Final Report
REDACTED

Transmission System Reliability Investigation

Emera Maine Reliability Solutions

Study Report

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Executive Summary

Note: This Study report has been prepared for Emera Maine on a portion of its transmission system formerly known as the Maine Public Service Company, which is now operating as the Maine Public District of Emera Maine. The report references this transmission system as "Maine Public Service" or "MPS".

The Maine Public Service (MPS) transmission and distribution system is electrically interconnected to the rest of the United States through the Canadian transmission system in New Brunswick. The MPS system has a combination of internal generation and interconnection tie lines with New Brunswick Power (NBP), who acts as the balancing authority for the entire Maritimes control area and ensures that energy and capacity are available for MPS customers. MPS' transmission system was designed around the historic, integrated-utility model in which generation and transmission were both owned and operated by the utility. The transmission system is dependent on the internal generation as well as the external interconnections for meeting system reliability standards. Over time, internal generators have retired or ceased operation to the extent that the system reliability is being threatened. The continued reduction of internal generation is driving the potential use of load shedding immediately following first contingency transmission outages.

The MPS system can be operated in two modes; interconnected to New Brunswick or with the northern portion served radial from Hydro Quebec and the southern portion served radial from New Brunswick through the Tinker T1 and Flo's Inn T1 138/69 kV transformers. When in radial mode the MPS system is essentially split into two parts. Concern over the impact on system reliability of this radial operating mode in combination with the continued reduction of internal generation has prompted an analysis to examine system reliability and the feasibility of various alternatives to address the existing and future reliability concerns of the MPS system.

RLC Engineering, LLC (RLC) was requested to prepare an assessment of the existing reliability needs of the MPS transmission system, the feasibility of six alternatives for interconnection with New England, the feasibility of eleven alternatives for additional transmission support from New Brunswick, and the feasibility of one internal generation alternative to address the identified needs. The needs assessment analyzed steady state voltage and thermal performance of the Maine Public Service (MPS) transmission system at forecasted 2013 summer and winter peak load levels following single and multiple element contingencies. Maine Public Utilities Commission (MPUC) Safe Harbor assumptions were applied to MPS generation; hydro was modeled at peak day typical output, wind generation was assumed at ten percent of name plate, and Fort Fairfield was assumed out-of-service. Both the interconnected and radial operating modes were tested. In addition, Maintenance Outage Analysis examined single element contingencies for four facility maintenance outages at 85% of peak load levels, consistent with MPUC Safe Harbor planning criteria. FERC Order No. 743 establishes a new definition of bulk electric system (BES) to include all transmission facilities operated at or above 100 kV, except defined radial facilities. To examine conformance to these heightened FERC standards, analysis included initial outage of the 138 kV lines that supply the MPS system.

Needs Assessment
The MPS transmission system reliability evaluation identified areas of weak performance and demonstrated the following key concerns.

First contingency (N-1) analysis of the interconnected configuration identified the following reliability concerns for the MPS system due to loss of a single transmission element:

1. Flo's Inn T1 138/69 kV transformer or 138 kV Line 3855 – The Flo's Inn T1 138/69 kV transformer is in series with the 138 kV Line 3855/1176 from NBP's Beechwood Substation which provides an interconnection between the NBP and MPS systems.
    - At the winter peak load level, interruption of this interconnection results in violations of the 0.90 pu low voltage criteria (prior to automatic system adjustments) along the radial 44 kV path from Mullen to Sherman. Voltages return to acceptable levels after the second 34.5 kV 5.4 MVAR Mullen capacitor switches in and automatic load tap changers adjust.
    - At the winter peak load level, loss of Flo's Inn T1 138/69 kV transformer shows thermal loading on the Tinker T1 138/69 kV transformer at 102% of the 72 MVA LTE rating.
    - At the summer peak load level, loss of Flo's Inn T1 138/69 kV transformer shows 69 kV Line 6901 (Tinker – ReEnergy Tap/Interfai) thermal loading at 102% of the 48 MVA LTE rating.

When operated in the radial configuration, the MPS system is split. The northern portion of the MPS system is interconnected to NBP by 69 kV Lines 88 and 89 from Iroquois Substation which is supplied radial from Hydro Quebec via 345 kV Line 3113 from Madawaska to Edmundston. This radial configuration ties northern Maine synchronously with HQ and totally isolated from the rest of the eastern interconnected system. This configuration also provides additional import capability into NBP from HQ. The southern portion of the MPS system is interconnected to NBP by two 138/69 kV transformers, one at Flo's Inn which is supplied radial on 138 kV Line 3855 from Beechwood and one at Tinker which is supplied radial on 138 kV Line 1144 which taps Line 1111 between Beechwood and Grand Falls.

N-1 analysis of the radial configuration identified the following reliability concerns for the MPS system due to loss of a single transmission element:

1. Flo's Inn T1 138/69 kV transformer or 138 kV Line 3855 – When in radial mode, loss of the Flo's Inn T1 138/69 kV transformer or 138 kV Line 3855 leaves one interconnection between NBP and the southern portion of the MPS system, the Tinker T1 138/69 kV transformer.
    - At the winter peak load level, this single element contingency reports voltage collapse within the MPS system.
    - At the summer peak load level, loss of Flo's Inn T1 138/69 kV transformer shows several thermal overloads
        - Tinker T1 138/69 kV transformer at 117% of the 72 MVA LTE rating.
        - 69 kV Line 6901 at 117% (Tinker – Fort Fairfield) and 112% (Fort Fairfield – ReEnergy Tap/Interfai) based on the 48 MVA LTE rating.
2. 138 kV Line 1111/1144 – The Tinker T1 138/69 kV transformer is in series with 138 kV Line 1144 which is tapped from 138 kV Line 1111 between Grand Falls and Beechwood. Therefore, a fault along 138 kV Line 1111/1144 interrupts Tinker T1 138/69 kV transformer and leaves the southern portion of the MPS system supplied by a single interconnection from Beechwood to Flo's Inn. At the winter peak load level, loss of 138 kV Line 1111/1144 results in violations of the 0.95 pu low voltage criteria at the 138 kV Flo's Inn bus.

3. Keswick T4 345/138 kV transformer – The Keswick T4 345/138 kV transformer is a major supply to the MPS system. At the winter peak load level, loss of the Keswick T4 345/138 kV transformer results in violations of the 0.95 pu low voltage criteria at the 138 kV Flo's Inn bus.

4. 345 kV Line 3113– When in radial mode, the two Edmundston 345/138 kV transformers are supplied radial on the 345 kV Line 3113 from Hydro Quebec's Madawaska Substation. Edmundston Substation in turn supplies a pocket of radial load which includes a portion of the western region of NBP's system and the northern portion of the MPS system. Interruption of Line 3113 consequentially isolates this pocket of radial load. For the 2013 load forecast, there is approximately 22.8 MW of consequential load loss at the winter peak load level, and 19.7 MW at summer peak. This loss of load is currently within the loss of load criteria.

Second contingency (N-1-1) analysis of the proposed Bulk Electric System facilities was performed to examine the interconnected configuration with initial outage of one of the two 138 kV Lines that supply the MPS system followed by a contingency. The primary concern identified from this assessment was coincident outage of the 138 kV Line 1111/1144 and Line 3855/1176. Initial outage of one 138 kV Line followed by loss of the other interrupts the two interconnections from NBP to the southern portion of the MPS system. The NBP system is subsequently unable to support the entire MPS system from the two northern interconnections at Iroquois. Voltage collapse occurs for all peak load conditions examined in this assessment.

Maintenance Outage Analysis of the four 138/69 kV transformers that support the MPS system was performed assuming the interconnected configuration for load levels at 85% of peak forecasted conditions. Several key MPS reliability concerns were identified for the four outage conditions:

1. Coincident Outage of Flo's Inn T1 and Tinker T1 138/69 kV Transformers – Initial outage of one 138/69 kV transformer followed by loss of the other 138/69 kV transformer interrupts the two interconnections from NBP to the southern portion of the MPS system. The resulting configuration leaves the entire MPS system supplied from the two northern 69 kV line interconnections at Iroquois. The NBP system is unable to support the MPS system at the 85% load level, resulting in voltage collapse for the conditions examined in this assessment.

2. Coincident Outage of Flo's Inn T1 138/69 kV Transformer and 69 kV Line 6901 Initial outage of Flo's Inn T1 138/69 kV transformer followed by loss of 69 kV Line 6901 from Tinker to Flo's Inn results in severely depressed voltages within MPS and potential voltage collapse for the conditions examined in this assessment.

3. Coincident Outage of Iroquois T1 & T2 138/69 kV Transformers – Initial outage of one Iroquois 138/69 kV transformer followed by loss of the other places additional burden on the southern interconnections between NBP and MPS. The Tinker T1 and Flo's Inn T1 138/69 kV transformers are forced to supply the entire MPS system load in addition to the NBP load served from Iroquois Substation. For the conditions examined in this assessment, voltage collapse occurs if the under voltage load shed scheme on 69 kV Lines 70 and 72 is not activated. With activation of the UVLS, low voltage remains for some conditions.

4. Thermal Overloads for Outage of Flo's Inn T1 138/69 kV Transformer - Within the MPS 69 kV system there is a looped path that connects the Tinker, Limestone, Caribou and Flo's Inn Substations. With Flo's Inn T1 138/69 kV transformer out of service, the Tinker T1 138/69 kV transformer is the primary supply to this 69 kV loop.
   - For the winter load level, Tinker T1 138/69 kV transformer pre-contingency loading was 113% of the 53 MVA normal rating.
   - For the summer conditions, loss of any segment of the 69 kV loop causes a thermal overload of Line 6901 between Tinker and the ReEnergy Tap/Interfai based on the 48 MVA LTE rating.

5. Thermal Overloads for Outage of Iroquois T1 or T2 138/69 kV Transformers - Initial outage of either Iroquois transformers followed by the loss of Flo's Inn T1 138/69 kV transformer places burden on the Tinker T1 138/69 kV transformer. The Tinker T1 138/69 kV transformer is forced to supply the entire

southern MPS system, for the winter load level, the Tinker T1 138/69 kV transformer was loaded as high as 109% of its LTE rating of 72 MVA.

Additional discussions of the Needs Assessment are included in Section 5.

New England Alternatives Assessment

The Study tested six configurations for interconnection with the Maine electric grid to address the MPS reliability issues reported in the Needs Assessment (M1 – M6):

- M1: Tap the 345 kV Line 3001 at Haynesville, add a step-down autotransformer to 115 kV, build new 115 kV transmission along the Bridal Path to Mullen, add a step-down transformer to 69 kV and tie to the existing MPS transmission system.
- M2: Same as M1 except Haynesville step-down autotransformer to 69 kV, build new 69 kV transmission along Bridal Path to Mullen.
- M3: Same as M1 except also tie in the First Wind Oakfield Wind Project with a tap.
- M4: Same as M1 except build new 345 kV line and move transformation from the Haynesville tap to Mullen.
- M5: Extend the planned and permitted First Wind Oakfield Wind Project 115 kV transmission line to Mullen, add a step-down transformer to 69 kV to tie to existing MPS transmission system, and expand the First Wind substation to a ring bus. The step-down substation at Mullen similar to M1.
- M6: Same as M5 except Oakfield Wind Project 115 kV transmission line upgraded to 345 kV, add a step–down transformer to 69 kV to tie to existing MPS transmission system, and expand the First Wind substation to a ring bus. The step-down substation at Mullen similar to M1.

The following observations were made in regard to the impact of the New England interconnection alternatives on the key MPS reliability concerns demonstrated in the Needs Assessment:

Impact on N-1 Reliability Concerns:

- In the interconnected configuration, all six New England interconnections address the MPS voltage concerns, and thermal loading concerns of the Tinker T1 138/69 kV transformer and 69 kV Line 6901 identified for loss of Flo's Inn T1 138/69 kV transformer or 138 kV Line 3855.
- In the radial configuration, all six New England interconnections address the voltage collapse and thermal overloads of the Tinker T1 138/69 kV transformer and 69 kV Line 6901 for loss of the Flo's Inn T1 138/69 kV transformer or 138 kV Line 3855.
- In the radial configuration, all six New England interconnections address the low voltage concerns for loss of the 138 kV Line 1111 or Keswick T4 345/138 kV transformer.
- All six New England interconnections require further analysis to examine appropriate coordination of the various voltage reactive devices in the Haynesville/Mullen area.
    - In general, M4 and M6 the 345 kV interconnections require the most coordination, and the 69 kV interconnection requires the least amount of coordination.
- All six New England interconnections require additional reactive support at the 69 kV Flo's Inn bus.
- M3, M5 and M6 which all include an Oakfield interconnection, require upgrade of 69 kV Line 6910 (Mullen – Monticello Tap – Bridgewater Tap) to provide adequate thermal capacity with Oakfield wind generation online for contingencies that leave Oakfield generation feeding directly into MPS.
- In the radial configuration, none of the alternatives address the consequential loss of the northern MPS system due to contingencies involving 345 kV Line 3113. For the 2013 load forecast this equates to approximately 22.8 MW of lost load at winter peak and 19.7 MW at summer peak. This is currently within the loss of load criteria.
- In general, all six New England alternatives provide equal support for the multiple element contingencies analyzed.

Impact on N-1-1 Reliability Concerns:

- All six New England interconnection alternatives improve system performance for the N-1-1 coincident outage of the 138 kV Lines 3855 and 1111 to a reliable level.
    - M1 – M4 which interconnect with 345 kV Line 3001 provide a stronger supply of power than M5 or M6 which interconnect further away at Keene Road Substation (assuming Oakfield wind offline). The strongest support is provided by the 345 kV alternative with the 115 kV and 69 kV alternatives providing less support than the 345 kV option, in that order.
- In general all six New England alternatives provide equal support for the remainder of the N-1-1 conditions analyzed:
    - Coincident outage of 138 kV Line 1111 and 345 kV Keswick 3-6 stuck breaker results in voltage collapse for M1 – M4. A 345 kV series breaker would eliminate this voltage collapse.

Impact on Maintenance Outage Reliability Concerns:

- All six New England interconnections eliminate the voltage collapse and thermal concerns seen in the Needs Assessment for the maintenance conditions analyzed.

The New England alternatives ameliorate all of the MPS reliability concerns identified in the Needs Assessment for single element contingencies. M3, M5 and M6 require thermal upgrade of 69 kV Line 6910 to provide adequate thermal capacity with Oakfield wind generation online. Minimal additional upgrades are required to address the MPS reliability concerns due to multiple element contingencies. Additional discussions of the New England alternatives are included in Section 6.

New Brunswick Alternatives Assessment
The Study tested four configurations for interconnection with New Brunswick Power to address the MPS reliability issues reported in the Needs Assessment (N1 - N4):

- N1: Upgrade the Tinker T1 138/69 kV Transformer to 100 MVA.
- N2: Additional Transformation from St. Andre 138 kV to Limestone 69 kV.
- N3: Additional Transformation from Tinker 138 kV to Fort Fairfield 69 kV.
- N4: Additional Transformation from Beechwood 138 kV to Mars Hill 69 kV.

The following observations were made in regard to the impact of the New Brunswick interconnection alternatives on the key MPS reliability concerns demonstrated in the Needs Assessment:

Impact on N-1 Reliability Concerns:

- In the interconnected configuration, all four New Brunswick alternatives address the low voltage concerns and the thermal loading concerns of the Tinker T1 138/69 kV transformer identified for loss of Flo's Inn T1 138/69 kV transformer or 138 kV Line 3855.
    - The Limestone alternative (N2) and the Mars Hill alternative (N4) eliminate the 69 kV Line 6901 thermal overload for the Flo's Inn T1 138/69 kV transformer contingency.
- In the radial configuration, for the single element loss of 138 kV Line 3855 or the Flo's Inn T1 138/69 kV transformer:
    - All four New Brunswick alternatives address the N-1 voltage collapse concerns of the underlying MPS system.
    - All four New Brunswick alternatives resolve the thermal overloads of the Tinker T1 138/69 kV transformer.
    - The Tinker Upgrade alternative (N1) results in a thermal overload of 138 kV Line 1144.
    - The Fort Fairfield alternative (N3) does not eliminate the thermal overloads of 69 kV Line 6901 (Fort Fairfield – ReEnergy Tap/Interfai).
- In the radial configuration, all four New Brunswick alternatives address the low voltage concerns for loss of 138 kV Line 1111 or the Keswick T4 345/138 kV transformer.
- In the radial configuration, none of the New Brunswick alternatives address the consequential loss of the northern MPS system due to contingencies involving 345 kV Line 3113. For the 2013 load forecast this equates to approximately 22.8 MW of lost load at winter peak and 19.7 MW at summer peak. This loss of load is currently within the loss of load criteria.
- In general, all four New Brunswick alternatives provide equal support in the interconnected configuration for multiple element contingencies.
- In general, the N2 New Brunswick alternative provides superior support in the radial configuration for multiple element contingencies.
    - N1, N3 and N4 report voltage collapse for 138 kV Beechwood bus fault or stuck breakers.

Impact on N-1-1 Reliability Concerns:

- N3 and N4, the Fort Fairfield and Mars Hill alternatives completely eliminate the MPS voltage concerns identified in the Needs Assessment for the N-1-1 coincident outage of the 138 kV Lines 3855 and 1111.
    - Since the Tinker alternative (N1) merely upgrades the Tinker T1 138/69 kV transformer, the alternative does not resolve MPS reliability concerns identified for loss of the transformer.
    - N2, the Limestone alternative addresses the voltage collapse concern; however it does not improve post-contingency voltages to levels above 0.95pu. Additional reactive support is required within MPS.
    - N3, the Fort Fairfield alternative results in an overload of 69 kV Line 6901 (Fort Fairfield – ReEnergy Tap/Interfai) for this coincident outage.
- In general, N2 and N4 outperform N1 and N3 for coincident single element outages.

    - N1 and N3 report voltage collapse for numerous 138 kV Line 3855 coincident outages.
- In general, N2 out performs N4 for coincident multiple element outages.
    - N4 connects directly to the 138 kV Beechwood Substation. Any stuck breaker or bus fault results in voltage collapse.

Impact on Maintenance Outage Reliability Concerns:

- Since the N1 Tinker alternative merely upgrades the Tinker T1 138/69 kV transformer, the alternative does not resolve MPS reliability concerns identified for loss of the Tinker T1 138/69 kV transformer.
    - Voltage collapse was reported for the coincident outage of the Flo's Inn T1 and Tinker T1 138/69 kV transformers.
- Alternatives N2 – N4 address the MPS reliability concerns for the coincident outage of the Flo's Inn T1 and Tinker T1 138/69 kV transformers.
- N4, the Mars Hill alternative is the only alternative that resolves the Flo's Inn T1 138/69 kV transformer maintenance outage with the 69 kV Line 6901 contingency:
    - The Tinker, Limestone and Fort Fairfield alternatives do not resolve the voltage collapse concern or thermal overloads.

None of the New Brunswick alternatives, as originally defined, ameliorate all of the MPS reliability concerns identified in the Needs Assessment. Additional upgrades are required to address reliability concerns within the MPS system. Further discussions for the New Brunswick alternatives are included in Section 7.

New Brunswick Power Alternatives Assessment
The Study tested an additional eight configurations for interconnection with New Brunswick Power to address the MPS reliability issues reported in the Needs Assessment (P2 – P8):

- P2: Additional Transformation from Woodstock 138 kV to Mullen 69 kV.
- P3: Additional Transformation from Beechwood 138 kV to Flo's Inn 69 kV.
- P4: Additional Transformation from Tinker 138 kV to Flo's Inn 69 kV.
- P4a: Additional Transformation from Tinker 138 kV to Flo's Inn 69 kV, Looped in and out of Tinker.
- P5: Additional Transformation From Grand Falls 138 kV to Limestone 69 kV.
- P6: Additional Transformation from St. Andre 138 kV to Limestone 69 kV.
- P7: Convert 69 kV Line 6901 to 138 kV, Tinker to Fort Fairfield.
- P8: Additional Transformation from Tinker 138 kV to Fort Fairfield 69 kV.

The following observations were made in regard to the impact of the New Brunswick Power interconnection alternatives on the key MPS reliability concerns demonstrated in the Needs Assessment:

Impact on N-1 Reliability Concerns:

- In the interconnected configuration, all eight New Brunswick Power alternatives address the low voltage concerns and the thermal loading concerns of the Tinker T1 138/69 kV transformer identified for loss of Flo's Inn T1 138/69 kV transformer or 138 kV Line 3855.
    - The Line 6901 rebuild alternative, P7 and Tinker to Fort Fairfield alternative, P8 did not eliminate the 69 kV Line 6901 thermal overload for the Flo's Inn T1 138/69 kV transformer contingency (Fort Fairfield – ReEnergy Tap/Interfai).
- In the radial configuration, for single element loss of 138 kV Line 3855 or the Flo's Inn T1 138/69 kV transformer:
    - All eight New Brunswick Power alternatives address the N-1 voltage collapse concerns of the underlying MPS system.
    - All eight New Brunswick Power alternatives resolve the thermal overloads of the Tinker T1 138/69 kV transformer.
    - P4, P7 and P8 result in a thermal overload of 138 kV Line 1144.
    - P7 and P8 result in thermal overload of 69 kV Line 6901 (Fort Fairfield – ReEnergy Tap/Interfai).
- In the radial configuration, all eight New Brunswick Power alternatives address the low voltage concerns for loss of 138 kV Line 1111 or the Keswick T4 345/138 kV transformer.
    - P4a results in thermal overload of 138 kV Line 1144.
- In the radial configuration, none of the New Brunswick Power alternatives address the consequential loss of the northern MPS system due to contingencies involving 345 kV Line 3113. For the 2013 load forecast this equates to approximately 22.8 MW of lost load at winter peak and 19.7 MW at summer peak. This loss of load is currently within the loss of load criteria.
- In general, seven New Brunswick Power alternatives provide equal support in the interconnected configuration for multiple element contingencies.
    - P3 reports voltage collapse for a 138 kV Beechwood stuck breaker or bus fault. A rebuild of the Beechwood Substation is required to eliminate this.
    - P2 requires a 138 kV 1126-1 series breaker at Beechwood to eliminate voltage collapse.
- In general, six New Brunswick Power alternatives provide equal support in the radial configuration for multiple element contingencies:
    - P3 and P7 report voltage collapse for a 138 kV Beechwood stuck breaker or bus fault. A rebuild of the Beechwood Substation is required to eliminate this.
    - P2 requires a 138 kV 1126-1 series breaker at Beechwood to eliminate voltage collapse.

Impact on N-1-1 Reliability Concerns:

- P2, P3, P4a and P6 completely eliminate the voltage concerns identified in the Needs Assessment for the N-1-1 coincident outage of the 138 kV Lines 3855 and 1111.
    - P4, P5, P7 and P8 still result in voltage collapse.
- In general, P2, P3 and P4a outperform the others for coincident single element outages.
    - P4, P5, P7 and P8 result in voltage collapse for the coincident outage of 138 kV Lines 3855 and 1111, as well as other coincident outages.
    - P6 results in voltage collapse for the coincident outage of 138 kV Line 3855 and 69 kV Line 6901.
    - P4a results in voltage collapse for the coincident outage of 138 kV Line 1111 north and Keswick T4 345/138 kV transformer.
- In general, P2 out performs P3 and P4a for coincident multiple element outages.
    - P3 and P4a report voltage collapse for numerous coincident outages of 138 kV Line 1111 and 345 kV Keswick stuck breakers, as well as 138 kV Beechwood stuck breakers.

Impact on Maintenance Outage Reliability Concerns:

- Since P7 and P8 New Brunswick Power alternatives do not add any additional support to MPS, these alternatives do not resolve MPS reliability concerns identified for loss of the Tinker T1 138/69 kV transformer. P4 taps the 138 kV Line 1111, and therefore does not address the MPS reliability concerns for loss of the Tinker T1 138/69 kV transformer either.
    - Voltage collapse was reported for coincident outage of the Flo's Inn T1 and Tinker T1 138/69 kV transformers for P4, P7 and P8.
- Alternatives P2, P3, P4a, P5 and P6 address the MPS reliability concerns for the coincident outage of the Flo's Inn T1 and Tinker T1 138/69 kV transformers.
- Alternatives P2 – P4a are the only alternatives that resolve the Flo's Inn T1 138/69 kV transformer maintenance outage with the 69 kV Line 6901 contingency:

None of the New Brunswick Power alternatives, as originally defined, ameliorate all of the MPS reliability concerns identified in the Needs Assessment. Additional upgrades are required to address reliability concerns within the MPS system. Further discussions for the New Brunswick Power alternatives are included in Section 8.

MPS Generation Assessment
The Study evaluated additional generation within MPS. Consistent with ISO-NE, NPCC and NERC planning criteria, two generators were modeled, one of which was always assumed out of service. The MPS Generator which was modeled in-service was 30 MW at Ashland Substation.

The following observations were made in regard to the impact of the MPS Generation on the key MPS reliability concerns demonstrated in the Needs Assessment:

Impact on N-1 Reliability Concerns:

- In the interconnected configuration, the MPS Generation addresses the MPS voltage concerns, and thermal loading concerns of the Tinker T1 138/69 kV transformer and 69 kV Line 6901 identified for loss of Flo's Inn T1 138/69 kV transformer or 138 kV Line 3855.
- In the radial configuration, the MPS Generation addresses the voltage collapse and thermal overloads of the Tinker T1 138/69 kV transformer and 69 kV Line 6901 for loss of the Flo's Inn T1 138/69 kV transformer or 138 kV Line 3855.
- In the radial configuration, the MPS Generation addresses the low voltage concerns for loss of the 138 kV Line 1111 or Keswick T4 345/138 kV transformer.
- In the radial configuration, the MPS Generation does not address the consequential loss of the northern MPS system due to contingencies involving 345 kV Line 3113. For the 2013 load forecast this equates to approximately 22.8 MW of lost load at winter peak and 19.7 MW at summer peak. This is currently within the loss of load criteria.
- The MPS Generation eliminates all reliability violations for N-1 single and multiple element contingencies.

Impact on N-1-1 Reliability Concerns:

- The MPS Generation does not eliminate the voltage collapse reported for the coincident outage of the 138 kV Line 3855 and 138 kV Line 1111.
- Additional reactive support within MPS is required to eliminate low voltages reported for numerous coincident outages.
- Voltage collapse was reported for the coincident outage of 138 kV Line 1111 and 138 kV Beechwood stuck breakers.
- Numerous multiple element coincident outages reported low voltages throughout MPS.

Impact on Maintenance Outage Reliability Concerns:

- The MPS Generation eliminated the voltage collapse and thermal concerns seen in the Needs Assessment for the maintenance conditions analyzed.

The MPS Generation alternative did not ameliorate all of the MPS reliability concerns identified in the Needs Assessment for single element contingencies. These issues as well as those associated with multiple element contingencies are discussed in Section 9.

From each of the four alternative groups discussed above, one or two alternatives were chosen as preferred. The following tables summarize the impacts of these preferred alternatives on the major reliability concerns identified in the Needs Assessment of the existing MPS system for single element contingencies. This report, and all appendices, supersedes any previous documentation in regards to this study.

Summary of Alternatives' Impact on Reliability Concerns 2013	New England Interconnection	New Brunswick Power Interconnections			Generation
	M1 Haynes. 115 kV	N2 St Andre to Limestone	P2 Woodstock to Mullen	P4a Tinker to Flo's Inn Looped	Ashland 30 MW
N-1 Condition - Single Element Contingencies					
Interconnected Mode					
345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O
Issues created by Alternatives					
345 kV Line 3001					
Keswick T4 345/138 kV Transformer				T (1144)	
Radial Mode					
Keswick T4 345/138 kV Transformer	O	O	O	T (1144)	O
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O
Impact on MPS System Performance: O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain FI = Low Voltage Violations at 138 kV Flo's Inn bus only MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust (A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations T = Thermal Overloads Remain VC = Voltage Collapse Concern Remains (thermal concern not noted)					

Table 1-1 Preferred Alternatives - N-1 Single Element Contingencies Results

Summary of Alternatives' Impact on Reliability Concerns 2013	New England Interconnection	New Brunswick Power Interconnections			Generation
	M1	N2	P2	P4a	Ashland
	Haynes. 115 kV	St Andre to Limestone	Woodstock to Mullen	Tinker to Flo's Inn Looped	30 MW
N-1-1 Condition - Single Element Contingencies					
138 kV Line 3855 & 138 kV Line 1111/1144	O	LV (A)	O	O	VC, T (88 & 89)
138 kV Line 3855 & 345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
138 kV Line 3855 & Keswick T4 345/138 kV Transformer	O	O	O	T (1144)	O
138 kV Line 3855 & 69 kV Line 6901	O	VC	O	O	O
138 kV Line 3855 & Mullen Shunt	O	LV (A)	O	O	LV (A)
138 kV Line 1111/1144 & 138 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	N & S –VC, N & S LV (F) with UVLS	VC - OK with UVLS
138 kV Line 1111/1144 & Keswick T4 345/138 kV Transformer	FI (A)	FI (A), T (6911)	T (88 & 89)	N - VC, S - T (1144)	FI (A)
138 kV Line 1111/1144 & 138 kV Line 1125-72	O	O	O	O	O
138 kV Line 1111/1144 & Mullen Shunt	O	LV (A)	O	O	LV (A)
138 kV Line 1111/1144 & numerous contingencies (base)	O	O	O	O	O
Issues created by Alternatives					
138 kV Line 3855 & 345 kV Line 3011				T (11442)	
138 kV Line 3855 & 69 kV Line 6903		T (6901)			
138 kV Line 3855 & 69 kV Line 6905		T (Tinker)			
138 kV Line 3855 & 69 kV Line 6920					LV (A)

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 1-2 Preferred Alternatives - N-1-1 Single Element Contingencies Results

Summary of Alternatives' Impact on Reliability Concerns 2013	New England Interconnection	New Brunswick Power Interconnections			Generation
	M1 Haynes. 115 kV	N2 St Andre to Limestone	P2 Woodstock to Mullen	P4a Tinker to Flo's Inn Looped	Ashland 30 MW
Maintenance Condition					
Flo's Inn T1 & Tinker T1 138/69 kV Transformers	O	MC	O	O	T (88 & 89)
Tinker T1 138/69 kV Transformer & 345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV & 345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Iroquois T1 or T2 138/69 kV Transformer & 345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Iroquois T1 or T2 & Iroquois T2 or T1 138/69 kV Transformers (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer & 345 kV Line 3011	O	O	O	T (11442)	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6901	O	VC, T (6904)	O	O	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6903	O	O	O	O	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6904	O	T (6901)	O	O	O
Flo's Inn T1 138/69 kV Transformer & Mullen/Ashland Shunt	O	O	O	O	O
Issues created by Alternatives					
Tinker T1 or Flo's Inn T1 or Iroquois T1 or Iroquois T2 138/69 kV Transformer & Keswick T4 345/138 kV Transformer				T (1144)	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 1-3 Preferred Alternatives - Maintenance Contingencies Results

Section 2
Introduction and Background Information

2.1 Background

The Maine Public Service (MPS) transmission and distribution system is electrically interconnected to the rest of the United States through the Canadian transmission system in New Brunswick. The MPS system has a combination of internal generation (privately owned to help ensure competition for energy within the state of Maine) and interconnection tie lines with New Brunswick Power (NBP), who acts as the balancing authority for the entire Maritimes control area and ensures that energy and capacity are available for MPS customers. As MPS' transmission system was designed around the historic, integrated-utility model in which generation and transmission were both owned and operated by the utility, it is dependent on the internal generation as well as the external interconnections for meeting its system reliability. Over time, internal generators have retired or ceased operation to the extent that the system reliability is being threatened.

As an example, recent studies in 2010 and 2012 by the Northern Maine Independent System Administrator (NMISA) have concluded that capacity issues exist on the Northern Maine Transmission System (NMTS) which consists of the MPS system and portions of the Eastern Maine Electric Coop (EMEC) system that are fed from MPS. Due to recent retirement/mothballing of the Sherman biomass generator (19 MVA) and the Ashland biomass generator (34 MVA), a load shedding scheme was implemented and capacitors were added on 69 kV Line 6910 near Mullen.

2.2 Study Objective

RLC performed this transmission reliability assessment to analyze steady state voltage and thermal performance of the Maine Public Service (MPS) transmission system. The study examined system performance at summer and winter peak load levels following single contingencies on the MPS, NBP and ISO-NE systems as well as multiple element contingencies on the NBP and ISO-NE systems. Single and multiple element contingencies were evaluated for various system configurations including all lines in-service and the initial outage of one of the two 138 kV lines that connect NBP and MPS (3855 or 1111/1144). Single element contingencies were examined for four facility maintenance outages at 85% of peak load levels.

FERC Order No. 743 establishes a new definition of bulk electric system (BES) to include all transmission facilities operated at or above 100 kV, except defined radial facilities. To examine conformance to these heightened FERC standards, analysis included initial outage of two 138 kV lines that supply the MPS system.

RLC also performed a transmission alternatives assessment to examine the impact and feasibility of eighteen transmission upgrade alternatives, and one generation alternative to address the needs of the MPS system. Of the eighteen transmission alternatives, six include creating a connection between the MPS system and some part of the Maine electric grid while the remaining twelve alternatives include upgrading an existing or adding an additional interconnection between the MPS and NBP systems.

The need for this study effort was driven by continued reduction of internal generation which creates reliability concerns within MPS. Following first contingency transmission outages, voltage and thermal violations exist and the potential use of load shedding could be required with today's configuration.

2.3 Assumptions, Methodology and Criteria

The study was performed consistent with MPS transmission planning criteria, and where applicable the Northeast Power Coordinating Council Directory 1, "*Basic Criteria for Design and Operation of Interconnected Power*

Systems," and ISO New England Planning Procedure No. 3, *"Reliability Standards for the New England Area Bulk Power Supply System,"* where applicable as well as applicable North American Electric Reliability Corporation (NERC) Reliability Standards. The BES definition as presently understood, though it has not been fully implemented, was also included.

Base cases were developed from the ISO-New England (ISO-NE) Planning Advisory Committee list of available FERC 715 data on the ISO-NE website. The MPS transmission system was modeled in detail for peak load conditions under a reasonably stressed generation dispatch. Selected single element contingencies on the MPS, NBP and ISO-NE transmission systems and multiple element contingencies on the NBP and ISO-NE transmission systems were simulated using standard modeling techniques and solution parameters. Results are tabulated for analysis of reliability violations and for assessment of upgrade alternatives.

The MPS electric transmission system was modeled to include its 34.5 kV, 46 kV and 69 kV lines and substation transformers. The ISO-NE system was modeled based on the bulk system model developed by ISO-NE and its member Transmission Owners for grid studies. NBP's 345, 230, 138 and 69 kV transmission system was included in this model. The Maine transmission system included the full MPRP build out as well as First Wind's Oakfield Project as approved by ISO-NE. The study tested with a base of year 2013 to identify the reliability needs of the existing MPS system and the feasibility of the transmission alternatives.

2.4 Study Area(s)

The area under study consists of the Northern Maine Transmission System (NMTS), the New Brunswick Power (NBP) and the ISO-New England (ISO-NE) bulk power system. The Maine electric systems of Bangor Hydro Electric (BHE) and Central Maine Power (CMP) were considered post-Maine Power Reliability Program (MPRP) and Downeast Reliability Project (DRP). A geographical map of the Maine 345 kV (blue) and 138/115 kV and 69 kV (red) transmission systems is shown in Figure 2-1 below. The Maine Public Service system is circled at the northern tip of Maine.

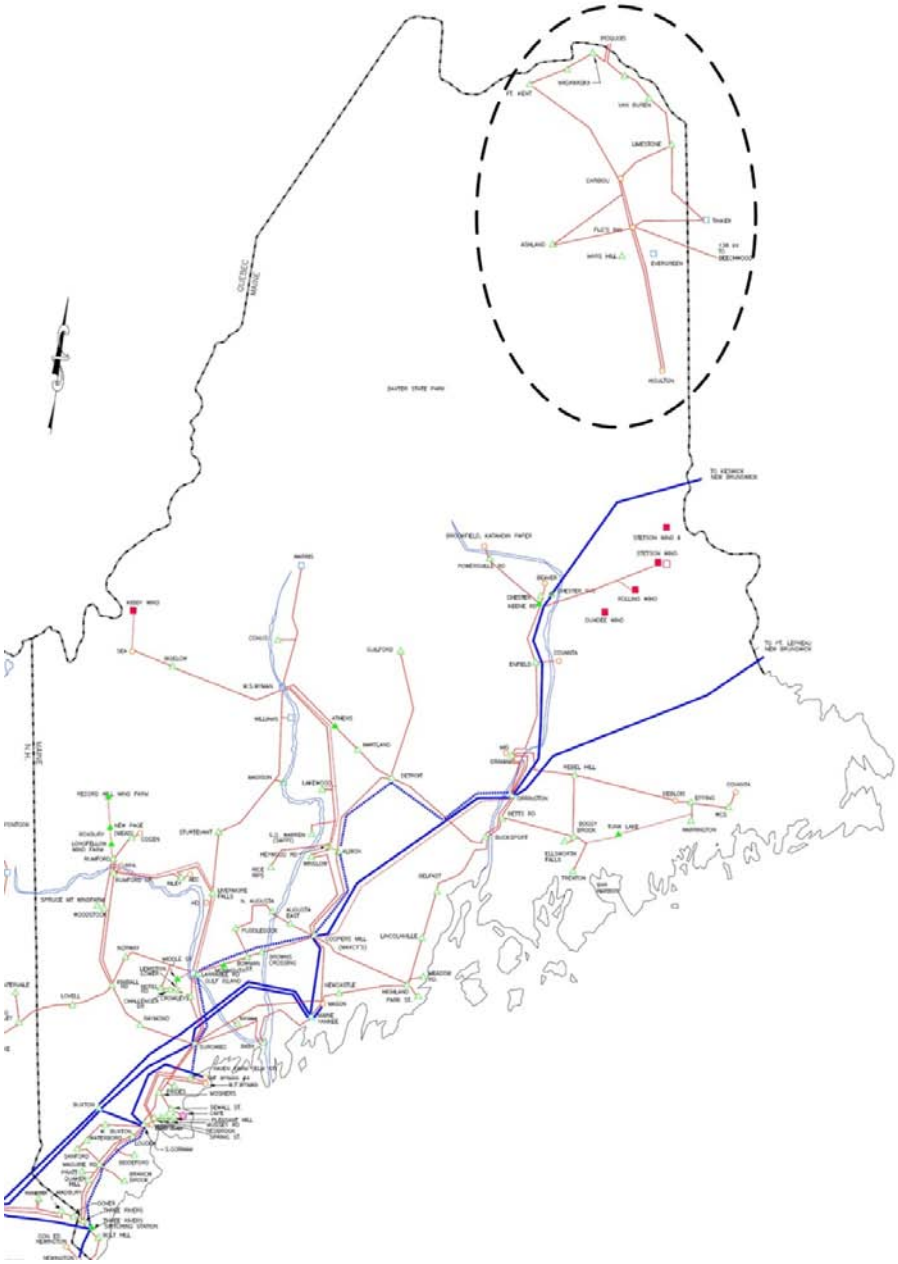
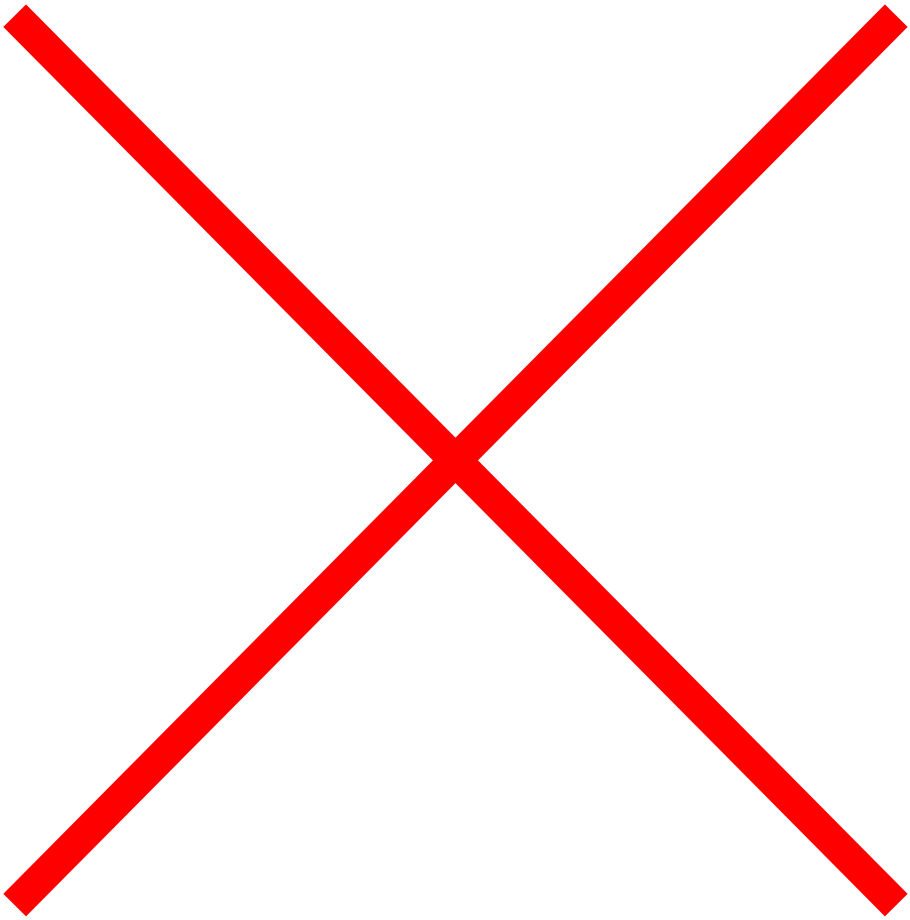


Figure 2-1 Transmission System with MPRP – Maine Public Service Circled

A breaker diagram of the Maine Public Service transmission system is shown in Figure 2-2 below.



REDACTED Diagram
CEII

Figure 2-2 Maine Public Service Transmission System Breaker Diagram

The New Brunswick extra-high voltage (EHV) and high voltage (HV) transmission system consists of approximately 4,200 miles of 345 kV, 230 kV, 138 kV and 69 kV transmission lines. Of interest in this study is the northwestern portion of the province near the Maine Public Service transmission system, and the New Brunswick–Maine transmission interface, including the Northeast Reliability Interconnection (NRI). Currently there are four 69 kV and one 138 kV radial interconnections between New Brunswick and Maine Public Service.

A geographical map of the New Brunswick 345 kV (blue), 230 kV (green), 138 kV (yellow) and 69 kV (red) transmission systems is shown in Figure 2-3 below.

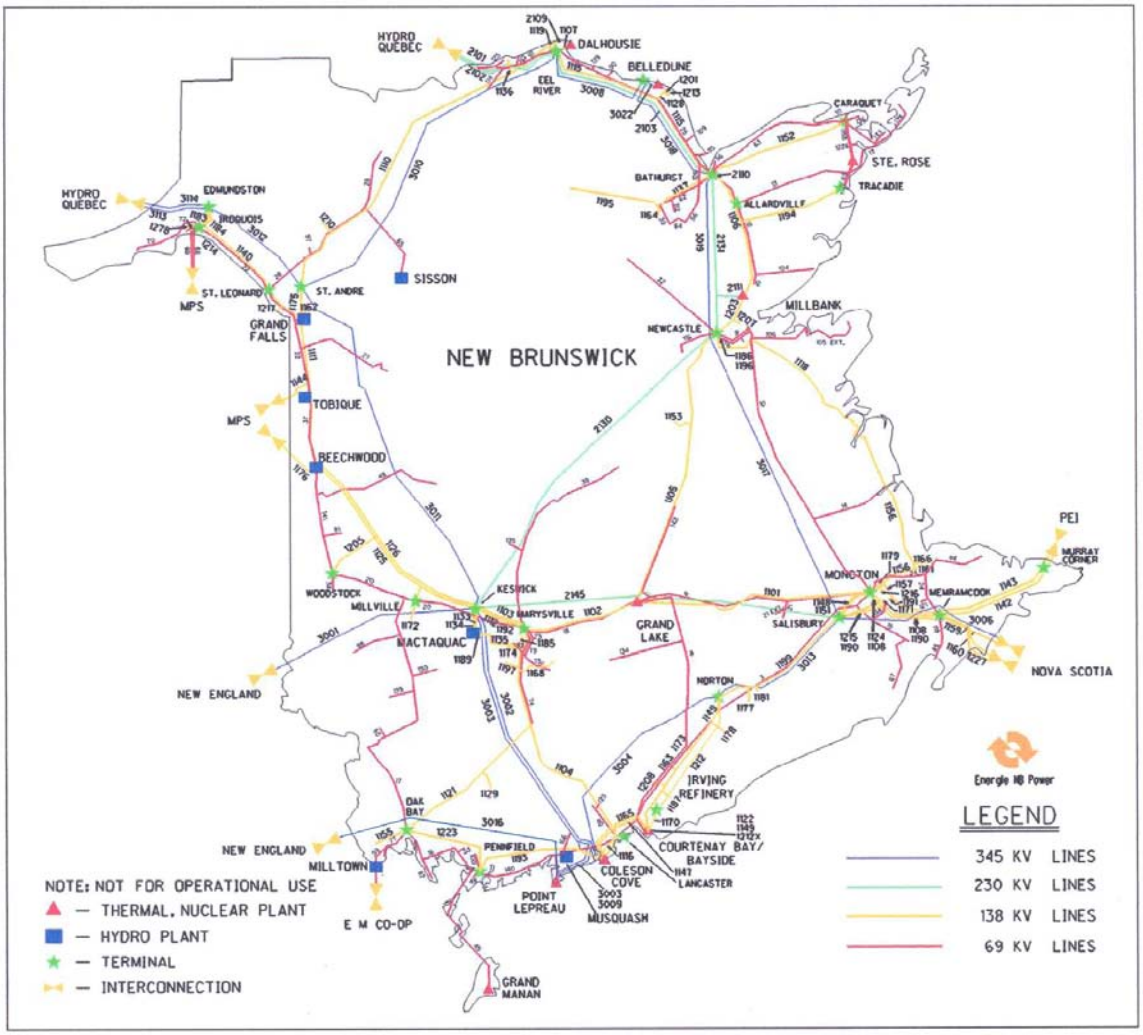


Figure 2-3 New Brunswick Transmission System

2.5 Study Horizon

The study horizon encompassed loads in 2013.

Section 3
Steady State Study Assumptions

3.1 Study Assumptions

RLC performed a steady state analysis of reasonably stressed conditions for single-element and multiple-element contingencies that investigate voltage and thermal performance of the MPS transmission system. Single element contingencies were evaluated on the MPS, NBP and ISO-NE systems, multiple element contingencies were evaluated on the NBP and ISO-NE systems.

Two MPS peak load levels were analyzed; 2013 MPS summer (112 MW) and winter (129 MW) peak load levels as the system exists today. N-1 contingencies and limited N-1-1 conditions were considered. Maintenance outage conditions were analyzed at 85% of peak load levels for year 2013.

3.2 Base Case Development

This Study utilized transmission system power flow models from the Planning Advisory Committee FERC 715 data available on the ISO-NE website. The most recent cases from 2012 were utilized. The NMTS was updated in these models from data provided by MPS.

The FERC 715 transmission model represents the NMTS at the 69 kV, 44 kV and 34.5 kV levels. The distribution step-down transformers were added to the model with loads depicted at the distribution voltage service levels.

In addition, the aggregate model of the Tinker Hydro generation station, included in the FERC 715 model, was replaced with a more detailed representation which included the five individual generators and two generator step-up transformers.

MPS transmission line impedance and thermal ratings were reviewed and updated according to data provided by MPS; the line specifications modeled can be seen in Table 3-1 and Table 3-2 below. The 2013 base cases were updated to represent the existing system topology.

The New Brunswick system was updated according to information provided by New Brunswick Power. Two NBP system capacitors were not modeled properly in the FERC 715 cases, they were updated as listed below:

- 138 kV 37.5 MVAR capacitor at Norton.
- 69 kV 10.8 MVAR capacitor at Bathurst.

Two NBP approved projects were included in the New Brunswick Power System:

- 69 kV 12.6 MVAR capacitor at Ortonville.
- 69 kV Kedgewick Substation upgraded to 138 kV and interconnected on 138 kV Line 1110 between St. Quentin and AVCELL LTD.

New Brunswick Power also specified that for New Brunswick loads greater than 2,500 MW, at least five Mactaquac units must be spinning. For this analysis NBP specified G1-G3 on-line at 201 MW total, G5 and G6 were modeled as Synchronous Condensers.

Line Number	From Bus Number	From Bus Name	To Bus Number	To Bus Name	Line R (pu)	Line X (pu)	Charging (pu)	Summer			Winter		
								Normal (MVA)	LTE (MVA)	STE (MVA)	Normal (MVA)	LTE (MVA)	STE (MVA)
34.5 kV Lines													
3470	190930	ASHLND-A 34.500	190969	LEVESASH 34.500	0.0400	0.0510	0.0001	26	32	32	26	32	32
	190969	LEVESASH 34.500	190973	SQUA PAN 34.500	0.3170	0.2760	0.0003	24	24	24	24	24	24
44 kV Lines													
4407	190949	EMEC LUD 44.000	190990	MULLEN-4 44.000	0.2540	0.3390	0.0012	34	41	41	34	41	41
	190949	EMEC LUD 44.000	190950	OAKFIELD 44.000	0.2400	0.3030	0.0011	37	37	37	37	37	37
	190950	OAKFIELD 44.000	190951	ISLAND F 44.000	0.1370	0.3500	0.0012	67	67	67	67	67	67
	190951	ISLAND F 44.000	190952	PATTEN 44.000	0.6460	0.3570	0.0012	19	19	19	19	19	19
	190952	PATTEN 44.000	190953	EMEC PAT 44.000	0.0001	0.0001	0.0000	28	28	28	28	28	28
	190953	EMEC PAT 44.000	190954	SHERMAN 44.000	0.2710	0.2290	0.0007	28	28	28	28	28	28
	190954	SHERMAN 44.000	190980	SHERLUMT 44.000	0.0180	0.0150	0.0001	28	28	28	28	28	28
	190955	SHERLUM 44.000	190980	SHERLUMT 44.000	0.0140	0.0120	0.0000	28	28	28	28	28	28
	190951	ISLAND F 44.000	190956	WHEELSHE 44.000	0.0990	0.5990	0.0019	98	121	121	98	121	121
	190956	WHEELSHE 44.000	190980	SHERLUMT 44.000	0.0010	0.0010	0.0000	23	28	28	23	28	28
138 kV Lines													
3855	190001	BEECHW 138.00	190985	BORDER-55 138.00	0.0150	0.0330	0.0086	110	132	132	132	158	158
	190985	BORDER-55 138.00	190988	FLOS INN 138.00	0.0210	0.0480	0.0124	108	116	120	144	146	149

Table 3-1 MPS 34.5 kV, 44 kV, and 138 kV Line Modeling

Line Number	From Bus Number	From Bus Name	To Bus Number	To Bus Name	Line R (pu)	Line X (pu)	Charging (pu)	Summer			Winter		
								Normal (MVA)	LTE (MVA)	STE (MVA)	Normal (MVA)	LTE (MVA)	STE (MVA)
69 kV Lines													
6901	190921	FLOS INN 69.000	190958	INTERFAI 69.000	0.0258	0.0940	0.0016	84	84	85	97	97	99
	190957	FT.FAIR 69.000	190958	INTERFAI 69.000	0.0022	0.0143	0.0002	48	48	49	72	72	73
	190957	FT-FAIR 69.000	190981	BORDER-1 69.000	0.0270	0.0740	0.0012	48	48	49	72	72	73
6903	190909	LIMESTON 69.000	190959	POND3TAP 69.000	0.0001	0.0001	0.0000	86	106	106	86	106	106
	190959	POND3TAP 69.000	190960	LORING T 69.000	0.0230	0.0600	0.0011	39	39	38	66	66	67
	190910	LORING 69.000	190960	LORING T 69.000	0.0170	0.0260	0.0004	65	65	65	65	65	65
	190960	LORING T 69.000	190987	O.CREEK3 69.000	0.0340	0.0880	0.0017	39	39	38	66	66	67
	190911	OTTER CR 69.000	190987	O.CREEK3 69.000	0.0010	0.0010	0.0000	65	65	65	65	65	65
	190914	CARIBOU- 69.000	190987	O.CREEK3 69.000	0.0200	0.0330	0.0006	51	60	85	56	60	67
6904	190903	TINKER-6 69.000	190982	BORDER-4 69.000	0.0080	0.0230	0.0004	39	39	38	66	66	67
	190909	LIMESTON 69.000	190982	BORDER-4 69.000	0.0530	0.1480	0.0024	39	39	38	66	66	67
6905	190091	IROQUS1 69.000	190983	BORDER-5 69.000	0.0130	0.0310	0.0005	24	29	29	29	35	35
	190977	FRASER T 69.000	190983	BORDER-5 69.000	0.0003	0.0008	0.0000	67	67	67	84	84	86
	190975	G.I. TAP 69.000	190977	FRASER T 69.000	0.0430	0.1190	0.0020	67	67	67	84	84	86
	190941	GRAND IS 69.000	190975	G.I. TAP 69.000	0.0050	0.0070	0.0001	65	65	65	65	65	65
	190974	V.B. TAP 69.000	190975	G.I. TAP 69.000	0.0804	0.2190	0.0038	67	67	67	84	84	86
	190940	VAN BURE 69.000	190974	V.B. TAP 69.000	0.0200	0.0290	0.0005	65	65	65	65	65	65
	190974	V.B. TAP 69.000	190991	LIMES EN 69.000	0.1130	0.3150	0.0053	67	67	67	84	84	86
	190909	LIMESTON 69.000	190991	LIMES EN 69.000	0.0001	0.0001	0.0000	67	67	67	84	84	86
6908	190915	NEW SWED 69.000	190916	FISH RIV 69.000	0.2847	0.5514	0.0077	45	45	46	57	57	57
	190915	NEW SWED 69.000	190961	O.CREEK8 69.000	0.0442	0.1230	0.0021	84	84	85	97	97	99
	190961	O.CREEK8 69.000	190992	CARIBOU 69.000	0.0090	0.0344	0.0006	84	84	85	97	97	99
	190914	CARIBOU- 69.000	190992	CARIBOU 69.000	0.0001	0.0001	0.0000	56	56	56	56	56	56
6909	190091	IROQUS1 69.000	190984	BORDER-9 69.000	0.0070	0.0290	0.0005	24	29	29	29	35	35
	190976	MAD TAP 69.000	190984	BORDER-9 69.000	0.0005	0.0013	0.0000	67	67	67	84	84	86
	190942	MADAWASK 69.000	190976	MAD TAP 69.000	0.0070	0.0100	0.0002	65	65	65	65	65	65
	190944	FRENCHVI 69.000	190976	MAD TAP 69.000	0.0416	0.1157	0.0019	67	67	67	84	84	86
	190916	FISH RIV 69.000	190944	FRENCHVI 69.000	0.0600	0.1670	0.0028	67	67	67	84	84	86
6910	190978	BRIDGE T 69.000	190999	MARHILLSPCC 69.000	0.0320	0.1292	0.0021	86	99	107	96	105	127
	190945	BRIDGEWA 69.000	190978	BRIDGE T 69.000	0.0030	0.0050	0.0001	65	65	65	65	65	65
	190978	BRIDGE T 69.000	190979	MONTI TA 69.000	0.0880	0.1650	0.0023	45	45	46	57	57	57
	190946	MONTICEL 69.000	190979	MONTI TA 69.000	0.0050	0.0080	0.0001	65	65	65	65	65	65
	190947	MULLEN-6 69.000	190979	MONTI TA 69.000	0.0930	0.1740	0.0024	45	45	46	57	57	57
6912	190914	CARIBOU- 69.000	190962	6911 TAP 69.000	0.0001	0.0001	0.0000	56	56	56	56	56	56
	190921	FLOS INN 69.000	190962	6911 TAP 69.000	0.0423	0.1538	0.0030	56	60	85	62	68	93
6913	190989	ASHLAND- 69.000	190994	ASHEND 69.000	0.0001	0.0001	0.0000	40	40	40	50	50	51
	190967	MAPLETON 69.000	190994	ASHEND 69.000	0.1410	0.1957	0.0035	40	40	40	50	50	51
	190927	MAPLETN 69.000	190967	MAPLETON 69.000	0.0060	0.0040	0.0001	31	31	31	31	31	31
	190923	P.I.S.S. 69.000	190967	MAPLETON 69.000	0.0360	0.0930	0.0018	40	40	40	50	50	51
	190923	P.I.S.S. 69.000	190993	P.I.SWS 69.000	0.0001	0.0001	0.0000	106	106	106	106	106	106
	190966	SKYWAY T 69.000	190993	P.I.SWS 69.000	0.0113	0.0298	0.0006	39	39	38	66	66	67
	190925	SKYWAY 69.000	190966	SKYWAY T 69.000	0.0120	0.0180	0.0003	65	65	65	65	65	65
6914	190921	FLOS INN 69.000	190926	NORTH P. 69.000	0.0180	0.0500	0.0008	39	39	38	66	66	67
6917	190908	POND 69.000	190959	POND3TAP 69.000	0.0130	0.0190	0.0003	24	24	22	39	39	40
6920	190965	MARS HIL 69.000	190999	MARHILLSPCC 69.000	0.0185	0.0513	0.0086	84	84	85	96	97	99
	190920	MARSHILL 69.000	190965	MARS HIL 69.000	0.0320	0.0460	0.0007	58	106	106	58	106	106
	190947	MULLEN-6 69.000	190965	MARS HIL 69.000	0.1382	0.3840	0.0064	84	84	85	96	97	99
6930	190914	CARIBOU- 69.000	190928	WASHBURN 69.000	0.0700	0.2140	0.0038	48	48	46	83	83	85
	190928	WASHBURN 69.000	190989	ASHLAND- 69.000	0.0970	0.2730	0.0044	39	39	38	66	66	67
6940	190921	FLOS INN 69.000	190963	MCCAIN/H 69.000	0.0180	0.0687	0.0012	101	105	107	112	120	127
	190917	MCCAINH 69.000	190963	MCCAIN/H 69.000	0.0180	0.0170	0.0003	48	48	48	48	48	48
	190963	MCCAIN/H 69.000	190999	MARHILLSPCC 69.000	0.0405	0.1542	0.0024	86	99	107	96	105	119
6950	190918	EASTON 69.000	190921	FLOS INN 69.000	0.0306	0.0916	0.0012	75	84	85	81	93	99
	190918	EASTON 69.000	190964	WESTF TA 69.000	0.0297	0.0825	0.0014	84	84	85	96	97	98
	190919	WESTFIEL 69.000	190964	WESTF TA 69.000	0.0010	0.0010	0.0000	106	106	106	106	106	106
	190964	WESTF TA 69.000	190999	MARHILLSPCC 69.000	0.0197	0.0548	0.0009	84	84	85	96	97	98

Table 3-2 MPS 69 kV Line Modeling

MPS capacitors and transformers were reviewed and updated according to data provided by MPS; the specifications modeled can be seen in Table 3-3 and Table 3-4 below.

MPS Capacitors								
Bus Number	Bus Name	Control Mode	Vhi (pu)	Vlo (pu)	Block 1 Steps	Block 1 Step Size (MVAR)	Block 2 Steps	Block 2 Step Size (MVAR)
190930	ASHLND-A 34.500	Switched	1.050	1.008	2	2.7	N/A	N/A
190937	PORTAGE 34.500	Switched	1.030	1.000	2	0.9	N/A	N/A
190947	MULLEN-6 69.000	Switched	1.050	0.959	2	5.4	N/A	N/A
190948	HOULTONW 34.500	Locked	N/A	N/A	N/A	4.8	1	4.05

Table 3-3 MPS Capacitor Modeling

From Bus Number	From Bus Name	To Bus Number	To Bus Name	R (pu)	X (pu)	Summer			Winter			Controlling Low Side	Vmax (pu)	Vmin (pu)
						Normal (MVA)	LTE (MVA)	STE (MVA)	Normal (MVA)	LTE (MVA)	STE (MVA)			
190903	TINKER-6 69.000	190986	TINKER-1 138.00	0.0137	0.1647	53	72	72	53	72	72	No	N/A	N/A
190921	FLOS INN 69.000	190988	FLOS INN 138.00	0.0068	0.0810	108.4	127.1	193.5	122.2	136.7	182.2	Yes	1.025	1.000
190947	MULLEN-6 69.000	190990	MULLEN-4 44.000	0.0216	0.2592	17.5	21.1	28.3	19.7	22.9	32	Yes	1.033	1.008
190947	MULLEN-6 69.000	190948	HOULTONW 34.500	0.0174	0.2083	36.4	42.7	65	41.1	45.9	61.2	Yes	1.025	1.000
190930	ASHLND-A 34.500	190989	ASHLAND- 69.000	0.0483	0.5800	13.6	16.5	22.1	15.4	17.9	25	Yes	1.025	1.000
190968	ASHLND-B 34.500	190989	ASHLAND- 69.000	0.0483	0.5800	13.6	16.5	22.1	15.4	17.9	25	Yes	1.025	1.000

Table 3-4 MPS Transformer Modeling

3.2.1.1 Interconnected and Radial Transmission Configurations

The MPS system can be operated in two modes; interconnected to New Brunswick as shown in Figure 2-2 or with the northern portion radial out of Hydro Quebec and the southern portion radial out of New Brunswick. The interconnected system was tested for all scenarios. The radial system was only tested for N-1 system conditions.

The radial mode consists of opening the breaker at MPS' Limestone Substation that terminates the 69 kV Line 6905, and opening the breaker at MPS' Caribou Substation that terminates the 69 kV Line 6908, as well as additional breakers opening in NBP's 138 kV and 345 kV systems. The end result is the MPS system is split; the northern portion served from Hydro Quebec, and the southern portion served from New Brunswick through the Tinker T1 and Flo's Inn T1 138/69 kV transformers. Figure 2-2 above and Figure 3-1 below have breakers circled and hi-lighted in red that are open when the MPS system is modeled as radial.

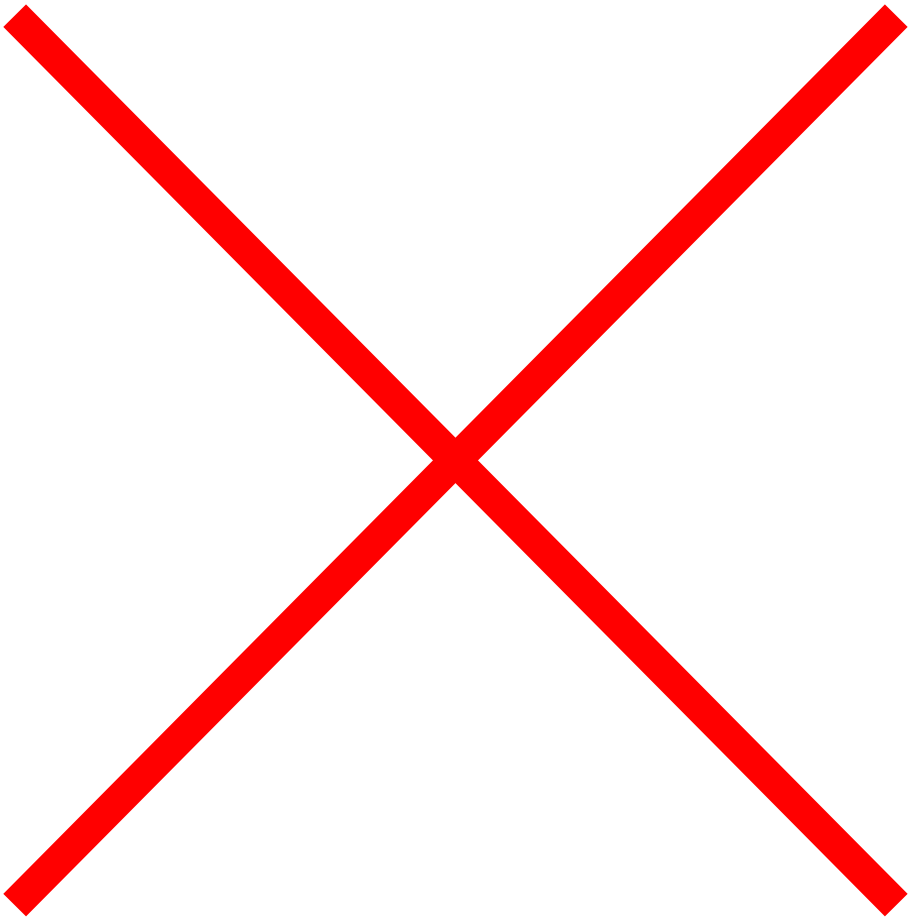


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Figure 3-1 Northwestern New Brunswick Breaker Diagram Showing Open Devices for Radial Connection with Hydro Quebec

In addition to the NBP open points for radial operation discussed above, NBP has multiple normally open points within its system. These open points are required in order to feed load radially in New Brunswick due to unacceptable voltage performance for certain N-1 contingencies. The following breakers/switches were modeled open for this analysis:

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3.2.1.2 Transmission Configurations for Needs Assessment

For the Needs Assessment, transmission system configurations were tested with contingency analysis during all lines in-service (N-0 base case and N-1 post-contingency), 138 kV line outage (N-1 base case and N-1-1 post-contingency) and 138/69 kV maintenance outage (N-1 base case and N-1-1 post-contingency) conditions. The MPS radial configuration was only modeled in the N-1 Analysis, this assumed that following a first contingency, or the scheduled maintenance of an element, the MPS system would be configured interconnected to increase the reliability of the MPS system. The following configurations and system conditions were tested:

- All Lines In (N-0) at peak load:

    - Interconnected configuration.
    - Radial configuration.
- Two N-1 outage conditions at peak load (N-1) for the interconnected configuration:
    - 138 kV Line 3855(Beechwood – Flo's Inn).
    - 138 kV Line 1111(Beechwood – Grand Falls).
- Four scheduled maintenance configurations at 85% load (N-1) for the interconnected configuration
    - Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855.
    - Tinker T1 138/69 kV Transformer or 138 kV Line 1144.
    - Iroquois T1 138/69 kV Transformer or 138 kV Line 1184.
    - Iroquois T2 138/69 kV Transformer or 138 kV Line 1183.

3.3 Generation Dispatch Assumptions (Additions & Retirements)

According to ISO-New England (ISO-NE), Northeast Power Coordination Council (NPCC) and North American Electric Reliability Corporation (NERC), planning with one or more generator out-of-service represents stressed system conditions for a reliability study and doing so conforms with applicable transmission system design criteria. In other words, testing a variety of plausible dispatch conditions which includes a generator entirely offline is a proper method to stress the transmission system.

MPS hydro conditions were modeled based upon peak hour of the four peak days, during each year of a five year period, for the transmission reliability evaluation. This assumption aligns with the MPUC Safe Harbor planning criteria. The following list depicts the major generation assumptions made:

- Beechwood Hydro at 50 MW (113 MW Maximum).
- Mactaquac Hydro at 201 MW (669 MW Maximum).
- Grand Falls Hydro at 48 MW (66 MW Maximum).
- Tinker Hydro #1-4 at 9 MW (12 MW maximum).
- Tinker Hydro #5 offline.
- Caribou Hydro at 1 MW (1 MW maximum – Two 0.5 MW units).
- Mars Hill Wind at 4.2 MW (42 MW maximum).
- Scopan Hydro offline.

The following generators in the MPS area are deactivated:

- Caribou Steam.
- Flo's Inn Diesels.
- Loring Diesels.
- Boralex Sherman.
- ReEnergy Ashland.

Other generation resources in the MPS area include:

- Fossil Fuel
    - Caribou Diesels (4 units - 7 MW total, assumed off).
    - Tinker Diesel (1 unit - 1 MW assumed off).
- Biomass
    - Fort Fairfield (33 MW assumed off).

New Brunswick major generation resources:

- Coal
    - Belledune 2 (467 MW).

- Oil
    - Coleson Cove 1-3 (972 MW).
    - Dalhousie 1 and 2 (299 MW – 2013 Retirement).
- Natural Gas
    - Courtenay Bay #3 (90 MW).
    - Bayside#6 (170 MW).
- Nuclear
    - Point Lepreau (705 MW).
- Hydro along New Brunswick's Saint John river systems:
    - Mactaquac 1-6 (669 MW maximum).
    - Grand Falls (66 MW maximum).
    - Beechwood (113 MW maximum).

For the N-1-1 analysis, 80% of the available fast start units within MPS were brought on-line, as depicted below. This is consistent with MPUC Safe Harbor planning criteria:

- Caribou Diesel #2 at 0 MW (2.55 MW Maximum).
- Caribou Diesel #3 at 2.55 MW (2.55 MW Maximum).
- Caribou Diesel #4 at 1 MW (1 MW Maximum).
- Caribou Diesel #5 at 1 MW (1 MW Maximum).
- Tinker Diesel #1 at 1 MW (1 MW Maximum).

Table 3-5 summarizes the base case generation conditions. Individual plant dispatches may be partially loaded to achieve the desired coincident heavy transfers.

Base Case Generation Summary							
Generator	Pmax	N-1		N-1-1		Maintenance Outage	
		Summer Peak	Winter Peak	Summer Peak	Winter Peak	Summer (85%)	Winter (85%)
Maine Public Service Area Generation							
TINKER HYDRO 1-4	12	9	9	9	9	9	9
TINKER HYDRO 5	22	0	0	0	0	0	0
TINKER DIESEL	1	0	0	1	1	0	0
CARIBOU HYDRO	2	1	1	1	1	1	1
CARIBOU DIESELS	7	0	0	4.55	4.55	0	0
MARS HILL WIND	42	4.2	4.2	4.2	4.2	4.2	4.2
FORT FAIRFIELD	36	0	0	0	0	0	0
FLOS INN	Retired	0	0	0	0	0	0
ASHLAND	Retired	0	0	0	0	0	0
SHERMAN	Retired	0	0	0	0	0	0
New Brunswick Area Generation							
TOBIQUE*	20	10	10	10	10	10	10
SISSON*	9	5	5	5	5	5	5
GRAND FALLS G1&G2*	33	24	24	24	24	24	24
GRAND FALLS G3&G4*	33	24	24	24	24	24	24
FRASER COGEN	50	40	40	40	40	40	40
BEECHWOOD G1&2*	72	50	50	50	50	50	50
BEECHWOOD G3	41	0	0	0	0	0	0
BAYSIDE6	170	170	170	170	170	170	170
C.BYG3	90	90	90	90	90	90	90
MACTAQUAC G1*	110	67	67	67	67	67	67
MACTAQUAC G2*	110	67	67	67	67	67	67
MACTAQUAC G3*	110	67	67	67	67	67	67
MACTAQUAC G4-6	339	0	0	0	0	0	0
PT LEPREAU	705	705	705	705	705	705	705
COLSON COVE G1	352	180	352	235	352	160	300
COLSON COVE G2	352	180	352	235	352	0	260
COLSON COVE G3	352	0	300	235	335	0	0
BELLDUNE G2	467	0	480	0	480	0	480
MILLBANK G1-4	100	0	0	0	396	0	0
ST ROSE G1	100	0	0	0	99	0	0

Table 3-5 Base Case Generation Summary

* Modeled with 90% power factor for reactive limits

3.4 Forecasted Load Levels

This study assessed system performance for both summer and winter load conditions within the Maine Public Service and NBP areas for the year 2013. Load levels for the MPS area were developed from actual forecast data provided by MPS. Table 3-6 shows the MPS forecasted load levels examined for this analysis.

MPS Seasonal Load Levels (losses not included)	2013	
	Summer	*Winter*
90/10 peak load	112 MW	129 MW
85% of 90/10 peak load	95 MW	110 MW

Table 3-6 MPS Forecasted Load Levels

Table 3-7 includes the load levels assumed for the NBP area and represents the sum of the load in Zones 1180 – 1190 in the FERC base cases. These load levels do not include Prince Edward Island or Nova Scotia.

NBP Seasonal Load Levels (losses not included)	2013	
	Summer	*Winter*
90/10 peak load	1674 MW	2926 MW
85% of 90/10 peak load	1423 MW	2487 MW

Table 3-7 NBP Area Load Levels

Each of the load levels were examined as follows:

Peak Load Levels

- All-Lines-In (N-0).
- All single & multiple element contingencies (N-1).
- Initial outage of 138 kV Line, all single & multiple element contingencies (N-1-1).
  - 345 kV and 138 kV contingencies were tested (N-1-1).

85% of Peak Load

- Scheduled maintenance outage conditions.
- Single element contingencies were tested.

3.5 Load Power Factor Assumptions

Load Power Factor in MPS is based on historic actual.

3.6 Transfer Levels

Low generation patterns, with DC imports from Hydro Quebec at zero and heavy imports from New England were analyzed for this Study. This scenario has historical been the worst case scenario for MPS.

Testing was done based on all normal Maine (ISO-NE) existing or anticipated interface levels, and done in a manner so as not to impact existing NB to NMTS transfer levels.

The N-1-1 analyses were performed with the New Brunswick to New England transfer adjusted to 0 MW. This adjustment simulated posturing of the NB tie following loss of the first major element.

Base Case Interface Summary - Interconnected Configuration						
Interface	N-1		N-1-1		Maintenance Outage	
	Summer Peak	Winter Peak	Summer Peak	Winter Peak	Summer (85%)	Winter (85%)
NB-MPS Interface	101	119	95	113	83	98
Madawaska DC Import	0	0	0	0	0	0
Eel River DC Import	0	0	0	0	0	0
HQ-NB Interface	0	0	0	0	0	0
NB-NS Interface	50	100	50	100	50	100
NB-PEI Interface	180	200	180	200	152	169
New Brunswick-New England	-346	-540	5	11	-328	-546
Orrington-South	141	-151	493	404	160	-157
Maine-New Hampshire	-384	-591	-37	-31	-365	-596

Table 3-8 Base Case Interface Summary - Interconnected Configuration

3.7 Description of Existing and Planned Protection and Control System Devices Included in the Study

Load shedding devices internal to the MPS system, with the exception for UF load shedding as required by NPCC, were not modeled for first contingency conditions. Load shedding devices are available for operational use, but they were not modeled in this planning study.

For several contingencies, under voltage load shedding on the NBP system was modeled. Two UVLS schemes were included; interruption of 69 kV Lines 70 & 72 based on Iroquois 69 kV voltage levels below 0.92pu, and interruption of 69 kV Lines 141 & 48 based on Beechwood 69 kV voltage levels below 0.92pu.

The 69 kV Mullen capacitor is comprised of two separate steps or banks, 5.4 MVAR each. These banks are able to switch in and out of service high speed post contingency. Both the close and trip times are a magnitude of single seconds. Numerous contingencies utilized the Mullen capacitor high speed switching ability to eliminate voltage collapse and/or low voltages prior to adjustment of load tap changers within the MPS system.

Section 4
Analysis Methodology

4.1 Planning and Performance Standards and Criteria

The study was performed consistent with MPS transmission planning criteria, the Northeast Power Coordinating Council Directory 1, *"Basic Criteria for Design and Operation of Interconnected Power Systems,"* and ISO New England Planning Procedure No. 3, *"Reliability Standards for the New England Area Bulk Power Supply System,"* where applicable as well as applicable North American Electric Reliability Corporation Reliability Standards. The BES definition as presently understood, though it has not been fully implemented, was also included.

4.2 Steady State Performance

The steady state portion of the Study was performed with Siemens PTI PSS/E load flow software package, Version 32 and standard contingency analysis software tools.

4.2.1 Steady State Thermal and Voltage Limits

Table 4-1 below identifies the voltage criteria used for the steady state voltage assessment.

Acceptance Criteria for Voltage Levels => 34.5 kV (Normal and Post-Contingency)		
System Condition	**High Limit (per-unit or pu)**	**Low Limit (per-unit or pu)**
Pre-contingency (all lines in)	1.05	0.95
Post-contingency Prior to LTC & switched shunt adjustments	1.1	0.90
Post-contingency After LTC & switched shunt adjustments	1.05	0.95

Table 4-1 Steady State Voltage Criteria

Point Lepreau 345 kV bus voltage was monitored to assure post-contingency levels equal to or greater than 340 kV (0.98 pu).

Table 4-2 below identifies the thermal criteria used for the steady state thermal assessment.

System Condition	Maximum Allowable Facility Loading
Pre-contingency (all lines in)	Normal rating
Post-contingency	Long-Time Emergency (LTE) Rating

Table 4-2 Steady State Thermal Criteria

All normal, LTE, and STE ratings in the NMTS for this study were based on the assumptions and recommendations in ISO New England Planning Procedure 7, "Procedures for Determining and Implementing Transmission Facility Ratings In New England".

4.2.2 Steady State Solution Parameters

The steady state analysis was performed with pre-contingency solution parameters that allowed adjustment of load tap-changing transformers (LTCs), static VAR devices (SVDs, including automatically-switched capacitors) and phase angle regulators (PARs). Post-contingent solutions were analyzed two ways; first only allowing adjustment of dynamic VAR sources such as generators in voltage control mode, second additionally allowing adjustment of load tap-changing transformer (LTCs) and automatically-switched capacitors.

Case	Generation V Control	Area Interchange	Transformer LTCs	Phase Angle Regulators	SVDs & Switched Shunts
Base	Regulating	Disabled	Stepping	Regulating	Regulating
Contingency	Regulating	Disabled	Disabled	Disabled	Disabled
	Regulating	Disabled	Stepping	Disabled	Regulating

Figure 4-1 Study Solution Parameters

4.2.3 Steady State Contingencies

Each base case was subjected to single contingencies such as the loss of a generator, transmission circuit or transformer and multiple element contingencies such as a stuck breaker or bus fault. Table 4-3 through Table 4-9 contain the 345 kV, 138 kV and 138/115 kV and 69 kV single element contingencies, 345 kV and 138 kV stuck breaker contingencies and 138 kV and 69 kV bus fault contingencies that were examined in the contingency analysis.

The NB DPL and 396 SPS actions for contingencies involving the 345 kV NB-NE tie lines (396, 390 and 3001) were not modeled for this analysis; these SPS's require no action when New England to New Brunswick transfers are at or above 0MW. For contingencies involving the NBP 345 kV Line 3011, the SPS action to runback the Madawaska DC import to zero was also not modeled, as the DC import was modeled at 0 MW for all scenarios.

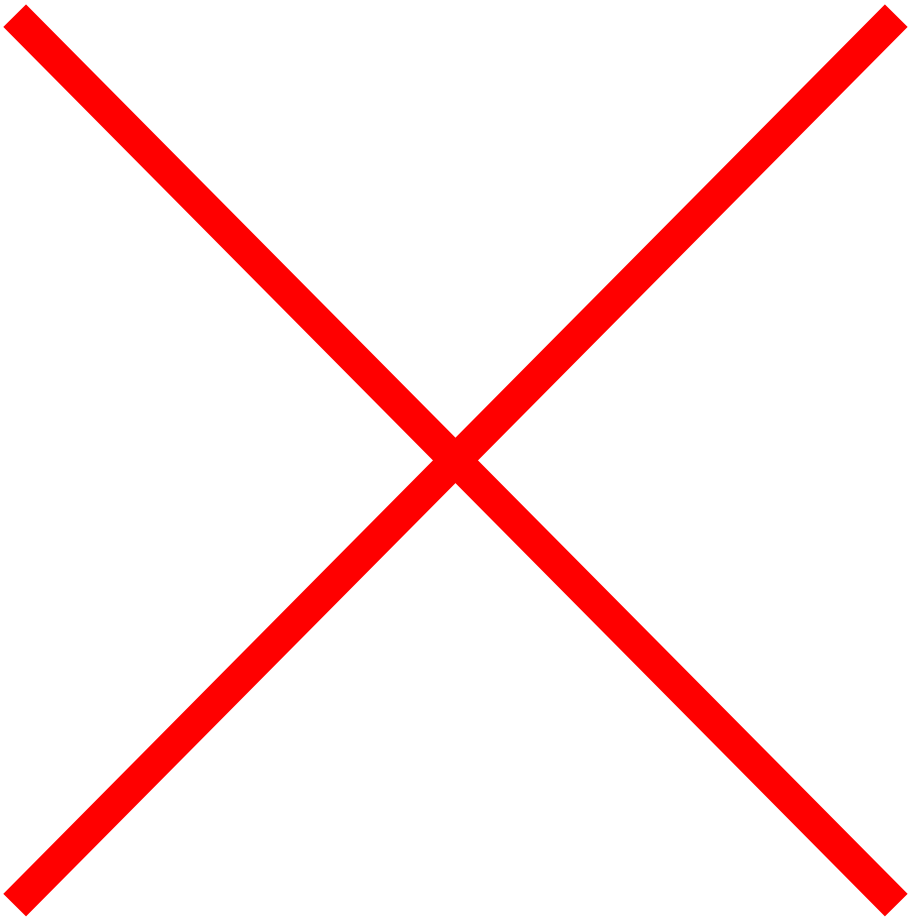

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Table 4-3 Single Element Transmission Line Contingencies

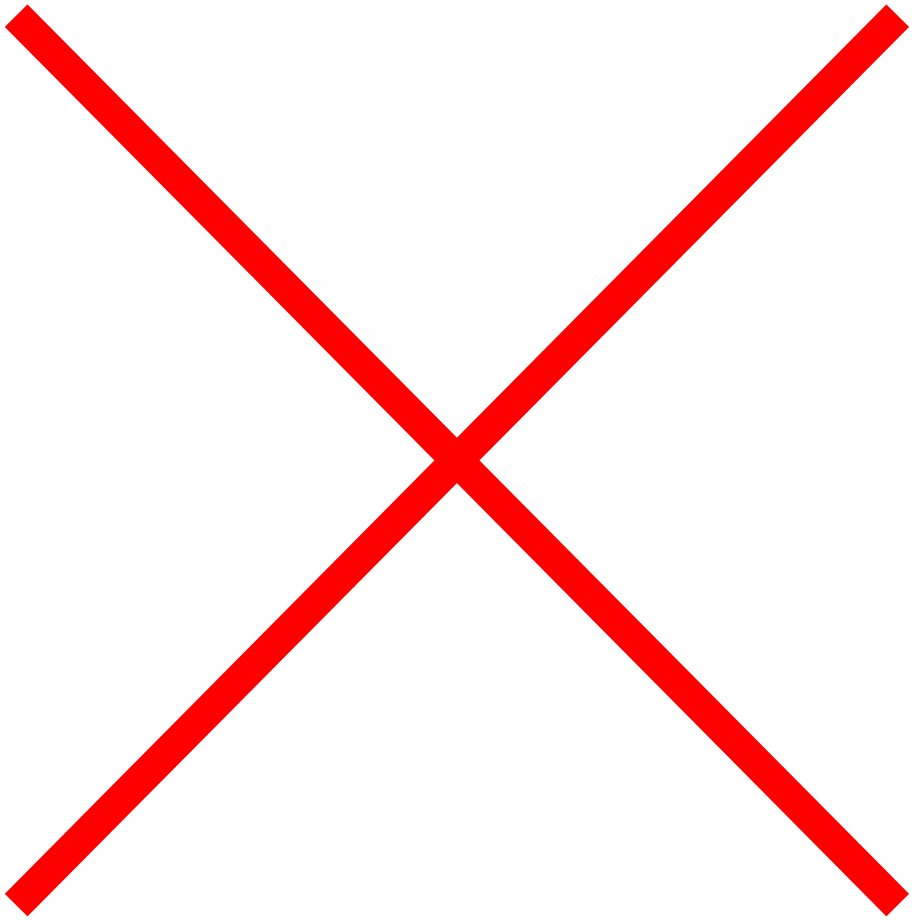

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Table 4-4 Single Element Transformer Contingencies

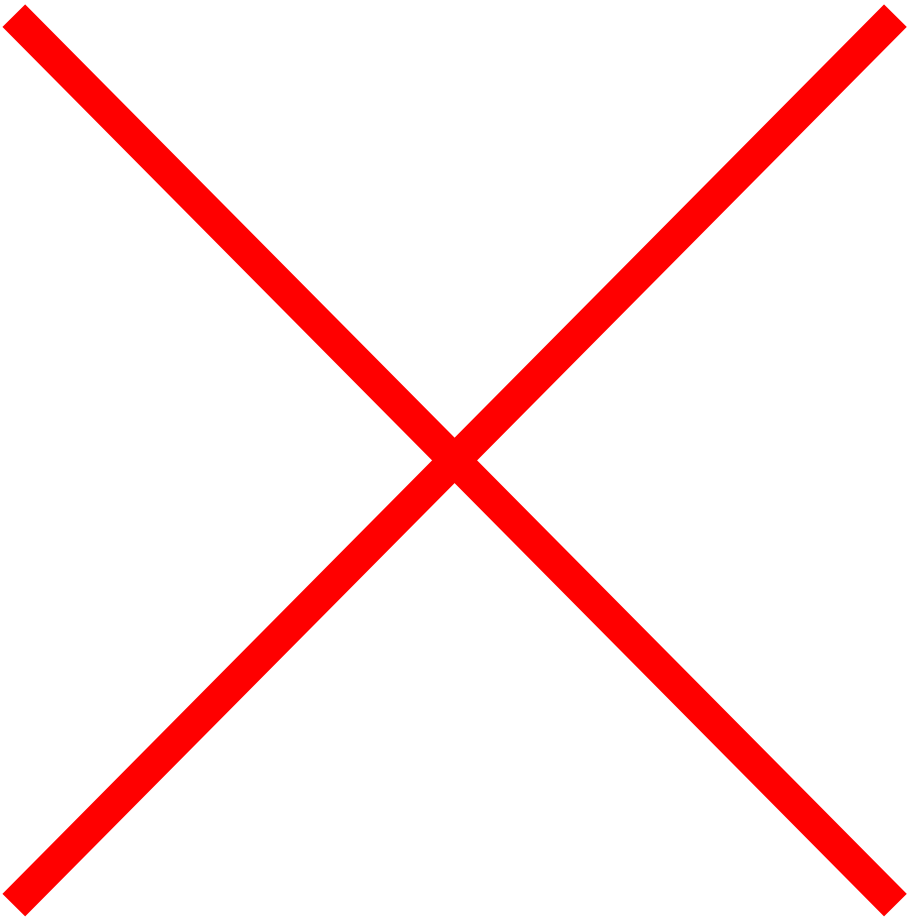

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Table 4-5 Single Element Generator/SVC Contingencies

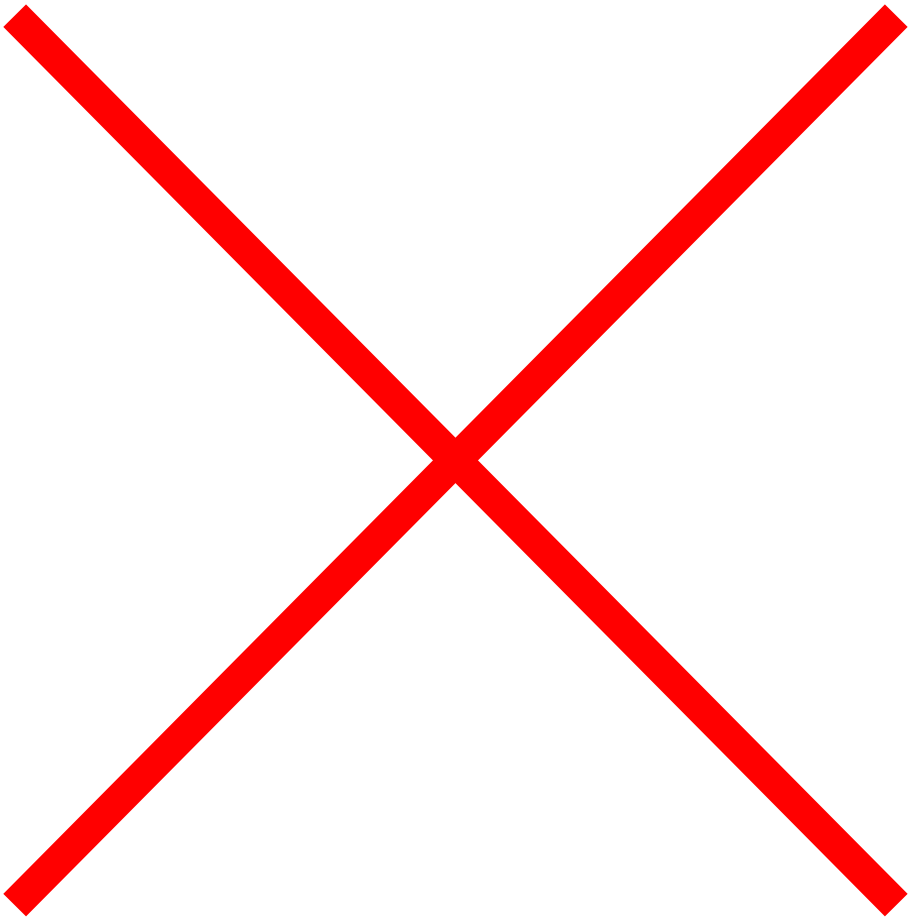

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Table 4-6 Single Element Capacitor Contingencies

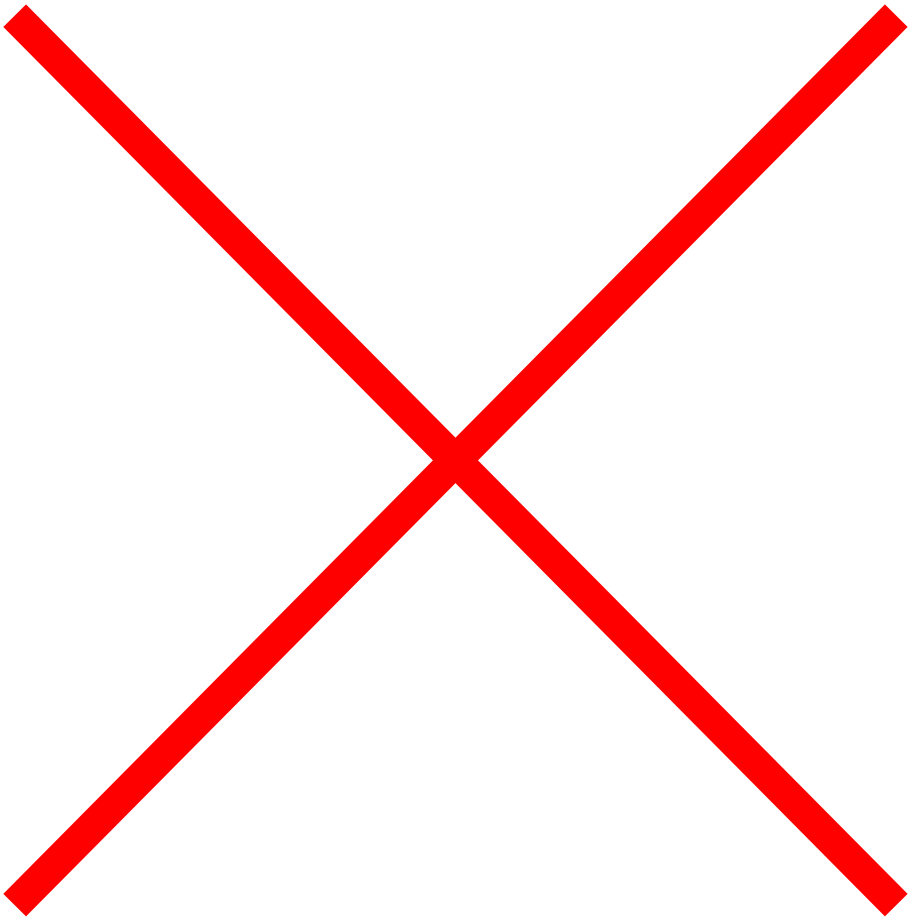

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Table 4-7 345 kV Multiple Element Stuck Breaker Contingencies

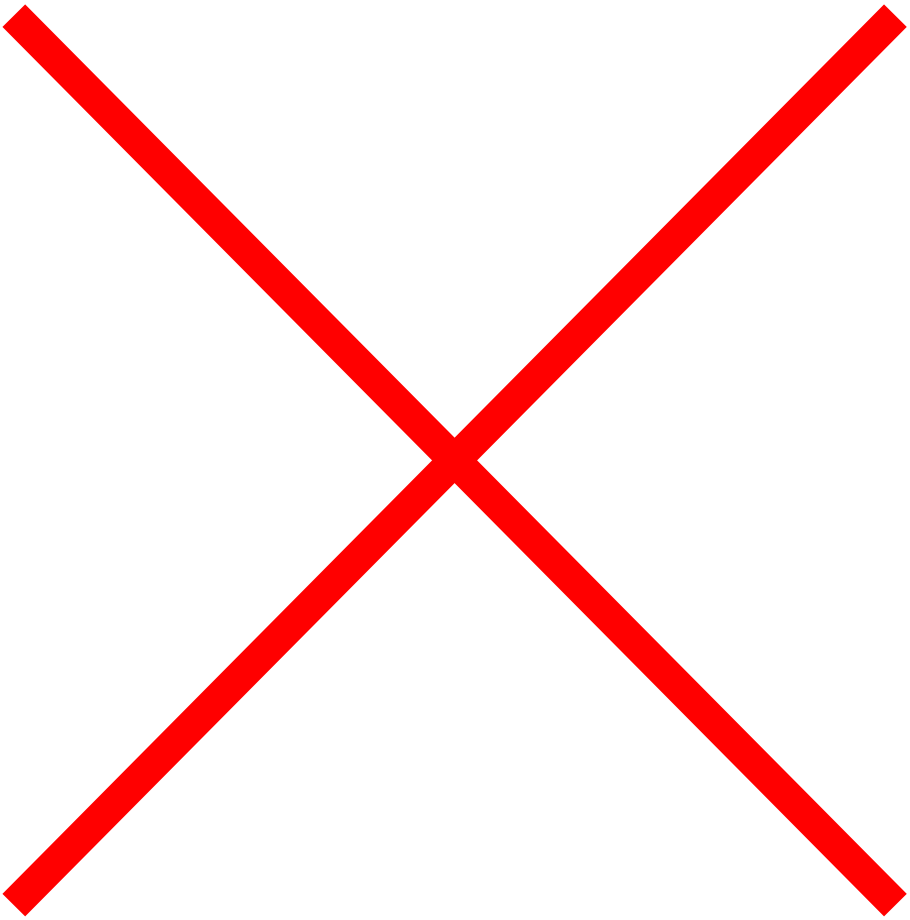

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Table 4-8 138 kV Multiple Element Stuck Breaker Contingencies

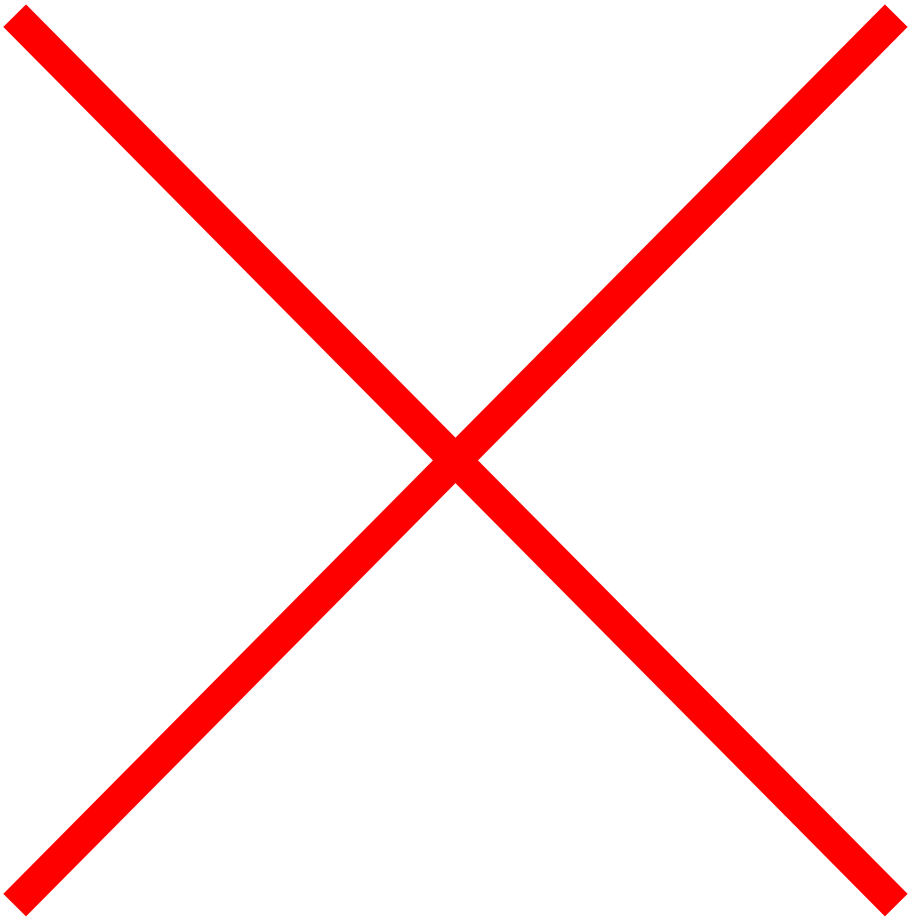

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Table 4-9 138 kV & 69 kV Multiple Element Bus Faults

4.3 Stability Testing

None requested at this time.

4.4 Short Circuit Faults Analysis

None recommended at this time.

Section 5
Needs Assessment

5.1 All-Lines-In (N-0) Analysis

5.1.1 2013 Winter Peak Load Level

5.1.1.1 Interconnected Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

5.1.1.2 Radial Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

5.1.2 2013 Summer Peak Load Level

5.1.2.1 Interconnected Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

5.1.2.2 Radial Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

5.2 N-1 Analysis

Table 5-1 through Table 5-11 summarizes the voltage and thermal reliability violations from the N-1 Needs Analysis of the existing MPS system. The voltage tables include violations on the MPS system (138 kV to 12.47 kV) relative to voltage criteria applicable to the two system states that were examined: prior to adjustment of LTCs and switched shunts and after adjustment of LTCs and switched shunts. The thermal tables summarize thermal loading violations for lines within the MPS system and for lines which supply power to the MPS system after adjustment of LTCs and switched shunts.

Results are included for both the interconnected and radial system configurations.

5.2.1 2013 Winter Peak Load Level

5.2.1.1 Interconnected Configuration

Voltage Performance

N-1 Voltage Violations - 2013 Winter Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 (without UVLS)	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Iroquois which opens 69 kV Lines 70 & 72
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855			X			0.897	
345 kV Keswick K3-3 SB (without Beechwood UVLS)	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Beechwood which opens 69 kV Lines 141 & 48
345 kV St. Andre AN3-1 SB (without UVLS)	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Iroquois which opens 69 kV Lines 70 & 72
345 kV St. Andre AN3-2 SB (without UVLS)	X	X	X	X	X	Voltage Collapse	
345 kV St. Andre AN3-2 SB (with UVLS)	X	X	X	X	X	0.860 - 0.900	Voltages less than 0.87 pu considered voltage collapse
138 kV Beechwood 1111-1 SB	X	X	X	X	X	0.857 - 0.900	Voltages less than 0.87 pu were considered voltage collapse
138 kV Beechwood 1125-1 SB	X	X	X	X	X	0.860 - 0.898	
138 kV Beechwood 1126-1 SB	X	X	X	X	X	0.861 - 0.899	
138 kV Beechwood 1176-1 SB	X	X	X	X	X	0.857 - 0.900	
138 kV Beechwood Bus Fault	X	X	X	X	X	0.860 - 0.898	

Table 5-1 N-1 Voltage Violations (LTCs & Switched Shunts Fixed)
2013 Winter Peak - Interconnected Configuration

N-1 Voltage Violations - 2013 Winter Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
After Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 (without UVLS)	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Iroquois which opens 69 kV Lines 70 & 72
345 kV Keswick K3-3 SB (without Beechwood UVLS)	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Beechwood which opens 69 kV Lines 141 & 48
345 kV St. Andre AN3-1 SB (without UVLS)	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Iroquois which opens 69 kV Lines 70 & 72
345 kV St. Andre AN3-2 SB (without UVLS)	X	X	X	X	X	Voltage Collapse	

Table 5-2 N-1 Voltage Violations (LTCs & Switched Shunts Adjusted)
2013 Winter Peak - Interconnected Configuration

Thermal Performance

N-1 Thermal Violations - 2013 Winter Peak Load Interconnected Configuration				
Thermally Overloaded Facility	Rating (MVA)	N-1 Contingency (Loss of)	Flow (% LTE)	Remarks
			Dispatch D3A	
After Adjustment of LTCs and Switched Shunts				
Tinker T1 138/69 kV Transformer	72	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	101.9%	

Table 5-3 N-1 Thermal Violations
2013 Winter Peak - Interconnected Configuration

5.2.1.2 Radial Configuration

Voltage Performance

N-1 Voltage Violations - 2013 Winter Peak Load Radial Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	X	X	X	X		0.783 - 0.895	Voltages less than 0.87 pu were considered voltage collapse
138 kV Beechwood 1111-1 SB	X	X	X	X	X	0.298 - 0.783	
138 kV Beechwood 1125-1 SB	X	X	X	X	X	0.296 - 0.763	
138 kV Beechwood 1126-1 SB	X	X	X	X	X	0.295 - 0.763	
138 kV Beechwood 1176-1 SB	X	X	X	X	X	0.298 - 0.763	
138 kV Beechwood Bus Fault	X	X	X	X	X	0.294 - 0.759	

Table 5-4 N-1 Voltage Violations (LTCs & Switched Shunts Fixed)
2013 Winter Peak - Radial Configuration

N-1 Voltage Violations - 2013 Winter Peak Load Radial Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
After Adjustment of LTCs and Switched Shunts							
Keswick T4 345/138 kV Transformer					X	0.944	
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855		X		X		0.930 - 0.946	
138 kV Line 1111					X	0.934	
345 kV Keswick K3-6 SB					X	0.946	
138 kV Beechwood 1111-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1125-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1126-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1176-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood Bus Fault	X	X	X	X	X	Voltage Collapse	
138 kV Grand Falls 1111-02 SB					X	0.934	
138 kV Keswick K1125-1139 SB					X	0.948	

Table 5-5 N-1 Voltage Violations (LTCs & Switched Shunts Adjusted)
2013 Winter Peak - Radial Configuration

Thermal Performance

There were no post-contingency violations of LTE loading criteria for the 2013 winter peak dispatches with the radial configuration.

5.2.2 2013 Summer Peak Load Level

5.2.2.1 Interconnected Configuration

Voltage Performance

N-1 Voltage Violations - 2013 Summer Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 (without UVLS)	X	X		X		0.878 - 0.898	Voltages less than 0.87 pu were considered voltage collapse Also modeled with UVLS at Iroquois which opens 69 kV Lines 70 & 72
345 kV St. Andre AN3-1 SB (without UVLS)	X	X	X	X	X	0.627 - 0.879	
345 kV St. Andre AN 3-2 SB (without UVLS)	X	X		X		0.843 - 0.892	

Table 5-6 N-1 Voltage Violations (LTCs & Switched Shunts Fixed)
2013 Summer Peak - Interconnected Configuration

N-1 Voltage Violations - 2013 Summer Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
After Adjustment of LTCs and Switched Shunts							
345 kV St. Andre AN3-1 SB (without UVLS)	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Iroquois which opens 69 kV Lines 70 & 72

Table 5-7 N-1 Voltage Violations (LTCs & Switched Shunts Adjusted)
2013 Summer Peak - Interconnected Configuration

Thermal Performance

N-1 Thermal Violations - 2013 Summer Peak Load Interconnected Configuration				
Thermally Overloaded Facility	Rating	N-1 Contingency (Loss of)	Flow (% LTE)	Remarks
			Dispatch D3A	
After Adjustment of LTCs and Switched Shunts				
69 kV Line 6901 Overload	48	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	101.7%	

Table 5-8 N-1 Thermal Violations
2013 Summer Peak - Interconnected Configuration

5.2.2.2 Radial Configuration

Voltage Performance

N-1 Voltage Violations - 2013 Summer Peak Load Radial Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
138 kV Beechwood 1111-1 SB	X	X	X	X		0.810 - 0.900	Voltages less than 0.87 pu were considered voltage collapse
138 kV Beechwood 1125-1 SB	X	X	X	X		0.812 - 0.896	
138 kV Beechwood 1126-1 SB	X	X	X	X		0.811 - 0.896	
138 kV Beechwood 1176-1 SB	X	X	X	X		0.810 - 0.900	
138 kV Beechwood Bus Fault	X	X	X	X		0.816 - 0.898	

Table 5-9 N-1 Voltage Violations (LTCs & Switched Shunts Fixed)
2013 Summer Peak - Radial Configuration

N-1 Voltage Violations - 2013 Summer Peak Load Radial Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
After Adjustment of LTCs and Switched Shunts							
138 kV Beechwood 1111-1 SB		X	X	X		0.930 - 0.947	
138 kV Beechwood 1125-1 SB		X	X	X		0.922 - 0.940	
138 kV Beechwood 1126-1 SB		X	X	X		0.917 - 0.936	
138 kV Beechwood 1176-1 SB		X	X	X		0.930 - 0.947	
138 kV Beechwood Bus Fault		X	X	X		0.935 - 0.949	

Table 5-10 N-1 Voltage Violations (LTCs & Switched Shunts Adjusted)
2013 Summer Peak - Radial Configuration

Thermal Performance

N-1 Thermal Violations - 2013 Summer Peak Load Radial Configuration				
Thermally Overloaded Facility	Rating	N-1 Contingency (Loss of)	Flow (% LTE)	Remarks
			Dispatch D3A	
After Adjustment of LTCs and Switched Shunts				
Tinker T1 138/69 kV Transformer	72	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	117.3%	
69 kV Line 6901 Overload	48	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	111.8 - 117.0%	

Table 5-11 N-1 Thermal Violations
2013 Summer Peak - Radial Configuration

5.3 N-1-1 Analysis

The N-1-1 Needs Analysis examined system reliability performance at peak load levels for the following two N-1 outage conditions assuming the interconnected system configuration:

- 138 kV Line 3855 (Beechwood – Flo's Inn).
- 138 kV Line 1111 (Beechwood – Grand Falls).

The complete list of contingencies tested previously for the N-1 Analysis was examined for the N-1-1 Analysis.

Table 5-12 through Table 5-23 summarizes the voltage and thermal reliability violations from the N-1-1 Needs Analysis of the existing MPS system. The voltage tables include violations on the MPS system (12.47 kV to 138 kV) relative to voltage criteria applicable to the two system states that were examined: prior to adjustment of LTCs and switched shunts and after adjustment of LTCs and switched shunts. The thermal tables summarize thermal loading violations for lines within the MPS system and for lines which supply power to the MPS system after adjustment of LTCs and switched shunts.

5.3.1 2013 Winter Peak Load Level

5.3.1.1 Interconnected Configuration

Voltage Performance

N-1-1 Voltage Violations - 2013 Winter Peak Load 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3B	
Prior to Adjustment of LTCs and Switched Shunts							
Keswick T4 345/138 kV Transformer	X	X	X	X	X	0.836 - 0.897	Voltages less than 0.87 pu were considered voltage collapse
345 kV Line 3012 without UVLS	X	X	X	X	X	Voltage Collapse	
345 kV Line 3012 with UVLS	X					0.886 - 0.896	
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	X	X	X	X	X	Voltage Collapse	
345 kV Keswick K3-3 SB	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Beechwood which opens 69 kV Lines 141 & 48
345 kV Keswick K3-6 SB	X	X	X	X	X	0.826 - 0.890	Voltages less than 0.87 pu were considered voltage collapse, did not activate Beechwood UVLS
345 kV St. Andre AN3-1 SB without UVLS	X	X	X	X	X	Voltage Collapse	
345 kV St. Andre AN3-1 SB with UVLS	X	X	X	X	X	0.833 - 0.900	Voltages less than 0.87 pu were considered voltage collapse
345 kV St. Andre AN3-2 SB without UVLS	X	X	X	X	X	Voltage Collapse	
345 kV St. Andre AN3-2 SB with UVLS	X	X	X	X	X	0.51 - 0.858	Voltages less than 0.87 pu were considered voltage collapse
138 kV Beechwood 1111-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1125-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1126-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1176-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood Bus Fault	X	X	X	X	X	Voltage Collapse	
138 kV Keswick K1125-1126 SB	X	X	X	X	X	Voltage Collapse	
138 kV Keswick K1125-1139 SB	X	X	X	X	X	0.869 - 0.900	

Table 5-12 N-1-1 Voltage Violations – 138 kV Line 1111/1144 Outage (LTCs & Switched Shunts Fixed) 2013 Winter Peak - Interconnected Configuration

N-1-1 Voltage Violations - 2013 Winter Peak Load 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3B	
After Adjustment of LTCs and Switched Shunts							
Keswick T4 345/138 kV Transformer				X	X	0.896 - 0.950	
345 kV Line 3012 without UVLS	X	X	X	X	X	Voltage Collapse	
345 kV Line 3012 with UVLS					X	0.948	
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	X	X	X	X	X	Voltage Collapse	
138 kV Line 1125/1172					X	0.926 - 0.943	
345 kV Keswick K3-3 SB	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Beechwood which opens 69 kV Lines 141 & 48
345 kV Keswick K3-3 SB with Beechwood UVLS					X	0.940	
345 kV Keswick K3-6 SB				X	X	0.902 - 0.950	
345 kV St. Andre AN3-1 SB without UVLS	X	X	X	X	X	Voltage Collapse	
345 kV St. Andre AN3-1 SB with UVLS					X	0.937	
345 kV St. Andre AN3-2 SB without UVLS	X	X	X	X	X	Voltage Collapse	
345 kV St. Andre AN3-2 SB with UVLS					X	0.924 - 0.946	
138 kV Beechwood 1111-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1125-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1126-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1176-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood Bus Fault	X	X	X	X	X	Voltage Collapse	
138 kV Keswick K1125-1126 SB	X	X	X	X	X	Voltage Collapse	
138 kV Keswick K1125-1139 SB	X	X		X	X	0.887 - 0.950	
Numerous Contingencies					X	0.946 - 0.950	

Table 5-13 N-1-1 Voltage Violations – 138 kV Line 1111/1144 Outage
(LTCs & Switched Shunts Adjusted)
2013 Winter Peak - Interconnected Configuration

N-1-1 Voltage Violations - 2013 Winter Peak Load 138 kV Line 3855/1176 (Beechwood - Flo's Inn) Outage Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3B	
Prior to Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 without UVLS	X	X	X	X		Voltage Collapse	
345 kV Line 3012 with UVLS	X	X	X	X		0.334 - 0.796	Voltages less than 0.87 pu were considered voltage collapse
Tinker T1 138/69 kV Transformer or138 kV Line 1111	X	X	X	X		Voltage Collapse	
69 kV Line 6901	X	X	X	X		0.32 - 0.89	Voltages less than 0.87 pu were considered voltage collapse
Mullen Shunt			X			0.896 - 0.900	
345 kV Keswick K3-3 SB			X			0.889 - 0.899	Did not activate Beechwood UVLS
345 kV Keswick K3-6 SB		X	X	X		0.877 - 0.900	Did not activate Beechwood UVLS
345 kV St. Andre AN3-1 SB without UVLS	X	X	X	X		Voltage Collapse	
345 kV St. Andre AN3-1 SB with UVLS	X	X	X	X		0.297 - 0.767	Voltages less than 0.87 pu were considered voltage collapse
345 kV St. Andre AN3--2 SB without UVLS	X	X	X	X		Voltage Collapse	
345 kV St. Andre AN3-2 SB with UVLS	X	X	X	X		Voltage Collapse	
138 kV Grand Falls 1111-02 SB	X	X	X	X		Voltage Collapse	

Table 5-14 N-1-1 Voltage Violations – 138 kV Line 3855/1176 Outage (LTCs & Switched Shunts Fixed) 2013 Winter Peak - Interconnected Configuration

N-1 Voltage Violations - 2013 Winter Peak Load 138 kV Line 3855/1176 (Beechwood - Flo's Inn) Outage Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3B	
After Adjustment of LTCs and Switched Shunts							
Keswick T4 345/138 kV Transformer		X		X		0.937 - 0.950	
345 kV Line 3012 without UVLS	X	X	X	X		Voltage Collapse	
345 kV Line 3012 with UVLS	X	X	X	X		Voltage Collapse	
Tinker T1 138/69 kV Transformer or 138 kV Line 1111	X	X	X	X		Voltage Collapse	
Houlton Shunt		X		X		0.914 - 0.944	
Mullen Shunt		X		X		0.913 - 0.944	
69 kV Line 6901	X	X	X	X		Voltage Collapse	
345 kV St. Andre AN3-1 SB without UVLS	X	X	X	X		Voltage Collapse	
345 kV St. Andre AN3-1 SB with UVLS	X	X	X	X		Voltage Collapse	
345 kV St. Andre AN3--2 SB without UVLS	X	X	X	X		Voltage Collapse	
345 kV St. Andre AN3-2 SB with UVLS	X	X	X	X		Voltage Collapse	
345 kV Keswick K3-6 SB		X		X		0.937 - 0.950	
138 kV Grand Falls 1111-02 SB	X	X	X	X		Voltage Collapse	
138 kV Grand Falls SB & BF that open end 1111		X		X		0.940 - 0.949	

Table 5-15 N-1-1 Voltage Violations – 138 kV Line 3855/1176 Outage
(LTCs & Switched Shunts Adjusted)
2013 Winter Peak - Interconnected Configuration

Thermal Performance

Within the MPS system, there were no post-contingency violations of the winter LTE ratings for the 138 kV Line 1111/1144 outage. The NBP 69 kV Lines 88 and 89 were loaded above the winter normal ratings as reported below.

N-1-1 Thermal Violations - 2013 Winter Peak Load 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage Interconnected Configuration				
Thermally Overloaded Facility	Rating	N-1 Contingency (Loss of)	Flow (% LTE)	Remarks
			Dispatch D3B	
After Adjustment of LTCs and Switched Shunts				
69 kV Line 88 Overload	35	138 kV Keswick 1125-39 SB	146.3%	
69 kV Line 89 Overload	35	138 kV Keswick 1125-39 SB	159.9%	

Table 5-16 N-1-1 Thermal Violations – 138 kV Line 1111/1144 Outage
2013 Winter Peak - Interconnected Configuration

N-1-1 Thermal Violations - 2013 Winter Peak Load 138 kV Line 3855/1176 (Beechwood - Flo's Inn) Outage Interconnected Configuration				
Thermally Overloaded Facility	Rating	N-1 Contingency (Loss of)	Flow (% LTE)	Remarks
			Dispatch D3B	
After Adjustment of LTCs and Switched Shunts				
Tinker T1 138/69 kV Transformer Overload	53	Base Case	127.7	
	72	Numerous Contingencies	100.8 - 108.6	
69 kV Line 88 Overload	35	345 kV Keswick 3-6 SB	101.2	
	35	Keswick T4 345/138 kV Transformer	101.3	

Table 5-17 N-1-1 Thermal Violations – 138 kV Line 3855/1176 Outage
2013 Winter Peak - Interconnected Configuration

5.3.2 2013 Summer Peak Load Level

5.3.2.1 Interconnected Configuration

Voltage Performance

N-1-1 Voltage Violations - 2013 Summer Peak Load 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3B	
Prior to Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 without UVLS	X	X	X	X		0.837 - 0.898	Also modeled with UVLS at Iroquois which open 69 kV Lines 70 & 72
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	X	X	X	X	X	0.282 - 0.899	Voltages less than 0.87 pu were considered voltage collapse
345 kV St. Andre AN3-1 SB without UVLS	X	X	X	X		0.572 - 0.879	Voltages less than 0.87 pu were considered voltage collapse
344 kV St. Andre AN3-2 SB without UVLS	X	X	X	X	X	0.653 - 0.873	Also modeled with UVLS at Iroquois which open 69 kV Lines 70 & 72
138 kV Beechwood 1111-1 SB	X	X	X	X	X	0.256 - 0.899	Voltages less than 0.87 pu were considered voltage collapse
138 kV Beechwood 1125-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1126-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1176-1 SB	X	X	X	X	X	0.256 - 0.899	Voltages less than 0.87 pu were considered voltage collapse
138 kV Beechwood Bus Fault	X	X	X	X	X	Voltage Collapse	

Table 5-18 N-1-1 Voltage Violations – 138 kV Line 1111/1144 Outage
(LTCs & Switched Shunts Fixed)
2013 Summer Peak - Interconnected Configuration

N-1 Voltage Violations - 2013 Summer Peak Load 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3B	
After Adjustment of LTCs and Switched Shunts							
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	X	X	X	X	X	Voltage Collapse	
Mullen Shunt			X			0.946 - 0.949	
345 kV St. Andre AN3-1 SB without UVLS	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Iroquois which open 69 kV Lines 70 & 72
138 kV Beechwood 1111-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1125-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1126-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood 1176-1 SB	X	X	X	X	X	Voltage Collapse	
138 kV Beechwood Bus Fault	X	X	X	X	X	Voltage Collapse	

Table 5-19 N-1-1 Voltage Violations – 138 kV Line 1111/1144 Outage
(LTCs & Switched Shunts Adjusted)
2013 Summer Peak - Interconnected Configuration

N-1-1 Voltage Violations - 2013 Summer Peak Load 138 kV Line 3855/1176 (Beechwood - Flo's Inn) Outage Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3B	
Prior to Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 without UVLS	X	X	X	X		0.413 - 0.824	Voltages less than 0.87 pu were considered voltage collapse. Also modeled with UVLS at Iroquois which open 69 kV Lines 70 & 72
Tinker T1 138/69 kV Transformer or 138 kV Line 1111	X	X	X	X		Voltage Collapse	
69 kV Line 6901	X	X	X	X		0.727 - 0.899	Voltages less than 0.87 pu were considered voltage collapse
Mullen Shunt			X	X		0.884 - 0.900	
345 kV St. Andre AN3-1 SB without UVLS	X	X	X	X		Voltage Collapse	
345 kV St. Andre AN3-1 SB with UVLS	X	X	X	X		0.430 - 0.814	Voltages less than 0.87 pu were considered voltage collapse
345 kV St. Andre AN3--2 SB without UVLS	X	X	X	X		0.382 - 0.806	
345 kV St. Andre AN3-2 SB with UVLS	X	X	X	X		0.873 - 0.899	
345 kV St. Andre AN3-6 SB			X			0.9	
138 kV Grand Falls 1111-02 SB	X	X	X	X		Voltage Collapse	

Table 5-20 N-1-1 Voltage Violations – 138 kV Line 3855/1176 Outage
(LTCs & Switched Shunts Fixed)
2013 Summer Peak - Interconnected Configuration

N-1-1 Voltage Violations - 2013 Summer Peak Load 138 kV Line 3855/1176 (Beechwood - Flo's Inn) Outage Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3B	
After Adjustment of LTCs and Switched Shunts							
All Lines In						0.888	
345 kV Line 3012 without UVLS	X	X	X	X		Voltage Collapse	
345 kV Line 3012 with UVLS			X	X		0.937 - 0.950	
Tinker T1 138/69 kV Transformer or 138 kV Line 1111	X	X	X	X		Voltage Collapse	
69 kV Line 6901	X	X	X	X		0.738 - 0.949	Voltages less than 0.87 pu were considered voltage collapse
138 kV Grand Falls 1111-02 SB	X	X	X	X		Voltage Collapse	
345 kV St. Andre AN3-1 SB without UVLS	X	X	X	X		Voltage Collapse	
345 kV St. Andre AN3-1 SB with UVLS	X	X	X	X		Voltage Collapse	
345 kV St. Andre AN3--2 SB without UVLS	X	X	X	X		Voltage Collapse	
345 kV St. Andre AN3-2 SB with UVLS			X	X		0.932 - 0.950	
Numerous Contingencies		X	X	X		0.883 - 0.950	

Table 5-21 N-1-1 Voltage Violations – 138 kV Line 3855/1176 Outage
(LTCs & Switched Shunts Adjusted)
2013 Summer Peak - Interconnected Configuration

Thermal Performance

Within the MPS system, there were no post-contingency violations of the winter LTE ratings for the 138 kV Line 1111/1144 outage. The NBP 69 kV Lines 88 and 89 were loaded above the winter normal ratings as reported below.

N-1 Voltage Violations - 2013 Summer Peak Load 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage Interconnected Configuration				
Thermally Overloaded Facility	Rating	N-1 Contingency (Loss of)	Flow (% LTE)	Remarks
			Dispatch D3B	
After Adjustment of LTCs and Switched Shunts				
69 kV Line 88 Overload	35	138 kV Keswick 1125-26 SB	103.7%	
69 kV Line 89 Overload	35	138 kV Keswick 1125-26 SB	101.2%	

Table 5-22 N-1-1 Thermal Violations – 138 kV Line 1111/1144 Outage
2013 Summer Peak - Interconnected Configuration

N-1-1 Thermal Violations - 2013 Summer Peak Load 138 kV Line 3855/1176 (Beechwood - Flo's Inn) Outage Interconnected Configuration				
Thermally Overloaded Facility	Rating	N-1 Contingency (Loss of)	Flow (% LTE)	Remarks
			Dispatch D3B	
After Adjustment of LTCs and Switched Shunts				
Tinker T1 138/69 kV Transformer Overload	53	Base Case	115.9	
	72	345 kV Line 3012 (with UVLS) & 345 kV St. Andre 3-6 SB	102.4 - 105.9	
69 kV Line 6901 Overload	48	Base Case, Numerous Contingencies	100.2 - 128.3	

Table 5-23 N-1-1 Thermal Violations – 138 kV Line 3855/1176 Outage
2013 Summer Peak - Interconnected Configuration

5.4 Maintenance Outage Analysis

The Maintenance Outage Analysis examined system reliability performance at 85% of peak load levels for the following four outage conditions assuming the interconnected system configuration:

- Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855.
- Tinker T1 138/69 kV Transformer or 138 kV Line 1144.
- Iroquois T1 138/69 kV Transformer or 138 kV Line 1184.
- Iroquois T2 138/69 kV Transformer or 138 kV Line 1183.

Only the single element contingencies were examined for the Maintenance Outage Analysis.

Table 5-25 through Table 5-28 summarizes the voltage and thermal reliability violations from the Maintenance Outage Analysis of the existing MPS system. The voltage tables include violations on the MPS system (12.47 kV to 138 kV) relative to voltage criteria applicable to the two system states that were examined: prior to adjustment of LTCs and switched shunts and after adjustment of LTCs and switched shunts. The thermal tables summarize thermal loading violations for lines within the MPS system and for lines which supply power to the MPS system after adjustment of LTCs and switched shunts.

5.4.1 85% of 2013 Winter Peak Load Level

5.4.1.1 Interconnected Configuration

Voltage Performance

Tinker T1 138/69 kV Transformer Maintenance Outage N-1 Voltage Violations - 85% of 2013 Winter Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 without UVLS	X	X	X	X	X	Voltage Collapse	
345 kV Line 3012 with UVLS	X		X	X		0.858 - 0.897	Voltages less than 0.87 pu were considered voltage collapse
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	X	X	X	X	X	Voltage Collapse	
After Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 without UVLS	X	X	X	X	X	Voltage Collapse	
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	X	X	X	X	X	Voltage Collapse	

Table 5-24 Maintenance Outage Voltage Violations – Tinker T1 Outage 85% of 2013 Winter Peak - Interconnected Configuration

Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Voltage Violations - 85% of 2013 Winter Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 without UVLS	X	X	X	X	X	Voltage Collapse	
345 kV Line 3012 with UVLS	X	X	X	X	X	0.486 - 0.843	Voltages less than 0.87 pu were considered voltage collapse
Tinker T1 138/69 kV Transformer or 138 kV Line 1111	X	X	X	X	X	Voltage Collapse	
69 kV Line 6901	X	X	X	X	X	0.730 - 0.891	Voltages less than 0.87 pu were considered voltage collapse
After Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 without UVLS	X	X	X	X	X	Voltage Collapse	
345 kV Line 3012 with UVLS	X	X	X	X	X	Voltage Collapse	
Tinker T1 138/69 kV Transformer or 138 kV Line 1111	X	X	X	X	X	Voltage Collapse	
69 kV Line 6901	X	X	X	X	X	0.876 - 0.949	

Table 5-25 Maintenance Outage Voltage Violations – Flo's Inn T1 Outage
85% of 2013 Winter Peak - Interconnected Configuration

Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Voltage Violations - 85% of 2013 Winter Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 without UVLS	X	X	X	X	X	Voltage Collapse	
Iroquois T2 138/69 kV Transformer without UVLS	X	X	X	X	X	Voltage Collapse	
After Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 without UVLS	X	X	X	X	X	Voltage Collapse	
Iroquois T2 138/69 kV Transformer without UVLS	X	X	X	X	X	Voltage Collapse	
Iroquois T2 138/69 kV Transformer with UVLS				X		0.928 - 0.938	

Table 5-26 Maintenance Outage Voltage Violations – Iroquois T1 Outage
85% of 2013 Winter Peak - Interconnected Configuration

Iroquois T2 138/69 kV Transformer Maintenance Outage N-1 Voltage Violations - 85% of 2013 Winter Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 without UVLS	X	X	X	X	X	Voltage Collapse	
Iroquois T1 138/69 kV Transformer without UVLS	X	X	X	X	X	Voltage Collapse	
After Adjustment of LTCs and Switched Shunts							
345 kV Line 3012 without UVLS	X	X	X	X	X	Voltage Collapse	
Iroquois T1 138/69 kV Transformer without UVLS	X	X	X	X	X	Voltage Collapse	
Iroquois T1 138/69 kV Transformer with UVLS				X	X	0.931 - 0.949	

Table 5-27 Maintenance Outage Voltage Violations – Iroquois T2 Outage
85% of 2013 Winter Peak - Interconnected Configuration

Thermal Performance

Within the MPS system, there were no post-contingency violations of the winter LTE ratings for the Tinker T1 138/69 kV transformer Maintenance Outage.

Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Thermal Violations - 85% of 2013 Winter Peak Load Interconnected Configuration				
Thermally Overloaded Facility	Rating	N-1 Contingency (Loss of)	Flow (% LTE)	Remarks
			Dispatch D3A	
After Adjustment of LTCs and Switched Shunts				
Tinker T1 138/69 kV Transformer Overload	53	Base	112.9	

Table 5-28 Maintenance Outage Thermal Violations – Flo's Inn T1 Outage
85% of 2013 Winter Peak - Interconnected Configuration

Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Thermal Violations - 85% of 2013 Winter Peak Load Interconnected Configuration				
Thermally Overloaded Facility	Rating	N-1 Contingency (Loss of)	Flow (% LTE)	Remarks
			Dispatch D3A	
After Adjustment of LTCs and Switched Shunts				
Tinker T1 138/69 kV Transformer Overload	72	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	108.6	
Iroquois T2 138/69 kV Transformer Maintenance Outage N-1 Thermal Violations - 85% of 2013 Winter Peak Load Interconnected Configuration				
After Adjustment of LTCs and Switched Shunts				
Tinker T1 138/69 kV Transformer Overload	72	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	107	

Table 5-29 Maintenance Outage Thermal Violations – Iroquois T1 & T2 Outages 85% of 2013 Winter Peak - Interconnected Configuration

5.4.2 85% of 2013 Summer Peak Load Level

5.4.2.1 Interconnected Configuration

Voltage Performance

Tinker T1 138/69 kV Transformer Maintenance Outage N-1 Voltage Violations - 85% of 2013 Summer Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	X	X	X	X	X	0.318 - 0.926	Voltages less than 0.87 pu were considered voltage collapse
After Adjustment of LTCs and Switched Shunts							
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	X	X	X	X	X	Voltage Collapse	

Table 5-30 Maintenance Outage Voltage Violations – Tinker T1 Outage 85% of 2013 Summer Peak - Interconnected Configuration

Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Voltage Violations - 85% of 2013 Summer Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
345 kV Line 3011		X	X	X		0.941 - 0.948	
Tinker T1 138/69 kV Transformer or 138 kV Line 1111	X	X	X	X	X	0.401 - 0.927	Voltages less than 0.87 pu were considered voltage collapse
69 kV Line 6901	X	X	X	X		0.870 - 0.945	
Ashland Shunt		X				0.946 - 0.949	
Mullen Shunt	X	X	X	X		0.919 - 0.949	
After Adjustment of LTCs and Switched Shunts							
Tinker T1 138/69 kV Transformer or 138 kV Line 1111	X	X	X	X	X	0.456 - 0.941	Voltages less than 0.87 pu were considered voltage collapse
69 kV Line 6901		X	X	X		0.880 - 0.932	
Mullen Shunt		X	X	X		0.920 - 0.949	

Table 5-31 Maintenance Outage Voltage Violations – Flo's Inn T1 Outage
85% of 2013 Summer Peak - Interconnected Configuration

Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Voltage Violations - 85% of 2013 Summer Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
Iroquois T2 138/69 kV Transformer (without UVLS)	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Iroquois which open 69 kV Lines 70 & 72
After Adjustment of LTCs and Switched Shunts							
Iroquois T2 138/69 kV Transformer (without UVLS)	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Iroquois which open 69 kV Lines 70 & 72

Table 5-32 Maintenance Outage Voltage Violations – Iroquois T1 Outage
85% of 2013 Summer Peak - Interconnected Configuration

Iroquois T2 138/69 kV Transformer Maintenance Outage N-1 Voltage Violations - 85% of 2013 Summer Peak Load Interconnected Configuration							
N-1 Contingency (Loss of)	MPS Voltage Levels (kV) with Criteria Violations					Voltage (pu)	Remarks
	12	35	44	69	138	Dispatch D3A	
Prior to Adjustment of LTCs and Switched Shunts							
Iroquois T1 138/69 kV Transformer (without UVLS)	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Iroquois which open 69 kV Lines 70 & 72
After Adjustment of LTCs and Switched Shunts							
Iroquois T1 138/69 kV Transformer (without UVLS)	X	X	X	X	X	Voltage Collapse	Also modeled with UVLS at Iroquois which open 69 kV Lines 70 & 72

Table 5-33 Maintenance Outage Voltage Violations – Iroquois T2 Outage
85% of 2013 Summer Peak - Interconnected Configuration

Thermal Performance

Within the MPS system, there were no post-contingency violations of the summer LTE ratings for the Tinker T1 138/69 kV transformer maintenance outage, or either of the Iroquois 138/69 kV transformer maintenance outages.

Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Thermal Violations - 85% of 2013 Summer Peak Load Interconnected Configuration				
Thermally Overloaded Facility	Rating	N-1 Contingency (Loss of)	Flow (% LTE) Dispatch D3A	Remarks
After Adjustment of LTCs and Switched Shunts				
Tinker T1 138/69 kV Transformer Overload	53	Base	103.5	
69 kV Line 6901 Overload	48	69 kV Line 6903	108.2 - 113.1	
69 kV Line 6901 Overload	48	69 kV Line 6904	100.9 - 106.3	
69 kV Line 6903 Overload	39	69 kV Line 6901	143.4 - 148.3	
69 kV Line 6904 Overload	39	69 kV Line 6901	123.7	

Table 5-34 Maintenance Outage Thermal Violations – Flo's Inn T1 Outage
85% of 2013 Summer Peak - Interconnected Configuration

Section 6
Assessment of New England Interconnection Alternatives

6.1 New England Reinforcement Testing

The Study tested six configurations for interconnection with the Maine electric grid to address the MPS reliability issues reported in the Needs Assessment (M1 – M6):

- M1: Tap the 345 kV Line 3001 at Haynesville, add a step-down autotransformer to 115 kV, build new 115 kV transmission along the Bridal Path to Mullen, add a step-down transformer to 69 kV and tie to the existing MPS transmission system.
- M2: Same as M1 except Haynesville step-down autotransformer to 69 kV, build new 69 kV transmission along Bridal Path to Mullen.
- M3: Same as M1 except also tie in the First Wind Oakfield Wind Project with a tap.
- M4: Same as M1 except build new 345 kV line and move transformation from the Haynesville tap to Mullen.
- M5: Extend the planned and permitted First Wind Oakfield Wind Project 115 kV transmission line to Mullen, add a step-down transformer to 69 kV to tie to existing MPS transmission system, and expand the First Wind substation to a ring bus. The step-down substation at Mullen similar to M1.
- M6: Same as M5 except Oakfield Wind Project 115 kV transmission line upgraded to 345 kV, add a step–down transformer to 69 kV to tie to existing MPS transmission system, and expand the First Wind substation to a ring bus. The step-down substation at Mullen similar to M1.

These six New England interconnections are depicted below in Figure 6-1 through Figure 6-5.

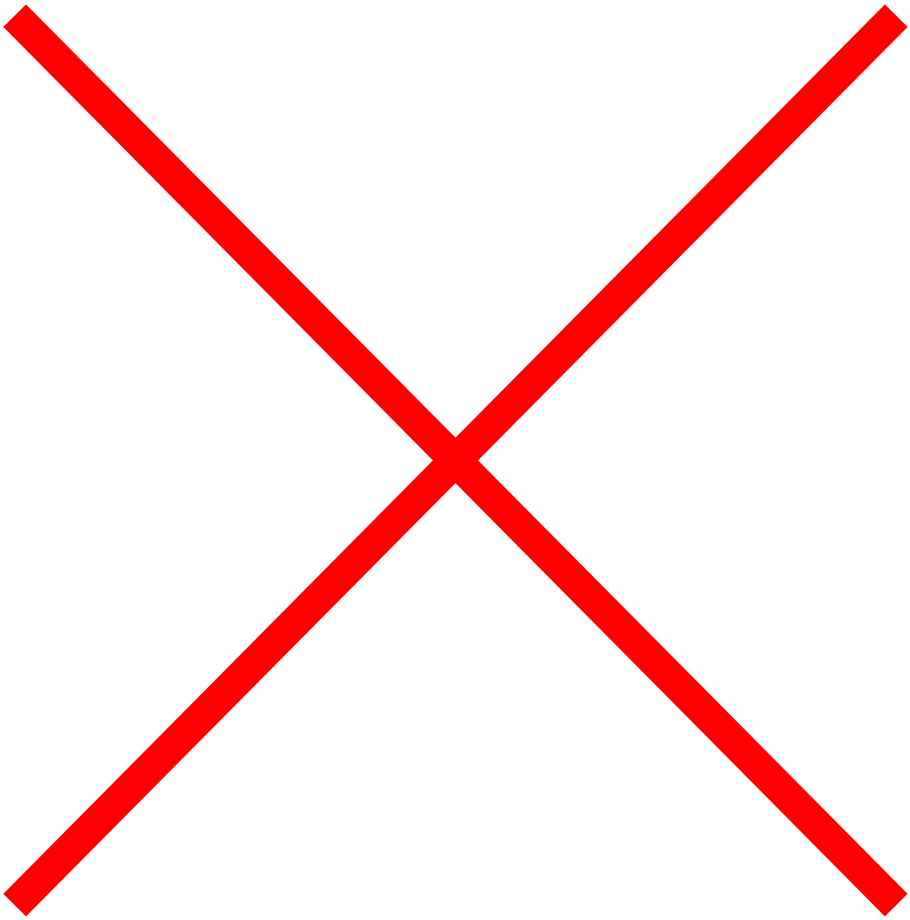

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Figure 6-1 New England Interconnection M1

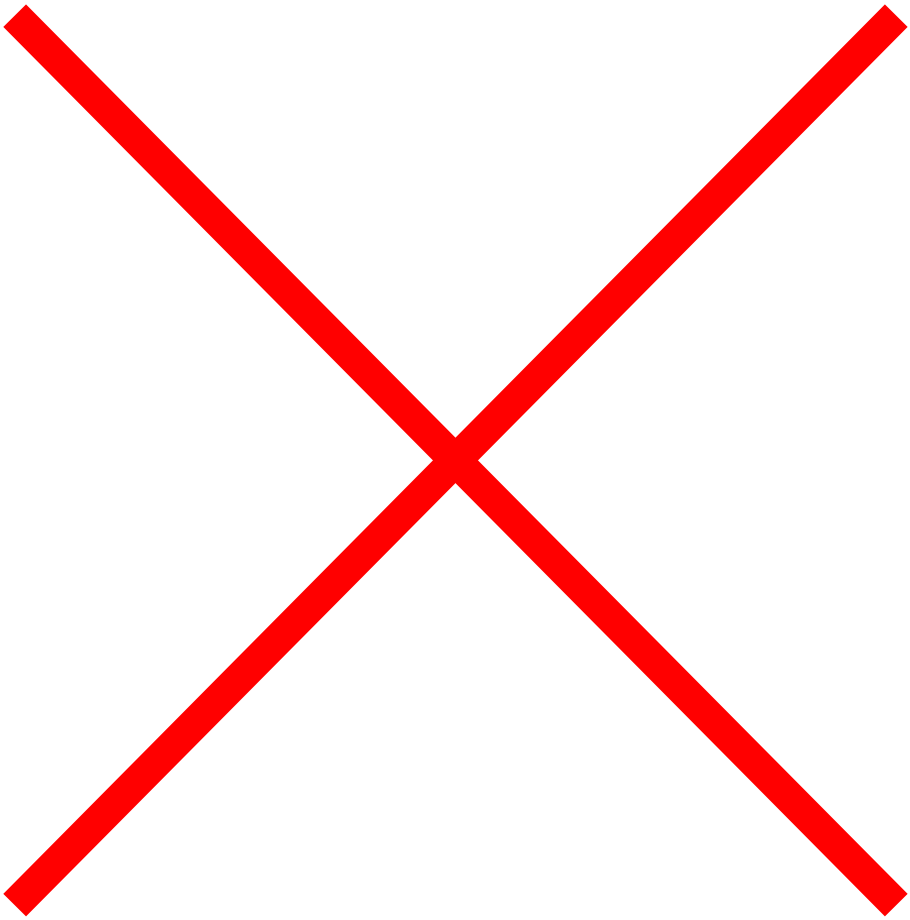

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Figure 6-2 New England Interconnection M2

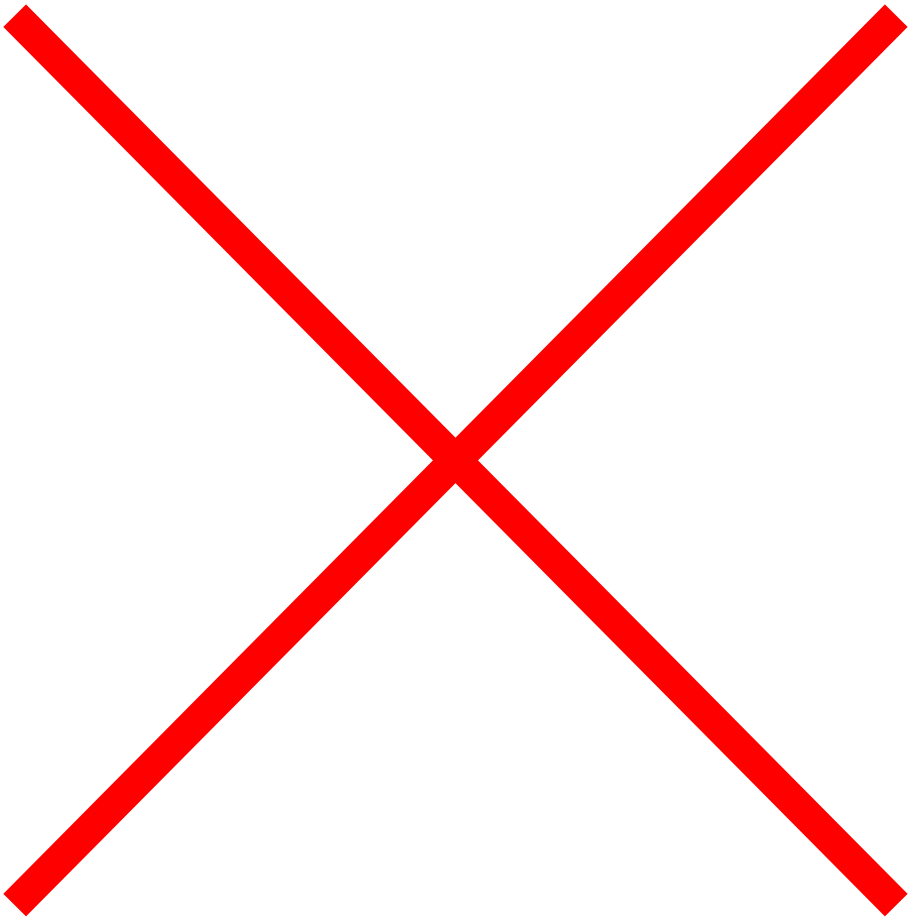

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Figure 6-3 New England Interconnection M3

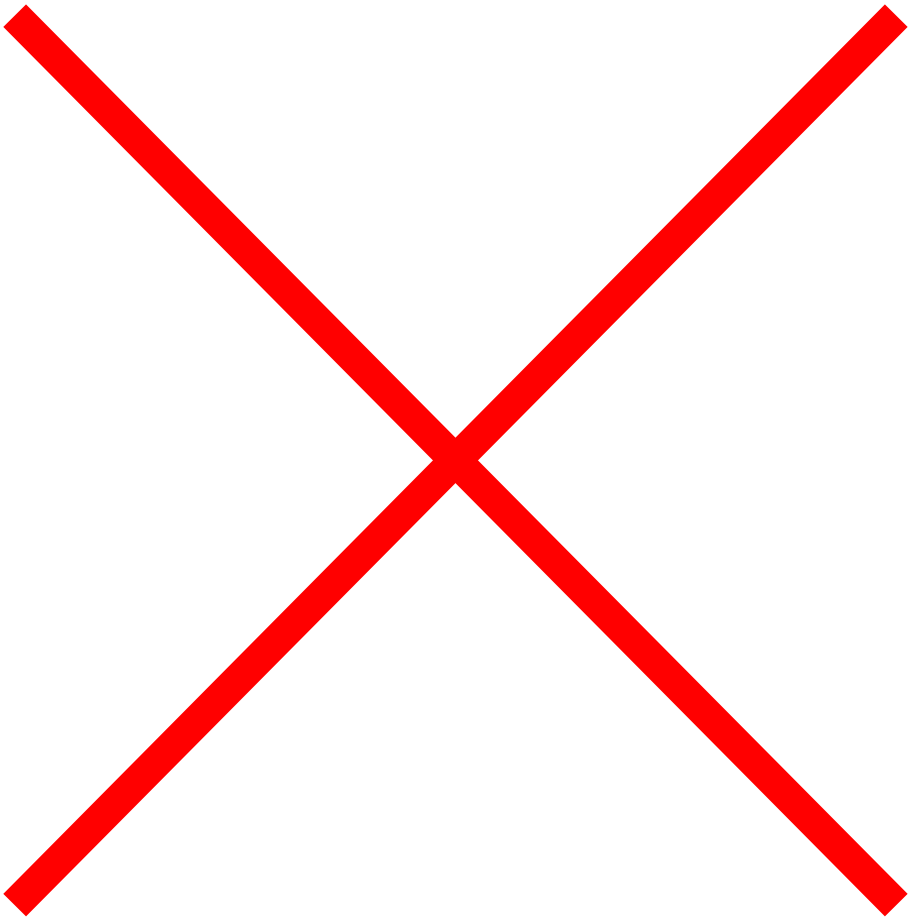

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Figure 6-4 New England Interconnection M4

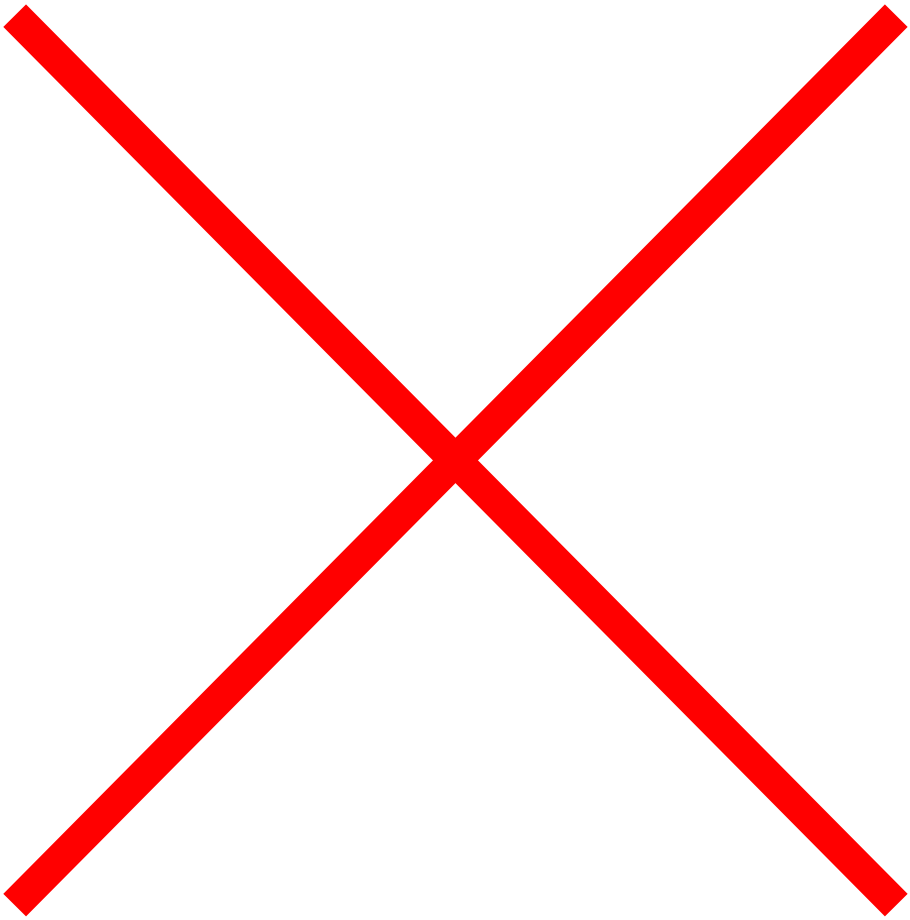

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Figure 6-5 New England Interconnection M5

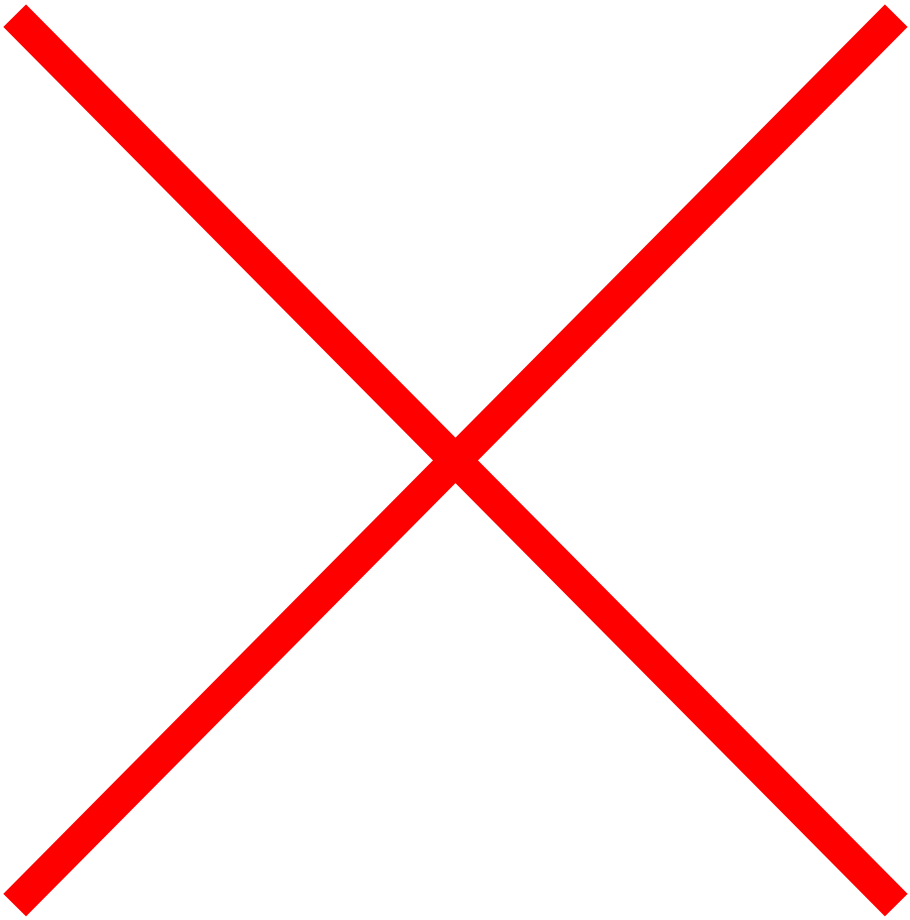

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Figure 6-6 New England Interconnection M6

6.2 New England Interconnections - Base Case Assumptions

Table 6-1 below describes the assumed line constants for each of the New England interconnections.

Alternative	From Bus	To Bus	kV	Length (miles)	R (pu)	X (pu)	B (pu)	Ratings (MVA)
M1	Haynesville	Mullen	115	26	0.0232	0.1434	0.0203	219/252/252
M2	Haynesville	Mullen	69	26	0.0640	0.3493	0.0085	154/191/191
M3	Haynesville	Oakfield	115	13	0.0116	0.0717	0.0102	219/252/252
M3	Oakfield	Mullen	115	13	0.0116	0.0717	0.0102	219/252/252
M3	Oakfield	Oakfield Tap	115	10	0.0089	0.0552	0.0078	219/252/252
M4	Haynesville	Mullen	345	26	0.0011	0.0129	0.2242	997/997/1068
M5	Oakfield	Mullen	115	60	0.0107	0.0662	0.0094	219/252/252
M6	Oakfield	Mullen	345	60	0.0030	0.0357	0.6192	997/997/1068

Table 6-1 New England Interconnection Line Constants

Table 6-2 below summarizes the transformer modeling information for each New England interconnection. M3 and M5, which change the interconnection of the Oakfield Wind Farm, reported that the Mullen 115/69 kV transformer would need to have an LTE rating of at least 140 MVA. This size was also utilized in M1 for consistency.

Alternative	From Bus	To Bus	FkV	TkV	R (pu)	X (pu)	Auto-Adj.	Hold Range (pu)	Ratings (MVA)
M1, M3	Haynesville	Haynesville	345	115	0.0016	0.03081	no	n/a	311/379/506
M1, M3, M5	Mullen	Mullen	115	69	0.00675	0.081	yes	1.025 – 1.00	140/140/140
M2	Haynesville	Haynesville	345	69	0.00106	0.0574	yes	1.025 – 1.00	249/282/306
M4, M6	Mullen	Mullen	345	69	0.00106	0.0574	yes	1.025 – 1.00	249/282/306

Table 6-2 New England Interconnection Transformer Modeling Information

6.3 New England Interconnections - System Configurations

For the New England alternatives assessment, transmission system configurations were tested with contingency analysis during all lines in-service (N-0 base case and N-1 post-contingency), 138 kV line outage (N-1 base case and N-1-1 post-contingency) and 138/69 kV maintenance outage (N-1 base case and N-1-1 post-contingency) conditions. The following configurations and system conditions were tested:

- All Lines In (N-0) at peak load:
    - Interconnected configuration.
    - Radial configuration.
- Two N-1 outage conditions at peak load (N-1) for the interconnected configuration:
    - 138 kV Line 3855 (Beechwood – Flo's Inn).
    - 138 kV Line 1111 (Beechwood – Grand Falls).
- Four scheduled maintenance configurations at 85% load (N-1) for the interconnected configuration
    - Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855.
    - Tinker T1 138/69 kV Transformer or 138 kV Line 1144.
    - Iroquois T1 138/69 kV Transformer or 138 kV Line 1184.
    - Iroquois T2 138/69 kV Transformer or 138 kV Line 1183.

6.4 New England Interconnections - Contingency List Additions and Modifications

The following tables contain the additional contingencies, and/or changes in contingency description based upon the New England alternative.

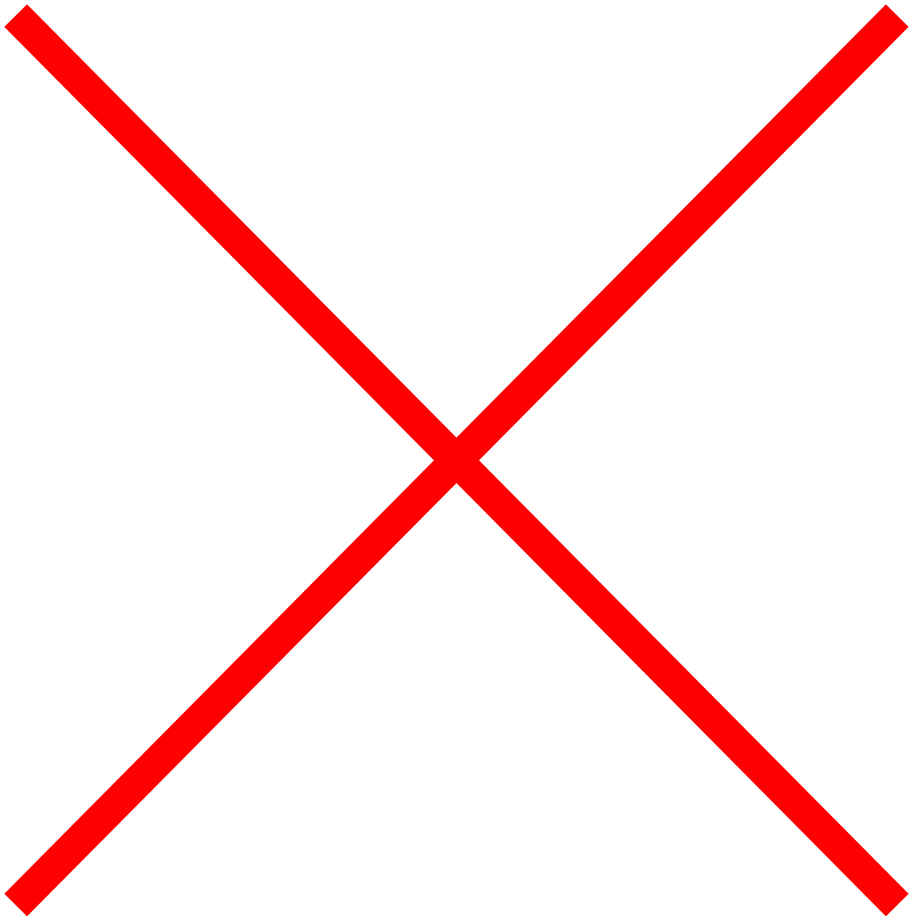

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Table 6-3
Category B – New England Alternatives Single Element Transmission Line Contingencies

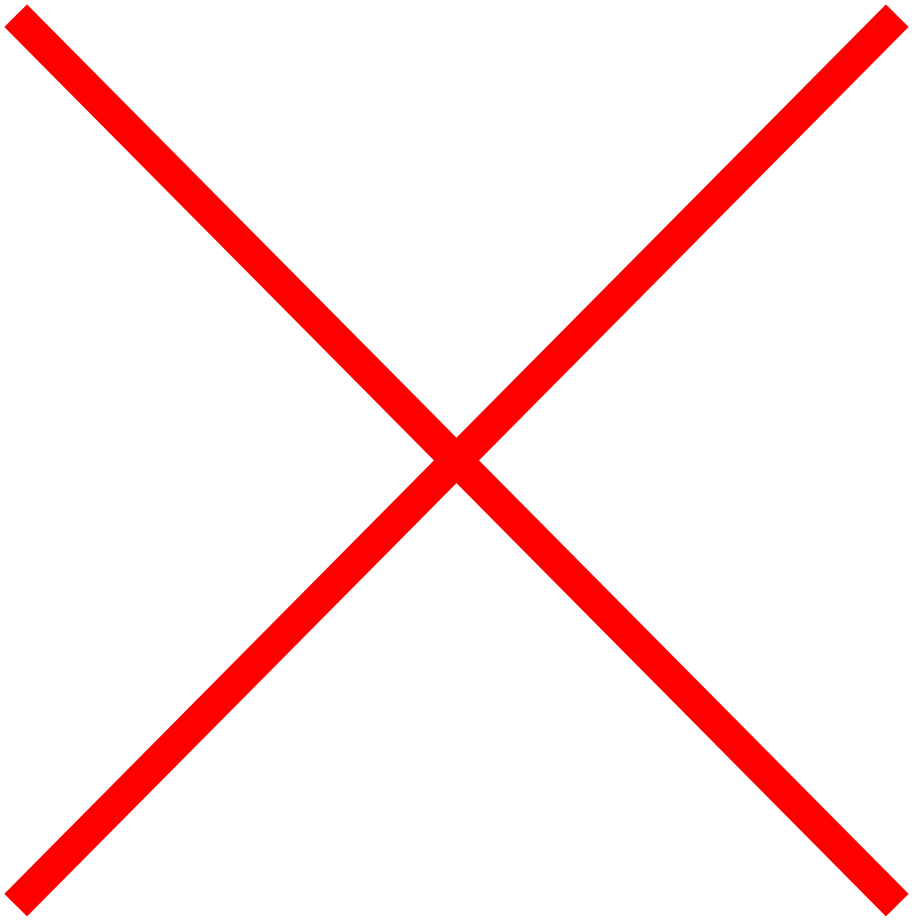

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Table 6-4
Category B – New England Alternatives Single Element Transformer Contingencies

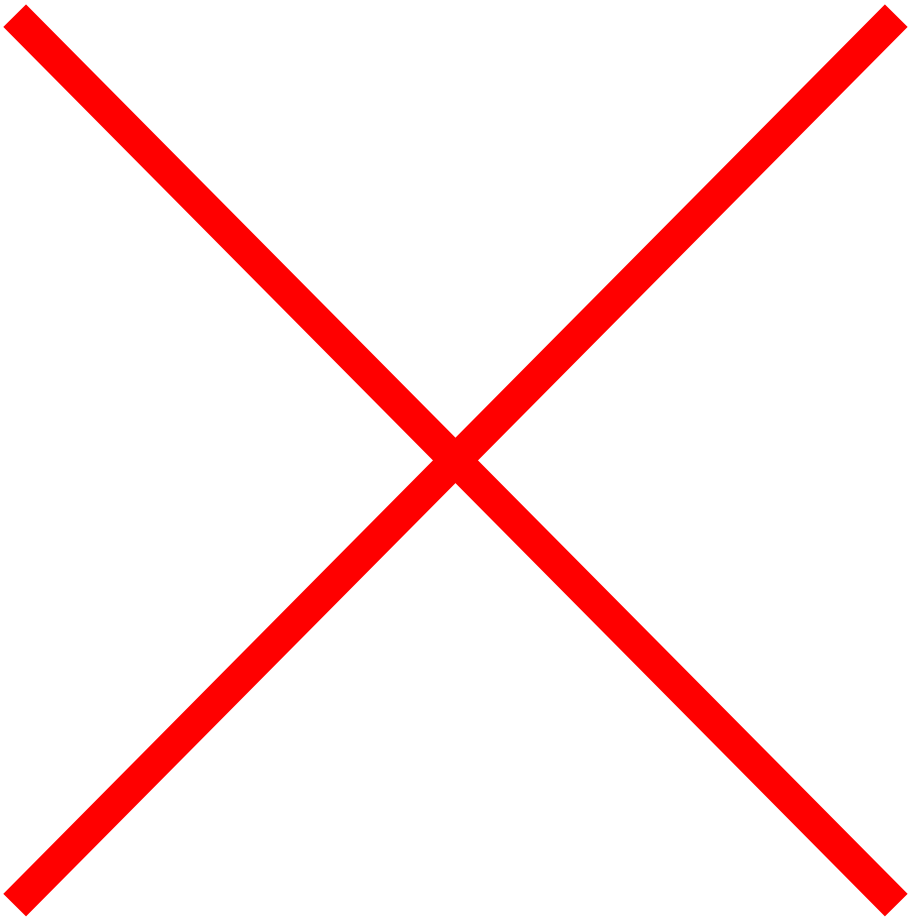

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Table 6-5
Category C – New England Alternatives Multiple Element Stuck Breaker Contingencies

6.5 New England Interconnections - All Lines In (N-0) Analysis

6.5.1 2013 Winter Peak Load Level

6.5.1.1 Interconnected Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

6.5.1.2 Radial Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

6.5.2 2013 Summer Peak Load Level

6.5.2.1 Interconnected Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

6.5.2.2 Radial Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

6.6 New England Interconnections - N-1 Analysis

N-1 Analysis was performed to examine the impact of each New England Interconnection on the MPS reliability issues identified in the Needs Assessment. M3 and M5 both include a tie with the First Wind Oakfield Wind Project. These alternatives were assessed with Oakfield Wind offline and then sensitivity to the full wind farm output was examined for thermal performance at the summer load levels for the N-1 Analysis.

Sensitivity to the radial system configuration was examined for the N-1 Analysis.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC". With a new connection to New England, for some contingencies voltage coordination would be required between the Mullen transformer, the new transformer added with the alternative and potentially the Mullen capacitor, this was noted with "Coordination Req".

6.6.1 2013 Winter Peak Load Level

6.6.1.1 Interconnected Configuration

New England Alternatives Assessment N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Winter Peak Load - Interconnected Configuration							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
Voltage Collapse	345 kV Line 3012	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Low Voltage Violations	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O	O
Voltage Collapse	345 kV Keswick K3-3 SB (UVLS not Required)	FI (A)	LV (F & A)	FI (A)	LV (A)	LV (F & A)	LV (F & A)
	345 kV St. Andre AN3-1 & AN3-2 SB (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	138 kV Beechwood SBs & Bus Fault	O	O	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O	O
Issues Created by Alternatives							
Low Voltage Violations	Loss of 345 kV 3001 Line					Coordination Req	
	Keswick T4 345/138 kV Transformer		FI (A)		FI (A)		FI (A)
	Loss of Mullen 345/69 kV Transformer						MC
	345 kV Keswick K3-5 SB	MC	MC	MC	MC	MC, LV (A)	LV (A)
	345 kV Keene Road K396-5 SB					MC	
	Contingencies involving loss of Keene Rd to Oakfield Line					Coordination Req	
	Contingencies involving loss of Haynesville to Mullen Line	MC			MC		
Voltage Collapse	345 kV Keswick K3-6 SB (UVLS not Required)	MC, LV (F & A)	MC, LV (F & A)	MC, LV (F & A)	MC, FI (A)	MC, LV (A)	LV (A)
69 kV Line 6910 Overload	345 kV Keswick K3-3 SB				X		X
	345 kV Line 3001, 345 KV Keswick K3-5 & K3-6 SB						X
Oakfield On-Line Sensitivity - Reliability Issue Identified with Alternative In-Service							
69 kV Line 6910 Overload	345 kV Keswick K3-3 SB	N/A		X	N/A	X	X
	Contingencies that leave Oakfield feeding radial into MPS					X	X
	Contingencies involving 69 kV Line 6920					X	

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue created by Alternative

Table 6-6 N-1 Analysis of New England Alternatives
2013 Winter Peak Load – Interconnected Configuration

6.6.1.2 Radial Configuration

New England Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Winter Peak Load - Radial Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
138 kV Low Voltage Violations	Keswick T4 345/138 kV Transformer	O	O	O	FI (A)	O	FI (A)
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O	O
138 kV Low Voltage Violations	138 kV Line 1111	O	O	O	O	O	O
138 kV Low Voltage Violations	345 kV Keswick K3-6 SB	MC, LV (F & A)	O	O	O	FI (A)	FI (A)
Voltage Collapse	138 kV Beechwood SBs & Bus Fault	O	O	O	O	O	O
138 kV Low Voltage Violations	138 kV Grand Falls 1111-02 SB	O	O	O	O	O	O
	138 kV Keswick K1125-1139 SB	O	O	O	FI (A)	O	O
Islanding/Consequential Load Loss of Northern MPS	345 kV Line 3113						
Issues Created by Alternatives							
138 kV Low Voltage Violations	345 kV Keswick K3-3 SB	FI (A)			FI (A)		FI (A)
Voltage Collapse	345 kV Keswick K3-5 SB	MC, LV (F)					
Low Voltage Violations	Contingencies involving loss of Haynesville to Mullen Line	MC					
Oakfield On-Line Sensitivity - Reliability Issue Identified with Alternative In-Service							
69 kV Line 6910 Overload	345 kV Keswick K3-3 & K3-6 SBs	N/A			N/A		X

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue created by Alternative

Table 6-7 N-1 Analysis of New England Alternatives
2013 Winter Peak Load – Radial Configuration

6.6.2 2013 Summer Peak Load Level

6.6.2.1 Interconnected Configuration

New England Alternatives Assessment N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Summer Peak Load - Interconnected Configuration							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
Voltage Collapse	Contingencies involving loss of 345 kV 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O	O
Issues Created by Alternative							
Low Voltage Violations	345 kV Keswick K3-5 SB			Coordination Req	MC		
	345 kV Keswick K3-6 SB			Coordination Req			
	Contingencies involving loss of Keene Road to Oakfield					Coordination Req	Coordination Req
Oakfield On-Line Sensitivity - Reliability Issue Identified with Alternative In-Service							
69 kV Line 6910 Overload	Contingencies that leave Oakfield feeding radial into MPS	N/A		X	N/A	X	X
	Contingencies involving 69 kV Line 6920					X	
Impact on MPS System Performance: O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain FI = Low Voltage Violations at 138 kV Flo's Inn bus only MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust (A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations T = Thermal Overloads Remain VC = Voltage Collapse Concern Remains (thermal concern not noted) X = Issue created by Alternative							

Table 6-8 N-1 Analysis of New England Alternatives
2013 Summer Peak Load – Interconnected Configuration

6.6.2.2 Radial Configuration

New England Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Summer Peak Load - Radial Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
Voltage Collapse	138 kV Beechwood SBs & Bus Fault	O	O	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855, 138 kV Beechwood SBs & Bus Fault	O	O	O	O	O	O
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855, 138 kV Beechwood SBs & Bus Fault	O	O	O	O	O	O
Islanding/Consequential Load Loss of Northern MPS	345 kV Line 3113						
Issues Created by Alternative							
Low Voltage Violations	Contingencies involving loss of Keene Road to Oakfield Line					Coordination Req	
Oakfield On-Line Sensitivity - Reliability Issue Identified with Alternative In-Service							
69 kV Line 6910 Overload	Contingencies that leave Oakfield feeding radial into MPS	N/A		X	N/A	X	X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 6-9 N-1 Analysis of New England Alternatives
2013 Summer Peak Load – Radial Configuration

6.7 New England Interconnections - N-1-1 Analysis

N-1-1 Analysis was performed to examine the impact of each New England alternative on the MPS reliability issues identified in the Needs Assessment for the following two N-1 outage conditions assuming the interconnected system configuration:

- 138 kV Line 1111 (Beechwood – Grand Falls).
- 138 kV Line 3855 (Beechwood – Flo's Inn).

As in the N-1 Analysis, M3, M5 and M6 were first assessed with Oakfield Wind offline and then sensitivity to the full wind farm output was examined for thermal performance at the summer load level.

The complete list of contingencies tested previously for the N-1 Analysis was examined for the N-1-1 Analysis. The tables below however, include discussion of contingencies at the 100 kV level and above.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC". With a new connection to New England, for some contingencies voltage coordination would be required between the Mullen transformer, the new transformer added with the alternative and potentially the Mullen capacitor, this was noted with "Coordination Req".

6.7.1 2013 Winter Peak Load Level

6.7.1.1 Interconnected Configuration

New England Alternatives Assessment 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage N-1-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Winter Peak Load - Interconnected Configuration							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak
138 kV Low Voltage Violations	Numerous Contingencies	O	O	O	O	O	O
Voltage Collapse	Keswick T4 345/138 kV Transformer	FI (A)	FI (A)	FI (A)	FI (A)	FI (A)	FI (A)
	345 kV L/O 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	MC	O	O	O	O
Voltage Collapse	345 kV Keswick K3-3 SB (UVLS not activated)	O	O	O	O	O	O
	345 kV Keswick K3-6 SB (UVLS not activated)	VC	VC	VC	VC	FI (A)	FI (A)
	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC	VC	VC	VC	VC	VC
	345 kV St. Andre AN3-1 SB (with UVLS)	O	O	O	O	O	O
	345 kV St. Andre AN3-2 SB (with UVLS)	LV (F)	LV (F)	LV (F)	LV (F)	LV (F)	LV (F)
	138 kV Beechwood SBs & BF	O	LV (A)	O	O	O	O
	138 kV Keswick K1125-1126 & K1125-1139 SB	FI (A)	FI (A)	FI (A)	FI (A)	FI (A)	FI (A)
Issues Created by Alternative							
69 kV Line 88 & 89 Overload	Keswick T4 345/138 kV Transformer		X			X	
69 kV Line 88 & 89 Overload	345 kV Keswick K3-6 SB					X	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 6-10 N-1-1 Analysis of New England Alternatives – 138 kV Line 1111/1144 Outage 2013 Winter Peak Load - Interconnected Configuration

New England Alternatives Assessment
138 kV Line 3855/1176 (Beechwood -Flo's Inn) Outage
N-1-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Winter Peak Load - Interconnected Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Low Voltage Violations	Keswick T4 345/138 kV Transformer	O	O	O	O	O	O
Voltage Collapse	Tinker T1 138/69 kV or 138 kV Line 1111	O	MC	O	O	O	O
Low Voltage Violations	345 kV Keswick K3-3 SB (UVLS not activated)	O	O	O	O	O	O
	345 kV Keswick K3-6 SB (UVLS not activated)	MC	MC, LV (F)	MC	MC, LV (F & A)	O	O
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SB (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	138 kV Grand Falls 1111-02 SB	O	LV (A)	O	O	O	O
Low Voltage Violations	138 kV Grand Falls SB & BF that open end 1111	O	O	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Base Case, Numerous Contingencies	O	O	O	O	O	O
69 kV Line 88 Overload	345 kV Keswick K3-6 SB, Keswick T4 345/138 kV Transformer	O	O	O	O	O	O
Issues Created by Alternative							
Low Voltage Violations	Contingencies involving L/O Haynesville to Mullen				MC		
	Contingencies involving L/O Oakfield to Mullen						MC

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 6-11 N-1-1 Analysis of New England Alternatives – 138 kV Line 3855/1176 Outage
2013 Winter Peak Load - Interconnected Configuration

6.7.2 2013 Summer Peak Load Level

6.7.2.1 Interconnected Configuration

New England Alternatives Assessment 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage N-1-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Summer Peak Load - Interconnected Configuration							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O	O
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-1 SBs (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	138 kV Beechwood SBs & Bus Fault	O	O	O	O	O	O
69 kV Line 88 Overload	138 kV Keswick K1125-1126SB	O	O	O	O	O	O
69 kV Line 89 Overload	138 kV Keswick K1125-1126SB	O	O	O	O	O	O
Issues Created by Alternative							
Low Voltage	345 kV Keswick K3-5 SB				MC		

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue created by Alternative

Table 6-12 N-1-1 Analysis of New England Alternatives – 138 kV Line 1111/1144 Outage
2013 Summer Peak Load - Interconnected Configuration

New England Alternatives Assessment 138 kV Line 3855/1176 (Beechwood -Flo's Inn) Outage N-1-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Summer Peak Load - Interconnected Configuration							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak
Low Voltage Violations	Base Case, Numerous Contingencies	O	O	O	O	O	O
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	O	O	O	O	O	O
Voltage Collapse	138 kV Grand Falls 1111-02 SB	O	O	O	O	O	O
	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Base Case, Numerous Contingencies	O	O	O	O	O	O
69 kV Line 6901 Overload	Base Case, Numerous Contingencies	O	O	O	O	O	O
Issues Created by Alternative							
Voltage Collapse	Contingencies involving L/O Haynesville to Mullen	MC	MC	MC	MC		
	Contingencies involving L/O Keene Rd to Oakfield					MC	
	Contingencies involving L/O Oakfield to Mullen					MC	MC

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 6-13 N-1-1 Analysis of New England Alternatives – 138 kV Line 3855/1176 Outage 2013 Summer Peak Load - Interconnected Configuration

Assessment of the N-1-1 voltage results for the two 138 kV line outages, 1111 and 3855, confirmed the need for further analysis to examine appropriate coordination of the various voltage reactive devices in the Haynesville/Mullen area: the existing shunt capacitors at Houlton and Mullen, the Mullen 69/44 kV transformer LTC and the new interconnection transformer(s) LTC and no –load taps. As an example, for each of the 138 kV Line outages it was necessary to have capacitors in-service pre-contingency at Houlton and Mullen to help maintain acceptable post-contingency voltage for loss of the new alternative supply. With the new transformation and voltage control at Mullen, the reactive support of the capacitors was pushed up onto the 345 kV system (pre-contingency). Without coordination of the various voltage control devices, pre-contingency high voltage occurs.

In addition, post-contingency high and low voltage violations were seen for alternatives M1-M4 which could likely be addressed through the previously mentioned coordination effort.

6.8 New England Interconnections - Maintenance Outage Analysis

Maintenance Outage Analysis was performed to examine the impact of each New England alternative on the MPS reliability issues identified in the Needs Assessment for the following four outage conditions at 85% of peak load, assuming the interconnected system configuration:

- Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855.
- Tinker T1 138/69 kV Transformer or 138 kV Line 1144.
- Iroquois T1 138/69 kV Transformer or 138 kV Line 1184.
- Iroquois T2 138/69 kV Transformer or 138 kV Line 1183.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC". With a new connection to New England, for some contingencies voltage coordination would be required between the Mullen transformer, the new transformer added with the alternative and potentially the Mullen capacitor, this was noted with "Coordination Req".

6.8.1 85% of 2013 Winter Peak Load Level

6.8.1.1 Interconnected Configuration

New England Alternatives Assessment Tinker T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load - Interconnected Configuration							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
Voltage Collapse	345 KV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O	O
Issues Created by Alternative							
Low Voltage Violations	Contingencies involving L/O Haynesville to Mullen				MC		
	Contingencies involving L/O Keene Rd to Oakfield					Coordination Req	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 6-14 Maintenance Outage Analysis of New England Alternatives – Tinker T1 Outage 85% of 2013 Winter Peak Load - Interconnected Configuration

New England Alternatives Assessment Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load - Interconnected Configuration							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
Voltage Collapse	345 KV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	O	MC	O	O	O	O
	69 kV Line 6901	O	O	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Base	O	O	O	O	O	O
Issues Created by Alternative							
Voltage Collapse	Contingencies involving L/O Haynesville to Mullen	MC	MC	MC	MC		
Low Voltage Violation	Contingencies involving L/O Keene Rd to Oakfield					Coordination Req	LV (A)
Voltage Collapse	Contingencies involving L/O Oakfield to Mullen					MC	MC

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 6-15 Maintenance Outage Analysis of New England Alternatives – Flo's Inn T1 Outage 85% of 2013 Winter Peak Load - Interconnected Configuration

New England Alternatives Assessment Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load - Interconnected Configuration							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
Voltage Collapse	345 KV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O	O
Iroquois T2 138/69 kV Transformer Maintenance Outage							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
Voltage Collapse	345 KV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 6-16 Maintenance Outage Analysis of New England Alternatives – Iroquois T1 or T2 Outages - 85% of 2013 Winter Peak Load - Interconnected Configuration

6.8.2 85% of 2013 Summer Peak Load Level

6.8.2.1 Interconnected Configuration

New England Alternatives Assessment Tinker T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load - Interconnected Configuration							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O	O
Issues Created by Alternative							
Low Voltage Violations	Loss of Keene Rd to Oakfield					Coordination Req	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 6-17 Maintenance Outage Analysis of New England Alternatives – Tinker T1 Outage 85% of 2013 Summer Peak Load - Interconnected Configuration

New England Alternatives Assessment Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load - Interconnected Configuration							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
Low Voltage Violations	345 kV Line 3011	O	O	O	O	O	O
Voltage Collapse	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	O	O	O	O	O	O
Low Voltage Violations	69 kV Line 6901	O	O	O	O	O	O
	Ashland Shunt	O	O	O	O	O	O
	Mullen Shunt	O	O	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Base	O	O	O	O	O	O
69 kV Line 6901 Overload	69 kV Lines 6903 & 6904	O	O	O	O	O	O
69 kV Line 6904 Overload	69 kV Line 6901	O	O	O	O	O	O
69 kV Line 6903 Overload	69 kV Line 6901	O	O	O	O	O	O
Issues Created by Alternative							
Low Voltage Violation	Loss of Keene Rd to Oakfield					Coordination Required	
Voltage Collapse	Contingencies involving L/O Haynesville to Mullen				MC		

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 6-18 Maintenance Outage Analysis of New England Alternatives – Flo's Inn T1 Outage 85% of 2013 Summer Peak Load - Interconnected Configuration

New England Alternatives Assessment Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load - Interconnected Configuration							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
Voltage Collapse	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Iroquois T2 138/69 kV Transformer Maintenance Outage							
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV-Oak.	M4 Haynes. 345 kV	M5 Keene 115 kV-Oak.	M6 Keene 345 kV-Oak.
Voltage Collapse	Iroquois T1 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 6-19 Maintenance Outage Analysis of New England Alternatives – Iroquois T1 & T2 Outages - 85% of 2013 Summer Peak Load - Interconnected Configuration

6.9 New England Alternatives Analysis Observations

6.9.1 N-1 Analysis of Interconnected System Configuration

- All six New England alternatives address the N-1 voltage reliability concerns of the underlying MPS system with minimal additional requirements for single element contingencies.
    - M2, M4 and M6 reported low voltage violations at the 138 kV Flo's Inn bus, these could be eliminated by additional reactive support at the 69 kV Flo's Inn bus.
    - M1, M4 and M6 require the Mullen capacitor banks to switch in-service high speed.
    - M5 and M6 require voltage coordination for contingencies that involve the loss of Keene Road to Oakfield.
- All six New England alternatives address the N-1 voltage reliability concerns of the underlying MPS system with minimal additional requirements for multiple element contingencies.
    - All six New England alternatives reported low voltage violations at the 138 kV Flo's Inn bus, as well as elsewhere within MPS, these could be eliminated by additional reactive support at the 69 kV Flo's Inn bus.
    - All six New England alternatives require the Mullen capacitor banks to switch in-service high speed.
    - M3, M5 and M6 require voltage coordination for contingencies that involve the loss of Keene Road to Oakfield, or Haynesville to Oakfield.
- All six New England alternatives address the N-1 thermal loading concerns of the Tinker T1 138/69 kV transformer and 69 kV Line 6901.
- Alternatives M3, M5 and M6 require upgrade of 69 kV Line 6910 (Mullen – Monticello Tap – Bridgewater Tap) to provide adequate thermal capacity with Oakfield wind generation online for contingencies that leave Oakfield generation feeding directly into MPS.
- Alternative M4:
    - A 345 kV reactor may be needed to account for the charging introduced to the system by the new 26 mile 345 kV line from Haynesville to Mullen.
    - An Open Line Detection (also known as "Line End Open") protection scheme may be necessary to sense the status of the two Haynesville 345 kV breakers and send a trip signal to the Mullen 345 kV breakers when the two Haynesville breakers open. This protection scheme was assumed in-service to eliminate high voltages reported in the prior analysis for scenarios with Line 3001 between Keswick and Haynesville open, and the new 345 kV line from Haynesville to Mullen open-ended.

A comparison of New England alternatives N-1 single element contingencies results can be seen below in Table 6-20. A comparison of New England alternatives N-1 multiple element contingencies results can be seen below in Table 6-21.

6.9.2 N-1 Analysis of Radial System Configuration

- In the radial configuration, none of the New England alternatives address the consequential loss of the northern MPS system due to contingencies involving 345 kV Line 3113. For the 2013 load forecast this equates to approximately 22.8 MW of lost load at winter peak and 19.7 MW at summer peak. This loss of load is currently within the loss of load criteria.
- All six New England alternatives address the N-1 voltage reliability concerns of the underlying MPS system with minimal additional requirements for single element contingencies.
    - M4 and M6 reported low voltage violations at the 138 kV Flo's Inn bus, these could be eliminated by additional reactive support at the 69 kV Flo's Inn bus.
    - M5 requires voltage coordination for contingencies that involve the loss of Keene Road to Oakfield.
- All six New England alternatives address the N-1 voltage reliability concerns of the underlying MPS system with minimal additional requirements for multiple element contingencies.
    - M1, M4, M5 and M6 reported low voltage violations at the 138 kV Flo's Inn bus, these could be eliminated by additional reactive support at the 69 kV Flo's Inn bus.
    - M1 requires the Mullen capacitor banks to switch in-service high speed.
    - M5 requires voltage coordination for contingencies that involve the loss of Keene Road to Oakfield.
- All six New England alternatives address the N-1 thermal loading concerns of the Tinker T1 138/69 kV transformer and 69 kV Line 6901.
- Alternatives M3, M5 and M6 require upgrade of 69 kV Line 6910 (Mullen – Monticello Tap – Bridgewater Tap) to provide adequate thermal capacity with Oakfield wind generation online for contingencies that leave Oakfield generation feeding directly into MPS.

A comparison of New England alternatives N-1 single element contingencies results can be seen below in Table 6-20. A comparison of New England alternatives N-1 multiple element contingencies results can be seen below in Table 6-21.

Summary of Alternatives' Impact on Reliability Concerns 2013	New England Interconnections - Oakfield Off-Line					
	M1	M2	M3	M4	M5	M6
	Haynes. 115 kV	Haynes. 69 kV	Haynes. 115 kV - Oak.	Haynes. 345 kV	Keene Rd. 115 kV - Oak.	Keene Rd. 345 kV - Oak.
N-1 Condition - Single Element Contingencies						
Interconnected Mode						
345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O	O
Issues created by Alternatives						
345 kV Line 3001						T (6910)
Keswick T4 345/138 kV Transformer		FI (A)		FI (A)		FI (A)
115 kV Haynesville to Mullen Line	MC			MC		
Mullen 345/69 kV Transformer						MC
Radial Mode						
Keswick T4 345/138 kV Transformer	O	O	O	FI (A)	O	FI (A)
Flo's Inn T1 138/69 kV or 138 kV Line 3855	O	O	O	O	O	O
345 kV Line 3113						
Issues created by Alternatives						
115 kV Haynesville to Mullen Line	MC					

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 6-20 N-1 Single Element Contingencies Results - New England Alternatives Comparison

Summary of Alternatives' Impact on Reliability Concerns 2013	New England Interconnections - Oakfield Off-Line					
	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV - Oak.	M4 Haynes. 345 kV	M5 Keene Rd. 115 kV - Oak.	M6 Keene Rd. 345 kV - Oak.
N-1 Condition - Multiple Element Contingencies						
Interconnected Mode						
Contingencies involving 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
345 kV Keswick K3-3 SB (without UVLS)	FI (A)	LV (F & A)	FI (A)	LV (A), T (6910)	LV (F & A)	LV (F & A), T (6910)
138 kV Beechwood Stuck Breakers	O	O	O	O	O	O
Issues created by Alternatives						
345 kV Keswick K3-5 SB	MC	MC	MC	MC	MC, LV (A)	LV (A), T (6910)
345 kV Keswick K3-6 SB	MC, LV (F & A)	MC, LV (F & A)	MC, LV (F & A)	MC, FI (A)	MC, LV (A)	LV (A), T (6910)
345 kV Keene Rd K396-5 SB					MC	
Contingencies involving loss of 115 kV Haynesville to Mullen Line	MC			MC		
Radial Mode						
345 kV Keswick K3-6 SB	MC, LV (F & A)	O	O	O	FI (A)	FI (A)
138 kV Beechwood Stuck Breakers	O	O	O	O	O	O
138 kV Grand Falls 1111-02SB, 138 kV Line 1111	O	O	O	O	O	O
138 kV Keswick K1125-1139 SB	O	O	O	FI (A)	O	O
Issues created by Alternatives						
345 kV Keswick K3-3 SB	FI (A)	O	O	FI (A)	O	FI (A)
345 kV Keswick K3-5 SB	MC, LV (F)					
Contingencies involving loss of Haynesville to Mullen Line	MC					

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 6-21 N-1 Multiple Element Contingencies - New England Alternatives Comparison

6.9.3 N-1-1 Analysis of Interconnected System Configuration

The coincident outage of the 138 kV Lines 3855 and 1111 includes outage of the Tinker T1 and Flo's Inn T1 138/69 kV transformers which leaves the MPS system supplied in the north from two 69 kV Lines 88 and 89 from Iroquois and in the south from the new interconnection. Alternatives M1 – M4 which interconnect with 345 kV Line 3001 provide a stronger supply of power than M5 and M6 which interconnect further away at Keene Road Substation (assuming Oakfield wind offline). The strongest support is provided by the 345 kV alternative (M4) with the 115 kV (M1 & M3) and 69 kV (M2) alternatives providing less support than the 345 kV option, in that order.

- All six New England alternatives address the MPS reliability needs identified in the N-1-1 Analysis for the coincident outage of the 138 kV Lines 3855 and 1111.
- Regardless of New England alternative, further analysis is needed to examine appropriate coordination of the various voltage reactive devices in the Haynesville/Mullen area.
- All six New England alternatives require additional reactive support at 69 kV Flo's Inn bus for the initial outage of 138 kV Line 1111, and loss of the Keswick T4 345/138 kV transformer.
    - M2 and M5 require 69 kV Lines 88 and 89 to be rebuilt for the same outage contingency combination as discussed above.
- All six New England alternatives eliminate the Tinker T1 138/69 kV transformer thermal overloads as identified in the Needs Assessment for the 138 kV 3855 Line Outage.
- M1-M4 reported voltage collapse for the initial outage of 138 kV Line 1111 and the 345 kV Keswick K3-6 stuck breaker contingency. This contingency removes the additional support added by each alternative. Keswick 345 kV Substation would need to be reconfigured to eliminate this stuck breaker combination.
- All six New England alternatives require additional reactive support at 69 kV Flo's Inn bus to eliminate low voltage reliability issues for a single element outage, followed by numerous multiple element contingencies.
- Alternative M5 and M6:
    - Require investigation of potential system modifications for conditions in which both 345 kV paths between New Brunswick and New England are interrupted. With both lines out of service the entire New Brunswick –New England transfer is forced through the MPS system and could create a potential voltage collapse scenario.
    - With Oakfield wind generation offline, the interconnection at Keene Road is weaker than the interconnections at Haynesville. For initial outage of 345 kV Line 390 or 3001 with either single element loss of the Flo's Inn T1 138/69 kV transformer or the multiple element 138 kV Beechwood stuck breakers and bus fault contingencies, the Tinker T1 138/69 kV transformer and 69 kV Line 6901 could overload depending on system conditions.

A comparison of New England alternatives N-1-1 single element contingencies (single element outage, followed by a single element contingency) results can be seen below in Table 6-22. A comparison of New England alternatives N-1-1 multiple element contingencies (single element outage, followed by a multiple element contingency) results can be seen below in Table 6-23.

Summary of Alternatives' Impact on Reliability Concerns 2013	New England Interconnections - Oakfield Off-Line					
	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV - Oak.	M4 Haynes. 345 kV	M5 Keene Rd. 115 kV - Oak.	M6 Keene Rd. 345 kV - Oak.
N-1-1 Condition - Single Element Contingencies						
138 kV Line 3855 & 138 kV Line 1111/1144	O	MC	O	O	O	O
138 kV Line 3855 & 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
138 kV Line 3855 & Keswick T4 345/138 kV Transformer	O	O	O	O	O	O
138 kV Line 3855 & 69 kV Line 6901	O	O	O	O	O	O
138 kV Line 3855 & Mullen Shunt	O	O	O	O	O	O
138 kV Line 1111/1144 & 138 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
138 kV Line 1111/1144 & Keswick T4 345/138 kV Transformer	FI (A)	FI (A), T (88 & 89)	FI (A)	FI (A)	FI (A), T (88 & 89)	FI (A)
138 kV Line 1111/1144 & 138 kV 1125-72 Line	O	O	O	O	O	O
138 kV Line 1111/1144 & Mullen Shunt	O	O	O	O	O	O
138 kV Line 1111/1144 & numerous contingencies (base)	O	O	O	O	O	O
Issues created by Alternatives						
138 kV Line 3855 & Haynesville to Mullen	MC	MC	MC	MC		
138 kV Line 3855 & Keene Rd to Oakfield					MC	
138 kV Line 3855 & Oakfield to Mullen					MC	MC

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 6-22 N-1-1 Single Element Contingencies Results – New England Alternatives Comparison

Summary of Alternatives' Impact on Reliability Concerns 2013	New England Interconnections - Oakfield Off-Line					
	M1 Haynes. 115 kV	M2 Haynes. 69 kV	M3 Haynes. 115 kV - Oak.	M4 Haynes. 345 kV	M5 Keene Rd. 115 kV - Oak.	M6 Keene Rd. 345 kV - Oak.
N-1-1 Condition - Multiple Element Contingencies						
138 kV Line 1111/1144 & Numerous Contingencies	O	O	O	O	O	O
138 kV Line 1111/1144 & Contingencies that involve 345 kV Line 3012 without UVLS	VC - LV (F) with UVLS	VC - LV (F) with UVLS	VC - LV (F) with UVLS	VC - LV (F) with UVLS	VC - LV (F) with UVLS	VC - LV (F) with UVLS
138 kV Line 1111/1144 & 345 kV Keswick K3-3 SB	O	O	O	O	O	O
138 kV Line 1111/1144 & 345 kV Keswick 3-6 SB	VC	VC	VC	VC	FI (A), T (88 & 89)	FI (A)
138 kV Line 1111/1144 & 138 kV Beechwood Stuck Breakers	O	LV (A)	O	O	O	O
138 kV Line 1111/1144 & 138 kV Keswick K1125-1126SB	FI (A)	FI (A)	FI (A)	FI (A)	FI (A)	FI (A)
138 kV Line 1111/1144 & 138 kV Keswick K1125-1139 SB	FI (A)	FI (A)	FI (A)	FI (A)	FI (A)	FI (A)
138 kV Line 3855 & 345 kV Keswick K3-3 SB	O	O	O	O	O	O
138 kV Line 3855 & 345 kV Keswick K3-6 SB	MC	MC, LV (F)	MC	MV, LV (F & A)	O	
138 kV Line 3855 & Contingencies that involve 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - LV (A) with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
138 kV Line 3855 & 138 kV Grand Falls 1111-02 SB	O	LV (A)	O	O	O	O
Issues created by Alternatives						
138 kV Line 3855 & Contingencies involving Haynesville to Mullen	MC	MC	MC	MC		
138 kV Line 3855 & Contingencies involving Keene Rd to Oakfield					MC	
138 kV Line 3855 & Contingencies involving Oakfield to Mullen					MC	MC

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 6-23 N-1-1 Multiple Element Contingencies Results – New England Alternatives Comparison

6.9.4 Maintenance Outage Analysis of Interconnected System Configuration

- Regardless of New England alternative, further analysis is needed to examine appropriate coordination of the various voltage reactive devices in the Haynesville/Mullen area.
- All six New England alternatives address the Maintenance voltage and thermal reliability concerns of the underlying MPS system for single element contingencies.

A comparison of the Maintenance Outage Analysis results for the New England alternatives can be seen below in Table 6-24.

Summary of Alternatives' Impact on Reliability Concerns 2013	New England Interconnections - Oakfield Off-Line					
	M1	M2	M3	M4	M5	M6
	Haynes. 115 kV	Haynes. 69 kV	Haynes. 115 kV - Oak.	Haynes. 345 kV	Keene Rd. 115 kV - Oak.	Keene Rd. 345 kV - Oak.
Maintenance Condition						
Flo's Inn T1 & Tinker T1 138/69 kV Transformers	O	MC	O	O	O	O
Tinker T1 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Iroquois T1 or T2 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Iroquois T1 or T2 & Iroquois T2 or T1 138/69 kV Transformers without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer & 345 kV Line 3011	O	O	O	O	O	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6901	O	O	O	O	O	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6903	O	O	O	O	O	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6904	O	O	O	O	O	O
Flo's Inn T1 138/69 kV Transformer & Mullen/Ashland Shunt	O	O	O	O	O	O
Issues created by Alternatives						
Tinker T1 138/69 kV Transformer & Haynesville to Mullen Line				MC		
Flo's Inn T1 138/69 kV Transformer & Haynesville to Mullen Line	MC	MC	MC	MC		
Flo's Inn T1 138/69 kV Transformer & Oakfield to Mullen Line					MC	MC

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 6-24 Maintenance Outage Analysis Results – New England Alternatives Comparison

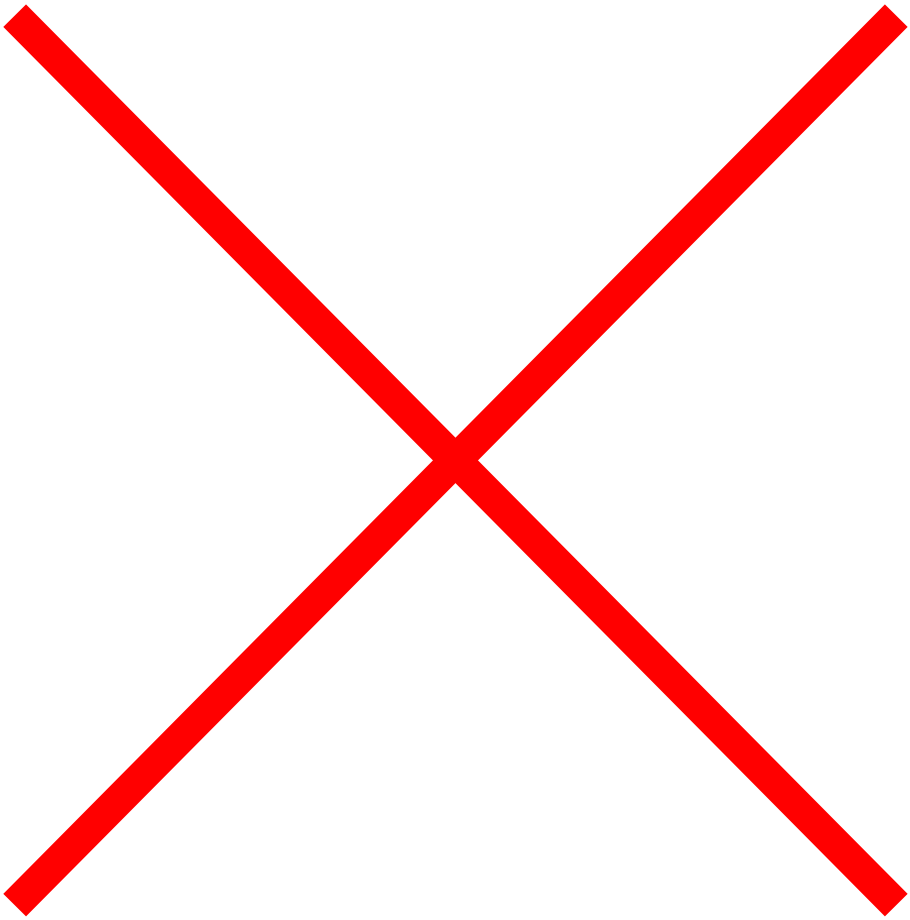
Section 7
Assessment of New Brunswick Interconnection Alternatives

7.1 New Brunswick Interconnections - Alternative Reinforcement Testing

The Study tested four configurations for interconnection with New Brunswick Power to address the MPS reliability issues reported in the Needs Assessment (N1 - N4):

- N1: Upgrade the Tinker T1 138/69 kV Transformer to 100 MVA.
- N2: Additional Transformation from St. Andre 138 kV to Limestone 69 kV.
- N3: Additional Transformation from Tinker 138 kV to Fort Fairfield 69 kV.
- N4: Additional Transformation from Beechwood 138 kV to Mars Hill 69 kV.

N2, N3 and N4 each represent a new interconnection with NBP and are depicted below in Figure 7-1 through Figure 7-3.



REDACTED Diagram
CEII

Figure 7-1 Limestone Alternative Proposed Interconnection N2

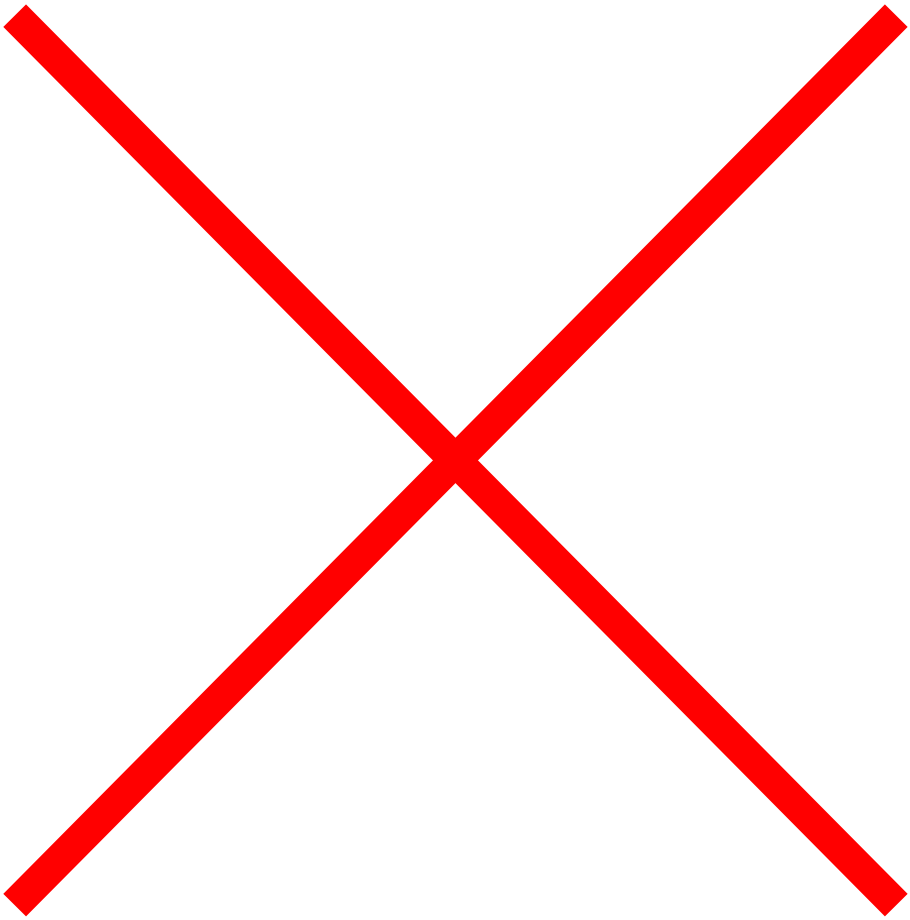


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Figure 7-2 Fort Fairfield Alternative Proposed Interconnection N3

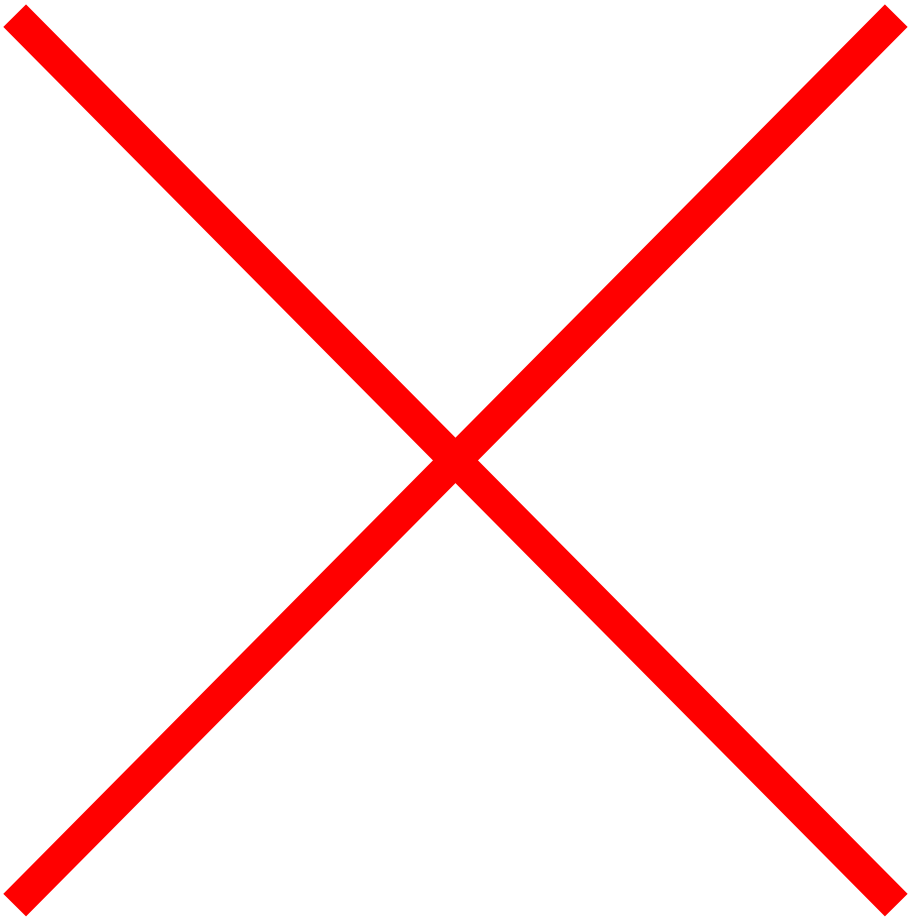

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Figure 7-3 Mars Hill Alternative Proposed Interconnection N4

7.2 New Brunswick Interconnections - Base Case Assumptions

The upgraded Tinker T1 138/69 kV transformer was modeled with an impedance of 7% and an X/R ratio of 38. Summer and winter normal/long time/short time ratings of 171/191/225 MVA were used.

The following assumptions were made for each of the transformation alternatives:

- With MPS radial, the Limestone transformer would stay connected to the southern part of the MPS system.
- Limestone - The new 138 kV line extends from St. Andre 138 kV Substation.
- Fort Fairfield – Line 1111 is separated at the 1144 Tap, and brought in and out of the 138 kV Tinker substation.
- Mars Hill – The new 138 kV line extends from the 138 kV Beechwood substation.
- The new 138 kV lines used the same conductor type and thermal ratings, and assumed the same length as the section of 138 kV line from St. Andre to Grand Falls.

    - Z = 0.00885 + j 0.03546, Charging = 0.00877, Normal/LTE/STE = 160/192/192 (Summer/Winter)
- The new 138/69 kV transformers assumed the same impedance and ratings as the existing Tinker T1 138/69 kV transformer.
    - Z = 0.01372 + j0.16467 (100 MVA Base), Summer Normal/LTE/STE = 56/72/92, Winter 71/86/112 MVA

7.3 New Brunswick Interconnections - System Configurations

For the New Brunswick alternatives assessment, transmission system configurations were tested with contingency analysis during all lines in-service (N-0 base case and N-1 post-contingency), 138 kV line outage (N-1 base case and N-1-1 post-contingency) and 138/69 kV maintenance outage (N-1 base case and N-1-1 post-contingency) conditions. The following configurations and system conditions were tested:

- All Lines In (N-0) at peak load:
    - Interconnected configuration .
    - Radial configuration.
- Two N-1 outage conditions at peak load (N-1) for the interconnected configuration:
    - 138 kV Line 3855 (Beechwood – Flo's Inn).
    - 138 kV Line 1111 (Beechwood – Grand Falls.)
- Four scheduled maintenance configurations at 85% load (N-1) for the interconnected configuration
    - Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855.
    - Tinker T1 138/69 kV Transformer or 138 kV Line 1144.
    - Iroquois T1 138/69 kV Transformer or 138 kV Line 1184.
    - Iroquois T2 138/69 kV Transformer or 138 kV Line 1183.

7.4 New Brunswick Interconnections - Contingency List Additions and Modifications

The following tables contain the additional contingencies, and/or changes in contingency descriptions relative to the four New Brunswick alternatives.

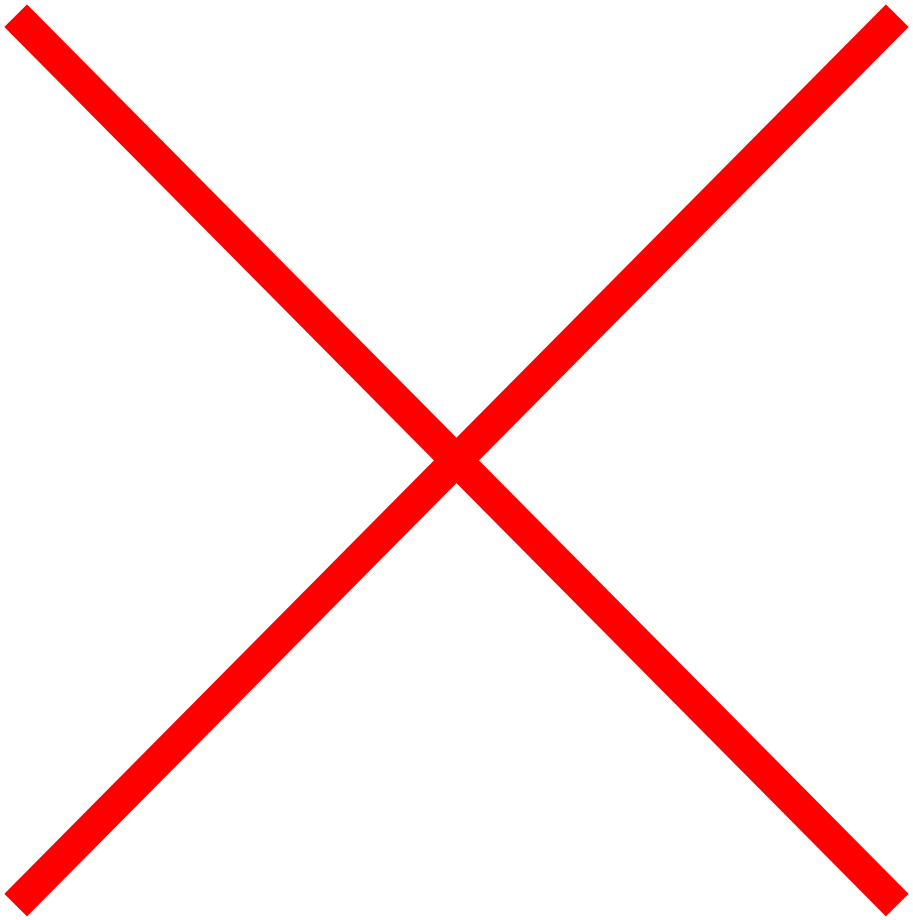

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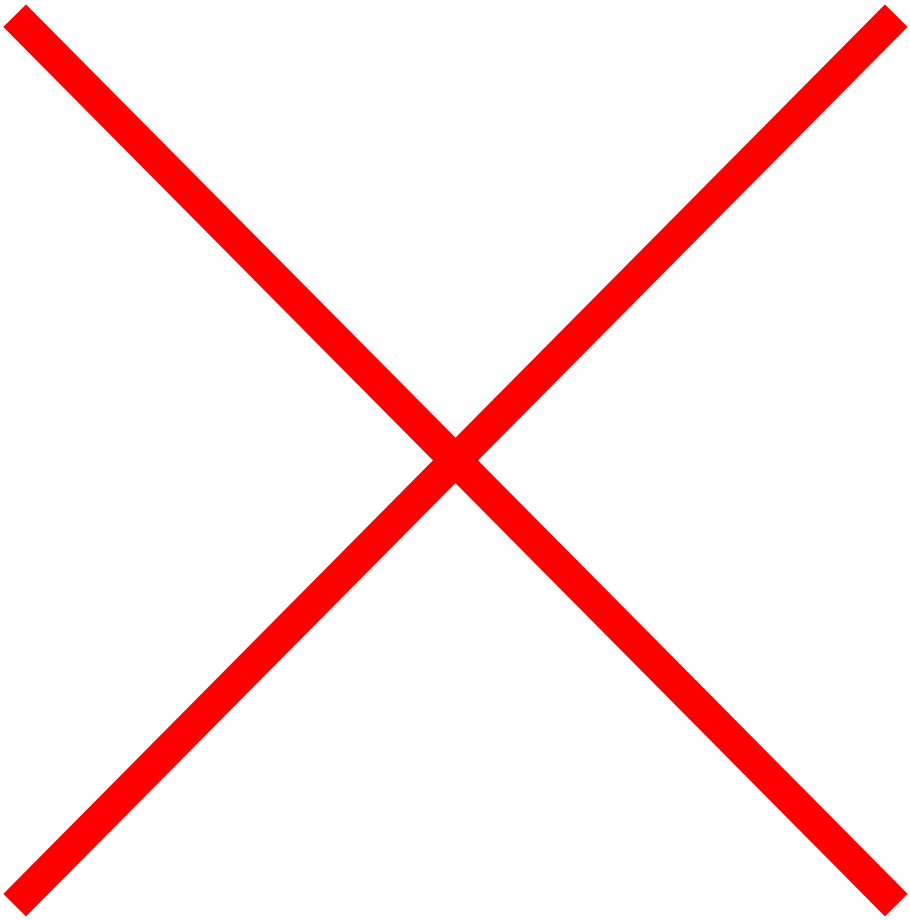
Table 7-1
Category B – New Brunswick Alternatives Single Element Transmission Line Contingencies



REDACTED Table
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Table 7-2
Category B – New Brunswick Alternatives Single Element Transformer Contingencies

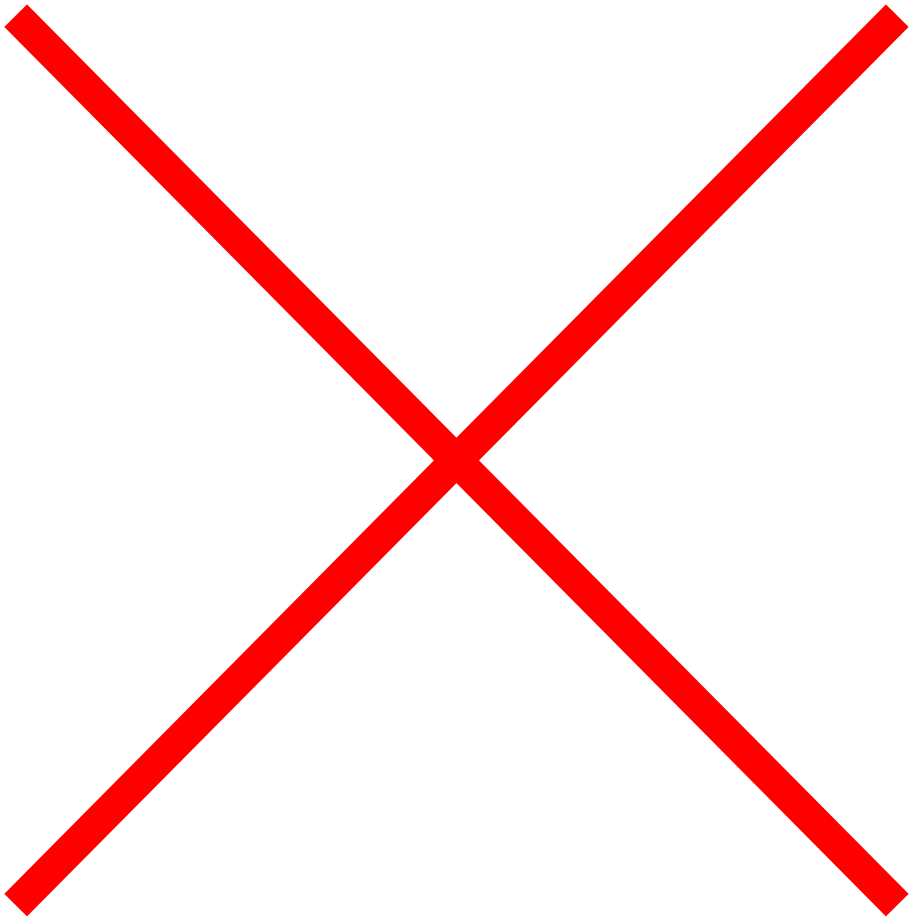

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Table 7-3
Category C – New Brunswick Alternatives Multiple Element Stuck Breaker Contingencies

7.5 New Brunswick Interconnections - All Lines In (N-0) Analysis

7.5.1 2013 Winter Peak Load Level

7.5.1.1 Interconnected Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

7.5.1.2 Radial Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

7.5.2 2013 Summer Peak Load Level

7.5.2.1 Interconnected Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

7.5.2.2 Radial Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

7.6 New Brunswick Interconnections - N-1 Analysis

N-1 Analysis was performed to examine the impact of each New Brunswick alternative on the MPS reliability issues identified in the Needs Assessment. Sensitivity to the radial system configuration was examined for the N-1 Analysis.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC".

7.6.1 2013 Winter Peak Load Level

7.6.1.1 Interconnected Configuration

New Brunswick Alternatives Assessment N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Winter Peak Load - Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Low Voltage Violations	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
Voltage Collapse	345 kV Keswick K3-3 SB (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	345 kV St. Andre AN3-1 SB (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	345 kV St. Andre AN3-2 SB (without UVLS)	VC - LV (F) with UVLS	VC - OK with UVLS	VC - LV (F) with UVLS	VC - LV (F) with UVLS
	138 kV Beechwood SBs & Bus Fault	MC	O	O	VC
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
Issues Created by Alternative					
138 kV Line 1144 Overload	345 kV Keswick K3-6 & 138 kV K1125-1139 SBs & Keswick T4 345/138 kV Transformer			X	
New 138 kV Line 1144-2 Overload	Keswick T4 345/138 kV Transformer			X	

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue created by Alternative

Table 7-4 N-1 Analysis of New Brunswick Alternatives
2013 Winter Peak Load – Interconnected Configuration

7.6.1.2 Radial Configuration

New Brunswick Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Winter Peak Load - Radial Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
138 kV Low Voltage Violations	Keswick T4 345/138 kV Transformer	O	O	O	FI (A)
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	MC	O	O	O
138 kV Low Voltage Violations	345 kV Keswick K3-6 SB	O	O	O	O
Voltage Collapse	138 kV Beechwood SBs & Bus Fault	VC	MC	VC	VC
138 kV Low Voltage Violations	138 kV Grand Falls 1111-02 SB, 138 kV Line 1111	FI (A)	O	O	O
	138 kV Keswick K1125-1139 SB	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
138 kV Line 1144 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	T	O	O	O
	138 kV Beechwood SBs & Bus Fault	VC	O	VC	VC
Islanding/Consequential Load Loss of Northern MPS	345 kV Line 3113				
Issues Created by Alternative					
138 kV Line 1144 Overload	Keswick T4 345/138 kV Transformer, 345 kV Keswick K3-6 SB, 345 kV Keswick K3-3 SB, 138 kV Keswick K1125-1139 SB			X	
New 138 kV Line 1144-2 Overload	Keswick T4 345/138 kV Transformer & Keswick K3-6 SB			X	

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue created by Alternative

Table 7-5 N-1 Analysis of New Brunswick Alternatives
2013 Winter Peak Load – Radial Configuration

7.6.2 2013 Summer Peak Load Level

7.6.2.1 Interconnected Configuration

New Brunswick Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Summer Peak Load - Interconnected Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	345 kV St. Andre AN3-1 & AN3-2 SB (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	T	O	T	O
Issues Created by Alternative					
69 kV Line 6901 Overload	138 kV Beechwood SBs & Bus Fault			X	

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue created by Alternative

Table 7-6 N-1 Analysis of New Brunswick Alternatives
2013 Summer Peak Load – Interconnected Configuration

7.6.2.2 Radial Configuration

New Brunswick Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Summer Peak Load - Radial Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Voltage Collapse	138 kV Beechwood SBs & Bus Fault	O	O	O	VC
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 KV Line 3855	O	O	O	O
	138 kV Beechwood SBs & Bus Fault	O	O	O	VC
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 KV Line 3855	T	O	T	O
	138 kV Beechwood SBs & Bus Fault	T	O	T	T
138 kV Line 1144 Overload	138 kV Beechwood SBs & Bus Fault	O	O	O	T
Islanding/Consequential Load Loss of Northern MPS	345 kV Line 3113				

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue created by Alternative

Table 7-7 N-1 Analysis of New Brunswick Alternatives
2013 Summer Peak Load – Radial Configuration

7.7 New Brunswick Interconnections - N-1-1 Analysis

N-1-1 Analysis was performed to examine the impact of each New Brunswick Alternative on the MPS reliability issues identified in the Needs Assessment for the following two N-1 outage conditions assuming the interconnected system configuration:

- 138 kV Line 1111 (Beechwood – Grand Falls).
- 138 kV Line 3855 (Beechwood – Flo's Inn).

The complete list of contingencies tested previously for the N-1 Analysis was examined for the N-1-1 Analysis. The tables below however, include discussion of contingencies at the 100 kV level and above.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC".

7.7.1 2013 Winter Peak Load Level

7.7.1.1 Interconnected Configuration

New Brunswick Alternatives Assessment 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage N-1-1 Voltage Violations - 2013 Winter Peak Load Interconnected Configuration						
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield		N4 Beechwood to Mars Hill
				Grand Falls to Tinker Outage	Tinker to Beechwood Outage	
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - FI (A) with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Keswick T4 345/138 kV Transformer	LV (F & A)	FI (A)	VC	O	LV (A)
Low Voltage Violations	138 kV Line 1125/1172	FI (A)	O	FI (A)	O	FI (A)
	Numerous contingencies	FI (A)	O	O	O	O
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	VC	MC	O	O	O
Voltage Collapse	345 kV Keswick K3-3 SB (without UVLS)	VC - OK with UVLS	O	VC - OK with UVLS	O	VC - OK with UVLS
	345 kV Keswick K3-6 SB (UVLS not activated)	VC	O	VC	O	VC
	345 kV St. Andre AN3-1 SB (without UVLS)	VC regardless of UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - LV (F) with UVLS
	345 kV St. Andre AN3-2 SB (without UVLS)	VC regardless of UVLS	VC - LV (F) with UVLS	VC - LV (F) with UVLS	VC - LV (F) with UVLS	VC regardless of UVLS
	138 kV Beechwood SBs & BF	VC	MC	VC	O	VC
	138 kV Keswick K1125-1126 SB	VC	FI (A)	VC	O	VC
	138 kV Keswick K1125-1139 SB	LV (F & A)	FI (A)	LV (F & A)	O	LV (F & A)
69 kV Line 88 Overload	138 kV Keswick K1125-1139 SB	T	O	T	O	T
69 kV Line 89 Overload	138 kV Keswick K1125-1139 SB	T	O	T	O	T

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue created by Alternative

Table 7-8 N-1-1 Analysis of New Brunswick Alternatives – 138 kV Line 1111/1144 Outage 2013 Winter Peak Load - Interconnected Configuration

New Brunswick Alternatives Assessment 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage N-1-1 Voltage Violations - 2013 Winter Peak Load Interconnected Configuration						
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield		N4 Beechwood to Mars Hill
				Grand Falls to Tinker Outage	Tinker to Beechwood Outage	
Issues Created by Alternative						
138 kV Line 1144 & 11442 Overload	Keswick T4 345/138 kV Transformer, 345 kV Keswick K3-3 & K3-6 SB, 138 kV Keswick K1125-1139 SB				X	
69 kV Line 88 & 89 Overload	345 kV Keswick K3-3UV & K3-6 SB, 138 kV K1125-1139 SB			X		
	Keswick T4 345/138 kV Transformer	X		X		X
69 kV Line 6911 Overload	Keswick T4 345/138 kV Transformer, 138 kV Keswick K3-6 SB		X			
(New) Limestone Transformer Overload	Flo's Inn T1 138/69 kV Transformer, 138 kV Line 3855, Keswick T4 345/138 kV Transformer, 345 kV Keswick K3-3 & K3-6 SB, 138 kV Keswick K1125-1139 SB		X			

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue created by Alternative

Table 7-9 N-1-1 Analysis of New Brunswick Alternatives – 138 kV Line 1111/1144 Outage
2013 Winter Peak Load - Interconnected Configuration
Issues Created by Alternative

New Brunswick Alternatives Assessment 138 kV Line 3855/1176 (Beechwood -Flo's Inn) Outage N-1-1 Voltage Violations - 2013 Winter Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC regardless of UVLS	VC - OK with UVLS	VC regardless of UVLS	VC - OK with UVLS
Low Voltage Violations	Keswick T4 345/138 kV Transformer	O	O	O	O
Voltage Collapse	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	VC	O	O	O
Low Voltage Violations	345 kV Keswick K3-3 & K3-6 SB	O	O	O	O
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC regardless of UVLS	VC regardless of UVLS	VC regardless of UVLS	VC regardless of UVLS
Voltage Collapse	138 kV Grand Falls 1111-02 SB	VC	O	O	O
Low Voltage Violations	138 kV Grand Falls SB & BF that open end 1111	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Base Case, Numerous Contingencies	O	T	O	O
69 kV Line 88	Keswick T4 345/138 kV Transformer, 345 kV Keswick K3-6 SB	O	O	O	O
Issues Created by Alternative					
138 kV Line 1144 Overload	Keswick T4 345/138 kV Transformer			X	
	345 kV Keswick K3-3 & K3-6 SB, 138 kV Keswick 1125-39 SB			X	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 7-10 N-1-1 Analysis of New Brunswick Alternatives – 138 kV Line 3855/1176 Outage 2013 Winter Peak Load - Interconnected Configuration

7.7.2 2013 Summer Peak Load Level

7.7.2.1 Interconnected Configuration

New Brunswick Alternatives Assessment 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage N-1-1 Voltage Violations - 2013 Summer Peak Load Interconnected Configuration						
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield		N4 Beechwood to Mars Hill
				Grand Falls to Tinker Outage	Tinker to Beechwood Outage	
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	VC	O	O	O	O
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	138 kV Beechwood SBs & Bus Fault	VC	LV (A)	VC	FI (A)	VC
69 kV Line 88 Overload	Keswick K1125-1126SB	T	O	T	T	T
69 kV Line 89 Overload	Keswick K1125-1126SB	T	O	T	T	T
Issues Created by Alternative						
69 kV Line 6903 Overload	138 kV Beechwood SBs & BF		X			
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855			X	X	

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue created by Alternative

Table 7-11 N-1-1 Analysis of New Brunswick Alternatives – 138 kV Line 1111/1144 Outage 2013 Summer Peak Load - Interconnected Configuration

New Brunswick Alternatives Assessment 138 kV Line 3855/1176 (Beechwood -Flo's Inn) Outage N-1-1 Voltage Violations - 2013 Summer Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Low Voltage Violations	Base Case, Numerous Contingencies	LV (A)	LV (A)	LV (A)	LV (F & A)
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	VC	LV (A)	O	O
Voltage Collapse	138 kV Grand Falls 1111-02 SB	VC	LV (A)	O	O
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC regardless of UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Base Case, Numerous Contingencies	O	O	O	O
69 kV Line 6901 Overload	Base Case, Numerous Contingencies	T	T	T	O
Issues Created by Alternative					
Low Voltage	345 kV St. Andre AN3-6 SB		X		
	138 kV Tinker 3-3 SB (New)			LV (A)	
	138 kV Beechwood SBs & BF				LV (A)
138 kV new Line 1144 (2) Overload	Contingencies involving loss of 345 kV Line 3011			X	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 7-12 N-1-1 Analysis of New Brunswick Alternatives – 138 kV Line 3855/1176 Outage 2013 Summer Peak Load - Interconnected Configuration

7.8 New Brunswick Interconnections - Maintenance Outage Analysis

Maintenance Outage Analysis was performed to examine the impact of each New Brunswick Alternative on the MPS reliability issues identified in the Needs Assessment for the following four outage conditions at 85% of peak load, assuming the interconnected system configuration:

- Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855.
- Tinker T1 138/69 kV Transformer or 138 kV Line 1144.
- Iroquois T1 138/69 kV Transformer or 138 kV Line 1184.
- Iroquois T2 138/69 kV Transformer or 138 kV Line 1183.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC".

7.8.1 2013 Winter Peak Load Level

7.8.1.1 Interconnected Configuration

New Brunswick Alternatives Assessment Tinker T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load - Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	VC	MC	O	O
138 kV Line 1144 Overload	Keswick T4 345/138 kV Transformer			X	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 7-13 Maintenance Outage Analysis of New Brunswick Alternatives – Tinker T1 Outage – 85% of 2013 Winter Peak Load - Interconnected Configuration

New Brunswick Alternatives Assessment Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load - Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - LV (F) with UVLS	VC - OK with UVLS
	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	VC	O	O	O
	69 kV Line 6901	VC	VC	VC	O
Tinker T1 138/69 kV Transformer Overload	Base	O	O	O	O
Issues Created by Alternative					
138 kV Line1144 (2) Overload	345 kV Line 3011			X	
138 kV Line 1144 Overload	Keswick T4 345/138 kV Transformer			X	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 7-14 Maintenance Outage Analysis of New Brunswick Alternatives – Flo's Inn T1 Outage – 85% of 2013 Winter Peak Load - Interconnected Configuration

New Brunswick Alternatives Assessment
Iroquois T1 138/69 kV Transformer Maintenance Outage
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
85% of 2013 Winter Peak Load - Interconnected Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
138 kV Line 1144 Overload	Keswick T4 345/138 kV Transformer			X	

Iroquois T2 138/69 kV Transformer Maintenance Outage

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Iroquois T1 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 KV Line 3855	O	O	O	O
138 kV Line 1144 Overload	Keswick T4 345/138 kV Transformer			X	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 7-15 Maintenance Outage Analysis of New Brunswick Alternatives – Iroquois T1 or T2 Outage – 85% of 2013 Winter Peak Load - Interconnected Configuration

7.8.2 2013 Summer Peak Load Level

7.8.2.1 Interconnected Configuration

New Brunswick Alternatives Assessment
Tinker T1 138/69 kV Transformer Maintenance Outage
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
85% of 2013 Summer Peak Load - Interconnected Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 3855	VC	O	O	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 7-16 Maintenance Outage Analysis of New Brunswick Alternatives – Tinker T1 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

New Brunswick Alternatives Assessment Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load - Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Low Voltage Violations	345 kV Line 3011	O	O	O	O
Voltage Collapse	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	VC	O	O	O
Low Voltage Violations	69 kV Line 6901	LV (F & A)	LV (F & A)	LV (F & A)	O
	Ashland Shunt	O	O	O	O
	Mullen Shunt	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Base	O	O	O	O
69 kV Line 6901 Overload	69 kV Line 6904	T	T	T	O
	69 kV Line 6903	T	O	T	O
69 kV Line 6904 Overload	69 kV Line 6901	T	T	T	O
69 kV Line 6903 Overload	69 kV Line 6901	T	O	T	O
Issues Created by Alternative					
69 kV Line 6901 Overload	69 kV Line 6912, 345 kV Line 3012	X		X	
	345 kV Line 3011			X	
138 kV Line1144 (2) Overload	345 kV Line 3011			X	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 7-17 Maintenance Outage Analysis of New Brunswick Alternatives – Flo's Inn T1 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

New Brunswick Alternatives Assessment Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load - Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Voltage Collapse	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Iroquois T2 138/69 kV Transformer Maintenance Outage					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	N1 Tinker Upgraded	N2 St. Andre to Limestone	N3 Tinker to Fort Fairfield	N4 Beechwood to Mars Hill
Voltage Collapse	Iroquois T1 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 7-18 Maintenance Outage Analysis of New Brunswick Alternatives – Iroquois T1 or T2 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

7.9 New Brunswick Alternatives Analysis Observations

7.9.1 N-1 Analysis of Interconnected System Configuration

- All four New Brunswick alternatives address the N-1 voltage reliability concerns of the underlying MPS system for single element contingencies.
- Alternatives N1 - N3 address the N-1 voltage reliability concerns of the underlying MPS system with minimal additional requirements for multiple element contingencies.
    - N4, the Mars Hill alternative, failed to converge for 138 kV Beechwood Stuck Breaker or 138 kV Bus Fault.
        - A rebuild of the 138 kV Beechwood substation is required to eliminate this issue.
    - N1, N3 and N4 require additional reactive support for contingencies involving loss of the 345 kV Line 3012.
    - N1 requires the Mullen capacitor banks to switch in-service high speed.
- Alternatives N1 – N3 address the N-1 thermal loading concern of the Tinker T1 138/69 kV transformer.
    - N4 did not eliminate voltage collapse for the 138 kV Beechwood bus fault and 138 kV stuck breakers, and therefore would not eliminate the thermal concerns at Tinker for these contingencies.
- N3, the Fort Fairfield alternative, requires upgrade of 69 kV Line 6901 (Tinker – ReEnergy Tap/Interfai) and 138 kV Line 1144 to provide adequate thermal capacity for multiple element contingencies.

A comparison of New Brunswick alternatives N-1 single element contingencies results can be seen below in Table 7-19. A comparison of New Brunswick alternatives N-1 multiple element contingencies results can be seen below in Table 7-20.

7.9.2 N-1 Analysis of Radial System Configuration

- In the radial configuration, none of the New Brunswick alternatives address the consequential loss of the northern MPS system due to contingencies involving 345 kV Line 3113. For the 2013 load forecast this equates to approximately 23 MW of lost load at winter peak and 20 MW at summer peak. This loss of load is currently within the loss of load criteria.
- All four New Brunswick alternatives address the N-1 voltage reliability concerns of the underlying MPS system with minimal additional requirements for single element contingencies.
    - N4, the Mars Hill alternative, reported low voltage violations at the 138 kV Flo's Inn bus, this could be eliminated by additional reactive support at the 69 kV Flo's Inn bus.
    - N1, the Tinker Upgrade alternative, requires the Mullen capacitor banks to be switched in-service high speed.
- N2, the Limestone alternative, addresses the N-1 voltage reliability concerns of the underlying MPS system for multiple element contingencies.
    - N2 requires the Mullen capacitor banks to be switched in-service high speed.
    - N1, N3 and N4 report voltage collapse for a 138 kV Beechwood Bus Fault or 138 kV stuck breaker.
        - A rebuild of the 138 kV Beechwood substation is required to eliminate this issues.
    - N1, reported low voltage violations at the 138 kV Flo's Inn bus for a 138 kV Grand Falls stuck breaker, this could be eliminated by additional reactive support at the 69 kV Flo's Inn bus.
- Alternatives N1 – N3 address the N-1 thermal loading concern of the Tinker T1 138/69 kV transformer.
    - N4, the Mars Hill alternative, did not eliminate voltage collapse for the 138 kV Beechwood bus fault and 138 kV stuck breakers, and therefore would not eliminate the thermal concerns at Tinker for these contingencies.

- N3, the Fort Fairfield alternative, requires upgrade of 69 kV Line 6901(Tinker – ReEnergy Tap/Interfai) and 138 kV Line 1144 to provide adequate thermal capacity for multiple element contingencies.
- N1, the Tinker Upgrade alternative, requires upgrade of 69 kV Line 6901 to provide adequate thermal capacity for multiple element contingencies.

A comparison of New Brunswick alternatives N-1 single element contingencies results can be seen below in Table 7-19. A comparison of New Brunswick alternatives N-1 multiple element contingencies results can be seen below in Table 7-20.

Summary of Alternatives' Impact on Reliability Concerns 2013	New Brunswick Interconnections			
	N1 Tinker Upgrade	N2 St Andre to Limestone	N3 Tinker to Ft Fairfield	N4 Beechwood to Mars Hill
N-1 Condition - Single Element Contingencies				
Interconnected Mode				
345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	T (6901)	O	T (6901)	O
Issues created by Alternatives				
Keswick T4 345/138 kV Transformer			T (1144, 11442)	
Radial Mode				
Keswick T4 345/138 kV Transformer	O	O	T (1144, 11442)	FI (A)
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	T (6901, 1144), MC	O	T (6901)	O
345 kV Line 3113				

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 7-19 N-1 Single Element Contingencies Results – New Brunswick Alternatives Comparison

Summary of Alternatives' Impact on Reliability Concerns 2013	New Brunswick Interconnections			
	N1 Tinker Upgrade	N2 St Andre to Limestone	N3 Tinker to Ft Fairfield	N4 Beechwood to Mars Hill
N-1 Condition - Multiple Element Contingencies				
Interconnected Mode				
Contingencies involving 345 kV Line 3012 without UVLS	VC - LV (F) with UVLS	VC - OK with UVLS	VC - LV (F) with UVLS	VC - LV (F) with UVLS
345 kV Keswick K3-3 SB (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
138 kV Beechwood Stuck Breakers	MC	O	T (6901)	VC
Issues created by Alternatives				
345 kV Keswick K3-6 SB			T (1144)	
138 kV Keswick K1125-1139 SB			T (1144)	
Radial Mode				
345 kV Keswick K3-6 SB	O	O	T (1144, 11442)	O
138 kV Beechwood Stuck Breakers	VC, T (6901)	MC	VC, T (6901)	VC
138 kV Grand Falls 1111-02SB, 138 kV Line 1111	FI (A)	O	O	O
138 kV Keswick K1125-1139 SB	O	O	T (1144)	O
Issues created by Alternatives				
345 kV Keswick K3-3 SB			T (1144)	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 7-20 N-1 Multiple Element Contingencies Results – New Brunswick Alternatives Comparison

7.9.3 N-1-1 Analysis of Interconnected System Configuration

The coincident outage of the 138 kV 3855 and 1111 Lines includes outage of the Tinker T1 and Flo's Inn T1 138/69 kV transformers which leaves the MPS system supplied in the north from two 69 k Lines 88 and 89 at Iroquois and in the south from the new interconnection for alternatives N2 – N4, N1 does not provide a new interconnection to New Brunswick. The most reliable support is provided by the St. Andre to Limestone, N2 alternative, followed by Tinker to Fort Fairfield N3, and lastly Beechwood to Mullen N4.

- N2, N3 and N4 address all of the MPS reliability needs identified in the N-1-1 Analysis for the coincident outage of the 138 kV Lines 3855 and 1111 with minimal additional requirements.
    - N2 requires additional reactive support within MPS.
    - N3 requires 69 kV Line 6901 (Tinker – ReEnergy Tap/Interfai) to be rebuilt.
- N1 requires significant upgrades to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
    - Voltage collapse was reported for 138 kV Line 3855 out of service and loss of the following elements:
        - 345 kV Line 3012.
        - 138 kV Line 1111.
        - 69 kV Line 6901.
    - Low voltages within MPS were reported for the following coincident outages:
        - 138 kV Line 3855 and 69 kV Mullen or Houlton Shunt.
        - 138 kV Line 3855 and 69 kV Line 6920.
        - 138 kV Line 1111 and numerous system elements.
    - 69 kV Line 6901 requires to be rebuilt for 138 kV Line 3855 out of service and loss of 69 kV Line 6903.
    - Additional voltage collapse was seen for a single element outage, followed by contingencies which remove multiple elements from service.
- N2 requires additional upgrades to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
    - Voltage collapse was reported for 138 kV Line 3855 out of service and loss of 69 kV Line 6901.
    - Low voltages within MPS were reported for the following coincident outages:
        - 138 kV Line 3855 and 138 kV Line 1111.
        - 138 kV Line 3855 and 69 kV Mullen Shunt.
        - 138 kV Line 1111 and Keswick T4 345/138 kV transformer.
        - 138 kV Line 1111 and 69 kV Mullen Shunt.
    - Thermal upgrades are required for the following system elements:
        - 69 kV Line 6911 for 138 kV Line 1111 out of service and loss of Keswick T4 345/138 kV transformer.
        - 69 kV Line 6901 for 138 kV Line 3855 out of service and loss of 69 kV Line 6903.
        - Tinker T1 138/69 kV transformer for 138 kV Line 3855 out of service and loss of 69 kV Line 6905.
    - Minimal additional violations were reported for a single element outage, followed by contingencies which remove multiple elements from service:
        - Voltage collapse for 138 kV Line 3855 out of service and 345 kV St. Andre AN3-2 stuck breaker.
        - 69 kV Line 6903 overload for 138 kV Line 1111 out of service and a 138 kV Beechwood stuck breaker
        - 69 kV Lines 88 and 89 overload for 138 kV Line 1111 and 138 kV Keswick K1125-1139 stuck breaker.
        - Minimal additional low voltages within MPS.

- N3 requires additional upgrades to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
    - Voltage collapse was reported for 138 kV Line 3855 out of service and loss of the following elements:
        - 345 kV Line 3012.
        - 69 kV Line 6901.
    - Voltage collapse was reported for 138 kV Line 1111 north out of service and loss of Keswick T4 345/138 kV transformer.
    - Low voltages within MPS were reported for the following coincident outages:
        - 138 kV Line 3855 and 69 kV Mullen Shunt.
        - 138 kV Line 1111 and 69 kV Mullen Shunt.
        - 138 kV Line 1111 north and 138 kV Line 1125-72.
    - Thermal upgrades are required for the following system elements:
        - 69 kV Line 6901 (Tinker – ReEnergy Tap/Interfai) for 138 kV Line 3855 out of service and loss of 138 kV Line 1111.
        - 138 kV Line 1144 for 138 kV Line 3855 out of service or 138 kV Line 1111 out of service and loss of Keswick T4 345/138 kV transformer, as well as 138 kV Line 3855 out of service and loss of 345 Line 3011.
        - 69 kV Line 88 & 89 for 138 kV Line 1111 out of service and loss of Keswick T4 345/138 kV transformer.
    - A single element outage, followed by contingencies which remove multiple elements from service, reported additional violations:
        - Voltage collapse was reported for the following coincident outages:
            - 138 kV Line 1111N and 345 kV Keswick K3-6 stuck breaker.
            - 138 kV Line 1111N and 138 kV Beechwood stuck breakers.
            - 138 kV Line 1111N and 138 kV Keswick K1125-1126stuck breaker.
            - 138 kV Line 3855 and 345 kV St. Andre AN3-1 or AN3-2 stuck breaker.
        - Minimal additional low voltages within MPS.
- N4 requires additional upgrades to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
    - Low voltages within MPS were reported for the following outage/contingency pairs:
        - 138 kV Line 1111 and Keswick T4 345/138 kV transformer.
        - 138 kV Line 1111 and 138 kV Line 1125-72.
    - Thermal upgrades are required for the following system elements:
        - 69 kV Line 88 and 89 for 138 kV Line 1111 out of service and loss of Keswick T4 345/138 kV transformer.
    - A single element outage, followed by contingencies which remove multiple elements from service, reported additional violations:
        - Voltage collapse was reported for the following coincident outages:
            - 138 kV Line 1111 and 345 kV St. Andre AN3-1 or AN3-2 stuck breaker.
            - 138 kV Line 1111 and 138 kV Beechwood stuck breakers.
            - 138 kV Line 1111 and 138 kV Keswick K1125-1126stuck breaker.
            - 138 kV Line 3855 and 345 kV St. Andre AN3-1 or AN3-2 stuck breaker.
        - Minimal additional low voltages within MPS.

A comparison of New Brunswick alternatives N-1-1 single element contingencies (single element outage, followed by a single element contingency) results can be seen below in Table 7-21. A comparison of New Brunswick alternatives N-1-1 multiple element contingencies (single element outage, followed by a multiple element contingency) results can be seen below in Table 7-22.

Summary of Alternatives' Impact on Reliability Concerns 2013	New Brunswick Interconnections			
	N1 Tinker Upgrade	N2 St Andre to Limestone	N3 Tinker to Ft Fairfield	N4 Beechwood to Mars Hill
N-1-1 Condition - Single Element Contingencies				
138 kV Line 3855 & 138 kV Line 1111/1144	VC	LV (A)	T (6901)	O
138 kV Line 3855 & 345 kV Line 3012 without UVLS	VC regardless of UVLS	VC - OK with UVLS	VC regardless of UVLS	VC - OK with UVLS
138 kV Line 3855 & Keswick T4 345/138 kV Transformer	O	O	T (1144)	O
138 kV Line 3855 & 69 kV Line 6901	VC	VC	VC	O
138 kV Line 3855 & Mullen Shunt	LV (A)	LV (A)	LV (A)	O
138 kV Line 1111/1144 & 138 kV Line 3012 without UVLS	VC - FI (A) with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
138 kV Line 1111/1144 & Keswick T4 345/138 kV Transformer	LV (F & A), T (88 & 89)	FI (A), T (6911)	N - VC, T (88 & 89), S - T (1144 & 11442)	LV (A), T (88 & 89)
138 kV Line 1111/1144 & 138 kV 1125-72 Line	FI (A)	O	N - FI (A)	FI (A)
138 kV Line 1111/1144 & Mullen Shunt	FI (A)	LV (A)	LV (A)	O
138 kV Line 1111/1144 & numerous contingencies (base)	FI (A)	O	O	O
Issues created by Alternatives				
138 kV Line 3855 & 345 kV Line 3011			T (1144)	
138 kV Line 3855 & Houlton Shunt	LV (A)			
138 kV Line 3855 & 69 kV Line 6903	T (6901)	T (6901)		
138 kV Line 3855 & 69 kV Line 6905		T (Tinker)		
138 kV Line 3855 & 69 kV Line 6920	LV (A)			

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 7-21 N-1-1 Single Element Contingencies Results – New Brunswick Alternatives Comparison

Summary of Alternatives' Impact on Reliability Concerns 2013	New Brunswick Interconnections			
	N1 Tinker Upgrade	N2 St Andre to Limestone	N3 Tinker to Ft Fairfield	N4 Beechwood to Mars Hill
N-1-1 Condition - Multiple Element Contingencies				
138 kV Line 1111/1144 & Numerous Contingencies	FI (A)	O	O	O
138 kV Line 1111/1144 & Contingencies that involve 345 kV Line 3012 without UVLS	VC regardless of UVLS	VC - LV (F) with UVLS	VC - LV (F) with UVLS	VC regardless of UVLS
138 kV Line 1111/1144 & 345 kV Keswick K3-3 SB	VC - OK with UVLS	O	VC – N T (1144 - S), (88 & 89) with UVLS	VC - OK with UVLS
138 kV Line 1111/1144 & 345 kV Keswick 3-6 SB	VC	T (6911)	N - VC, S - T (1144)	VC
138 kV Line 1111/1144 & 138 kV Beechwood Stuck Breakers	VC	LV (A), T (6903)	N - VC, S - FI (A)	VC
138 kV Line 1111/1144 & 138 kV Keswick K1125-1126SB	VC, T (88 and 89)	FI (A)	N - VC, S - T (88 and 89)	VC
138 kV Line 1111/1144 & 138 kV Keswick K1125-1139 SB	LV (F & A), T (88 & 89)	FI (A), T (88 & 89)	N - LV (F & A), T (88 & 89), S - T (1144 & 2)	LV (F & A), T (88 & 89)
138 kV Line 3855 & 345 kV Keswick K3-3 SB	O	O	T (1144)	O
138 kV Line 3855 & 345 kV Keswick K3-6 SB	O	O	T (1144)	O
138 kV Line 3855 & Contingencies that involve 345 kV Line 3012 without UVLS	VC regardless of UVLS	VC regardless of UVLS	VC regardless of UVLS	VC regardless of UVLS
138 kV Line 3855 & 138 kV Grand Falls 1111-02 SB	VC	LV (A)	O	O
Issues created by Alternatives				
138 kV Line 3855 & 345 kV Keswick K3-2 SB			T (1144)	
138 kV Line 3855 & 345 kV St. Andre AN3-6 SB		LV (F & A)		
138 kV Line 3855 & 138 kV Beechwood SBs				LV (A)
138 kV Line 3855 & New Tinker-3 SB			LV (A)	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 7-22 N-1-1 Multiple Element Contingencies Results – New Brunswick Alternatives Comparison

7.9.4 Maintenance Outage Analysis of Interconnected System Configuration

- New Brunswick alternatives N2 – N4 eliminate the voltage collapse seen in the Needs Assessment for the coincident outage of both Flo's Inn T1 and Tinker T1 138/69 kV transformers.
    - N2 requires Mullen capacitor banks to switch in-service high speed.
    - N1 does not eliminate the voltage collapse.
- Alternative N4 eliminates the voltage collapse seen in the Needs Assessment for the coincident outage of the Flo's Inn T1 138/69 kV transformer and the 69 kV Line 6901.
    - N1-N3 do not eliminate this voltage collapse.
- All four alternatives eliminate the Tinker T1 138/69 kV transformer thermal overload seen in the Needs Assessment for the Flo's Inn T1 138/69 kV transformer out of service.
- N1 reported the following additional violations:
    - 69 kV Line 6901 overloaded for numerous coincident outage conditions.
    - 69 kV Lines 6903 and 6904 overloaded for the coincident outage of Flo's Inn T1 138/69 kV transformer and 69 kV Line 6901.
- N2 reported the following additional violations:
    - 69 kV Line 6901 overloaded for the coincident outage of Flo's Inn T1 138/69 kV transformer and 69 kV Line 6904.
    - 69 kV Line 6904 overloaded for the coincident outage of Flo's Inn T1 138/69 kV transformer and 69 kV Line 6901.
- N3 reported the following additional violations:
    - 69 kV Line 6901 (Tinker – ReEnergy Tap/Interfai) overloaded for numerous coincident outage conditions.
    - 69 kV Lines 6903 and 6904 overloaded for the coincident outage of Flo's Inn T1 138/69 kV transformer and 69 kV Line 6901.
    - 138 kV Line 1144 overloaded for numerous coincident outage conditions.
    - Low voltages within MPS for the coincident outage of Flo's Inn T1 138/69 kV transformer and 345 kV Line 3012 with under voltage load shed.

A comparison of the Maintenance Outage Analysis results for the New Brunswick alternatives can be seen below in Table 7-23.

Summary of Alternatives' Impact on Reliability Concerns 2013	New Brunswick Interconnections			
	N1 Tinker Upgrade	N2 St Andre to Limestone	N3 Tinker to Ft Fairfield	N4 Beechwood to Mars Hill
Maintenance Condition				
Flo's Inn T1 & Tinker T1 138/69 kV Transformers	VC	MC	O	O
Tinker T1 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - T (6901) with UVLS	VC - OK with UVLS	VC - LV (F), T (6901) with UVLS	VC - OK with UVLS
Iroquois T1 or T2 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Iroquois T1 or T2 & Iroquois T2 or T1 138/69 kV Transformers without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer & 345 kV Line 3011	O	O	T (11442, 6901)	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6901	VC, T (6903, 6904)	VC, T (6904)	VC, T (6903, 6904)	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6903	T (6901)	O	T (6901)	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6904	T (6901)	T (6901)	T (6901)	O
Issues created by Alternatives				
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6912	T (6901)		T (6901)	
Tinker T1 or Flo's Inn T1 or Iroquois T1 or Iroquois T2 138/69 kV Transformer & Keswick T4 345/138 kV Transformer			T (1144)	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 7-23 Maintenance Outage Analysis Results – New Brunswick Alternatives Comparison

Section 8
Assessment of New Brunswick Power Interconnection Alternatives

8.1 New Brunswick Power Interconnections - Alternative Reinforcement Testing

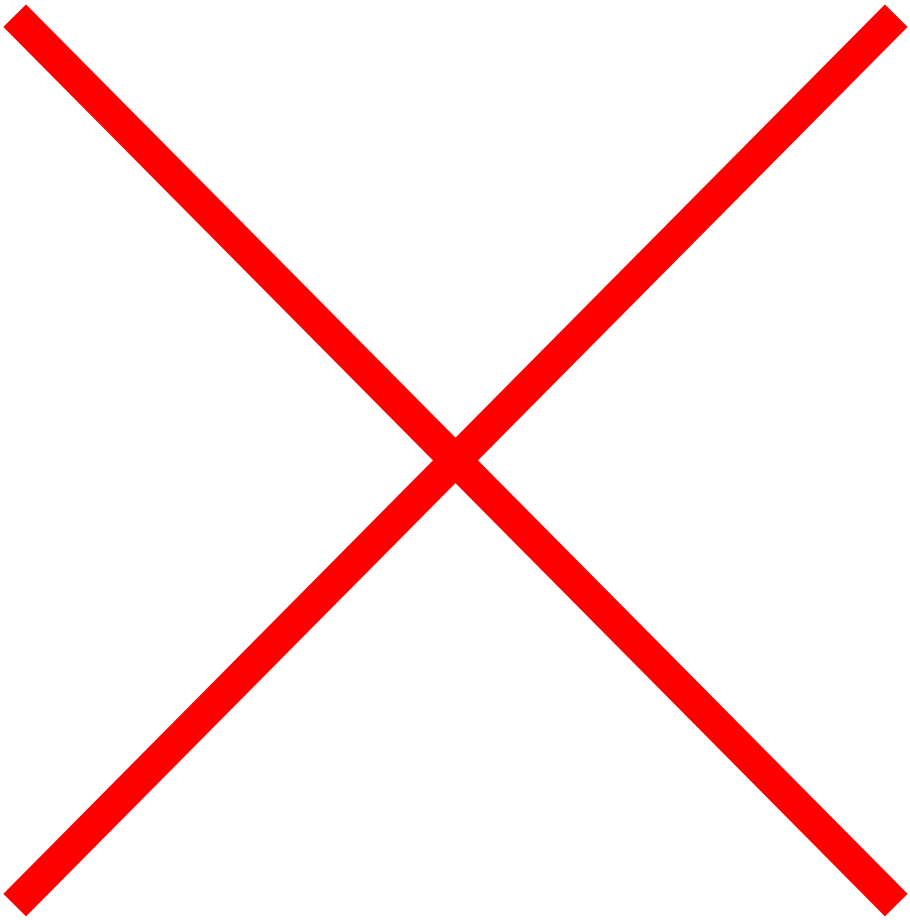
The Study tested an additional eight alternatives for interconnection with New Brunswick Power to address the MPS reliability issues reported in the Needs Assessment (P2 – P8). These additional interconnections were proposed by New Brunswick Power, and therefore will be referred to as New Brunswick "Power" alternatives to differentiate them from the four New Brunswick alternatives discussed above. These alternatives will be referred to as "P" alternatives. P1 is omitted from the list, because it was the same as N1, upgrading the Tinker T1 138/69 kV transformer.

- P2: Additional Transformation from Woodstock 138 kV to Mullen 69 kV.
- P3: Additional Transformation from Beechwood 138 kV to Flo's Inn 69 kV.
- P4: Additional Transformation from Tinker 138 kV to Flo's Inn 69 kV.
- P4a: Additional Transformation from Tinker 138 kV to Flo's Inn 69 kV, Looped in and out of Tinker.
- P5: Additional Transformation From Grand Falls 138 kV to Limestone 69 kV.
- P6: Additional Transformation from St. Andre 138 kV to Limestone 69 kV.
- P7: Convert 69 kV Line 6901 to 138 kV.
- P8: Additional Transformation from Tinker 138 kV to Fort Fairfield 69 kV.

All eight of the New Brunswick Power alternatives include the following NBP system capacitors as part of the alternative description:

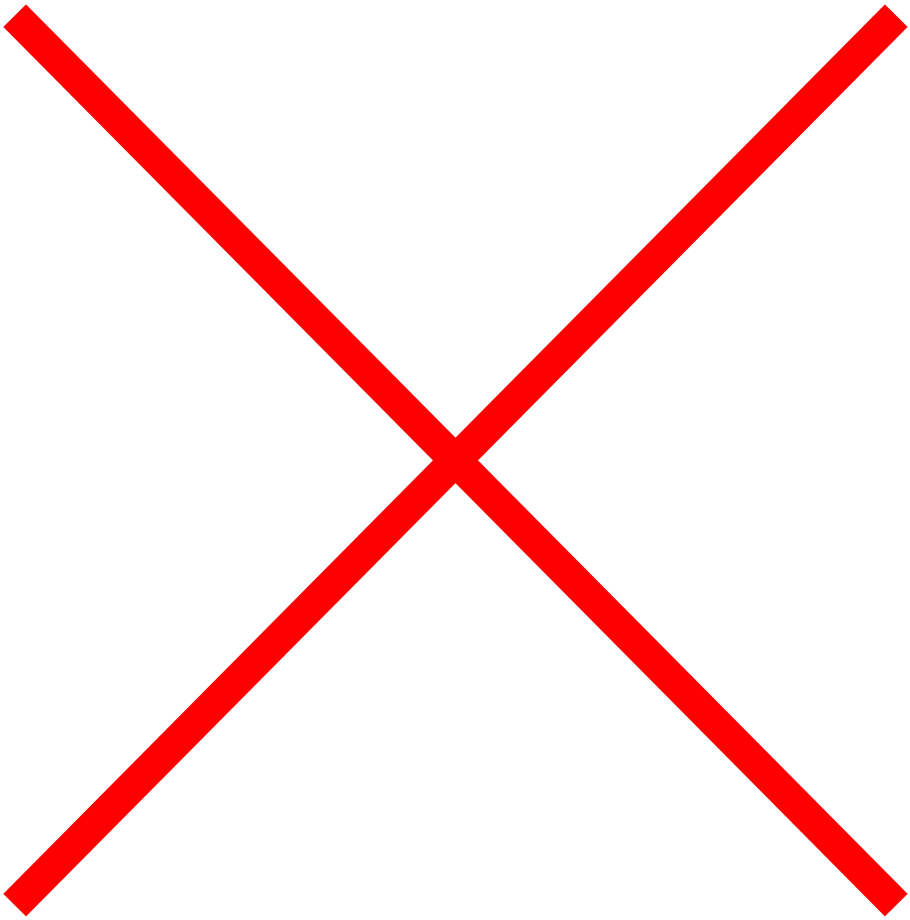
- 69 kV 10 MVAR capacitor at St. Leonard.
- 69 kV 10 MVAR capacitor at Woodstock.

Alternatives P2 – P8 each represent a new interconnection with NBP and are depicted below in Figure 8-1 through Figure 8-8.



REDACTED Diagram
CEII

Figure 8-1 Woodstock to Mullen Proposed Interconnection P2



REDACTED Diagram
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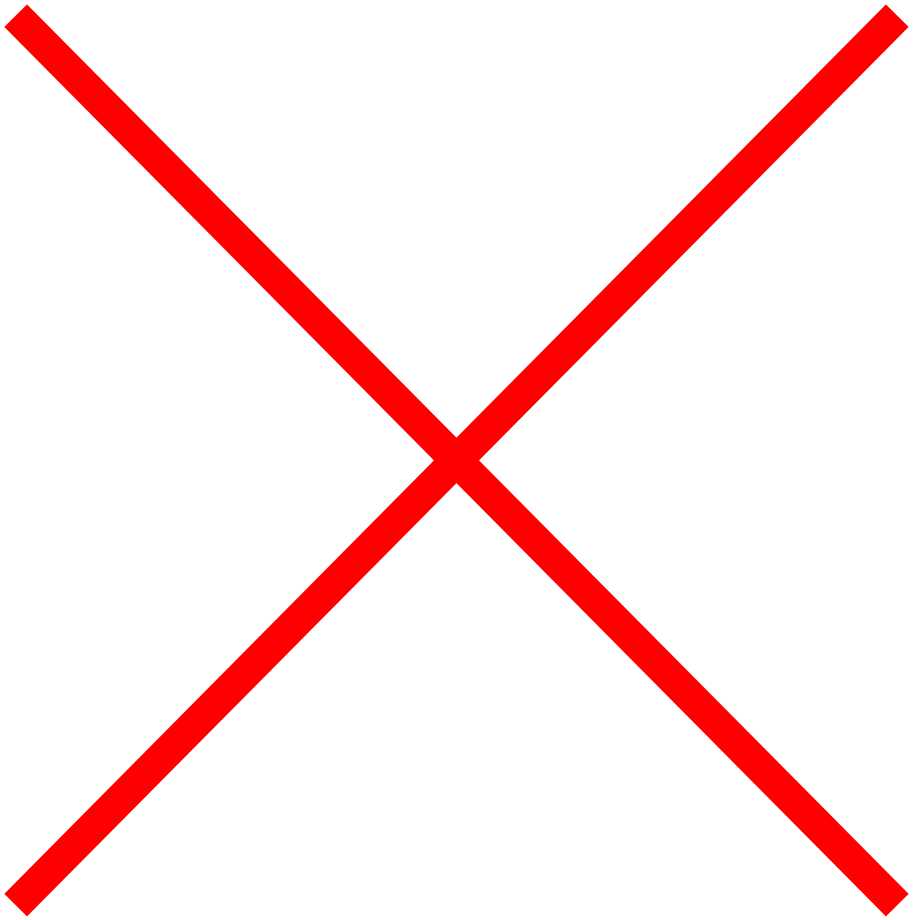
Figure 8-2 Tinker to Fort Fairfield Proposed Interconnection P3



REDACTED Diagram
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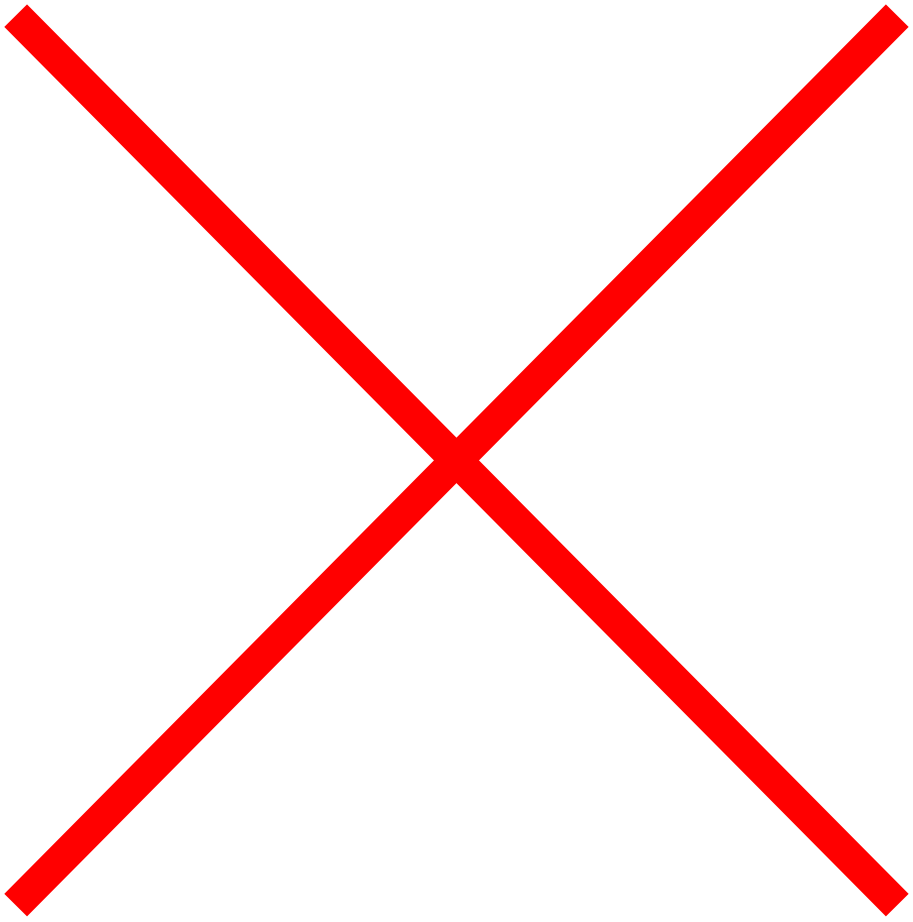
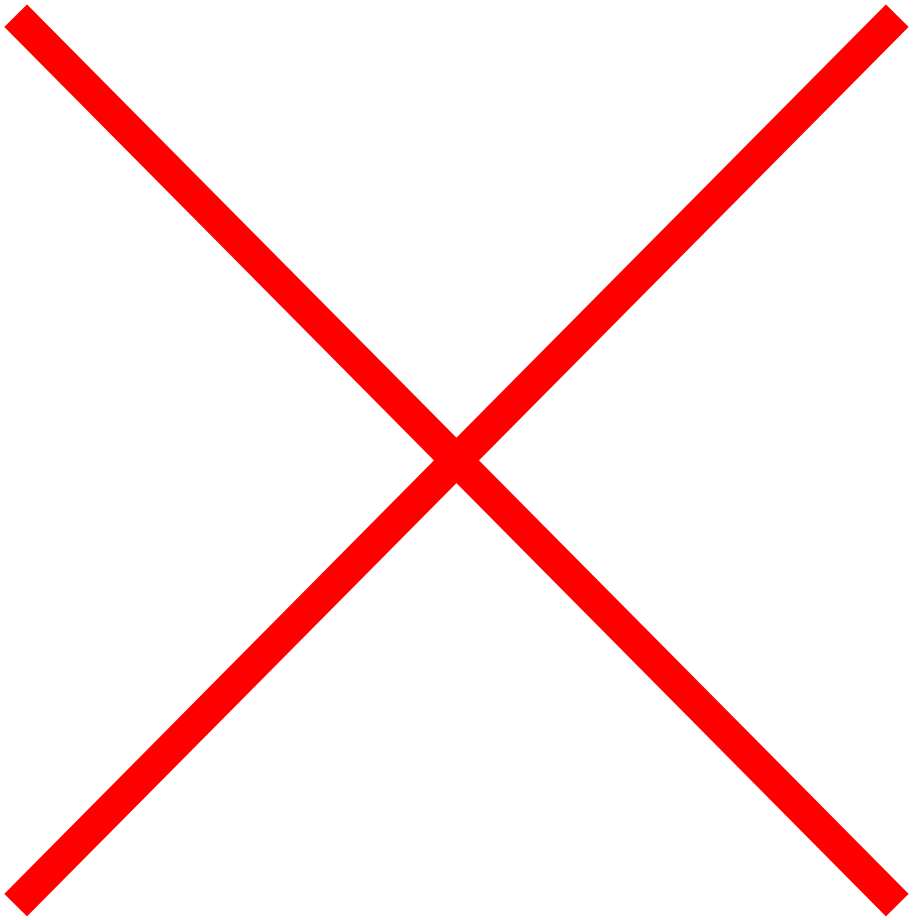
Figure 8-3 Tinker to Flo's Inn Proposed Interconnection P4



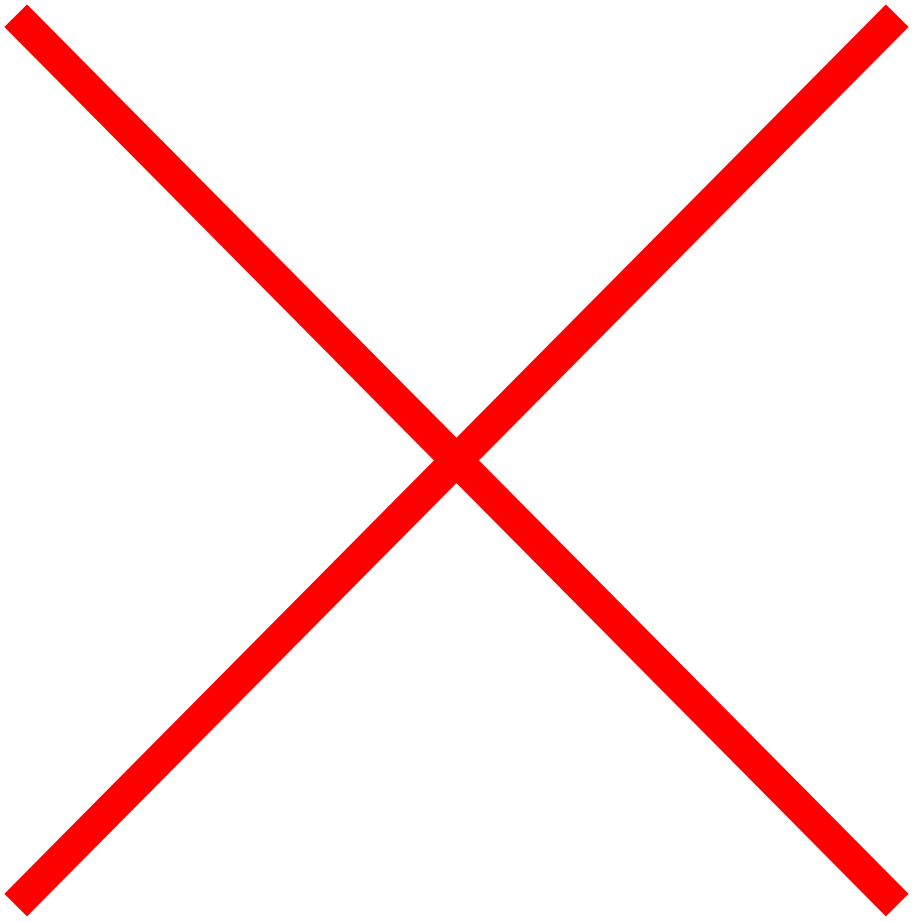
REDACTED Diagram
CEII

Figure 8-4 Tinker to Flo's Inn – Looped Proposed Interconnection P4a



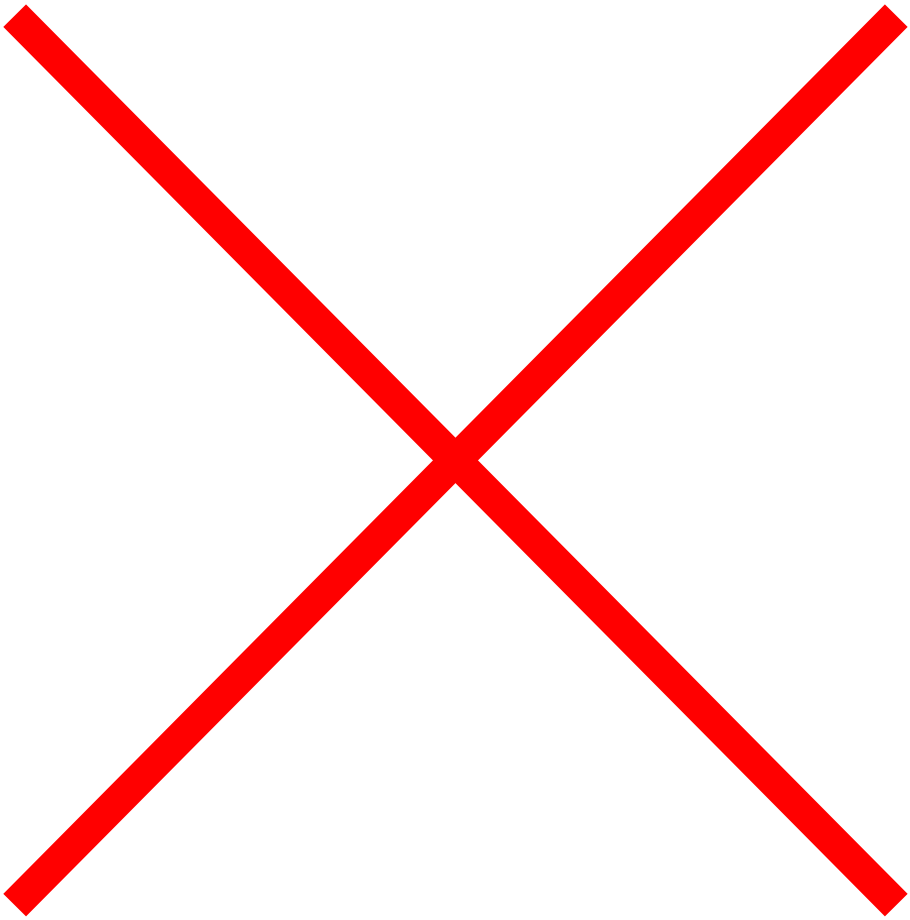
REDACTED Diagram
CEII

Figure 8-5 Grand Falls to Limestone Proposed Interconnection P5



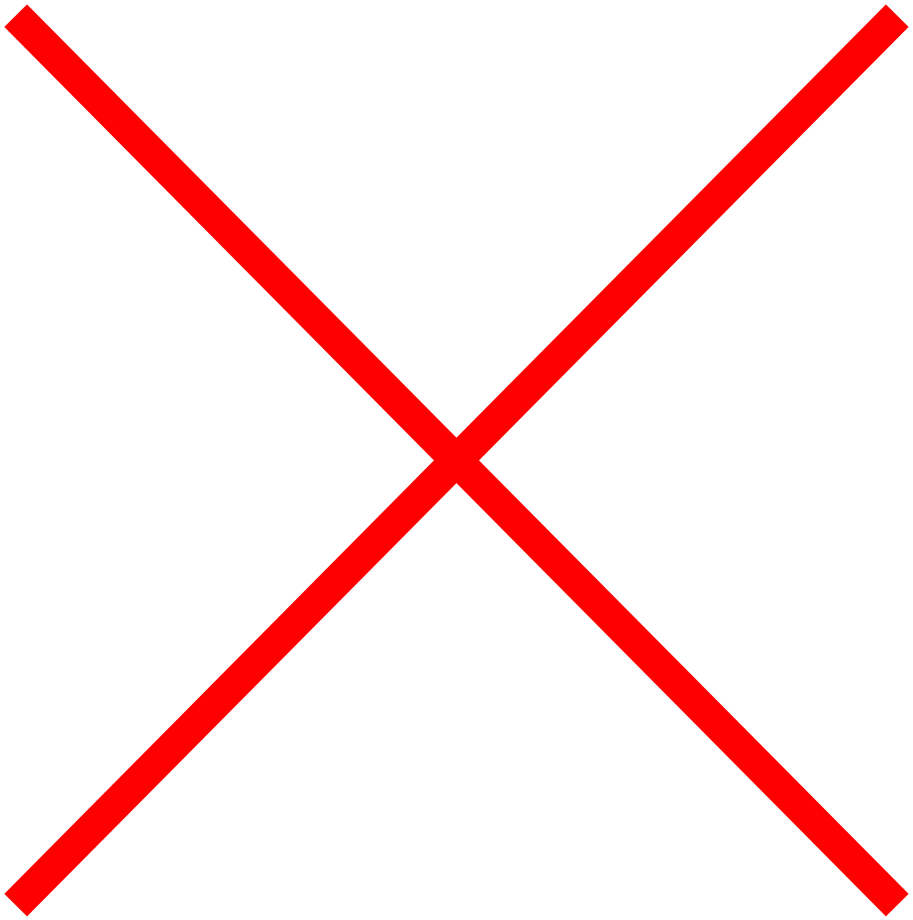
REDACTED Diagram
CEII

Figure 8-6 St. Andre to Limestone Proposed Interconnection P6



REDACTED Diagram
CEII

Figure 8-7 69 kV Line 6901 Upgraded to 138 kV Proposed Interconnection P7



REDACTED Diagram
CEII

Figure 8-8 Tinker to Fort Fairfield Proposed Interconnection P8

8.2 New Brunswick Power Interconnections - Base Case Assumptions

For each New Brunswick Power alternative, the new138/69 kV transformer was modeled replicating the existing Flo's Inn T1 138/69 kV transformer:

- Z = 0.00675 + j 0.081 pu (Zbase = 100MVA).
- Normal/LTE/STE MVA Rating = 122/137/182.
- Regulating the 69 kV Bus between 1.0 pu and 1.025 pu.
- 0.00625 step size.

Table 8-1 below describes the assumed line constants for each of the New Brunswick Power interconnections.

New Brunswick Power Alternative	From Bus	To Bus	kV	Length	795 ACSR Conductor		Charging	Rating (MVA)		
				(Miles)	R (pu)	X (pu)	B (pu)	Normal	LTE	STE
P2	Woodstock	Mullen	138	17.4	0.0104	0.0626	0.0191	215	258	310
P3	Beechwood	Flo's Inn	138	20.5	0.0123	0.0738	0.0226	215	258	310
P4	Tinker	Flo's Inn	138	13.7	0.0082	0.0492	0.0150	215	258	310
P4a	Tinker	Flo's Inn	138	13.7	0.0082	0.0492	0.0150	215	258	310
P5	Grand Falls	Limestone	138	12.4	0.0075	0.0447	0.0137	215	258	310
P6	St. Andre	Limestone	138	19.3	0.0116	0.0693	0.0212	215	258	310
P7	Tinker	Fort Fairfield	138	7.5	0.0045	0.0268	0.0082	215	258	310
P8	Tinker	Fort Fairfield	138	7.5	0.0045	0.0268	0.0082	215	258	310

Table 8-1 New Brunswick Power Interconnection Line Constants

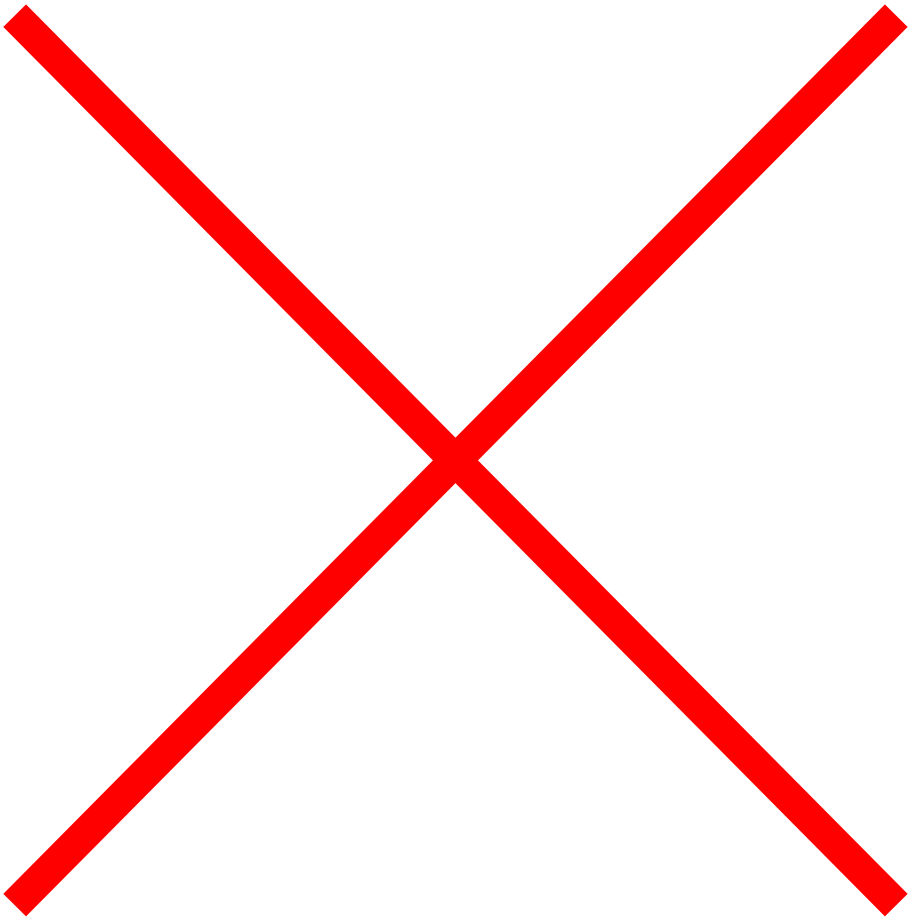
8.3 New Brunswick Power Interconnections - System Configurations

For the New Brunswick Power alternatives assessment, transmission system configurations were tested with contingency analysis during all lines in-service (N-0 base case and N-1 post-contingency), 138 kV line outage (N-1 base case and N-1-1 post-contingency) and 138/69 kV maintenance outage (N-1 base case and N-1-1 post-contingency) conditions. The following configurations and system conditions were tested:

- All Lines In (N-0) at peak load:
    - Interconnected configuration.
    - Radial configuration.
- Two N-1 outage conditions at peak load (N-1) for the interconnected configuration:
    - 138 kV Line 3855 (Beechwood – Flo's Inn).
    - 138 kV Line 1111 (Beechwood – Grand Falls).
- Four scheduled maintenance configurations at 85% load (N-1) for the interconnected configuration
    - Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855.
    - Tinker T1 138/69 kV Transformer or 138 kV Line 1144.
    - Iroquois T1 138/69 kV Transformer or 138 kV Line 1184.
    - Iroquois T2 138/69 kV Transformer or 138 kV Line 1183.

8.4 New Brunswick Power Interconnections - Contingency List Additions and Modifications

The following tables contain the additional contingencies, and/or changes in contingency descriptions relative to the four New Brunswick Power alternatives.



REDACTED Table
CEII

Table 8-2
Category B – New Brunswick Power Alternatives Single Element Transmission Line Contingencies

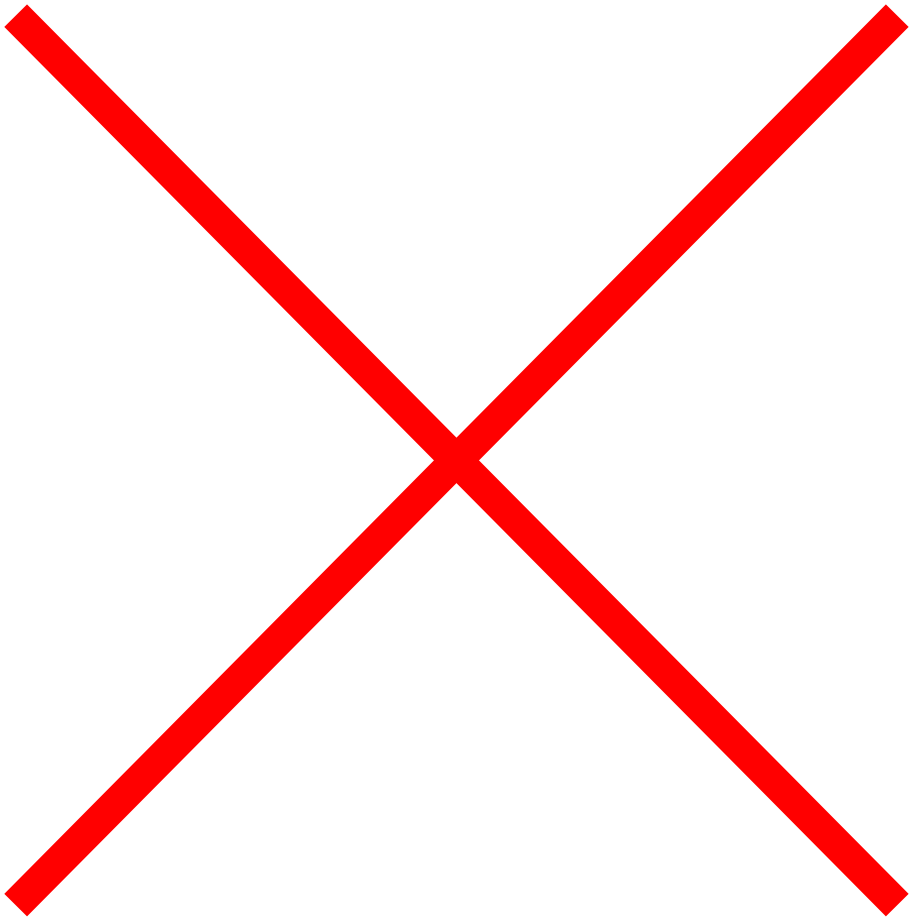


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Table 8-3
Category B – New Brunswick Alternatives Single Element Transformer Contingencies

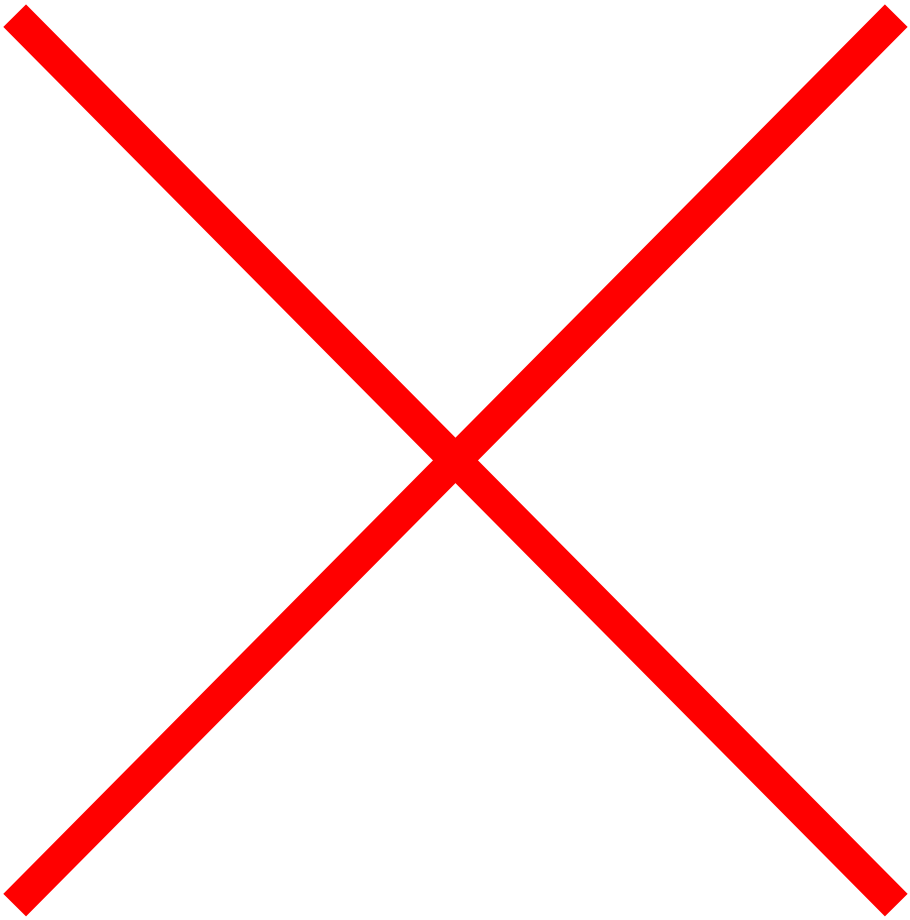

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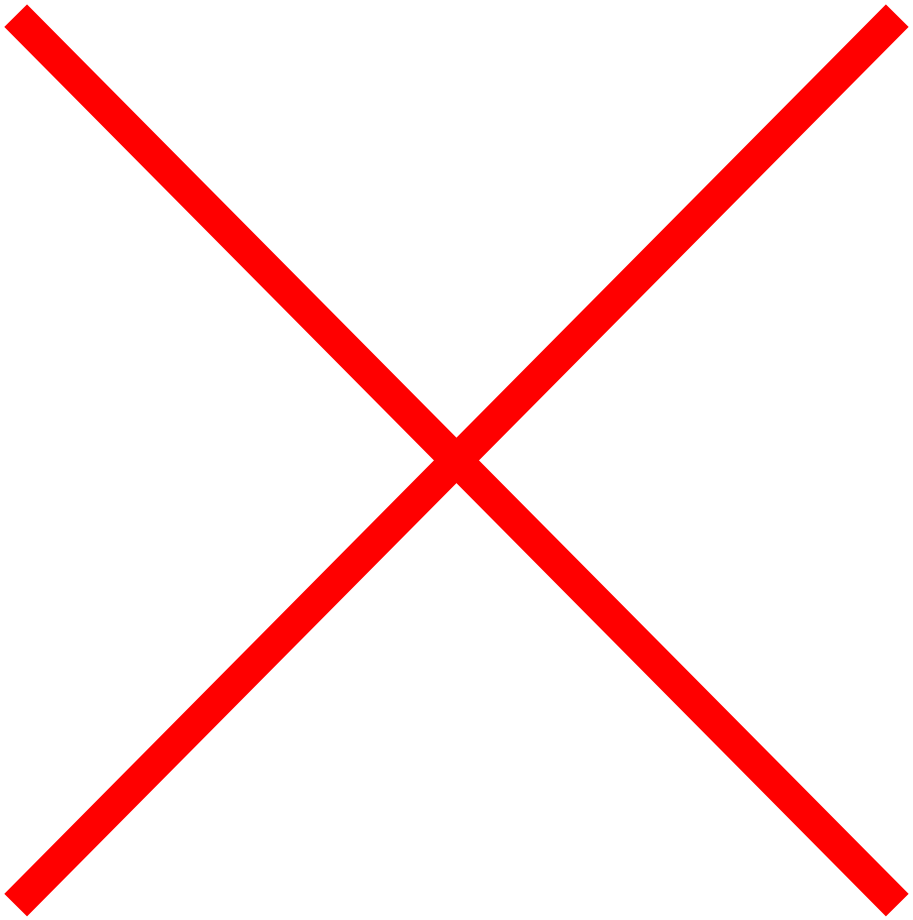
Table 8-4
Category C – New Brunswick Alternatives Multiple Element Stuck Breaker Contingencies



REDACTED Table
CEII

Table 8-5
Category C – New Brunswick Alternatives Multiple Element Stuck Breaker Contingencies

8.5 New Brunswick Power Interconnections - All Lines In (N-0) Analysis

8.5.1 2013 Winter Peak Load Level

8.5.1.1 Interconnected Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

8.5.1.2 Radial Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

8.5.2 2013 Summer Peak Load Level

8.5.2.1 Interconnected Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

8.5.2.2 Radial Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

8.6 New Brunswick Power Interconnections - N-1 Analysis

N-1 Analysis was performed to examine the impact of each New Brunswick Power alternative on the MPS reliability issues identified in the Needs Assessment. Sensitivity to the radial system configuration was examined for the N-1 Analysis.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC".

Due to page limitations, each table of results below is split into two separate tables. The first denotes results for alternatives P2 – P4a, and the second table denotes results for alternatives P5 – P7.

8.6.1 2013 Winter Peak Load Level

8.6.1.1 Interconnected Configuration

New Brunswick Power Alternatives Assessment N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Winter Peak Load - Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Low Voltage Violations	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
Voltage Collapse	345 kV Keswick K3-3 SB (without Beechwood UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	138 kV Beechwood K1126-1 SB	VC	VC	O	O
	138 kV Beechwood SBs & Bus Fault	O	VC	O	O
	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	345 kV St. Andre AN3-2 SB with UVLS	O	O	O	LV (F)
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
Issues Created by Alternative					
138 kV Line 1144 (2)	345 kV Keswick K3-6 SB, 138 kV Keswick K1125-1139 SB, Keswick T4 345/138 kV Transformer				X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-6 N-1 Analysis of New Brunswick Power Alternatives P2 – P4a
2013 Winter Peak Load – Interconnected Configuration

New Brunswick Power Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Winter Peak Load - Interconnected Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Low Voltage Violations	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
Voltage Collapse	345 kV Keswick K3-3 SB (without Beechwood UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	138 kV Beechwood K1126-1 SB	O	O	O	O
	138 kV Beechwood SBs & Bus Fault	O	O	O	O
	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-7 N-1 Analysis of New Brunswick Power Alternatives P5 – P8
2013 Winter Peak Load – Interconnected Configuration

8.6.1.2 Radial Configuration

New Brunswick Power Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Winter Peak Load - Radial Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
138 kV Low Voltage Violations	345 kV Keswick K3-6 SB, Keswick T4 345/138 kV Transformer, 138 kV Keswick K1125-1139 SB	O	O	O	O
Voltage Collapse	138 kV Beechwood K1126-1SB	VC	VC	O	O
	138 kV Beechwood SBs & Bus Fault	O	VC	O	O
138 kV Low Voltage Violations	138 kV Grand Falls 1111-02 SB, 138 kV Line 1111	O	O	O	O
Islanding/Consequential Load Loss of Northern MPS	345 kV Line 3113				
Issues Created by Alternative					
138 kV Line 1144 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855			X	
	138 kV Beechwood SBs & Bus Fault			X	X
	Keswick T4 345/138 kV Transformer, 345 kV Keswick K3-3 SB, 345 kV Keswick K3-6 SB, 138 kV Keswick K1125-1139 SB				X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-8 N-1 Analysis of New Brunswick Power Alternatives P2 – P4a
2013 Winter Peak Load – Radial Configuration

New Brunswick Power Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Winter Peak Load - Radial Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
138 kV Low Voltage Violations	345 kV Keswick K3-6 SB, Keswick T4 345/138 kV Transformer, 138 kV Keswick K1125-1139 SB	O	O	O	O
Voltage Collapse	138 kV Beechwood K1126-1SB	MC	MC	MC	VC
	138 kV Beechwood SBs & Bus Fault	MC	MC	MC	VC
138 kV Low Voltage Violations	138 kV Grand Falls 1111-02 SB, 138 kV Line 1111	FI (A)	O	O	FI (A)
Islanding/Consequential Load Loss of Northern MPS	345 kV Line 3113				
Issues Created by Alternative					
138 kV Line 1144 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855			X	X
	138 kV Beechwood SBs & Bus Fault			X	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-9 N-1 Analysis of New Brunswick Power Alternatives P5 – P8
2013 Winter Peak Load – Radial Configuration

8.6.2 2013 Summer Peak Load Level

8.6.2.1 Interconnected Configuration

New Brunswick Power Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Summer Peak Load - Interconnected Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - LV (F) with UVLS	VC - OK with UVLS	VC - OK with UVLS
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
	138 kV Beechwood SBs & Bus Fault	O	O	O	O
Issues Created by Alternative					
138 kV Line 1144 (2)	345 kV Keswick K3-2 SB and 345 kV St. Andre AN3-2 SB				X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-10 N-1 Analysis of New Brunswick Power Alternatives P2 – P4a
2013 Summer Peak Load – Interconnected Configuration

New Brunswick Power Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Summer Peak Load - Interconnected Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - LV (F) with UVLS	VC - OK with UVLS	VC - OK with UVLS
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	T	T
	138 kV Beechwood SBs & Bus Fault	O	O	T	T

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-11 N-1 Analysis of New Brunswick Power Alternatives P5 – P8a
2013 Summer Peak Load – Interconnected Configuration

8.6.2.2 Radial Configuration

New Brunswick Power Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Summer Peak Load - Radial Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	138 kV Beechwood K1126-1SB	VC	VC	O	O
	138 kV Beechwood SBs & Bus Fault	O	VC	O	O
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
Islanding/Consequential Load Loss of Northern MPS	345 kV Line 3113				
Issues Created by Alternative					
69 kV Line 6901 Overload	138 kV Beechwood SBs & Bus Fault	1126-1 only			

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-12 N-1 Analysis of New Brunswick Power Alternatives P2 – P4a
2013 Summer Peak Load – Radial Configuration

New Brunswick Power Alternatives Assessment
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
2013 Summer Peak Load - Radial Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	138 kV Beechwood K1126-1SB	O	O	O	O
	138 kV Beechwood SBs & Bus Fault	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	T	T
Islanding/Consequential Load Loss of Northern MPS	345 kV Line 3113				
Issues Created by Alternative					
69 kV Line 6901 Overload	138 kV Beechwood SBs & Bus Fault			X	X
69 kV Line 6903 Overload	138 kV Beechwood SBs & Bus Fault	X	X		

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-13 N-1 Analysis of New Brunswick Power Alternatives P5 – P8
2013 Summer Peak Load – Radial Configuration

8.7 New Brunswick Power Interconnections - N-1-1 Analysis

N-1-1 Analysis was performed to examine the impact of each New Brunswick Power alternative on the MPS reliability issues identified in the Needs Assessment for the following two N-1 outage conditions assuming the interconnected system configuration:

- 138 kV Line 1111 (Beechwood – Grand Falls).
- 138 kV Line 3855 (Beechwood – Flo's Inn).

The complete list of contingencies tested previously for the N-1 Analysis was examined for the N-1-1 Analysis. The tables below however, include discussion of contingencies at the 100 kV level and above.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC".

Due to page limitations, each table of results below is split into two separate tables. The first denotes results for alternatives P2 – P4a, and the second table denotes results for alternatives P5 – P7.

8.7.1 2013 Winter Peak Load Level

8.7.1.1 Interconnected Configuration

New Brunswick Power Alternatives Assessment 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage N-1-1 Voltage Violations - 2013 Winter Peak Load Interconnected Configuration						
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4A	
					N	S
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - FI (A) with UVLS	VC - OK with UVLS	VC - LV (F) with UVLS
	Keswick T4 345/138 kV Transformer	O	LV (F & A)	VC	VC	O
	Flo's Inn T1 138/69 kV Transformer or 138 kV 3855	O	O	VC	O	O
Low Voltage Violations	138 kV Line 1125/1172	O	O	FI (A)	O	O
	Numerous contingencies	O	O	O	O	O
Voltage Collapse	345 kV Keswick K3-3 SB (UVLS would not have activated)	LV (F & A)	VC	VC	VC	O
	345 kV Keswick K3-6 SB	O	VC	VC	VC	O
	345 kV St. Andre AN3-1 SB (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - FI (A) with UVLS	VC - LV (F) with UVLS	VC regardless of UVLS
	345 kV St. Andre AN3-2 SB (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - LV (F) & FI (A) with UVLS	VC - LV (F) with UVLS	VC regardless of UVLS
	138 kV Beechwood SBs & BF	LV (A), 1126-1 only	VC	VC	VC	O
	138 kV Keswick K1125-1126 SB	VC	VC	VC	VC	O
	139 kV Keswick K1125-1139 SB	LV (A)	LV (F & A)	LV (F & A)	VC	O
69 kV Line 88 Overload	138 kV Keswick K1125-1139 SB	T	T	T	VC	T
69 kV Line 89 Overload	138 kV Keswick K1125-1139 SB	T	T	T	VC	T
Issues Created by Alternative						
69 kV Line 88 Overload	345 kV Keswick K3-3 & K3-6 SBs & Keswick T4 Transformer	X				
69 kV Line 89 Overload	345 kV Keswick K3-3 & K3-6 SBs & Keswick T4 Transformer	X				
69 kV Line 1144 Overload	345 kV Keswick K3-3 & K3-6 SBs, Keswick T4 & 138 kV K1125-1139 SB					X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-14 N-1-1 Analysis of New Brunswick Power Alternatives P2 – P4a – 138 kV Line 1111/1144 Outage - 2013 Winter Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage N-1-1 Voltage Violations - 2013 Winter Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Keswick T4 345/138 kV Transformer	FI (A)	FI (A)	VC	LV (F & A)
	Flo's Inn T1 138/69 kV Transformer or 138 kV 3855	VC	MC	VC	VC
Low Voltage Violations	138 kV Line 1125/1172	O	O	FI (A)	FI (A)
	Numerous contingencies	O	O	O	O
Voltage Collapse	345 kV Keswick K3-3 SB (UVLS would not have activated)	FI (A)	O	VC	VC
	345 kV Keswick K3-6 SB	FI (A)	FI (A)	VC	VC
	345 kV St. Andre AN3-1 SB (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - FI (A) with UVLS
	345 kV St. Andre AN3-2 SB (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - LF (F & A) with UVLS	VC - LV (F & A) with UVLS
	138 kV Beechwood SBs & BF	VC	MC	VC	VC
	138 kV Keswick K1125-1126 SB	FI (A)	FI (A)	VC	VC
	139 kV Keswick K1125-1139 SB	FI (A)	FI (A)	LV (F & A)	LV (F & A)
69 kV Line 88 Overload	138 kV Keswick K1125-1139 SB	O	O	T	T
69 kV Line 89 Overload	138 kV Keswick K1125-1139 SB	O	O	T	T

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-15 N-1-1 Analysis of New Brunswick Power Alternatives P5 – P8 – 138 kV Line 1111/1144 Outage - 2013 Winter Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment
138 kV Line 3855/1176 (Beechwood -Flo's Inn) Outage
N-1-1 Voltage Violations - 2013 Winter Peak Load
Interconnected Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Low Voltage Violations	Keswick T4 345/138 kV Transformer	O	O	O	O
Voltage Collapse	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	O	O	O	O
Voltage Collapse	69 kV Line 6901	O	O	O	O
Voltage Collapse	345 kV Keswick K3-3 & K3-6 SB	O	O	O	O
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Voltage Collapse	138 kV Grand Falls 1111-02 SB	O	O	O	O
Low Voltage Violations	138 kV Grand Falls SB & BF that open end 1111	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Base Case, Numerous Contingencies	O	O	O	O
69 kV Line 88 Overload	Keswick T4 345/138 kV Transformer, 345 kV Keswick K3-6 SB	O	O	O	O
Issues Created by Alternative					
138 kV Line 1144 Overload	Numerous Contingencies			X	X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-16 N-1-1 Analysis of New Brunswick Power Alternatives P2 – P4a – 138 kV Line 3855/1176 Outage - 2013 Winter Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment 138 kV Line 3855/1176 (Beechwood -Flo's Inn) Outage N-1-1 Voltage Violations - 2013 Winter Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Low Voltage Violations	Keswick T4 345/138 kV Transformer	O	O	O	O
Voltage Collapse	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	O	O	O	O
Voltage Collapse	345 kV Keswick K3-3 & K3-6 SB	O	O	O	O
	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	138 kV Grand Falls 1111-02 SB	O	O	O	O
Low Voltage Violations	138 kV Grand Falls SB & BF that open end 1111	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Base Case, Numerous Contingencies	O	O	O	O
69 kV Line 88 Overload	Keswick T4 345/138 kV Transformer, 345 kV Keswick K3-6 SB	O	O	O	O
Issues Created by Alternative					
Voltage Collapse	Fort Fairfield Transformer			X	
138 kV Line 1144 Overload	Numerous Contingencies			X	X
69 kV Line 6901 Overload	69 kV Line 6903	X	X		

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue created by Alternative

Table 8-17 N-1-1 Analysis of New Brunswick Power Alternatives P5 – P8 – 138 kV Line 3855/1176 Outage - 2013 Winter Peak Load - Interconnected Configuration

8.7.2 2013 Summer Peak Load Level

8.7.2.1 Interconnected Configuration

New Brunswick Power Alternatives Assessment 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage N-1-1 Voltage Violations - 2013 Summer Peak Load Interconnected Configuration						
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4A	
					N	S
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - Ok with UVLS	VC - OK with UVLS	VC - OK with UVLS
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	VC	O	O
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	138 kV Beechwood SBs & Bus Fault	1126-1 only	VC	VC	VC	O
69 kV Line 88 Overload	138 kV Keswick K1125-1126SB	T	T	T	T	O
69 kV Line 89 Overload	138 kV Keswick K1125-1126SB	T	T	T	T	O
Issues Created by Alternative						
69 kV Line 3855 Overload	345 kV St. Andre AN3-1 SB with UVLS					X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-18 N-1-1 Analysis of New Brunswick Power Alternatives P2 – P4a – 138 kV Line 1111/1144 Outage - 2013 Summer Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage N-1-1 Voltage Violations - 2013 Summer Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	VC	VC
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	138 kV Beechwood SBs & Bus Fault	O	O	VC	VC
69 kV Line 88 Overload	138 kV Keswick K1125-1126SB	O	O	T	T
69 kV Line 89 Overload	138 kV Keswick K1125-1126SB	O	O	T	T
Issues Created by Alternative					
69 kV Line 6903 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	X			

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-19 N-1-1 Analysis of New Brunswick Power Alternatives P5 – P8 – 138 kV Line 1111/1144 Outage - 2013 Summer Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment 138 kV Line 3855/1176 (Beechwood -Flo's Inn) Outage N-1-1 Voltage Violations - 2013 Summer Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	O	O	VC	O
	69 kV Line 6901	O	O	O	O
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	138 kV Grand Falls 1111-02 SB	O	O	VC	O
Tinker T1 138/69 kV Transformer Overload	Base Case, Numerous Contingencies	O	O	O	O
69 kV Line 6901 Overload	Base Case, Numerous Contingencies	O	O	O	O
Issues Created by Alternative					
Low Voltage Violations	138 kV Beechwood SBs & Bus Fault		LV (A)		
	138 kV New Tinker-3 SB				LV (A)
138 kV Line 1144 Overload	345 kV St. Andre AN3-1 SB			X	
138 kV Line 11442 Overload	Numerous Contingencies				X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-20 N-1-1 Analysis of New Brunswick Power Alternatives P2 – P4a – 138 kV Line 3855/1176 Outage - 2013 Summer Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment 138 kV Line 3855/1176 (Beechwood -Flo's Inn) Outage N-1-1 Voltage Violations - 2013 Summer Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	O	LV (A)	VC	VC
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	138 kV Grand Falls 1111-02 SB	VC	O	VC	VC
Tinker T1 138/69 kV Transformer Overload	Base Case, Numerous Contingencies	O	O	O	O
69 kV Line 6901 Overload	Base Case, Numerous Contingencies	T	T	T	T
Issues Created by Alternative					
Voltage Collapse	Fort Fairfield Transformer			X	
Low Voltage Violations	69 kV Line 6920	LV (A)	LV (A)		
138 kV Line 1144 Overload	345 kV St. Andre AN3-1 SB			X	X
138 kV Line 11442 Overload	Numerous Contingencies				
69 kV 6903 Overload	69 kV Line 6901	X			

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 8-21 N-1-1 Analysis of New Brunswick Power Alternatives P5 – P8 – 138 kV Line 3855/1176 Outage - 2013 Summer Peak Load - Interconnected Configuration

8.8 New Brunswick Power Interconnections - Maintenance Outage Analysis

Maintenance Outage Analysis was performed to examine the impact of each New Brunswick Power alternative on the MPS reliability issues identified in the Needs Assessment for the following four outage conditions at 85% of peak load, assuming the interconnected system configuration:

- Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855.
- Tinker T1 138/69 kV Transformer or 138 kV Line 1144.
- Iroquois T1 138/69 kV Transformer or 138 kV Line 1184.
- Iroquois T2 138/69 kV Transformer or 138 kV Line 1183.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC".

Due to page limitations, each table of results below is split into two separate tables. The first denotes results for alternatives P2 – P4a, and the second table denotes results for alternatives P5 – P7.

8.8.1 2013 Winter Peak Load Level

8.8.1.1 Interconnected Configuration

New Brunswick Power Alternatives Assessment Tinker T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Flo's Inn T1 138/69 kV Transformer or 3855	O	O	O	O
Issues Created by Alternative					
138 kV Line 1144 Overload	Keswick T4 345/138 kV Transformer				X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue Created by Alternative

Table 8-22 Maintenance Outage Analysis of New Brunswick Power Alternatives P2 – P4a – Tinker T1 Outages – 85% of 2013 Winter Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment Tinker T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Flo's Inn T1 138/69 kV Transformer or 3855	O	O	O	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue Created by Alternative

Table 8-23 Maintenance Outage Analysis of New Brunswick Power Alternatives P5 – P8 – Tinker T1 Outages – 85% of 2013 Winter Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	O	O	VC	O
	69 kV Line 6901	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Base	O	O	O	O
Issues Created by Alternative					
138 kV Line 11442 Overload	345 kV Line 3011 & Keswick T4 345/138 kV Transformer				X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue Created by Alternative

Table 8-24 Maintenance Outage Analysis of New Brunswick Power Alternatives P2 – P4a – Flo's Inn Outage – 85% of 2013 Winter Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	O	O	VC	VC
	69 kV Line 6901	VC	VC	VC	N - O S - VC
Tinker T1 138/69 kV Transformer Overload	Base	O	O	O	O
Issues Created by Alternative					
Voltage Collapse	Fort Fairfield Transformer			X	

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)
X = Issue Created by Alternative

Table 8-25 Maintenance Outage Analysis of New Brunswick Power Alternatives P5 – P8 – Flo's Inn Outage – 85% of 2013 Winter Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV 3855	O	O	O	O
Issues Created by Alternative					
138 kV Line 11442 Overload	Keswick T4 345/138 kV Transformer				X
Iroquois T2 138/69 kV Transformer Maintenance Outage					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4 Tinker to Flo's Inn Looped
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Iroquois T1 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV 3855	O	O	O	O
Issues Created by Alternative					
138 kV Line 11442 Overload	Keswick T4 345/138 kV Transformer				X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue Created by Alternative

Table 8-26 Maintenance Outage Analysis of New Brunswick Power Alternatives P2 – P4a – Iroquois T1 or T2 Outage – 85% of 2013 Winter Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV 3855	O	O	O	O
Iroquois T2 138/69 kV Transformer Maintenance Outage					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
	Iroquois T1 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV 3855	O	O	O	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue Created by Alternative

Table 8-27 Maintenance Outage Analysis of New Brunswick Power Alternatives P5 – P8 – Iroquois T1 or T2 Outage – 85% of 2013 Winter Peak Load - Interconnected Configuration

8.8.2 2013 Summer Peak Load Level

8.8.2.1 Interconnected Configuration

New Brunswick Power Alternatives Assessment Tinker T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue Created by Alternative

Table 8-28 Maintenance Outage Analysis of New Brunswick Power Alternatives P2 – P4a – Tinker T1 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment Tinker T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O
Issues Created by Alternative					
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855			X	X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue Created by Alternative

Table 8-29 Maintenance Outage Analysis of New Brunswick Power Alternatives P5 – P8 – Tinker T1 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment
Flo's Inn T1 138/69 kV Transformer Maintenance Outage
N-1 Analysis - Comparison of Alternative Impact on Reliability Issues
85% of 2013 Summer Peak Load Interconnected Configuration

Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Low Voltage Violations	345 kV Line 3011	O	O	O	O
Voltage Collapse	Tinker T1 138/69 kV Transformer or 138 KV Line 1111	O	O	VC	O
Low Voltage Violations	69 kV Line 6901	O	O	O	O
	Ashland Shunt	O	O	O	O
	Mullen Shunt	O	O	O	O
Tinker T1 138/69 kV Transformer Overload	Base	O	O	O	O
69 kV Line 6901 Overload	69 kV Line 6903	O	O	O	O
	69 kV Line 6904	O	O	O	O
69 kV Line 6904 Overload	69 kV Line 6901	O	O	O	O
69 kV Line 6903 Overload	69 kV Line 6901	O	O	O	O
Issues Created by Alternative					
138 kV Line 11442 Overload	345 kV Line 3011				X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue Created by Alternative

Table 8-30 Maintenance Outage Analysis of New Brunswick Power Alternatives P2 – P4a – Flo's Inn T1 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Low Voltage Violations	345 kV Line 3011	O	O	O	O
Voltage Collapse	Tinker T1 138/69 kV Transformer or 138 KV Line 1111	O	O	VC	VC
Low Voltage Violations	69 kV Line 6901	LV (F & A)	LV (F & A)	LV (F & A)	N - O S - VC
	Ashland Shunt	O	O	O	O
	Mullen Shunt	LV (A)	LV (A)	O	O
Tinker T1 138/69 kV Transformer Overload	Base	O	O	O	O
69 kV Line 6901 Overload	69 kV Line 6903	T	T	T	T
	69 kV Line 6904	O	O	T	T
69 kV Line 6904 Overload	69 kV Line 6901	O	O	T	N - O S - T
69 kV Line 6903 Overload	69 kV Line 6901	T	T	T	N - O S - T
Issues Created by Alternative					
Voltage Collapse	Fort Fairfield Transformer			X	
69 kV Line 6901 Overload	Base, 69 kV Line 6912, Iroquois T1 & T2 138/69 kV Transformers				X
	345 kV Line 3011 & 345 kV Line 3012 (with UVLS)			X	X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue Created by Alternative

Table 8-31 Maintenance Outage Analysis of New Brunswick Power Alternatives P5 – P8 – Flo's Inn T1 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Iroquois T2 138/69 kV Transformer Maintenance Outage					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped
Voltage Collapse	Iroquois T1 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Impact on MPS System Performance: O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain FI = Low Voltage Violations at 138 kV Flo's Inn bus only MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust (A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations T = Thermal Overloads Remain VC = Voltage Collapse Concern Remains (thermal concern not noted) X = Issue Created by Alternative					

Table 8-32 Maintenance Outage Analysis of New Brunswick Power Alternatives P2 – P4a – Iroquois T1 or T2 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

New Brunswick Power Alternatives Assessment Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load Interconnected Configuration					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Issues Created by Alternative					
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855				X
Iroquois T2 138/69 kV Transformer Maintenance Outage					
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Voltage Collapse	Iroquois T1 138/69 kV Transformer (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Impact on MPS System Performance: O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain FI = Low Voltage Violations at 138 kV Flo's Inn bus only MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust (A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations T = Thermal Overloads Remain VC = Voltage Collapse Concern Remains (thermal concern not noted) X = Issue Created by Alternative					

Table 8-33 Maintenance Outage Analysis of New Brunswick Power Alternatives P5 – P8 – Iroquois T1 or T2 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

8.9 New Brunswick Power Alternatives Analysis Observations

8.9.1 N-1 Analysis of Interconnected System Configuration

- All eight New Brunswick Power alternatives address the N-1 voltage reliability concerns of the underlying MPS system for single element contingencies.
- All eight New Brunswick Power alternatives address the N-1 voltage reliability concerns of the underlying MPS system with minimal additional requirements for multiple element contingencies.
    - P2 requires a 138 kV 1126-1 series breaker at Beechwood to eliminate voltage collapse for a 1126-1 stuck breaker contingency.
    - P3, P4a, and P6 require the Mullen capacitor banks to switch in-service high speed.
- All eight New Brunswick Power alternatives address the N-1 thermal loading concerns of the Tinker T1 138/69 kV transformer.
- P2 – P6 address the N-1 thermal loading concerns of the 69 kV Line 6901.
    - P7 and P8 report thermal overloads for the section of 69 kV Line 6901 (Tinker – ReEnergy Tap/Interfai) that isn't reconstructed for single and multiple element contingencies.
- P4a requires upgrade of 138 kV Line 1144 to provide adequate thermal capacity for single and multiple element contingencies.

A comparison of New Brunswick Power alternatives N-1 single element contingencies results can be seen below in Table 8-34. A comparison of New Brunswick Power alternatives N-1 multiple element contingencies results can be seen below in Table 8-35.

8.9.2 N-1 Analysis of Radial System Configuration

- In the radial configuration, none of the New Brunswick Power alternatives address the consequential loss of the northern MPS system due to contingencies involving 345 kV Line 3113. For the 2013 load forecast this equates to approximately 23 MW of lost load at winter peak and 20 MW at summer peak. This loss of load is currently within the loss of load criteria.
- All eight New Brunswick Power alternatives address the N-1 voltage reliability concerns of the underlying MPS system for single element contingencies.
- Seven of the eight New Brunswick Power alternatives address the N-1 voltage reliability concerns of the underlying MPS system with minimal additional requirements for multiple element contingencies.
    - P3, which interconnects into 138 kV Beechwood substation, would require a rebuild of the 138 kV Beechwood substation to eliminate any Beechwood stuck breaker or bus fault. These contingencies report voltage collapse for this alternative.
    - P2 requires a 138 kV 1126-1 series breaker at Beechwood to eliminate voltage collapse for a 1126-1 stuck breaker contingency.
    - P5, P6, P7 and P8 require the Mullen capacitor banks to switch in-service high speed.
    - P5 and P8 report low voltage violations at the 138 kV Flo's Inn bus, these could be eliminated by additional reactive support at the 69 kV Flo's Inn bus.
- All eight New Brunswick Power alternatives address the N-1 thermal loading concerns of the Tinker T1 138/69 kV transformer.
- P2 – P6 address the N-1 thermal loading concerns of the 69 kV Line 6901.
    - P7 and P8 report thermal overloads for the section of 69 kV Line 6901 (Tinker – ReEnergy Tap/Interfai) that isn't reconstructed.
- P4, P4a, and P7 require upgrade of 138 kV Line 1144 to provide adequate thermal capacity for single and multiple element contingencies.
- P5 and P6 require upgrade of 69 kV Line 6903 to provide adequate thermal capacity for multiple element contingencies.

A comparison of New Brunswick Power alternatives N-1 single element contingencies results can be seen below in Table 8-34. A comparison of New Brunswick Power alternatives N-1 multiple element contingencies results can be seen below in Table 8-35.

Summary of Alternatives' Impact on Reliability Concerns 2013	New Brunswick Power Interconnections							
	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
N-1 Condition - Single Element Contingencies								
Interconnected Mode								
345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	O	O	O	O	T (6901)	T (6901)
Issues created by Alternatives								
Keswick T4 345/138 kV Transformer				T (1144)				
Radial Mode								
Keswick T4 345/138 kV Transformer	O	O	O	T (1144)	O	O	O	O
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O	O	T (1144)	O	O	O	T (6901/1144)	T (6901/1144)
345 kV Line 3113								

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 8-34 N-1 Single Element Contingencies Results – New Brunswick Power Alternatives Comparison

Summary of Alternatives' Impact on Reliability Concerns 2013	New Brunswick Power Interconnections							
	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
N-1 Condition - Multiple Element Contingencies								
Interconnected Mode								
Contingencies involving 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - LV (F) with UVLS	VC - OK with UVLS	VC - LV (F), T (11442) with UVLS	VC - OK with UVLS	VC - LV (F) with UVLS	VC - OK with UVLS	VC - OK with UVLS
345 kV Keswick K3-3 SB (without UVLS)	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
138 kV Beechwood Stuck Breakers	VC 1126-1 SB only	VC	O	O	O	O	T (6901)	T (6901)
Issues created by Alternatives								
345 kV Keswick K3-2 SB				T (11442)				
345 kV Keswick K3-6 SB				T (11442)				
138 kV Keswick K1125-1139 SB				T (1144)				
Radial Mode								
345 kV Keswick K3-6 SB	O	O	O	T (1144)	O	O	O	O
138 kV Beechwood Stuck Breakers	VC 1126-1 SB only	VC	T (1144)	T (1144)	MC, T (6903)	MC, T (6903)	MC, T (6901/1144)	VC, T (6901)
138 kV Grand Falls 1111-02SB, 138 kV Line 1111	O	O	O	O	FI (A)	O	O	FI (A)
138 kV Keswick K1125-1139 SB	O	O	O	T (1144)	O	O	O	O
Issues created by Alternatives								
345 kV Keswick K3-3 SB				T (1144)				

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 8-35 N-1 Multiple Element Contingencies Results – New Brunswick Power Alternatives Comparison

8.9.3 N-1-1 Analysis of Interconnected System Configuration

The coincident outage of the 138 kV Lines 3855 and 1111 includes outage of the Tinker T1 and Flo's Inn T1 138/69 kV transformers which leaves the MPS system supplied in the north from two 69 kV Lines 88 and 89 at Iroquois and in the south from the new interconnection for alternatives P2 – P6 and P8, P7 does not provide a new interconnection to New Brunswick. The most reliable support is provided by Woodstock to Mullen, P2, followed by Tinker to Flo's Inn with the 1144 Looped in and out of Tinker, P4a and St. Andre to Limestone, P6. Upgrading the 69 kV Line 6901 to 138 kV was the lowest performer, and P3 the Beechwood interconnection would require a substantial rebuild of the 138 kV Beechwood substation. The remaining three alternatives vary between these bracketing alternatives in performance.

- P2, P3, P4a and P6 address all of the MPS reliability needs identified in the N-1-1 Analysis for the coincident outage of 138 kV Lines 3855 and 1111 with minimal additional requirements.
    - P6 requires additional reactive support within MPS.
- P2 requires additional upgrades to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
    - Thermal upgrades are required for 69 kV Lines 88 and 89 for the coincident outage of the 138 Line 1111 and the Keswick T4 345/138 kV transformer.
    - A single element outage, followed by contingencies which remove multiple elements from service, reported minimal additional violations:
        - Voltage collapse for 138 kV Line 1111 out of service and Beechwood 1126-1 stuck breaker.
            - This could be eliminated with a 138 kV 1126-1 series breaker.
        - Voltage collapse for 138 kV Line 1111 out of service and a 138 kV Keswick K1125-1126 stuck breaker.
            - This could be eliminated with a 138 kV K1125/26 series breaker.
        - Low voltages within MPS were reported for the following coincident outages:
            - 138 kV Line 1111 and 345 kV Keswick K3-3 Stuck Breaker.
            - 138 kV Line 1111 and 138 kV Keswick K1125-1139 Stuck Breaker.
                - These could be eliminated with a capacitor within MPS.
- P3 requires an additional upgrade to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
    - Low voltages within MPS were reported for the coincident outage of 138 kV Line 1111 and Keswick T4 345/138 kV transformer.
        - This could be eliminated with additional reactive support within MPS.
    - A single element outage, followed by contingencies which remove multiple elements from service, reported additional violations:
        - Voltage collapse was reported for the following coincident outages:
            - 138 kV Line 1111 and 345 kV Keswick K3-3 stuck breaker.
            - 138 kV Line 1111 and 345 kV Keswick K3-6 stuck breaker.
            - 138 kV Line 1111 and 138 kV Beechwood stuck breakers.
            - 138 kV Line 1111 and 138 kV Keswick K1125-1126stuck breaker.
        - Thermal upgrades are required for 69 kV Lines 88 and 89 for the coincident outage of the 138 Line 1111 and numerous 138 kV Keswick stuck breakers.
        - Low voltages within MPS were reported for the coincident outage of 138 kV Line 1111 and 138 kV Keswick K1125-1139 stuck breaker.
- P4 requires additional upgrades to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
    - Voltage collapse was reported for the following coincident outages:
        - 138 kV Line 1111 and 138 kV Line 3855.
        - 138 kV Line 1111 and Keswick T4 345/138 kV transformer.
    - Low voltages within MPS were reported for numerous coincident outages.

- Thermal upgrade required for 138 kV Line 1144 for the coincident outage of 138 kV Line 3855 and 345 kV Line 3012 with UVLS modeled.
- A single element outage, followed by contingencies which remove multiple elements from service, reported additional violations:
  - Voltage collapse was reported for the following coincident outages:
    - 138 kV Line 1111 and 345 kV Keswick K3-3 stuck breaker.
    - 138 kV Line 1111 and 345 kV Keswick K3-6 stuck breaker.
    - 138 kV Line 1111 and 138 kV Beechwood stuck breakers.
    - 138 kV Line 1111 and 138 kV Keswick K1125-1126stuck breaker.
    - 138 kV Line 3855 and 138 kV Grand Falls 1111-02 stuck breaker.
  - Thermal upgrades are required for 69 kV Lines 88 and 89 for the coincident outage of the 138 Line 1111 and numerous 138 kV Keswick stuck breakers.
  - Thermal upgrade required for 138 kV Line 1144 and the coincident outage of the 138 Line 3855 and numerous stuck breaker contingencies.
  - Low voltages within MPS were reported for the coincident outage of 138 kV Line 1111 and 138 kV Keswick K1125-1139 stuck breaker, as well as 138 kV Line 1111 and 345 kV St. Andre AN3-1 and AN3-2 stuck breakers.

- P4a requires additional upgrades to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
  - Voltage collapse was reported for the 138 kV Line 1111 north out of service and loss of the Keswick T4 345/138 kV transformer.
    - A second Keswick 345/138 kV transformer would be required to eliminate this.
  - Thermal upgrade required for 138 kV Line 1144 for the numerous coincident outages.
  - Low voltages within MPS were reported for the coincident outage of the 138 kV Line 1111 and 345 kV Line 3012 with UVLS modeled.
    - Additional reactive support within MPS could eliminate these low voltages.
  - A single element outage, followed by contingencies which remove multiple elements from service, reported additional violations:
    - Voltage collapse was reported for the following coincident outages:
      - 138 kV Line 1111 south and 345 kV St. Andre AN3-1 and AN3-2 stuck breakers.
      - 138 kV Line 1111 north and numerous 345 kV and 138 kV Keswick stuck breakers.
      - 138 kV Line 1111 and 138 kV Beechwood stuck breakers.
      - 138 kV Line 3855 and 345 kV St. Andre AN3-1 and AN3-2 stuck breakers.
    - Thermal upgrade required for 345 kV Line 3855 for the coincident outage of the 138 kV Line 1111 south and 345 kV St. Andre AN3-1 and 3-2 stuck breakers.

- P5 requires additional upgrades to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
  - Voltage collapse was reported for the 138 kV Line 1111 north out of service and loss of the Keswick T4 345/138 kV transformer.
  - Voltage collapse was reported for the 138 kV Line 3855 out of service and loss of the 69 kV Line 6901.
  - Thermal upgrade required for 69 kV Line 6903 for the coincident outage of 138 kV Line 3855 and 138 kV Line 1111 or 69 kV Line 6901.
  - Thermal upgrade required for 69 kV Line 6901 for the coincident outage of the 138 kV Line 3855 and 69 kV Line 6903.
  - Low voltages within MPS were reported for the numerous coincident outages.
  - A single element outage, followed by contingencies which remove multiple elements from service, reported additional violations:
    - Voltage collapse was reported for the following coincident outages:
      - 138 kV Line 1111 and 138 kV Beechwood stuck breakers.

                - 138 kV Line 3855 and 138 kV Grand Falls 1111-02 stuck breaker.
            - Additional low voltages were reported within MPS for numerous coincident outages.
- P6 requires additional upgrades to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
    - Voltage collapse was reported for the 138 kV Line 3855 out of service and 69 kV Line 6901.
    - Low voltages within MPS were reported for numerous coincident outages.
    - Thermal upgrade required for 69 kV Line 6901 for the coincident outage of 138 kV Line 3855 and 69 kV Line 6903.
    - A single element outage, followed by contingencies which remove multiple elements from service, reported additional violations:
        - Additional low voltages were reported within MPS for numerous coincident outages.
        - Thermal upgrade required of 69 kV Line 88 and 89 for the coincident outage of 138 kV Line 1111 and 138 kV Keswick 1125-39 stuck breaker.
- P7 requires additional upgrades to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
    - Voltage collapse was reported for the following coincident outages:
        - 138 kV Line 3855 out of service and 138 kV Line 1111.
        - 138 kV Line 3855 out of service and 69 kV Line 6901.
        - 138 kV Line 1111 out of service and Keswick T4 345/138 kV transformer.
        - 138 kV Line 3855 out of service and new Fort Fairfield transformer.
    - Low voltages within MPS were reported for the coincident outages of 138 kV Line 1111 and the Mullen capacitor or the 138 kV Line 1125-72.
    - A single element outage, followed by contingencies which remove multiple elements from service, reported additional violations:
        - Voltage collapse was reported for the following coincident outages:
            - 138 kV Line 1111 and 345 kV Keswick K3-3 stuck breaker.
            - 138 kV Line 1111 and 345 kV Keswick K3-6 stuck breaker.
            - 138 kV Line 1111 and 138 kV Beechwood stuck breakers.
            - 138 kV Line 1111 and 138 kV Keswick K1125-1126stuck breaker.
            - 138 kV Line 3855 and 138 kV Grand Falls 1111-02 stuck breaker.
        - Thermal upgrades required for 69 kV Lines 88 and 89 for the coincident outage of 138 kV Line 1111 and numerous Keswick 138 kV stuck breakers.
- P8 requires additional upgrades to meet MPS reliability criteria for a single element outage, followed by single element contingencies:
    - Voltage collapse was reported for the following coincident outages:
        - 138 kV Line 3855 out of service and 138 kV Line 1111.
        - 138 kV Line 3855 out of service and 69 kV Line 6901 south.
    - Low voltages within MPS were reported for the coincident outages of 138 kV Line 1111 and numerous contingencies.
    - A single element outage, followed by contingencies which remove multiple elements from service, reported additional violations:
        - Voltage collapse was reported for the following coincident outages:
            - 138 kV Line 1111 and 345 kV Keswick K3-3 stuck breaker.
            - 138 kV Line 1111 and 345 kV Keswick K3-6 stuck breaker.
            - 138 kV Line 1111 and 138 kV Beechwood stuck breakers.
            - 138 kV Line 1111 and 138 kV Keswick K1125-1126stuck breaker.
            - 138 kV Line 3855 and 138 kV Grand Falls 1111-02 stuck breaker.
        - Thermal upgrades required for 69 kV Lines 88 and 89 for the coincident outage of 138 kV Line 1111 and numerous Keswick 138 kV stuck breakers.

A comparison of New Brunswick Power alternatives N-1-1 single element contingencies (single element outage, followed by a single element contingency) results can be seen below in Table 8-36. A comparison of New Brunswick Power alternatives N-1-1 multiple element contingencies (single element outage, followed by a multiple element contingency) results can be seen below in Table 8-37.

Impact on Reliability Concerns 2013	New Brunswick Power Interconnections							
	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
N-1-1 Condition - Single Element Contingencies								
138 kV Line 3855 & 138 kV Line 1111/1144	O	O	VC	O	VC, T (6903)	MC	VC	VC
138 kV Line 3855 & 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - T (1144) with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
138 kV Line 3855 & Keswick T4 345/138 kV Transformer	O	O	O	T (1144)	O	O	O	O
138 kV Line 3855 & 69 kV Line 6901	O	O	O	O	VC , T (6903)	VC	VC	N - O, S - VC
138 kV Line 3855 & Mullen Shunt	O	O	O	O	O	O	O	O
138 kV Line 1111/1144 & 138 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - FI (A) with UVLS	N & S –VC, N & S - LV (F) with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
138 kV Line 1111/1144 & Keswick T4 345/138 kV Transformer	T (88 & 89)	LV (F & A)	VC	N - VC, S - T (1144)	FI (A)	FI (A)	VC	LV (F & A)
138 kV Line 1111/1144 & 138 kV 1125-72 Line	O	O	FI (A)	O	O	O	FI (A)	FI (A)
138 kV Line 1111/1144 & Mullen Shunt	O	O	LV (A)	O	LV (A)	LV (A)	LV (A)	LV (A)
138 kV Line 1111/1144 & numerous contingencies (base)	O	O	O	O	O	O	O	O
Issues created by Alternatives								
138 kV Line 3855 & 345 kV 3011 Line				T (11442)				
138 kV Line 3855 & 69 kV Line 6903					T (6901)	T (6901)		
138 kV Line 3855 & 69 kV Line 6920					LV (A)	LV (A)		
138 kV Line 3855 & New F. Fairfield Transformer							VC	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 8-36 N-1-1 Single Element Contingencies Results – New Brunswick Power Alternatives Comparison

Impact on Reliability Concerns 2013	New Brunswick Power Interconnections							
	P2	P3	P4	P4a	P5	P6	P7	P8
	Woodstock to Mullen	Beechwood to Flo's Inn	Tinker to Flo's Inn	Tinker to Flo's Inn Looped	Grand Falls to Limestone	St. Andre to Limestone	6901 to 138 kV	Tinker to Fort Fairfield
N-1-1 Condition - Multiple Element Contingencies								
138 kV Line 1111/1144 & Numerous Contingencies	O	O	O	O	O	O	O	O
138 kV Line 1111/1144 & Contingencies that involve 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - LV (F & A) with UVLS	N - LV (F), S - VC, T (3855) with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - LV (F & A) with UVLS	VC - LV (F & A) with UVLS
138 kV Line 1111/1144 & 345 kV Keswick K3-3 SB	LV (F & A), T (88 & 89)	VC	VC	N - VC, S - T (1144)	FI (A)	O	VC	VC
138 kV Line 1111/1144 & 345 kV Keswick 3-6 SB	T (88 & 89)	VC	VC	N - VC, S - T (1144)	FI (A)	FI (A)	VC	VC
138 kV Line 1111/1144 & 138 kV Beechwood Stuck Breakers	VC 1126-1 SB only	VC	VC	N - VC, S - O	VC	MC	VC	VC
138 kV Line 1111/1144 & 138 kV Keswick K1125-1126SB	VC, T (88 & 89)	VC, T (88 & 89)	VC, T (88 & 89)	N - VC, T (88 & 89), S - O	FI (A)	FI (A)	VC, T (88 & 89)	VC, T (88 & 89)
138 kV Line 1111/1144 & 138 kV Keswick K1125-1139 SB	LV (A), T (88 & 89)	LV (F & A), T (88 & 89)	LV (F & A), T (88 & 89)	N - VC, S - T (1144)	FI (A)	FI (A), T (88 & 89)	LV (F & A), T (88 & 89)	LV (F & A), T (88 & 89)
138 kV Line 3855 & 345 kV Keswick K3-3 SB	O	O	O	T (1144)	O	O	O	O
138 kV Line 3855 & 345 kV Keswick K3-6 SB	O	O	O	T (1144)	O	O	O	O
138 kV Line 3855 & Contingencies that involve 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - T (1144) with UVLS	VC - T (11442) with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
138 kV Line 3855 & 138 kV Grand Falls 1111-02 SB	O	O	VC	O	VC	O	VC	VC
Issues created by Alternatives								
138 kV Line 3855 & 345 kV Keswick K3-2 SB				T (11442)				
138 kV Line 3855 & 138 kV Edmundston ED1-1 SB			T (1144)					
138 kV Line 3855 & 138 kV Edmundston ED1-4 SB			T (1144)					
138 kV Line 3855 & 138 kV Keswick K1125-1139 SB				T (1144)				
138 kV Line 3855 & New Tinker-3 SB				LV (A)				

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 8-37 N-1-1 Multiple Element Contingencies Results – New Brunswick Power Alternatives Comparison

8.9.4 Maintenance Outage Analysis of Interconnected System Configuration

- Alternatives P2, P3, P4a, P5 and P6 eliminate the voltage collapse seen in the Needs Assessment for the coincident outage of both Flo's Inn T1 and Tinker T1 138/69 kV transformers.
    - P4, P7 and P8 do not eliminate the voltage collapse.
- Alternatives P2 –P4a eliminate the voltage collapse seen in the Needs Assessment for the coincident outage of the Flo's Inn T1 138/69 kV transformer and the 69 kV Line 6901.
    - P5-P8 do not eliminate this voltage collapse.
- Alternative P7 reports voltage collapse for the coincident outage of the Flo's Inn T1 138/69 kV transformer and the new Fort Fairfield Transformer.
- Alternatives P5 and P6 require additional reactive support within MPS for the coincident outage of the Flo's Inn T1 138/69 kV transformer and either the Mullen or the Houlton capacitor.
- All eight New Brunswick Power alternatives eliminate the Tinker T1 138/69 kV transformer thermal overload seen in the Needs Assessment for the Flo's Inn T1 138/69 kV Transformer out of service.
- Alternatives P5 – P8 require an upgrade of 69 kV Line 6901 to provide adequate thermal capability for numerous coincident outages.
- Alternatives P5 – P7 require an upgrade of 69 kV Line 6903 to provide adequate thermal capability for the coincident outage of Flo's Inn T1 138/69 kV transformer and 69 kV Line 6901.
- Alternative P4a requires an upgrade of 138 kV Line 1144 to provide adequate thermal capability for numerous coincident outages.

A comparison of the Maintenance Outage Analysis results for the New Brunswick Power alternatives can be seen below in Table 8-38 and Table 8-39 below.

Summary of Alternatives' Impact on Reliability Concerns 2013	New Brunswick Power Interconnections							
	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Maintenance Condition								
Flo's Inn T1 & Tinker T1 138/69 kV Transformers	O	O	VC for Loss of 1111	O	O	O	VC, T (6901)	VC, T (6901)
Tinker T1 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - T (6901) with UVLS	VC - T(6901) with UVLS
Iroquois T1 or T2 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Iroquois T1 or T2 & Iroquois T2 or T1 138/69 kV Transformers without UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer & 345 kV Line 3011	O	O	O	T (11442)	O	O	T (6901)	T (6901)
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6901	O	O	O	O	VC, T (6903)	VC, T (6903)	VC, T (6903, 6904)	S - VC
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6903	O	O	O	O	T (6901)	T (6901)	T (6901)	T (6901)
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6904	O	O	O	O	O	O	T (6901)	T (6901)
Flo's Inn T1 138/69 kV Transformer & Mullen/Ashland Shunt	O	O	O	O	LV (A)	LV (A)	O	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at Flo's Inn 138 kV bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 8-38 Maintenance Outage Analysis Results – New Brunswick Power Alternatives Comparison

Summary of Alternatives' Impact on Reliability Concerns 2013	New Brunswick Power Interconnections							
	P2 Woodstock to Mullen	P3 Beechwood to Flo's Inn	P4 Tinker to Flo's Inn	P4a Tinker to Flo's Inn Looped	P5 Grand Falls to Limestone	P6 St. Andre to Limestone	P7 6901 to 138 kV	P8 Tinker to Fort Fairfield
Maintenance Condition								
Issues created by Alternatives								
Flo's Inn T1 138/69 kV Transformer & New Fort Fairfield Transformer							VC	
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6912								T (6901)
Flo's Inn T1 138/69 kV Transformer & Base, Iroquois T1 or T2 138/69 kV Transformers								T (6901)
Tinker T1 or Flo's Inn T1 or Iroquois T1 or Iroquois T2 138/69 kV Transformer & Keswick T4 345/138 kV Transformer				T (1144)				
Iroquois T1 or T2 138/69 kV Transformer & 3855								T (6901)

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at Flo's Inn 138 kV bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 8-39 Maintenance Outage Analysis Results – New Brunswick Power Alternatives Comparison - Issues Created by Alternative

Section 9 Assessment of MPS Generation Alternative

9.1 MPS Generation - Alternative Reinforcement Testing

The Study evaluated additional generation within MPS. Consistent with ISO-NE, NPCC and NERC planning criteria, two generators were modeled, one of which was always assumed out of service. The MPS Generator which was modeled in-service was 30 MW at Ashland Substation.

9.2 MPS Generation - System Configurations

For the Generation Assessment, transmission system configurations were tested with contingency analysis during all lines in-service (N-0 base case and N-1 post-contingency), 138 kV line outage (N-1 base case and N-1-1 post-contingency) and 138/69 kV maintenance outage (N-1 base case and N-1-1 post-contingency) conditions. The following configurations and system conditions were tested:

- All Lines In (N-0) at peak load:
    - Interconnected configuration.
    - Radial configuration.
- Two N-1 outage conditions at peak load (N-1) for the interconnected configuration:
    - 138 kV Line 3855 (Beechwood – Flo's Inn).
    - 138 kV Line 1111 (Beechwood – Grand Falls).
- Four scheduled maintenance configurations at 85% load (N-1) for the interconnected configuration
    - Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855.
    - Tinker T1 138/69 kV Transformer or 138 kV Line 1144.
    - Iroquois T1 138/69 kV Transformer or 138 kV Line 1184.
    - Iroquois T2 138/69 kV Transformer or 138 kV Line 1183.

9.3 MPS Generation - Contingency List Additions and Modifications

Loss of the new generation at Ashland was added to the contingency list.

9.4 MPS Generation - All Lines In (N-0) Analysis

9.4.1 2013 Winter Peak Load Level

9.4.1.1 Interconnected Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

9.4.1.2 Radial Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

9.4.2 2013 Summer Peak Load Level

9.4.2.1 Interconnected Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

9.4.2.2 Radial Configuration

There were no violations of normal voltage or thermal criteria on MPS facilities in the "all-lines-in" base case.

9.5 MPS Generation - N-1 Analysis

N-1 Analysis was performed to examine the impact of MPS Generation on the MPS reliability issues identified in the Needs Assessment. Sensitivity to the radial system configuration was examined for the N-1 Analysis.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC".

9.5.1 2013 Winter Peak Load Level

9.5.1.1 Interconnected Configuration

MPS Generation Assessment N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Winter Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS
Low Voltage Violations	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O
Voltage Collapse	345 kV Keswick K3-3 SB (UVLS not Required)	O
	345 kV St. Andre AN3-1 & AN3-2 SB	VC - OK with UVLS
	138 kV Beechwood SBs & Bus Fault	O
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-1 N-1 Analysis of MPS Generation
2013 Winter Peak Load – Interconnected Configuration

9.5.1.2 Radial Configuration

MPS Generation Assessment N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Winter Peak Load - Radial Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
138 kV Low Voltage Violations	Keswick T4 345/138 kV Transformer	O
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O
138 kV Low Voltage Violations	138 kV Line 1111	O
	345 kV Keswick K3-6 SB	O
Voltage Collapse	138 kV Beechwood SBs & Bus Fault	O
138 kV Low Voltage Violations	138 kV Grand Falls 1111-02 SB	O
	138 kV Keswick K1125-1139 SB	O
Islanding/Consequential Load Loss of Northern MPS	345 kV Line 3113	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-2 N-1 Analysis of MPS Generation
2013 Winter Peak Load – Radial Configuration

9.5.2 2013 Summer Peak Load Level

9.5.2.1 Interconnected Configuration

MPS Generation Assessment N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Summer Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SB	VC - OK with UVLS
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-3 N-1 Analysis of MPS Generation
2013 Summer Peak Load – Interconnected Configuration

9.5.2.2 Radial Configuration

MPS Generation Assessment N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Summer Peak Load - Radial Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	M6 Keene 345 kV-Oak.
Voltage Collapse	138 kV Beechwood SBs & Bus Fault	O
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855, 138 kV Beechwood SBs & Bus Fault	O
69 kV Line 6901 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855, 138 kV Beechwood SBs & Bus Fault	O
Islanding/Consequential Load Loss of Northern MPS	345 kV Line 3113	

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-4 N-1 Analysis of MPS Generation
2013 Summer Peak Load – Radial Configuration

9.6 MPS Generation - N-1-1 Analysis

N-1-1 Analysis was performed to examine the impact of MPS Generation on the MPS reliability issues identified in the Needs Assessment for the following two N-1 outage conditions assuming the interconnected system configuration:

- 138 kV Line 1111 (Beechwood – Grand Falls).
- 138 kV Line 3855 (Beechwood – Flo's Inn).

The complete list of contingencies tested previously for the N-1 Analysis was examined for the N-1-1 Analysis. The tables below however, include discussion of contingencies at the 100 kV level and above.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC".

9.6.1 2013 Winter Peak Load Level

9.6.1.1 Interconnected Configuration

MPS Generation Assessment 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage N-1-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Winter Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
138 kV Low Voltage Violations	Numerous Contingencies	O
Voltage Collapse	Keswick T4 345/138 kV Transformer	FI (A)
	345 kV L/O 3012 (without UVLS)	VC - OK with UVLS
	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	VC
Voltage Collapse	345 kV Keswick K3-3 SB (without UVLS)	FI (A)
	345 kV Keswick K3-6 SB (UVLS not activated)	FI (A)
	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	O
	345 kV St. Andre AN3-2 SB (with UVLS)	VC - FI (A) with UVLS
	138 kV Beechwood SBs & BF	VC
	138 kV Keswick K1125-1126 & K1125-1139 SB	FI (A)
69 kV Line 88 Overload	Keswick T4 345/138 kV Transformer, 345 kV Keswick K3-3 & K 3-6 SB	T
	138 kV Keswick K1125-1126& K1125-1139 SBs	T
69 kV Line 89 Overload	Keswick T4 345/138 kV Transformer, 345 kV Keswick K3-3 & K 3-6 SB	T
	138 kV Keswick K1125-1126& K1125-1139 SBs	T

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-5 N-1-1 Analysis of MPS Generation – 138 kV Line 1111/1144 Outage 2013 Winter Peak Load - Interconnected Configuration

MPS Generation Assessment 138 kV Line 3855/1176 (Beechwood -Flo's Inn) Outage N-1-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Winter Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS
Low Voltage Violations	Keswick T4 345/138 kV Transformer	O
Voltage Collapse	Tinker T1 138/69 kV or 138 kV Line 1111	LV (A)
Low Voltage Violations	345 kV Keswick K3-3 SB (UVLS not activated)	O
	345 kV Keswick K3-6 SB (UVLS not activated)	O
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SBs (with UVLS)	VC - LV (F) with UVLS
	138 kV Grand Falls 1111-02 SB	LV (A)
Low Voltage Violations	138 kV Grand Falls SB & BF that open end 1111	O
Tinker T1 138/69 kV Transformer Overload	Base Case, Numerous Contingencies	O
69 kV Line 88 Overload	345 kV Keswick K3-6 SB, Keswick T4 345/138 kV Transformer	O
Issues Created by Alternative		
69 kV Line 88 Overload	Tinker T1 138/69 kV Transformer or 138 kV Line 1111, 138 kV Grand Falls 1111-02 SB	X
69 kV Line 89 Overload	Tinker T1 138/69 kV Transformer or 138 kV Line 1111, 138 kV Grand Falls 1111-02 SB	X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-6 N-1-1 Analysis of MPS Generation – 138 kV Line 3855/1176 Outage
2013 Winter Peak Load - Interconnected Configuration

9.6.2 2013 Summer Peak Load Level

9.6.2.1 Interconnected Configuration

MPS Generation Assessment 138 kV Line 1111/1144 (Beechwood - Tinker - Grand Falls) Outage N-1-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Summer Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS
	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	LV (A)
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS
	138 kV Beechwood SBs & Bus Fault	LV (A)
69 kV Line 88 Overload	138 kV Keswick K1125-1126SB	O
69 kV Line 89 Overload	138 kV Keswick K1125-1126SB	O
Issues Created by Alternative		
69 kV Line 88 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855, 138 kV Beechwood SBs & Bus Fault	X
69 kV Line 89 Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855, 138 kV Beechwood SBs & Bus Fault	X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-7 N-1-1 Analysis of MPS Generation – 138 kV Line 1111/1144 Outage 2013 Summer Peak Load - Interconnected Configuration

MPS Generation Assessment 138 kV Line 3855/1176 (Beechwood -Flo's Inn) Outage N-1-1 Analysis - Comparison of Alternative Impact on Reliability Issues 2013 Summer Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Low Voltage Violations	Numerous Contingencies	LV (F & A)
Voltage Collapse	345 kV Line 3012 (without UVLS)	VC - OK with UVLS
	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	LV (A)
Voltage Collapse	345 kV St. Andre AN3-1 & AN3-2 SBs (without UVLS)	VC - OK with UVLS
	138 kV Grand Falls 1111-02 SB	LV (A)
Tinker T1 138/69 kV Transformer Overload	Base Case, Numerous Contingencies	O
69 kV Line 6901 Overload	Base Case, Numerous Contingencies	O
Issues Created by Alternative		
69 kV Line 88 Overload	Tinker T1 138/69 kV Transformer or 138 kV Line 1111, 138 kV Grand Falls 1111-02 SB	X
69 kV Line 89 Overload	Tinker T1 138/69 kV Transformer or 138 kV Line 1111, 138 kV Grand Falls 1111-02 SB	X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-8 N-1-1 Analysis of MPS Generation – 138 kV Line 3855/1176 Outage 2013 Summer Peak Load - Interconnected Configuration

9.7 MPS Generation - Maintenance Outage Analysis

Maintenance Outage Analysis was performed to examine the impact of MPS Generation on the MPS reliability issues identified in the Needs Assessment for the following four outage conditions at 85% of peak load, assuming the interconnected system configuration:

- Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855.
- Tinker T1 138/69 kV Transformer or 138 kV Line 1144.
- Iroquois T1 138/69 kV Transformer or 138 kV Line 1184.
- Iroquois T2 138/69 kV Transformer or 138 kV Line 1183.

The following tables illustrate the impact of each alternative on the MPS reliability issues identified in the Needs Assessment. If a particular reliability issue was eliminated due to installation of an alternative, then it was noted with an "O" in the column corresponding to the alternative. If a voltage collapse situation improves to a low voltage condition, then "LV" is entered in the table. If a voltage collapse situation or thermal overload remains, then "VC" or "T" is entered in the table. Reliability issues that arise due to the alternative are noted with an "X".

Low voltages were sometimes specific to the 138 kV Flo's Inn bus, these were denoted with "FI", the Mullen capacitor banks are high speed, when their high speed switching was required to eliminate voltage collapse or low voltages it was noted with "MC".

9.7.1 2013 Winter Peak Load Level

9.7.1.1 Interconnected Configuration

MPS Generation Assessment Tinker T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Voltage Collapse	345 KV Line 3012 (without UVLS)	VC - OK with UVLS
	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O
Issues Created by Alternative		
69 kV Line 88 & 89 Overload	Flo's T1 138/69 kV Transformer and 138 kV Line 3855	X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-9 Maintenance Outage Analysis of Generation – Tinker T1 Outages – 85% of 2013 Winter Peak Load - Interconnected Configuration

MPS Generation Assessment Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Voltage Collapse	345 KV Line 3012 (without UVLS)	VC - OK with UVLS
	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	O
	69 kV Line 6901	O
Tinker T1 138/69 kV Transformer Overload	Base	O
Issues Created by Alternative		
69 kV Line 88 & 89 Overload	Tinker T1 138/69 kV Transformer and 138 kV Line 1111	X

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-10 Maintenance Outage Analysis of Generation – Flo's Inn Outage – 85% of 2013 Winter Peak Load - Interconnected Configuration

MPS Generation Assessment Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Winter Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Voltage Collapse	345 KV Line 3012 (without UVLS)	VC - OK with UVLS
	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O
Iroquois T2 138/69 kV Transformer Maintenance Outage		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Voltage Collapse	345 KV Line 3012 (without UVLS)	VC - OK with UVLS
	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS
Tinker T1 138/69 kV Transformer Overload	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-11 Maintenance Outage Analysis of Generation – Iroquois T1 or T2 Outage – 85% of 2013 Winter Peak Load - Interconnected Configuration

9.7.2 2013 Summer Peak Load Level

9.7.2.1 Interconnected Configuration

MPS Generation Assessment Tinker T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Voltage Collapse	Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-12 Maintenance Outage Analysis of Generation – Tinker T1 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

MPS Generation Assessment Flo's Inn T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Low Voltage Violations	345 kV Line 3011	O
Voltage Collapse	Tinker T1 138/69 kV Transformer or 138 kV Line 1111	O
Low Voltage Violations	69 kV Line 6901	O
	Ashland Shunt	O
	Mullen Shunt	O
Tinker T1 138/69 kV Transformer Overload	Base	O
69 kV Line 6901 Overload	69 kV Lines 6903 & 6904	O
69 kV Line 6904 Overload	69 kV Line 6901	O
69 kV Line 6903 Overload	69 kV Line 6901	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-13 Maintenance Outage Analysis of Generation – Flo's Inn T1 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

MPS Generation Assessment Iroquois T1 138/69 kV Transformer Maintenance Outage N-1 Analysis - Comparison of Alternative Impact on Reliability Issues 85% of 2013 Summer Peak Load - Interconnected Configuration		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Voltage Collapse	Iroquois T2 138/69 kV Transformer (without UVLS)	VC - OK with UVLS
Iroquois T2 138/69 kV Transformer Maintenance Outage		
Reliability Issue Identified in Needs Assessment	N-1 Contingency (Loss of)	Ashland Generation
Voltage Collapse	Iroquois T1 138/69 kV Transformer (without UVLS)	VC - OK with UVLS

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

X = Issue created by Alternative

Table 9-14 Maintenance Outage Analysis of Generation – Iroquois T1 or T2 Outage – 85% of 2013 Summer Peak Load - Interconnected Configuration

9.8 MPS Generation Alternative Analysis Observations

9.8.1 N-1 Analysis of Interconnected System Configuration

- The MPS Generation alternative addresses the N-1 voltage reliability concerns of the underlying MPS system for single and multiple element contingencies.
- The MPS Generation alternative addresses the N-1 thermal loading concerns of the Tinker T1 138/69 kV transformer and 69 kV Line 6901.

The MPS Generation alternative N-1 single element contingencies results can be seen below in Table 9-15. The MPS Generation alternative N-1 multiple element contingencies results can be seen below in Table 9-16.

9.8.2 N-1 Analysis of Radial System Configuration

- In the radial configuration, the MPS Generation alternative does not address the consequential loss of the northern MPS system due to contingencies involving 345 kV Line 3113. For the 2013 load forecast this equates to approximately 22.8 MW of lost load at winter peak and 19.7 MW at summer peak. This loss of load is currently within the loss of load criteria.
- The MPS Generation alternative addresses the N-1 voltage reliability concerns of the underlying MPS system for single and multiple element contingencies.
- The MPS Generation alternative addresses the N-1 thermal loading concerns of the Tinker T1 138/69 kV transformer and 69 kV Line 6901.

The MPS Generation alternative N-1 single element contingencies results can be seen below in Table 9-15. The MPS Generation alternative N-1 multiple element contingencies results can be seen below in Table 9-16.

Summary of Alternatives' Impact on Reliability Concerns 2013	Generation Ashland 30 MW
N-1 Condition - Single Element Contingencies	
Interconnected Mode	
345 kV Line 3012 without UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O
Radial Mode	
Keswick T4 345/138 kV Transformer	O
Flo's Inn T1 138/69 kV Transformer or 138 kV Line 3855	O
345 kV Line 3113	

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 9-15 N-1 Single Element Contingencies Results – MPS Generation Assessment

Summary of Alternatives' Impact on Reliability Concerns 2013	Generation
	Ashland
	30 MW
N-1 Condition - Multiple Element Contingencies	
Interconnected Mode	
Contingencies involving 345 kV Line 3012 without UVLS	VC - OK with UVLS
345 kV Keswick K3-3 SB (without UVLS)	O
138 kV Beechwood Stuck Breakers	O
Radial Mode	
345 kV Keswick K3-6 SB	O
138 kV Beechwood Stuck Breakers	O
138 kV Grand Falls 1111-02SB, 138 kV Line 1111	O
138 kV Keswick K1125-1139 SB	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 9-16 N-1 Multiple Element Contingencies Results – MPS Generation Assessment

9.8.3 N-1-1 Analysis of Interconnected System Configuration

The coincident outage of the 138 kV 3855 and 1111 Lines includes outage of the Tinker T1 and Flo's Inn T1 138/69 kV transformers which leaves the MPS system supplied in the north from two 69 kV Lines 88 and 89 from Iroquois. Adding 30 MW of generation at Ashland Substation is inadequate to support the MPS System.

- The MPS Generation alternative does not address the MPS reliability needs identified in the N-1-1 Analysis of the coincident outage of 138 kV Lines 3855 and 1111.
    - 69 kV Lines 88 and 89 require upgrade to provide adequate thermal capacity.
- The MPS Generation alternative requires additional reactive support at 69 kV Flo's Inn bus for the initial outage of 138 kV Line 1111, and loss of the Keswick T4 345/138 kV transformer or the 69 kV Mullen Capacitor.
- The MPS Generation alternative requires additional reactive support at 69 kV Flo's Inn bus for the initial outage of 138 kV Line 3855, and loss of the kV Mullen Capacitor.
- The MPS Generation alternative reported voltage collapse for the initial outage of the 138 kV Line 1111 and the 138 kV Beechwood bus fault of stuck breaker contingencies.
- The MPS Generation alternative requires additional reactive support at 69 kV Flo's Inn bus to eliminate low voltage reliability issues for numerous multiple element contingencies.

The MPS Generation alternative N-1-1 single element contingencies (single element outage, followed by a single element contingency) results can be seen below in Table 9-17. The MPS Generation alternative N-1-1 multiple element contingencies (single element outage, followed by a multiple element contingency) results can be seen below in Table 9-18.

Summary of Alternatives' Impact on Reliability Concerns 2013	Generation Ashland 30 MW
N-1-1 Condition - Single Element Contingencies	
138 kV Line 3855 & 138 kV Line 1111/1144	VC, T (88 & 89)
138 kV Line 3855 & 345 kV Line 3012 without UVLS	VC - OK with UVLS
138 kV Line 3855 & Keswick T4 345/138 kV Transformer	O
138 kV Line 3855 & 69 kV Line 6901	O
138 kV Line 3855 & Mullen Shunt	LV (A)
138 kV Line 1111/1144 & 138 kV Line 3012 without UVLS	VC - OK with UVLS
138 kV Line 1111/1144 & Keswick T4 345/138 kV Transformer	FI (A)
138 kV Line 1111/1144 & 138 kV Line 1125-72	O
138 kV Line 1111/1144 & Mullen Shunt	LV (A)
138 kV Line 1111/1144 & numerous contingencies (base)	O

Impact on MPS System Performance:
O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated
LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain
FI = Low Voltage Violations at 138 kV Flo's Inn bus only
MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust
(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations
T = Thermal Overloads Remain
VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 9-17 N-1-1 Single Element Contingencies Results – MPS Generation Assessment

Summary of Alternatives' Impact on Reliability Concerns 2013	Generation Ashland 30 MW
N-1-1 Condition - Multiple Element Contingencies	
138 kV Line 1111/1144 & Numerous Contingencies	O
138 kV Line 1111/1144 & Contingencies that involve 345 kV Line 3012 without UVLS	VC - FI (A) with UVLS
138 kV Line 1111/1144 & 345 kV Keswick K3-3 SB	FI (A), T (88 & 89)
138 kV Line 1111/1144 & 345 kV Keswick 3-6 SB	FI (A), T (88 & 89)
138 kV Line 1111/1144 & 138 kV Beechwood Stuck Breakers	VC
138 kV Line 1111/1144 & 138 kV Keswick K1125-1126SB	FI (A), T (88 & 89)
138 kV Line 1111/1144 & 138 kV Keswick K1125-1139 SB	FI (A), T (88 & 89)
138 kV Line 3855 & 345 kV Keswick K3-3 SB	O
138 kV Line 3855 & 345 kV Keswick K3-6 SB	O
138 kV Line 3855 & Contingencies that involve 345 kV Line 3012 without UVLS	VC - LV (F) with UVLS
138 kV Line 3855 & 138 kV Grand Falls 1111-02 SB	LV (A), T (88 & 89)

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 9-18 N-1-1 Multiple Element Contingencies Results – MPS Generation Assessment

9.8.4 Maintenance Outage Analysis of Interconnected System Configuration

- The MPS Generation alternative addresses the Maintenance voltage and thermal reliability concerns of the underlying MPS system for single element contingencies with minimal additional upgrades.
    - 69 kV Lines 88 and 89 require upgrade to provide adequate thermal capacity.

The Maintenance Outage Analysis results for the MPS Generation alternative can be seen below in Table 9-19.

Summary of Alternatives' Impact on Reliability Concerns 2013	Generation Ashland 30 MW
Maintenance Condition	
Flo's Inn T1 & Tinker T1 138/69 kV Transformers	T (88 & 89)
Tinker T1 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - OK with UVLS
Iroquois T1 or T2 138/69 kV Transformer & 345 kV Line 3012 without UVLS	VC - OK with UVLS
Iroquois T1 or T2 & Iroquois T2 or T1 138/69 kV Transformers without UVLS	VC - OK with UVLS
Flo's Inn T1 138/69 kV Transformer & 345 kV Line 3011	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6901	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6903	O
Flo's Inn T1 138/69 kV Transformer & 69 kV Line 6904	O
Flo's Inn T1 138/69 kV Transformer & Mullen/Ashland Shunt	O

Impact on MPS System Performance:

O = Voltage Collapse, Low Voltage and/or Thermal Overloads Eliminated

LV = Voltage Collapse Eliminated but Low Voltage Concerns Remain - OR Low Voltages Remain

FI = Low Voltage Violations at 138 kV Flo's Inn bus only

MC = Requires high speed switching of Mullen Capacitors to eliminate low voltages or voltage collapse before LTC's can adjust

(A) or (F) = Pertain to System Elements Fixed or Adjusting Post Contingency for Voltage Violations

T = Thermal Overloads Remain

VC = Voltage Collapse Concern Remains (thermal concern not noted)

Table 9-19 Maintenance Outage Analysis Results – MPS Generation Assessment

Appendix A – Steady State Base Case Summaries for Needs Assessment

Included in Appendix A:

Appendix A1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix A2: Dispatch 3A - 2013 Winter Radial N-1
Appendix A3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix A4: Dispatch 3A - 2013 Summer Radial N-1
Appendix A5: Dispatch 3B - 2013 Winter Interconnected N-1-1
Appendix A6: Dispatch 3B - 2013 Summer Interconnected N-1-1
Appendix A7: Dispatch 3A - 2013 85% Winter Interconnected Maintenance
Appendix A8: Dispatch 3A - 2013 85% Summer Interconnected Maintenance

Appendix B – Steady State Base Case Draw Files for Needs Assessment

Included in Appendix B:

Appendix B1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix B2: Dispatch 3A - 2013 Winter Radial N-1
Appendix B3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix B4: Dispatch 3A - 2013 Summer Radial N-1
Appendix B5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix B6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix B7: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix B8: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix B9: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix B10: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix B11: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix B12: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix B13: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix B14: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix B15: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix B16: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix C – Steady State Base Case Draw Files for New England Alternatives Assessment

Included in Appendix C:

Appendix C1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix C2: Dispatch 3A - 2013 Winter Radial N-1
Appendix C3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix C4: Dispatch 3A - 2013 Summer Radial N-1
Appendix C5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix C6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix C7: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix C8: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix C9: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix C10: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix C11: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix C12: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix C13: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix C14: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix C15: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix C16: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix D – Steady State Base Case Draw Files for New Brunswick Alternatives Assessment

Included in Appendix D:

Appendix D1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix D2: Dispatch 3A - 2013 Winter Radial N-1
Appendix D3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix D4: Dispatch 3A - 2013 Summer Radial N-1
Appendix D5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix D6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix D7: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix D8: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix D9: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix D10: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix D11: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix D12: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix D13: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix D14: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix D15: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix D16: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix E – Steady State Base Case Draw Files for New Brunswick Power Alternatives Assessment

Included in Appendix E:

Appendix E1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix E2: Dispatch 3A - 2013 Winter Radial N-1
Appendix E3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix E4: Dispatch 3A - 2013 Summer Radial N-1
Appendix E5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix E6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix E7: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix E8: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix E9: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix E10: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix E11: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix E12: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix E13: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix E14: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix E15: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix E16: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix F – Steady State Base Case Draw Files for MPS Generation Alternatives Assessment

Included in Appendix F:

Appendix F1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix F2: Dispatch 3A - 2013 Winter Radial N-1
Appendix F3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix F4: Dispatch 3A - 2013 Summer Radial N-1
Appendix F5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix F6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix F7: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix F8: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix F9: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix F10: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix F11: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix F12: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix F13: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix F14: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix F15: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix F16: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix G – Steady State Voltage Results for Needs Assessment

Included in Appendix G:

Appendix G1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix G2: Dispatch 3A - 2013 Winter Radial N-1
Appendix G3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix G4: Dispatch 3A - 2013 Summer Radial N-1
Appendix G5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix G6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix G7: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix G8: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix G9: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix G10: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix G11: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix G12: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix G13: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix G14: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix G15: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix G16: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix H – Steady State Thermal Results for Needs Assessment

Included in Appendix H:

Appendix H1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix H2: Dispatch 3A - 2013 Winter Radial N-1
Appendix H3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix H4: Dispatch 3A - 2013 Summer Radial N-1
Appendix H5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix H6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix H7: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix H8: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix H9: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix H10: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix H11: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix H12: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix H13: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix H14: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix H15: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix H16: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix I – Steady State Voltage Results for New England Alternatives Assessment

Included in Appendix I:

Appendix I1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix I2: Dispatch 3A - 2013 Winter Radial N-1
Appendix I3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix I4: Dispatch 3A - 2013 Summer Radial N-1
Appendix I5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix I6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix I7: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix I8: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix I9: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix I10: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix I11: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix I12: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix I13: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix I14: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix I15: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix I16: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix J – Steady State Thermal Results for New England Alternatives Assessment

Included in Appendix J:

Appendix J1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix J2: Dispatch 3A - 2013 Winter Radial N-1
Appendix J3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix J4: Dispatch 3A - 2013 Summer Radial N-1
Appendix J5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix J6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix J7: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix J8: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix J9: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix J10: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix J11: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix J12: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix J13: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix J14: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix J15: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix J16: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix K – Steady State Voltage Results for New Brunswick Alternatives Assessment

Included in Appendix K:

Appendix K1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix K2: Dispatch 3A - 2013 Winter Radial N-1
Appendix K3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix K4: Dispatch 3A - 2013 Summer Radial N-1
Appendix K5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix K6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix K7: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111N OOS
Appendix K8: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111S OOS
Appendix K9: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix K10: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix K11: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111N OOS
Appendix K12: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111S OOS
Appendix K13: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix K14: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix K15: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix K16: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix K17: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix K18: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix K19: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix K20: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix L – Steady State Thermal Results for New Brunswick Alternatives Assessment

Included in Appendix L:

Appendix L1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix L2: Dispatch 3A - 2013 Winter Radial N-1
Appendix L3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix L4: Dispatch 3A - 2013 Summer Radial N-1
Appendix L5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix L6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix L7: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111N OOS
Appendix L8: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111S OOS
Appendix L9: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix L10: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix L11: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111N OOS
Appendix L12: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111S OOS
Appendix L13: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix L14: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix L15: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix L16: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix L17: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix L18: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix L19: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix L20: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix M – Steady State Voltage Results for New Brunswick Power Alternatives Assessment

Included in Appendix M:

Appendix M1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix M2: Dispatch 3A - 2013 Winter Radial N-1
Appendix M3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix M4: Dispatch 3A - 2013 Summer Radial N-1
Appendix M5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix M6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix M7: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111N OOS
Appendix M8: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111S OOS
Appendix M9: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix M10: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix M11: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111N OOS
Appendix M12: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111S OOS
Appendix M13: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix M14: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix M15: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix M16: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix M17: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix M18: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix M19: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix M20: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix N – Steady State Thermal Results for New Brunswick Power Alternatives Assessment

Included in Appendix N:

Appendix N1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix N2: Dispatch 3A - 2013 Winter Radial N-1
Appendix N3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix N4: Dispatch 3A - 2013 Summer Radial N-1
Appendix N5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix N6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix N7: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111N OOS
Appendix N8: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111S OOS
Appendix N9: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix N10: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix N11: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111N OOS
Appendix N12: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111S OOS
Appendix N13: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix N14: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix N15: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix N16: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix N17: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix N18: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix N19: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix N20: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix O – Steady State Voltage Results for MPS Generation Alternative Assessment

Included in Appendix O:

Appendix O1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix O2: Dispatch 3A - 2013 Winter Radial N-1
Appendix O3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix O4: Dispatch 3A - 2013 Summer Radial N-1
Appendix O5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix O6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix O7: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix O8: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix O9: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix O10: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix O11: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix O12: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix O13: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix O14: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix O15: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix O16: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS

Appendix P – Steady State Thermal Results for MPS Generation Alternative Assessment

Included in Appendix P:

Appendix P1: Dispatch 3A - 2013 Winter Interconnected N-1
Appendix P2: Dispatch 3A - 2013 Winter Radial N-1
Appendix P3: Dispatch 3A - 2013 Summer Interconnected N-1
Appendix P4: Dispatch 3A - 2013 Summer Radial N-1
Appendix P5: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 1111 OOS
Appendix P6: Dispatch 3B - 2013 Winter Interconnected 138 kV Line 3855 OOS
Appendix P7: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 1111 OOS
Appendix P8: Dispatch 3B - 2013 Summer Interconnected 138 kV Line 3855 OOS
Appendix P9: Dispatch 3A - 2013 85% Winter Interconnected Tinker T1 OOS
Appendix P10: Dispatch 3A - 2013 85% Winter Interconnected Flo's Inn T1 OOS
Appendix P11: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T1 OOS
Appendix P12: Dispatch 3A - 2013 85% Winter Interconnected Iroquois T2 OOS
Appendix P13: Dispatch 3A - 2013 85% Summer Interconnected Tinker T1 OOS
Appendix P14: Dispatch 3A - 2013 85% Summer Interconnected Flo's Inn T1 OOS
Appendix P15: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T1 OOS
Appendix P16: Dispatch 3A - 2013 85% Summer Interconnected Iroquois T2 OOS