

Appendix B: PJM Feasibility Study

***Generation Interconnection
Feasibility Study Report***

For

***PJM Generation Interconnection Request Queue
Position AA1-123***

Highland – Sammis 345kV

February 2015

Updated March 2015

Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

General

The Interconnection Customer (IC) is proposing to install an 1152MW (1105MW Capacity) natural gas facility to be located in Columbia County, OH interconnecting into the ATSI area. This means that the remaining 47MW can be curtailed should a system reliability constraint occur. The IC has proposed in-service date is for December 1, 2020.

This Generation Interconnection Feasibility Study provides analysis results to aid the IC in assessing the practicality and cost of incorporating the facility into the PJM system. This study was limited to load flow analyses of probable contingencies. If the IC elects to pursue a System Impact Study, a more comprehensive analysis will be performed.

Point of Interconnection

AA1-123 will interconnect with the ATSI transmission system at one of two options. Option 1 is to connect at Highland – Sammis 345kV line. Option 2 is to connect at the simultaneous tap of Sammis – Boardman, Toronto – Dobins and Toronto – Nevada 138kV lines.

Option 1

Interconnection Work

To accommodate this interconnection, installing a new three-breaker ring bus substation, along with installing single channel transfer trip transmitters at appropriate existing Shenango and Hoytdale 345kV substations will be required. It will cost **\$11,726,000** (with an extra **\$2,832,100** for a total of **\$14,558,100** if applicable) and will take approximately **33 months** to complete the work. For full cost breakdown, see **Table 1** and **Table 2** below. This cost estimate does not include any costs listed in the Network Upgrades section of this report. This cost estimate also assumes that the Interconnection Customer will provide all right-of-way, permits, easements, etc. that will be needed and that there are no environmental issues with any of the new properties associated with this project, no delays in acquiring the necessary permits for implementing the defined direct/non-direct connection work, and that all system outages will be allowed when requested. The single line is shown below in **Figure 1**.

The IC is required to construct all connection facilities in accordance with the ATSI published standards.

In addition to the FE facilities, Interconnection Customer will also be responsible for meeting all criteria as specified in the applicable sections of the FE "Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of fully rated 345 kV circuit breakers to permit tripping of each entire unit.
2. The purchase and installation of the minimum required FE generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

3. The purchase and installation of supervisory control and data acquisition (SCADA) equipment to provide information in a compatible format to the FE Transmission System Control Center.
4. The establishment of dedicated communication circuits for SCADA to the FE Transmission System Control Center.
5. A compliance with the FE and PJM generator power factor and voltage control requirements.
6. The execution of a back-up service agreement to serve the customer load supplied from the AA1-123 generation project metering point when the units are out-of-service. This assumes the intent of Interconnection Customer is to net the generation with the load.

The above requirements are in addition to any metering or other requirements imposed by PJM.

Below is a list of ATSI protection requirements for AA1-123:

AA1-123 345kV Ring Bus Substation

345kV Transmission Line Protection

- Highland line exit Primary Relaying
New SEL-421-5 directional comparison blocking line relaying operating over power line carrier (PLC) communications.

New Ametek/Pulsar UPLC on/off carrier set for use with directional comparison blocking line relaying.

New CCVT's with carrier accessories in one phase and at least two secondary windings, line tuner and wavetrap for use with PLC relaying and DTT.
- Highland line exit Backup Relaying
New SEL-421 non-pilot direct tripping backup relay.
- Highland line exit Direct Transfer Trip Relaying
New Ametek/Pulsar UPLC carrier set for use as dual channel transmitter in direct transfer trip relaying from AA1-123 Ring Bus to Highland.
- Sammis line exit Primary Relaying
New SEL-411L current differential line operating over direct fiber-optic communications.
- Sammis line exit Backup Relaying
New SEL-411L current differential line operating over direct fiber-optic communications.
- AA1-123 Ring Bus – AA1-123 Plant line exit Primary Relaying
New SEL-411L current differential line operating over direct fiber-optic communications.

- AA1-123 Ring Bus – AA1-123 Plant line exit Backup Relaying
New SEL-411L current differential line operating over direct fiber-optic communications.

345kV AA1-123 Ring Bus – Sammis Transmission Line Communications

- AA1-123 Ring Bus to Sammis
Install two separately routed 1300 nm single mode fiber-optic cable with dedicated fibers for use with SEL-411L primary and SEL-411L backup relaying.

345kV AA1-123 Ring Bus – AA1-123 Plant Transmission Line Communications

- AA1-123 Ring Bus to AA1-123 Plant
Install two separately routed 1300 nm single mode fiber-optic cable with dedicated fibers for use with SEL-411L primary and SEL-411L backup relaying.

345kV Breaker Failure to Trip Protection

- AA1-123 345kV Breaker Failure to Trip Relaying
New SEL-501 breaker failure to trip relaying (1 on each of three 345kV breakers). The breaker failure to trip relaying on each Highland line exit breaker shall initiate direct transfer trip to Highland over power line carrier (UPLC). The breaker failure to trip relaying on each Sammis line exit breaker shall initiate direct transfer trip to Sammis via the SEL-411L primary and backup line relays (fiber). The breaker failure to trip relaying on each AA1-123 Plant line exit breaker shall initiate direct transfer trip to AA1-123 Plant via the SEL-411L primary and backup line relays (fiber).

AA1-123 Plant 345kV

345kV Transmission Line Protection @ AA1-123 Plant

- AA1-123 Ring Bus - AA1-123 Plant line Primary Relaying
New SEL-411L current differential line operating over dedicated fiber-optic communications.
- AA1-123 Ring Bus - AA1-123 Plant line Backup Relaying
New SEL-411L current differential line operating over dedicated fiber-optic communications.

345kV Bus & GSU Transformer Protection @ AA1-123 Plant (minimum protection to meet FE requirements)

- To be determined later.

FE System Modifications

Highland Substation

345kV Transmission Line Protection

- AA1-123 Ring Bus line exit Primary Relaying

New SEL-421-5 directional comparison blocking line relaying operating over power line carrier (PLC) communications.

New Ametek/Pulsar UPLC on/off carrier set for use with directional comparison blocking line relaying.

New line tuner and wavetrap for use with PLC relaying and DTT.

- AA1-123 Ring Bus line exit Backup Relaying
New SEL-421 non-pilot direct tripping backup relay.
- AA1-123 line exit Direct Transfer Trip Relaying
New Ametek/Pulsar UPLC carrier set for use as dual channel transmitter in direct transfer trip relaying from Highland to AA1-123 Ring Bus

345kV Breaker Failure to Trip Protection

- AA1-123 345kV Breaker Failure to Trip Relaying
New SEL-501 breaker failure to trip relaying (1 for each 345kV breaker on the AA1-123 Ring Bus line exit). The breaker failure to trip relaying shall initiate direct transfer trip to AA1-123 Ring Bus over power line carrier (UPLC).

Sammis Substation

345kV Transmission Line Protection

- AA1-123 Ring Bus line exit Primary Relaying
New SEL-411L current differential line operating over direct fiber-optic communications.
- AA1-123 Ring Bus line exit Backup Relaying
New SEL-411L current differential line operating over direct fiber-optic communications.

345kV Breaker Failure to Trip Protection

- AA1-123 345kV Breaker Failure to Trip Relaying
Maintain SEL-352 breaker failure to trip relaying. The breaker failure to trip relaying on each AA1-123 Ring Bus line exit breaker shall be modified to initiate direct transfer trip to AA1-123 Ring Bus via the SEL-411L primary and backup line relays (fiber).

Direct Connection Cost Estimate

The total preliminary cost estimate for Direct Connection work is given in the following tables below.

For ATSI building Direct Connection cost estimates:

Table 1. Direct Connection Cost Estimate			
Description	Total Cost	Tax	Total Cost with Tax
Install a new 345kV three-breaker ring bus substation.	\$8,378,600	\$2,023,500	\$10,402,100
Install a line loop approximately 600 ft in length to new 345kV three-breaker ring bus substation.	\$3,016,600	\$728,600	\$3,745,200
Total	\$11,395,200	\$2,752,100	\$14,147,300

Non-Direct Connection Cost Estimate

The total preliminary cost estimate for Non-Direct Connection work is given in the following tables below:

For ATSI building Direct Connection cost estimates:

Table 2. Non-Direct Connection Cost Estimate			
Description	Total Cost	Tax	Total Cost with Tax
At Highland substation, replace existing line relaying to Sammis with new panel including dual SEL-421s to interconnection substation.	\$184,000	\$44,500	\$228,500
At Sammis substation, replace existing line relaying to Highland with new panel including dual SEL-411s to interconnection substation.	\$146,800	\$35,500	\$182,300
Total	\$330,800	\$80,000	\$410,800

Revenue Metering and SCADA Requirements

For PJM: Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for Interconnection Customer's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

For ATSI: The Interconnection Customer will be required to comply with all FE Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "FirstEnergy Requirements for Transmission Connected Facilities" document located at the following links:

<http://www.firstenergycorp.com/feconnect>

<http://www.pjm.com/planning/design-engineering/to-tech-standards.aspx>

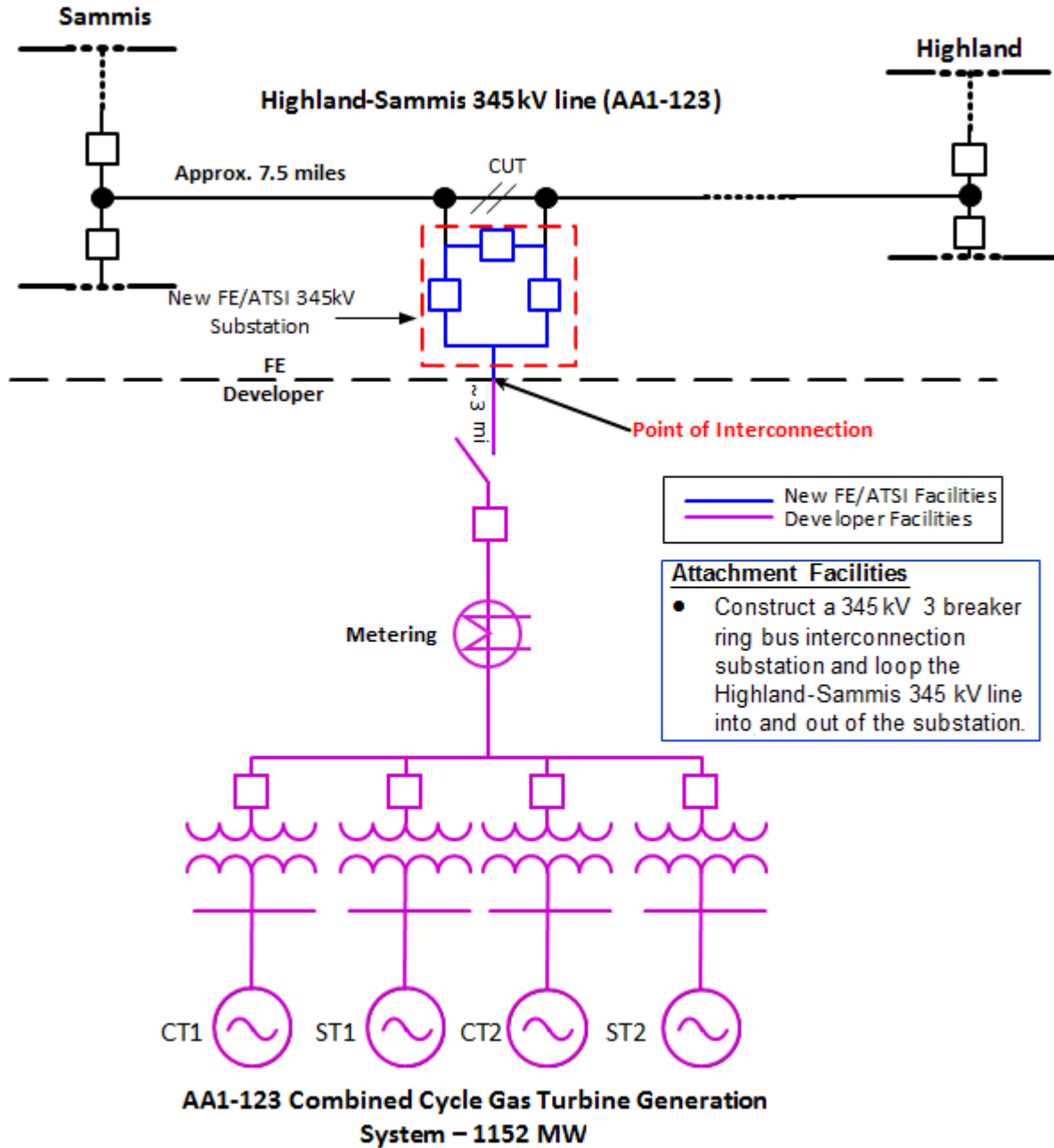


Figure 1. Single Line Diagram

Network Impacts

The Queue Project AA1-123 was studied as an 1152 MW (1105 MW Capacity) injection into the Sammis – Highland 345kV line in the ATSI area. Project AA1-123 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AA1-123 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

No violations were found.

Multiple Facility Contingency

(Double Circuit Tower Line(DCTL), Line with Failed Breaker(LFFB) and Bus Fault(Bus) contingencies for the full energy output)

Item 1a. (FE - FE) The 02HANNA-02JUNIPER 345 kV line (from bus 238781 to bus 238850 ckt 1) loads from 98.1% to 104.91% (**DC power flow**) of its emergency rating (1793 MVA) for the tower line contingency outage of 'C5-TWL-NR065'. This project contributes approximately 122.07 MW to the thermal violation.

```
CONTINGENCY 'C5-TWL-NR065'                                /* HANNA-CHAMBERLIN &
MANSFIELD-NORTHFIELD 345KV
DISCONNECT BRANCH FROM BUS 238615 TO BUS 238781 CKT 1      /*
02CHAMBR 345.00 02HANNA 345.00
DISCONNECT BRANCH FROM BUS 239358 TO BUS 238941 CKT 1      /* 02NFIELD
345.00 02MANSFD 345.00
END
```

Please refer to Appendix 1 for a table containing the generators having contribution to this flowgate.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue.)

Item 2a. (PENELEC - PENELEC) The 26N.MESHPN-26OXBOW 230 kV line (from bus 200706 to bus 200708 ckt 1) loads from 146.29% to 148.58% (**DC power flow**) of its normal rating (478 MVA) for non-contingency condition. This project contributes approximately 24.29 MW to the thermal violation.

Please refer to Appendix 2 for a table containing the generators having contribution to this flowgate.

Item 2b. (AP - AP) The 01BUTLER-01KARNSC 138 kV line (from bus 235152 to bus 235197 ckt 1) loads from 131.29% to 132.05% (**DC power flow**) of its emergency rating

(182 MVA) for the single line contingency outage of 'B_LINE_SY_018'. This project contributes approximately 12.9 MW to the thermal violation.

```
CONTINGENCY 'B_LINE_SY_018'                                /* 3-TERMINAL LINE PERRY-
AT-ERIE W 345 CK 1
  DISCONNECT BRANCH FROM BUS 239036 TO BUS 238547 CKT 1      /* 02PERRY
345.00 02AT 345.00
  DISCONNECT BRANCH FROM BUS 238547 TO BUS 239082 CKT 1      /* 02AT
345.00 02S8-ATT 345.00
  DISCONNECT BRANCH FROM BUS 239082 TO BUS 238544 CKT 8      /* 02S8-ATT
345.00 02ASH_3 138.00
  DISCONNECT BRANCH FROM BUS 238547 TO BUS 200599 CKT 1      /* 02AT
345.00 ERIE W 345.00
END
```

Please refer to Appendix 3 for a table containing the generators having contribution to this flowgate.

Short Circuit

(Summary of impacted circuit breakers)

PJM has completed the short circuit analysis of the AA1-123 queue project **Highland – Sammis 345kV**. One option was considered during this study: the primary option was a tap of the Sammis – Highland 345kV line. PJM analysis found **no new breakers** to be over duty in the ATSI transmission area.

System Reinforcements

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. "Network Impacts", initially caused by the addition of this project generation)

For Item 1a, the overload on the 02HANNA-02JUNIPER 345 kV line can be mitigated by replacing the auxiliary CT with a higher thermal factor. The upgrade is estimated to cost **\$96,800** (with an extra **\$22,100** tax for a total of **\$118,900** if applicable) and take approximately **9 months**.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

For Item 2a, the overload on 26N.MESHPPN-26OXBOW 230 kV line can be mitigated by baselines b2552.1 and b2552.2 will mitigate this overload. Baseline b2552.1 will reconductor the Penelec side of the North Meshoppen – Oxbow – Lackawanna 230kV line and upgrade terminal equipment estimated to be completed by 6/1/19. Baseline b2552.2 will upgrade breaker bay and replace wave trap at Lackawanna 230kV substation on the PPL side of the North Meshoppen –

Oxbow – Lackawanna 230kV line. This facility was overloaded by a prior project within this queue and the upgrade may be shared by multiple projects. No cost allocations for this upgrade will be given at this time due to the baselines. However, if these baselines are cancelled, cost allocations would be required for all projects that show a contribution to these overloads.

For Item 2b, the overload on 01BUTLER-01KARNSC 138 kV line can be mitigated by reconductoring approximately 15.6 miles of the Butler – Karns City 138kV line and replacement of other terminal line equipment. The upgrade is estimated to cost **\$14,365,100** (with an extra **\$4,252,200** in tax for a total of **\$18,617,300** if applicable) and will take approximately **26 months**. For a full cost breakdown by specific upgrade description, please see **Table 3** below. This overload has been caused by a prior project.

Table 3. Butler – Karns City 138kV			
Description	Total Cost	Tax	Total Cost with Tax
At the Karns City 138kV substation, replace line side disconnect risers and connectors and revise relay settings as necessary on the Butler line terminal.	\$14,800	\$4,400	\$19,200
At the Butler 138kV substation, reconductor the Karns City line terminal including wave trap, line and bus side disconnects.	\$86,400	\$25,600	\$112,000
Reconductor approximately 15.6 miles of the Butler – Karns City 138kV line to achieve a 228MVA summer emergency rating.	\$14,263,900	\$4,222,200	\$18,486,100
Total	\$14,365,100	\$4,252,200	\$18,617,300

Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of the surrounding generation. Any potential problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which analyzes all overload conditions associated with the overloaded element(s) identified. As a result of the aggregate energy resources in the area, the following violations were identified:

Item 3a. (AP - AP) The 01BUTLER-01KARNSC 138 kV line (from bus 235152 to bus 235197 ckt 1) loads from 131.27% to 132.01% (**DC power flow**) of its emergency rating (182 MVA) for the single line contingency outage of 'B_LINE_SY_018'. This project contributes approximately 13.44 MW to the thermal violation.

CONTINGENCY 'B_LINE_SY_018'
AT-ERIE W 345 CK 1

/* 3-TERMINAL LINE PERRY-

DISCONNECT BRANCH FROM BUS 239036 TO BUS 238547 CKT 1 /* 02PERRY
345.00 02AT 345.00
DISCONNECT BRANCH FROM BUS 238547 TO BUS 239082 CKT 1 /* 02AT
345.00 02S8-ATT 345.00
DISCONNECT BRANCH FROM BUS 239082 TO BUS 238544 CKT 8 /* 02S8-ATT
345.00 02ASH_3 138.00
DISCONNECT BRANCH FROM BUS 238547 TO BUS 200599 CKT 1 /* 02AT
345.00 ERIE W 345.00
END

Option 2

Revenue Metering and SCADA Requirements

For PJM: Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for Interconnection Customer's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

For ATSI: The Interconnection Customer will be required to comply with all FE Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "FirstEnergy Requirements for Transmission Connected Facilities" document located at the following links:

<http://www.firstenergycorp.com/feconnect>

<http://www.pjm.com/planning/design-engineering/to-tech-standards.aspx>

Network Impacts

The Queue Project AA1-123 was studied as an 1152 MW (1105 MW Capacity) injection as a tap of the Sammis – Boardman, Toronto – Dobins and Toronto – Nevada 138kV lines in the ATSI area. Project AA1-123 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AA1-123 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Analysis - 2018

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

Item 4a. (FE - FE) The 02BORDMN 138/69 kV transformer (from bus 238578 to bus 238577 ckt 2) loads from 61.11% to 153.13% (**DC power flow**) of its emergency rating (81 MVA) for the single line contingency outage of 'B_LIN1_ER_032'. This project contributes approximately 74.53 MW to the thermal violation.

```
CONTINGENCY 'B_LIN1_ER_032'                                /* BOARDMAN-RIVERBEND
138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 239166 CKT 1      /*
02BORDMN 138.00 02WCKLIF 138.00
DISCONNECT BRANCH FROM BUS 239077 TO BUS 239166 CKT 1      /* 02RVERBD
138.00 02WCKLIF 138.00
REDUCE BUS 239166 LOAD BY 100 PERCENT                        /* 02WCKLIF 138.00
DISCONNECT BUS 239166                                        /* 02WCKLIF 138.00
END
```

Please refer to Appendix 4 for a table containing the generators having contribution to this flowgate.

Item 4b. (FE - FE) The 02BORDMN 138/69 kV transformer (from bus 238578 to bus 238577 ckt 2) loads from 46.54% to 138.56% (**DC power flow**) of its emergency rating (81 MVA) for the single line contingency outage of 'B_LINE1_ER_035'. This project contributes approximately 74.53 MW to the thermal violation.

```
CONTINGENCY 'B_LINE1_ER_035'                                /* RIVERBEND-SALT
SPRINGS 138KV
DISCONNECT BRANCH FROM BUS 239120 TO BUS 239077 CKT 1      /* 02SSPRNG
138.00 02RVERBD 138.00
END
```

Item 4c. (FE - FE) The 02DOBINS-02LOWELL 138 kV line (from bus 238664 to bus 238910 ckt 1) loads from 55.91% to 160.99% (**DC power flow**) of its normal rating (141 MVA) for non-contingency condition. This project contributes approximately 148.17 MW to the thermal violation.

Item 4d. (FE - FE) The 02DOBINS-02LOWELL 138 kV line (from bus 238664 to bus 238910 ckt 1) loads from 52.14% to 147.08% (**DC power flow**) of its emergency rating (182 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 172.8 MW to the thermal violation.

```
CONTINGENCY 'B_LINE1_ER_033_B'                              /* BOARDMAN-SAMMIS
138KV
DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1      /* AA1-123
TAP1 138.00 02BORDMN 138.00
END
```

Item 4e. (FE - FE) The 02DOBINS-02LOWELL 138 kV line (from bus 238664 to bus 238910 ckt 1) loads from 49.19% to 139.28% (**DC power flow**) of its emergency rating (182 MVA) for the single line contingency outage of '02BORDMN-02TORONTO_138_A'. This project contributes approximately 163.97 MW to the thermal violation.

```
CONTINGENCY '02BORDMN-02TORONTO_138_A'                      /* LINE
02BORDMN TO 02TORONTO 138
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1      /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BUS 238998                                       /* ISOLATE 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 919014 TO BUS 238998 CKT 1      /* AA1-123
TAP3 138.00 02NEVADA 138.00
END
```

Item 4f. (FE - FE) The 02LNC.PK-02ELWOD+ 138 kV line (from bus 238905 to bus 238696 ckt 1) loads from 20.69% to 100.68% (**DC power flow**) of its emergency rating (155 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 123.98 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_033_B' /* BOARDMAN-SAMMIS
138KV
DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1 /* AA1-123
TAP1 138.00 02BORDMN 138.00
END

Item 4g. (FE - FE) The 02LOWELL-02LNC.PK 138 kV line (from bus 238910 to bus 238905 ckt 1) loads from 49.79% to 132.36% (**DC power flow**) of its emergency rating (155 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 127.98 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_033_B' /* BOARDMAN-SAMMIS
138KV
DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1 /* AA1-123
TAP1 138.00 02BORDMN 138.00
END

Item 4h. (FE - FE) The 02LOWELL-02LNC.PK 138 kV line (from bus 238910 to bus 238905 ckt 1) loads from 46.0% to 128.85% (**DC power flow**) of its emergency rating (155 MVA) for the single line contingency outage of 'B_TRAN1_ER_021'. This project contributes approximately 128.41 MW to the thermal violation.

CONTINGENCY 'B_TRAN1_ER_021' /* LOWELLVILLE 138-69KV
TRANSFORMER NO. 8
DISCONNECT BRANCH FROM BUS 238910 TO BUS 238911 CKT 8 /* 02LOWELL
138.00 02LOWELV 69.00
END

Item 4i. (FE - FE) The 02LOWELL 138/69 kV transformer (from bus 238910 to bus 238911 ckt 8) loads from 67.38% to 223.98% (**DC power flow**) of its emergency rating (42 MVA) for the single line contingency outage of 'B_LINE1_ER_029'. This project contributes approximately 65.77 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_029' /* LINCOLN PARK-
LOWELLVILLE 138KV
DISCONNECT BRANCH FROM BUS 238910 TO BUS 238905 CKT 1 /* 02LOWELL
138.00 02LNC.PK 138.00
END

Please refer to Appendix 5 for a table containing the generators having contribution to this flowgate.

Item 4j. (FE - FE) The 02LOWELL 138/69 kV transformer (from bus 238910 to bus 238911 ckt 8) loads from 39.29% to 188.86% (**DC power flow**) of its emergency rating (42

MVA) for the single line contingency outage of 'B_LINE1_ER_027'. This project contributes approximately 62.82 MW to the thermal violation.

```
CONTINGENCY 'B_LINE1_ER_027'                                /* LINCOLN PARK-MASURY
138KV
DISCONNECT BRANCH FROM BUS 238696 TO BUS 238944 CKT 1      /*
02ELWOD+ 138.00 02MASURY 138.00
DISCONNECT BRANCH FROM BUS 238696 TO BUS 238905 CKT 1      /*
02ELWOD+ 138.00 02LNC.PK 138.00
DISCONNECT BRANCH FROM BUS 238696 TO BUS 238697 CKT 1      /*
02ELWOD+ 138.00 02ELWOOD 138.00
REDUCE BUS 238697 LOAD BY 100 PERCENT                        /* 02ELWOOD 138.00
DISCONNECT BUS 238697                                        /* 02ELWOOD 138.00
END
```

Item 4k. (FE - FE) The 02NEVADA-02BORDMN 138 kV line (from bus 238998 to bus 238578 ckt 1) loads from 51.1% to 161.57% (**DC power flow**) of its emergency rating (165 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 182.28 MW to the thermal violation.

```
CONTINGENCY 'B_LINE1_ER_033_B'                                /* BOARDMAN-SAMMIS
138KV
DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1      /* AA1-123
TAP1 138.00 02BORDMN 138.00
END
```

Please refer to Appendix 6 for a table containing the generators having contribution to this flowgate.

Item 4l. (FE - FE) The 02NEVADA-02BORDMN 138 kV line (from bus 238998 to bus 238578 ckt 1) loads from 33.28% to 126.58% (**DC power flow**) of its normal rating (128 MVA) for non-contingency condition. This project contributes approximately 119.43 MW to the thermal violation.

Item 4m. (FE - FE) The 02NEVADA-02BORDMN 138 kV line (from bus 238998 to bus 238578 ckt 1) loads from 35.27% to 122.12% (**DC power flow**) of its emergency rating (165 MVA) for the single line contingency outage of 'B_LINE1_ER_031_A1'. This project contributes approximately 143.3 MW to the thermal violation.

```
CONTINGENCY 'B_LINE1_ER_031_A1'                                /* LOWELLVILLE-
TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238910 TO BUS 238664 CKT 1      /* 02LOWELL
138.00 02DOBINS 138.00
DISCONNECT BRANCH FROM BUS 919013 TO BUS 238664 CKT 1      /* AA1-123
TAP2 138.00 02DOBINS 138.00
REDUCE BUS 238664 LOAD BY 100 PERCENT                        /* 02DOBINS 138.00
```

DISCONNECT BUS 238664
END

/* 02DOBINS 138.00

Item 4n. (FE - FE) The 02SAMMIS-02HAGAN 138 kV line (from bus 239093 to bus 239372 ckt 1) loads from 61.58% to 102.31% (**DC power flow**) of its emergency rating (189 MVA) for the single line contingency outage of '02SAMMIS-02TORONTO_138'. This project contributes approximately 76.96 MW to the thermal violation.

CONTINGENCY '02SAMMIS-02TORONTO_138' /* LINE 02SAMMIS
TO 02TORONTO 138
DISCONNECT BRANCH FROM BUS 239093 TO BUS 239369 CKT 1 /* 02SAMMIS
138.00 02TORONTO 138.00
END

Please refer to Appendix 7 for a table containing the generators having contribution to this flowgate.

Item 4o. (FE - FE) The 02SAMMIS-02HAGAN 138 kV line (from bus 239093 to bus 239372 ckt 1) loads from 68.48% to 100.3% (**DC power flow**) of its emergency rating (189 MVA) for the single line contingency outage of 'B_LINE1_ER_066'. This project contributes approximately 60.13 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_066' /* PIDGEON-SAMMIS 138KV
DISCONNECT BRANCH FROM BUS 239093 TO BUS 239042 CKT 1 /* 02SAMMIS
138.00 02PIDGON 138.00
END

Item 4p. (FE - FE) The AA1-123 TAP1-02BORDMN 138 kV line (from bus 919010 to bus 238578 ckt 1) loads from 50.07% to 132.24% (**DC power flow**) of its emergency rating (266 MVA) for the single line contingency outage of '02BORDMN-02TORONTO_138_A'. This project contributes approximately 218.57 MW to the thermal violation.

CONTINGENCY '02BORDMN-02TORONTO_138_A' /* LINE
02BORDMN TO 02TORONTO 138
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BUS 238998 /* ISOLATE 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 919014 TO BUS 238998 CKT 1 /* AA1-123
TAP3 138.00 02NEVADA 138.00
END

Item 4q. (FE - FE) The AA1-123 TAP1-02BORDMN 138 kV line (from bus 919010 to bus 238578 ckt 1) loads from 48.15% to 121.84% (**DC power flow**) of its emergency rating (266 MVA) for the single line contingency outage of 'B_LINE1_ER_031_A1'. This project contributes approximately 196.04 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_031_A1' /* LOWELLVILLE-TORONTO 138KV
 DISCONNECT BRANCH FROM BUS 238910 TO BUS 238664 CKT 1 /* 02LOWELL 138.00 02DOBINS 138.00
 DISCONNECT BRANCH FROM BUS 919013 TO BUS 238664 CKT 1 /* AA1-123 TAP2 138.00 02DOBINS 138.00
 REDUCE BUS 238664 LOAD BY 100 PERCENT /* 02DOBINS 138.00
 DISCONNECT BUS 238664 /* 02DOBINS 138.00
 END

Item 4r. (FE - FE) The AA1-123 TAP1-02BORDMN 138 kV line (from bus 919010 to bus 238578 ckt 1) loads from 47.36% to 119.97% (**DC power flow**) of its normal rating (225 MVA) for non-contingency condition. This project contributes approximately 163.36 MW to the thermal violation.

Item 4s. (FE - FE) The AA1-123 TAP3-02NEVADA 138 kV line (from bus 919014 to bus 238998 ckt 1) loads from 62.55% to 158.99% (**DC power flow**) of its emergency rating (189 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 182.28 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_033_B' /* BOARDMAN-SAMMIS 138KV
 DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1 /* AA1-123 TAP1 138.00 02BORDMN 138.00
 END

Please refer to Appendix 8 for a table containing the generators having contribution to this flowgate.

Item 4t. (FE - FE) The AA1-123 TAP3-02NEVADA 138 kV line (from bus 919014 to bus 238998 ckt 1) loads from 48.73% to 124.55% (**DC power flow**) of its emergency rating (189 MVA) for the single line contingency outage of 'B_LINE1_ER_031_A1'. This project contributes approximately 143.3 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_031_A1' /* LOWELLVILLE-TORONTO 138KV
 DISCONNECT BRANCH FROM BUS 238910 TO BUS 238664 CKT 1 /* 02LOWELL 138.00 02DOBINS 138.00
 DISCONNECT BRANCH FROM BUS 919013 TO BUS 238664 CKT 1 /* AA1-123 TAP2 138.00 02DOBINS 138.00
 REDUCE BUS 238664 LOAD BY 100 PERCENT /* 02DOBINS 138.00
 DISCONNECT BUS 238664 /* 02DOBINS 138.00
 END

Multiple Facility Contingency

(Double Circuit Tower Line(DCTL), Line with Failed Breaker(LFFB) and Bus Fault(Bus) contingencies for the full energy output)

Item 5a. (FE - FE) The 02BORDMN-02WCKLIF 138 kV line (from bus 238578 to bus 239166 ckt 1) loads from 28.98% to 112.48% (**DC power flow**) of its emergency rating (249 MVA) for the tower line contingency outage of 'C5-TWL-ER014'. This project contributes approximately 207.91 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER014' /* LINCOLN PARK-
LOWELLVILLE & SHENANGO-BOARDMAN 138KV
DISCONNECT BRANCH FROM BUS 239107 TO BUS 238927 CKT 1 /*
02SHNAGO 138.00 02LTV SL 138.00
DISCONNECT BRANCH FROM BUS 238905 TO BUS 238910 CKT 1 /* 02LNC.PK
138.00 02LOWELL 138.00
END

Please refer to Appendix 9 for a table containing the generators having contribution to this flowgate.

Item 5b. (FE - FE) The 02DOBINS-02LOWELL 138 kV line (from bus 238664 to bus 238910 ckt 1) loads from 63.3% to 212.23% (**DC power flow**) of its emergency rating (182 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 271.05 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Please refer to Appendix 10 for a table containing the generators having contribution to this flowgate.

Item 5c. (FE - FE) The 02DOBINS-02LOWELL 138 kV line (from bus 238664 to bus 238910 ckt 1) loads from 66.37% to 191.02% (**DC power flow**) of its emergency rating (182 MVA) for the tower line contingency outage of 'C5-TWL-ER16A1'. This project contributes approximately 226.85 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A1' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 919014 TO BUS 238998 CKT 1 /* AA1-123
TAP 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Item 5d. (FE - FE) The 02ELWOD+-02MASURY 138 kV line (from bus 238696 to bus 238944 ckt 1) loads from 19.58% to 136.79% (**DC power flow**) of its emergency rating (165 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 193.4 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Please refer to Appendix 11 for a table containing the generators having contribution to this flowgate.

Item 5e. (FE - FE) The 02ELWOD+-02MASURY 138 kV line (from bus 238696 to bus 238944 ckt 1) loads from 22.06% to 120.18% (**DC power flow**) of its emergency rating (165 MVA) for the tower line contingency outage of 'C5-TWL-ER16A1'. This project contributes approximately 161.9 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A1' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 919014 TO BUS 238998 CKT 1 /* AA1-123
TAP 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00

DISCONNECT BUS 240180
END

/* NEVADA 69.00

Item 5f. (FE - FE) The 02HANNA-02JUNIPER 345 kV line (from bus 238781 to bus 238850 ckt 1) loads from 98.1% to 100.34% (**DC power flow**) of its emergency rating (1793 MVA) for the tower line contingency outage of 'C5-TWL-NR065'. This project contributes approximately 88.91 MW to the thermal violation.

CONTINGENCY 'C5-TWL-NR065' /* HANNA-CHAMBERLIN &
MANSFIELD-NORTHFIELD 345KV
DISCONNECT BRANCH FROM BUS 238615 TO BUS 238781 CKT 1 /*
02CHAMBR 345.00 02HANNA 345.00
DISCONNECT BRANCH FROM BUS 239358 TO BUS 238941 CKT 1 /* 02NFIELD
345.00 02MANSFD 345.00
END

Please refer to Appendix 12 for a table containing the generators having contribution to this flowgate.

Item 5g. (FE - FE) The 02LNC.PK-02ELWOD+ 138 kV line (from bus 238905 to bus 238696 ckt 1) loads from 30.32% to 155.1% (**DC power flow**) of its emergency rating (155 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 193.4 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Please refer to Appendix 13 for a table containing the generators having contribution to this flowgate.

Item 5h. (FE - FE) The 02LNC.PK-02ELWOD+ 138 kV line (from bus 238905 to bus 238696 ckt 1) loads from 32.9% to 137.36% (**DC power flow**) of its emergency rating (155 MVA) for the tower line contingency outage of 'C5-TWL-ER16A1'. This project contributes approximately 161.9 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A1' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV

DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 919014 TO BUS 238998 CKT 1 /* AA1-123
TAP 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Item 5i. (FE - FE) The 02LOWELL-02LNC.PK 138 kV line (from bus 238910 to bus 238905 ckt 1) loads from 59.74% to 188.54% (**DC power flow**) of its emergency rating (155 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 199.64 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Please refer to Appendix 14 for a table containing the generators having contribution to this flowgate.

Item 5j. (FE - FE) The 02LOWELL-02LNC.PK 138 kV line (from bus 238910 to bus 238905 ckt 1) loads from 62.39% to 170.21% (**DC power flow**) of its emergency rating (155 MVA) for the tower line contingency outage of 'C5-TWL-ER16A1'. This project contributes approximately 167.12 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A1' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 919014 TO BUS 238998 CKT 1 /* AA1-123
TAP 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Item 5k. (FE - FE) The 02LOWELL 138/69 kV transformer (from bus 238910 to bus 238911 ckt 8) loads from 67.62% to 145.4% (**DC power flow**) of its emergency rating (42 MVA) for the tower line contingency outage of 'C5-TWL-ER014'. This project contributes approximately 72.52 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER014' /* LINCOLN PARK-
LOWELLVILLE & SHENANGO-BOARDMAN 138KV
DISCONNECT BRANCH FROM BUS 239107 TO BUS 238927 CKT 1 /*
02SHNAGO 138.00 02LTV SL 138.00
DISCONNECT BRANCH FROM BUS 238905 TO BUS 238910 CKT 1 /* 02LNC.PK
138.00 02LOWELL 138.00
END

Item 5l. (FE - FE) The 02SAMMIS-02TORONTO 138 kV line (from bus 239093 to bus 239369 ckt 1) loads from 67.48% to 126.49% (**DC power flow**) of its emergency rating (310 MVA) for the tower line contingency outage of 'C5-TWL-ER12B'. This project contributes approximately 182.94 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER12B' /* SAMMIS-02HAGAN &
SAMMIS-PIDGEON 138KV
DISCONNECT BRANCH FROM BUS 239093 TO BUS 239372 CKT 1 /* 02SAMMIS
138.00 02HAGAN 138.00
DISCONNECT BRANCH FROM BUS 239042 TO BUS 239093 CKT 1 /* 02PIDGON
138.00 02SAMMIS 138.00
END

Please refer to Appendix 15 for a table containing the generators having contribution to this flowgate.

Item 5m. (FE - FE) The 02WCKLIF-02RVERBD 138 kV line (from bus 239166 to bus 239077 ckt 1) loads from 21.64% to 114.88% (**DC power flow**) of its emergency rating (223 MVA) for the tower line contingency outage of 'C5-TWL-ER014'. This project contributes approximately 207.91 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER014' /* LINCOLN PARK-
LOWELLVILLE & SHENANGO-BOARDMAN 138KV
DISCONNECT BRANCH FROM BUS 239107 TO BUS 238927 CKT 1 /*
02SHNAGO 138.00 02LTV SL 138.00
DISCONNECT BRANCH FROM BUS 238905 TO BUS 238910 CKT 1 /* 02LNC.PK
138.00 02LOWELL 138.00
END

Please refer to Appendix 16 for a table containing the generators having contribution to this flowgate.

Item 5n. (FE - FE) The AA1-123 TAP1-02BORDMN 138 kV line (from bus 919010 to bus 238578 ckt 1) loads from 34.96% to 162.35% (**DC power flow**) of its emergency rating (266 MVA) for the tower line contingency outage of 'C5-TWL-ER16A3'. This project contributes approximately 338.85 MW to the thermal violation.

```

CONTINGENCY 'C5-TWL-ER16A3'                                /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
  DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1      /*
02BORDMN 138.00 02NEVADA 138.00
  DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1      /*
02TORONTO 138.00 AA1-123 TAP 138.00
  DISCONNECT BRANCH FROM BUS 919010 TO BUS 239093 CKT 1      /* AA1-123
TAP 138.00 02SAMMIS 138.00
  DISCONNECT BUS 238998                                       /* 02NEVADA 138.00
  DISCONNECT BUS 240180                                       /* NEVADA 69.00
END

```

Please refer to Appendix 17 for a table containing the generators having contribution to this flowgate.

Item 5o. (FE - FE) The AA1-123 TAP1-02BORDMN 138 kV line (from bus 919010 to bus 238578 ckt 1) loads from 49.81% to 151.1% (**DC power flow**) of its emergency rating (266 MVA) for the tower line contingency outage of 'C5-TWL-ER028A1'. This project contributes approximately 269.43 MW to the thermal violation.

```

CONTINGENCY 'C5-TWL-ER028A1'                                /* KNOX-SAMMIS &
TORONTO-NEVADA-BOARDMAN 138 KV
  DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1      /*
02BORDMN 138.00 02NEVADA 138.00
  DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1      /*
02TORONTO 138.00 AA1-123 TAP 138.00
  DISCONNECT BUS 238998                                       /* 02NEVADA 138.00
  DISCONNECT BUS 240180                                       /* NEVADA 69.00
  DISCONNECT BRANCH FROM BUS 239093 TO BUS 239372 CKT 1      /* 02SAMMIS
138.00 02HAGAN 138.00
END

```

Item 5p. (FE - FE) The AA1-123 TAP1-02SAMMIS 138 kV line (from bus 919010 to bus 239093 ckt 1) loads from 25.56% to 109.63% (**DC power flow**) of its emergency rating (266 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 359.61 MW to the thermal violation.

```

CONTINGENCY 'C5-TWL-ER16A2'                                /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
  DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1      /*
02BORDMN 138.00 02NEVADA 138.00

```

DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Please refer to Appendix 18 for a table containing the generators having contribution to this flowgate.

Item 5q. (FE - FE) The AA1-123 TAP2-02DOBINS 138 kV line (from bus 919013 to bus 238664 ckt 1) loads from 41.03% to 120.99% (**DC power flow**) of its emergency rating (339 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 271.05 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Please refer to Appendix 19 for a table containing the generators having contribution to this flowgate.

Item 5r. (FE - FE) The AA1-123 TAP2-02DOBINS 138 kV line (from bus 919013 to bus 238664 ckt 1) loads from 42.68% to 109.6% (**DC power flow**) of its emergency rating (339 MVA) for the tower line contingency outage of 'C5-TWL-ER16A1'. This project contributes approximately 226.85 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A1' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 919014 TO BUS 238998 CKT 1 /* AA1-123
TAP 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00

END

Item 5s. (FE - FE) The AA1-123 TAP2-02TORONTO 138 kV line (from bus 919013 to bus 239369 ckt 1) loads from 22.09% to 131.7% (**DC power flow**) of its emergency rating (339 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 521.35 MW to the thermal violation.

```
CONTINGENCY 'C5-TWL-ER16A2'                                /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
  DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1      /*
02BORDMN 138.00 02NEVADA 138.00
  DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1      /*
02TORONTO 138.00 AA1-123 TAP 138.00
  DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1      /*
02BORDMN 138.00 AA1-123 TAP 138.00
  DISCONNECT BUS 238998                                        /* 02NEVADA 138.00
  DISCONNECT BUS 240180                                        /* NEVADA 69.00
END
```

Please refer to Appendix 20 for a table containing the generators having contribution to this flowgate.

Item 5t. (FE - FE) The AA1-123 TAP2-02TORONTO 138 kV line (from bus 919013 to bus 239369 ckt 1) loads from 53.71% to 113.29% (**DC power flow**) of its emergency rating (339 MVA) for the tower line contingency outage of 'C5-TWL-ER16A3'. This project contributes approximately 566.1 MW to the thermal violation.

```
CONTINGENCY 'C5-TWL-ER16A3'                                /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
  DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1      /*
02BORDMN 138.00 02NEVADA 138.00
  DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1      /*
02TORONTO 138.00 AA1-123 TAP 138.00
  DISCONNECT BRANCH FROM BUS 919010 TO BUS 239093 CKT 1      /* AA1-123
TAP 138.00 02SAMMIS 138.00
  DISCONNECT BUS 238998                                        /* 02NEVADA 138.00
  DISCONNECT BUS 240180                                        /* NEVADA 69.00
END
```

Item 5u. (FE - FE) The AA1-123 TAP3-02TORONTO 138 kV line (from bus 919014 to bus 239369 ckt 1) loads from 54.61% to 121.67% (**DC power flow**) of its emergency rating (189 MVA) for the line fault with failed breaker contingency outage of 'C2-BRK-ER144_A'. This project contributes approximately 333.17 MW to the thermal violation.

```
CONTINGENCY 'C2-BRK-ER144_A'                                /* TORONTO BRKR
FAILURE - NEW BKR G
```

DISCONNECT BRANCH FROM BUS 239093 TO BUS 239369 CKT 1 /* 02SAMMIS
 138.00 02TORONTO 138.00
 DISCONNECT BRANCH FROM BUS 919013 TO BUS 239369 CKT 1 /* AA1-123
 TAP 138.00 02TORONTO 138.00
 END

Please refer to Appendix 21 for a table containing the generators having contribution to this flowgate.

Item 5v. (FE - FE) The AA1-123 TAP3-02TORONTO 138 kV line (from bus 919014 to bus 239369 ckt 1) loads from 54.61% to 121.67% (**DC power flow**) of its emergency rating (189 MVA) for the tower line contingency outage of 'C5-TWL-ER027_A'. This project contributes approximately 333.17 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER027_A' /* TORONTO - SAMMIS &
 TORONTO - DOBBINS 138 KV
 DISCONNECT BRANCH FROM BUS 239093 TO BUS 239369 CKT 1 /* 02SAMMIS
 138.00 02TORONTO 138.00
 DISCONNECT BRANCH FROM BUS 919013 TO BUS 239369 CKT 1 /* AA1-123
 TAP 138.00 02TORONTO 138.00
 END

Item 5w. (FE - FE) The AA1-123 TAP3-02TORONTO 138 kV line (from bus 919014 to bus 239369 ckt 1) loads from 16.46% to 116.17% (**DC power flow**) of its emergency rating (189 MVA) for the line fault with failed breaker contingency outage of 'C2-BRK-ER151'. This project contributes approximately 250.65 MW to the thermal violation.

CONTINGENCY 'C2-BRK-ER151' /* BOARDMAN 138KV BKR
 FAILURE B:84
 DISCONNECT BUS 238578 /* 02BORDMN 138.00
 DISCONNECT BUS 238998 /* 02NEVADA 138.00
 DISCONNECT BUS 240180 /* NEVADA 69.00
 END

Item 5x. (FE - FE) The AA1-123 TAP3-02TORONTO 138 kV line (from bus 919014 to bus 239369 ckt 1) loads from 16.93% to 115.65% (**DC power flow**) of its emergency rating (189 MVA) for the tower line contingency outage of 'C5-TWL-ER16A1'. This project contributes approximately 250.58 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A1' /* BOARDMAN-SAMMIS &
 BOARDMAN-NEVADA-TORONTO 138KV
 DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
 02BORDMN 138.00 02NEVADA 138.00
 DISCONNECT BRANCH FROM BUS 919014 TO BUS 238998 CKT 1 /* AA1-123
 TAP 138.00 02NEVADA 138.00

DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
 02BORDMN 138.00 AA1-123 TAP 138.00
 DISCONNECT BUS 238998 /* 02NEVADA 138.00
 DISCONNECT BUS 240180 /* NEVADA 69.00
 END

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue.)

Item 6a. (AP - AP) The 01BUTLER-01KARNSC 138 kV line (from bus 235152 to bus 235197 ckt 1) loads from 131.42% to 132.4% (**DC power flow**) of its emergency rating (182 MVA) for the single line contingency outage of 'B_LINE_SY_017'. This project contributes approximately 14.34 MW to the thermal violation.

CONTINGENCY 'B_LINE_SY_017' /* LINE 02AT TO ERIE W 345
 CK 1
 DISCONNECT BRANCH FROM BUS 238547 TO BUS 200599 CKT 1 /* 02AT
 345.00 ERIE W 345.00
 END

Please refer to Appendix 22 for a table containing the generators having contribution to this flowgate.

Item 6b. (AP - AP) The 01BUTLER-01KARNSC 138 kV line (from bus 235152 to bus 235197 ckt 1) loads from 131.42% to 132.4% (**DC power flow**) of its emergency rating (182 MVA) for the single line contingency outage of 'DQE_163'. This project contributes approximately 14.34 MW to the thermal violation.

CONTINGENCY 'DQE_163' /* LINE ERIE W TO 02PERRY 345
 CK 1
 DISCONNECT BRANCH FROM BUS 238547 TO BUS 239036 CKT 1
 DISCONNECT BRANCH FROM BUS 200599 TO BUS 238547 CKT 1
 END

Short Circuit

(Summary of impacted circuit breakers)

PJM has completed the short circuit analysis of the AA1-123 queue project **Highland – Sammis 345kV**. One option was considered during this study: the secondary option was a tap of the Sammis – Boardman 138kV line, Toronto – Dobbins 138kV line and Toronto – Nevada 138kV line. PJM analysis found **3 new breakers** to be over duty in the ATSI transmission area. The breakers are listed below:

Bus_NO	BUS	BREAKER	Duty % with AA1-123	Duty % without AA1-123	Duty % Difference	Notes
0	BOARDMAN 138 138.kV	101-B-1	109.12%	86.43%	22.69%	New Overduty
0	BOARDMAN 138 138.kV	101-B-82	109.12%	86.43%	22.69%	New Overduty
0	BOARDMAN 138 138.kV	101-B-83	109.12%	86.43%	22.69%	New Overduty

PJM analysis showed a significant fault contribution (i.e. above 3%) to **3 breakers**, which were already identified as over-duty in the ATSI transmission area. The breakers are listed below:

Bus_NO	BUS	BREAKER	Duty % with AA1-123	Duty % without AA1-123	Duty % Difference	Notes
9275	LOWLVILLE138 138.kV	110-B-4	129.25%	108.22%	21.03%	Over 100%, > 3% contribution
9518	WICKLIFFE138 138.kV	144-B-103	115.41%	105.45%	9.97%	Over 100%, > 3% contribution

Should this option be chosen, short circuit mitigations and cost estimates will be provided as a part of the System Impact Study.

System Reinforcements

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. "Network Impacts", initially caused by the addition of this project generation)

Should this option be chosen, mitigations and cost estimates will be provided as a part of the System Impact Study.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

Should this option be chosen, mitigations and cost estimates will be provided as a part of the System Impact Study.

Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of the surrounding generation. Any potential problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which analyzes all overload conditions associated with the overloaded element(s) identified. As a result of the aggregate energy resources in the area, the following violations were identified:

Item 7a. (AP - AP) The 01BUTLER-01KARNSC 138 kV line (from bus 235152 to bus 235197 ckt 1) loads from 131.41% to 132.39% (**DC power flow**) of its emergency rating (182 MVA) for the single line contingency outage of 'DQE_163'. This project contributes approximately 14.95 MW to the thermal violation.

CONTINGENCY 'DQE_163' /* LINE ERIE W TO 02PERRY 345
CK 1
DISCONNECT BRANCH FROM BUS 238547 TO BUS 239036 CKT 1
DISCONNECT BRANCH FROM BUS 200599 TO BUS 238547 CKT 1
END

Item 7b. (FE - FE) The 02BORDMN 138/69 kV transformer (from bus 238578 to bus 238577 ckt 2) loads from 61.11% to 104.33% (**DC power flow**) of its emergency rating (81 MVA) for the single line contingency outage of 'B_LIN1_ER_032'. This project contributes approximately 77.7 MW to the thermal violation.

CONTINGENCY 'B_LIN1_ER_032' /* BOARDMAN-RIVERBEND
138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 239166 CKT 1 /*
02BORDMN 138.00 02WCKLIF 138.00
DISCONNECT BRANCH FROM BUS 239077 TO BUS 239166 CKT 1 /* 02RVERBD
138.00 02WCKLIF 138.00
REDUCE BUS 239166 LOAD BY 100 PERCENT /* 02WCKLIF 138.00
DISCONNECT BUS 239166 /* 02WCKLIF 138.00
END

Item 7c. (FE - FE) The 02DOBINS-02LOWELL 138 kV line (from bus 238664 to bus 238910 ckt 1) loads from 55.25% to 164.8% (**DC power flow**) of its normal rating (141 MVA) for non-contingency condition. This project contributes approximately 154.47 MW to the thermal violation.

Item 7d. (FE - FE) The 02DOBINS-02LOWELL 138 kV line (from bus 238664 to bus 238910 ckt 1) loads from 51.54% to 150.52% (**DC power flow**) of its emergency rating (182 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 180.15 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_033_B' /* BOARDMAN-SAMMIS
138KV
DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1 /* AA1-123
TAP1 138.00 02BORDMN 138.00
END

Item 7e. (FE - FE) The 02LNC.PK-02ELWOD+ 138 kV line (from bus 238905 to bus 238696 ckt 1) loads from 20.65% to 104.04% (**DC power flow**) of its emergency rating (155 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 129.25 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_033_B' /* BOARDMAN-SAMMIS
138KV
DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1 /* AA1-123
TAP1 138.00 02BORDMN 138.00
END

Item 7f. (FE - FE) The 02LOWELL-02LNC.PK 138 kV line (from bus 238910 to bus 238905 ckt 1) loads from 49.74% to 135.82% (**DC power flow**) of its emergency rating (155 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 133.42 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_033_B' /* BOARDMAN-SAMMIS
138KV
DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1 /* AA1-123
TAP1 138.00 02BORDMN 138.00
END

Item 7g. (FE - FE) The 02LOWELL 138/69 kV transformer (from bus 238910 to bus 238911 ckt 8) loads from 67.38% to 140.93% (**DC power flow**) of its emergency rating (42 MVA) for the single line contingency outage of 'B_LINE1_ER_029'. This project contributes approximately 68.57 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_029' /* LINCOLN PARK-
LOWELLVILLE 138KV
DISCONNECT BRANCH FROM BUS 238910 TO BUS 238905 CKT 1 /* 02LOWELL
138.00 02LNC.PK 138.00
END

Item 7h. (FE - FE) The 02NEVADA-02BORDMN 138 kV line (from bus 238998 to bus 238578 ckt 1) loads from 50.42% to 165.6% (**DC power flow**) of its emergency rating (165 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 190.03 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_033_B' /* BOARDMAN-SAMMIS
 138KV
 DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1 /* AA1-123
 TAP1 138.00 02BORDMN 138.00
 END

Item 7i. (FE - FE) The 02NEVADA-02BORDMN 138 kV line (from bus 238998 to bus 238578 ckt 1) loads from 33.28% to 130.55% (**DC power flow**) of its normal rating (128 MVA) for non-contingency condition. This project contributes approximately 124.51 MW to the thermal violation.

Item 7j. (FE - FE) The AA1-123 TAP1-02BORDMN 138 kV line (from bus 919010 to bus 238578 ckt 1) loads from 49.55% to 135.21% (**DC power flow**) of its emergency rating (266 MVA) for the single line contingency outage of '02BORDMN-02TORONTO_138_A'. This project contributes approximately 227.87 MW to the thermal violation.

CONTINGENCY '02BORDMN-02TORONTO_138_A' /* LINE
 02BORDMN TO 02TORONTO 138
 DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
 02BORDMN 138.00 02NEVADA 138.00
 DISCONNECT BUS 238998 /* ISOLATE 02NEVADA 138.00
 DISCONNECT BRANCH FROM BUS 919014 TO BUS 238998 CKT 1 /* AA1-123
 TAP3 138.00 02NEVADA 138.00
 END

Item 7k. (FE - FE) The AA1-123 TAP1-02BORDMN 138 kV line (from bus 919010 to bus 238578 ckt 1) loads from 46.89% to 122.58% (**DC power flow**) of its normal rating (225 MVA) for non-contingency condition. This project contributes approximately 170.31 MW to the thermal violation.

Item 7l. (FE - FE) The AA1-123 TAP3-02NEVADA 138 kV line (from bus 919014 to bus 238998 ckt 1) loads from 61.96% to 162.5% (**DC power flow**) of its emergency rating (189 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 190.03 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_033_B' /* BOARDMAN-SAMMIS
 138KV
 DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1 /* AA1-123
 TAP1 138.00 02BORDMN 138.00
 END

Appendices

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact.

It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

Appendix 1

(FE - FE) The 02HANNA-02JUNIPER 345 kV line (from bus 238781 to bus 238850 ckt 1) loads from 98.1% to 104.91% (**DC power flow**) of its emergency rating (1793 MVA) for the tower line contingency outage of 'C5-TWL-NR065'. This project contributes approximately 122.07 MW to the thermal violation.

CONTINGENCY 'C5-TWL-NR065'
MANSFIELD-NORTHFIELD 345KV

/* HANNA-CHAMBERLIN &

DISCONNECT BRANCH FROM BUS 238615 TO BUS 238781 CKT 1 /*
02CHAMBR 345.00 02HANNA 345.00

DISCONNECT BRANCH FROM BUS 239358 TO BUS 238941 CKT 1 /* 02NFIELD
345.00 02MANSFD 345.00

END

Bus Number	Bus Name	Full Contribution
239297	02CPPW41	-9.43
240213	02-H093	0.72
238965	02MNFDG1	4.03
238966	02MNFDG2	4.03
238967	02MNFDG3	4.03
239214	02NILE-A	0.14
253925	15AES1	9.23
253926	15AES2	2.31
253900	15BVRVL1	4.25
253901	15BVRVL2	4.27
239276	COLLW 11	-7.9
299983	U3-029 C	0.18
299984	U3-029 E	1.11
299988	U3-030 C	0.18
299989	U3-030 E	0.5
LTF	Y3-059	27.13
915951	Y3-092	177.82
915691	Y3-103 C	8.95
915692	Y3-103 E	9.97
917131	Z2-028 OP1	86.73
918321	AA1-044 C	93.41
918322	AA1-044 E	13.96
LTF	AA1-074	16.28
919011	AA1-123 C OP	117.09
919012	AA1-123 E OP	4.98

Appendix 2

(PENELEC - PENELEC) The 26N.MESHPN-26OXBOW 230 kV line (from bus 200706 to bus 200708 ckt 1) loads from 146.29% to 148.58% (**DC power flow**) of its normal rating (478 MVA) for non-contingency condition. This project contributes approximately 24.29 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
200887	26ARMNA MT	0.29
203261	26BLOSSBCT	0.27
200828	26HNSMLK 1	0.18
200829	26HNSMLK 2	0.18
200830	26HNSMLK 3	0.18
200831	26HNSMLK 4	0.18
200832	26HNSMLK 5	0.18
200838	26HOMER C2	2.19
200839	26HOMER C3	2.32
200849	26LAKVU GN	0.02
203283	26MANOR	0.03
200851	26MEHOOP3	1.44
200649	26PENNTech	0.23
200608	26PINEY #1	0.08
200662	26SCRUB GR	0.27
200642	26SENECA#1	1.13
200643	26SENECA#2	1.13
200644	26SENECA#3	0.16
200715	26SHAWVL 1	13.17
200722	26SHAWVL 2	13.38
200665	26SHAWVL 3	19.34
200666	26SHAWVL 4	19.17
294572	P-028 C	0.73
290085	Q-036 C	0.04
290113	Q-063 C	0.09
291011	S-103	0.32
292391	T-121 C	2.54
292078	V1-034	0.16
903643	W3-099 C	1.39
907991	X1-078	24.49
907461	X1-109 C	16.28
LTF	X3-050	28.79
913191	Y1-047	7.97
LTF	Y2-044	23.51
914101	Y2-055	3.45
914121	Y2-060	1.81

915551	Y3-062 C	0.27
915951	Y3-092	67.36
LTF	Z1-019	170.51
916051	Z1-038	7.9
916201	Z1-069 C	2.86
916311	Z1-087	4.53
916351	Z1-091	8.68
916361	Z1-092	7.25
916491	Z1-105	0.87
916541	Z1-110	7.35
917071	Z2-011	7.35
917621	Z2-103	0.52
918221	AA1-037	0.33
918291	AA1-041	5.65
918701	AA1-085 C	1.26
918871	AA1-106	7.35
918921	AA1-111	197.5
919011	AA1-123 C OP	24.29

Appendix 3

(AP - AP) The 01BUTLER-01KARNSC 138 kV line (from bus 235152 to bus 235197 ckt 1) loads from 131.29% to 132.05% (**DC power flow**) of its emergency rating (182 MVA) for the single line contingency outage of 'B_LINE_SY_018'. This project contributes approximately 12.9 MW to the thermal violation.

CONTINGENCY 'B_LINE_SY_018'

/* 3-TERMINAL LINE PERRY-

AT-ERIE W 345 CK 1

DISCONNECT BRANCH FROM BUS 239036 TO BUS 238547 CKT 1 /* 02PERRY
345.00 02AT 345.00

DISCONNECT BRANCH FROM BUS 238547 TO BUS 239082 CKT 1 /* 02AT
345.00 02S8-ATT 345.00

DISCONNECT BRANCH FROM BUS 239082 TO BUS 238544 CKT 8 /* 02S8-ATT
345.00 02ASH_3 138.00

DISCONNECT BRANCH FROM BUS 238547 TO BUS 200599 CKT 1 /* 02AT
345.00 ERIE W 345.00

END

Bus Number	Bus Name	Full Contribution
915951	Y3-092	84.71
917131	Z2-028 OP1	1.51
918321	AA1-044 C	12.47
919011	AA1-123 C OP	12.9

Appendix 4

(FE - FE) The 02BORDMN 138/69 kV transformer (from bus 238578 to bus 238577 ckt 2) loads from 61.11% to 153.13% (**DC power flow**) of its emergency rating (81 MVA) for the single line contingency outage of 'B_LIN1_ER_032'. This project contributes approximately 74.53 MW to the thermal violation.

```
CONTINGENCY 'B_LIN1_ER_032'                                /* BOARDMAN-RIVERBEND
138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 239166 CKT 1      /*
02BORDMN 138.00 02WCKLIF 138.00
DISCONNECT BRANCH FROM BUS 239077 TO BUS 239166 CKT 1      /* 02RVERBD
138.00 02WCKLIF 138.00
REDUCE BUS 239166 LOAD BY 100 PERCENT                        /* 02WCKLIF 138.00
DISCONNECT BUS 239166                                        /* 02WCKLIF 138.00
END
```

Bus Number	Bus Name	Full Contribution
919011	AA1-123 C OP	74.53

Appendix 5

(FE - FE) The 02LOWELL 138/69 kV transformer (from bus 238910 to bus 238911 ckt 8) loads from 67.38% to 223.98% (**DC power flow**) of its emergency rating (42 MVA) for the single line contingency outage of 'B_LINE1_ER_029'. This project contributes approximately 65.77 MW to the thermal violation.

```
CONTINGENCY 'B_LINE1_ER_029'                                /* LINCOLN PARK-
LOWELLVILLE 138KV
DISCONNECT BRANCH FROM BUS 238910 TO BUS 238905 CKT 1      /* 02LOWELL
138.00 02LNC.PK 138.00
END
```

Bus Number	Bus Name	Full Contribution
919011	AA1-123 C OP	65.77

Appendix 6

(FE - FE) The 02NEVADA-02BORDMN 138 kV line (from bus 238998 to bus 238578 ckt 1) loads from 51.1% to 161.57% (**DC power flow**) of its emergency rating (165 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 182.28 MW to the thermal violation.

```
CONTINGENCY 'B_LINE1_ER_033_B'                                /* BOARDMAN-SAMMIS
138KV
DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1      /* AA1-123
TAP1 138.00 02BORDMN 138.00
```

END

Bus Number	Bus Name	Full Contribution
239085	02SAMMG1	0.54
239086	02SAMMG2	0.54
239093	02SAMMIS	0.04
919011	AA1-123 C OP	182.28

Appendix 7

(FE - FE) The 02SAMMIS-02HAGAN 138 kV line (from bus 239093 to bus 239372 ckt 1) loads from 61.58% to 102.31% (**DC power flow**) of its emergency rating (189 MVA) for the single line contingency outage of '02SAMMIS-02TORONTO_138'. This project contributes approximately 76.96 MW to the thermal violation.

CONTINGENCY '02SAMMIS-02TORONTO_138' /* LINE 02SAMMIS
TO 02TORONTO 138
DISCONNECT BRANCH FROM BUS 239093 TO BUS 239369 CKT 1 /* 02SAMMIS
138.00 02TORONTO 138.00
END

Bus Number	Bus Name	Full Contribution
239085	02SAMMG1	2.22
239086	02SAMMG2	2.22
239093	02SAMMIS	0.16
919011	AA1-123 C OP	76.96

Appendix 8

(FE - FE) The AA1-123 TAP3-02NEVADA 138 kV line (from bus 919014 to bus 238998 ckt 1) loads from 62.55% to 158.99% (**DC power flow**) of its emergency rating (189 MVA) for the single line contingency outage of 'B_LINE1_ER_033_B'. This project contributes approximately 182.28 MW to the thermal violation.

CONTINGENCY 'B_LINE1_ER_033_B' /* BOARDMAN-SAMMIS
138KV
DISCONNECT BRANCH FROM BUS 919010 TO BUS 238578 CKT 1 /* AA1-123
TAP1 138.00 02BORDMN 138.00
END

Bus Number	Bus Name	Full Contribution
239085	02SAMMG1	0.54
239086	02SAMMG2	0.54
239093	02SAMMIS	0.04
919011	AA1-123 C OP	182.28

Appendix 9

(FE - FE) The 02BORDMN-02WCKLIF 138 kV line (from bus 238578 to bus 239166 ckt 1) loads from 28.98% to 112.48% (**DC power flow**) of its emergency rating (249 MVA) for the tower line contingency outage of 'C5-TWL-ER014'. This project contributes approximately 207.91 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER014' /* LINCOLN PARK-
LOWELLVILLE & SHENANGO-BOARDMAN 138KV
DISCONNECT BRANCH FROM BUS 239107 TO BUS 238927 CKT 1 /*
02SHNAGO 138.00 02LTV SL 138.00
DISCONNECT BRANCH FROM BUS 238905 TO BUS 238910 CKT 1 /* 02LNC.PK
138.00 02LOWELL 138.00
END

Bus Number	Bus Name	Full Contribution
240213	02-H093	0.43
919011	AA1-123 C OP	199.43
919012	AA1-123 E OP	8.48

Appendix 10

(FE - FE) The 02DOBINS-02LOWELL 138 kV line (from bus 238664 to bus 238910 ckt 1) loads from 63.3% to 212.23% (**DC power flow**) of its emergency rating (182 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 271.05 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Bus Number	Bus Name	Full Contribution
919011	AA1-123 C OP	260.
919012	AA1-123 E OP	11.06

Appendix 11

(FE - FE) The 02ELWOD+-02MASURY 138 kV line (from bus 238696 to bus 238944 ckt 1) loads from 19.58% to 136.79% (**DC power flow**) of its emergency rating (165 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 193.4 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Bus Number	Bus Name	Full Contribution
919011	AA1-123 C OP	185.51
919012	AA1-123 E OP	7.89

Appendix 12

(FE - FE) The 02HANNA-02JUNIPER 345 kV line (from bus 238781 to bus 238850 ckt 1) loads from 98.1% to 100.34% (**DC power flow**) of its emergency rating (1793 MVA) for the tower line contingency outage of 'C5-TWL-NR065'. This project contributes approximately 88.91 MW to the thermal violation.

CONTINGENCY 'C5-TWL-NR065' /* HANNA-CHAMBERLIN &
MANSFIELD-NORTHFIELD 345KV
DISCONNECT BRANCH FROM BUS 238615 TO BUS 238781 CKT 1 /*
02CHAMBR 345.00 02HANNA 345.00
DISCONNECT BRANCH FROM BUS 239358 TO BUS 238941 CKT 1 /* 02NFIELD
345.00 02MANSFD 345.00
END

Bus Number	Bus Name	Full Contribution
239297	02CPPW41	-9.43
240213	02-H093	0.72
238965	02MNFDG1	4.03
238966	02MNFDG2	4.03
238967	02MNFDG3	4.03
239214	02NILE-A	0.14
253925	15AES1	9.23
253926	15AES2	2.31

253900	15BVRVL1	4.25
253901	15BVRVL2	4.27
918321	AA1-044 C	93.39
918322	AA1-044 E	13.96
LTF	AA1-074	16.28
919011	AA1-123 C OP	85.28
919012	AA1-123 E OP	3.63
239276	COLLW 11	-7.9

Appendix 13

(FE - FE) The 02LNC.PK-02ELWOD+ 138 kV line (from bus 238905 to bus 238696 ckt 1) loads from 30.32% to 155.1% (**DC power flow**) of its emergency rating (155 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 193.4 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Bus Number	Bus Name	Full Contribution
919011	AA1-123 C OP	185.51
919012	AA1-123 E OP	7.89

Appendix 14

(FE - FE) The 02LOWELL-02LNC.PK 138 kV line (from bus 238910 to bus 238905 ckt 1) loads from 59.74% to 188.54% (**DC power flow**) of its emergency rating (155 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 199.64 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00

DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Bus Number	Bus Name	Full Contribution
919011	AA1-123 C OP	191.5
919012	AA1-123 E OP	8.15

Appendix 15

(FE - FE) The 02SAMMIS-02TORONTO 138 kV line (from bus 239093 to bus 239369 ckt 1) loads from 67.48% to 126.49% (**DC power flow**) of its emergency rating (310 MVA) for the tower line contingency outage of 'C5-TWL-ER12B'. This project contributes approximately 182.94 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER12B' /* SAMMIS-02HAGAN &
SAMMIS-PIDGEON 138KV
DISCONNECT BRANCH FROM BUS 239093 TO BUS 239372 CKT 1 /* 02SAMMIS
138.00 02HAGAN 138.00
DISCONNECT BRANCH FROM BUS 239042 TO BUS 239093 CKT 1 /* 02PIDGON
138.00 02SAMMIS 138.00
END

Bus Number	Bus Name	Full Contribution
239085	02SAMMG1	6.55
239086	02SAMMG2	6.55
239093	02SAMMIS	0.47
919011	AA1-123 C OP	175.47
919012	AA1-123 E OP	7.46

Appendix 16

(FE - FE) The 02WCKLIF-02RVERBD 138 kV line (from bus 239166 to bus 239077 ckt 1) loads from 21.64% to 114.88% (**DC power flow**) of its emergency rating (223 MVA) for the tower line contingency outage of 'C5-TWL-ER014'. This project contributes approximately 207.91 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER014' /* LINCOLN PARK-
LOWELLVILLE & SHENANGO-BOARDMAN 138KV
DISCONNECT BRANCH FROM BUS 239107 TO BUS 238927 CKT 1 /*
02SHNAGO 138.00 02LTV SL 138.00
DISCONNECT BRANCH FROM BUS 238905 TO BUS 238910 CKT 1 /* 02LNC.PK
138.00 02LOWELL 138.00
END

Bus Number	Bus Name	Full Contribution
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240213	02-H093	0.43
919011	AA1-123 C OP	199.43
919012	AA1-123 E OP	8.48

Appendix 17

(FE - FE) The AA1-123 TAP1-02BORDMN 138 kV line (from bus 919010 to bus 238578 ckt 1) loads from 34.96% to 162.35% (**DC power flow**) of its emergency rating (266 MVA) for the tower line contingency outage of 'C5-TWL-ER16A3'. This project contributes approximately 338.85 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A3' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 919010 TO BUS 239093 CKT 1 /* AA1-123
TAP 138.00 02SAMMIS 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Bus Number	Bus Name	Full Contribution
919011	AA1-123 C OP	325.02
919012	AA1-123 E OP	13.82

Appendix 18

(FE - FE) The AA1-123 TAP1-02SAMMIS 138 kV line (from bus 919010 to bus 239093 ckt 1) loads from 25.56% to 109.63% (**DC power flow**) of its emergency rating (266 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 359.61 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Bus Number	Bus Name	Full Contribution
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919011	AA1-123 C OP	344.94
919012	AA1-123 E OP	14.67

Appendix 19

(FE - FE) The AA1-123 TAP2-02DOBINS 138 kV line (from bus 919013 to bus 238664 ckt 1) loads from 41.03% to 120.99% (**DC power flow**) of its emergency rating (339 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 271.05 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Bus Number	Bus Name	Full Contribution
919011	AA1-123 C OP	260.
919012	AA1-123 E OP	11.06

Appendix 20

(FE - FE) The AA1-123 TAP2-02TORONTO 138 kV line (from bus 919013 to bus 239369 ckt 1) loads from 22.09% to 131.7% (**DC power flow**) of its emergency rating (339 MVA) for the tower line contingency outage of 'C5-TWL-ER16A2'. This project contributes approximately 521.35 MW to the thermal violation.

CONTINGENCY 'C5-TWL-ER16A2' /* BOARDMAN-SAMMIS &
BOARDMAN-NEVADA-TORONTO 138KV
DISCONNECT BRANCH FROM BUS 238578 TO BUS 238998 CKT 1 /*
02BORDMN 138.00 02NEVADA 138.00
DISCONNECT BRANCH FROM BUS 239369 TO BUS 919014 CKT 1 /*
02TORONTO 138.00 AA1-123 TAP 138.00
DISCONNECT BRANCH FROM BUS 238578 TO BUS 919010 CKT 1 /*
02BORDMN 138.00 AA1-123 TAP 138.00
DISCONNECT BUS 238998 /* 02NEVADA 138.00
DISCONNECT BUS 240180 /* NEVADA 69.00
END

Bus Number	Bus Name	Full Contribution
919011	AA1-123 C OP	500.08

919012	AA1-123 E OP	21.27
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Appendix 21

(FE - FE) The AA1-123 TAP3-02TORONTO 138 kV line (from bus 919014 to bus 239369 ckt 1) loads from 54.61% to 121.67% (**DC power flow**) of its emergency rating (189 MVA) for the line fault with failed breaker contingency outage of 'C2-BRK-ER144_A'. This project contributes approximately 333.17 MW to the thermal violation.

CONTINGENCY 'C2-BRK-ER144_A'

/* TORONTO BRKR

FAILURE - NEW BKR G

DISCONNECT BRANCH FROM BUS 239093 TO BUS 239369 CKT 1 /* 02SAMMIS
138.00 02TORONTO 138.00

DISCONNECT BRANCH FROM BUS 919013 TO BUS 239369 CKT 1 /* AA1-123
TAP 138.00 02TORONTO 138.00

END

Bus Number	Bus Name	Full Contribution
240213	02-H093	0.57
239085	02SAMMG1	1.45
239086	02SAMMG2	1.45
239093	02SAMMIS	0.1
919011	AA1-123 C OP	319.58
919012	AA1-123 E OP	13.59

Appendix 22

(AP - AP) The 01BUTLER-01KARNSC 138 kV line (from bus 235152 to bus 235197 ckt 1) loads from 131.42% to 132.4% (**DC power flow**) of its emergency rating (182 MVA) for the single line contingency outage of 'B_LINE_SY_017'. This project contributes approximately 14.34 MW to the thermal violation.

CONTINGENCY 'B_LINE_SY_017'

/* LINE 02AT TO ERIE W 345

CK 1

DISCONNECT BRANCH FROM BUS 238547 TO BUS 200599 CKT 1 /* 02AT
345.00 ERIE W 345.00

END

Bus Number	Bus Name	Full Contribution
918321	AA1-044 C	12.47
919011	AA1-123 C OP	14.34

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