Stn. 115kV W7W | N/A | 121.6 | 117.5 | -3.35 | 119.8 | -1.48 |
| New Auto. Stn. 115kV W12W | N/A | 121.6 | 117.5 | -3.35 | 119.8 | -1.48 |
| Woodstock 27.6kV | 27.7 | 27.9 | 26.9 | -3.41 | 28.6 | 2.51 |
| Lafarge CTS 14.4kV | 12.9 | 14.5 | 14.4 | -0.35 | 14.4 | -0.69 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Lafarge CTS 4.4kV | 4.1 | 4.4 | 4.4 | -0.63 | 4.4 | 0.00 |
| Brantford 27.6kV | 28.2 | 28.2 | 25.7 | -8.75 | 28.1 | -0.35 |
| Ingersoll 27.6kV | 27.6 | 27.9 | 26.1 | -6.29 | 27.8 | -0.36 |
| Toyota 13.8kV | 13.0 | 13.6 | 13.1 | -3.56 | 13.3 | -2.21 |

**Table 7: Loss of Worst W7W Section (Woodstock side)**

| | *Existing System* | *With Woodstock Area Plan* | *Before ULTC Post-C Voltage* | | *After ULTC Post-C Voltage* | |
|---|---|---|---|---|---|---|
| | *Pre-C Voltage (kV)* | *Pre-C Voltage (kV)* | *Voltage (kV)* | *% Change (%)* | *Voltage (kV)* | *% Change (%)* |
| Buchanan TS 230 kV | 239.1 | 239.5 | 239.6 | 0.04 | 239.3 | -0.08 |
| Middleport TS 230 kV East | 244.8 | 244.7 | 244.7 | -0.02 | 244.4 | -0.12 |
| Middleport TS 230 kV West | 244.6 | 244.5 | 244.6 | 0.04 | 244.4 | -0.04 |
| Brantford 230kV M32W | 242.1 | 242.0 | 242.2 | 0.08 | 242.0 | 0.00 |
| Brantford 230kV M33W | 243.8 | 243.8 | 243.7 | -0.05 | 243.4 | -0.16 |
| Ingersoll 230kV M32W | 238.8 | 237.6 | 239.4 | 0.75 | 239.1 | 0.63 |
| Ingersoll 230kV M33W | 239.3 | 238.5 | 236.6 | -0.80 | 236.0 | -1.05 |
| New Auto. Stn. 230kV M32W | N/A | 237.2 | 239.4 | 0.92 | 239.1 | 0.80 |
| New Auto. Stn. 230kV M33W | N/A | 238.1 | 235.9 | -0.91 | 235.3 | -1.18 |
| Buchanan TS 115 kV | 122.3 | 123.2 | 123.2 | 0.04 | 123.1 | -0.08 |
| Lafarge CTS 115kV W7W / W12W | 116.1 | 122.4 | 122.5 | 0.05 | 122.3 | -0.08 |
| Woodstock 115kV W7W | 115.0 | 119.2 | 0 | N/A | 0 | N/A |
| Woodstock 115kV W12W | 117.7 | 119.8 | 115.0 | -3.98 | 118.9 | -0.75 |
| Toyota 115kV B8W (future) | 114.0 | 118.4 | 0 | N/A | 0 | N/A |
| New Auto. Stn. 115kV W7W | N/A | 121.6 | 0 | N/A | 0 | N/A |
| New Auto. Stn. 115kV W12W | N/A | 121.6 | 119.0 | -2.17 | 123.0 | 1.15 |
| Woodstock 27.6kV | 27.7 | 27.9 | 25.6 | -8.24 | 28.4 | 1.79 |
| Lafarge CTS 14.4kV | 12.9 | 14.5 | 14.5 | 0.14 | 14.5 | 0.00 |
| Lafarge CTS 4.4kV | 4.1 | 4.4 | 4.4 | -0.13 | 4.4 | 0.00 |
| Brantford 27.6kV | 28.2 | 28.2 | 28.2 | -0.05 | 28.2 | 0.00 |
| Ingersoll 27.6kV | 27.6 | 27.9 | 27.9 | -0.02 | 28.2 | 1.08 |
| Toyota 13.8kV | 13.0 | 13.6 | 0 | N/A | 0 | N/A |

**Table 8: Loss of Worst W12W Section (Woodstock side)**

| | *Existing System* | *With Woodstock Area Plan* | *Before ULTC Post-C Voltage* | | *After ULTC Post-C Voltage* | |
|---|---|---|---|---|---|---|
| | *Pre-C Voltage (kV)* | *Pre-C Voltage (kV)* | *Voltage (kV)* | *% Change (%)* | *Voltage (kV)* | *% Change (%)* |
| Buchanan TS 230 kV | 239.1 | 239.5 | 239.3 | -0.08 | 239.0 | -0.21 |
| Middleport TS 230 kV East | 244.8 | 244.7 | 244.7 | 0.01 | 244.5 | -0.08 |
| Middleport TS 230 kV West | 244.6 | 244.5 | 244.4 | -0.05 | 244.1 | -0.16 |
| Brantford 230kV M32W | 242.1 | 242.0 | 241.6 | -0.18 | 241.2 | -0.33 |
| Brantford 230kV M33W | 243.8 | 243.8 | 243.8 | -0.02 | 243.5 | -0.12 |
| Ingersoll 230kV M32W | 238.8 | 237.6 | 235.0 | -1.08 | 234.4 | -1.35 |
| Ingersoll 230kV M33W | 239.3 | 238.5 | 239.6 | 0.45 | 239.2 | 0.29 |
| New Auto. Stn. 230kV M32W | N/A | 237.2 | 234.2 | -1.25 | 233.5 | -1.56 |
| New Auto. Stn. 230kV M33W | N/A | 238.1 | 239.6 | 0.62 | 239.2 | 0.46 |
| Buchanan TS 115 kV | 122.3 | 123.2 | 123.1 | -0.08 | 122.9 | -0.24 |
| Lafarge CTS 115kV W7W / W12W | 116.1 | 122.4 | 122.3 | -0.07 | 122.1 | -0.25 |
| Woodstock 115kV W7W | 115.0 | 119.2 | 113.8 | -4.55 | 118.5 | -0.59 |
| Woodstock 115kV W12W | 117.7 | 119.8 | 0 | N/A | 0 | N/A |

| | | | | | | |
|---|---|---|---|---|---|---|
| Toyota 115kV B8W (future) | 114.0 | 118.4 | 112.9 | -4.62 | 117.6 | -0.68 |
| New Auto. Stn. 115kV W7W | N/A | 121.6 | 118.4 | -2.62 | 123.3 | 1.40 |
| New Auto. Stn. 115kV W12W | N/A | 121.6 | 0 | N/A | 0 | N/A |
| Woodstock 27.6kV | 27.7 | 27.9 | 25.3 | -9.22 | 28.8 | 3.23 |
| Lafarge CTS 14.4kV | 12.9 | 14.5 | 14.5 | 0.03 | 14.5 | 0.00 |
| Lafarge CTS 4.4kV | 4.1 | 4.4 | 4.4 | -0.25 | 4.4 | 0.00 |
| Brantford 27.6kV | 28.2 | 28.2 | 28.2 | -0.16 | 28.1 | -0.35 |
| Ingersoll 27.6kV | 27.6 | 27.9 | 27.8 | -0.30 | 28.4 | 1.79 |
| Toyota 13.8kV | 13.0 | 13.6 | 12.9 | -4.78 | 13.5 | -0.74 |

**Table 9: Loss of W7W Section (Lafarge side)**

| | *Existing System* | *With Woodstock Area Plan* | *Before ULTC Post-C Voltage* | | *After ULTC Post-C Voltage* | |
|---|---|---|---|---|---|---|
| | *Pre-C Voltage (kV)* | *Pre-C Voltage (kV)* | *Voltage (kV)* | *% Change (%)* | *Voltage (kV)* | *% Change (%)* |
| Buchanan TS 230 kV | 239.1 | 239.5 | 239.6 | 0.05 | 239.6 | 0.04 |
| Middleport TS 230 kV East | 244.8 | 244.7 | 244.8 | 0.02 | 244.8 | 0.04 |
| Middleport TS 230 kV West | 244.6 | 244.5 | 244.5 | 0.02 | 244.6 | 0.04 |
| Brantford 230kV M32W | 242.1 | 242.0 | 242.0 | -0.01 | 242.0 | 0.00 |
| Brantford 230kV M33W | 243.8 | 243.8 | 243.8 | -0.01 | 243.8 | 0.00 |
| Ingersoll 230kV M32W | 238.8 | 237.6 | 237.6 | 0.02 | 237.7 | 0.04 |
| Ingersoll 230kV M33W | 239.3 | 238.5 | 238.5 | 0.01 | 238.5 | 0.00 |
| New Auto. Stn. 230kV M32W | N/A | 237.2 | 237.3 | 0.03 | 237.3 | 0.04 |
| New Auto. Stn. 230kV M33W | N/A | 238.1 | 238.2 | 0.04 | 238.2 | 0.04 |
| Buchanan TS 115 kV | 122.3 | 123.2 | 123.3 | 0.07 | 123.3 | 0.08 |
| Lafarge CTS 115kV W7W / W12W | 116.1 | 122.4 | 0 | N/A | 0 | N/A |
| Woodstock 115kV W7W | 115.0 | 119.2 | 119.2 | 0.04 | 119.3 | 0.08 |
| Woodstock 115kV W12W | 117.7 | 119.8 | 119.8 | 0.00 | 119.8 | 0.00 |
| Toyota 115kV B8W (future) | 114.0 | 118.4 | 118.4 | -0.01 | 118.4 | 0.00 |
| New Auto. Stn. 115kV W7W | N/A | 121.6 | 121.6 | 0.00 | 121.6 | 0.00 |
| New Auto. Stn. 115kV W12W | N/A | 121.6 | 121.6 | 0.00 | 121.6 | 0.00 |
| Woodstock 27.6kV | 27.7 | 27.9 | 27.9 | 0.00 | 27.9 | 0.00 |
| Lafarge CTS 14.4kV | 12.9 | 14.5 | 0 | N/A | 0 | N/A |
| Lafarge CTS 4.4kV | 4.1 | 4.4 | 0 | N/A | 0 | N/A |
| Brantford 27.6kV | 28.2 | 28.2 | 28.2 | -0.07 | 28.2 | 0.00 |
| Ingersoll 27.6kV | 27.6 | 27.9 | 27.9 | 0.03 | 27.9 | 0.00 |
| Toyota 13.8kV | 13.0 | 13.6 | 13.6 | -0.14 | 13.6 | 0.00 |

**Table 10: Loss of W12W Section (Lafarge side)**

| | *Existing System* | *With Woodstock Area Plan* | *Before ULTC Post-C Voltage* | | *After ULTC Post-C Voltage* | |
|---|---|---|---|---|---|---|
| | *Pre-C Voltage (kV)* | *Pre-C Voltage (kV)* | *Voltage (kV)* | *% Change (%)* | *Voltage (kV)* | *% Change (%)* |
| Buchanan TS 230 kV | 239.1 | 239.5 | 239.5 | 0.00 | 239.5 | 0.00 |
| Middleport TS 230 kV East | 244.8 | 244.7 | 244.7 | 0.01 | 244.7 | 0.00 |
| Middleport TS 230 kV West | 244.6 | 244.5 | 244.5 | 0.01 | 244.5 | 0.00 |
| Brantford 230kV M32W | 242.1 | 242.0 | 242.0 | -0.02 | 241.9 | -0.04 |
| Brantford 230kV M33W | 243.8 | 243.8 | 243.8 | -0.02 | 243.7 | -0.04 |
| Ingersoll 230kV M32W | 238.8 | 237.6 | 237.6 | -0.02 | 237.6 | 0.00 |
| Ingersoll 230kV M33W | 239.3 | 238.5 | 238.4 | -0.03 | 238.4 | -0.04 |
| New Auto. Stn. 230kV M32W | N/A | 237.2 | 237.2 | -0.01 | 237.2 | 0.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| New Auto. Stn. 230kV M33W | N/A | 238.1 | 238.1 | 0.01 | 238.1 | 0.00 |
| Buchanan TS 115 kV | 122.3 | 123.2 | 123.2 | -0.02 | 123.2 | 0.00 |
| Lafarge CTS 115kV W7W / W12W | 116.1 | 122.4 | 122.4 | -0.02 | 122.4 | 0.00 |
| Woodstock 115kV W7W | 115.0 | 119.2 | 119.2 | 0.01 | 119.2 | 0.00 |
| Woodstock 115kV W12W | 117.7 | 119.8 | 119.8 | -0.03 | 119.8 | 0.00 |
| Toyota 115kV B8W (future) | 114.0 | 118.4 | 118.3 | -0.05 | 118.3 | -0.08 |
| New Auto. Stn. 115kV W7W | N/A | 121.6 | 121.6 | -0.04 | 121.5 | -0.08 |
| New Auto. Stn. 115kV W12W | N/A | 121.6 | 121.6 | -0.04 | 121.5 | -0.08 |
| Woodstock 27.6kV | 27.7 | 27.9 | 27.9 | -0.03 | 27.9 | 0.00 |
| Lafarge CTS 14.4kV | 12.9 | 14.5 | 14.5 | 0.08 | 14.5 | 0.00 |
| Lafarge CTS 4.4kV | 4.1 | 4.4 | 4.4 | -0.20 | 4.4 | 0.00 |
| Brantford 27.6kV | 28.2 | 28.2 | 28.2 | -0.08 | 28.2 | 0.00 |
| Ingersoll 27.6kV | 27.6 | 27.9 | 27.9 | 0.00 | 27.9 | 0.00 |
| Toyota 13.8kV | 13.0 | 13.6 | 13.6 | -0.17 | 13.6 | 0.00 |

**Table 11: Loss of Worst W12W Section (Woodstock side) – Cap Woodstock Load to 10-day LTR**

| | *Existing System* | *With Woodstock Area Plan* | *Before ULTC Post-C Voltage* | | *After ULTC Post-C Voltage* | |
|---|---|---|---|---|---|---|
| | *Pre-C Voltage (kV)* | *Pre-C Voltage (kV)* | *Voltage (kV)* | *% Change (%)* | *Voltage (kV)* | *% Change (%)* |
| Buchanan TS 230 kV | 239.1 | 240.0 | 239.8 | -0.08 | 239.5 | -0.21 |
| Middleport TS 230 kV East | 244.8 | 244.9 | 244.9 | 0 | 244.8 | -0.04 |
| Middleport TS 230 kV West | 244.6 | 244.7 | 244.6 | -0.04 | 244.4 | -0.12 |
| Brantford 230kV M32W | 242.1 | 242.3 | 242.0 | -0.12 | 241.7 | -0.25 |
| Brantford 230kV M33W | 243.8 | 244.0 | 243.9 | -0.04 | 243.8 | -0.08 |
| Ingersoll 230kV M32W | 238.8 | 238.7 | 236.9 | -0.75 | 236.2 | -1.05 |
| Ingersoll 230kV M33W | 239.3 | 239.5 | 240.1 | 0.25 | 239.8 | 0.13 |
| New Auto. Stn. 230kV M32W | N/A | 238.4 | 236.3 | -0.88 | 235.5 | -1.22 |
| New Auto. Stn. 230kV M33W | N/A | 239.3 | 240.1 | 0.33 | 239.8 | 0.21 |
| Buchanan TS 115 kV | 122.3 | 123.4 | 123.3 | -0.08 | 123.2 | -0.16 |
| Lafarge CTS 115kV W7W / W12W | 116.1 | 122.7 | 122.6 | -0.08 | 122.4 | -0.24 |
| Woodstock 115kV W7W | 115.0 | 120.9 | 117.3 | -2.98 | 113.1 | -3.97 |
| Woodstock 115kV W12W | 117.7 | 121.5 | 0 | N/A | 0 | N/A |
| Toyota 115kV B8W (future) | 114.0 | 120.1 | 116.5 | -3.00 | 115.3 | -4.00 |
| New Auto. Stn. 115kV W7W | N/A | 122.6 | 120.6 | -1.63 | 119.9 | -2.20 |
| New Auto. Stn. 115kV W12W | N/A | 122.6 | 0 | N/A | 0 | N/A |
| Woodstock 27.6kV | 27.7 | 28.8 | 27.2 | -5.56 | 28.1 | -2.43 |
| Lafarge CTS 14.4kV | 12.9 | 14.5 | 14.5 | 0.03 | 14.5 | 0.00 |
| Lafarge CTS 4.4kV | 4.1 | 4.4 | 4.4 | -0.25 | 4.4 | 0.00 |
| Brantford 27.6kV | 28.2 | 28.3 | 28.2 | -0.33 | 28.2 | -0.35 |
| Ingersoll 27.6kV | 27.6 | 28.7 | 28.6 | -0.35 | 28.5 | -0.70 |
| Toyota 13.8kV | 13.0 | 13.9 | 13.5 | -2.88 | 14.1 | 1.44 |

The maximum and minimum phase-to-phase voltages given in the IESO's Transmission Assessment Criteria and Canadian Standard Association document CAN-3-C235-83 are as follows:

| *Nominal Voltage (kV)* | *Maximum Voltage (kV)* | *Minimum Voltage (kV)* |
|---|---|---|
| 230 | 250* | 220 |
| 115 | 127 * | 113 |
| 44 | +6% nominal = 46.64 | -6% nominal = 41.51 |
| 27.6 | +6% nominal = 29.26 | -6% nominal = 26.04 |

*Certain buses can be assigned specific maximum and minimum voltages as required for operations. In northern Ontario, the maximum continuous voltage for the 230 and 115kV systems can be as high as 260kV and 132kV respectively. *[from IESO document IMO_REQ_0041 Issue 2.0]*

## 5.0 CONNECTION LINE RELIABILITY

The incorporation of the 14km of rebuilt line will improve structural reliability of the transmission line that supplies Woodstock. The existing W7W/W12W towers are over 80 years old; the old line has had structural failures. The new structures will have a structural reliability that would remain undamaged for 20-year return storms. The structural reliability of the existing M32W/M33W line is in the process of being upgraded to approximately 20-year return storm capability. The line extension will have better reliability than the pre-existing sections of the M32W/M33W line.

Also, the impact of additional exposure length is expected to be mitigated by the installation of high voltage circuit switchers at the HV side of 230kV autotransformers. The 230kV circuit switcher will reliably isolate disturbances associated with the autotransformer and the 115kV transmission system. In the event of a switcher/breaker failure, transfer trip signals would initiate isolation of circuit M32W/M33W at Middleport TS, Buchanan TS and Burlington TS (if required). The tie breaker and ring 115kV switching configuration make the 115kV loads vulnerable to breaker failures. In general, breaker failures are low probability events and would not lead to a significant impact on the overall 115kV supply reliability. The tie breaker and ring configuration improve voltage performance and reduce the instances of momentary outages for loads connected to B8W

## 6.0 PRELIMINARY OUTAGE IMPACT ASSESSMENT

Outages associated with the construction work to connect the autotransformer facility to Hydro One's system will be identified when a detailed construction schedule is established. The line work requires a bypass circuit to be built to facilitate the required outages. Exact outage schedule will be made available during the detailed engineering phases of the project development.

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

This Customer Impact Assessment (CIA) presents results of short-circuit and voltage performance study analysis.

The report has confirmed that the Woodstock Area Transmission Reinforcement Plan can be incorporated without any adverse impact on W7W/W12W/B8W and M32W/M33W customers provided that facilities conforming to TSC requirements are installed.