Generation Interconnection
Impact Study Report

For

PJM Generation Interconnection Request
Queue Position AC2-080
Olive – Reynolds (NIPSCO) 345 kV

July 2018

Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. 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. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

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 or merchant transmission upgrade, may also contribute to the need for the same network reinforcement.

The System Impact 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

RES America Developments Inc. proposes to install PJM Project #AC2-080, a 200.0 MW (26.0 MW Capacity) wind generating facility in Pulaski County, Indiana (see Figure 2). The generating facility will consist of 58 Vestas V136 machines. The primary point of interconnection will be to AEP's Olive – Reynolds (NIPSCO) 345 kV circuit #1 (see Figure 1).

The requested in service date is December 31, 2019.

Attachment Facilities

Primary Point of Interconnection (Olive – Reynolds (NIPSCO) 345 kV Circuit #1)

To accommodate the interconnection on the Olive – Reynolds (NIPSCO) 345 kV circuit #1, a new three (3) circuit breaker 345 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus will be constructed (see Figure 1). Installation of associated protection and control equipment, 345 kV line risers, SCADA, and 345 kV revenue metering will also be required. AEP reserves the right to specify the final acceptable configuration considering design practices, future expansion, and compliance requirements.

New Switching Station Work and Cost:

- Construct a new three (3) circuit breaker 345 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus. Installation of associated protection and control equipment, 345 kV line risers, SCADA, and 345 kV revenue metering will also be required (see Figure 1).
    - **Estimated Station Cost: $8,000,000**

Direct Connection Cost Estimate

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

For AEP building Direct Connection cost estimates:

Description	Total Cost
Olive – Reynolds (NIPSCO) 345 kV T-Line Cut In	**$1,200,000**
Total	**$1,200,000**

Table 1

Non-Direct Connection Cost Estimate

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

For AEP building Non-Direct Connection cost estimates:

Description	Estimated Cost
345 kV Revenue Metering	$350,000
Install line protection and controls at the new 345 kV switching station.	$1,250,000
Upgrade line protection and controls at the Olive 345 kV substation.	$350,000
Upgrade line protection and control settings at the Reynolds (NIPSCO) 345 kV substation.	NIPSCO to provide scope and estimate
Total	**$1,950,000**

Table 2

Interconnection Customer Requirements

It is understood that RES Americas is responsible for all costs associated with this interconnection. The cost of RES Americas' generating plant and the costs for the line connecting the generating plant to the point of interconnection are not included in this report; these are assumed to be RES Americas' responsibility.

The Generation Interconnection Agreement does not in or by itself establish a requirement for American Electric Power to provide power for consumption at the Interconnection Customer's facilities. A separate agreement may be reached with the local utility that provides service in the area to ensure that infrastructure is in place to meet this demand and proper metering equipment is installed. It is the responsibility of the Interconnection Customer to contact the local service provider to determine if a local service agreement is required.

Requirement from the PJM Open Access Transmission Tariff:

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the

Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

Revenue Metering and SCADA Requirements

PJM Requirements

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

AEP Requirements

The Interconnection Customer will be required to comply with all AEP Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "Requirements for Connection of New Facilities or Changes to Existing Facilities Connected to the AEP Transmission System" document located at the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-aep/aep-interconnection-requirements.ashx

Network Impacts

The Queue Project AC2-080 was evaluated as a 200.0 MW (Capacity 26.0 MW) injection tapping the Olive – Reynolds 345 kV line in the AEP area. Project AC2-080 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-080 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Base Case Used

Summer Peak Analysis – 2020 Case

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
'6189_C2_05HANG R 765-D1'	CONTINGENCY '6189_C2_05HANG R 765-D1' OPEN BRANCH FROM BUS 242921 TO BUS 242924 CKT 1 / 242921 05CORNU 765 242924 05HANG R 765 1 OPEN BRANCH FROM BUS 242924 TO BUS 243208 CKT 1 / 242924 05HANG R 765 243208 05JEFRSO 765 1 END

Contingency Name	Description
2978_C2_05DUMONT 765-B_A	CONTINGENCY '2978_C2_05DUMONT 765-B_A' OPEN BRANCH FROM BUS 243206 TO BUS 920251 CKT 1 / 243206 05DUMONT 765 920251 X1-020 TAP 765 1 OPEN BRANCH FROM BUS 243206 TO BUS 270644 CKT 1 / 243206 05DUMONT 765 270644 WILTON ; 765 1 END
112-65-BT4-5__	CONTINGENCY '112-65-BT4-5__' TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765 TRIP BRANCH FROM BUS 275233 TO BUS 270644 CKT 1 / WILTO;4M 345 WILTO; 765 TRIP BRANCH FROM BUS 275233 TO BUS 270927 CKT 1 / WILTO;4M 345 WILTO; R 345 TRIP BRANCH FROM BUS 275233 TO BUS 275333 CKT 1 / WILTO;4M 345 WILTO;4C 33 END
112-65-BT3-4__	CONTINGENCY '112-65-BT3-4__' TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765 TRIP BRANCH FROM BUS 275232 TO BUS 270644 CKT 1 / WILTO;3M 345 WILTO; 765 TRIP BRANCH FROM BUS 275232 TO BUS 270926 CKT 1 / WILTO;3M 345 WILTO; B 345 TRIP BRANCH FROM BUS 275232 TO BUS 275332 CKT 1 / WILTO;3M 345 WILTO;3C 33 END
8649_B2_TOR546	CONTINGENCY '8649_B2_TOR546' OPEN BRANCH FROM BUS 242924 TO BUS 243208 CKT 1 / 242924 05HANG R 765 243208 05JEFRSO 765 1 END
695_B2	CONTINGENCY '695_B2' OPEN BRANCH FROM BUS 243206 TO BUS 270644 CKT 1 / 243206 05DUMONT 765 270644 WILTO; 765 1 END

Contingency Name	Description
'7441_B2_TOR100545_A'	CONTINGENCY '7441_B2_TOR100545_A' OPEN BRANCH FROM BUS 242928 TO BUS 926650 CKT 1 / 242928 05MARYSV 765 246999 05SORENS 765 1 END

Table 3

Summer Peak Analysis - 2020

Generator Deliverability

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

None

Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

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)

AC2-080 Contribution to Previously Identified Overloads												
	Contingency				Bus		Loading		Rating			
#	Type	Name	Affected Area	Facility Description	From	To	Initial	Final	Type	MVA	MW Con.	FG App.
1	LFFB	'6189_C2_05HANG R 765-D1'	AEP-OVEC	05JEFRSO-06CLIFTY 345 kV line	242865	248000	106.35	106.75	ER	2045	29.17	1
2	LFFB	2978_C2_05DUMONT 765-B_A	AEP - AEP	X2-052 TAP-05DUMONT 345 kV line	247610	243219	117.07	118.64	ER	1409	27.35	2
3	LFFB	112-65-BT4-5__	AEP - AEP	X2-052 TAP-05DUMONT 345 kV line	247610	243219	109.44	109.94	ER	1409	23.08	
4	LFFB	112-65-BT3-4__	AEP - AEP	X2-052 TAP-05DUMONT 345 kV line	247610	243219	109.44	109.93	ER	1409	23.08	

Table 4

Steady-State Voltage Requirements

(Results of the steady-state voltage studies should be inserted here)

None

Short Circuit
(Summary of impacted circuit breakers)

None

Stability and Reactive Power Requirement
(Results of the dynamic studies should be inserted here)

No problems identified

Affected System Analysis & Mitigation

LGEE Impacts:

None

MISO Impacts:

RES America Developments Inc. will need to enter into a MISO Agreement to implement any relay setting changes at Reynolds (NIPSCO) Substation

Duke, Progress & TVA Impacts:

None

OVEC Impacts:

Baseline upgrade B2878 to replace Clifty riser(s) which will raise the SE rating to 2354 MVA. AC2-080 does not have any cost responsibility. AC2-080 may need this baseline upgrade in-service to be deliverable to the PJM system. If AC2-080 comes into service prior to completion of B2878, AC2-080 may need an interim study.

Delivery of Energy Portion of Interconnection Request

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

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 will study all overload conditions associated with the overloaded element(s) identified.

AC2-080 Delivery of Energy Portion of Interconnection Request												
	Contingency				Bus		Loading		Rating			FG
#	Type	Name	Affected Area	Facility Description	From	To	Initial	Final	Type	MVA	MW Con.	App.
1	N-1	8649_B2_TOR546	AEP - OVEC	05JEFRSO-06CLIFTY 345 kV line	242865	248000	122.75	122.72	ER	1756	29.2	
2	N-1	8649_B2_TOR546	AEP - AEP	05SORENS-AC1-225 TAP 765 kV line	246999	928360	100.74	100.79	NR	1409	51.32	
3	N-1	'695_B2'	AEP - AEP	X2-052 TAP-05DUMONT 345 kV line	247610	243219	109.36	109.86	NR	1409	23.09	

Table 5

Summer Peak Load Flow Analysis Reinforcements

New System Reinforcements

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

None

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)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

1. To relieve the Jefferson – Clifty 345 kV line:
   The Jefferson end SE rating is 2354 MVA and is sufficient.

   The Clifty end SE rating is 2045 MVA. There is a planned 2018 baseline upgrade B2878 to replace Clifty riser(s) which will raise the SE rating to 2354 MVA.

   AC2-080 does not have any cost responsibility. AC2-080 may need this baseline upgrade in-service to be deliverable to the PJM system. If AC2-080 comes into service prior to completion of B2878, AC2-080 may need an interim study.

2. To relieve the X2-052 Tap - Dumont 345 kV line:

   Sag study results show that line remediation work will include the replacement of tower 20 with a custom steel pole and the removal of swing angle brackets on 2 structures. Cost estimate is $1.0775M. New SE rating to be 1868 MVA. PJM Network Upgrade N4512.

   This upgrade is driven by a prior queue. Per PJM cost allocation rules, AC2-080 presently does not receive cost allocation for this upgrade. Note: as changes to the interconnection process occur, such as prior queued projects withdrawing from the queue, AC2-080 could receive cost allocation.

   AC2-080 may need this network upgrade in-service to be deliverable to the PJM system. If AC2-080 comes into service prior to completion of this network upgrade, AC2-080 may need an interim study.

Light Load Analysis - 2020

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

None

Multiple Facility Contingency
(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

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)

1. (AEP - AEP) The 05MADDOX-05E LIMA 345 kV line (from bus 246929 to bus 242935 ckt 1) loads from 106.14% to 107.46% (AC power flow) of its normal rating (897 MVA) for the single line contingency outage of '7441_B2_TOR100545_A'. This project contributes approximately 11.82 MW to the thermal violation.

CONTINGENCY '7441_B2_TOR100545_A'
OPEN BRANCH FROM BUS 242928 TO BUS 926650 CKT 1 / 242928 05MARYSV 765 246999 05SORENS 765 1
END

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

Light Load Load Flow Analysis Reinforcements

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

None

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)

(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

1. **To relieve the Maddox – E. Lima 345 kV line overload:**

   Reinforcement: Existing baseline upgrades B2833 and B2969. Re-conductor the Maddox – E Lima 345 kV line. Replace terminal equipment at Maddox -E Lima 345 kV circuit.
   New Ratings upon completion: 2433/2653 (SN/SE)
   In-service date: 2022

   Project AC2-080 will need the baseline upgrades in order to be deliverable. It will be determined during the Facilities Study Phase whether the baseline upgrades B2833 and B2969 can be advanced to 2020.

   Cost Estimate: The cost for advancement of the baseline upgrades B2833 and B2969 will be determined in the Facilities Study Phase.

Contribution to Previously Identified System Reinforcements (All)

(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)

(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

#	Overloaded Facility	Upgrade Description	Schedule	Estimated Cost
#1	**JEFERSON-CLIFTY 345 kV line (Summer Peak Load Flow Reinforcement)**	Baseline upgrade B2878 (replace Clifty Creek Line risers) will raise AEP end ratings to 2354/2354 MVA SN/SE	Projected ISD: 12/31/2018	N/A
#2	**X2-052 TAP-DUMONT 345 kV line (Summer Peak Load Flow Reinforcement)**	The following work determined during the sag study will be required to resolve the X2-052 Tap – Dumont 345 kV line overload: Replace tower 20 with a custom steel pole and the removal of swing angle brackets on 2 structures (PJM Network Upgrade N4512). New SE rating to be 1868 MVA. This overload is caused by the AB1 Queue.	Projected ISD: 04/29/2018	N/A
#3	**The MADDOX-E. LIMA 345 kV line (Light Load Reinforcement)**	Baseline upgrade B2833 to re-conductor the 30.2 mile section of Maddox creek – East Lima 345 kV line. New ratings after the baseline upgrade : 2433/2653 (SN/SE)	Projected ISD: 12/01/2021	N/A

Table 8

Schedule

It is anticipated that the time between receipt of executed agreements and Commercial Operation may range from 12 to 18 months if no line work is required. If line work is required, construction time would be between 24 to 36 months after signing an interconnection agreement. This schedule does not take into account the identified baseline upgrades in this report.

Note: The time provided between anticipated normal completion of System Impact, Facilities Studies, subsequent execution of ISA and ICSA documents, and the proposed Backfeed Date is shorter than usual and may be difficult to achieve.

Conclusion

Based upon the results of this Impact Study, the construction of the 200.0 MW (26.0 MW Capacity) wind generating facility of RES Americas (PJM Project #AC2-080) will require the following additional interconnection charges. This plan of service will interconnect the proposed wind generating facility in a manner that will provide operational reliability and flexibility to both the AEP system and the RES Americas generating facility.

Cost Breakdown for Point of Interconnection (Olive-Reynolds 345 kV)			
Network Upgrade Type	**Network Upgrade Number**	**Description**	**Estimated Cost**
Attachment	**n5735**	New 345 kV Switching Station with protection and controls	$9,250,000
Non-Direct Connection Network Upgrade	**n5736**	Olive – Reynolds (NIPSCO) 345 kV T-Line Cut In	$1,200,000
	n5737	345 kV Revenue Metering	$350,000
	n5738	Upgrade line protection and controls at the Olive 345 kV substation.	$350,000
		Total	**$11,150,000**

Table 8

The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements.

Figure 1: Point of Interconnection (Olive – Reynolds (NIPSCO) 345 kV Circuit #1)

Single-Line Diagram

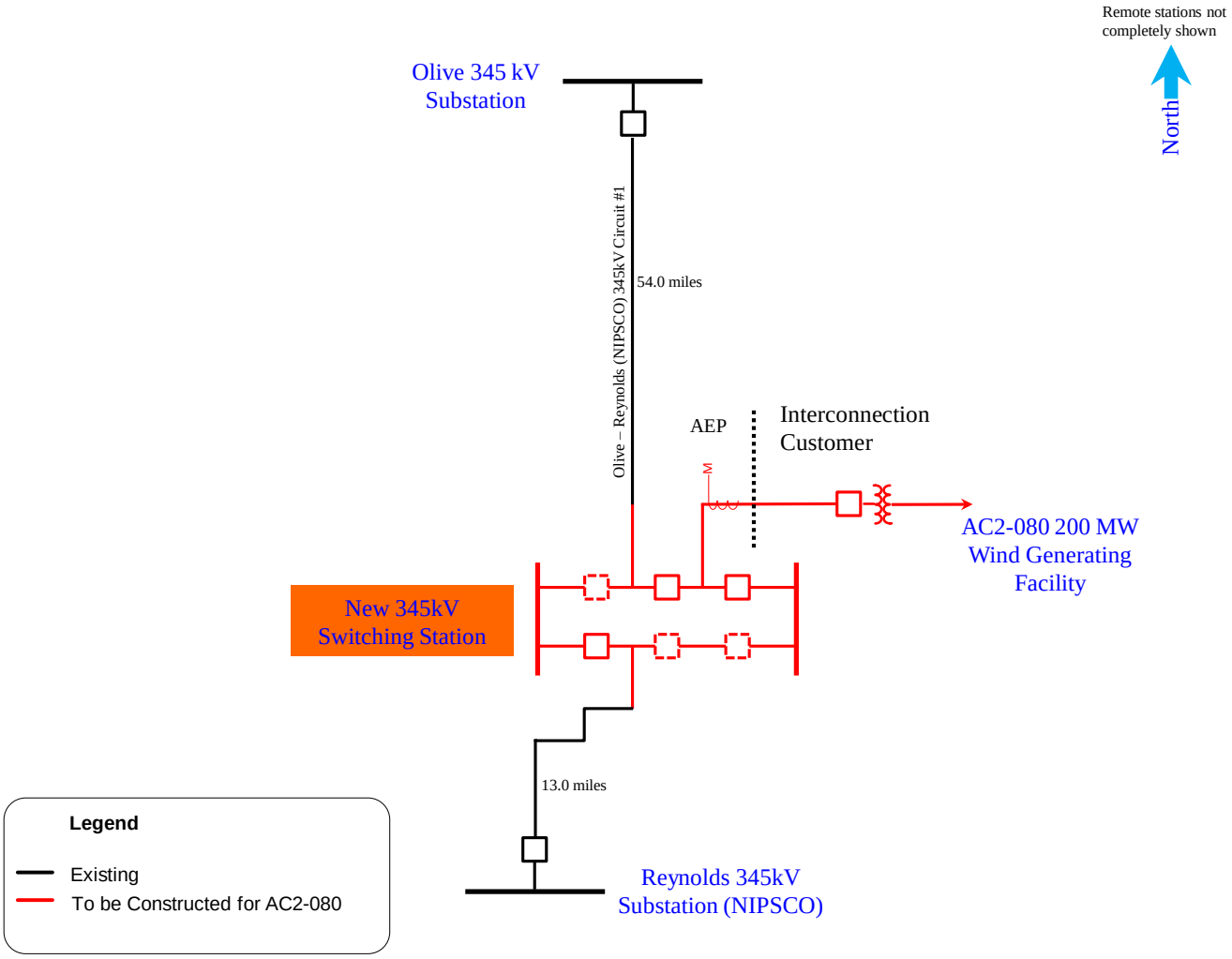
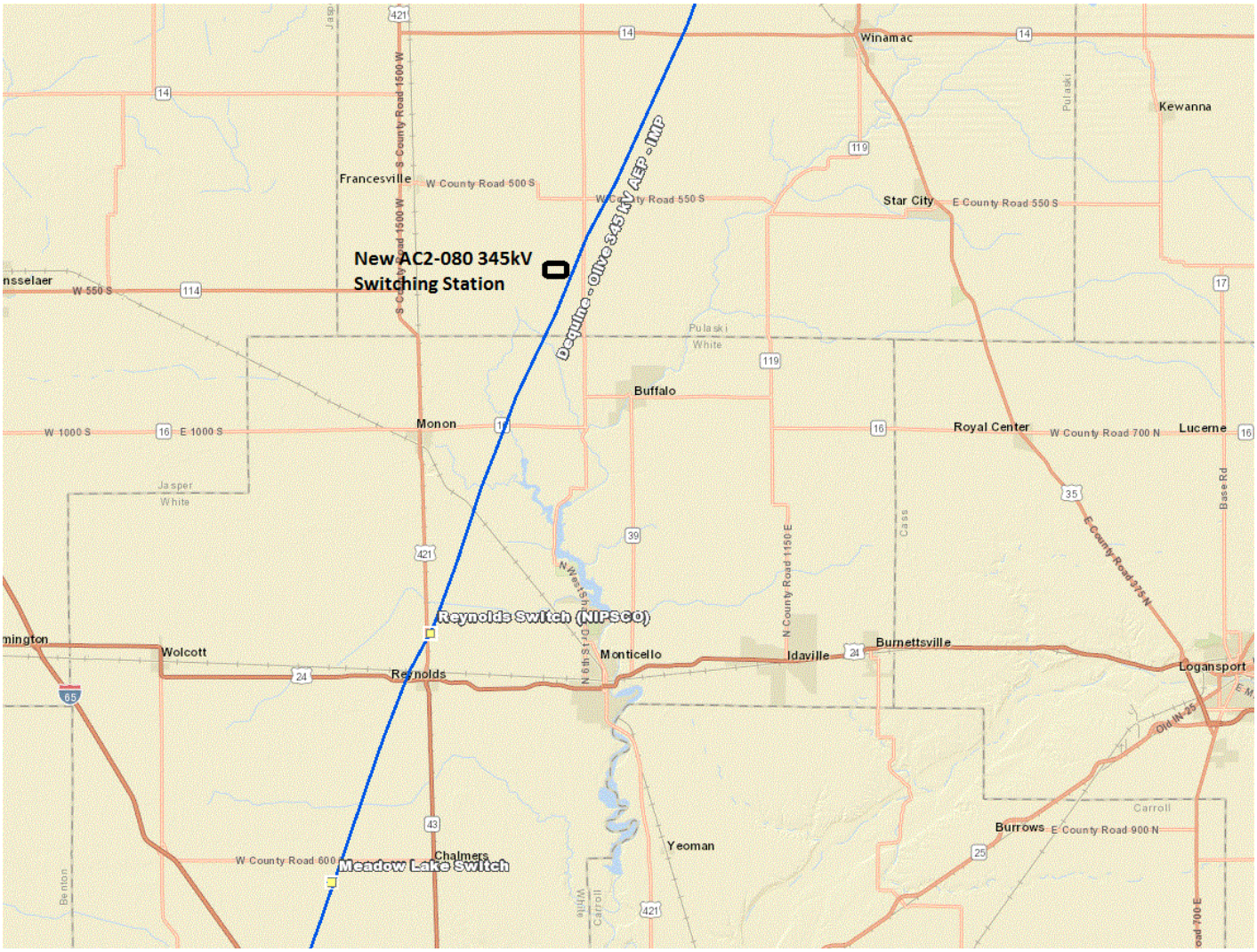


Figure 2: Point of Interconnection (Olive – Reynolds (NIPSCO) 345 kV Circuit #1)



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 - Summer Peak Load Flow

(AEP - OVEC) The 05JEFRSO-06CLIFTY 345 kV line (from bus 242865 to bus 248000 ckt Z1) loads from 106.35% to 106.75% (DC power flow) of its emergency rating (2045 MVA) for the line fault with failed breaker contingency outage of '6189_C2_05HANG R 765-D1'. This project contributes approximately 29.17 MW to the thermal violation.

CONTINGENCY '6189_C2_05HANG R 765-D1'
OPEN BRANCH FROM BUS 242921 TO BUS 242924 CKT 1 / 242921 05CORNU 765 242924 05HANG R 765 1
OPEN BRANCH FROM BUS 242924 TO BUS 243208 CKT 1 / 242924 05HANG R 765 243208 05JEFRSO 765 1
END

Bus Number	*Bus Name*	*Full Contribution*
243441	*05CKG2*	*23.34*
243859	*05FR-11G C*	*0.54*
247900	*05FR-11G E*	*11.19*
243862	*05FR-12G C*	*0.53*
247901	*05FR-12G E*	*11.01*
243864	*05FR-21G C*	*0.57*
247902	*05FR-21G E*	*11.77*
243866	*05FR-22G C*	*0.54*
247903	*05FR-22G E*	*11.27*
243870	*05FR-3G C*	*1.1*
247904	*05FR-3G E*	*22.82*
243873	*05FR-4G C*	*0.85*
247905	*05FR-4G E*	*17.16*
246909	*05MDL-1G C*	*1.14*
247906	*05MDL-1G E*	*23.52*
246910	*05MDL-2G C*	*0.57*
247907	*05MDL-2G E*	*11.66*
246976	*05MDL-3G C*	*0.57*
247912	*05MDL-3G E*	*12.19*
246979	*05MDL-4G C*	*1.14*
247913	*05MDL-4G E*	*11.63*
243442	*05RKG1*	*81.96*
243443	*05RKG2*	*80.71*
932601	*AC2-080 C O1*	*3.79*
932602	*AC2-080 E O1*	*25.37*
932931	*AC2-117*	*4.92*
933281	*AC2-140*	*4.31*
933411	*AC2-154 C*	*2.02*
933412	*AC2-154 E*	*3.3*
933441	*AC2-157 C*	*13.21*

933442	*AC2-157 E*	*21.55*
275149	*KEMPTON ;1E*	*14.91*
275148	*MILKS GRV;1E*	*14.91*
884780	*S-058 C*	*43.78*
884781	*S-058 E*	*131.33*
247556	*T-127 C*	*2.98*
247943	*T-127 E*	*11.93*
920252	*X1-020 C*	*31.44*
920253	*X1-020 E*	*210.43*
247611	*X2-052*	*14.52*
910542	*X3-005 E*	*0.6*
900404	*X3-028 C*	*260.75*
900405	*X3-028 E*	*347.66*
913222	*Y1-054 E*	*-2.32*
247629	*Y3-038*	*2.23*
915662	*Y3-099 E*	*0.24*
915672	*Y3-100 E*	*0.24*
LTF	*Z1-043*	*25.99*
247633	*Z1-051 C*	*1.82*
247634	*Z1-051 E*	*2.16*
916182	*Z1-065 E*	*0.66*
LTF	*Z1-112*	*8.67*
916651	*Z1-127 1*	*1.42*
916652	*Z1-127 2*	*0.71*
920882	*Z2-114 C*	*0.05*
920883	*Z2-114 E*	*0.27*
LTF	*AA1-001*	*4.94*
LTF	*AA1-071*	*5.78*
918972	*AA1-116 E*	*2.13*
918982	*AA1-117 E*	*2.13*
921692	*AA2-035*	*44.62*
922592	*AB1-006 C*	*3.83*
922593	*AB1-006 E*	*25.63*
922912	*AB1-080*	*4.45*
922982	*AB1-087 C OP*	*95.61*
922992	*AB1-088 C OP*	*95.61*
923022	*AB1-091 C OP*	*58.64*
LTF	*AB2-013*	*14.77*
925242	*AB2-178 E*	*2.42*
926391	*AC1-040 C*	*18.33*
926392	*AC1-040 E*	*29.9*
926661	*AC1-067 OP*	*117.07*

Appendix 2 - Summer Peak Load Flow

(AEP - AEP) The X2-052 TAP-05DUMONT 345 kV line (from bus 247610 to bus 243219 ckt 2) loads from 117.07% to 118.64% (AC power flow) of its emergency rating (1409 MVA) for the line fault with failed breaker contingency outage of '2978_C2_05DUMONT 765-B_A'. This project contributes approximately 27.35 MW to the thermal violation.

CONTINGENCY '2978_C2_05DUMONT 765-B_A'
OPEN BRANCH FROM BUS 243206 TO BUS 920251 CKT 1 / 243206 05DUMONT 765 920251 X1-020 TAP 765 1
OPEN BRANCH FROM BUS 243206 TO BUS 270644 CKT 1 / 243206 05DUMONT 765 270644 WILTON ; 765 1
END

Bus Number	*Bus Name*	*Full Contribution*
247900	*05FR-11G E*	*7.01*
247901	*05FR-12G E*	*6.89*
247902	*05FR-21G E*	*7.37*
247903	*05FR-22G E*	*7.05*
247904	*05FR-3G E*	*14.28*
247905	*05FR-4G E*	*10.74*
246909	*05MDL-1G C*	*0.78*
247906	*05MDL-1G E*	*16.07*
246910	*05MDL-2G C*	*0.39*
247907	*05MDL-2G E*	*7.97*
246976	*05MDL-3G C*	*0.39*
247912	*05MDL-3G E*	*8.33*
246979	*05MDL-4G C*	*0.78*
247913	*05MDL-4G E*	*7.95*
932011	*AC2-007 C*	*0.49*
932012	*AC2-007 E*	*0.91*
932601	*AC2-080 C O1*	*3.56*
932602	*AC2-080 E O1*	*23.79*
932881	*AC2-115 1*	*1.39*
932891	*AC2-115 2*	*1.39*
932921	*AC2-116*	*0.49*
932931	*AC2-117*	*5.19*
933341	*AC2-147 C*	*0.52*
933342	*AC2-147 E*	*0.84*
933351	*AC2-148 C*	*0.51*
933352	*AC2-148 E*	*0.84*
933361	*AC2-149 C*	*0.54*
933362	*AC2-149 E*	*0.88*
933371	*AC2-150 C*	*0.51*
933372	*AC2-150 E*	*0.84*

933381	*AC2-151 C*	*0.56*
933382	*AC2-151 E*	*0.92*
933401	*AC2-153 C*	*0.27*
933402	*AC2-153 E*	*0.44*
933411	*AC2-154 C*	*1.42*
933412	*AC2-154 E*	*2.32*
933431	*AC2-156 C O1*	*0.55*
933432	*AC2-156 E O1*	*0.9*
933511	*AC2-166 C*	*1.35*
933512	*AC2-166 E*	*1.49*
274832	*ANNAWAN ; 1U*	*6.64*
274849	*CRESCENT ;1U*	*3.6*
274859	*EASYR;U1 E*	*6.5*
274860	*EASYR;U2 E*	*6.5*
290051	*GSG-6; E*	*6.11*
275149	*KEMPTON ;1E*	*10.49*
290108	*LEEDK;1U E*	*14.11*
274850	*MENDOTA H;RU*	*3.51*
275148	*MILKS GRV;1E*	*10.49*
293061	*N-015 E*	*9.02*
293516	*O-009 E1*	*5.46*
293517	*O-009 E2*	*2.77*
293518	*O-009 E3*	*3.05*
293715	*O-029 E*	*5.84*
293716	*O-029 E*	*3.2*
293717	*O-029 E*	*2.94*
293771	*O-035 E*	*3.91*
293644	*O22 E1*	*5.87*
293645	*O22 E2*	*11.39*
290021	*O50 E*	*11.35*
294392	*P-010 E*	*11.46*
294763	*P-046 E*	*5.51*
274830	*PWR VTREC;1U*	*3.55*
274831	*PWR VTREC;2U*	*3.55*
274722	*S-055 E*	*6.49*
884780	*S-058 C*	*28.87*
884781	*S-058 E*	*86.62*
295111	*SUBLETTE E*	*1.59*
247556	*T-127 C*	*2.04*
247943	*T-127 E*	*8.15*
291984	*U4-033*	*0.78*
274814	*UNIV PK N;0U*	*0.59*
274805	*UNIV PK N;1U*	*0.59*
274806	*UNIV PK N;2U*	*0.59*

274807	*UNIV PK N;3U*	*0.59*
274808	*UNIV PK N;4U*	*0.59*
274809	*UNIV PK N;5U*	*0.59*
274810	*UNIV PK N;6U*	*0.59*
274811	*UNIV PK N;7U*	*0.59*
274812	*UNIV PK N;8U*	*0.59*
274813	*UNIV PK N;9U*	*0.59*
274815	*UNIV PK N;XU*	*0.59*
274816	*UNIV PK N;YU*	*0.59*
920173	*W3-046 E*	*14.26*
295109	*WESTBROOK E*	*3.27*
247611	*X2-052*	*72.76*
910542	*X3-005 E*	*0.37*
920462	*Y2-103*	*25.96*
920472	*Y3-013 1*	*2.16*
920482	*Y3-013 2*	*2.16*
920492	*Y3-013 3*	*2.16*
LTF	*Z1-043*	*17.45*
247634	*Z1-051 E*	*-1.73*
916502	*Z1-106 E1*	*0.73*
916504	*Z1-106 E2*	*0.73*
916512	*Z1-107 E*	*1.51*
916522	*Z1-108 E*	*1.44*
LTF	*Z1-112*	*6.06*
916651	*Z1-127 1*	*0.96*
916652	*Z1-127 2*	*0.57*
920782	*Z2-081*	*0.95*
920882	*Z2-114 C*	*0.08*
920883	*Z2-114 E*	*0.39*
920932	*AA1-018 C*	*1.46*
920933	*AA1-018 E*	*9.74*
LTF	*AA1-071*	*4.04*
921222	*AA1-078*	*0.44*
918972	*AA1-116 E*	*1.5*
918982	*AA1-117 E*	*1.5*
921632	*AA1-146*	*10.48*
921682	*AA2-030*	*10.48*
921692	*AA2-035*	*74.44*
921702	*AA2-039 C*	*1.02*
921703	*AA2-039 E*	*6.8*
922053	*AA2-107 E*	*1.42*
922183	*AA2-123 E*	*1.42*
922592	*AB1-006 C*	*2.62*
922593	*AB1-006 E*	*17.51*

922912	*AB1-080*	*22.33*
923002	*AB1-089 C*	*38.42*
923012	*AB1-090 C*	*38.42*
923022	*AB1-091 C OP*	*40.91*
930761	*AB1-122 1*	*42.37*
930762	*AB1-122 2*	*41.27*
923562	*AB1-172*	*0.47*
LTF	*AB2-013*	*9.87*
924471	*AB2-096*	*24.66*
925161	*AB2-173 C*	*1.87*
925301	*AB2-191 C*	*0.59*
925302	*AB2-191 E*	*0.81*
926321	*AC1-033 C*	*0.86*
926322	*AC1-033 E*	*5.75*
927081	*AC1-109*	*2.19*
927101	*AC1-110*	*2.18*
927121	*AC1-111*	*2.63*
927191	*AC1-113*	*1.39*
927211	*AC1-114*	*1.39*
927501	*AC1-142A*	*4.81*
927621	*AC1-153 C1*	*44.86*
927623	*AC1-153 C2*	*46.05*
927622	*AC1-153 E1*	*1.79*
927624	*AC1-153 E2*	*1.84*
927781	*AC1-168 C OP*	*0.69*
927782	*AC1-168 E OP*	*4.66*
927951	*AC1-185*	*3.25*
928141	*AC1-204*	*41.57*
928142	*AC1-204*	*41.57*
928251	*AC1-214 C OP*	*1.26*
928252	*AC1-214 E OP*	*3.99*

Appendix 3 - Light Load

(AEP - AEP) The 05MADDOX-05E LIMA 345 kV line (from bus 246929 to bus 242935 ckt 1) loads from 104.51% to 105.83% (AC power flow) of its normal rating (897 MVA) for the single line contingency outage of '7441_B2_TOR100545_A'. This project contributes approximately 11.82 MW to the thermal violation.

CONTINGENCY '7441_B2_TOR100545_A'
OPEN BRANCH FROM BUS 242928 TO BUS 926650 CKT 1 / 242928 05MARYSV 765 246999 05SORENS 765 1
END

Bus Number	*Bus Name*	*Full Contribution*
246936	*05BLCK-1 C*	*4.63*
247908	*05BLCK-1 E*	*5.1*
246937	*05BLCK-2 C*	*4.63*
247909	*05BLCK-2 E*	*5.1*
246938	*05BLCK-3 C*	*4.67*
247910	*05BLCK-3 E*	*5.19*
243859	*05FR-11G C*	*0.53*
243862	*05FR-12G C*	*0.52*
247901	*05FR-12G E*	*0.58*
243864	*05FR-21G C*	*0.56*
247902	*05FR-21G E*	*0.62*
243866	*05FR-22G C*	*0.54*
243870	*05FR-3G C*	*1.08*
247904	*05FR-3G E*	*1.19*
243873	*05FR-4G C*	*0.84*
247905	*05FR-4G E*	*0.9*
243795	*05HDWTR1G C*	*0.68*
247967	*05HDWTR1G E*	*1.26*
246909	*05MDL-1G C*	*1.14*
247906	*05MDL-1G E*	*1.25*
246910	*05MDL-2G C*	*0.57*
247907	*05MDL-2G E*	*0.62*
246976	*05MDL-3G C*	*0.57*
247912	*05MDL-3G E*	*0.65*
246979	*05MDL-4G C*	*1.14*
247913	*05MDL-4G E*	*0.62*
246953	*05TIMB G C*	*1.14*
247911	*05TIMB G E*	*1.26*
246991	*05WLD G1 C*	*0.34*
247914	*05WLD G1 E*	*0.62*
247255	*05WLD G2 C*	*0.36*

247958	*05WLD G2 E*	*0.66*
932601	*AC2-080 C O1*	*1.54*
932602	*AC2-080 E O1*	*10.28*
932801	*AC2-104 C*	*5.26*
932802	*AC2-104 E*	*35.2*
933281	*AC2-140*	*3.08*
933591	*AC2-176 C O1*	*0.96*
933592	*AC2-176 E O1*	*6.4*
933601	*AC2-177 C O1*	*1.37*
933602	*AC2-177 E O1*	*9.15*
274857	*BIG SKY ;U1*	*0.66*
274858	*BIG SKY ;U2*	*0.66*
274877	*BISHOP HL;1U*	*0.54*
274878	*BISHOP HL;2U*	*0.54*
275146	*BOONE HTG;1E*	*4.52*
274883	*BOONE HTG;1U*	*1.13*
275145	*BOONE HTG;2E*	*4.52*
274884	*BOONE HTG;2U*	*1.13*
294401	*BSHIL;1U E*	*0.59*
294410	*BSHIL;2U E*	*0.59*
274848	*CAMPGROVE;RU*	*0.8*
274890	*CAYUG;1U E*	*0.92*
274891	*CAYUG;2U E*	*0.92*
274863	*CAYUGA RI;1U*	*0.84*
274864	*CAYUGA RI;2U*	*0.84*
274849	*CRESCENT ;1U*	*0.41*
274859	*EASYR;U1 E*	*0.73*
274860	*EASYR;U2 E*	*0.73*
274856	*ECOGROVE ;U1*	*0.56*
274871	*GR RIDGE ;2U*	*1.12*
274855	*GSG-6 ;RU*	*0.62*
290051	*GSG-6; E*	*0.68*
275149	*KEMPTON ;1E*	*1.16*
274881	*KEMPTON ;1U*	*1.05*
990901	*L-005 E*	*0.88*
274872	*LEE DEKAL;1U*	*1.37*
290108	*LEEDK;1U E*	*1.57*
274850	*MENDOTA H;RU*	*0.39*
275148	*MILKS GRV;1E*	*1.16*
274880	*MILKS GRV;1U*	*1.05*
274879	*MINONK ;1U*	*1.15*
293061	*N-015 E*	*0.98*
293513	*O-009 C1*	*1.12*
293514	*O-009 C2*	*0.57*

293515	*O-009 C3*	*0.63*
293516	*O-009 E1*	*4.47*
293517	*O-009 E2*	*2.27*
293518	*O-009 E3*	*2.5*
293712	*O-029 C*	*0.6*
293713	*O-029 C*	*0.33*
293714	*O-029 C*	*0.3*
293715	*O-029 E*	*0.66*
293716	*O-029 E*	*0.36*
293717	*O-029 E*	*0.33*
293771	*O-035 E*	*0.44*
293644	*O22 E1*	*0.65*
293645	*O22 E2*	*1.27*
290021	*O50 E*	*1.27*
294392	*P-010 E*	*1.24*
294763	*P-046 E*	*0.62*
274851	*PROVIDENC;RU*	*0.4*
296308	*R-030 C1*	*1.81*
296271	*R-030 C2*	*1.81*
296125	*R-030 C3*	*1.83*
296309	*R-030 E1*	*7.23*
296272	*R-030 E2*	*7.23*
296128	*R-030 E3*	*7.32*
247534	*R-048 C*	*0.42*
247928	*R-048 E*	*1.69*
290261	*S-027 C*	*1.04*
290265	*S-028 C*	*1.04*
884780	*S-058*	*30.66*
247536	*S-071 C*	*1.27*
247929	*S-071 E*	*5.06*
295110	*SUBLETTE C*	*0.09*
295111	*SUBLETTE E*	*0.18*
247556	*T-127 C*	*0.16*
247943	*T-127 E*	*0.63*
247521	*T-131 C*	*2.53*
247925	*T-131 E*	*10.12*
274861	*TOP CROP ;1U*	*0.59*
274862	*TOP CROP ;2U*	*1.15*
274853	*TWINGROVE;U1*	*1.14*
274854	*TWINGROVE;U2*	*1.14*
247543	*V3-007 C*	*1.37*
247935	*V3-007 E*	*9.15*
247568	*V3-015 C*	*3.09*
247949	*V3-015 E*	*20.7*

900371	*V4-046*	*0.44*
900381	*V4-047*	*0.44*
900391	*V4-048*	*1.5*
900401	*V4-049*	*1.5*
276150	*W2-048 E*	*3.1*
903212	*W3-046 E*	*11.64*
247588	*W4-004 C*	*0.47*
247946	*W4-004 E*	*3.16*
905081	*W4-005 C*	*0.32*
905082	*W4-005 E*	*2.13*
247589	*W4-008 C*	*0.47*
247953	*W4-008 E*	*3.16*
274873	*WALNR;1U*	*1.15*
294500	*WALNR;1U E*	*4.62*
274874	*WALNR;2U*	*1.15*
294502	*WALNR;2U E*	*4.62*
295108	*WESTBROOK C*	*0.2*
295109	*WESTBROOK E*	*0.36*
907001	*X1-020 C*	*11.58*
907002	*X1-020 E*	*77.46*
909052	*X2-022 E*	*9.36*
247633	*Z1-051*	*1.02*
247634	*Z1-051 E*	*1.54*
916211	*Z1-072*	*0.07*
916221	*Z1-073*	*0.05*
917501	*Z2-087 C*	*1.41*
917502	*Z2-087 E*	*9.47*
918051	*AA1-018 C*	*1.13*
918052	*AA1-018 E*	*7.58*
919621	*AA2-039 C*	*1.05*
919622	*AA2-039 E*	*7.04*
920501	*AA2-148 C OP*	*0.92*
920502	*AA2-148 E OP*	*6.15*
930041	*AB1-006 C*	*1.48*
930042	*AB1-006 E*	*9.89*
923811	*AB2-016 C*	*5.19*
923812	*AB2-016 E*	*34.76*
923881	*AB2-028 C*	*1.35*
923882	*AB2-028 E*	*9.03*
924041	*AB2-047 C OP*	*1.76*
924042	*AB2-047 E OP*	*11.8*
924211	*AB2-065 C*	*0.65*
924212	*AB2-065 E*	*4.37*
924261	*AB2-070 C OP*	*1.3*

924262	*AB2-070 E OP*	*8.7*
925301	*AB2-191 C*	*0.75*
925302	*AB2-191 E*	*0.66*
926051	*AC1-033 C*	*0.71*
926052	*AC1-033 E*	*4.74*
926111	*AC1-053 C*	*1.3*
926112	*AC1-053 E*	*8.67*
LTF	*AC1-133*	*0.11*
926491	*AC1-168 C OP*	*0.57*
926492	*AC1-168 E OP*	*3.79*
926501	*AC1-171 C OP*	*0.53*
926502	*AC1-171 E OP*	*3.57*
926521	*AC1-173 C*	*0.83*
926522	*AC1-173 E*	*5.56*
926531	*AC1-176 C*	*0.58*
926532	*AC1-176 E*	*3.88*
926641	*AC1-214 C OP*	*1.07*
926642	*AC1-214 E OP*	*3.24*
926651	*AC1-225 C OP*	*3.15*
926652	*AC1-225 E OP*	*21.13*