MONTANA ALBERTA TIE LTD

MONTANA-ALBERTA TIE LTD.
PROJECT REVIEW GROUP

PHASE 2 STUDY REPORT

PROJECT REVIEW GROUP ACCEPTED
JULY 24, 2007

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I. EXECUTIVE SUMMARY

Project Overview

Montana Alberta Tie, Ltd. (MATL), a wholly owned subsidiary of Tonbridge Power Inc., is proposing to build a 240/230 kV merchant transmission line from the Lethbridge area in southern Alberta to Great Falls in west-central Montana. This project is Alberta's first direct interconnection to the United States and Montana's first direct interconnection with Alberta. The Project will provide import/export opportunities for power markets in Montana and Alberta and enable wind development opportunities in southern Alberta and northern Montana since the transmission route traverses a region of substantial wind development potential.

The MATL project is a 240/230kV, 330 MVA transmission line designed for continuous bi-directional power transfers of over 300 MW. The project consists of a new substation, named MATL 120S, located approximately 15 km north of the City of Lethbridge, Alberta that ties into the existing 240 kV Alberta Interconnected Electric System (AIES) system. A phase shifting transformer will be installed in the MATL 120S substation to control flows both north and south and to step the voltage down from the Alberta nominal system voltage of 240 kV to transmission line voltage of 230 kV. A mid-point substation named Marias will be built approximately 10 km south of the town of Cut Bank, Montana. The Marias Substation will contain shunt and series capacitance for voltage support and the substation will be a connection point for proposed wind generation projects in the area. At the south end, the MATL transmission line will terminate at the existing Great Falls, Montana, 230 kV substation. The Great Falls Substation is owned and operated by NorthWestern Energy Inc. The transmission line is approximately 346 km long, uses single Falcon 1590 kcmil conductor, and will be built of a combination of monopole and H-frame structures.

Phase 2 Path Rating Process

On August 19, 2005, MATL initiated the WECC Regional Planning Process for the MATL project through an invitation letter to WECC Planning Coordination Committee (PCC) and Technical Studies Subcommittee (TSS) to form a Regional Planning Review group. A project review group was formed and on December 7, 2005, MATL submitted a Regional Planning Project Report to the PCC. No comments were received during the 30 day comment period. Accordingly, on January 23, 2007, the PCC notified MATL that the Regional Planning Project Review had been completed.

On September 20, 2005, MATL initiated the WECC Path Rating Process for the MATL Project through the submittal of a Comprehensive Progress Report to the PCC and TSS as well as an invitation to form a Path Rating Project Review Group (PRG). During the 60-day comment period, MATL received requests from WECC members to participate in the PRG. On February 2, 2006, the TSS confirmed the MATL Project had achieved Phase 2 status.

As a result of a combination of regulatory, commercial and technical factors, MATL made scope changes to the project and notified the PCC and the TSS of these changes on August 30, 2006. The most notable changes were the addition of series compensation to the transmission line at the Marias Substation in order to increase the emergency rating of the MATL project and the inclusion of a 120MW of wind generation connection to the Marias Substation. Because of these major changes, MATL re-opened the PRG to new WECC members. Two new members subsequently joined.

Study Plan

The MATL PRG developed a study plan to analyze the impact of the MATL system on neighboring systems. The Phase 2 study is based on a planned in service date of the MATL project of 2008. The MATL Rating Study Scope included the MATL proposed path rating flows defined as -300 MW power transfers into the connection point in Alberta (MATL 120S) from Montana (north flows) and +325 MW power transfers (metered at MATL 120S) from Alberta toward NorthWestern Energy system in Montana (south flows) under the WECC 2007 Heavy Summer and 2007 Light Spring base cases. These flows are effectively 300 MW delivered at the interface ends of the line as MATL line losses at rated flow are approximately 25 MW. Sensitivities include Great Falls, Montana generation, a wind generation connection at the Marias Substation and wind generation in southern Alberta. The wind generation sensitivity at Marias was subsequently removed from the study scope by MATL (with the concurrence of the MATL PRG) in order to expedite the submittal of the Phase 2 Project Rating Report. The TSS was notified of the removal of the Marias wind generation sensitivity on June 11, 2007.

The MATL PRG has performed and reviewed Phase 2 Rating studies according to the guidelines in the WECC “Procedures for Regional Planning Project Review and Rating Transmission Facilities”. The purpose of these studies is to demonstrate that the MATL project conforms, or will be able to conform to, all applicable Reliability Criteria. In addition, these studies:

- identify the planned non-simultaneous transfer capability and the planned simultaneous path transfer capability limits for the proposed project configuration,
- address the mitigation of simultaneous transfer capability issues relative to the existing system, and
- resolve comments from BPA, NWE, and BCTC on the MATL Comprehensive Progress Report.

No changes to the current existing WECC path ratings are contemplated or implied in this report.

Conclusion

In conclusion, the non-simultaneous study demonstrates the MATL project meets NERC/WECC Planning and reliability standards for the proposed path rating of 300 MW northbound and 325 MW southbound, as defined at the MATL 120S metering point, under certain conditions stipulated in this Report.

The conditions identified that require remedial action schemes (RAS) are:

1. Loss of Langdon - Cranbrook,

2. Loss of Cranbrook - Selkirk,
3. Loss of Selkirk - Ashton Creek and Selkirk - Vaseux Lake,
4. Loss of both Ingledow - Custer lines (when BC would separate from the US), and
5. Loss of both Custer - Monroe lines (when BC would separate from the US).

These five contingencies will require a RAS to trip MATL to prevent voltage collapse or transient instability from occurring. The RAS is intended to be armed at all times that the MATL project is in service. If the RAS is out of service for any reason, it is expected that the MATL line will need to be taken out of service to preserve system reliability. Future operating studies may look at possibly defining a lower boundary for RAS arming. If system flows are below the boundary levels defined in the studies, then the RAS may not need to be armed.

In addition to the above RAS, other conditions identified that require mitigation are:

1. Loss of the MATL tie when Nelway - Boundary flow is at or near its limits and the MATL flow is in the same direction as the Nelway - Boundary flow will require either a RAS to trip Nelway - Boundary or an operating procedure to issue a tap changer adjustment order for the Nelway phase shifting transformer.

2. Loss of large amounts of generation in Montana due to operation of the Colstrip ATR can cause a large increase in flows on the MATL project. In order to mitigate these overloads, the MATL phase shifting transformer will need to be adjusted or the MATL line will need to be tripped.

This study also identified simultaneous transfer capability of MATL versus Path 1, Path 3 and Path 8. Nomograms were developed for these simultaneous relationships for the cases studied. In all nomograms, the metering point on MATL is assumed to be the MATL 120S Substation. For the cases studied, MATL and either Path 1 or Path 3 cannot both simultaneously achieve rated transfers due to constraints outside the MATL line and Path 1 or Path 3. Under these operating conditions, simultaneous operating limits (nomograms) or other mitigation methods are required to meet NERC/WECC Planning Standards. Studies for Path 8 indicate there is potential for interaction between MATL and Path 8 transfers. Further operational studies are required to confirm impacts, if any, and corresponding mitigation. These simultaneous conditions are:

1. High simultaneous transfers on Path 1 and MATL,

2. High simultaneous transfers on Path 3 and MATL,

3. High simultaneous transfers on Path 8 and MATL (not confirmed)

Further details regarding the magnitude of the required curtailments and the contingencies that create the need for these curtailments are provided in the Results sections of this report. This report identified limits of simultaneous interactions for specific system conditions defined for MATL path rating purposes. Further studies for a variety of system conditions are needed to establish actual operating limits.

A thorough investigation of flowgates in the Great Falls area has uncovered the existence of five potential flowgates that can limit export from Great Falls in the north-to-south direction.

The first four of these flowgates have limits that allow anywhere from 245 MW to 675 MW of additional power to be injected into the Great Falls 230 kV bus under heavy summer conditions and anywhere from 510 MW to 640 MW of additional power to be injected into the Great Falls 230 kV bus under light spring conditions[1].

The last flowgate (the Great Falls - Landers Fork - Ovando 230 kV flowgate) is constrained by voltage deviations on NWE's 100 kV system in the vicinity of Townsend. Because this constraint is based on voltage deviations, it is difficult to quantify this limit as a function of MW flows through a flowgate. While studies have shown that the other four flowgate limits are usually reached first, there is a possibility that the Great Falls - Landers Fork - Ovando 230 kV flowgate could be limiting. For this reason, either system reinforcements or a RAS may be needed to mitigate the impacts of the Great Falls - Landers Fork - Ovando 230 kV line outage.

The conclusions are based on a comparative analysis between pre-project base case conditions and the base case with the proposed MATL project under the same conditions. This study did not investigate conditions that could not meet WECC/NERC reliability in the pre-project case. In particular, Path 1 flows used in this study were well below the 1000 MW east to west and 1200 MW west to east path rating limit because of limitations in the AIES system.

Mitigation Plan

Also required as part of the Phase 2 process is the mitigation plan. MATL's mitigation plan is to:

- develop a mitigation implementation and responsibility plan
- design and implement protection, control and remedial action schemes to meet the mitigation objectives identified in this report or that may be identified through the operating study process,
- comply with WECC Procedures for Project Rating Review subject to the requirements or orders from the connecting Transmission Service Providers or Path Operators.
- operate within transfer capabilities identified in this report or that may be identified through operational studies,
- design and operate to NERC/WECC Planning Standards,
- develop operating procedures or operate to procedures of respective connecting electrical system operators to maintain WECC reliability, and
- negotiate agreements to resolve conflicts as a means to formulate a mitigation strategy with impacted parties where applicable.

For impacts to Path 3 flows as identified in the MATL vs. Path 3 nomogram, MATL's mitigation plan is to:

[1] Note that these additional power injections are subject to the conditions defined in the base cases and were used for the PRG's analysis of the MATL project. Actual allowable power transfer limits will be determined by the area electrical system operator(s).

A. Develop, fund and implement a RAS mutually acceptable to BCTC and/or AESO as appropriate which will reduce or eliminate the MATL impact

B. If the RAS cannot be implemented prior to MATL being energized, MATL, BCTC and other affected transmission operators will develop operating procedures to keep the amount of power that Path 3 can transfer protected from being diminished due to MATL flows. This operating procedure may include curtailing MATL.

C. If a RAS cannot be implemented to fully protect Path 3 transfers from being diminished due to MATL flows, operating procedures to protect Path 3 transfers will be in place along with the RAS.

The details of the mitigation plan will be developed in coordination with impacted electrical system operators and other impacted parties. MATL proposes to execute this plan in Phase 3.

Next Steps

Completion of Phase 2 (acceptance of this report by WECC) is one step towards the construction and ultimate operation of the proposed Montana – Alberta 240/230 kV merchant transmission line. More operational study work including development of operational procedures and tools as well as the detailed design and implementation of remedial action schemes (RAS) is required to fully define definitely the envelope of operation for this project. The time to study, design and implement the special protection schemes in addition to the necessary review by the WECC Remedial Action Scheme Reliability Subcommittee (RASRS) could be upwards of one year or more, which may restrict the operational capability of the proposed merchant transmission line until final design, review and implementation of the remedial action schemes are complete.

II. INTRODUCTION

Montana Alberta Tie, Ltd. (MATL), a wholly owned subsidiary of Tonbridge Power Inc., is proposing to build a 240/230 kV merchant transmission line from near Lethbridge in southern Alberta to Great Falls in west-central Montana. This project is Alberta's first interconnection to the United States and Montana's first interconnection with Alberta. The Project will provide import/export opportunities for power markets in Montana and Alberta and enable wind development opportunities (neglecting operating issues such as regulation) in southern Alberta and northern Montana since the transmission route traverses a region of substantial wind development potential.

The MATL project is a 240/230 kV, 330 MVA transmission line designed for continuous bi-directional power transfers. The project consists of a new substation, named MATL 102S, located approximately 15 km north of the City of Lethbridge, Alberta that ties into the existing 240 kV Alberta Interconnected Electric System (AIES) system. A phase shifting transformer will be installed in the MATL 120S substation to control flows both north and south and to step the voltage down from the Alberta nominal system voltage of 240 kV to transmission line voltage of 230 kV. A mid-point substation named Marias will be built 10 km south of the town of Cut Bank, Montana. The Marias Substation will contain shunt and series capacitance for voltage support and the substation is anticipated to be a connection point for proposed wind generation projects in the area[2]. At the south end, the MATL transmission line will terminate at the existing Great Falls, Montana, 230kV substation. The Great Falls Substation is owned and operated by NorthWestern Energy Inc. The transmission line is approximately 346 km long, uses single Falcon 1590 kcmil conductor, and will be built of a combination of monopole and H-frame structures. This Phase 2 study is based on a planned in service date of the MATL project of 2008. Figure 2.1, below, graphically illustrates the proposed route for the MATL project.

[2] This Phase 2 study has not included any wind generation connected to Marias and additional study work (including path rating modifications per the applicable WECC path rating process in effect at the time of the request) will be required before any wind generation can interconnect to the MATL project.

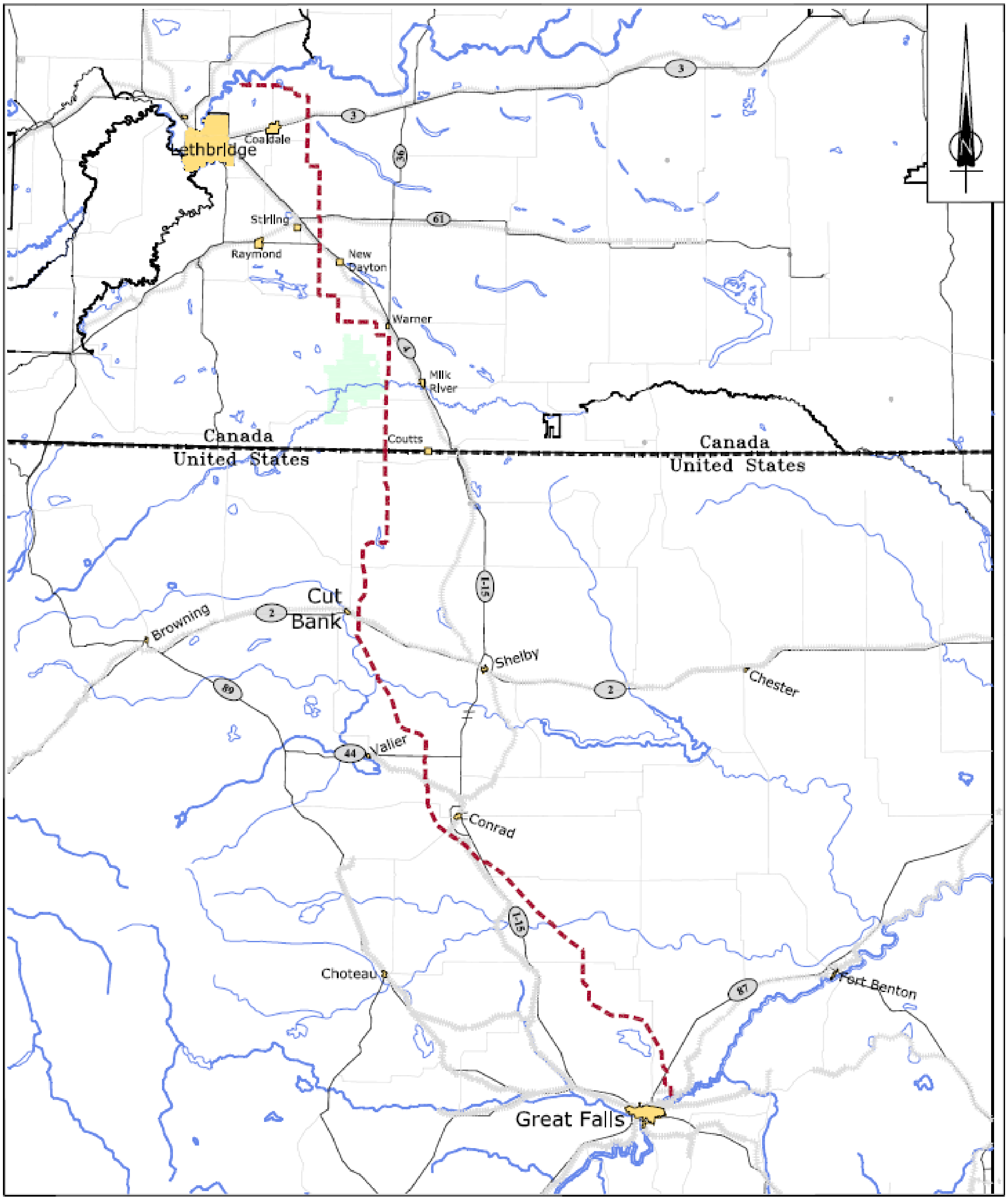

Figure 2.1: MATL Proposed Route Map

2.1 ENGINEERING OVERVIEW

MATL's transmission system consists of three substations and connecting transmission circuit. The proposed transmission line is designed for a path rating of +325/-300 MW transfer capability (positive transfer is defined as flow southbound). The system is designed and will be operated according to WECC/NERC reliability criteria. In Alberta, the system will be designed to Alberta Electrical and Communications Utility Code (AECUC), and Canadian Standards Association code where applicable. In Montana, the system will be designed to the National Electric Standards Code (NESC) and other State or National codes. Where applicable, industry standards such as the Institute of Electric and Electronic Engineers (IEEE) and American National Standards Institute (ANSI) will apply.

Figure 2.2 on the next page shows the facilities that constitute the proposed system.

MATL 120S Substation

The new MATL 120S Substation will be located approximately 15 km north east of AltaLink's existing North Lethbridge 370S substation. The substation will be built and owned in two parts. AltaLink will design and construct the interconnection portion and MATL will design and construct the transmission portion. AltaLink's portion consists of a three breaker ring bus and the tie into the existing 240 kV transmission line, which is located next to the facility. The MATL portion consists of two 50MVAR shunt capacitors, a phase shifting transformer (PST) and a line breaker. The PST is rated at 330MVA with a phase angle range of +/-70 degrees (+/-79 degrees internal) through a 64 step tap changer. This tap changer is adjustable through its full range under load. The PST is capable of controlling over 300 MW of power flow in both directions but studies show the PST can reach phase angle limits prior to reaching 300 MW during certain system conditions that are discussed in the Results Section. The proposed path rating is very near or may exceed the nameplate power rating of the PST. MATL will install temperature alarms or curtail flows during high ambient temperatures to mitigate.

Marias Substation

MATL proposes to build a mid-point substation approximately 10 km south of the town of Cut Bank in Montana. The function of the Marias Substation is to 1) break the transmission line into two sections for protection and control purposes, 2) provide transmission line reactive support and 3) provide a potential future direct connection point for proposed wind projects in the area. Marias consists of four 40 MVAR shunt capacitors two series capacitors and a three breaker ring bus. The transmission line is 65% compensated on the north section and 50% compensated on the south section.

Great Falls Substation

The MATL transmission line terminates at the NorthWestern Energy's (NWE) Great Falls 230kV Substation. NWE will design and construct the modifications to the existing substation to accommodate MATL's interconnection.

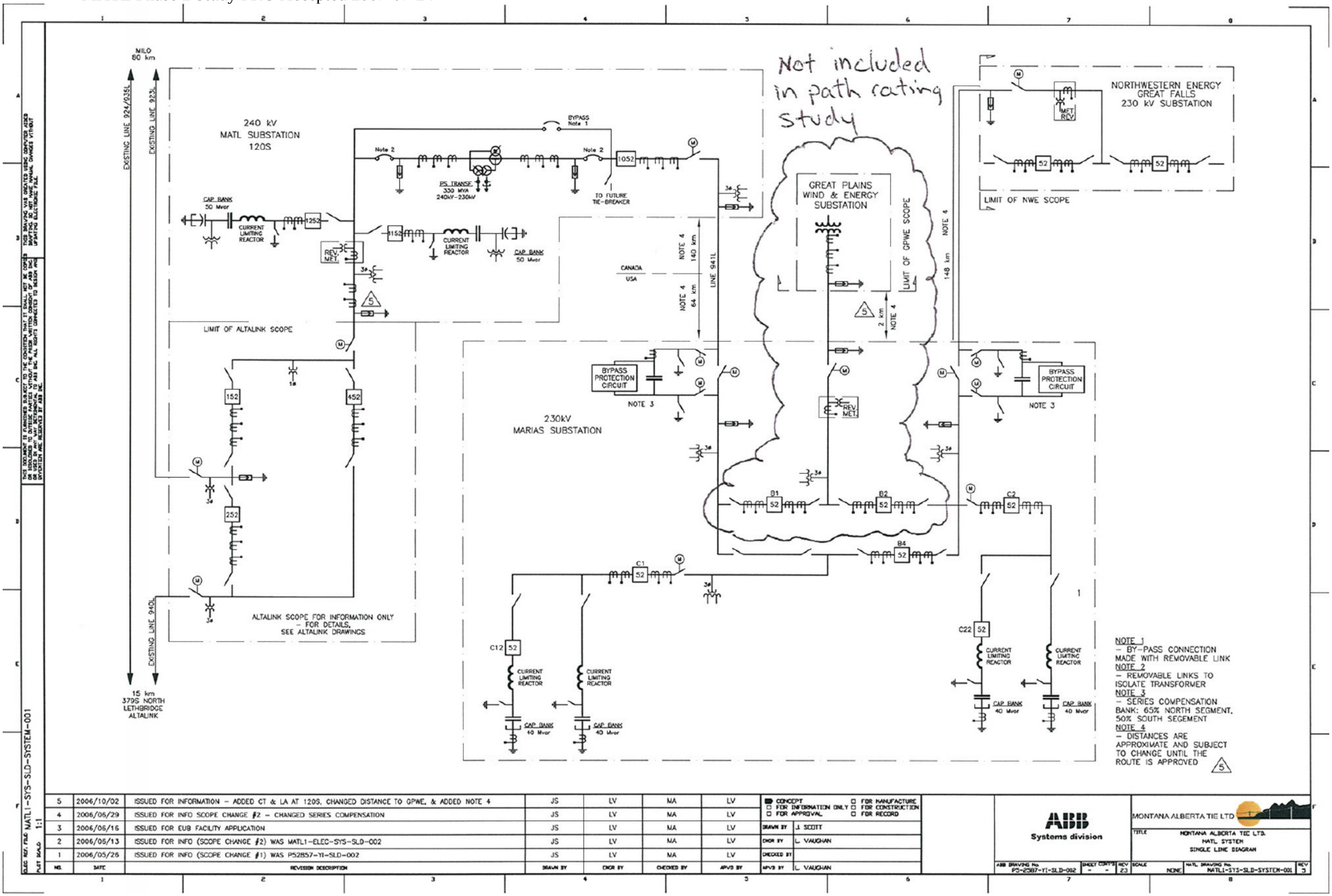

Figure 2.2: MATL Single Line Diagram

2.2 OPERATION OVERVIEW

Subject to negotiations, the Alberta Electric System Operator (AESO) and NorthWestern Energy (NWE) will be the Balancing Authorities and Transmission Operators of the MATL line. The Alberta portion of the MATL system will be in the control area of AESO and the Montana portion of the MATL system will be in the control area of NWE.

MATL will be actively involved in the design and implementation of the Protection & Control, RASs, and any other mitigation measures, as determined through the operational study which will follow the present PRG Phase 2 study. These operational studies will have to be done in close cooperation with the affected parties (e.g. AESO, NWE, and BCTC) through joint studies. The implementation process also involves developing specific tools and operating procedures. These tools and operating procedures are necessary steps that need to be completed before the MATL Project can be placed in service, and will add considerable time (upward of one year) to the project commissioning process.

2.3 WECC PATH RATING OVERVIEW

MATL proposes to build a new path in the WECC grid connecting Alberta to Montana (see Figure 2.3). In accordance with Western Electrical Coordinating Council (WECC) “Procedures for Regional Planning Project Review and Rating Transmission Facilities”, MATL has performed Phase 2 Rating studies. These studies demonstrated that the MATL project will be able to conform to all applicable Reliability Criteria. In addition, these studies:

- identify the planned non-simultaneous transfer capability and simultaneous path transfer capability limits for the proposed project configuration,
- address the mitigation of simultaneous transfer capability problems relative to the existing system, and
- resolve comments from BPA, NWE and BCTC on the MATL Comprehensive Progress Report.

In addition, this report documents some limited sensitivity analyses that were performed to check the interaction of MATL with up to 700 MW of new wind and other generation resources in southern Alberta.

It should be noted that the revised scope of work included the performance of a sensitivity analysis to determine the impact of up to 120 MW of wind generation connected to the MATL project at the Marias switching station. MATL has requested that this wind interconnection sensitivity be removed from this Phase 2 study and the study scope. The MATL PRG has approved removing this sensitivity analysis[3]. As part of any future analysis, a redefinition of the MATL path may be requested. This future analysis may require a review of the WECC Project Rating following the WECC Project Rating Review Process in effect at the time this analysis is performed.

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[3] This Phase 2 study has not included any wind generation connected to Marias and additional study work will be required before any wind generation can interconnect to the MATL project.

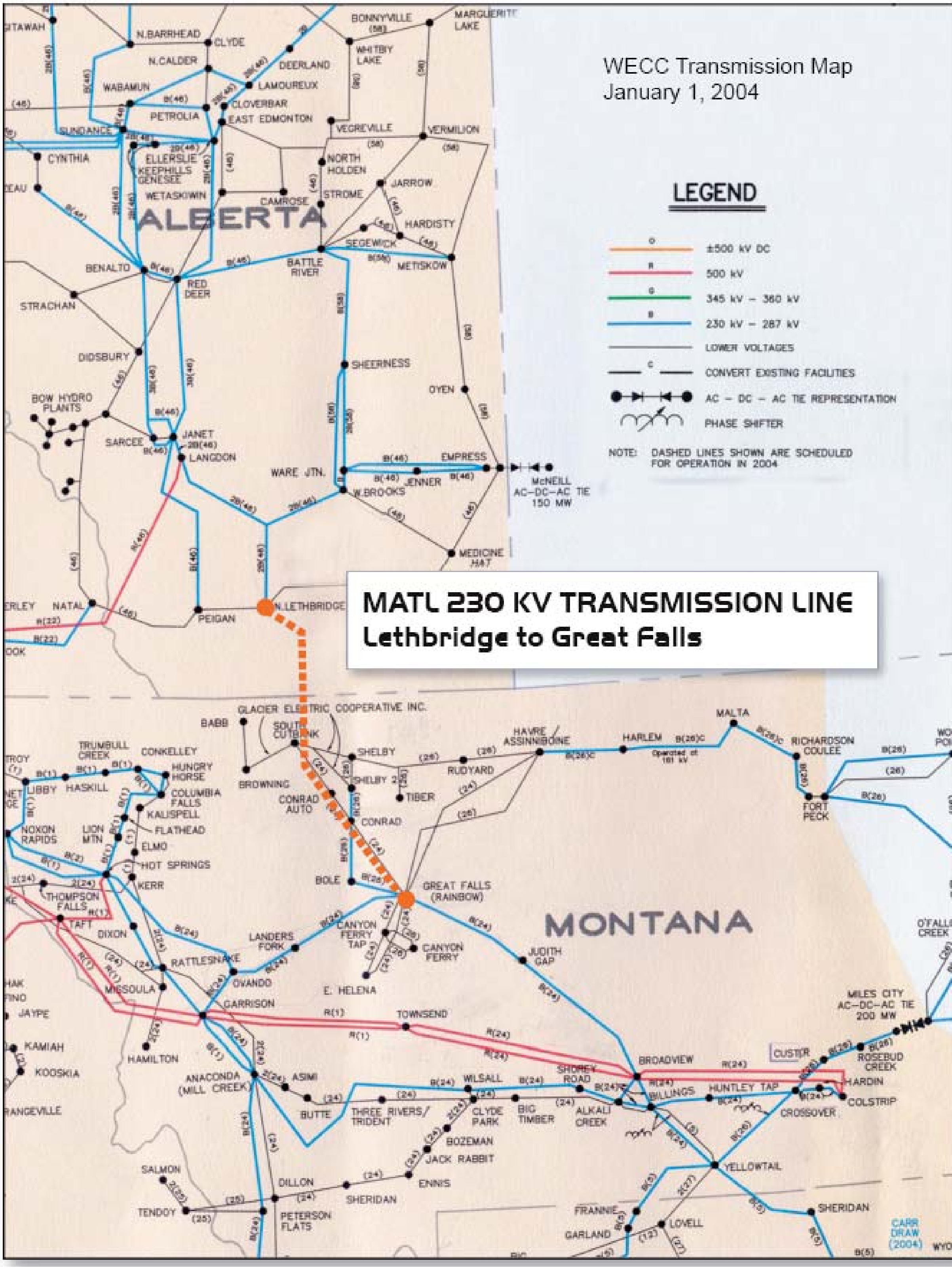


Figure 2.3: Map Showing MATL Connections to WECC Grid

III. STUDY CONCLUSIONS

A. Baseline Analysis – Non-simultaneous

The results of the non-simultaneous studies show that with proper mitigation, the addition of the MATL project will not adversely affect the reliability of the WECC grid for the proposed path rating of +325 / -300 MW between Alberta and Montana (metered at MATL 120S, positive transfer is flow southbound).

The five contingencies were identified that require remedial action schemes (RAS) to trip the MATL project to preserve the reliability of the WECC grid. These five contingencies are:

1. Loss of Langdon - Cranbrook,
2. Loss of Cranbrook - Selkirk,
3. Loss of Selkirk - Ashton Creek and Selkirk - Vaseux Lake,
4. Loss of both Ingledow - Custer lines (when BC would separate from the US), and
5. Loss of both Custer - Monroe lines (when BC would separate from the US).

These five contingencies will require a RAS to trip MATL to prevent voltage collapse or transient instability from occurring. The RAS may be designed as a local detection based RAS (measured on MATL tie) to direct trip the MATL tie. The RAS is intended to be armed at all times that the MATL project is in service. If the RAS is out of service for any reason, it is expected that the MATL line will need to be taken out of service to preserve system reliability. Future operating studies may look at possibly defining a lower boundary for RAS arming. If system flows are below the boundary levels defined in the studies, then the RAS may not need to be armed.

Loss of the MATL tie when Nelway - Boundary flow is at or near its limits and the MATL flow is in the same direction as the Nelway - Boundary flow will require either a RAS to trip Nelway - Boundary or an operating procedure to issue a tap changer adjustment order for the Nelway phase shifting transformer.

Loss of large amounts of generation in Montana due to operation of the Colstrip ATR can cause a large increase in flows on the MATL project. In order to mitigate these overloads, the MATL phase shifting transformer will need to be adjusted or the MATL line will need to be tripped.

The conclusions are based on a comparative analysis between pre-project base case conditions and the base case with the proposed MATL project under the same conditions. This study did not investigate conditions that could not meet WECC/NERC reliability in the pre-project case. In particular, Path 1 flows were well below the 1000 MW east to west and 1200 MW west to east path rating limit because of constraints in the Alberta system.

B. Simultaneous Analyses

This study also addresses simultaneous capability of MATL versus Path 1, Path 3 and Path 8. Nomograms are developed for these simultaneous relationships. In all nomograms, the metering point on MATL is assumed to be the MATL 120S Substation.

The conclusions from simultanous studies are also based on a comparative analysis between pre-project base case conditions and the base case with the proposed MATL project under the same conditions. This study did not investigate conditions that could not meet WECC/NERC reliability in the pre-project case. In particular, Path 1 flows in the studied cases were well below the 1000 MW east to west and 1200 MW west to east path rating limit because of constraints in the Alberta system. It must be clarified that as the nomograms of Path 1 vs MATL tie, or Path 3 vs MATL tie in this report are based on particular system conditions only and the purpose of these nomograms is just for identifying the impact of the MATL addition so that potential solutions such as RAS or other mitigation measures could be provided. These results shall not be interpreted as an operating OTC nomogram.

1. Path 8 (Montana to Northwest)

An interaction was discovered between MATL and Path 8. However, the strength of this interaction was very weak. Other mitigation methods would be much more effective at relieving the overloads identified in these studies than reducing Path 8 flows.

2. Path 1 (Alberta-British Columbia)

Cases with westbound flow on Path 1 showed Path 1 and the MATL Path share the total Alberta export which is limited due to constraints in the Alberta system. Mitigation measures are required under simultaneous conditions to operate within WECC reliability standards.

Cases with eastbound flow in some circumstances had significant interactions on a thermal, reactive margin, and transient stability basis. The results of these studies showed that reactive margin and transient stability were not limiting in any of the cases studied. Results are also dependent on the assumptions that are made regarding the flows on the Nelway - Boundary path. In addition, under conditions of high Path 1 imports into Alberta, loss of both Langdon - Janet 240 kV lines may require the development of a capacitor switching RAS to provide adequate voltage support and reactive margin. Currently, the import limit for this contingency is based on thermal loading on other lines in the area.

3. Path 3 (Northwest-Canada)

An interaction was discovered between MATL and Path 3 when transfers on both paths are close to their limits in southbound direction. The dominant contingency is loss of Custer-Monroe 500 kV #1 and #2. A new RAS may be required for this contingency and a new function may need to be added in the existing BC RAS for two other contingencies (the Ingledow-Custer 500 kV #1 or #2 line, and the Ingledow-Custer 500 kV #1 and #2 lines) to transfer trip Path 1 to reduce or eliminate the nomogram. These RAS additions would compensate for the simultaneous transfer impacts on the net import or export into Alberta and how this net import or export can affect the requirements to open the Alberta to BC tie for these contingencies. The simultaneous interactions determined during these studies may be reduced or eliminated through revision of the BC remedial action schemes discussed above.

For impacts to Path 3 flows as identified in the MATL vs. Path 3 nomogram, MATL's mitigation plan is to:

A. Develop, fund and implement a RAS mutually acceptable to BCTC and/or AESO as appropriate which will reduce or eliminate the MATL impact

B. If the RAS cannot be implemented prior to MATL being energized, MATL, BCTC and other affected transmission operators will develop operating procedures to keep the amount of power that Path 3 can transfer protected from being diminished due to MATL flows. This operating procedure may include curtailing MATL.

C. If a RAS cannot be implemented to fully protect Path 3 transfers from being diminished due to MATL flows, operating procedures to protect Path 3 transfers will remain in place along with the RAS

4. Path 6 (West of Hatwai)[4]

Path 6 was studied in conjunction with Path 8 and the conclusions for this path are presented above in the Path 8 section.

C. Sensitivity Analyses

The south of Great Falls path has numerous flowgates that can limit north-to-south transfers on the MATL project. Heavy summer conditions are much more restrictive than spring conditions. Also, the amount of generation connected to the Montana system in the vicinity of Great Falls has an impact on transfer capability of the system.

The results of the sensitivity analysis demonstrated a significant impact on the system operating limits based on the magnitude of the wind generation dispatch in southern Alberta. In most cases the impacts caused by the southern Alberta generation exceeded the impacts caused by MATL.

[4] The West of Hatwai sensitivities will be performed as part of the Path 8 studies.

III. NON-SIMULTANEOUS ANALYSIS STUDY RESULTS

Responses to all comments on the MATL Comprehensive Progress Report received within the 60-day review period ending November 20, 2005 are provided in the MATL Path Rating Study Report as Appendix B. To the extent possible, most of the comments, suggestions and requests have been addressed in these studies. The remaining comments were resolved prior to the initiation of these Phase 2 studies.

III.A STUDY CONDITIONS

To ensure NERC/WECC Planning Standards are met while achieving MATL's planned rating of +325/-300 MW, power system studies have been performed using WECC base cases and all applicable reliability criteria. Two base cases, a 2006 light summer (modified to represent 2007 light spring conditions), and a 2007 heavy summer were analyzed. The non-simultaneous base cases used in this study were sent out for review and comment and were approved by the PRG for use in these Phase 2 studies.

1. Base Case Description

Two base cases representing the 2007 time period were used for the studies. The first case represents 2007 heavy summer (HS) conditions and was developed from the WECC 07hs2a1 base case that was approved and posted on the WECC web site in January 2005. The second case represents 2007 light spring (LSP) conditions and was developed from the WECC 06ls1ap base case that was approved and posted on the WECC web site in December 2005. From these two base cases a total of six study cases were created:

Case III-1a: 2007 HS pre-project case
Case III-1b: 2007 HS post-project case with 325 MW north to south flow on MATL
Case III-1c: 2007 HS post-project case with 300 MW south to north flow on MATL
Case III-2a: 2007 LSP pre-project case
Case III-2b: 2007 LSP post-project case with 325 MW north to south flow on MATL
Case III-2c: 2007 LSP post-project case with 300 MW south to north flow on MATL

Table 1 below lists the pertinent interface flows for these six base cases. All the MATL flows (both north-to-south and south-to north) for all of the flow summary tables in this report are metered at the MATL_AB 240 kV bus.

Table 1: Non-Simultaneous Base Case Interface Flows

				Interface Flow (MW)					
Interface Number	Interface Name	Interface Rating 1	Interface Rating 2	07 HS Pre-Project Case	07 HS Post-Project North-to-South Case	07 HS Post-Project South-to-North Case	07 LSp Pre-Project Case	07 LSp Post-Project North-to-South Case	07 LSp Post-Project South-to-North Case
	MATL (N to S is +)	300	-300	N/A	325	-299	N/A	326	-308
	Nelway-Boundary 230 kV (N to S is +)	400	-400	395	395	395	-331	-332	-332
1	ALBERTA - BRITISH COLUMBIA	1000	-1200	-400	-398.3	-413.5	399.5	401.7	396.1
2	ALBERTA - SASKATCHEWAN	150	-150	0.1	0.1	0.1	0.1	0.1	0.1
3	NORTHWEST - CANADA	2000	-3150	-2000.5	-2002.1	-1988.1	1500.5	1496.4	1505.5
4	WEST OF CASCADES - NORTH	9800	-9800	3637.3	3699.7	3651.8	3843.2	3850.8	3832
5	WEST OF CASCADES - SOUTH	7000	-7000	3738.3	3767.4	3726.8	2465.6	2429.2	2454.7
6	WEST OF HATWAI	4300	N/A	2890.4	3120.7	2649.4	3725.1	3928.1	3557.1
8	MONTANA - NORTHWEST	2200	-1350	1443.4	1687.1	1195.2	1989.9	2207.4	1813.2
9	WEST OF BROADVIEW	2573	N/A	2164.8	2165.8	2237	2283.2	2251.8	2298
10	WEST OF COLSTRIP	2598	N/A	2065.8	2100	2119.7	2127.8	2096.8	2128.7
11	WEST OF CROSSOVER	2598	N/A	2181.1	2177.6	2254.7	2237.4	2210.7	2234.4
14	IDAHO - NORTHWEST	2400	-1200	-39.6	-39.8	-43.4	991.6	1013.7	990
15	MIDWAY - LOS BANOS	4800	-2000	1198.1	1075.5	1244	1536.5	1535.3	1530.5
16	IDAHO - SIERRA	500	-360	111.5	116.9	108.8	-132.5	-131.3	-134
17	BORAH WEST	2307	N/A	1172.7	1177.6	1166.6	1638.7	1663.1	1636.5
18	IDAHO - MONTANA	351	-337	-255.4	-288.9	-238.8	-42.7	-66.6	-18.2
19	BRIDGER WEST	2200	N/A	2206.4	2203.3	2205.7	2241.3	2226.8	2238.1
20	PATH C	1000	-1000	-214.4	-238.5	-204.6	123.8	138.2	149.2
21	ARIZONA - CALIFORNIA	5700	0	5626.1	5683.1	5610.2	3367.1	3365.8	3369.2
46	WEST OF COLORADO RIVER (WOR)	10118	-10118	4710.2	4756.3	4696.3	3424.7	3423.7	3421.6
49	EAST OF COLORADO RIVER (EOR)	7550	N/A	968	984	968	938.4	938.5	940.2
53	BILLINGS - YELLOWTAIL	400	-400	-161.6	-166.3	-161.9	-107.2	-102.9	-107.8
55	BROWNLEE EAST	1750	N/A	48.6	49	48.4	11.6	11	11.5
65	PACIFIC DC INTERTIE (PDCI)	3100	-3100	3090.9	3096.4	3096	2000	2000	2000
66	COI	4800	-3675	3219.6	3519.4	3178.5	802.8	671.8	682
73	NORTH OF JOHN DAY	7900	-7900	6392.4	6656	6365	2563.6	2660.8	2464.9
75	MIDPOINT - SUMMER LAKE	1500	-400	325.2	347.5	316	945.7	963.5	935.2
76	ALTURAS PROJECT	300	-300	259.1	257.5	258.9	153.1	152.8	154.6
80	MONTANA - SOUTHEAST	600	-600	-201	-168	-221	-145	-145	-142
500	Southern CA Imports	N/A	N/A	7270	7288.3	7272.9	6425.8	6425.1	6422
501	South of KEG Cutplane (SOK)	1880	N/A	1483.5	1669.5	1268	752.6	1507	753.8
502	North of Calgary Cutplane (NOC)	1330	N/A	947.3	1251.3	666.4	652.1	1186.3	525
503	Fort McMurray Flowgate	600	-600	335.7	335.5	336.1	119.9	99.4	118.7

2. Generation Assumptions

Planned future generation projects were modeled in the base cases if they are Level 1 or 2 as defined in the approach shown in Appendix 1 of the Study Scope. In addition, the following generation sensitivities were performed.

a. 188 MW of wind generation at Judith Gap South (Level 1),
b. 280 MW of gas fired generation at Great Falls (Level 3)[5],
c. 268 MW of coal fired generation at Great Falls (Level 3),
d. 700 MW of total installed wind generation in southern Alberta (Level 1).

[5] Since the onset of the MATL Phase 2 Studies, this generator has withdrawn from NorthWestern Energy's interconnection queue. Near completion of the Studies, this generator project has been re-instated by another company. The project is now behind MATL in NWE's interconnection queue.

3. New Transmission Line Project Assumptions

a. The West of Hatwai upgrades (Path 6) are assumed to be in-service,

b. In addition, the Benewah-Shawnee 230 kV line[6] will be modeled in all study cases, and

c. The Idaho-Montana upgrades (Path 18) listed below are also assumed to be in-service:

   a. another 12 MVAr of switched shunt capacitors on the 69 kV bus at Dillon,
   b. a switched shunt capacitor bank on the 230 kV bus at Peterson Flats with a 35 MVAR (at 242 kV) rating, and
   c. a 37.7 MVAr switched shunt capacitor bank on the bus at the Mill Creek (Anaconda) substation at the north terminal of the AMPS line.

d. The southwest Alberta 240 kV transmission line development is in service for all study cases.

4. WECC Major Path Flow/Path Rating Assumptions

The transmission paths listed in Table 2 below are the major paths out of Montana and Alberta. The pre-project non-simultaneous WECC rating of each path is also listed. However, the actual path transfer capabilities fluctuate with changes in load, generation conditions, local transmission operator transmission issues, and because of interactions with other paths in the WECC. Therefore, path flows may be limited such that they do not exceed known operating constraints that are in effect for the conditions that are being studied.

[6] This line will not be in service until December 2007. However, this project is a committed project. By modeling this line in service, any impacts that MATL may have on the system after this line is energized can be determined. Operational studies will determine any additional system limitations for the time period before this line is energized.

Table 2: Major Montana and Alberta Transmission Paths

Path No.	**Transfer Path**	**Path Rating (MW)**	**Desired Flow (MW)**	
			07LSp	**07HS**
Path 1	Alberta-British Columbia	1000 MW E to W 1200 MW W to E	400 MW E to W	400 MW W to E
Path 3	Northwest-Canada	3150 MW N to S 2000 MW S to N	1500 S to N	2000 N to S
Path 6	West of Hatwai	4300 E to W	High	High
Path 8	Montana to Northwest	2200 MW E to W 1350 MW W to E	2200 E to W	High
Path 18	Idaho-Montana	356 MW N to S[7] 337 MW S to N	Float[8]	Float[8]

III.B STUDY METHODOLOGY

- The power flow base cases(s) and dynamic stability data including the new WECC approved governor model were developed in General Electric PSLF version 16.0 format (and PTI PSS/E versions 29.5 and 30.2). Because of intricacies associated with the Colstrip ATR relay and the Miles City DC (MCDC) tie, cases that are meant to investigate performance with Path 8 fully loaded westbound utilized the Siemens PTI PSS/E program[9] so that established modeling of the ATR and MCDC could be accomplished. Some screening studies were performed using the GE-PSLF program, but the final analysis was done using the Siemens PTI PSS/E program.

- For all areas outside BC, Montana, and Alberta, the network topology and loads reflect information provided to WECC by each respective area.

- The study complied with the NERC/WECC Planning Standards (April 10, 2003).

1. Power Flow Analysis (study criteria and contingency list)

Power flow studies were performed under normal, and selected critical bulk single and double contingency conditions to ensure the Project meets the planning standards. Contingencies that involve loss of significant amounts of load or generation dropping were not modeled using powerflow techniques. These contingencies were only simulated using dynamic simulations and post-transient power flow methods.

Study Criteria:

[7] NWE limits the flow on Path 18 to 337 MW. NWE will require the study to limit flows on path 18 to 337 MW. The difference (356-337=19MW) is treated as TRM (Transmission Reliability Margin), and is not available for scheduling. NWE would take operator action to reduce the flows on Path 18 if the flow exceeds 337 MW.

[8] A sensitivity case will be developed to test the impact of MATL on Path 18. In order to achieve the rated flows on Path 18, some of the other path flows that are specified above may need to be modified.

[9] Version 30.2 was used for studies on the light spring cases and version 29.5 was used for studies on the heavy summer cases.

a. Under normal conditions, bus voltages were maintained between 0.95 p.u. and 1.05 p.u., unless other specific minimum operating voltage requirements exist. All line and transformer loadings must be below normal continuous ratings.

b. Study Criteria during Contingency Conditions:

- No transmission element will be loaded above its respective emergency rating as provided in the base cases. Overloads that were not caused by the MATL Project were flagged separately.
- Equipment emergency voltage limits (high or low) will not be exceeded. (As a proxy for these emergency voltage limits, bus voltages were flagged if they exceeded 1.1 p.u.)
- Bus voltage deviations from the base case voltage shall not exceed established planning limits (refer to the Study Scope – April 28, 2006 included as Appendix A.1 of this report).
- No loss of load is allowed for NERC Category "B" contingencies except loss of the Langdon – Cranbrook 500 kV line and only if this load is dropped via an SPS.

c. Tables 3a & 3b provide contingencies to be simulated in the power flow analysis.

Table 3a - List of NERC Category "B" Contingencies for Power Flow Analysis

1. MATL PS – Marias 230 kV line
2. Marias – Great Falls 230 kV line
3. All 230 and 500 kV lines in Montana
4. All 161 kV and lower voltage lines in Montana north of Great Falls
5. All 240 and 500 kV lines in Alberta south of a Keephills-Ellerslie-Genesee (KEG) cut plane
6. All 138 and 69 kV lines in Alberta south of Calgary – Sheerness cut plane
7. Cranbrook – Langdon 500 kV line
8. Ingledow - Custer #1 500 kV line
9. Custer - Monroe #1 500 kV line
10. Cranbrook – Nelway 230 kV line
11. Nelway – Boundary 230 kV line
12. Taft – Bell 500 kV line
13. Taft – Dworshak 500 kV line
14. Dworshak – Hatwai 500 kV line
15. Garrison-Taft #1 500 kV line
16. Boundary-Usk 230 kV line

Table 3b - List of NERC Category "C" Contingencies for Power Flow Analysis

17. Taft – Bell and Taft – Garrison #1 500 kV lines

18. Boundary-Bell #1 230 kV and Bell-Usk 230 kV lines
19. Boundary-Bell #3 230 kV and Addy-Bell #1 115 kV line

2. Post-Transient Studies (study criteria and contingency list)

Study Assumptions:

a. All loads were modeled as constant MVA during the first few minutes following an outage or disturbance.

b. All voltages at distribution substations were restored to normal values by voltage regulators and other voltage control devices.

c. Generator MVAR limits were modeled as single values for each generator as provided in the WECC power flow cases, since the individual reactive power capability curves were not modeled.

d. In the post transient time frame only automatic actions were assumed, no manual intervention was assumed.

e. Remedial actions such as generator dropping, load shedding or blocking of automatic generation control (AGC) were not considered for NERC Category "B" contingencies except for loss of the Langdon – Cranbrook 500 kV line, or as allowed by the PRG.

f. The reactive margin was measured at ten locations:

   - MATL_AB 240 kV,
   - Marias 230 kV,
   - Great Falls 230 kV,
   - Garrison 500 kV,
   - Ovando 230 kV,
   - Broadview 230 kV,
   - Cranbrook 500 kV,
   - Boundary 230 kV,
   - Natal 138 kV, and
   - Langdon 240 kV substations.

   These selected critical buses, which were determined by the PRG, were all checked to ensure adequate reactive margin per WECC voltage stability criteria was available for all contingencies studied. In addition, post-transient simulations were performed on cases with +5% and +2.5% additional power flow on MATL to demonstrate compliance with the WECC Voltage Stability Criteria (May 1998).

g. Other Assumptions

   - Area Interchange: Disabled

- Governor Blocking: Baseload Flag will be used per current WECC practice.
- DC Line Transformer Tap Automatic Adjustment: Enabled
- Generator Voltage Control set to the generator terminal bus except generators that have Line Drop Compensators or are otherwise set to control a remote bus. The following units are set to control remote buses:

  Maple Valley-SVC 19.6
  Keeler-SVC 19.6
  East Hunter 1 24.0
  East Hunter 2 24.0
  East Hunter 3 22.0
  Huntington G1 22.0
  Huntington G2 22.0

- Phase Shifter Control: Disabled
- Switched Shunt Devices: Disabled - except where automatic controls or remedial action schemes are in place.
- Transformer tap ULTC's locked unless they are automatic.

Study Criteria:

h. The post-transient voltage deviations should meet the NERC/WECC Planning Standards (April 10, 2003) (refer to the Study Scope in Appendix A.1).

i. Tables 4a & 4b provide a list of contingencies that will be simulated for post-transient voltage analysis.

Table 4a - List of NERC Category "B" Contingencies for Post-Transient Voltage

1. MATL PS – Marias 230 kV line
2. Marias – Great Falls 230 kV line
3. Colstrip – Broadview #1 500 kV line
4. Broadview – Townsend – Garrison #1 500 kV line
5. Garrison – Taft #1 500 kV line
6. Langdon – Cranbrook 500 kV line
7. Cranbrook – Selkirk 500 kV line(RAS used)
8. Ingledow - Custer #1 500 kV line
9. Custer - Monroe #1 500 kV line
10. Selkirk – Ashton Creek 500 kV line(RAS used)
11. Selkirk – Vaseux Lake 500 kV line(RAS used)
12. Nicola – Meridian 500 kV line(RAS used)

13. Nelway – Boundary 230 kV line(RAS used)
14. A 450 MW generator at Genesee
15. Langdon – Janet #1 240 kV line

Table 4b - List of NERC Category "C" Contingencies for Post-Transient Voltage

16. Ingledow – Custer #1 and #2 500 kV lines(RAS used)
17. Custer – Monroe #1 and #2 500 kV lines(RAS used)
18. Broadview – Townsend – Garrison #1 and #2 500 kV lines
19. Garrison – Taft #1 and #2 500 kV lines
20. Both Nicola – Ashton Creek #1 and #2 500 kV lines(RAS used)
21. Both Nicola – Ingledow and Nicola – Meridian 500 kV lines(RAS used)
22. Both Selkirk – Ashton Creek and Selkirk – Vaseux Lake 500 kV lines(RAS used)
23. Both Sundance to Benalto 240 kV lines
24. Both Benalto – Sarcee 240 kV lines
25. Both Benalto – Keephills 240 kV lines
26. Both Janet – Red Deer 240 kV lines
27. Both Red Deer – Ellerslie 240 kV lines
28. Both Langdon – Janet 240 kV lines
29. Both W. Brooks - Langdon - N. Lethbridge 240 kV lines
30. W. Brooks – Langdon – N. Lethbridge and W. Brooks – Langdon – MATL (923L/927L)
31. W. Brooks – Langdon – N. Lethbridge (924L/935L) and MATL – N. Lethbridge (940L)

3. Transient Stability Analysis (study criteria and contingency list)

Transient stability studies were performed to assess the impact on the dynamic performance of the heavily stressed paths under the projected 2007 system conditions under various contingencies. A pre-project benchmark base case was established to represent the system stability limits. The study will determine the most critical fault condition that would limit the MATL non-simultaneous transfer capability.

Study Criteria:

a. All machines in the system shall remain in synchronism as demonstrated by their relative rotor angles.

b. System stability was evaluated based on the damping of the relative rotor angles and the damping of the voltage magnitude swings.

c. Transient voltage dips and duration requirements must meet the criteria of the NERC/WECC Planning Standards (April 10, 2003) (refer to Appendix 3 of the Study Scope).

d. Tables 5a & 5b provide the three phase fault contingencies to be simulated in the stability analysis[10].

Table 5a - List of NERC Category "B" Contingencies for Transient Stability

1. MATL PS – Marias 230 kV line
2. Marias – Great Falls 230 kV line
3. Colstrip – Broadview #1 500 kV line[11]
4. Broadview – Townsend – Garrison #1 500 kV line[11]
5. Garrison – Taft #1 500 kV line[11]
6. Langdon – Cranbrook 500 kV line
7. Cranbrook – Selkirk 500 kV line(RAS used)
8. Ingledow - Custer #1 500 kV line
9. Custer - Monroe #1 500 kV line
10. Selkirk – Ashton Creek 500 kV line(RAS used)
11. Selkirk – Vaseux Lake 500 kV line(RAS used)
12. Nicola – Meridian 500 kV line(RAS used)
13. Nelway – Boundary 230 kV line(RAS used)
14. A 450 MW generator at Genesee
15. Langdon – Janet #1 240 kV line

Table 5b - List of NERC Category "C" Contingencies for Transient Stability

16. Taft 500 kV Breaker Failure at Bell/Garrison #1 position
17. Taft 500 kV Breaker Failure at Bell/Garrison #1 position with 1-phase fault and delayed clearing
18. Ingledow – Custer #1 and #2 500 kV lines(RAS used)
19. Custer – Monroe #1 and #2 500 kV lines(RAS used)
20. Broadview – Townsend – Garrison #1 and #2 500 kV lines[11]
21. Broadview – Townsend – Garrison #1 and #2 500 kV lines with double-single-phase faults and unsuccessful reclose[11]
22. Garrison – Taft #1 and #2 500 kV lines[11]
23. Both Nicola – Ashton Creek #1 and #2 500 kV lines(RAS used)
24. Both Nicola – Ingledow and Nicola – Meridian 500 kV lines(RAS used)
25. Both Selkirk – Ashton Creek and Selkirk – Vaseux Lake 500 kV lines(RAS used)
26. Both Sundance to Benalto 240 kV lines

[10] Switching sequences for all contingencies are provided in Appendix I.
[11] These contingencies need to include the Colstrip Acceleration Trend Relay (ATR) and Miles City DC (MCDC) modeling and will need to be simulated using the PSS/E software.

27. Both Benalto – Sarcee 240 kV lines
28. Both Benalto – Keephills 240 kV lines
29. Both Janet – Red Deer 240 kV line
30. Both Red Deer – Ellerslie 240 kV lines
31. Both Langdon – Janet 240 kV lines
32. Both W. Brooks - Langdon - N. Lethbridge 240 kV lines
33. W. Brooks – Langdon – N. Lethbridge and W. Brooks – Langdon – MATL (923L/927L)
34. W. Brooks – Langdon – N. Lethbridge (924L/935L) and MATL – N. Lethbridge (940L)

III.C STUDY RESULTS

1. Powerflow Study Results

Heavy summer non-simultaneous powerflow results are provided in Appendix C.1.A and light spring non-simultaneous powerflow results are provide in Appendix C.1.B. The heavy summer studies determined that the following facilities (Table 6) could be adversely impacted by the MATL project. Simultaneous relationships between the flows on these facilities and the flows on the MATL project are developed in Sections III.C.4 and IV below.

Table 6: Facilities Adversely Impacted by MATL (Heavy Summer)

FROM BUS	KV	TO BUS	KV	ID	SEC
JUDITHGP	100.00-	JUDITHGP	230.00	#1	0
CANFERTB	100.00-	E HELENA	100.00	#1	1
CANFERTA	100.00-	E HELENA	100.00	#1	1
PEIGAN 7	138.00-	OLDMANW4	138.00	#70	1
OLDMANW4	138.00-	FORT MA7	138.00	#70	1
RAYRS TP	69.00-	STIRLIN8	69.00	#25	1
NTL138	138.00-	LCCTAP	138.00	#1	1
NLY230	230.00-	NLYPHS	230.00	#2	0

The relationships between MATL and the loading on the Judith Gap 230/100 kV transformer and between MATL and the loading on the Canyon Ferry-East Helena 100 kV lines are described in the South of Great Falls Flowgates report in Appendix G. These three overloads can be mitigated by maintaining flows on the NWE system within the limits prescribed in the Flowgates report.

The Peigan 7-OldmanW4 and OldmanW4-Fort Ma7 240 kV line overloads and the Rayrs TP-Stirling8 69 kV line overload have all been identified in the ABB Impact Report performed for the MATL Needs Application to the AEUB. Appropriate mitigation measures for these contingencies have been identified in the MATL Needs Application.

Mitigation measures or nomogram relationships for the Natal-LCC Tap 138 kV line and for the Nelway 230 kV phase shifting transformer are discussed in Section IV, below. Section IV also documents a number of contingencies internal to the AESO system that can limit the total import/export capability of Path 1 under certain conditions.

The light spring studies determined that the following facilities (Table 7) could be adversely impacted by the MATL project. Simultaneous relationships between the flows on these facilities and the flows on the MATL project are developed in Sections III.C.4 and IV below.

Table 7: Facilities Adversely Impacted by MATL (Light Spring)

FROM BUS	KV	TO BUS	KV	ID	SEC
JUDITHGP	100.00-	JUDITHGP	230.00	#1	0
RAYRS TP	69.00-	STIRLIN8	69.00	#25	1
NLY230	230.00-	SEL230	230.00	#1	1
NLYPHS	230.00-	NLY230	230.00	#2	0

The relationships between MATL and the loading on the Judith Gap 230/100 kV transformer are described in the South of Great Falls Flowgates report in Appendix G. This overload can be mitigated by maintaining flows on the NWE system within the limits prescribed in the Flowgates report.

The Rayrs TP-Stirling8 69 kV line overload has been identified in the ABB Impact Report performed for the MATL Needs Application to the AEUB. Appropriate mitigation measures for this contingency have been identified in the MATL Needs Application.

Overloading on the Nelway-Selkirk 230 kV line and on the Nelway 230 kV phase shifting transformer for loss of the MATL tie will require either a RAS to trip the Nelway-Boundary line or an operating procedure to issue a tap changer adjustment order for the Nelway phase shifting transformer.

2a. Post-transient Powerflow Study Results

Heavy summer non-simultaneous post-transient powerflow results (branch loading, voltage deviation, and powerflow plots) are provided in Appendix C.2.A and light spring non-simultaneous post-transient powerflow results are provided in Appendix C.2.B. The heavy summer post-transient powerflow studies identified the facilities listed in Table 8 as having overloads made worse by the addition of the MATL project. Simultaneous relationships between the flows on these facilities and the flows on the MATL project are developed in Sections III.C.4 and IV below. Table 9 documents the buses with post-transient voltage deviations that were adversely impacted by the addition of the MATL Project.

Table 8: Facilities Adversely Impacted by MATL (Heavy Summer)

FROM BUS	KV	TO BUS	KV	ID
EFDTAP	138.0	GRHTAP	138.0	#1
FRO T274	138.0	GRHTAP	138.0	#1

NTL138	138.0	LCCTAP	138.0	#1
JANET 4	240.0	E CALGAR	240.0	#17
NLY230	230.0	NLYPHS	230.0	#2
NTL 66	66.0	NTL T1	138.0	#1
NTL 66	66.0	NTL T2	138.0	#2
NTL VR	138.0	NTL T1	138.0	#1
NTL VR	138.0	NTL T2	138.0	#2
NTL138	138.0	NTL VR	138.0	#1

Table 9: Voltage Deviations Adversely Impacted by MATL (Heavy Summer)

		% DEVIATION	
BUS NAME	**KV**	**PRE**	**N2S**
CHROMEAT	100.0	<5.0%	5.50%
ABSAROKE	100.0	<5.0%	5.30%
ABSRKE-R	100.0	<5.0%	5.30%
BGTMBERA	161.0	<5.0%	5.10%
COLBUSAT	100.0	<5.0%	5.10%
DUCKCR-R	161.0	<5.0%	5.10%
STLWTRSM	100.0	<5.0%	5.10%
EMIGT AT	161.0	<5.0%	5.00%

The overloads on the EFDTap-GRHTap, GRHTap-FRO T274, NTL138-LCCTap 138 kV lines and on the Janet-East Calgary 240 kV line are due to the generation dispatch in the basecases. (Generation on the 138 kV circuits running from Pocaterra to Calgary was dispatched down in an attempt to achieve the desired flow on the Nelway-Boundary line. When the generation is dispatched normally, these overloads can be eliminated.) Mitigation measures or nomogram relationships for the Natal transformers, the NTL138-NTL VR 138 kV line and for the Nelway 230 kV phase shifting transformer are discussed in Section IV, below.

According to NWE there are studies underway to reinforce the system in the area where the post-transient voltage deviation violations identified in Table 9 occurred. These reinforcements are required due to local load growth. The reinforcements developed as a result of these studies should resolve these voltage violations and therefore mitigating these voltage violations are not the responsibility of MATL.

Table 10: Facilities Adversely Impacted by MATL (Light Spring)

FROM BUS	**KV**	**TO BUS**	**KV**	**ID**
HARDIN	115.0	HARDINA2	69.0	#1
JEFFERSN	161.0	JFRSNPHA	161.0	#1
MATL_AB	240.0	MATL_AB	230.0	#1
BOUNDARY	230.0	NLYPHS	230.0	#1
NLY230	230.0	NLYPHS	230.0	#2
SEL230	230.0	NLY230	230.0	#1

Table 11: Voltage Deviations Adversely Impacted by MATL (Light Spring)

			% DEVIATION	
BUS NAME	**KV**	**PRE**	**N2S**	**S2N**
MARIAS	230.0	N/A	7.20%	-9.00%

The overload on the Hardin transformer is due to a modeling error in the light spring base case and is not due to the presence of the MATL project. (The 69 kV line from Hardin that is fed from the Hardin 115/69 kV transformer should be radial from Hardin and should not be connected through to Huntley as incorrectly modeled in the light spring case. This overload would not occur if there was no parallel 69 kV path through to Huntley.) The overload on the Jefferson phase shifting transformer can be mitigated by setting the pre-disturbance angle such that the flow on the phase shifter is the same as in the pre-MATL case.

The overload on the MATL line occurs for loss of the Colstrip-Broadview line, generation pickup in Alberta and BC cause the increased flows on MATL. This overload can be mitigated by adjusting the angle of the MATL phase shifter.

Overloading on the Nelway-Selkirk 230 kV line and on the Nelway 230 kV phase shifting transformer for loss of the MATL tie will require either a RAS to trip the Nelway-Boundary line or an operating procedure to issue a tap changer adjustment order for the Nelway phase shifting transformer.

The voltage deviation on the Marias 230 kV bus is acceptable as long as MATL agrees that deviations of this magnitude will be allowed at the Marias bus.

Post-transient powerflow plots for all of the heavy summer cases summarized in Appendix C.2.a are included in Appendix C.2.a. Post-transient powerflow plots for all of the light spring cases summarized in Appendix C.2.b are included in Appendix C.2.b.

2b. Post-transient Reactive Margin Study Results

Reactive margin studies were performed on both the heavy summer and light spring base cases. Reactive margin summaries and Q/V curves for the critical buses are given in Appendix C.2.a for the heavy summer cases and in Appendix C.2.b for the light spring cases.

The minimum reactive margin for the heavy summer studies was 27 MVAr at Broadview 230 kV for loss of the Broadview-Garrison #1 500 kV line. The case with 5% additional flow on MATL had a margin of 24 MVAr. The minimum reactive margin for the light spring studies was 101 MVAr at Broadview 230 kV for loss of the Selkirk-Ashton Creek 500 kV line. The case with 5% additional flow on MATL actually had slightly more margin (106 MVAr at Broadview 230 kV). Even though these reactive margins are fairly low, the performance of the system fully meets the current WECC standard for reactive margin[12] for all contingencies studied.

Q/V plots for all of the critical buses and critical contingencies are provided in Appendices C.2.a and C.2.b.

3. Transient Study Results

Heavy summer non-simultaneous transient results (a case summary table as well as transient and transient snapshot powerflow plots) are provided in Appendix C.3.a and light spring non-simultaneous transient results are provided in Appendix C.3.b.

Most contingencies listed in the heavy summer transient summary table exhibited acceptable performance (no violations of the NERC/WECC Planning Standards). For contingencies that create islands, a RAS to trip MATL will be required to prevent voltage collapse or transient instability from occurring. These contingencies are:

1. Loss of Langdon - Cranbrook,
2. Loss of Cranbrook - Selkirk,
3. Loss of Selkirk - Ashton Creek and Selkirk - Vaseux Lake,
4. Loss of both Ingledow - Custer lines (when BC would separate from the US), and
5. Loss of both Custer - Monroe lines (when BC would separate from the US).

The RAS may be designed as a local detection based RAS (measured on MATL tie) to direct trip the MATL tie. The RAS is intended to be armed at all times that the MATL project is in service. If the RAS is out of service for any reason, it is expected that the MATL line will need to be taken out of service to preserve system reliability. Future operating studies may look at possibly defining a lower boundary for RAS arming. If system flows are below the boundary levels defined in the studies, then the RAS may not need to be armed.

For the contingencies where violations did occur, additional studies were conducted to demonstrate that the violations seen in these cases were not due to the MATL project, but rather were due to pre-existing conditions in the basecase (either generation dispatch levels or import or export levels).

For example, case 13 (loss of both Keephills-Benalto 240 kV lines) has 27 voltage dip violations in the pre-MATL case and 161 voltage dip violations in the post-MATL case (with MATL flows of 325 MW in the north-to-south direction). However, if the Alberta export is increased by 300 MW in the pre-MATL case (so that total Alberta export equals that of the post-MATL north-to-south case), then the number of voltage dip violations for this same contingency (see case 13a) increases to 258. These three contingencies demonstrate that for this outage, the number of voltage dip violations is a function of the Alberta export level, not the presence of the MATL project. Similar sensitivity studies were performed on the other

[12] WECC Voltage Stability Criteria, Undervoltage Load Shedding Strategy and Reactive Power Reserve Monitoring Methodology – May 1998

contingencies that show simulated criteria violations to demonstrate that the MATL project does not adversely impact the transient performance of the WECC grid.

Most light spring contingencies demonstrated acceptable transient performance. As described for the heavy summer non-simultaneous transient cases above, the light spring transient cases where unacceptable performance was exhibited were re-run modifying certain parameters of the case to demonstrate that the violations seen were not caused by the MATL project. For example, for the Nelway-Boundary 230 kV line outage, there is a minor frequency deviation violation at Boundary. This frequency deviation violation is essentially the same in all three cases studied (pre-MATL, post-MATL north-to-south, and post-MATL south-to-north). Therefore, MATL does not cause this criteria violation. Also, it should be noted that frequency deviation violations were seen in eastern Montana for certain Colstrip system outages. [NorthWestern Energy has determined that these violations are acceptable as long as no underfrequency loadshedding occurs for any single contingency.] Finally, there was marginal damping for the Selkirk-Ashton Creek and Selkirk-Vaseux Lake 500 kV N-2 contingency in the north-to-south post-MATL case. Sensitivity cases were run to demonstrate that reducing the flow on Path 8 to the same level as that in the pre-MATL case produced the same level of damping in both the pre-MATL case and the post-MATL north-to-south case. Therefore, the oscillations seen in this case appear to be a function of the stress level on Path 8 not a function of MATL flows.

4. Waneta-Boundary Powerflow Sensitivity Analysis

At the request of BCTC, an additional sensitivity analysis was performed on the heavy summer and light spring non-simultaneous cases. For this sensitivity analysis, a heavy summer and light spring base case with south-to-north flow on Path 3 and south-to-north flow on MATL was modified to open the tie between Waneta and Nelway Tap and close the tie between Waneta and Boundary. (The Nelway phase shifting transformer and the Nelway-Boundary 230 kV line was still in service.) The path flows for these cases is provided in Table 12, below.

Table 12: Waneta-Boundary Sensitivity Base Case Interface Flows

				Interface Flow (MW)					
Interface Number	Interface Name	Interface Rating 1	Interface Rating 2	07 HS Post-Project South-to-North Case	Waneta-Boundary 07 HS Post-Project South-to-North Case	07 HS Post-Project North-to-South Case	Waneta-Boundary 07 HS Post-Project North-to-South Case	07 LSp Post-Project South-to-North Case	Waneta-Boundary 07 LSp Post-Project South-to-North Case
	MATL (N to S is +)	300	-300	-299	-306	325	328	-308	-313
	Nelway-Boundary 230 kV (N to S is +)	400	-400	395	51	396	100	-332	-95
	Waneta-Boundary 230 kV (N to S is +)	400	-400	0	285	0	303	0	-292
1	ALBERTA - BRITISH COLUMBIA	1000	-1200	-413.5	-400.2	-398.2	-399.2	396.1	399.8
2	ALBERTA - SASKATCHEWAN	150	-150	0.1	0.1	0.1	0.1	0.1	0.1
3	NORTHWEST - CANADA	2000	-3150	-1988.1	-2188.7	-2002.2	-2729.7	1505.5	1954.2
4	WEST OF CASCADES - NORTH	9800	-9800	3651.8	3432.4	3700.4	3053.5	3832	4194.5
5	WEST OF CASCADES - SOUTH	7000	-7000	3726.8	3705.9	3767.5	3721.4	2454.7	2478.7
6	WEST OF HATWAI	4300	N/A	2649.4	2377.2	3121.2	2894.7	3557.1	3509.8
8	MONTANA - NORTHWEST	2200	-1350	1195.2	1232.5	1687	1707	1813.2	1819.6
9	WEST OF BROADVIEW	2573	N/A	2237	2287.8	2165.7	2177.1	2298	2315.7
10	WEST OF COLSTRIP	2598	N/A	2119.7	2176.7	2100	2103.3	2128.7	2148.7
11	WEST OF CROSSOVER	2598	N/A	2254.7	2309.2	2177.5	2184.1	2234.4	2269.8
14	IDAHO - NORTHWEST	2400	-1200	-43.4	-78.9	-39.8	-41.6	990	974.8
15	MIDWAY - LOS BANOS	4800	-2000	1244	1227.2	1075.6	1067.4	1530.5	1557.9
16	IDAHO - SIERRA	500	-360	108.8	115.5	117	114.1	-134	-131.1
17	BORAH WEST	2307	N/A	1166.6	1139.3	1177.6	1173.1	1636.5	1623.1
18	IDAHO - MONTANA	351	-337	-238.8	-239.6	-288.9	-282.3	-18.2	-21
19	BRIDGER WEST	2200	N/A	2205.7	2203.9	2203.3	2201.6	2238.1	2255.4
20	PATH C	1000	-1000	-204.6	-232.2	-238.5	-235.8	149.2	117.1
21	ARIZONA - CALIFORNIA	5700	0	5610.2	5676.8	5683.1	5679.9	3369.2	3025.6
46	WEST OF COLORADO RIVER (WOR)	10118	-10118	4696.3	4772.7	4756.3	4748.4	3421.6	3512
49	EAST OF COLORADO RIVER (EOR)	7550	N/A	968	1062.1	984.1	979.6	940.2	695.6
53	BILLINGS - YELLOWTAIL	400	-400	-161.9	-159.5	-166.3	-171.5	-107.8	-90.5
55	BROWNLEE EAST	1750	N/A	48.4	49.1	49	49.1	11.5	11.7
65	PACIFIC DC INTERTIE (PDCI)	3100	-3100	3096	3100.1	3096.4	3096.8	2000	2000
66	COI	4800	-3675	3178.5	1104.6	3519.6	1266.6	682	656.1
73	NORTH OF JOHN DAY	7900	-7900	6365	6412.8	6656.2	6669.8	2464.9	2463.5
75	MIDPOINT - SUMMER LAKE	1500	-400	316	286.9	347.5	342.3	935.2	923.4
76	ALTURAS PROJECT	300	-300	258.9	261.6	257.5	260.2	154.6	159.3
80	MONTANA - SOUTHEAST	600	-600	-221	-215.9	3.7	-176.3	-142	-140.7
500	Southern CA Imports	N/A	N/A	7272.9	7246.1	7288.3	7284.6	6422	6403.6
501	South of KEG Cutplane (SOK)	1880	N/A	1268	1269.1	1669.5	1600.7	753.8	777
502	North of Calgary Cutplane (NOC)	1330	N/A	666.4	673.1	1251.3	1251.2	525	524.2
503	Fort McMurray Flowgate	600	-600	336.1	336.2	335.5	335.8	118.7	40.2

Table 13 lists the contingencies that were run for this sensitivity analysis.

Table 13: Waneta-Boundary Sensitivity Analysis Contingencies

1. MATL PS – Marias 230 kV line
2. Colstrip-Broadview 500 kV line with RAS
3. Broadview-Garrison 500 kV line with RAS
4. Banff-West Cascade Tap 138 kV line
5. Can Cem9-742L Jct 138 kV line
6. Hussar-Namaka 138 kV line
7. Pocaterra-Fording Coal 138 kV line
8. West Cascade Tap-54L Jnc 138 kV line
9. Sandhill-Dome Empress 138 kV line
10. Ingledow-Custer 500 kV line
11. Custer-Monroe 500 kV line
12. Taft-Bell 500 kV line with RAS

The results of this analysis showed that there were no overloads on either the Nelway-Boundary or Waneta-Boundary paths for either the heavy summer or light spring base cases for any of the contingencies studied. See Appendix C.4 for a complete summary of these results.

5. Reduced US to BC Senstivity Analysis

At the request of BCTC, an additional sensitivity analysis was performed on the light spring non-simultaneous case. The purpose of this sensitivity was to determine if there were any impacts due to MATL on the magnitude of Path 1 transfers at which separation of Alberta from BC is required for contingencies that cause BC and Alberta to separate from the rest of the WECC. For this sensitivity analysis, a set of light spring base cases was developed from the non-simultaneous light spring base case: one pre-project case, one post-MATL north-to-south case, and one post-MATL south-to-north case. Table 14 lists the path flows for these three base cases.

Table 14: Reduced US to BC Sensitivity Base Case Interface Flows

Interface Number	Interface Name	Interface Rating 1	Interface Rating 2	07 LSp Reduced US to BC Pre-Project Case	07 LSp Reduced US to BC Post-Project North-to-South Case	07 LSp Reduced US to BC Post-Project South-to-North Case
	MATL (N to S is +)	300	-300	0	319	-313
	Nelway-Boundary 230 kV (N to S is +)	400	-400	-319	-322	-318
	Waneta-Boundary 230 kV (N to S is +)	400	-400	0	0	0
1	ALBERTA - BRITISH COLUMBIA	1000	-1200	401	393.9	400.7
2	ALBERTA - SASKATCHEWAN	150	-150	0.1	0.1	0.1
3	NORTHWEST - CANADA	2000	-3150	1096.8	1104.1	1097.3
4	WEST OF CASCADES - NORTH	9800	-9800	3607.7	3610.8	3608
5	WEST OF CASCADES - SOUTH	7000	-7000	2443.1	2443.4	2443.3
6	WEST OF HATWAI	4300	N/A	3521.7	3523.3	3516.1
8	MONTANA - NORTHWEST	2200	-1350	1767.5	1772.5	1761.6
9	WEST OF BROADVIEW	2573	N/A	1949.9	1678.8	2297.5
10	WEST OF COLSTRIP	2598	N/A	1763.7	1485.8	2128.5
11	WEST OF CROSSOVER	2598	N/A	1883.9	1595.7	2238
14	IDAHO - NORTHWEST	2400	-1200	856	858.3	860
15	MIDWAY - LOS BANOS	4800	-2000	694.5	694.6	697.5
16	IDAHO - SIERRA	500	-360	-114.5	-114.4	-116.4
17	BORAH WEST	2307	N/A	1531.6	1534	1533.2
18	IDAHO - MONTANA	351	-337	-65.3	-69.5	-60.2
19	BRIDGER WEST	2200	N/A	2201.4	2200.3	2206.2
20	PATH C	1000	-1000	24	23.2	26.6
21	ARIZONA - CALIFORNIA	5700	0	3247.3	3247.3	3249
46	WEST OF COLORADO RIVER (WOR)	10118	-10118	3349.3	3349.4	3351.2
49	EAST OF COLORADO RIVER (EOR)	7550	N/A	1047.6	1047.6	1048.2
53	BILLINGS - YELLOWTAIL	400	-400	-103.2	-115.9	-103.7
55	BROWNLEE EAST	1750	N/A	14.6	14.6	14.6
65	PACIFIC DC INTERTIE (PDCI)	3100	-3100	2000	2000	2000
66	COI	4800	-3675	1295.3	1293.5	1291.1
73	NORTH OF JOHN DAY	7900	-7900	3063.9	3060.7	3061.1
75	MIDPOINT - SUMMER LAKE	1500	-400	876	877.6	878.5
76	ALTURAS PROJECT	300	-300	164.9	164.8	168.6
80	MONTANA - SOUTHEAST	600	-600	-151	-152.4	-142.1
500	Southern CA Imports	N/A	N/A	6206.2	6206.2	6207.5
501	South of KEG Cutplane (SOK)	1880	N/A	829.1	1002.7	760.3
502	North of Calgary Cutplane (NOC)	1330	N/A	602.5	929.2	524.3
503	Fort McMurray Flowgate	600	-600	39.7	36.6	40.4

The following two critical transient stability contingencies were simulated on these sensitivity cases:

1. Ingledow-Custer #1 and #2 500 kV lines with RAS, and
2. Custer-Monroe #1 and #2 500 kV lines with RAS.

A summary table as well as transient and transient snapshot power flow plots of these simulations is provided in Appendix C.5. As shown in the summary table, the pre-MATL case had 80 transient voltage dip violations for the Custer-Monroe #1 and #2 500 kV line outage, while the north-to-south case had 104 transient voltage dip violations and the south-to-north case had none. These results indicate that the net export from Alberta (the sum of Path 1 and MATL) will need to be used in the determination of the appropriate RAS for both of these two contingencies. Similar effects are also seen in the Path 1 and Path 3 simultaneous studies discussed in the next section.

IV. SIMULTANEOUS ANALYSES STUDY RESULTS

As delineated in the MATL Phase 2 Study Scope, simultaneous analyses were performed on three separate paths:

- Path 1 (Alberta - British Columbia),
- Path 3 (Northwest - British Columbia), and
- Path 8 (Montana - Northwest).

Based on comments received on the MATL Comprehensive Progress Report, these studies, to the extent possible, assessed the potential impact of MATL on the above three simultaneous paths in accordance with the WECC rating procedures.

IV.1 Path 1 – Alberta-British Columbia

Power flow cases were developed to assess the impact of MATL on the transfer capability of Path 1. Thermal, post-transient and transient stability studies were performed to study the relationship between flows on MATL and a heavily stressed Langdon-Cranbrook line under a 2007 timeframe. The following principles were applied in conducting the simultaneous MATL/Path 1 studies:

1. The Path 1 simultaneous cases were derived from the 2007 non-simultaneous heavy summer (HS) cases. Four pre-project cases were developed:

    1. one with maximum westbound flow on Path 1 and medium southbound flow on Path 3,
    2. one with maximum westbound flow on path 1 and medium northbound flow on Path 3,
    3. one with maximum eastbound flow on Path 1 and medium southbound flow on Path 3, and
    4. one with maximum eastbound flow on Path 1 and medium northbound flow on Path 3.

    For each of the Path 1 flow scenarios two post-project cases were developed, one with 325 MW flowing from Alberta to Montana (north to south) on MATL and one with 300 MW flowing from Montana to Alberta (south to north) on MATL (subject to phase-shifter angle limitations). In total, four pre-project cases and eight post-project cases were developed.

The following methodology was used in conducting the simultaneous Path 1 studies:

1. Path 1 flow was increased in the pre-project cases to establish the Path 1 limits based on the most limiting condition. This benchmark case was set up to with the intent to meet all applicable reliability criteria.

2. In the post-project cases, flows on MATL were then increased to the proposed project rating, which is +325/-300 MW. If necessary, a nomogram was developed to assure that the system with MATL added still met all applicable reliability criteria.

3. The MATL Montana to Alberta (south to north) flow was increased by removing generation in Alberta and increasing generation output in Montana. MATL Alberta to Montana (north to south) flow was increased by adding generation in Alberta and decreasing generation output in Montana.

4. The MATL phase shifter was used to force the scheduled power to all flow on the MATL line.

The following twelve cases were developed to perform the Path 1 analysis.

Case IV.2-1a: Pre-project case with Path 1 at maximum westbound Alberta to B.C. flow (target 800 MW) and Path 3 at 1950 MW B.C. to Washington southbound flow comprised of 1950 MW from Ingledow to Custer and 0 MW from Nelway to Boundary (developed from the 2007 heavy summer case).
Case IV.2-1b: Post-Project with 325 MW scheduled from Alberta to Montana (north to south) on MATL.
Case IV.2-1c: Post-Project with 300 MW scheduled from Montana to Alberta (south to north) on MATL.
Case IV.2-2a Pre-project case with Path 1 at maximum westbound Alberta to B.C. flow (target 800 MW) and Path 3 at 1800 MW Washington to B.C northbound flow comprised of about 1400 MW from Custer to Ingledow and 400 MW from Boundary to Nelway (developed from the 2007 heavy summer case).
Case IV.2-2b: Post-Project with 325 MW scheduled from Alberta to Montana (north to south) on MATL.
Case IV.2-2c: Post-Project with 300 MW scheduled from Montana to Alberta (south to north) on MATL.
Case IV.2-3a: Pre-project case with Path 1 at maximum B.C. to Alberta eastbound flow (target 780 MW) and Path 3 at 2350 MW B.C. to Washington southbound flow comprised of 1950 MW from Ingledow to Custer and 400 MW from Nelway to Boundary (developed from the 2007 heavy summer case).
Case IV.2-3b: Post-Project with 325 MW scheduled from Alberta to Montana (north to south) on MATL.
Case IV.2-3c: Post-Project with 300 MW scheduled from Montana to Alberta (south to north) on MATL.

Case IV.2-4a: Pre-project case with Path 1 at maximum B.C. to Alberta eastbound flow (target 780 MW) and Path 3 at 1900 MW Washington to B.C. northbound flow comprised of 1500 MW from Custer to Ingledow and 400 MW from Boundary to Nelway (developed from the 2007 heavy summer case).
Case IV.2-4b: Post-Project with 325 MW scheduled from Alberta to Montana (north to south) on MATL.
Case IV.2-4c: Post-Project with 300 MW scheduled from Montana to Alberta (south to north) on MATL.

The following contingencies were simulated for the power flow analysis:

1. MATL PS – Marias 230 kV line[13]
2. Marias – Great Falls 230 kV line
3. All 230 and 500 kV lines in Montana (Cases IV.2-1a, b, and c only)
4. All single 240 and 500 kV lines in Alberta south of a KEG cut plane (Cases IV.2-1a, b, and c and Cases IV.2-4a, b, and c only)
5. All 138 and 69 kV lines in Alberta south of a Calgary – Sheerness cut plane (Cases IV.2-1a, b, and c and Cases IV.2-4a, b, and c only)
6. Ingledow - Custer #1 500 kV line
7. Custer - Monroe #1 500 kV line
8. Langdon – Janet #1 240 kV line

The following three phase fault contingencies were simulated for the transient stability analysis (clearing times and switching sequence are included in Appendix I):

1. MATL PS – Marias 230 kV line
2. Marias – Great Falls 230 kV line
3. Langdon – Cranbrook 500 kV line[14]
4. Cranbrook – Selkirk 500 kV line(RAS used)
5. Ingledow - Custer #1 500 kV line
6. Custer - Monroe #1 500 kV line
7. Ingledow – Custer #1 and #2 500 kV lines(RAS used)
8. Custer – Monroe #1 and #2 500 kV lines(RAS used)
9. Selkirk – Ashton Creek 500 kV line(RAS used)
10. Selkirk – Vaseux Lake 500 kV line(RAS used)
11. Nicola – Meridian 500 kV line(RAS used)
12. Selkirk – Ashton and Selkirk – Vaseux Lake 500 kV lines(RAS used)
13. Ashton Creek – Nicola #1 and #2 500 kV lines(RAS used)
14. Nicola – Ingledow and Nicola – Meridian 500 kV lines(RAS used)
15. Nelway – Boundary 230 kV line(RAS used)

[13] Outage of either the MATL – Marias or Marias – Great Fall segment of the MATL line also resulted in the removal of the other segment of MATL.
[14] ILRAS was not simulated for this outage. All applicable criteria were met without ILRAS due to differing frequency responses of the PSLF and PSS/E models.

16. A 450 MW generator at Genesee
17. Langdon – Janet #1 240 kV line
18. Both Sundance to Benalto 240 kV lines
19. Both Benalto – Sarcee 240 kV lines
20. Both Benalto – Keephills 240 kV lines
21. Both Janet – Red Deer 240 kV line
22. Both Red Deer – Ellerslie 240 kV lines
23. Both Langdon – Janet 240 kV lines
24. Both W. Brooks - Langdon - N. Lethbridge 240 kV lines
25. W. Brooks – Langdon – N. Lethbridge and W. Brooks – Langdon – MATL (923L/927L)
26. W. Brooks – Langdon – N. Lethbridge (924L/935L) and MATL – N. Lethbridge (940L)

The following contingencies were simulated for the post-transient analysis:

1. MATL PS – Marias 230 kV line
2. Marias – Great Falls 230 kV line
3. Langdon – Cranbrook 500 kV line
4. Cranbrook – Selkirk 500 kV line(RAS used)
5. Ingledow - Custer #1 500 kV line
6. Custer - Monroe #1 500 kV line
7. Ingledow – Custer #1 and #2 500 kV lines(RAS used)
8. Custer – Monroe #1 and #2 500 kV lines(RAS used)
9. Selkirk – Ashton Creek 500 kV line(RAS used)
10. Selkirk – Vaseux Lake 500 kV line(RAS used)
11. Nicola – Meridian 500 kV line(RAS used)
12. Selkirk – Ashton and Selkirk – Vaseux Lake 500 kV lines(RAS used)
13. Ashton Creek – Nicola #1 and #2 500 kV lines(RAS used)
14. Nicola – Ingledow and Nicola – Meridian 500 kV lines(RAS used)
15. Nelway – Boundary 230 kV line(RAS used)
16. A 450 MW generator at Genesee
17. Langdon – Janet #1 240 kV line
18. Both Sundance to Benalto 240 kV lines
19. Both Benalto – Sarcee 240 kV lines
20. Both Benalto – Keephills 240 kV lines
21. Both Janet – Red Deer 240 kV line
22. Both Red Deer – Ellerslie 240 kV lines
23. Both Langdon – Janet 240 kV lines
24. Both W. Brooks - Langdon - N. Lethbridge 240 kV lines
25. W. Brooks – Langdon – N. Lethbridge and W. Brooks – Langdon – MATL (923L/927L)
26. W. Brooks – Langdon – N. Lethbridge (924L/935L) and MATL – N. Lethbridge (940L)

Table IV.1-1 below provides a listing of the path flows for all of the Path 1 base cases.

IV.1b Study Results

IV.1.b.1 Power Flow Results

The power flow results are presented in Appendix D.1 and in Figures IV.1-1 through IV.1-8 below.

The following methodology was used to develop the nomogram relationships documented in Figures IV.1-1 to IV.1.8. For each case, a series of contingency runs were made with varying levels of Path 1 flows[15]. These results are documented in Appendix D.1 on the worksheets identified with the "IV2xAyzzz" tabs. On the tab, x refers to the case series (1, 2, 3, or 4); y refers to the comparison case (B for north-to-south MATL flows and C for south-to-north MATL flows); and zzz refers to the magnitude of the Path 1 flows (0, 400, or 800 MW). The results were compared by looking at the cases with varying Path 1 flows to identify any overloads that were sensitive to Path 1 loading. These sensitive contingencies were then subjected to additional screening to determine the combinations of MATL and Path 1 flows that just eliminated the critical overloads.

The results of this additional screening are presented in Appendix D.1 on the worksheets with the IV2xy tabs. On these tabs, x refers to the case series (1, 2, 3, or 4) and y refers to the MATL status in the case (A for pre-MATL, B for north-to-south MATL flows and C for south-to-north MATL flows). Each base case listed in the first column is keyed to identify the MATL and Path 1 flows in the case. If there is only one set of numbers, then these numbers refer to the Path 1 flows in MW. If there are two sets of numbers, then the first set of numbers refers to the MATL flows (in MW) and the second set of numbers refers to the Path 1 flows (in MW). By comparing two base cases with just slightly different flows where one has an overload and the other does not, a nomogram point can be determined. A summary of all of the nomogram points is provided in the worksheet identified with the "Nomogram Key" tab and in Tables IV.1-2 and IV.1-3 below.

It should be noted that for this power flow analysis, voltages were not checked for violations. Only thermal limits were taken into account in determining nomogram limits identified in Appendix D.1 and in the nomograms in Figures IV.1-1 through IV.1-8. Voltage deviations were checked as part of the post-transient analysis, section IV.1b2.

[15] For the power flow analysis, the Nelway phase shifting transformer was held at a fixed angle. Therefore, as Path 1 flows were decreased, the flow on the Nelway-Boundary path changed although the total Path 3 flow remained constant.

All the NTL T1 (or T2) overloading problems can be resolved by the existing NTL T1 (or T2) Overload RAS which will transfer trip the two Natal 138 kV interties at the BC-Alberta separating points (Pocaterra and Natal) if overloading on the transformers is detected. With this Overload RAS, the limiting contingency will change and the nomogram limits will increase. A sensitivity study was undertaken to determine the impact of this Overload RAS on the nomogram limits. This sensitivity study determined the limits on Path 1 with MATL at maximum flow (either north-to-south or south-to-north). The results of this sensitivity study are provided in Table IV.1-4.

As documented in Table 1V.1-4, the maximum exports out of Alberta for cases IV.2-1b and IV.2-2b are limited by thermal loading following an internal AESO contingency. Case IV.2-1c is constrained by thermal loading in Alberta and case IV.2-2c is constrained by voltage deviations in Alberta. Figures IV.1-1 through IV.1-4 have been revised to document these sensitivity results. It should be noted that the upper point of the sensitivity nomograms were not verified by study, but rather were assumed to follow a pattern of a MW reduction in MATL flow corresponding to an equal increase in Path 1 flow.

In Figures IV.1-2 and IV.1-4 the area indicated by the light tan shading is a region of potential operation that was not completely studied for this report. (Post-transient powerflow analysis was performed in this region, but a reactive margin assessment and transient stability studies were not done.) It is possible that future operational studies will find acceptable areas of operation in this region of the nomograms.

Table IV.1-1: Path Flows for Path 1 Base Cases

Interface Number	Interface Name	Interface Rating 1	Interface Rating 2	Interface Flow (MW)											
				07hs_pre_ iv2-1a_ rev25tcl4 .sav	07hs_pst_ iv2-1b_ rev25tcl4 .sav	07hs_pst_ iv2-1c_ rev25tcl4 .sav	07hs_pre_ iv2-2a_ rev25tcl4 .sav	07hs_pst_ iv2-2b_ rev25tcl4 .sav	07hs_pst_ iv2-2c_ rev25tcl4 .sav	07hs_pre_ iv2-3a_ rev25tcl4 .sav	07hs_pst_ iv2-3b_ rev25tcl4 .sav	07hs_pst_ iv2-3c_ rev25tcl4 .sav	07hs_pre_ iv2-4a_ rev25tcl4 .sav	07hs_pst_ iv2-4b_ rev25tcl4 .sav	07hs_pst_ iv2-4c_ rev25tcl4 .sav
				IV2-1A	IV2-1B	IV2-1C	IV2-2A	IV2-2B	IV2-2C	IV2-3A	IV2-3B	IV2-3C	IV2-4A	IV2-4B	IV2-4C
	MATL (N to S is +)			N/A	328	-182	N/A	328	-305	N/A	330	-312	N/A	328	-306
	Nelway-Boundary 230 kV (N to S is +)			-3.2	-3.1	4.5	-326	-327	-326	393	394	394	-395	-400	-388
1	ALBERTA - BRITISH COLUMBIA	1000	-1200	800.6	801	801	800.6	800.7	801.6	-779.6	-781.9	-774.5	-779.5	-781.8	-780.2
2	ALBERTA - SASKATCHEWAN	150	-150	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3	NORTHWEST - CANADA	2000	-3150	-1950.6	-1951.5	-1951.2	1797	1798.7	1794.5	-2351.4	-2346.7	-2355.6	1899.5	1902	1899.3
4	WEST OF CASCADES - NORTH	9800	-9800	3328.3	3285.3	3386.6	5966.8	6201.1	6334.3	3447.9	3401.7	3414	5834.9	5823.3	5827.3
5	WEST OF CASCADES - SOUTH	7000	-7000	3704	3792.2	3722.9	3853.9	3978.8	3896.6	3781.4	3780.3	3759.4	3751.7	3714.9	3747.7
6	WEST OF HATWAI	2800	0	2537.8	2772.6	2466.5	2506.2	2487.8	1945.7	2887.7	1340.6	2587.4	2477.8	72.1	2237.3
8	MONTANA - NORTHWEST	2200	-1350	1452.7	1697.6	1373.2	1481.2	1722.4	1162.9	1442.8	-129.4	1132.9	1473.7	-929.2	1144.4
9	WEST OF BROADVIEW	2573	0	2195	2178.7	2303.2	2211	2191.6	2232.4	2193.3	181.6	2212.1	2206.2	-188.5	2212.1
10	WEST OF COLSTRIP	2598	0	2095.7	2096	2185.7	2095.7	2095.7	2093.8	2095.3	23.4	2095.9	2095.5	-71.6	2093.6
11	WEST OF CROSSOVER	2598	0	2221.9	2202.4	2288.4	2227.1	2210.3	2206.9	2208.9	185	2241.4	2225.4	-2.4	2240
14	IDAHO - NORTHWEST	2400	-1200	-52.2	-48.9	-60.1	-69.7	-44.1	-97.8	-39.2	-131.8	-73.7	-80.2	-226.7	-111.9
15	MIDWAY - LOS BANOS	4800	-2000	1193.6	1212.1	1191.1	1190.8	1193.3	1189.6	1197	1152	1176.1	1189.7	1157.1	1190
16	IDAHO - SIERRA	500	-360	110.4	113.3	111.4	113.4	111	116.8	112.1	111.5	110.9	113	121.4	112.6
17	BORAH WEST	2307	0	1158.8	1166.2	1152.5	1144.4	1166.4	1121.3	1173.7	1079.9	1137.3	1133.5	996.8	1103.2
18	IDAHO - MONTANA	337	-337	-248	-269.2	-243.6	-236.5	-259	-230.4	-254.8	-155.4	-230.7	-238.9	-78.3	-227.9
19	BRIDGER WEST	2200	0	2195.7	2191.9	2197.8	2195	2192.8	2183.3	2206.8	2186.7	2183.8	2180.5	2185.4	2161.3
20	PATH C	1000	-1000	-212.5	-221.9	-216.4	-215.6	-212.6	-223.3	-213.2	-195.5	-207.7	-216.7	-202.2	-220.6
21	ARIZONA - CALIFORNIA	5700	0	5626.8	5640.3	5624.6	5612.4	5627.4	5610.5	5630.9	5583.6	5601.7	5611.5	5575	5610.6
46	WEST OF COLORADO RIVER (WOR)	10118	-10118	4707.9	4719.9	4706.4	4704.8	4708.1	4704.3	4710.2	4679.5	4695.1	4704.2	4682.4	4704.5
49	EAST OF COLORADO RIVER (EOR)	7550	0	968.3	972.1	967.7	963.6	968.5	962.9	969.5	955.1	960.6	963.4	951.9	963.1
53	BILLINGS - YELLOWTAIL	400	-400	-151.6	-154.3	-195.6	-162.7	-159.8	-204.9	-163	-149.6	-149.8	-159.5	-156.9	-151.2
55	BROWNLEE EAST	1750	0	48.9	49.6	49.2	49.9	49.3	50.2	48.5	50.6	48.8	50.3	54.3	51
65	PACIFIC DC INTERTIE (PDCI)	3100	-3100	3090.9	3090.6	3091	3090.8	3090.7	3090.5	3090.8	3091.4	3091.4	3091	3090.6	3090.8
66	COI	4800	-3675	1150.5	1198.2	1140.6	1102.2	1094.3	1115.6	1099.2	1017.5	1005.6	1133.9	1200.9	1211.4
73	NORTH OF JOHN DAY	7900	-7900	6385.5	6221.1	6456.3	4955.9	5375.2	5884	6521.5	6022.5	6358.3	4989.3	4247.8	5115.3
75	MIDPOINT - SUMMER LAKE	1500	-400	309.5	326.3	307	285.9	311.7	277	325.2	215.6	281.1	282.2	140.9	264.2
76	ALTURAS PROJECT	300	-300	260.2	257.8	259.9	257.6	258	255.6	258	257.2	259.5	259.1	250.2	258.6
80	MONTANA - SOUTHEAST	600	-600	-201.6	-184.7	-222.4	-217.9	-198.1	-241.9	-200.5	-235.4	-219.2	-213.1	-240.4	-221.3
500	Southern CA Imports	0	0	7268.7	7272.6	7268.1	7269	7268.5	7268.7	7269.3	7260.8	7266	7268.8	7262.3	7268.9
501	South of KEG Cutplane (SOK)	1880	0	1596.1	1582	1602	1596.2	1582.7	1589.3	1074.5	1157.4	831.2	1070.2	1214.3	835.3
502	North of Calgary Cutplane (NOC)	1330	0	1289.8	1287	1294.3	1289.8	1288	1282.5	559.4	897.3	253.4	559.4	895.5	253.8
503	Fort McMurray Flowgate	600	-600	433.3	433.3	433.3	433.3	434.2	433.3	336.2	336.5	336.7	336.2	336.4	336.6

Figure IV.1-1: Nomogram Relationships for Path 1 Case IV.2-1b

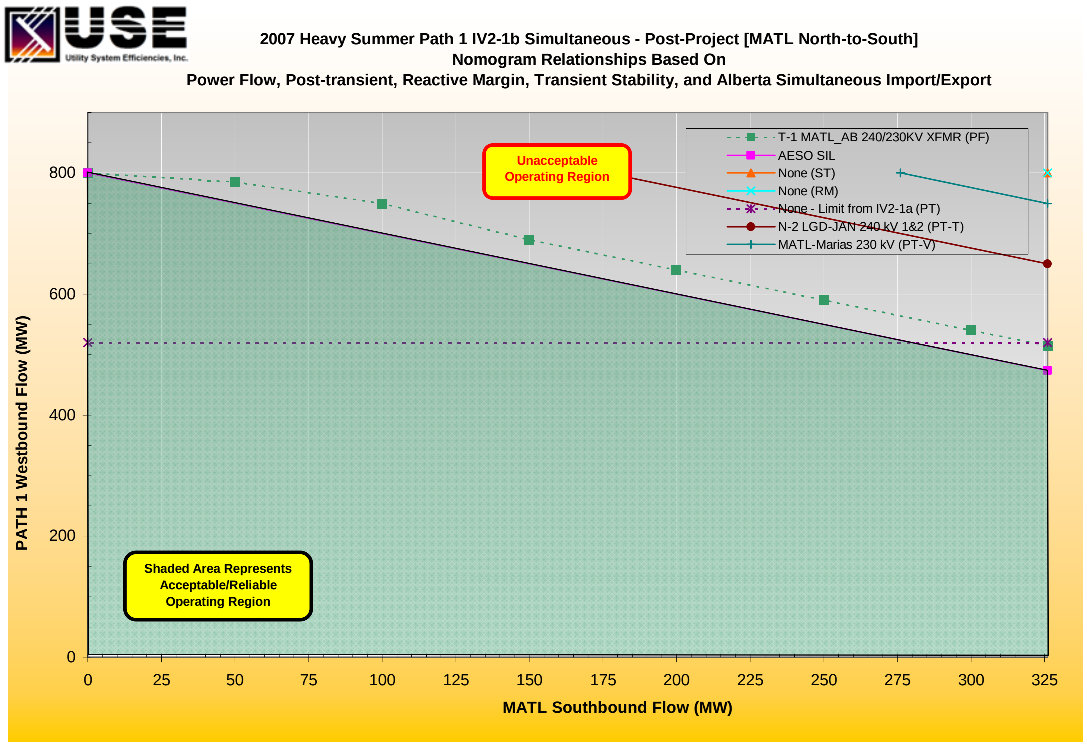


Figure IV.1-2: Nomogram Relationships for Path 1 Case IV.2-1c

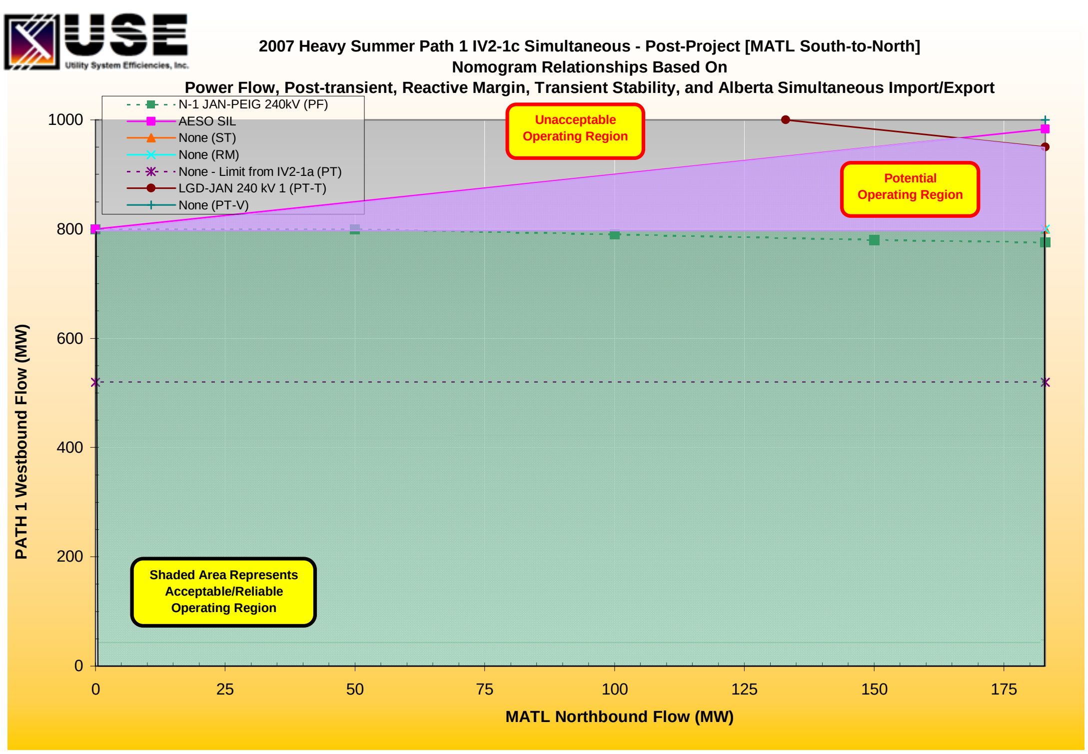


Figure IV.1-3: Nomogram Relationships for Path 1 Case IV.2-2b

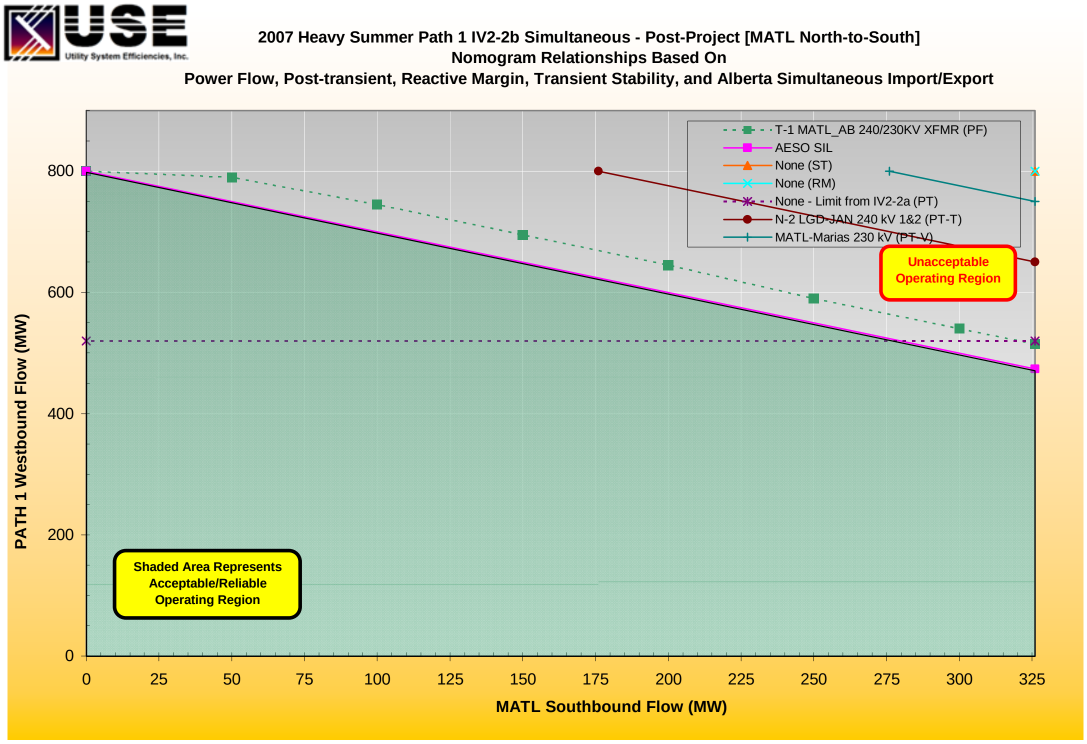


Figure IV.1-4: Nomogram Relationships for Path 1 Case IV.2-2c

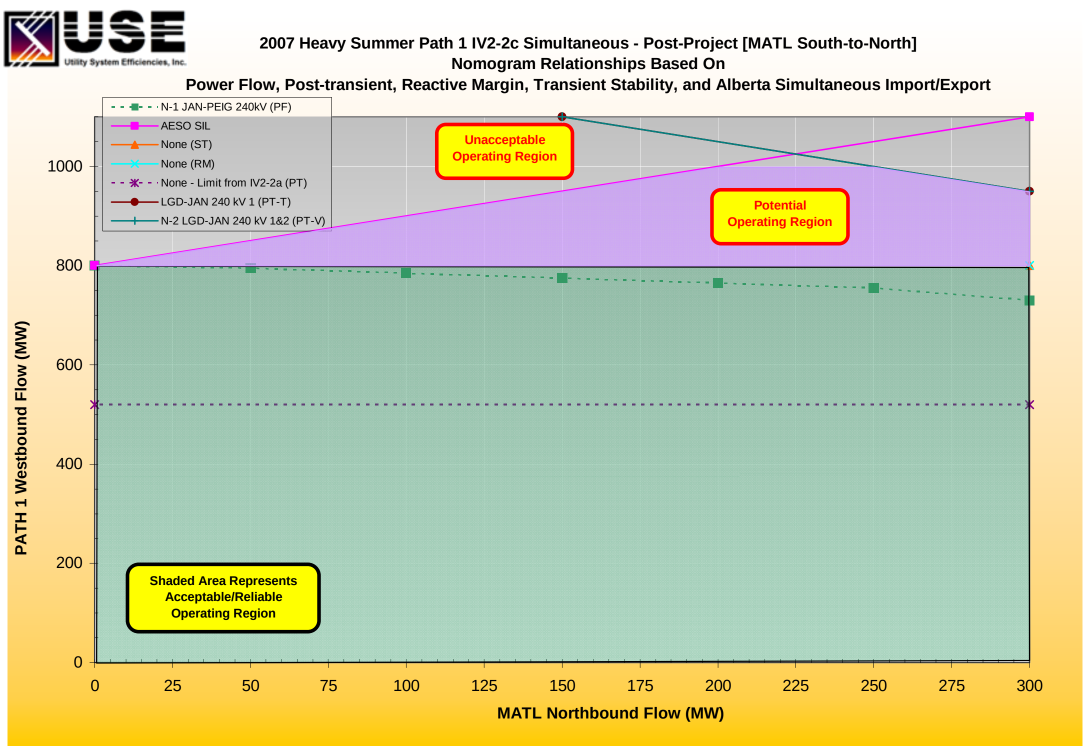


Figure IV.1-5: Nomogram Relationships for Path 1 Case IV.2-3b

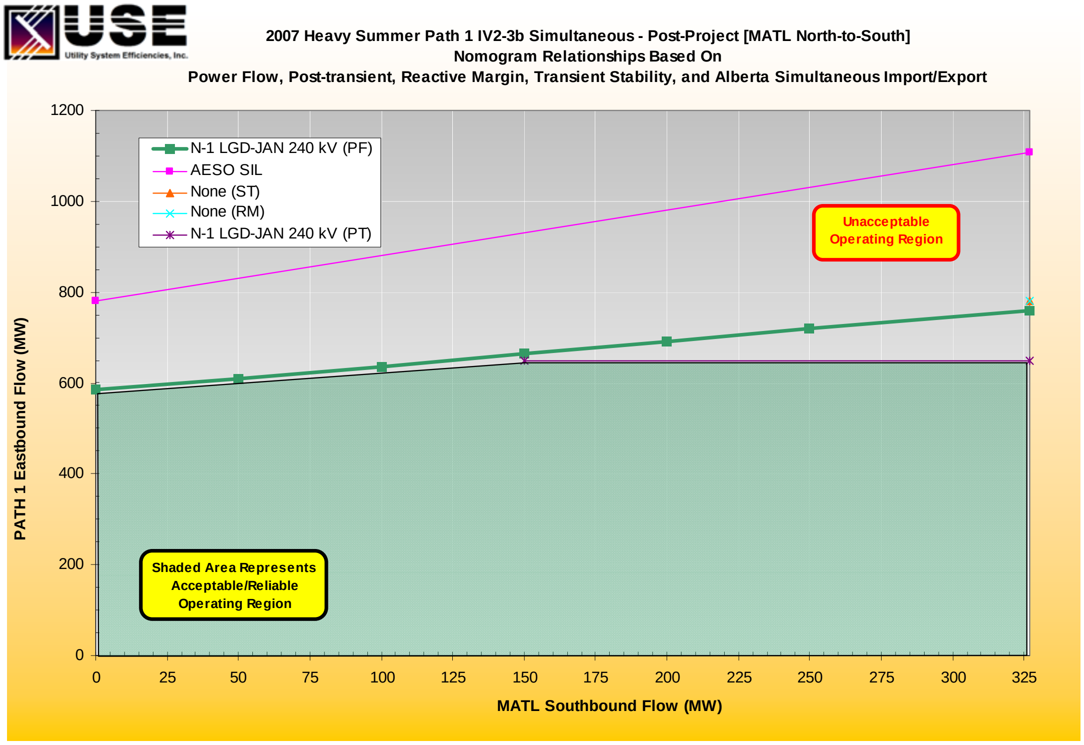


Figure IV.1-6: Nomogram Relationships for Path 1 Case IV.2-3c

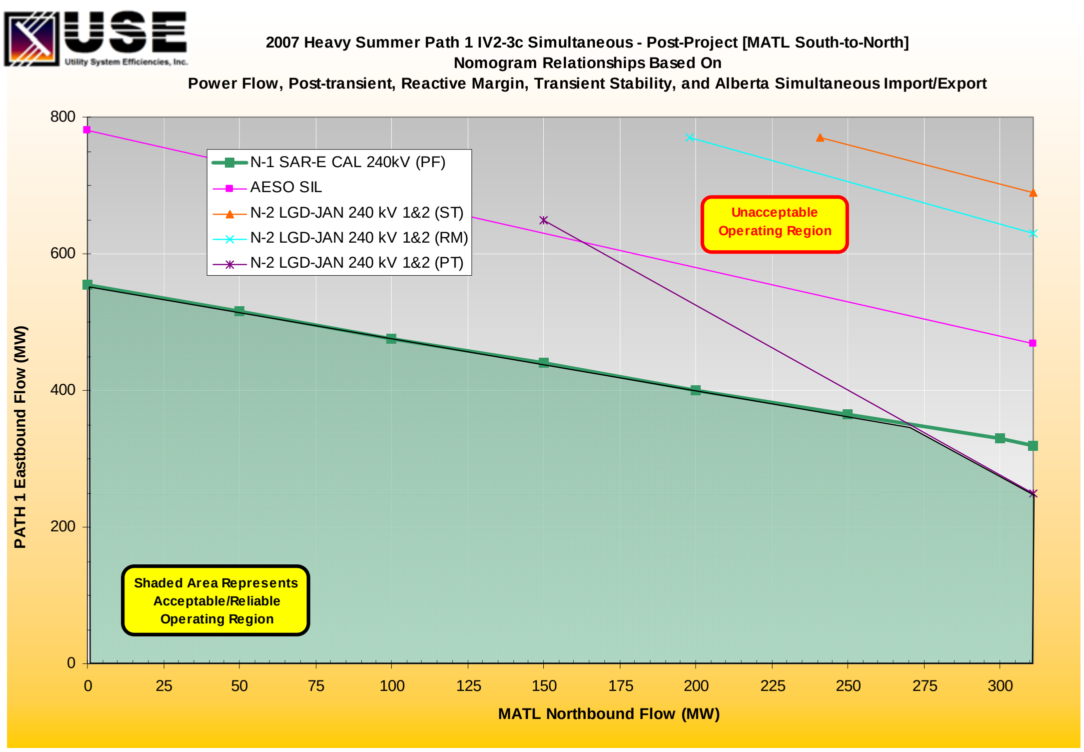


Figure IV.1-7: Nomogram Relationships for Path 1 Case IV.2-4b

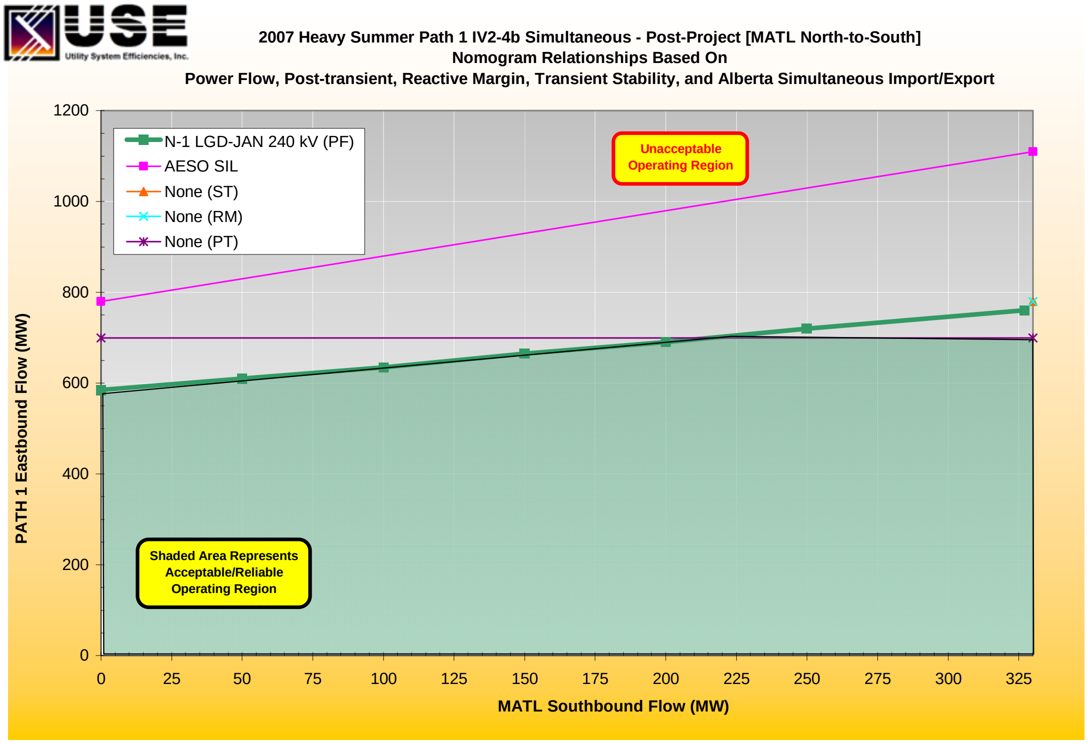


Figure IV.1-8: Nomogram Relationships for Path 1 Case IV.2-4c

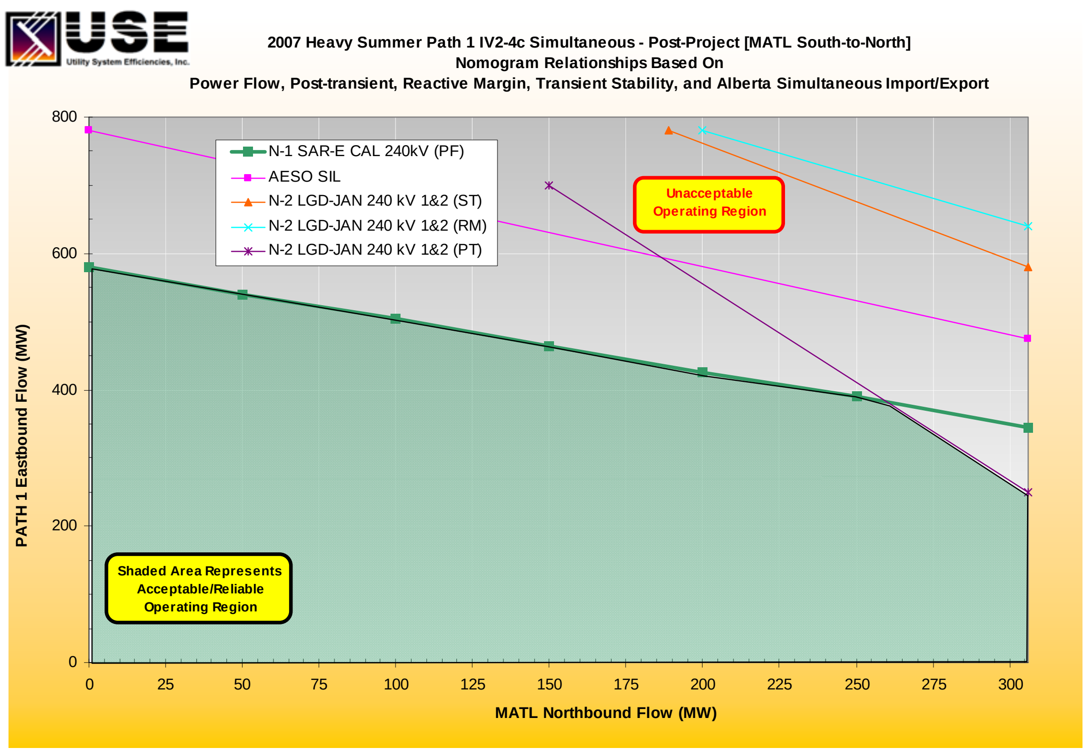


Table IV.1-2: Summary of Power Flow Nomogram Points for Cases IV2-1 and IV2-2

WorkSheet	**Case**	**MATL**	**PATH 1 E-W**	**Limiting Contingency**		**Overloaded Element**		
IV21A	21A	NA	793	N-1 LGD-JAN 240 kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0

WorkSheet	**Case**	**MATL N-S**	**PATH 1 E-W**	**Limiting Contingency**		**Overloaded Element**		
IV21B	21B	326	515	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV21B	21B	300	540	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV21B	21B	250	590	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV21B	21B	200	640	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV21B	21B	150	690	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV21B	21B	100	750	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV21B	21B	50	785	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV21B	21B	0	800					

WorkSheet	**Case**	**MATL S-N**	**PATH 1 E-W**	**Limiting Contingency**		**Overloaded Element**		
IV21C	21C	183	775	N-1 JAN-PEIG 240kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV21C	21C	150	780	N-1 JAN-PEIG 240kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV21C	21C	100	790	N-1 JAN-PEIG 240kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV21C	21C	50	800	N-1 JAN-PEIG 240kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV21C	21C	0	800					

WorkSheet	**Case**	**MATL**	**PATH 1 E-W**	**Limiting Contingency**		**Overloaded Element**		
IV22A	22A	NA	800	N-1 LGD-JAN 240 kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0

WorkSheet	**Case**	**MATL N-S**	**PATH 1 E-W**	**Limiting Contingency**		**Overloaded Element**		
IV22B	22B	326	515	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22B	22B	300	540	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22B	22B	250	590	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22B	22B	200	645	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22B	22B	150	695	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22B	22B	100	745	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22B	22B	50	790	T-1 MATL_AB 240/230KV XFMR (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22B	22B	0	800					

WorkSheet	**Case**	**MATL S-N**	**PATH 1 E-W**	**Limiting Contingency**		**Overloaded Element**		
IV22C	22C	300	730	N-1 JAN-PEIG 240kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22C	22C	250	755	N-1 JAN-PEIG 240kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22C	22C	200	765	N-1 LGD-JAN 240 kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22C	22C	150	775	N-1 LGD-JAN 240 kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22C	22C	100	785	N-1 LGD-JAN 240 kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22C	22C	50	795	N-1 LGD-JAN 240 kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0
IV22C	22C	0	800	N-1 LGD-JAN 240 kV (PF)	NTL T1	138.00-NTL VR	138.00 #1	0

Table IV.1-2: Summary of Power Flow Nomogram Points for Cases IV2-3 and IV2-4

WorkSheet	Case	MATL	PATH 1 W-E	Limiting Contingency	Overloaded Element
IV23A	23A	NA	600	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV23A	23A	NA	790	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1

WorkSheet	Case	MATL N-S	PATH 1 W-E	Limiting Contingency	Overloaded Element
IV23B	23B	327	760	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV23B	23B	250	720	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV23B	23B	200	690	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV23B	23B	150	665	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV23B	23B	100	635	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV23B	23B	50	610	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV23B	23B	0	585	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1

WorkSheet	Case	MATL S-N	PATH 1 W-E	Limiting Contingency	Overloaded Element
IV23C-1	23C	311	320	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV23C-1	23C	300	330	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV23C-1	23C	250	365	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV23C-1	23C	200	400	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV23C-1	23C	150	440	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV23C-1	23C	100	475	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV23C-1	23C	50	515	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV23C-1	23C	0	555	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0

WorkSheet	Case	MATL	PATH 1 W-E	Limiting Contingency	Overloaded Element
IV24A	24A	NA	585	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV24A	24A	NA	760	N-1 COCH-BEAR 138kV (PF)	JUMP TP1 138.00-SARCEE 7 138.00 #50 1
IV24A	24A	NA	790	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1

WorkSheet	Case	MATL N-S	PATH 1 W-E	Limiting Contingency	Overloaded Element
IV24B	24B	330	750	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV24B	24B	300	735	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV24B	24B	250	710	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV24B	24B	200	680	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV24B	24B	150	655	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV24B	24B	100	625	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV24B	24B	50	600	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1
IV24B	24B	0	575	N-1 LGD-JAN 240 kV (PF)	LANGDON9 240.00-JANET 4 240.00 #37 1

WorkSheet	Case	MATL S-N	PATH 1 W-E	Limiting Contingency	Overloaded Element
IV24C-1	24C	306	345	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV24C-1	24C	250	390	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV24C-1	24C	200	425	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV24C-1	24C	150	465	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV24C-1	24C	100	505	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV24C-1	24C	50	540	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0
IV24C-1	24C	0	580	N-1 SAR-E CAL 240kV (PF)	E CALGAR 240.00-ENMX2SD9 138.00 #T1 0

The above nomograms were driven from a set of base cases configured to reveal the impact of MATL on the Alberta system for the purpose of the MATL Path Rating study. Therefore, Path 1 limitations as identified in these nomograms may not reflect the current operating levels or established path ratings.

Table IV.1-4: Natal Transformer RAS Sensitivity Results

Case	MATL N-S	PATH 1 E-W	Limit	Limiting Contingency	Overloaded Element
21B	326	650	Thermal	N-2 LGD-JAN 240 kV 1&2 (PT-T)	MATL-LETH 240 kV

Case	MATL N-S	PATH 1 E-W	Limit	Limiting Contingency	Location with Maximum Voltage Deviation
21B	326	750	Voltage Deviation	MATL-Marias 230 kV (PT-V)	CBK500 500 kV Bus

Case	MATL S-N	PATH 1 E-W	Limit	Limiting Contingency	Overloaded Element
21C	183	950	Thermal	LGD-JAN 240 kV 1 (PT-T)	LGD-JAN 240 kV 2

Case	MATL S-N	PATH 1 E-W	Limit	Limiting Contingency	Location with Maximum Voltage Deviation
21C	183	1000	Voltage Deviation	None	None

Case	MATL N-S	PATH 1 E-W	Limit	Limiting Contingency	Overloaded Element
22B	326	650	Thermal	N-2 LGD-JAN 240 kV 1&2 (PT-T)	MATL-LETH 240 kV

Case	MATL N-S	PATH 1 E-W	Limit	Limiting Contingency	Location with Maximum Voltage Deviation
22B	326	750	Voltage Deviation	MATL-Marias 230 kV (PT-V)	CBK500 500 kV Bus

Case	MATL S-N	PATH 1 E-W	Limit	Limiting Contingency	Overloaded Element
22C	300	950	Thermal	LGD-JAN 240 kV 1 (PT-T)	LGD-JAN 240 kV 2
22C	300	950	Thermal	ING-CUS 500 kV 1 (PT-T)	SEL-NLY 240 kV

Case	MATL S-N	PATH 1 E-W	Limit	Limiting Contingency	Location with Maximum Voltage Deviation
22C	300	950	Voltage Deviation	N-2 LGD-JAN 240 kV 1&2 (PT-V)	LGD 240 kV Bus
22C	300	1000	Voltage Deviation	ACK-NIC 1&2 500 kV (PT-V)	WDS 12 12 kV Bus

IV.1.b.2 Post-transient Results

The post-transient results are presented in Appendix D.2 and in Figures IV.1-1 through IV.1-8 above.

For the post-transient analysis, the following methodology was used. First all post-transient contingencies were run on the pre-MATL base case with varying levels of Path 1 flows[16]. These results are documented in the Appendix D.2.2 workbook on the worksheets with the tabs "IV2xA_THERM_RAW" where x refers to the case series (1, 2, 3, or 4) For the contingencies that were sensitive to Path 1 flows, additional runs were made to more accurately determine the acceptable Path 1 flows. These refined results are presented in the worksheets with tabs "IV2xA_THERM_FINE" and if necessary ""IV2xA_THERM_FINE-2".

For the identified Path 1 limit cases, voltage deviations were checked. These voltage deviation results are presented in the worksheets with tabs "IV2xA_VOLT_RAW" or "IV2xA_VOLT_FINE". It should be noted that there were no unacceptable voltage deviations in any pre-MATL case at the identified thermal limits.

Next all contingencies were run on cases with Path 1 flows set as determined above and with the MATL project added at maximum north-to-south and south-to-north flows. These results are documented in the worksheets identified with tabs "IV2xABCTHRM" and "IV2xABCVOLT". From these results it was

[16] For the Path 1 post-transient analysis, the Nelway phase shifting transformer was held at a fixed MW schedule. Therefore, as Path 1 flows were decreased, the angle on the Nelway phase shifting transformer changed, but the flows on the Nelway - Boundary path remained constant.

determined if reductions in MATL flows would be necessary to meet reliability criteria.

For cases IV2-1 and IV2-2, no nomogram relationships were necessary for the addition of MATL. However, case IV2-2c did create an overload on the Nelway phase shifting transformer for loss of the MATL tie. This contingency overload is not a function of Path 1 flows, but a reduction of MATL flows to -200 MW was sufficient to mitigate this overload.

For cases IV2-3 and IV2-4, there were nomogram relationships between MATL and Path 1. These nomogram relationships are documented in the worksheets identified with the “IV2xy_THERM” and “IV2xy_VOLT” tabs. On these tabs, x refers to the case series (1, 2, 3, or 4) and y refers to the direction of MATL flows (B for north-to-south MATL flows and C for south-to-north MATL flows). A summary of these results are provided in Table IV.1-5 below.

Table IV.1-5: Summary of Post-transient Nomogram Points

Case	MATL N-S	PATH 1 E-W	Limiting Contingency	Overloaded Element
21B	326	520	None - Limit from IV2-1a (PT)	None
21B	0	520	None - Limit from IV2-1a (PT)	None
Case	**MATL S-N**	**PATH 1 E-W**	**Limiting Contingency**	**Overloaded Element**
21C	183	520	None - Limit from IV2-1a (PT)	None
21C	0	520	None - Limit from IV2-1a (PT)	None
Case	**MATL N-S**	**PATH 1 E-W**	**Limiting Contingency**	**Overloaded Element**
22B	326	520	None - Limit from IV2-2a (PT)	None
22B	0	520	None - Limit from IV2-2a (PT)	None
Case	**MATL S-N**	**PATH 1 E-W**	**Limiting Contingency**	**Overloaded Element**
22C	300	520	None - Limit from IV2-2a (PT)	None
22C	0	520	None - Limit from IV2-2a (PT)	None
Case	**MATL N-S**	**PATH 1 W-E**	**Limiting Contingency**	**Overloaded Element**
23B	327	650	N-1 LGD-JAN 240 kV (PT)	LGD-JAN 240 kV #37
23B	150	650	N-1 LGD-JAN 240 kV (PT)	LGD-JAN 240 kV #37
Case	**MATL S-N**	**PATH 1 W-E**	**Limiting Contingency**	**Overloaded Element**
23C	311	250	N-2 LGD-JAN 240 kV 1&2 (PT)	MATL-LETH 240 kV
23C	150	650	N-2 LGD-JAN 240 kV 1&2 (PT)	MATL-LETH 240 kV
Case	**MATL N-S**	**PATH 1 W-E**	**Limiting Contingency**	**Overloaded Element**
24B	330	700	None (PT)	None
24B	0	700	None (PT)	None
Case	**MATL S-N**	**PATH 1 W-E**	**Limiting Contingency**	**Overloaded Element**
24C	306	250	N-2 LGD-JAN 240 kV 1&2 (PT)	MATL-LETH 240 kV
24C	150	700	N-2 LGD-JAN 240 kV 1&2 (PT)	MATL-LETH 240 kV

It should be noted that cases IV2-3c and IV2-4c had voltage deviation violations at the nomogram points specified above (up to 5.4%). These violations occurred on 115 kV buses in Montana for loss of a 450 MW Genesee unit. These deviations were not considered to be limiting because additional shunt compensation that is available on the MATL line was not switched for this contingency. It is likely that switching in additional shunt compensation would mitigate these voltage deviation violations. In the event that the shunt compensation switching is not effective at mitigating these voltage deviation violations, curtailments of Path 1 to -150 MW for the IV2-3c case and to -200 MW for the IV2-4c case would be necessary. Curtailment of MATL flows would also be effective.

IV.1.b.3 Reactive Margin Results

The reactive margin results are presented in Appendix D.2 and in Figures IV.1-1 through IV.1-8 above. All cases had adequate reactive margin except cases IV2-3c and IV2-4c. For these two cases, curtailments were necessary to get solutions for the Langdon - Janet 240 kV N-2 contingency. For this contingency and for the loss of Genesee unit #3, a RAS switching all 240 kV capacitors in the Calgary area was utilized to get the results presented in this report. This RAS is not necessary to maintain the ratings of either Path 1 or MATL. However, there could be additional restrictions to the operating nomograms presented above if this RAS is not implemented. If this RAS is not implemented, then additional reductions in Path 1 or MATL flows may be necessary to maintain adequate reactive margin. Table IV.1-6 documents the results of the reactive margin analysis.

Table IV.1-6: Summary of Path 1 Reactive Margin Based Nomogram Points

Case	MATL N-S	PATH 1 E-W	Limiting Contingency
21B	326	800	None (RM)
Case	**MATL S-N**	**PATH 1 E-W**	**Limiting Contingency**
21C	183	800	None (RM)
Case	**MATL N-S**	**PATH 1 E-W**	**Limiting Contingency**
22B	326	800	None (RM)
Case	**MATL S-N**	**PATH 1 E-W**	**Limiting Contingency**
22C	300	800	None (RM)
23B	327	780	None (RM)
Case	**MATL S-N**	**PATH 1 W-E**	**Limiting Contingency**
23C	311	630	N-2 LGD-JAN 240 kV 1&2 (RM)
23C	198	771	N-2 LGD-JAN 240 kV 1&2 (RM)
Case	**MATL N-S**	**PATH 1 W-E**	**Limiting Contingency**
24B	330	780	None (RM)
Case	**MATL S-N**	**PATH 1 W-E**	**Limiting Contingency**
23C	306	640	N-2 LGD-JAN 240 kV 1&2 (RM)
23C	200	780	N-2 LGD-JAN 240 kV 1&2 (RM)

Q/V curves for the most restrictive contingency for each Path 1 study case are provided in Appendix D.2

IV.1.b.4 Transient Stability Results

The transient stability results are presented in Appendix D.3 and in Figures IV.1-1 through IV.1-8 above. Cases IV2.1 and IV2-2 exhibited acceptable transient performance for all contingencies studied at maximum MATL flows (both directions) and at maximum Path 1 flows. Cases IV2-3 and IV2-4 had some contingencies that required curtailments of either MATL or Path 1 flows for some contingencies. Table IV1-7 provides a summary of these results.

Table IV1-7: Summary of Path 1 Transient Stability Based Nomogram Points

Case	MATL N-S	PATH 1 E-W	Limiting Contingency
21B	326	800	None (ST)
Case	**MATL S-N**	**PATH 1 E-W**	**Limiting Contingency**
21C	183	800	None (ST)
Case	**MATL N-S**	**PATH 1 E-W**	**Limiting Contingency**
22B	326	800	None (ST)
Case	**MATL S-N**	**PATH 1 E-W**	**Limiting Contingency**
22C	300	800	None (ST)
Case	**MATL N-S**	**PATH 1 W-E**	**Limiting Contingency**
23A	N/A	720	Genesee #3
Case	**MATL N-S**	**PATH 1 W-E**	**Limiting Contingency**
23B	327	780	None (ST)
Case	**MATL S-N**	**PATH 1 W-E**	**Limiting Contingency**
23C	311	690	N-2 LGD-JAN 240 kV 1&2 (ST)
23C	241	771	N-2 LGD-JAN 240 kV 1&2 (ST)
Case	**MATL N-S**	**PATH 1 W-E**	**Limiting Contingency**
24A	N/A	690	Genesee #3
Case	**MATL N-S**	**PATH 1 W-E**	**Limiting Contingency**
24B	330	780	None (ST)
Case	**MATL S-N**	**PATH 1 W-E**	**Limiting Contingency**
23C	306	580	N-2 LGD-JAN 240 kV 1&2 (ST)
23C	189	780	N-2 LGD-JAN 240 kV 1&2 (ST)

Note that to get adequate transient system performance from the pre-project cases, Sundance generation had to be reduced to 1000 MW and all 240 kV double contingencies within Alberta were simulated with double line-to-ground faults and 4 cycle clearing times.

In addition to the transient results presented above, each nomogram (Figures IV.1-1 through IV.1-8) also has a limitation denoted as "AESO SIL". The AESO SIL is the Alberta simultaneous import / export limit and is based on maximum over or underfrequency excursions in Alberta for contingencies that island Alberta from the rest of WECC. For these Path 1 simultaneous studies, this SIL limit was not verified using our simultaneous study models, but rather was used directly based on the extensive work historically performed by the AESO using their detailed operations models.

In summary, the study results in Sections IV.1.b.1, IV.1.b.2, IV.1.b.3 and IV.1.b.4 (with westbound flow on Path 1) show that Path 1 and the MATL Path share the total Alberta export capability, which is limited due to constrains in the Alberta system.

Cases with eastbound flow in some circumstances had significant interactions on a thermal, reactive margin, and transient stability basis. The results of these studies showed that reactive margin and transient stability were not limiting in any of the cases studied. Under conditions of high Path 1 imports into Alberta, loss of both Langdon - Janet 240 kV lines may require the development of a capacitor switching RAS to provide adequate voltage support and reactive margin. Currently, the import limit for this contingency is based on thermal loading on other lines in the area. However, as load grows in the southern Alberta, reactive margin could become a limit.

IV.2 <u>Path #3 – British Columbia-Northwest</u>

IV.2a Base Case Development

Power flow cases were developed to assess the impact of MATL on the transfer capability of Path 3. Post-transient and transient stability studies were performed to study the relationship between flows on MATL and a heavily stressed Path 3 during the 2007 timeframe.

The Path 3 simultaneous cases were derived from two 2007 non-simultaneous LSP and HS cases. Two pre-project cases were developed:

1. one with maximum northbound flow on Path 3 and medium westbound flow on Path 1, and
2. one with maximum southbound flow on path 3 and low westbound flow on Path 1.

For each of the Path 3 flow scenarios two post-project cases were developed: one case with 325 MW of import to Montana (north to south) on MATL and one case with 300 MW of export from Montana (south to north) on MATL (subject to phase-shifter angle limitations). In total, there were two pre-project cases and four post-project cases.

The following methodology was used in conducting the simultaneous MATL/Path 3 studies:

1. Path 3 (B.C. to Washington) southbound flow was increased in the pre-project cases to establish the Path 3 limits based on the most limiting condition and keeping the same flow at the North of John Day (NJD) cut plan as was in the base cases. This benchmark case should meet all applicable reliability criteria. Similarly but in the opposite direction, Path 3 northbound flow was increased in the pre-project cases by increasing generation at units north of the NJD cut plane in the base cases.
2. In the post-project cases, flows on MATL were increased to the proposed project rating, which is +325/-300 MW. .
3. The MATL south to north flow was increased by removing generation in Alberta and increasing generation output in Montana. MATL north to south flow were increased by adding generation in Alberta and decreasing generation output in Montana.
4. The MATL phase shifter was used to force the scheduled power to all flow on the MATL line.

The following six cases were developed to perform the MATL/Path 3 analysis.

Case IV.3-1a: Pre-project case with Path 3 at 2000 MW northbound flow including 1600 MW from Custer to Ingledow and 400 MW from Boundary to Nelway, and Path 1 at 400 MW westbound flow (developed from the 07 light spring case).
Case IV.3-1b: Post-Project with 325 MW scheduled north to south on MATL.
Case IV.3-1c: Post-Project with 300 MW scheduled south to north on MATL.
Case IV.3-2a: Pre-project case with Path 3 at 3150 MW southbound flow including 2750 MW from Ingledow to Custer and 400 MW from Nelway to Boundary, and Path 1 at 450 MW westbound flow (developed from the 07 HS case).
Case IV.3-2b: Post-Project with 325 MW scheduled north to south on MATL.
Case IV.3-2c: Post-Project with 300 MW scheduled south to north on MATL.

Table IV.2-1 provides a listing of the path flows for all of the Path 3 base cases.

Table IV.2-1: Path Flows for Path 3 Base Cases

				Interface Flow (MW)					
Interface Number	**Interface Name**	**Interface Rating 1**	**Interface Rating 2**	**07 HS Pre-Project Case**	**07 HS Post-Project North-to-South Case**	**07 HS Post-Project South-to-North Case**	**07 LSp Pre-Project Case**	**07 LSp Post-Project North-to-South Case**	**07 LSp Post-Project South-to-North Case**
	MATL (N to S is +)	300	-300	N/A	325	-218	N/A	329	-311
	Nelway-Boundary 230 kV (N to S is +)	400	-400	395	395	397	-321	-320	-320
1	ALBERTA - BRITISH COLUMBIA	1000	-1200	449.6	450.1	447.1	400.3	398.8	398.7
2	ALBERTA - SASKATCHEWAN	150	-150	0.1	0.1	0.1	0.1	0.1	0.1
3	NORTHWEST - CANADA	2000	-3150	-3150.2	-3149.3	-3147.3	1999.6	2000.3	2000.1
4	WEST OF CASCADES - NORTH	9800	-9800	2603.4	2605.8	2595.2	4300.2	4337.5	4310
5	WEST OF CASCADES - SOUTH	7000	-7000	3671	3669.6	3618.5	2488.7	2592	2415.9
6	WEST OF HATWAI	4300	N/A	2893.1	2896.8	2858.4	3630.5	3404.8	3059.8
8	MONTANA - NORTHWEST	2200	-1350	1445	1447.2	1405.9	1878.6	1639.5	1285.2
9	WEST OF BROADVIEW	2573	N/A	2191.1	1907.2	2372.9	2270.4	1660.7	1963.8
10	WEST OF COLSTRIP	2598	N/A	2096.1	1794.7	2185.4	2109.7	1486.6	1804
11	WEST OF CROSSOVER	2598	N/A	2220.8	1928.2	2336.1	2219.1	1603.9	1925
14	IDAHO - NORTHWEST	2400	-1200	-39.4	-40.3	-5.9	988.2	1012.3	954.9
15	MIDWAY - LOS BANOS	4800	-2000	1199.3	1197	1470.9	1525.2	1795.1	1514.8
16	IDAHO - SIERRA	500	-360	111.1	111.3	106.5	-135.1	-140.4	-136.8
17	BORAH WEST	2307	N/A	1172.2	1171.9	1199.2	1633.9	1651.8	1600.8
18	IDAHO - MONTANA	351	-337	-251.1	-258.2	-233.2	-30.6	0	22.4
19	BRIDGER WEST	2200	N/A	2208.3	2203.1	2216.9	2242.8	2248.6	2239
20	PATH C	1000	-1000	-212.6	-215.4	-174.6	129.6	174.5	152.3
21	ARIZONA - CALIFORNIA	5700	N/A	5626.2	5624.7	5572.9	3361.6	3347.4	3359.7
46	WEST OF COLORADO RIVER (WOR)	10118	-10118	4710.2	4708.9	4853.5	3417.3	3571.7	3411.4
49	EAST OF COLORADO RIVER (EOR)	7550	N/A	968.1	967.6	937	936.3	907.6	935.9
53	BILLINGS - YELLOWTAIL	400	-400	-148.8	-151	-219.8	-112	-106.2	-93
55	BROWNLEE EAST	1750	N/A	48.6	48.7	47.8	11.5	10.8	12.3
65	PACIFIC DC INTERTIE (PDCI)	3100	-3100	3090.8	3090.8	3088.6	2000	2000	2000
66	COI	4800	-3675	1113.6	1114.8	975	694.5	413.6	701.9
73	NORTH OF JOHN DAY	7900	-7900	6383	6383	6346.2	2479.1	2456	2455.7
75	MIDPOINT - SUMMER LAKE	1500	-400	322	322.1	333.6	937.1	938.7	903.8
76	ALTURAS PROJECT	300	-300	259.2	259.3	259.3	153.4	152.2	157
80	MONTANA - SOUTHEAST	600	-600	-197	-208	-294	-150	-149	-142
500	Southern CA Imports	N/A	N/A	7270	7269.5	7345.5	6420.8	6555.4	6416
501	South of KEG Cutplane (SOK)	1880	N/A	2293.9	2322.4	2103.2	752.7	860.4	497
502	North of Calgary Cutplane (NOC)	1330	N/A	1772.3	2134	1572.4	652.7	895.9	342.4
503	Fort McMurray Flowgate	600	-600	335.5	335.9	336	119.9	119.9	119.4

The following contingencies were simulated for the transient stability analysis (fault clearing times and switching sequence are included in Appendix I):

1. MATL PS – Marias 230 kV line
2. Marias – Great Falls 230 kV line
3. Langdon – Cranbrook 500 kV line
4. Cranbrook – Selkirk 500 kV line(RAS used)
5. Ingledow - Custer #1 500 kV line(RAS used)
6. Custer - Monroe #1 500 kV line
7. Ingledow – Custer #1 and #2 500 kV lines(RAS used)
8. Custer – Monroe #1 and #2 500 kV lines(RAS used)
9. Nelway – Boundary 230 kV line(RAS used)

10. Boundary-Bell #1 230 kV and Bell-Usk 230 kV lines
11. Boundary-Bell #3 230 kV and Addy-Bell #1 115 kV line

The following contingencies were simulated for the post-transient analysis:

12. MATL PS – Marias 230 kV line
13. Marias – Great Falls 230 kV line
14. Langdon – Cranbrook 500 kV line
15. Cranbrook – Selkirk 500 kV line(RAS used)
16. Ingledow - Custer #1 500 kV line(RAS used)
17. Custer - Monroe #1 500 kV line
18. Ingledow – Custer #1 and #2 500 kV lines(RAS used)
19. Custer – Monroe #1 and #2 500 kV lines(RAS used)
20. Nelway – Boundary 230 kV line(RAS used)
21. Boundary-Bell #1 230 kV and Bell-Usk 230 kV lines
22. Boundary-Bell #3 230 kV and Addy-Bell #1 115 kV line

IV.2b Study Results

IV.2.b.1 Post-Transient Powerflow

The post-transient powerflow analysis determined that only one line was overloaded under contingency conditions at maximum Path 3 and north-to-south MATL flows. This facility is listed in Table IV.2.b-1, below. The overload occurred in the case representing heavy summer conditions. There were no post-transient thermal overloads in the light spring cases.

Table IV.2.b-1: Facilities Adversely Impacted by MATL

FROM BUS	KV	TO BUS	KV	ID
NLY230	230.0	NLYPHS	230.0	#2

Sensitivity analyses were run to determine the corner points of the post-transient powerflow nomogram. These points were found to be 260 MW on MATL when Path 3 is at maximum north to south flows and 3044 MW south to north on Path 3 when MATL is at maximum north to south flow. These points are outside the acceptable operating limits found in the transient analysis (see section IV.2.b.3 below). Therefore the transient nomogram will set the limits on the simultaneous transfers between Path 3 and MATL.

There were no voltage deviation violations for either the heavy summer or the light spring cases. Complete contingency details are provided in Appendix E.1.

IV.2.b.2 Reactive Margin

Reactive margin studies were performed on both the heavy summer and light spring Path 3 Simultaneous base cases. Reactive margin summaries and Q/V curves for the critical buses are given in Appendix E.1.a for the heavy summer cases and in Appendix E.1.b for the light spring cases.

The minimum reactive margin for the heavy summer studies was 61 MVAr at Langdon 240 kV for loss of the Custer-Monroe #1 and #2 500 kV lines. The case with 5% additional flow on MATL had a margin of 20 MVAr. The minimum reactive margin for the light spring studies was 238 MVAr at Natal 138 kV for loss of the MATL 230 kV line. The case with 5% additional flow on MATL had 228 MVAr. Even though the heavy summer reactive margins are fairly low, the performance of the system fully meets the current WECC standard for reactive margin for all contingencies studied.

Q/V plots for all of the critical buses and critical contingencies are provided in Appendices E.1.a and E.1.b for the heavy summer and light spring cases, respectively.

IV.2.b.2 Transient Stability

Path 3 Simultaneous study transient results (a case summary table as well as transient and transient snapshot powerflow plots) are provided in Appendix E.2.a and light spring non-simultaneous transient results are provided in Appendix E.2.b.

Most pre-MATL contingencies listed in the heavy summer transient summary table exhibited acceptable performance (no violations of the NERC/WECC Planning Standards). However, three contingencies exhibited transient voltage dip violations in the area between Edmonton and Calgary. The contingencies that exhibited violations were:

- the Ingledow - Custer #1 500 kV line,
- the Ingledow - Custer #1 and #2 500 kV lines, and
- the Custer - Monroe #1 and #2 500 kV lines.

It was determined, based on these results, that the export on Path 1 was too high in this pre-MATL case. After the Path 1 flows were reduced to 40 MW (east-to-west) (from 450 MW east-to-west in the initial case) those three contingencies exhibited acceptable system performance[17]. This Path 1 flow level was used as the new starting point for the post-MATL north-to-south and south-to-north cases if violations occurred for any of the post-MATL contingencies.

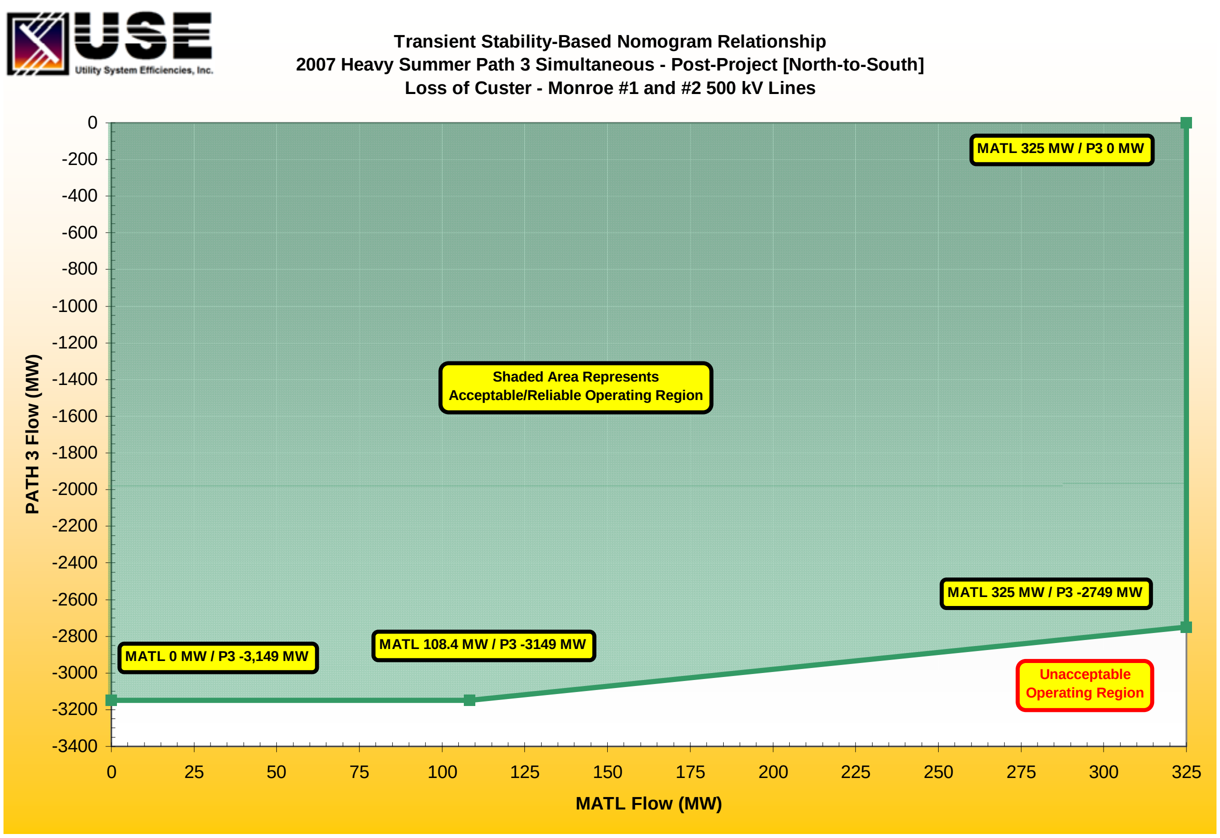
For the north-to-south post-MATL cases all contingencies exhibited acceptable performance except:

[17] Based on discussions with the AESO, it was determined that the 450 MW export conditions in the Path 3 cases exceeded the allowable export from Alberta (based on Alberta loading conditions). 40 MW export is within guidelines set in the current operating procedure (OP-304).

- the Ingledow - Custer #1 500 kV line,
- the Ingledow - Custer #1 and #2 500 kV lines, and
- the Custer - Monroe #1 and #2 500 kV lines.

The worst contingency of the three was loss of the Custer - Monroe #1 and #2 500 kV lines. This contingency was used to develop the Path 3 - MATL nomogram shown in Figure IV.2.b-1. Once the nomogram corner points were determined for this contingency, the other two contingencies were checked at these points to be sure performance was acceptable.

Figure IV.2.b-1: Heavy Summer Path 3 Nomogram



For example, a Custer - Monroe #1 and #2 outage was run at Path 1 flows of 450 MW, Path 3 flows of -3150 MW, and MATL flows of 325 MW (Case 22 in Appendix E.2.a1). This case had 394 voltage dip criteria violations. Another case was run at Path 1 flows of 45 MW, Path 3 flows of -3150 MW, and MATL flows of 113 MW (Case 27). This case had only 1 voltage dip violation. A final case was run at Path 1 flows of 45 MW, Path 3 flows of -3150 MW, and MATL flows of 108 MW (Case 26). This case had no criteria violations and therefore was the case that determined the lower left hand nomogram point. The switching sequence used for all of these cases was as follows:

Time	Switching Action
0	Apply 3-p fault at bus CUSTER
4	Clear fault at bus CUSTER
	Trip CUSTER-MONROE #1 and #2 500 kV lines
	Insert Brake Resistor 400 MW at GMS138
12	Drop 1880 MW of generation at MCA, REV, and GMS
44	Remove Brake Resistors at 50517 (GMS138)

A new RAS may be required for this contingency and a new function may be required in the existing BC RAS for the other two contingencies (the Ingledow-Custer 500 kV #1 or #2 line, and the Ingledow-Custer 500 kV #1 and #2 lines) to separate Alberta from BC for these conditions so that higher Path 1 and or MATL flows can be achieved. Investigation into the new/modified RAS was not performed for these studies, but could be done as part of the operations studies.

The Path 1 limitations described in Section IV.1 were determined with Path 3 at intermediate levels of stress. Based on the results of both of these analyses (Path 1 and Path 3), there may be a relationship between Path 1 and Path 3 that will need to be explored in the operating studies phase.

The south-to-north post MATL cases were all acceptable at maximum Path 3 flow (BC to NW) and at maximum achievable MATL flow. It should be noted that MATL is flow constrained under these system conditions due to phase shifter angle limitations and that the maximum MATL flow studied was 217 MW south to north.

Most pre-MATL contingencies listed in the light spring transient summary table exhibited acceptable performance (no violations of the NERC/WECC Planning Standards). However, three contingencies exhibited violations. It was again determined that the export on Path 1 was too high in this pre-MATL case. After Path 1 flows were reduced to 270 MW (from 400 MW in the initial case) those three contingencies exhibited acceptable system performance[18]. This Path 1 flow level was used as the new starting point for the post-MATL north-to-south and south-to-north cases if violations occurred for any of the post-MATL contingencies.

All of the contingencies on both the post-MATL cases (north-to-south and south-to-north) exhibited acceptable performance at maximum Path 3 flow (NW to BC) and at maximum MATL flow based on Path 1 of 270 MW (E to W). Therefore, there were no simultaneous interactions between Path 3 and MATL identified under light spring conditions using RAS to trip the MATL tie under the conditions studied.

[18] With 400 MW export from AB to BC in the Path 3 cases the AB-BC tie would need to be tripped via existing RAS to prevent voltage criteria violations within AB. These studies did not simulate this RAS; however, at 270 MW export no voltage violations occurred and tripping the AB-BC tie was not necessary.

IV.3 Path 8 – Montana to Northwest

IV.3a Base Case Development

Power flow cases were developed to assess the impact of MATL on the transfer capability of Path 8. Thermal, post-transient and transient stability studies were performed to study the relationship between flows on MATL and a heavily stressed Path 8 system under a 2007 timeframe. The following principles were applied in conducting the simultaneous MATL/Path 8 studies:

1. The Path 8 simultaneous cases were derived from the 2007 light spring non-simultaneous case. One case was developed with maximum westbound flow on Path 8[19] and with 327 MW of import to Montana (north to south) on MATL. A second case was developed with maximum westbound flow on Path 8 and with 313 MW of export from Montana (south to north) on MATL.

The following methodology was used in conducting the simultaneous Path 8 studies:

1. Path 8 flow was increased in the pre-project cases to establish the Path 8 corner point based on the most limiting condition. This benchmark case must meet all applicable reliability criteria.
2. In the post-project cases, flows on MATL were increased by the proposed project rating[20], which is 325 MW north to south and 300 MW south to north. Additional voltage support and/or other transmission-facilities were added or flows were reduced on Path 8 until the post-project corner point cases met all applicable reliability criteria. Generation displacements were done in such a way as to maximize the stress on Path 8.
3. The MATL flow was increased south to north by removing generation in Alberta and increasing generation output in Montana and/or Wyoming.
4. The MATL phase shifter was used to force the scheduled power to all flow on the MATL line.

The following three cases were developed to perform the Path 8 analysis.

1. Pre-project case with Path 8 at maximum.
2. Post-Project with 325 MW scheduled from north to south on MATL.
3. Post-Project with 300 MW scheduled from south to north on MATL.

Table IV.3-1 lists major interface and path flows in the cases used for the Path 8 analyses.

[19] The west of Hatwai flow will be set as high as feasible.
[20] If the project is flow limited because of external flows and the angle limits on the phase shifting transformer, then the flow will be increased until the angle limit is reached.

Table IV.3-1: Path Flows for the Path 8 Base Cases

Interface Number	Interface Name	Interface Rating 1	Interface Rating 2	Interface Flow (MW) 07 LSp Pre-Project Case	07 LSp Post-Project North-to-South Case	07 LSp Post-Project North-to-South Case +5%	07 LSp Post-Project South-to-North Case	07 LSp Post-Project South-to-North Case +5%
	MATL (N to S is +)	300	-300	NA	327	343	-313	-328
	Nelway - Boundary (N to S is +)	400	-400	-385	-383	-383	-384	-385
1	ALBERTA - BRITISH COLUMBIA	1000	-1200	401	404	403	400	399
2	ALBERTA - SASKATCHEWAN	150	-150	0	0	0	0	0
3	NORTHWEST - CANADA	2000	-3150	1499	1496	1497	1500	1502
4	WEST OF CASCADES - NORTH	9800	-9800	3780	3779	3779	3715	3716
5	WEST OF CASCADES - SOUTH	7000	-7000	2462	2462	2462	2463	2463
6	WEST OF HATWAI	4300	N/A	3875	3878	3879	3883	3881
8	MONTANA - NORTHWEST	2200	-1350	2204	2204	2205	2205	2204
9	WEST OF BROADVIEW	2573	N/A	2550	2431	2418	2671	2691
10	WEST OF COLSTRIP	2598	N/A	2126	2017	2004	2091	2112
11	WEST OF CROSSOVER	2598	N/A	2312	2203	2190	2343	2363
14	IDAHO - NORTHWEST	2400	-1200	901	902	902	1147	1147
15	MIDWAY - LOS BANOS	4800	-2000	1511	1510	1510	1674	1674
16	IDAHO - SIERRA	500	-360	-134	-133	-133	-151	-151
17	BORAH WEST	2307	N/A	1565	1566	1566	1775	1775
18	IDAHO - MONTANA	351	-337	-76	-77	-78	-17	-17
19	BRIDGER WEST	2200	N/A	2122	2122	2122	2203	2204
20	PATH C	1000	-1000	117	117	117	326	326
21	ARIZONA - CALIFORNIA	5700	N/A	3319	3319	3319	3449	3449
46	WEST OF COLORADO RIVER (WOR)	10118	-10118	3375	3375	3375	3485	3485
49	EAST OF COLORADO RIVER (EOR)	7550	N/A	918	918	918	974	974
53	BILLINGS - YELLOWTAIL	400	-400	-300	-298	-298	-393	-393
55	BROWNLEE EAST	1750	N/A	13	13	13	9	9
65	PACIFIC DC INTERTIE (PDCI)	3100	-3100	2000	2000	2000	2000	2000
66	COI	4800	-3675	708	706	706	541	538
73	NORTH OF JOHN DAY	7900	-7900	2544	2542	2542	2243	2240
75	MIDPOINT - SUMMER LAKE	1500	-400	884	885	885	1043	1043
76	ALTURAS PROJECT	300	-300	160	160	160	136	136
80	MONTANA - SOUTHEAST	600	-600	-409	-409	-409	-568	-570
500	Southern CA Imports	N/A	N/A	6392	6392	6392	6460	6460
501	South of KEG Cutplane (SOK)	1880	N/A	753	1086	1086	431	431
502	North of Calgary Cutplane (NOC)	1330	N/A	653	1000	1017	342	326
503	Fort McMurray Flowgate	600	-600	120	286	286	120	120

The following contingencies were simulated for the power flow analysis:

1. MATL PS – Marias 230 kV line
2. Marias – Great Falls 230 kV line
3. Great Falls – Judith Gap South 230 kV line
4. Judith Gap South – Broadview 230 kV line
5. Great Falls – Landers Fork – Ovando 230 kV line
6. Ovando – Hot Springs 230 kV line
7. Ovando – Garrison 230 kV line
8. Colstrip – Broadview #1 500 kV line
9. Broadview – Townsend – Garrison #1 500 kV line
10. Garrison – Taft #1 500 kV line
11. Langdon – Cranbrook 500 kV line
12. Cranbrook – Selkirk 500 kV line(RAS used)
13. Taft – Bell 500 kV line

14. Taft – Dworshak 500 kV line
15. Dworshak – Hatwai 500 kV line
16. Taft – Bell and Taft – Garrison #1 500 kV lines

The following three phase fault contingencies were simulated for the transient stability analysis (clearing times and switching sequences are included in Appendix I):

1. MATL PS – Marias 230 kV line
2. Marias – Great Falls 230 kV line
3. Great Falls – Judith Gap South 230 kV line
4. Judith Gap South – Broadview 230 kV line
5. Great Falls – Landers Fork – Ovando 230 kV line
6. Ovando – Hot Springs 230 kV line
7. Ovando – Garrison 230 kV line
8. Colstrip – Broadview #1 500 kV line[21]
9. Broadview – Townsend – Garrison #1 500 kV line[21]
10. Garrison – Taft #1 500 kV line[21]
11. Langdon – Cranbrook 500 kV line
12. Cranbrook – Selkirk 500 kV line(RAS used)
13. Colstrip – Broadview #1 and #2 500 kV lines[21]
14. Broadview – Townsend – Garrison #1 and #2 500 kV lines[21]
15. Garrison – Taft #1 and #2 500 kV lines[21]
16. Taft 500 kV Breaker Failure at Bell/Garrison #1 position

The following contingencies were simulated for the post-transient analysis:

1. MATL PS – Marias 230 kV line
2. Marias – Great Falls 230 kV line
3. Great Falls – Judith Gap South 230 kV line
4. Judith Gap South – Broadview 230 kV line
5. Great Falls – Landers Fork 230 – Ovando 230 kV line
6. Ovando – Hot Springs 230 kV line
7. Ovando – Garrison 230 kV line
8. Colstrip – Broadview #1 500 kV line
9. Broadview – Townsend – Garrison #1 500 kV line
10. Garrison – Taft #1 500 kV line
11. Langdon – Cranbrook 500 kV line
12. Cranbrook – Selkirk 500 kV line(RAS used)
13. Colstrip – Broadview #1 and #2 500 kV lines[22]

[21] RAS must be modeled (simulate ATR).

14. Broadview – Townsend – Garrison #1 and #2 500 kV lines[22]
15. Garrison – Taft #1 and #2 500 kV lines[22]

IV.3b Study Results

All technical analyses (traditional power flow, post-transient governor power flow, reactive margin, and transient stability) for the 2007 Light Spring Path 8 simultaneous studies were performed on the "corner point". The corner point, in this instance, was maximum simultaneous power flows on MATL (325 MW north-to-south and 300 MW south-to-north) and Path 8 (2,200 MW). Appendix F.1 contains the summary power flow information, while Appendix F.2 contains the post-transient and reactive margin summary information and post-transient powerflow plots. Appendix F.3 contains the summary information and dynamic plots for the transient studies.

Under anticipated 2007 Light Spring pre-project and post-project (north-to-south) conditions, no reliability concerns were identified[23]. Under anticipated 2007 Light Spring post-project conditions (south-to-north), however, there were three (3) primary concerns[24] at the “corner point”:

1. For loss of either Langdon - Cranbrook or Cranbrook - Selkirk 500-kV lines, growing oscillations were observed during 20-second transient stability simulations. This result is subject to confirmation in the operating studies (see below).
2. For loss of either MATL - Cutbank or Cutbank - Great Falls 230-kV lines, thermal overloads were observed on the Nelway phase shifter during traditional power flow analysis.
3. For loss of either MATL - Cutbank or Cutbank - Great Falls 230-kV lines, thermal overloads (comparable to traditional power flow analysis results) were observed on the Nelway phase shifter during post-transient governor power flow.

Initial studies appeared to indicate a traditional power flow sensitivity between Path 8 flows and MATL flows (see Appendix F.1). This sensitivity was related to overloads on the Nelway phase shifting transformer for loss of the MATL line. Further investigation revealed that this sensitivity was actually related to the manner in which

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[22] These cases will require governor powerflow methods with ATR actions assumed. The transient study will dictate the amount of tripping to assume in the governor powerflow.

[23] For loss of the Colstrip - Broadview, Broadview - Garrison, or Garrison - Taft 500 kV line, there were frequency deviations below 59.60 Hz for more than 20 cycles for all three cases (pre-project, post-project north-to-south, and post-project south-to-north). [NOTE: However, NorthWestern Energy has determined that these frequency deviations are acceptable as long as no underfrequency loadshedding occurs for any single contingency.] There were also overloads on the Hardin 115/69 kV transformer and on the series capacitors in the Colstrip - Broadview 500 kV line. As mentioned previously, MATL is not responsible for the Hardin transformer overloads. The Colstrip - Broadview series capacitors have an overload capability of 110% for 30 minutes. The loading seen on the Colstrip - Broadview series capacitors was within this short term emergency capability and is therefore not a problem.

[24] For the south-to-north case, there were overloads on the Billings 230 kV and Rimrock 161 kV phase shifting transformers (PSTs) and on the Yellowtail 230/161 kV transformer for several outages on the Colstrip 500 kV system. Adjusting the angle of the Billings 230 kV and Rimrock 161 kV PST to no less than -10 degrees relieved all three of these overloads.

the Path 8 redispatch was performed. In the original studies, Path 8 was reduced by scheduling power from the Northwest into Montana. Some of that power flowed to Montana via BC (north via the Ingledow - Custer 500 kV lines and then south via the Nelway-Boundary line). This “loop flow” reduced the flow on the Nelway phase shifting transformer and appeared to create a sensitivity between Path 8 and MATL. However, if the Nelway phase shifting transformer’s angle is adjusted to hold the same power flow in both the original case and the case with reduced Path 8 flows, then there is no significant difference in the results between the two cases (see Appendix F.1). These results demonstrate that, similar to the relationship found in the Path 1 Studies, when the Nelway -Boundary flows are high and MATL flows are in the same directions as Nelway - Boundary flows, a RAS or operating procedure will be needed to mitigate the overload on the Nelway phase shifting transformer[25].

A sensitivity analysis using the loss of the MATL-Marias 230 kV line was run on the corner point south-to-north post-MATL case. The Nelway phase shifting transformer (PST) angle was adjusted post-contingency to see if it was possible to reduce the post-contingency flow through the Nelway PST to 250 MW after the MATL contingency. This reduction in flow is necessary to allow the Nelway PST to cool off after being exposed to the higher than normal post-contingency loadings. Table IV.3-2 summarizes the results of this analysis.

[25] Overloads also occurred on the Nelway - Boundary and Nelway - Selkirk 230 kV lines, but these overloads were smaller than the overload on the Nelway phase shifting transformer.

Table IV.3-2: Nelway PST Angle Sensitivity Results

MATL Out; No PST Adjust **Nelway PST Angle = -5.0 Degrees**

From	Fname	Fkv	To	Tname	Tkv	CK	P	Q	MVA	Amps	% Rate	Rate	Unit	Area	Zone	Ploss	Qloss
62011	HOLTER	6.6	62120	HOLTER	100	1	49	4.7	49.2	4289.1	246	20	Mva	62	627	0	2.77
62010	HAUSER	2.4	62093	HAUSER	69	1	16	7	17.5	4046.2	139.6	12.5	Mva	62	627	0	1.08
62001	KERR12	13.8	62066	KERR	115	1	121.9	8.6	122.2	5095.7	128.4	95.2	Mva	62	629	0	10.23
50784	NLY230	230	50822	NLYPHS	230	2	-488.4	14.6	488.7	1194.8	123.2	400	Mva	50	500	1.84	63.89
62038	BEAGLE	6.6	62123	BEAGLE	100	1	18	-11	21.1	1823.6	118.6	18.8	Mva	62	622	0	2.16
50783	SEL230	230	50784	NLY230	230	1	-471.9	23.5	472.5	1165.1	110.8	1051.8	Amp	50	500	4.66	29.2
62042	BILGEN I	13.8	62101	BILINGSX	50	1	65	9.6	65.7	2748.3	109.5	60	Mva	62	623	0	10.44
62043	MONTANA1	13.8	62059	MONTANA1	115	1	42	1.9	42	1707.2	105.5	40	Mva	62	628	0	5.9
47740	CENTR G1	20	47741	CENTR P1	500	1	705	-165.9	724.3	21466.7	105	728	Mva	40	400	2.21	134.43
54136	E EDMON4	240	54806	946/947N	240	46	-526.7	-116.3	539.4	1225.3	102.1	1200.4	Amp	54	570	0	-0.03
45025	BOYLE	230	45064	BOYLE 2	11	1	-38.8	18.6	43	102.7	101.7	42.3	Mva	40	484	0.2	5.56
54128	ELLERSLI	240	54805	946/947X	240	47	529.2	120.5	542.7	1220.4	101.7	1200.4	Amp	54	570	0	-0.03
50772	KCL G4	13.8	50788	KCL230	230	4	140	50.4	148.8	5821.5	101.2	147	Mva	50	500	0.47	16.61
45290	LEMOLO2	12	45292	LEMOLO2	115	1	33	10.8	34.7	1601.2	100.1	34.7	Mva	40	471	0.12	2.67

MATL Out; PST Adjusted **Nelway PST Angle = -25.1 Degrees**

From	Fname	Fkv	To	Tname	Tkv	CK	P	Q	MVA	Amps	% Rate	Rate	Unit	Area	Zone	Ploss	Qloss
62038	BEAGLE	6.6	62123	BEAGLE	100	1	18	-11	21.1	1824.9	118.6	18.8	Mva	62	622	0	2.16
62042	BILGEN I	13.8	62101	BILINGSX	50	1	65	9.7	65.7	2748.9	109.5	60	Mva	62	623	0	10.44
62043	MONTANA1	13.8	62059	MONTANA1	115	1	42	1.7	42	1706.9	105.5	40	Mva	62	628	0	5.9
47740	CENTR G1	20	47741	CENTR P1	500	1	705	-137.9	718.4	21127.4	103.3	728	Mva	40	400	2.14	130.21
62011	HOLTER	6.6	62120	HOLTER	100	1	49	6	49.3	4295.3	102.8	48	Mva	62	627	0	2.78
54136	E EDMON4	240	54806	946/947N	240	46	-526.7	-116.3	539.4	1225.3	102.1	1200.4	Amp	54	570	0	-0.03
45025	BOYLE	230	45064	BOYLE 2	11	1	-38.8	18.6	43	102.7	101.7	42.3	Mva	40	484	0.2	5.56
54128	ELLERSLI	240	54805	946/947X	240	47	529.2	120.5	542.7	1220.3	101.7	1200.4	Amp	54	570	0	-0.03
50772	KCL G4	13.8	50788	KCL230	230	4	140	50.4	148.8	5821.5	101.2	147	Mva	50	500	0.47	16.61
50769	KCL G1	13.8	50788	KCL230	230	1	140	-29.3	143	5965.1	100.1	147	Mva	50	500	0.5	17.4
45290	LEMOLO2	12	45292	LEMOLO2	115	1	33	10.8	34.7	1601.3	100.1	34.7	Mva	40	471	0.12	2.67
50771	KCL G3	13.8	50788	KCL230	230	3	140	-29.3	143	5964.8	100.1	147	Mva	50	500	0.5	17.37
50784	NLY230	230	50822	NLYPHS	230	2	-249.8	-1.6	249.8	607.2	62.7	400	Mva	50	500	0.47	16.5

As can be seen from this table, adjusting the Nelway PST from -5 degrees to -25.1 degrees reduces the post-contingency loading on the Nelway PST from 488.7 MVA to 249.8 MVA. Since the range of the Nelway PST is +/- 40 degrees, an operating procedure to adjust the taps on the Nelway PST following loss of the MATL line appears to be feasible.

The impact of MATL versus Path 8 using transient stability simulation analysis was inconclusive. The path interaction requires further studies to confirm the findings of this report (see Appendix F.3).

V. SENSITIVITY ANALYSES

The following two sensitivity analyses were also performed as part of the MATL Phase 2 studies.

V.1 GREAT FALLS AREA GENERATION ADDITIONS

A sensitivity analysis was performed to assess the impact of the addition of the following planned future generation projects on the NorthWestern Energy system:

(1) 188 MW of total wind generation at Judith Gap South,
(2) 280 MW of gas fired generation at Great Falls[26], and
(3) 268 MW of coal fired generation at Great Falls.

System impacts south of Great Falls were studied using through the use of flowgates (flowgates are a collection of transmission lines that together form a constraint or restriction on the total power that may flow).

A thorough investigation of flowgates in the Great Falls area has uncovered the existence of five potential flowgates that can limit export from Great Falls in the north-to-south direction. The five identified flow gates are:

(1) Canyon Ferry - East Helena,
(2) Holter 100 kV Outflow,
(3) Judith Gap - Broadview Constraint,
(4) Martinsdale 100 kV Constraint, and
(5) Great Falls - Landers Fork - Ovando 230 kV.

The first four of these flowgates have limits that allow anywhere from 245 MW to 675 MW of additional power to be injected into the Great Falls 230 kV bus under heavy summer conditions and anywhere from 510 MW to 640 MW of additional power to be injected into the Great Falls 230 kV bus under light spring conditions. Note that these additional power injections are subject to the conditions defined in the base cases and are used for the PRG's analysis of the MATL project. Actual allowable power transfer limits will be determined by the area electrical system operator(s).

The Great Falls - Landers Fork - Ovando 230 kV flowgate is constrained by voltage deviations on NWE's 100 kV system in the vicinity of Townsend. Because this constraint is based on voltage deviations, it is difficult to quantify this limit as a function of MW flows through a flowgate. While studies have shown that the other four flowgate limits are usually reached first, there is a possibility that the Great Falls - Landers Fork - Ovando 230 kV flowgate could be limiting. For this reason, either system reinforcements or a RAS may be

[26] Since the onset of the MATL Phase 2 Studies, this generator has withdrawn from NorthWestern Energy's interconnection queue.

needed to mitigate the impacts of the Great Falls - Landers Fork - Ovando 230 kV line outage.

Appendix G contains the complete Great Falls Flowgate study report.

V.2 SOUTHERN ALBERTA GENERATION ADDITIONS

V.2a Base Case Development

A sensitivity analysis was performed on the post-MATL case with the inclusion of the proposed new generation projects in southern Alberta. This sensitivity assessed reliability requirements of the combined new generation additions and the MATL project. Eight additional base cases with the new generation added were created for this sensitivity:

- 07HS with Path 1 at maximum westbound flow (target 800 MW E to W[27]), MATL exporting 325 MW from Alberta (from Case IV.2-1b), and southern Alberta wind generation dispatched at minimum (0 MW)
- 07HS with Path 1 at maximum westbound flow (target 800 MW E to W), MATL exporting 325 MW from Alberta (from Case IV.2-1b), and southern Alberta wind generation dispatched at maximum (700 MW)
- 07HS with Path 1 at maximum westbound flow (target 800 MW E to W), MATL importing 300 MW from Montana (from Case IV.2-1c), and southern Alberta wind generation dispatched at minimum (0 MW)
- 07HS with Path 1 at maximum westbound flow (target 800 MW E to W), MATL importing 300 MW from Montana (from Case IV.2-1c), and southern Alberta wind generation dispatched at maximum (700 MW)
- 07HS with Path 1 at maximum eastbound flow (target 400 MW W to E), MATL exporting 325 MW from Alberta (from Case III-1.b), and southern Alberta wind generation dispatched at minimum (0 MW)
- 07HS with Path 1 at maximum eastbound flow (target 400 MW W to E), MATL exporting 325 MW from Alberta (from Case III-1.b), and southern Alberta wind generation dispatched at maximum (700 MW)
- 07HS with Path 1 at maximum eastbound flow (target 400 MW W to E), MATL importing 300 MW from Montana (from Case III-1.c), and southern Alberta wind generation dispatched at minimum (0 MW)
- 07HS with Path 1 at maximum eastbound flow (target 400 MW W to E), MATL importing 300 MW from Montana (from Case III-1.c), and southern Alberta wind generation dispatched at maximum (700 MW)

Table V.2-1 provides the path flows for the starting cases described above.

Table V.2-1: Path Flows for the Path 1 Southern Alberta Wind Base Cases

[27] For heavy summer conditions, OP-304 currently restricts power flow from Alberta to BC to approximately zero from an operational perspective.

Interface Number	Interface Name	Interface Rating 1	Interface Rating 2	Interface Flow (MW)							
				pre_07hs_ pst_iv2-1b-1_v1b1_rev03tcl.sav	pst_07hs_ pst_iv2-1b-2_v1b2_rev03tcl.sav	Pre_07hs_ pst_iv2-1c-1_v1b3_rev03tcl.sav	pst_07hs_ pst_iv2-1c-2_v1b4_rev03tcl.sav	pre_07hs_ ns_pst_n2s-1_v1b5_rev23ntcl.sav	pst_07hs_ ns_pst_n2s-2_v1b6_rev23ntcl.sav	pre_07hs_ ns_pst_s2n-1_v1b7_rev24ntcl.sav	pst_07hs_ ns_pst_s2n-2_v1b8_rev24ntcl.sav
				V1B1	**V1B2**	**V1B3**	**V1B4**	**V1B5**	**V1B6**	**V1B7**	**V1B8**
	MATL (N to S is +)			326	328	-192.1	-165.2	327	327.0	-306.9	-308.2
	Nelway-Boundary 230 kV (N to S is +)			0.5	2.3	-3.2	-3.3	394.8	394.8	394.5	394.4
	Southern Alberta Wind			0	700	0	700	0	700	0	700
1	ALBERTA - BRITISH COLUMBIA	1000	-1200	802.7	800.2	799.6	802.1	-374.6	-375.1	-374.3	-373.2
2	ALBERTA - SASKATCHEWAN	150	-150	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3	NORTHWEST - CANADA	2000	-3150	-1952.2	-1949.9	-1949.3	-1952.1	-2000.3	-1999.7	-2000.8	-2000.9
4	WEST OF CASCADES - NORTH	9800	-9800	3286.9	3287.1	3287.1	3390.9	3701.9	3702.3	3641.7	3641.7
5	WEST OF CASCADES - SOUTH	7000	-7000	3792.3	3792.3	3792.3	3726.4	3765.8	3765.9	3732.6	3732.6
6	WEST OF HATWAI	4300	N/A	2774	2773.6	2773.6	2513	3124.2	3126.1	2638	2637
8	MONTANA - NORTHWEST	2200	-1350	1696.6	1697.9	1400	1422.7	1690	1692.1	1183.6	1182.7
9	WEST OF BROADVIEW	2573	N/A	2179.1	2178.5	2178.5	2293.8	2167.8	2168.2	2237.1	2238.1
10	WEST OF COLSTRIP	2598	N/A	2096.7	2096	2096	2184.6	2102.1	2103.1	2122.5	2123.5
11	WEST OF CROSSOVER	2598	N/A	2203.1	2202.4	2202.4	2285.3	2179.7	2180.5	2256.6	2257.6
14	IDAHO - NORTHWEST	2400	-1200	-48.9	-48.7	-48.7	-55.5	-36	-35.9	-59	-59.2
15	MIDWAY - LOS BANOS	4800	-2000	1211.7	1211.6	1211.6	1197.6	1073.6	1073.7	1256.8	1256.8
16	IDAHO - SIERRA	500	-360	113.3	113.3	113.3	110.5	115.4	115.3	112.5	112.5
17	BORAH WEST	2307	N/A	1166.2	1166.3	1166.3	1156.4	1179.7	1179.8	1156.2	1156
18	IDAHO - MONTANA	351	-337	-268.7	-268.8	-268.8	-246.8	-288.4	-288	-239.8	-239.6
19	BRIDGER WEST	2200	N/A	2192.2	2192.2	2192.2	2200.1	2204.1	2204.4	2203.2	2203.2
20	PATH C	1000	-1000	-221.6	-221.6	-221.6	-217.5	-236.7	-236.4	-213.8	-213.7
21	ARIZONA - CALIFORNIA	5700	N/A	5640.4	5640.4	5640.4	5629.5	5684.7	5684.8	5613.7	5613.6
46	WEST OF COLORADO RIVER (WOR)	10118	-10118	4720	4720	4720	4710.6	4755.1	4755.2	4704.2	4704.2
49	EAST OF COLORADO RIVER (EOR)	7550	N/A	972.1	972.1	972.1	969	984.8	984.8	968.6	968.6
53	BILLINGS - YELLOWTAIL	400	-400	-154.2	-154.2	-154.2	-189.4	-166.3	-165.9	-160.1	-160.1
55	BROWNLEE EAST	1750	N/A	49.6	49.6	49.6	49.1	49	49	48.8	48.8
65	PACIFIC DC INTERTIE (PDCI)	3100	-3100	3090.5	3090.5	3090.5	3090.8	3096.7	3096.7	3095.4	3095.4
66	COI	4800	-3675	3404.9	3403.9	3404	3303	3522.6	3522	3165.1	3165.1
73	NORTH OF JOHN DAY	7900	-7900	6220.5	6219.6	6219.6	6487.7	6658.1	6657.5	6359.7	6359.8
75	MIDPOINT - SUMMER LAKE	1500	-400	326.3	326.4	326.4	313.5	350.1	350.2	306.3	306.2
76	ALTURAS PROJECT	300	-300	257.8	257.8	257.8	258.4	259.3	259.3	255.4	255.4
500	Southern CA Imports	N/A	N/A	7272.6	7272.6	7272.6	7269.5	7287.7	7287.8	7275.6	7275.6
501	South of KEG Cutplane (SOK)	1880	N/A	1585.9	1262.9	1262.9	1314.2	1672.3	1533.2	1272.6	953.1
502	North of Calgary Cutplane (NOC)	1330	N/A	1513.8	802.1	1501.6	841.1	1334.5	789.1	909.9	244.3

All contingencies that were run for the Path 1 studies were assessed for this sensitivity analysis. (See section IV.1 for a listing of the contingencies studied.)

V.2b Study Results

V.2.b.1 Power Flow Study Results

Appendix H.1.a provides summary results of the power flow studies performed for the Southern Alberta Wind Sensitivity analysis. These tables are set up to compare cases with 0 MW of southern Alberta wind generation to cases with 700 MW of southern Alberta wind generation. Each table is set up in the following order:

- Base case thermal overload comparison,
- Contingency thermal overload comparison,
- Base case voltage comparison, and
- Contingency voltage comparison.

As can be seen from the tables in Appendix H.1.a, there were quite a large number of overloads and voltage violations that were either created or made worse by the addition of 700 MW of new generation in southern Alberta.

However, it should be noted that the transmission plan for southern Alberta modeled in these cases was the plan developed in early 2006. This plan may have changed since then and therefore some of the criteria violations identified in these studies may no longer be a problem. Because these studies were sensitivity studies and because these studies were performed to assess the impact of the southern Alberta wind generation on cases with MATL already in service, no mitigation plans were developed for the criteria violations identified in Appendix H.1.a.

BCTC did request that a limited number of studies be performed on the above cases to determine the combined impact of MATL and the southern Alberta wind generation on the 138 kV transmission system in southeastern. The results of these additional studies are presented below.

Appendix H.1.b contains the complete results, and Table V.2-2 below contains a summary of the additional studies requested by BCTC. First, cases were created without MATL for each of the four scenarios being studied. These cases were tuned to eliminate any overloads on the BCTC system. Overloads were mitigated by reducing Path 1 flows for 138 kV system overloads or by adjusting the Nelway PST for Nelway-Boundary overloads. Next, MATL was added to these cases at maximum achievable north-to-south or south-to-north flow (as appropriate). If necessary, Path 1 flows and MATL flows were reduced to determine steady state "nomogram" points for the base cases. These cases are indicated in Table V.2-2 using light green shading. These steady state points were acceptable for steady state conditions, but may or may not be acceptable under contingency conditions. The last step in these sensitivity studies was to test all cases for overloads following loss of the MATL project. These cases, if necessary, are indicated in Table V.2-2 using light blue shading. If curtailments were needed either in the steady state analysis or in the contingency analysis, the acceptable flow levels (nomogram points) are indicated with light yellow shading.

All the NTL T1 (or T2) overloading problems can be resolved by the existing NTL T1 (or T2) Overload RAS which will transfer trip the two Natal 138 kV interties at the BC-Alberta separating points (Pocaterra and Natal) if overloading on the transformers is detected. With this Overload RAS, the limiting contingency described in Table V.2-2 below may change and the nomogram limits may increase. However, because this sensitivity analysis was simply done to determine any possible interactions between southern Alberta wind generation and MATL and Path 1 flows, and not to determine mitigation measures, no additional sensitivity studies were run on for this analysis.

Table V.2-2: Southern Alberta Wind Sensitivity Power Flow Results

Case	Path Flows and Generation					Overloaded Facility	% Loading (N or E)	Contingency	Comment
	Path 3	Path 1	SAW	MATL	NLY-BDY				
V1B1	-1952	803	0	300	0.5	NTL T2 - NTL VR 138.00 #2	104.64	N/A	Starting Base Case
	-1953	802	0	N/A	0.3	NTL VR - NTL T1 138 #1	106.7	N/A	MATL Out
	-1953	764	0	N/A	0.6	NTL VR - NTL T1 138 #1	99.9	N/A	No Steady State O/L
	-1953	767	0	300	-1.9	NTL T2 - NTL VR 138.00 #2	100.1	N/A	No Steady State O/L
	-1953	767	0	300	-1.9	NTL VR - NTL T1 138	123.7	MATL - Marias 230	Starting Contingency Base Case
	-1952	632	0	301	1.1	NTL VR - NTL T1 138	99.8	MATL - Marias 230	No Contingency O/L
	-1953	767	0	170	1.5	NTL VR - NTL T1 138	100	MATL - Marias 230	No Contingency O/L
V1B2	-1950	800	700	300	2.3	NTL VR - NTL T1 138 #1	156.35	N/A	Starting Base Case
	-1977	827	700	N/A	1.5	NTL VR - NTL T1 138 #1	165.5	N/A	MATL Out
	-1980	486	700	N/A	0.4	NTL VR - NTL T1 138 #1	99.9	N/A	No Steady State O/L
	-1950	521	700	302	1.1	NTL VR - NTL T1 138 #1	100	N/A	No Steady State O/L
	-1950	521	700	302	1.1	NTL VR - NTL T1 138 #1	120.9	MATL - Marias 230	Starting Contingency Base Case
	-1947	309	700	302	0.5	NTL VR - NTL T1 138 #1	99.7	MATL - Marias 230	No Contingency O/L
	-1954	486	700	155	1.2	NTL VR - NTL T1 138 #1	100.1	MATL - Marias 230	No Contingency O/L
VIB3	-1949	800	0	-192	-3.2	-	-	-	No Steady State or Contingency O/L; No Adjustments Necessary
V1B4	-1952	802	700	-165	-3.3	NTL VR - NTL T1 138 #1	149.57	N/A	Starting Base Case
	-1952	802	700	N/A	0	NTL VR - NTL T1 138 #1	145.1	N/A	MATL Out
	-1952	535	700	N/A	-1.3	NTL VR - NTL T1 138 #1	99.9	N/A	No Steady State O/L
	-1949	516.5	700	-163	-1.7	NTL VR - NTL T1 138 #1	100	N/A	No Steady State or Contingency O/L
	-1948	535	700	-81.4	1.8	NTL VR - NTL T1 138 #1	100.1	N/A	No Steady State or Contingency O/L
V1B5	-2000	-375	0	300	395	NTL VR - NTL T1 138 #1	100.71	-	Only Minor Steady State O/L and No Contingency O/L; No Adjustments Necessary
V1B6	-2000	-375	700	302	395	NTL138 - LCCTAP 138 #1	102.8	N/A	Starting Base Case
	-2029	-347	700	N/A	395	NTL138 - LCCTAP 138 #1	109.1	N/A	MATL Out
	-2029	-231	700	N/A	395	NTL138 - LCCTAP 138 #1	100.1	N/A	No Steady State O/L
	-2000	-338	700	302	395	NTL138 - LCCTAP 138 #1	99.9	N/A	No Steady State O/L
	-2000	-338	700	302	395	NLY230 - NLYPHS 230 #1	122.4	MATL - Marias 230	Starting Contingency Base Case
	-2004	-34	700	299	394	NLY230 - NLYPHS 230 #1	121.8	MATL - Marias 230	O/L is not a function of Path 1 Flows
	-2000	-232	700	5.7	395	NLY230 - NLYPHS 230 #1	100.2	MATL - Marias 230	No Contingency O/L
V1B7	-2001	-374	0	-307	395	-	-	N/A	No Steady State O/L; No Adjustments Necessary
	-2001	-374	0	-307	395	NTL 66 - NTL T1 138 #1	108.25	MATL - Marias 230	Starting Contingency Base Case
	-2000	-280	0	-307	395	NTL 66 - NTL T1 138 #1	100.1	MATL - Marias 230	No Contingency O/L
	-2001	-374	0	-210	395	NTL 66 - NTL T1 138 #1	99.8	MATL - Marias 230	No Contingency O/L
V1B8	-2001	-373	700	-308	394	NTL138 - LCCTAP 138 #1	126.81	N/A	Starting Base Case
	-1993	-382	700	N/A	394	NTL138 - LCCTAP 138 #1	121	N/A	MATL Out
	-1992	-109.1	700	N/A	394	NTL VR - NTL T1 138 #1	100	N/A	No Steady State O/L
	-1998	27.1	700	-307	395	NTL VR - NTL T1 138 #1	100	N/A	No Steady State O/L
	-1999	-110	700	-106.9	395	NTL VR - NTL T1 138 #1	100	N/A	No Steady State O/L
	-1998	27.1	700	-307	395	NTL138 - LCCTAP 138 #1	112	MATL - Marias 230	Starting Contingency Base Case
	-1999	-110	700	-106.9	395	NTL138 - LCCTAP 138 #1	105.3	MATL - Marias 230	Starting Contingency Base Case
	-1997	179	700	-306	395	NTL138 - LCCTAP 138 #1	100	MATL - Marias 230	No Contingency O/L
	-1999	-109	700	-25	395	NTL138 - LCCTAP 138 #1	99.9	MATL - Marias 230	No Contingency O/L

V.2.b.2 Post-transient Study Results

Appendix H.2.a contains summary tables listing the post-transient results for the southern Alberta wind sensitivity analysis. As can be seen from the tables in Appendix H.2.a, there were quite a large number of overloads and voltage deviation violations that were either created or made worse by the addition of 700 MW of new generation in southern Alberta. There were also a number of cases where the addition of 700 MW of generation decreased or eliminated an overload. However, as mentioned earlier, it should be noted that the transmission plan for southern Alberta modeled in these cases was the plan developed in early 2006. This plan may have changed since then and therefore some of the criteria violations identified in these studies may no longer be a problem. Because these studies were sensitivity studies and because these studies were performed to assess the impact of the southern Alberta wind generation on cases with MATL already in service, no mitigation plans were developed for the criteria violations identified in Appendix H.2.a.

Appendix H.2.b contains power flow plots for all of the post-transient cases listed in Appendix H.2.a.

All southern Alberta wind sensitivity cases were tested at +5% additional flow on the MATL line. All post-transient contingencies run on the cases with increased MATL flow solved. These results demonstrate that all southern Alberta wind sensitivity cases meet the WECC reactive margin criteria.

V.2.b.3 Transient Study Results

Appendix H.3.a contains summary tables listing the post-transient results for the southern Alberta wind sensitivity analysis. All cases exhibited acceptable transient performance except for a few contingencies performed using cases V1B7 and V1B8. Even though the development of mitigation for the cases that exhibited unacceptable transient performance is not required, nomogram points for cases V1B7 and V1B8 were developed. The curtailments necessary are described below.

For case V1B7 (post-MATL), flows on Path 1 had to be reduced to -280 MW to prevent Alberta from separating from BC for loss of the Ingledow-Custer #1 and #2 500 kV lines. In addition, Path 1 flows needed to be reduced to -290 MW to prevent criteria violations for the Selkirk-Ashton Creek, Selkirk-Vaseux Lake N-2 contingency. Additional RAS may resolve the two problems above. Nomogram points of -80 MW on Path 1, -306 MW on MATL and -375 MW on Path 1, -80 MW on MATL were established for the Langdon-Janet #1 and #2 240 kV line outage.

For case V1B8 (post-MATL) flows on Path 1 had to be reduced to -280 MW to prevent Alberta from separating from BC for loss of the Ingledow-Custer #1 and #2 500 kV lines. Additional RAS may resolve the above problem. Nomogram points of -285 MW on Path 1, -308 MW on MATL and -374 MW on Path 1, -289 MW on MATL were established for the Langdon-Janet #1 and #2 240 kV line outage.

The nomogram points described above are only based on transient stability performance and may need to be reduced further based on thermal loading or voltage considerations.

Appendix H.3.b contains transient and transient snapshot power flow plots for all of the transient cases listed in Appendix H.3.a.

APPENDIX A.1:

STUDY SCOPE – APRIL 28, 2006

APPENDIX A.2:

PROJECT REVIEW GROUP MEMBERS

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APPENDIX B:

RESPONSES TO COMMENTS ON THE COMPREHENSIVE PROGRESS REPORT

APPENDIX B.1:

RESPONSES TO COMMENTS FROM BCTC

APPENDIX B.2:

RESPONSES TO COMMENTS FROM BPA

APPENDIX B.3:

RESPONSES TO COMMENTS FROM NORTHWESTERN ENERGY

APPENDIX C:

NON-SIMULTANEOUS RESULTS

APPENDIX C.1.A:

NON-SIMULTANEOUS POWERFLOW RESULTS
-
HEAVY SUMMER

APPENDIX C.1.B:

NON-SIMULTANEOUS POWERFLOW RESULTS
-
LIGHT SPRING

APPENDIX C.2.A:

NON-SIMULTANEOUS POST-TRANSIENT RESULTS
-
HEAVY SUMMER

APPENDIX C.2.B:

NON-SIMULTANEOUS POST-TRANSIENT RESULTS
-
LIGHT SPRING

APPENDIX C.3.A:

NON-SIMULTANEOUS STABILITY RESULTS
-
HEAVY SUMMER

APPENDIX C.3.B:

NON-SIMULTANEOUS STABILITY RESULTS
-
LIGHT SPRING

APPENDIX C.4:

NON-SIMULTANEOUS WANETA-BOUNDARY SENSITIVITY

APPENDIX C.5:

NON-SIMULTANEOUS REDUCED U2B SENSITIVITY

APPENDIX D:

PATH 1 SIMULTANEOUS RESULTS

APPENDIX D.1:

PATH 1 SIMULTANEOUS POWERFLOW RESULTS

APPENDIX D.2:

PATH 1 SIMULTANEOUS POST-TRANSIENT RESULTS

APPENDIX D.3:

PATH 1 SIMULTANEOUS STABILITY RESULTS

APPENDIX E:

PATH 3 SIMULTANEOUS RESULTS

APPENDIX E.1:

PATH 3 SIMULTANEOUS POST-TRANSIENT RESULTS

APPENDIX E.2:

PATH 3 SIMULTANEOUS STABILITY RESULTS

APPENDIX F:

PATH 8 SIMULTANEOUS RESULTS

APPENDIX F.1:

PATH 8 SIMULTANEOUS POWERFLOW RESULTS

APPENDIX F.2:

PATH 8 SIMULTANEOUS POST-TRANSIENT RESULTS

APPENDIX F.3:

PATH 8 SIMULTANEOUS STABILITY RESULTS

APPENDIX G:

SENSITIVITY RESULTS
-
SOUTH OF GREAT FALLS FLOWGATES

APPENDIX H:

PATH 1 SENSITIVITY RESULTS
-
SOUTHERN ALBERTA GENERATION

APPENDIX H.1:

PATH 1 SENSITIVITY POWERFLOW RESULTS
-
SOUTHERN ALBERTA GENERATION

APPENDIX H.2:

PATH 1 SENSITIVITY POST-TRANSIENT RESULTS
-
SOUTHERN ALBERTA GENERATION

APPENDIX H.3:

PATH 1 SENSITIVITY TRANSIENT RESULTS
-
SOUTHERN ALBERTA GENERATION

APPENDIX I:

SWITCHING SEQUENCES