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BY COURIER

March 29, 2018

Ms. Kirsten Walli
Board Secretary
Ontario Energy Board
Suite 2700, 2300 Yonge Street
P.O. Box 2319
Toronto, ON M4P 1E4

Dear Ms. Walli:

EB-2017-0364– Hydro One Networks Inc.'s Section 92 – Lake Superior Link Project – Additional Evidence

As articulated in the evidence already filed with the Ontario Energy Board for this Application, Hydro One is now providing the final System Impact Assessment ("SIA") for this Project, to be documented as Exhibit F, Tab 1, Schedule 1, Attachment 3, and the draft Customer Impact Assessment ("CIA") which will be referenced as Exhibit G, Tab 1, Schedule 1, Attachment 2.

As anticipated, the findings of the final SIA confirms that the Project will have no material adverse impact on the reliability of the integrated power system and that the project modifications are expected to be adequate for the targeted westward transfer level of 450 MW across the East-West Tie.

Analogous to the evidence already before the Board, the draft CIA confirms that the proposed transmission facilities will have no material adverse reliability impact on existing customers in the area, and, on the contrary, the reliability will improve in Northwest Ontario as a result of the Project. Hydro One expects that the final review period of the CIA will be completed by the end of April and the final CIA will be filed with the OEB shortly thereafter. Hydro One does not believe this should prejudice or delay the OEB's review of the Application and Evidence in this case in any way.

Hydro One recently held public drop-in sessions to talk to communities in the project area about our proposal. Nine project information meetings were held during the week of March 19, and we were very encouraged by the positive comments and thoughtful questions we received. These meetings helped attendees understand not only Hydro One's project but cleared some confusion over the two competing applications.

Hydro One hopes that with the filing of these two documents, the OEB will deem its application now complete such that the hearing process can commence.

An electronic copy of this correspondence, an updated Exhibit List and the attached additional evidence has been filed using the Board's Regulatory Electronic Submission System (RESS).

Sincerely,

ORIGINAL SIGNED BY FRANK D’ANDREA

Frank D'Andrea

Attach

Exhibit List

Exh	Tab	Schedule	Attachment	Contents
A				
	1	1		Exhibit List
B				
	1	1		Application
	1	1	1	Order in Council
	2	1		Project Overview
	2	1	1	IESO Third Update Report - Assessment of the Rationale for the East-West Tie Expansion
	2	1	2	IESO Updated Assessment of the Need for the East-West Tie Expansion
	2	1	3	Schematic Diagram of Proposed Wawa TS - Marathon TS Circuits
	2	1	4	Schematic Diagram of Proposed Marathon TS – Lakehead TS Circuits
	3	1		Evidence In Support of Need
	3	1	1	August 4, 2017 Letter from Ministry of Energy
	3	1	2	December 4, 2017 Letter from Ministry of Energy
	4	1		Project Classification and Categorization
	5	1		Cost Benefit Analysis and Options
	6	1		Quantitative Benefits

REPORT

System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Final SIA Report

CAA ID: 2017-628
Project: Lake Superior Link
Applicant: Hydro One Networks Inc.

Engineering Studies Department
Independent Electricity System Operator

Date: March 28, 2018

Document Name	System Impact Assessment Report
Issue	Final SIA Report
Reason for Issue	Request for connection assessment
Effective Date	March 28, 2018

System Impact Assessment Report

Acknowledgement

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

Disclaimers

IESO

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

Conditional approval of the proposed connection is based on information provided to the IESO by the connection applicant and Hydro One at the time the assessment was carried out. The IESO assumes no responsibility for the accuracy or completeness of such information, including the results of studies carried out by Hydro One at the request of the IESO. Furthermore, the conditional approval is subject to further consideration due to changes to this information, or to additional information that may become available after the conditional approval has been granted.

If the connection applicant has engaged a consultant to perform connection assessment studies, the connection applicant acknowledges that the IESO will be relying on such studies in conducting its assessment and that the IESO assumes no responsibility for the accuracy or completeness of such studies including, without limitation, any changes to IESO base case models made by the consultant. The IESO reserves the right to repeat any or all connection studies performed by the consultant if necessary to meet IESO requirements.

Conditional approval of the proposed connection means that there are no significant reliability issues or concerns that would prevent connection of the proposed project to the IESO-controlled grid. However, the conditional approval does not ensure that a project will meet all connection requirements. In addition, further issues or concerns may be identified by the transmitter(s) during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with physical or equipment limitations, or with the Transmission System Code, before connection can be made.

This report has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. This report has been prepared solely for use by the connection applicant and the IESO in accordance with Chapter 4, Section 6 of the Market Rules. This report does not in any way constitute an endorsement, agreement, consent or acknowledgment of any kind of the proposed connection for the purposes of obtaining or administering a contract with the IESO for the procurement of electricity supply, generation, demand response, conservation and demand management or ancillary services.

The IESO assumes no responsibility to any third party for any use, which it makes of this report. Any liability which the IESO may have to the connection applicant in respect of this report is governed by Chapter 1, Section 13 of the Market Rules. In the event that the IESO provides a draft of this report to the connection applicant, the connection applicant must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to the connection applicant. Although the IESO will use its best efforts to advise you of any such changes, it is the responsibility of the connection applicant to ensure that the most recent version of this report is being used.

Hydro One

The results reported in this report are based on the information available to Hydro One, at the time of the study, suitable for a system impact assessment of this transmission system reinforcement proposal.

The short circuit and thermal loading levels have been computed based on the information available at the time of the study. These levels may be higher or lower if the connection information changes as a result of, but not limited to, subsequent design modifications or when more accurate test measurement data is available.

This study does not assess the short circuit or thermal loading impact of the proposed facilities on load and generation customers.

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

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

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

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Executive Summary

Project Description

The 230 kV East-West Tie (the "East-West Tie") consists of the 230 kV transmission circuits from Wawa TS to Marathon TS to Lakehead TS (the "terminal transformer stations"). Hydro One Networks Inc. (the "connection applicant" and "transmitter") is proposing to reinforce the East-West Tie by adding new 230 kV transmission circuits: M37L and M38L from Lakehead TS to Marathon TS, and W35M and W36M from Marathon TS to Wawa TS, under the name Lake Superior Link (the "project"), with the proposed in service date in December 2021. The project will be almost entirely configured as double-circuit lines located in parallel with the existing East-West Tie circuits except for a 35 km section between Wawa TS and Marathon TS where the existing double circuit towers of W21M and W22M will be replaced with quadruple circuit towers to accommodate the new W35M and W36M circuits.

To connect the project, the connection applicant is proposing modifications at its terminal transformer stations that are identical to those it proposed for CAA_ID 2016-568, namely:

- Reconfigure the 230 kV switchyards at the terminal transformer stations:
  - Wawa TS: from 5 breakers ring bus to 2 buses, 4 diameters, 11 breakers;
  - Marathon TS: from 4 breaker ring bus to 2 buses, 4 diameters,14 breakers;
  - Lakehead TS: from 2 buses, 2 diameters, 6 breakers to 2 buses, 4 diameters, 11 breakers.
- Re-terminate the existing 230 kV transmission circuits M23L, M24L, W21M, W22M and W23K at their respective terminal transformer stations;
- Install two shunt reactors each rated 65 Mvar at 250 kV at Marathon TS;
- Install a shunt reactor rated 125 Mvar at 250 kV at Lakehead TS;
- Install a shunt capacitor bank rated 125 Mvar at 250 kV at Lakehead TS;
- Update the Northwest Special Protection Scheme #2 (NW SPS 2) Special Protection System (SPS) to include the new contingency conditions arising from the reconfiguration of the 230 kV switchyards at the terminal transformer stations, as detailed in section 4.8 of this report; and
- Change the existing protections, control and telecommunication facilities for the reconfiguration of the switchyard at the terminal transformer stations and install new protection, control and telecommunication facilities for the project.

The connection applicant is targeting an increase to the westward transfer capability of the East-West Tie to 450 MW following the incorporation of the project.

Notification of Conditional Approval

The project will have no material adverse impact on the reliability of the integrated power system. It is therefore recommended that the IESO issue a *Notification of Conditional Approval* for *Connection* of the project subject to the requirements listed in this report.

Findings

The SIA identified the following:

1. The project will have no material adverse impact on the reliability of the integrated power system. The proposed modifications are expected to be adequate for the targeted westward transfer level of 450 MW across the East-West Tie;
2. The modifications proposed by the connection applicant for the terminal transformer stations are acceptable to the IESO;
3. The proposed reactive control devices are appropriate to control voltages within applicable ranges under all foreseeable conditions. Since the voltages near the project are strongly dependent on the flows across the East-West Tie that vary significantly throughout the day, these reactive control devices will likely be switched multiple times a day;
4. The existing parallel 115 kV circuits A5A, A1B and T1M between Alexander SS and Marathon TS are adequate to support a westward transfer capability across the East-West Tie of 450 MW, while respecting normal contingencies;
5. Under the North American Electric Reliability Corporation's (NERC) definition of the Bulk Electric System (BES), all the 230 kV transmission equipment installed for this project will be categorized as BES elements;
6. At the westward transfer levels of about 450 MW studied in this report, the project's equipment will not fall within the Northeast Power Coordinating Council (NPCC) definition of the Bulk Power System (BPS). As stated in the final SIA report under CAA_ID 2016-568, it is expected that, once the new SVC is installed at Marathon TS, the East-West Tie transfer capability can be increased to 650 MW westward. At this increased transfer level, Marathon TS, together with all of the 230 kV circuits that terminate at that station (existing: M23L, M24L, W21M and W22M, and new: M37L, M38L, W35M and W36M) are expected to fall within the NPCC's BPS definition. Additional tests will be required to determine the future status of the terminal transformer stations, once the model for the Marathon SVC becomes available;
7. Extreme contingencies that result in the loss of the four 230 kV circuits of the East-West Tie such as failure of a quadruple circuit tower can result in separation between the Northwest transmission zone and the rest of the IESO-controlled grid. Following such events, timely system restoration is critical to avoid the risk of supply shortages to the customers in the zone; and
8. Outages to the existing East-West Tie circuits will be required to install the project, especially the 35 km section between Wawa TS and Marathon TS where the existing double circuit towers of W21M and W22M will be replaced with quadruple circuit towers to accommodate the new W35M and W36M circuits. An outage plan that contains the details of this replacement has not been presented to the IESO at the time of this report.

Connection Requirements

1. To avoid any possible conflict between the operation of the updated NW SPS 2 and the local voltage based capacitor and reactor switching schemes, the connection applicant must initiate in a timely manner a review of the voltage settings of all the local schemes by the IESO, participate as the equipment owner in the review and implement the new settings, once agreed upon, in a timely manner.
   Note: the connection applicant initiated this process with the IESO in February, 2018.
2. After finalizing the engineering design, the connection applicant shall submit a restoration plan acceptable to the IESO that documents the restoration options for the East-West Tie corridor and

describes how the circuits will be restored following extreme contingencies such as the loss of towers.

3. At least twenty four months before the commencement of system-impactive project related outages, the connection applicant shall submit an outage plan acceptable to the IESO for the installation of the 35 km section between Wawa TS and Marathon TS where the existing double circuit towers of W21M and W22M will be replaced with quadruple circuit towers.
4. The connection applicant shall satisfy all general requirements listed in section 2 of this report.

Recommendations

As previously recommended in CAA_ID 2016-568, when the existing synchronous condenser, C8, at Lakehead TS reaches its end-of-life, the connection applicant is recommended to consider replacing it with an SVC that has a rating of at least ± 100 Mvar.

– End of Section –

1. Project Description

1.1 Introduction

The Ontario 230 kV East-West Tie (the "East-West Tie") consists of the 230 kV transmission circuits from Wawa TS to Marathon TS to Lakehead TS (the "terminal transformer stations"). Hydro One Networks Inc. (the "connection applicant" and "transmitter") is proposing to reinforce the East-West Tie by adding new 230 kV transmission circuits: M37L and M38L from Lakehead TS to Marathon TS, and W35M and W36M from Marathon TS to Wawa TS, under the name Lake Superior Link (the "project"), with the proposed in service date in December 2021. The project will be almost entirely configured as double-circuit lines located parallel with the existing East-West Tie circuits except for a 35 km section between Wawa TS and Marathon TS where the existing double circuit towers of W21M and W22M will be replaced with quadruple circuit towers to accommodate the new W35M and W36M circuits.

To connect the project, the connection applicant is proposing modifications at its terminal transformer stations that are identical to those it proposed for CAA_ID 2016-568, namely:

- Reconfigure the 230 kV switchyards at the terminal transformer stations:
    - Wawa TS: from 5 breakers ring bus to 2 buses, 4 diameters, 11 breakers;
    - Marathon TS: from 4 breaker ring bus to 2 buses, 4 diameters,14 breakers;
    - Lakehead TS: from 2 buses, 2 diameters, 6 breakers to 2 buses, 4 diameters, 11 breakers.
- Re-terminate the existing 230 kV transmission circuits M23L, M24L W21M, W22M and W23K at their respective terminal transformer stations;
- Install two shunt reactors each rated 65 Mvar at 250 kV at Marathon TS;
- Install a shunt reactor rated 125 Mvar at 250 kV at Lakehead TS;
- Install a shunt capacitor bank rated 125 Mvar at 250 kV at Lakehead TS;
- Update Northwest Special Protection Scheme #2 (NW SPS 2) to include the new contingency conditions arising from the reconfiguration of the 230 kV switchyards at the terminal transformer stations, as detailed in section 4.8 of this report; and
- Change the existing protections, control and telecommunication facilities for the reconfiguration of the switchyard at the terminal transformer stations and install new protection, control and telecommunication facilities for the project.

The connection applicant is targeting an increase to the westward transfer capability of the East-West Tie to 450 MW following the incorporation of the project.

1.2 Arrangement of Terminal Transformer Stations

The detailed station modifications proposed by the connection applicant for the terminal transformer stations are presented in section 1.2 of CAA_ID 2016-568. The single line diagrams proposed for the terminal transformer station are replicated in Figures 1-3:

The following figure shows the proposed configuration at Lakehead TS:

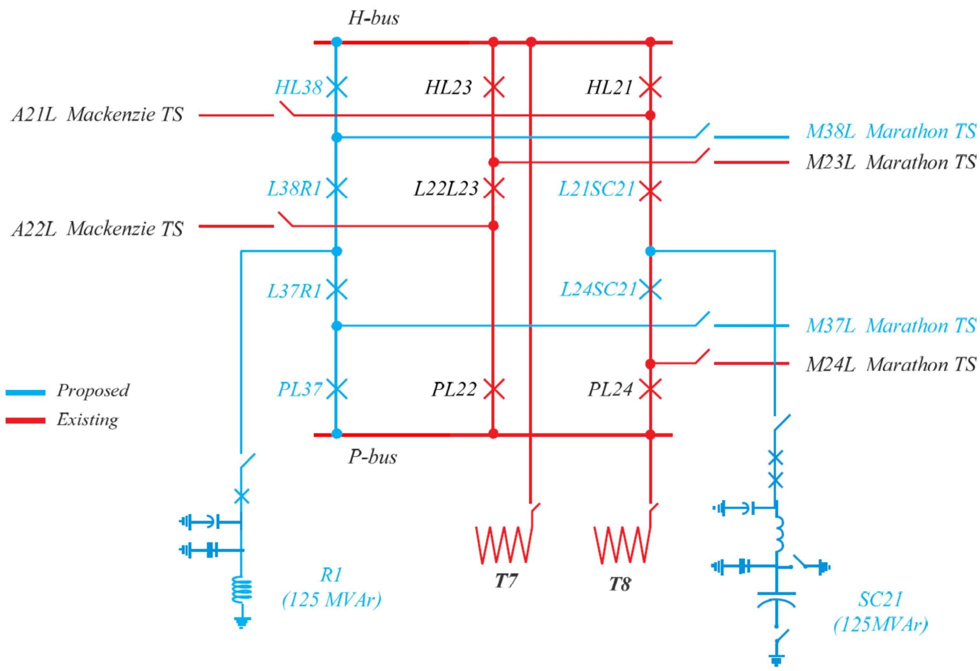

Figure 1: Lakehead TS – proposed station configuration

The following figure shows the proposed configuration at Marathon TS:

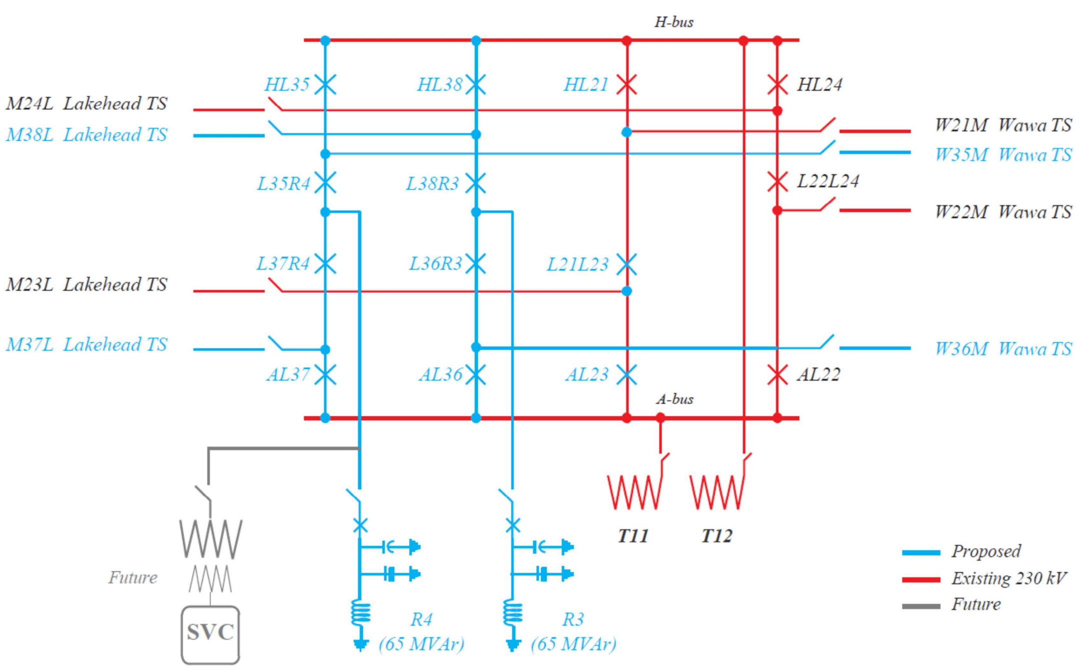

Figure 2: Marathon TS - proposed station configuration

The following figure shows the proposed configuration at Wawa TS:

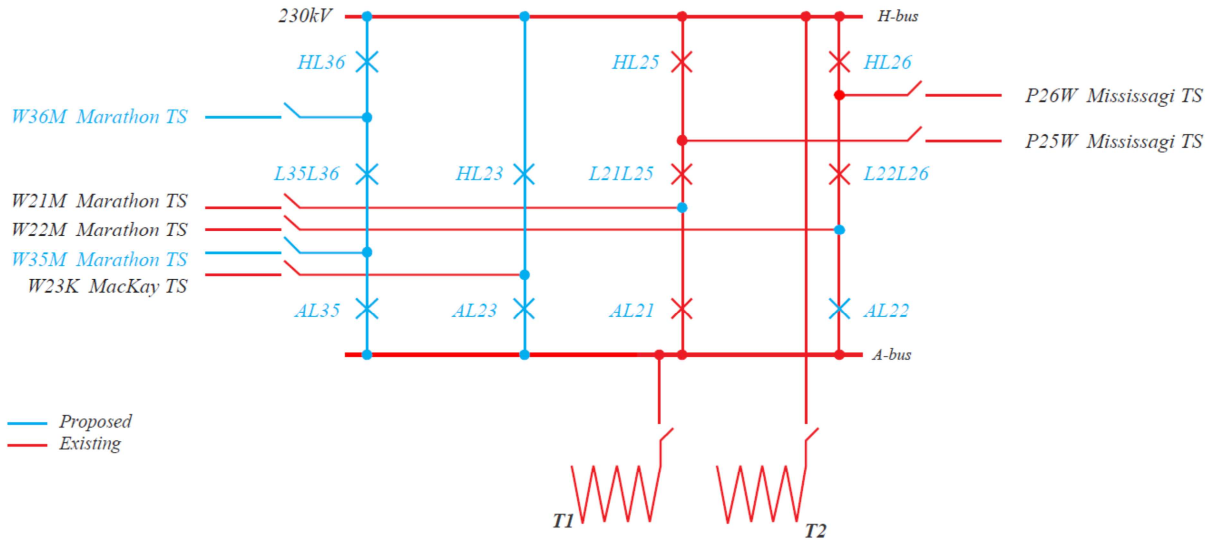

Figure 3: Wawa TS – proposed station configuration

The modifications proposed by the connection applicant for the terminal transformer stations and the additional upgrades will eliminate breaker-failure conditions that can impose restrictions on the current operation of the East-West Tie and are therefore acceptable to the IESO.

– End of Section –

2. General Requirements

The connection applicant shall satisfy all applicable requirements specified in the Market Rules, the Transmission System Code (TSC) and Reliability Standards. The following sections highlight some of the general requirements that are applicable to the project and terminal transformer stations.

2.1 Reliability Standards

Under the North-American Electric Reliability Corporation's (NERC) Bulk Electric system (BES) definition, all 230 kV elements of the project and terminal transformer stations will be classified as BES.

The connection applicant shall ensure that the project and the terminal transformer stations comply with the applicable NERC reliability standards. To determine the standard requirements that are applicable to this project and the terminal transformer stations, the IESO provides a mapping tool titled "NERC Reliability Standard Mapping Tool/Spreadsheet," which can be accessed at the IESO's public website: http://www.ieso.ca/en/sector-participants/system-reliability/applicability-criteria-for-compliance-with-reliability-requirements

Note, the connection applicant may request an exemption to the application of the BES definition. The procedure for submitting an application for exemption can be found in Market Manual 11.4: "Ontario Bulk Electric System (BES) Exception" at the IESO's website: http://www.ieso.ca/-/media/files/ieso/document-library/market-rules-and-manuals-library/market-manuals/reliability-compliance/rc-ontariobesexception.pdf

At the westward transfer levels of about 450 MW targeted by the connection applicant, the project and the terminal transformer stations will not fall within the Northeast Power Coordinating Council (NPCC) definition of the Bulk Power System (BPS). As stated in the final SIA report under CAA_ID 2016-568, it is expected that once the new SVC is installed at Marathon TS that the East-West Tie transfer capability can be increased to 650 MW westward. At this increased transfer level, Marathon TS, together with all 230 kV circuits that terminate at that station (existing: M23L, M24L, W21M and W22M, and new: M37L, M38L, W35M and W36M) are expected to fall within NPCC's definition of BPS.

Additional assessments will be required, once the connection applicant provides the model for the future Marathon SVC, to determine if Lakehead TS, Wawa TS and Mississagi TS and their associated 230 kV circuits will also be classified as BPS.

However, the IESO recommends that any new facilities that the connection applicant is planning to install for the project should be suitable for their future designation to ensure that they remain compliant with the applicable NPCC criteria. To determine the standard requirements that would be applicable to the project and the terminal transformer stations, the IESO provides a mapping tool titled "NPCC Criteria Mapping Spreadsheet," which can be accessed at the IESO's public website: http://www.ieso.ca/en/sector-participants/system-reliability/applicability-criteria-for-compliance-with-reliability-requirements .

The IESO's criteria for determining applicability of NERC reliability standards and NPCC Criteria can be found in the Market Manual 11.1: "Applicability Criteria for Compliance with NERC Reliability Standards and NPCC Criteria" at the IESO's website: http://www.ieso.ca/-/media/files/ieso/document-library/market-rules-and-manuals-library/market-manuals/reliability-compliance/ieso-applicability-criteria-for-compliance-with-nerc-standards-and-npcc-criteria.pdf

Compliance with these reliability standards will be monitored and assessed as part of the IESO's Ontario Reliability Compliance Program (ORCP). For more details about compliance with applicable reliability standards, the connection applicant is encouraged to contact orcp@ieso.ca and also visit the following webpage: http://www.ieso.ca/sitecore/content/ieso/home/sector-participants/system-reliability/ontario-reliability-compliance-program

Along with other system elements in Ontario, the BPS and BES classifications of the project and the terminal transformer stations will be periodically re-evaluated as the electrical system evolves.

2.2 Voltage Levels

The connection applicant shall ensure that the equipment installed at the project and its terminal transformer stations meets the voltage requirements specified in Section 4.2 and Section 4.3 of the Ontario Resource Transmission Assessment Criteria (ORTAC).

2.3 Fault Levels

The TSC requires the new equipment to be designed to withstand the fault levels in the area where the equipment is installed. Thus, the connection applicant shall ensure that all new equipment installed at the project and the terminal transformer stations is designed to withstand the fault levels in the area. If any future system changes result in an increased fault level higher than the equipment's capability, the connection applicant will be required to replace the equipment with higher rated equipment capable of withstanding the increased fault level, up to the maximum fault level specified in the TSC. Appendix 2 of the TSC establishes the maximum fault levels for the transmission system. For the 230 kV system, the maximum 3 phase symmetrical fault level is 63 kA and the maximum single line to ground symmetrical fault level is 80 kA (usually limited to 63 kA).

Appendix 2 of the TSC states that the maximum rated interrupting time for the 230 kV breakers must be ≤ 3 cycles. Thus, the connection applicant shall ensure that the breakers installed at the terminal transformer station meet the required interrupting time specified in the TSC. Fault interrupting devices must be able to interrupt fault currents at the maximum continuous voltage of 250 kV.

2.4 Protection Systems

The connection applicant shall ensure that the protection systems installed at the terminal transformer stations are designed to satisfy all the requirements of the TSC. New protection systems must be coordinated with the existing protection systems.

The protection systems must only trip the appropriate equipment required to isolate the fault. After the project begins commercial operation, if an improper trip of any 230 kV circuit occurs, the project or the deficient part of a terminal transformer station may be disconnected from the IESO-controlled grid until the problem is resolved.

The project and the terminal transformer stations shall have the capability to ride through routine switching events and design criteria contingencies in the grid that do not disconnect the project or any part of the terminal transformer stations by configuration. Standard fault detection, auxiliary relaying, communication, and rated breaker interrupting times are to be assumed.

Special Protection Systems (SPSs) can be operated more efficiently if the IESO operators have the ability to arm/disarm them directly (remotely). The connection applicant must therefore work with the IESO to install facilities that allow arming and disarming of the updated NW SPS 2 directly from the IESO control room.

Protection modifications that are different from those considered in this SIA must be submitted by the connection applicant to the IESO at least six (6) months before any modifications are to be implemented. If those modifications result in adverse reliability impacts, mitigation solutions must be developed.

The connection applicant must provide during the IESO Market Registration process the actual protection operating times, in accordance with Market Manual 2: Market Administration, Part 2.20: Performance Validation (Sections 4.8 and 4.9).

2.5 Connection Equipment

The connection applicant shall ensure that the connection equipment at the terminal transformer stations is designed to be fully operational in all reasonably foreseeable ambient temperature conditions. The connection applicant must also ensure that connection equipment is designed such that the adverse effects of its failure on the IESO-controlled grid are mitigated.

2.6 Disturbance Recording

The connection applicant shall extend the coverage of the existing disturbance recording devices at the terminal transformer stations to cover the new 230 kV transmission circuits: M37L, M38L, W35M and W36M. These modifications are required to meet the technical specifications provided by the IESO during the Market Registration process. The devices will be used to monitor and record electric quantities on the system in order to verify the dynamic response of generators. The quantities to be recorded and the trigger settings, expected to be similar with the quantities recorded and trigger settings for the existing East-West Tie circuits, will be provided by the IESO during the IESO Market Registration process.

2.7 Telemetry

According to Section 7.3 of Chapter 4 of the Market Rules, the connection applicant shall provide to the IESO the applicable telemetry data listed in Appendix 4.16 of the Market Rules on a continual basis. The whole telemetry list will be finalized during the IESO Market Registration process and is expected to be similar to the existing East-West Tie circuits. At a minimum, the same quantities and statuses that are provided for existing equipment, circuits and SPS at the terminal transformer stations must also be provided for the new equipment, circuits and SPS that are installed for the project.

The data shall be provided with equipment that meets the requirements set forth in Appendix 2.2, Chapter 2 of the Market Rules and Section 5.3 of Market Manual 1.2, in accordance with the performance standards set forth in Appendix 4.19 subject to Section 7.6A of Chapter 4 of the Market Rules.

As part of the IESO Market Registration process, the connection applicant must complete end to end testing of all necessary telemetry points with the IESO to ensure that standards are met and that sign conventions are understood. All found anomalies must be corrected before IESO final approval to connect any phase of the project is granted.

2.8 Power System Restoration

The connection applicant is already a restoration participant. Details regarding restoration participant requirements will be finalized during the IESO Market Registration process.

2.9 IESO Market Registration Process

The connection applicant shall initiate and complete the IESO's Market Registration process in a timely manner, at least eight months before energization to the IESO-controlled grid and prior to the commencement of any project related outages, in order to obtain IESO final approval.

The connection applicant is required to provide "as-built" equipment data for the project during the IESO Market Registration process to allow the IESO to incorporate this project into IESO work systems and to perform any additional reliability studies.

If the submitted equipment data differ materially from the ones used in this assessment, then further analysis of the project may need to be done by the IESO before final approval to connect is granted.

At the sole discretion of the IESO, performance tests may be required at the project and its terminal transformer stations. The objectives of these tests are to demonstrate that equipment performance meets the IESO requirements, and to confirm models and data are suitable for IESO purposes. The transmitter may also have its own testing requirements. The IESO and the transmitter will coordinate their tests, share measurements and cooperate on analysis to the extent possible.

Once the IESO's Market Registration process has been successfully completed, the IESO will provide the connection applicant with a Registration Approval Notification (RAN) document, confirming that the project is fully authorized to connect to the IESO-controlled grid. For more details about this process, the connection applicant is encouraged to contact IESO's Market Registration at market.registration@ieso.ca

During the IESO Market Registration process, a new Facility Description Document (FDD) for the updated NW SPS 2 must be provided three months prior to in-service. The FDD must contain the finalized SPS matrix as well as expected operating times. The actual operating times must be measured during commissioning, documented as a Performance Validation Record, and posted on Hydro One - IESO secured web portal.

If the FDD or performance testing as per the Performance Validation Record indicates a change in design or slower than expected operating times than what was assumed in this assessment, then further analysis of the project will need to be done by the IESO. This may delay the grant of IESO final approval.

2.10 Project Status

As per Market Manual 2.10, the connection application will be required to provide a status report of the project and its terminal transformer stations with respect to its progress upon request of the IESO. The project status report form can be found on the IESO web site at http://www.ieso.ca/imoweb/pubs/caa/caa_f1399_StatusReport.doc. Failure to comply with project status requirements listed in Market Manual 2.10 will result in the project being withdrawn.

The connection applicant will be required to also provide updates and notifications in order for the IESO to determine if the project is "committed" as per Market Manual 2.10. A committed project is a project that has demonstrated to the IESO a high probability of being placed into service.

This project will be deemed committed by the IESO when the connection applicant, as a licensed transmitter, identifies the project in their Plans for New or Modified Facilities Information Submittal Form for 18-Month Outlook (IESO_FORM_1484), or Plans for Retired, New or Modified Facilities Information Submittal Form (IESO_FORM_1494) provided to the IESO as part of its submission for the IESO 18-Month Outlook and other reliability assessments.

– End of Section –

3. Models and Data

3.1 Parameters of the Project

The connection applicant provided the following parameters for the project:

Table 1: Connection points and circuit lengths

Circuits:		M37L and M38L
Section	From:	Lakehead TS
	To:	Marathon TS
Length:		230 km
Continuous rating		Summer: 1120 A, Winter 1300A
Long Term Emergency rating		Summer: 1440 A, Winter 1580 A
Short Term Emergency rating		Summer: 1440 A, Winter 1580 A
Circuits:		New: W35M and W36M; Existing: W21M and W22M
Section	From:	Marathon TS
	To:	Wawa TS
Length:		168 km
Continuous rating		Summer: 1120 A, Winter 1300A
Long Term Emergency rating		Summer: 1440 A, Winter 1580 A
Short Term Emergency rating		Summer: 1440 A, Winter 1580 A

Circuits W21M, W22M, W35M and W36M share common towers for a 35 km section. On these quadruple circuit common towers the circuits are arranged horizontally in the following order on the cross-arms: W35M – W21M – (tower) – W22M –W36M. The line sections from Wawa TS to Marathon TS are in the following order: 95 km double circuit, 35 km quadruple circuit and 38 km double circuit.

Table 2: Line impedances provided by the connection applicant

Circuit	Positive-Sequence Impedance			Zero-Sequence Impedance		
	R (ohm)	X (ohm)	B (mho)	R (ohm)	X (ohm)	B (mho)
M37L	12.6	112.9	0.000789	65.3	278.7	0.000499
M38L	12.6	112.9	0.000789	66.2	274.3	0.000506
W35M	9.2	82.4	0.000573	47.0	204.8	0.000374
W36M	9.2	82.4	0.000573	47.5	202.2	0.000378
W21M	13.3	82.4	0.000570	65.5	266.7	0.000301
W22M	13.3	82.4	0.000570	65.5	266.7	0.000301

3.2 Parameters of the Proposed Station Equipment

Details of the station equipment proposed for installation at the terminal transformer stations are presented in section 3.1 of CAA_ID 2016-568. The equipment proposed by the connection applicant for the terminal transformer stations satisfies all applicable requirements and as such it is acceptable to the IESO.

3.3 Models of the Proposed Equipment

The transmission circuits and station configurations proposed by the connection applicant were modelled in PSS/E for this study. The per unit (p.u.) line impedances presented in Table 3, that were derived from the line impedances (ohm) provided by the connection applicant, were used to model the project's transmission circuits:

Table 3: Line impedances used for simulations

Circuit	Positive-Sequence Impedance			Zero-Sequence Impedance		
	(p.u. V_B = 220 kV, S_B = 100MVA)					
	R	X	B	R	X	B
M37L	0.026033058	0.233264463	0.381876000	0.134917355	0.575826446	0.241516000
M38L	0.026033058	0.233264463	0.381876000	0.136776860	0.566735537	0.244904000
W35M	0.019008264	0.170247934	0.277332000	0.097107438	0.423140496	0.181016000
W36M	0.019008264	0.170247934	0.277332000	0.098140496	0.417768595	0.182952000
W21M	0.027479339	0.170247934	0.275880000	0.135330579	0.551033058	0.145684000
W22M	0.027479339	0.170247934	0.275880000	0.135330579	0.551033058	0.145684000

– End of Section –

4. System Impact Assessment

This System Impact Assessment (SIA) focused exclusively on the area from Lakehead TS to Marathon TS to Wawa TS that will be directly affected by the project. The project is expected to improve the overall performance of the local transmission system by enabling higher transfers into (westward) and out of (eastwards) the Northwest transmission zone. The following studies were performed to confirm that the project has the required performance to achieve the westward transfer capability of 450 MW targeted by the connection applicant (there is currently no target for the eastward transfer capability):

1. Steady state voltage and voltage stability (Section 4.3) to confirm that the proposed upgrades are sufficient to achieve the westward transfer capability targeted by the connection applicant;
2. Equipment loading (Section 4.4) to confirm that existing equipment is adequate for the westward transfer capability targeted by the connection applicant;
3. Fault level analysis (Section 4.5) to confirm that existing and proposed equipment has adequate capability to interrupt local short circuit currents;
4. Operability assessment (Section 4.6) to confirm that local voltages can be maintained within the required range under all foreseeable operating conditions;
5. Protection Impact Assessment (PIA), included in Appendix C of this report, performed by the transmitter on behalf of the IESO; and
6. Relay margin and transient stability analysis (Section 4.7), based on the PIA results.

The following Sections present the Standards and Criteria used in this study (Section 4.1); the Study Assumptions (Section 4.2); and the Study Results (Sections 4.3 to 4.7). The connection applicant‘s proposed update to the NW SPS 2 is also included in the report (Section 4.8).

4.1 Standards and Criteria

The project was assessed against the NERC TPL-001 criteria for the loss of up to two elements. The following table lists all the conditions studied and associated fault types.

Table 4: Contingency and fault types respected as per the NERC TPL-001 criteria

Conditions:	Fault Type
All elements I/S: Loss of one element	3 phase fault
All elements I/S: Loss of two elements (breaker failure)	LG fault
All elements I/S: Loss of two elements (adjacent circuits on the same tower)	LG fault on different phase of adjacent circuits

Note that extreme contingencies resulting in the loss of the four 230 kV circuits of the East-West Tie such as failure of a quadruple circuit tower can result in separation between the Northwest transmission zone and the rest of the IESO-controlled grid. Following such events, timely system restoration is critical to avoid the risk of supply shortages to the customers in the zone.

The Northwest zone is prone to thunderstorms from April 1st to October 31st. If there is a credible risk of four circuits tripping during those thunderstorms, especially those sharing the same towers, the IESO will need to posture the system to withstand the loss of all four circuits by either reducing the transfer pre-contingency or by arming load rejection. The updated NW SPS 2, as proposed by the connection applicant, does not provide features for detecting extreme contingencies involving more than 2 circuits. Arming for two double-contingencies in preparation for the loss of the four circuits may be acceptable, but could result in unnecessary load disconnection if a double contingency occurs. The connection applicant is recommended to consider the cost effectiveness of integrating features for detecting extreme contingencies within the updated NW SPS 2 to reduce the exposure to affected customers.

The voltage, equipment loading and transient performance of the integrated power system was evaluated against the following ORTAC sections:

- Voltage decline of 10% or less for both pre and post ULTC action is acceptable (section 4.3).
- Minimum pre-contingency voltages on 230 kV and 115 kV buses are 220 kV and 113 kV, respectively (section 4.2).
- Maximum pre-contingency voltages on 230 kV and 115 kV buses are 250 kV and 127 kV, respectively (section 4.2).
- Minimum post-contingency voltages on 230 kV and 115 kV buses are 207 kV and 108 kV, respectively (section 4.3).
- Maximum post-contingency voltages on 230 kV and 115 kV buses are 250 kV and 127 kV (section 4.3).
- Steady state voltage stability must be demonstrated such that the maximum acceptable pre-contingency power transfer must be 10% lower than the voltage instability point of the pre-contingency P-V curve and 5% lower than the voltage instability point of the post-contingency P-V curve (section 4.5).
- With all transmission facilities in service, equipment loading must be within continuous ratings, with any one element out of service, equipment loading must be within applicable long-term emergency (LTE) ratings, and with any two elements out of service, equipment loading must be within applicable short-term emergency (STE) ratings (section 7.1).
- All line and equipment loads shall be within their continuous ratings with all elements in service and within their LTE ratings with any one element out of service. Immediately following contingencies, lines may be loaded up to their STE ratings where control actions such as re-dispatch, switching, etc. are available to reduce the loading to the LTE ratings (section 4.7.2).
- The minimum post-fault positive sequence voltage sag must remain above 70% of nominal voltage and must not remain below 80% of nominal voltage for more than 250 ms within 10 s following a fault (section 4.4).

For the relay margin analysis the following criteria, listed in Market Manual 7.4: IESO-Controlled Grid Operating Policies (section 4.3.9) was used:

- Following fault clearance or the loss of an element without a fault, the margin on all instantaneous and timed distance relays that are part of the BES or BPS, including generator loss of excitation and out-of-step relaying at major generating stations, must be at least 20% and 10% respectively.
- The margin on all relays at local system stations, generator loss of excitation and out-of-step protections on small generating units, or those associated with transformer backup protections, must be at least 15% on all instantaneous relays and 0% on all timed relays having a time delay setting less than or equal to 0.4 seconds.
- For all relays having a time delay setting greater than 0.4 seconds, the apparent impedance may enter the timed tripping characteristic, provided that there is a margin of 50% on time. For example, the apparent impedance does not remain within the tripping characteristic for a period of time greater than one-half of the relay time delay setting.
- The margin on all system relays, such as change of power relays, must be at least 10%.

4.2 Study Assumptions

The main study assumptions are similar to those established in section 4.2 of CAA_ID 2016-568 and consistent with those presented in the latest Updated Assessment of the Need for the East-West tie Expansion (the "latest need assessment") report. A summary of the main study assumptions is included below:

Generation Assumptions:

- In the Northwest transmission zone, the output from the existing hydroelectric facilities was set to 342 MW, representing approximately 40% of their peak output. A further contribution of 77 MW was also assumed to be available from the existing thermal facilities in this zone, resulting in a total zone generation of 419 MW**.** Atikokan GS and Thunder Bay GS biomass fired thermal facilities and the Greenwich WGS were assumed to be out-of-service.
- In the Northeast transmission zone, the output from the existing hydroelectric facilities was set to 1397 MW, representing approximately 47% of their peak output. The existing thermal generation in the area was assumed to contribute a further 406 MW (around 50% of their maximum), wind at 70 MW (20% of its maximum) and solar at 41 MW (77% of its maximum) for a total generation in the zone of 1915 MW.
- The dispatch of generation in southern Ontario has negligible impact on the project and as such a generic dispatch corresponding to peak summer conditions was used.

Load Assumptions:

- In the Northwest transmission zone, the peak load of about 797 MW was used, which is close to the reference scenario of the latest need assessment. This load level would give a peak demand of approximately 876 MW once the transmission losses of approximately 78 MW have been factored in.
- The load in Northeast was set to 1150 MW, which yields a peak demand of approximately 1240 MW once the transmission losses of approximately 90 MW were factored in.
- Demand in southern Ontario has negligible impact on the project and as such a generic summer peak demand was used.

Transfers on the East-West Tie and on the Sudbury Flow West Interface

The demand and generation assumptions in the Northwest and Northeast transmission zones resulted in:

- A Sudbury Flow West (SFW) transfer of 318 MW;
- A Flow into Wawa TS of 470 MW;
- An East-West Tie transfer (as measured at Wawa TS) of 464 MW westwards;
- A Flow from Marathon TS to Lakehead TS of 429 MW; and
- A Flow from Lakehead TS to MacKenzie TS of 128 MW.

The phase-angle regulators (PARs) on the interconnections with Minnesota and Manitoba were adjusted to achieve zero transfers across these interconnections.

4.3 Voltage Stability and Steady-State Voltage

The voltage stability performance of the East-West Tie after the incorporation of the project was evaluated using PV-analysis. The voltage stability limits and applicable margins were calculated according to section 4.5 of the ORTAC with all elements in service and under a set of critical contingencies. The contingencies involved the loss of either the existing or the new double circuit transmission lines on each section of the reinforced East-West Tie and also included mitigation measures that can be implemented automatically via the updated NW SPS 2.

The voltage stability limits were then compared with the relevant pre- or post-contingency East-West Tie transfers to confirm they would not be restrictive.

The following table summarizes the results of the voltage stability analysis. The results confirm that the East-West Tie is expected to have the capability to support westward flow of at least 450 MW targeted by the connection applicant.

Table 5: Summary of voltage stability results

Scenario:	East-West Tie flow (MW)	Flow at the point of voltage instability (MW)	Voltage Stability Limit (MW)	Margin (MW)
All elements in service, pre-contingency	463.7	614.6	553.1	89.4
Post M23L+M24L contingency	476.3	578.6	549.7	73.4
Post M37L+M38L contingency	481.4	598.7	568.8	87.4
Post W21M+W22M contingency	471.1	596.9	567.1	96.0
Post W35M+W36M contingency	481.2	600.2	570.2	89.0
Post P25W+P26W contingency	465.5	542.3	515.2	49.7

In Table 5:

- "East-West Tie flow" represents the pre or post contingency flow across the interface, measured at Wawa TS, for each scenarios;
- "Flow at the point of voltage instability" is the maximum transfer that could be achieved in the simulation before the load flow analysis failed to converge (indicating the potential for voltage instability);
- "Voltage Stability Limit" is calculated after deducting the required 10% pre-contingency or 5% post-contingency margin from the "Flow at the point of voltage instability"; and
- "Margin" is the difference between the "Voltage Stability Limit" and the "East-West Tie flow". A positive margin confirms that the ORTAC criteria are satisfied.

Additional results of the P-V analysis are presented in Appendix A.

The pre and post contingency steady state voltage levels were determined via load flow simulations that included any actions of the updated NW SPS 2 needed to control the amount of reactive compensation that would remain in-service to support the post-contingency transfers (more details are available in Section 4.6). Pre and post contingency voltages on all 230 kV buses west of and including Wawa TS were found to satisfy the criteria in sections 4.2 and 4.3 of the ORTAC, as shown in the following table:

Table 6: Summary of voltage levels and voltage changes

Scenario	Pre-contingency	Loss of M23L+M24L				Loss of M37L+M38L			
		Pre tap action		Post tap action		Pre tap action		Post tap action	
Monitored bus:		Voltage (kV)	Change (%)	Voltage (kV)	Change (%)	Voltage (kV)	Change (%)	Voltage (kV)	Change (%)
MacKenzie 230 kV	246.1	246.6	0.20%	246.9	0.33%	246.6	0.22%	246.7	0.24%
Lakehead 230 kV	243.0	243.1	0.04%	243.0	0.00%	243.2	0.08%	243.0	0.00%
Marathon 230 kV	239.9	239.5	-0.17%	237.2	-1.13%	243.1	1.33%	240.2	0.13%
Wawa 230 kV	242.4	242.8	0.17%	240.7	-0.70%	244.7	0.95%	242.1	-0.12%

Scenario	Pre-contingency	Loss of W21M+W22M				Loss of W35M+W36M			
		Pre tap action		Post tap action		Pre tap action		Post tap action	
Monitored bus		Voltage (kV)	Change (%)	Voltage (kV)	Change (%)	Voltage (kV)	Change (%)	Voltage (kV)	Change (%)
MacKenzie 230 kV	246.1	246.5	0.16%	246.7	0.24%	246.5	0.16%	246.8	0.28%
Lakehead 230 kV	243.0	243.0	0.00%	243.0	0.00%	243.0	0.00%	243.0	0.00%
Marathon 230 kV	239.9	246.5	2.75%	245.5	2.33%	245.3	2.25%	244.5	1.92%
Wawa 230 kV	242.4	245.9	1.44%	244.6	0.91%	246.9	1.86%	246.1	1.53%

The largest post-contingency voltage change (2.75% - on the Marathon TS 230 kV bus following the loss of W21M and W22M) satisfies the requirement of section 4.3 of the ORTAC.

4.4 Equipment Loading Assessment

The equipment loading assessment was performed primarily to confirm that the existing 115 kV circuits A5A, A1B and T1M between Alexander SS and Marathon TS are adequate for the westward transfers of 450 MW across the East-West Tie targeted by the connection applicant.

Upon completion of the project, there will be four 230 kV circuits between Marathon TS and Lakehead TS (the new circuits M37L and M38L, together with the existing circuits M23L and M24L) and these will be operated in parallel with the series-connected 115 kV circuits T1M, A1B and A5A, between Marathon TS and Alexander SS.

Pre-contingency

With all transmission circuits in-service, and with an increased East-West Tie transfer of 450 MW, the reduced impedance presented by the four 230kV circuits will result in lower transfers via the 115 kV path than occur presently, as shown in the following table.

Table 7: Re-distribution of flow between 230 kV and 115 kV parallel systems

Power flows:	M23L	M24L	M37L	M38L	T1M	East-West Tie Transfer
Before project (MW)	132.2	132.2	-	-	49.7	350MW
After project (MW)	96.5	96.5	98.0	98.0	40.0	450MW

Under a westward transfer of 350 MW across the East-West Tie (maximum achieved before the project), the simulation showed that bringing the project in service needed an angle reduction on the Manitoba and Minnesota PARs of about 17.5 degree (roughly the equivalent of 4 taps of the Manitoba PARs or 3 taps of the Minnesota PARs) to maintain zero transfers across the interconnections. After increasing the westward transfer with the project in service to 450 MW, the PAR angles had to be increased back by about 16.7 degrees to achieve zero transfers across the interconnections. Absent any significant change in generation or load in the Northwest transmission zone or in the interprovincial/international exchanges across the interconnections, the range of the existing PARs is expected to be sufficient for controlling the interconnection flows within schedules following the incorporation of the project.

Post-contingency

Following contingencies involving the existing 230 kV lines or the project's lines between Marathon TS and Lakehead TS, the post-contingency flows with an enhanced pre-contingency East-West Tie transfer or 450 MW are presented in the following table:

Table 8: Summary of equipment loading results

Monitored equipment			LTE	All I/S	Post M24L	Post M37L	Post M23L+M24L	Post M37L+M38L
Circuit	From	To	(A)	(A)	(A)	(A)	(A)	(A)
T1M	Marathon TS	Pic jct	460	235	272	273	345	343
T1M	Pic jct	Angler's jct	460	208	245	246	317	316
T1M	Angler's jct	Terrace Bay	460	208	245	246	317	316
A1B	Terrace Bay	Ter Bay jct	570	207	244	244	315	315
A1B	Ter Bay jct	Aguasabon SS	570	134	163	162	222	202
A5A	Aguasabon SS	Schreiber jct	430	135	174	174	245	235
A5A	Schreiber jct	Minnova jct	430	124	162	162	233	221
A5A	Minnova jct	Alexander_SS	430	119	157	158	238	217
M23L	Marathon TS	Greenwich jct*	940	243	308	309	0	416
M24L	Marathon TS	Greenwich jct*	1020	243	0	309	0	415
M37L	Marathon TS	Lakehead TS	1440	243	309	0	422	0
M38L	Marathon TS	Lakehead TS	1440	243	309	309	422	0

* most limiting section of the line.

To simplify the reporting only the LTE of the line sections are presented. The pre-contingency results with all elements in service are shown for reference only; no pre-contingency flow exceeded the continuous ratings of the monitored circuits.

The analysis shows that all post-contingency flows, with one and two elements out of service are within the LTE of the 115 kV circuits, an indication that these circuits are adequate for the transfer levels targeted by the connection applicant.

4.5 Fault Level Analysis

The fault level calculation was conducted by the transmitter on behalf of the IESO to identify the impact of the project on local short circuit levels. Changes in local short circuit levels as a result of incorporating the project are very small and not expected to have adverse impact on the reliability of the integrated power system. The tests were performed assuming all existing and committed generators in service (including Atikokan GS, Thunder Bay GS and Greenwich WGS).

Table 9: Fault level before and after completion of the project

		Lowest rated breaker		Before the project				After the project			
				Three phase fault		Line to ground fault		Three phase fault		Line to ground fault	
Station Name	Bus kV	Symm	Asym	Symm	Asym	Symm	Asym	Symm	Asym	Symm	Asym
		kA	kA	kA	kA	kA	kA	kA	kA	kA	kA
MacKenzie TS	220	38.5	46.2	6.354	8.046	6.543	8.487	6.462	8.161	6.620	8.573
	115	31.5	37.8	6.131	7.483	7.369	9.406	6.173	7.526	7.409	9.449
Lakehead TS	220	38.5	46.2	7.335	9.140	7.530	9.871	8.198	10.164	8.218	10.734
	115	31.0	34.1	17.596	19.707	19.477	22.794	18.636	20.903	20.416	23.937
Marathon TS	220	38.5	46.2	5.227	5.806	5.068	5.832	7.034	8.028	6.451	7.650
	115	34.7	41.6	7.334	7.811	9.434	9.434	8.453	9.305	9.805	11.095

		Lowest rated breaker		Before the project				After the project			
				Three phase fault		Line to ground fault		Three phase fault		Line to ground fault	
Wawa TS	220	38.5	46.2	6.754	7.749	6.072	7.653	7.671	8.836	6.763	8.577
	115	20.7	22.7	8.601	9.610	10.334	12.155	9.108	10.274	10.893	12.962
Terrace Bay SS	115	40.0	48.0	4.907	5.925	3.846	4.510	5.002	6.023	3.885	4.549
Aguasabon SS	115	40.0	48.0	4.738	5.490	4.108	5.120	4.817	5.568	4.148	5.163

The highest expected short circuit levels, both 230 kV and 115 kV are shown to be within the lowest rated breaker capability at all stations in the area.

The following table shows the changes in fault level from before to after the incorporation project:

Table 10: Fault level changes following the incorporation of the project

Station Name	Voltage (kV)	Three phase fault		Line to ground fault	
		Symmetrical (kA)	Asymmetrical (kA)	Symmetrical (kA)	Asymmetrical (kA)
MacKenzie TS	220	0.108	0.115	0.077	0.086
	115	0.042	0.043	0.040	0.043
Lakehead TS	220	0.863	1.024	0.688	0.863
	115	1.040	1.196	0.939	1.143
Marathon TS	220	1.807	2.222	1.383	1.818
	115	1.119	1.494	0.371	1.661
Wawa TS	220	0.917	1.087	0.691	0.924
	115	0.507	0.664	0.559	0.807
Terrace Bay	115	0.095	0.098	0.039	0.039
Aguasabon	115	0.079	0.078	0.040	0.043

This assessment has shown that the increase in short circuit levels following the incorporation of the project will not have a material adverse impact on the reliability of the integrated power system.

4.6 Operability Assessment

The nature of the East-West tie, consisting of multiple, very long transmission circuits subjected to flows that can change from zero to maximum in either direction on a daily basis, presents many operational challenges. An assessment was performed to identify if there is an effective operating philosophy for the reactive devices proposed to be installed at the terminal transformer stations. Identification of an effective operating philosophy that permits maintaining voltages within applicable ranges under all foreseeable conditions confirms that the appropriate reactive devices and controls are in place.

The suggested operating philosophy for the reactive devices near the East-West tie is as follows:

1. Have sufficient reactors in service at all times to compensate for the additional reactive contribution of the in-service (new or existing) transmission circuits and switch the shunt capacitors at the terminal transformer stations, as required, to provide the appropriate level of reactive support for the prevailing transfers.
2. Arm the updated NW SPS 2 such that in-service capacitors are switched out following the loss of reactors or autotransformers and in-service reactors are switched out following the loss of transmission circuits.

This operating philosophy should permit successful control of voltages within the entire range of transfers. This was confirmed by using the following three scenarios that were prepared assuming all elements in service, pre-contingency:

1. Targeted westwards transfer: 450 MW
2. Median westwards transfer: 225 MW
3. Zero transfer.

Detailed diagrams of these three scenarios are available in Appendix B.

This study only looked at load supply scenarios (westward transfers) because they would have the lowest number of local generation units on-line, which makes pre and post contingency voltage control more challenging. A larger number of generation units on-line would be needed to support eastward flows, while their reactive capability could be used for voltage control, reducing the reliance on transmission devices.

Contingencies involving the loss of circuits were investigated in Section 4.3 of this report so only the loss of reactive control devices and autotransformers were considered in this section. The following table shows the post-contingency voltage levels on the main 230 kV and 115 kV buses following different contingencies with an East-West Tie transfer of 450 MW – Scenario #1. The contingencies include the loss of a reactor (RX) and/or an autotransformer (ATX), or the loss of one autotransformer while the companion autotransformer is already out of service (for maintenance, repair or following a fault). Loss of both 230 kV reactors at Marathon TS was also considered.

Table 11: Summary of voltage levels (kV) - Scenario #1

Terminal Station		Wawa TS		Marathon TS		Lakehead TS		MacKenzie TS
Autotransformer/Reactor Outages		230 kV	115 kV	230 kV	115 kV	230 kV	115 kV	230 kV
Pre-contingency		242	124	240	125	243	123	246
Wawa TS	1 ATX out	245	126	242	126	243	123	246
	2 ATXs out	245	N/A	244	126	243	124	247
Marathon TS	1 ATX out	243	124	240	125	243	123	246
	2 ATXs out	245	127	242	122	243	124	246
	1 ATX & 1 RX out	245	125	245	127	243	122	246
	2 RXs out	246	126	247	126	243	122	246
Lakehead TS	1 ATX out	243	124	240	125	243	124	247
	2 ATXs out	245	124	241	128	238	121	237
	1 ATX & 1RX out	243	124	240	125	243	124	247

Consistent with the suggested operating philosophy presented above, actions of the updated NW SPS 2 were required for some of these contingencies, examples being:

- tripping of the tertiary-connected capacitors at Marathon TS following the loss of the 230 kV Marathon TS reactor assuming the first 230 kV reactor is out of service pre-contingency for maintenance or repairs;
- load rejection of around 100 MW to maintain post-contingency stability in the Lakehead TS 115 kV area following the loss of the second Lakehead TS transformer assuming the first one out of service pre-contingency for maintenance or repairs; or
- tripping of the Lakehead TS 230 kV capacitor following the loss of the Lakehead TS reactor.

The following table shows the results for Scenario #2 (East-West tie transfer of 225 MW westwards):

Table 12: Summary of voltage levels (kV) - Scenario #2

Terminal Station		Wawa TS		Marathon TS		Lakehead TS		MacKenzie TS
Autotransformer/Reactor Outages		230 kV	115 kV	230 kV	115 kV	230 kV	115 kV	230 kV
Pre-contingency		244	123	242	124	243	125	248
Wawa TS	1 ATX out	245	122	243	124	243	125	248
	2 ATXs out	248	N/A	243	123	243	124	248
Marathon TS	1 ATX out	244	123	243	123	243	125	248
	2 ATXs out	245	124	245	122	243	124	248
	1ATX & 1 RX out	246	124	247	125	243	124	248
	2 RXs out	246	123	248	125	243	123	248
Lakehead TS	1 ATX out	243	123	241	124	241	123	246
	2 ATXs out	244	124	243	123	245	116	246
	1 ATX & 1RX out	242	122	241	122	246	122	249

Actions of the updated NW SPS 2 were required for some of these contingencies, examples being:

- tripping of all the tertiary-connected capacitors at Marathon TS and Wawa TS following the loss of the second Marathon TS 230 kV reactor assuming that the first 230 kV reactor is out of service pre-contingency for maintenance or repairs;
- load rejection of around 50 MW to maintain post-contingency stability in the Lakehead TS 115 kV area following the loss of the second Lakehead TS transformer assuming that the first autotransformer is out of service pre-contingency for maintenance or repairs;
- tripping of the Lakehead TS 230 kV capacitor following the loss of the Lakehead TS reactor; or
- tripping of the Lakehead TS 230 kV capacitor and all tertiary-connected capacitors at Marathon TS and Wawa TS following the loss of the Lakehead TS reactor assuming that one Lakehead TS autotransformer is out of service pre-contingency for maintenance or repairs.

The following table shows the results for Scenario #3 (East-West Tie transfers close to zero):

Table 13: Summary of voltage levels (kV) – Scenario #3

Station		Wawa TS		Marathon TS		Lakehead TS		MacKenzie TS
Autotransformer/Reactor Outages		230 kV	115 kV	230 kV	115 kV	230 kV	115 kV	230 kV
Pre-contingency		239	124	241	123	243	125	245
Wawa TS	1 TX out	242	124	242	124	243	124	245
	2 TXs out	247	N/A	244	123	243	124	245
Marathon TS	1 TX out	239	124	241	124	243	125	245
	2 TXs out	241	124	244	123	243	124	245
	1 TX & 1 RX out	242	125	245	125	243	124	245
	2 RXs out	243	125	247	123	243	125	245
Lakehead TS	1 TX out	239	123	239	123	240	124	243
	2 TXs out	240	123	241	124	243	120	244
	1 TX & 1RX out	240	123	241	122	246	123	246

The actions of the updated NW SPS 2 for scenario #3 only involved tripping the in-service tertiary-connected capacitor at Marathon TS following the loss of the second Wawa TS autotransformer or the second Marathon TS reactor. All other capacitors were taken out of service pre-contingency to control voltages within acceptable ranges under near zero westwards flows across the East-West Tie.

The analysis shows that the proposed voltage control devices will be appropriate to maintain local voltages within applicable ranges under high, median and zero transfers across the East-West Tie and as such it is expected that they will be adequate for all other intermediate flow levels. A switching study was completed to determine if these reactive devices are properly sized. Switching of reactive devices will unlikely be required under high or near zero transfer, it will most likely occur when flows are transitioning between those two states. For this reason, Scenario #2 was used as it represents a steady state operating point that is closer to when reactive devices will most likely need to be switched while transfers are increasing or decreasing. The following table summarizes the voltage changes following reactive device switching at the main stations assuming all elements in service:

Table 14: Summary of voltage changes following reactive devices switching

Station	Switched Equipment	Wawa TS		Marathon TS		Lakehead TS		MacKenzie TS
		230 kV	115 kV	230 kV	115 kV	230 kV	115 kV	230 kV
Lakehead TS	230 kV Capacitor-off	0.22%	0.16%	0.38%	0.28%	0.68%	1.83%	0.30%
	230 kV Capacitor-on	0.22%	0.16%	0.38%	0.28%	0.68%	1.83%	0.30%
	230 kV Reactor-off	0.22%	0.16%	0.38%	0.28%	0.68%	1.83%	0.30%
	230 kV Reactor-on	0.22%	0.16%	0.38%	0.28%	0.67%	1.86%	0.30%
Marathon TS	230 kV Reactor-off	0.92%	0.66%	1.67%	1.40%	0.00%	0.79%	0.03%
	230 kV Reactor-on	0.91%	0.65%	1.64%	1.38%	0.00%	0.79%	0.03%
	Tertiary Reactor-off	0.48%	0.34%	0.87%	2.21%	0.00%	0.42%	0.02%
	Tertiary Reactor-on	0.48%	0.34%	0.87%	2.17%	0.00%	0.42%	0.02%
	Tertiary-Capacitor-off	0.49%	0.35%	0.91%	1.96%	0.35%	0.13%	0.20%
	Tertiary-Capacitor-on	0.50%	0.35%	0.91%	1.99%	0.35%	0.13%	0.20%
Wawa TS	Tertiary Reactor-off	0.72%	1.71%	0.39%	0.31%	0.00%	0.18%	0.01%
	Tertiary Reactor-on	0.72%	1.68%	0.39%	0.31%	0.00%	0.18%	0.01%
	Tertiary-Capacitor-off	0.56%	1.32%	0.31%	0.25%	0.03%	0.11%	0.01%
	Tertiary-Capacitor-on	0.56%	1.34%	0.31%	0.25%	0.03%	0.11%	0.01%

The voltage changes presented in this table were calculated assuming that the dynamic voltage control devices locate at Lakehead TS: synchronous condenser and static var compensator (SVC) are available and prepared (by freeing sufficient range) prior to switching. It should be noted that switching the proposed Lakehead TS capacitor and reactor need to be carefully prepared by freeing sufficient dynamic range on both the SVC and the synchronous condenser, otherwise unacceptable voltage changes could occur.

The following analysis shows that under the same scenario, assuming both devices unavailable, the voltage change that occurs when switching either the Lakehead 230 kV reactor or capacitor will be beyond criteria (violations shown in red on Table 15 below). The bus voltages are also more likely to exceed their ranges.

Table 15: Summary of voltage changes in absence of dynamic support

Station	Switched Equipment	Wawa TS		Marathon TS		Lakehead TS		MacKenzie TS
		230 kV	115 kV	230 kV	115 kV	230 kV	115 kV	230 kV
Lakehead TS	230 kV Capacitor-off	2.27%	1.91%	3.62%	3.46%	5.75%	4.90%	3.70%
	230 kV Capacitor-on	2.32%	1.95%	3.76%	3.58%	6.10%	5.15%	3.84%
	230 kV Reactor-off	2.55%	2.14%	4.08%	3.89%	6.47%	5.52%	4.16%
	230 kV Reactor-on	2.48%	2.10%	3.92%	3.74%	6.08%	5.23%	4.00%

With just one of the SVC or the synchronous condenser available, the voltage change that occurs when switching either the Lakehead 230 kV reactor or capacitor is expected to be within criteria only if there is sufficient dynamic range on the available SVC or synchronous condenser prior to the switching. It should be noted that under some system conditions, to create sufficient dynamic range, operators may need to switch in or out smaller reactors or capacitors at adjacent transformer stations.

This section demonstrated that the proposed reactive control devices are appropriate to control voltages within applicable range under all foreseeable conditions. Since the voltages near the project are strongly dependent on the flows across the tie and because the flows across the tie can vary over a wide range throughout the day, these reactive control devices may need to be switched multiple times a day. The ability to remotely arm the updated NW SPS 2 directly from the IESO control room will help simplify this process.

4.7 Relay Margin and Transient Stability Analysis

The relay margin analysis is required to ensure that out of zone tripping does not occur as a result of the addition/modification of power system equipment or modifications to protection settings.

The analysis is performed by simulating contingencies on elements in the vicinity of the line whose relay margin is being assessed and determining the associated trajectory of the apparent line impedance. To check if the required relay margin is maintained after the simulated fault is cleared, the trajectory of the apparent line impedance is compared to the relay characteristic of the line(s) that are not expected to trip.

The protection impact assessment (PIA) performed by the transmitter on behalf of the IESO indicates that existing protections setting at the three terminal transformer stations modified for the project remain unchanged and provides the settings of the new protections proposed to be installed for the project. It also indicates that no other protections in the zone require modifications for this project's incorporation.

In order to assess the relay margins for the new and existing relays at Lakehead TS, Marathon TS and Wawa TS the following representative contingencies were simulated:

1. Three phase fault (clearing time: local - 83 ms, remote - 108 ms) followed by the loss of one transmission circuit:
    a. M23L at Lakehead TS and at Marathon TS (2 cases)
    b. M37L at Lakehead TS and at Marathon TS (2 cases)
    c. W22M at Marathon TS and at Wawa TS (2 cases)
    d. W35M at Marathon TS and at Wawa TS (2 cases)
2. Line-to-line-to-ground (LLG) fault (clearing time: local - 83 ms, remote - 108 ms) followed by the loss of 2 adjacent transmission circuits:
    a. M23L and M24L at Lakehead TS and Marathon TS (2 cases)
    b. M37L and M38L at Lakehead TS and Marathon TS (2 cases)
    c. W21M and W22M at Marathon TS and Wawa TS (2 cases)

d. W35M and W21M at Marathon TS and Wawa TS (2 cases) – to account for the new double contingencies introduced by the proposed quadruple circuit towers. For the relay margin analysis the fault was simulated near the station for a longer total clearing time to obtain a more conservative impedance trajectory. To note is that because of the location of these towers, this fault can occur within zone one of both line protections (located at Marathon TS and at Wawa TS) and have a shorter clearing time, so its associated relay margins will be higher.

e. W35M and W36M at Marathon TS and Wawa TS (2 cases)

3. Line-to-ground (LG) fault and breaker failure - stuck breaker - (clearing time: remote - 108 ms, total - 181 ms) followed by the loss of two transmission circuits:

   a. L22L23 breaker failure at Lakehead TS followed by the loss of M23L and A22L (1 case)

   b. L21L23 breaker failure at Marathon TS followed by the loss of M23L and W21M (1 case)

   c. L22L24 breaker failure at Marathon TS followed by the loss of W22M and M24L (1 case)

   d. L22L26 breaker failure at Wawa TS followed by the loss of W22M and P26W (1 case)

   e. L21L25 breaker failure at Wawa TS followed by the loss of W21M and P25W (1 case)

   f. L35L36 breaker failure at Wawa TS followed by the loss of W35M and W36M (1 case)

These faults were simulated assuming the desired westward flow of approximately 450 MW across the East-West Tie to also confirm that the local system is transiently stable following a recognized contingency.

The analysis shows that the relay margins and post-contingency transient voltages satisfy the applicable criteria, an indication that the proposed protection modifications, as presented in the PIA, are acceptable to the IESO and the integrated power system is expected to have a stable dynamic behavior following the incorporation of the project.

Appendix C presents some sample results of the relay margin and transient stability analysis.

4.8 Updated NW SPS 2

As a result of project, the connection applicant has proposed updates to the existing NW SPS 2 remedial action scheme. These updates correspond to the new facilities and new station configurations, including the addition of new contingencies and actions to facilitate the operation of the IESO-controlled grid. Furthermore, they will help with the re-preparation of the grid within 30 minutes following contingencies. The updates proposed to the existing NW SPS 2 (CAA ID 2014-EX712) include:

1. Adding 14 new single and double contingencies involving 230 kV transmission circuits:

- W35M, W36M, W35M+W36M, W21M+W35M, W21M+W36M, W22M+W35M and W22M+W36M;
- M37L, M38L and M37L+M38L;
- P25W, P26W and P25W+P26W; and
- W23K.

2. Removing 4 Marathon TS breaker failure contingencies;
3. Removing 4 Lakehead TS breaker failure contingencies;
4. Adding 2 new contingencies “Lakehead TS Reactor R1” and “Lakehead TS Capacitor SC21;
5. Replacing 2 Lakehead TS transformer (T7 and T8) contingencies with one “Lakehead TS T7 OR T8” contingency (i.e., trip of one of the two transformers when its companion is out of service of maintenance or repairs);

6. Adding 2 new transformer contingencies “Marathon TS T11 <u>OR</u> T12” and “Wawa TS T1 <u>OR</u> T2” (i.e., trip of one of the two transformers at each station when its companion is out of service for maintenance or repairs);
7. Adding 5 new actions to:
   - Trip Marathon TS 230 kV reactor R3;
   - Trip Marathon TS 230 kV reactor R4;
   - Trip Lakehead TS 230 kV reactor R1;
   - Trip Lakehead TS 230 kV capacitor SC21; and
   - Trip Lakehead TS 115 kV capacitor SC11.
8. Removing 115 kV transmission circuit A5A cross-trip action.

All updates as proposed by the connection applicant for NW SPS 2 are acceptable to the IESO. The proposed selection matrix for contingencies and responses of the updated NW SPS 2 is presented in Figure 4 below.

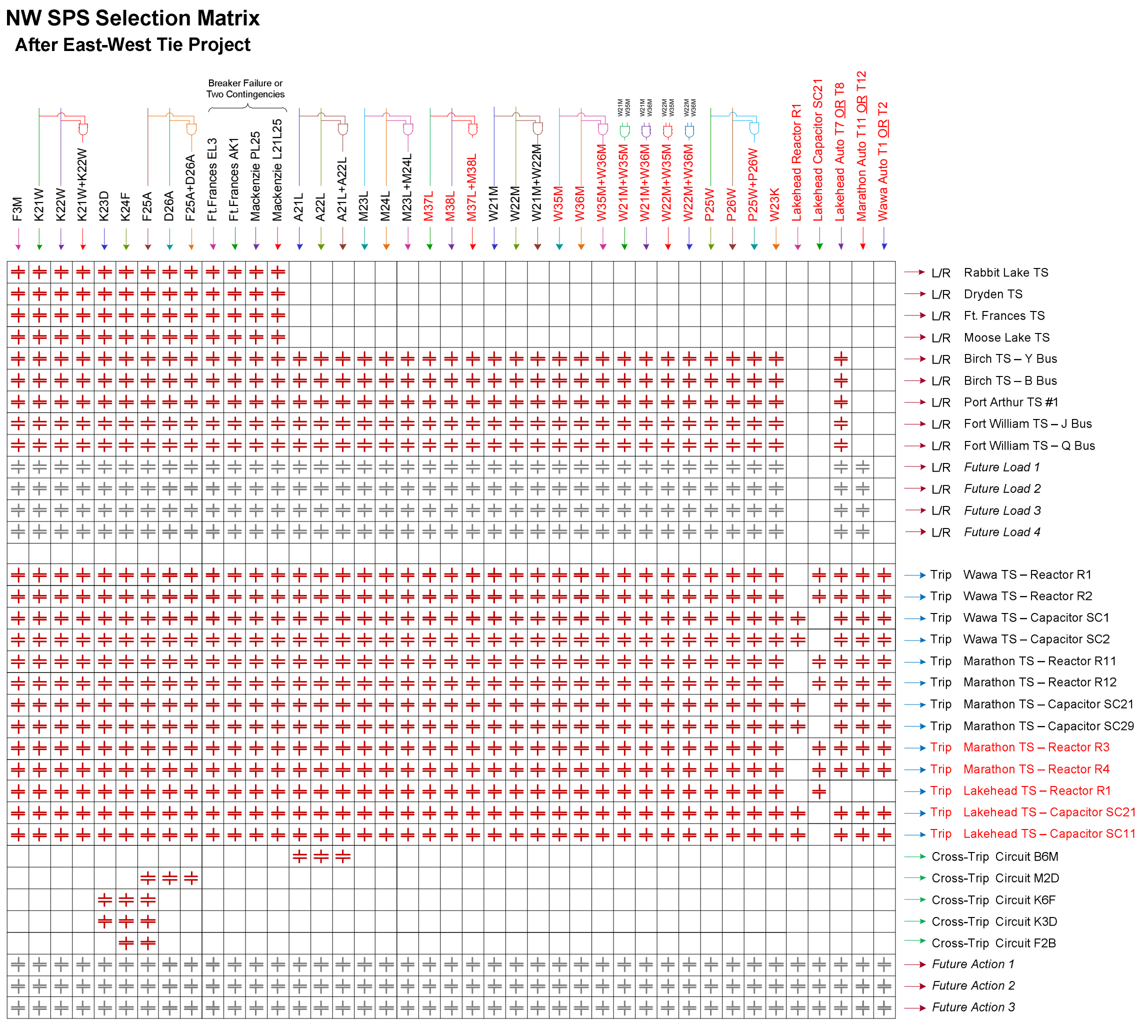

Figure 4: Proposed updates to NW SPS 2

– End of Section –

Appendix A: P-V Analysis Results

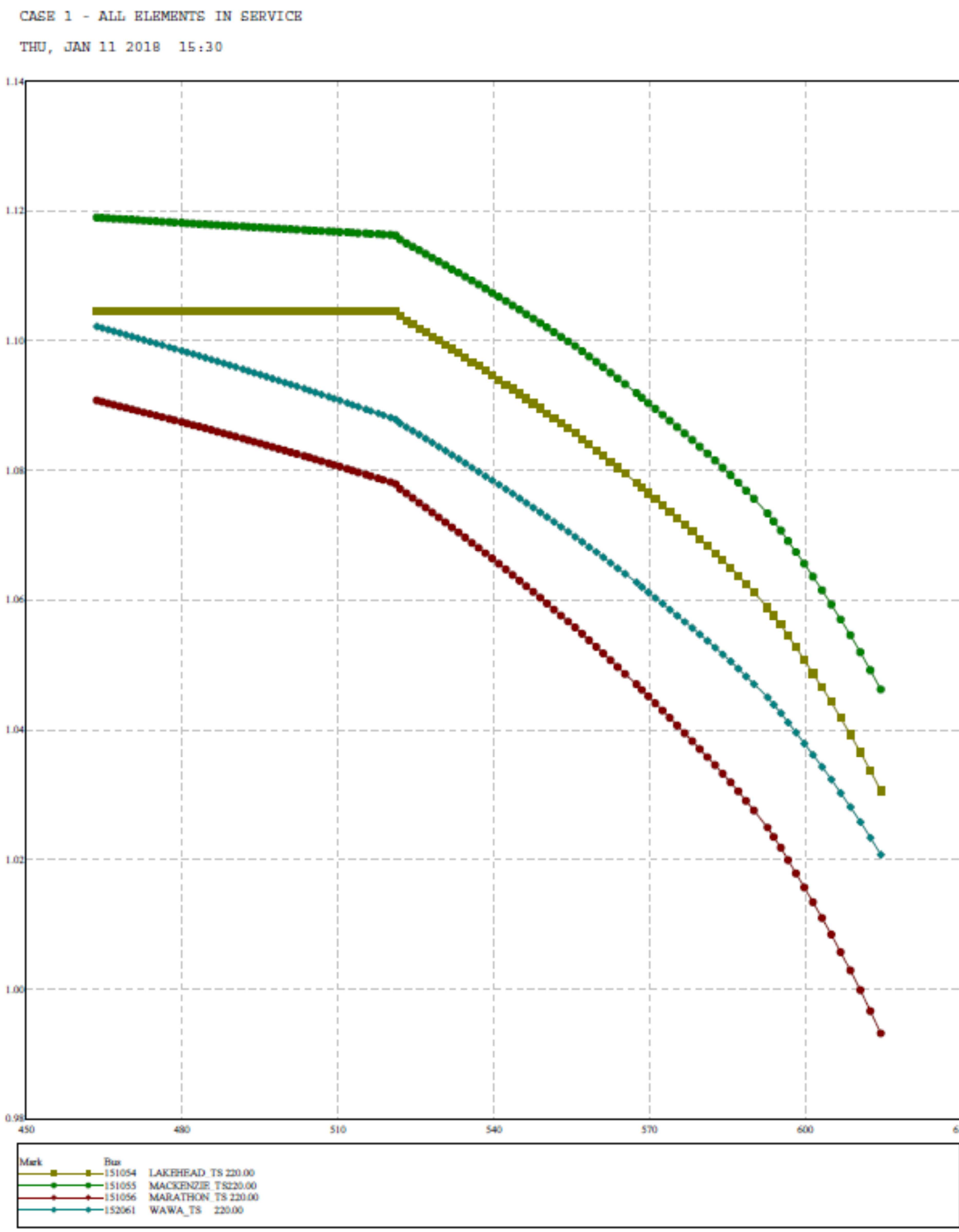

Figure 5: PV - all elements in service, pre-contingency

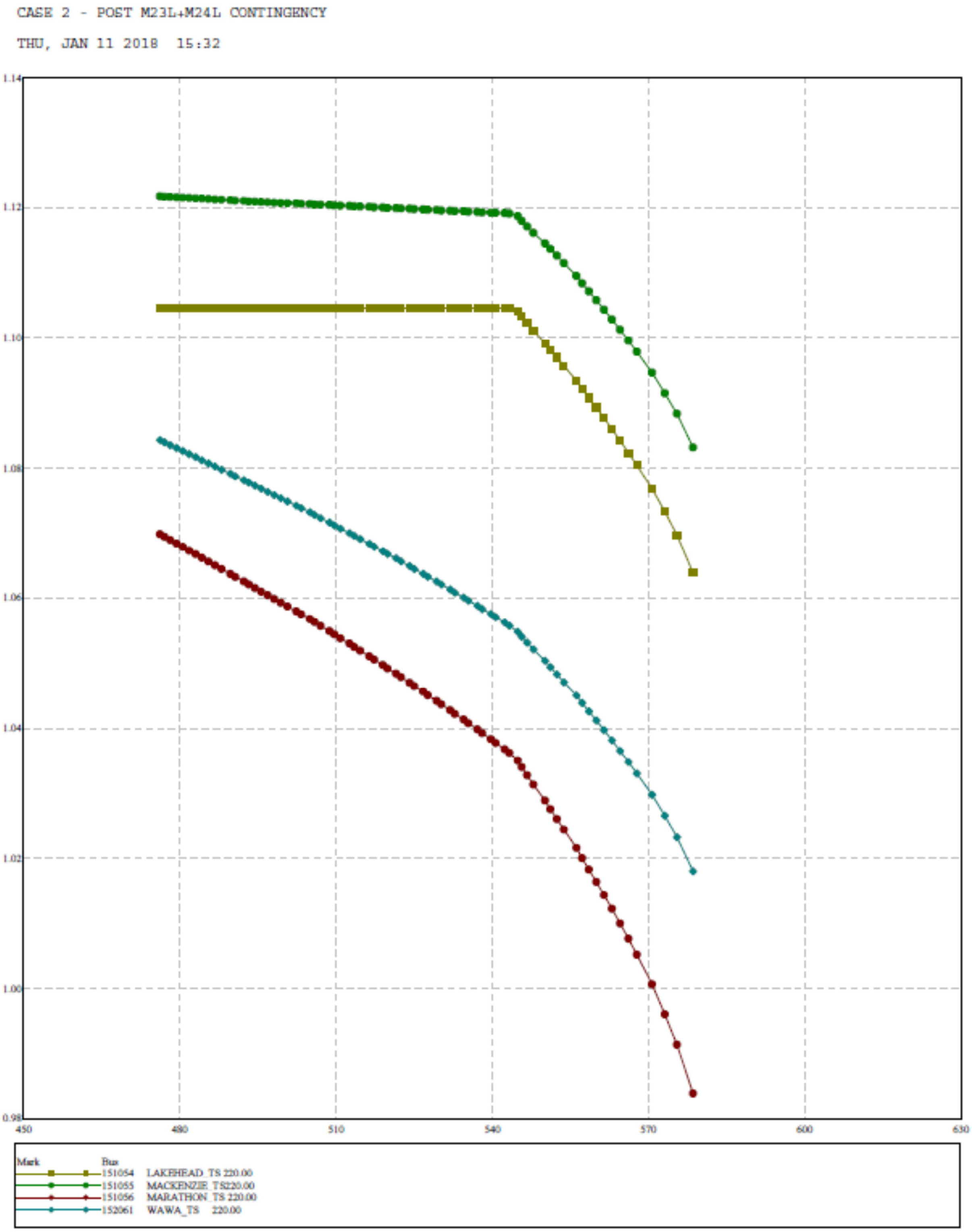

Figure 6: PV - post M23L+M24L contingency

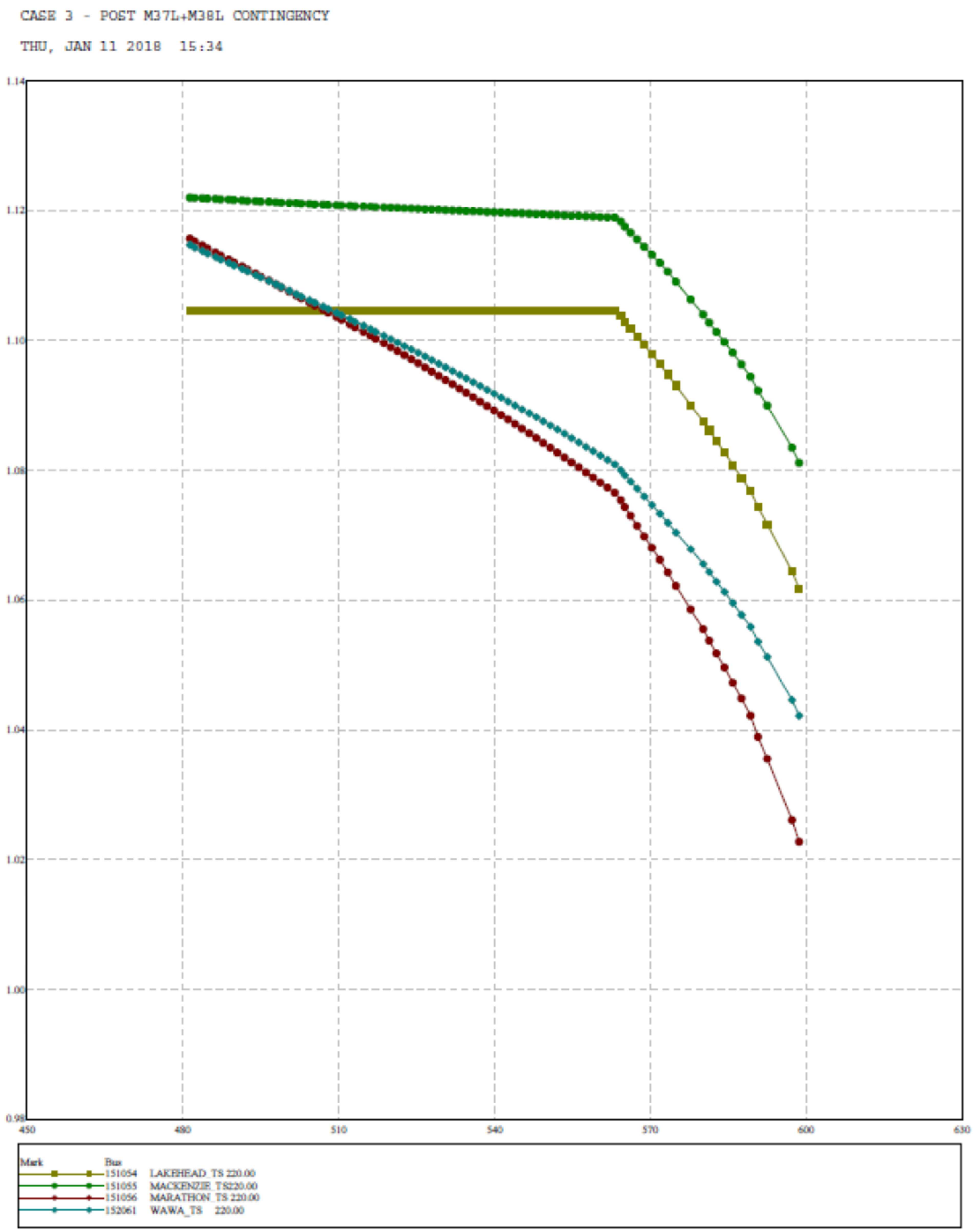

Figure 7: PV - post M37L+M38L contingency

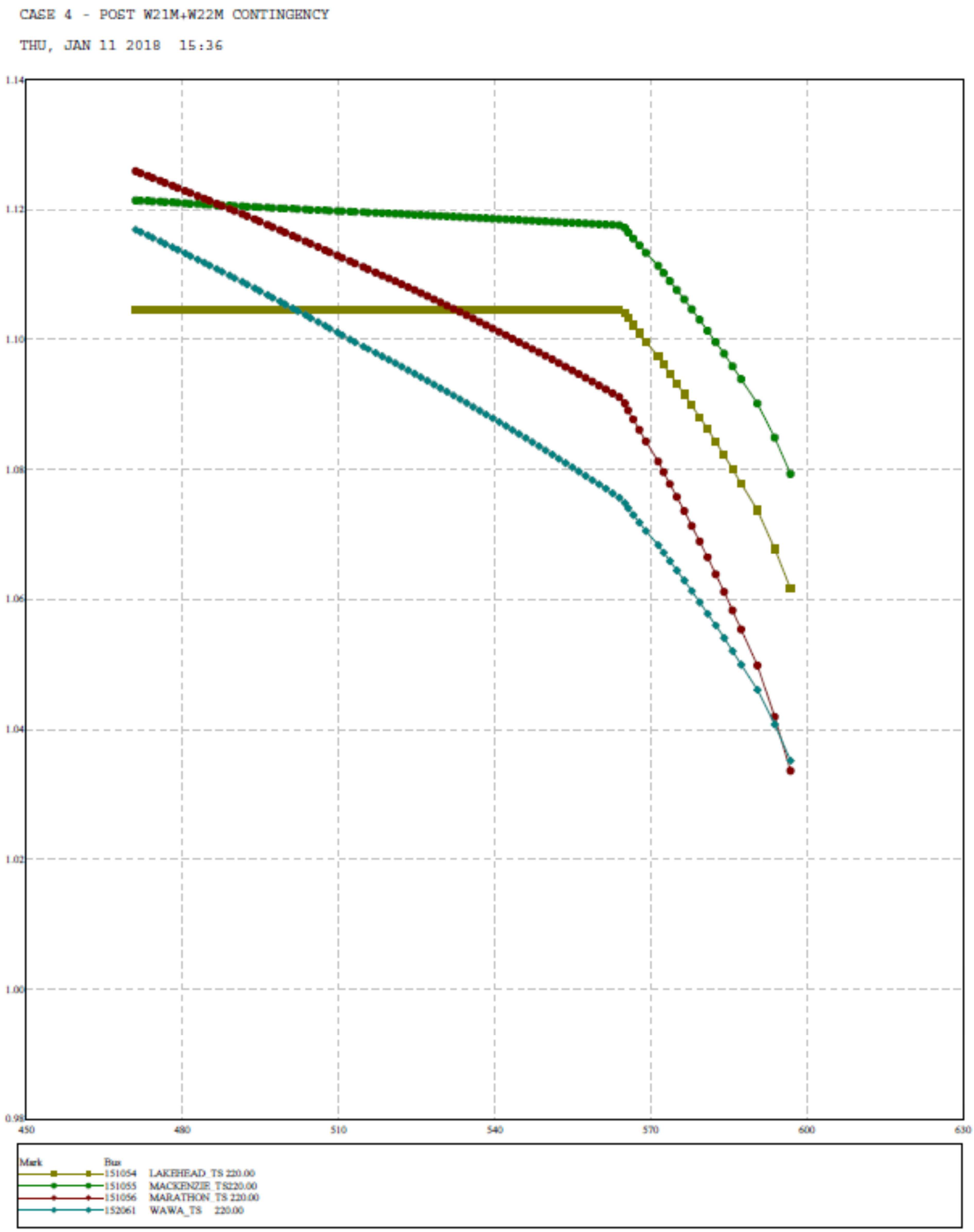

Figure 8: PV - post W21M+W22M contingency

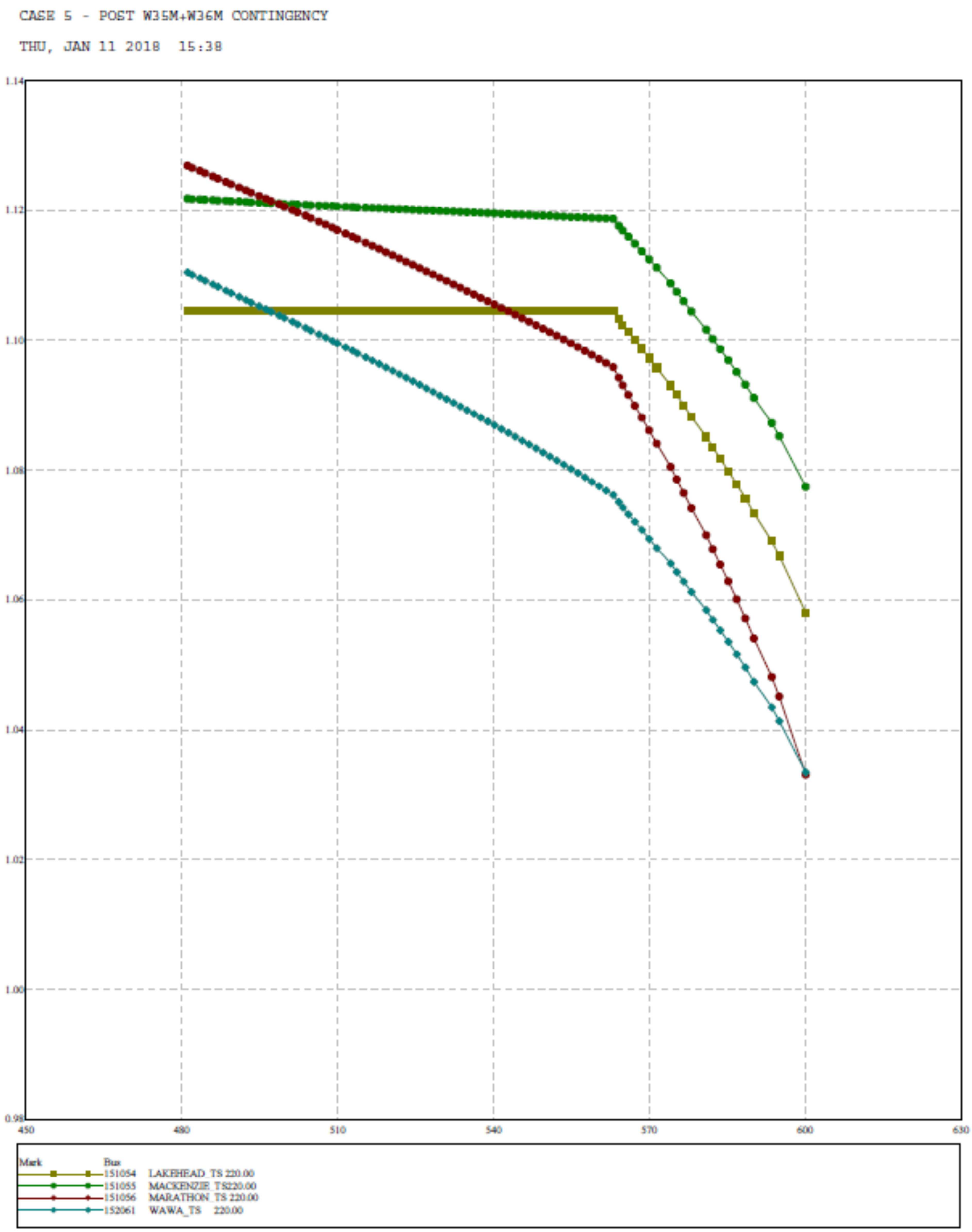

Figure 9: PV - post W35M+W36M contingency

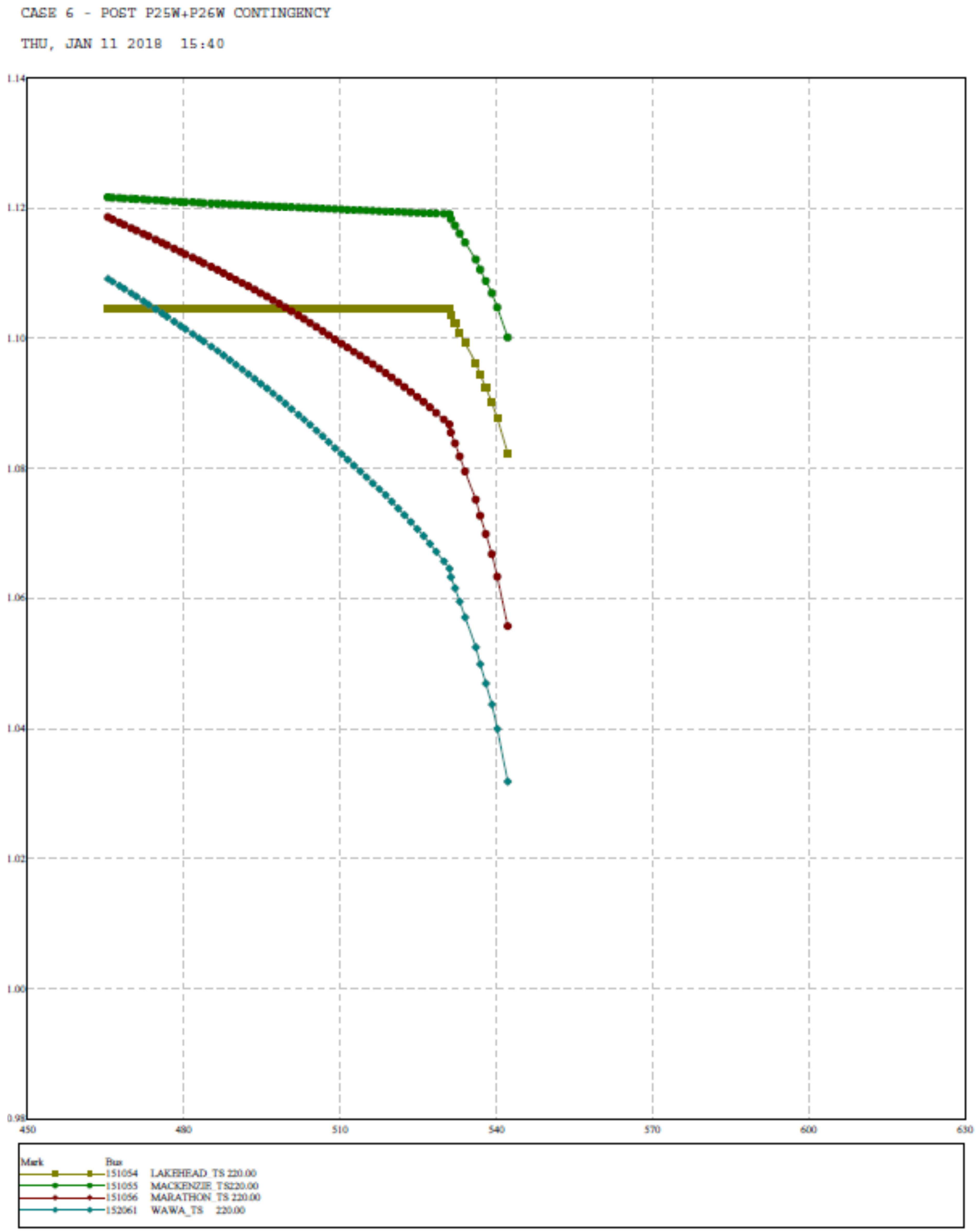

Figure 10: PV - post P25W+P26W contingency

– End of Section –

Appendix B: Power flows scenarios used in this study

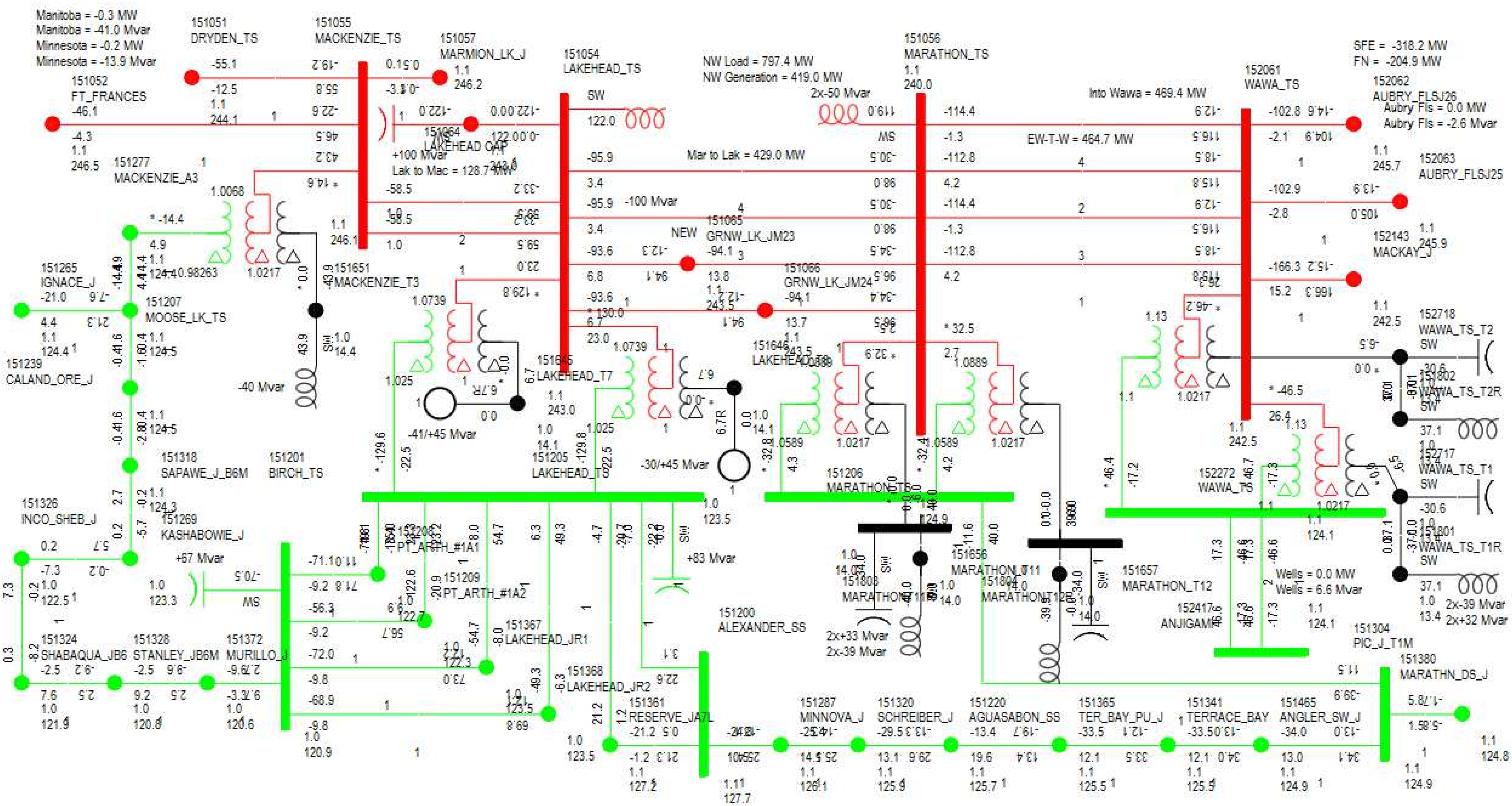

Figure 11: PV and operability base scenario with 450 MW transfer

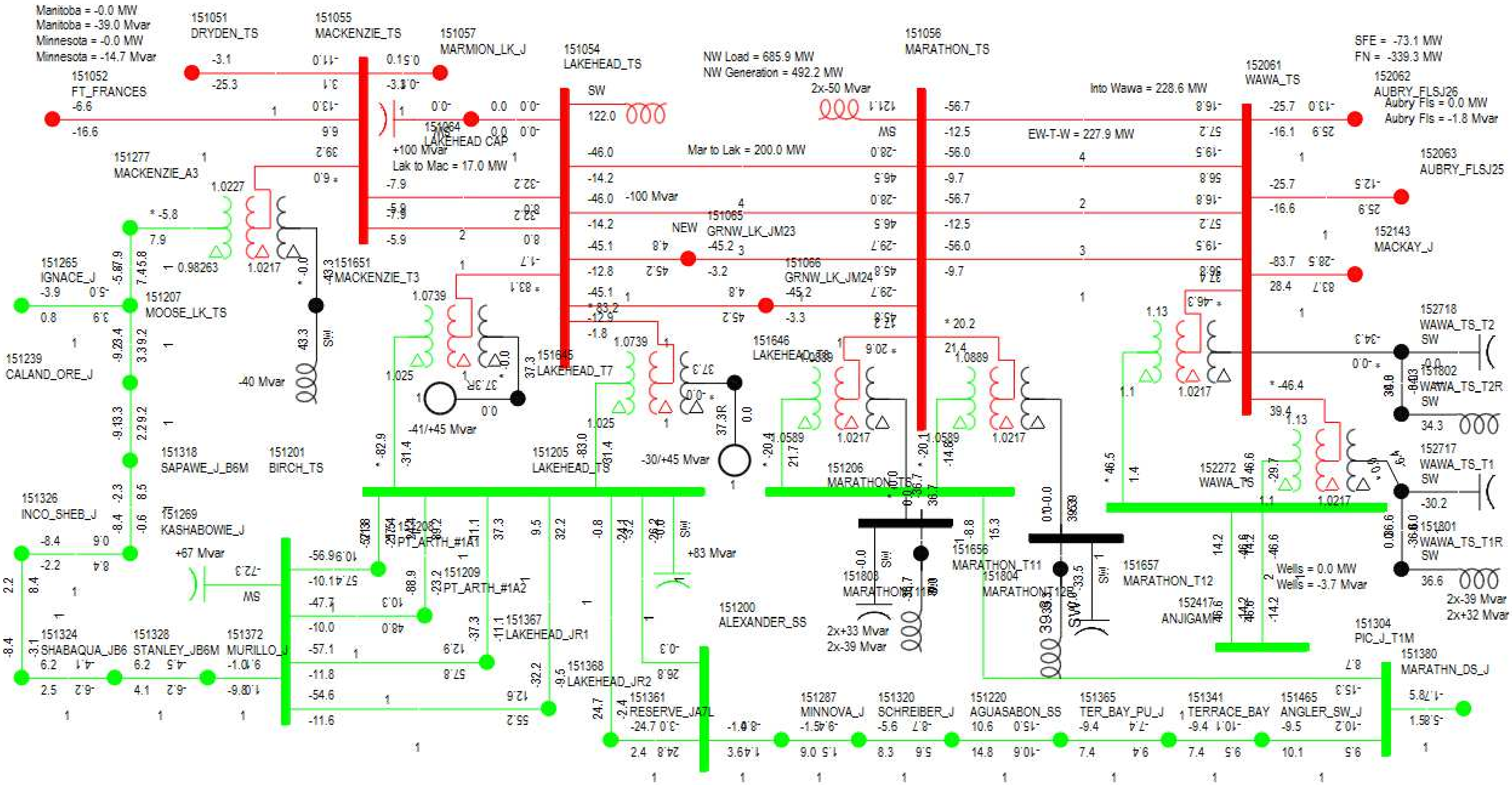

Figure 12: Median flows scenario with 225 MW transfer

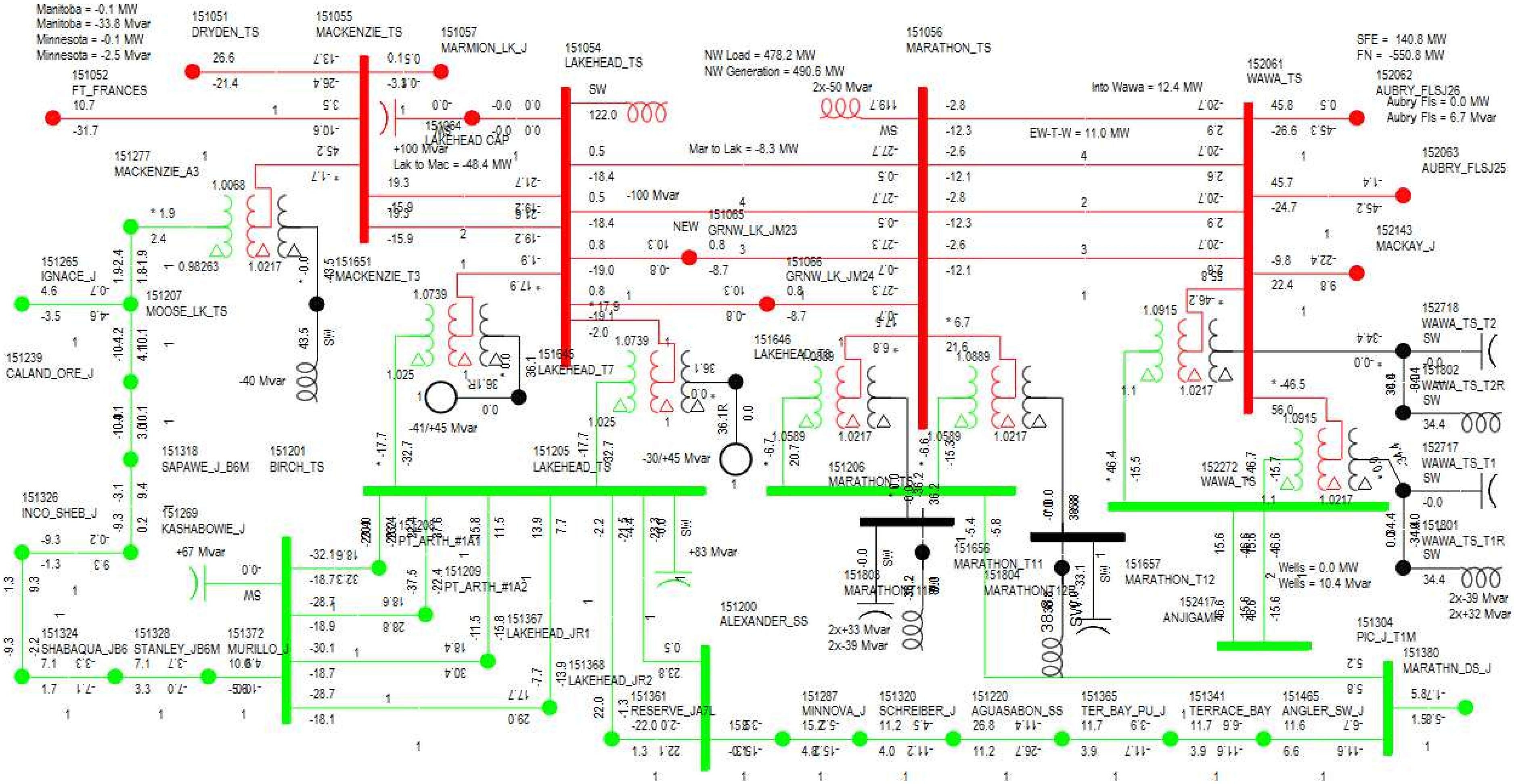

Figure 13: Zero flow scenario

– End of Section –

Appendix C: Protection Impact Assessment

Hydro One Networks Inc.
483 Bay Street
Toronto, Ontario
M5G 2P5

PROTECTION IMPACT ASSESSMENT

EAST WEST TIE LINE

PCT – 932

REV #4

Date: December 12, 2017

Disclaimer

This Protection Impact Assessment has been prepared solely for the IESO for the purpose of assisting the IESO in preparing the System Impact Assessment for the proposed connection of the proposed transmission facilities to the IESO–controlled grid. This report has not been prepared for any other purpose and should not be used or relied upon by any person, including the connection applicant, for any other purpose.

This Protection Impact Assessment was prepared based on information provided to the IESO and Hydro One by the connection applicant in the application to request a connection assessment at the time the assessment was carried out. It is intended to highlight significant impacts, if any, to affected transmission protections early in the project development process. The results of this Protection Impact Assessment are also subject to change to accommodate the requirements of the IESO and other regulatory or legal requirements. In addition, further issues or concerns may be identified by Hydro One during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with the Transmission System Code legal requirements, and any applicable reliability standards, or to accommodate any changes to the IESO-controlled grid that may have occurred in the meantime.

Hydro One shall not be liable to any third party, including the connection applicant, which uses the results of the Protection Impact Assessment under any circumstances, whether any of the said liability, loss or damages arises in contract, tort or otherwise.

Revision History

Revision	Date	Change
R0	December 12, 2017	Released Revision

1 INTRODUCTION

1.1 GENERAL

This PIA study is prepared for the IESO to assess the potential impact of the proposed new connection of two lines between stations Wawa TS & Marathon TS, and two lines between Marathon TS & Lakehead TS, as well as new station configuration of Wawa, Marathon and Lakehead to accommodate those new lines and new 230kV reactors/capacitor. The primary focus of this study is on protecting Hydro One system equipment while meeting IESO System Reliability Criteria.

1.2 DESCRIPTION OF THE PROPOSED CONNECTION

The expansion of the East-West Tie by new double-circuit 230 kV lines from Wawa TS to Marathon TS and from Marathon TS to Lakehead TS will increase the existing East-West transfer capability. Hydro One will connect these new 230 kV circuits to Wawa TS, Marathon TS and Lakehead TS as shown in Figure 1.

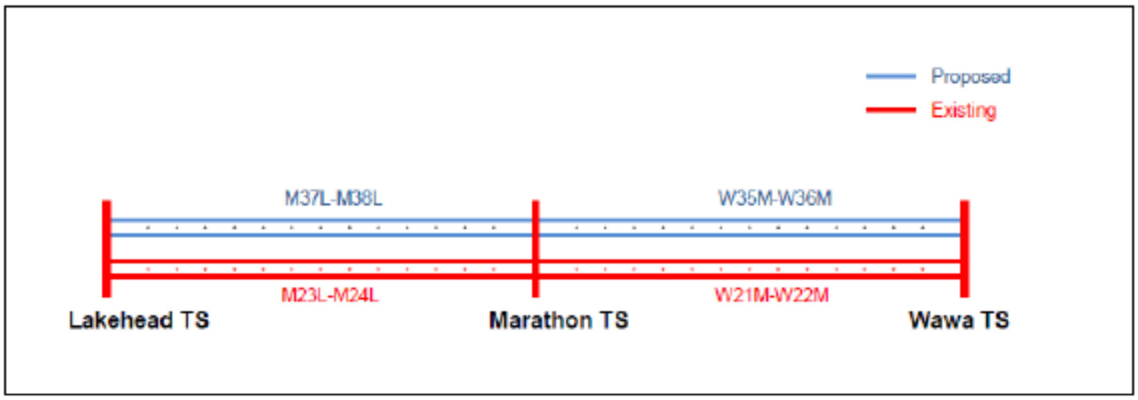

Figure 1 – Existing and proposed 230 kV Lines between Wawa and Lakehead TS.

1.3 ASSUMPTION

Telecommunication aided protection scheme for the new lines will be required.

1.4 DESCRIPTION OF THE EXISTING PROTECTION SYSTEM

Currently the lines M23L/M24L have Directional Comparison Blocking schemes in the A and B groups and utilize Power Line Carrier as the teleprotection mediums. The lines W21M/W22M use Permissive Overreaching Schemes in the A and B groups and utilize PLC as the teleprotection mediums.

2 PROPOSED PROTECTION & TELEPROTECTION SCHEME

2.1 GENERAL

The installations of the proposed connections are feasible as long as the proposed changes/additions are made.

2.2 Specific Protection Requirements

2.2.1 Wawa TS

Extensive 230kV station work will commence at Wawa to reconfigure the 5 breaker ring bus to a 2 bus, 4 diameter, 11 breaker, breaker-and-a-half scheme. Figure 2 is the proposed station single line.

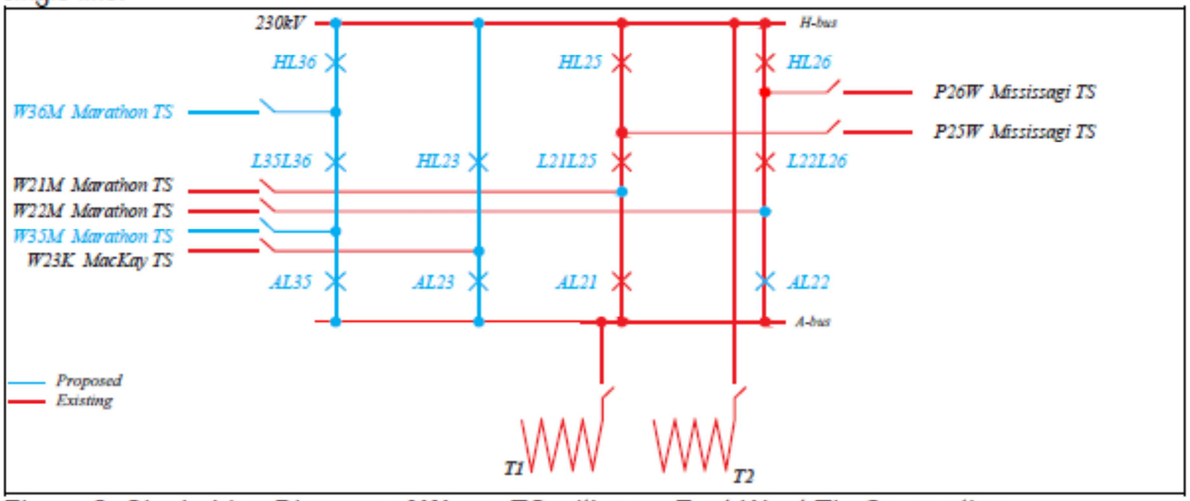

Figure 2: Single Line Diagram of **Wawa** TS with new East-West Tie Connection
(Nomenclature for breakers and new circuits are IESO suggestions)

Except for the 230kV line protections, the station 230kV system will be protected with:

- A and B breaker protections;
- A and B 230kV bus differential protections;
- A and B 230kV differential for T1/T2 auto-transformers;

For 230kV W21M/W22M/W35M/W36M lines, the following schemes shall be utilized to protect these lines:

- PLC shall be used for the main teleprotection in both the A and B groups. Fiber shall be used for the alternate teleprotection in both the A and B groups.
- A permissive overreaching scheme shall be used in both the A and B protections as per Hydro One standards.
- Zone 1 settings shall be set to 75/80% (for ground and phase respectively) of the positive sequence line impedance between Wawa TS and Marathon TS.
- Zone 2 settings shall be set to 125% (for ground and phase respectively) of the positive sequence line impedance between Wawa TS and Marathon TS.

The protection scheme for P25W/P26W (POTT for both 'A' and 'B' groups) and W23K (DCB for both 'A' and 'B' groups) will be retained unchanged, but the line protections will be upgraded to HONI latest standards.

2.2.2 Marathon TS

Extensive 230kV station work will commence to reconfigure the 4 breaker ring bus to a 2 bus, 4 diameter, 14 breaker. Figure 3 is the proposed station single line.

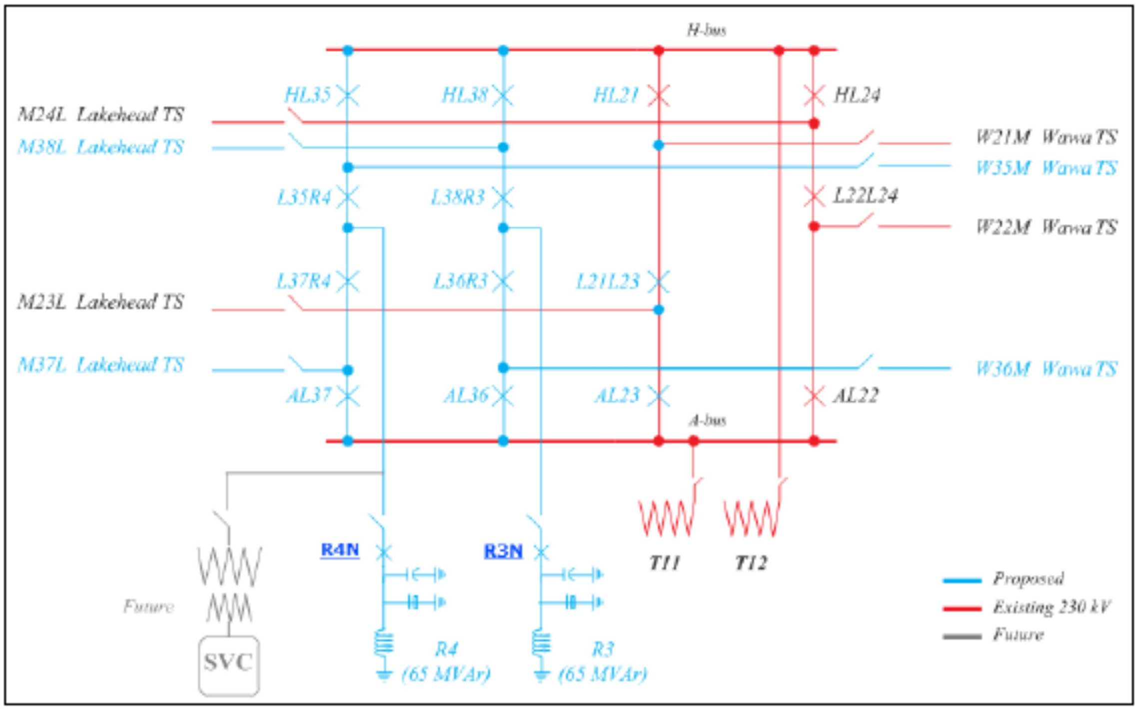

Figure 3: Single Line Diagram of **Marathon** TS with new East-West Tie Connection (Nomenclature for breakers and new circuits are IESO suggestions)

Except for the 230kV line protections, the station 230kV system will be protected with:

- A and B breaker protections;
- A and B 230kV bus differential protections;
- A and B 230kV differential for T11/T12 auto-transformers;
- A and B differential for R3/R4 reactors.

For 230kV W21M/W22M/W35M/W36M lines:

- — PLC shall be used for the main teleprotection in both the A and B groups. Fiber shall be used for the alternate teleprotection in both the A and B groups.
- — A permissive overreaching scheme shall be used in both the A and B protections as per Hydro One standards.
- — Zone 1 settings shall be set to 75/80% (for ground and phase respectively) of the positive sequence line impedance between Wawa TS and Marathon TS.
- — Zone 2 settings shall be set to 125% (for ground and phase respectively) of the positive sequence line impedance between Wawa TS and Marathon TS.

For 230kV new line M37L/M38L:

- — PLC shall be used for the main teleprotection in both the A and B groups. Fiber shall be used for the alternate teleprotection in both the A and B groups.

— A permissive overreaching scheme shall be used in both the A and B protections as per Hydro One standards.
— Zone 1 settings shall be set to 75/80% (for ground and phase respectively) of the positive sequence line impedance between Marathon TS and Lakehead TS.
— Zone 2 settings shall be set to 125% (for ground and phase respectively) of the positive sequence line impedance between Marathon TS and Lakehead TS.

The protection schemes for existing 230kV M23L/M24L (DCB for both A and B groups) will be kept unchanged, but the teleprotection shall be changed from PLC for both channels to PLC and Fiber for the main and alternate teleprotection paths.

2.2.3 Lakehead TS

Add a new diameter and 5 new breakers on the 230kV side of the station for termination of the new circuits and re-termination of the existing circuits, as well as reactor with its switching breaker, and capacitor bank with its breakers, as shown in Figure 4.

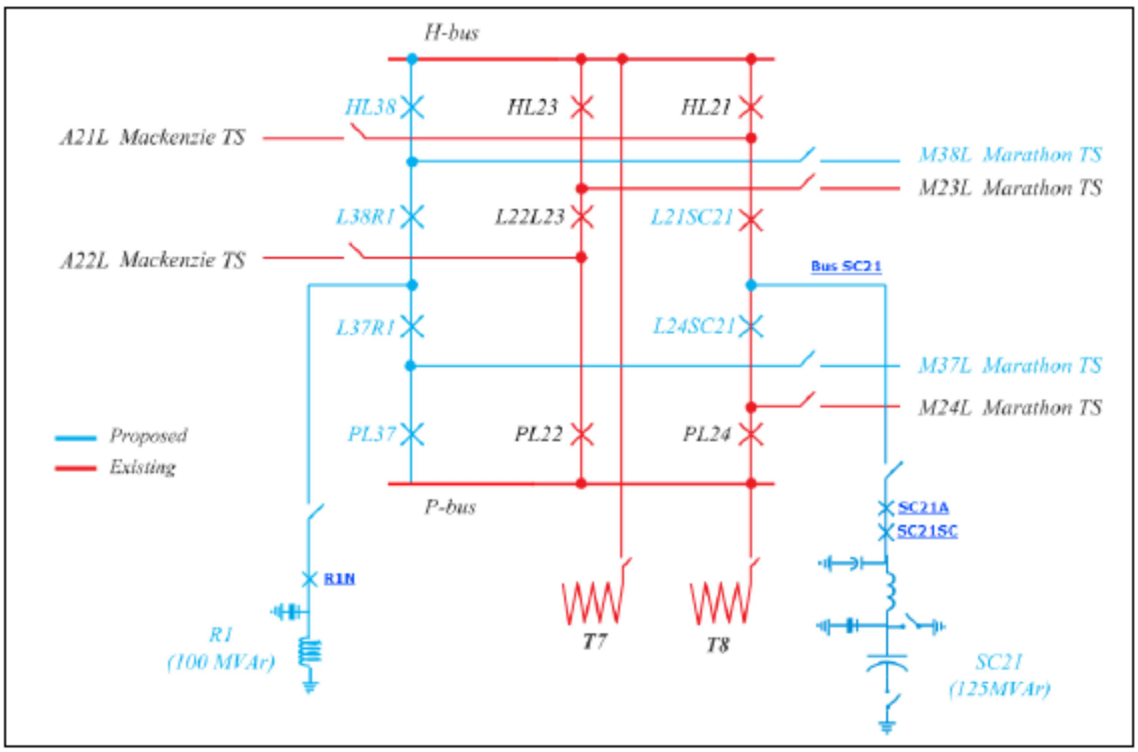

Figure 4: Single Line Diagram of **Lakehead** TS with new East-West Tie Connection (Nomenclature for breakers and new circuits are IESO suggestions)

Except for the 230kV line protections, the station 230kV system will be protected with:

- A and B breaker protections (excluding capacitor breakers);
- A and B 230kV bus differential protections;
- A and B 230kV differential for T7/T8 auto-transformers;

- A and B differential for R1 reactors.
- A and B protections for shunt capacitor SC21.

For new 230kV lines M37L/M38L:

- PLC shall be used for the main teleprotection in both the A and B groups. Fiber shall be used for the alternate teleprotection in both the A and B groups.
- A permissive overreaching scheme shall be used in both the A and B protections as per Hydro One standards.
- Zone 1 settings shall be set to 75/80% (for ground and phase respectively) of the positive sequence line impedance between Marathon TS and Lakehead TS.
- Zone 2 settings shall be set to 125% (for ground and phase respectively) of the positive sequence line impedance between Marathon TS and Lakehead TS.

The protection schemes for existing 230kV M23L/M24L (DCB for both A and B groups); A21L/A22L (DCB for A group and POTT for B group) will be kept unchanged. The teleprotection for M23L/M24L shall be changed from PLC for main and alternate to PLC for the main teleprotection path and fiber for the alternate teleprotection path.

2.3 TELE-PROTECTION

On the main corridor Lakehead-Marathon-Wawa:

- Fiber shall be installed on the new lines which shall be utilized for the alternate teleprotection path
- The existing PLC on the parallel lines shall be utilized for the main teleprotection path.

For other lines, the teleprotection schemes will be kept unchanged.

2.4 LONGEST FAULT CLEARING TIME

— The longest fault on the B protection POTT (permissive overreaching transfer trip) on the SONET:
  - This can be defined by the following situation (one line end open, which requires permissive echo)
    MR + TP (transfer trip) + MR + TP (permissive echo) + MR + BTM + BKR =
    25ms + 15ms + 10ms + 15ms + 10ms + 6ms + 50ms = **131ms**
  - For normal condition will be:
    MP+TP+MRTL+BTM+BRK=25ms + 15ms + 10ms + 6ms + 50ms = 106ms

The following functional specifications listed below are outside the scope of Protection Impact Assessment that deals exclusively with protection and teleprotection. However, should this become a project it will be addressed according to IESO Market Rules in the future in a PCT Planning Specification (former Appendix E) of a Transmission Planning Specification.

- *DC Station Services*
- *Relay Rooms, Cables and Wiring*
- *SCADA*
- *Power System Telecommunication (excluding Tele-protection)*
- *Station LAN*
- *Cyber Security*
- *Power System Monitoring*
- *Revenue Metering*
- *Infrastructure*
- *Aurora Vulnerability*
- *Functional Specification Compliance*
- *Project Completion Requirements*

Appendix D: Relay margin and transient stability analysis results

The following figures show some representative results of the relay margin analysis:

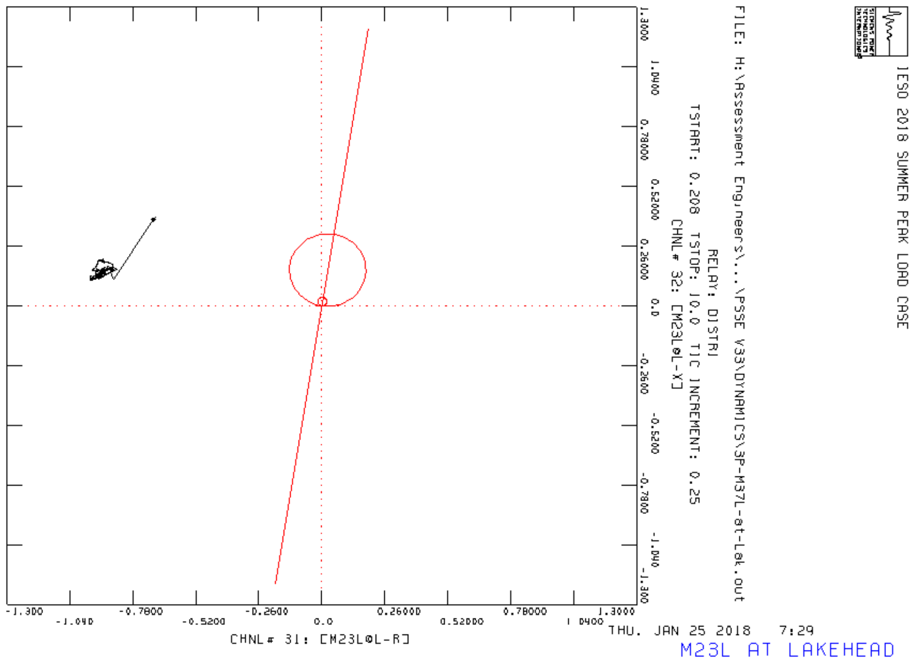

Figure 14: 3 phase fault on M37L at Lakehead TS

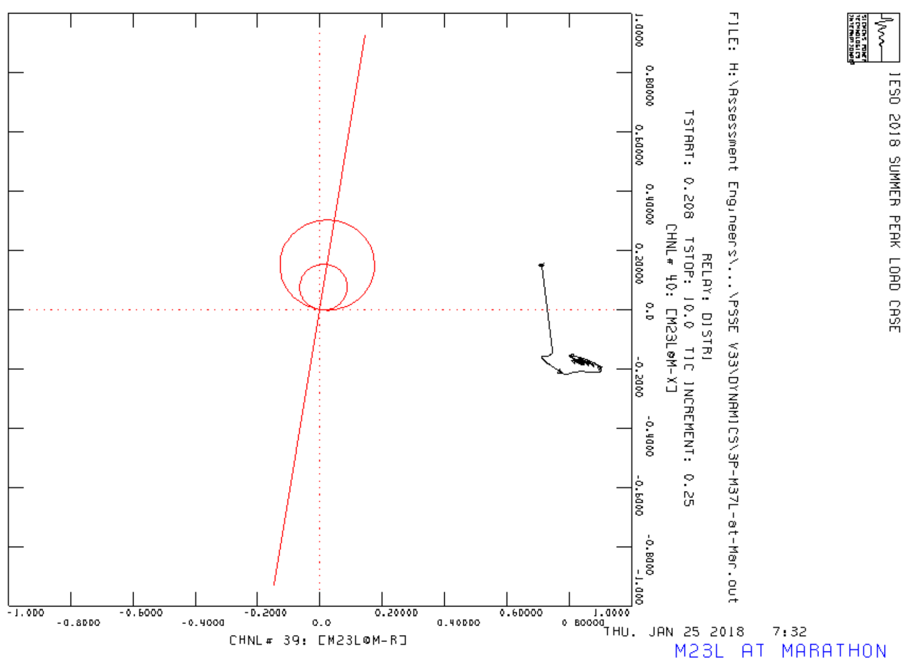

Figure 15: 3 phase fault on M37L at Marathon TS

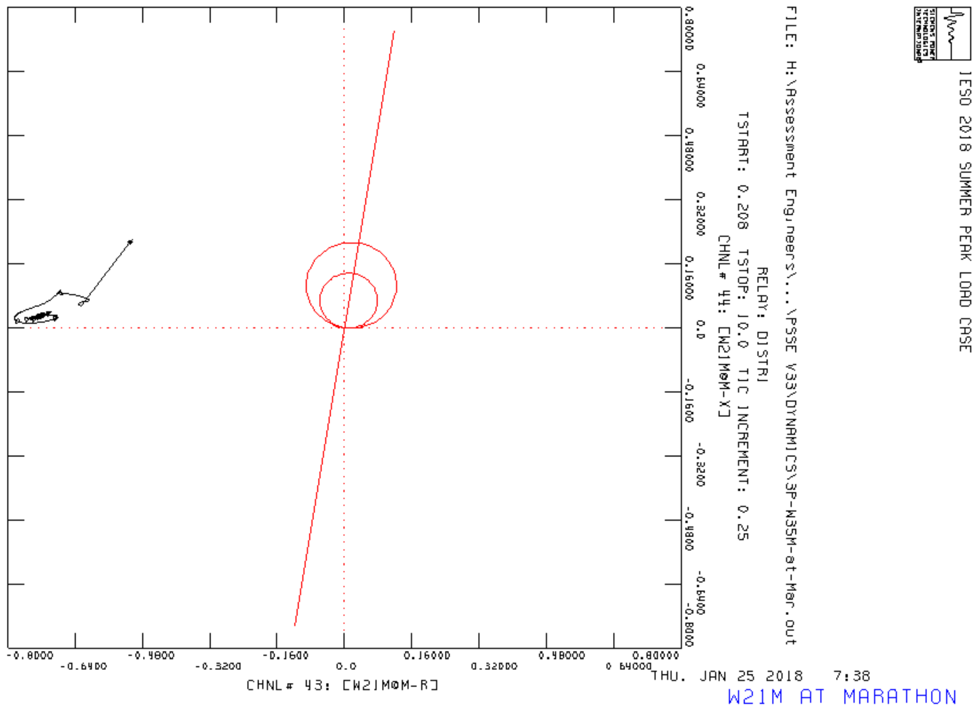

Figure 16: 3 phase fault on W35M at Marathon TS

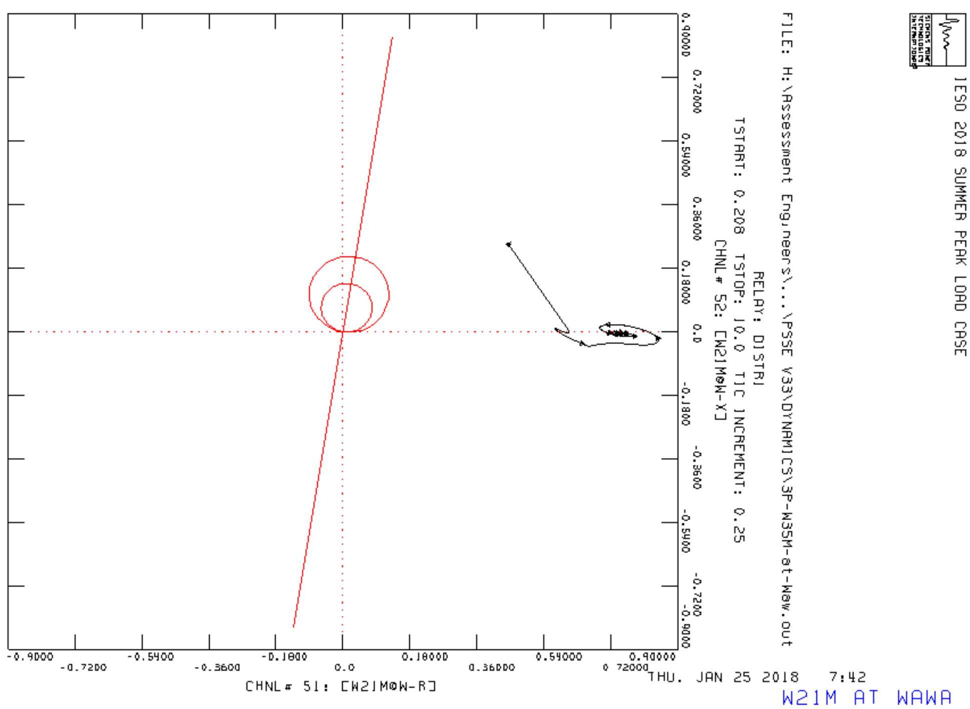

Figure 17: 3 phase fault on W35M at Wawa TS

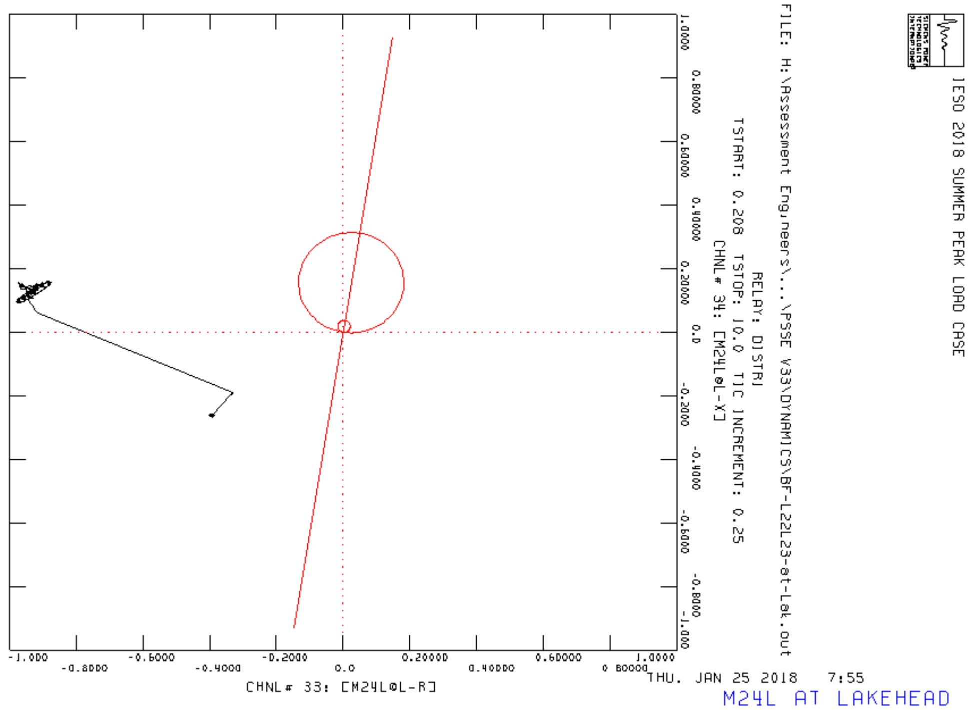

Figure 18: L22L23 breaker failure at Lakehead TS

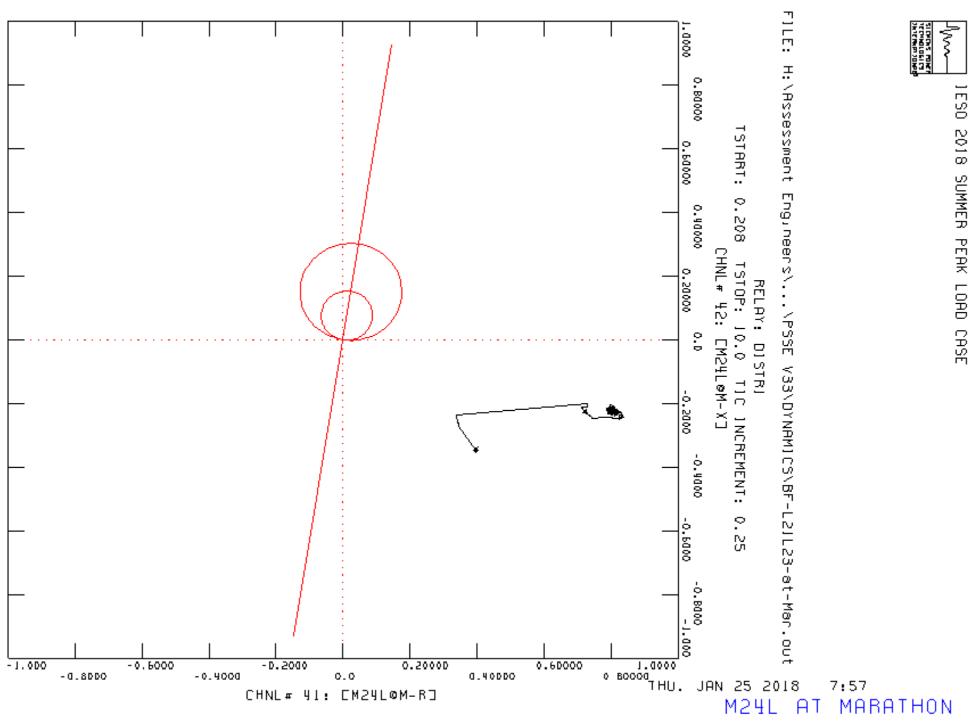

Figure 19: L21L23 breaker failure at Marathon TS

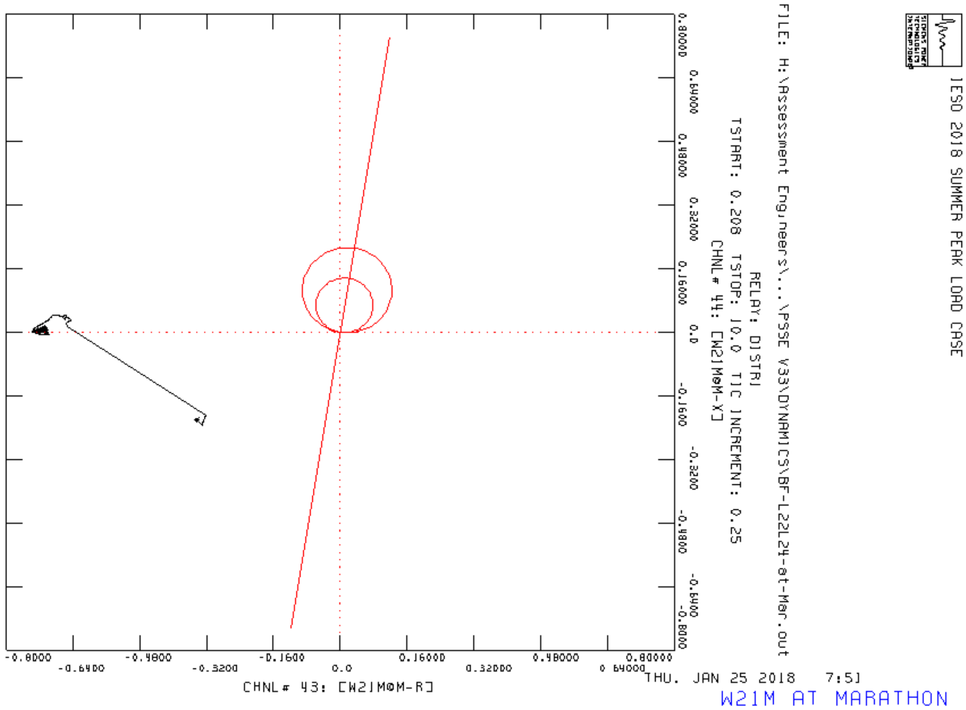

Figure 20: L22L24 breaker failure at Marathon TS

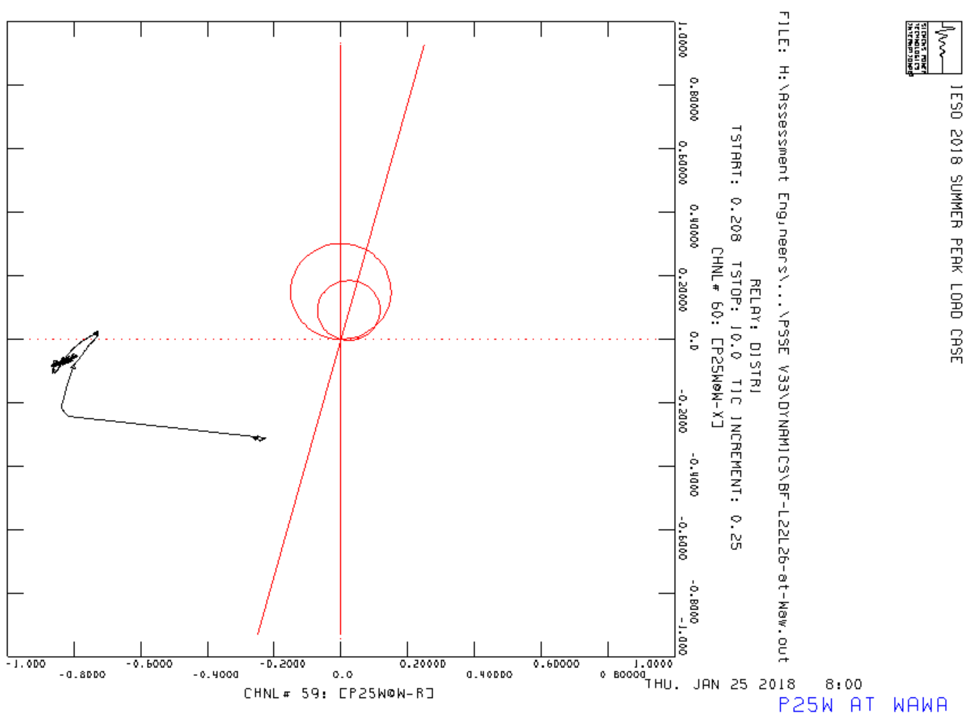

Figure 21: L22L26 breaker failure at Wawa TS

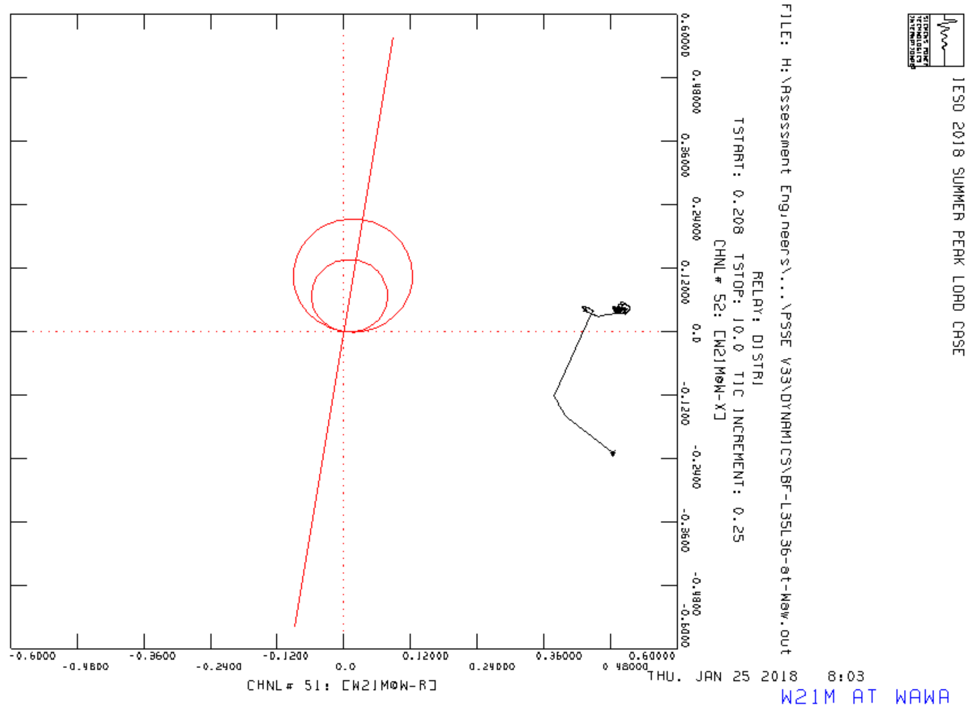

Figure 22: L35L36 breaker failure at Wawa TS

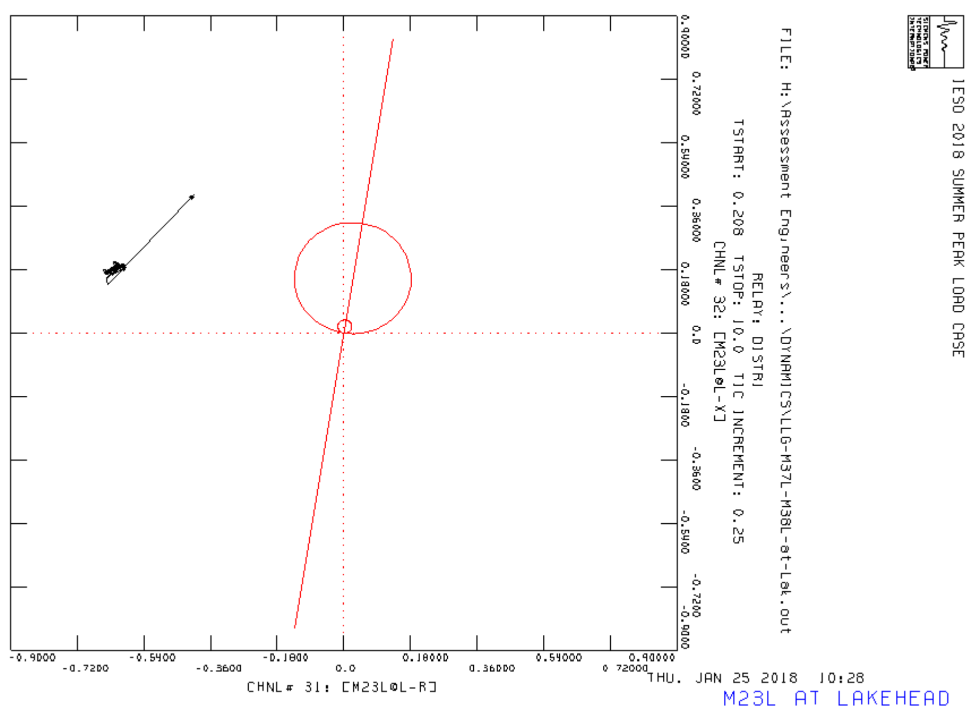

Figure 23: LLG fault on M37L/M38L at Lakehead TS

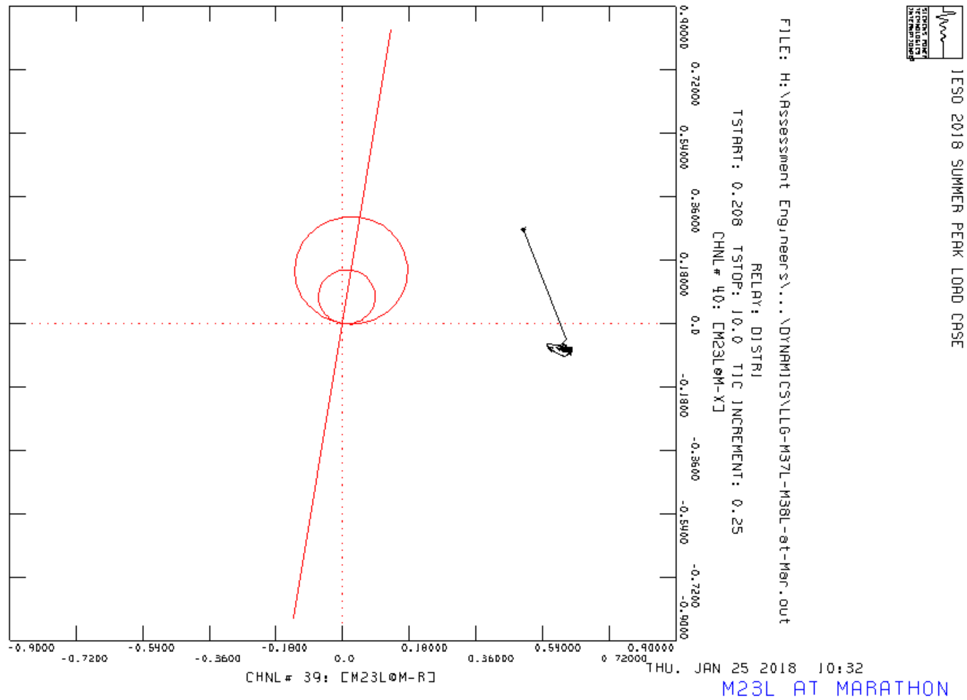

Figure 24: LLG fault on M37L/M38L at Marathon TS

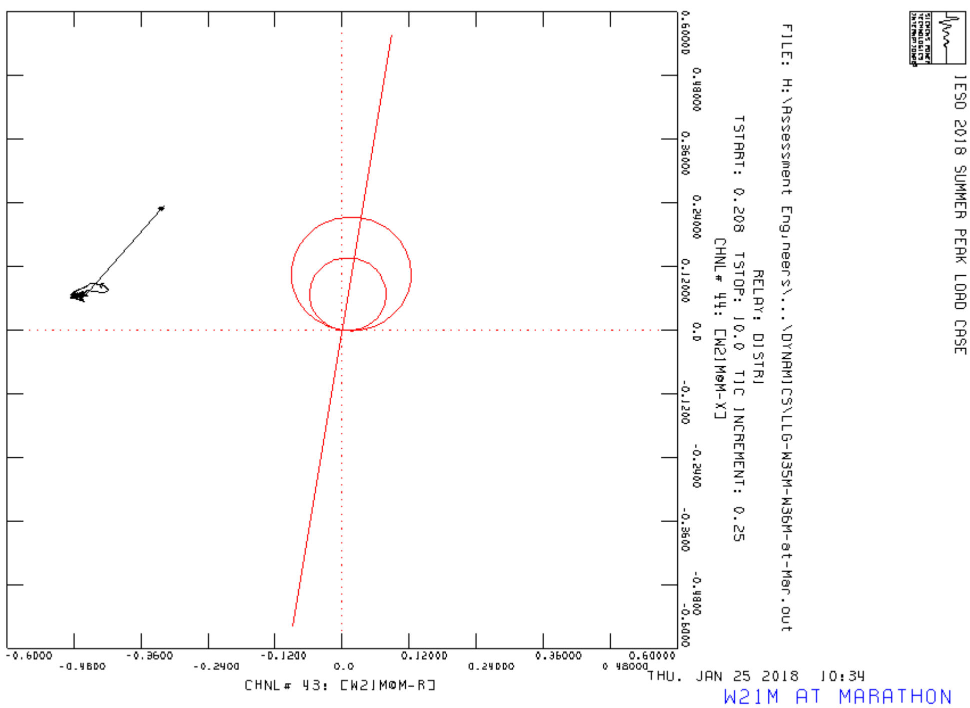

Figure 25: LLG fault on W35M/W36M at Marathon TS

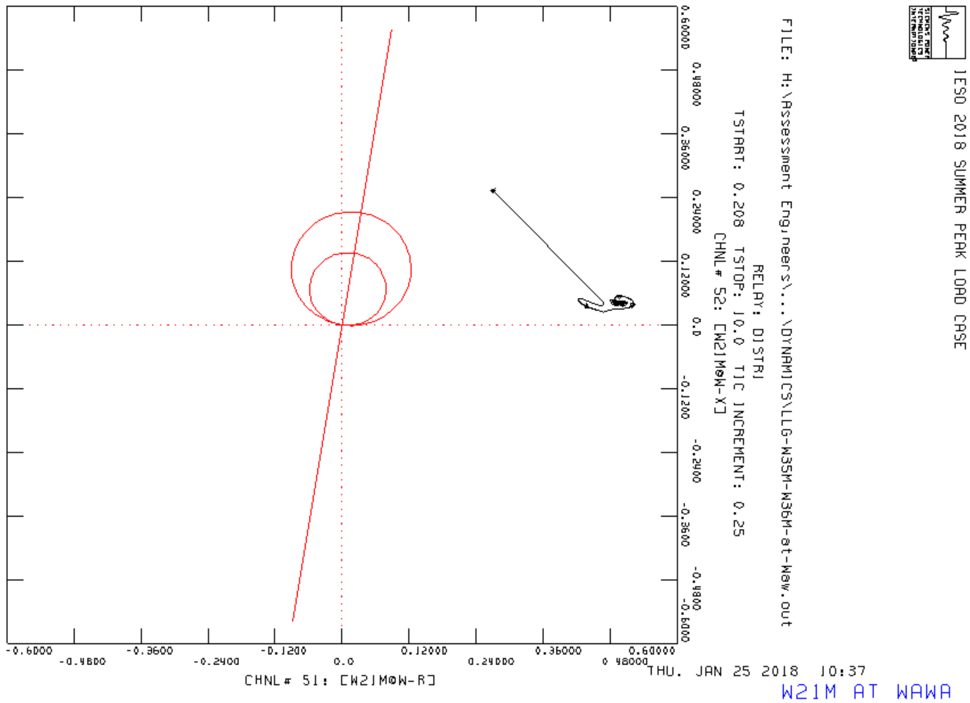

Figure 26: LLG fault on W35M/W36M at Wawa TS

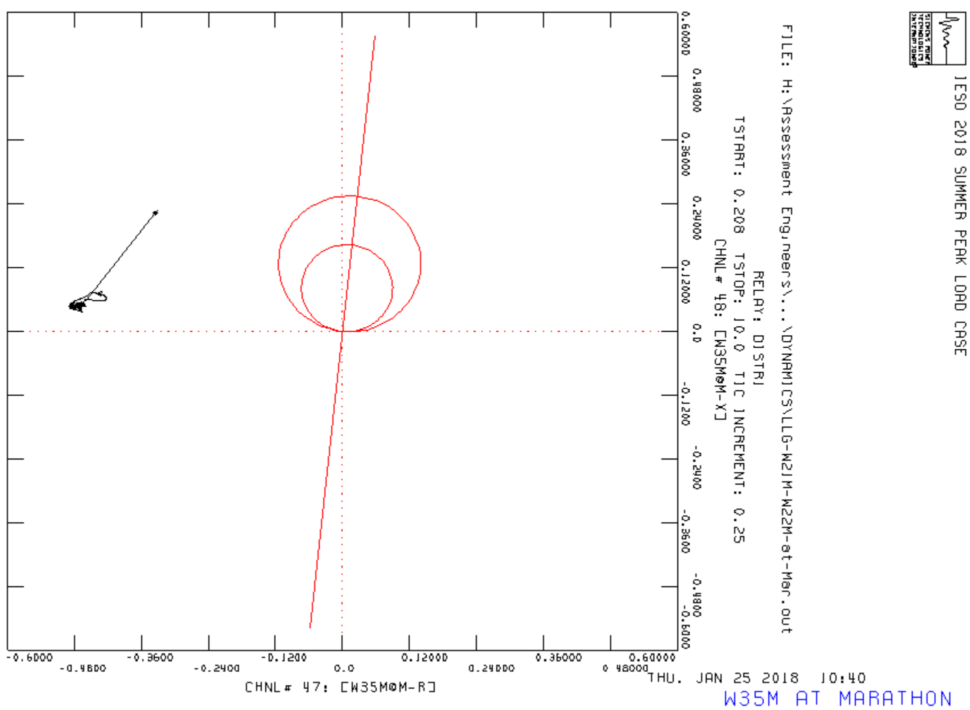

Figure 27: LLG fault on W21M/W21M at Marathon TS

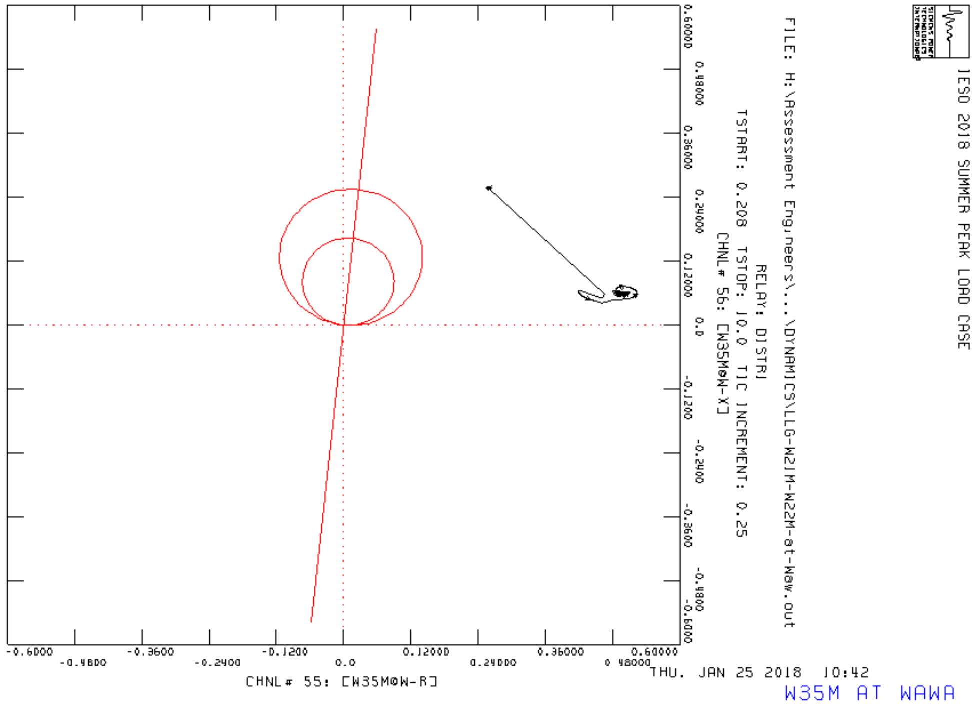

Figure 28: LLG fault on W21M/W22M at Wawa TS

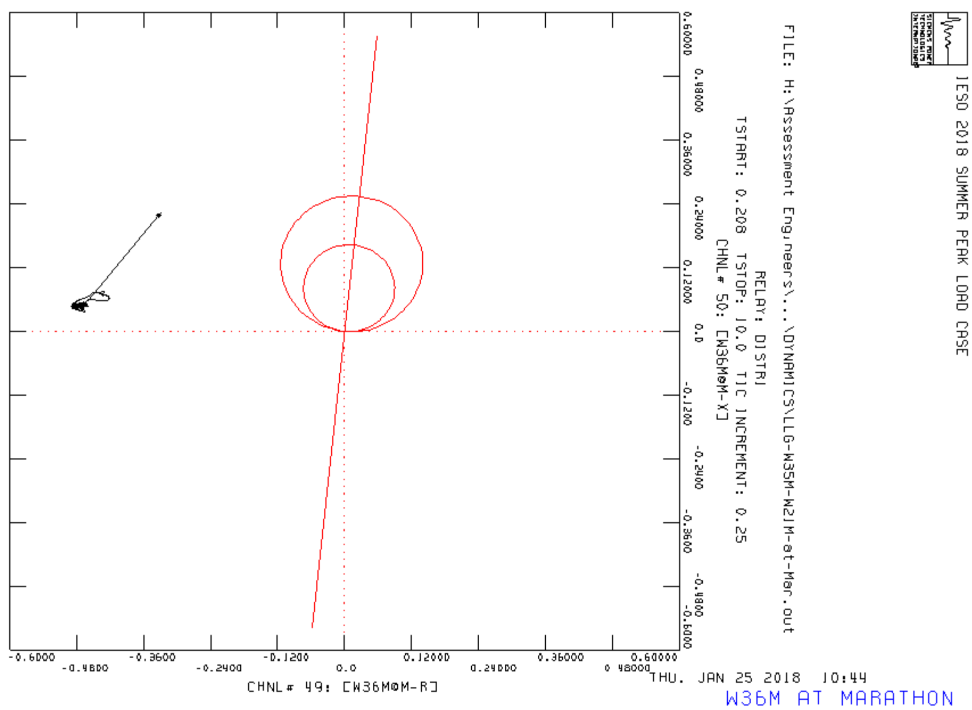

Figure 29: LLG fault on W35M/W21M at Marathon TS

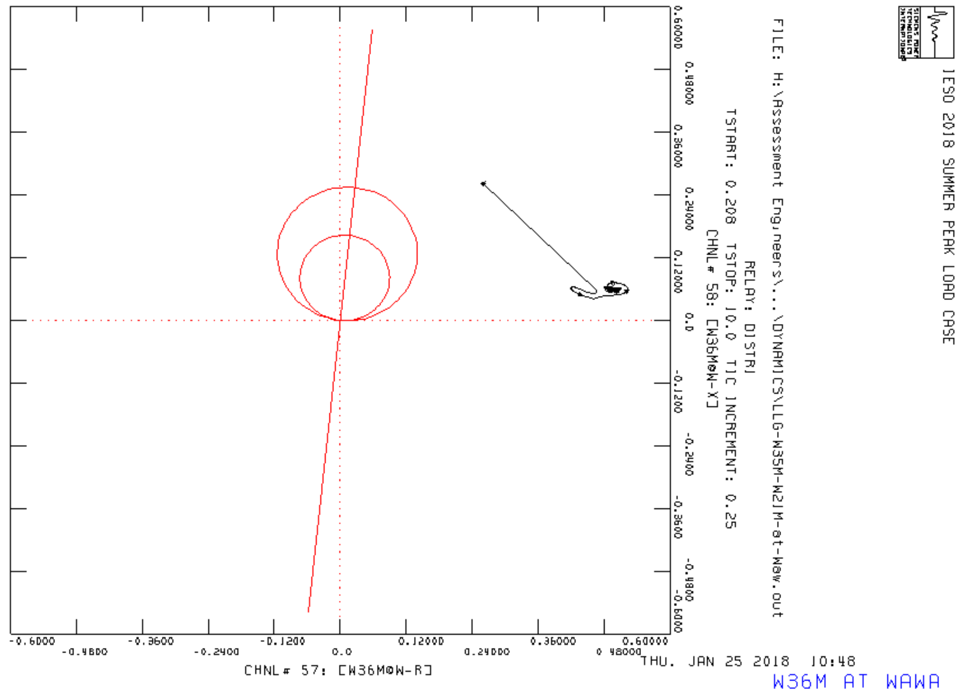

Figure 30: LLG fault on W35M/W21M at Wawa TS

As shown in the previous figures, the relay margins are sufficiently large indicating that the protection settings are acceptable to the IESO.

The following figures show the dynamic voltage response on the main buses in the area following representative faults (note that NW SPS 2 responses, if applicable, were not included):

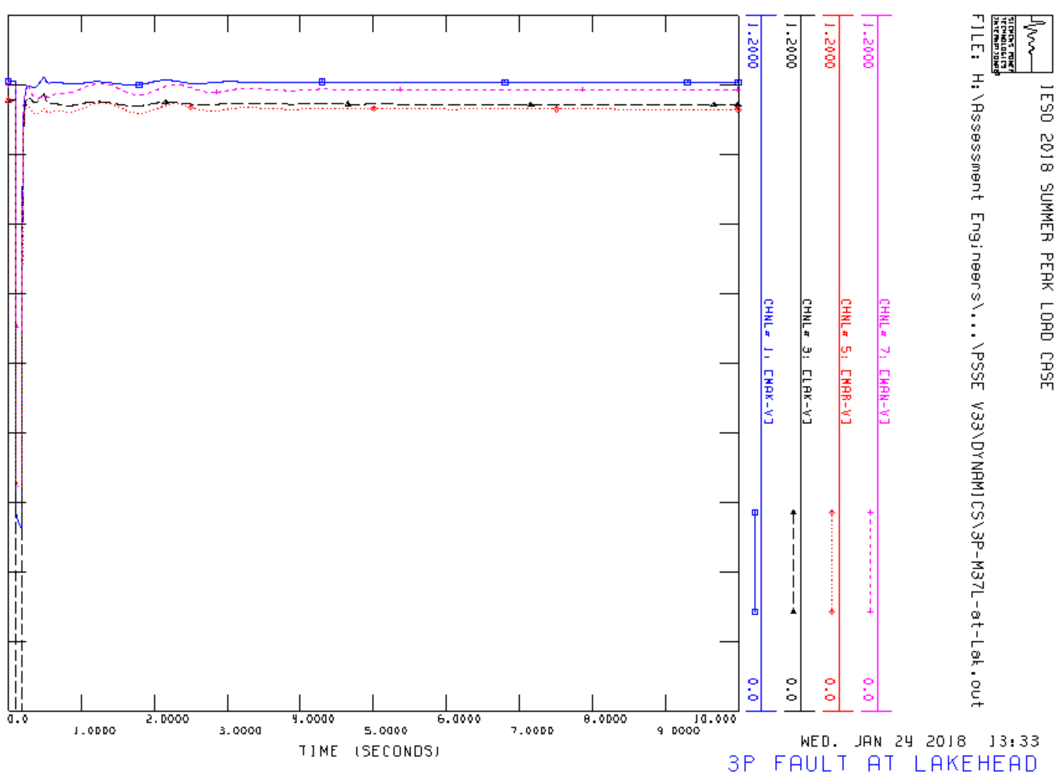

Figure 31: Main bus voltages following a 3P fault near Lakehead TS

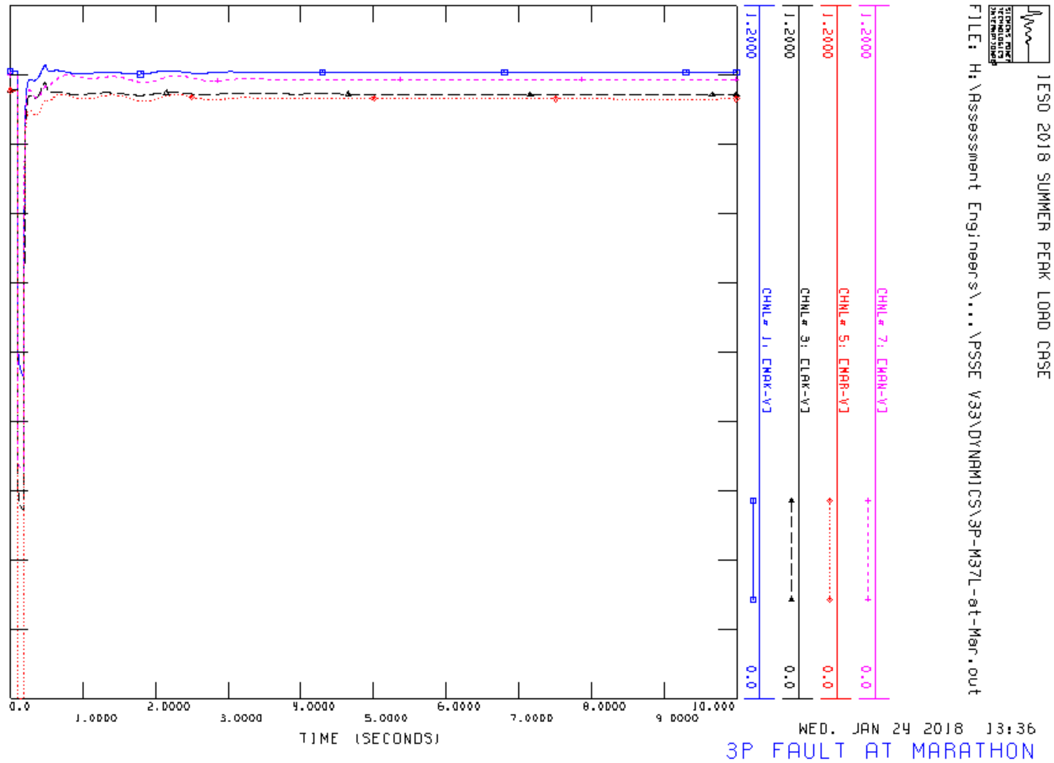

Figure 32: Main bus voltages following a 3P fault near Marathon TS

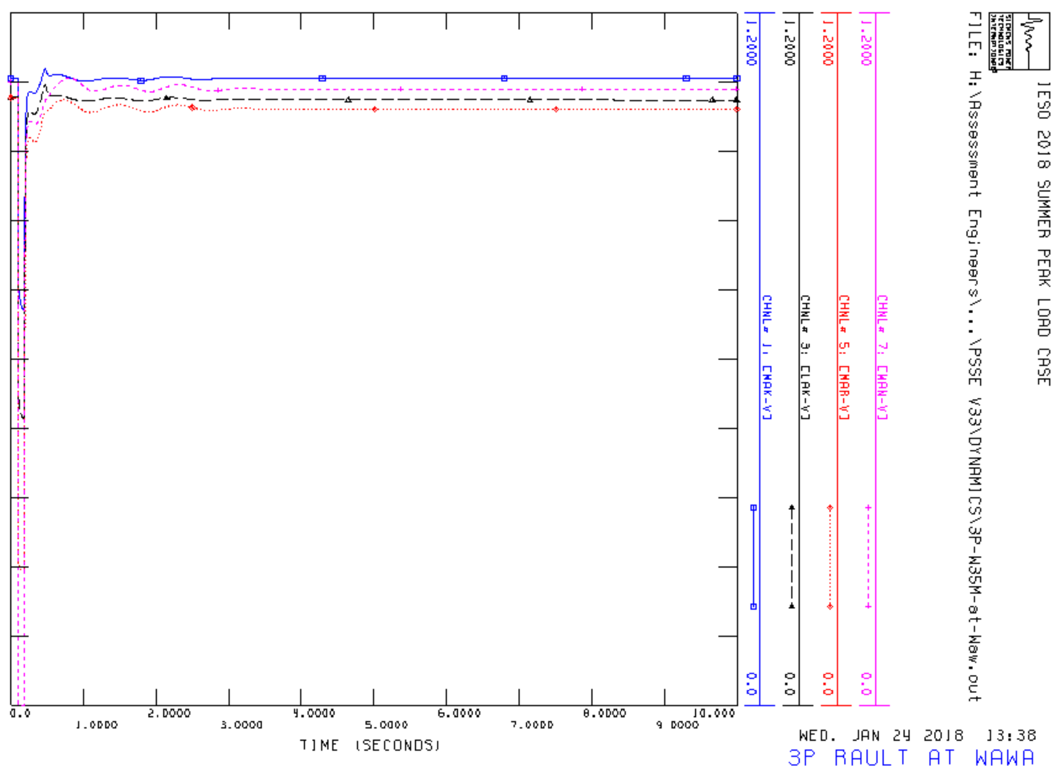

Figure 33: Main bus voltages following a 3P fault near Wawa TS

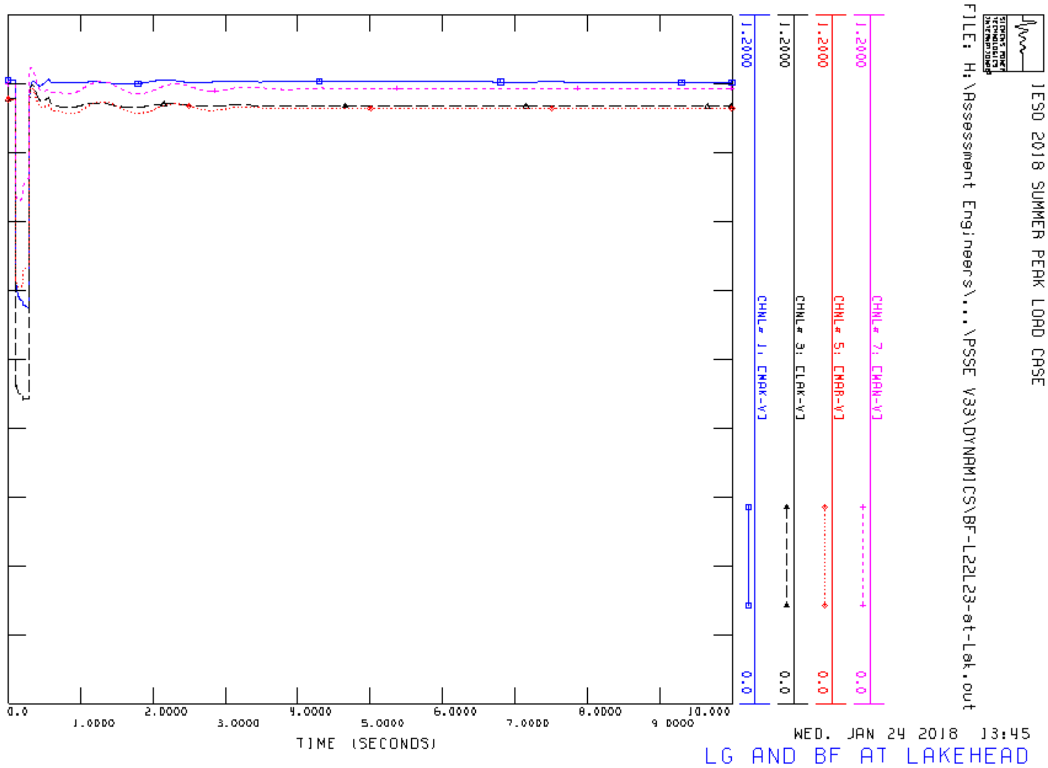

Figure 34: Main bus voltages after an L-G fault and breaker failure at Lakehead TS

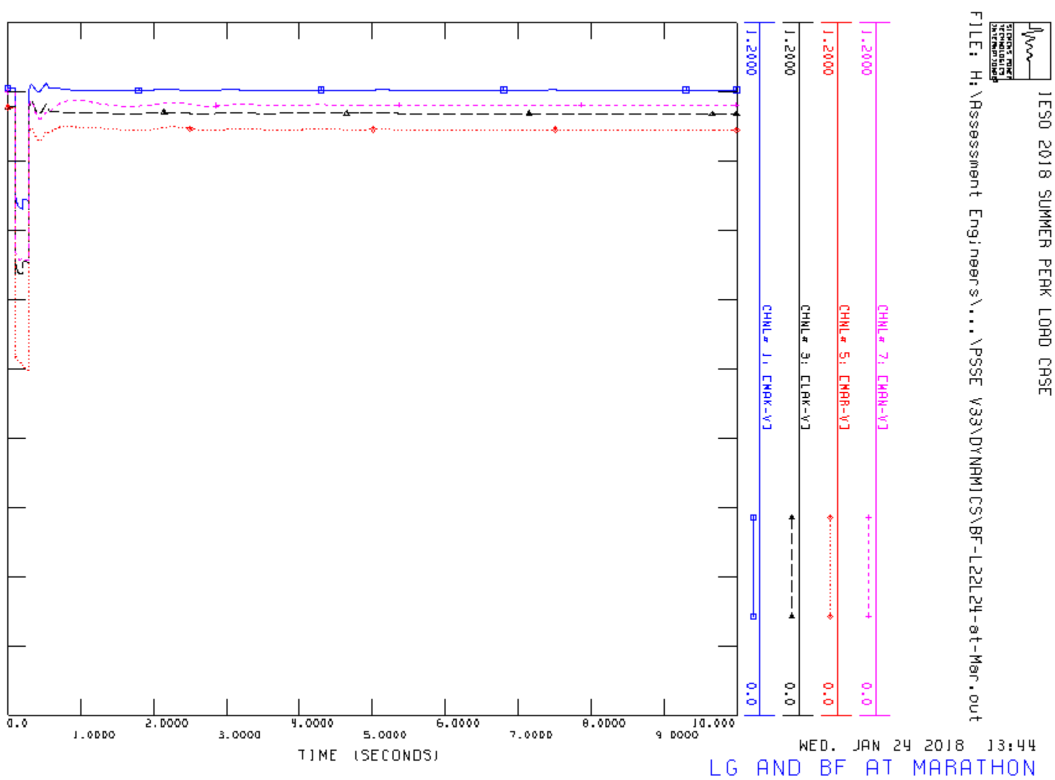

Figure 35: Main bus voltages after an L-G fault and breaker failure at Marathon TS

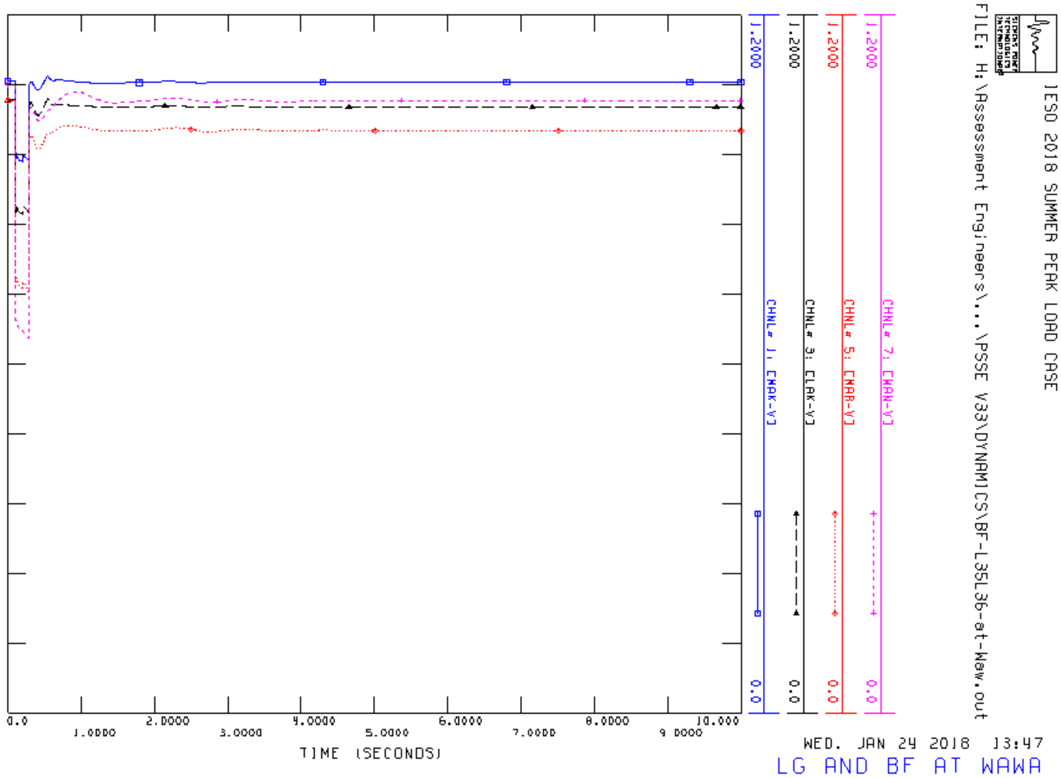

Figure 36: Main bus voltages after an L-G fault and breaker failure at Wawa TS

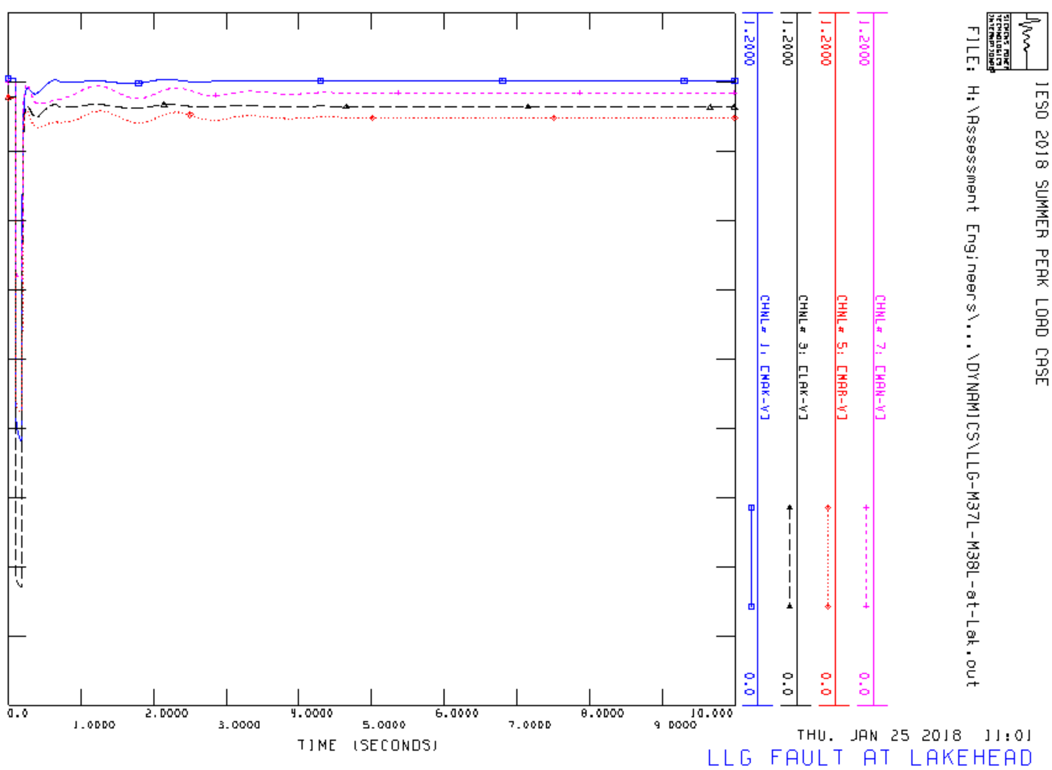

Figure 37: Main bus voltages after an LLG fault at Lakehead TS

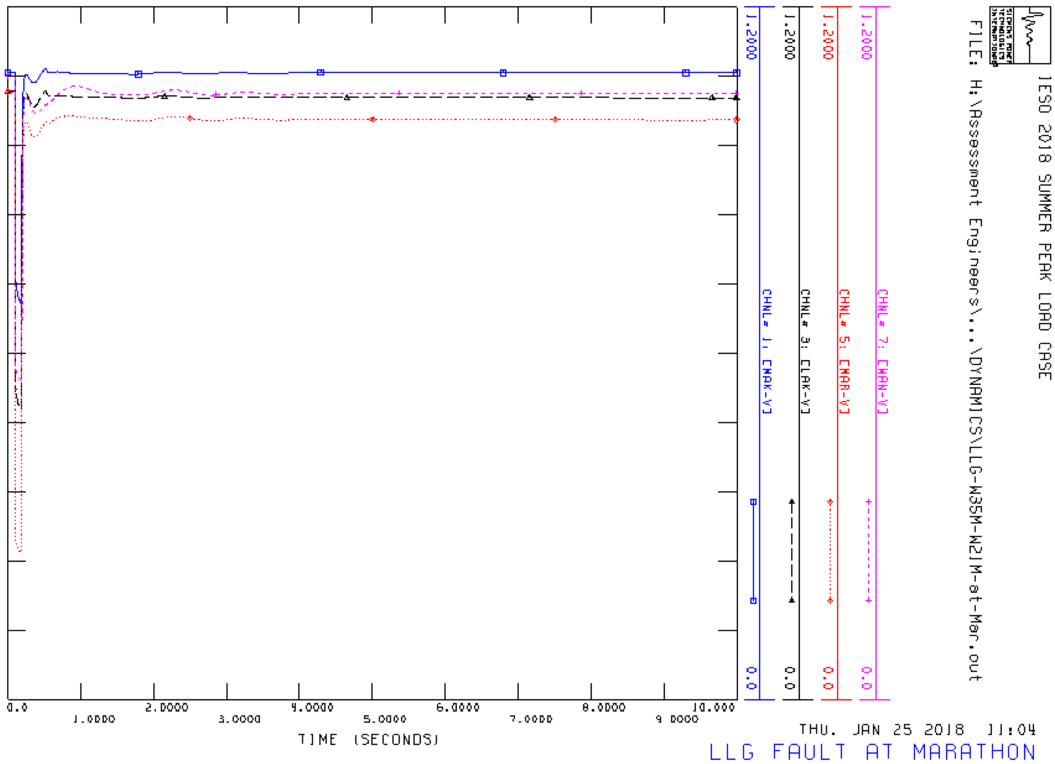

Figure 38: Main bus voltages after an LLG fault at Marathon TS

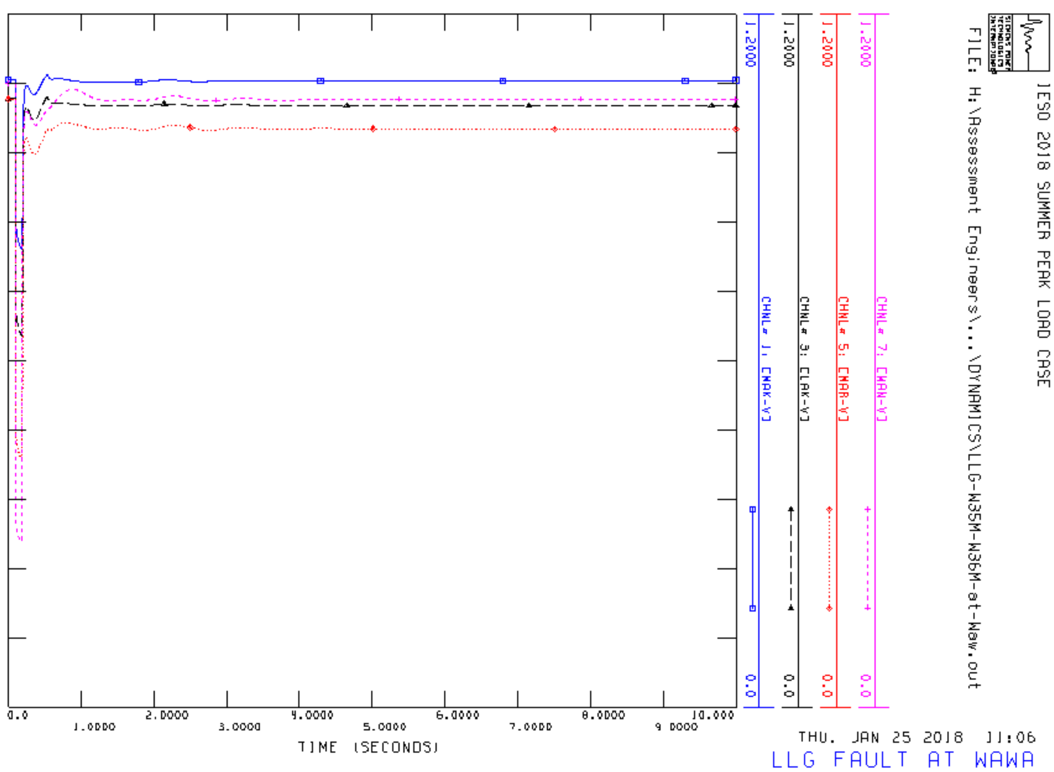

Figure 39: Main bus voltages after an LLG fault at Wawa TS

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CUSTOMER IMPACT ASSESSMENT

LAKE SUPERIOR LINK
&
EAST-WEST TIE STATION PROJECTS

Plan/Project #: **AR 25032**

Revision: **Draft**

Date: **March 26, 2018**

Issued by: **Transmission Planning (North&West) Department**
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DISCLAIMER

This Customer Impact Assessment was prepared based on preliminary information available about the proposed *East-West Tie Expansion* project, consisting of construction of 230 kV double-circuit, overhead transmission lines between Wawa Transformer Station (TS), Marathon TS and Lakehead TS (called *Lake Superior Link* project) and reconfiguration and enhancement of these three terminal stations (called *E-W Tie Station* project). This report is intended to highlight significant impacts, if any, to affected transmission customers early in the project development process and thus allow an opportunity for these parties to bring forward any concerns that they may have, including those needed for the review of the connection and for any possible application for Leave to Construct. Subsequent changes to the required modifications or the implementation plan may affect the impacts of the proposed connection identified in this Customer Impact Assessment. The results of this Customer Impact Assessment and the estimate of the outage requirements are subject to change to accommodate the requirements of the IESO and other regulatory or municipal authority requirements. The fault levels computed as part of this Customer Impact Assessment are meant to assess current conditions in the study horizon and are not intended to be for the purposes of sizing equipment or making other project design decisions. Many other factors beyond the existing fault levels go into project design decisions.

Hydro One Networks Inc. shall not be liable, whether in contract, tort or any other theory of liability, to any person who uses the results of the Customer Impact Assessment under any circumstances whatsoever for any damages arising out of such use unless such liability is created under some other contractual obligation between Hydro One Networks Inc. and such person.

Contents

Executive Summary

The East-West Tie (E-W Tie) Expansion was identified as one of the priority transmission projects in the government of Ontario's 2010 Long-Term Energy Plan and was included in the 2013 Long-Term Energy Plan. It consists of new 230 kV double-circuit lines that will be connected between Hydro One's existing Wawa Transmission Station (TS), Marathon TS and Lakehead TS, located near the cities of Wawa, Marathon and Thunder Bay, respectively.

Based on three Need Update reports by the IESO for to the Ontario Energy Board (OEB), confirming the need and preference for the project, the government's 2017 Long-Term Energy Plan stated:

> The East-West Tie Line would provide a long-term, reliable supply of electricity to meet the growth in demand and changes to the supply mix in Northwest Ontario.

There are two applications to the OEB for the construction of the new E-W Tie lines. Upper Canada Transmission (tradename NextBridge) has proposed to build the new lines with a total length of approximately 450 km. The IESO's System Impact Assessments (SIA) and Hydro One's Customer Impact Assessment (CIA) for NextBridge's proposal were issued in 2016-2017. Hydro One has proposed to build the new lines with a total length of approximately 400 km by utilizing, to a great extent, the existing transmission corridors. The Hydro One's proposed E-W Tie lines, called Lake Superior Link (LSL), as well as the proposed station expansions and new facilities, are the subject of this CIA.

Hydro One's proposed E-W Tie Expansion project consists of:

- Construction of a new 168 km, 230 kV double-circuit transmission line between Wawa TS and Marathon TS, with one Optical Ground Wire and one regular skywire, 133 km will be on a new right-of-way (ROW) parallel to the existing Hydro One 230 kV transmission line and 35 km will be on the same ROW as the existing line where the new and existing 230 kV circuits will be on new four-circuit transmission towers.

- Construction of a new 235 km, 230 kV double-circuit transmission line between Marathon TS and Lakehead TS, with one Optical Ground Wire and one regular skywire, on a new ROW which for 178 km will parallel the existing Hydro One 230 kV transmission line

- Reconfiguration of the above three stations and addition of breakers and switches for connection of the new circuits and re-termination of some of the existing circuits

- Addition of the following reactive power sources:
  - Two new 230 kV shunt reactors, rated at 65 MVAr each, at Marathon TS
  - A new 230 kV shunt reactor, rated at 125 MVAr, at Lakehead TS
  - A new shunt capacitor bank, rated at 125 MVAr, at Lakehead TS

- Revision of the new Northwest Special Protection Scheme (NW SPS 2) for the new and reconfigured transmission lines and shunt capacitors and reactors, as well as addition of new contingencies at Marathon TS and Wawa TS

- Expansion and upgrade of the protection, control and telecommunication facilities

The IESO has carried out the System Impact Assessment (SIA) studies to assess the impact of the project as proposed by Hydro One on voltage performance, thermal loading and short-circuit currents in the area. The results and findings of the studies are reported in SIA report CAA ID 2017-628, “Lake Superior Link”. The SIA has confirmed that,

- The project provides 450 MW transfer capability between Northeast and Northwest regions of Ontario,
- Voltage performance in the area remains within the Market Rules requirements,
- Thermal loading of the facilities remains within their ratings, and
- The impact of the project on short-circuit currents is relatively small, and
- Transient response of the system (in particular, relay margin assessment) is acceptable.

This Customer Impact Assessment (CIA) report describes the potential impact of the E-W Tie Expansion project, consisting of Hydro One’s proposed Lake Superior Link project (new 230 kV transmission lines) and E-W Tie Station project (expansion of Wawa TS, Marathon TS and Lakehead TS) on short circuit current, voltage and power supply reliability of the customers in the affected area. The findings of this CIA are:

1. The project has relatively small impact on Short-Circuit Levels in the area since it does not significantly reduce the net (equivalent) impedance between the affected stations and the sources of short-circuit current (i.e., generators).

2. The project has no adverse impact on voltage performance in the area. The addition of new reactive power sources and NW SPS 2 will allow for effective control of the voltages within the planning and operating criteria under various contingencies and outage conditions. Switching of the new shunt reactors and capacitor bank will not cause voltage variations beyond the applicable criteria.

3. The project will improve the customer power supply reliability in the area. Addition of the new E-W Tie transmission line, reconfiguration of the E-W Tie stations, reactive power sources and revised NW SPS 2 ensure supply adequacy and reliability in Northwest under local generation shortages and various outages and contingencies.

CUSTOMER IMPACT ASSESSMENT
LAKE SUPERIOR LINK
&
EAST-WEST TIE STATION PROJECTS

1. Introduction

The Minister of Energy has recommended the East-West Tie (E-W Tie) Expansion project in the 2010 Long-Term Energy Plan (LTEP), 2013 LTEP and 2017 LTEP. The IESO, in its latest Need update report to the OEB, dated December 1, 2017, stated that:

> "This report confirms the rationale for the East-West Tie ("E-W Tie") Expansion project based on updated information and study results. This project continues to be the IESO's recommended option to maintain a reliable and cost-effective supply of electricity to the Northwest for the long term."

The proposed E-W Tie Expansion consists of:

- New 230 kV double-circuit transmission lines along the north shore of Lake Superior, connecting to Wawa Transformer Station (TS), Marathon TS and Lakehead TS
- Expansion of the three terminal station with the connection of the new circuits, retermination of some of the existing circuits, and installation of new circuit breakers, switching facilities, and protection, control and communication facilities
- Installation of new shunt reactors and capacitor bank to control the voltage and support the targeted power transfer capability

The initial plan (in 2014) was according to the IESO's Feasibility Study, which targeted 650 MW transfer capability between Northeast and Northwest regions of Ontario. In the 2015 Update Report, the IESO recommended two stages for the project. The first stage will provide 450 MW transfer capability between Northeast and Northwest regions of Ontario. In the future, when the need arises, the second stage of the project will increased this transfer capability to 650 MW by the installation of an SVC at Marathon TS and upgrading sections of the Marathon-Alexander 115 kV circuits.

Hydro One has proposed to build the new E-W Tie transmission lines, called Lake Superior Link (LSL), with a total length of approximately 400 km by utilizing, to a great extent, the existing transmission corridors.

As part of the Connection Assessment and Approval (CAA) process, the IESO has conducted the System Impact Assessment (SIA) for the proposed LSL and issued the report CAA ID 2017-628, "Lake Superior Link". The SIA report confirms that with the proposed facilities, under the expected operating conditions (i.e., up to 450 MW East-West transfer), voltage performance in the area remain within the Market Rules requirements, the thermal loading of the facilities remain within their ratings, and the impact on short-circuit currents is relatively small.

This Customer Impact Assessment (**CIA**), carried out by Hydro One in accordance with the requirements of the OEB Transmission System Code, reviews the impact of the project on the existing customers in the area. Table 1 lists the transmission customers in the area from east of Wawa to west of Thunder Bay.

Table 1: Transmission Customers in the Project's Area

Stations / Junctions	Circuits	Customers
Mississagi TS – 230 kV	P21G, P22G	• Brookfield Renewable Power
Aubrey Falls – 230 kV	P25W, P26W	• Mississagi Power Trust
Chapleau Jct – 115 kV Chapleau DS – 115 kV	W2C	• Chapleau Public Utilities Corporation • Tembec Industries Inc. • Hydro One Distribution
Greenwich Jct – 230 kV	M23L, M24L	• Greenwich Windfarm LP
Pic Jct – 115 kV Marathon DS Jct - 115 kV	T1M	• Marathon Pulp Inc. • Hydro One Distribution
Terrace Bay SS - 115 kV AV Terrace Bay Jct – 115 kV	T1M, A1B	• AV Terrace Bay Inc.
Aguasabon SS – 115 kV	A1B, A5A	• Ontario Power Generation Inc. • Hydro One Distribution
Schreiber Jct – 115 kV	A5A	• Hydro One Distribution
Minnova Jct – 115 kV	A5A	• FQM (Akubra) Inc.
Pic DS - 115 kV	M2W	• Hydro One Distribution
Manitouwadge Jct - 115 kV Manitouwadge TS - 115 kV	M2W	• Kagiano Power • Haavaldsrud Timber Co. Ltd. • Glencore Canada Corporation • Hydro One Distribution
Black River Junction - 115 kV	M2W	• Cpot Title Corp
Umbata Falls Jct - 115 kV	M2W	• Umbata Falls LP
Hemlo Mine Jct - 115 kV	M2W	• Williams Operating Corp
Animki Jct – 115 kV	M2W	• Pic Mobert Hydro Inc.
White River DS - 115 kV	M2W	• Hydro One Distribution
Birch TS – 115 kV		• Thunder Bay Hydro
Port Arthur TS #1 – 115 kV		• Thunder Bay Hydro • Lac Des Iles Mines Ltd. • Ontario Power Generation Inc. • Hydro One Distribution
Alexander SS – 115 kV		• Ontario Power Generation Inc.
Pine Portage SS – 115 kV		• Ontario Power Generation Inc.
Nipigon Jct – 115 kV	56M1, 57M1	• Hydro One Distribution
Red Rock Jct – 115 kV	56M1	• Red Rock Mill Inc. • Hydro One Distribution
A.P. Nipigon Jct – 115 kV	A4L	• Atlantic Power LP
Beardmore Jct – 115 kV	A4L	• The Power Limited Partnership • Hydro One Distribution
Jellicoe DS #3 Jct – 115 kV	A4L	• Hydro One Distribution
Roxmark Jct – 115 kV	A4L	• Roxmark Mine Limited
Long Lac TS – 115 kV, 44 kV	A4L	• Hydro One Distribution
Murillo Jct – 115 kV	B6M	• Ontario Power Generation Inc. • Hydro One Distribution
Shabaqua Jct – 115 kV Sapawe Jct – 115 kV	B6M	• Hydro One Distribution

Stations / Junctions	Circuits	Customers
Fort William TS – 115 kV, 25 kV		• Thunder Bay Hydro
St. Paul Jct – 115 kV	Q5B	• Resolute FP Canada Inc.
James St. Jct – 115 kV	Q4B, Q5B	• Resolute FP Canada Inc.
Thunder Bay SS – 115 kV		• Resolute FP Canada Inc. • Ontario Power Generation Inc.
Moose Lake TS – 44 kV		• Atikokan Hydro Inc.

The Hydro One Sault Ste Marie (HO-SSM) system is connected to the grid at Hydro One's Wawa TS and Mississagi TS and covers an area south of Wawa. The HO-SSM's connected customers are not listed in the above table.

2. Proposed Facilities

The proposed new line and station facilities consist of the following (see also Figures 1 to 6)

- **New East-West Tie Transmission Lines**

  A new 168 km 230 kV double-circuit transmission line between Wawa TS and Marathon TS[1] and a new 235 km 230 kV double-circuit transmission line between Marathon TS and Lakehead TS, as shown on the map in Figures 1 and schematic diagram in Figure 2, with:

  - Single 1192.5 kcmil ACSR conductor per phase
  - One Optical Ground Wire
  - One Alumoweld skywire

- **Station Expansions with New Facilities**

  Reconfiguration of Wawa TS, Marathon TS and Lakehead TS, as shown in schematic diagrams in Figures 3 to 5, with the addition of new bus work and new breakers and switches, for connection of the new circuits, re-termination of some of the existing circuits, and addition of the following reactive power sources:

  - Two 230 kV shunt reactors, rated at 65 MVAr each, at Marathon TS
  - A 230 kV shunt reactor, rated at 125 MVAr, at Lakehead TS
  - A 230 kV shunt capacitor bank, rated at 125 MVAr, at Lakehead TS

- **Revised and Expanded Special Protection Scheme**

  Revision of the Northwest Special Protection Scheme 2 (NW SPS 2) according to the new station configurations and addition of new contingencies and actions for the new and existing facilities, as shown in Figure 6, including:

  a. Addition of 14 new single and double contingencies (new East-West Tie circuits and existing circuits east/south of Wawa TS):

[1] For 35 km, the new and existing 230 kV circuits will be on new four-circuit transmission towers.

    - W35M, W36M, W35M+W36M, W21M+W35M, W21M+W36M, W22M+W35M and W22M+W36M
    - M37L, M38L and M37L+M38L
    - P25W, P26W and P25W+P26W
    - W23K

b. Removal of 4 Marathon breaker failure contingencies
c. Removal of 4 Lakehead breaker failure contingencies
d. Addition of 2 new contingencies “Lakehead Reactor R1” and “Lakehead Capacitor SC21”
e. Replacement of 2 Lakehead transformer (T7 and T8) contingencies with one “Lakehead T7 OR T8” contingency (i.e., trip of one of the two transformers)
f. Addition of 2 new transformer contingencies “Marathon T11 OR T12” and “Wawa T1 OR T2” (i.e., trip of one of the two transformers at each station)
g. Addition of 5 new actions to,
    - Trip Marathon 230 kV reactor R3
    - Trip Marathon 230 kV reactor R4
    - Trip Lakehead 230 kV reactor R1
    - Trip Lakehead 230 kV capacitor SC21
    - Trip Lakehead 115 kV capacitor SC11

h. Removal of A5A cross-trip action

3. Customer Impact Assessment Scope

The purpose of this CIA is to assess the potential impacts of the proposed new and modified transmission facilities on the existing connected load and generation customers in the affected area.

A review of the following potential impacts on existing customers is conducted in this CIA:

- Short-circuit current
- Voltage
- Power supply reliability

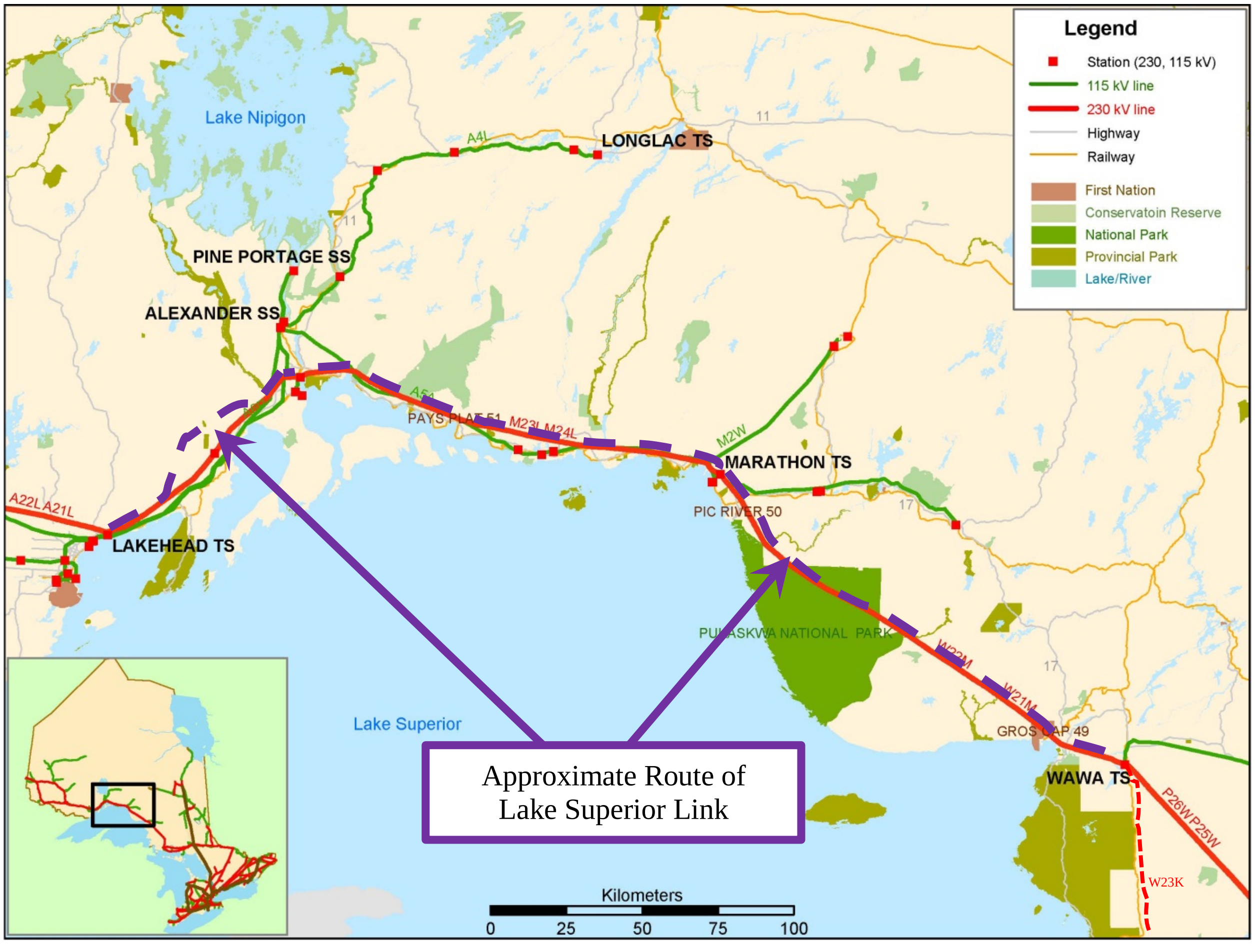

Figure 1: East-West Tie Expansion Area

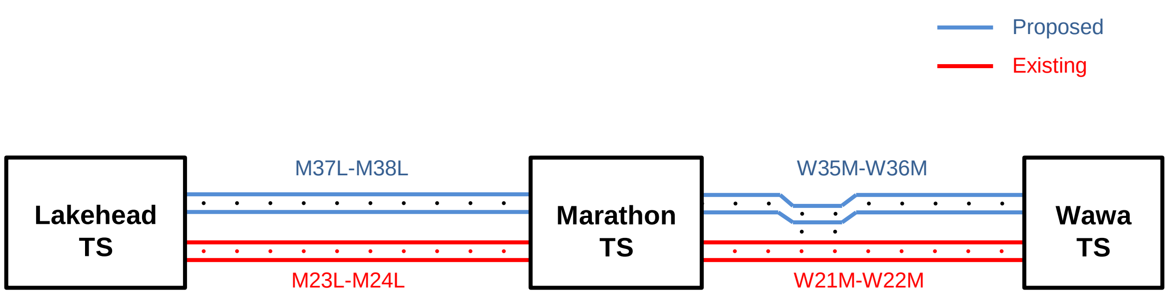

Figure 2: Schematic Diagram of the Proposed and Existing 230 kV Transmission Lines between Wawa TS and Lakehead TS

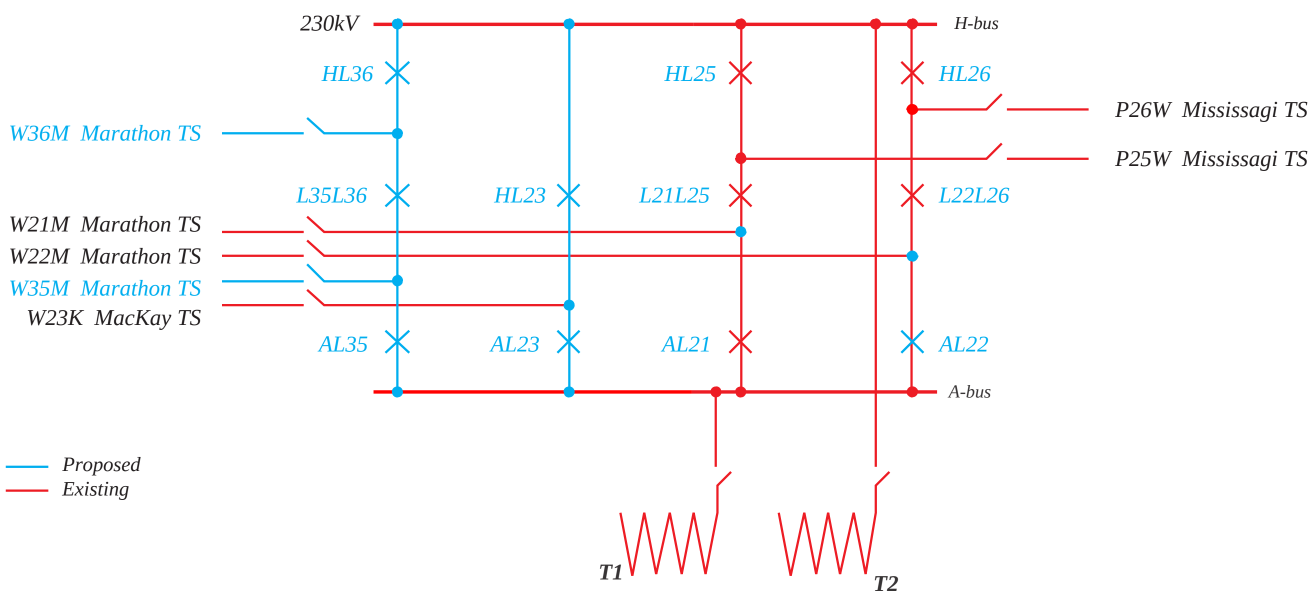

Figure 3: Schematic Diagram of Wawa TS (230 kV Facilities)

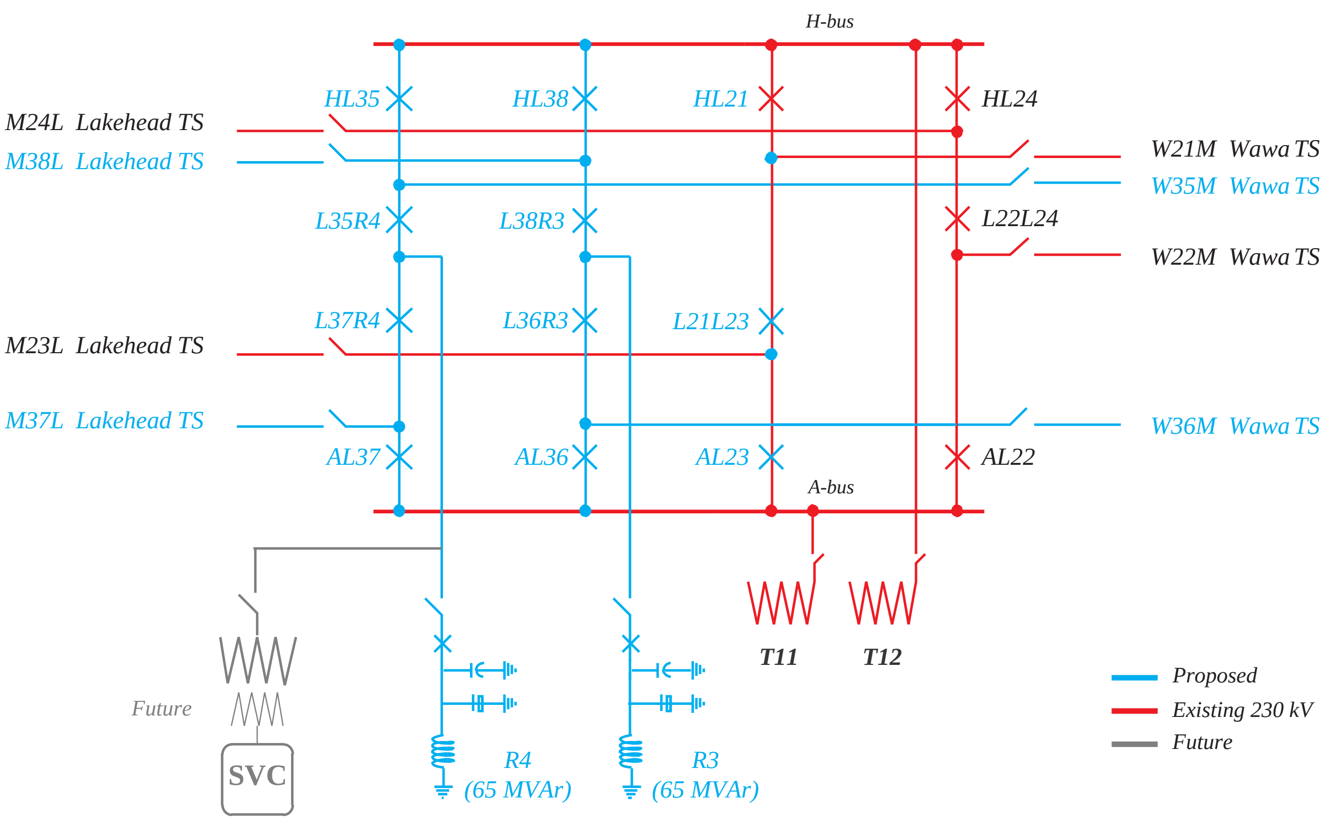

Figure 4: Schematic Diagram of Marathon TS (230 kV Facilities)

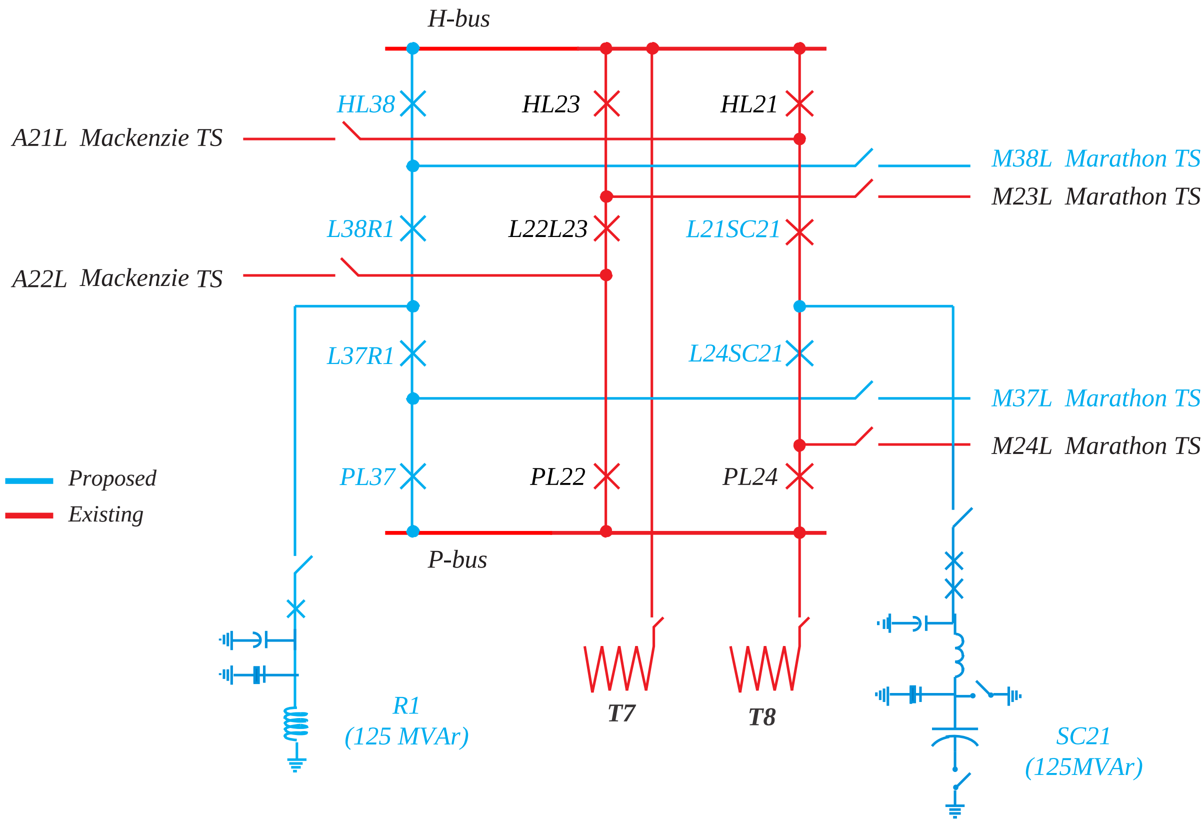

Figure 5: Schematic Diagram of Lakehead TS (230 kV Facilities)

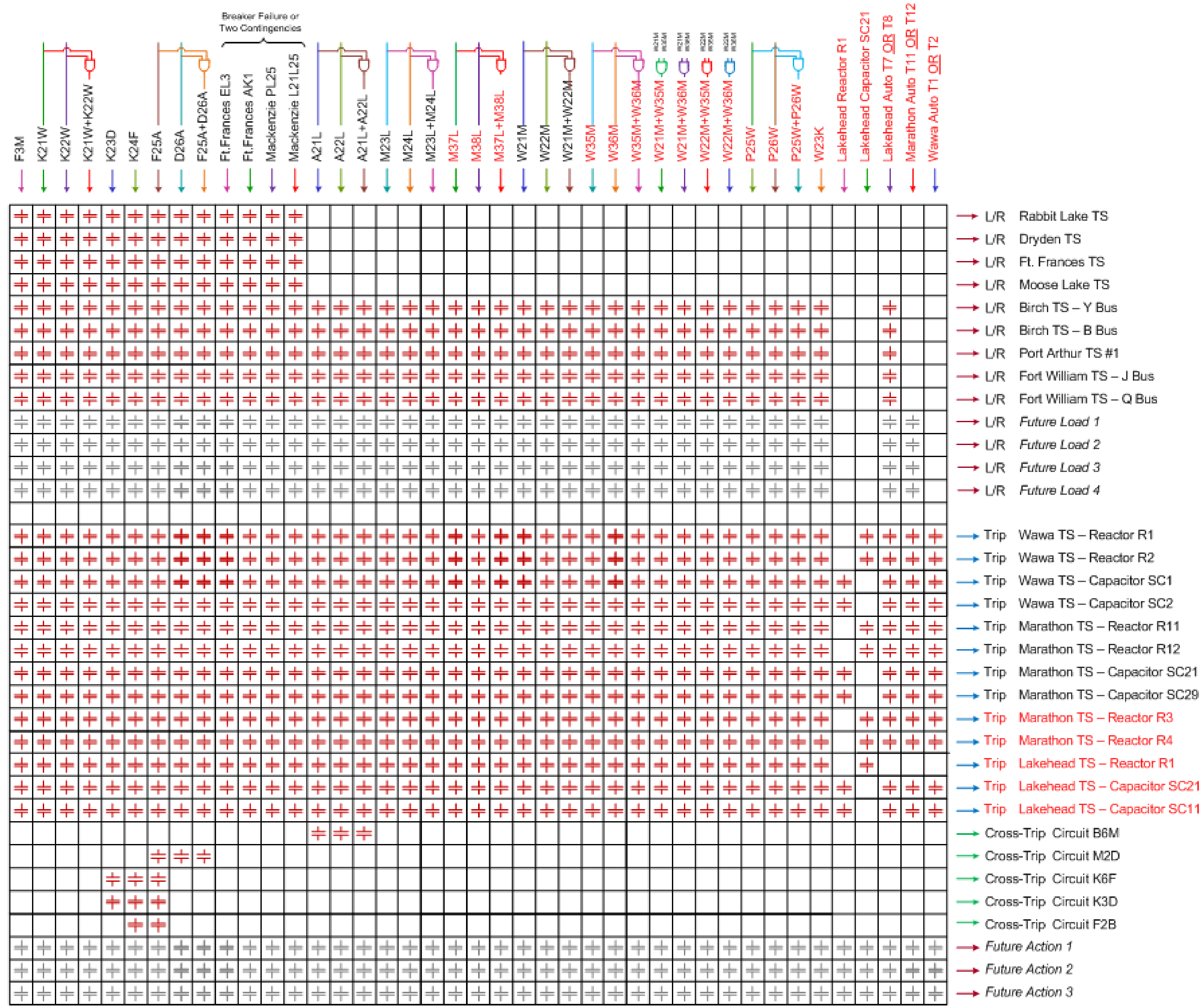

Figure 6: Revised Northwest SPS (NW SPS 2) Contingencies, Actions and Selection Matrix

4. Short-Circuit Impact

The proposed transmission reinforcement has a relatively small impact on Short-Circuit Levels in the area since, it does not significantly reduce the equivalent impedance between the existing sources of short-circuit current, i.e. generators, and the customer connection points.

Table 2 shows the short-circuit currents (Symmetrical and Asymmetrical; for three-phase faults and single-phase-to-ground faults) at the main buses in the area, before and after the E-W Tie Expansion, with the assumption of all existing and committed generators being in service, including Atikokan and one Thunder Bay unit. Table 3 shows the change in the short-circuit current as a result of the project.

As can be seen in Table 3, the increase in short-circuit currents at main buses are relatively small. The biggest increase, close to 2 kA, is at Marathon 230 kV bus, however as seen in Table 2, at this location at present the short-circuit current is relatively low (below 6 kA). At Lakehead 115 kV bus, where the short-circuit current approaches 23 kA at present, there will be an increase of less than 1.2 kA.

At Terrace Bay and Aguasabon the increase in short-circuit current is less than 100 A. The increase in short-circuit current at other locations in the area are similar or smaller than the change at the nearby buses shown in Table 3.

Table 2: Short-Circuit Currents at Main Buses

	Before E-W Tie Expansion				**After E-W Tie Expansion**			
	Three Phase SC Current (kA)		Line to Ground SC Current (kA)		Three Phase SC Current (kA)		Line to Ground SC Current (kA)	
Station / Bus	Symm	Asymm	Symm	Asymm	Symm	Asymm	Symm	Asymm
MacKenzie 230 kV	6.354	8.046	6.543	8.487	6.462	8.161	6.620	8.573
MacKenzie 115 kV	6.131	7.483	7.369	9.406	6.173	7.526	7.409	9.449
Lakehead 230 kV	7.335	9.140	7.530	9.871	8.198	10.164	8.218	10.734
Lakehead 115 kV	17.596	19.707	19.477	22.794	18.636	20.903	20.416	23.937
Marathon 230 kV	5.227	5.806	5.068	5.832	7.034	8.028	6.451	7.650
Marathon 115 kV	7.334	7.811	9.434	9.434	8.453	9.305	9.805	11.095
Wawa 230 kV	6.754	7.749	6.072	7.653	7.671	8.836	6.763	8.577
Wawa 115 kV	8.601	9.610	10.334	12.155	9.108	10.274	10.893	12.962
Terrace Bay 115 kV	4.907	5.925	3.846	4.510	5.002	6.023	3.885	4.549
Aguasabon 115 kV	4.738	5.490	4.108	5.120	4.817	5.568	4.148	5.163

Table 3: Increase in Short-Circuit Currents As a Result of East-West Tie Expansion

Station / Bus	Three Phase SC Current Increase (kA)		Line to Ground SC Current Increase (kA)	
	Symmetrical	Asymmetrical	Symmetrical	Asymmetrical
MacKenzie 230 kV	0.108	0.115	0.077	0.086
MacKenzie 115 kV	0.042	0.043	0.040	0.043
Lakehead 230 kV	0.863	1.024	0.688	0.863
Lakehead 115 kV	1.040	1.196	0.939	1.143
Marathon 230 kV	1.807	2.222	1.383	1.818
Marathon 115 kV	1.119	1.494	0.371	1.661
Wawa 230 kV	0.917	1.087	0.691	0.924
Wawa 115 kV	0.507	0.664	0.559	0.807
Terrace Bay 115 kV	0.095	0.098	0.039	0.039
Aguasabon 115 kV	0.079	0.078	0.040	0.043

5. Voltage Impact

Addition of the new facilities improves the voltage performance in the area as a result of the strengthened transmission system and the addition of new shunt reactors and capacitor bank. These reactive power devices will allow the existing SVC and the Synchronous Condenser (SC) at Lakehead TS to be utilized more effectively for maintaining acceptable voltages before and after contingencies and switching actions.

Switching Assessment

Table A.1 in the appendix shows the change of voltage at the main buses and customer connection points following the switching of the new capacitor bank at Lakehead TS and the new shunt reactor at Marathon TS.

The largest voltage change following Lakehead TS capacitor bank switching is 2.8% (at Lakehead 230 kV bus), which is below the 4% maximum voltage change criteria in the Ontario Resource and Transmission Assessment Criteria (ORTAC). Switching of the new shunt reactor at Lakehead TS will have similar effect on voltages. Normally, the capacitor bank will be switched in (out) when the SVC and SC at Lakehead TS are producing (absorbing) reactive power. In response, the SVC and SC will compensate and reduce (increase) their reactive power output which reduces the impact on voltages. Similarly the new Lakehead TS shunt reactor will be switched in (out) when the SVC and SC are absorbing (producing) reactive power and in response they will compensate and reduce the impact on voltages. This will allow more room for the SVC and SC to respond to contingencies.

The largest voltage change following the new Marathon TS shunt reactor switching is 2.2% (at Marathon 230 kV bus), which is also below the 4% maximum voltage change criteria in ORTAC.

Steady State Voltage Assessment

The pre-switching (base case) voltages shown in Table A.1, for a medium transfer scenario, are within the ORTAC criteria of,

220 kV < Voltage of 230 kV buses < 250 kV
113 kV < Voltage of 115 kV buses < 127 kV

The IESO's SIA (CAA ID 2017-628) has examined the voltage performance of the main buses for double-circuit contingencies as well as single and double outage/contingency of transformers and shunt reactors. It has found that pre-contingency and post-contingency voltages of the main buses remain within the ORTAC criteria for low, medium and high transfer scenarios.

NW SPS 2 will allow the voltages to be controlled within the ORTAC criteria following contingencies under various East-West transfer conditions, by switching the shunt capacitor banks and reactors in the area, or even rejecting some of the loads, if necessary, for severe contingencies or outage conditions.

6. Supply Reliability Impact

Currently, the NERC and ORTAC criteria contingencies of simultaneous loss of the two existing E-W Tie circuits or loss of one circuit when the companion circuit is out of service, will result in the separation of Northwest Ontario from the rest of the system, or it could overload the only remaining 115 kV circuit connecting Marathon TS to the west. This limits the pre-contingency East-West transfer.

The IESO's SIA (CAA ID 2017-628) has determined that the addition of the new double-circuit lines and the station facilities and reconfigurations will allow up to 450 MW transfer between Northeast and Northwest Ontario, respecting all double-circuit and breaker fault/failure contingencies (which could result in simultaneous loss of two transmission elements) when all elements are in-service, or the loss of one circuit when another circuit is out of service.

Addition of the new circuits, reconfiguration of Wawa TS and Marathon TS from ring bus to bus-diameter arrangement and compliance with the planning and operating requirements of the NERC reliability standards will improve the security and reliability of supply for the affected customers.

Customer Impact during Construction

The outage schedule during the construction work will be developed during detailed engineering and execution phase of the project. The risk of interruptions will be managed with proper outage planning and co-ordination by Hydro One and the IESO. Construction will be staged by Hydro One with the goal of minimizing possible customer interruptions. The schedules will be communicated to the affected customers and stakeholders in advance of the outages.

7. Conclusions

This CIA report describes the impact of the proposed East-West Tie Expansion, consisting of the new 230 kV transmission lines, station reconfigurations and new station facilities, on the customers in the area.

The short-circuit levels at customer transmission connection points will not increase significantly as a result of this project.

The voltage assessments described in the SIA (CAA ID 2017-628) report and the switching studies described in this CIA report show that voltage performance remains within the Planning Criteria. The new reactive power sources and the Northwest Special Protection Scheme 2 (NW SPS 2) will support the 450 MW east-west transfer capability and maintain the pre and post-contingency voltages within acceptable limits.

The proposed transmission facilities have no material adverse reliability impact on existing customers in the area, on the contrary, the reliability will improve in Northwest Ontario.

Appendix

Switching Assessment Results

Table A.1 shows the voltage of main buses and customer connection points before and after,

- Switching off the new 230 kV capacitor bank at Lakehead TS, and
- Switching off the new 230 kV shunt reactor at Marathon TS

It also show the percentage change in voltages (delta-V) for the above switching actions.

Table A.1: Voltages Before and After Switching of New Capacitor Bank and Reactor

Name & Nominal kV Of Bus or Connection Point	Pre-Switching Voltage (kV)	After Lakehead Capacitor Switching		After Marathon Reactor Switching	
		Voltage (kV)	delta-V(%)	Voltage (kV)	delta-V(%)
ATIKOKAN_TGS, 230	235.69	231.82	-1.6	237.04	0.6
AUBRY_FLSJ25, 230	241.85	241.01	-0.3	243.13	0.5
DRYDEN_TS, 230	234.83	232.83	-0.9	235.61	0.3
FT_FRANCES, 230	238.82	236.72	-0.9	239.69	0.4
GRNW_LK_JM23, 230	225.25	219.54	-2.5	227.93	1.2
LAKEHEAD_TS , 230	223.08	216.84	-2.8	225.16	0.9
MACKENZIE_TS, 230	236.06	232.20	-1.6	237.40	0.6
MARATHON_TS , 230	226.67	223.31	-1.5	231.63	2.2
MISSISSAGI , 230	241.72	241.07	-0.3	242.72	0.4
WAWA_TS, 230	233.93	232.10	-0.8	236.74	1.2
ABITIBI_JQ4B, 115	121.82	120.25	-1.3	122.38	0.5
ABITIBI_JQ5B, 115	120.65	118.93	-1.4	121.26	0.5
AGUASABON_SS, 115	122.87	122.04	-0.7	123.91	0.8
ALEXANDER_SS, 115	125.75	125.02	-0.6	126.13	0.3
ANIMKI_JCT, 115	117.70	116.38	-1.1	119.74	1.7
AP_NIPIGON , 115	125.01	124.15	-0.7	125.41	0.3
BEARDMORE_J , 115	124.09	123.14	-0.8	124.52	0.3
BIRCH_TS , 115	121.01	119.27	-1.4	121.62	0.5
BLACK_R_JM2W, 115	121.60	120.28	-1.1	123.64	1.7
BOWATER_G6 , 115	122.16	120.64	-1.2	122.70	0.4
FT_WILLM_Q4B, 115	120.98	119.33	-1.4	121.57	0.5
FT_WILLM_Q5B, 115	120.32	118.60	-1.4	120.94	0.5
HEMLO_MINE_J, 115	117.81	116.49	-1.1	119.84	1.7
INCO_SHEB_J , 115	120.52	118.89	-1.4	121.08	0.5
JELLICOE_#3J, 115	122.72	121.64	-0.9	123.16	0.4

Name & Nominal kV Of Bus or Connection Point	Pre-Switching Voltage (kV)	After Lakehead Capacitor Switching		After Marathon Reactor Switching	
		Voltage (kV)	delta-V(%)	Voltage (kV)	delta-V(%)
KASHABOWIE_J, 115	120.32	118.70	-1.4	120.88	0.5
LAC_DES_CSS , 115	120.89	119.87	-0.9	121.26	0.3
LAC_DES_ILSJ, 115	120.92	119.89	-0.9	121.29	0.3
LAKEHEAD_TS , 115	123.36	121.44	-1.6	124.02	0.5
LONGLAC_TS , 115	120.40	119.30	-0.9	120.85	0.4
MACKENZIE_A3, 115	118.54	116.86	-1.4	119.12	0.5
MANITOUWADGE, 115	124.60	123.02	-1.3	126.83	1.8
MARATHN_DS_J, 115	124.07	122.56	-1.2	126.29	1.8
MARATHON_TS , 115	124.26	122.71	-1.2	126.54	1.8
MINNOVA_J , 115	123.51	122.69	-0.7	124.44	0.8
MOOSE_LK_TS , 115	119.21	117.64	-1.3	119.75	0.4
MURILLO_J , 115	120.80	119.18	-1.3	121.36	0.5
NIPIGNON_J , 115	125.24	124.35	-0.7	125.68	0.4
PIC_J_M2W , 115	124.30	122.75	-1.2	126.57	1.8
PIC_J_T1M , 115	124.16	122.65	-1.2	126.37	1.8
PT_ARTH_#1A1, 115	122.41	120.57	-1.5	123.05	0.5
RED_ROCK_J , 115	125.16	124.28	-0.7	125.61	0.4
RESFP_KRFTQ4, 115	120.41	120.41	0.0	120.41	0.0
RESFP_KRFTQ5, 115	120.51	118.82	-1.4	121.12	0.5
RESFP_TB_Q5B, 115	120.54	118.84	-1.4	121.16	0.5
SAPAWE_J_B6M, 115	119.60	118.01	-1.3	120.14	0.5
SCHREIBER_J , 115	123.20	122.37	-0.7	124.18	0.8
SHABAQUA_JB6, 115	120.57	118.94	-1.4	121.14	0.5
SILVER_FALLS, 115	121.16	120.21	-0.8	121.50	0.3
STANLEY_JB6M, 115	120.77	119.15	-1.3	121.33	0.5
TCP_NIPIGN_J, 115	125.01	124.15	-0.7	125.41	0.3
TER_BAY_PU_J, 115	122.66	121.77	-0.7	123.79	0.9
TERRACE_BAY , 115	122.66	121.77	-0.7	123.79	0.9
THUN_BAY_Q9B, 115	120.99	119.25	-1.4	121.60	0.5
UMBATA_FLS_J, 115	120.57	119.29	-1.1	122.54	1.6
WAWA_TS , 115	124.49	123.80	-0.6	125.63	0.9
WHITE_RIVER, 115	116.48	115.14	-1.1	118.55	1.8
WILLIAMS_M_J, 115	117.90	116.58	-1.1	119.93	1.7
WILLROY_J , 115	124.60	123.02	-1.3	126.83	1.8