Generator Interconnection System Impact Study Report

Cumberland County, NC
1235 MW Combined Cycle Plant
Queue #398

June 14, 2018
Duke Energy Progress
Transmission Department

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1 PURPOSE

The purpose of this System Impact Study is to assess the impacts of the 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. This interim report presents only the power flow results. 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 requests are described in Table 1 below.

Table 1: Interconnection Requests

DEP Generator Interconnection Queue No.	MW	Requested In-Service Date	County	Interconnection Facility
398	1235	10/1/2022	Cumberland County, NC	Cumberland 500 kV Substation, 230 kV switchyard

2 ASSUMPTIONS

The following System Impact Study results are from the DEP internal power-flow 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 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.

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 would construct, own and operate the electrical infrastructure that would 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.

All queue requests, as well as nearby existing and prior-queued generation, were modeled and assumed to be operating at full output.

All relevant contingency categories from NERC Standard TPL-001-4 have been analyzed in this study. Contingency analysis study results show that interconnection of these generation facilities **DOES** result in potential thermal overloads on the DEP system. The following facilities will need to be upgraded to accommodate the proposed generation:

Table 2: Network Upgrades

Facility	Sections	Length (mi)	Upgrade	Cost Estimate ($M)	Time To Complete (years)
Cumberland-Erwin 230kV line	New line	35	Construct new line with 6-1590 ACSR conductor	120	5
Cumberland-Clinton 230kV line	New line	35	Construct new line with 3-795 ACSS conductor	130	5
Clinton-Mount Olive 115kV line	Clinton-SREMC Hargrove POD, SREMC Hargrove POD-Faison Highway Industrial	6.9	Uprate line to full 212 deg conductor rating	3.5	4
Lee Sub-Mount Olive 115kV line	Mount Olive-Mount Olive West Tap, Mount Olive Tap-Mount Olive Industrial	3.5	Uprate line to full 212 deg conductor rating	1.8	3
Cumberland-Delco 230kV line	NA	NA	Uprate CT ratio at Cumberland sub terminal from 1200A to 1600A	0.1	2
Harris-Apex US#1 230kV line	New Hill – Apex US1	NA	Uprate 2000A switch to 3000A	0.5	2
Total				**255.9**	**5**

The substation terminations for the two (2) new 230 kV lines are shown on Figures 1, 2, and 3 in Appendix I. These results are dependent on assumptions regarding prior-queued

interconnection requests. If any prior-queued requests drop out of the queue, these results may change.

3.2 Stability Analysis Results

A stability analysis was performed to determine the impact of the proposed generation addition on the DEP transmission system and other nearby generation. All queue requests, as well as nearby existing and prior-queued generation, were modeled and assumed to be operating at full output. The proposed plant was modeled considering the specific layout and number of generators (two 512 MVA gas-fired combustion turbine generators and one 706 MVA heat recovery steam generator). The model included representation of the proposed generator step-up transformers (8% @ 339/452/565 MVA for each CTG and 8% @ 468/624/780 MVA for the STG). The interconnection to the DEP transmission system was via three separate, radial 230kV transmission lines from the power island to the Cumberland 230kV switchyard, one for each generator.

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 three proposed generating units. The PSS for the two CTs 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 the 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.

A representative set of faults was simulated to determine if there would be any adverse impact to the transmission system as a result of the proposed generation. The stability evaluation did not identify any stability related problems. All generators stayed on-line and stable for all simulated faults. If the Customer data changes from that provided, these results will need to be reevaluated.

3.3 Power Factor Requirements

DEP's Large Generator Interconnection Procedure (LGIP) requires the proposed generation to be capable of delivering the requested MW 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 inverter capabilities, collector field configuration, impedances and line charging, and transformer impedances were used. The results of the original analysis indicated that the proposed plant design **DOES MEET** the 0.95 lagging power factor requirement at the POI for the requested MW delivery level. Table 2 below summarizes the approved MW at the POI, along with the MVAR capability at the POI and the capacitor size required to meet the 0.95 lagging power factor requirement at the POI.

Table 3: MW Approved and MVAR Capability Required at the POI and Minimum Capacitor Size Required to Meet Power Factor Requirements

DEP Generator Interconnection Queue No.	MW Requested	MW Approved at POI	MVAR Capability Required at POI
398	1235	1235	406

3.4 Short Circuit Analysis Results

A short circuit analysis was performed to assess the impact of the proposed generation addition on transmission system equipment capabilities. The analysis indicates that some short circuit equipment capabilities will be exceeded as result from the proposed generation additions and associated transmission upgrades. In particular, 5 breakers in the 230kV switchyard of the Cumberland 500kV substation need to be replaced.

Location	Equipment	Count	Upgrade	Cost Estimate ($M)
Cumberland 500kV	230kV Breakers	5	Replacement	2.5

In addition, short circuit increases of at least 3% were tabulated at wholesale customer Points of Delivery (PODs). Wholesale customers have been notified of the impact and their Affected System Studies must be completed before Q398 can be completed.

The results of the short circuit study 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.

3.5 Harmonics Assessment

No harmonics issues are expected for synchronous generators.

3.6 Estimate of Interconnection Cost

Q398

The power island for Q398 is assumed to be less than one (1) mile from the Cumberland 500 kV Substation. Three (3) 230 kV tie lines will be constructed from the power island to the Cumberland 500 kV Substation and terminated on the 230 kV buses at Cumberland. The terminations at Cumberland can be seen on Figure 1. The estimates include the assumption that DEP will acquire and use a portion of the property that the Customer will secure for the addition of the facility.

Tie Lines

Description:	DEP will construct three (3) 230 kV tie lines from the Q398 power island to the Cumberland 500 kV Substation and terminate them on the 230 kV buses at Cumberland (See Figure 1).
Estimated Cost:	$6,500,000

Total Interconnection Cost Estimate: $6,500,000

4 SUMMARY

This Generator Interconnection System Impact Study assesses the impact of interconnecting a new generation facility with requested summer/winter ratings of 1130/1235 MW. Power flow analysis found multiple overloading issues requiring long lead time network upgrades. Stability and power factor analyses found no issues. Short-circuit analyses by Affected Systems are still pending. Interconnection upgrades to the DEP Transmission System are necessary to accommodate Q398.

DEP will require approximately 60 months after a firm written agreement to proceed is obtained from the customer.

The additional cost for telecommunications and metering can be estimated as a monthly charge of $3,000/month per interconnection.

Power-flow	$255,900,000	
Stability	$0	
Short Circuit - Duke Energy	$2,500,000	
Short Circuit - Affected Systems	$tbd	
Interconnection	$6,500,000	
Total Estimate	$264,900,000	(plus any Affected System costs)

Study Completed by: Bill Quaintance

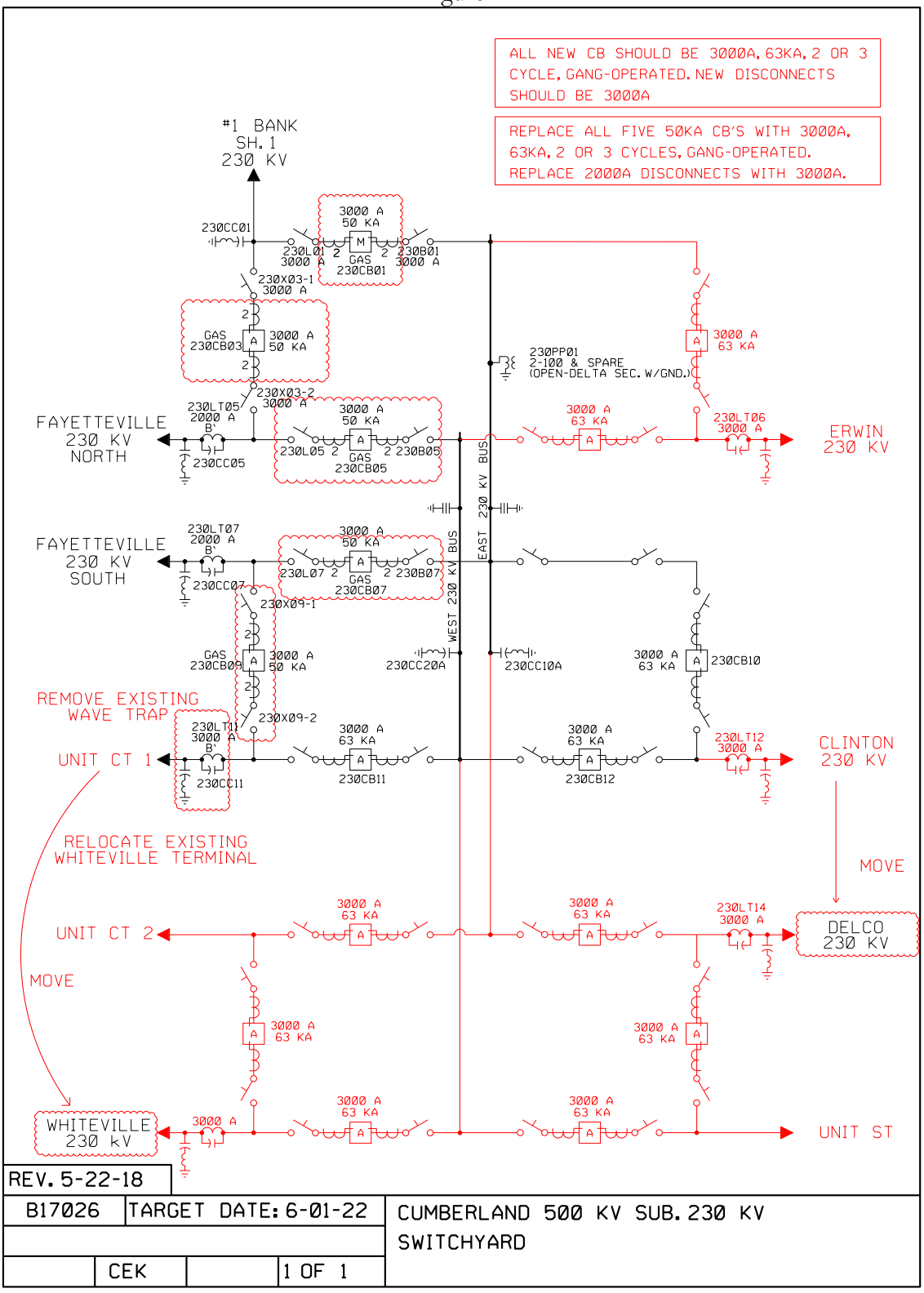
Bill Quaintance, PE, Duke Energy Progress

Reviewed by: Mark Byrd

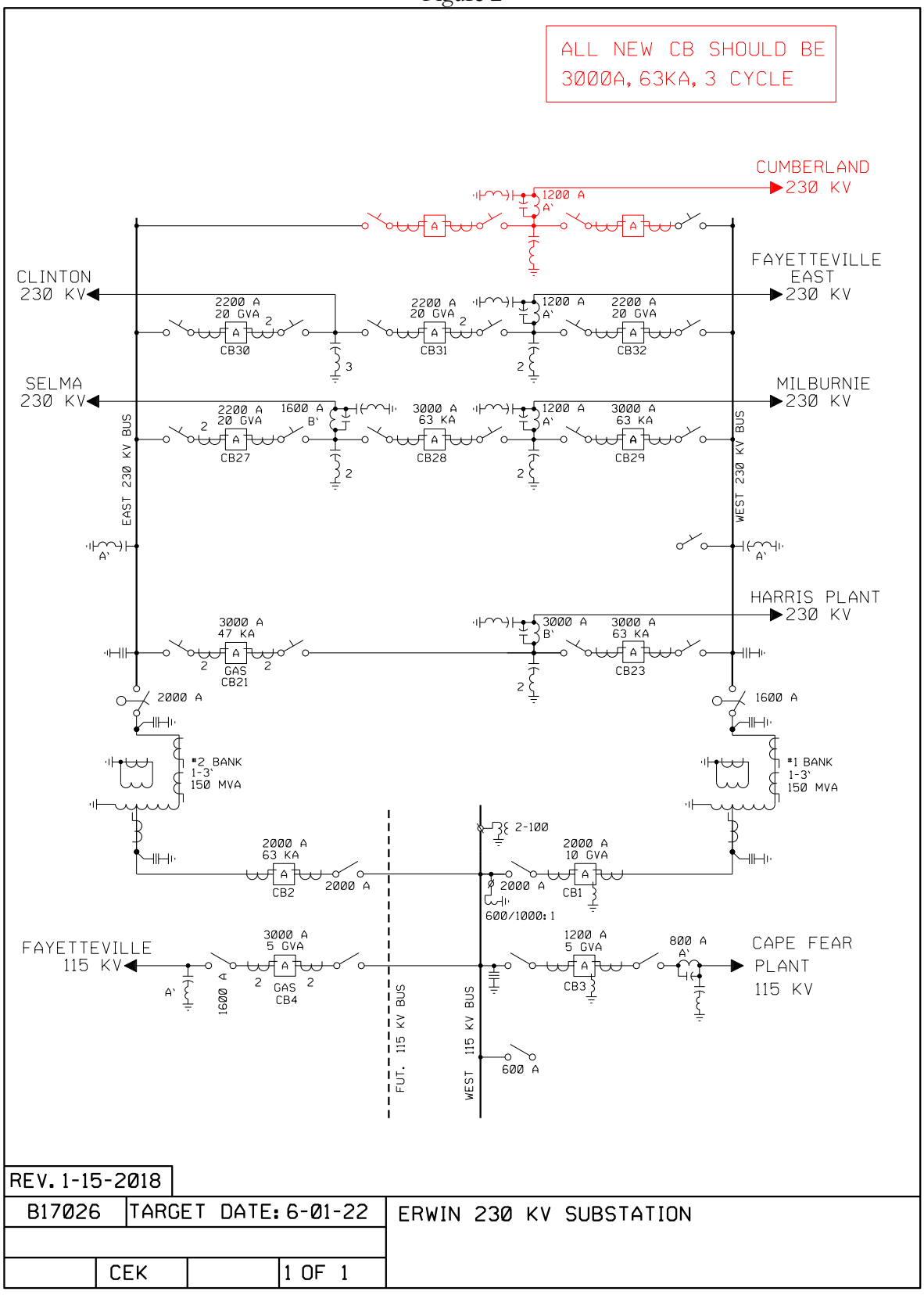
Mark Byrd, PE, Duke Energy Progress

APPENDIX I : FIGURES

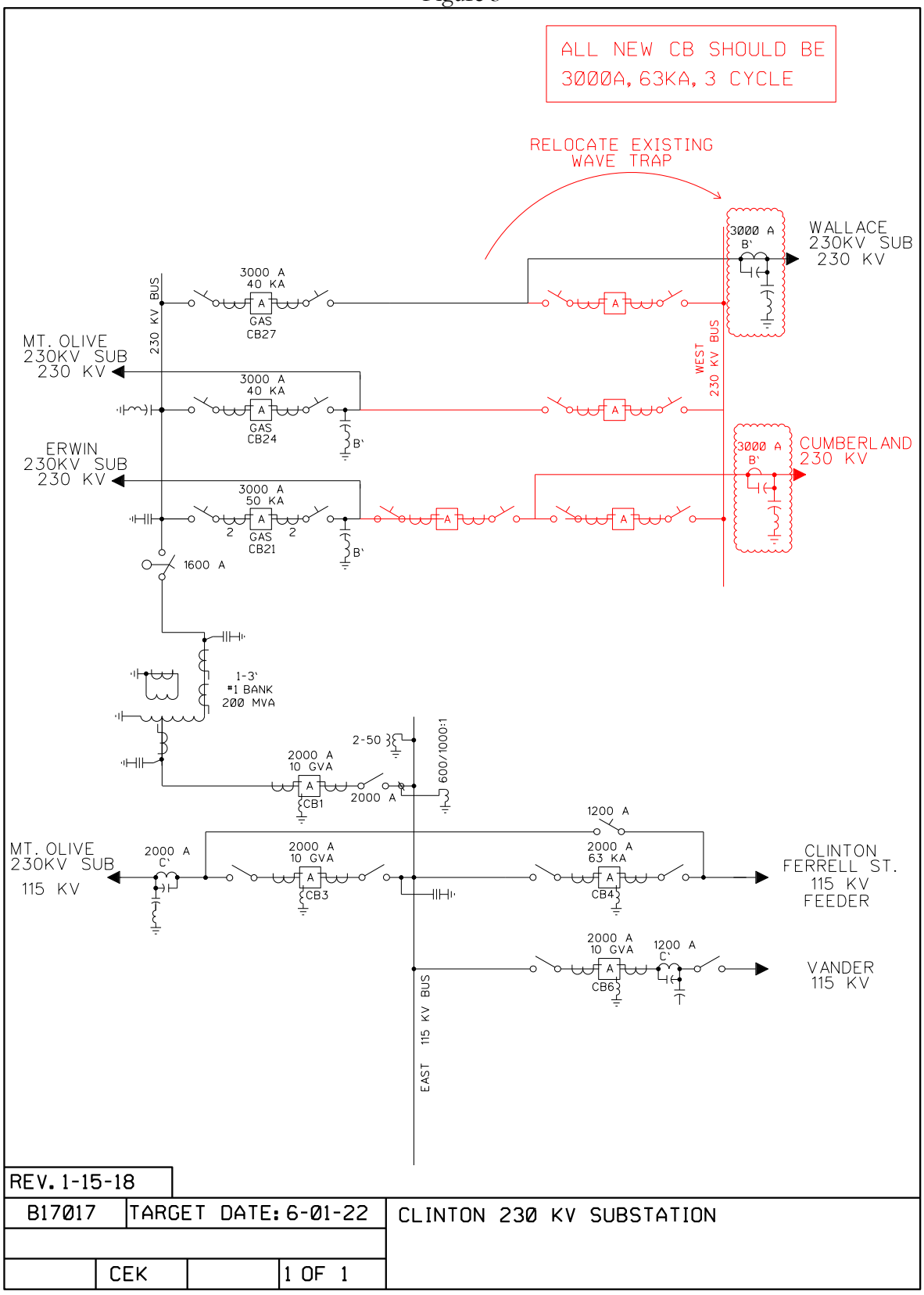
-Figure 1-

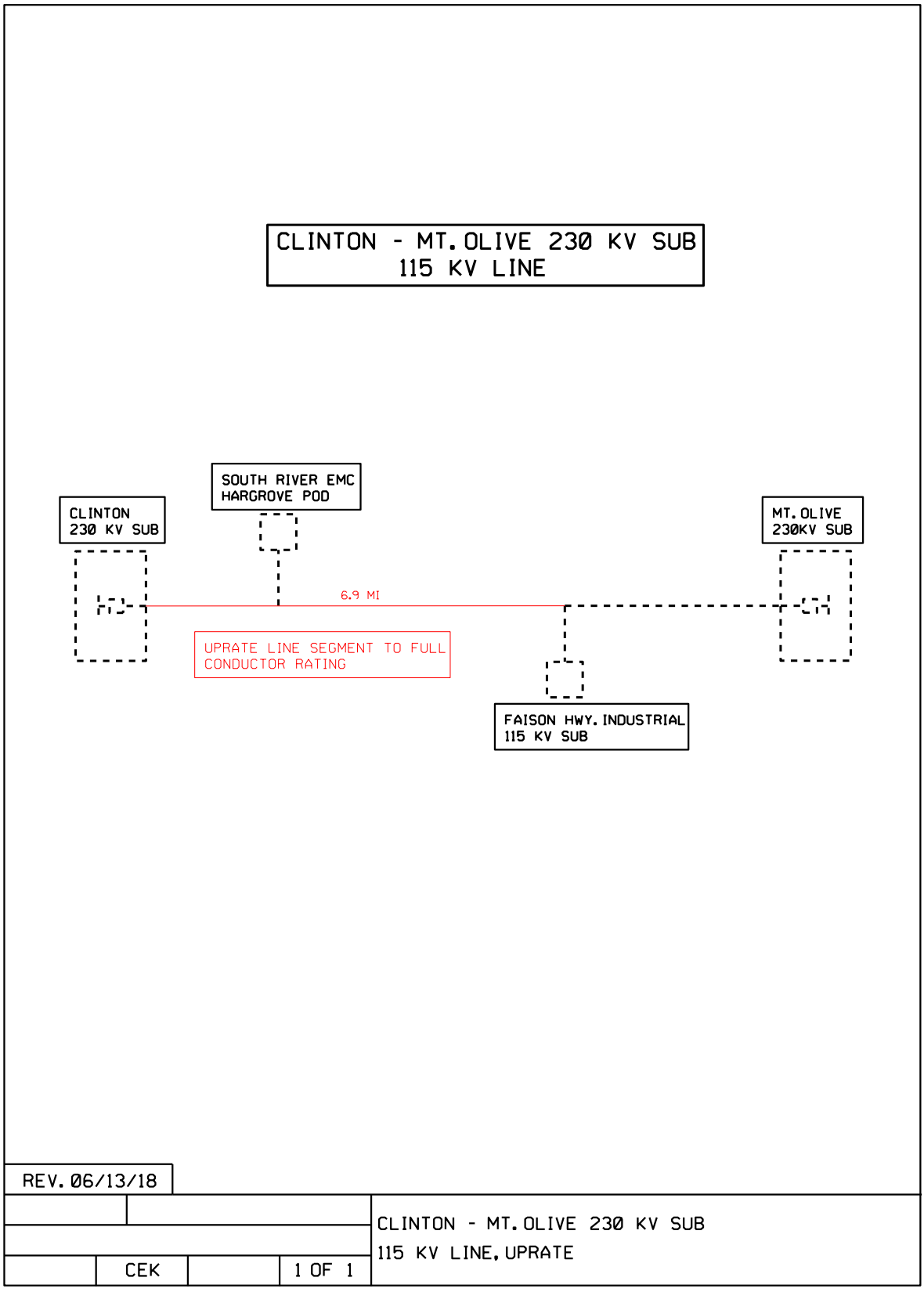


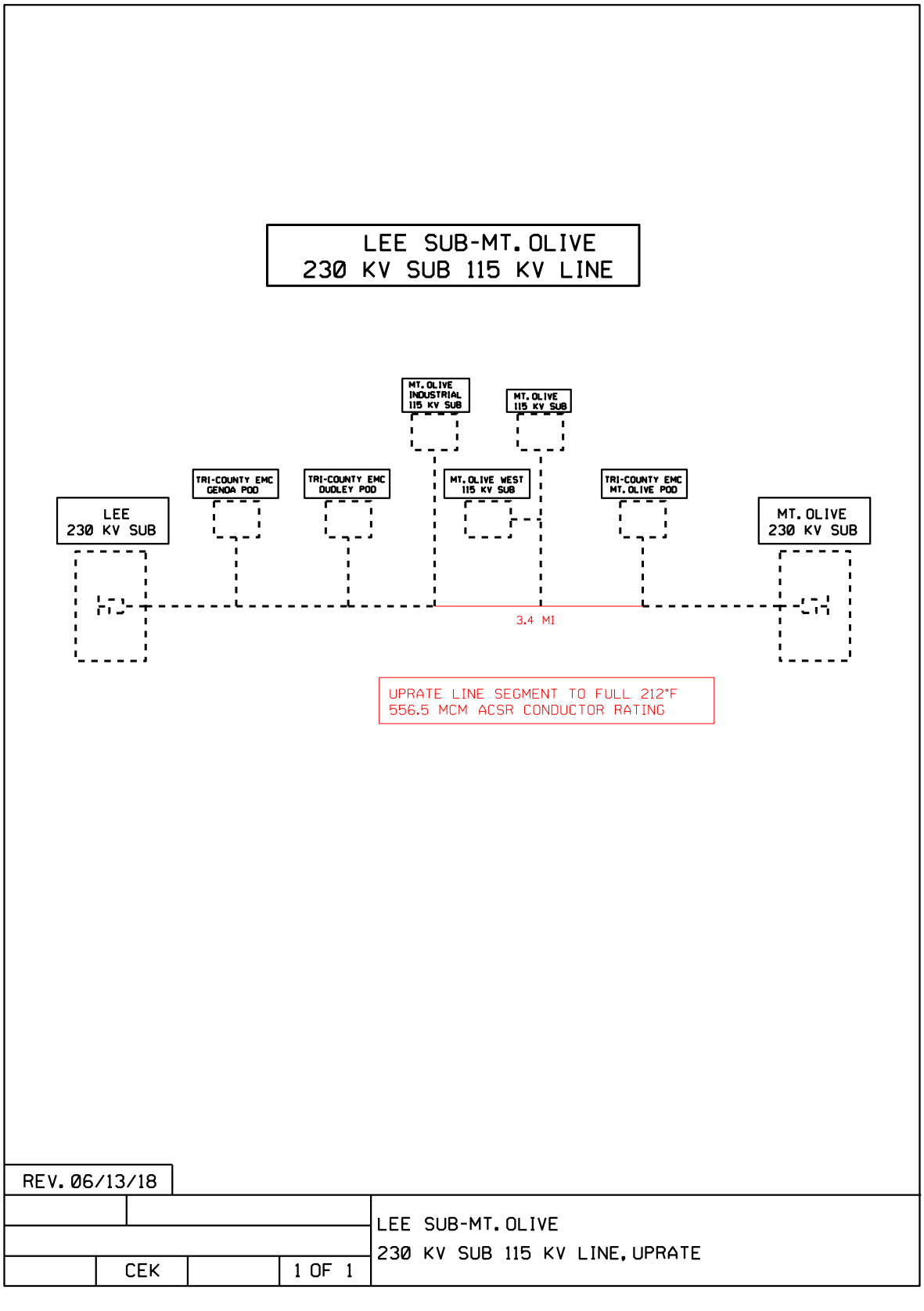
-Figure 2-

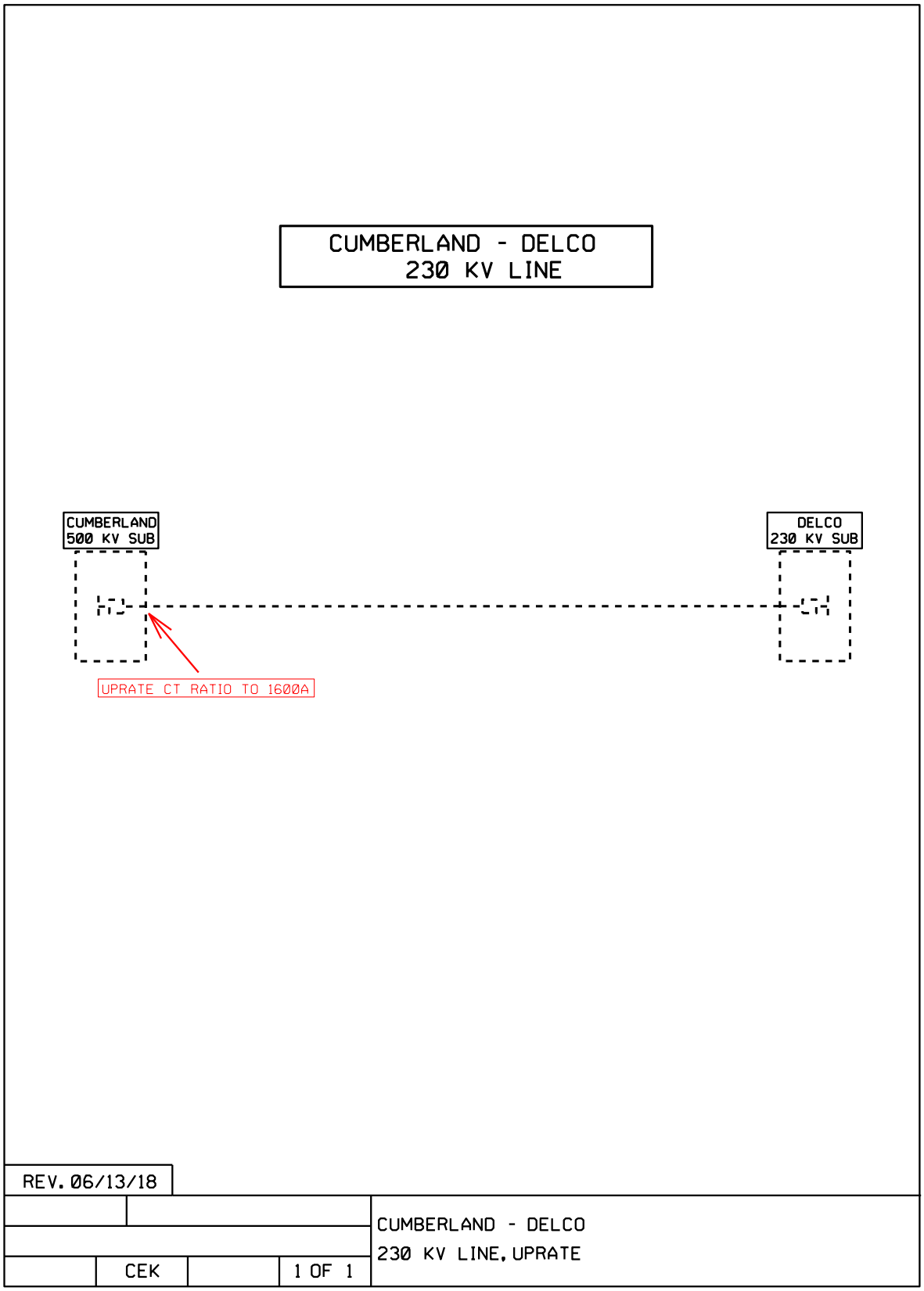

ALL NEW CB SHOULD BE
3000A, 63KA, 3 CYCLE
CUMBERLAND
230 KV
1200 A
CLINTON
230 KV
FAYETTEVILLE
EAST
230 KV
2200 A
20 GVA
CB30
2200 A
20 GVA
CB31
1200 A
2200 A
20 GVA
CB32
SELMA
230 KV
MILBURNIE
230 KV
2200 A
20 GVA
1600 A
CB27
3000 A
63 KA
CB28
1200 A
3000 A
63 KA
CB29
EAST 230 KV BUS
WEST 230 KV BUS
HARRIS PLANT
230 KV
3000 A
47 KA
GAS
CB21
3000 A
3000 A
63 KA
CB23
2000 A
1600 A
#2 BANK
1-3
150 MVA
#1 BANK
1-3
150 MVA
2-100
2000 A
63 KA
CB2
2000 A
2000 A
10 GVA
CB1
600/1000:1
FAYETTEVILLE
115 KV
3000 A
5 GVA
GAS
CB4
1600 A
1200 A
5 GVA
CB3
800 A
CAPE FEAR
PLANT
115 KV
FUT. 115 KV BUS
WEST 115 KV BUS
600 A
REV. 1-15-2018
B17026
TARGET DATE: 6-01-22
ERWIN 230 KV SUBSTATION
CEK
1 OF 1

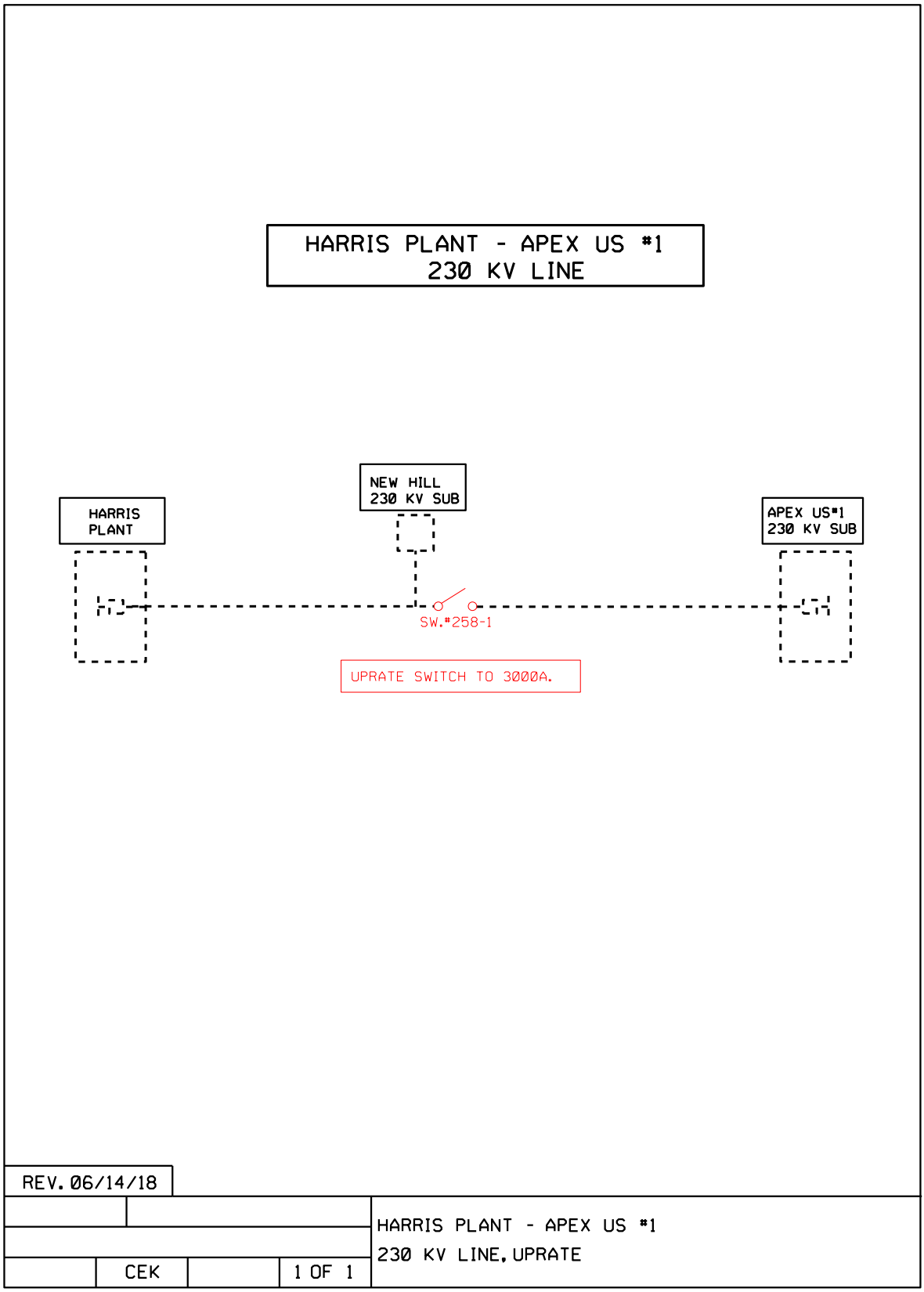
-Figure 3-


ALL NEW CB SHOULD BE
3000A, 63KA, 3 CYCLE
RELOCATE EXISTING
WAVE TRAP
WALLACE
230KV SUB
230 KV
3000 A
B`
230 KV BUS
3000 A
40 KA
GAS
CB27
MT. OLIVE
230KV SUB
230 KV
WEST
230 KV BUS
3000 A
40 KA
GAS
CB24
B`
ERWIN
230KV SUB
230 KV
CUMBERLAND
230 KV
3000 A
50 KA
2
GAS
CB21
2
B`
1600 A
1-3`
#1 BANK
200 MVA
2-50
600/1000:1
2000 A
10 GVA
CB1
2000 A
1200 A
MT. OLIVE
230KV SUB
115 KV
2000 A
C`
2000 A
10 GVA
CB3
2000 A
63 KA
CB4
CLINTON
FERRELL ST.
115 KV
FEEDER
2000 A
10 GVA
CB6
1200 A
C`
VANDER
115 KV
EAST 115 KV BUS
REV. 1-15-18
B17017
TARGET DATE: 6-01-22
CLINTON 230 KV SUBSTATION
CEK
1 OF 1


CLINTON - MT. OLIVE 230 KV SUB
115 KV LINE
SOUTH RIVER EMC
HARGROVE POD
CLINTON
230 KV SUB
MT. OLIVE
230KV SUB
6.9 MI
UPRATE LINE SEGMENT TO FULL
CONDUCTOR RATING
FAISON HWY. INDUSTRIAL
115 KV SUB
REV. 06/13/18
CLINTON - MT. OLIVE 230 KV SUB
115 KV LINE, UPRATE
CEK
1 OF 1


LEE SUB-MT. OLIVE
230 KV SUB 115 KV LINE
MT. OLIVE INDUSTRIAL 115 KV SUB
MT. OLIVE 115 KV SUB
TRI-COUNTY EMC GENOA POD
TRI-COUNTY EMC DUDLEY POD
MT. OLIVE WEST 115 KV SUB
TRI-COUNTY EMC MT. OLIVE POD
LEE 230 KV SUB
MT. OLIVE 230 KV SUB
3.4 MI
UPRATE LINE SEGMENT TO FULL 212°F
556.5 MCM ACSR CONDUCTOR RATING
REV. 06/13/18
CEK
1 OF 1
LEE SUB-MT. OLIVE
230 KV SUB 115 KV LINE, UPRATE


CUMBERLAND - DELCO
230 KV LINE
CUMBERLAND
500 KV SUB
DELCO
230 KV SUB
UPRATE CT RATIO TO 1600A
REV. 06/13/18
CUMBERLAND - DELCO
230 KV LINE, UPRATE
CEK
1 OF 1


HARRIS PLANT - APEX US #1
230 KV LINE
NEW HILL
230 KV SUB
HARRIS
PLANT
APEX US#1
230 KV SUB
SW.#258-1
UPRATE SWITCH TO 3000A.
REV. 06/14/18
HARRIS PLANT - APEX US #1
230 KV LINE, UPRATE
CEK
1 OF 1