Revised
Generation Interconnection
System Impact Study Report

For

PJM Generation Interconnection Request
Queue Position AD2-158

"Old Chapel-Millville 138 kV"

46.5 MW Capacity / 77.5 MW Energy

February 2020
Revision 2

Introduction

This System Impact Study has been prepared in accordance with the PJM Open Access Transmission Tariff, 36.2, as well as the System Impact Study Agreement between **Round Hill Solar, LLC**, the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is **The Potomac Edison Company (Potomac Edison)**.

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: 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 an Interconnection Customer 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 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 System Impact Study is performed.

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.

Update from June 5, 2019 Revised System Impact Study Report

Project cost remains the same. Customer has cleared their Reactive Deficiency with including an additional inverter into their design. "Stability and Reactive Power Requirement for Low Voltage Ride Through" section of this report has been updated to reflect this.

General

The IC has proposed a **77.5 MW** solar generating facility to be located in Charles Town city, Jefferson County, West Virginia. PJM recognizes **46.5 MW** as Capacity Interconnection Rights for this project. The proposed in-service date is **September 1, 2020**. **This study does not imply a Potomac Edison ("Transmission Owner") commitment to this in-service date.**

Point of Interconnection (POI)

The AD2-158 solar project will interconnect with the Potomac Edison transmission system by constructing a new 138 kV three (3) breaker ring bus (Wheatland Substation) and looping the Old Chapel-Millville 138 kV line into the new station. The new Wheatland Substation will be located approximately 5.3 miles from Millville substation. The POI will be at the ITO-owned deadend structure inside the substation yard where the generator lead line terminates.

Attachment 1 shows the one-line diagram for this project. **Attachment 2** provides the proposed location for the point of interconnection. **Attachment 3** provides the site plan.

Cost Summary

The **AD2-158 "Old Chapel-Millville 138 kV"** project will be responsible for the following costs. These costs do not include CIAC Tax Gross-up:

Description	Total Cost
Attachment Facilities	$ 486,500
Direct Connection Work	$ 6,174,600
Non-Direct Connection Work	$ 716,800
New System Upgrades	$ 0
Previously Identified Upgrades	$ 0
Total Costs	**$ 7,377,900**

The transmission and substation costs given above exclude any applicable state or federal taxes. If at a future date Federal CIAC (contribution in aid of construction) taxes are deemed necessary by the IRS for this project, ITO shall be reimbursed by the Interconnection Customer for such taxes.

The required Attachment Facilities, Direct Connection, and Non-Direct Connection work for the interconnection of the AD2-158 generation project to the ITO's Transmission System is detailed in the following sections. The associated one-line with the generation project is shown in **Attachment 1**.

Note that all cost estimates contained in this document were produced without a detailed engineering review and are therefore subject to change. IC will be responsible for the actual cost of the work that is implemented. ITO herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission or subtransmission systems.

Transmission Owner Scope of Work

Attachment Facilities

The total preliminary cost estimate for the Attachment Facilities work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
SCADA: Estimated (1) In-sub fiber run to provide communications and control to Round Hill Solar site. Assumed fiber communications will be ran by developer from Round Hill Solar site to AD1-158 perimeter. Estimated In-sub fiber runs from Millville and Wheatland substation control houses to last structure for OPGW build. Estimated SCADA work at Millville & Double Toll Gate substations to support wavetrap and relay installations. ***PJM Network Upgrade Number n6078***	$ 323,700
Revenue Metering: Revenue metering - engineering oversight of specification and design of new revenue metering that will be installed by power producer (interconnection customer - Round Hill Solar) at their location (AD2-158) and connected to Wheatland substation on the Old Chapel - Millville line. Coordinate FE MV90 access to the new meter. ***PJM Network Upgrade Number n6078***	$ 3,200
Fiber: Estimated 1.0 mi of ADSS Fiber to the Backbone (or next MPLS hop) to support SCADA transport. ***PJM Network Upgrade Number n6078***	$ 115,800
Modify nameplates and drawings related to AD2-158 ***PJM Network Upgrade Number n6078***	$ 43,800
Total Attachment Facility Costs	**$ 486,500**

Direct Connection Cost Estimate

The total preliminary cost estimate for the Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Wheatland Substation- New 3 breaker 138 kV ring bus substation. ***PJM Network Upgrade Number n6079***	$ 4,953,700
Project Management, Commissioning, Environmental, Forestry, Real Estate, and Right of Way ***PJM Network Upgrade Number n6079***	$ 1,220,900
Total Direct Connection Facility Costs	**$ 6,174,600**

Non-Direct Connection Cost Estimate

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Transmission Tie-In to Wheatland Substation: Cut the Double Toll Gate-Millville 138 kV line and install a line loop to the proposed Wheatland Substation. ***PJM Network Upgrade Number n6080***	$ 209,400
Double Toll Gate Substation Relay Upgrade: For the AD2-158 interconnect, install new slip-over CTs (3), wave trap, tuner, coax, and anti-islanding transmitter. Replace line relaying at Double Toll Gate substation. ***PJM Network Upgrade Number n6081***	$ 282,700
Millville Substation Relay Upgrade: Replace line relaying and carrier equipment ***PJM Network Upgrade Number n6082***	$ 224,700
Total Non-Direct Connection Facility Costs	**$ 716,800**

Schedule

Based on the extent of the ITO interconnection work required to support the AD2-158 generation project, it is expected to take a minimum of **18 months** from the date of a fully executed Interconnection Construction Service Agreement. This includes preliminary payment that compensates FE for the first three months of the engineering design work that is related to the Attachment Facilities and Direction Connection work at Wheatland substation. This assumes that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined direct connection and network upgrades, and that PJM will allow all transmission system outages when requested.

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 Attachment O, Appendix 2, Section 8.

Potomac Edison Requirements

The IC will be required to comply with all FE revenue metering requirements for generation interconnection customers which can be found in FE's "Requirements for Transmission Connected Facilities" document located at:

http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx.

Potomac Edison Analysis and Connection Requirements:

Power Flow Analysis

PJM performed a power flow analysis of the transmission system using a 2021 summer peak load flow model and the results were verified by FE. Additionally, FE performed an analysis of its underlying transmission <100 kV system. The [QUEUE] project did not contribute to any overloads on the FE transmission system.

Short Circuit Analysis

PJM performed a short circuit analysis and the results were verified by FE. The connection of [QUEUE] project to the system does not result in any newly overdutied circuit breakers on the FE transmission system and does not have a significant fault current contribution to existing overdutied circuit breakers.

Stability Analysis

PJM performed the stability analysis for this project. See the Network Impact section below for results.

System Protection

The IC must design its Customer Facilities in accordance with all applicable standards, including the standards in FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx. Preliminary Protection requirements will be provided as part of the Facilities Study. Detailed Protection Requirements will be provided once the project enters the construction phase.

The proposed Customer Facilities must be designed in accordance with FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx. In particular, the IC is responsible for the following:

1. The purchase and installation of a fully rated [PRI POI VOLTAGE] kV circuit breaker to protect the [QUEUE] generator lead line. A single circuit breaker must be used to protect this line; if the project has several GSU transformers, the individual GSU transformer breakers cannot be used to protect this line.

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. Compliance with the FE and PJM generator power factor and voltage control requirements.

5. The execution of a back-up service agreement to serve the customer load supplied from the [QUEUE] generation project metering point when the units are out-of-service. This assumes the intent of the IC is to net the generation with the load.

The IC will also be required to meet all PJM, ReliabilityFirst, and NERC reliability criteria and operating procedures for standards compliance. For example, the IC will need to properly locate and report the over and under voltage and over and under frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and ReliabilityFirst audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the FE system.

Power Factor Requirements

The IC shall design its solar powered Customer Facility with the ability to maintain a power factor of at least 0.95 leading (absorbing VARs) to 0.95 lagging (supplying VARs) measured at the high-side of the facility substation transformer(s) connected to the FE transmission system.

Network Impacts

The Queue Project AD2-158 was evaluated as a 77.5 MW (Capacity 46.5 MW) injection into a tap of the Millville – Old Chapel 138 kV line in the APS area. Project AD2-158 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD2-158 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2021

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)

None

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 developer 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.

None

Short Circuit

(Summary of impacted circuit breakers)

None

Stability and Reactive Power Requirement for Low Voltage Ride Through

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

The reactive power capability of AD2-158 meets the 0.95 leading and 0.95 lagging PF requirement at the high side of the main transformer as shown in Table 1 below:

Table 1: AD2-158 Reactive Power Capability Assessment

Generator	MFO (MW)	Required Power Factor Range		Maximum Lagging (MVAr)	Minimum Leading (MVAr)
		Lagging	Leading		
AD2-158	77.5	0.95	0.95		
Total Reactive Power Required				25.5	−25.5
Reactive Power from Generators				**Qmax**	**Qmin**
				22.54	−22.54
Customer Planned Compensation				33	0
Reactive Power Losses				−14.4	−14.4
Total Available MVAR at high side of Main transformer				41.14	−36.94
Deficiency in Reactive Power				Meet	Meet

Affected System Analysis & Mitigation

None

Light Load Analysis - 2021

Not required for this customer.

System Reinforcements

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)

None

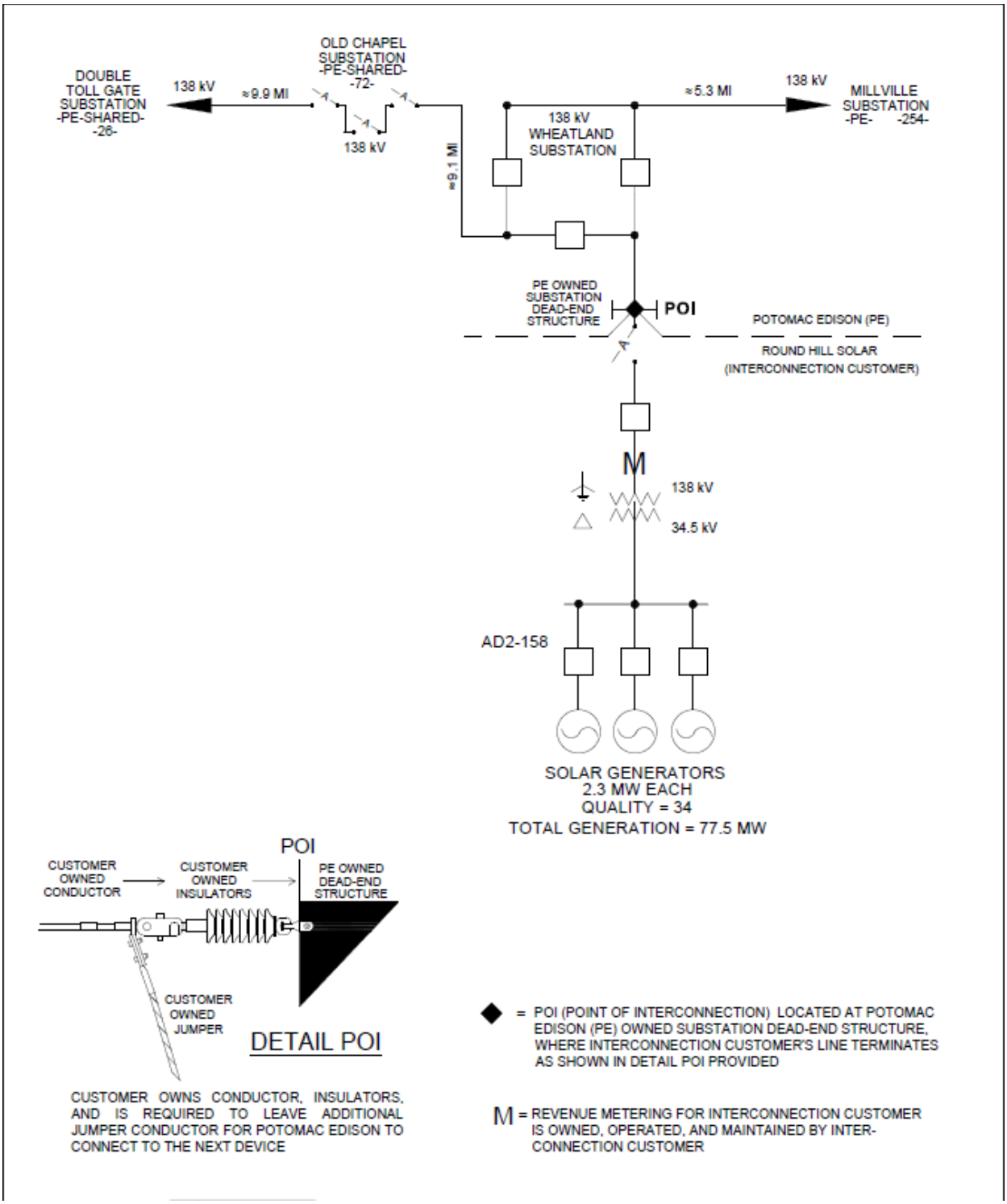
Short Circuit
(Summary form of Cost allocation for breakers will be inserted here if any)

None

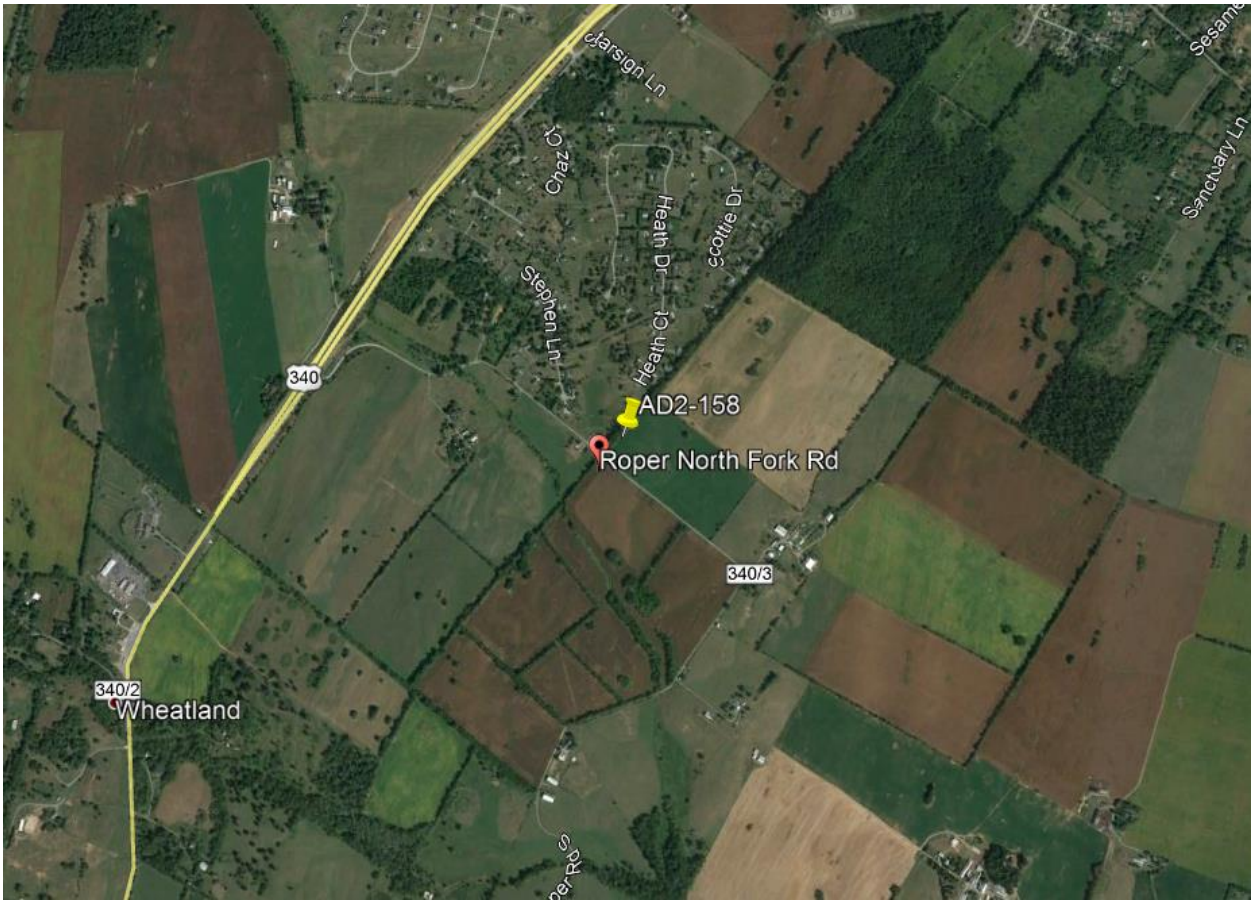
Stability and Reactive Power Requirement
(Results of the dynamic studies should be inserted here)

None

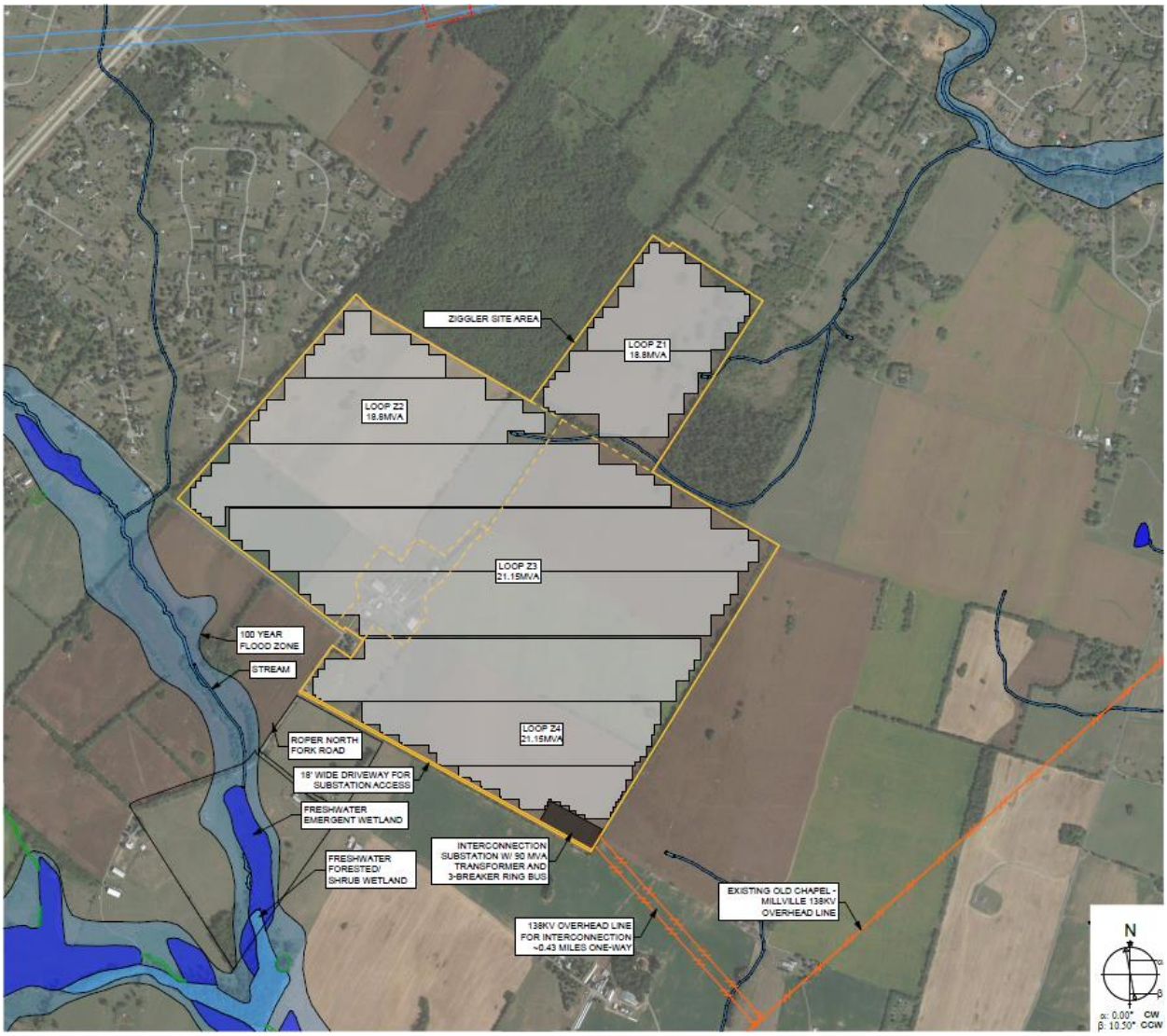
Attachment 1. AD2-158 "Old Chapel-Millville 138 kV"
One Line Diagram



Attachment 2. AD2-158 "Old Chapel-Millville 138 kV"
Project Location



Attachment 3. AD2-158 "Old Chapel-Millville 138 kV"
Site Plan



Attachment 4. AD2-158 "Old Chapel-Millville 138 kV"
Plant Model for Stability Analysis