Independent Electricity Market Operator

IMO_REP_0090

CONNECTION ASSESSMENT & APPROVAL PROCESS

Preliminary Assessment Report

Project: *Dundas TS#2*

Applicant: *Hydro One Networks Inc.*

CAA ID 2002-052

Final Report

Long Term Forecasts & Assessments Department
Consistent Information Set Department

November 11, 2002

Preliminary Assessment Report

Dundas TS#2

Acknowledgement

The IMO wished to acknowledge the assistance of Hydro One in completing this assessment.

Disclaimers

IMO

This report has been prepared solely for the purpose of assessing, on a preliminary basis, whether the connection applicant's proposed connection with the IMO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether a System Impact Assessment of the proposed connection should be conducted under Chapter 4, section 6 of the *Market Rules*. 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, Hydro One and the IMO in accordance with Chapter 4, section 6 of the *Market Rules*. The IMO assumes no responsibility to any third party for any use which it makes of this report. Any liability which the IMO 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 IMO provides a draft of this report to the connection applicant, you must be aware that the IMO may revise drafts of this report at any time in its sole discretion without notice to you. Although the IMO 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 preliminary feasibility 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 preliminary feasibility 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 rating 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 IMO 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.

Executive Summary

This Preliminary Assessment has examined the impact of a new proposed transformer station, Dundas TS#2, on the reliability of the IMO-controlled grid. This project was subject to an expedited Connection Assessment process and it is not required to undergo a System Impact Assessment.

Proposed Project

Hydro One Networks Inc. proposes to build a new 115-27.6 kV Transformer Station with installed transformation of 2 x 50/66.6/83.3 MVA rating. The new Dundas TS#2 will be a standard DESN arrangement. The planned station is to be located adjacent to the Dundas TS within the existing Dundas TS property and connected to the double circuit 115 kV line B12/B13. Initially, the new station will be used to supply about 32 MW of existing load which will be transferred from Dundas TS and Burlington TS. The applicant estimated that the station load would reach 80 MW by year 2026.

The target in-service data for the facility is July 30, 2003.

A schematic diagram of the 115 kV transmission in the Beach-Burlington area and the location of the proposed Transformer Station are shown in Figure 1.

Impact on System Reliability

This Preliminary Assessment has examined the impact of connecting Dundas TS to the 115 kV double circuit line B12/B13 emanating from Burlington TS, on the reliability of the *IMO-controlled grid*. The studies concluded that:

1. The new TS will result in increased reliability of load supply to the local customers because it provides relief to existing DESN stations which are presently running over their capabilities.

2. The proposed project will not materially affect the reliability of the IMO-controlled grid or the load-meeting capability of the existing system.

3. The addition of the new supply point does not have a significant effect on the short circuit currents observed at the other transformer stations connected to this circuit.

Although the assessment has identified that the addition of the new Dundas TS#2 benefits the load supply reliability in the area, concerns have been raised regarding the capability of the existing 230 kV and 115 kV transmission facilities, (1) to supply the Burlington area loads without breaches of the Market Rules requirements and, (2) to meet the transmission system design criteria.

IMO's Requirements for Connection

The applicant is required to ensure that the Dundas TS#2 load meets the Market Rules power factor requirements.

It is required that Hydro One Network Inc. provide the IMO with the following information as soon as it becomes available:

1. A confirmation that an underfrequency load shedding relay, which will have the capability of tripping up to 35% of the station load (12% at 59.3 Hz and additional 23% at 58.8 Hz) is to be installed. Appropriate settings for the relay will be provided by the IMO prior to commissioning.
2. A confirmation that voltage reduction facilities will be provided, with the capability of reducing the distribution voltage by 3% to 5%.
3. A confirmation that the transfer trip protection scheme was installed as required by the Transmission System Code.

Need for System Impact Assessment

The analysis that was performed under this Preliminary Assessment has covered all the system reliability issues related to the connection of the proposed Dundas TS#2 to the *IMO-controlled grid*. Therefore, a System Impact Assessment is considered to be unnecessary for this project.

Customer Impact Assessment

Hydro One Networks Inc., has that this project will not have an adverse impact on any of the existing customers connected in the in the area and hence a detailed Customer Impact Assessment is not required.

Notification of Approval for Connection Proposal

It is recommended that Notification of Approval be granted for this connection proposal, subject to the implementation by Hydro One Networks Inc. of all the requirements listed in section 7.

1.0 Project Description

Hydro One Networks Inc. proposes to build a new 115-27.6 kV Transformer Station with installed transformation of 2 x 50/66.6/83.3 MVA rating. The new Dundas TS#2 will be a standard DESN arrangement. The planned station is to be located adjacent to the Dundas TS within the existing Dundas TS property and connected to the double circuit 115 kV line B12/B13. Initially, the new station will be used to supply about 32 MW of existing load which will be transferred from Dundas TS and Burlington TS. The applicant estimated that the station load will reach 80 MW by year 2026.

The target in-service data for the facility is July 30, 2003.

A schematic diagram of the 115 kV transmission in the Beach-Burlington area and the location of the proposed Transformer Station are shown in Figure 1.

2.0 Review of Connection Proposal

2.1 Connection Arrangement

The proposed DESN will be equipped with two new 110 kV-28 kV transformers that will be connected to the existing 115 kV double circuit 115 kV line B12/B13.

Each transformer is to be connected to the IMO-controlled grid via one motor operated 115 kV disconnect switch rated for continuous operation at 700 A. Each transformer is to be switched by means of an 26 kV breaker rated as follows:

- Continuous rating 2000 A
- Fault interrupting capability 17 kA
- Maximum operating voltage 29.0 V

The LV bus-tie breaker is to be operated normally-closed. The station will be equipped with six feeder positions and each feeder position will be equipped with one 1200 A, 17 kA 26.7 kV breaker.

The transformers are identical and configured with an ungrounded wye winding on the high side and zigzag winding on the low voltage side. Each of the low voltage side winding neutrals is grounded via a 1.5 ohms reactor. Each transformer is equipped with HV under-load tap changer with a range of about +10.0% to –17.5% that is to be achieved in $\pm$11 steps.

Figure 2 shows a detailed single line diagram of the proposed Transformer Station.

The line taps from the station to the 115 kV circuit are to be short and thus their impedance was considered negligible in this assessment. The revenue meters are to be located on the LV side of the station.

2.2 Power Factor

The *Market Rules* require that wholesale customers and distributors connected to the IMO-controlled grid shall operate at a power factor within the range 90% lagging to 90% leading as measured at the *defined meter point.*

The information received with the connection application indicates that station design does not provide for installation LV shunt capacitors and capacitor breakers.

The applicant is however required to ensure that load power factor, when measured at the *defined meter point* location meets the Market Rules requirements.

2.3 Underfrequency Load Shedding Requirements

The *Market Rules* (Chapter 5 section 10.4) require that each distributor and connected wholesale customer, in conjunction with the relevant transmitter, make arrangements to enable the automatic disconnection of up to 35% of its peak demand for conditions of system under-frequency. To meet this requirement an underfrequency load shedding (UFLS) scheme must be installed at the station. The single line diagram does not show the presence of the UFLS scheme.

2.4 Voltage Reduction Facilities Requirements

The *Market Rules* (Chapter 4 Appendix 4.3) requires that distributors connected to the *IMO controlled grid* with directly connected load facilities of aggregated rating of 20 MVA or more and the capability to regulate distribution voltage under load, shall install and maintain facilities to provide *voltage reduction capability* to achieve load reduction during periods when supply resources are limited. *Voltage reduction capability* represents the capability of reducing demand by lowering the customer voltage by 3% and 5% and having the controlling authority to be able to effect the voltage reduction within five minutes of receipt of the direction from the IMO.

2.5 On-line Monitoring

The *Market Rules* (Chapter 4 section 7.4) require that each transmitter shall provide the IMO on a continual basis with on-line monitored quantities as specified in Appendix 4.16. It is required that Hydro One Networks Inc. install all the equipment needed to monitor the information required by the IMO on a continuous basis. The IMO requires that the status of all isolating disconnect switches and breakers be monitored on a continual basis.

2.6 Protection Systems

The applicant has indicated that the station equipment and station control/protection were designed to meet the intent of the Transmission System Code. Diagram IP10268 A.R0 that was provided by HONI shows each transformer being separated from the transmission system via a motorized disconnection switch. For this particular arrangement the Transmission System Code requires that transfer trip of the Transmitter's breakers at the terminal stations be provided for transformer faults or for a condition of failure to operate of the LT breakers. In the case of Dundas TS#2, which is to be connected to the double circuit 115 kV line B12/B13 the transfer trip must be sent to the Burlington TS and Newton SS terminals of the faulted circuit.

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 protection systems associated with B12/B13 are to be revised as required.

3.0 Data Verification

Based on standards for supply of municipal electrical utilities the capability of a DESN 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 load curves, and temperature data specific to the transformer location. HONI has indicated that the transformer LTR will be 95.4 MVA.

Information of the projected ultimate station loading indicates that by 2026 load supplied from Dundas TS#2 will only reach the maximum continuous rating of one transformer.

The proposed Dundas TS#2 will be equipped with two new 110 kV-28 kV transformers that are to be connected to the existing 115 kV double circuit 115 kV line B12/B13 via motorized disconnect switch. A full description of the connection arrangement is included in section 2.1 of this report.

The positive sequence transformer impedance for one transformer is 12.5% on 50 MVA base.

The system performance standards listed in the Transmission System Code requires that the 115 kV and 27.6 kV systems fault levels not exceed 50 kA and 17 kA, respectively. It is assumed that any new transmission equipment that is exposed to short circuit duty during system operations, should be required to withstand these maximum allowable short circuit currents. The LV breakers proposed for installation at Dundas TS#2 meet the interrupting capability recommended by the TSC.

Since the design and specifications of the transformers and the associated breakers and disconnect switches have not been yet finalized, it is expected that the proponent will provide when available, the “as built” transformer information to meet the requirements of the facility registration process.

4.0 Fault Level Assessment

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 Dundas TS #2 the high voltage winding is ungrounded, hence line-to-ground faults occurring on the distribution side will have no impact on the short circuit levels.

5.0 Impact on System Reliability

The connection assessment study concentrated on identifying the effect of the proposed DESN on thermal loading of the transmission lines and transformers, and system voltages for pre and post contingency situations.

In addition, the adequacy of the existing Burlington area transmission system to supply the 2003 area load was investigated and concerns related to the ability of the area transmission to supply the future load growth were identified. These results are described in Appendix A.

The studies were performed for a system with all elements in service under conditions of peak load conditions.

It is planned that some of the existing load will be connected to the new station providing relief to existing DESN stations which are presently running over their capability and thus realizing an improvement to the reliability of supply to the local customers. For example, the load connected to the existing Dundas TS is to be limited to the station’s summer 10 day LTR of 96.7 MVA.

The addition of the new DESN is not expected to affect the reliability of the IMO-controlled grid because it does not considerably increase the chance or duration of system outages. Since the new TS is the only station connected to the 115 kV line B12/B13, any loss associated with this new transformer station will not result in supply interruption to existing loads in the area.

5.1 Description of Area Transmission

The 115 kV and 230 kV area transmission is shown in Figure 1 together with the proposed location of Dundas TS#2. The Beach-Burlington load which is connected to the 115 kV transmission system is supplied via a number of 115 kV circuits emanating from Burlington 115 kV and Beach 115 kV switchyards. Burlington 230/115 kV and Beach 230/115 kV transformer stations effectively supplying the entire 115 kV load in the area. The local 115 kV transmission comprises of:

- The double circuit 115 kV lines H5K/H6K from Beach and B10/B11 from Burlington which join at Gage TS at a point which is operated normally open providing for the separate supply of Gage T5/T6/T8/T9 via B10/B11 and Gage T3/T4 via H5K/H6K,
- The double circuit 115 kV line HL3/HL4 from Beach TS to Newton SS which is operated normally split between Stirton TS and Elgin TS thus supplying Birmingham TS, Slater Steel and Stirton TS from the Beach end and Elgin TS from Burlington end.
- The double circuit 115 kV line B12/B13 from Burlington TS to Newton SS also providing radial supply to Brant TS,
- The double circuit 115 kV line B3/B4 from Burlington TS to Newton which supplies Dundas TS, McMaster TS and Mohawk TS and
- The double circuit 115 kV line B6G/B5G from Burlington TS which provides radial supply to Westover TS, Puslinch TS, ABB, Guelph Hanton and Cedar TS loads.

The 2002 summer peak coincident load that is being normally supplied from Burlington was about 770 MVA.

The area transmission is also equipped with one 230 kV, 300 Mvar shunt capacitor installed at Burlington TS and no 115 kV shunt capacitors.

The 115 kV Burlington transmission system is equipped with a number of in-line disconnect switches which are used to transfer the loads, if needed, from Burlington TS to other bulk transformer stations.

Normal Operation

Under normal operating conditions, Burlington TS provides supply to:

- Gage T5/T6/T8/T9
- Brant TS
- Westover TS, Puslinch TS, ABB load and Cedar TS.

Load Transfer Alternatives

In-line disconnect switches are available to provide for alternative supplies for some of the area loads in case of an outage involving one transformer at Burlington TS. Present operating practices allow for the transfer of:

- the loads connected to the 115 kV double circuit line B6G/B5G to Detweiler TS via D9G/D7G to a maximum of 120 MW,
- Gage T5/T6/T8/T9 load to Beach TS to a maximum of 100 MW, and

- Maximum 50 MW of Brant TS load to Buchanan TS via the 115 kV circuit B8W only in emergency situations.

5.2 System Performance in 2002

From the system data that is collected during real time operation, records of voltages and power flows at Burlington TS were retrieved and are displayed in Diagrams 1 and 2 below.

The system's past performance records indicate that the peak power flow over the four Burlington transformers were as high as 730 MW and voltages were as low as 117.5 kV.

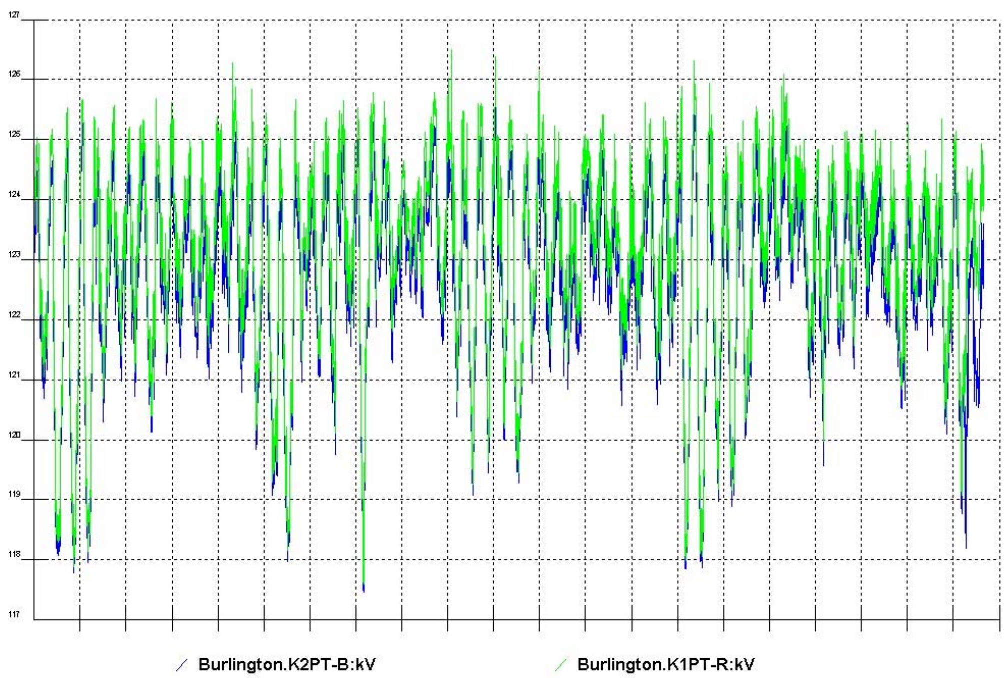


Diagram 1. 115 kV Voltage Records from May 1 to August 20, 2002

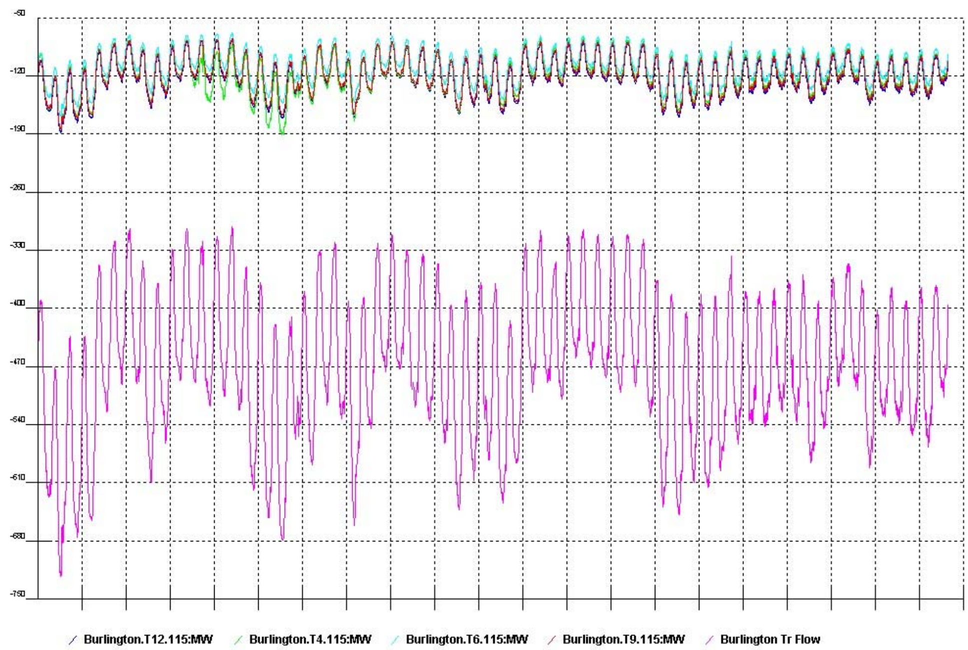


Diagram 2. Records of Burlington TS Power Flow for July and August, 2002

5.3 Study Assumptions

The main analysis was performed for a system with all elements in service, for year 2003 under conditions of summer peak loads and normal operating system configurations.

Table 1 below lists the expected summer peak loads at the stations that are being currently supplied from the 115 kV circuits originating at Burlington TS as they were used in the studies.

Table 1. Load Growth Forecast to 2010

Forecast Summer Peak Loads (MVA)									
Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Station	**Loads Supplied via B3/B4 and B12/B13**								
Elgin TS	101	102	104	106	107	109	111	113	115
Dundas TS	113	87	88	90	91	93	94	96	97
McMaster TS	18	18	19	19	19	19	20	20	20
Mohawk TS	90	90	92	94	95	96	98	100	102
Dundas TS#2	-	32	33	35	37	39	39	40	41
Newton TS	48	48	50	50	50	52	52	53	54
Brant TS	96	98	99	101	102	104	106	108	109
Total	**464**	**476**	**485**	**494**	**503**	**512**	**521**	**529**	**538**
Station	**Loads Supplied via B6G/B5G**								
IPP Westover	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2
Puslinch	31.4	31.9	32.4	32.9	33.5	34.0	34.6	35.1	35.7
Guelph Hanton	45.7	46.4	47.2	47.9	48.7	49.5	50.3	51.1	52.0
ABB	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5
Cedar TS	38.9	39.6	40.2	40.9	41.5	42.2	42.9	43.6	44.3
Total	**122.8**	**124.8**	**126.8**	**128.9**	**131.0**	**133.1**	**135.3**	**137.5**	**139.7**
Total Burlington 115 kV Area Load (including radial loads supplied via B7/B8, andB10/B11)									
Load(MW)	**757**	**769**	**782**	**795**	**808**	**821**	**834**	**848**	**862**

The following assumptions were used in determining the station loads that are listed in Table 1:

- All loads were escalated by 1.63% per year until 2010, which is the factor corresponding to the official 10 year normal load growth forecast for the Hamilton area,
- The new Dundas TS#2, upon coming into service will assume 31.6 MVA of existing load, thus relieving the loading of some of the existing stations which presently run over their design capacity,
- All loads were modeled with a power factor equal or close to 0.9 measured at the 115 kV connection point.

An inspection of the actual power flowing over the Burlington autotransformers recorded during the summer of 2002 shows a maximum flow of about 772 MVA. This value is comparable to the 2002 load assumptions used in the study when also accounting for 3% system losses (1.03*757=779 MVA).

Table 2 lists the rating of the critical sections of the 115 kV circuits in the Burlington area as they were used in the study.

Table 2. 115 kV Lines Thermal Ratings

Circuit, Sections (Conductor)		Max Op. Temp. (^{0}C)	Thermal ratings		
			Continuous (30^{0}C ambient) operating at 93^{0}C Amps MVA @113 kV	**Emergency** Continuous at Max Op Temp or 127 C Amps, MVA @113 kV	**15 min LTR** At Max Operating Temperature Amps, MVA @113 kV
B3 & B4	Burlington x Horning (1)*	127^{0}C	**950 A 186 MVA**	**1220 A 238 MVA**	**1600 A 313 MVA**
	Horning x Newton (2)*	118^{0}C	**710 A 134 MVA**	**910 A 178 MVA**	**1000 A 195 MVA**
	Horning x Mohawk TS TAP (3)*	90^{0}C	**450 A 88 MVA**	**570 A 110 MVA**	**450 A 88 MVA**
B12 & B13	Burlington x Horning	127^{0}C	**780 A 152 MVA**	**1000 A 195 MVA**	**1230 A 240 MVA**
B5G & B6G	Harper x Puslinch	93^{0}C	**620 A 121 MVA**	**790 A 155 MVA**	**670 A 131 MVA**

* Reference number indicating which rating was used in calculating the % post-contingency circuit loadings in Table 5.

The thermal ratings of the Burlington TS autotransformers that were used in this study are summarized in Table 3.

Table 3. Transformer Ratings

Facility Name	**Continuous (MVA)**	**10 Day LTR (MVA)**	**15 MinuteLTR (MVA)**
Burlington T4	215	254	306
Burlington T6	215	254	306
Burlington T9	250	297	374
Burlington T12	250	297	357

5.4 Impact on the 115 kV Transmission

This section covers the effect that the proposed development is going to have on the reliability of the area transmission system.

5.4.1 Thermal Loading – B12 & B13

Linear analysis was first performed for year 2003 summer peak load conditions with all transmission elements in service, and for the loss of one critical transmission element. The transmission system losses were assumed to be 3% and were included in the total MVA flows.

A set of transmission distribution factors and outage distribution factors was established for the transmission elements of interest, as listed in Table 4.

Table 4. Power Distribution Factors (All in Service and Outage)

Outage Element	Outage Distribution Factors			
	B3	**B4**	**B12**	**B13**
B3	-	0.44	.274	.275
B4	0.44	-	.274	.275
B12	.293	.296	-	.381
B13	.293	.296	.381	-

Using the loads shown in Table 1, the thermal ratings shown in Tables 2 and 3, and the power distribution factors obtained from the linear analysis as they are listed in Table 4, calculations were performed to establish the thermal capability of the Burlington area transmission facilities to supply the load.

The study was done for year 2003 and all the results are summarized in Table 5. For cases where potential future supply problems were observed, analysis was also performed to identify the year when the capability of the existing facilities would become inadequate.

Table 5. Estimates of Pre and Post Contingency Power Flows for 2003

Transmission Element	**Pre contingency Flows (MVA) % of cont. rating**	**Post Contingency Flows**				
		B3 % of Emergency Rating (1)	**B4 % of Emergency Rating (1)**	**B12 % of Emergency Rating (1)**	**B13 % of Emergency Rating (1)**	**B12&B13 % Emergency Rating (1)**
B3	126.0 68%	0	181.7 76%	160.9 68%	160.9 68%	**229** **96%**
B4	126.5 68%	181.7 76%	0	161.8 68%	161.8 68%	**229** **96%**
B12	119.1 78%	153.7 79%	153.8 79%	0	164.5 84%	0
B13	119.1 78%	153.8 79%	152 78%	164.5 84%	0	0

It was estimated that in 2003 the Burlington area summer peak load including losses could be 792 MVA. The results of this assessment indicate that:

- with all transmission elements in service the power flows are within the continuous thermal capability of the respective elements,
- for a contingency involving the loss of one 115 kV circuits between Burlington and Newton the post contingency loading on the remaining three circuits will be well within their respective emergency rating,
- a contingency involving the double circuit line B3/B4 will result in loss of power supply to about 200 MW of load consisting of Dundas TS, McMaster TS and Mohawk TS, since there is no alternative HV supply for these stations. It is expected that restoration of load can be achieved in less than eight hours as required by the load supply criteria,
- a contingency involving the double circuit line B12/B13 will result in post contingency loading of the remaining circuits *to about 96% of their emergency ratings*.

System operating control actions are presently in place to allow for the transfer of up to 120 MW (133 MVA) of Burlington load to Detweiler TS in the event of the permanent loss of one Burlington transformer.

Loss of Single 115 kV Circuit

The results indicate that for any contingency involving any one of the 115 kV circuits B3, B4, B12 or B13 the power flowing over the remaining three circuits will be well under the emergency rating of these circuits in 2003.

An assessment that was performed for later years indicated that by 2010 the post contingency power flows might be stating to approach the emergency rating of these circuits. The results indicate that for the loss of B12 or B13 the companion circuit could become loaded to 95% of its emergency rating.

6. Conclusions and Recommendations

This Preliminary Assessment has examined the impact of connecting Dundas TS to the 115 kV double circuit line B12/B13 emanating from Burlington TS, on the reliability of the *IMO-controlled grid*. The studies concluded that:

1. The new TS will result in increased reliability of load supply to the local customers because it provides relief to existing DESN stations which are presently running over their capabilities.
2. The proposed project will not materially affect the reliability of the IMO-controlled grid or the load-meeting capability of the existing system.
3. The addition of the new supply point does not have a significant effect on the short circuit currents observed at the other transformer stations connected to this circuit.

Although the assessment has identified that the addition of the new Dundas TS#2 contributes to an increase in the load supply reliability, concerns have been raised regarding the capability of the existing 230 kV and 115 kV transmission facilities, (1) to supply the Burlington area loads without breaches of the Market Rules requirements and, (2) to meet the transmission system design criteria.

7. IMO's Requirements for Connection

The applicant is required to ensure that load connected to the new Dundas TS#2 will meet the Market Rules power factor requirements.

It is required that Hydro One Network Inc. provide the IMO with the following information as soon as it becomes available:

1. A confirmation that an underfrequency load shedding relay, which will have the capability of tripping up to 35% of the station load (12% at 59.3 Hz and additional 23% at 58.8 Hz) is to be installed. Appropriate settings for the relay will be provided by the IMO prior to commissioning.
2. A confirmation that voltage reduction facilities will be provided, with the capability of reducing the distribution voltage by 3% to 5%.
3. A confirmation that the transfer trip protection scheme was installed as required by the Transmission System Code.

8. Need for System Impact Assessment

The analysis that was performed under this Preliminary Assessment has covered all the system reliability issues related to the connection of the proposed Dundas TS#2 to the *IMO-controlled grid*. Therefore, a System Impact Assessment is considered to be unnecessary for this project.

9. Customer Impact Assessment

Hydro One Networks Inc., has concluded that this project will not have an adverse impact on any of the existing customers connected in the in the area and hence a detailed Customer Impact Assessment is not required.

10. Notification of Approval for Connection Proposal

It is recommended that Notification of Approval be granted for this connection proposal, subject to the implementation by Hydro One Networks Inc. of all the requirements listed in section 7.

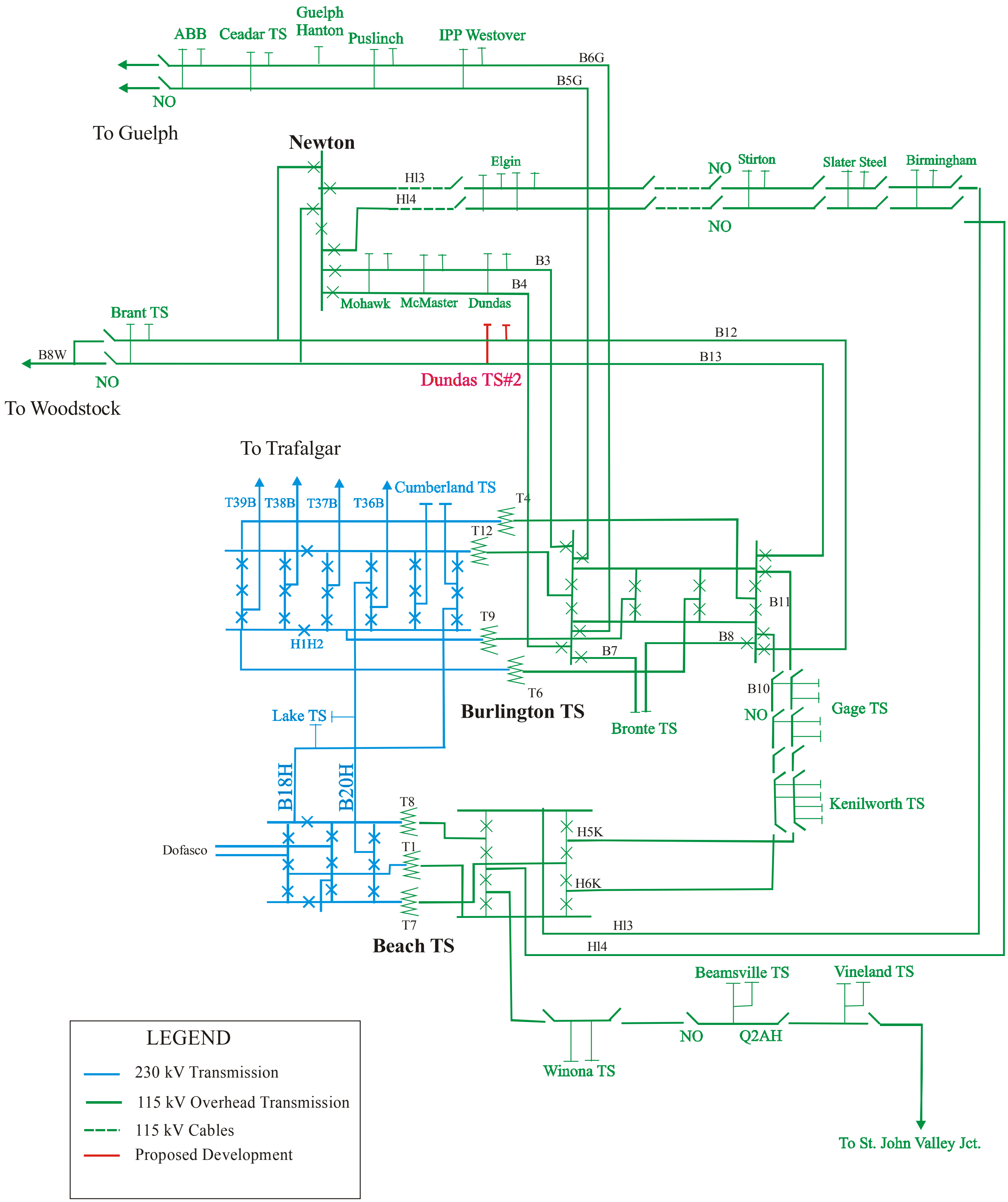
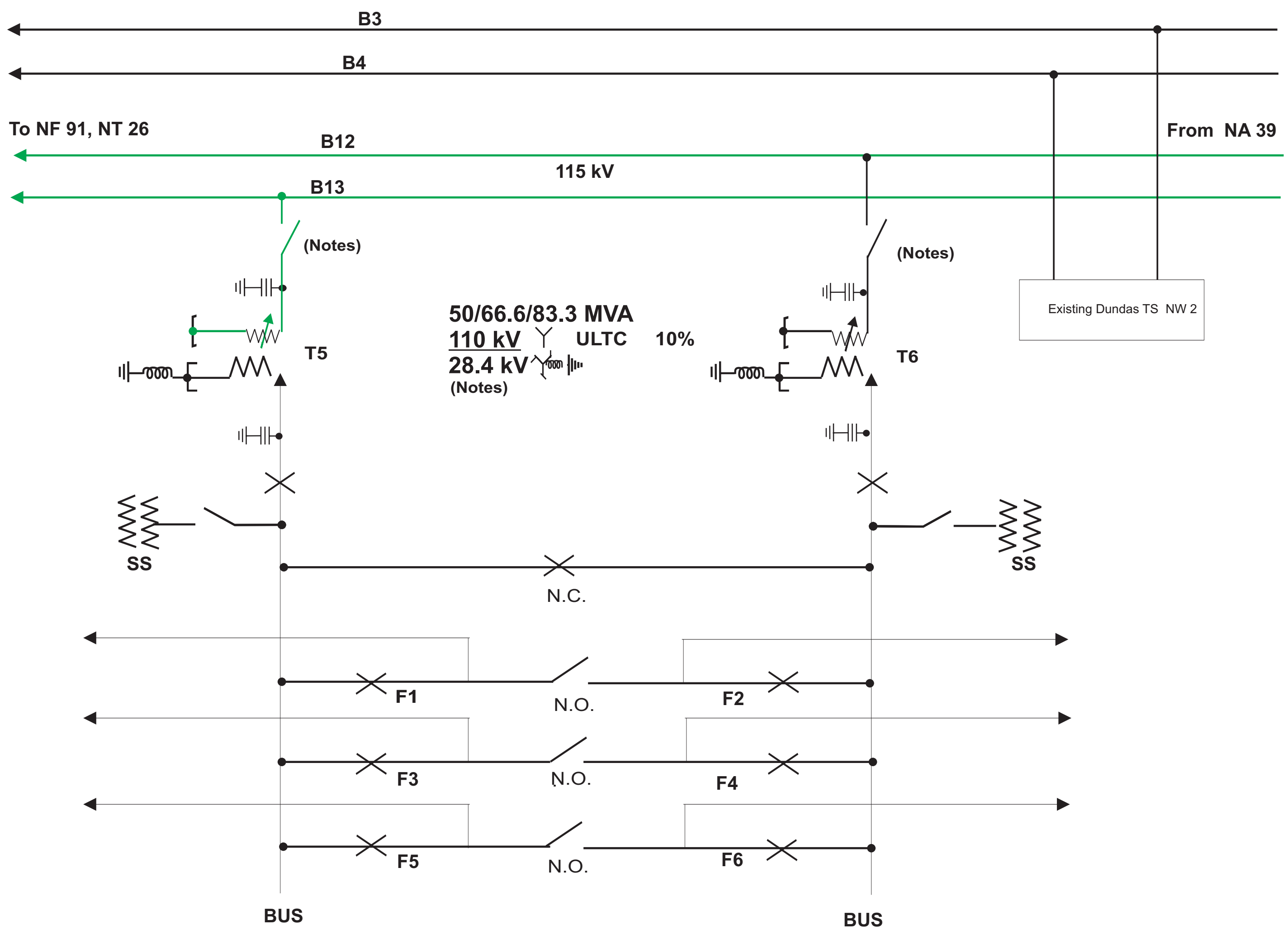


Figure 1. Burlington to Beach Area 115 kV Transmission



Shows electrical connections only but not physical order

Alternate transformer winding configuration Delta(HV)/ WYE (LV) with LV neutral grounded via neutral reactor.

Preliminary ULTC range: **10%**

Transformer HV switching -115 kV motor operated disconnect switch.

Checked ____________________________

Approved ___________________________

FIGURE 2. Dundas TS #2: Build 115-27.6 kV Transformer Station

Appendix A

Burlington 115 kV Area Transmission Review

1.0 Introduction

This review was carried out in conjunction with the Connection Assessment that was performed for the incorporation of Dundas TS#2. It focuses on the adequacy of the existing Burlington area transmission system to supply the area load and identified any limitation that may occur.

Detailed descriptions of the Burlington area transmission system and all the study assumptions are given in sections 5.1 and 5.3 of the report.

2.0 IMO Guidelines for Connection Assessments

The IMO has been developing a set of proposed guidelines for determining the effect of new developments on the system reliability and establishing the need to reinforce the transmission system. It has been proposed that the following contingencies constitute the "design criteria contingencies" set:

- Single transmission element contingency,
- Double-circuit line contingency,
- Stuck breaker condition.

The proposed guidelines that were used in this study specify that with all transmission elements in service in pre-contingency:

- any design-criteria contingency must not result in the loss of 500 MW or more of load.
- if any design criteria contingency results in the loss of 250MW to 500 MW at least half of the load must be restored within 30 minutes and the remaining load in eight hours.
- if any design-criteria contingency will result in a supply interruption to 150 MW to 250 MW load then, the supply must be restored within eight hours.
- the power flows over the transmission elements must be within their continuous thermal ratings,
- any design-criteria contingency must not result in power flows which exceed the limited time ratings of the equipment,
- the steady state voltages must be within the ranges required by the Market Rules,
- the post-contingency decline in voltage must be less than 10%.

3.0 Assessment of Burlington 230/115 kV Transmission Thermal Loading

Linear analysis was first performed for year 2003 summer peak load conditions with all transmission elements in service, and for the loss of one critical transmission element. The transmission system losses were assumed to be 3% and were included in the total MVA flows.

A set of transmission distribution factors and outage distribution factors was established for the transmission elements of interest, as listed in Table 4A. In summary, these factors show that:

- with all transmission elements in service, the power flowing into the 115 kV Burlington area pocket is distributed almost equally over the four Burlington 230/115 kV autotransformers,
- for a contingency associated with T4, the power flow would distribute evenly over the remaining three transformers in post contingency,
- for a contingency associated with anyone of the other three autotransformers about 37 % of the power flow would show up on T4 in post-contingency.

Table 4A. Power Distribution Factors (All in Service and Outage)

Element	BurlingtonT4	BurlingtonT6	BurlingtonT9	BurlingtonT12
Transfer Distribution Factor	.248	.237	.256	.259
Outage Element	Outage Distribution Factors			
	T4	T6	T9	T12
T4	-	.334	.33	.336
T6	.371	-	.292	.337
T9	.369	.34	-	.291
T12	.372	.293	.335	-

Calculations were performed to establish the thermal capability of the Burlington 230/115 kV area transmission facilities to supply the load.
The study was done for year 2003 and all the results are summarized in Table 5A. For cases where potential future supply problems were observed, analysis was also performed to identify the year when the capability of the existing facilities would become inadequate.

Table 5A. Estimates of Pre and Post Contingency Power Flows for 2003

Transmission Element (cont., 10day LTR)	**Pre contingency Flows (MVA) % of cont. rating**	**Post Contingency Flows**				
		Outage Element				**Loss of T6&T9 due to stuck 230 kV Breaker H1H2 %15 min LTR**
		T4 % 10 Day LTR	**T6 % 10 Day LTR**	**T9 % 10 Day LTR**	**T12 % 10 Day LTR**	
Burlington T4 (215, 254MVA, 306MVA)	196.4	0	**266 105%**	**271.2 107%**	**272.7 110%**	**391.7 128%**
Burlington T6 (215, 254 MVA, 306MVA)	187.7	**253.3 100%**	0	**256.7 101%**	247.8 92%	0
Burlington T9 (250, 297 MVA, 374MVA)	202.9	267.7 90%	257.7 8.7%	0	271.6 90%	0
Burlington T12 (250, 297 MVA, 357MVA)	205.1	271.1 91%	268.3 90%	264.1 84%	0	**386 112%**
Total MVA	**792**					

It was estimated that in 2003 the Burlington area summer peak load including losses could reach about 792 MVA. The results of this assessment indicate that:

- by 2003 with one transformer out of service the *peak Burlington area load (assuming 0.95 pf) may exceed the Burlington TS load capability* (254x2 +297=805 MVA),
- for a contingency associated with T4 the post-contingency power flow over T9 *may exceed its 10 day LTR but not the 15 minute LTR*,

- for a contingency associated with any one of the 230/115 kV autotransformers but not T4 the post-contingency power flow over T4 will *exceed its 10 day LTR but not the 15 minute LTR*,
- for a contingency involving T6 or T9 and assuming that H1H2 bus-tie breaker does not operate both transformers will be temporarily lost by configuration and the flows on the remaining two autotransformers *exceed the 15 minute LTR of the transformers*,
- for a contingency involving T4 or T12 and assuming that A1A2 bus-tie breaker does not operate both transformers will be temporarily lost by configuration and the flows on the remaining two autotransformers *exceed the 15 minute LTR of the transformers*,
- a contingency involving the double circuit line B3/B4 will result in loss of power supply to about 200 MW of load consisting of Dundas TS, McMaster TS and Mohawk TS, since there is no alternative HV supply for these stations. It is expected that restoration of load can be achieved in less than eight hours as required by the load supply criteria (section 5.2).
- a contingency involving the double circuit line B12/B13 will result in post contingency loading of the remaining circuits *to about 96% of their emergency ratings*.

System operating control actions are presently in place to allow for the transfer of up to 120 MW (133 MVA) of Burlington load to Detweiler TS in the event of the permanent loss of one Burlington transformer.

Loss of T9

The study results indicate that for a contingency involving T9 is it expected that under peak load conditions T4 will become loaded over its 10 day rating.

Assuming that for stressed system conditions Detweiler can accommodate the extra load and that the load transfer can be performed in 15 minutes then, after the load switching is executed 659 MVA load (792-133 = 659 MVA) will continue to be supplied via the remaining three transformers. Calculations show that T4 could become loaded to 236 MVA. *This power flow exceeds the continuous rating of the transformers but not its 10 day LTR*.

If however, Detweiler cannot accommodate the load transfer, but Beach TS can take over 100 MW (111 MVA) then the post-contingency flow on T4 will be slightly higher.

Loss of Two Autotransformers Due 230 kV Stuck Breaker

The study results indicate that, for the loss of T6 and T9 due to H1H2 stuck breaker condition or the loss of T4 and T12 due to A1A3 stuck breaker situation the *power flows on the remaining two autotransformers will exceed their respective 15 minute LTR*.

With the existing configuration of Burlington 230 kV switchyard the clearing of a fault associated with either T6 or T9 requires the opening of the bus-tie breaker H1H2. Should this breaker fail to operate, then the isolation of the entire H1-H2 bus must follow and hence both T6 and T9 would become disconnected from the system.

The situation is identical for the other two autotransformers connected to the A1-A2 bus.

It is recommended that Hydro One implement as soon as possible a plan to install additional transformation capability at Burlington TS since by 2003 the estimated peak load will be reaching the load capability of this station, and in case of a transformer fault and stuck breaker condition the post-contingency power flows will exceed the 15 minute LTR of the remaining transformers.

4.0 Voltage Assessment

A study was carried out to evaluate the steady state and post contingency voltages that will likely be experienced in 2003 for peak load conditions in the Burlington area.

The voltage assessment study used based on the following assumptions:

- Gage TS load was transferred to Beach TS because it was learned from past operating experiences that during peak load conditions this load is normally transferred to Beach TS,
- A selected single element contingency was the loss of T4. This represents the most critical contingency because the clearing of this fault will also be taking out of service the 230 kV shunt capacitor SC21 due to the present arrangement of Burlington 230 kV switchyard.

The results of this study are summarized in Table 6A.

Table 6A. Voltage Assessment

Station	Year 2003		
	Pre-contingency (kV) Shunt Cap I/S @ Burlington 230 kV	Contingency (% Voltage Decline)	
		Loss of T4 and Shunt Cap	Loss of T4 & T12 and Shunt Cap
Burlington 230 kV	240.1	236.7 1.4%	236 1.7%
Burlington 115 kV	118.5	115.1 3%	111.0 6.3%
Newton 115 kV	114.6	111 3.1%	106.6 7%
Brant 115 kV	109.7	105.8 3.6	101.1 7.8%
Cedar 115 kV	112.1	109.9 2%	105.3 6%

The pre-contingency study results indicate that for peak load conditions, voltages at Burlington 115 kV bus could be as low as 118 kV and, Brant TS and Cedar TS voltages could potentially be lower than the minimum required by the Market Rules. However, it should be emphasized that these studies were carried out for loads that exhibit the minimum power factors required by the Market Rules. In reality the loads in the area could have higher power factors, hence demand for bulk reactive power would be less and 115 kV voltages higher.

It should also be noted that the Burlington voltage obtained in the study is comparable with the 2002 summer records shown in diagram 2 of section 5.3 of the main report.

Historical records of voltages at Brant TS and Cedar TS are not presently available to verify the past performance of the system. However, a system snapshot that was taken on July 2, 2002 – one of this summer's high demand days – indicates that the voltage at Brant TS was 112 kV. This voltage level is below the minimum of 113 kV required by the Market Rules.

The condition of the steady state voltages will gradually become worse as the load in the Burlington area increases.

The post-contingency simulation results show that the voltage decline at each 115 kV station in the area meets the requirements of the *Market Rules*.

It is recommended that Hydro One implement as soon as possible a plan to provide additional voltage supporting facilities in the Burlington 115 kV area to meet the minimum requirement for 113 kV pre-contingency system voltages.

5.0 Burlington Area Study Conclusions

The examination of the Burlington 115 kV system raised concerns with respect to the capability of the present transmission facilities to continue proving reliable load supply beyond 2004. The assessment concluded that the maximum power transfer capability of Burlington 230/115 kV transformation facilities could be exceeded and 115 voltages could be lower then required for summer peak load conditions.

The detailed conclusions are summarized below.

1. With all transmission elements in service the power flows are within the continuous thermal capability of the respective elements.
2. By 2003 or 2004, with one transformer out of service the peak Burlington area load will exceed the Burlington TS load capability.
3. For a contingency associated with one Burlington 230/115 kV autotransformer the post-contingency power flow over at least one of the remaining autotransformers will exceed its 10-day LTR.
4. For a contingency involving T6 or T9 and assuming that H1H2 bus-tie breaker does not operate both transformers will be temporarily lost by configuration and the flows on the remaining two autotransformers exceed the 15 minute LTR of the transformers.
5. For a contingency involving T4 or T12 and assuming that A1A2 bus-tie breaker does not operate both transformers will be temporarily lost by configuration and the flows on the remaining two autotransformers exceed the 15 minute LTR of the transformers.
6. A contingency involving the double circuit line B3/B4 will result in loss of power supply to about 200 MW of load consisting of Dundas TS, McMaster TS and Mohawk TS, since there is no alternative HV supply for these stations. It is expected that restoration of load can be achieved in less than eight hours as required by the load supply criteria (section 5.2).
7. A contingency involving the double circuit line B12/B13 will result in post contingency loading of the remaining circuits to about 96% of their emergency ratings.
8. Pre-contingency voltages at Burlington 115 kV bus could be as low as 118 kV and, at Brant TS and Cedar TS could potentially be lower than 113 kV.

It is recommended that Hydro One Networks initiate a study to identify options for addressing IMO's concerns with respect to near future limitation of the Burlington 230/115 kV transformer station and the low station voltages in the Burlington 115 kV load area.

6.0 IMO's Recommendation for System Reinforcements

It is strongly recommended that Hydro One implement as soon as possible a plan to install additional transformation capability at Burlington TS since by 2003 or 2004 the estimated peak load will be reaching the load capability of this station. In addition, for certain recognized contingencies, the post-contingency power flows will exceed the 15 minute LTR of Burlington 230/115 kV autotransformers.

It is strongly recommended that Hydro One implement as soon as possible a plan to provide additional voltage supporting facilities in the Burlington 115 kV area to meet the minimum requirement for 113 kV pre-contingency system voltages.