MEMPHIS LIGHT, GAS & WATER DIVISION

SYSTEM IMPACT STUDY

MAR 2014
(REVISION 3)

CLEAN LINE ENERGY PARTNERS

SHELBY – 3500 MW

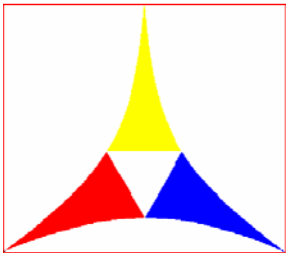

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TABLE OF CONTENTS

CLEAN LINE SYSTEM IMPACT STUDY REV. 3

Disclaimer

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SIGNATURES

CLEAN LINE SYSTEM IMPACT STUDY REV. 3

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EXECUTIVE SUMMARY

The proposed 3500 MW interconnection at Shelby was studied for both MLGW peak and off-peak conditions, using the full generation capacity at Allen Steam Plant. Each case demonstrated a 2016 power flow model which included TVA's proposed system improvements as a result of the interconnection. The cases also include an Entergy system upgrade not evaluated in earlier versions of this system impact study. A fault study was also performed with ASPEN software to compare pre and post interconnection injected fault models using equivalents at all TVA/MLGW delivery points. TVA contracts a third party to run a stability study on their service area. MLGW is included in the TVA system therefore is covered by the TVA stability study.

The MLGW results are as follows:

Shelby:

Contingency #01 Result **Pg #: 7,8,16,17**
Uprate Allen – Holmes transmission line (35 – 47):
[redacted]

Contingency #02 Result **Pg #: 7,9,16,17**
Uprate Allen – Pidgeon transmission line (35 – 82):
[redacted]

Contingency #03 Result **Pg #: 7,10,16-18**
Mitigation Plan – Close Normally-Open Sectionalizing Breaker at Shelby (65)
[redacted]

Contingency #04 Result **Pg #: 7,11-13,16,17,19,20**
Uprate Shelby – NE Gate transmission line #1 (65 – 33):
[redacted]

Uprate Shelby – NE Gate transmission line #2 (65 – 33):
[redacted]

TOTAL impact cost ~ [redacted]

* Colors correspond to contingencies throughout the System Impact document.

Expiration:

A new System Impact Study may be required if a Facility Study is not requested by **June 25, 2014** (90 calendar days from the date of this document's approval)

ACKNOWLEDGEMENTS

MLGW's Bulk Transmission Planning team would like to acknowledge the technical assistance and expertise received from the Transmission Interconnection Planning team at TVA. The collaboration of both teams made the success of this study possible.

PROCESS

As stated above, this System Impact Study (SIS) consists of a power flow analysis and a short circuit analysis. A stability analysis for the MLGW system is included in TVA's impact study.

The purpose of this impact study is to provide a preliminary cost estimate and project time duration that is necessary to rectify the impacts identified in this study. A detailed cost estimate and construction schedule is to be included in the Facility Study, to be performed at the request of the interconnecting party, as outlined in the latest MLGW Facility Connection Requirements document. This System Impact Study is valid for 90 days after the report submission to the interconnecting party. If the Requesting Entity decides to proceed with the proposed interconnection, the Requesting Entity should request a Facility Study before this System Impact Study expires. (See page 2)

All costs presented within the content of this study are present value.

DEFINITION OF SYSTEM IMPACT

MLGW defines a "system impact" as follows:

A loading increase ≥ 5% on transmission lines or transformers	AND	Loading on transmission lines and/or transformers ≥ 100%	For Category A, B and select Category C power flow studies
A total fault current increase ≥ 5%	AND	Any breaker that is susceptible to total fault currents ≥ 95% of rating	In Isc studies
Bus voltage change ≥ 5%	AND	Bus voltage ≤ 0.95 nominal	For Category A, B and select Category C power flow studies
Any new transient stability issues**			In dynamic studies performed by TVA
Any new negative impacts on existing stability issues**			In dynamic studies performed by TVA

Table 1: MLGW System Impact Criteria

These criteria definitions are listed MLGW's most recent Facility Connection Requirements document that is published by MLGW's Bulk Planning Engineering department. This document is also available for evaluation at http://www.mlgw.com/images/content/files/pdf/FacilityConnectionReqmts.pdf. MLGW's Category A, B and C power flow study definitions are defined in MLGW's annual Transmission Reliability Assessment and are available upon request to approved parties.

** -- TVA has performed the associated transient stability studies for MLGW's system for this study, and TVA's report will include any transient stability issues on MLGW's system.

SHELBY STUDY – 3500 MW

METHODOLOGY

SHELBY STUDY – 3500 MW

Prior to this MLGW Revision 3 study, TVA performed an additional power flow system impact study and determined the impacts to their system. TVA has developed solutions to these impacts, which MLGW has included in the power flow cases that were shared by TVA for analysis. MLGW has verified that the TVA cases model accurate data for the MLGW system.

MLGW then studied peak and off-peak case conditions with full generation capability at Allen Steam Plant. The generation level at the TVA-owned Allen Steam Plant has a direct impact on transmission loadings in Shelby County. Under normal conditions, the coal-fired units are running without the gas-fired units; however, there are times when both the coal-fired and gas-fired units are online. Furthermore, MLGW's peak loadings occur in the summer while TVA experiences peak loading conditions in the summer as well as the winter. For this study, TVA and MLGW have chosen to examine what is considered "worst case" scenarios. These cases include the proposed Shelby interconnection in both summer and winter peak cases, with coal-fired and gas-fired units online.

Below are the cases examined for the Shelby Study:

- 2016 Summer base case, Allen coal & gas units
- 2016 Winter base case, Allen coal & gas units
- 2016 Summer with 3500 MW inject at "Shelby", with TVA's improvements, Allen coal & gas units
- 2016 Winter with 3500 MW inject at "Shelby", with TVA's improvements, Allen coal & gas units

TVA provided fault analysis equivalents for cases with and without the proposed 3500 MW Clean Line interconnection. MLGW verified that the TVA cases modeled the MLGW system accurately. MLGW then compared the fault current for each bus within its system, considering the symmetrical and unsymmetrical portions of the fault to determine the impacts. See page 4 for the definition of an impact.

RESULTS

SHELBY STUDY – 3500 MW

[redacted]

[redacted] impact cost of the Shelby 3500 MW interconnect case is estimated to be [redacted]

ONE – LINE: TRANSMISSION LINE

SHELBY STUDY – 3500 MW

Contingency #01: Loss of circuit Allen – Pidgeon (35-82)

[redacted]

[redacted] **Inject Case**

[redacted]

Proposed generation causes the overload of MLGW circuit #35661. Due to a previous system study, circuit #35561 will be uprated to its 100°C rating. No cost will be associated with this uprate.

ONE – LINE: TRANSMISSION LINE

SHELBY STUDY – 3500 MW

Contingency #02: Loss of double circuit tower, Allen – Holmes AND Allen – Horn Lake (35-47, 35-Horn Lake)

2016 Winter Base Case

2016 Winter Inject Case

Proposed generation causes the overload of MLGW circuit #35671. Due to a previous system study this circuit was identified to be uprated to its 100°C rating. The uprate reduces the cost for this overload to $0.

ONE – LINE: TRANSMISSION LINE

SHELBY STUDY – 3500 MW

Contingency #03: N-1-1 Contingency, Shelby#1 Transformer & Fite -- Shelby (65-36)

2016 Summer Base Case

2016 Summer Inject Case

Proposed generation causes the overload of circuit #33629. MLGW will relieve the overload on circuit #33629 by operating the normally-open sectionalizing breaker at Shelby substation.

ONE – LINE: TRANSMISSION LINE

SHELBY STUDY – 3500 MW

Contingency #04: Loss of double circuit towers, Shelby – Fite AND Shelby – Millington (65-36, 65-15)

2016 Summer Base Case

2016 Summer Inject Case

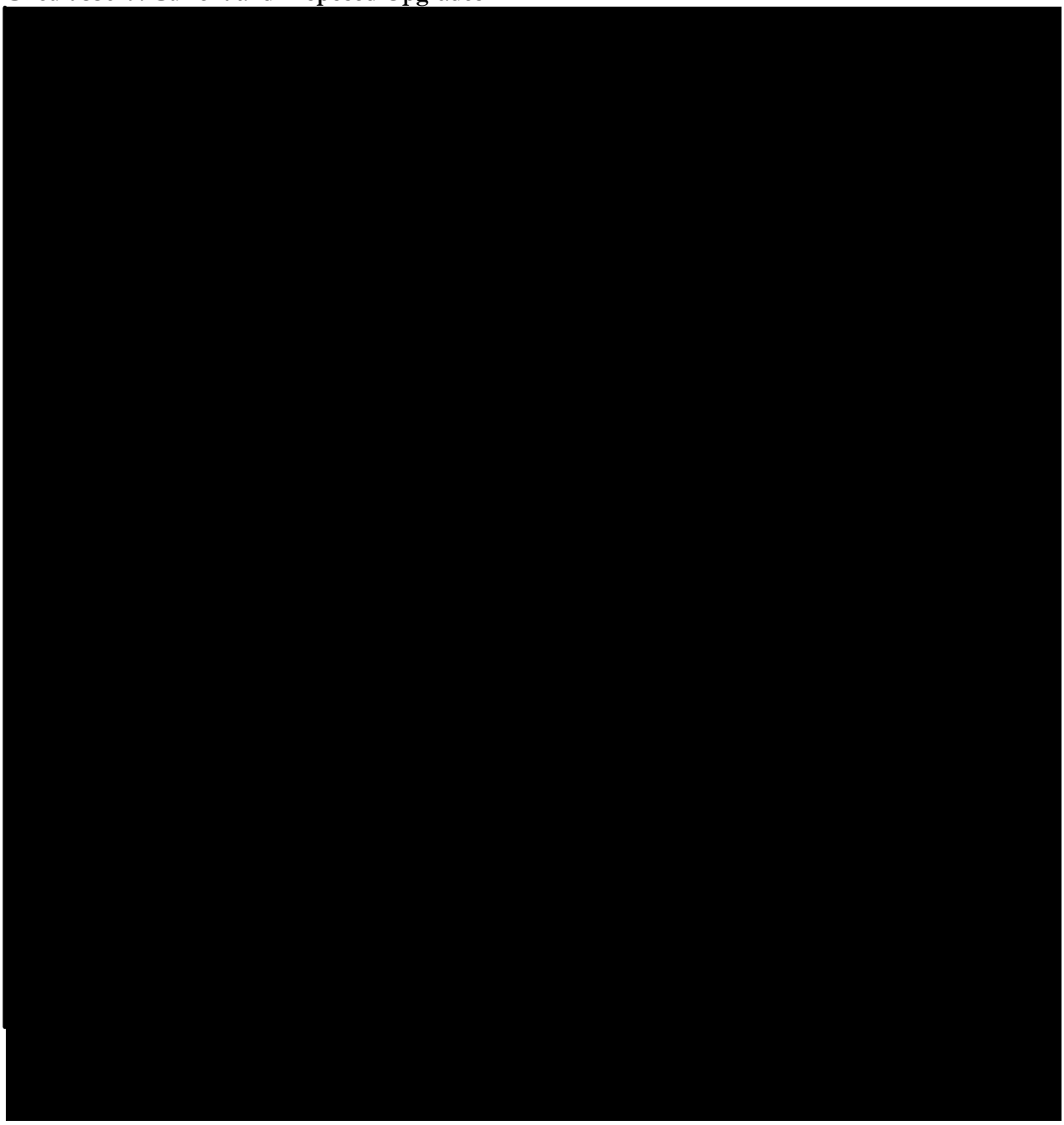
Proposed generation causes the overload of circuits #33629 and #33687. During a previous system study, these lines were identified to be uprated to their 100°C rating. Despite this, the terminal equipment still limits the circuits to ratings that are unacceptable for these conditions. The upgrades and costs are discussed on the following pages.

ONE – LINE: TERMINAL EQUIPMENT

SHELBY STUDY – 3500 MW

For Contingency #04**,** proposed generation causes the bus cable, wave trap, relay and meters at Substations 33 and 65 to need replacing at a total approximate cost of [redacted]. The following figures show the one-line diagrams of current and proposed upgrades.

Circuit 33629: Current and Proposed Upgrades



ONE – LINE: TERMINAL EQUIPMENT

SHELBY STUDY – 3500 MW

Circuit 33687: Current and Proposed Upgrades

ALTERNATIVES CONSIDERED

Alternatives considered in this SIS include the possible addition of a transmission switching station on the MLGW BES. However, as in iteration 1 of this study, that proposal was proved to be cost ineffective.

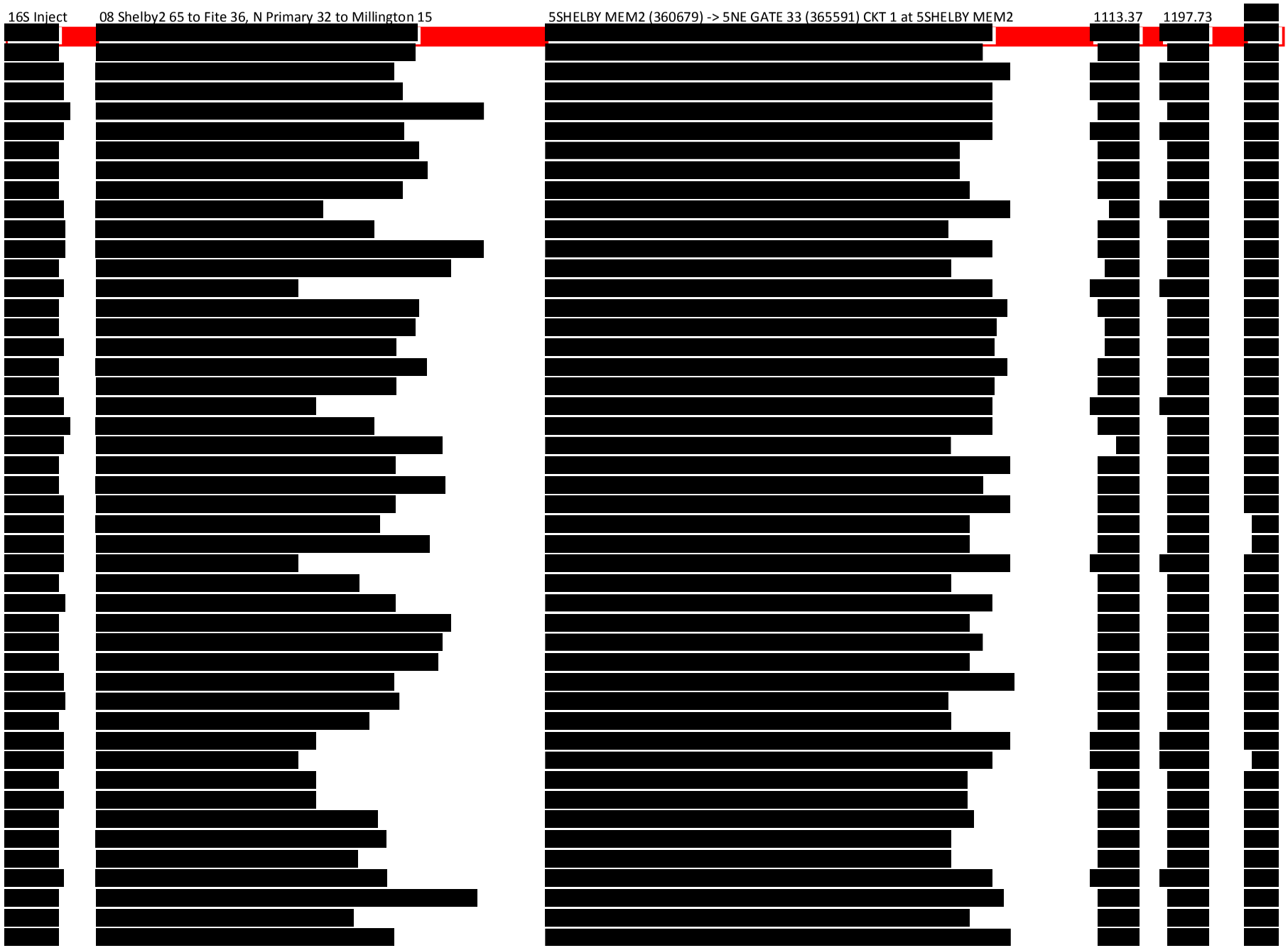
SUPPORTING DOCUMENTATION

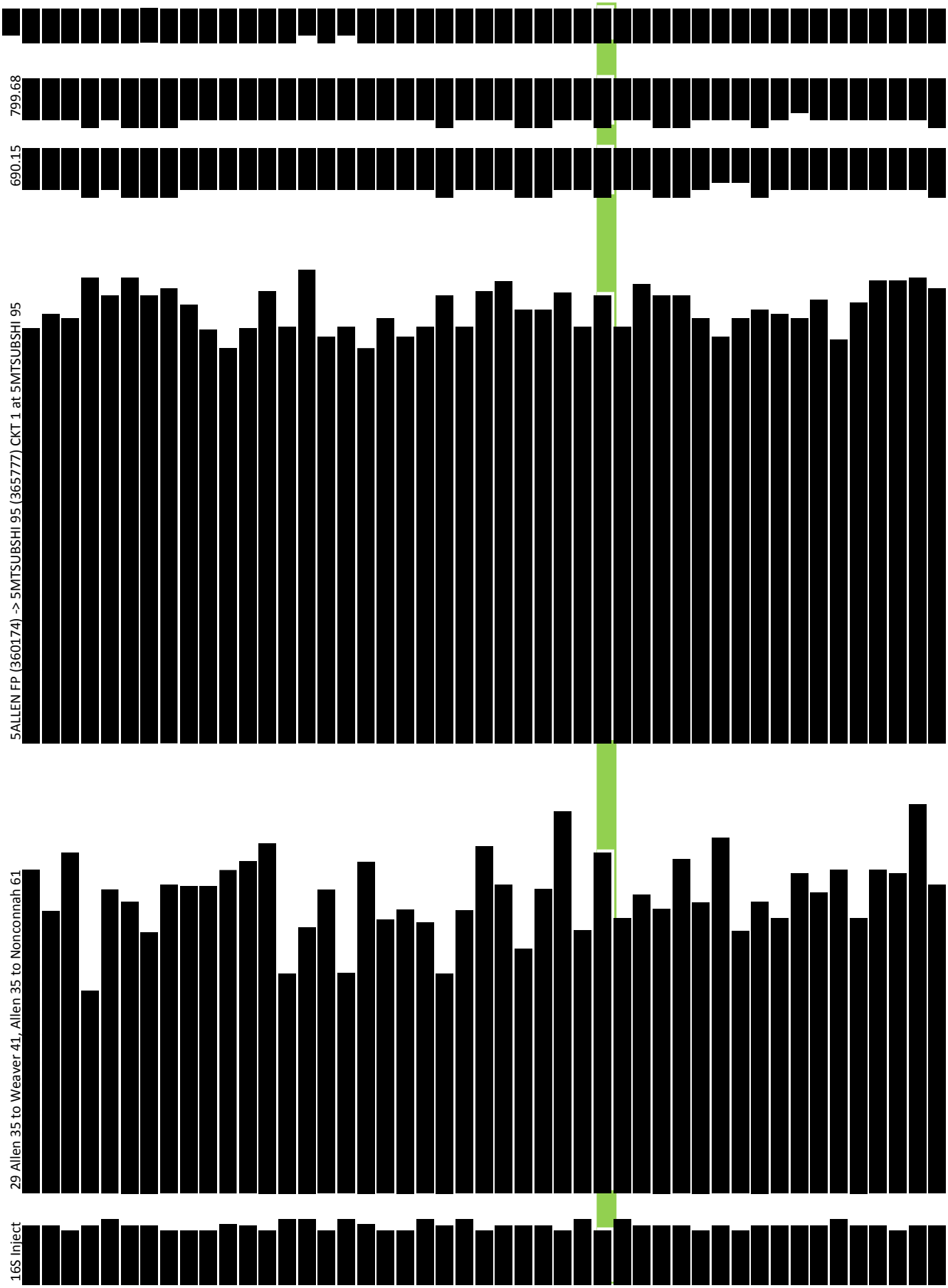
	Contingency				
	Outage of Allen 35 to Pidgeon 82	**Outage of Allen 35 to Horn Lake & Allen 35 to Holmes 47**	**Outage of SHELBY#1 Xfrmr & Shelby2 65 to Fite 36**	**Outage of Shelby 65 to Millington 15 & Shelby 65 to Fite 36**	
Element Overloaded	Allen 35 to Holmes 47	Allen 35 to Pidgeon 82	Shelby2 65 to NE Gate 33	Shelby1 65 to NE Gate 33	Shelby2 65 to NE Gate 33
16 Summer Base Case			[redacted]	[redacted]	[redacted]
16 Summer Inject Case			[redacted]	[redacted]	[redacted]
16 Winter Base Case	[redacted]	[redacted]			
16 Winter Inject Case	[redacted]	[redacted]			

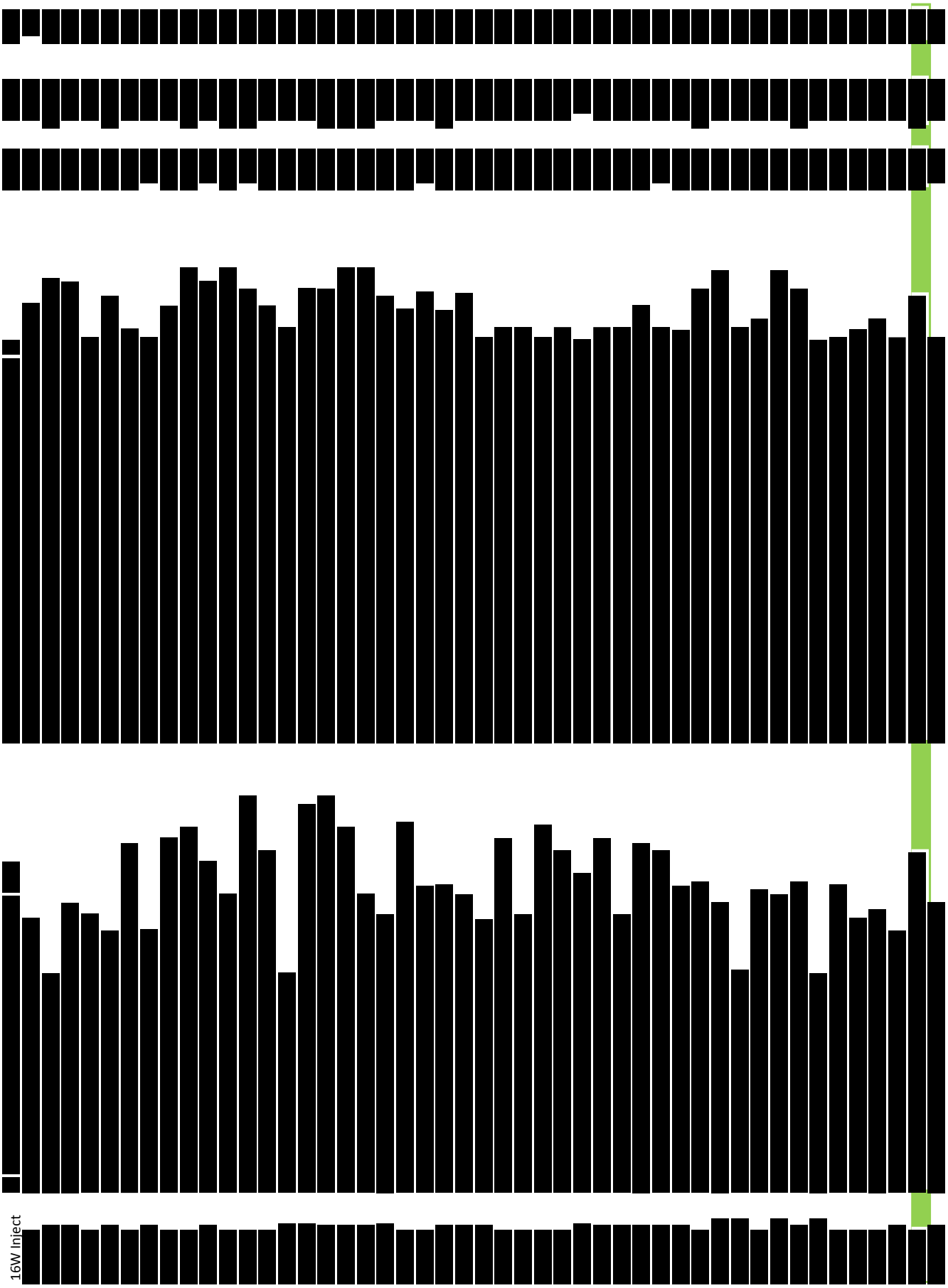
Colors correspond to outage records on next page

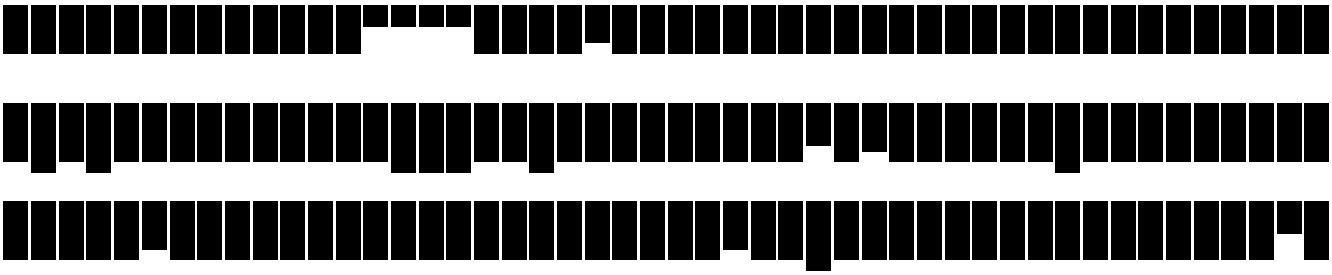
[redacted] **Outage Summary -- Shows Results > 80%**

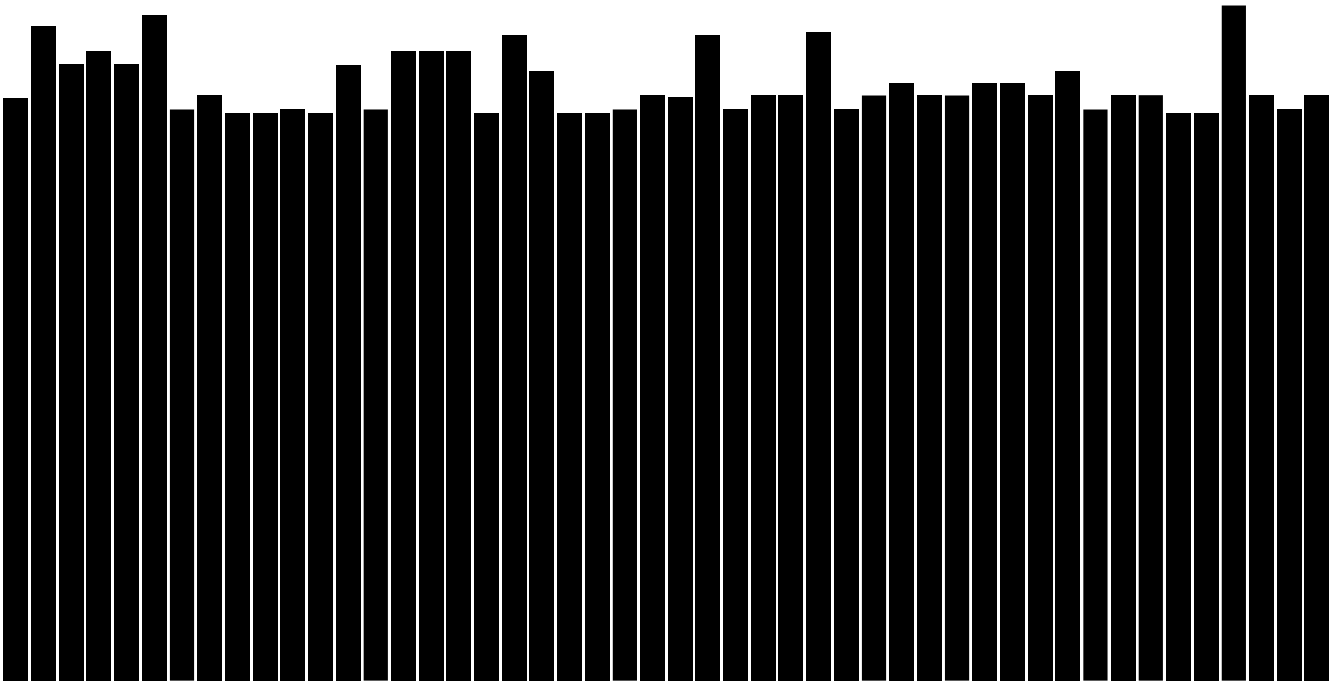
Case	Contingency	Element	Value	Limit	Percent
16S Inject	16 5SHELBY#1 TN to 8SHELSTR, Shelby2 65 to Fite 36	5SHELBY MEM2 (360679) -> 5NE GATE 33 (365591) CKT 1 at 5SHELBY MEM2	1338.26	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

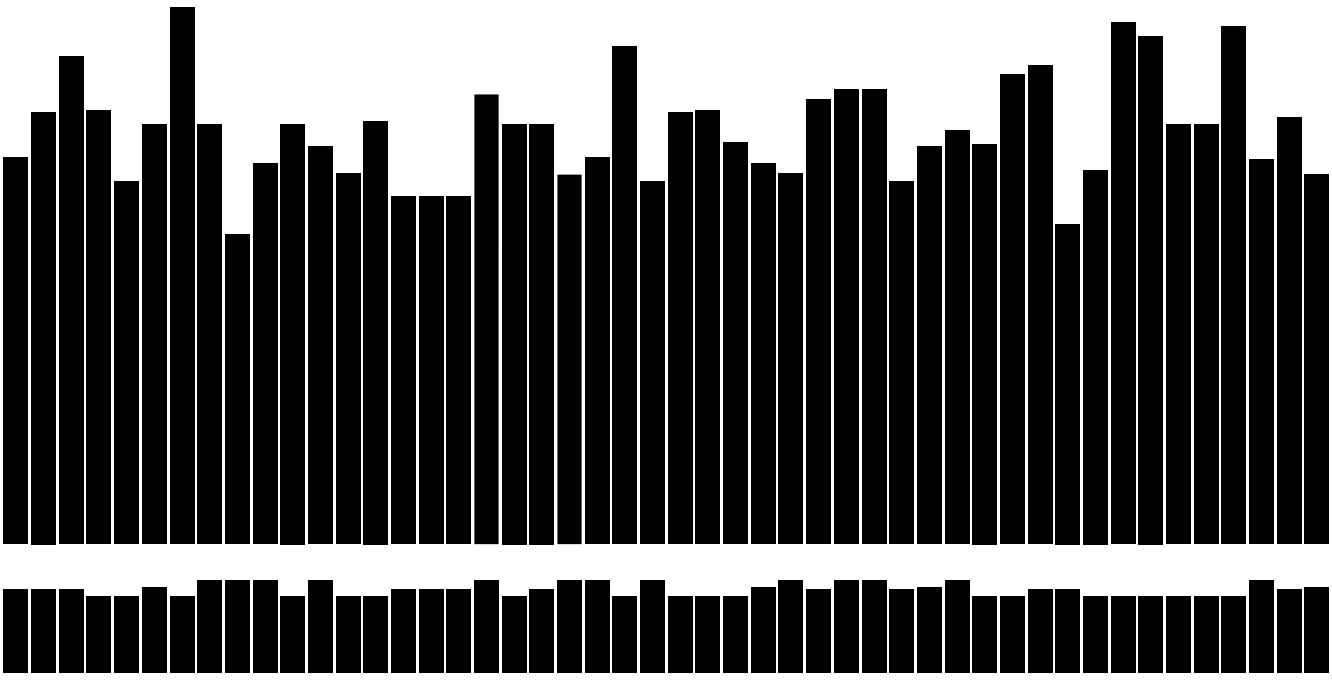

16S Inject
08 Shelby2 65 to Fite 36, N Primary 32 to Millington 15
5SHELBY MEM2 (360679) -> 5NE GATE 33 (365591) CKT 1 at 5SHELBY MEM2
1113.37
1197.73

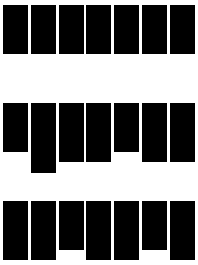

799.68
690.15
5ALLEN FP (360174) -> 5MTSUBSHI 95 (365777) CKT 1 at 5MTSUBSHI 95
29 Allen 35 to Weaver 41, Allen 35 to Nonconnah 61
16S Inject

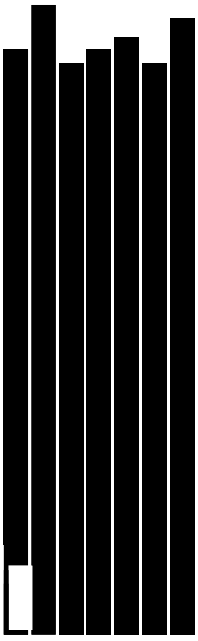

16W Inject

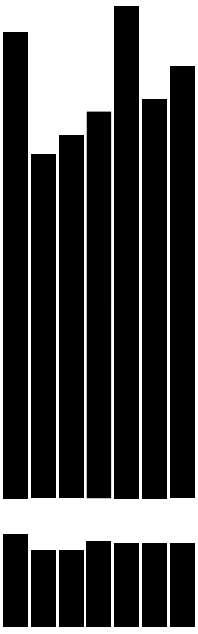












Short Circuit analysis

BUS NAME	NOM. KV	Base Case *Total Isc*	Shelby *Total Isc*	Maximum Isc increase
01 S Gate	115	28334	28341	0.0%
02E N Gate	115	24991	24999	0.0%
02W N Gate	115	25365	25374	0.0%
03 Third St	115	12407	12409	0.0%
04 Front	115	12339	12340	0.0%
05 Poplar	161	17817	17827	0.1%
06 Willett	115	19358	19363	0.0%
07 Chelsea	161	21797	21811	0.1%
11 Mallory	161	25221	25229	0.0%
13 Woodstock	115	12508	12510	0.0%
14 Frayser	115	15203	15207	0.0%
15 Millington	161	15099	15114	0.1%
21 Crump	115	20148	20153	0.0%
23 Brookfield	161	33370	33396	0.1%
24 DuPont	115	13051	13053	0.0%
25 Getwell	115	18014	18019	0.0%
26 Macon	115	16902	16907	0.0%
27 Millbranch	115	14930	14933	0.0%
28 Winchester	161	26761	26777	0.1%
31 S Primary	161	42935	42962	0.1%
32 N Primary	161	33116	33149	0.1%
33 NE Gate	115	21657	21665	0.0%
33 NE Gate	161	47373	47440	0.1%
34 SE Gate	115	25461	25468	0.0%
34 SE Gate	161	51754	51811	0.1%
35 Allen Steam Plant	161	58293	58322	0.1%
36 Fite Rd	115	11571	11573	0.0%
36 Fite Rd	161	21820	21838	0.1%
38 Raleigh	161	22103	22118	0.1%
39N Cordova	161	48330	48398	0.1%
39 S Cordova	161	42724	42767	0.1%
41 Weaver	161	23876	23883	0.0%
42 Southern	161	19362	19370	0.0%
43 Elmore	161	27842	27864	0.1%
44 Oakville	161	27193	27207	0.1%
45 McLemore	161	26244	26252	0.0%
46 N Frayser	161	18759	18771	0.1%
47 Holmes	161	42536	42565	0.1%
48 Yale Rd	161	28986	29012	0.1%

BUS NAME	NOM. KV	Base Case *Total Isc*	Shelby *Total Isc*	Maximum Isc increase
49 University	161	22587	22602	0.1%
61 Nonconnah	161	29453	29465	0.0%
62 Valero Refinery	161	25181	25189	0.0%
65 Shelby	161	43346	43109	-0.5%
66 Collierville	161	30562	30585	0.1%
67 Buoy St	161	27048	27056	0.0%
68 Arlington	161	18758	18768	0.1%
69 Freeport	161	52861	52903	0.1%
71 Clarke Rd	161	19551	19559	0.0%
72 TrinityRd	161	30314	30339	0.1%
73 Houston Levee	161	26137	26155	0.1%
74 Shelby Drive	161	24136	24147	0.0%
76 Dunlap	115	19340	19345	0.0%
77 Poplar Estates	161	33132	33156	0.1%
79 Shelton	161	16254	16261	0.0%
81 Fletcher Creek	161	28907	28931	0.1%
82 Pidgeon	161	41692	41709	0.0%
84 N Bartlett	161	15296	15302	0.0%
85 Lakeland	161	27210	27232	0.1%
86 Collierville Gate	161	31360	31384	0.1%
87 Shady Grove	161	30102	30123	0.1%
93 Praxair	115	12695	12697	0.0%