Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AB2-149

Ivor – Oak Ridge 115kV
19MW Capacity / 50MW Energy

September / 2016

Introduction

This Feasibility Study has been prepared in accordance with the PJM Open Access Transmission Tariff, 36.2, as well as the Feasibility Study Agreement between the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Virginia Electric and Power Company (VEPCO).

Preface

The intent of the Feasibility Study is to determine a plan, with high level estimated cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the IC. The IC may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the IC 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 IC is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by ITO, the costs may be included in the study.

General

The IC has proposed a solar generating facility located in Isle of Wight County, VA. The installed facilities will have a total capability of 50 MW with 19 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 10/31/2017. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AB2-149 will interconnect with the ITO transmission system at one of the following points of interconnection:

Option 1 will connect via a new three breaker ring bus switching station that connects on the Ivor – Oak Ridge 115kV line #23.

Option 2 will connect via a new three breaker ring bus switching station that connects at the Windsor DP - Myrtle 115kV line #44.

Cost Summary

The AB2-169 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$1,500,000
Direct Connection Network Upgrades	$4,500,000
Non Direct Connection Network Upgrades	$700,000
Total Costs	**$6,700,000**

Attachment Facilities

Generation Substation: Install metering and associated protection equipment. Estimated Cost $500,000.

Transmission: Construct approximately one span of 115 kV Attachment line between the generation substation and a new AB2-149 115 kV Switching Substation. The estimated cost for this work is $1,000,000.

The estimated total cost of the Attachment Facilities is $1,500,000. It is estimated to take 18-24 months to complete this work. These costs do not include CIAC Tax Gross-up. The single line is shown below in Attachment 1.

Direct Connection Cost Estimate

Substation: Establish the new 115 kV AB2-149 Switching Substation (interconnection substation). The estimated cost of this work scope is $4,500,000. It is estimated to take 24-36 months to complete this work.

Non-Direct Connection Cost Estimate

Transmission: Install transmission structure in-line with transmission line to allow the proposed interconnection switching station to be interconnected with the transmission system. Estimated cost is $700,000 dollars and is estimated to take 24-30 months to complete.

Remote Terminal Work: During the Facilities Study, ITO's System Protection Engineering Department will review transmission line protection as well as anti-islanding required to accommodate the new generation and interconnection substation. System Protection Engineering will determine the minimal acceptable protection requirements to reliably interconnect the proposed generating facility with the transmission system. The review is based on maintaining system reliability by reviewing ITO's protection requirements with the known transmission system configuration which includes generating facilities in the area. This review may determine that transmission line protection and communication upgrades are required at remote substations.

Interconnection Customer Requirements

ITO's Facility Connection Requirements as posted on PJM's website
http://www.pjm.com/~/media/planning/plan-standards/private-dominion/facility-connection-requirements1.ashx

Voltage Ride Through Requirements - The Customer Facility shall be designed to remain in service (not trip) for voltages and times as specified for the Eastern Interconnection in Attachment 1 of NERC Reliability Standard PRC-024-1, and successor Reliability Standards, for both high and low voltage conditions, irrespective of generator size, subject to the permissive trip exceptions established in PRC-024-1 (and successor Reliability Standards).

Frequency Ride Through Requirements - The Customer Facility shall be designed to remain in service (not trip) for frequencies and times as specified in Attachment 2 of NERC Reliability

Standard PRC-024-1, and successor Reliability Standards, for both high and low frequency condition, irrespective of generator size, subject to the permissive trip exceptions established in PRC-024-1 (and successor Reliability Standards).

Reactive Power - The Generation Interconnection Customer shall design its non-synchronous Customer Facility with the ability to maintain a power factor of at least 0.95 leading to 0.95 lagging measured at the generator's terminals.

Revenue Metering and SCADA Requirements

PJM Requirements

The IC 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.

Option One

Network Impacts

The Queue Project AB2-149 was evaluated as a 50.0 MW (Capacity 19.0 MW) injection tapping the Oak Ridge-Ivor 115kV line in the ITO area. Project AB2-149 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB2-149 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
LN 208-259	CONTINGENCY 'LN 208-259' OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1 /* 6CHSTF A 230.00 - 6IRON208 230.00 OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1 /* 6IRON208 230.00 - 6SOUWEST 230.00 OPEN BUS 314309 /* ISLAND OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00 END
LN 106	CONTINGENCY 'LN 106' OPEN BRANCH FROM BUS 314262 TO BUS 314280 CKT 1 /* 3NEWBO_1 115.00 - 3NEWBOHE 115.00 OPEN BRANCH FROM BUS 314273 TO BUS 314280 CKT 1 /* 3BAKRS P 115.00 - 3NEWBOHE 115.00 OPEN BRANCH FROM BUS 314280 TO BUS 314329 CKT 1 /* 3NEWBOHE 115.00 - 3POE 115.00 OPEN BRANCH FROM BUS 313879 TO BUS 314273 CKT 1 /* 3SADL_2 115.00 - 3BAKRS P 115.00 OPEN BUS 314262 /* ISLAND OPEN BUS 314273 /* ISLAND OPEN BUS 314280 /* ISLAND END

Summer Peak Analysis - 2020

System Reinforcement responsible by ITO

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution
1	DCTL	LN 208-259	DVP - DVP	6CHARCTY-6LAKESD 230 kV line	314225	314227	1	DC	126.61	127.08	ER	399	4.11
2	DCTL	LN 208-259	DVP - DVP	6MESSER-6CHARCTY 230 kV line	314228	314225	1	DC	140.12	140.58	ER	399	4.11
3	DCTL	LN 208-259	DVP - DVP	6CHSTF B-6MESSER 230 kV line	314287	314228	1	DC	140.3	140.76	ER	399	4.11

PJM baseline project (b2745) will eliminate the identified overloads. The scheduled in service date b2745 is 06/01/2020.

Generator Deliverability

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

None

Multiple Facility Contingency

(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)

None

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None

Contributions to previously identified circuit breakers found to be over-duty:

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)

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
4	DCTL	LN 208-259	DVP - DVP	6CHARCTY-6LAKESD 230 kV line	314225	314227	1	DC	126.61	127.08	ER	399	4.11	1
5	DCTL	LN 208-259	DVP - DVP	6MESSER-6CHARCTY 230 kV line	314228	314225	1	DC	140.12	140.58	ER	399	4.11	2
6	DCTL	LN 208-259	DVP - DVP	6CHSTF B-6MESSER 230 kV line	314287	314228	1	DC	140.3	140.76	ER	399	4.11	3

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

To be determined during Impact Study.

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

To be determined during Impact Study.

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)

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
# 1, 4	6CHARCTY-6LAKESD 230 kV line	Rebuild 21.32 miles of the Chesterfield - Lakeside 230kV transmission line by 6/1/2020	b2745	**$**
# 2, 5	6MESSER-6CHARCTY 230 kV line	Rebuild 21.32 miles of the Chesterfield - Lakeside 230kV transmission line by 6/1/2020	b2745	**$**
# 3, 6	6CHSTF B-6MESSER 230 kV line	Rebuild 21.32 miles of the Chesterfield - Lakeside 230kV transmission line by 6/1/2020	b2745	
			Total New Network Upgrades	**$**

Potential Congestion due to Local Energy Deliverability

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 IC can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed below. 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 shall study all overload conditions associated with the overloaded element(s) identified.

	Contingency		Affected		Bus			Power	Loading %		Rating		MW
#	Type	Name	Area	Facility Description	From	To	Circuit	Flow	Initial	Final	Type	MVA	Contribution
7	N-1	LN 106	DVP - DVP	3OAKRI23-3SUFFOLK 115 kV line	314532	314536	1	DC	84.75	116.4	ER	118	50.0
8	N-1	LN 106	DVP - DVP	AB2-149 TAP-3OAKRI23 115 kV line	924940	314532	1	DC	84.75	126.19	ER	118	50.0

Light Load Analysis

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

ITO Analysis

ITO assessed the impact of the proposed Queue Project #AB2-149 interconnection of a 50.0 MW Energy (19 MW Capacity) injection into the ITO's Transmission System, for compliance with NERC Reliability Criteria on ITO's Transmission System. The system was assessed using the summer 2020 RTEP case provided to ITO by PJM. When performing a generation analysis, ITO's main analysis will be load flow study results under single contingency (both normal and stressed system conditions). ITO Criteria considers a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. A full listing of ITO's Planning Criteria and interconnection requirements can be found in the ITO's Facility Connection Requirements which are publicly available at: http://www.dom.com.

The results of these studies evaluate the system under a limited set of operating conditions and do not guarantee the full delivery of the capacity and associated energy of this proposed generation facility under all operating conditions. NERC Planning and Operating Reliability Criteria allow for the re-dispatch of generating units to resolve projected and actual deficiencies in real time and planning studies. Specifically NERC Category C Contingency Conditions (Bus Fault, Tower Line, N-1-1, and Stuck Breaker scenarios) allow for re-dispatch of generating units to resolve potential reliability deficiencies. For ITO's Planning Criteria the re-dispatch of generating units for these contingency conditions is allowed as long as the projected loading does not exceed 100% of a facility Load Dump Rating.

As part of its generation impact analysis, the ITO routinely evaluates the impact that a proposed new generation resource will have under maximum generation conditions, stress system conditions and import/export system conditions (greater than 20 MW). The results of these studies are discussed in more detail below.

Category B Analysis (Single Contingency):

1. System Normal – No deficiencies identified
2. Critical System Condition (No Surry 230 kV Unit) – No deficiencies identified.

Category C Analysis: (Multiple Facility Analysis)

1. Bus Fault - No deficiencies identified
2. Line Stuck Breaker - No deficiencies identified
3. Tower Line – No deficiencies identified

Affected System Analysis & Mitigation

Duke, Progress & TVA Impacts:

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

Option Two

Network Impacts

The Queue Project AB2-149 was evaluated as a 50.0 MW (Capacity 19.0 MW) injection tapping the Myrtle-Windsor 115kV line in the ITO area. Project AB2-149 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB2-149 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
LN 15	CONTINGENCY 'LN 15' OPEN BRANCH FROM BUS 314292 TO BUS 314350 CKT 1 /* 3DISPUTN 115.00 - 3WVLY DP 115.00 OPEN BRANCH FROM BUS 314292 TO BUS 314329 CKT 1 /* 3DISPUTN 115.00 - 3POE 115.00 OPEN BRANCH FROM BUS 314347 TO BUS 314351 CKT 1 /* 3WAKEFLD 115.00 - 3WAVERLY 115.00 OPEN BRANCH FROM BUS 314350 TO BUS 314351 CKT 1 /* 3WVLY DP 115.00 - 3WAVERLY 115.00 OPEN BRANCH FROM BUS 313878 TO BUS 314347 CKT 1 /* 3SADL_1 115.00 - 3WAKEFLD 115.00 OPEN BUS 314292 /* ISLAND OPEN BUS 314347 /* ISLAND OPEN BUS 314350 /* ISLAND OPEN BUS 314351 /* ISLAND END

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 contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)

None

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None

Contributions to previously identified circuit breakers found to be over-duty:

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)

None

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

To be determined during Impact Study.

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

To be determined during Impact Study.

Potential Congestion due to Local Energy Deliverability

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 IC can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

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	Contingency		Affected		Bus			Power	Loading %		Rating		MW
#	Type	Name	Area	Facility Description	From	To	Circuit	Flow	Initial	Final	Type	MVA	Contribution
1	N-1	LN 15	DVP - DVP	3OAKRI44-3SUFFOLK 115 kV line	313803	314536	1	DC	77.91	106.61	ER	118	50.0
2	N-1	LN 15	DVP - DVP	3OAKRI44-3SUFFOLK 115 kV line3MYRTLE-3OAKRI44 115 kV line	314531	313803	1	DC	77.91	106.61	ER	118	50.0
3	N-1	LN 15	DVP - DVP	AB2-149 TAP-3MYRTLE 115 kV line	924940	314531	1	DC	82.4	120.08	ER	118	50.0

Light Load Analysis

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

ITO Analysis

ITO assessed the impact of the proposed Queue Project #AB2-149 interconnection of a 50.0 MW Energy (19 MW Capacity) injection into the ITO's Transmission System, for compliance with NERC Reliability Criteria on ITO's Transmission System. The system was assessed using the summer 2020 RTEP case provided to ITO by PJM. When performing a generation analysis, ITO's main analysis will be load flow study results under single contingency (both normal and stressed system conditions). ITO Criteria considers a transmission facility overloaded if it exceeds 94% of its

emergency rating under normal and stressed system conditions. A full listing of ITO's Planning Criteria and interconnection requirements can be found in the ITO's Facility Connection Requirements which are publicly available at: http://www.dom.com.

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As part of its generation impact analysis, the ITO routinely evaluates the impact that a proposed new generation resource will have under maximum generation conditions, stress system conditions and import/export system conditions (greater than 20 MW). The results of these studies are discussed in more detail below.

Category B Analysis (Single Contingency):

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4. Critical System Condition (No Surry 230 kV Unit) – No deficiencies identified.

Category C Analysis: (Multiple Facility Analysis)

4. Bus Fault - No deficiencies identified
5. Line Stuck Breaker - No deficiencies identified
6. Tower Line – No deficiencies identified

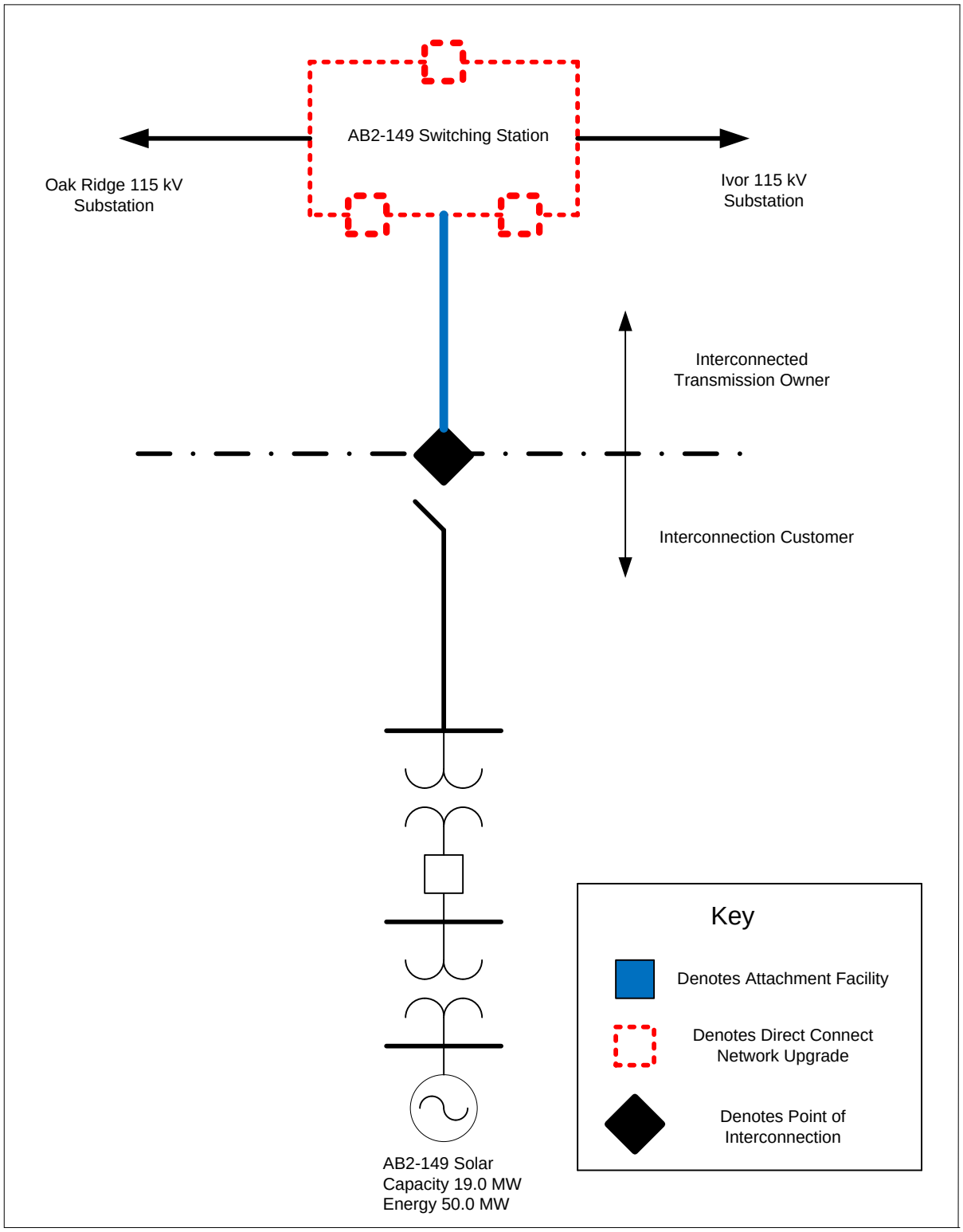
Affected System Analysis & Mitigation

Duke, Progress & TVA Impacts:

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

Attachment 1.

System Configuration



Attachment 2.

Flowgate Appendices – Option 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. When a flowgate is identified in multiple analysis the appendix is presented for only the analysis with the greatest overload.

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

(DVP - DVP) The 6CHARCTY-6LAKESD 230 kV line (from bus 314225 to bus 314227 ckt 1) loads from 126.61% to 127.08% (**DC power flow**) of its emergency rating (399 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 4.11 MW to the thermal violation.

CONTINGENCY 'LN 208-259'
OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1 /* 6CHSTF A 230.00 - 6IRON208 230.00
OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1 /* 6IRON208 230.00 - 6SOUWEST 230.00
OPEN BUS 314309 /* ISLAND
OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00
END

Bus Number	*Bus Name*	*Full Contribution*
315065	*1CHESTF6*	*37.23*
315077	*1HOPHCF1*	*2.16*
315078	*1HOPHCF2*	*2.16*
315079	*1HOPHCF3*	*2.16*
315080	*1HOPHCF4*	*3.27*
315076	*1HOPPOLC*	*1.84*
315073	*1STONECA*	*5.67*
314784	*1WEYRHSB*	*0.66*
314314	*3LOCKS*	*1.04*
314539	*3UNCAMP*	*0.86*
314541	*3WATKINS*	*0.25*
314229	*6MT R221*	*-0.33*
292791	*U1-032 E*	*2.95*
900672	*V4-068 E*	*0.11*
901082	*W1-029E*	*13.49*
902241	*W2-022 C OP1*	*0.49*
902242	*W2-022 E OP1*	*3.31*
903520	*W3-066 C1OP1*	*0.98*
903531	*W3-066 C2OP1*	*0.98*
903522	*W3-066 E1OP1*	*6.54*
903532	*W3-066 E2OP1*	*6.54*
907092	*X1-038 E*	*2.15*
913392	*Y1-086 E*	*0.63*
914231	*Y2-077*	*0.87*
916042	*Z1-036 E*	*13.59*
916192	*Z1-068 E*	*0.53*

917122	*Z2-027 E*	*0.31*
917332	*Z2-043 E*	*0.34*
917342	*Z2-044 E*	*0.18*
917592	*Z2-099 E*	*0.16*
921092	*AA1-049 C*	*0.68*
921093	*AA1-049 E*	*0.32*
921162	*AA1-063AC*	*3.19*
921163	*AA1-063AE*	*1.51*
918512	*AA1-065 E OP*	*1.48*
918562	*AA1-072 E*	*0.06*
921532	*AA1-132 C*	*2.1*
921533	*AA1-132 E*	*0.9*
921552	*AA1-134 C*	*2.89*
921553	*AA1-134 E*	*1.24*
921562	*AA1-135 C*	*2.95*
921563	*AA1-135 E*	*1.26*
921572	*AA1-138 C*	*3.*
921573	*AA1-138 E*	*1.29*
921752	*AA2-053 C*	*3.26*
921753	*AA2-053 E*	*1.4*
921762	*AA2-057 C*	*2.35*
921763	*AA2-057 E*	*1.17*
921772	*AA2-059 C*	*0.72*
921773	*AA2-059 E*	*0.33*
921862	*AA2-068 C*	*0.76*
921863	*AA2-068 E*	*0.35*
920022	*AA2-086 E*	*0.09*
921982	*AA2-088 C*	*2.33*
921983	*AA2-088 E*	*3.81*
922032	*AA2-105 C*	*0.85*
922033	*AA2-105 E*	*0.4*
922072	*AA2-113 C*	*0.85*
922073	*AA2-113 E*	*0.4*
922442	*AA2-165 C*	*0.32*
922443	*AA2-165 E*	*0.15*
922472	*AA2-169 C*	*0.71*
922473	*AA2-169 E*	*0.33*
922512	*AA2-174 C*	*0.15*
922513	*AA2-174 E*	*0.16*
922522	*AA2-177 C*	*6.39*
922523	*AA2-177 E*	*2.74*
922532	*AA2-178 C*	*2.96*
922533	*AA2-178 E*	*1.27*
922602	*AB1-013 C*	*0.89*
922603	*AB1-013 E*	*5.98*

922722	*AB1-053 C*	*0.44*
922723	*AB1-053 E*	*0.25*
922732	*AB1-054 C*	*2.47*
922733	*AB1-054 E*	*1.22*
922882	*AB1-077 C*	*1.01*
922883	*AB1-077 E*	*6.75*
923262	*AB1-132 C OP*	*5.97*
923263	*AB1-132 E OP*	*2.56*
923572	*AB1-173 C OP*	*0.99*
923573	*AB1-173 E OP*	*0.46*
923582	*AB1-173AC OP*	*0.99*
923583	*AB1-173AE OP*	*0.46*
923801	*AB2-015 C OP*	*3.8*
923802	*AB2-015 E OP*	*2.76*
923831	*AB2-022 C*	*0.66*
923832	*AB2-022 E*	*0.35*
923851	*AB2-025 C*	*1.62*
923852	*AB2-025 E*	*0.73*
923911	*AB2-031 C OP*	*0.98*
923912	*AB2-031 E OP*	*0.48*
923981	*AB2-039 C OP*	*5.76*
923982	*AB2-039 E OP*	*4.71*
923991	*AB2-040 C OP*	*3.33*
923992	*AB2-040 E OP*	*2.51*
924011	*AB2-042 C OP*	*6.68*
924012	*AB2-042 E OP*	*5.32*
924071	*AB2-051 C OP*	*39.06*
924072	*AB2-051 E OP*	*6.07*
924381	*AB2-087 C*	*0.19*
924382	*AB2-087 E*	*0.09*
924501	*AB2-099 C*	*0.2*
924502	*AB2-099 E*	*0.09*
924511	*AB2-100 C*	*5.58*
924512	*AB2-100 E*	*2.75*
924761	*AB2-128 C*	*4.78*
924762	*AB2-128 E*	*1.88*
924811	*AB2-134 C OP*	*8.19*
924812	*AB2-134 E OP*	*10.95*
924931	*AB2-147 C*	*1.18*
924932	*AB2-147 E*	*1.92*
924941	*AB2-149 C OP*	*1.56*
924942	*AB2-149 E OP*	*2.55*
924951	*AB2-150 C OP*	*1.18*
924952	*AB2-150 E OP*	*1.92*
924961	*AB2-152*	*15.85*

925051	*AB2-160 C OP*	*4.19*
925052	*AB2-160 E OP*	*6.83*
925061	*AB2-161 C OP*	*1.99*
925062	*AB2-161 E OP*	*3.24*
925121	*AB2-169 C OP*	*2.02*
925122	*AB2-169 E OP*	*1.81*
925141	*AB2-171 C OP*	*1.75*
925142	*AB2-171 E OP*	*2.85*
925171	*AB2-174 C OP*	*3.17*
925172	*AB2-174 E OP*	*2.87*
925281	*AB2-186 C*	*0.18*
925282	*AB2-186 E*	*0.08*
925291	*AB2-188 C OP*	*0.73*
925292	*AB2-188 E OP*	*0.33*
925331	*AB2-190 C*	*14.6*
925332	*AB2-190 E*	*3.65*

Appendix 2

(DVP - DVP) The 6MESSER-6CHARCTY 230 kV line (from bus 314228 to bus 314225 ckt 1) loads from 140.12% to 140.58% (**DC power flow**) of its emergency rating (399 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 4.11 MW to the thermal violation.

CONTINGENCY 'LN 208-259'
 OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1 /* 6CHSTF A 230.00 - 6IRON208 230.00
 OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1 /* 6IRON208 230.00 - 6SOUWEST 230.00
 OPEN BUS 314309 /* ISLAND
 OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00
 END

Bus Number	*Bus Name*	*Full Contribution*
315065	*1CHESTF6*	*37.23*
315077	*1HOPHCF1*	*2.16*
315078	*1HOPHCF2*	*2.16*
315079	*1HOPHCF3*	*2.16*
315080	*1HOPHCF4*	*3.27*
315076	*1HOPPOLC*	*1.84*
315073	*1STONECA*	*5.67*
314784	*1WEYRHSB*	*0.66*
314314	*3LOCKS*	*1.04*
314539	*3UNCAMP*	*0.86*
314541	*3WATKINS*	*0.25*
314229	*6MT R221*	*-0.33*
292791	*U1-032 E*	*2.95*
900672	*V4-068 E*	*0.11*
901082	*W1-029E*	*13.49*
902241	*W2-022 C OP1*	*0.49*
902242	*W2-022 E OP1*	*3.31*
903520	*W3-066 C1OP1*	*0.98*
903531	*W3-066 C2OP1*	*0.98*
903522	*W3-066 E1OP1*	*6.54*
903532	*W3-066 E2OP1*	*6.54*
907092	*X1-038 E*	*2.15*
913392	*Y1-086 E*	*0.63*
914231	*Y2-077*	*0.87*

916042	*Z1-036 E*	*13.59*
916192	*Z1-068 E*	*0.53*
917122	*Z2-027 E*	*0.31*
917332	*Z2-043 E*	*0.34*
917342	*Z2-044 E*	*0.18*
917592	*Z2-099 E*	*0.16*
921092	*AA1-049 C*	*0.68*
921093	*AA1-049 E*	*0.32*
921162	*AA1-063AC*	*3.19*
921163	*AA1-063AE*	*1.51*
918512	*AA1-065 E OP*	*1.48*
918562	*AA1-072 E*	*0.06*
921532	*AA1-132 C*	*2.1*
921533	*AA1-132 E*	*0.9*
921552	*AA1-134 C*	*2.89*
921553	*AA1-134 E*	*1.24*
921562	*AA1-135 C*	*2.95*
921563	*AA1-135 E*	*1.26*
921572	*AA1-138 C*	*3.*
921573	*AA1-138 E*	*1.29*
921752	*AA2-053 C*	*3.26*
921753	*AA2-053 E*	*1.4*
921762	*AA2-057 C*	*2.35*
921763	*AA2-057 E*	*1.17*
921772	*AA2-059 C*	*0.72*
921773	*AA2-059 E*	*0.33*
921862	*AA2-068 C*	*0.76*
921863	*AA2-068 E*	*0.35*
920022	*AA2-086 E*	*0.09*
921982	*AA2-088 C*	*2.33*
921983	*AA2-088 E*	*3.81*
922032	*AA2-105 C*	*0.85*
922033	*AA2-105 E*	*0.4*
922072	*AA2-113 C*	*0.85*
922073	*AA2-113 E*	*0.4*
922442	*AA2-165 C*	*0.32*
922443	*AA2-165 E*	*0.15*
922472	*AA2-169 C*	*0.71*
922473	*AA2-169 E*	*0.33*
922512	*AA2-174 C*	*0.15*
922513	*AA2-174 E*	*0.16*
922522	*AA2-177 C*	*6.39*
922523	*AA2-177 E*	*2.74*
922532	*AA2-178 C*	*2.96*
922533	*AA2-178 E*	*1.27*

922602	*AB1-013 C*	*0.89*
922603	*AB1-013 E*	*5.98*
922722	*AB1-053 C*	*0.44*
922723	*AB1-053 E*	*0.25*
922732	*AB1-054 C*	*2.47*
922733	*AB1-054 E*	*1.22*
922882	*AB1-077 C*	*1.01*
922883	*AB1-077 E*	*6.75*
923262	*AB1-132 C OP*	*5.97*
923263	*AB1-132 E OP*	*2.56*
923572	*AB1-173 C OP*	*0.99*
923573	*AB1-173 E OP*	*0.46*
923582	*AB1-173AC OP*	*0.99*
923583	*AB1-173AE OP*	*0.46*
923801	*AB2-015 C OP*	*3.8*
923802	*AB2-015 E OP*	*2.76*
923831	*AB2-022 C*	*0.66*
923832	*AB2-022 E*	*0.35*
923851	*AB2-025 C*	*1.62*
923852	*AB2-025 E*	*0.73*
923911	*AB2-031 C OP*	*0.98*
923912	*AB2-031 E OP*	*0.48*
923981	*AB2-039 C OP*	*5.76*
923982	*AB2-039 E OP*	*4.71*
923991	*AB2-040 C OP*	*3.33*
923992	*AB2-040 E OP*	*2.51*
924011	*AB2-042 C OP*	*6.68*
924012	*AB2-042 E OP*	*5.32*
924071	*AB2-051 C OP*	*39.06*
924072	*AB2-051 E OP*	*6.07*
924381	*AB2-087 C*	*0.19*
924382	*AB2-087 E*	*0.09*
924501	*AB2-099 C*	*0.2*
924502	*AB2-099 E*	*0.09*
924511	*AB2-100 C*	*5.58*
924512	*AB2-100 E*	*2.75*
924761	*AB2-128 C*	*4.78*
924762	*AB2-128 E*	*1.88*
924811	*AB2-134 C OP*	*8.19*
924812	*AB2-134 E OP*	*10.95*
924931	*AB2-147 C*	*1.18*
924932	*AB2-147 E*	*1.92*
924941	*AB2-149 C OP*	*1.56*
924942	*AB2-149 E OP*	*2.55*
924951	*AB2-150 C OP*	*1.18*

924952	*AB2-150 E OP*	*1.92*
924961	*AB2-152*	*15.85*
925051	*AB2-160 C OP*	*4.19*
925052	*AB2-160 E OP*	*6.83*
925061	*AB2-161 C OP*	*1.99*
925062	*AB2-161 E OP*	*3.24*
925121	*AB2-169 C OP*	*2.02*
925122	*AB2-169 E OP*	*1.81*
925141	*AB2-171 C OP*	*1.75*
925142	*AB2-171 E OP*	*2.85*
925171	*AB2-174 C OP*	*3.17*
925172	*AB2-174 E OP*	*2.87*
925281	*AB2-186 C*	*0.18*
925282	*AB2-186 E*	*0.08*
925291	*AB2-188 C OP*	*0.73*
925292	*AB2-188 E OP*	*0.33*
925331	*AB2-190 C*	*14.6*
925332	*AB2-190 E*	*3.65*

Appendix 3

(DVP - DVP) The 6CHSTF B-6MESSER 230 kV line (from bus 314287 to bus 314228 ckt 1) loads from 140.3% to 140.76% (**DC power flow**) of its emergency rating (399 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 4.11 MW to the thermal violation.

CONTINGENCY 'LN 208-259'
OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1 /* 6CHSTF A 230.00 - 6IRON208 230.00
OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1 /* 6IRON208 230.00 - 6SOUWEST 230.00
OPEN BUS 314309 /* ISLAND
OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00
END

Bus Number	*Bus Name*	*Full Contribution*
315065	*1CHESTF6*	*37.23*
315077	*1HOPHCF1*	*2.16*
315078	*1HOPHCF2*	*2.16*
315079	*1HOPHCF3*	*2.16*
315080	*1HOPHCF4*	*3.27*
315076	*1HOPPOLC*	*1.84*
315073	*1STONECA*	*5.67*
314784	*1WEYRHSB*	*0.66*
314314	*3LOCKS*	*1.04*
314539	*3UNCAMP*	*0.86*
314541	*3WATKINS*	*0.25*
314229	*6MT R221*	*-0.33*
292791	*U1-032 E*	*2.95*
900672	*V4-068 E*	*0.11*
901082	*W1-029E*	*13.49*
902241	*W2-022 C OP1*	*0.49*
902242	*W2-022 E OP1*	*3.31*
903520	*W3-066 C1OP1*	*0.98*
903531	*W3-066 C2OP1*	*0.98*
903522	*W3-066 E1OP1*	*6.54*
903532	*W3-066 E2OP1*	*6.54*
907092	*X1-038 E*	*2.15*
913392	*Y1-086 E*	*0.63*
914231	*Y2-077*	*0.87*

916042	*Z1-036 E*	*13.59*
916192	*Z1-068 E*	*0.53*
917122	*Z2-027 E*	*0.31*
917332	*Z2-043 E*	*0.34*
917342	*Z2-044 E*	*0.18*
917592	*Z2-099 E*	*0.16*
921092	*AA1-049 C*	*0.68*
921093	*AA1-049 E*	*0.32*
921162	*AA1-063AC*	*3.19*
921163	*AA1-063AE*	*1.51*
918512	*AA1-065 E OP*	*1.48*
918562	*AA1-072 E*	*0.06*
921532	*AA1-132 C*	*2.1*
921533	*AA1-132 E*	*0.9*
921552	*AA1-134 C*	*2.89*
921553	*AA1-134 E*	*1.24*
921562	*AA1-135 C*	*2.95*
921563	*AA1-135 E*	*1.26*
921572	*AA1-138 C*	*3.*
921573	*AA1-138 E*	*1.29*
921752	*AA2-053 C*	*3.26*
921753	*AA2-053 E*	*1.4*
921762	*AA2-057 C*	*2.35*
921763	*AA2-057 E*	*1.17*
921772	*AA2-059 C*	*0.72*
921773	*AA2-059 E*	*0.33*
921862	*AA2-068 C*	*0.76*
921863	*AA2-068 E*	*0.35*
920022	*AA2-086 E*	*0.09*
921982	*AA2-088 C*	*2.33*
921983	*AA2-088 E*	*3.81*
922032	*AA2-105 C*	*0.85*
922033	*AA2-105 E*	*0.4*
922072	*AA2-113 C*	*0.85*
922073	*AA2-113 E*	*0.4*
922442	*AA2-165 C*	*0.32*
922443	*AA2-165 E*	*0.15*
922472	*AA2-169 C*	*0.71*
922473	*AA2-169 E*	*0.33*
922512	*AA2-174 C*	*0.15*
922513	*AA2-174 E*	*0.16*
922522	*AA2-177 C*	*6.39*
922523	*AA2-177 E*	*2.74*
922532	*AA2-178 C*	*2.96*
922533	*AA2-178 E*	*1.27*

922602	*AB1-013 C*	*0.89*
922603	*AB1-013 E*	*5.98*
922722	*AB1-053 C*	*0.44*
922723	*AB1-053 E*	*0.25*
922732	*AB1-054 C*	*2.47*
922733	*AB1-054 E*	*1.22*
922882	*AB1-077 C*	*1.01*
922883	*AB1-077 E*	*6.75*
923262	*AB1-132 C OP*	*5.97*
923263	*AB1-132 E OP*	*2.56*
923572	*AB1-173 C OP*	*0.99*
923573	*AB1-173 E OP*	*0.46*
923582	*AB1-173AC OP*	*0.99*
923583	*AB1-173AE OP*	*0.46*
923801	*AB2-015 C OP*	*3.8*
923802	*AB2-015 E OP*	*2.76*
923831	*AB2-022 C*	*0.66*
923832	*AB2-022 E*	*0.35*
923851	*AB2-025 C*	*1.62*
923852	*AB2-025 E*	*0.73*
923911	*AB2-031 C OP*	*0.98*
923912	*AB2-031 E OP*	*0.48*
923981	*AB2-039 C OP*	*5.76*
923982	*AB2-039 E OP*	*4.71*
923991	*AB2-040 C OP*	*3.33*
923992	*AB2-040 E OP*	*2.51*
924011	*AB2-042 C OP*	*6.68*
924012	*AB2-042 E OP*	*5.32*
924071	*AB2-051 C OP*	*39.06*
924072	*AB2-051 E OP*	*6.07*
924381	*AB2-087 C*	*0.19*
924382	*AB2-087 E*	*0.09*
924501	*AB2-099 C*	*0.2*
924502	*AB2-099 E*	*0.09*
924511	*AB2-100 C*	*5.58*
924512	*AB2-100 E*	*2.75*
924761	*AB2-128 C*	*4.78*
924762	*AB2-128 E*	*1.88*
924811	*AB2-134 C OP*	*8.19*
924812	*AB2-134 E OP*	*10.95*
924931	*AB2-147 C*	*1.18*
924932	*AB2-147 E*	*1.92*
924941	*AB2-149 C OP*	*1.56*
924942	*AB2-149 E OP*	*2.55*
924951	*AB2-150 C OP*	*1.18*

924952	*AB2-150 E OP*	*1.92*
924961	*AB2-152*	*15.85*
925051	*AB2-160 C OP*	*4.19*
925052	*AB2-160 E OP*	*6.83*
925061	*AB2-161 C OP*	*1.99*
925062	*AB2-161 E OP*	*3.24*
925121	*AB2-169 C OP*	*2.02*
925122	*AB2-169 E OP*	*1.81*
925141	*AB2-171 C OP*	*1.75*
925142	*AB2-171 E OP*	*2.85*
925171	*AB2-174 C OP*	*3.17*
925172	*AB2-174 E OP*	*2.87*
925281	*AB2-186 C*	*0.18*
925282	*AB2-186 E*	*0.08*
925291	*AB2-188 C OP*	*0.73*
925292	*AB2-188 E OP*	*0.33*
925331	*AB2-190 C*	*14.6*
925332	*AB2-190 E*	*3.65*