Generator Interconnection Impact Study Report

Buncombe County, NC
2 x 280 MW Combined Cycle Plant
Queue #368, #369

April 22, 2016
Duke Energy Progress
Transmission Department

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1 PURPOSE

The purpose of this Impact Study is to assess the impacts of generator interconnection requests on the reliability of the Duke Energy Progress (DEP) transmission system with respect to power flow, power factor, stability, and short circuit. Estimates of the cost and time required to interconnect the generation, as well as to resolve the impacts as determined in this analysis, are also included. The DEP internal system analysis consists of an evaluation of the internal DEP transmission system utilizing documented transmission planning criteria. The relevant generator interconnection requests are described in Table 1 below.

Table 1: Interconnection Requests

DEP Generator Interconnection Queue No.	MW	Requested In-Service Date	County	Interconnection Facility
Queue #368	280	12/1/2019	Buncombe County, NC	Asheville SEP 115 kV bus
Queue #369	280	12/1/2019	Buncombe County, NC	Asheville SEP 230 kV bus

2 ASSUMPTIONS

The following Impact study results are from the DEP internal power-flow and dynamic models that reflect specific conditions of the DEP system at points in time consistent with the generator interconnection requests being evaluated. The cases include the most recent information for load, generation, transmission, interchange, and other pertinent data necessary for analysis. Future years may include transmission, generation, and interchange modifications that are not budgeted and for which no firm commitments have been made. Further, DEP retains the right to make modifications to the modeling cases as needed if additional information is available or if specific scenarios necessitate changes. For the systems surrounding DEP, data is based on the ERAG MMWG model. The suitability of the model for use by others is the sole responsibility of the user. Prior queued generator interconnection requests were considered in this analysis. Additionally, the existing Asheville Coal Units 1 and 2 were assumed to be retired and not included in the study.

The results of this analysis are based on Interconnection Customer's queue requests including generation equipment data provided. If the facility technical data or interconnection points to the transmission system change, the results of this analysis may need to be reevaluated.

This study was based on the following assumptions:

- CUSTOMER will construct, own and operate the electrical infrastructure that will connect their generation to DEP's facilities, including any step up transformers and lines from the generators, but excluding the circuit breaker in the new breaker station where applicable.

3 RESULTS

3.1 Power-flow Analysis Results

Facilities that may require upgrade within the first three to five years following the in-service date are identified. Based on projected load growth on the DEP transmission system, facilities of concern are those with post-contingency loadings of 95% or greater of their thermal rating and low voltage of 92% and below, for the requested in-service year or the in-service year of a higher queued request. The identification of these facilities is crucial due to the construction lead times necessary for certain system upgrades. This process will ensure that appropriate focus is given to these problem areas to investigate whether construction of upgrade projects is achievable to accommodate the requested interconnection service.

Contingency analysis study results show that interconnection of these generation facilities requires the following network upgrades.

To add the proposed Asheville CC plant and maintain required import capability, the following power flow related upgrades are required:

Upgrades at Asheville SEP site

Equipment	Action	In Service By Date
Asheville 230/115 transformers	Replace with 448 MVA banks	12/1/2019
Bus Tie Breakers (CB12 and 13) and associated equipment connecting Asheville SEP 115 West and CT buses	Upgrade to 3000A, 63kA, IPO	12/1/2019
Bus Tie Breakers (CB 14 and 18) and associated equipment connecting Asheville SEP 115 East and CT buses	Upgrade to 3000A, 63kA, IPO	12/1/2019
Bus Differential protection on all 230 and 115 kV buses at Asheville SEP	Install redundant bus differential protection	12/1/2019
Asheville 230 kV Capacitor	Add new 72 Mvar Capacitor	12/1/2019
Asheville 115 kV North Tie line	Reconductor	12/1/2019
Asheville 115 kV South Tie line	Reconductor	12/1/2019

Upgrades at Other Substations

Equipment	Action	In Service By Date
Canton end of Canton-Pisgah 115 kV line	Upgrade switches, wave trap, CT ratio to 2000A	12/1/2019
Pisgah end of Canton-Pisgah 115 kV line	Upgrade wave trap (and other equipment, if any) to 2000A	12/1/2019
Pisgah 115/100 kV transformers	Replace with 2x150 MVA and 150 MVA spare (will also be spare for other 115/100kV transformers)	12/1/2019
Pisgah-Shiloh 230kV double circuit outage	Add a -50/+150 Mvar SVC at Cane River 230kV and convert to a four-breaker ring bus	12/1/2019
Enka 230/115 Transformer	Increase rating or install 2nd bank	12/1/2021

3.2 Stability Analysis Results

A stability analysis was performed to determine the impact of the proposed combined cycle generation additions on the DEP transmission system and other nearby generation. The analysis considered two 1-on-1 combined cycle groups, one connected to the Asheville Plant 230 kV switchyard and one connected to the 115 kV switchyard as shown in Figure 1. The combustion turbine units (CTs) were modeled as 225 MVA, 18 kV, 0.85 power factor generators with a 185 MW gross full load output. The steam turbine units (STs) were modeled as 120 MVA, 13.8 kV, 0.85 power factor generators with a 103 MW gross full load output. The inertia constant (H) for the CTs and STs are 5.063 and 6.766 kW-sec/kVA, respectively. As discussed with the Customer, the generator step up transformers were modeled as typical GSUs with an 8% impedance on their own naturally-cooled MVA base. All relevant prior-queued requests and existing generation (except for Asheville Coal Units 1 and 2) were modeled and assumed to be operating at full output.

A representative set of faults were simulated, using the plant configuration as shown in Figure 1, to determine if there would be any adverse impact to the transmission system as a result of the proposed generation. The stability study results indicate that the 115 kV line, 115/230 kV transformer, and bus tie circuit breakers will need to be replaced with independent pole operator (IPO) circuit breakers to maintain an adequate stability margin for the proposed new units and the existing simple cycle CTs at Asheville Plant. Additionally, the line circuit breakers in the Asheville Plant 230 kV switchyard will need to be IPO breakers to maintain an adequate stability margin. Figure 1 shows the required breaker replacements necessary to address thermal, stability, and short circuit concerns.

Prolonged oscillations following system disturbances on the DEP Transmission System can occur under certain system conditions due to the minimal natural damping available. The installation of power system stabilizers (PSS) on the proposed generation is required to mitigate these oscillations. Therefore, the Customer will need to include a power system stabilizer with the excitation systems for all four proposed generating units. The PSS for each CT will be required to be enabled. This will require a tuning study and commissioning of the PSS for the each CT prior to commercial operation. For each ST, the PSS would be disabled until needed in the future, so no tuning study or commissioning would be required initially. The installation of power system stabilizers for this new generation is consistent with the SERC Power System Stabilizer Guideline.

The results of the stability analysis are based on Customer provided generation equipment data and location. Also, the prudent use of engineering assumptions and typical values for some data were used. If the units' technical data or interconnection points to the transmission system changes, the results of this analysis may need to be reevaluated.

3.3 Short Circuit Analysis Results

A short circuit analysis was performed to assess the impact of the proposed solar generation addition on transmission system equipment capabilities. The analysis results indicate that several circuit breakers in the Asheville Plant 115 kV switchyard will need to be replaced to maintain adequate short circuit interrupting capability margin. Note that a number of these breakers had to be replaced based on either the power flow analysis results (e.g., due to the breaker continuous current rating) or the stability analysis results (e.g., due to the need for IPO type breakers). The short circuit driven circuit breaker replacements are included in Figure 1.

The results of the short circuit analysis are based on Customer provided generation equipment data and location. Also, the prudent use of engineering assumptions and typical values for some data were used. If the units' technical data or interconnection points to the transmission system changes, the results of this analysis may need to be reevaluated.

3.4 Power Factor Requirements

DEP's Large Generator Interconnection Procedure (LGIP) requires the proposed generation to be capable of delivering the power to the Point of Interconnection (POI) at a 0.95 lagging power factor. For analysis of the power factor requirement, the Customer-supplied data regarding generator capabilities and transformer impedances were used. The results of the analysis indicate that the proposed plant **DOES meet** the 0.95 lagging power factor requirement at the POI for the requested MW delivery levels.

3.5 Harmonics Assessment

No harmonic issues are expected with the addition of the proposed synchronous generators.

3.6 Interconnection of Customer's Generation

The point of interconnection for Queue #368 is the Asheville SEP 115 kV switchyard, including a new bay on the West bus and an existing bay on the East bus. The point of interconnection for Queue #369 is the Asheville SEP 230 kV switchyard. The station one-line is provided as Figure 1.

3.7 Estimate of Interconnection and Network Costs

Interconnection Upgrades at Asheville SEP site

- Generator interconnection lines - One 230 kV and two 115 kV lines
- Generator step-up transformers and associated equipment

Cost Estimate - $25 million

Network Upgrades at Asheville SEP site

- Add new bay to Asheville SEP 115kV West bus.
- Replace all 115kV breakers in the Asheville SEP 115kV switchyard.
- Replace all 230kV breakers in the Asheville SEP 230kV switchyard.
- Replace both 336 MVA 230/115kV autotransformers with 448 MVA banks at Asheville SEP, and purchase a third as spare.
- Reconductor both 115kV lines connecting the Asheville SEP 230/115kV autotransformers with the 115kV switchyard.
- Reroute Pisgah 230kV lines to the other side of Asheville SEP 230kV switchyard.
- Add 72 Mvar capacitor to Asheville SEP 230kV switchyard.

Cost Estimate - $30 million

Network Upgrades at Other Substations

- Upgrade ancillary equipment to 2000A at Canton and Pisgah ends of the Canton-Pisgah 115kV line.
- Replace both 100 MVA 115/100kV autotransformers with 150 MVA banks at DEC's Pisgah Forest Tie station, and purchase a third as spare.
- Add a 150 Mvar SVC to Cane River 230kV switchyard, including creating a four-breaker ring bus.
- Add a second 230/115kV autotransformer at Enka 230kV substation, if necessary.

Cost Estimate - $35 million

Total Cost Estimate - $90 million

4 SUMMARY

This Generator Interconnection Impact Study assessed the impact of interconnecting two new 1-on-1 combined cycle generation facilities with requested capabilities of 280 MW each, or 560 MW total. Based on the data provided by the Customer, the requested MW injection is approved pending the upgrades identified in this report. Interconnection and network upgrades on the DEP Transmission System are necessary to accommodate Q368 and Q369.

Current estimates are that the proposed upgrades **CAN** be completed to meet the Customer's requested schedule.

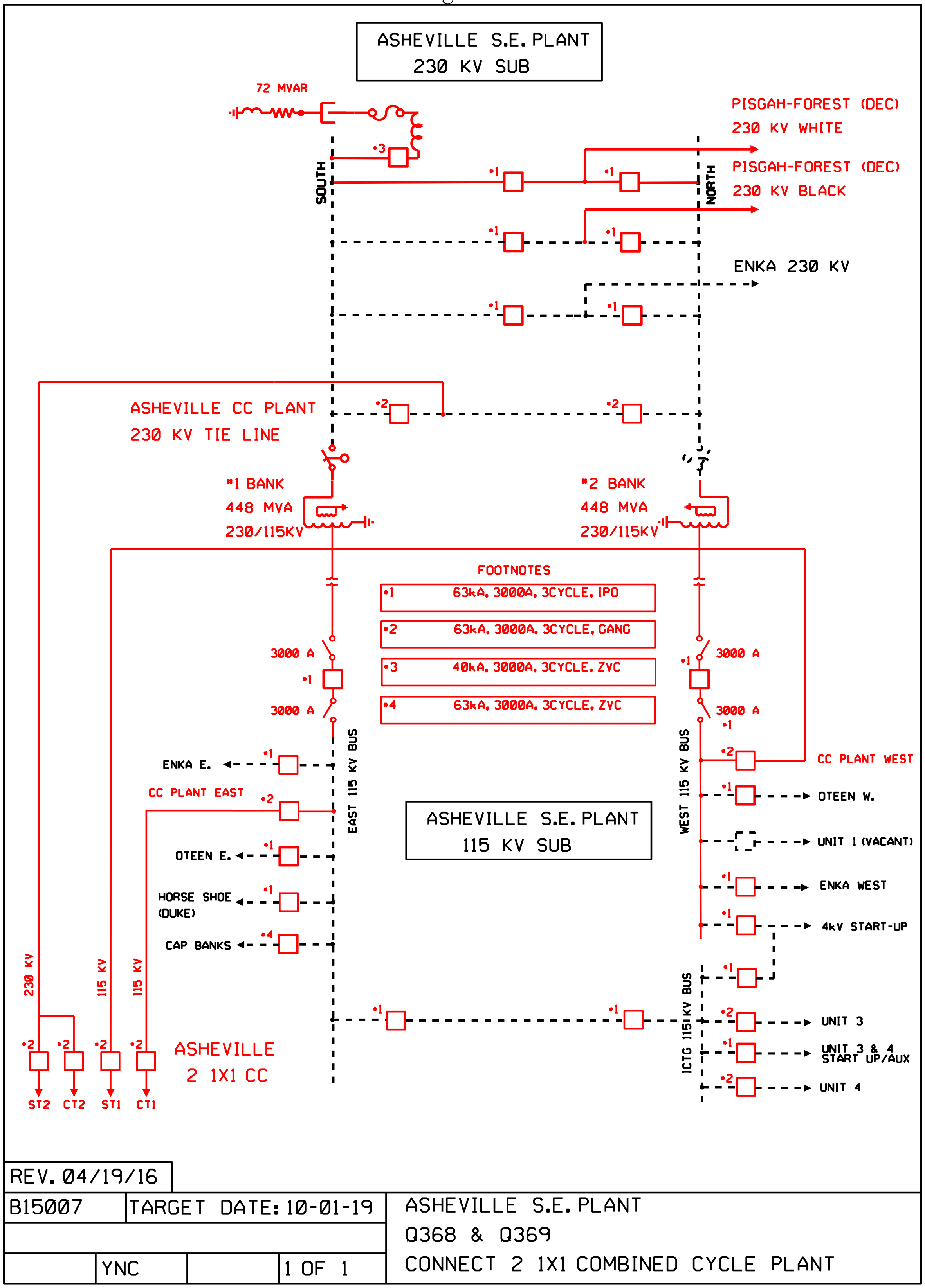
Interconnection Costs	$25,000,000
Network Upgrades - Asheville	$30,000,000
Network Upgrades - Other	$35,000,000
Total Estimate	$90,000,000

Study Completed by: Bill Quaintance
Bill Quaintance, PE, Duke Energy Progress

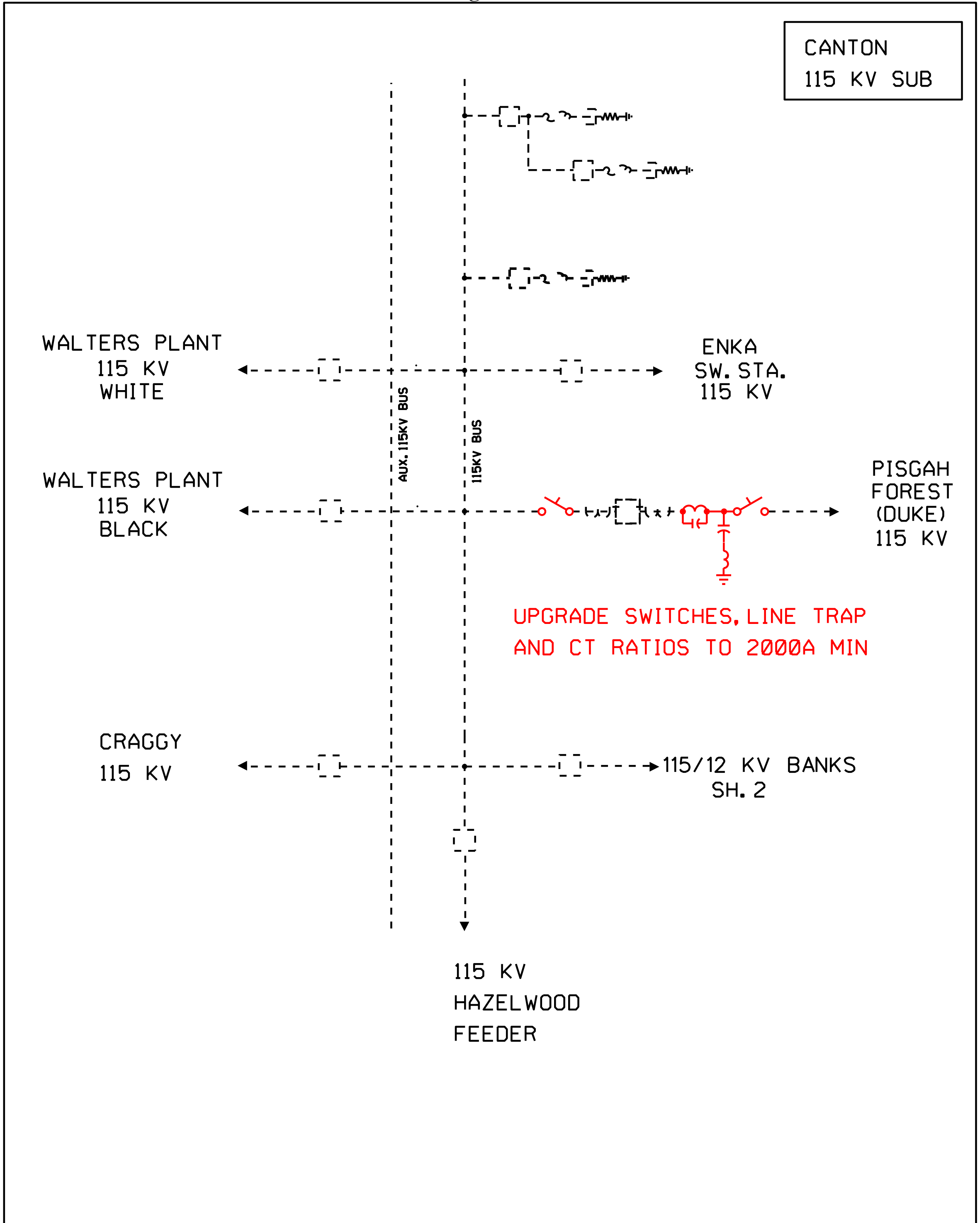
Reviewed by: Mark Byrd
Mark Byrd, PE, Duke Energy Progress

APPENDIX I : FIGURES

-Figure 1-


ASHEVILLE S.E. PLANT
230 KV SUB
72 MVAR
PISGAH-FOREST (DEC)
230 KV WHITE
PISGAH-FOREST (DEC)
230 KV BLACK
SOUTH
NORTH
ENKA 230 KV
ASHEVILLE CC PLANT
230 KV TIE LINE
#1 BANK
448 MVA
230/115KV
#2 BANK
448 MVA
230/115KV
FOOTNOTES
•1 63kA, 3000A, 3CYCLE, IPO
•2 63kA, 3000A, 3CYCLE, GANG
•3 40kA, 3000A, 3CYCLE, ZVC
•4 63kA, 3000A, 3CYCLE, ZVC
3000 A
3000 A
ENKA E.
CC PLANT EAST
OTEEN E.
HORSE SHOE
(DUKE)
CAP BANKS
EAST 115 KV BUS
WEST 115 KV BUS
ASHEVILLE S.E. PLANT
115 KV SUB
CC PLANT WEST
OTEEN W.
UNIT 1 (VACANT)
ENKA WEST
4kV START-UP
ICTG 115 KV BUS
UNIT 3
UNIT 3 & 4
START UP/AUX
UNIT 4
230 KV
115 KV
115 KV
ASHEVILLE
2 1X1 CC
ST2
CT2
ST1
CT1
REV. 04/19/16
B15007
TARGET DATE: 10-01-19
ASHEVILLE S.E. PLANT
Q368 & Q369
CONNECT 2 1X1 COMBINED CYCLE PLANT
YNC
1 OF 1

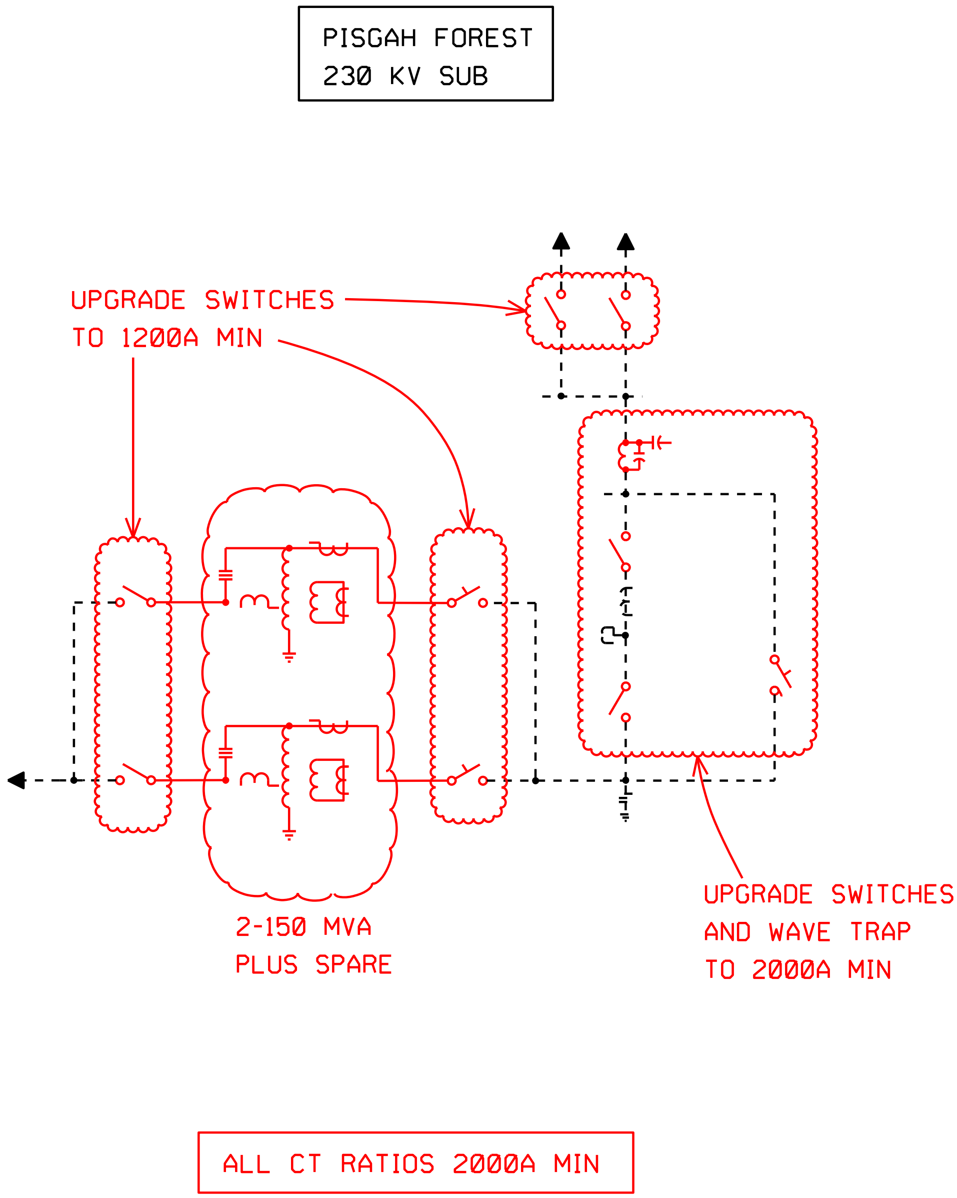
-Figure 2-



REV. 04/21/16

	TARGET DATE: 12-01-19			CANTON SUB, UPGRADE ANCILLARY EQUIPMENT
	KAH		1 OF 1	

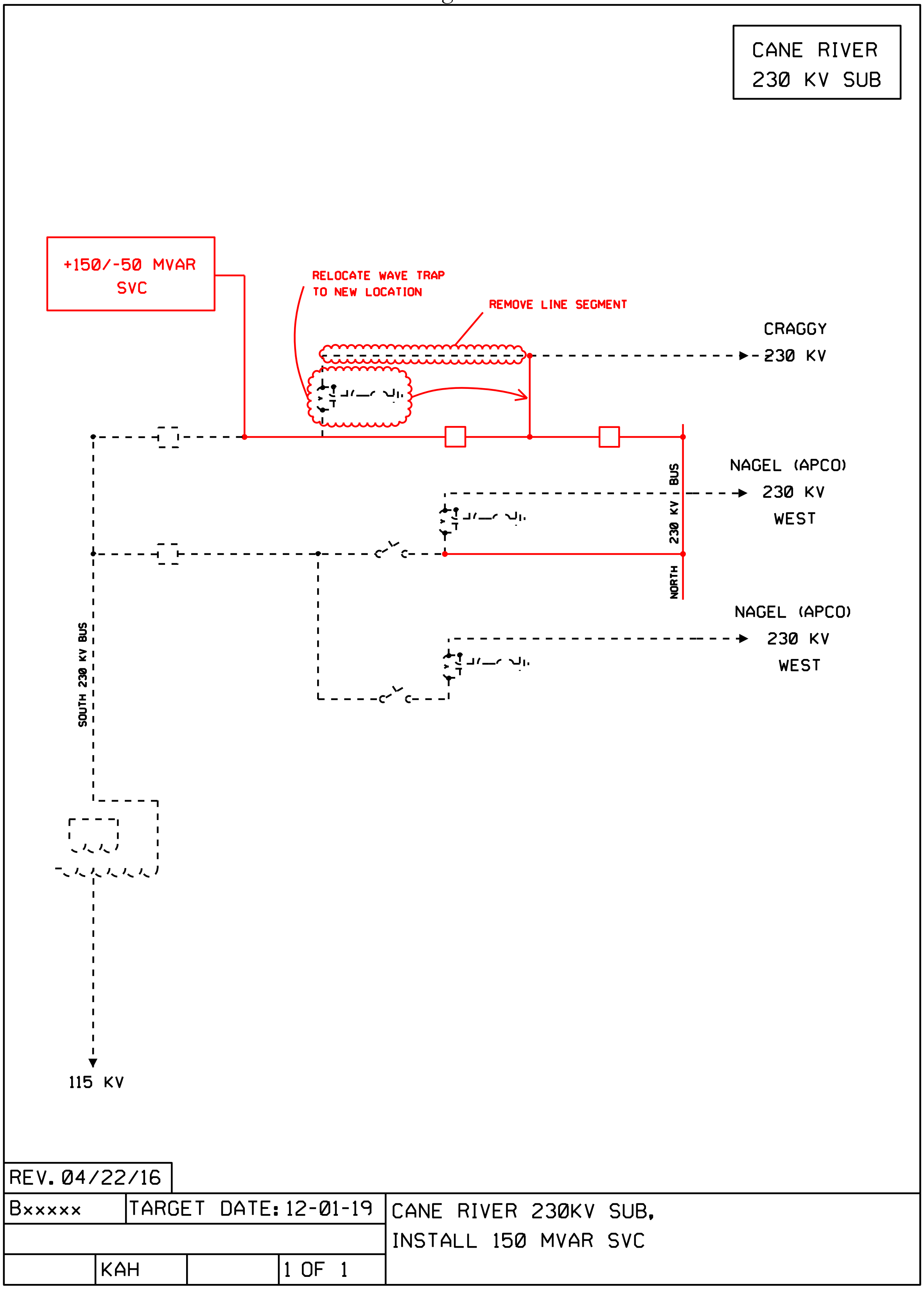
-Figure 3-



REV. 04/21/16

	TARGET DATE: 12-01-19			DPC PISGAH FOREST SUB, UPGRADE ANCILLARY EQUIPMENT
	KAH		1 OF 1	

-Figure 4-


CANE RIVER
230 KV SUB
+150/-50 MVAR
SVC
RELOCATE WAVE TRAP
TO NEW LOCATION
REMOVE LINE SEGMENT
CRAGGY
230 KV
NAGEL (APCO)
230 KV
WEST
NORTH 230 KV BUS
NAGEL (APCO)
230 KV
WEST
SOUTH 230 KV BUS
115 KV
REV. 04/22/16
Bxxxxx
TARGET DATE: 12-01-19
CANE RIVER 230KV SUB,
INSTALL 150 MVAR SVC
KAH
1 OF 1