Greater Ottawa

REGIONAL INFRASTRUCTURE PLAN

December 2, 2015

hydro one

[This page is intentionally left blank]

Prepared and supported by:

Company
Hydro One Networks Inc. (Lead Transmitter)
Hydro Ottawa Limited
Independent Electricity System Operator
Hydro One Networks Inc. (Distribution)
Hydro Hawkesbury Inc.
Ottawa River Power Corporation

[This page is intentionally left blank]

DISCLAIMER

This Regional Infrastructure Plan ("RIP") report was prepared for the purpose of developing an electricity infrastructure plan to address all near and mid-term needs identified in previous planning phases and also any additional needs identified based on new and/or updated information provided by the RIP Working Group.

The preferred solution(s) that have been identified in this report may be reevaluated based on the findings of further analysis. The load forecast and results reported in this RIP report are based on the information provided and assumptions made by the participants of the RIP Working Group.

Working Group participants, their respective affiliated organizations, and Hydro One Networks Inc. (collectively, "the Authors") make no representations or warranties (express, implied, statutory or otherwise) as to the RIP report or its contents, including, without limitation, the accuracy or completeness of the information therein and shall not, under any circumstances whatsoever, be liable to each other, or to any third party for whom the RIP report was prepared ("the Intended Third Parties"), or to any other third party reading or receiving the RIP report ("the Other Third Parties"), for any direct, indirect or consequential loss or damages or for any punitive, incidental or special damages or any loss of profit, loss of contract, loss of opportunity or loss of goodwill resulting from or in any way related to the reliance on, acceptance or use of the RIP report or its contents by any person or entity, including, but not limited to, the aforementioned persons and entities.

[This page is intentionally left blank]

EXECUTIVE SUMMARY

THIS REGIONAL INFRASTRUCTURE PLAN ("RIP") WAS PREPARED BY HYDRO ONE AND THE WORKING GROUP IN ACCORDANCE WITH THE ONTARIO TRANSMISSION SYSTEM CODE REQUIREMENTS. IT IDENTIFIES INVESTMENTS IN TRANSMISSION FACILITIES, DISTRIBUTION FACILITIES, OR BOTH, THAT SHOULD BE DEVELOPED AND IMPLEMENTED TO MEET THE ELECTRICITY INFRASTRUCTURE NEEDS WITHIN THE GREATER OTTAWA REGION.

The participants of the RIP Working Group included members from the following organizations:

- Hydro Ottawa Limited
- Hydro Hawkesbury Inc.
- Hydro One Networks Inc. (Distribution)
- Independent Electricity System Operator
- Hydro One Networks Inc. (Transmission)
- Ottawa River Power Corporation

This RIP provides a consolidated summary of needs and recommended plans for both the Ottawa Area Sub-Region and Outer Ottawa Area Sub-Region that make up the Greater Ottawa Region for the near term (up to 5 years) and the mid-term (5 to 10 years). No long term needs and associated plans (10 to 20 years) have been identified.

This RIP is the final phase of the regional planning process and it follows the completion of the Ottawa Sub-Region's Integrated Regional Resource Plan ("IRRP") by the IESO in April 2015 and the Outer Ottawa Area Sub-Region's Needs Assessment ("NA") Study by Hydro One in July 2014.

The major infrastructure investments planned for the Greater Ottawa Region over the near and mid-term, identified in the various phases of the regional planning process, are given in the Table below.

No.	Project	I/S date	Cost
1	Almonte TS: addition of breaker to sectionalize line M29C	November 2015	$4.7M
2	Russell TS and Riverdale TS: construction of feeder ties to allow extra load transfers	2017-2020	$2.0M
3	Lisgar TS: replacement of transformers T1 and T2	December 2017	$13.9M
4	Hawthorne TS: replacement of autotransformers T5 and T6	May 2018	$15.7M
5	Overbrook TS: replacement of transformers T3 and T4	June 2018	$1.1M[(1)]
6	115kV Circuit A6R: additional tap to off load Circuit A4K	June 2019	$9-11M
7	Hawthorne TS: replacement of transformers T7 and T8 and add one 44kV feeder position	October 2019	$1.1M[(2)]
8	King Edward TS: Replace Transformer T4	June 2021	$12M

[(1)] The transformers are at end of life and are being replaced as part of Hydro One sustainment program. The cost shown here represents the incremental cost of installing the next larger size units.

[(2)] Incremental cost for larger transformer only.

The IRRP study had also identified the need for additional 230/115 kV autotransformation capacity at Merivale TS and provision for a supply for a new station in the southwest area. The options to address these needs are still being studied by the Working Group and as part of the IESO community engagement activities. The Working Group expects to finalize recommendation to address these needs by summer 2016.

Investments to address the other mid-term needs, for cases where a decision is not required until 2020, will be reviewed and finalized in the next regional planning cycle.

No long term needs were identified at this time. As per the OEB mandate, the Regional Plan should be reviewed and/or updated at least every five years. The region will continue to be monitored and should there be a need that emerges due to a change in load forecast or any other reason, the next regional planning cycle will be started earlier to address the need.

TABLE OF CONTENTS

List of Figures

List of Tables

[This page is intentionally left blank]

1. INTRODUCTION

THIS REPORT PRESENTS THE REGIONAL INFRASTRUCTURE PLAN ("RIP") TO ADDRESS THE ELECTRICITY NEEDS OF THE GREATER OTTAWA REGION.

The report was prepared by Hydro One Networks Inc. ("Hydro One") and documents the results of the joint study carried out by Hydro One, Hydro Ottawa Limited ("Hydro Ottawa"), Hydro Hawkesbury Inc. ("Hydro Hawkesbury"), Ottawa River Power Corporation ("ORPC") and the Independent Electricity System Operator ("IESO") in accordance with the Regional Planning process established by the Ontario Energy Board ("OEB") in 2013.

The Greater Ottawa Region covers the municipalities bordering the Ottawa River from Arnprior in the West to Hawkesbury in the East and North of Highway 43. At the center of this region is the City of Ottawa. Electrical supply to the Region is provided from fifty-two 230 kV and 115 kV step-down transformer stations. The summer 2015 area load of the Region was about 1800 MW. The boundaries of the Region are shown in Figure 1-1 below.

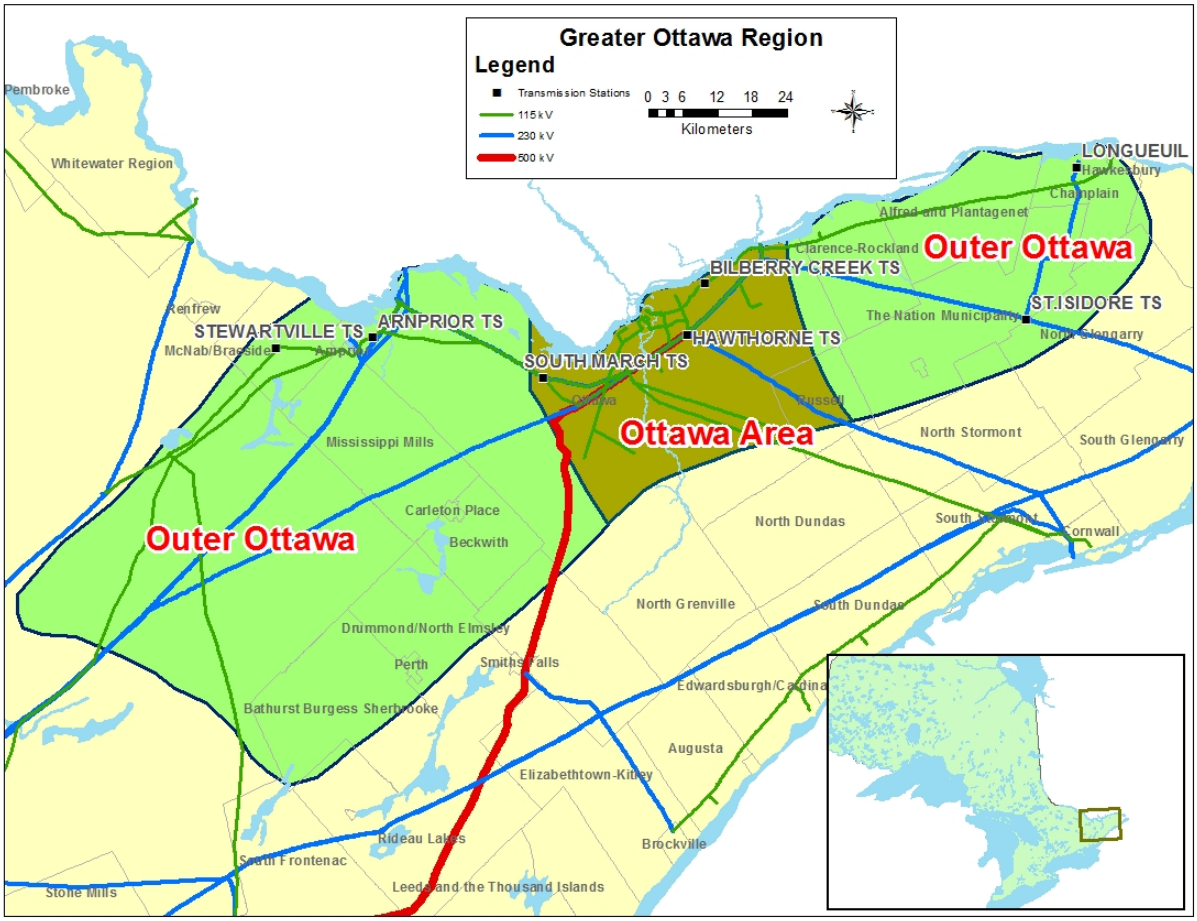

Figure 1-1 Greater Ottawa Region

1.1 Scope and Objectives

This RIP report examines the needs in the Greater Ottawa Region. Its objectives are to: identify new supply needs that may have emerged since previous planning phases (e.g. Needs Assessment, Local Plan, and/or Integrated Regional Resource Plan); assess and develop a wires plans to address these needs; provide the status of wires planning currently underway or completed for specific needs; and identify investments in transmission and distribution facilities or both that should be developed and implemented to meet the electricity infrastructure needs within the region.

The RIP reviews factors such as the load forecast, transmission and distribution system capability along with any updates with respect to local plans, conservation and demand management ("CDM"), renewable and non-renewable generation development, and other electricity system and local drivers that may impact the need and alternatives under consideration.

The scope of this RIP is as follows:

- A consolidated report of the needs and relevant plans to address near and mid-term needs (2015-2025) identified in previous planning phases (Needs Assessment, Scoping Assessment, Local Plan or Integrated Regional Resource Plan).
- Identification of any new needs over the 2015-2025 period and a wires plan to address these needs based on new and/or updated information.
- Develop a plan to address any longer term needs identified by the Working Group

The IRRP or RIP Working Group did not identify any long term needs at this time. If required, further assessment will be undertaken in the next planning cycle because adequate time is available to plan for required facilities.

1.2 Structure

The rest of the report is organized as follows:

- Section 2 provides an overview of the regional planning process.
- Section 3 describes the region.
- Section 4 describes the transmission work completed over the last ten years.
- Section 5 describes the load forecast and study assumptions used in this assessment.
- Section 6 describes the results of the adequacy assessment of the transmission facilities and identifies the needs.
- Section 7 discusses the needs and provides the alternatives and preferred solutions.
- Section 8 provides the conclusion and next steps.

2. REGIONAL PLANNING PROCESS

2.1 Overview

Planning for the electricity system in Ontario is done at essentially three levels: bulk system planning, regional system planning, and distribution system planning. These levels differ in the facilities that are considered and the scope of impact on the electricity system. Planning at the bulk system level typically looks at issues that impact the system on a provincial level, while planning at the regional and distribution levels looks at issues on a more regional or localized level.

Regional planning looks at supply and reliability issues at a regional or local area level. Therefore, it largely considers the 115 kV and 230 kV portions of the power system that supply various parts of the province.

2.2 Regional Planning Process

A structured regional planning process was established by the Ontario Energy Board ("OEB") in 2013 through amendments to the Transmission System Code ("TSC") and Distribution System Code ("DSC"). The process consists of four phases: the Needs Assessment [1] ("NA"), the Scoping Assessment ("SA"), the Integrated Regional Resource Plan ("IRRP"), and the Regional Infrastructure Plan ("RIP").

The regional planning process begins with the NA phase, which is led by the transmitter to determine if there are regional needs. The NA phase identifies the needs and the Working Group determines whether further regional coordination is necessary to address them. If no further regional coordination is required, further planning is undertaken by the transmitter and the impacted local distribution company ("LDC") or customer and develops a Local Plan ("LP") to address them. These needs are local in nature and can be best addressed by a straight forward wires solution.

In situations where identified needs require coordination at the regional or sub-regional levels, the IESO initiates the SA phase. During this phase, the IESO, in collaboration with the transmitter and impacted LDCs, reviews the information collected as part of the NA phase, along with additional information on potential non-wires alternatives, and makes a decision on the most appropriate regional planning approach. The approach is either a RIP, which is led by the transmitter, or an IRRP, which is led by the IESO. If more than one sub-region was identified in the NA phase, it is possible that a different approach could be taken for different sub-regions.

The IRRP phase will generally assess infrastructure (wires) versus resource (CDM and Distributed Generation) options at a higher or more macro level, but sufficient to permit a comparison of options. If the IRRP phase identifies that infrastructure options may be most appropriate to meet a need, the RIP phase will conduct detailed planning to identify and assess the specific wires alternatives and recommend

[1] Also referred to as Needs Screening.

a preferred wires solution. Similarly, resource options that the IRRP identifies as best suited to meet a need are then further planned in greater detail by the IESO. The IRRP phase also includes IESO led stakeholder engagement with municipalities and establishes a Local Advisory Committee in the region or sub-region. Since the Ottawa Sub-Region was in transition to the new regional planning process, the IESO led IRRP engagement for this sub-region was initiated after the completion of the IRRP.

The RIP phase is the final stage of the regional planning process and involves: confirmation of previously identified needs; identification of any new needs that may have emerged since the start of the planning cycle; and development of a wires plan to address the needs where a wires solution would be the best overall approach. This phase is led and coordinated by the transmitter and the deliverable of this stage is a comprehensive report of a wires plan for the region. Once completed, this report can be referenced in rate filing submissions or as part of LDC rate applications with a planning status letter provided by the transmitter. Reflecting the timelines provisions of the RIP, plan level stakeholder engagement is not undertaken at this stage. However, stakeholder engagement at a project specific level will be conducted as part of the project approval requirement.

The regional planning process specifies a 20 year planning assessment period for the IRRP. No specific period has been specified for the RIP. The RIP focuses on the wires options and, given the forecast uncertainty and the fact that adequate time is available to identify and plan new wire facilities in subsequent planning cycles, a study period of 10 years is considered adequate for the RIP. The only exception would be the case where major regional transmission is required for an area with limited or no transmission facilities. In these cases the RIP would review and assess longer term needs if identified in the IRRP.

To efficiently manage the regional planning process, Hydro One has been undertaking wires planning activities in collaboration with the IESO and LDCs for the region as part of and/or in parallel with:

- Planning activities that were already underway in the region prior to the new regional planning process taking effect.
- The NA, SA, and LP phases of regional planning.
- Participating in and conducting wires planning as part of the IRRP for the region or sub-region.

Figure 2-1 illustrates the various phases of the regional planning process (NA, SA, IRRP, and RIP) and their respective phase trigger, lead, and outcome.

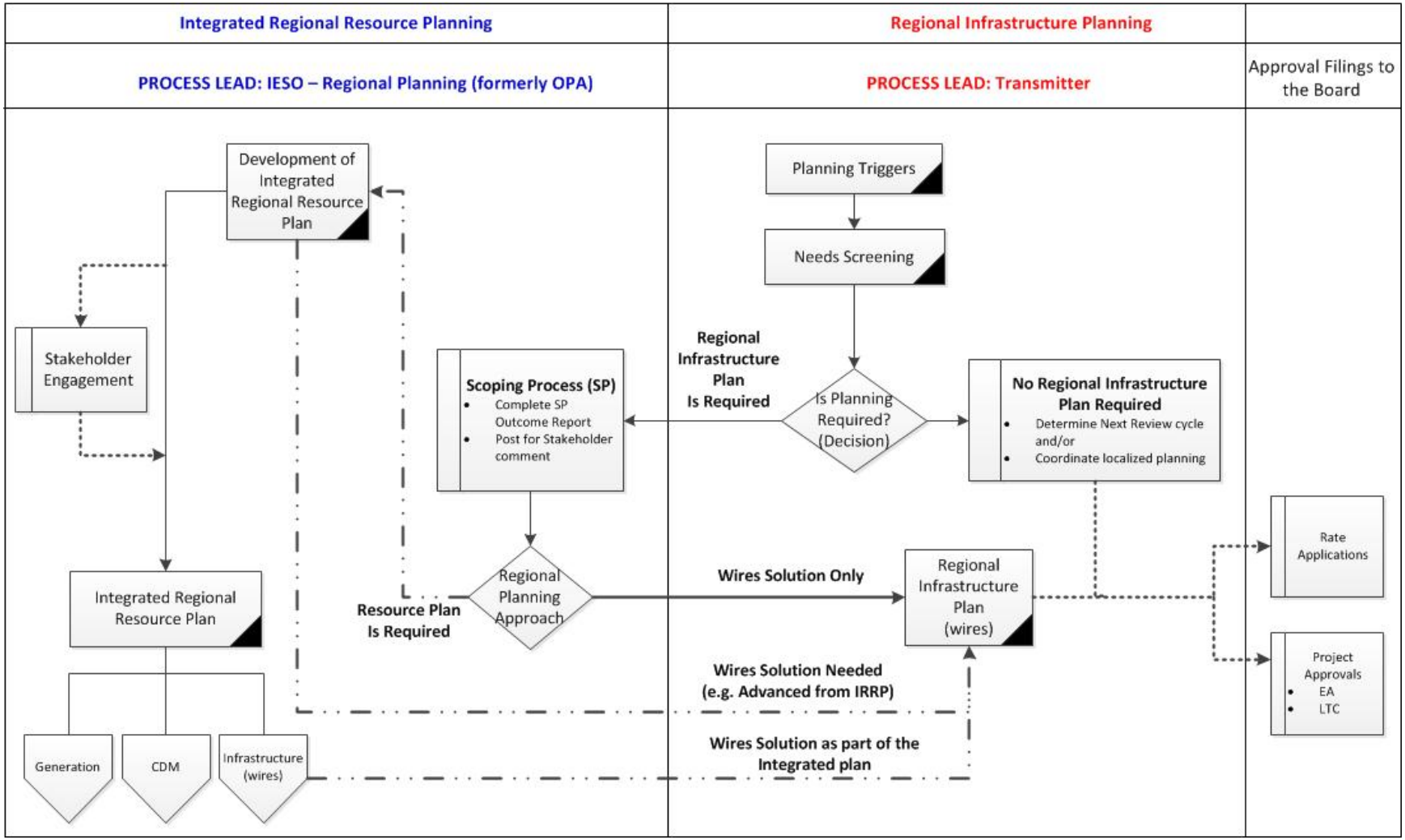

Figure 2-1 Regional Planning Process Flowchart

2.3 RIP Methodology

The RIP phase consists of a four step process (see Figure 2-2) as follows:

1. Data Gathering: The first step of the process is the review of planning assessment data collected in the previous stages of the regional planning process. Hydro One collects this information and reviews it with the Working Group to reconfirm or update the information as required. The data collected includes:
   - Net peak demand forecast at the transformer station level. This includes the effect of any distributed generation or conservation and demand management programs.
   - Existing area network and capabilities including any bulk system power flow assumptions.
   - Other data and assumptions as applicable such as asset conditions; load transfer capabilities, and previously committed transmission and distribution system plans.
2. Technical Assessment: The second step is a technical assessment to review the adequacy of the regional system including any previously identified needs. Additional near and mid-term needs may be identified at this stage.
3. Alternative Development: The third step is the development of wires options to address the needs and to come up with a preferred alternative based on an assessment of technical considerations, feasibility, environmental impact and costs.
4. Implementation Plan: The fourth and last step is the development of the implementation plan for the preferred alternative.

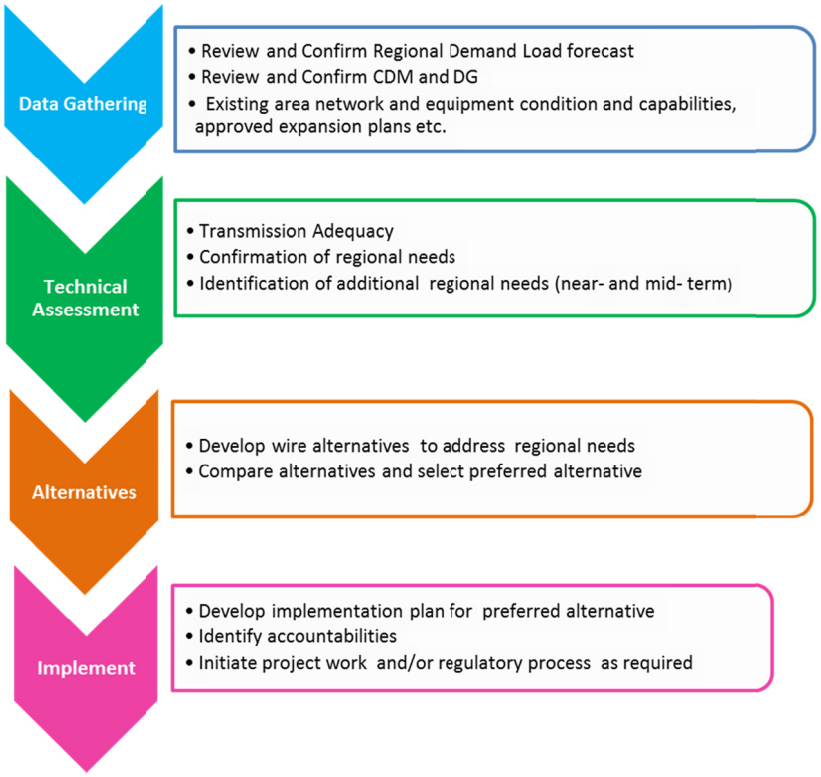

Figure 2-2 RIP Methodology

3. REGIONAL CHARACTERISTICS

THE GREATER OTTAWA REGION COVERS THE MUNICIPALITIES BORDERING THE OTTAWA RIVER FROM ARNPRIOR IN THE WEST TO HAWKESBURY IN THE EAST AND NORTH OF HIGHWAY 43. AT THE CENTER OF THIS REGION IS THE CITY OF OTTAWA (SEE FIGURE 3-1). ELECTRICAL SUPPLY TO THE REGION IS PROVIDED FROM FIFTY-TWO 230 KV AND 115 KV STEP-DOWN TRANSFORMER STATIONS. THE 2015 SUMMER PEAK AREA LOAD OF THE REGION WAS APPROXIMATELY 1840 MW.

Bulk electrical supply to the Greater Ottawa Region is provided through the 500/230 kV Hawthorne TS and a network of 230 kV and 115 kV transmission lines and step-down transformation facilities. The area has been divided into two sub-regions as shown in Figure 1-1 and described below:

- The Ottawa Sub-Region comprises primarily the City of Ottawa. It is supplied by two 230/115 kV autotransformer stations (Hawthorne TS and Merivale TS, eight 230 kV and thirty-three 115 kV transformer stations stepping down to a lower voltage. Local generation in the area consists of the 74 MW Ottawa Health Science Non-Utility Generator ("NUG") located near the downtown area and connected to the 115 kV network. The Ottawa Sub-Region is shown in Figure 3-1 below.

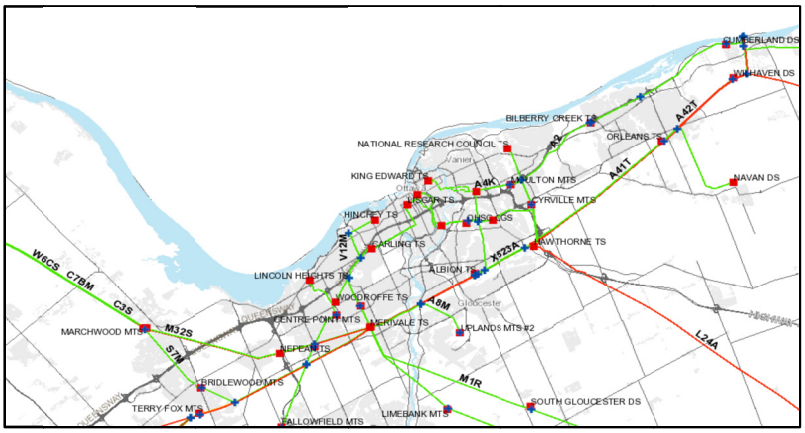

Figure 3-1 Ottawa Sub-Region

Hydro Ottawa is the main LDC that serves the electricity demand for the City of Ottawa. Hydro One Distribution supplies load in the outlying areas of the sub-region. Both Hydro Ottawa and Hydro One Distribution receive power at the step-down transformer stations and distribute it to the end users, i.e. industrial, commercial and residential customers.

- The Outer Ottawa Sub-Region covers the remaining area of the Greater Ottawa Region. The eastern area (shown in Figure 3-2) is served by three 230 and five 115 kV step-down transformer stations. Hydro One Distribution and Hydro Hawkesbury are the LDCs in the area that distribute power from the stations to the end use customers. It also includes a large industrial customer, Ivaco Rolling Mills, in L'Orignal, Ontario.

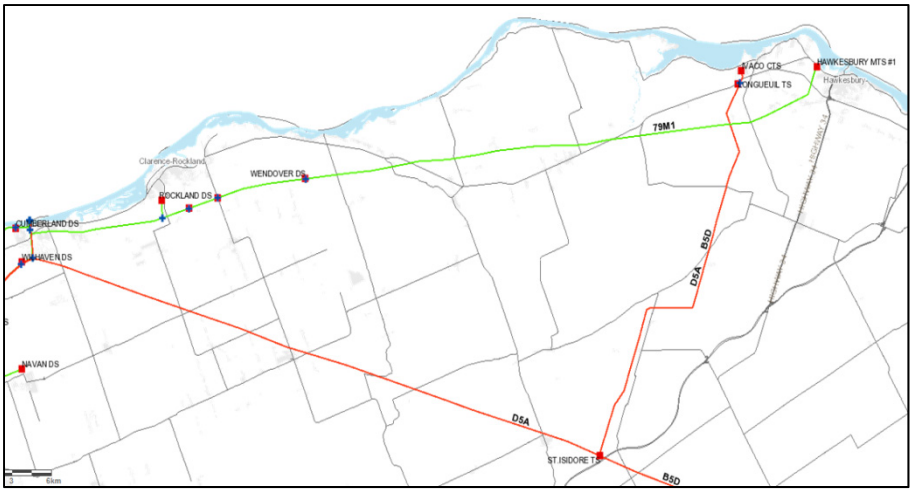

Figure 3-2 Outer Ottawa Sub-Region, Eastern Area

The western area of the Outer Ottawa Sub-Region is served by one 230 kV and two 115 kV step-down transformer stations. Hydro One Distribution is the LDC that supplies end use customers for these stations. The area includes the following generating stations: Barrett Chute GS, Chats Falls GS and Stewartville GS with a peak generation capacity of about 450 MW.

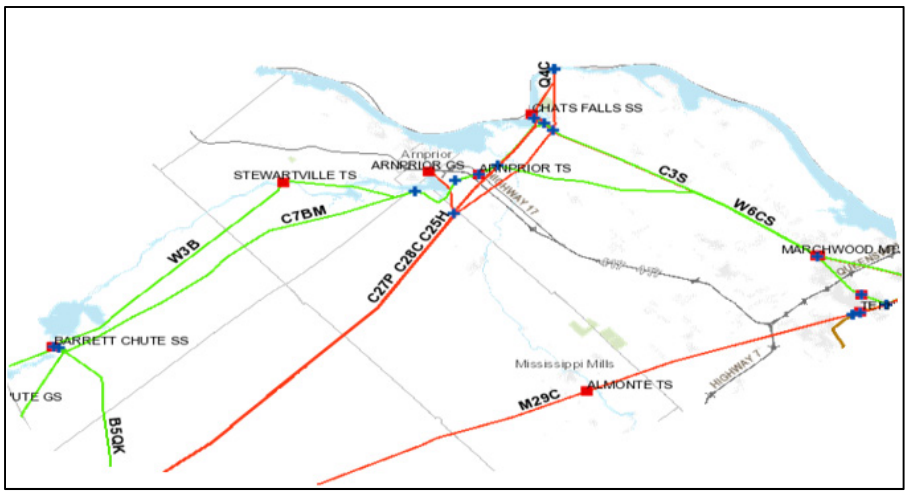

Figure 3-3 Outer Ottawa, Western Area

An electrical single line diagram for the Greater Ottawa Region facilities is shown in Figure 3-4.

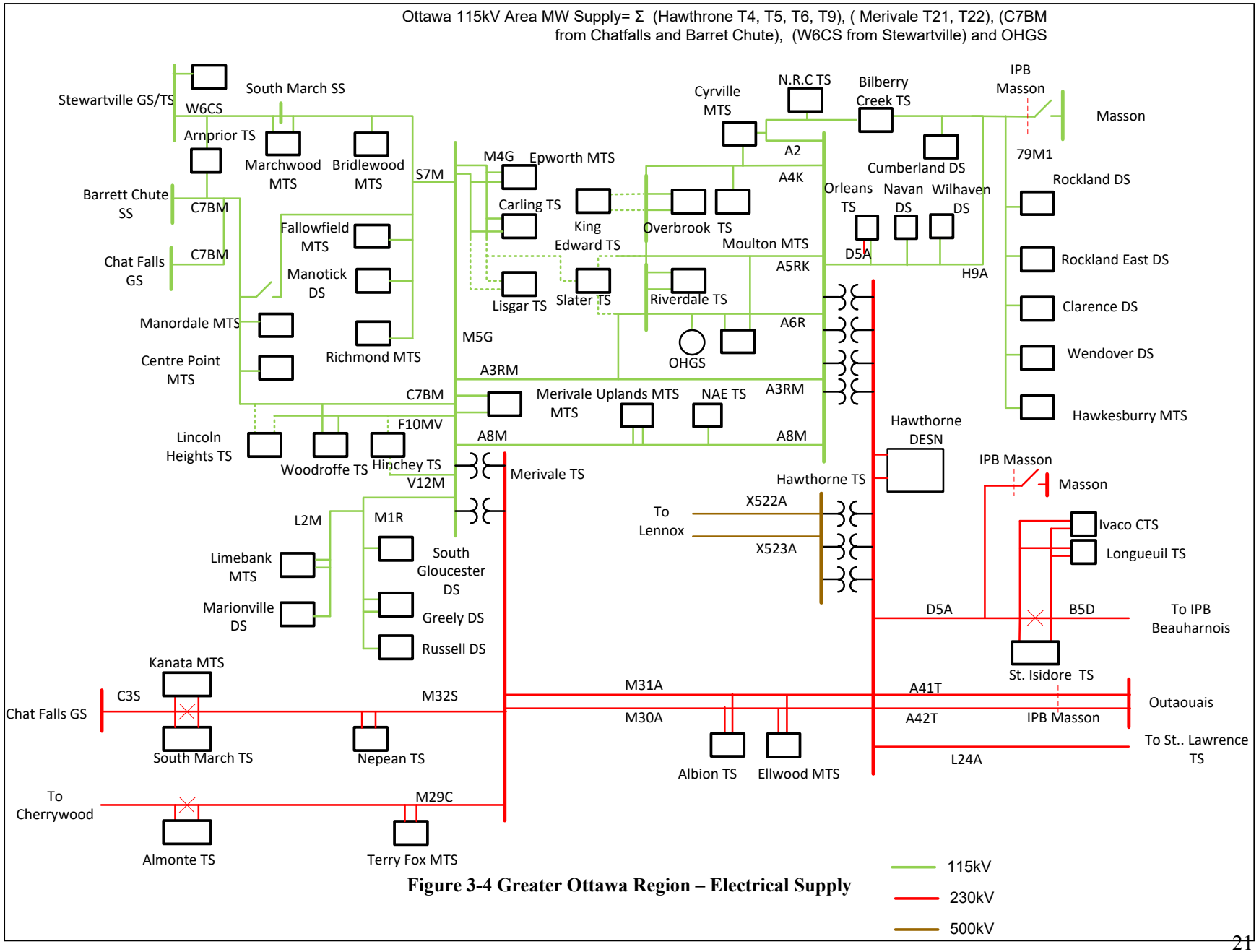

Figure 3-4 Greater Ottawa Region – Electrical Supply

4. TRANSMISSION FACILITIES COMPLETED OVER LAST TEN YEARS OR CURRENTLY UNDERWAY

OVER THE LAST 10 YEARS A NUMBER OF TRANSMISSION PROJECTS HAVE BEEN COMPLETED, OR ARE UNDERWAY, AIMED AT IMPROVING THE SUPPLY TO THE GREATER OTTAWA REGION IN GENERAL AND THE CITY OF OTTAWA IN PARTICULAR.

These projects were identified as a result of either: joint Hydro One, IESO and Hydro Ottawa planning studies to meet the needs of Hydro Ottawa or Hydro One Distribution; and/or, to meet provincial government policies. A brief listing of the completed projects over the last 10 years is given below:

- Hawthorne TS x Gamble Junction double circuit 230 kV Overhead line (2008) – the single 115 kV circuit H9A was rebuilt as a two circuit 230 kV tower line with increased capacity. Connect Cyrville MTS (2008) – connected new Hydro Ottawa owned Cyrville TS to 115 kV circuits A4K and A2.
- Hawthorne TS x Outaouais TS double circuit 230 kV line (2009) – built to provide up to 1250MW of transfer capability with Hydro Quebec as part of the new HVDC interconnection.
- Connect Ellwood MTS (2012) – connected new Hydro Ottawa owned Ellwood TS to 230 kV circuits M30A and M31A.
- Connect Terry Fox MTS (2013) – connected new Hydro Ottawa owned Terry Fox MTS to 230 kV circuit M29C.
- Hawthorne TS 115 kV switchyard Upgrade (2014) – replaced 115 kV breakers with inadequate short circuit capability with new breakers of higher short circuit capability. This work improved system reliability by allowing 115kV switchyards to be operated with bus tie closed. This work also facilitated incorporation of DG in the Ottawa area.
- Build new Orleans TS (2015) – built a new step-down transformer station in East Ottawa supplied from 230 kV circuit D5A and 115 kV circuits H9A. This station will provide additional load meeting capability to meet Hydro One Distribution and Hydro Ottawa requirements. It will also provide improved reliability for Hydro One Distribution customers in the Orleans-Cumberland area.
- Hinchey TS (2015) – Connect idle winding of transformer T1/T2 to new Hydro Ottawa metalclad switchgear.

The following projects are currently underway:

- Add 230 kV inline breaker on 230 kV circuit M29C at Almonte TS (2015) – to improve reliability of supply for Almonte TS and Terry Fox MTS.
- Replace 45/75 MVA, 115/13.2 kV step down transformers with new 60/100 MVA, 115/13.2 kV at Overbrook TS (2017) – the existing transformers are at end-of-life and the new replacement transformers have a higher rated capacity and will provide additional load meeting capability.

- Replace 225 MVA, 230/115 kV autotransformers T5 and T6 at Hawthorne TS with new 250 MVA, 230/115 kV autotransformers (2018) – the existing transformers have inadequate capacity and were identified and recommended for replacement during the IRRP phase for the Ottawa Sub-Region [1].
- Replace 50/83 MVA, 230/44 kV step down transformers with new 75/125 MVA, 230/44 kV units at Hawthorne TS (2019) – the existing transformers are at end-of-life and the new replacement transformers have a higher rated capacity and will provide additional load meeting capability.

5. FORECAST AND OTHER STUDY ASSUMPTIONS

5.1 Load Forecast

The load in the Greater Ottawa Area is forecast to increase at an average rate of approximately 2.25% annually up to 2020, at 0.96% between 2020 and 2025 and at 0.45% beyond 2025. The growth rate varies across the Region with most of the growth concentrated in the Ottawa Sub-region.

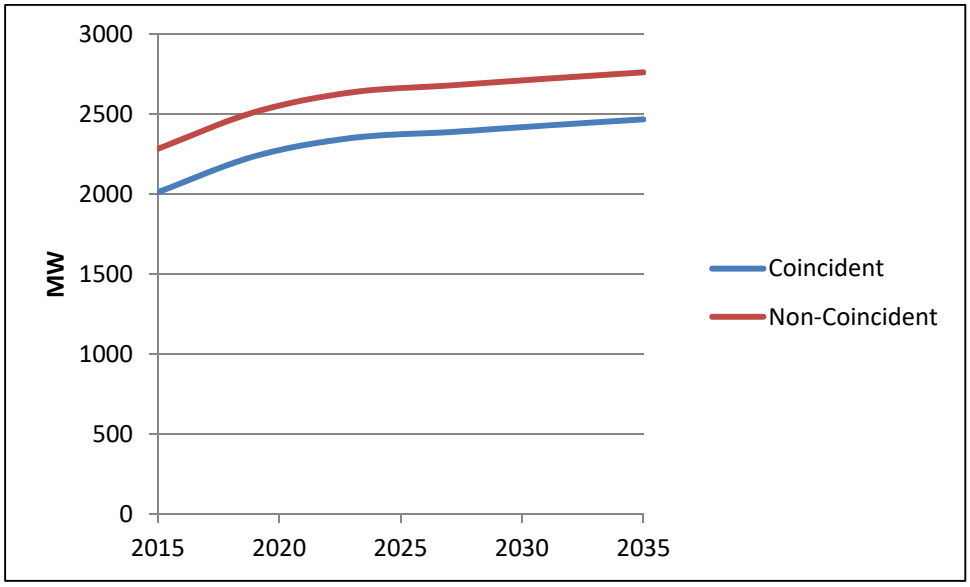

Figure 5-1 Greater Ottawa Region Summer Extreme Weather Peak Forecast

Figure 5-1 shows the Greater Ottawa Region extreme weather peak summer coincident and non-coincident load forecast. The coincident forecast represents the sum of the peak load at the time of the region's peak load and represents loads that would be seen by the autotransformer stations and is used to determine the need for additional auto-transformation capacity. The non-coincident forecast represents the sum of the individual stations peak load and is used to determine the need for stations and line capacity. Coincident and Non-coincident load forecasts for the individual stations in the Greater Ottawa Region are given in Appendix A.

The RIP load forecast was developed as follows:

- RIP Working Group participants confirmed that the load forecast, CDM, and DG information used in the IESO's 2015 IRRP for the Ottawa Sub-Region[1] and Hydro One's 2014 NA [2] was still valid and there were no changes.
- The station coincident loads used in the RIP are as given in the IRRP for Ottawa Sub-Region and NA for the Outer Ottawa Sub-Region. The coincident loading is used for evaluating the adequacy of bulk transmission circuits and the 230/115kV autotransformers.

- Stations non-coincident load forecast was developed using the summer 2015 actual peak load adjusted for extreme weather and applying the station net growth rates as identified in the IRRP and NA. The non-coincident forecast is used to determine adequacy of station capacity. The net growth rate accounts for CDM measures and connected DG. Details on the CDM and connected DG are provided in the IRRP [1] and NA for Ottawa Sub-Region [2] and are not repeated here.

5.2 Other Study Assumptions

The following other assumptions are made in this report.

- The study period for the RIP Assessments is 2015-2025.
- All planned facilities for which work has been initiated and are listed in Section 4 are assumed to be in-service.
- Summer is the critical period with respect to line and transformer loadings. The assessment is based therefore based on summer peak loads.
- Station capacity adequacy is assessed by comparing the non-coincident peak load with the station's normal planning supply capacity, assuming a 90% lagging power factor for stations having no low-voltage capacitor banks and 95% lagging power factor for stations having low-voltage capacitor banks. Normal planning supply capacity for transformer stations in this Sub-Region is determined by the summer 10-Day Limited Time Rating (LTR).
- Adequacy assessment is conducted as per ORTAC.

6. ADEQUACY OF FACILITIES AND REGIONAL NEEDS OVER THE 2015-2025 PERIOD

THIS SECTION REVIEWS THE ADEQUACY OF THE EXISTING TRANSMISSION AND DELIVERY STATION FACILITIES SUPPLYING THE GREATER OTTAWA REGION AND LISTS THE FACILITIES REQUIRING REINFORCEMENT OVER THE NEAR AND MID-TERM. NO LONG TERM NEEDS HAVE BEEN IDENTIFIED.

Within the current regional planning cycle two regional assessments have been conducted for the Greater Ottawa Region. The April 2015 Ottawa Sub-Region IRRP report [1] was prepared by the IESO in conjunction with Hydro One and Hydro Ottawa. The July 2014 Outer Ottawa Sub-Region NA report [2] was prepared by Hydro One and considered the remainder of the Greater Ottawa region.

The IRRP [1] and NA [2] planning assessments identified a number of regional needs to meet the area forecast load demand over the near to mid-term between 2015 and 2025. These regional needs are summarized in Table 6.1 and include needs for which work is already underway and/or being addressed by an LP study. A detailed description and status of work initiated or planned to meet these needs is given in Section 7.

A review of the loading on the transmission lines and stations in the Greater Ottawa Region was also carried out as part of the RIP report. Sections 6.1 to 6.3 present the results of this review. Additional needs identified as a result of the review are also listed in Table 6-1.

Table 6-1 Near and Mid-Term Regional Needs

Type	Section	Needs	Timing[4]
Needs identified in IRRP [1] and NA [2]			
230/115kV Transformation Capacity	7.1	Hawthorne TS T5 and T6 – LTR[1] exceeded	2018[2]
	7.2.1	Merivale TS T22 - LTR[1] exceeded	2019
Transmission Circuit Capacity	7.2.2	S7M Circuit – Capacity	2019 and 2026
	7.3	A4K Circuit - Capacity	2019[2]
Station Capacity	7.4	Center 115kV Area - Capacity	2017-2021[3]
	7.5	Hawthorne TS T7 and T8 – LTR[1] exceeded	2019
	7.2.2	South West Area - Capacity	2020
	7.6	Bilberry Creek TS - Refurbishment	2023
Supply Security, Reliability and Restoration	7.7	Almonte TS/Terry Fox MTS - Reliability	2015
	7.8	Orleans TS - Reliability	No plan recommended[5]
	7.9	B5D+D5A Circuits – Restoration	No plan recommended[5]
	7.10	Load Loss for S7M Contingency	No plan recommended[5]
Voltage Regulation	7.11	79M1 Circuit – Voltage Regulation	2023
	7.12	Stewartville TS – Voltage Regulation	No plan recommended[5]
	7.13	Almonte TS/Terry Fox MTS –Voltage Regulation	No plan recommended[5]
	7.14	Almonte TS – Low Power Factor	No plan recommended[5]
Additional Needs identified in RIP			
	7.2.1	Merivale TS T22 and Hawthorne TS T9 – Continuous ratings exceeded	2024/25
	7.4.2.4	King Edward TS – Capacity	2021

[1] LTR – Limited time ratings to accommodate emergency loading for a short time under contingency conditions
[2] Projects have been initiated.
[3] Miscellaneous stations. Some are already in execution.
[4] Timing shows the proposed in service date for project underway, and the need date for the projects not yet started.
[5] Review did not recommend plan for mitigation. Please see the need details in Section 7.

6.1 500 and 230 kV Transmission Facilities

All 500 kV and 230 kV transmission circuits in the Greater Ottawa Region are classified as part of the Bulk Electricity System ("BES"). They connect the Region to the rest of Ontario's transmission system and to the Hydro Quebec transmission system. A number of these circuits also serve local area stations within the region and the power flow on them depends on the bulk system transfers as well as local area loads. These circuits are as follows (refer to Figure 3-4):

1. Hawthorne TS to Merivale TS 230 kV transmission circuits M30A/M31A – supply Albion TS and Ellwood TS.
2. Hawthorne TS to Cornwall 230 kV transmission circuits D5A/B5D/B31L – supply Orleans TS, St. Isidore TS and Longueuil TS. Also connects to Hydro Quebec at Beauharnois Station and to Lievre Power at Masson GS.
3. Merivale TS to Chats Falls 230 kV transmission circuits M32S/C3S – supply Nepean TS, South March TS and Kanata MTS
4. Merivale TS x Cherrywood TS 230 kV transmission circuits E29C/E34M (M29C) – supply Terry Fox MTS and Almonte TS.

Based on current forecast station loadings and bulk transfers, the M30A/M31A circuits will require reinforcement by 2020. The M30A/M31A upgrade will be addressed by Hydro One based on the recommendation stemming from an IESO Bulk System Planning study [6]. All other 230 kV circuits are expected to be adequate over the study period.

6.2 230/115 kV Transformation Facilities

Almost sixty percent of the Region load is supplied from the 115 kV transmission system. The primary source of 115 kV supply is from 230/115 kV autotransformers at Hawthorne TS and Merivale TS. Additional support is provided from 115 kV generation at Barrett Chute GS, Stewartville GS, part of Chats Falls GS, and the Ottawa Health Science NUG and the Ottawa River generation at Chaudière. Support from DG and CDM was considered as part of the load forecast.

Table 6-2 summarizes the results of the adequacy studies and gives the need dates for reinforcement of the 230/115 kV autotransformer facilities at Hawthorne TS and Merivale TS. Assuming no change in the system configuration, the forecasted loading will result in the Limited Time Rating ("LTR") of the Merivale autotransformer being exceeded by 2019 and the continuous rating of the Merivale and Hawthorne autotransformers by 2024/25.

The need dates are sensitive to the availability of hydraulic generation from Barrett Chute GS, Stewartville GS and Chats Falls GS and are based on 98% dependable generation availability as per ORTAC criteria. This corresponds to about 18 MW of available generation. A higher level of generator output from these stations would defer the need dates.

The need dates assume that the Hawthorne TS 225 MVA, 230/115 kV autotransformers T5 and T6 have been replaced with new 250 MVA units. The T5 and T6 replacement work is underway and is therefore not identified in the table below.

Table 6-2 Adequacy of 230/115 kV Autotransformer Facilities

Overloaded Facilities	2015 MVA Loading	MVA Load Meeting Capability	Limiting Contingency	Need Date
Merivale TS 230/115kV autotransformer T22	261	312[(1)]	T21	2019
Merivale TS 230/115kV autotransformer T21	182	250	[(2)]	2024
Hawthorne TS 230/115kV autotransformer T9	189	250	[(2)]	2025

[(1)] Limited time rating exceeded.

[(2)] Continuous rating exceeded with all elements in service based on existing system configuration

6.3 115 kV Transmission Facilities

The Greater Ottawa Region 115 kV transmission facilities can be divided in five main sections: Please see Figure 3-4 for the single line diagram.

1. Hawthorne 115 kV Center – has four circuits A3RM, A4K, A5RK and A6R. Reinforcement is required for the A4K circuit as a loss of the A5RK circuit would result in the loading exceeding the rating on the A4K circuit between Hawthorne TS and Moulton MTS (for details see Section 7.3).
2. Hawthorne 115 kV East – has two circuits A2 and H9A/79M1. These are expected to be adequate over the study period.
3. Merivale 115 kV Center – has two circuits M4G and M5G. These are expected to be adequate over the study period.
4. Merivale 115 kV West – has five circuits C7BM, F10MV, S7M, V12M and W6CS. Upgrading is required of the S7M tap to Fallowfield TS since forecasted loading will exceed circuit continuous rating (for details see section 7.4)
5. Merivale 115 kV South – has two circuits L2M and M1R. These circuits are adequate for the study period.

The loading on the limiting sections is summarized in Table 6-3.

Table 6-3 Adequacy of 115 kV Circuits

Corridor	Section	Overloaded Circuit	Rating (A)	Contingency	2015 Loading (A)	Need Date
1. Hawthorne TS x Blackburn Jct. x Overbrook TS	Hawthorne TS x Moulton TS	A4K	1070	A5RK	1006	2017
4. S7M tap to Fallowfield MTS	STR R14-R15 x Fallowfield Jct.[2]	S7M	590	All facilities in-service[1]	278	2024

[1] Continuous rating exceeded.
[2] Please see Figure 7-4.

6.4 Step-Down Transformation Facilities

There are a total of fifty-two step-down transmission connected transformer stations in the Greater Ottawa Region. The stations have been grouped based on the geographical area and supply configuration. The non-coincident station loading in each area and the associated station capacity and need date for relief is provided in Table 6-4 below. As shown areas requiring additional transformation capacity are the Center 115kV area, the South West 115kV area and the South 115kV area. Table 6-5 shows the non-coincident station loads for all areas which are adequate over the 2015-2025 study period. Details of the areas and associated stations are given in Appendix B.

Table 6-4 Adequacy of Step-Down Transformer Stations - Areas Requiring Relief

Area/Supply	Capacity (MW)	2015 Loading (MW)	Need Date
Center 115	569[1]	516	2018
South West 115	70	60	2019
South 115	182	151	2024

[1] With Overbrook TS 45/75 MVA transformers replaced with larger 60/100 MVA units.

Table 6-5 Adequacy of Step-Down Transformer Stations – Areas Adequate

Area/Supply	Capacity (MW)	2015 Loading (MW)	2025 Loading (MW)
East 115	340	231	229
West 115	504	351	425
Center 230/13.2kV	147	121	126
Center 230/44kV	153[(1)]	103	136
West 230	397	382	389
Outer East 115	80	56	62
Outer West 115	106	83	96
Outer East 230	149[(2)]	92	90
Outer West 230	100	48	45

[(1)] With Hawthorne TS 50/83 MVA transformers replaced with larger 75/125 MVA size units.
[(2)] Includes Longueuil TS and St Isidore TS load.

7. REGIONAL PLANS

This section discusses needs, presents wires alternatives and the current preferred wires solution for addressing the electrical supply needs for the Greater Ottawa Region. These needs are listed in table 6-1 and include needs previously identified in the IRRP for the Ottawa Sub-Region [1] and the NA for the Outer Ottawa Sub-Region [2] as well as the adequacy assessment carried out as part of the current RIP report.

7.1 Hawthorne Autotransformer T5 and T6

7.1.1 Description

Hawthorne TS is a major supply point for the city of Ottawa (Figure 7 -1). The station has four 230kV/115 kV autotransformers. Two of these autotransformers, T5 and T6, have lower ratings, with 225 MVA continuous and 256 MVA LTR, respectively. Under contingency conditions, i.e. one of the autotransformers out of service, the ratings of these two autotransformers are exceeded and this limits the supply to the 115 kV network from the 230 kV system. As the load continues to grow on the 115 kV network, this limitation needs to be addressed. This had been identified as a near term need in the Ottawa Sub-Region IRRP [1] and was included in the Ontario Power Authority's ("OPA", now part of IESO) June 2014 letter to Hydro One [5].

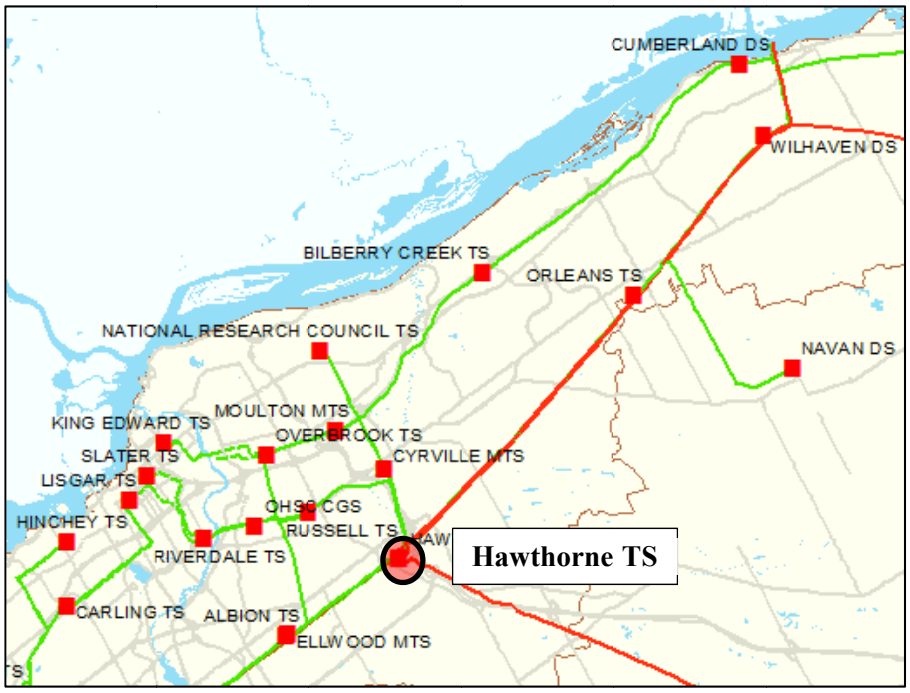

Figure 7-1 Hawthorne TS

7.1.2 Recommended Plan and Current Status

Hydro One has established a project to replace autotransformers T5 and T6 with new higher rated autotransformers. These autotransformers will have an LTR of at least 350 MVA. This investment will provide additional capacity and meet the needs of the area. It is expected that the project will be completed in 2018.

The cost of this project is expected to be $15.7 million. The project will be a transmission pool investment as the autotransformers provide supply to all customers in the Greater Ottawa Region.

7.2 Autotransformation Capacity and South West Area Station Capacity

7.2.1 Merivale TS Autotransformers T21 and T22/Hawthorne Autotransformer T9

Merivale TS has two 230 kV/115 kV autotransformers with an LTR station capacity of 312 MVA. The station is supplied from Hawthorne TS and from generators located west of Ottawa, along the Ottawa River and the Madawaska River. Merivale TS is shown in Figure 7-2.

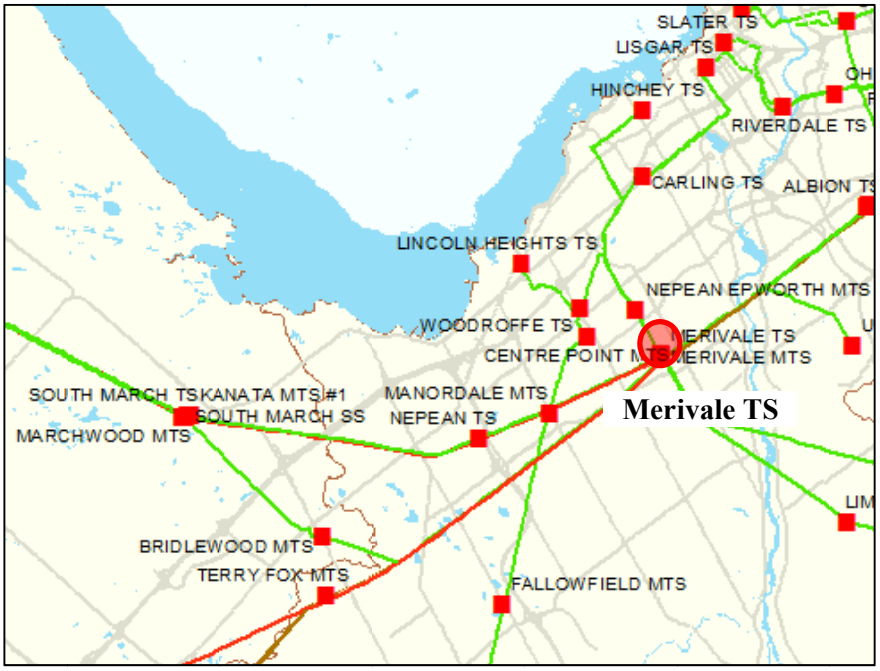

Figure 7-2 Merivale TS

The expected load growth provided by the LDCs and the minimum hydro generation assumption described in Section 6.2 causes the station capacity to be exceeded under contingency conditions by 2019. In addition, it is expected that autotransformers at Merivale TS and Hawthorne TS will reach their continuous loading limits of 250 MVA by 2024 and 2025. The exact timing of the autotransformer needs is dependent on the following factors:

- The South West area load forecast includes a proposed connection of a single large load increase coming into service in 2019.
- The need date is sensitive to generation at Stewartville GS, Barrett Chute GS and Chats Falls GS as its effect is to reduce the flow through the autotransformers.
- A potential solution to the need for additional supply capacity in the South West Area is a new 230 kV supply station which would remove some of the demand growth and existing load from the 115 kV network (see Section 7.2.2 for a complete description of this issue). This work would also help defer the need for additional autotransformer capacity at Merivale TS.

In order to address the Merivale TS autotransformer capacity concerns, additional 230/115 kV transformation capacity or load transfer from the 115 kV to the 230 kV system is required.

The provision of additional transformation capacity requires replacing the Merivale TS T22 autotransformer with a newer higher rated transformer in 2019 and adding a third autotransformer at the station in 2024. Alternatively a third transformer can be added at Merivale TS by 2019. To meet the required 2019 need date a decision on the autotransformer work is required by summer 2016.

Transferring load to the 230kV system requires establishing a new 230/27.6kV transformer station in the South West area to pick up some of the existing load and all of the new load growth. This is described in the following section.

7.2.2 Supply to South West Area – Line and Station Capacity

The South West area is served by Fallowfield MTS, Richmond MTS and Manotick DS connected to the 115kV circuit S7M out of Merivale TS. Load demand in the area is expected to increase by 52 MW in the next 10 years and both the line and station capacity are forecast to be exceeded by 2019.

The line limitation was identified in the OPA's June 2014 letter [5] to Hydro One. A section of the S7M circuit between the main line at STR R14-R15 JCT and Fallowfield Junction (see Figure 7-3 below) had a capacity of 420A. Hydro One review of the line capacity showed that the line rating was limited to respect safety clearances due to an underbuilt distribution feeder at Fallowfield MTS. This issue has been resolved with Hydro Ottawa carrying out the necessary work to lower the distribution feeder and increase the transmission line clearance. The line rating has been increased to 590A and is now adequate to meet forecast load until 2026.

Additional transformation capacity is required in the South West Area and both Fallowfield MTS and Richmond DS require load relief. Hydro Ottawa is planning for a capacity increase at Richmond DS and potentially a new station to relieve Fallowfield MTS in the Barrhaven area.

The IESO has initiated a public engagement process to gather community input for a preferred supply plan for the area including consideration of the potential for incremental CDM and DG resources and/or transmission expansion in the form of a new TS. The IRRP [1] recommended that given the required

timeline, it would be beneficial for early transmission planning options to be started in parallel to the engagement process, prior to completing the integrated plan.

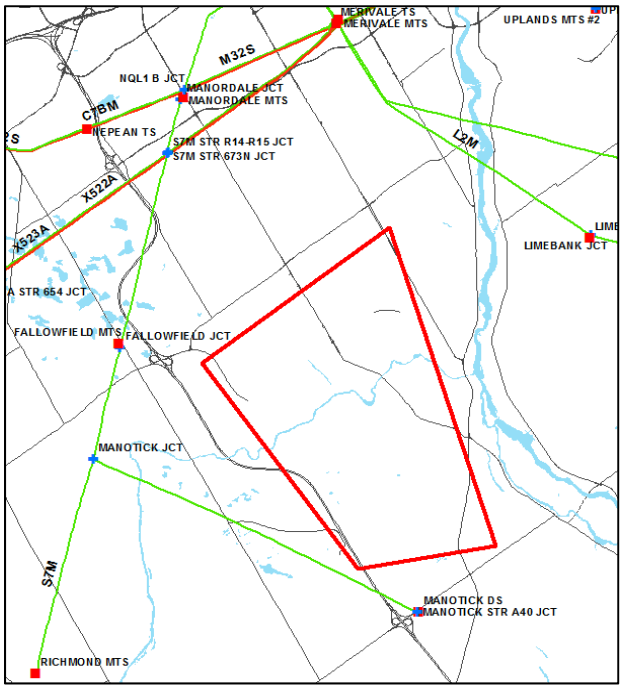

Figure 7-3 South West Area

At a high level, there are two main wire options to supply the South West area:

a) 115kV Option: Build a new 115/27.6kV transformer station and reinforce the existing 115 kV supply
b) 230kV option: Build a new 230/27.6kV transformer station and provide a new 230 kV transmission supply to the area.

The main advantage of the 115 kV option is that it defers the need for new transmission line until 2026. It however has a number of disadvantages: (a) loading will continue to increase on the 115kV system necessitating additional transformation capacity a Merivale TS by 2019 and Hawthorne TS by 2025, (b) all area stations remain on a single line supply until new transmission is built, and (c) the new 115 kV supply will provide less incremental capacity for the future.

The 230 kV option has the advantage of providing relief for the 230/115 kV autotransformers at Merivale TS and Hawthorne TS as well as provide more capacity to serve the area load. It also improves the area reliability by providing a second source of supply. The disadvantage is that transmission reinforcement will be required by 2019 and decision needs to be made as soon as possible.

The RIP has considered two options as examples for providing 230 kV supply to the area. Both examples consider building new double circuit 230 kV lines on existing Right of Way (“ROW”) in accordance with

the provincial government policy to maximize ROW use. The two options are described below (also refer to Figure 7-3).

- *S7M Based Option - Rebuild S7M as a double circuit 230 kV line.*

  This option would require rebuilding the existing single circuit115 kV circuit S7M tap to Fallowfield MTS as a new double circuit 230 kV line. The line would extend from the S7M STR R14-R15 JCT (on the main line) to Manotick Jct. Depending on the station location, a part of S7M from Manotick JCT to Manotick DS would also have to be rebuilt for a total line rebuild of up to 15.5 km. One circuit would be operated at 115 kV and continue to supply Fallowfield MTS, Richmond DS and Manotick DS. The other circuit would be tapped off the 230 kV circuit M29C which is adjacent to S7M at STR R14-R15 JCT and will be used to supply the new Hydro Ottawa station. This option may require sections of the existing ROW to be widened to accommodate the 230 kV circuits. Additional real estate rights will have to be obtained. EA and OEB Leave to Construct (Section 92) approvals will also be required.

- *L2M Based Option - Rebuild L2M as a double circuit 230 kV Line*

  This option would require rebuilding the existing 115 kV circuit L2M from Merivale TS to past Limebank MTS as a new double circuit 230 kV line. This section of the line would be constructed using the existing L2M ROW for a distance of 8.5 km. A new 6-8 km long ROW would need to be acquired going west from the L2M ROW to bring the transmission line to the load area, crossing the Rideau River. One circuit on the new line would remain L2M and be operated at 115 kV. The other circuit would connect to circuit M32S at Merivale TS and be operated at 230 kV. The new station will be supplied from the 230 kV circuit.

7.2.3 Recommended Plan and Current Status

The needs for autotransformation capacity and a new station in south west are interrelated. Further analysis is required to determine the impact of the 230 kV supply options for the new south west station on the Merivale TS and Hawthorne TS autotransformers. The planning assessment will consider whether a 115kV supply to the new station in combination with the addition of an autotransformer at Merivale is more cost effective than a 230kV supply.

The IESO is currently carrying out community engagement activities in the Ottawa region. The Working Group will be discussing the supply options for the South West area in conjunction with the autotransformer upgrade work at Merivale TS and expect to recommend a preferred plan for the area by summer 2016.

7.3 115 kV Transmission Circuit A4K Supply Capacity

7.3.1 Description

Circuit A4K is a 115 kV circuit supplying four downtown stations: Overbrook TS, King Edward TS, Cyrville MTS and Moulton MTS. Loading on the A4K this circuit can exceed its rating under peak load conditions for loss of 115 kV circuit A5RK. This need was identified as a near term need in the Ottawa Sub-Region IRRP [1] and included in the OPA's June 2014 letter to Hydro One [5]. In this letter, the preferred plan to relieve circuit A4K is outlined. This plan consists of rebuilding an approximately 2 km long section of single circuit 115 kV circuit A5RK between Overbrook TS to Riverdale Jct. as a double circuit line (see Figure 7-4). One of the circuits would remain A5RK and the other would be tapped to circuit A6R. Overbrook TS will be reconfigured to be supplied from circuits A5RK/A6R instead A4K/A5RK. This reconfiguration would remove Overbrook TS load from 115 kV circuit A4K and eliminate the overloading on A4K for the loss of A5RK.

7.3.2 Current Status

Hydro One has initiated the development work for this line rebuild. The project is currently in the engineering and estimating phase. The project is not expected to require Leave to Construct (Section 92) approval, but will require Environmental Assessment ("EA") approvals.

The project is expected to be in service by spring 2019 and preliminary estimates suggest the cost to be approximately $9 million to $11 million. This work will be part of the Line Connection pool and costs will be recovered from the rate revenue and/or customer capital contribution in accordance with the TSC. As a result, the LDC may be required to make a capital contribution.

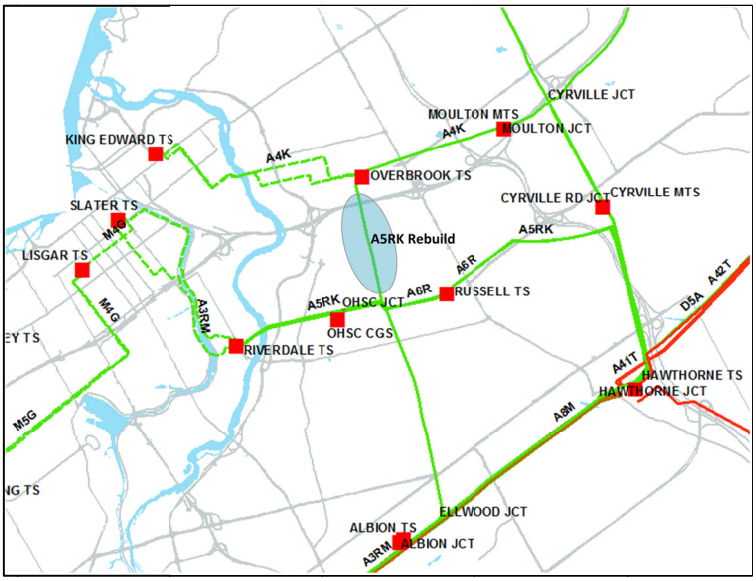

Figure 7-4 Option to Rebuild A5RK as Double-Circuit 115 kV Line

In the interim, Hydro One and Hydro Ottawa have operational mitigating measures to manage the overload on 115 kV circuit A4K if it becomes of concern before Hydro One has completed the line rebuild work. These measures include the transfer of Cyrville MTS to single supply from circuit A2 only by opening the A4K breaker at Cyrville MTS, and the transfer of some load from Moulton MTS to other stations in the area.

7.4 Station Capacity – Ottawa Centre 115 kV Area

7.4.1 Description

The Ottawa Center 115 kV area covers the City of Ottawa downtown district and extends from the Ottawa River in the north to Smyth Road in the south as shown in Figure 7-5 below. It is served by six 115/13.2 kV step-down transformer stations – King Edward TS, Lisgar TS, Overbrook TS, Riverdale TS, Russell TS and Slater TS. Most of the area stations are at or near capacity. Even with the Overbrook upgrade work now underway additional load meeting capability is forecast to be required by 2018 as shown in Table 6.3.

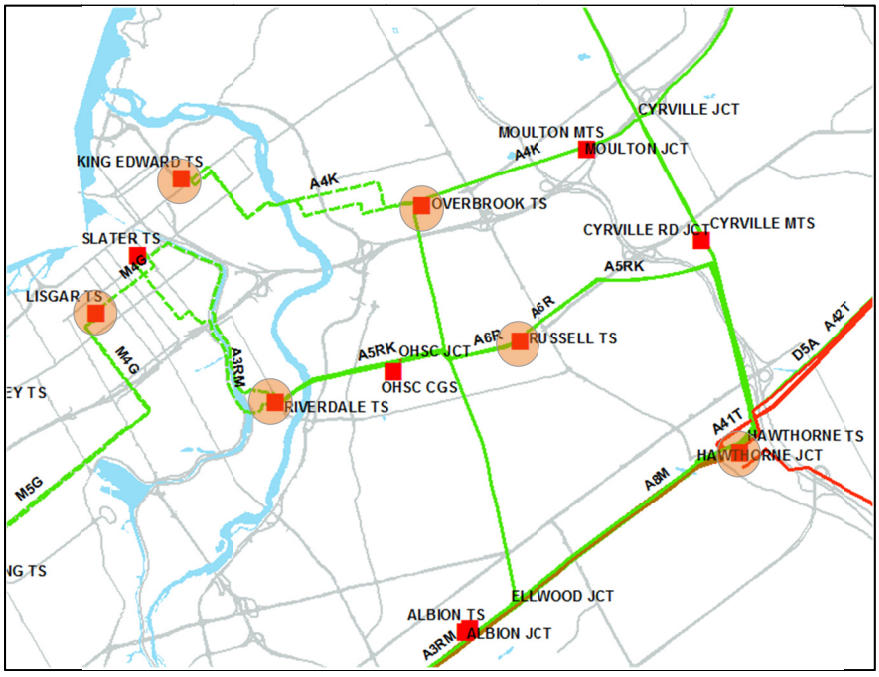

Figure 7-5 Downtown Ottawa Stations

7.4.2 Recommended Plan and Current Status

The existing step-down stations in the area are equipped with older 45/75 MVA transformers which have a LTR of between 70-80 MW. The preferred alternative to provide additional transformation capacity in the area is to replace these units with larger sized 100 MVA units where possible with an LTR of up to 130 MW.

During this regional planning cycle, the Working Group participants agreed to take advantage of transformer replacements necessitated by end-of-life considerations as this was the lowest cost and most practical option to provide additional capacity. The alternative of building a new station to provide capacity was ruled out because of the high cost and the difficulty in acquiring an appropriate site.

Upgrade of the end of life transformers at Overbrook TS is currently underway. In the future, the Working Group will continue to look for opportunities to upgrade based on end-of-life considerations of transformers. Hydro One will keep the Working Group informed of these opportunities. In addition, load transfers are also recommended to utilize available capacity at adjacent stations.

7.4.2.1 Russell TS and Riverdale TS

The loading on these stations will be kept within limits by Hydro Ottawa building feeder ties to transfer excess loads to other area stations. This will keep the loading on the transformers at these stations within their rating. A high level cost estimate of Hydro Ottawa's distribution work is $2 million.

7.4.2.2 Overbrook TS

Hydro One had identified that the step-down transformers at Overbrook TS were approaching end-of-life and consideration was therefore given to upgrading the transformers at the station. Accordingly Overbrook TS transformers are being replaced with larger sized units which will increase the station capacity from 72 MW to 130 MW. The work is underway and planned to be completed in Q2 2018. The incremental cost of upgrading to larger transformers is estimated to be $1.1 million. The cost of upgrading is expected to be recovered from incremental rate revenue in accordance with the TSC. Based on current forecast Hydro Ottawa is not expected to pay any capital contribution for this project.

7.4.2.3 Lisgar TS

Lisgar TS has two 75 MVA transformers. To meet the forecast load requirement additional transformation capacity is required in the Central 115kV area. Hydro Ottawa has therefore asked that the Lisgar TS transformers be replaced with larger 100 MVA units. The cost of the work is estimated to be about $14 million and will be recovered from rate revenue and customer capital contribution in accordance with the TSC. The target in-service date is Q4 2017.

7.4.2.4 King Edward TS

The capacity at King Edward TS is 71 MW. By replacing the limiting transformer T4 and additional low voltage ("LV") components such as circuit breakers and cable, a higher capacity of up to 130 MW can be achieved at King Edward TS.

Considering the Overbrook TS and Lisgar TS upgrades, adequate capacity will be available in the Center area until 2021. After discussion with Hydro Ottawa, the King Edward TS transformer upgrade work is tentatively scheduled for an in-service date of 2021. The project cost is estimated to be about $12M and will be recovered from rate revenue and customer capital contribution in accordance with the TSC.

7.5 Station Capacity - Hawthorne TS 44kV

Hawthorne TS has two 50/83 MVA, 230/44kV transformers with an LTR of 89 MW. Additional 44kV capacity is required at the station. Hydro One identified that the step- down transformers at Hawthorne TS were approaching end-of-life and needed to be replaced. The lowest cost alternative to provide this additional capacity was to take advantage of the transformer replacement work and install larger 75/125 MVA transformers with an LTR of 153 MW. This work is currently underway and planned to be completed by summer 2019.

Additional 44kV feeder positions will be required to utilize this increased capacity. These feeders will be added as required.

The incremental cost of upgrading to larger transformers is estimated to be approximately $1.1 million. Feeder position costs have not been estimated at this time. Incremental transformer costs and the feeder costs will be recovered in accordance with the TSC. Based on the current forecast Hydro Ottawa is not expected to pay any capital contribution for this project.

7.6 Bilberry Creek TS End of Life

7.6.1 Description

Bilberry Creek TS is a 115/27.6 kV step-down transformer in East Ottawa, supplying up to 85 MW of load customers to both Hydro Ottawa and Hydro One Distribution. The station was built in 1964 and a number of its key components have been identified for replacement by Hydro One. This station's refurbishment work is to be complete by 2023. A decision will be required by 2020 on whether to refurbish the station and keep the load on the 115 kV system or to retire the station and move the load over to the 230 kV system by supplying it from the newly built Orleans TS.

A Local Plan [3] carried out by Hydro One shows that the two options are similar in costs. The retirement option however, may be more attractive particularly if 115 kV load growth rate is high in the Ottawa Center area. The retirement option will reduce the loading of the 230 kV/115 kV autotransformers at Hawthorne TS and Merivale TS and make it available for the Ottawa Center 115 kV load. Figure 7-6 shows the area under consideration.

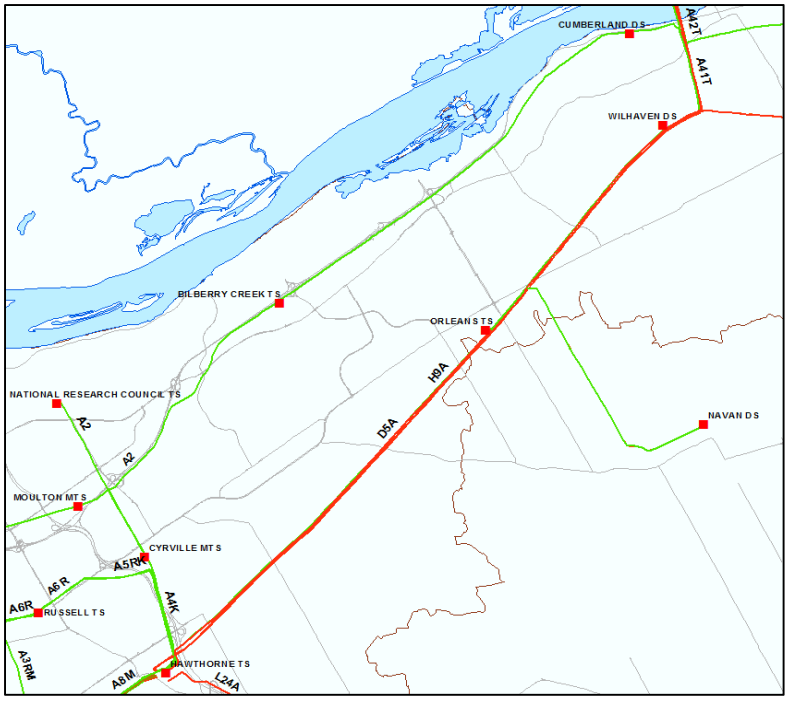

Figure 7-6 Bilberry Creek TS and the East Ottawa Area

7.6.2 Recommended Plan and Current Status

The two alternatives are very similar in cost and each has its own pros and cons. The refurbishment option minimizes work on the distribution system, but leaves the load on the 115kV system and with lower overall capacity to meet long term growth. The retirement option moves Bilberry Creek load to the 230kV system with higher long term load meeting capability but involves relocating distribution feeders from Bilberry Creek TS to Orleans TS.

The Working Group has recommended that a decision on Bilberry Creek refurbishment be deferred to the next regional planning cycle as there is still sufficient time to make an investment decision.

7.7 Almonte TS and Terry Fox TS Reliability

7.7.1 Description

Almonte TS and Terry Fox MTS are supplied from the 319 km long 230kV circuit M29C, see Figure 7-7. Due to the long length of the line the exposure to outages is high. The line has averaged approximately 6-7 interruptions per year over the last 10 years. With Terry Fox MTS coming into service in 2013, concerns were expressed about the number of outages that would be seen by the station. This issue was identified in the Ottawa Sub-Region IRRP [1] and the OPA's June 2014 letter [5].

7.7.2 Recommended Plan and Current Status

Hydro One had initiated a project in 2012 to install a 230 kV circuit breaker at Almonte TS. This breaker would sectionalize the M29C line into two sections: E29C – 281 km Cherrywood TS to Almonte TS; and E34M – 38 km Almonte TS to Merivale TS. This breaker will help with the number of interruptions at Almonte TS and Terry Fox MTS by eliminating outages due to the Almonte TS x Cherrywood section of the circuit.

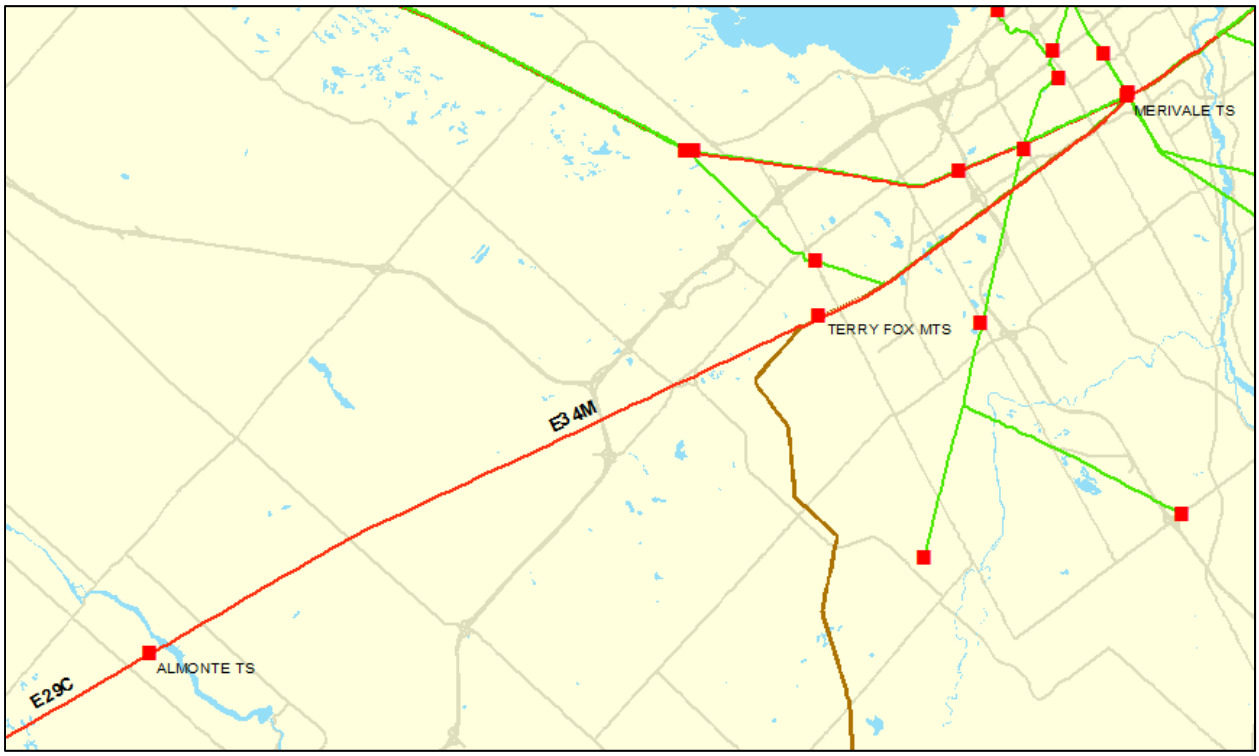

Figure 7-7 Lines E29C and E34M (M29C). In-Line Breaker at Almonte TS.

The total cost of this project is estimated to be $4.7 million and the project is scheduled to be completed by December 2015.

A second supply from Merivale TS to Terry Fox MTS was previously considered as an option to improve reliability. However it was decided to install the in-line breaker at Almonte TS since it was the cost effective and provided reliability improvement to both Almonte TS and Terry Fox MTS.

It should be noted that the Terry Fox TS is operated with the LV bus tie open. This arrangement has the disadvantage that in case of a transformer outage, the load connected to that transformer will be lost momentarily before the bus tie is closed to allow all loads to be supplied from the other side. A second supply to Terry Fox MTS can still be considered to address this issue as the load increases as part of a longer term supply plan. This will continue to be reviewed.

7.8 Orleans TS Reliability

7.8.1 Description

Orleans TS is a new station Hydro One built in East Ottawa to provide additional transformation capability and improve supply reliability for Hydro One Distribution customers connected to the 115 kV circuit H9A.

The Orleans TS is built adjacent to the double circuit H9A/D5A line about 10 km from Hawthorne TS and has one step-down transformer station supplied from 230 kV circuit D5A and the second step-down transformer supplied from the 115 kV circuit H9A. The station is operated with the LV bus tie open so as to avoid any power flow between the 230 kV and 115 kV systems through the station transformers. This arrangement has the disadvantage that in case of a circuit or transformer outage, the load connected to that circuit or transformer will be lost momentarily before the bus tie is closed to allow all loads to be supplied from the other side.

7.8.2 Recommended Plan and Current Status

Orleans TS has greatly improved the reliability of customers previous supplied from Wilhaven DS and Navan DS connected to 115kV circuit H9A. The customers experienced sustained interruptions every time circuit H9A had an outage. With the Orleans TS LV bus tie arrangement customer are exposed to a momentary interruption only as the load is picked up by closing the bus tie. This arrangement was accepted as a cost effective alternative to building 10 km of transmission line between Hawthorne TS and Orleans TS to provide a dual supply to Orleans TS.

Depending on the decision taken for Bilberry Creek TS described in section 7.6, Orleans TS could be converted to a 230 kV station and the LV bus tie closed. This option would be preferred if Bilberry Creek TS is recommended to be retired. If Bilberry Creek TS is refurbished then the plan will see Orleans TS continued operation with two different voltage supplies.

The Working Group recommendation is to monitor the performance of Orleans TS to see if mitigation measures are warranted. The Working Group will further review this issue in the next regional planning cycle as part of the Bilberry TS retirement study. No further action is required at this time.

7.9 Load Restoration for the Loss of B5D/D5A

7.9.1 Description and Current Status

The NA report for the Outer Ottawa Sub-Region [2] identified that the combined loss of circuits D5A and B5D would result in a load loss of up to 174 MW. The stations considered in this analysis are St Isidore TS, Longueil TS, and Ivaco CTS. Orleans TS is also supplied by D5A however; its second supply is H9A and is not considered for the combined loss of D5A/B5D. As indicated in ORTAC, any load lost above 150 MW must be restored within 4 hours and all load be restored within 8 hours.

A LP report [4] carried out by Hydro One shows that historically, the coincidental occurrence of forced sustained outages of B5D and D5A are rare and in all cases one of the circuits was restored in less than 4 hours as per ORTAC. The report concludes that no further action is required at this time.

7.10 Load Loss for S7M Contingency

7.10.1 Description and Current Status

Circuit S7M is the single supply for the following stations: Bridlewood MTS, Fallowfield MTS, Manotick DS, and Richmond DS. The combined load at these four stations is expected to exceed 150 MW by 2022. The ORTAC requires that not more than 150MW of load may be interrupted by configuration. However, given that the 150 MW limit is anticipated in the long term, no action is required at this time.

7.11 Voltage Regulation on 115kV Circuit 79M1

7.11.1 Description and Current Status

The 115 kV circuit 79M1 supplies Rockland DS, Rockland East DS, Clarence DS, Wendover DS, and Hawkesbury MTS. The NA for Outer Ottawa Sub-Region [2] identified that the voltage at Hawkesbury TS will approach operating limits under peak load and contingency conditions by 2023.

As mentioned in the Outer Ottawa Sub-Region NA report [2], Hydro One monitors the status of the network. Given the timing for this need, this will be reassessed during the next regional planning cycle.

7.12 Voltage at Stewartville TS

7.12.1 Description and Current Status

The load on the Stewartville TS is expected to increase significantly as a result of the connection of a large utility load forecasted for 2018. This load may require reactive support to help maintain the voltages within limits during peak load conditions and no generation at Stewartville GS.

A connection impact assessment will be undertaken by Hydro One as part of connecting the utility load. Any requirements to connect the load, including reactive power support, will be outlined in the document.

7.13 Voltage Drop at Terry Fox MTS for E34M open at the Merivale End

7.13.1 Description

Circuit E34M/E29C (new name for circuit M29C following the installation of a breaker at Almonte TS) is a 319 km line between Cherrywood TS in Pickering, and Merivale TS in Ottawa. If the circuit E34M (Almonte-Merivale) is open at the Merivale end, Terry Fox MTS and Almonte TS will be supplied

radially by Cherrywood TS. Given the distance between the Greater Ottawa stations and Cherrywood TS, voltages are lower than acceptable limits during normal and peak load periods and only load of up to 25 MW can be supplied with acceptable voltage. The 2012 IESO System Impact Assessment ("SIA") recommended the installation of 20 MVARs of capacitor banks at Terry Fox MTS to meet a peak load of up to 48 MW.

7.13.2 Recommended Plan and Current Status

It is recommended that Hydro Ottawa install 20 MVARs of capacitor banks at Terry Fox MTS. This should be adequate for the near term.

Terry Fox MTS is part of the Ottawa Area under voltage load rejection scheme ("UVLS"). This scheme is designed to shed the station load if the 230 kV supply voltage to the station drops below 204 kV when it is activated. Currently the scheme is only armed when the entire Ottawa Area UVLS is armed. It is proposed to modify the scheme so that it can be selectively armed when loading levels are higher than 48MW and under conditions that may result in a circuit M29C line end open at Merivale TS.

Historically the probability of this line end open occurring is low and it would typically occur while terminal maintenance is done at Merivale. By scheduling maintenance during off peak periods, the impact can be significantly reduced. No mitigation measures are therefore recommended at this time. Hydro One and Hydro Ottawa will be monitoring the system performance and the matter will be reconsidered in the next planning cycle based on operating experience.

7.14 Low Power Factor at Almonte TS

7.14.1 Description and Current Status

The IESO's SIA for Almonte T3 replacement noted a low power factor at Almonte TS. This potential issue was also reported in the Outer Ottawa Sub-Region NA report [2].

Hydro One has reviewed the power factor at Almonte TS. The station power factor varies from 0.89 to 0.95 at the LV bus which translates into approximately 0.86 to 0.92 on the HV bus. Part of the reason for the lower power factor is that the station has 29 MW of DG which generally operates at unity power factor. The generation reduces the net power in MW seen at the metering point. This reduction in power results in a lower power factor as seen from the HV bus since the generation does not offset the reactive power demand of the station. No action is required as the load power factor without DG is within the acceptable limits.

8. CONCLUSION AND NEXT STEPS

THIS REGIONAL INFRASTRUCTURE PLAN REPORT CONCLUDES THE REGIONAL PLANNING PROCESS FOR THE GREATER OTTAWA REGION. THIS REPORT MEETS THE INTENT OF THE PROCESS DESCRIBED IN SECTION 2 WHICH IS ENDORSED BY THE OEB AND MANDATED IN THE TSC AND DSC.

This RIP report addresses near term and mid-term regional needs identified in the earlier phases of the Regional Planning process and during the RIP phase. Next Steps, Lead Responsibility, and Timeframes for implementing the wires solutions for the near term needs are summarized in the Table 8-1 below.

Investments to address the mid-term needs, for cases where there is time to make a decision, will be reviewed and finalized in the next regional planning cycle. These needs are summarized in Table 8-2.

No long term needs were identified at this time. As per the OEB mandate, the Regional Plan should be reviewed and/or updated at least every five years.. The region will continue to be monitored and should there be a need that emerges due to a change in load forecast or any other reason, the next regional planning cycle will be started earlier to address the need.

Table 8-1 Regional Plans – Next Steps, Lead Responsibility and Plan In-Service Dates

No.	Project	Next Steps	Lead Responsibility	I/S Date	Cost
1	Almonte TS: addition of breaker to sectionalize line M29C	Construction in the final stages	Hydro One	Dec. 2015	$4.7M
2	Russell TS and Riverdale TS: construction of feeder ties to allow extra load transfers	LDC will lead this work	Hydro Ottawa	2017-2020	$2.0M
3	Lisgar TS: replacement of transformers T1 and T2	Transmitter to carry out this work	Hydro One	Dec. 2017	$13.9M
4	Hawthorne TS: replacement of autotransformers T5 and T6	Transmitter to carry out this work	Hydro One	May 2018	$15.7M
5	Overbrook TS: replacement of transformers T3 and T4	Transmitter to carry out this work	Hydro One	June 2018	$1.1M[(1)]
6	A6R: additional tap to offload A4K	Transmitter to carry out this work	Hydro One	June 2019	$9-11M
7	Hawthorne TS: replacement of transformers T7 and T8 and add one 44kV feeder position	Transmitter to carry out this work	Hydro One	Oct. 2019	$1.1M[(2)]
8	New South West Station And Merivale 230/115kV Transformation Capacity	IESO and Hydro Ottawa leading consultation	IESO/Hydro Ottawa	2020	--- [(3)]
9	King Edward TS: Replace Transformer T4	Transmitter to carry out this work	Hydro One	June 2021	$12M

[(1)] Incremental cost for larger transformer only.
[(2)] Incremental cost for larger transformer only. Feeder costs have not been estimated at this time.
[(3)] The Working Group expects to make a final recommendation on this plan by early 2016.

Table 8-2 List of Mid-Term Needs to be Reviewed in Next Regional Planning Cycle

No.	Need	Timing
1	Bilberry Creek TS - Refurbishment	2023
2	Orleans TS - Reliability	2023[(1)]
3	79M1 Circuit – Voltage regulation	2023

(1) Performance will be monitored to see if mitigation measures are warranted. Need will be reviewed along with Bilberry Creek TS refurbishment.

9. REFERENCES

[1]. Independent Electricity System Operator, "Ottawa Area Integrated Regional Resource Plan", 28 April 2015.
http://www.ieso.ca/Documents/Regional-Planning/Greater_Ottawa/2015-Ottawa-IRRP-Report.pdf

[2]. Hydro One, "Needs Screening Report, Greater Ottawa Region – Outer Ottawa Sub Region", 28 July 2014.
http://www.hydroone.com/RegionalPlanning/Ottawa/Documents/Needs%20Assessment%20Report%20-%20Greater%20Ottawa%20-%20Outer%20Ottawa%20SubRegion.pdf

[3]. Hydro One, "Local Planning Report – Supply to East Ottawa Area", 26 November 2015.
http://www.hydroone.com/RegionalPlanning/Ottawa/Documents/Local%20Planning%20Report%20-%20Supply%20to%20East%20Ottawa%20Area.pdf

[4]. Hydro One, "Local Planning Report - B5D-D5A Load Restoration", 22 September 2015.
http://www.hydroone.com/RegionalPlanning/Ottawa/Documents/Local%20Planning%20Report%20-%20B5D-D5A%20Load%20Restoration.pdf

[5]. Hydro One, "OPA Letter – Ottawa Area Regional Planning", 27 June 2014.
http://www.hydroone.com/RegionalPlanning/Ottawa/Documents/Letter%20to%20H1%20RE%20Ottawa.pdf

[6]. Independent Electricity System Operator, "Review of Ontario Interties", 14 October 2014.
http://www.ieso.ca/Documents/IntertieReport-20141014.pdf

APPENDIX A: STATIONS IN THE GREATER OTTAWA REGION

No.	Station	Voltage (kV)	Supply Circuits
1	Albion TS	230	M30A, M31A
2	Almonte TS	230	M29C (E34M, E29C)
3	Arnprior TS	115	W6CS, C7BM
4	Bilberry Creek TS	115	A2, H9A
5	Bridlewood MTS	115	S7M
6	Carling TS	115	M4G, M5G
7	Centrepoint MTS	115	C7BM
8	Clarence DS	115	79M1
9	Cumberland DS	115	H9A
10	Cyrville MTS	115	A2, A4K
11	Ellwood TS	230	M30A, M31A
12	Epworth MTS	115	M4G, M5G
13	Fallowfield DS	115	S7M
14	Greely DS	115	M1R
15	Hawkesbury MTS	115	79M1
16	Hawthorne	230	-
18	Ivaco	230	D5A
19	Kanata MTS	230	C3S, M32S
20	King Edward TS	115	A4K, A5RK
21	Limebank MTS	115	L2M
22	Lincoln Heights TS	115	C7BM, F10MV
23	Lisgar TS	115	M4G, M5G
24	Longueuil TS	115	B5D, D5A
25	Manordale MTS	115	C7BM
26	Manotick DS	115	S7M
27	Marchwood MTS	115	S7M, W6CS
28	Marionville DS	115	L2M
29	Merivale TS	115	-
30	Moulton MTS	115	A4RK
31	Nation Research TS	115	A2
32	National Aeronautical CTS	115	A8M
33	Navan DS	115	H9A
34	Nepean TS	115	M32S
35	Orleans TS	230 & 115	D5A, H9A
36	Overbrook TS	115	A4K, A5RK
38	Riverdale TS	115	A3RM, A5RK
39	Rockland DS	115	79M1
40	Rockland East DS	115	79M1

41	Russell DS	115	M1R
42	Russell TS	115	A5RK, A6R
43	Slater TS	115	A3RM, A5RK, M4G
44	South Gloucester DS	115	M1R
45	South March	230	C3S, M32S
46	St. Isidore TS	230	B5D, D5A
47	Stewartville TS	115	W3B, W6CS
48	Terry Fox MTS	230	M29C (E34M)
49	Uplands MTS	115	A8M
50	Wendover DS	115	79M1
51	Wilhaven DS	115	H9A
52	Woodroffe TS	115	C7BM, F10MV

APPENDIX B: TRANSMISSION LINES IN THE GREATER OTTAWA REGION

Location	Circuit Designations	Voltage (kV)
Hawthorne TS – Merivale TS	M30A, M31A	230
Hawthorne TS – St Isidore TS	D5A	230
Merivale TS – Almonte TS	E34C (formally M29C)	230
Merivale TS – South March TS	M32S	230
South March SS – Chats Falls SS	C3S	230
Hawthorne TS – Bilberry Creek TS	A2	115
Hawthorne TS - Merivale TS	A3RM, A8M	115
Hawthorne TS – Overbrook TS	A4K, A5RK	115
Hawthorne TS – Riverdale TS	A6R	115
Hawthorne TS – Hawkesbury MTS	H9A/79M1	115
Merivale TS – Chats Falls TS	C7BM	115
Merivale TS – Hinchey TS	F10MV, V12M	115
Merivale TS – Lisgar TS	M4G, M5G	115
Merivale TS – South March SS	S7M	115
Stewartville TS – South March SS	W6CS	115
Stewartville TS – Barrett Chute TS	W3B	115

APPENDIX C: DISTRIBUTORS IN THE GREATER OTTAWA REGION

Distributor Name	Station Name	Connection Type
Hydro 2000	Longueuil TS	Dx
Hydro Hawkesbury	Hawkesbury MTS	Tx
	Longueil TS	Dx
Hydro One	Almonte TS	Tx
	Arnprior TS	Tx
	Bilberry Creek TS	Tx
	Clarence DS	Tx
	Cumberland DS	Tx
	Greely DS	Tx
	Hawthorne TS	Tx
	Longueil TS	Tx
	Manotick DS	Tx
	Marionville DS	Tx
	Navan DS	Tx
	Orleans TS	Tx
	Rockland DS	Tx
	Rockland East DS	Tx
	Russell DS	Tx
	South Gloucester DS	Tx
	St Isidore TS	Tx
	Stewartville TS	Tx
	Wilhaven DS	Tx
Hydro Ottawa	Albion TS	Tx
	Almonte TS	Dx
	Bilberry Creek TS	Tx
	Bridlewood MTS	Tx
	Carling TS	Tx
	Centrepoint MTS	Tx
	Cyrville MTS	Tx
	Ellwood MTS	Tx
	Nepean Epworth MTS	Tx
	Fallowfield DS	Tx
	Hawthorne TS	Dx, Tx
	Hinchey TS	Tx
	Kanata MTS	Tx
	King Edward TS	Tx

Hydro Ottawa	Limebank MTS	Tx
	Lincoln Heights TS	Tx
	Lisgar TS	Tx
	Manordale MTS	Tx
	Marchwood MTS	Tx
	Moulton MTS	Tx
	Merivale MTS	Tx
	Nepean TS	Tx
	Orleans TS	Tx
	Overbrook TS	Tx
	Richmond MTS	Tx
	Riverdale TS	Tx
	Russell TS	Tx
	Slater TS	Tx
	South Gloucester DS	Dx
	South March TS	Dx, Tx
	St Isidore TS	Dx
	Terry Fox MTS	Tx
	Upland MTS	Tx
	Woodroffe TS	Tx
Ottawa River Power Corporation	Almonte TS	Dx
Renfrew Hydro	Stewartville TS	Dx

APPENDIX D: AREA STATIONS LOAD FORECAST

Table D-1 Stations Coincident Load Forecast (MW)

Area	Station	LTR	2015	2016	2017	2018	2019	2020	2021	2023	2025	2027	2029	2031	2033	2035
Center 115	King Edward TS	71	70	67	69	75	75	75	76	77	78	77	77	78	77	77
	Lisgar TS	75	64	67	71	74	74	75	75	87	88	90	90	90	89	89
	Overbrook TS	130	85	91	94	100	101	102	108	110	111	112	113	114	115	116
	Riverdale TS	105	102	99	102	111	112	112	114	118	119	120	121	123	123	124
	Russell TS	69	61	63	65	73	73	73	73	73	73	73	73	73	73	73
	Slater TS	118	106	113	114	116	115	114	114	113	112	112	111	110	110	110
	Total	**569**	**488**	**501**	**515**	**549**	**549**	**550**	**559**	**578**	**581**	**584**	**586**	**588**	**589**	**590**
Center 230	Albion	88	71	72	73	73	73	73	74	74	75	75	76	77	77	77
	Ellwood TS	59	27	28	28	28	28	28	28	28	28	28	28	28	29	29
	Hawthorne	153	107	117	120	124	126	128	132	137	136	140	138	139	138	138
	Total	**300**	**206**	**217**	**221**	**225**	**227**	**229**	**234**	**239**	**239**	**243**	**243**	**244**	**243**	**243**
East 115	Bilberry Creek TS	85	87	54	54	54	54	54	54	54	55	55	55	55	55	56
	Cumberland DS	15	5	6	6	6	6	6	6	6	6	6	6	6	7	7
	Cyrville MTS	59	24	30	35	35	37	38	40	42	44	44	44	44	44	44
	Moulton MTS	34	31	32	32	32	32	32	32	33	33	33	33	34	34	34
	Nation Research TS	25	18	18	18	18	18	18	18	18	18	18	18	18	18	18
	Navan DS	15	6	6	6	6	6	6	6	6	6	6	6	5	5	5
	Orleans TS	51	0	45	46	46	47	48	48	50	50	51	52	54	55	57
	Wilhaven DS	58	49	4	5	5	6	6	6	7	10	11	12	12	14	16
	Total	**340**	**221**	**193**	**201**	**202**	**205**	**208**	**210**	**215**	**221**	**224**	**226**	**228**	**232**	**237**
East 230	Orleans TS	51	0	45	46	46	47	48	48	50	50	51	52	54	55	57
	Total	51	**0**	**45**	**46**	**46**	**47**	**48**	**48**	**50**	**50**	**51**	**52**	**54**	**55**	**57**
South 115	Greely DS	40	17	18	18	18	18	18	18	18	18	18	19	19	19	19
	Limebank MTS	68	44	47	49	52	54	56	59	64	70	76	82	89	88	88
	Marionville DS	28	13	14	14	14	14	14	14	14	14	14	14	15	15	15
	National Aeronautical CTS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Russell DS	8	3	3	3	3	3	3	3	3	3	3	3	3	3	4
	South Gloucester DS	8	4	4	4	4	4	4	4	4	4	5	5	5	5	5
	Uplands MTS	30	25	26	26	27	27	27	27	28	29	29	30	30	30	30
	Total	**182**	**109**	**112**	**115**	**118**	**121**	**123**	**126**	**133**	**140**	**147**	**154**	**161**	**161**	**161**
South West 115	Fallowfield DS	48	36	39	38	41	49	51	54	58	61	67	71	76	82	89
	Manotick DS	17	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Richmond DS	5	9	10	11	13	31	34	36	36	37	38	39	38	38	38
	Total	**70**	**52**	**56**	**56**	**61**	**87**	**92**	**97**	**101**	**106**	**112**	**118**	**122**	**127**	**134**

West 115	Bridlewood MTS	37	22	22	23	22	22	22	23	39	39	39	39	39	39	39
	Carling TS	93	82	83	84	85	86	86	87	93	95	96	98	99	100	102
	Centrepoint MTS	35	17	17	17	17	17	16	16	16	16	16	16	16	16	16
	Epworth	25	15	15	16	16	16	16	15	15	15	15	15	15	15	15
	Hinchey TS	77	58	60	62	66	68	70	72	67	71	75	79	83	87	90
	Lincoln Heights TS	71	45	45	45	45	44	44	44	49	49	49	48	48	48	48
	Manordale MTS	22	11	11	11	11	11	11	11	11	11	11	11	10	10	10
	Marchwood MTS	34	34	34	34	35	34	34	34	35	34	35	35	35	36	37
	Merivale TS	18	14	14	13	15	15	15	15	16	17	19	20	20	19	19
	Woodroffe TS	92	39	40	41	42	42	43	43	53	54	55	56	56	57	58
	Total	**504**	**336**	**340**	**346**	**353**	**355**	**356**	**362**	**395**	**402**	**410**	**417**	**421**	**427**	**434**
West 230	Kanata MTS	55	46	47	47	47	47	46	47	47	48	48	48	48	48	48
	Nepean TS	144	145	144	143	143	141	139	138	136	134	132	130	128	127	127
	South March	109	116	110	115	119	123	126	131	123	104	104	104	104	103	104
	Terry Fox MTS	90	39	50	78	83	65	65	64	63	63	62	61	60	60	60
	Total	**397**	**346**	**351**	**383**	**391**	**376**	**376**	**380**	**370**	**349**	**345**	**343**	**340**	**337**	**338**
Outer East 115	Clarence DS	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Hawkesbury MTS	18	15	15	15	15	15	15	15	15	16	16	16	16	16	16
	Rockland DS	9	8	8	8	8	8	8	9	9	9	9	9	9	9	9
	Rockland East DS	15	12	12	12	12	12	12	12	13	13	13	13	13	13	13
	Wendover TS	34	12	12	12	12	12	12	12	14	14	14	14	13	13	13
	Total	**80**	**49**	**49**	**50**	**50**	**50**	**50**	**51**	**55**	**55**	**55**	**55**	**55**	**55**	**56**
Outer East 230	Ivaco	100	40	40	40	40	40	40	40	40	40	40	40	40	40	40
	Longueuil TS	98	31	31	31	31	30	30	30	30	30	30	30	30	30	30
	St. Isidore TS	52	35	35	36	35	35	35	35	35	35	35	35	35	35	35
	Total	**249**	**106**	**106**	**106**	**106**	**106**	**105**	**105**	**105**	**105**	**105**	**105**	**105**	**105**	**105**
Outer West 115	Arnprior TS	51	36	36	36	36	35	35	35	34	34	34	34	34	34	34
	Stewartville TS	55	30	30	30	46	46	45	45	45	45	45	45	45	45	45
	Total	**106**	**66**	**66**	**66**	**82**	**81**	**80**	**80**	**79**	**79**	**79**	**79**	**79**	**79**	**79**
Outer West 230	Almonte TS	100	35	34	34	34	34	33	33	33	33	33	33	33	33	33
	Total	**100**	**35**	**34**	**34**	**34**	**34**	**33**	**33**	**33**	**33**	**33**	**33**	**33**	**33**	**33**
Regional Total		**2948**	**2013**	**2069**	**2140**	**2219**	**2238**	**2249**	**2285**	**2352**	**2360**	**2388**	**2411**	**2430**	**2445**	**2468**

Table D-2 Stations Non Coincident Forecast (MW)

Area	Station	LTR	2015	2016	2017	2018	2019	2020	2021	2023	2025	2027	2029	2031	2033	2035
Center 115	King Edward TS	71	88	84	87	93	93	93	94	96	97	97	96	97	96	96
	Lisgar TS	75	67	70	74	78	78	78	79	91	92	94	94	94	93	93
	Overbrook TS	130	84	91	93	99	100	102	107	109	110	111	112	113	114	115
	Riverdale TS	105	78	76	78	84	85	86	87	90	91	92	93	93	94	95
	Russell TS	69	74	77	80	90	89	89	89	89	89	89	90	90	90	90
	Slater TS	118	125	133	134	136	135	134	134	133	132	131	131	130	129	129
	Total	**569**	**516**	**530**	**546**	**580**	**581**	**581**	**590**	**608**	**612**	**614**	**615**	**617**	**617**	**619**
Center 230	Albion	88	77	79	80	80	80	80	80	81	82	82	83	84	84	84
	Ellwood TS	59	43	43	44	44	44	43	44	44	44	44	44	45	45	45
	Hawthorne	153	103	115	120	124	126	128	132	137	136	140	138	139	138	138
	Total	**300**	**223**	**238**	**243**	**248**	**250**	**251**	**256**	**262**	**262**	**266**	**266**	**267**	**266**	**267**
East 115	Bilberry Creek TS	85	87	54	54	54	54	54	54	54	55	55	55	55	55	56
	Cumberland DS	15	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Cyrville MTS	59	25	31	37	37	39	40	42	44	47	47	47	47	47	47
	Moulton MTS	34	40	40	40	41	40	40	41	41	41	42	42	42	43	43
	Nation Research TS	25	18	19	19	19	19	18	19	19	19	18	18	18	18	18
	Navan DS	15	6	6	6	6	6	5	5	5	5	5	5	5	5	5
	Orleans TS	51	0	45	46	46	47	48	48	50	50	51	52	54	55	57
	Wilhaven DS	58	53	4	5	5	6	6	6	7	10	11	12	12	14	16
	Total	**340**	**231**	**200**	**208**	**209**	**212**	**215**	**217**	**223**	**229**	**231**	**234**	**236**	**240**	**244**
East 230	Orleans TS	51	0	45	46	46	47	48	48	50	50	51	52	54	55	57
	Total	**51**	**0**	**45**	**46**	**46**	**47**	**48**	**48**	**50**	**50**	**51**	**52**	**54**	**55**	**57**
South 115	Greely DS	40	35	35	36	36	36	36	36	36	37	37	37	38	38	38
	Limebank MTS	68	47	49	52	54	56	59	61	67	73	79	86	93	92	92
	Marionville DS	28	31	31	31	32	32	31	32	32	32	33	33	33	34	34
	National Aeronautical CTS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Russell DS	8	12	13	13	13	13	13	13	13	13	13	13	13	13	13
	South Gloucester DS	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Uplands MTS	30	20	20	20	21	21	21	21	22	22	23	23	24	23	23
	Total	**182**	**151**	**155**	**159**	**162**	**165**	**167**	**171**	**178**	**185**	**193**	**201**	**209**	**209**	**209**
South West 115	Fallowfield DS	48	45	49	48	51	61	64	68	72	76	84	89	95	102	111
	Manotick DS	17	8	8	9	9	9	9	9	9	9	9	9	9	9	9
	Richmond DS	5	7	7	8	10	22	24	25	26	27	27	28	28	27	27
	Total	**70**	**60**	**64**	**65**	**69**	**92**	**97**	**102**	**107**	**112**	**120**	**126**	**131**	**139**	**147**

West 115	Bridlewood MTS	37	34	34	35	35	34	34	35	61	61	60	61	61	60	60
	Carling TS	93	88	89	90	91	92	92	93	100	102	103	105	106	107	109
	Centrepoint MTS	35	21	21	21	21	21	21	21	21	21	20	20	20	20	20
	Epworth	25	15	15	16	16	16	16	16	16	15	15	15	15	15	15
	Hinchey TS	77	47	49	51	54	55	57	59	54	57	61	64	67	70	73
	Lincoln Heights TS	71	48	48	48	48	47	47	47	53	52	52	52	51	51	51
	Manordale MTS	22	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Marchwood MTS	34	35	35	35	36	35	35	36	36	36	36	36	36	37	38
	Merivale TS	18	18	19	18	20	20	20	20	22	23	26	27	26	26	26
	Woodroffe TS	92	35	36	36	37	38	38	39	47	48	49	49	50	51	51
	Total	**504**	**351**	**355**	**361**	**368**	**369**	**369**	**375**	**419**	**425**	**432**	**439**	**443**	**448**	**454**
West 230	Kanata MTS	55	87	88	88	88	88	87	88	89	89	90	90	90	90	90
	Nepean TS	144	153	152	151	150	148	146	145	144	141	139	137	135	133	133
	South March	109	98	93	97	101	104	107	110	102	87	87	87	87	86	87
	Terry Fox MTS	90	44	57	88	93	74	73	72	71	71	70	69	68	67	67
	Total	**397**	**382**	**390**	**424**	**432**	**414**	**412**	**416**	**406**	**389**	**385**	**383**	**379**	**377**	**377**
Outer East 115	Clarence DS	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Hawkesbury MTS	18	17	17	17	17	17	17	17	18	18	18	18	18	19	19
	Rockland DS	9	17	17	17	18	18	18	18	19	19	19	19	19	19	19
	Rockland East DS	15	11	11	11	12	12	12	12	13	13	13	13	13	13	13
	Wendover TS	34	9	9	9	9	9	9	10	11	11	11	10	10	10	10
	Total	**80**	**56**	**56**	**56**	**57**	**57**	**57**	**57**	**62**	**62**	**63**	**63**	**63**	**63**	**63**
Outer East 230	Ivaco	100	92	92	92	92	92	92	92	92	92	92	92	92	92	92
	Longueuil TS	98	44	44	44	44	43	43	43	43	43	43	43	43	43	43
	St. Isidore TS	52	48	48	48	48	47	47	47	47	47	47	47	47	47	47
	Total	**249**	**184**	**184**	**184**	**184**	**183**	**182**	**182**	**182**	**182**	**182**	**182**	**182**	**182**	**182**
Outer West 115	Arnprior TS	51	51	51	51	51	50	49	49	49	49	49	49	49	49	49
	Stewartville TS	55	32	32	32	49	49	48	48	48	48	48	48	48	48	48
	Total	**106**	**83**	**82**	**82**	**100**	**99**	**97**	**97**	**96**	**96**	**96**	**96**	**96**	**96**	**96**
Outer West 230	Almonte TS	100	48	48	47	47	47	46	46	45	45	45	45	45	45	45
	Total	**100**	**48**	**48**	**47**	**47**	**47**	**46**	**46**	**45**	**45**	**45**	**45**	**45**	**45**	**45**
Region Total		**2948**	**2284**	**2346**	**2421**	**2503**	**2514**	**2522**	**2558**	**2637**	**2650**	**2680**	**2702**	**2722**	**2738**	**2762**

APPENDIX E: LIST OF ACRONYMS

Acronym	Description
A	Ampere
BES	Bulk Electric System
BPS	Bulk Power System
CDM	Conservation and Demand Management
CIA	Customer Impact Assessment
CGS	Customer Generating Station
CTS	Customer Transformer Station
DESN	Dual Element Spot Network
DG	Distributed Generation
DSC	Distribution System Code
GS	Generating Station
GTA	Greater Toronto Area
HV	High Voltage
IESO	Independent Electricity System Operator
IRRP	Integrated Regional Resource Plan
kV	Kilovolt
LDC	Local Distribution Company
LP	Local Plan
LTE	Long Term Emergency
LTR	Limited Time Rating
LV	Low Voltage
MTS	Municipal Transformer Station
MW	Megawatt
MVA	Mega Volt-Ampere
MVAR	Mega Volt-Ampere Reactive
NA	Needs Assessment
NERC	North American Electric Reliability Corporation
NGS	Nuclear Generating Station
NPCC	Northeast Power Coordinating Council Inc.
NUG	Non-Utility Generator
OEB	Ontario Energy Board
OPA	Ontario Power Authority
ORTAC	Ontario Resource and Transmission Assessment Criteria
PF	Power Factor
PPWG	Planning Process Working Group
RIP	Regional Infrastructure Plan
ROW	Right-of-Way
SA	Scoping Assessment
SIA	System Impact Assessment
SPS	Special Protection Scheme
SS	Switching Station
TS	Transformer Station
TSC	Transmission System Code
UFLS	Under Frequency Load Shedding
ULTC	Under Load Tap Changer
UVLS	Under Voltage Load Rejection Scheme