GTA West Supply Study

Adequacy of Transmission Facilities

And

Transmission Supply Plan 2005 – 2015

February 16, 2006

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Foreword

This report is the result of a joint study by Enersource Hydro Mississauga, Halton Hills Hydro Inc., Hydro One Brampton, Hydro One Networks Inc. Distribution, Milton Hydro and Hydro One Networks Inc. Transmission. The study team members were:

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The load forecast is based on information available to Enersource Hydro Mississauga, Hydro One Brampton, Toronto Hydro Electric System, Halton Hills Hydro, Milton Hydro and Hydro One-Distribution.

The preferred plans have been selected and endorsed based primarily on technical considerations. Where applicable, these plans will be subject to Environmental Assessment approval and / or Ontario Energy Board (OEB) approval. The issue of cost allocation between utilities was not addressed.

Signatures

We have reviewed this report and concur with its recommendations. This endorsement shall not operate as a waiver of any participant's rights due to material changes in load forecasts or economic considerations.

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Date: February 16, 2006

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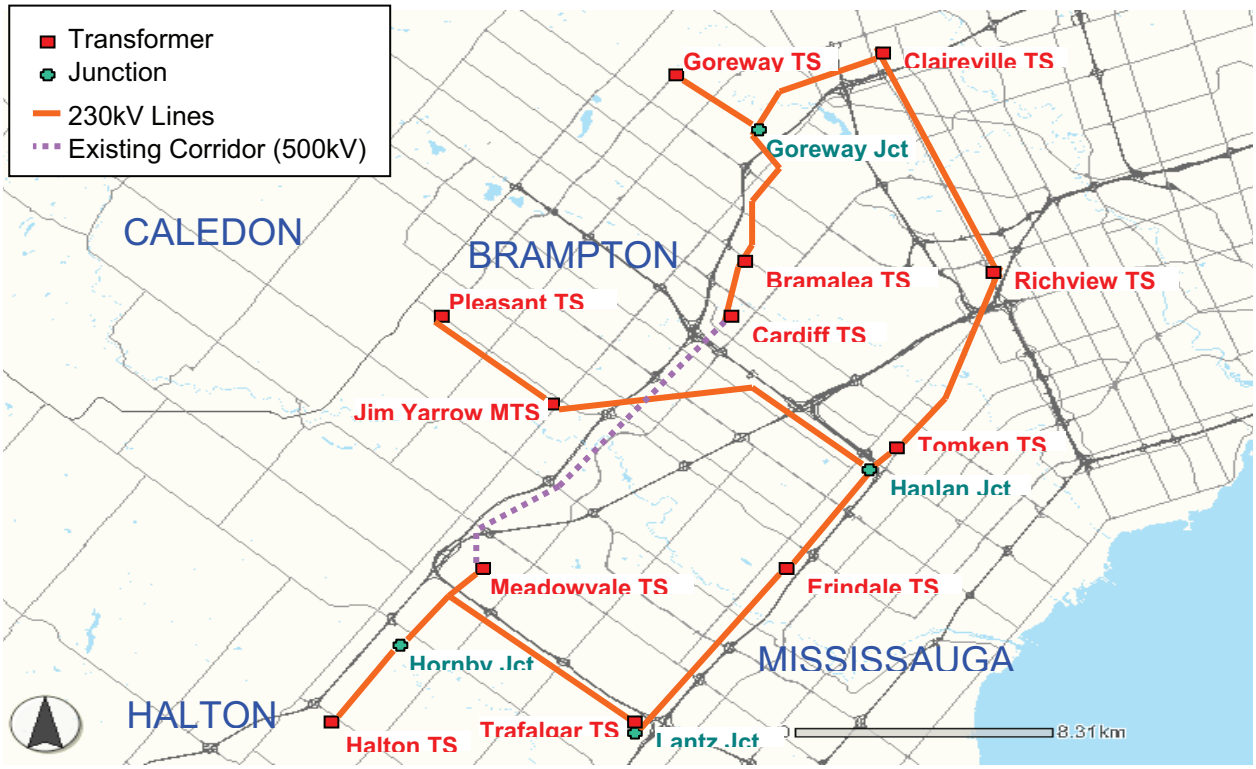
EXECUTIVE SUMMARY

Background

For the purpose of this study, Greater Toronto Area (GTA) West includes the area roughly bordered geographically by Highway 27 to the east, King Street to the north, Regional Road 25 to the west and Highway 403/407 to the south. Much of the study area is Peel Region, with a small section of both Halton Region and Toronto.

The electrical supply in this area is provided through 500 kV and 230 kV transmission lines and step down transformation facilities as shown in Map 1. The distribution system within this area is at two different voltage levels, 44 kV and 27.6 kV. Load forecasts provided by the Local Distribution Companies (LDCs) in GTA West indicate that electrical load growth is expected to continue at a summer average rate of 2.6% per year at the 27.6 kV sub-transmission level and 1.5% per year at the 44 kV sub-transmission level, for the next ten years.

Map 1: Existing Transmission Facilities in GTA West.



In June of 2004, a joint utility planning study was initiated between five of the six LDCs in GTA West and Hydro One Networks Inc. - Transmission. The LDC participants in this joint study were:

- Enersource Hydro Mississauga (EHM)
- Halton Hills Hydro Inc. (HHH)
- Hydro One Brampton (HOB)
- Hydro One Networks Inc. – Distribution (HONI – Dx)
- Milton Hydro Distribution Inc. (MHD)

This study identified the need for transmission capacity and voltage stability in GTA West, and assessed the capability of the transmission system to meet the load requirements for the 10 year study period (from 2005 to 2015). An additional assessment for expected 2024 conditions was also undertaken to evaluate the proposed plans with respect to the long-term system requirements and identify potential gaps. Several transmission alternatives were investigated to address the needs and deficiencies as soon as practical.

Need

The needs assessed in this study were evaluated and identified based on the occurrence of a single contingency.

Station Overloads (230/27.6 kV)

- Transformers T1/T2 at Bramalea Transmission Station (TS) are currently exceeding their summer capacity limit[1] (2005)
- Transformers T1/T2 at Erindale TS are currently exceeding their summer capacity limit (2005)
- Transformers T5/T6 at Pleasant TS are currently loaded to their summer capacity limit (2005)
- Transformers T1/T2 at Jim Yarrow Municipal Transmission Station (MTS) are expected to exceed their summer capacity limit by summer 2009[2]
- Transformers T5/T6 at Goreway TS are expected to reach their summer capacity limit by summer 2011[3]
- Transformers T3/T4 at Halton TS are expected to reach their summer capacity limit by summer 2011

Station Overloads (230/44 kV)

- Transformers T1/T2 at Meadowvale TS are currently exceeding their summer capacity limits (2005)
- Transformers T3/T4 and T5/T6 at Erindale TS are expected to exceed their summer capacity limit by summer 2006[4]
- Transformers T1/T2 at Pleasant TS are expected to exceed their summer capacity limits by summer 2011

Voltage Deficiencies

- Meadowvale TS is currently experiencing voltage deficiencies during periods of high summer loading and is below Operating and Planning Standards[5]

Circuit Overloads

- Segments of circuits R19T/R21T are expected to reach thermal capacity limits as per Operating and Planning Standards by summer 2009
- Segments of circuits T38B/T39B are expected to be nearing thermal capacity limits as per Operating and Planning Standards by summer 2015

[1] "summer capacity limit" is discussed in Section 2.
[2] Jim Yarrow MTS forecast includes load transfers from Bramalea TS (transformers T1/T2) and Pleasant TS (transformers T5/T6).
[3] Goreway TS (transformers T5/T6) forecast includes load transfers from Bramalea TS (transformers T1/T2).
[4] Erindale TS (T3/T4, 230/44 kV) will experience unacceptable voltage decline before transformers reach capacity, while transformers T5/T6 will be at the transformer capacity limit.
[5] Please refer to Section 5 for details on Operating and Planning Standards.

Forced Load Transfers

Due to the rapid load growth in this area, and the lack of local transmission resources, several stations have been and/or will be forced to designate cascading load transfers to other stations in order to mitigate operating risks until further capacity can be supplied.

This study was conducted under the assumption that by 2005 additional station capacity would be provided by a new TS (Cardiff TS coming into service in May 2005). Some immediate load relief is possible via load transfers between stations operating at the same sub-transmission voltage levels, however the load growth in this area is such that new step down facilities will be required before 2007. Load transfers between different sub-transmission voltage levels are either not technically possible or economically prohibitive.

Recommended Transmission Reinforcements

A number of options were considered to address the needs as indicated above, and after a thorough technical analysis and review, the following recommendations were made:

- Install by summer 2007 Low Voltage (LV) capacitors at Meadowvale TS (2 capacitor banks, 32.4 MVAR at 46 kV)
- For short-term relief and as they become necessary, perform load transfers:
  - From Bramalea TS (T1/T2, 230/27.6 kV) to Goreway TS (T5/T6, 230/27.6 kV) and Jim Yarrow MTS (T1/T2, 230/27.6 kV)
  - From Pleasant TS (T5/T6, 230/27.6 kV) to Jim Yarrow MTS (T1/T2, 230/27.6 kV)
  - From Erindale TS (T1/T2, 230/27.6 kV) to Cardiff TS (T1/T2, 230/27.6 kV)
  - From Meadowvale TS (T1/T2, 230/44 kV) to Erindale TS (T3/T4, 230/44 kV)
- Construct by summer 2008 Winston TS with two 230/44 kV, 75/125 MVA transformers in the vicinity of Winston Churchill Blvd. and Highway 403
- Extend by summer 2009 circuits V72R and V73R from Cardiff TS to the Pleasant TS tap and construct Hurontario Switching Station (SS). Radially re-supply Jim Yarrow MTS from this SS
- Construct by summer 2009 Pleasant TS #3 with two 230/27.6 kV, 75/125 MVA transformers on the existing Pleasant TS site
- Construct by summer 2011 Goreway TS #2 with two 230/27.6 kV, 75/125 MVA transformers on the existing Goreway TS site
- Install by summer 2011 a second 230/44 kV, 50/83 MVA transformer at Goreway TS
- Construct by summer 2011 either Steeles TS or James Snow TS with two 230/27.6 kV, 50/83 MVA transformers. The Steeles TS location would be in the vicinity of Steeles Avenue and Trafalgar Road while the James Snow TS location would be in the vicinity of Steeles Avenue and James Snow Parkway

Recommendations

Several recommendations can be drawn from this study to address the current system deficiencies and provide system capacity to meet forecasted load growth. These recommendations are:

1. Subject to the Ontario Power Authority's integrative review (Integrated Power System Plan) Hydro One Networks Inc. to initiate the approval processes required for the extension of circuits V72R and V73R and the construction of Hurontario SS.

2. Hydro One Networks Inc. to commence the detailed specification and engineering of the LV capacitors at Meadowvale TS.

3. Hydro One Networks Inc. to commence the preliminary engineering and consultation with the LDCs, and to initiate the approval processes on the construction of a new TS , Winston TS, in the vicinity of Winston Churchill Blvd. and Highway 403 in Mississauga.

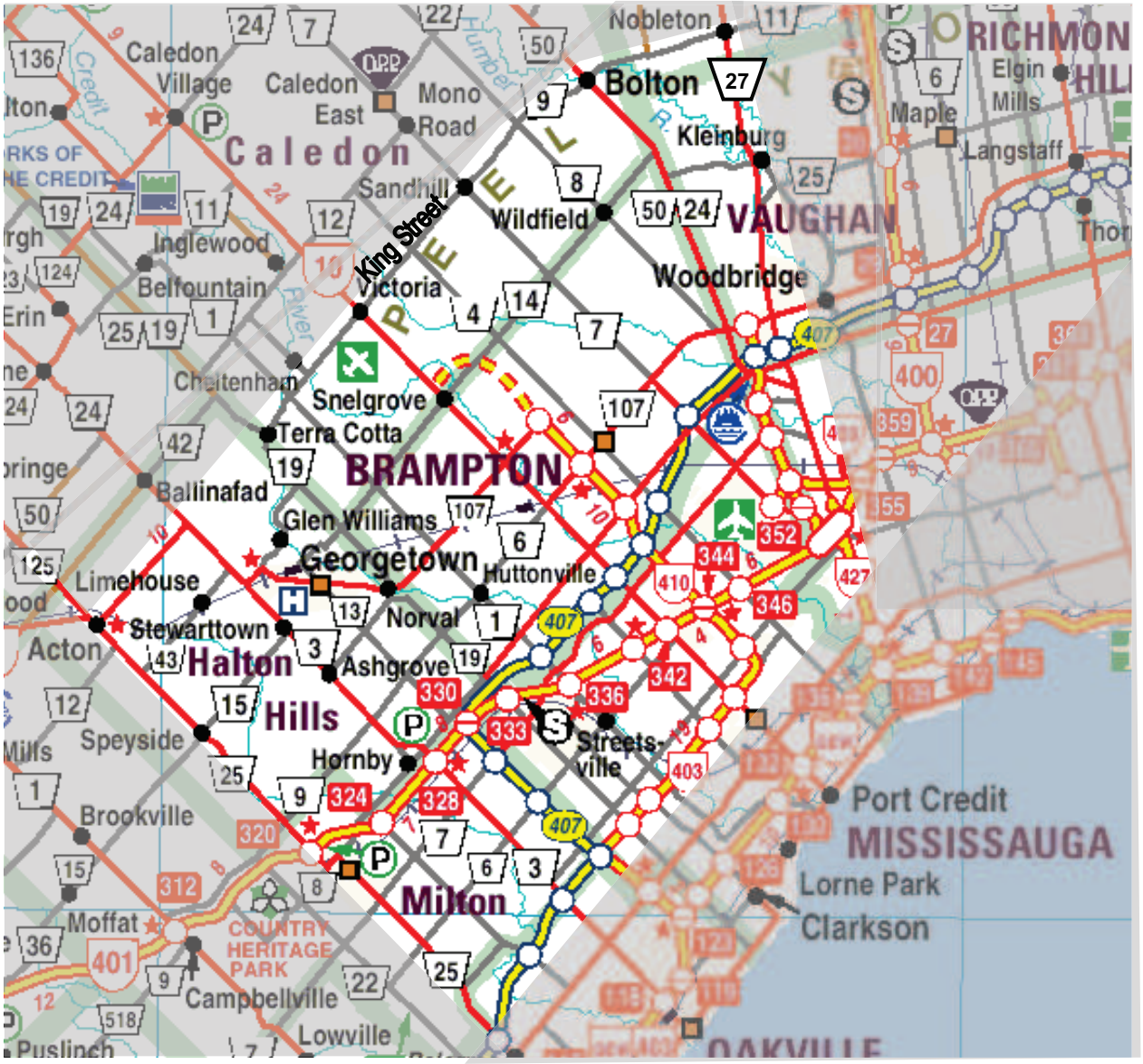
4. The LDCs to continue to transfer loads as necessary to mitigate potential operating risks until transmission capacity is established.

5. The LDCs to continue to monitor load growth in the GTA West area and to review options for long-term growth based on the location of new developments and load forecasts.

1. INTRODUCTION

For the purpose of this study, Greater Toronto Area (GTA) West includes the area roughly bordered by Highway 27 to the east, King Street to the north, Regional Road 25 to the west and Highways 403/407 to the south (refer to Map 2). Much of the study area is Peel Region, with a small section of both Halton Region and Toronto.

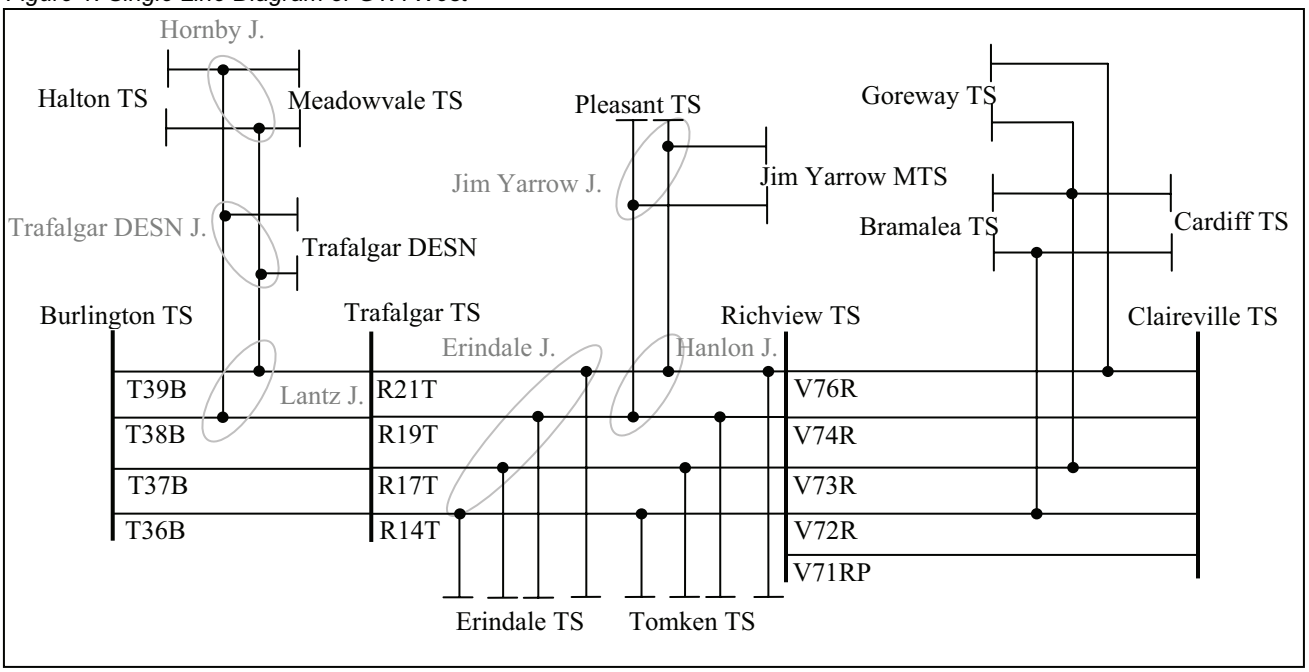
Map 2: Study Geographical Area[6]



Electrical supply in this area is provided through 500 kV and 230 kV transmission lines and step down transformation facilities (Transmission Station, TS; Municipal Transmission Station, MTS) as shown in Map 1 and Figure 1.

[6] Map clip from http://www.mto.gov.on.ca/english/traveller/map/images/pdf/southont/sheets/Map3.pdf

Figure 1: Single Line Diagram of GTA West



The northern Mississauga and Brampton area is expected to have a large rate of load growth for the upcoming years as a result of population growth and development projects taking place in this area. Load growth trends in this area indicate that recent transmission upgrades and newly built or planned stations, including the construction of Jim Yarrow MTS and Cardiff TS, will not be able to provide the required transformation capacity. For this reason, in June 2004, five of the six Local Distribution Companies (LDCs) in GTA West and Hydro One initiated a joint study.

The purpose of this joint study was to assess the load growth in GTA West and ensure that adequate transmission and connection facilities will be available to meet the electrical demand requirements over the upcoming decade, 2005 to 2015.

Six Local Distribution Companies (LDCs) own and operate assets in the specified study area. These companies are:

- Enersource Hydro Mississauga (EHM)
- Halton Hills Hydro Inc. (HHH)
- Hydro One Brampton (HOB)
- Hydro One Networks Inc. – Distribution (HONI – Dx)
- Milton Hydro Distribution Inc. (MHD)
- Toronto Hydro Electric System (THES)

With the exclusion of Toronto Hydro Electric System[7], the above listed LDCs participated in this joint study.

[7] Toronto Hydro Electric System did not participate in this study beyond providing load forecasts, as their asset locations and circumstances are such that they are able to resolve capacity issues via load transfers between various transmission facilities within their jurisdiction.

2. EXISTING TRANSMISSION SYSTEM AND NEEDS

GTA West is supported by two main 500/230 kV TSs (Claireville TS and Trafalgar TS) transforming electricity from 500 kV to 230 kV, and one 230 kV electrical system hub (Richview TS).

There are ten step-down transmission facilities that were analyzed in this study. These stations step the transmission voltage of 230 kV down to a sub-transmission level, either 27.6 kV or 44 kV, for distribution of electricity to the end-use customer. Table 1 lists the stations and their associated step-down transformer voltage capability. Four of the ten existing TSs (Bramalea TS, Erindale TS, Goreway TS and Pleasant TS) in the study area have the ability to step-down to both sub-transmission voltages. The remaining stations are only able to step-down to one sub-transmission voltage.

Table 1: Transmission Step-down Facilities Within GTA West

Station	230 / 27.6 kV	230 / 44 kV
Bramalea TS	Transformers T1/T2	Transformers T3/T4 and T5/T6
Cardiff TS	Transformers T1/T2	
Erindale TS	Transformers T1/T2	Transformers T3/T4 and T5/T6
Goreway TS	Transformers T5/T6	Transformer T4
Halton TS	Transformers T1/T2	
Jim Yarrow MTS	Transformers T1/T2	
Meadowvale TS		Transformers T1/T2
Pleasant TS	Transformers T5/T6	Transformers T1/T2
Richview TS	Transformers T1/T2, T5/T6 and T7/T8	
Tomken TS		Transformers T1/T2 and T3/T4

The above mentioned TSs are connected as follows (refer to Figure 1 and Map 1):

1. Trafalgar TS and Richview TS are connected via four 230 kV circuits (R14T, R17T, R19T and R21T). Erindale TS and Tomken TS are tapped off of these circuits. Two radial extensions from R19T and R21T at Hanlon Junction supply Pleasant TS and Jim Yarrow MTS.

2. Richview TS and Claireville TS are connected via five 230 kV circuits (V71RP, V72R, V73R, V74R, V76R). Goreway TS, Bramalea TS and Cardiff TS are tapped off of these circuits.

3. Meadowvale TS and Halton TS are supplied via two radial extensions from two 230 kV circuits (T38B and T39B) connecting Trafalgar TS and Burlington TS.

The study area was identified as summer critical[8]. Load forecasts provided by the LDCs indicate that electrical load growth is expected to continue at a summer average rate of 2.6% per year at the 27.6 kV sub-transmission level and 1.5 % per year at the 44 kV sub-transmission level, for the next ten years.

[8] Summer critical means less available margin between loading and applicable equipment ratings during this particular season.

Some stations in the study area are already peaking above their summer capacity limit (Limited Time Rating, LTR)[9], as well as experiencing voltage deficiencies related to high loading. The particular needs of this system were identified using a single contingency analysis. Those needs and the associated need dates are detailed below. Refer to Table 2 for a summary.

Station Overloads (230/27.6 kV)

- Transformers T1/T2 at Bramalea TS are currently exceeding their summer 10-day LTR (2005)
- Transformers T1/T2 at Erindale TS are currently exceeding their summer 10-day LTR (2005)
- Transformers T5/T6 at Pleasant TS are currently loaded to their summer 10-day LTR (2005)
- Transformers T1/T2 at Jim Yarrow MTS are expected to exceed their station summer 10-day LTR by summer 2009[10]
- Transformers T5/T6 at Goreway TS are expected to reach their summer 10-day LTR by summer 2011[11]
- Transformers T3/T4 at Halton TS are expected to reach their summer 10-day LTR by summer 2011

Station Overloads (230/44 kV)

- Transformers T1/T2 at Meadowvale TS are currently exceeding their summer 10-day LTR (2005)
- Transformers T3/T4 and T5/T6 at Erindale TS are expected to exceed their summer 10-day LTR by summer 2006
- Transformers T1/T2 at Pleasant TS are expected to exceed their summer 10-day LTR by summer 2011

Voltage Deficiencies

- Meadowvale TS is currently experiencing voltage deficiencies during periods of high summer loading and is below Operating and Planning Standards (refer to Section 5 for definition of Operating and Planning Standards)

Circuit Overloads[12]

- Segments of circuits R19T/R21T are expected to reach summer thermal capacity limits as per Operating and Planning Standards (refer to section 5) by 2009
- Segments of circuits T38B/T39B are expected to be nearing summer thermal capacity limits as per Operating and Planning Standards by 2015

[9] For planning purposes, the LTRs, or thermal capacity limits, referred to in this study are emergency ratings for electrical equipment to acknowledge that equipment ratings can be exceeded for a certain length of time without causing undue stress on the equipment. For transformers, this is a 10-day LTR and for circuits or lines this is a 15-minute LTR immediate post fault, and continuous rating for steady state post fault.

[10] Jim Yarrow MTS load growth forecast includes load transfers from Bramalea TS (T1/T2, 230/27.6 kV) and Pleasant TS (T5/T6, 230/27.6 kV).

[11] Goreway TS (T5/T6) load growth forecast includes load transfers from Bramalea TS (T1/T2).

[12] These circuit overloads were observed in a basecase loadflow with a Flow East Towards Toronto (FETT) transfer of approximately 3600 MW.

Table 2: Summary of Transmission Needs and Need Dates

Year	27.6 kV Stations	44 kV Stations	Circuits
2005 (Present)	Bramalea TS (T1/T2) Erindale TS (T1/T2) Pleasant TS (T5/T6)	Meadowvale TS (T1/T2)	
2006		Erindale TS (T3/T4 and T5/T6)	
2009	Jim Yarrow MTS (T1/T2)		R19T/R21T
2011	Goreway TS (T5/T6) Halton TS (T3/T4)	Pleasant TS (T1/T2)	

3. LOAD GROWTH

Load forecasts provided by LDCs in GTA West indicate that electrical load growth is expected to continue at a summer average rate of 2.6% per year for the next ten years at the 27.6 kV level and at 1.5% per year at the 44 kV level (refer to Table 3). More detailed load forecasts, including station capacity data, can be found in Appendix A.

Table 3: Forecast – Summer Peak Load (MW)

	Forecast Load in MW											
230/27.6 kV Stations	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	
1. Bramalea TS[1,2,3]	193	174	175	177	179	181	183	183	184	184	184	
2. Cardiff TS[1]	0	101	103	105	107	110	112	112	112	113	113	
3. Erindale TS[1,4]	233	167	170	174	177	181	185	185	186	187	187	
4. Goreway TS[3]	148	155	163	170	177	184	192	200	208	216	224	
5. Halton TS	97	114	131	149	162	166	170	175	179	183	188	
6. Jim Yarrow MTS[2]	95	100	113	125	138	152	166	180	196	211	225	
7. Pleasant TS[2]	198	198	198	198	198	198	198	198	198	198	198	
8. Richview TS	354	362	364	368	371	374	377	380	385	388	392	
Total:	1318	1371	1418	1466	1509	1546	1582	1614	1647	1680	1710	Avg.
Growth Rate:		4.0%	3.4%	3.4%	3.0%	2.4%	2.4%	2.0%	2.1%	2.0%	1.8%	2.6%
230/44 kV Stations	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	
1. Bramalea TS[1,2,3]	179	184	188	192	196	201	205	210	215	220	224	
2. Goreway TS[3]	28	29	30	31	32	34	35	36	37	39	40	
3. Erindale TS[1,4]	360	374	384	394	405	415	425	427	429	431	433	
4. Meadowvale TS[4]	181	181	181	181	181	181	181	181	181	181	181	
5. Pleasant TS[2]	131	136	140	144	148	152	156	161	164	170	174	
6. Tomken TS	312	314	316	317	319	321	322	323	324	325	326	
Total:	1191	1217	1239	1260	1281	1303	1324	1337	1350	1364	1377	Avg.
Growth Rate:		2.3%	1.8%	1.7%	1.7%	1.7%	1.7%	1.0%	0.9%	1.1%	0.9%	1.5%

1 Net load; includes load transfers from Bramalea TS and Erindale TS to Cardiff TS.
2 Net load; includes load transfers from Pleasant TS and Bramalea TS.
3 Net load; Includes load transfers from Bramalea TS.
4 Net load; Includes load transfers from Meadowvale TS to Erindale TS

The major load centres during the ten-year study period exist in the north and westerly parts of the city of Mississauga at the 44 kV sub-transmission level. As well, major load centres exist in the west and northeasterly parts of Brampton at both 44 and 27.6 kV sub-transmission levels. The study area is considered summer critical.

4. SYSTEM ASSUMPTIONS

Certain assumptions were made in order to assess the effects of different contingencies to verify the system capacity. The assumptions used in the study were:

1. If a coincident peak load forecast was not provided by the LDC, the coincident peaks were calculated using the factors in Table 4.

Table 4: Coincidence Factors

LDC	Coincidence Factor
Enersource Hydro Mississauga	Coincident peak forecast provided
Halton Hills Hydro Inc.	Coincident peak forecast provided
Hydro One Brampton	Coincident peak forecast provided
HONI Dx	Coincident peak forecast provided
Milton Hydro Distribution Inc.	0.95
Toronto Hydro Electric System	0.95

2. Power factors were provided by each LDC and used in this study as listed in Table 5.

Table 5: Power Factors

LDC	Power Factor	
Enersource Hydro Mississauga	0.9	
Halton Hills Hydro Inc.	0.9	
Hydro One Brampton	Bramalea TS (27.6 kV) – 0.88[13] Goreway TS (27.6 kV) – 0.92 Jim Yarrow MTS (27.6 kV) – 0.92 Pleasant TS (27.6 kV) – 0.93	Bramalea TS (44 kV) – 0.88[14] Goreway TS (44 kV) – 0.85 Pleasant TS (44 kV) – 0.88[15]
Hydro One Networks Inc. – Distribution	0.88	
Milton Hydro Distribution Inc.	0.9	
Toronto Hydro Electric System	0.9	

3. A study period of 10 years, from 2005 to 2015, was used to assess the transmission requirements.

4. Equipment summer continuous ratings and LTRs were based on a daytime ambient temperature of 30°C with a wind speed of 4 km/hour.

5. Hydro One Brampton shifts 60% of Bramalea TS (T1/T2, 27.6 kV) load growth to Jim Yarrow MTS (T1/T2, 27.6 kV) and 40% of Bramalea TS (T1/T2, 27.6 kV) load growth to Goreway TS (T5/T6, 27.6 kV).

6. Hydro One Brampton shifts all future load growth at Pleasant TS (T5/T6, 27.6 kV) to Jim Yarrow MTS (T1/T2, 27.6 kV)

[13] Low voltage (LV) capacitors have been installed at Bramalea TS to compensate for the power factor.
[14] LV capacitors have been installed at Bramalea TS to compensate for the power factor.
[15] LV capacitors have been installed at Pleasant TS to compensate for the power factor.

7. Toronto Hydro Electric System transfers load amongst the Richview TS step-down facilities (27.6 kV) so that they remain under the station capacity limit (10-day LTR).

8. Enersource Hydro Mississauga is unable to create more 44 kV ties between Tomken TS and Erindale TS due to the geography of the region and the lack of sub-transmission corridors. Thus, extra load from Erindale TS (T5/T6, 44 kV) and Meadowvale TS (T1/T2, 44 kV) are to be shifted to Erindale TS (T3/T4, 44 kV).

9. Powerflow simulation analysis was based on the July 2004 load flow basecase with loads increased to represent the year under study. LDCs provided load forecasts from 2004 to 2024.

5. OPERATING AND PLANNING STANDARDS

The following Operating and Planning Standards were followed throughout this assessment.

The Independent Electricity System Operator's (IESO) Planning and Operating Standards indicate that[16]:

- The minimum voltage on the 230 kV transmission system under normal conditions is 220 kV, with a maximum allowable decline of 10% for a single element contingency;
- A maximum allowable voltage decline of 10% at all buses before tap changer action takes place;
- A maximum allowable voltage decline of 10% at high voltage and a maximum decline of 5% at low voltage (sub-transmission level) buses after tap changer action takes place; and,
- Voltage rises to be within 4% upon capacitor switching.

All transmission circuits and stations must be loaded to within their applicable ratings. When assessing thermal constraints at TSs, loading must not exceed the 10-day LTR in the event of a single contingency, both immediate post fault (before tap changer action takes place) and steady state post fault (after tap changer action takes place). Thermal constraints on transmission circuits are such that they must not exceed the 15-minute LTR for immediate post fault and must not exceed the continuous rating for steady state post fault for a single contingency.

For area supply planning purposes, the IESO stipulates the following guideline for loads greater than 500 MW in the IESO Supply Deliverability Guidelines:

> *"With all transmission elements in service, any single element or double circuit contingency should not result in an interruption of supply to a load level of 500MW or more."*[17]

[16] IESO Transmission Assessment Criteria, IMO_REQ_0041
http://www.ieso.ca/imoweb/pubs/marketAdmin/IMO_REQ_0041_TransmissionAssessmentCriteria.pdf
[17] IESO Supply Deliverability Guidelines, IMO_GDL_0021
www.ieso.ca/imoweb/pubs/marketAdmin/IMO_GDL_0021_IMOSupplyAvailabilityGuidelines.pdf

6. ADEQUACY OF EXISTING FACILITIES

This section reviews the adequacy of the existing 500 kV and 230 kV transmission facilities to supply the load in GTA West to step-down transformation facilities Bramalea TS, Cardiff TS, Erindale TS, Goreway TS, Halton TS, Jim Yarrow MTS, Meadowvale TS, Pleasant TS, Richview TS, and Tomken TS. The transformation capacity at these load stations is also reviewed.

6.1 230 kV Transmission System

Four circuits (R14T, R17T, R19T and R21T) extend between Richiview TS and Trafalgar TS to supply electricity to Erindale TS, Tomken TS, Pleasant TS and Jim Yarrow MTS as well as carry power to Richview and transmission facilities further east. Circuits R14T and R17T have the capability to supply the forecasted load growth for the study period without any observable thermal or voltage limitations. Circuits R19T and R21T reach thermal limits by 2009. Circuits R19T and R21T supply electricity to more than 500 MW of load and are thus operating beyond the adequate system reliability and security guidelines as outlined in the IESO Supply Deliverability Guidelines.

Four circuits (T36B, T37B, T38B and T39B) extend between Trafalgar TS and Burlington TS. Step-down transformation facilities tapped off of circuits T38B and T39B within the defined GTA West geographic area were included in this study. Circuits T36B and T37B were only assessed in those situations where a contingency redistributed significant amounts of electricity along those lines. Step-down facilities tapped off of these lines were not included in this study. Under all contingencies, circuits T36B and T37B did not display any thermal loading or voltage deficiency limitations during the study period. The loss of either circuits T38B or T39B caused voltage deficiencies starting in 2005 at Meadowvale TS and in 2012 at Halton TS LV buses. By 2015, the segment of circuits T38B and T39B between Lantz Junction and Trafalgar TS DESN[18] (approximately the distance of one tower span) is loaded to approximately 80% of its continuous rating, steady state post contingency.[19]

Five circuits (V71RP, V72R, V73R, V74R and V76R) extend from Claireville TS to Richview TS. Bramalea TS and Cardiff TS are tapped off of a radial extension of V72R and V73R. Goreway TS is tapped off of a radial extension of V73R and V76R. By 2008, circuits V72R, V73R and V76R will be loaded up to 50% of their continuous rating pre-contingency on the segments between Claireville TS and Richview TS. In the same year, under steady state post contingency, these three circuits are not loaded beyond 60% of their continuous rating. On the radial tap extending from circuit V72R, the loading does not exceed 21% of its continuous rating and likewise for V73R. For circuit V76R, the loading does not exceed 14%. At the end of the study period, 2015, the loading on the three radial segments of circuits V72R, V73R and V76R does not exceed 32% of their continuous rating.

6.2 Step Down Transformation Facilities

Of imminent concern in this assessment is the step-down transformer capacity in GTA West. Several stations were found, at the very early stages of the study period, to be operating beyond Operating and Planning Standards (please refer to Section 5). A total of seven TSs require

[18] DESN – Dual Element Spot Network; a step down facility who has the same name as a Transformer Station (TS) whose purpose is to transform electricity from one high voltage to another. The term DESN is used to identify the load connection TS.
[19] Where the contingency is the loss of the parallel circuit.

either additional capacity or voltage correction by the end of the study period; some of these at two separate sub-transmission levels. Further load forecast information can be found in Appendix A.

- Bramalea TS has step-down transformation capability to both 44 kV and 27.6 kV. Transformers T1 and T2 step-down voltage from 230 kV to 27.6 kV, and are already exceeding capacity. At this time, additional load growth in the Bramalea TS area at voltage level 27.6 kV is being transferred to Jim Yarrow MTS (60%) and Goreway TS (40%). This station has no additional capacity to supply the increasing load in the area. Due to the influx of local generation[20] in the Bramalea TS area connected to the 44 kV sub-transmission system, the transformation facilities connected to the 44 kV system were not found to be near thermal limits, nor were any voltage deficiencies identified during the study period.

- Erindale TS has step-down transformation capability to both 44 kV and 27.6 kV. Transformers T1 and T2 step-down voltage from 230 kV to the 27.6 kV level. These transformers are currently loaded beyond their summer 10-day LTR. Load is being transferred to Cardiff TS and will continue to be transferred until transformers T1 and T2 at Erindale TS are within their summer 10-day LTR. Transformers T5 and T6 (44 kV) are also currently loaded beyond their summer 10-day LTR. However, there is some available capacity on transformers T3 and T4 (44 kV) to which load is being transferred from transformers T5 and T6. With these and other 44 kV load transfers from Meadowvale TS, transformers T5 and T6 at Erindale TS are expected to be loaded to capacity by 2005, and transformers T3 and T4 at Erindale TS (44 kV) are expected to be loaded beyond capacity by 2006. There is additional capacity at Tomken TS (44 kV) for load transfers, however, there are insufficient sub-transmission right-of-ways on which to build distribution lines between these two stations. Thus 44 kV Erindale TS load cannot be transferred to Tomken TS.

- Pleasant TS has step-down transformation capability to both 44 kV and 27.6 kV. Transformers T5 and T6 transform electricity from 230 kV to the 27.6 kV level. These transformers are currently loaded to their summer 10-day LTR and all additional load is being transferred to Jim Yarrow MTS. Transformers T1 and T2 transform electricity from 230 kV to the 44 kV level. These transformers are expected to reach their summer 10-day LTR by summer 2011.

- Meadowvale TS has step-down transformation capability to 44 kV. This station is currently loaded to its summer 10-day LTR and all additional load is being transferred to Erindale TS.

- Halton TS has step-down transformation capability to 27.6 kV. This station is expected to be loaded to its summer 10-day LTR by 2011.

- Jim Yarrow MTS has step-down transformation capability to 27.6 kV. Jim Yarrow MTS is currently receiving load transfers from Pleasant TS and Bramalea TS. The load at this station is expected to exceed its summer 10-day LTR by 2009.

- Goreway TS has step-down transformation capability to both 44 kV and 27.6 kV. Load forecasts suggest that transformers T5 and T6 at Goreway TS, which transform from 230 kV to 27.6 kV, will be loaded to their summer 10-day LTR by 2011. This is assuming that the

[20] Local generation on the Bramalea TS 44 kV system: Greater Toronto Airport Authority, McDonell Douglas CGS and Algonquin Power Energy from Waste.

low voltage buses have balanced loads and taking into consideration the load transfers from Bramalea TS. Transformer T4 (44 kV) at Goreway TS, does not display any problems during the study period.

- Cardiff TS was placed in-service in 2005. This station transforms from 230 kV to 27.6 kV. Load forecasts suggest that this station will be exceeding its summer 10-day LTR by the end of the study period, 2015.

6.3 Load Transfer Capability

Load transfer capability within the sub-transmission systems has enabled some of the immediate concerns at several stations to be temporarily addressed. Due to the rapid load growth in several areas of GTA West, and the lack of local transmission resources, several stations have been and/or will be forced to designate cascading load transfers to other stations in order to mitigate operating risks until further capacity can be supplied. These load transfers are from:

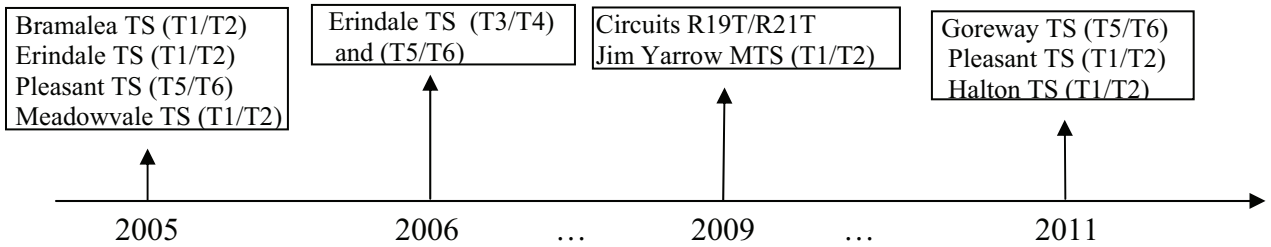
- Transformers T1/T2 at Bramalea TS (27.6 kV) to transformers T5/T6 at Goreway TS (27.6 kV), transformers T1/T2 at Jim Yarrow MTS (27.6 kV) and transformers T1/T2 at Cardiff TS (27.6 kV);
- Transformers T1/T2 at Erindale TS (27.6 kV) to transformers T1/T2 at Cardiff TS (27.6 kV);
- Transformers T5/T6 at Pleasant TS (27.6 kV) to transformers T1/T2 at Jim Yarrow MTS (27.6 kV); and,
- Transformers T1/T2 at Meadowvale TS (44 kV) to transformers T3/T4 at Erindale TS (44 kV).

These load transfers have already been or are in the process of being initiated by the LDCs. However, the load transfers do not address the overall load growth requirements, transmission capacity and voltage deficiencies, and in fact will accelerate transmission capacity needs at other stations.

6.4 Summary of Needs

A summary of the needs to be addressed via transmission, step-down transformation, and voltage correction facilities as proposed in this study are shown in Figure 2. The need dates for the study area indicate that several new TSs are required immediately.

Figure 2: Summary of Needs, 2005 – 2015



In order to identify potential solutions that would address more than one need, the needs identified in this study were combined into different groups taking into account the load transfer activities outlined in Section 6.3, the voltage transformation capabilities at the stations and the geographic load growth. These groups of needs, shown in Table 6, may have slightly different need dates than the dates shown in Figure 2.

Table 6: Geographic / Voltage Level Grouping of Needs

Group	Voltage Level	Need Date
Erindale TS / Meadowvale TS	44 kV	2006
Pleasant TS / Jim Yarrow MTS	27.6 kV	2009
Circuits R19T / R21T	230 kV	2009
Bramalea TS / Goreway TS	27.6 kV	2011
Pleasant TS	44 kV	2011
Halton TS	27.6 kV	2012

7. POSSIBLE OPTIONS TO ADDRESS SUPPLY CAPACITY & VOLTAGE STABILITY

This section outlines all possible options considered in the study in order to address the identified needs in GTA West. Table 7 itemizes the options that are rejected and those that are further analyzed. These options address the overall transmission concerns that arise, despite the load transfers that are in progress. In some cases, options were proposed to address issues at two voltage levels. For this reason, some options may occur twice in the following table under different needs.

Table 7: Summary of Options

Option	Description	Status
"Do Nothing"	"Do Nothing"	Rejected
Meadowvale TS Voltage Decline		
LVC	Install Low Voltage (LV) Capacitors – 2, 32.4 MVAr at 46 kV	Further Analyzed
Relief for Erindale TS and Meadowvale TS (44 kV)		
EM1	New DESN at Meadowvale TS (Meadowvale TS #2); two 230/44/27.6 kV, 75/125 MVA transformers	Rejected
EM2	New DESN at Meadowvale TS (Meadowvale TS #2); two 230/44 kV, 75/125 MVA transformers	Further Analyzed
EM3	New DESN, Winston TS, in the vicinity of Winston Churchill Blvd and Highway 403; two 230/44 kV, 75/125 MVA transformers	Further Analyzed
Relief for Goreway TS and Bramalea TS (27.6 kV)		
GB1	New DESN, North Central Brampton TS, in the vicinity of Bovaird Drive and Heart Lake Road; two 230/27.6 kV, 75/125 MVA transformers	Rejected
GB2	New DESN at Cardiff TS (Cardiff TS #2); two 230/27.6 kV, 75/125 MVA transformers	Rejected
GB3	New DESN at Goreway TS (Goreway TS #2); two 230/27.6 kV, 75/125 MVA transformers	Further Analyzed
Relief for Pleasant TS (44 kV)		
EM2	New DESN at Meadowvale TS (Meadowvale TS #2); two 230/44 kV, 75/125 MVA transformers and cascading load transfers from Pleasant TS	Rejected
EM3	New DESN, Winston TS, in the vicinity of Winston Churchill Blvd and Highway 403; two 230/44 kV, 75/125 MVA transformers and cascading load transfers from Pleasant TS (44 kV).	Rejected
P1	New DESN at Pleasant TS (Pleasant TS #3); two 230/44/27.6 kV, 75/125 MVA transformers	Rejected
P2	2nd 230/44 kV, 50/83 MVA transformer at Goreway TS; cascading load transfers from Pleasant TS	Further Analyzed
Relief for Pleasant TS and Jim Yarrow MTS (27.6 kV)		
EM1	New DESN at Meadowvale TS (Meadowvale TS #2); two 230/44/27.6 kV, 75/125 MVA transformers	Rejected

GB1	New DESN, North Central Brampton TS, in the vicinity of Bovaird Drive and Heart Lake Road; two 230/27.6 kV, 75/125 MVA transformers	Rejected
P1	New DESN at Pleasant TS (Pleasant TS #3); two 230/44/27.6 kV, 75/125 MVA transformers	Rejected
PJ1	New DESN at Pleasant TS (Pleasant TS #3); two 230/27.6 kV, 75/125 MVA transformers	Further Analyzed
PJ2	New DESN, Orlando TS, in the vicinity of Mississauga Rd and Highway 407; two 230/27.6 kV, 75/125 MVA transformers	Rejected
Relief for Halton TS (27.6 kV)		
EM1	New DESN at Meadowvale TS (Meadowvale TS #2); two 230/44/27.6 kV, 75/125 MVA transformers	Rejected
H1	New DESN at Halton TS (Halton TS #2); two 230/27.6 kV, 50/83 MVA transformers	Rejected
H2	New DESN, Steeles TS, in the vicinity of Steeles Ave. and Trafalgar Rd; two 230/27.6 kV, 50/83 MVA transformers	Further Analyzed
H3	New DESN, James Snow TS, in the vicinity of Steeles Ave. and James Snow Parkway; two 230/27.6 kV, 50/83 MVA transformers	Further Analyzed
Relief for circuits R19T/R21T and 500 MW IESO Guideline Restriction (230 kV)		
T1	Extend circuits V72R/V73R from Cardiff TS to the Pleasant TS tap and construct a new Switching Station (SS), Hurontario SS, west of Hurontario Street	Further Analyzed
T2	Extend circuits V72R/V73R from Cardiff TS to Jim Yarrow MTS and re-supply Jim Yarrow MTS	Rejected
T3	Extend circuits T38B/T39B from Meadowvale TS to the Pleasant TS tap and construct a new SS, Hurontario SS, west of Hurontario Street	Further Analyzed
T4	Extend circuits T38B/T39B from Meadowvale TS to Jim Yarrow MTS and re-supply Jim Yarrow MTS	Rejected
T5	Reconductor circuits R19T/R21T from Trafalgar TS to Erindale Junction and from Hanlon Junction to Jim Yarrow Junction	Rejected
T6	Extend circuits V73R/V76R from Goreway TS to the Pleasant TS tap and construct a new SS, Pleasant SS	Rejected

7.1 "Do Nothing"

The "Do Nothing" approach will aggravate the existing load supply and transmission capacity problems and accelerate capacity problems with circuits R19T/R21T.

For circuits R19T/R21T, this approach does not satisfy the IESO requirements stipulated in the guideline for loads greater than 500 MW.

This alternative is not an acceptable approach and is not considered further.

7.2 Meadowvale TS Voltage Decline

LVC: ***Install Low Voltage Capacitors***
Installation of LV capacitors at Meadowvale TS will allow the station to meet minimum voltage requirements in the event of a single contingency.

7.3 Relief of Erindale TS and Meadowvale TS (44 kV)

EM1: ***Meadowvale TS #2***
A new 230/44/27.6 kV, 75/125 MVA DESN at Meadowvale TS would provide capacity for the Erindale TS and Meadowvale TS areas. The use of a three winding transformer to transform voltages to two sub-transmission levels (44 kV and 27.6 kV) would mean that Jim Yarrow MTS and Pleasant TS and/or Halton TS may also take advantage of the capacity offered by this proposed new DESN. This option was considered and rejected on the basis that a single DESN would not be able to supply the necessary capacity for both the 44 kV and 27.6 kV needs in the surrounding area over the next ten years.

EM2: ***Meadowvale TS #2***
A new 230/44 kV, 75/125 MVA DESN at Meadowvale TS would provide capacity for Erindale TS and Meadowvale TS at the 44 kV sub-transmission level. This option was further evaluated.

EM3: ***Winston TS***
A new 230/44 kV, 75/125 MVA DESN in the vicinity of Winston Churchill Boulevard (or Erin Mills Parkway) and Highway 403 would provide additional capacity off-loading Erindale TS and Meadowvale TS. This option was further evaluated.

7.4 Relief for Goreway TS and Bramalea TS (27.6 kV)

GB1: ***North Central Brampton TS***
A new 230/27.6 kV, 75/125 MVA DESN in North Central Brampton in the vicinity of Bovaird Drive and Heart Lake Road would provide transmission capacity to relieve Goreway TS and Bramalea TS. This option does not completely satisfy the needs of the LDC and therefore was considered and rejected.

GB2: ***Cardiff TS #2***
A new 230/27.6 kV, 75/125 MVA DESN at Cardiff TS would provide additional transmission capacity relieving Goreway TS and Bramalea TS. There is insufficient room for the required facilities on the existing site and this option does not completely satisfy the needs of the LDC and therefore was considered and rejected.

GB3: ***Goreway TS #2***
A new 230/27.6 kV, 75/125 MVA DESN at Goreway TS would provide transmission capacity to relieve both Goreway TS and Bramalea TS. The location of this DESN is closer to the load centre and would be in an overall more ideal location than the other two proposals (GB1 and GB2). Thus, this option was considered further.

7.5 Relief for Pleasant TS (44 kV)

EM2: ***Meadowvale TS #2***
Same as above (EM2, Section 7.3), with the addition of cascading load transfers from Pleasant TS to the new DESN at Meadowvale TS. However, cascading load transfers from Pleasant TS to Meadowvale TS would be complex and costly for the LDC, thus this option was considered and rejected.

EM3: ***Winston TS***
Same as above (EM3, Section 7.3), with the addition of cascading load transfers from Pleasant TS to the new DESN at Winston TS. However, cascading load transfers from Pleasant TS to the proposed station in the vicinity of Winston Churchill Blvd and Highway 403 would be complex and costly for the LDC, thus this option was considered and rejected.

P1: ***Pleasant TS #3***
A new 230/44/27.6 kV, 75/125 MVA DESN at Pleasant TS would provide additional transmission capacity to Pleasant TS at the 44 kV sub-transmission level, as well as address needed capacity at the 27.6 kV sub-transmission level for Pleasant TS and Jim Yarrow MTS. However, the capacity requirements for 27.6 kV are large enough to require a whole DESN while the capacity requirements at the 44 kV level are small enough to make this transformer size uneconomic. Thus, this option was considered and rejected.

P2: ***Goreway TS 44 kV DESN***
Install a second 230/44 kV, 50/83 MVA transformer at Goreway TS. This would provide the required transmission capacity for Pleasant TS at the 44 kV sub-transmission level, as well as complete the DESN at Goreway TS, providing redundancy and thereby reducing operating risks to the load already established there. This option was considered further.

7.6 Relief for Pleasant TS and Jim Yarrow MTS (27.6 kV)

EM1: ***Meadowvale TS #2***
Same as above (EM1, Section 7.3) with the addition of cascading load transfers at the 27.6 kV level from Pleasant TS and Jim Yarrow MTS to the new DESN at Meadowvale TS. The load requirements for Pleasant TS and Jim Yarrow MTS are such that they would require an entire 75/125 MVA DESN. Thus, this option of sharing between the two sub-transmission levels was considered and rejected.

GB1: ***North Central Brampton TS***
Same as above (GB1, Section 7.4) with the addition of cascading load transfers from Pleasant TS and Jim Yarrow MTS (27.6 kV) to this new DESN. However, the load requirements at the 27.6 kV sub-transmission level do not permit the sharing of a single DESN as it would not provide enough capacity to the 27.6 kV level. Thus, this option was considered and rejected.

PJ1: ***Pleasant TS #3***
A new 230/27.6 kV, 75/125 MVA DESN at Pleasant TS would provide the needed capacity at the 27.6 kV sub-transmission level. This option was considered further.

PJ2: ***Orlando TS***
A new 230/27.6 kV, 75/125 MVA DESN in the vicinity of Mississauga Road and Highway 407 would provide the needed transmission capacity. However, the location of this proposed DESN is too far away from the load centre. Thus, this option was considered and rejected.

7.7 Relief for Halton TS (27.6 kV)

EM1: Meadowvale TS #2
Same as above (EM1, Section 7.3), with the addition of load transfers from Halton TS to Meadowvale TS #2. This option would not provide enough capacity at the 44 kV level for the requirements of Meadowvale TS and Erindale TS. This option was therefore considered and rejected.

H1: ***Halton TS #2***
A new 230/27.6 kV, 50/83 MVA DESN at Halton TS would provide transmission capacity for the load growth near Halton TS at the 27.6 kV level. However, this option does not completely satisfy the needs of the LDC. Thus, this option was considered and rejected.

H2: ***Steeles TS***
A new 230/27.6 kV, 50/83 MVA DESN in the vicinity of Steeles Avenue and Trafalgar Road would provide transmission capacity for the load growth near Halton TS at the 27.6 kV level. This option was preferred by the LDCs and was considered further.

H3: ***James Snow TS***
A new 230/27.6 kV, 50/83 MVA DESN in the vicinity of James Snow Parkway and Steeles Avenue would provide transmission capacity for the load growth near Halton TS at the 27.6 kV level. This option was preferred by the LDCs and was considered further.

7.8 Relief for Circuits R19T/R21T and IESO 500 MW Guideline Restriction (230 kV)

T1: ***Circuits V72R/V73R Extension and Hurontario SS***
Circuits V72R and V73R are extended from Cardiff TS west to the Pleasant TS tap (approximately 4 km in length). A new SS is constructed at this junction, Hurontario SS. Jim Yarrow MTS is radially re-supplied from the new SS. This effectively provides a second source of power for the Pleasant TS tap, off-loading circuits R19T and R21T from Erindale Junction to Hanlon Junction and from Hanlon Junction to Jim Yarrow Junction. The new SS satisfies the IESO requirements stipulated in the guideline for loads greater than 500 MW by creating an isolation point on circuits R19T and R21T.

T2: ***Circuits V72R/V73R Extension and Re-supply Jim Yarrow MTS***
Circuits V72R and V73R are extended from Cardiff TS west to Jim Yarrow MTS. Jim Yarrow MTS is re-supplied from this extension. This option would place too much load on circuits V72R/V73R and was thus considered and rejected.

T3: Circuits T38B/T39B Extension and Hurontario SS
Circuits T38B and T39B are extended from Meadowvale TS east to the Pleasant tap (approximately 9 km). A new SS is constructed at this junction, Hurontario SS, and Jim Yarrow MTS is radially re-supplied from the new SS.

T4: ***Circuits T38B/T39B Extension and Re-supply Jim Yarrow MTS***
Circuits T38B and T39B are extended from Meadowvale TS east to Jim Yarrow MTS. Jim Yarrow MTS is re-supplied from this extension. This option would place too much load on circuits T38B/T39B and was thus considered and rejected.

T5: ***Reconductor Circuits R19T/R21T***
Circuits R19T and R21T are reconductored between Erindale Junction and Hanlon Junction (5.1 km in length) and between Hanlon Junction and Jim Yarrow Junction (11.6 km in length). For circuits R19T and R21T, this option does not satisfy the IESO requirements stipulated in the guideline for loads greater than 500 MW and was therefore considered and rejected.

T6: ***Circuits V73R/V76R Extension and Pleasant SS***
Circuits V73R and V76R are extended from Goreway TS to the Pleasant TS tap and a new SS (Pleasant SS) is constructed at this junction. However, there is insufficient space at Pleasant

TS to economically incorporate both a third DESN as well as a new SS. Moreover, this option would require at least 13 km of double circuit underground cable at a cost of $5-10 Million/km as there is no available transmission right-of-way. This option was considered cost prohibitive. It was therefore considered and rejected.

7.9 Consideration of Local Generation

Several local power generating stations (GS) in the Brampton area are currently in-service and/or are expected to be in-service within the next 12-24 months. Despite rapid load growth, the 44 kV DESN at Bramalea TS was not a concern throughout the study period as the local generation is connected to the system at the 44 kV sub-transmission level. This local generation has sufficiently off-loaded the transformers of the 44 kV DESN at Bramalea TS such that new transmission capacity was not an identified requirement throughout the study period. However, this local generation does not affect the loading of the 27.6 kV DESN at Bramalea TS. As such, this DESN still poses a problem, requiring immediate load transfers to various other TSs in the Brampton area, in addition to future planned transmission capacity.

A large GS in the vicinity of Goreway TS area is also proposed. A qualitative analysis shows that this GS, even at a 900 MW capacity, will not resolve any of the needs identified in this study. The transmission capacity needed in the Bramalea TS, Goreway TS and Cardiff TS areas would be unresolved by connecting a GS at the 230 kV high voltage level. However, this proposed GS could potentially increase the usability of an extension of circuits V72R/V73R to the Pleasant TS tap, with the establishment of Hurontario SS as outlined in option T1.

8. PLANS: OPTION COMBINATIONS

The options listed in the previous section that were considered worth further analysis were combined into several combinations and evolved into four plans as shown in Table 8. These plans effectively resolve all transmission capacity problems throughout the study period from 2005 to 2015.

Table 8: Plans: Option Combinations

Need	Year	Plan			
		A	B	C	D
Pleasant TS/Jim Yarrow MTS (27.6 kV)	2009	PJ1	PJ1	PJ1	PJ1
Bramalea TS/Goreway TS (27.6 kV)	2011	GB3	GB3	GB3	GB3
Erindale TS/Meadowvale TS (44 kV)	2006	EM3	EM3	EM2	EM2
Pleasant TS (44 kV)	2011	P2	P2	P2	P2
Halton TS (27.6 kV)*	2012	H2	H2	H2	H2
R19T/R21T and IESO 500 MW Guideline	2009	T1	T3	T1	T3

* Option H3 would be supplied from the same tap as H2, thus results from H2 were considered to satisfactorily represent option H3 for the purposes of this study.

Please refer to Figures 3, 4, 5 and 6 for schematic diagrams of the above plans.

Figure 3: Plan A

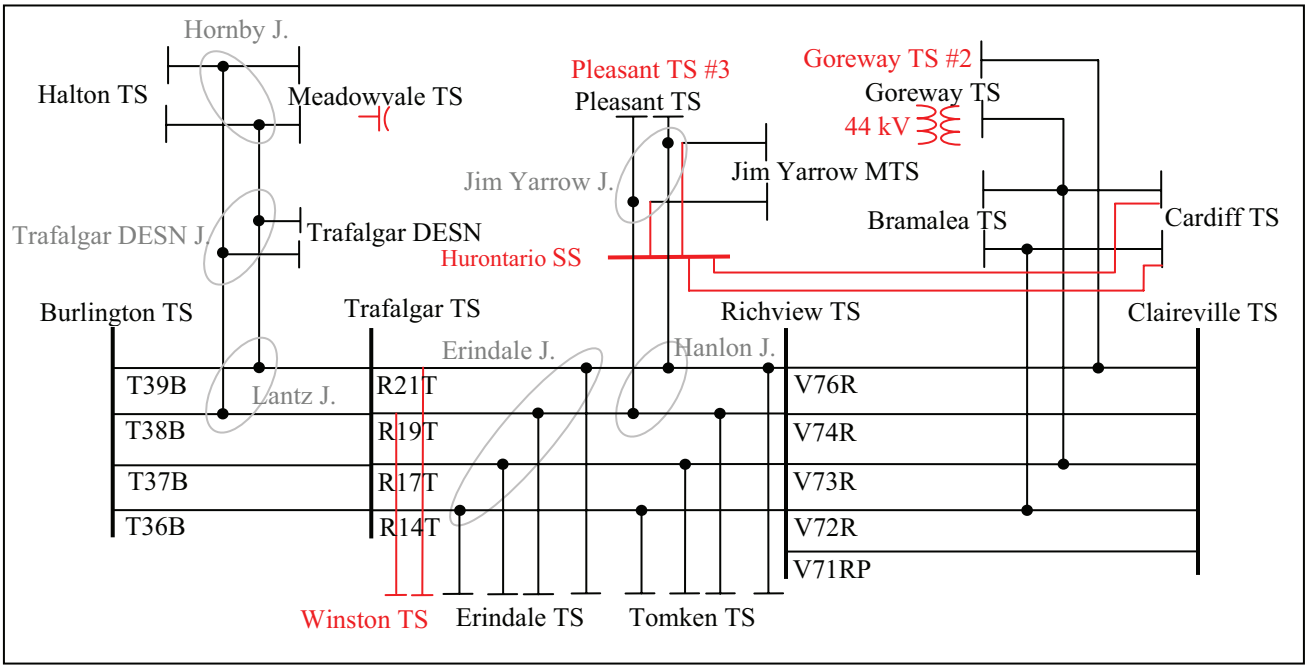


Figure 4:Plan B

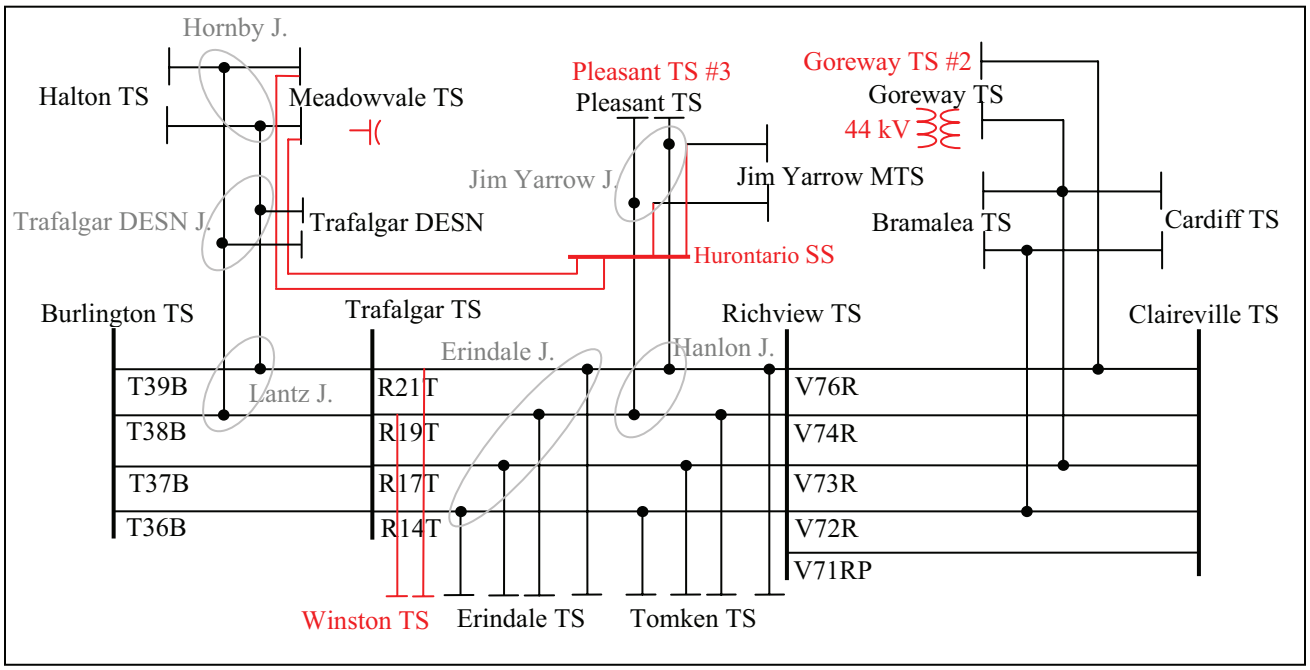


Figure 5: Plan C

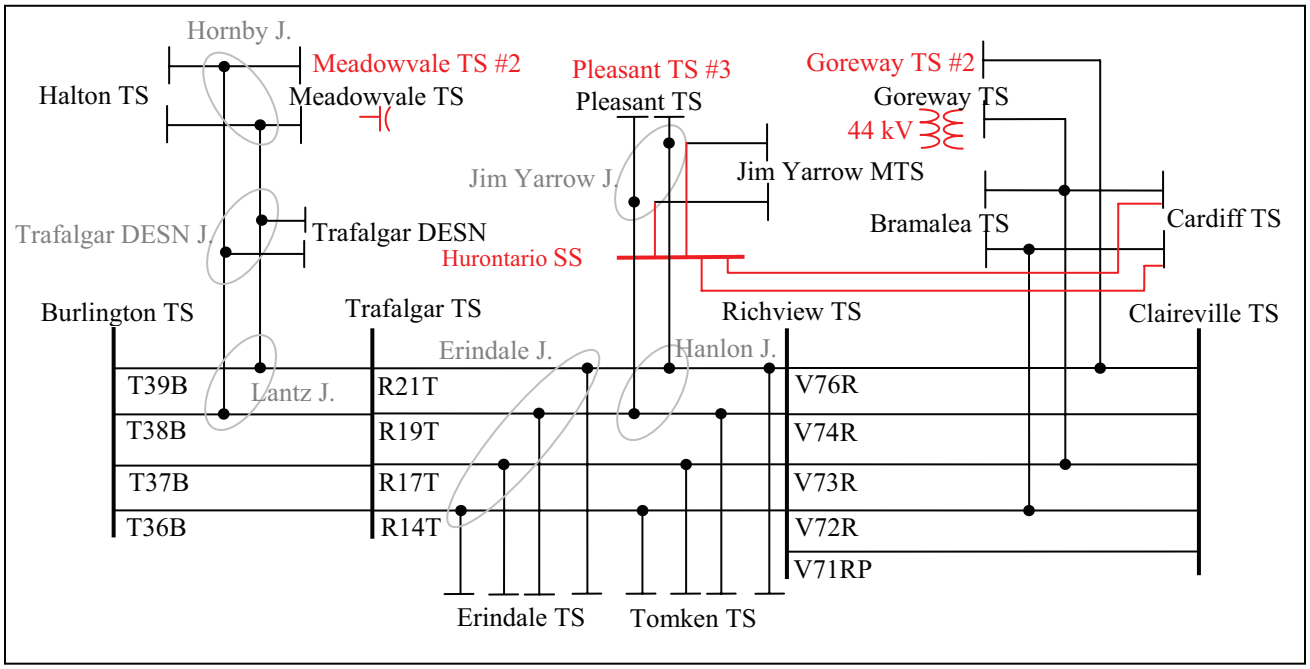
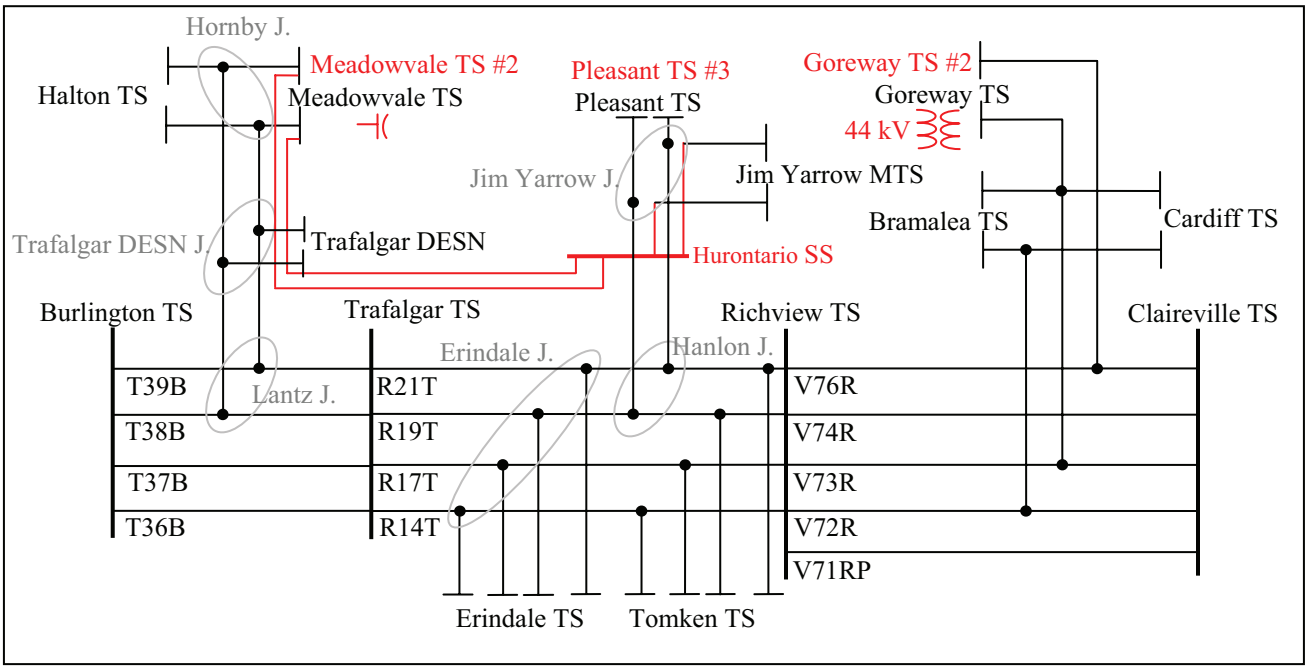


Figure 6: Plan D



9. SELECTION OF PREFERRED PLAN

The Shaw Power Technologies Inc. PSS/E software[21] was used to assess the transmission capacity for the existing facilities and for the proposed plans in GTA West. All plans address the needs identified during the 10-year study period. Specific loadflow results can be found in Appendix C.

9.1 2015 Technical Evaluation

9.1.1 Plan A: Extension of Circuits V72R/V73R, Winston TS

Plan A addresses all of the identified needs in this study. This Plan includes the extension of circuits V72R and V73R from Cardiff TS across to the proposed new SS, Hurontario SS, located on the Pleasant TS tap. Jim Yarrow MTS is radially re-supplied from Hurontario SS. The proposed new TS, Winston TS, tapped from circuits R19T and R21T will support the growing 44 kV load, off-loading Meadowvale TS and Erindale TS. New 230/27.6 kV transformation capacity is provided at Pleasant TS and Goreway TS and new 230/44 kV transformation capacity is provided at Goreway TS.

Technically, Plan A performed well. The majority of the high voltage buses were within an acceptable voltage range of between 240 and 243 kV pre-contingency. The following contingencies were observed: loss of circuit V72R, loss of circuit T38B, loss of circuit R19T Upper[22], loss of circuit R19T Lower[23], and loss of circuit R14T. Since the ratings on the double circuits[24] were consistent, it is a good assumption that the loss of the other circuit in the double circuit pair would warrant the same technical results. These contingencies revealed that Erindale TS and Meadowvale TS may need to transfer further load to the new TS, Winston TS, in order to maintain transformer operation below the summer 10-day LTR. The load at Cardiff TS exceeds the station capacity, steady state post fault (107%). The voltage at Hurontario SS was 240.5 kV and the voltage at Cardiff TS was 240.7 kV. The loading on the extension of circuits V72R and V73R was approximately 280 MW total and each line was loaded to 18% of its continuous rating, under pre-fault conditions. Winston TS placed additional load on circuits R19T and R21T, however this load is tapped off prior to the line sections of concern (Erindale Junction to Hanlon Junction and Hanlon Junction to Hurontario SS).

9.1.2 Plan B: Extension of Circuits T38B/T39B, Winston TS

Plan B involved the extension of circuits T38B and T39B from Meadowvale TS across to the proposed new SS, Hurontario SS, located along the Pleasant TS tap. The new proposed TS, Winston TS, is tapped from circuits R19T and R21T. New 230/27.6 kV transformation capacity is provided at Pleasant TS and Goreway TS and new 230/44 kV transformation capacity is provided at Goreway TS. Plan B performed adequately, though the voltages were not quite as high as for Plan A. Again, Cardiff TS exceeded capacity, steady state post fault (107%). The voltage at Hurontario SS was 239.2 kV and the voltage at Meadowvale TS was 239.3 kV. Meadowvale TS, Halton TS and Erindale TS exceeded capacity steady state post fault. The voltages on the Pleasant TS tap were low, and Pleasant TS 230/44 kV transformers were nearly loaded to capacity steady state post fault (~96%). The loading on the extension of circuits T38B and T39B was approximately 250 MW total and each line was loaded to 20% of its continuous rating under pre-fault conditions.

[21] Copyright © 1976 – 2004 Siemens Power
[22] R19T Upper is the portion of circuit R19T north of Hurontario SS.
[23] R19T Lower is the portion of circuit R19T between Richview TS and Trafalgar TS and from Hanlon Junction to Hurontario SS.
[24] A line of supporting structures that carries two power circuits.

9.1.3 Plan C: Extension of Circuits V72R/V73R, Meadowvale TS #2

Plan C performed similarly to Plan A. The only difference between these two plans is the addition of Meadowvale TS #2 in place of the new TS, Winston TS. New 230/27.6 kV transformation capacity is provided at Pleasant TS and Goreway TS and new 230/44 kV transformation capacity is provided at Goreway TS. These similarities were reflected in the results of the technical analysis. Again, Cardiff TS exceeded capacity, steady state post fault (107%). Meadowvale TS may need to transfer additional load onto Meadowvale TS #2. The voltage at Hurontario SS was 240.4 kV pre-fault. The voltage at Cardiff TS is 240.6 and the voltage at Meadowvale TS was 239.9 kV. The loading on the extension of circuits V72R and V73R was approximately 290 MW total and each line was loaded to 19% of its continuous rating, under pre-fault conditions.

9.1.4 Plan D: Extension of Circuits T38B/T39B, Meadowvale TS #2

Plan D performed similarly to Plan B. Again the only difference between these two plans is the addition of Meadowvale TS #2 in place of the new TS, Winston TS. New 230/27.6 kV transformation capacity is provided at Pleasant TS and Goreway TS and new 230/44 kV transformation capacity is provided at Goreway TS. The overall system voltages were slightly lower especially on the Meadowvale TS tap. Again, Cardiff TS exceeded capacity, steady state post fault (107%). Erindale TS may need to transfer more load onto Meadowvale TS #2. The voltage at Hurontario SS was 238.5 kV. The voltage at Meadowvale TS was 238.6 kV. The total load on the extension of circuits T38B and T39B was approximately 240 MW, with each line loaded to approximately 19% of its continuous rating, under pre-fault conditions. On the loss of circuit R19T, the line section between Erindale Junction and Hanlon Junction on circuit R21T is loaded to 43% of continuous, steady state post fault. On the loss of circuit T38B, the line section between Lantz Junction and Trafalgar DESN Junction on T39B is loaded to 86% and the line section between Trafalgar DESN Junction and Hornby Junction on the same line is loaded to 78%.

9.1.5 Plans A and C Versus Plans B and D: Circuit Extension V72R/V73R Versus T38B/T39B

The intent of extending either circuits V72R/V73R or T38B/T39B is to off-load circuits R19T/R21T between Hanlon Junction and the proposed new Hurontario SS. Table 9 shows that the extension of circuits V72R/V73R (Plans A and C) allows circuits R19T/R21T to be off-loaded more than the extension of circuits T38B/T39B (Plans B and D). In Plans A and C, circuit R21T is loaded to 37% and 35% respectively, of its continuous current loading capacity. While for Plans B and D, circuit R21T is loaded to 41% and 43% respectively. Approximately 60% of the reactive support for the Pleasant tap comes from the Richview/Claireville area and 40% from the Trafalgar area. The extension of T38B/T39B causes all of the reactive support from Richview/Claireville to flow along R21T. This increases the flow along the line segment between Hanlon Junction and Hurontario SS, causing it to be loaded higher in Plans B and D than in Plans A and C.

Table 9: Impact on Circuit R21T, With Loss of Circuit R19T Lower

Loss of R19T Lower, 2015 Steady State Post Contingency	**Plan**			
	V72R/ V73R	T38B/ T39B	V72R/ V73R	T38B/ T39B
	A	**B**	**C**	**D**
From Hanlon J. to Hurontario SS	37%	41%	35%	43%
From Erindale J. to Hanlon J.	62%	48%	55%	43%
Note: All % values are a percentage of current loading, continuous rating				

Another line segment of concern on circuits R19T/R21T was between Erindale Junction and Hanlon Junction. Table 9 shows that Plans B and D (48% and 43%) actually allow this section of the circuits to be off-loaded more than Plans A and C (62% and 55%). The extension of circuits T38B/T39B changes the flow on circuit R21T such that Tomken TS is mainly supplied from Richview TS whereas the extension of circuits V72R/V73R causes Tomken TS to be mainly supplied from Trafalgar TS. Supplying Tomken from the Trafalgar side of R21T increases the loading on the line segment between Erindale Junction and Hanlon Junction, causing it to be loaded higher in Plans A and C than in Plans B and D.

9.1.6 Plans A and B Versus Plans C and D: Winston TS Versus Meadowvale TS #2

Circuits T38B/T39B are affected by the options of whether to construct the new TS, Winston TS or add Meadowvale TS #2. Increased load on circuits T38B/T39B could precipitate the need for reconductoring sections of these lines sooner than anticipated. Table 10 shows the impact.

Table 10: Impact on Circuit T39B With Loss of Circuit T38B

Loss of T38B, 2015 Steady State Post Contingency	**Plan**			
	Winston TS		Meadowvale TS #2	
	A	**B**	**C**	**D**
Lantz J. to Trafalgar DESN J.	71%	77%	86%	86%
Trafalgar DESN J. to Hornby J.	63%	69%	78%	78%
Note: All % values are a percentage of current loading, continuous rating				

Plans A and B represent the Winston TS option while Plans C and D represent the Meadowvale TS #2 option. Line segments Lantz Junction to Trafalgar DESN Junction and Trafalgar DESN Junction to Hornby Junction were identified as being most susceptible to over-loading on circuits T38B/T39B. As shown in Table 10, the current loading on circuit T39B, between Lantz Junction and Trafalgar DESN Junction, is considerably less for Winston TS (71% and 77%) than for Meadowvale TS #2 (86% and 86%). Similarly, on the line segment between Trafalgar DESN Junction and Hornby Junction the current loading is less for Winston TS (63% and 69%) versus Meadowvale TS #2 (78% and 78%).

9.1.7 Plan A Versus Plans B, C and D: Trafalgar TS and Claireville TS Autotransformers

The loads flowing on the Trafalgar TS and Claireville TS autotransformers were observed and compared amongst the four plans to determine their impact. The Trafalgar TS autotransformers were within their capacity limits for the duration of the study period. The Claireville TS autotransformers were at their capacity limits by the end of the study period. Resolving issues with the loading on the autotransformers at Claireville TS requires further investigation beyond the GTA West study, and is therefore considered outside of the scope of this study. It is assumed that measures, independent of this study, are being taken to resolve this issue[25]. However, none of the options being considered will change the recommendations of this study.

The basecase conditions relevant to the loading on the Trafalgar TS and Claireville TS autotransformers were:

- Summer peak load of 26,000 MW
- Flow East Towards Toronto (FETT) transfers of approximately 3600 MW
- Queenston Flow West (QFW) transfers of approximately 500 MW
- 6 Pickering GS units, 4 Darlington GS units, 6 Bruce GS units and 0 Lakeview GS units modelled

[25] Some of the options being considered include Goreway GS and other generation in GTA West as well as additional autotransformers at Parkway TS.

- Local 44 kV generation connected to Bramalea TS in-service
- Proposed Goreway GS not in-service

Table 11 shows the impact each plan had on the autotransformers,. Plan A was used as a base for the comparison, and Plans B, C and D were compared to Plan A to show the difference in the megawatt (MW) flow. The flows were normalized by the number of autotransformers at each of the stations (2 at Trafalgar TS, 4 at Claireville TS).

Table 11: Autotransformer Impact

	Plan Comparison			
Stations / Plans	**A**	**B**	**C**	**D**
Trafalgar TS	--	22	-7	22
Claireville TS	--	-20	4	-17
Note: Numbers are in Δ MW/Autotransformer				

There is no material effect on the flows on the autotransformers at either Trafalgar TS or Claireville TS when comparing the construction of Winston TS (Plans A and B) to the construction of Meadowvale TS #2 (Plans C and D). The following conclusions can be drawn when comparing the extension of circuits V72R/V73R (Plans A and C) to the extension of circuits T38B/T39B (Plans B and D):

- the extension of V72R/V73R will increase the flow on the Claireville TS autotransformers.
- the extension of T38B/T39B will increase the flow on the Trafalgar TS autotransformers.

Overall, the flow differential between the four plans is minimal and not considered material.

9.1.8 Preferred Plan

HV Voltages in Plan A were within a very acceptable range, and slightly higher than in Plans B, C or D. Winston TS (Plans A and B) is a better technical choice than Meadowvale TS #2 (Plans C and D) as there are indications that the addition of Meadowvale TS #2 could lead to transmission problems well into the future. When comparing the extension of circuits V72R/V73R (Plan A) to the extension of circuits T38B/T39B (Plan B), Table 10 clearly shows that the current loading percentages for Plan A are less than for Plan B. Specifically, the extension of circuits T38B/T39B places additional stress on certain line segments which may advance the need for reconductoring these line sections on circuits T38B/T39B. The flows on the autotransformers at Trafalgar TS and Claireville TS were marginally different between the four plans, with the new 44 kV TS (Winston TS/Meadowvale TS #2) having no material effect whatsoever. In consideration of the technical analysis for the year 2015, the best choice is Plan A, which includes the extension of circuits V72R/V73R and the construction of a new TS, Winston TS.

9.1.9 2024 Technical Assessment

All plans met the needs identified in the 10-year study period. These plans were further technically evaluated with respect to the long-term system planning requirements by assessing them for the expected 2024 conditions. This method provides a snapshot of the long-term viability of each of the plans, and how each would perform under the increasing load growth that is expected in the GTA West. The study participants provided load forecasts up to the year 2024. Overall, with respect to long-term system planning requirements in GTA West, Plan A performed technically better than the other plans. Refer to Appendix B for results of the 2024 Technical Assessment.

9.2 Cost Comparison

Table 12 shows representative costs comparing potential total cost for each of the proposed options. These estimated costs are preliminary and are used for comparison only. The most economic plan is Plan C and the second most economic is Plan A. Both of these plans encompass the extension of circuits V72R/V73R, and differ only in regards to the construction of Winston TS (Plan A, $15M) versus Meadowvale TS #2 (Plan C, $10M). However, considering the degree of accuracy of the preliminary costs, the differential between the plans is nominal.

Table 12: Cost Comparison of Option Combinations

Plan	A	B	C	D
LVC	1	1	1	1
PJ1	10	10	10	10
GB3	10	10	10	10
EM2	--	--	10	10
EM3	15	15	--	--
P2	3	3	3	3
H2	15	15	15	15
T1	32	--	32	--
T3	--	42	--	42
Total:	**86**	**96**	**81**	**91**
Note: all numbers are listed as $ Million				

10. DISCUSSION

Overall, Plan A performed technically better than Plans B, C or D. Generally, the HV system voltages were slightly higher for Plan A. The specific sections of circuits R19T/R21T were off-loaded sufficiently to eliminate the need for reconductoring. The four plans displayed relatively minimal change to the flow distribution on the Trafalgar TS and Claireville TS autotransformers.

In the long-term, Plan A did not advance further transmission problems along circuits T38B/T39B or cause problems along any other circuits. Placing additional reactive power on the HV system for voltage support could enhance Plan A. All of the new deficiencies observed in the 2024 outlook (refer to Appendix B) could be resolved via load transfers between stations and/or addition of LV capacitors and HV reactive support.

Discussion with the LDCs determined that Winston TS is the preferred option to Meadowvale TS #2 as there are indications that the addition of Meadowvale TS #2 could lead to transmission problems well into the future. This eliminates Plans C and D. Between the remaining two plans (Plans A and B), Plan A is more economic as shown in Table 12. The reason for this is that the extension of circuits V72R and V73R is 5 km shorter than the extension of circuits T38B and T39B. Thus, Plan A is the preferred alternative.

11. CONCLUSIONS

The following conclusions can be reached from the analysis performed for this study:

- Bramalea TS (27.6 kV), Pleasant TS (27.6 kV) and Erindale TS (27.6 kV) are currently loaded to or beyond their capability and are being forced to transfer load to other stations to mitigate operating risks.

- Meadowvale TS (44 kV) and Erindale TS (44 kV) are expected to be at capacity by 2006. The earliest possible option to relieve the loading at Meadowvale TS and Erindale TS (44 kV) is 2008 with the addition of the proposed TS, Winston TS.

- Meadowvale TS will currently suffer voltage declines greater than 10% under immediate post fault conditions. This voltage stability problem can be rectified with a LV capacitor. The earliest that a LV capacitor could be installed at Meadowvale TS is summer 2007.

- Circuits R19T/R21T are currently (2005) beyond the IESO requirements stipulated in the guideline for loads greater than 500 MW. Segments of these lines are expected to be at capacity by 2009. The earliest possible option to address this problem can be implemented by 2009.

- Pleasant TS T1/T2 (44 kV) is expected to be at capacity by 2011. Option P2 (Goreway TS 44 kV DESN) can address this issue as early as 2011.

- Pleasant TS and Jim Yarrow MTS (27.6 kV) are expected to exceed capacity by 2009. Option PJ1 (Pleasant TS #3) can address this issue as early as 2009.

- Bramalea TS and Goreway TS (27.6 kV) are expected to be at capacity by 2011. Option GB3 (Goreway TS #2) can address these issues as early as 2011.

- Halton TS (27.6 kV) is expected to be at capacity by 2011. Options H2 (Steeles TS) or H3 (James Snow TS) can address this issue as early as 2011.

- The preferred Plan to meet all of these needs is Plan A, consisting of the following:
    1. Install LV capacitors at Meadowvale TS;
    2. Build Winston TS;
    3. Extend circuits V72R/V73R from Cardiff TS to the Pleasant TS tap, build Hurontario SS, and radially re-supply Jim Yarrow MTS;
    4. Add a 2nd 230/44 kV transformer at Goreway TS (44 kV DESN);
    5. Build Pleasant TS #3; and,
    6. Build Goreway TS #2.

12. RECOMMENDATIONS

Several recommendations can be drawn from this study to address the current system deficiencies and provide system capacity to meet forecasted load growth. These recommendations are:

1. Subject to the Ontario Power Authority's integrative review (Integrated Power System Plan) Hydro One Networks Inc. to initiate the approval processes required for the extension of circuits V72R and V73R and the construction of Hurontario SS.

2. Hydro One Networks Inc. to commence the detailed specification and engineering of the LV capacitors for Meadowvale TS.

3. Hydro One Networks Inc. to commence the preliminary engineering and consultation with the LDCs, and to initiate the approval processes on the construction of a new TS, Winston TS, in the vicinity of Winston Churchill Blvd. and Highway 403.

4. The LDCs to continue to transfer loads as necessary to mitigate potential operating risks until additional transmission capacity becomes available.

5. The LDCs and Hydro One to continue to monitor load growth in the GTA West area and to review options for long-term growth based on the location of new developments and load forecasts.

APPENDIX A: LOAD FORECASTING DATA

Table A1 below shows the coincident load forecast from 2005 to 2015 for all stations in MVA. It includes the station or DESN LTR (limited time rating). The data in this table does not include load transfers to new stations proposed in this study, however it does include load transfers to existing stations as proposed by the LDCs. Please note, Richview DESN load was neglected as it was assumed that Toronto Hydro Electric System would manage their load between DESNs to reduce operating risks when necessary.

Table A1: Coincident Load Forecast in MVA

		Forecast Load in MVA												
	Station - 27.6 kV	**LTR (MVA)**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	
1.	Bramalea T1/T2	172.6	**217**	**195**	**197**	**199**	**201**	**203**	**205**	**206**	**206**	**206**	**207**	
2.	Cardiff TS	126.1	0	112	115	117	119	122	124	125	125	125	**126**	
3.	Erindale T1/T2	190.8	**259**	186	189	**193**	**197**	**201**	**205**	**206**	**207**	**207**	**208**	
4.	Goreway T5/T6	191.8	161	169	177	184	**192**	**200**	**209**	**217**	**226**	**235**	**243**	
5.	Halton TS	206.6	108	127	146	165	180	184	189	194	199	204	**208**	
6.	Jim Yarrow MTS	174.0	104	109	122	136	150	165	**180**	**196**	**213**	**229**	**244**	
7.	Pleasant T5/T6	198.6	**213**	**213**	**213**	**213**	**213**	**213**	**213**	**213**	**213**	**213**	**213**	
8.	*Richview T1/T2*	*172.6*	*152*	*154*	*155*	*157*	*158*	*160*	*161*	*163*	*165*	*167*	*168*	
9.	*Richview T5/T6*	*198.4*	*116*	*119*	*121*	*122*	*123*	*124*	*125*	*126*	*127*	*128*	*129*	
10.	*Richview T7/T8*	*88.1*	***137***	***141***	***142***	***143***	***144***	***145***	***146***	***147***	***149***	***150***	***151***	
	Total:		1466	1524	1576	1629	1677	1717	1758	1792	1829	1865	1898	Avg.
	Growth Rate			4.0%	3.4%	3.3%	2.9%	2.4%	2.3%	2.0%	2.0%	2.0%	1.8%	2.6%
	Station - 44 kV	**LTR (MVA)**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	
1.	Bramalea T3/T4[26]	117.4	**118**	**118**	**118**	**118**	**118**	**118**	**118**	**118**	**118**	**118**	**118**	
2.	Bramalea T5/T6	176.8	83	89	94	98	103	108	112	118	123	129	134	
3.	Goreway T4	95.4	33	34	36	37	38	40	41	42	44	45	47	
4.	Erindale T5/T6	171.9	**184**	**184**	**184**	**184**	**184**	**184**	**184**	**184**	**184**	**184**	**184**	
5.	Erindale T3/T4[27]	209.1	**216**	**231**	**243**	**254**	**266**	**277**	**289**	**291**	**293**	**295**	**297**	
6.	Meadowvale TS	200.7	**201**	**201**	**201**	**201**	**201**	**201**	**201**	**201**	**201**	**201**	**201**	
7.	Pleasant T1/T2	164.5	148	153	157	162	**166**	**171**	**176**	**181**	**185**	**191**	**196**	
8.	Tomken T1/T2	183.0	166	168	169	170	171	172	173	173	174	175	175	
9.	Tomken T3/T4	202.9	180	181	182	183	183	184	185	185	186	187	187	
	Total:		1329	1359	1383	1407	1431	1455	1479	1494	1508	1525	1539	Avg.
	Growth Rate			2.3%	1.8%	1.7%	1.7%	1.7%	1.7%	1.0%	0.9%	1.1%	0.9%	1.5%

The numbers in bold indicate those that are at or above the station LTR. In some cases, there are LV capacitors at the stations which indirectly provide additional capacity at the station and effectively raises the LTR at the station. The numbers in bolded red indicate where the loading at the station has become larger than this inflated LTR value provided by the LV capacitors. In other cases, a voltage decline issue arose while the study was being conducted which indicated that the voltage decline at a

[26] Bramalea T3/T4 (44 kV) appears to be loaded beyond its summer 10-day LTR, however, this problem is addressed by local generation.
[27] Includes load transfers from Meadowvale TS and from Erindale T5/T6.

particular station reached an unacceptable level prior to the station load being at capacity. These numbers were indicated in red, non-bolded font. All of the red numbers (bolded and non-bolded) indicate where load must be transferred to another station (new or existing) to mitigate operating risks.

For some stations where there was a single customer, it was necessary to review the non-coincident load forecast information in order to determine when the station peak would surpass the station LTR and further capacity or LV capacitors would be required to mitigate operating risks. These stations and/or DESNS are shown in Table A2. At stations where there were multiple customers reporting load forecasting information, coincident data was utilized to provide the need dates for additional transformation capacity.

Table A2: Non-Coincident Load Forecast

	Forecast Load in MVA											
	LTR	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Jim Yarrow MTS	174.0	120.6	138.2	154.6	169.5	**184.9**	**200.8**	**217.4**	**234.5**	**252.1**	**270.5**	**286.7**

APPENDIX B: 2024 TECHNICAL ASSESSMENT

All plans address the needs identified during the 10-year study period. These plans were further technically evaluated with respect to the long-term system planning requirements by assessing them for the expected year 2024 conditions. This method provides a snapshot of the long-term viability of each of the plans, and how each would perform under the increasing load growth that is expected in GTA West. The study participants provided load forecasts up to the year 2024. Specific loadflow results can be found in Appendix D.

All plans met the needs identified in the 10 year study period.

12.1.1 Plan A: V72R/V73R Extension, "Winston TS"

The assessment of Plan A through the years 2015 to 2024 identified the development of several future deficiencies in GTA West.

The overall system voltages in the study area were quite low, ranging from 232 kV at Pleasant TS. The loading at Pleasant TS is very high, and LV capacitors on the proposed Pleasant TS #3 LV buses would assist in supporting the voltage at this station. Additional reactive support may also be of benefit on the high voltage (HV) system at the proposed Hurontario SS.

Upon the loss of circuits R19T between Hurontario SS and Pleasant TS, the low voltages decline nearly 10% at Pleasant TS and decline more than 10% on the Pleasant TS #3 LV bus, under immediate post fault conditions. The loading at Pleasant TS #3 (27.6 kV) is beyond capacity (103% of the summer 10-day LTR) using the voltage varying load method. Under steady state post fault conditions, a voltage collapse occurs at Pleasant TS #3 by 2024, due to the high loading combined with the depressed voltage at both the transmission and sub-transmission levels. This problem could be addressed with the addition of LV capacitors at Pleasant TS #3, or by transferring load from Pleasant TS #3 to another station. Of additional note is the overloading of circuit R21T between Hurontario SS and Pleasant TS. This was noticeable under steady state post fault conditions with the use of a pair of LV capacitors at Pleasant TS #3. Under this scenario, this circuit was loaded to 110% of its continuous rating, steady state post fault.

For the loss of the lower portion of circuit R19T, the low transmission system voltages contribute to the overload of Erindale T5 (106%) under steady state post fault conditions. There is plenty of capacity at Winston TS to transfer any excess load from Erindale TS (T5/T6). However, it is advisable that if the transmission system voltages can be well supported with reactive power, then the load will not have to be transferred.

The loss of circuit V73R identified that the 44 kV DESN at Goreway TS was loaded beyond its summer 10-day LTR. This significantly depresses the voltage levels at Goreway TS during a single contingency. The 44 kV DESN at Goreway TS is loaded to 131% under immediate post fault conditions (using the voltage varying load method) and to 167% under steady state post fault conditions. The 27.6 kV load at Goreway TS is also over the summer 10-day LTR (101%). However, there is spare capacity at Goreway TS #2 to transfer any excess load from Goreway TS.

The loss of circuit T38B identified that Meadowvale TS and Halton TS were above their summer 10-day LTRs (loaded to 102% and 100% respectively, under steady state post fault conditions). This is due to the overall depressed transmission system voltage. There is spare capacity at

Winston TS and Steeles TS to transfer load from Meadowvale TS and Halton TS, respectively. However, if the transmission system voltages can be improved with reactive support, load would not have to be transferred.

12.1.2 Plan B: T38B/T39B Extension, "Winston TS"

Plan B also meets all of the needs identified in the study period. The same deficiencies arose at Pleasant TS #3 and Goreway TS as well as on circuits R19T and R21T between Hurontario SS and Pleasant TS. The problems at Erindale TS and Meadowvale TS were also present as well.

With the extension of circuits T38B and T39B (Plan B), circuits R19T/R21T was offloaded more in Plan B in comparison to Plan A, as previously identified in section 8.1. The HV system voltages are approximately 2 to 3 kV lower for Plan B than for Plan A.

12.1.3 Plan C: V72R/V73R Extension, Meadowvale TS #2

Plan C performed slightly worse than Plan A. Meadowvale TS #2 had lower voltages than Winston TS (234.9 kV versus 237.8 kV). Overall, the voltages on the Meadowvale TS/Halton TS tap are lower for Plan C compared to Plan A.

The contingency where circuit T38B or T39B was forced from service is of concern for Plan C. Under immediate post fault conditions, the LV buses at Halton TS declined nearly 10% using the voltage varying load method. Under steady state post fault conditions, the system voltages for Plan C were generally lower than for Plan A. As well, the following segments of the in-service circuit (T39B) was loaded over 95% of its continuous rating (the same results would be expected on T38B with T39B removed from service). Hornby Junction by Trafalgar DESN Junction was 95.5% of its continuous rating, and Lantz Junction by Trafalgar DESN Junction was 103.4% of its continuous rating. Under the implementation of Plan C, these line sections would require reconductoring sometime between 2015 and 2024. Halton TS and Meadowvale TS are overloaded sometime before 2024 under steady state post fault conditions.

Overall, Plan C did not perform, technically, as well as Plan A. There are indications that the addition of Meadowvale TS #2 could lead to transmission problems on circuits T38B/T39B as well as voltage problems on the Meadowvale TS/Halton TS tap well into the future.

12.1.4 Plan D: T38B/T39B Extension, Meadowvale TS #2

Due to the fact that the LDCs preferred the option of Winston TS over Meadowvale TS #2, and the extension of circuits V72R/V73R was more cost effective than the extension of circuits T38B/T39B, this option was not reviewed further.