CL 261

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RS-01-261

November 8, 2001

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Clinton Power Station, Unit 1
Facility Operating License No. NPF-62
<u>NRC Docket No. 50-461</u>

Subject: Additional Electrical Systems Information Supporting the License Amendment Request to Permit Uprated Power Operation at Clinton Power Station

References: (1) Letter from J. M. Heffley (AmerGen Energy Company, LLC) to U.S. NRC, "Request for License Amendment for Extended Power Uprate Operation," dated June 18, 2001

(2) Letter from J. B. Hopkins (U.S. NRC) to O. D. Kingsley (Exelon Generation Company, LLC), "Clinton Power Station, Unit 1 – Request For Additional Information (TAC No. MB2210)," dated November 5, 2001

In Reference 1, AmerGen Energy Company, LLC (i.e., AmerGen) submitted a request for changes to the Facility Operating License No. NPF-62 and Appendix A to the Facility Operating License, Technical Specifications (TS), for Clinton Power Station (CPS) to allow operation at an uprated power level. The proposed changes in Reference 1 would allow CPS to operate at a power level of 3473 megawatts thermal (MWt). This represents an increase of approximately 20 percent rated core thermal power over the current 100 percent power level of 2894 MWt. The NRC, in Reference 2 requested additional information regarding the proposed changes in Reference 1. Attachment A of this letter provides the CPS extended power uprate (EPU) grid stability analysis requested in Question 6.1 of Reference 2. Responses to the remaining NRC Questions in Reference 2 will be provided separately.

The EPU grid stability analysis as summarized in the attached CPS Special Studies Report, was performed by Illinois Power Company (IP) Transmission Services group to evaluate the impact of operating CPS at EPU conditions. The purpose of this analysis is to evaluate the stability of the interconnected power system for two levels of increased electrical output. Phase 1 of the study analyzes an increase of 105 megawatts electric (MWe) above the current operating level of 965 MWe for the first operating cycle (i.e., Cycle 9) following implementation. Phase 2 of the study analyzes an increase of 175 MWe above the current operating level of 965 MWe for operating cycles beyond Cycle 9. The Special Studies Report includes

965 MWe + 280 : [illegible] MWe

discussions of the IP planning criteria, power flow and stability databases, Phase 1 and Phase 2 EPU models, fault scenarios studied, and simulation results.

The results of the CPS Special Studies Report demonstrate that both the non-EPU (i.e., current) model and the Phase 1 EPU model responses are stable in all 10 faults studied. Thus, no grid stability modifications are necessary for operation at Phase 1 uprated power levels.

The results of the CPS Special Studies Report also demonstrate that the Phase 2 EPU model responses are stable for all but two of the fault scenarios studied. The two fault scenarios involved double-line-to-ground faults with breaker failure scenarios. Thus, a grid stability modification is necessary for operation at Phase 2 uprated power levels. The report recommends reducing the breaker failure clearing times by three cycles for both nearby and remote breakers.

CPS is currently considering additional modifications to improve the material condition of the main generator. Final design parameters for modifications to the turbine and generator will involve small changes to some of the input parameters used in the grid stability study. As the magnitude of those changes will be small, the conclusions and recommended actions of this grid stability study are not expected to change significantly.

AmerGen commits to implementing the recommended actions of the CPS Special Studies Report prior to power increases above the affected EPU modeled cycle.

Should you have any questions related to this information, please contact Mr. T. A. Byam at (630) 657-2804.

Respectfully,

K. A. Ainger

K. A. Ainger
Director – Licensing
Mid-West Regional Operating Group

Attachments:

Affidavit
Attachment: Clinton Power Station Special Studies Report on Grid Stability Analysis

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Clinton Power Station
Office of Nuclear Facility Safety – Illinois Department of Nuclear Safety

STATE OF ILLINOIS	)	
COUNTY OF DUPAGE	)	
IN THE MATTER OF	)	
AMERGEN ENERGY COMPANY, LLC	)	**Docket Number**
CLINTON POWER STATION, UNIT 1	)	**50-461**

SUBJECT: **Additional Electrical Systems Information Supporting the License Amendment Request to Permit Uprated Power Operation at Clinton Power Station**

AFFIDAVIT

I affirm that the content of this transmittal is true and correct to the best of my knowledge, information and belief.

K. A. Ainger
K. A. Ainger
Director – Licensing
Mid-West Regional Operating Group

Subscribed and sworn to before me, a Notary Public in and for the State above named, this 8th day of November, 2001.

Timothy A. Byam
Notary Public

" OFFICIAL SEAL "
Timothy A. Byam
Notary Public, State of Illinois
My Commission Expires 11/24/2001

ATTACHMENT

Clinton Power Station
Special Studies Report on Grid Stability Analysis

I. Introduction

A Special Studies Report on grid stability was performed by Illinois Power Company (IP) Transmission Services group to evaluate the impact of operating Clinton Power Station (CPS) at extended power uprate (EPU) conditions. The purpose of this analysis was to evaluate the stability of the interconnected power system for two levels of increased electrical output. The first phase (Phase 1) of the analysis evaluated an increase of 105 megawatts electric (MWe) for the first operating cycle (i.e., Cycle 9) following implementation. Phase 2 analyzes an increase of 175 MWe for operating cycles beyond Cycle 9.

II. Illinois Power Planning Criteria

CPS is connected to the offsite power sources through the IP transmission system that must be capable of withstanding (i.e., the system should remain stable) the following transient stability conditions:

1. A permanent three-phase fault on any element (i.e., transmission line) with due regard to reclosing facilities.

2. A permanent double-line-to-ground fault on any element with delayed clearing resulting from the failure of a breaker to open properly with due regard to reclosing facilities.

3. A permanent phase-to-ground fault on the same phase of both circuits for a double-circuit tower line with due regard to reclosing facilities.

III. Scenarios

Ten scenarios were evaluated for each base case to satisfy the IP planning criteria. Each scenario is based on the transmission system configuration determined by a load flow analysis. These 10 scenarios were evaluated for four distinct base cases as described below:

- The system as it is presently in 2001,
- Replacement of the generator step-up transformer at the power plant,
- Phase 1 upgrade of 105 MWe with the new generator step-up transformer,
- Phase 2 upgrade of 175 MWe with the new generator step-up transformer and the Piatt County Generator connected on the Rising 345 kV line.

Scenario 9 was the only scenario evaluated for the fifth base case described below:

- Phase 1 upgrade of 105 MWe with the new generator step-up transformer and the Piatt County Generator connected on the Rising 345 kV line.

The 10 scenarios are described below for the first three base cases.

1. Scenario 1 is a "no fault" scenario where CPS is tripped 0.20 seconds after the simulation begins.

2. Scenario 2 is a permanent three-phase fault on the Clinton to Brokaw 345 kV line near CPS. Clinton Breakers 4502 and 4506 open in 4 cycles. Brokaw Breaker 4536 opens in 5 cycles. Brokaw Breakers 1376, 1562 and 1582 open in 6 cycles. Brokaw Breaker 4536 recloses in 2 seconds and trips in 5 cycles for a permanent fault. Clinton Breaker 4502 recloses 8 seconds later and trips in 4 cycles for a permanent fault.

3. Scenario 3 is a permanent three-phase fault on the Clinton to Latham 345 kV line near CPS. Clinton Breakers 4510 and 4518 open in 4 cycles. Latham Breaker 4571 and Oreana Breaker B020 opens in 5 cycles. Latham Breaker 4571 recloses in 2 seconds and trips in 5 cycles for a permanent fault. Latham Breaker 4571 recloses 16 seconds later and trips in 5 cycles for a permanent fault.

4. Scenario 4 is a permanent three-phase fault on the Clinton to Rising 345 kV line near CPS. Clinton Breakers 4518 and 4522 open in 4 cycles. Rising Breakers 1592 and 1554 and Oreana Breakers 1610 and 1614 open in 6 cycles. Clinton Breaker 4522 recloses in 10 seconds and trips in 4 cycles for a permanent fault.

5. Scenario 5 is a permanent three-phase fault on the Clinton to Latham 345 kV line and the Clinton to Rising 345 kV line near CPS. Clinton Breakers 4510, 4518 and 4522 open in 4 cycles. Latham Breaker 4571 opens in 5 cycles. Rising Breakers 1592 and 1554 and Oreana Breakers 1610 and 1614 open in 6 cycles. Latham Breaker 4571 recloses in 2 seconds and trips in 5 cycles for a permanent fault. Clinton Breaker 4522 recloses 8 seconds later and then trips in 4 cycles for a permanent fault. Latham Breaker 4571 recloses 8 seconds later and trips in 5 cycles for a permanent fault.

6. Scenario 6 is a permanent double-line-to-ground fault on the Clinton to Brokaw 345 kV line combined with the failure of Clinton Breaker 4502 to open properly. Clinton Breaker 4506 opens in 4 cycles. Brokaw Breaker 4536 opens in 5 cycles. Brokaw Breakers 1376, 1562 and 1582 open in 6 cycles. Clinton Breaker 4522 opens in 13 cycles. No reclosing takes place.

7. Scenario 7 is a permanent double-line-to-ground fault on the Clinton to Rising 345 kV line combined with the failure of Clinton Breaker 4518 to open properly. Clinton Breaker 4522 opens in 4 cycles. Rising Breakers 1592 and 1554 and Oreana Breakers 1610 and 1614 open in 6 cycles. Clinton Breaker 4510 opens in 13 cycles. Latham Breaker 4571 and Oreana Breaker B020 opens in 14 cycles. Clinton Breaker 4522 recloses in 10 seconds and trips in 4 cycles.

8. Scenario 8 is a permanent double-line-to-ground fault on the Clinton to Rising 345 kV line combined with the failure of Clinton Breaker 4522 to open properly. Clinton Breaker 4518 opens in 4 cycles. Rising Breakers 1592 and 1554 and Oreana Breakers 1610 and 1614 open in 6 cycles. Clinton Breaker 4502 opens in 13 cycles. No reclosing takes place.

9. Scenario 9 is a permanent double-line-to-ground fault on the Clinton to Latham 345 kV line combined with the failure of Clinton Breaker 4518 to open properly. Clinton Breaker 4510 opens in 4 cycles. Latham Breaker 4571 and Oreana Breaker B020 opens in 5 cycles. Clinton Breaker 4522 opens in 13 cycles.

Rising Breakers 1592 and 1554 and Oreana Breakers 1610 and 1614 open in 14 cycles. No reclosing takes place.

10. Scenario 10 is a permanent three-phase fault on the Kincaid to Latham to Pontiac 345 kV line near Latham. In addition, the Kincaid to Brokaw to Pontiac 345 kV line is taken out of service before the fault is applied. Latham Breaker 4571 opens in 4 cycles. Latham Breakers 1346, 1342, 1566, Pontiac Breaker 2102 and Kincaid Breaker 2102 open in 5 cycles. Pontiac Breaker 2102 recloses in 5 seconds and trips in 5 cycles for a permanent fault.

The 10 scenarios for the fourth base case are described below. These scenarios differ from those used to evaluate the other base cases because of the addition of the breakers at Piatt County and Oreana required by the Piatt County Generation project. Scenario 9 from this list is applicable for the fifth base case.

1. Scenario 1 is a no fault scenario where CPS is tripped 0.20 seconds after the simulation begins.

2. Scenario 2 is a permanent three-phase fault on the Clinton to Brokaw 345 kV line near CPS. Clinton Breakers 4502 and 4506 open in 4 cycles. Brokaw Breaker 4536 opens in 5 cycles. Brokaw Breakers 1376, 1562 and 1582 open in 6 cycles. Brokaw Breaker 4536 recloses in 2 seconds and trips in 5 cycles for a permanent fault. Clinton Breaker 4502 recloses 8 seconds later and trips in 4 cycles for a permanent fault.

3. Scenario 3 is a permanent three-phase fault on the Clinton to Latham 345 kV line near CPS. Clinton Breakers 4510 and 4518 open in 4 cycles. Latham Breaker 4571 and Oreana Breaker B020 open in 5 cycles. Latham Breaker 4571 recloses in 2 seconds and trips in 5 cycles for a permanent fault. Latham Breaker 4571 recloses 16 seconds later and trips in 5 cycles for a permanent fault.

4. Scenario 4 is a permanent three-phase fault on the Clinton to Piatt County 345 kV line near CPS. Clinton Breakers 4518 and 4522 open in 4 cycles. Piatt County Breakers and Oreana Breaker B021 open in 5 cycles. Clinton Breaker 4522 recloses in 10 seconds and trips in 4 cycles for a permanent fault.

5. Scenario 5 is a permanent three-phase fault on the Clinton to Latham 345 kV line and the Clinton to Piatt County 345 kV line near CPS. Clinton Breakers 4510, 4518 and 4522 open in 4 cycles. Latham Breaker 4571, Oreana Breakers B020 and B021 and Piatt County Breakers open in 5 cycles. Latham Breaker 4571 recloses in 2 seconds and trips in 5 cycles for a permanent fault. Clinton Breaker 4522 recloses 8 seconds later and then trips in 4 cycles for a permanent fault. Latham Breaker 4571 recloses 8 seconds later and trips in 5 cycles for a permanent fault.

6. Scenario 6 is a permanent double-line-to-ground fault on the Clinton to Brokaw 345 kV line combined with the failure of Clinton Breaker 4502 to open properly. Clinton Breaker 4506 opens in 4 cycles. Brokaw Breaker 4536 opens in 5 cycles. Brokaw Breakers 1376, 1562 and 1582 open in 6 cycles. Clinton Breaker 4522 opens in 13 cycles. No reclosing takes place.

7. Scenario 7 is a permanent double-line-to-ground fault on the Clinton to Piatt County 345 kV line combined with the failure of Clinton Breaker 4518 to open properly. Clinton Breaker 4522 opens in 4 cycles. Piatt County breakers and Oreana Breaker B021 open in 5 cycles. Clinton Breaker 4510 opens in 13 cycles. Latham Breaker 4571 and Oreana Breaker B020 opens in 14 cycles. Clinton Breaker 4522 recloses in 10 seconds and trips in 4 cycles.

8. Scenario 8 is a permanent double-line-to-ground fault on the Clinton to Piatt County 345 kV line combined with the failure of Clinton Breaker 4522 to open properly. Clinton Breaker 4518 opens in 4 cycles. Piatt County breakers and Oreana Breaker B021 open in 5 cycles. Clinton Breaker 4502 opens in 13 cycles. No reclosing takes place.

9. Scenario 9 is a permanent double-line-to-ground fault on the Clinton to Latham 345 kV line combined with the failure of Clinton Breaker 4518 to open properly. Clinton Breaker 4510 opens in 4 cycles. Latham Breaker 4571 and Oreana Breaker B020 open in 5 cycles. Clinton Breaker 4522 opens in 13 cycles. Piatt County breakers and Oreana Breaker B021 open in 14 cycles. No reclosing takes place.

10. Scenario 10 is a permanent three-phase fault on the Kincaid to Latham to Pontiac 345 kV line near Latham. In addition, the Kincaid to Brokaw to Pontiac 345 kV line is taken out of service before the fault is applied. Latham Breaker 4571 opens in 4 cycles. Latham Breakers 1346, 1342, 1566, Pontiac Breaker 2102 and Kincaid Breaker 2102 open in 5 cycles. Pontiac Breaker 2102 recloses in 5 seconds and trips in 5 cycles for a permanent fault.

IV. Case Description

The stability base case is an updated version of the North American Electric Reliability Council (NERC) System Dynamics Data Working Group (SDDWG) summer 2004 base case. It models most of the Eastern US interconnection. The personnel at Mid American Interconnected Network (MAIN) completed the update in December 2000. In this model, the following key units are running at the specified levels:

Havana 1-5	–	238 MWe
Havana 6	–	428 MWe
Vermilion 1	–	72 MWe
Vermilion 2	–	102 MWe
Tilton 1-4	–	176 MWe
Kincaid 1	–	539 MWe
Kincaid 2	–	539 MWe

V. Data Description

A one-line diagram of the proposed power plant upgrade and the interconnection to the IP transmission system is shown in Exhibit 1. The substation arrangement represents the present configuration that exists at the plant. For the Phase 2 simulation, a proposed power plant in Piatt County was also modeled. This power plant was interconnected to the transmission system via the Clinton to Rising 345 kV line as shown in Exhibit 2. Net output from this plant was 450 MWe.

The power plant upgrade was studied in two phases. In Phase 1, a 105 MWe upgrade was modeled yielding a total generation of 1080 MWe. For Phase 2, a 175 MWe upgrade was modeled resulting in total generation of 1150 MWe. An auxiliary load of 45 MWe was modeled in both Phase 1 and Phase 2.

The generator and excitation system were modeled in detail. PSSE models were used to represent these components. Data was provided for the GENROU and ESAC3A models in documents ELPU-0351 and ELPU-579. The governor response was not modeled in the simulations.

VI. Results

The following results were observed for the first base case evaluated.

1. The phase angle swing and speed deviations for Kincaid Unit 2 and Vermilion Unit 2 are shown in Exhibit 3 for Scenario 1. In this scenario, CPS was tripped off-line. The swings were not severe and the system remained stable. A phase angle swing of 10 degrees occurred for Kincaid Unit 2 and 5 degrees for Vermilion Unit 2. Speed deviation ranged from 0.0002 to –0.0018 for Kincaid Unit 2 and 0.0003 to –0.0010 for Vermilion Unit 2. Oscillations for both units had dampened out by the end of the 5-second simulation period.

2. The phase angle swing and speed deviations for CPS are shown in Exhibit 4 for Scenario 2. The swings were severe but the system remained stable. Angle swung 32 degrees and speed deviation varied from 0.0084 to –0.0080. Oscillations had mostly dampened out by the end of the 5-second simulation period.

3. The phase angle swing and speed deviations for CPS are shown in Exhibit 5 for Scenario 3. The swings were severe but the system remained stable. Angle swung 27 degrees and speed deviation varied from 0.0083 to –0.0077. Oscillations had mostly dampened out by the end of the 5-second simulation period.

4. The phase angle swing and speed deviations for CPS are shown in Exhibit 6 for Scenario 4. The swings were severe but the system remained stable. Angle swung 27 degrees and speed deviation varied from 0.0083 to –0.0077. Oscillations had mostly dampened out by the end of the 5-second simulation period.

5. The phase angle swing and speed deviations for CPS are shown in Exhibit 7 for Scenario 5. The swings were severe but the system remained stable. Angle swung 33 degrees and speed deviation varied from 0.0084 to –0.0081. Oscillations were damping out by the end of the 5-second simulation period.

6. The phase angle swing and speed deviations for CPS are shown in Exhibit 8 for Scenario 6. The swings were extremely severe but the system remained stable. Angle swung 87 degrees and speed deviation varied from 0.0178 to –0.0204. Oscillations were damping out by the end of the 5-second simulation period.

7. The phase angle swing and speed deviations for CPS are shown in Exhibit 9 for Scenario 7. The swings were extremely severe but the system remained stable. Angle swung 90 degrees and speed deviation varied from 0.0166 to –0.0200. Oscillations were damping out by the end of the 5-second simulation period.

8. The phase angle swing and speed deviations for CPS are shown in Exhibit 10 for Scenario 8. The swings were extremely severe but the system remained stable. Angle swung 75 degrees and speed deviation varied from 0.0166 to –0.0197. Oscillations were damping out by the end of the 5-second simulation period.

9. The phase angle swing and speed deviations for CPS are shown in Exhibit 11 for Scenario 9. The swings were extremely severe but the system remained stable. Angle swung 93 degrees and speed deviation varied from 0.0173 to –0.0200. Oscillations were damping out by the end of the 5-second simulation period.

10. The phase angle swing and speed deviations for CPS are shown in Exhibit 12 for Scenario 10. The swings were severe but the system remained stable. Angle swung 28 degrees and speed deviation varied from 0.0063 to –0.0054. Oscillations were damping out by the end of the 5-second simulation period.

The following results were observed for the second base case evaluated.

1. The phased angle swing and speed deviations for Kincaid Unit 2 and Vermilion Unit 2 are shown in Exhibit 13 for Scenario 1. In this scenario, CPS was tripped off-line. The swings were not severe and the system remained stable. Angle swing of 12 degrees occurred for Kincaid Unit 2 and 6 degrees for Vermilion Unit 2. Speed deviation ranged from 0.0002 to –0.0018 for Kincaid Unit 2 and 0.0003 to –0.0010 for Vermilion Unit 2. Oscillations for both units had mostly dampened out by the end of the 5-second simulation period.

2. The phase angle swing and speed deviations for CPS are shown in Exhibit 14 for Scenario 2. The swings were severe but the system remained stable. Angle swung 30 degrees and speed deviation varied from 0.0083 to –0.0075. Oscillations had mostly dampened out by the end of the 5-second simulation period.

3. The phase angle swing and speed deviations for CPS are shown in Exhibit 15 for Scenario 3. The swings were severe but the system remained stable. Angle swung 25 degrees and speed deviation varied from 0.0083 to –0.0073. Oscillations had mostly dampened out by the end of the 5-second simulation period.

4. The phase angle swing and speed deviations for CPS are shown in Exhibit 16 for Scenario 4. The swings were severe but the system remained stable. Angle swung 26 degrees and speed deviation varied from 0.0083 to –0.0072. Oscillations had mostly dampened out by the end of the 5-second simulation period.

5. The phase angle swing and speed deviations for CPS are shown in Exhibit 17 for Scenario 5. The swings were severe but the system remained stable. Angle swung 32 degrees and speed deviation varied from 0.0084 to –0.0076. Oscillations were damping out by the end of the 5-second simulation period.

6. The phase angle swing and speed deviations for CPS are shown in Exhibit 18 for Scenario 6. The swings were extremely severe but the system remained stable. Angle swung 76 degrees and speed deviation varied from 0.0171 to –0.0192. Oscillations were damping out by the end of the 5-second simulation period.

7. The phase angle swing and speed deviations for CPS are shown in Exhibit 19 for Scenario 7. The swings were extremely severe but the system remained stable. Angle swung 77 degrees and speed deviation varied from 0.0158 to –0.0188. Oscillations were damping out by the end of the 5-second simulation period.

8. The phase angle swing and speed deviations for CPS are shown in Exhibit 20 for Scenario 8. The swings were extremely severe but the system remained stable. Angle swung 66 degrees and speed deviation varied from 0.0158 to –0.0183. Oscillations were mostly dampened out by the end of the 5-second simulation period.

9. The phase angle swing and speed deviations for CPS are shown in Exhibit 21 for Scenario 9. The swings were extremely severe but the system remained stable. Angle swung 78 degrees and speed deviation varied from 0.0166 to –0.0189. Oscillations were damping out by the end of the 5-second simulation period.

10. The phase angle swing and speed deviations for CPS are shown in Exhibit 22 for Scenario 10. The swings were severe but the system remained stable. Angle swung 25 degrees and speed deviation varied from 0.0061 to –0.0047. Oscillations were damping out by the end of the 5-second simulation period.

The following results were observed for the third base case evaluated.

1. The phase angle swing and speed deviations for Kincaid Unit 2 and Vermilion Unit 2 are shown in Exhibit 23 for Scenario 1. In this scenario, CPS was tripped off-line. The swings were not severe and the system remained stable. Angle swing of 10 degrees occurred for Kincaid Unit 2 and 5 degrees for Vermilion Unit 2. Speed deviation ranged from 0.0002 to –0.0020 for Kincaid Unit 2 and 0.0003 to –0.0011 for Vermilion Unit 2. Oscillations for both units had dampened out by the end of the 5-second simulation period.

2. The phase angle swing and speed deviations for CPS are shown in Exhibit 24 for Scenario 2. The swings were severe but the system remained stable. Angle swung 33 degrees and speed deviation varied from 0.0092 to –0.0083. Oscillations had mostly dampened out by the end of the 5-second simulation period.

3. The phase angle swing and speed deviations for CPS are shown in Exhibit 25 for Scenario 3. The swings were severe but the system remained stable. Angle swung 28 degrees and speed deviation varied from 0.0092 to –0.0082. Oscillations had dampened out by the end of the 5-second simulation period.

4. The phase angle swing and speed deviations for CPS are shown in Exhibit 26 for Scenario 4. The swings were severe but the system remained stable. Angle swung 28 degrees and speed deviation varied from 0.0092 to –0.0080. Oscillations had dampened out by the end of the 5-second simulation period.

5. The phase angle swing and speed deviations for CPS are shown in Exhibit 27 for Scenario 5. The swings were severe but the system remained stable. Angle swung 35 degrees and speed deviation varied from 0.0093 to –0.0085. Oscillations were damping out by the end of the 5-second simulation period.

6. The phase angle swing and speed deviations for CPS are shown in Exhibit 28 for Scenario 6. The swings were extremely severe but the system remained stable. Angle swung 89 degrees and speed deviation varied from 0.0190 to –0.0217. Oscillations were damping out by the end of the 5-second simulation period.

7. The phase angle swing and speed deviations for CPS are shown in Exhibit 29 for Scenario 7. The swings were extremely severe but the system remained stable. Angle swung 91 degrees and speed deviation varied from 0.0176 to –0.0213. Oscillations were damping out by the end of the 5-second simulation period.

8. The phase angle swing and speed deviations for CPS are shown in Exhibit 30 for Scenario 8. The swings were extremely severe but the system remained stable. Angle swung 76 degrees and speed deviation varied from 0.0176 to –0.0207. Oscillations were mostly dampened out by the end of the 5-second simulation period.

9. The phase angle swing and speed deviations for CPS are shown in Exhibit 31 for Scenario 9. The swings were extremely severe but the system remained stable. Angle swung 95 degrees and speed deviation varied from 0.0184 to –0.0215. Oscillations were damping out by the end of the 5-second simulation period.

10. The phase angle swing and speed deviations for CPS are shown in Exhibit 32 for Scenario 10. The swings were severe but the system remained stable. Angle swung 28 degrees and speed deviation varied from 0.0068 to –0.0052. Oscillations were mostly dampened out by the end of the 5-second simulation period.

The following results were observed for the fourth base case evaluated.

1. The phase angle swing and speed deviations for Kincaid Unit 2 and Vermilion Unit 2 are shown in Exhibit 33 for Scenario 1. In this scenario, CPS was tripped off-line. The swings were not severe and the system remained stable. Angle swing of 12 degrees occurred for Kincaid Unit 2 and 6 degrees for Vermilion Unit 2. Speed deviation ranged from 0.0003 to –0.0021 for Kincaid Unit 2 and 0.00004 to –0.0011 for Vermilion Unit 2. Oscillations for both units had dampened out by the end of the 5-second simulation period.

2. The phase angle swing and speed deviations for CPS are shown in Exhibit 34 for Scenario 2. The swings were severe but the system remained stable. Angle swung 37 degrees and speed deviation varied from 0.0099 to –0.0078. Oscillations had mostly dampened out by the end of the 5-second simulation period.

3. The phase angle swing and speed deviations for CPS are shown in Exhibit 35 for Scenario 3. The swings were very severe but the system remained stable. Angle swung 33 degrees and speed deviation varied from 0.0102 to –0.0086. Oscillations had dampened out by the end of the 5-second simulation period.

4. The phase angle swing and speed deviations for CPS are shown in Exhibit 36 for Scenario 4. The swings were very severe but the system remained stable. Angle swung 30 degrees and speed deviation varied from 0.0101 to –0.0090. Oscillations had dampened out by the end of the 5-second simulation period.

5. The phase angle swing and speed deviations for CPS are shown in Exhibit 37 for Scenario 5. The swings were severe but the system remained stable. Angle swung 37 degrees and speed deviation varied from 0.0099 to –0.0090. Oscillations were damping out by the end of the 5-second simulation period.

6. The phase angle swing and speed deviations for CPS are shown in Exhibit 38 for Scenario 6. The swings were extremely severe but the system remained stable. Angle swung 100 degrees and speed deviation varied from 0.0196 to –0.0194. Oscillations were damping out by the end of the 5-second simulation period.

7. The phase angle swing and speed deviations for CPS are shown in Exhibit 39 for Scenario 7. The swings were extremely severe resulting in the unit loosing synchronism with the system and becoming unstable.

8. The phase angle swing and speed deviations for CPS are shown in Exhibit 40 for Scenario 8. The swings were extremely severe but the system remained stable. Angle swung 86 degrees and speed deviation varied from 0.0186 to –0.0222. Oscillations were mostly dampened out by the end of the 5-second simulation period.

9. The phase angle swing and speed deviations for CPS are shown in Exhibit 41 for Scenario 9. The swings were extremely severe resulting in the unit loosing synchronism with the system and becoming unstable.

10. The phase angle swing and speed deviations for CPS are shown in Exhibit 42 for Scenario 10. The swings were severe but the system remained stable. Angle swung 39 degrees and speed deviation varied from 0.0076 to –0.0048. Oscillations were damping out by the end of the 5-second simulation period.

The following results were observed for the fourth base case for Scenarios 6, 7, 8 and 9 with faster breaker failure clearing times.

6. The phase angle swing and speed deviations for CPS are shown in Exhibit 43 for Scenario 6. The swings were extremely severe but the system remained stable. Angle swung 62 degrees and speed deviation varied from 0.0154 to –0.0134. Oscillations were mostly dampened out by the end of the 5-second simulation period.

7. The phase angle swing and speed deviations for CPS are shown in Exhibit 44 for Scenario 7. The swings were extremely severe but the system remained stable. Angle swung 66 degrees and speed deviation varied from 0.0147 to –0.0159. Oscillations were damping out by the end of the 5-second simulation period.

8. The phase angle swing and speed deviations for CPS are shown in Exhibit 45 for Scenario 8. The swings were extremely severe but the system remained stable. Angle swung 54 degrees and speed deviation varied from 0.0147 to –0.0155. Oscillations were dampened out by the end of the 5-second simulation period.

9. The phase angle swing and speed deviations for CPS are shown in Exhibit 46 for Scenario 9. The swings were extremely severe but the system remained stable. Angle swung 65 degrees and speed deviation varied from 0.0149 to –0.0156. Oscillations were damping out by the end of the 5-second simulation period.

The following results were observed for the fifth base case evaluated.

9. The phase angle swing and speed deviations for CPS are shown in Exhibit 47 for Scenario 9. The swings were extremely severe but the system remained stable. Angle swung 93 degrees and speed deviation varied from 0.0176 to –0.204. Oscillations were damping out by the end of the 5-second simulation period.

VII. <u>Discussion</u>

For the purposes of this discussion, a scenario is considered to be severe when the speed deviation exceeds 0.5%. A speed deviation that exceeds 1.0% is considered to be very severe and a speed deviation that exceeds 1.5% it is considered to be extremely severe.

In the first base case, all the three-phase fault scenarios were found to be severe. All double-line-to-ground fault with breaker failure scenarios were found to be extremely severe. As expected the double-line-to-ground fault with breaker failure scenarios were more severe than the three-phase fault scenarios. None of the scenarios resulted in an unstable condition. The largest phase angle swing of 93 degrees occurred in Scenario 9 and the largest speed deviation of 1.8% to –2.0% occurred in Scenario 6.

In the second base case, all the three-phase fault scenarios were found to be severe. All double-line-to-ground fault with breaker failure scenarios were found to be extremely severe. As expected the double-line-to-ground with breaker failure fault scenarios were more severe than the three-phase fault scenarios. None of the scenarios resulted in an unstable condition. The largest phase angle swing of 78 degrees occurred in Scenario 9 and the largest speed deviation of 1.7% to –1.9% occurred in Scenario 6.

By comparing the results from the second and first base cases it can be seen that the addition of the new transformer with a lower impedance reduced the phase angle swing and speed deviation. The phase angle swing was reduced by 15 degrees or 16%. Speed deviation was reduced 0.2%.

In the third base case, all the three-phase fault scenarios were found to be severe. All double-line-to-ground fault with breaker failure scenarios were found to be extremely severe. As expected the double-line-ground fault with breaker failure scenarios were more severe than the three-phase fault scenarios. None of the scenarios resulted in an unstable condition. The largest phase angle swing of 95 degrees occurred in Scenario 9 and the largest speed deviation of 1.9% to –2.2% occurred in Scenario 6.

By comparing the results from the third and second base cases it can be seen that the upgrade of 105 MWe increased both the angle swing and speed deviation. The phase angle swing increased 17 degrees or 22%. Speed deviation increased 0.5%.

In the fourth base case, two scenarios resulted in an unstable condition. The scenarios were Scenario 7 and Scenario 9. Voltage plots for the nearby buses for both unstable scenarios are shown in Exhibits 48 through 57. Both are double-line-to-ground fault with breaker failure scenarios. The breaker failure clearing time in these scenarios was 13-14 cycles. An additional cycle is required for transmitting the signal to remote breakers. This resulted in a clearing time of 13 cycles for the nearby breakers and 14 cycles for the remote breakers.

It was determined that the delay time for back-up breaker operation for a breaker failure could be reduced by 0.05 seconds or 3 cycles. The clearing time could be reduced to 10 cycles for the nearby breakers and 11 cycles for the remote breakers. Only the double-line-to-ground fault with breaker failure scenarios were affected by these changes. Scenarios 6, 7, 8 and 9 were simulated with the new breaker failure clearing times. With these changes none of the double-line-ground fault with breaker failure scenarios resulted in an unstable condition. The largest angle swing of 66 degrees and speed deviation of 1.5% to –1.6% occurred in Scenario 7.

By comparing the results from the fourth and third base cases it can be seen that the additional upgrade of 70 MWe with reduced breaker failure clearing times decreased the worst case phase angle swing and speed deviation. The angle swing was reduced by 29 degrees or 30%. Speed deviation was reduced by 1.0%.

In the advent that the first upgrade could not be implemented before the installation and connection of the Piatt County generator, one of the unstable cases found for the fourth base case was examined using a fifth base case. In this case the Piatt County generator was brought on-line and the Phase 1 upgrade was implemented. The angle swing of 93 degrees and speed deviation 1.8% to –2.0% were similar to the worst case results found for the third base case.

The swings dampened out or showed signs of damping out for all of the stable scenarios simulated. Thus it appears that a power system stabilizer is not required for this upgrade; however, if the customer so desires, a power system stabilizer can be tuned for this generation upgrade.

VIII. Conclusion

The transmission system remained stable during the simulation of the fault scenarios required by Illinois Power's planning criteria with the following recommended change implemented.

- Reduce breaker failure clearing times from 13 to 10 cycles for nearby breakers and reduce the time delay at CPS to change breaker failure clearing times from 14 to 11 cycles for remote breakers.

Without this change CPS, as defined in Phase 2, will become unstable for two of the double-line-to-ground fault with breaker failure scenarios investigated.

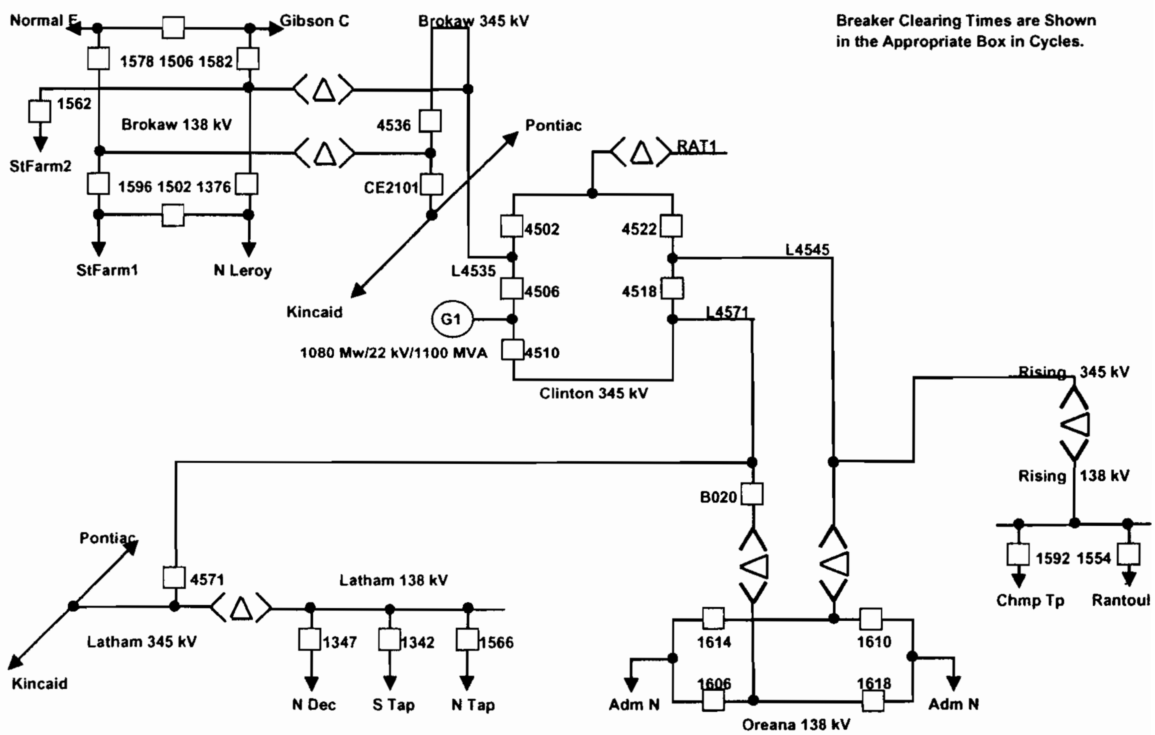


Exhibit 1. One-line diagram for Phase 1 upgrade.

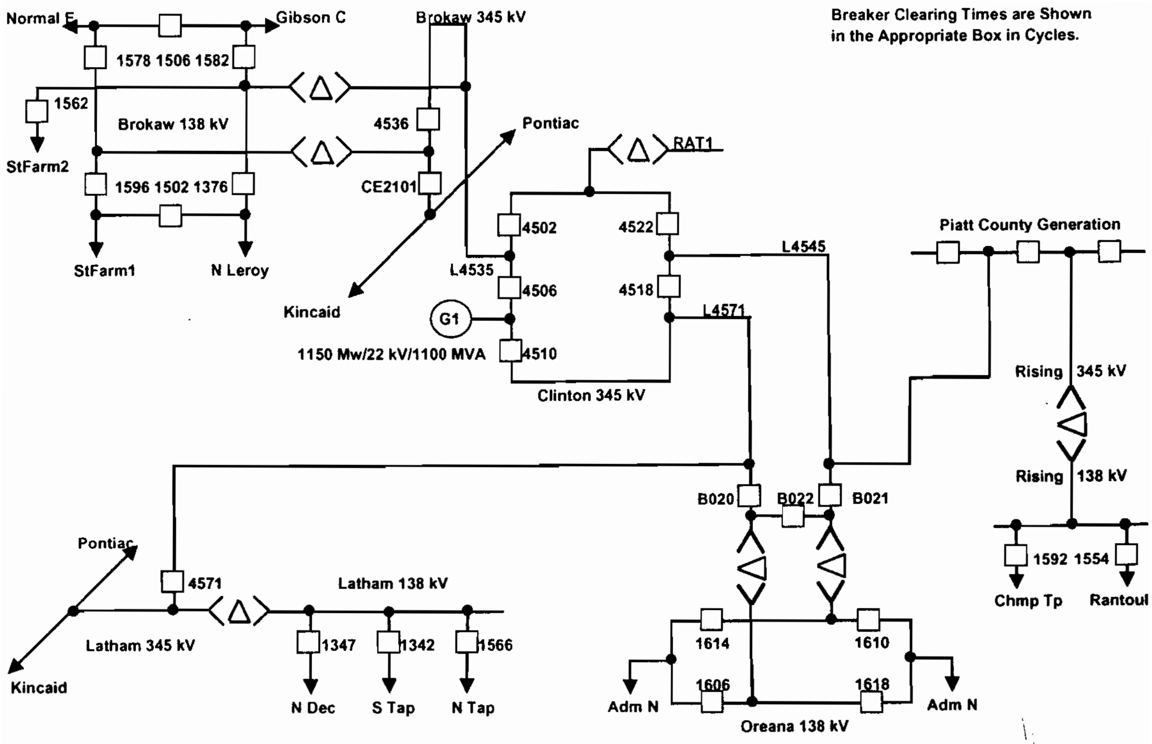
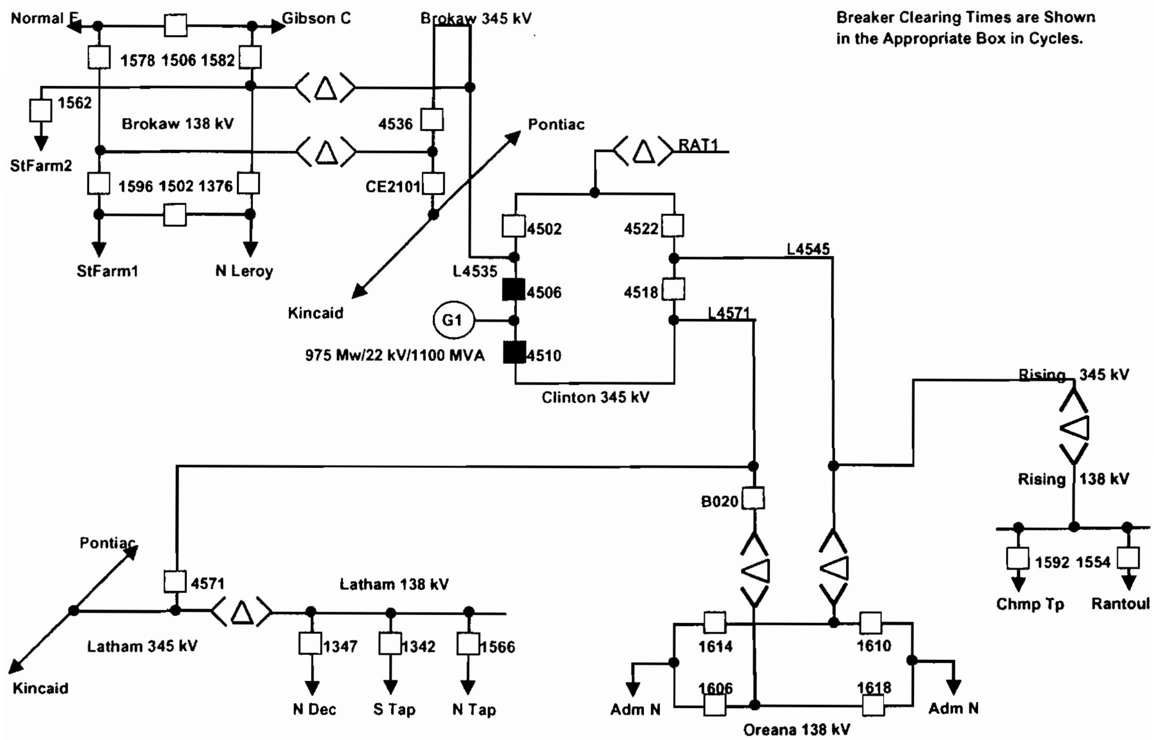


Exhibit 2. One-line diagram for Phase 2 upgrade.



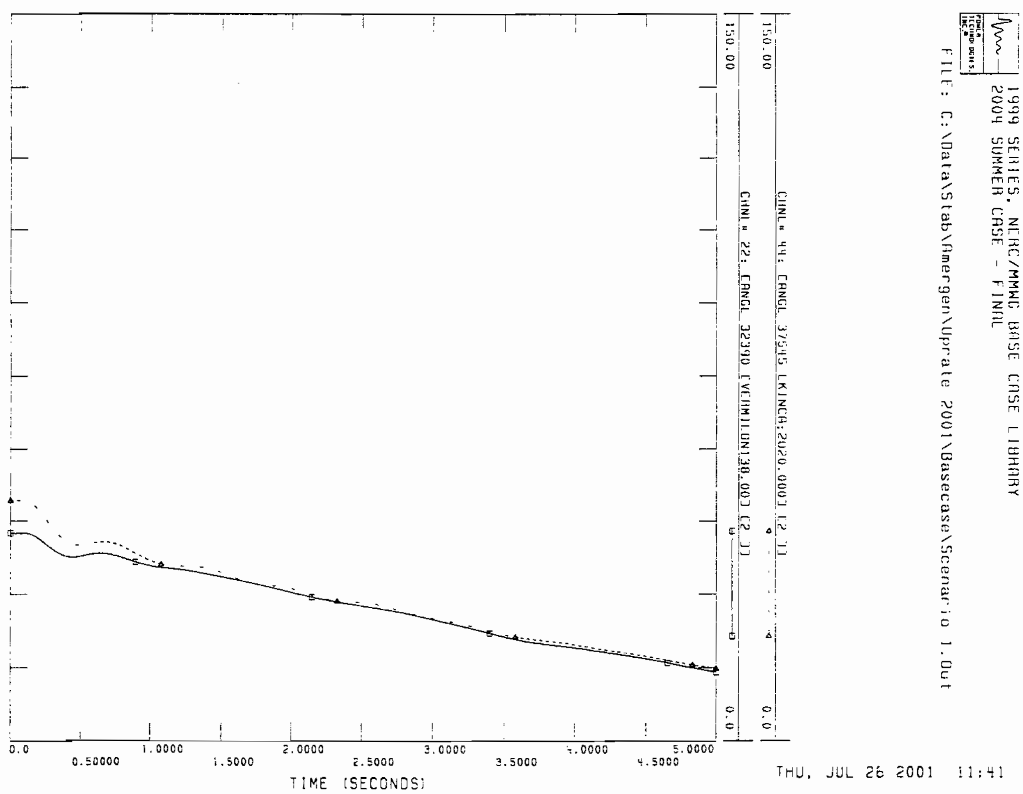


Exhibit 3: CPS tripped with no fault, Case 1.

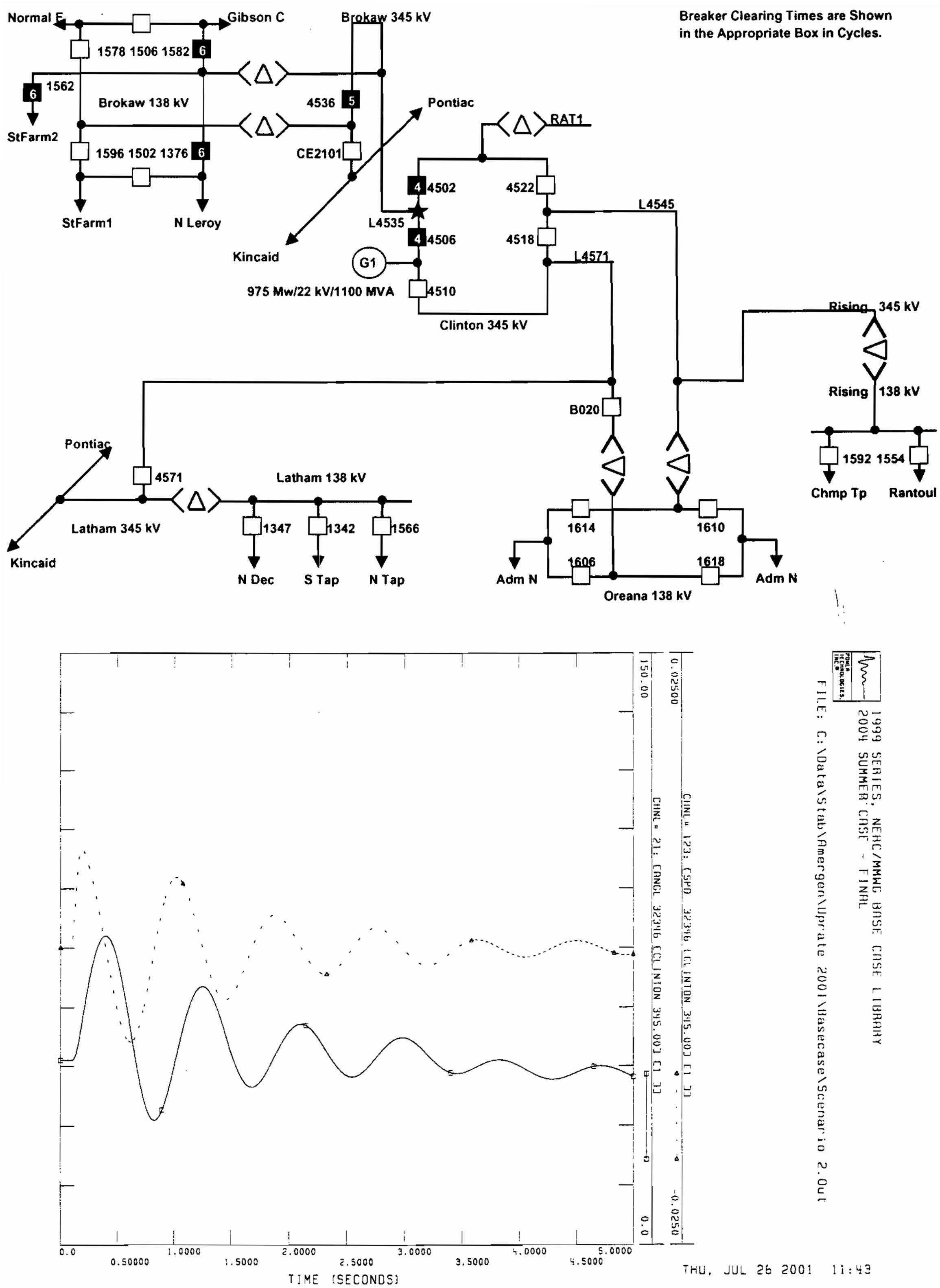


Exhibit 4: 3-Phase fault on the Clinton to Brokaw 345 kV line at CPS, Case 1.

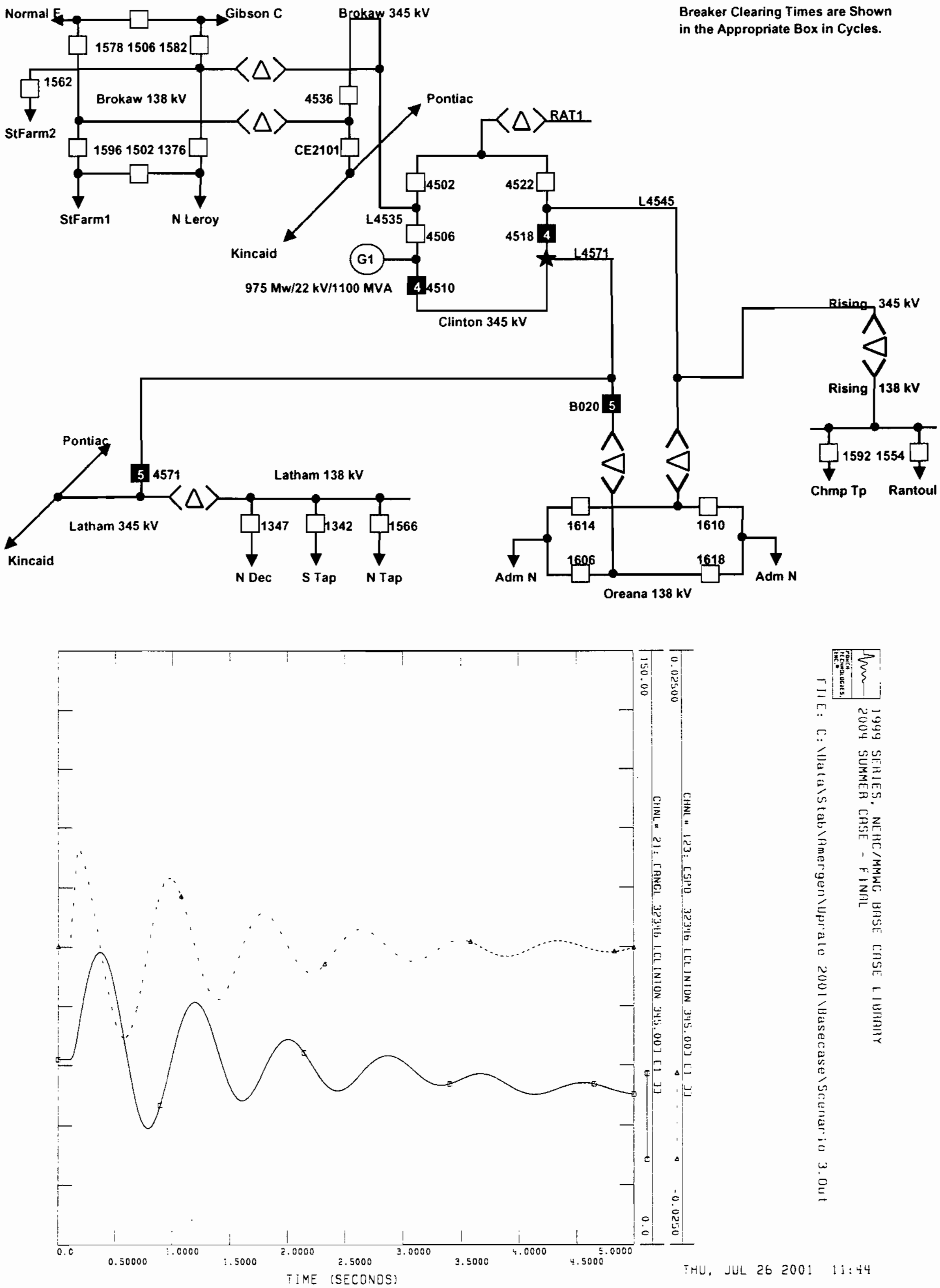


Exhibit 5: 3-Phase fault on the Clinton to Latham 345 kV line at CPS, Case 1.

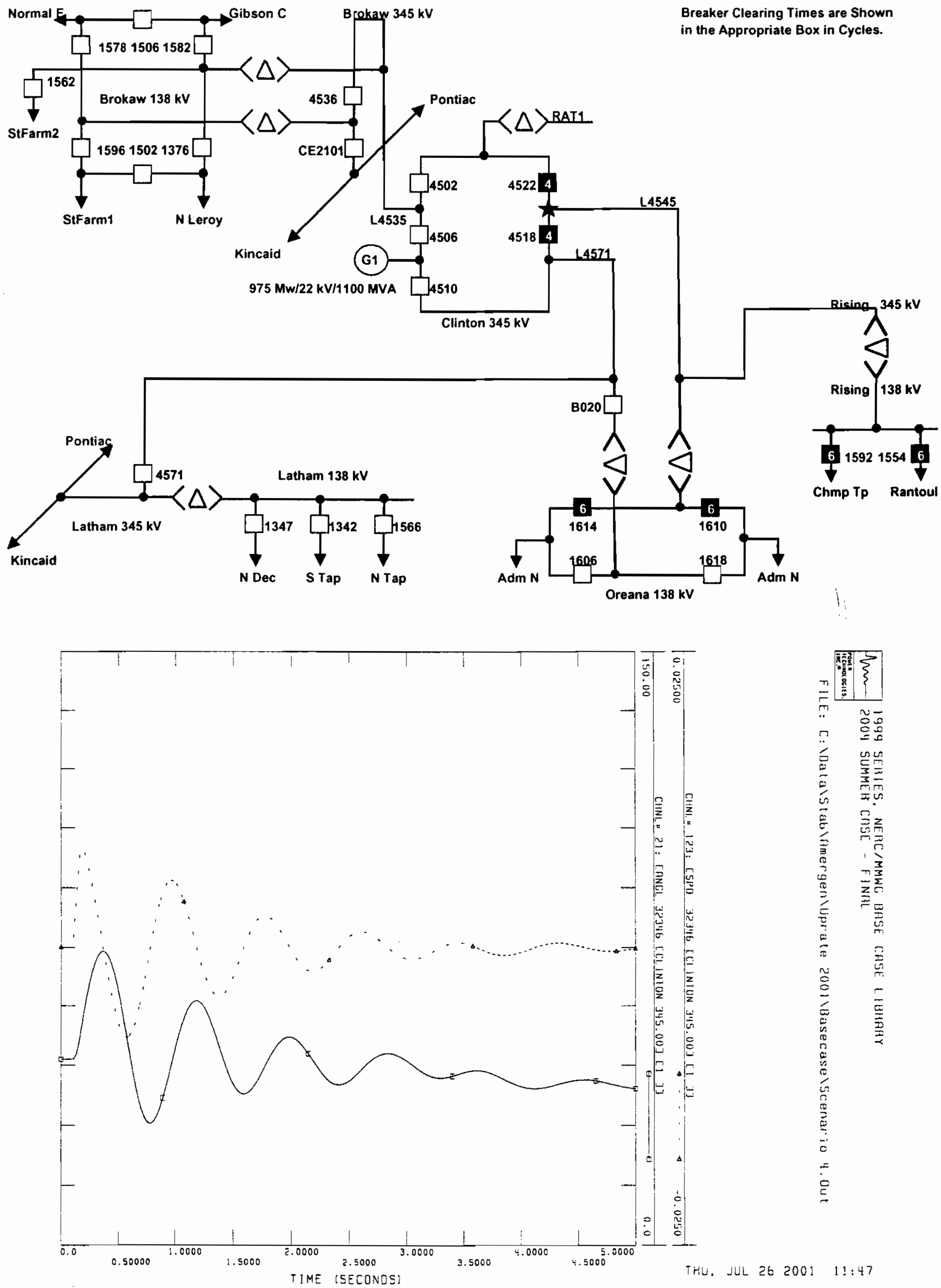
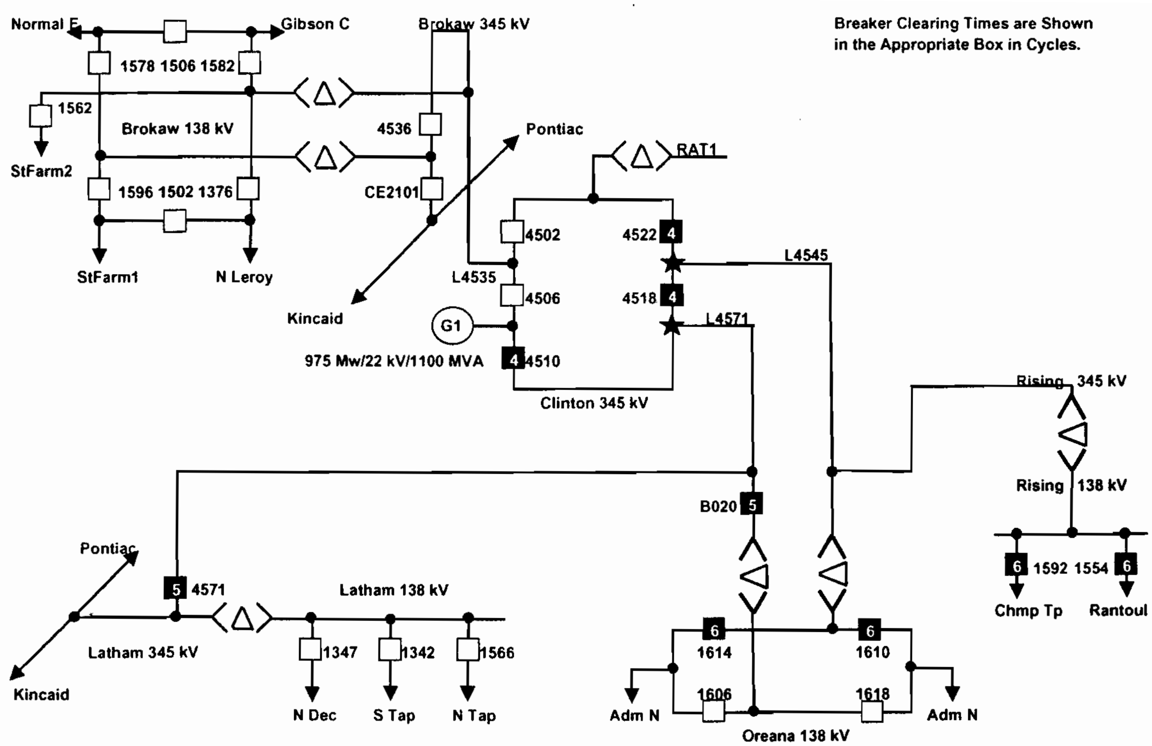


Exhibit 6: 3-Phase fault on the Clinton to Oreana to Rising 345 kV line at CPS, Case 1.



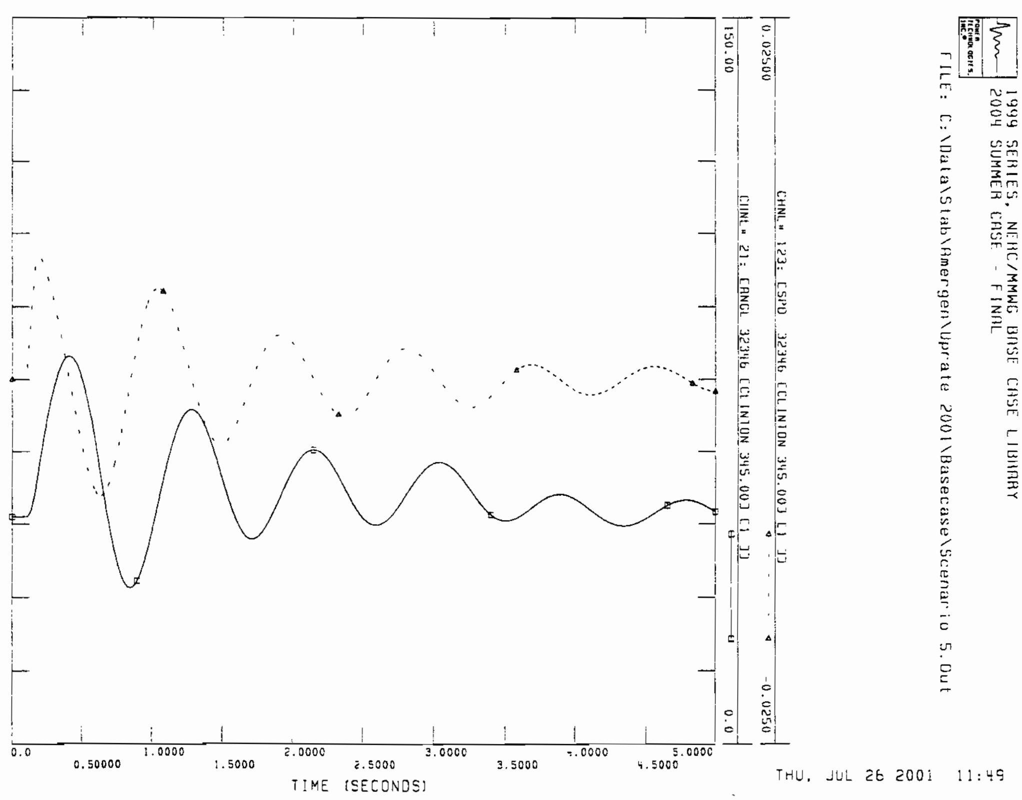
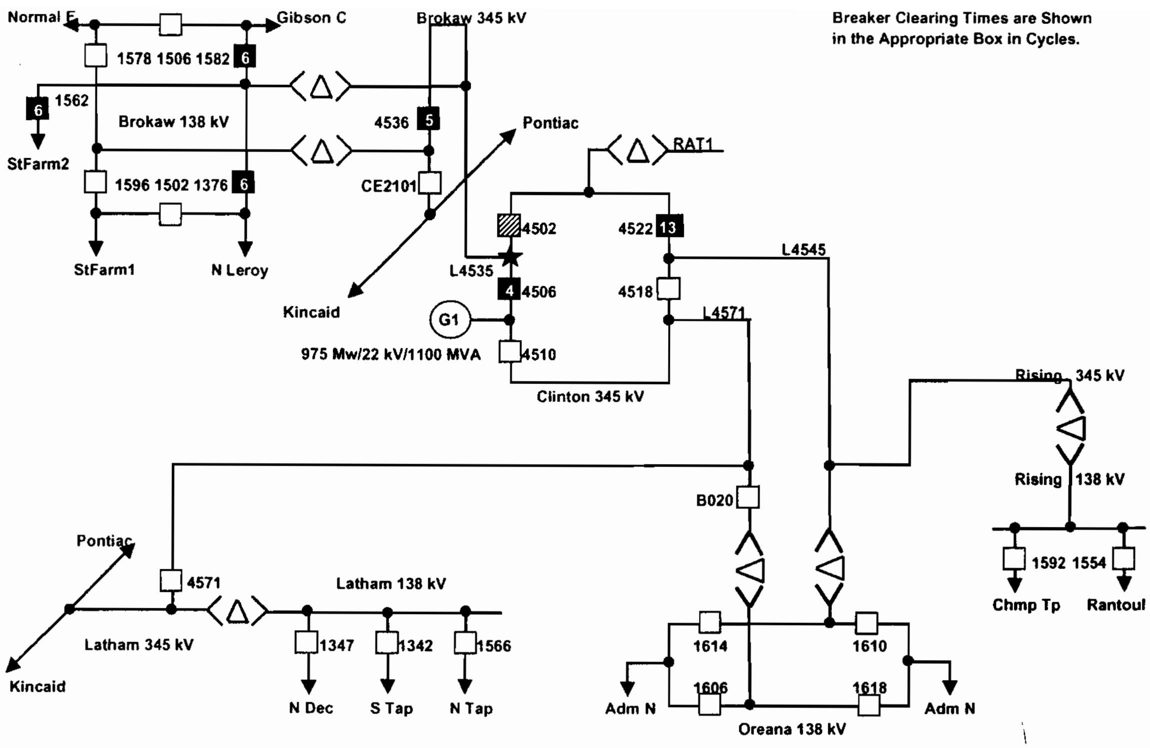


Exhibit 7: 3-Phase simultaneous fault on the double circuit Clinton to Latham and Clinton to Oreana to Rising 345 kV lines at CPS, Case 1.



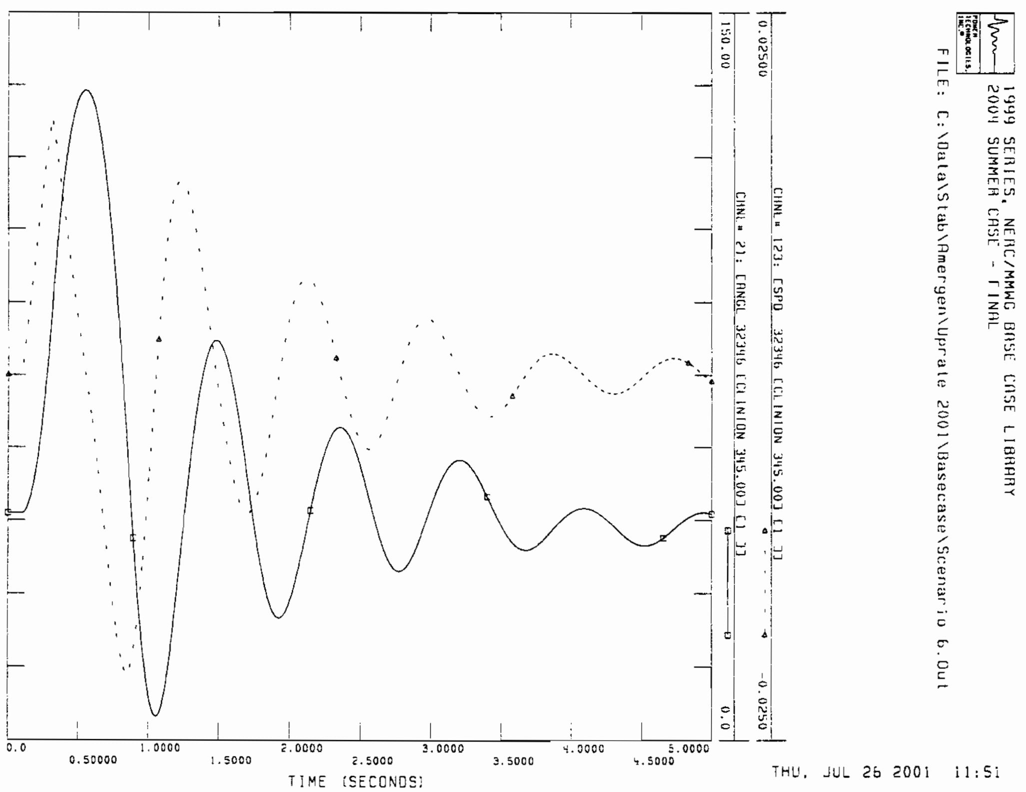
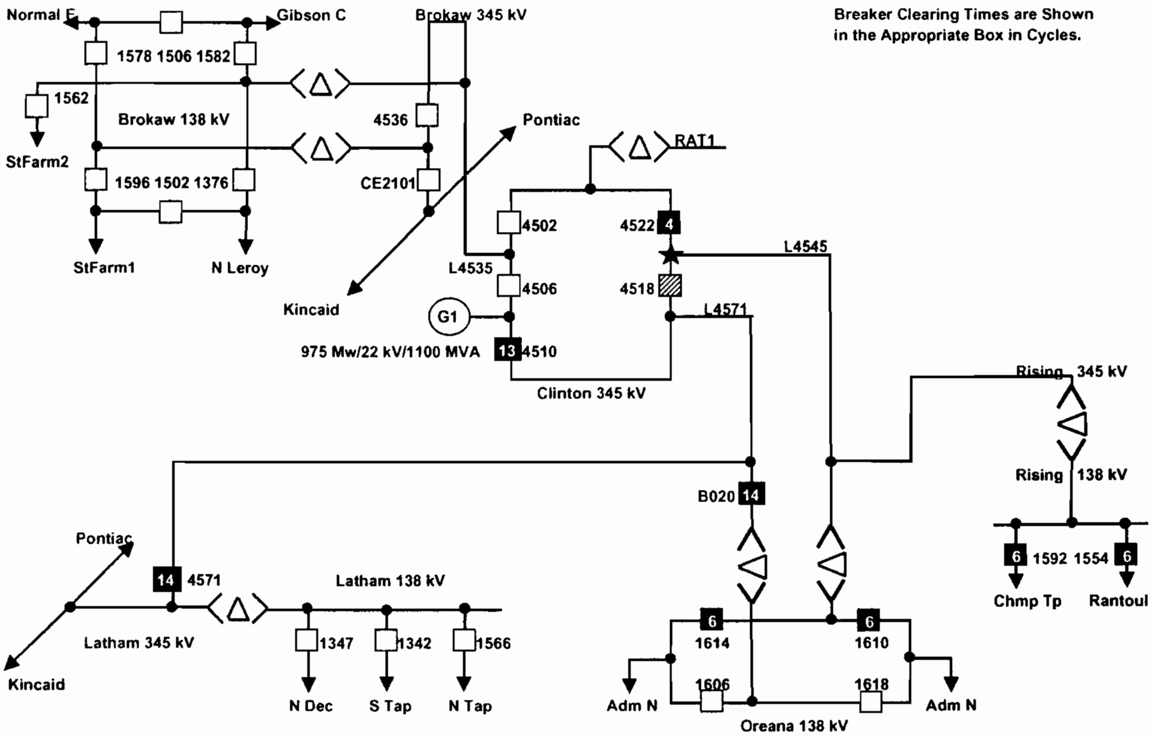


Exhibit 8: Double-line-ground fault on the Clinton to Brokaw 345 kV line at CPS with failure of Breaker 4502, Case 1.



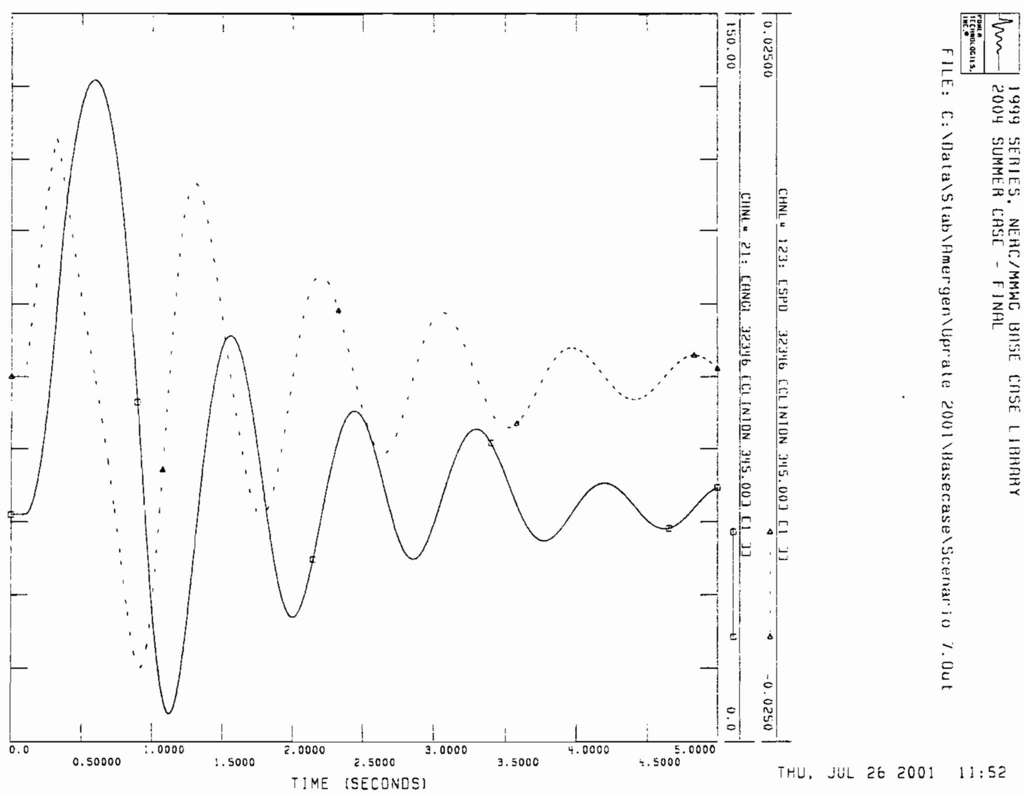
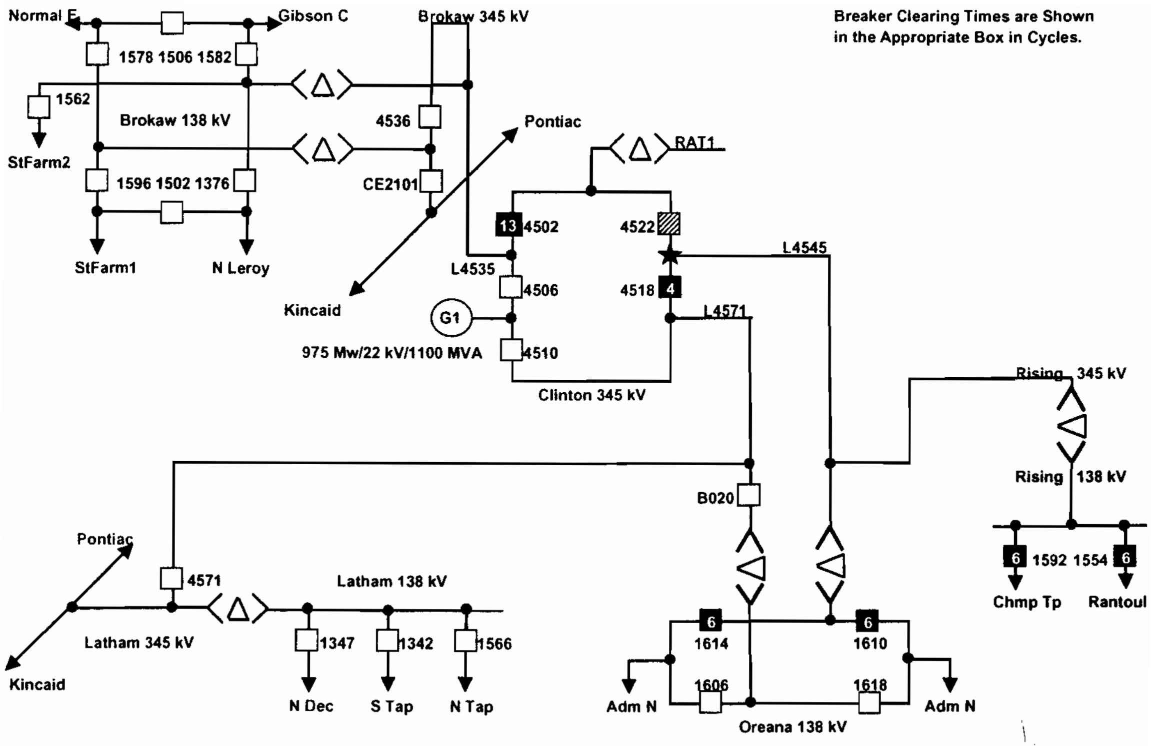


Exhibit 9: Double-line-ground fault on the Clinton to Oreana to Rising 345 kV line at CPS with failure of Breaker 4518, Case 1.



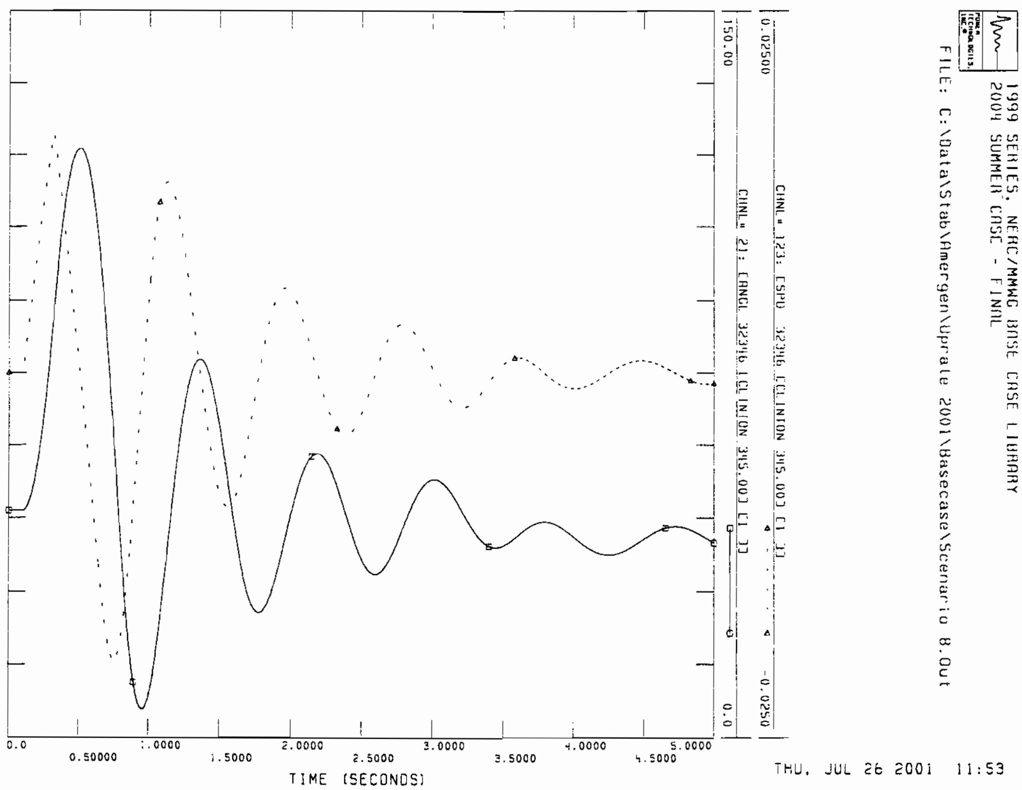
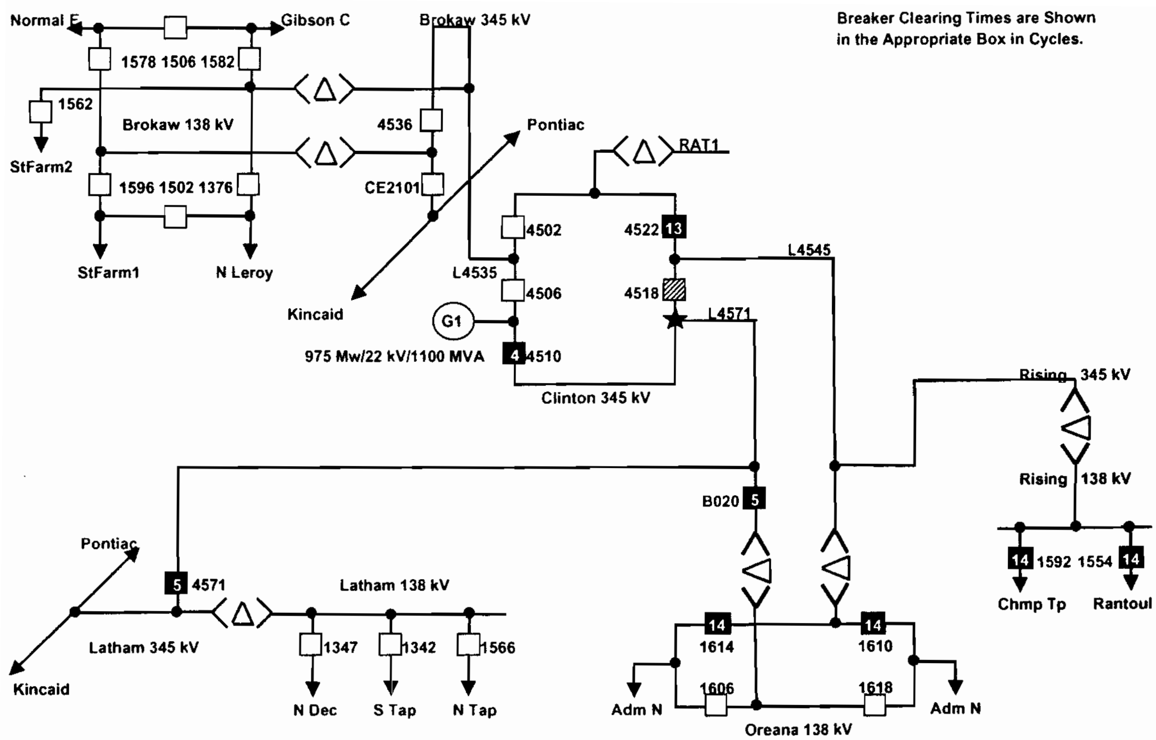


Exhibit 10: Double-line-ground fault on the Clinton to Oreana to Rising 345 kV line at CPS with failure of Breaker 4522, Case 1.



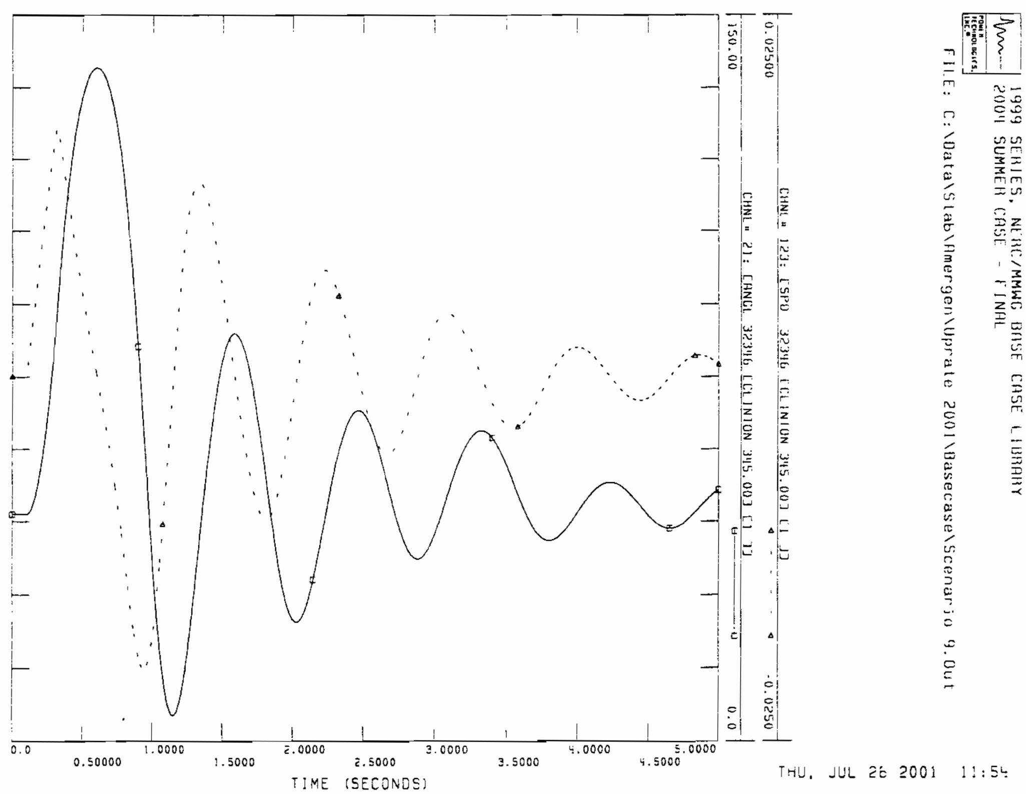
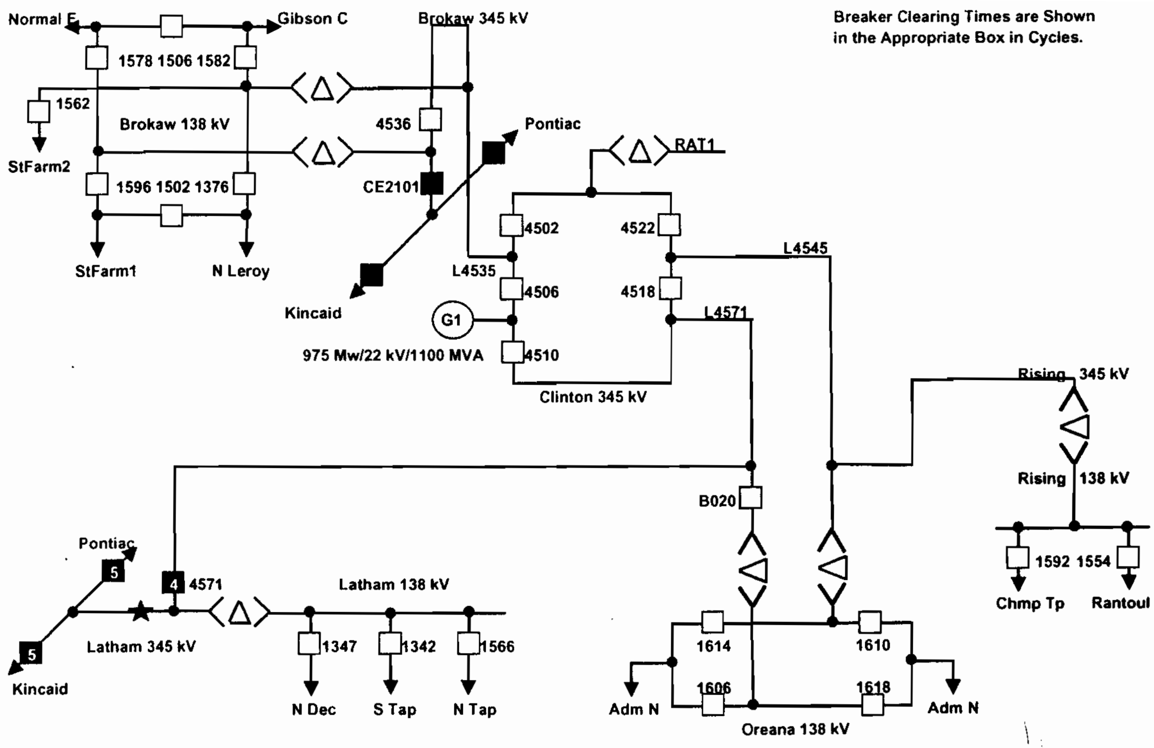


Exhibit 11: Double-line-ground fault on the Clinton to Latham 345 kV line at CPS with failure of Breaker 4518, Case 1.



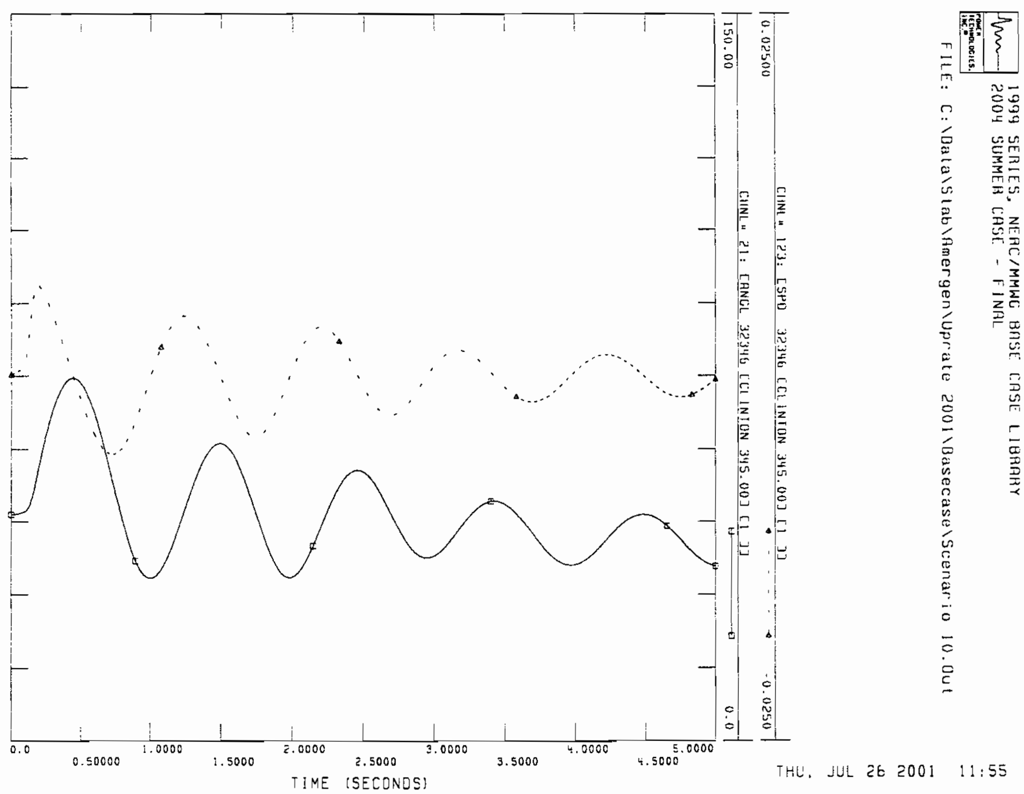


Exhibit 12: 3-Phase fault on the Kincaid to Latham to Pontiac 345 kV line at Latham with the Kincaid to Brokaw to Pontiac 345 kV line out of service, Case 1.

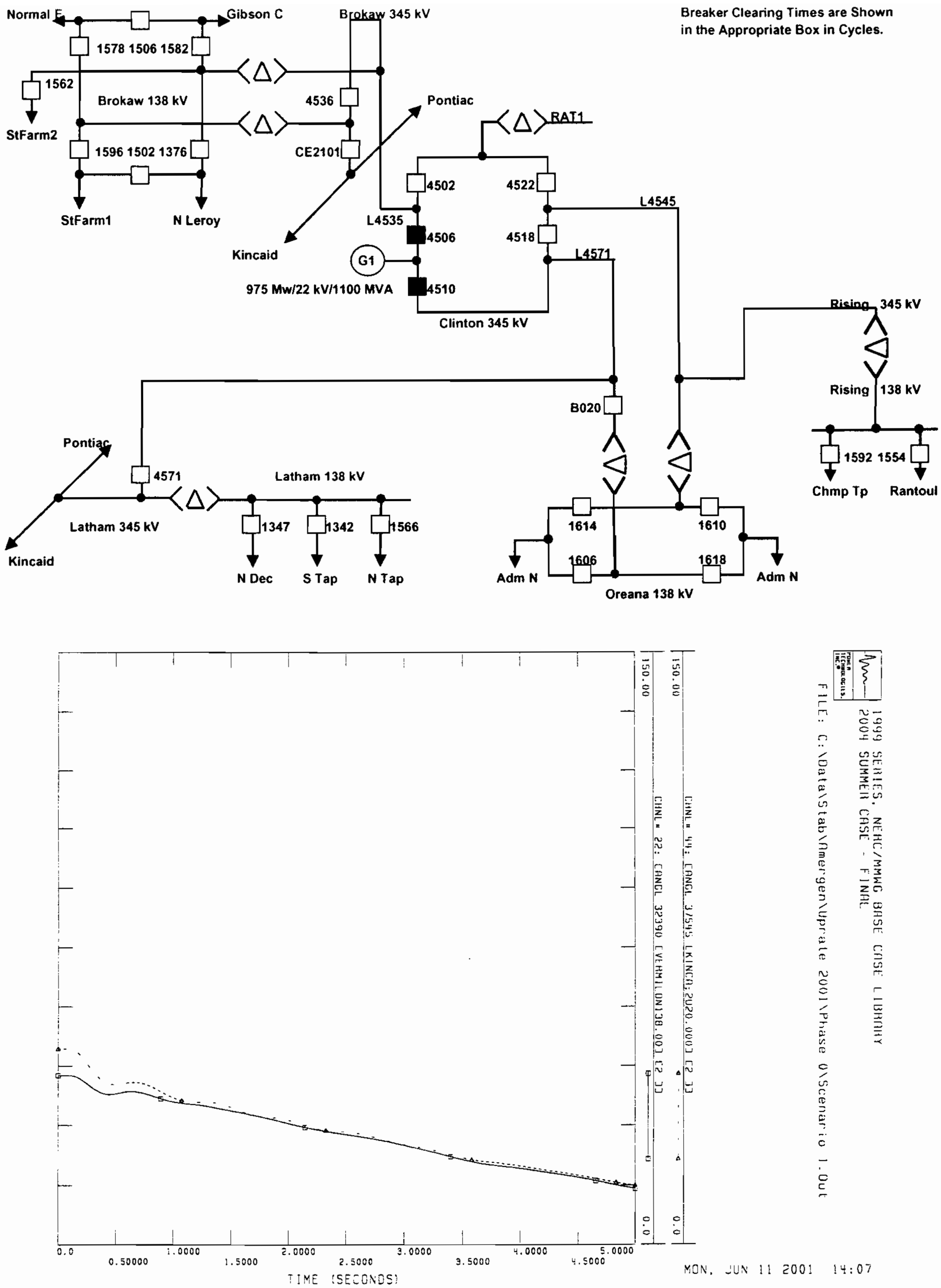
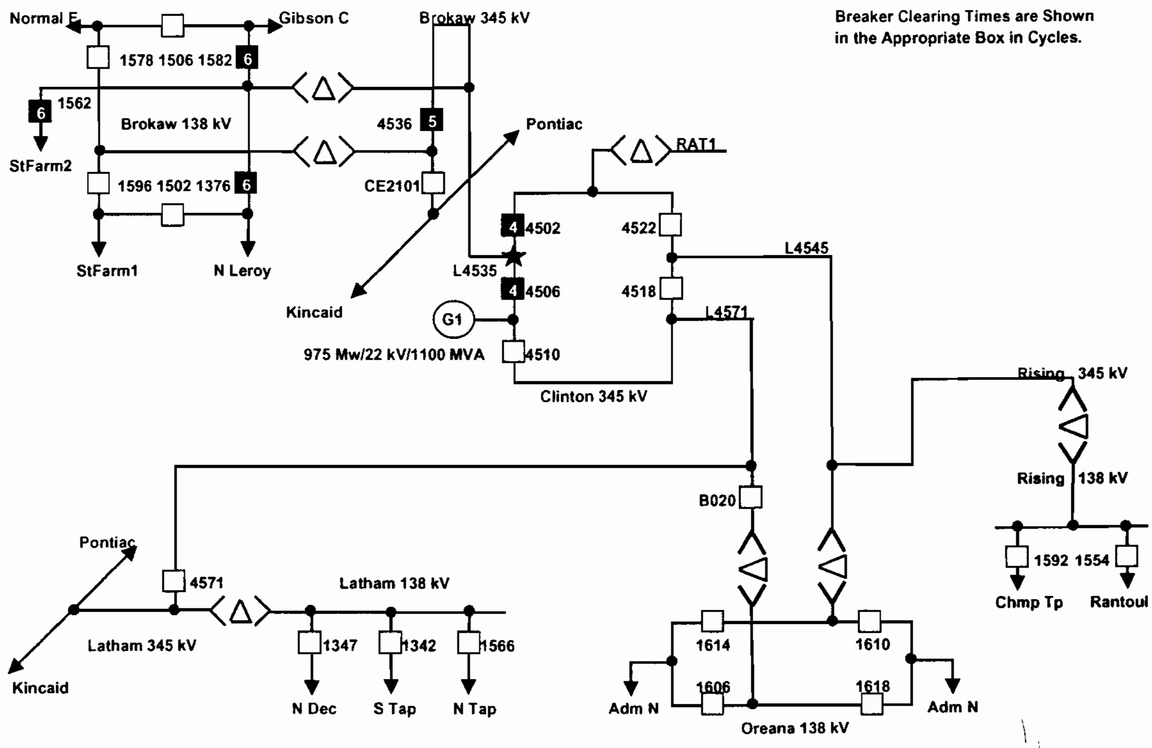


Exhibit 13: CPS tripped with no fault, Case 2.



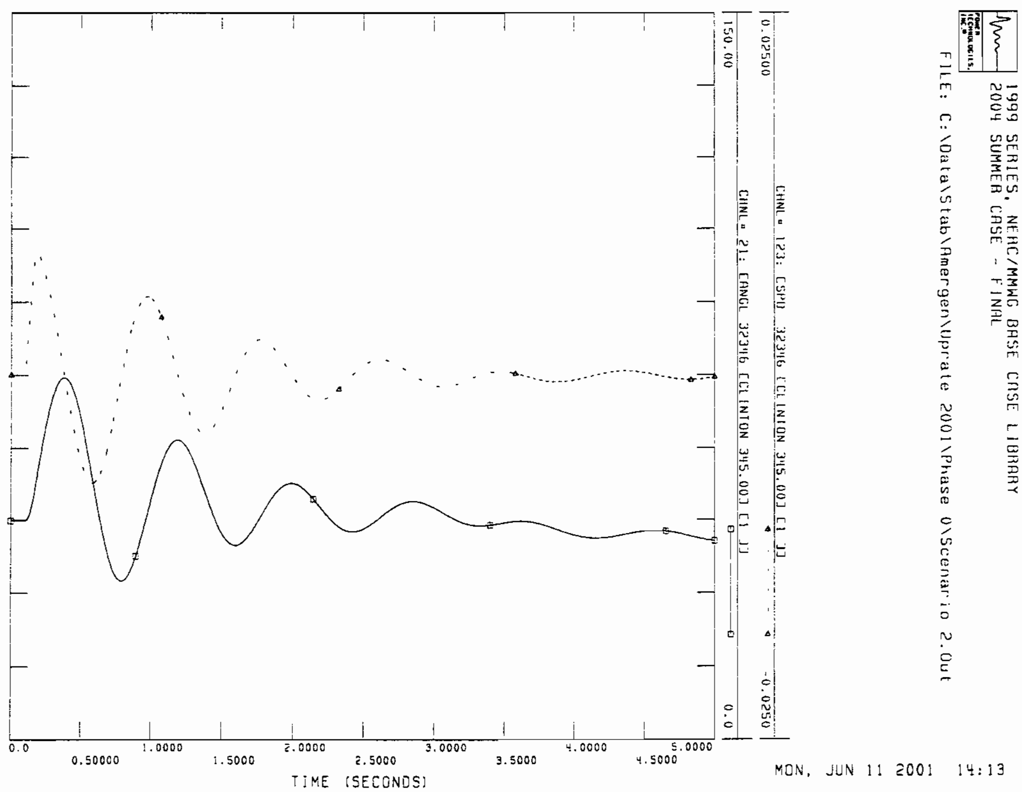


Exhibit 14: 3-Phase fault on the Clinton to Brokaw 345 kV line at CPS, Case 2.

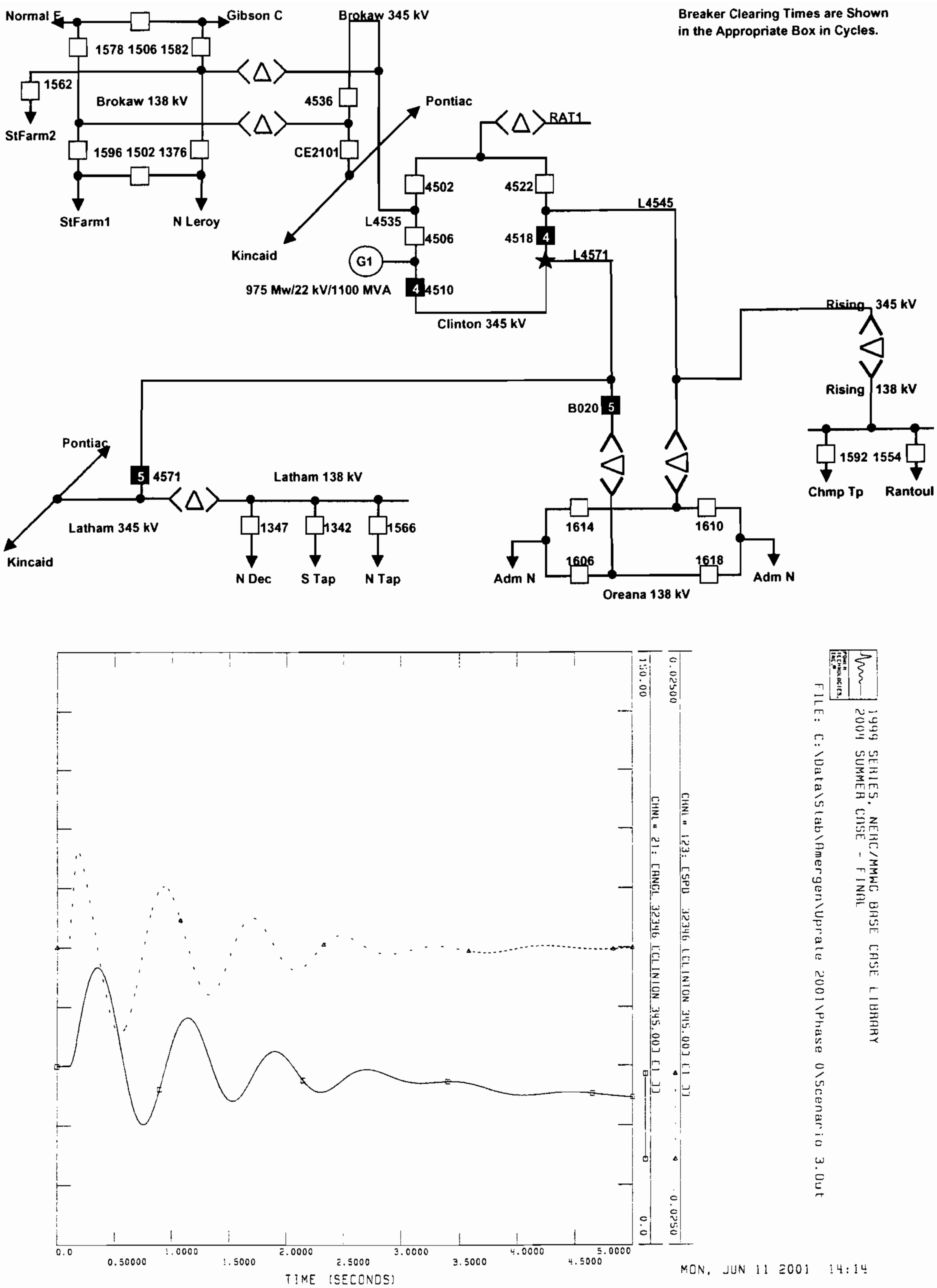


Exhibit 15: 3-Phase fault on the Clinton to Latham 345 kV line at CPS, Case 2.

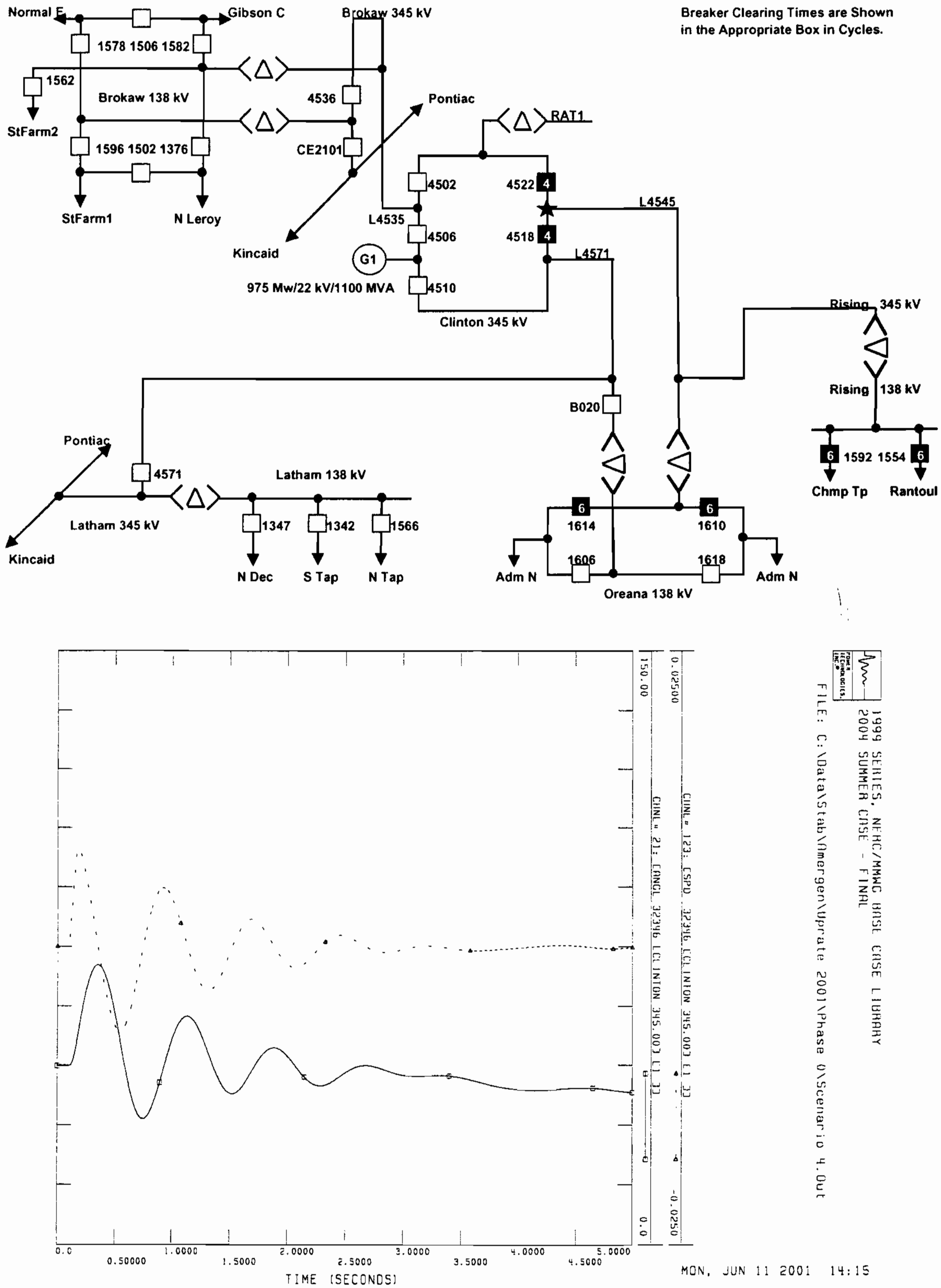
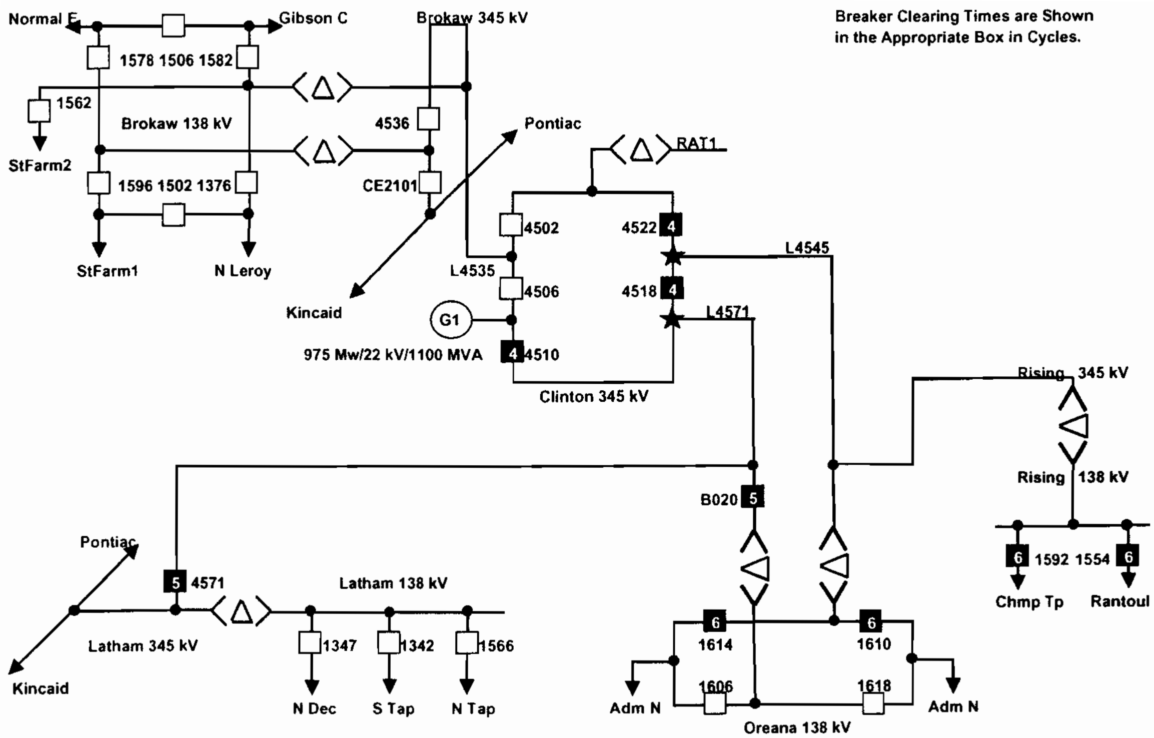


Exhibit 16: 3-Phase fault on the Clinton to Oreana to Rising 345 kV line at CPS, Case 2.



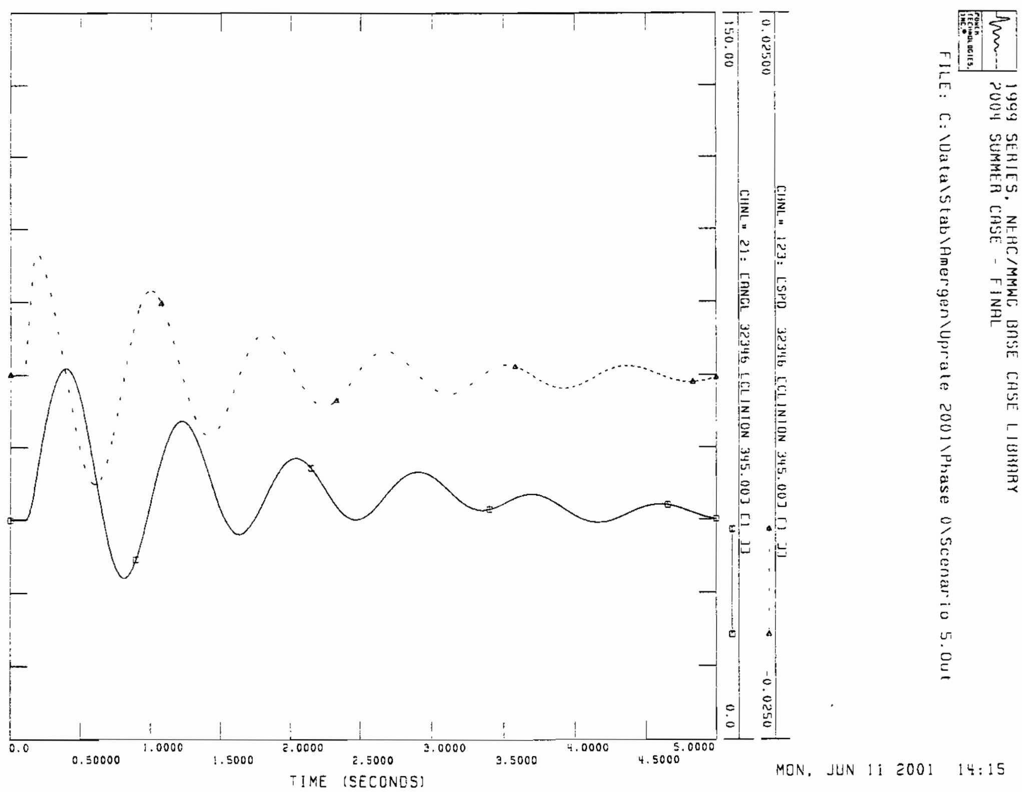
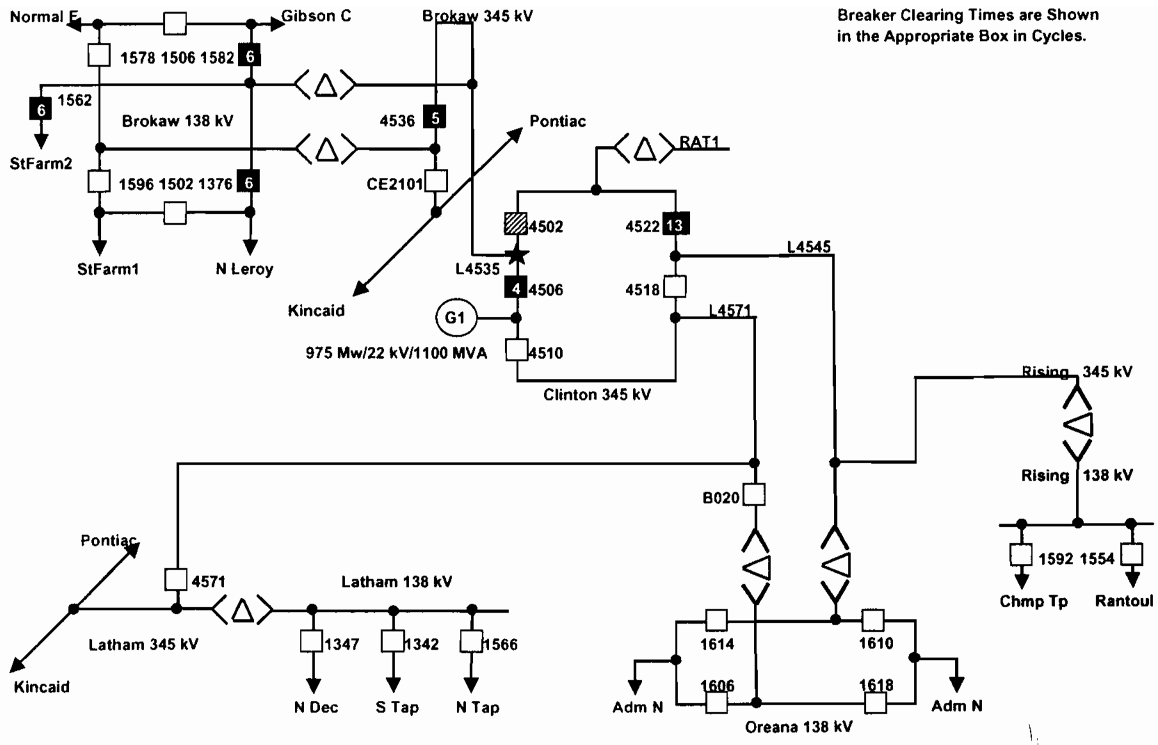


Exhibit 17: 3-Phase simultaneous fault on the double circuit Clinton to Latham and Clinton to Oreana to Rising 345 kV lines at CPS, Case 2.



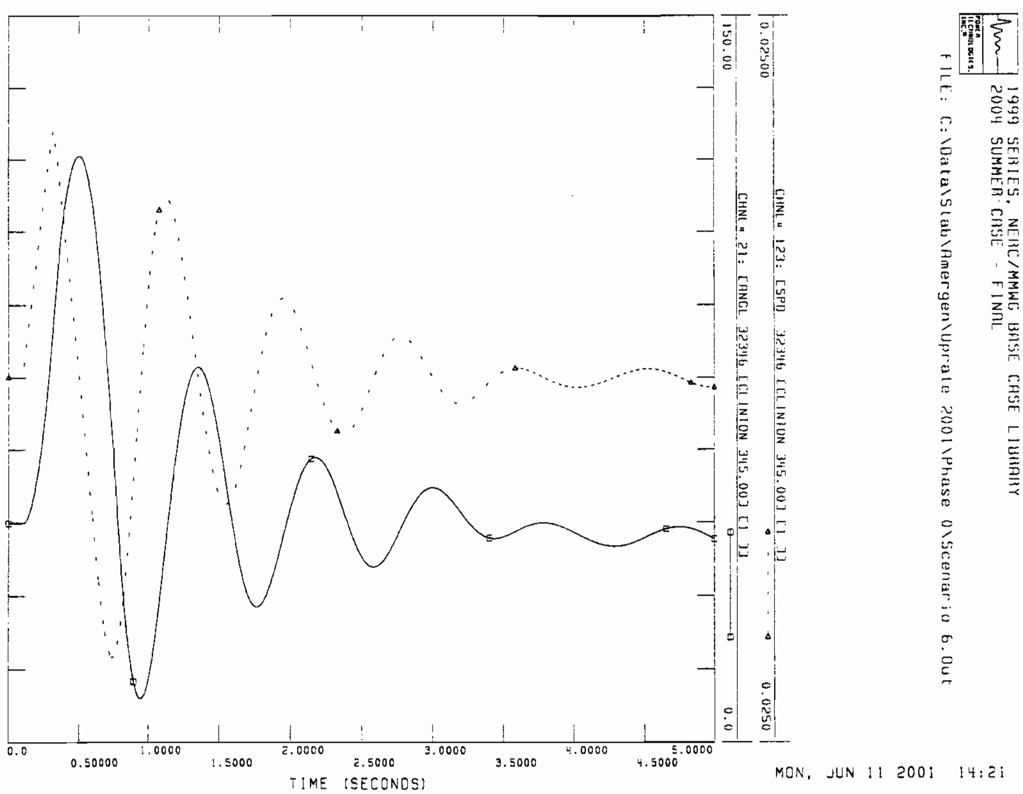


Exhibit 18: Double-line-ground fault on the Clinton to Brokaw 345 kV line at CPS with failure of Breaker 4502, Case 2.

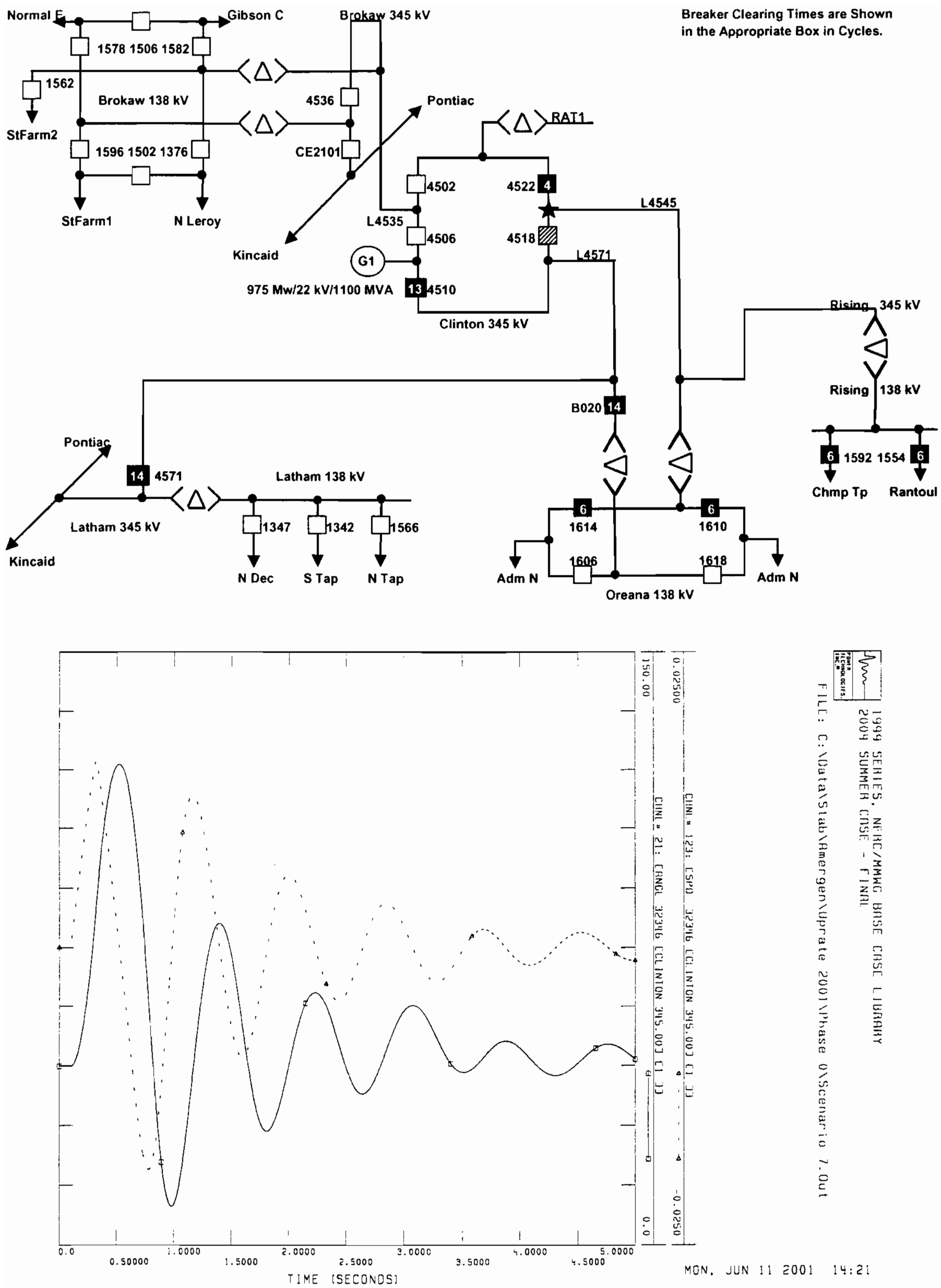


Exhibit 19: Double-line-ground fault on the Clinton to Oreana to Rising 345 kV line at CPS with failure of Breaker 4518, Case 2.

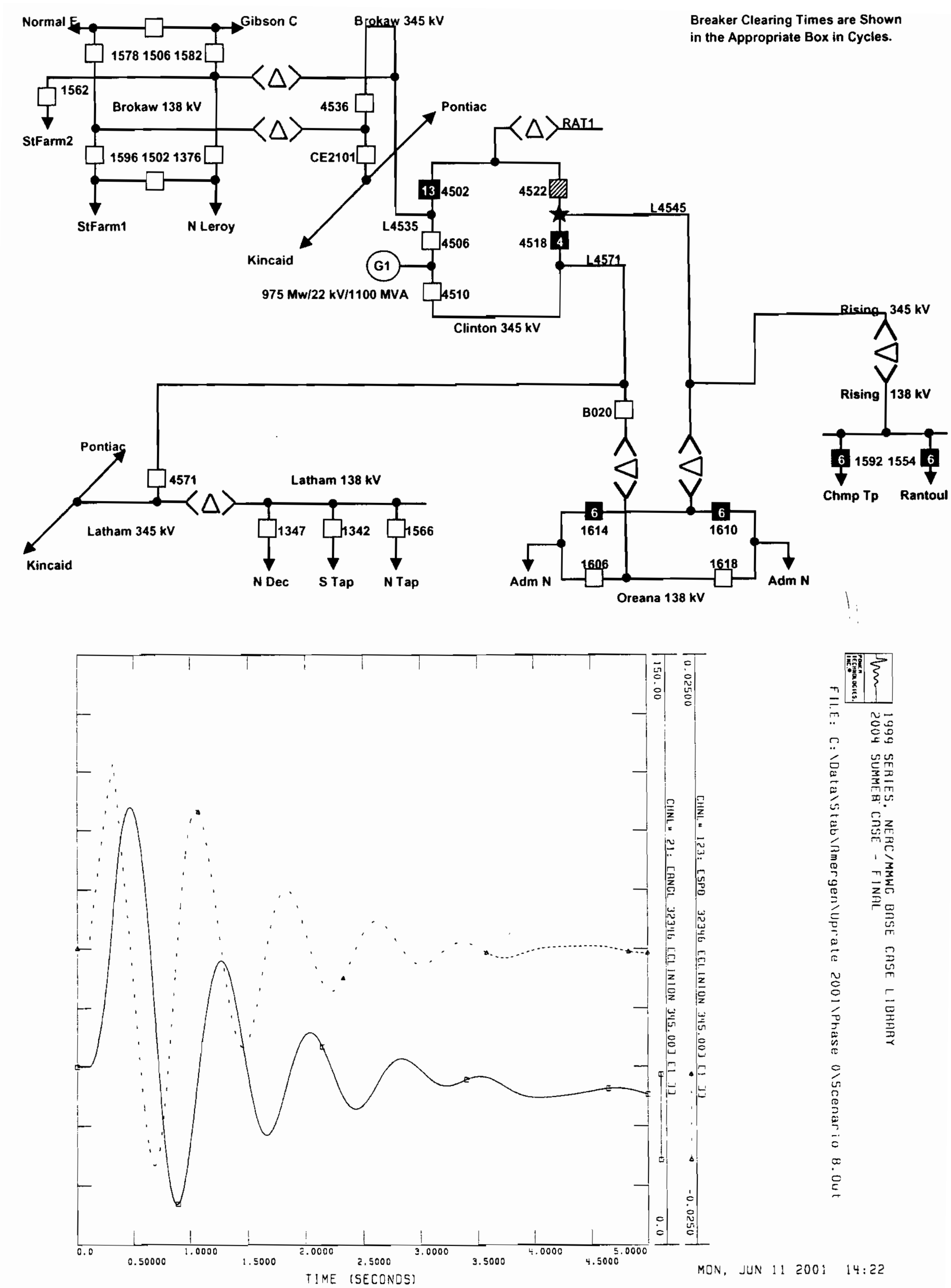


Exhibit 20: Double-line-ground fault on the Clinton to Oreana to Rising 345 kV line at CPS with failure of Breaker 4522, Case 2.

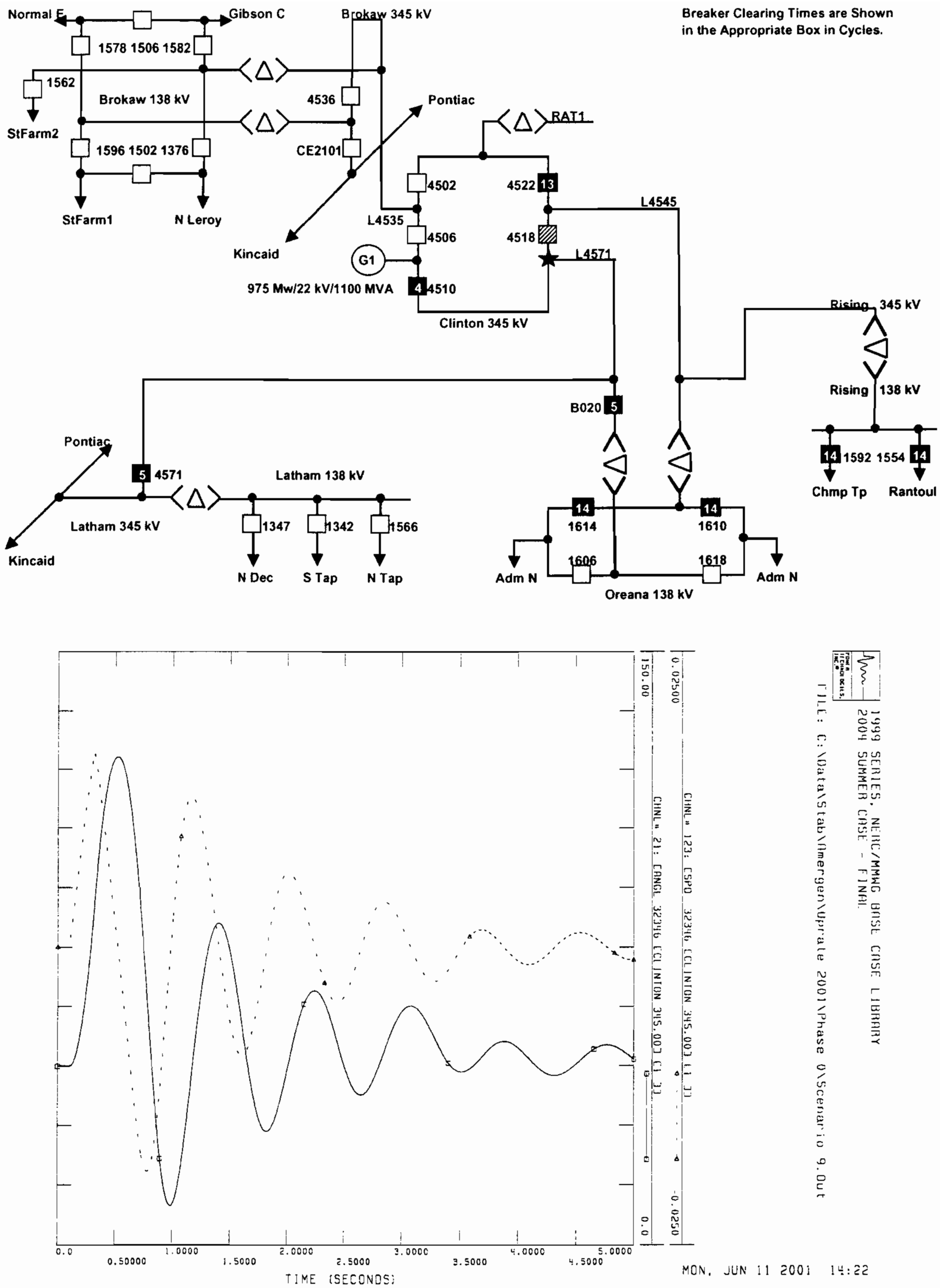


Exhibit 21: Double-line-ground fault on the Clinton to Latham 345 kV line at CPS with failure of Breaker 4518, Case 2.

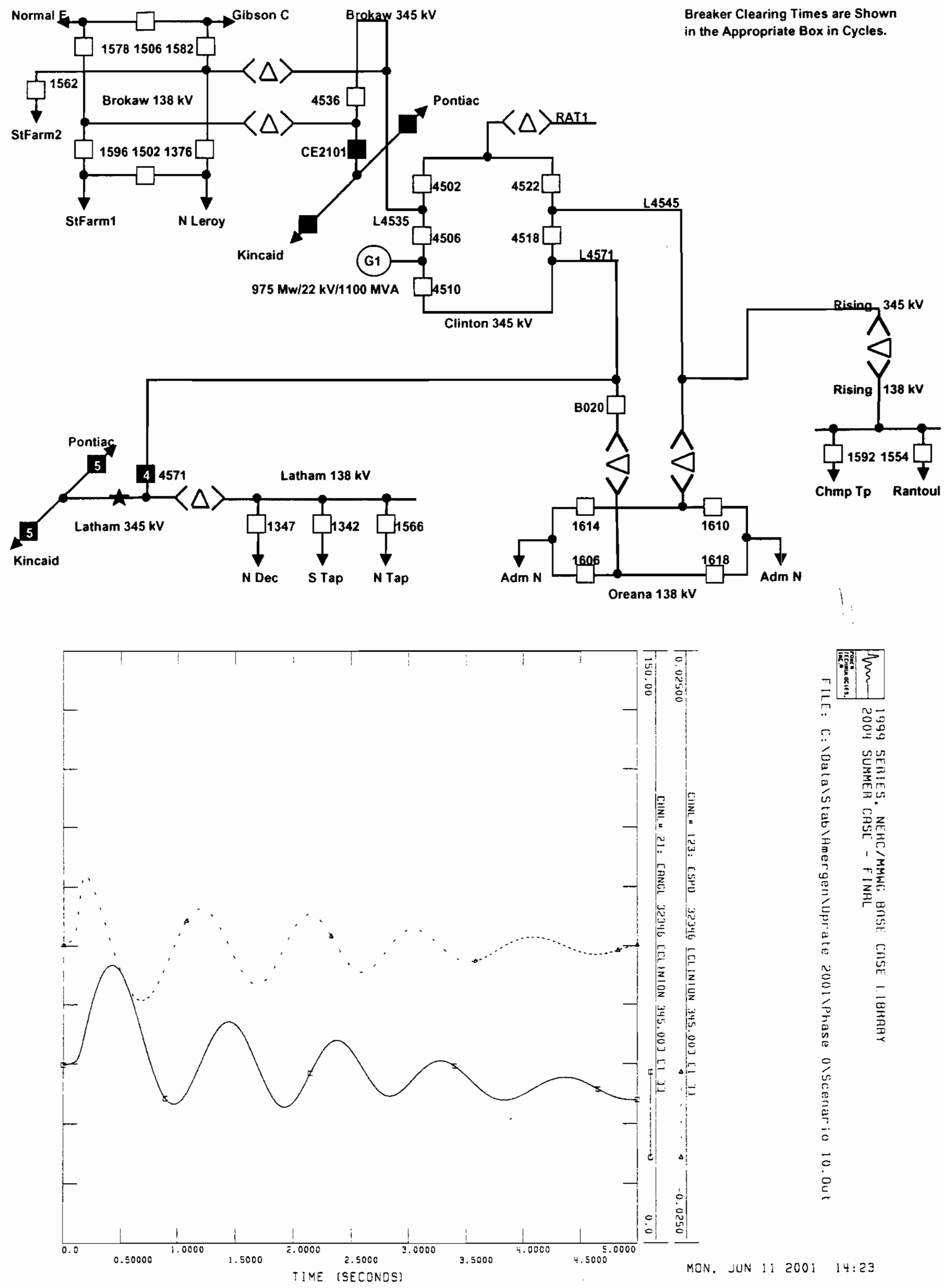
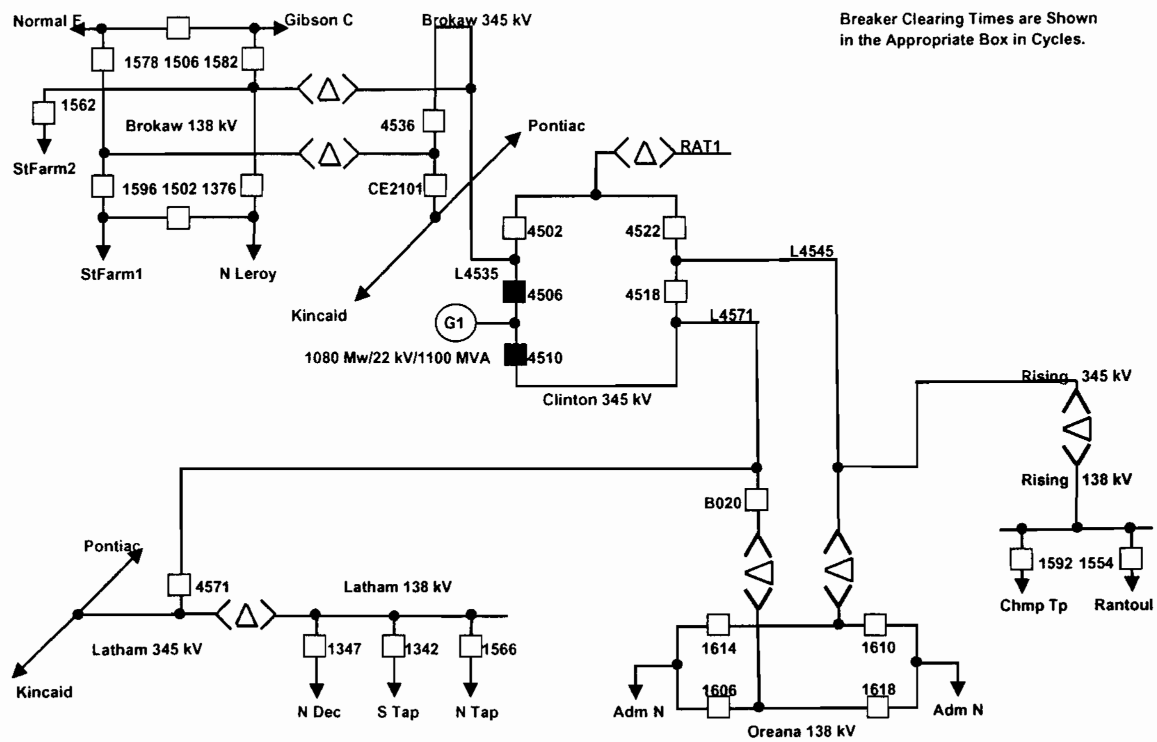


Exhibit 22: 3-Phase fault on the Kincaid to Latham to Pontiac 345 kV line at Latham with the Kincaid to Brokaw to Pontiac 345 kV line out of service, Case 2.



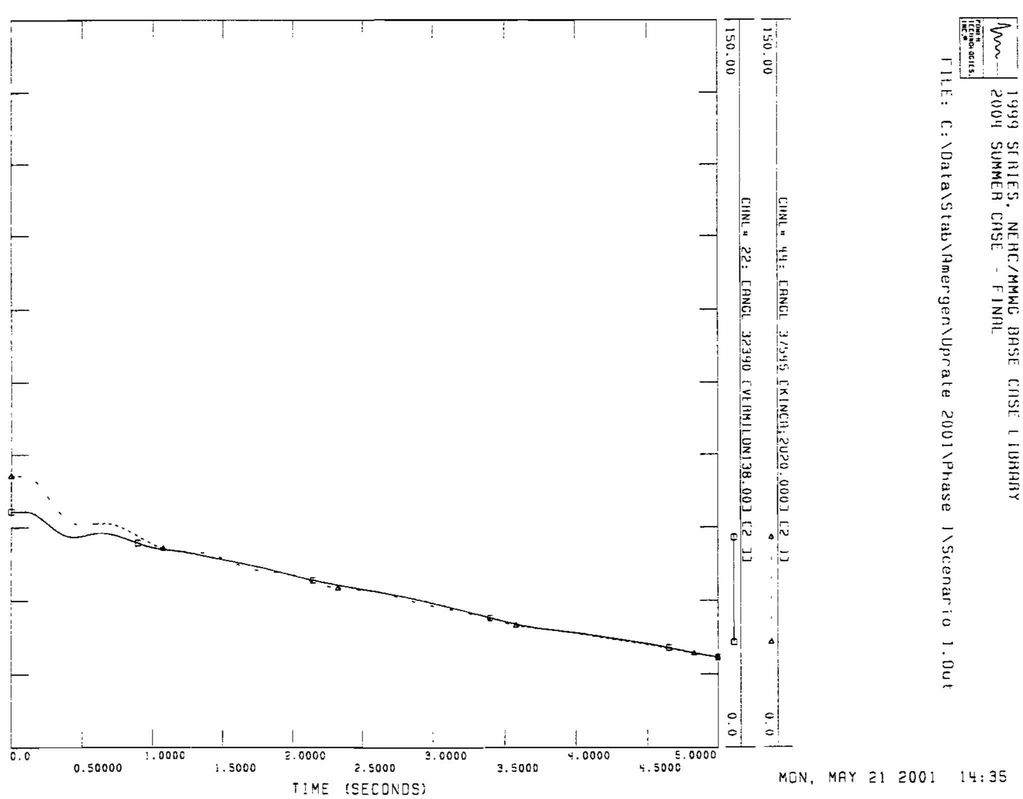


Exhibit 23: CPS tripped with no fault, Case 3.

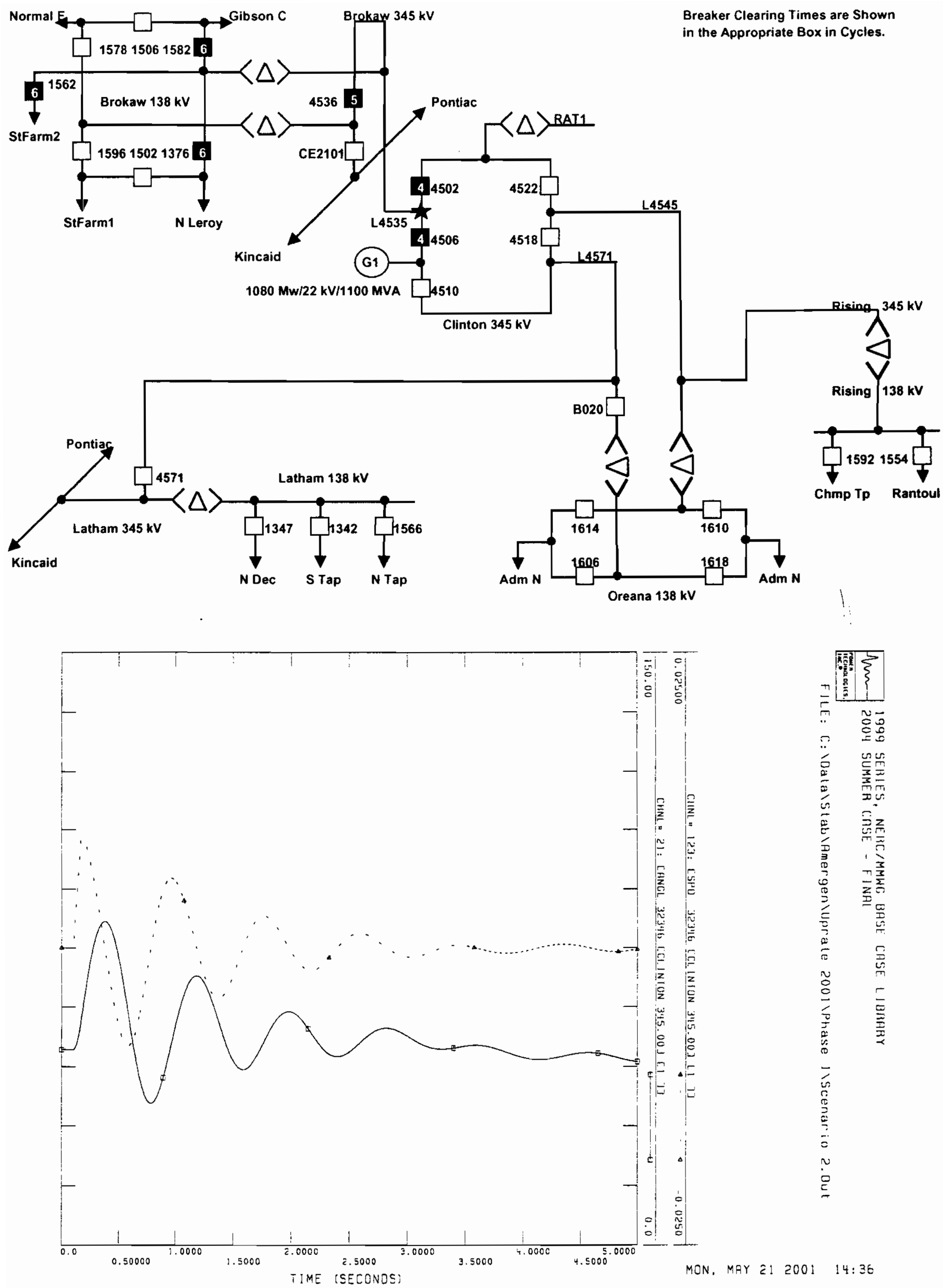
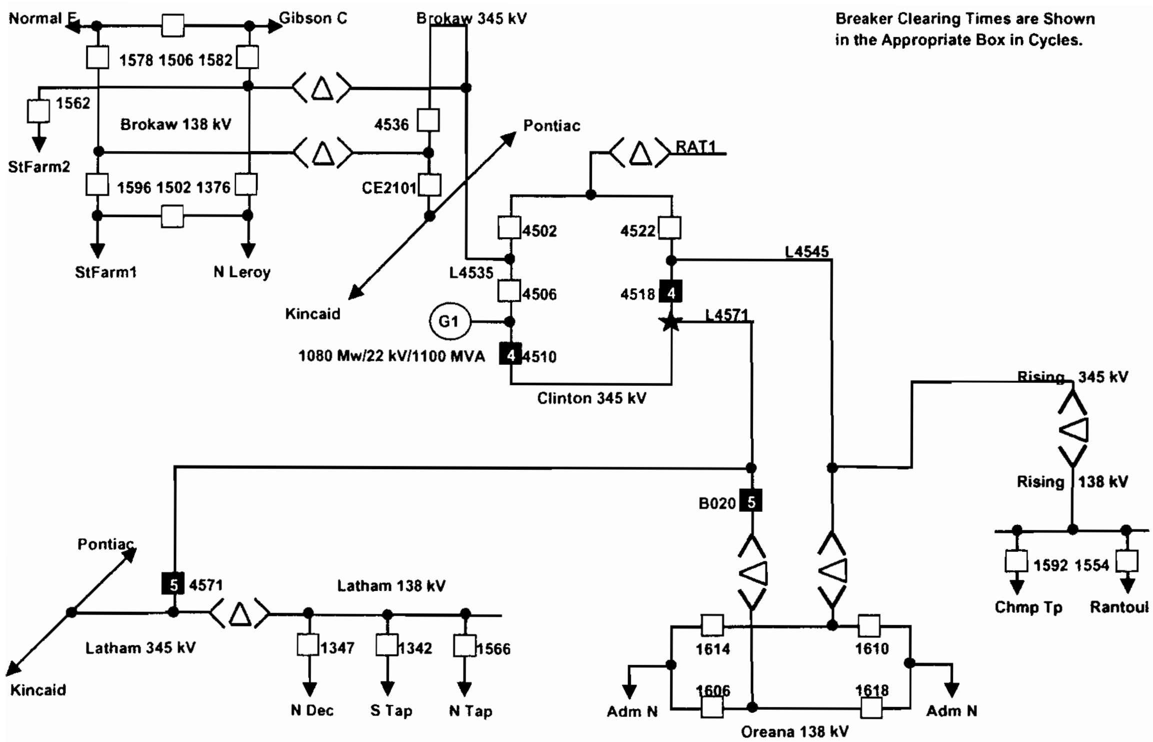


Exhibit 24: 3-Phase fault on the Clinton to Brokaw 345 kV line at CPS, Case 3.



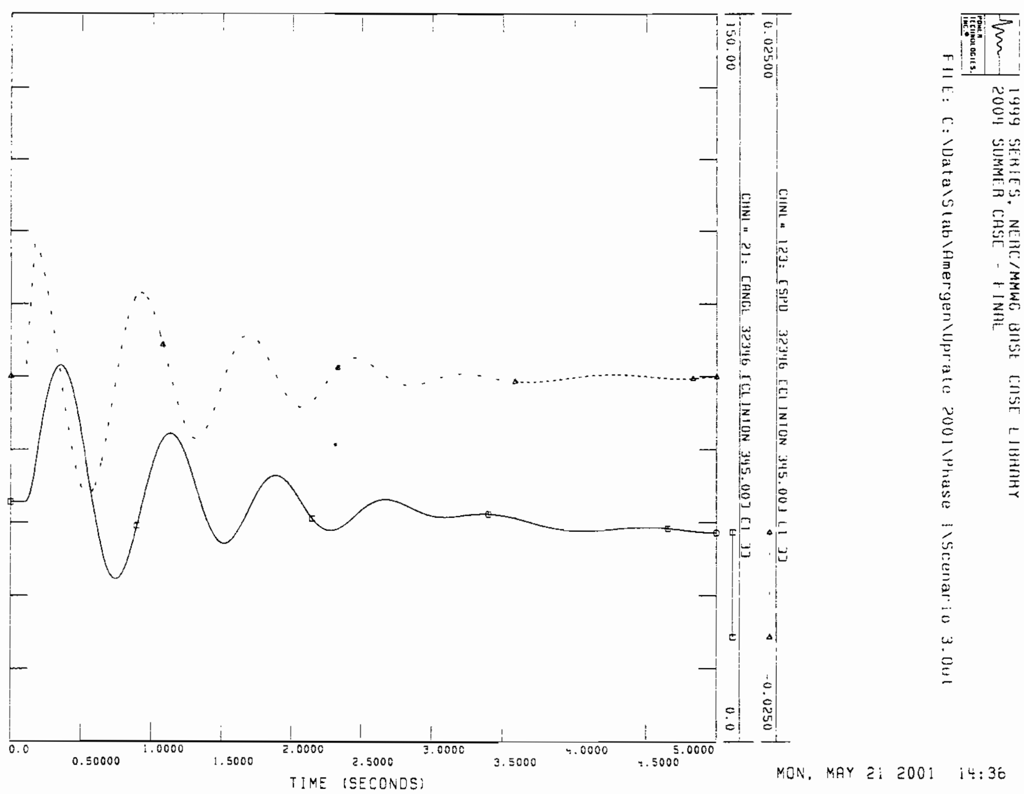
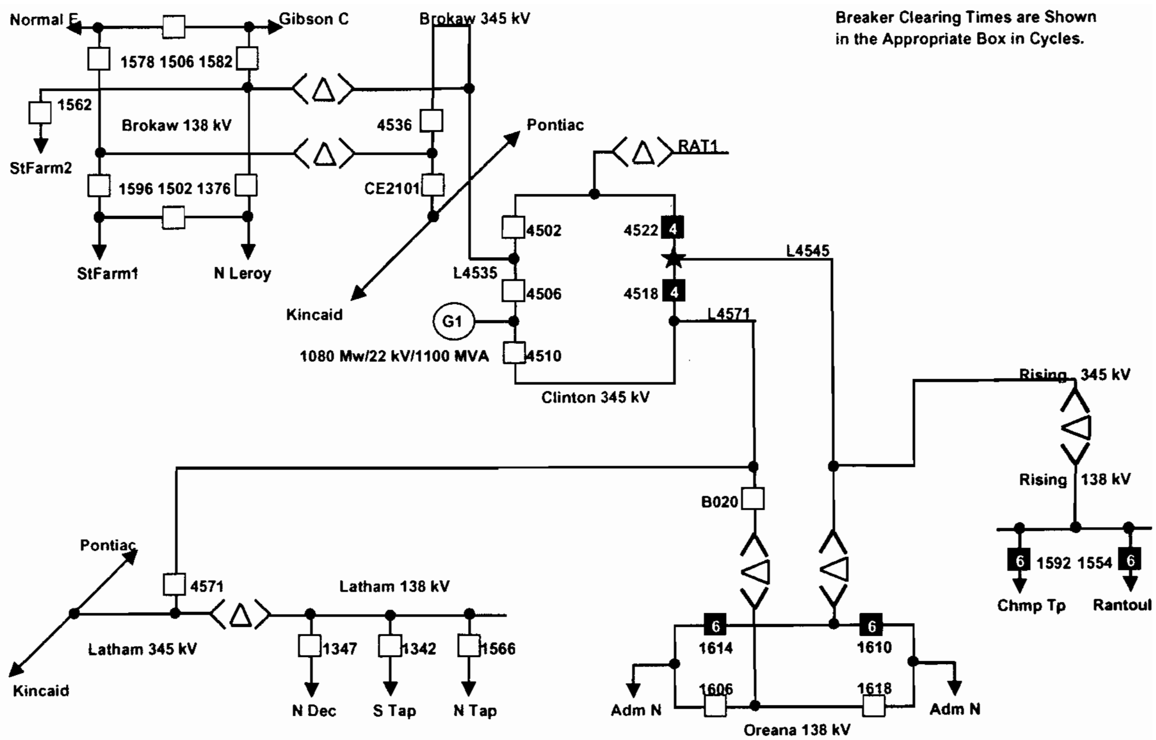


Exhibit 25: 3-Phase fault on the Clinton to Latham 345 kV line at CPS, Case 3.



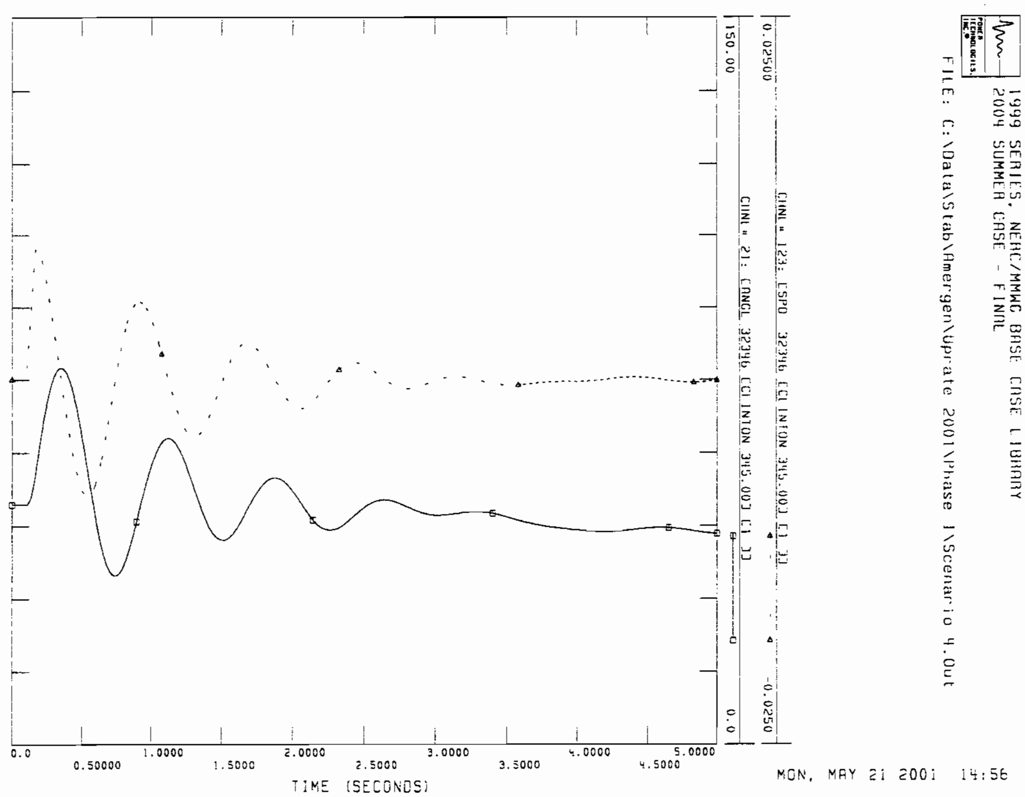
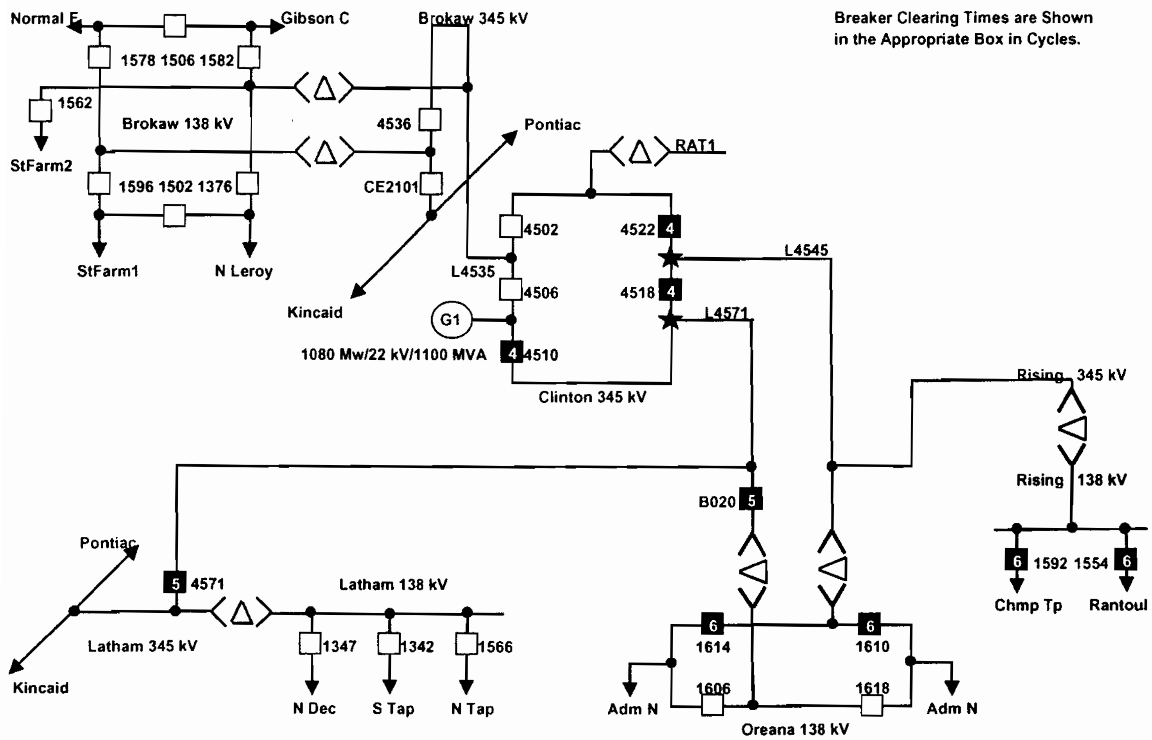


Exhibit 26: 3-Phase fault on the Clinton to Oreana to Rising 345 kV line at CPS, Case 3.



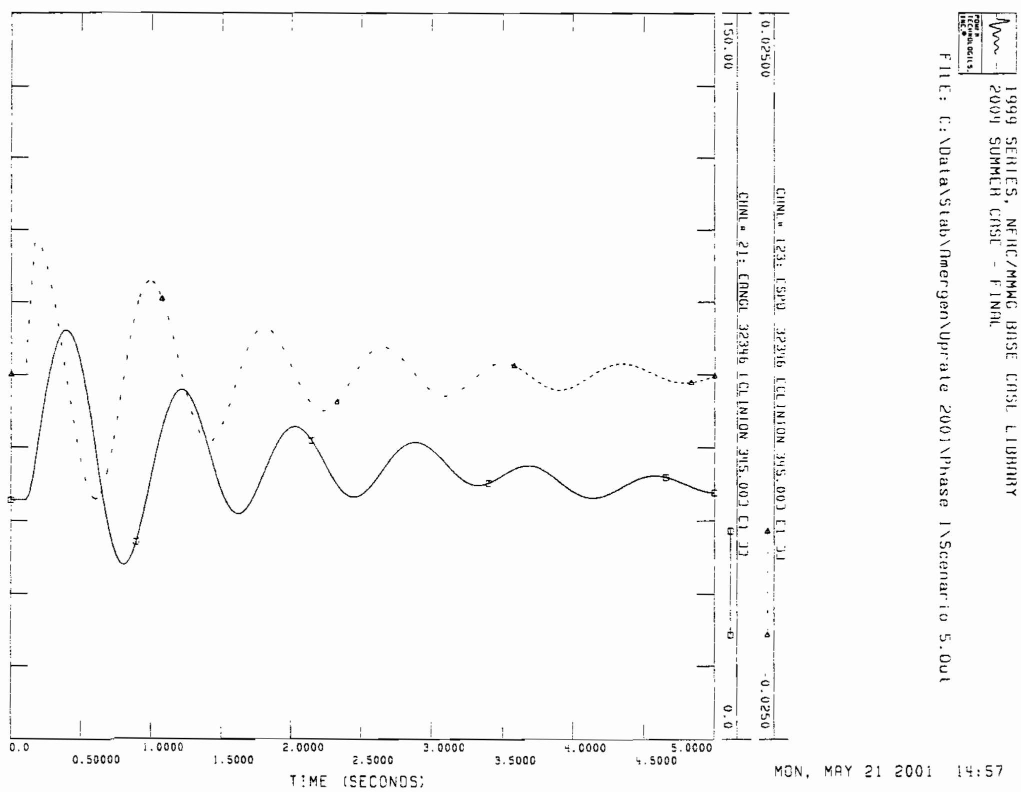
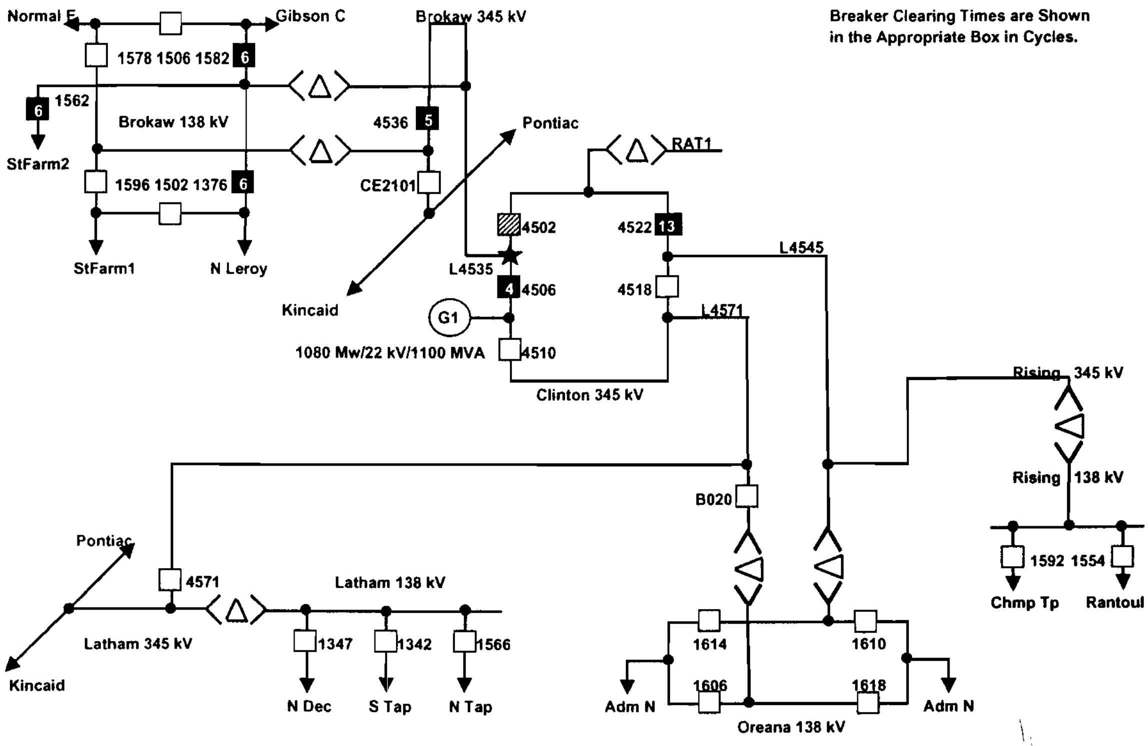


Exhibit 27: 3-Phase simultaneous fault on the double circuit Clinton to Latham and Clinton to Oreana to Rising 345 kV lines at CPS, Case 3.



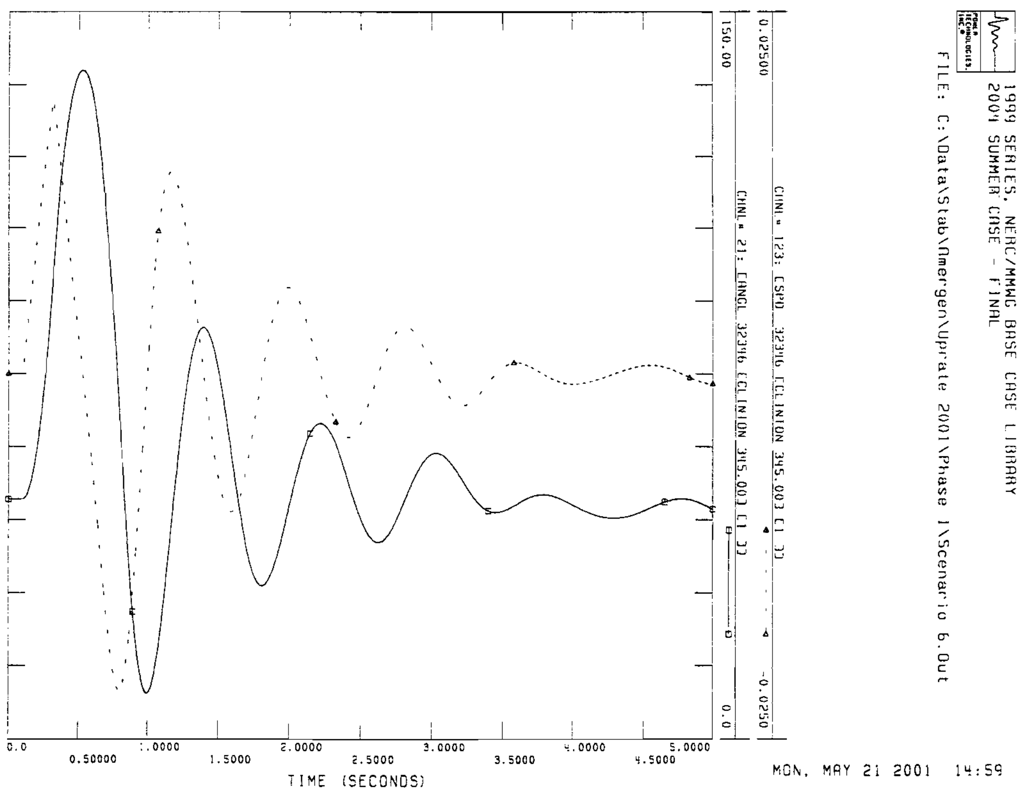


Exhibit 28: Double-line-ground fault on the Clinton to Brokaw 345 kV line at CPS with failure of Breaker 4502, Case 3.

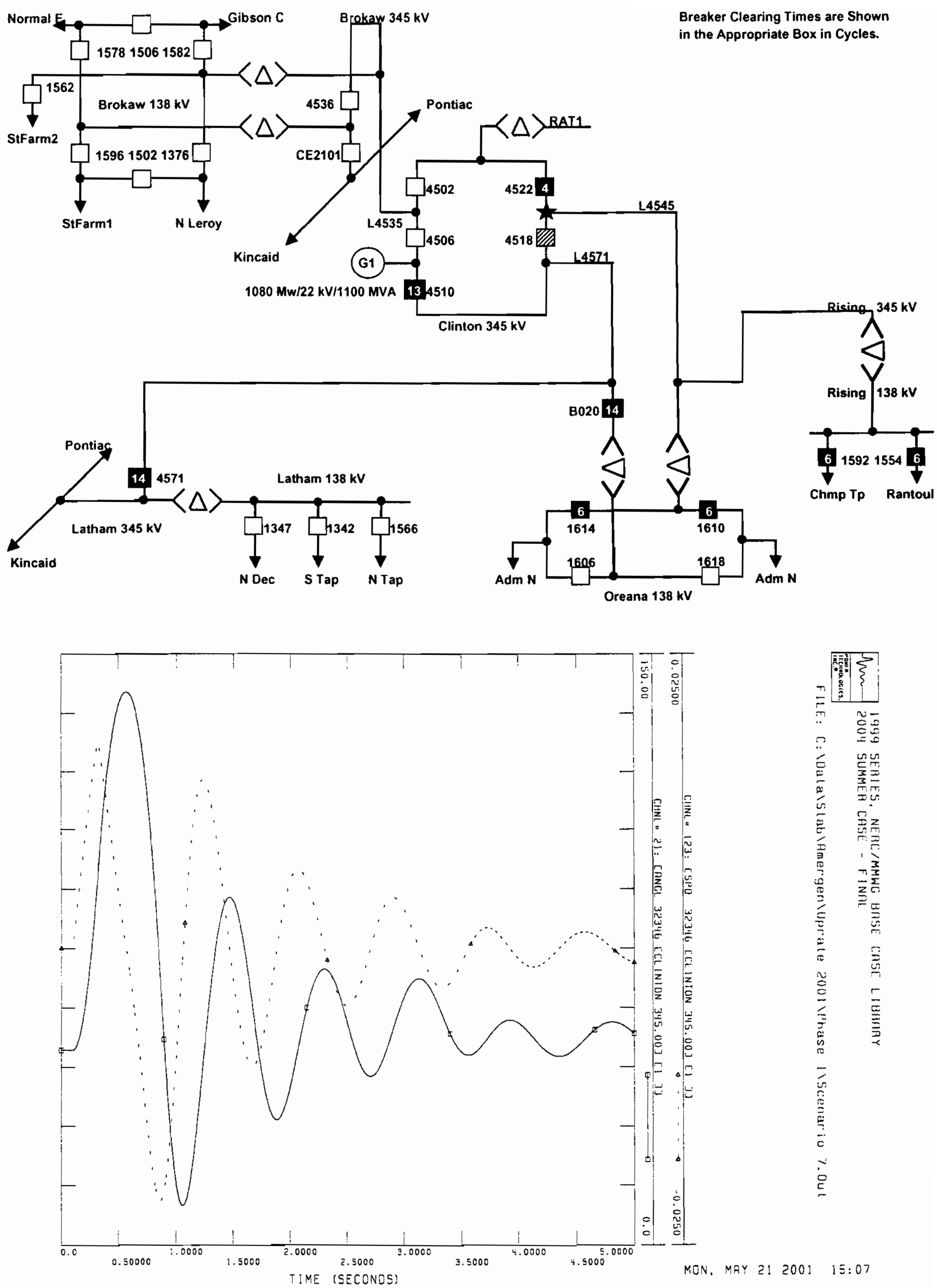
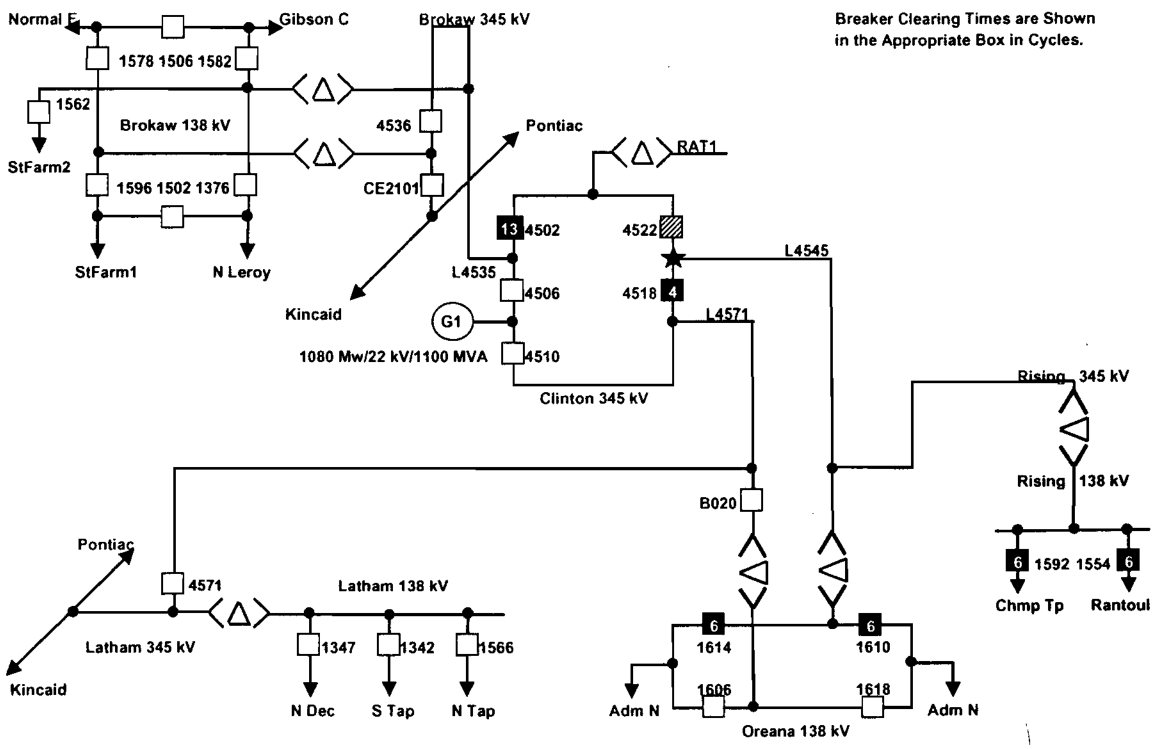


Exhibit 29: Double-line-ground fault on the Clinton to Oreana to Rising 345 kV line at CPS with failure of Breaker 4518, Case 3.



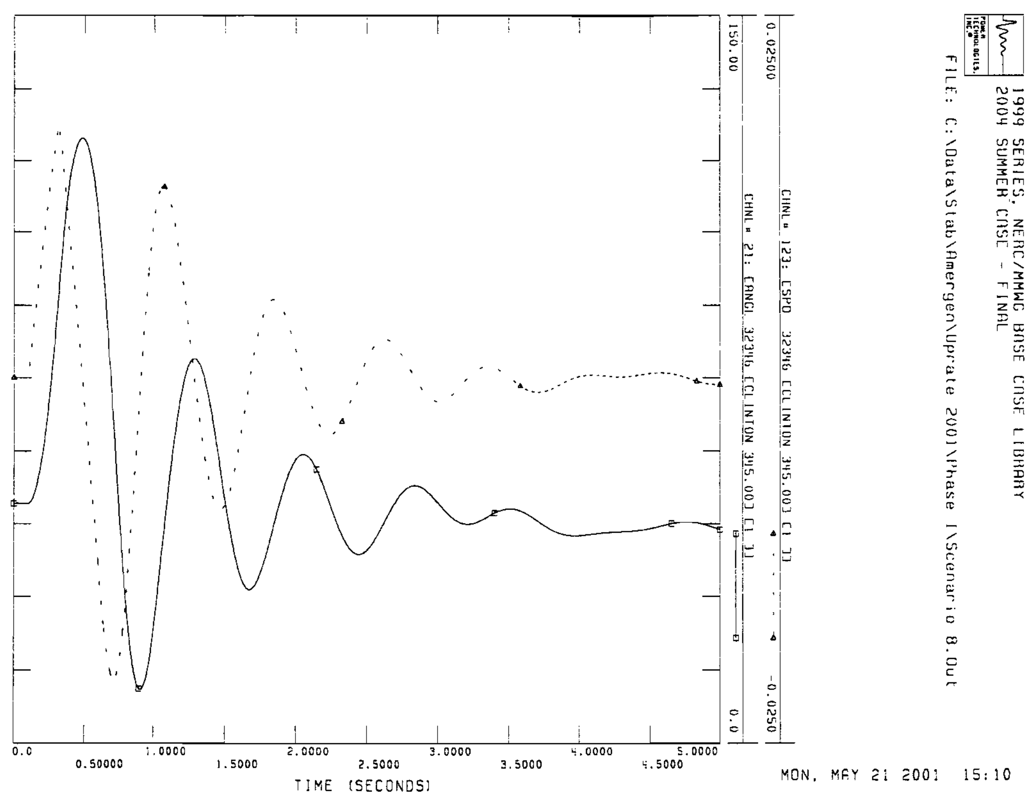
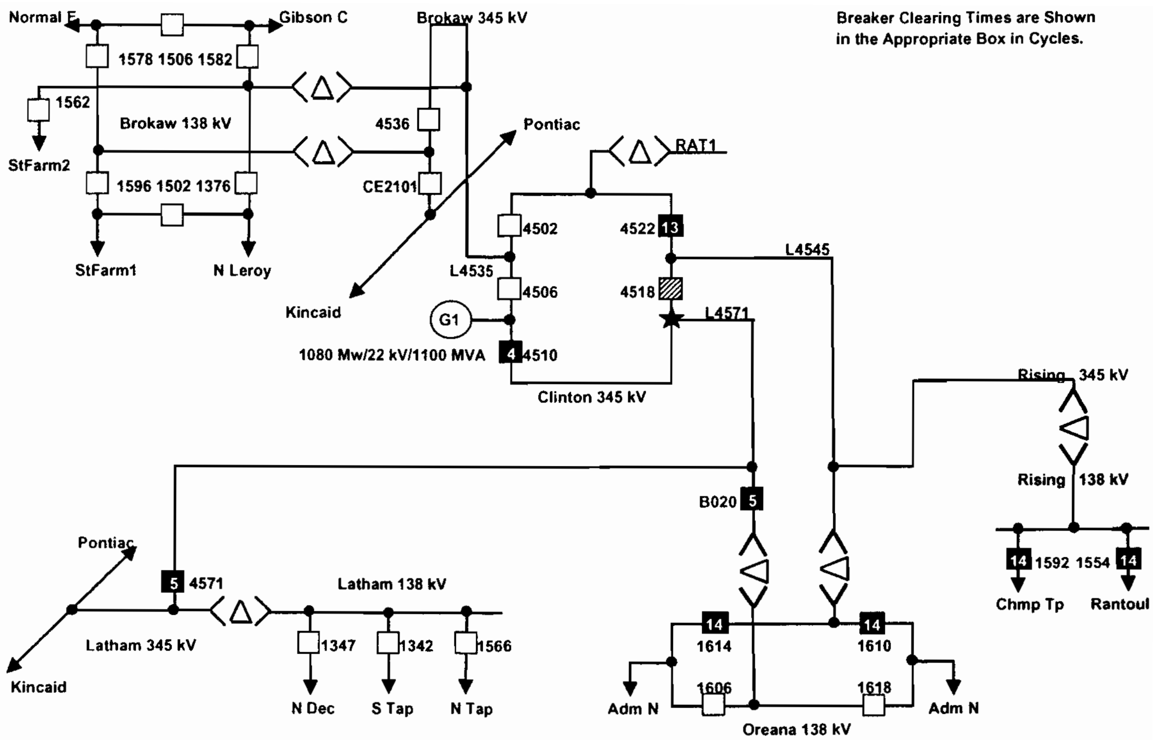


Exhibit 30: Double-line-ground fault on the Clinton to Oreana to Rising 345 kV line at CPS with failure of Breaker 4522, Case 3.



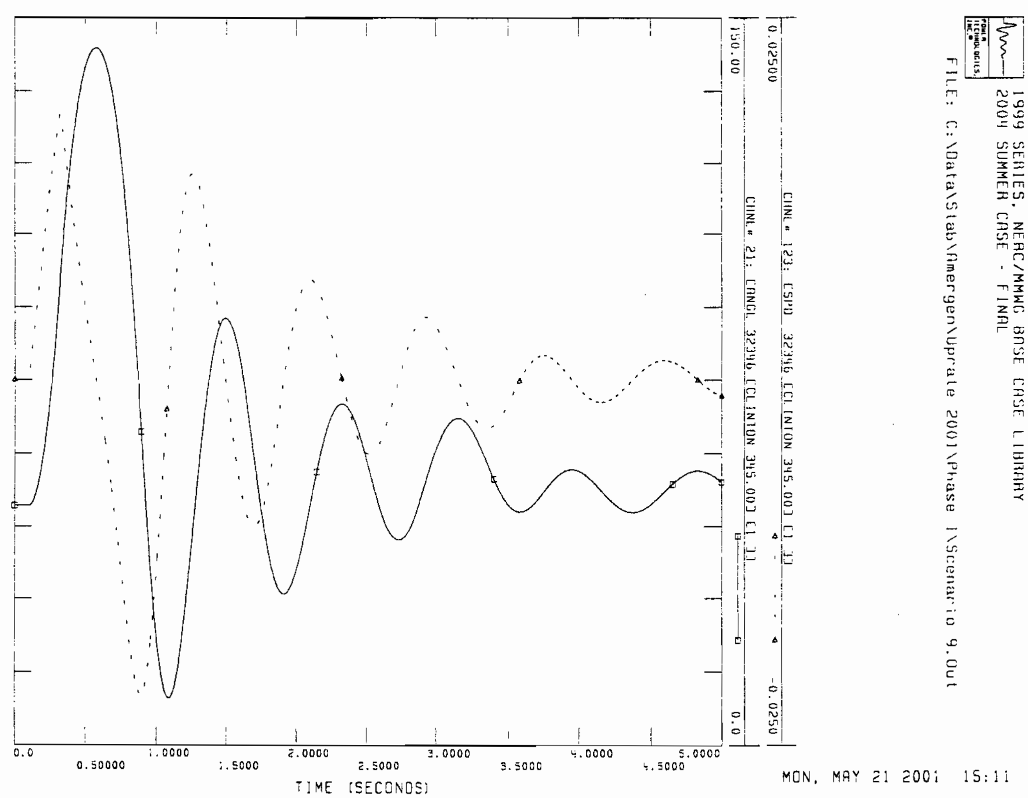
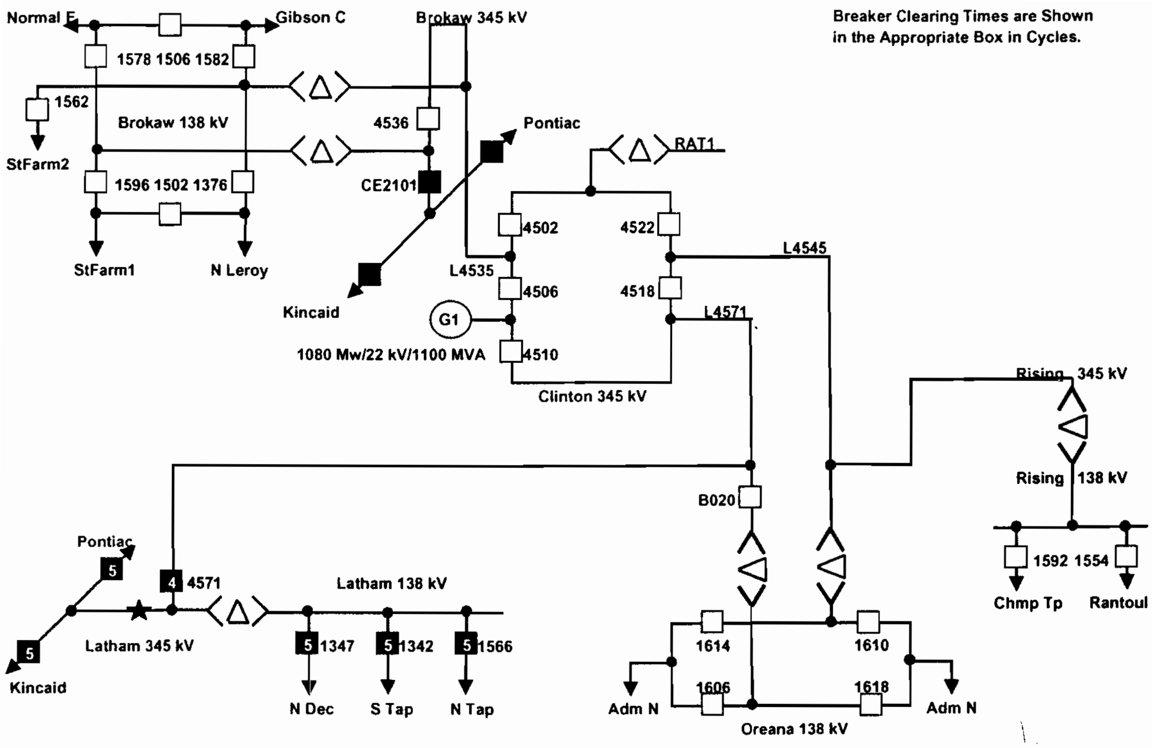


Exhibit 31: Double-line-ground fault on the Clinton to Latham 345 kV line at CPS with failure of Breaker 4518, Case 3.



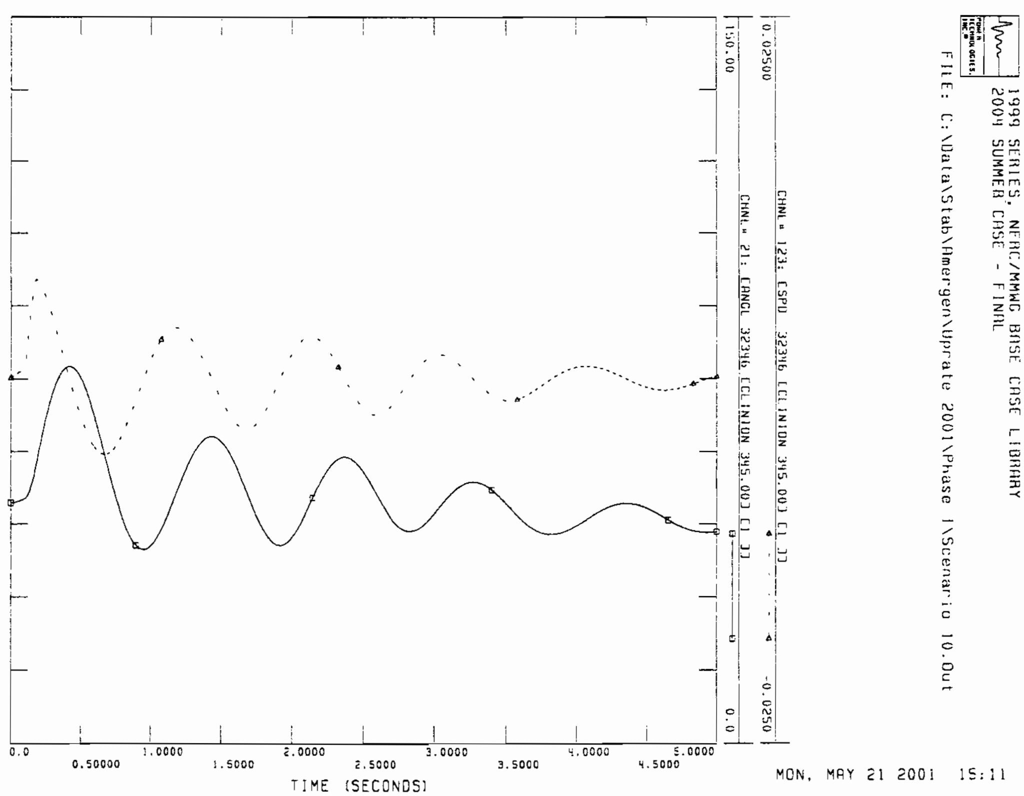
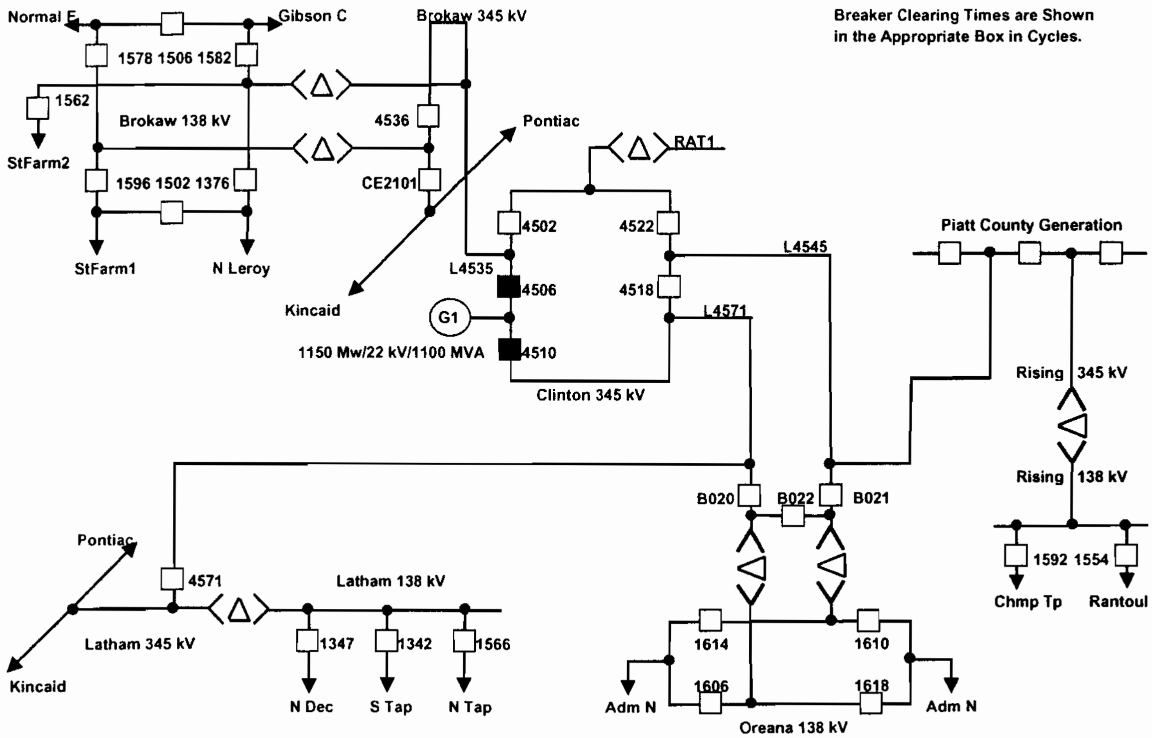


Exhibit 32: 3-Phase fault on the Kincaid to Latham to Pontiac 345 kV line at Latham with the Kincaid to Brokaw to Pontiac 345 kV line out of service, Case 3.



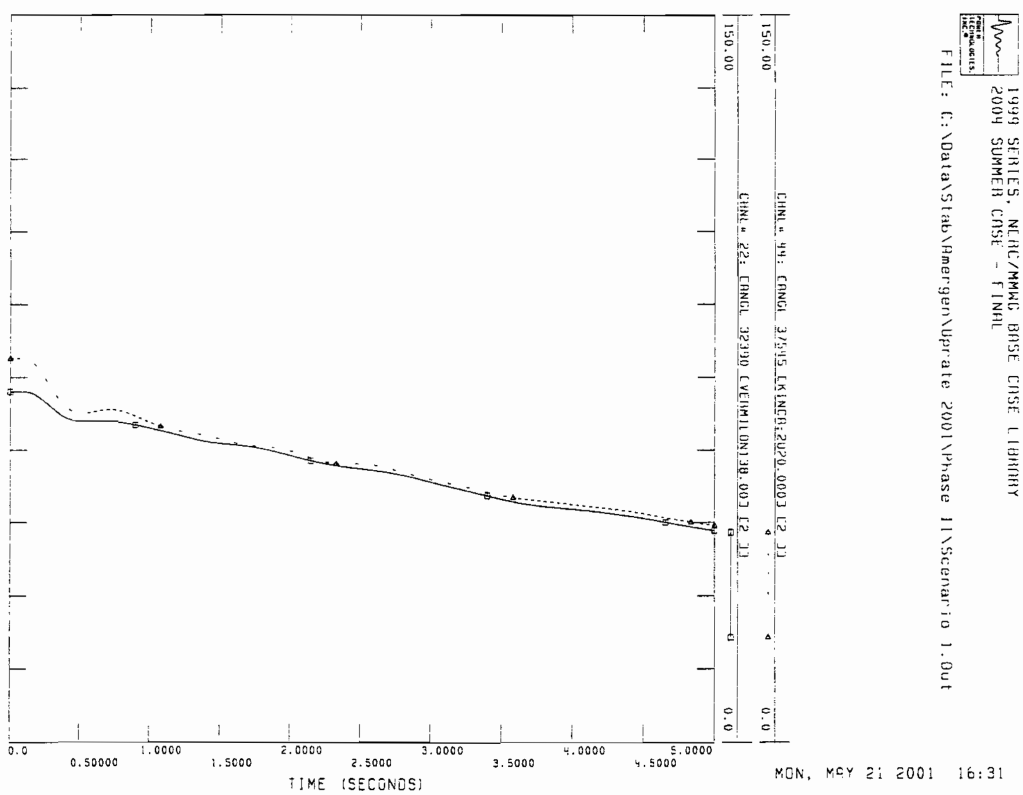
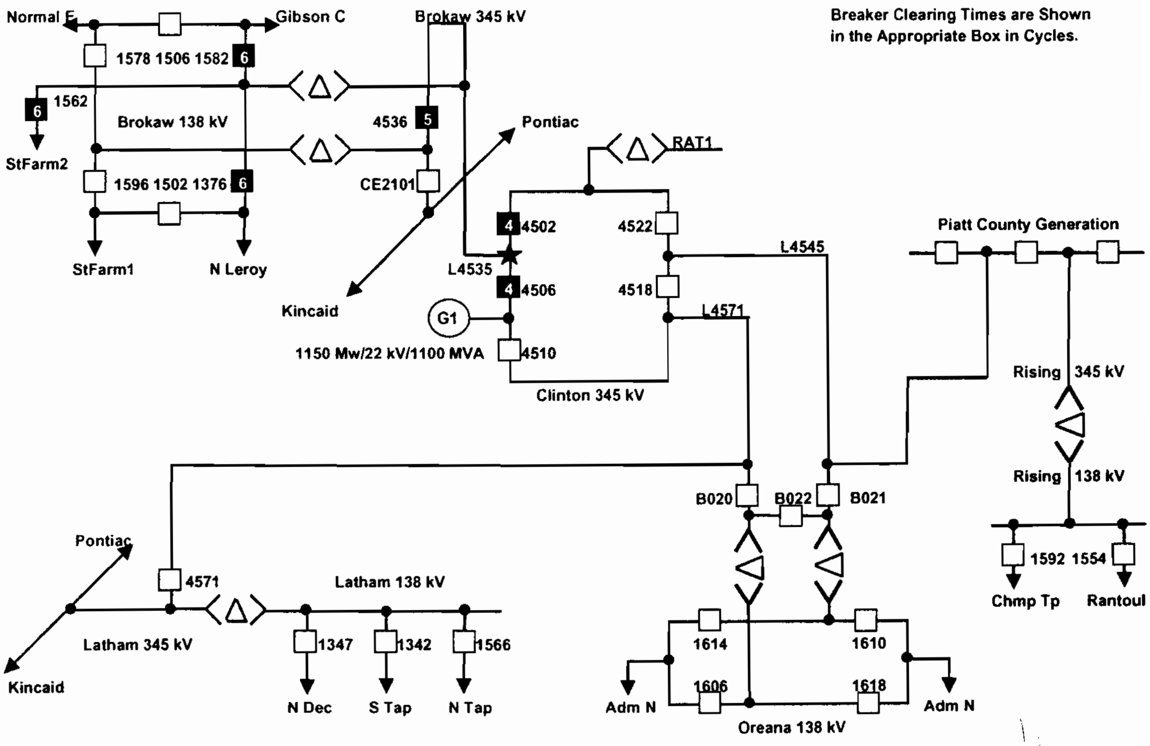


Exhibit 33: CPS tripped with no fault, Case 4.



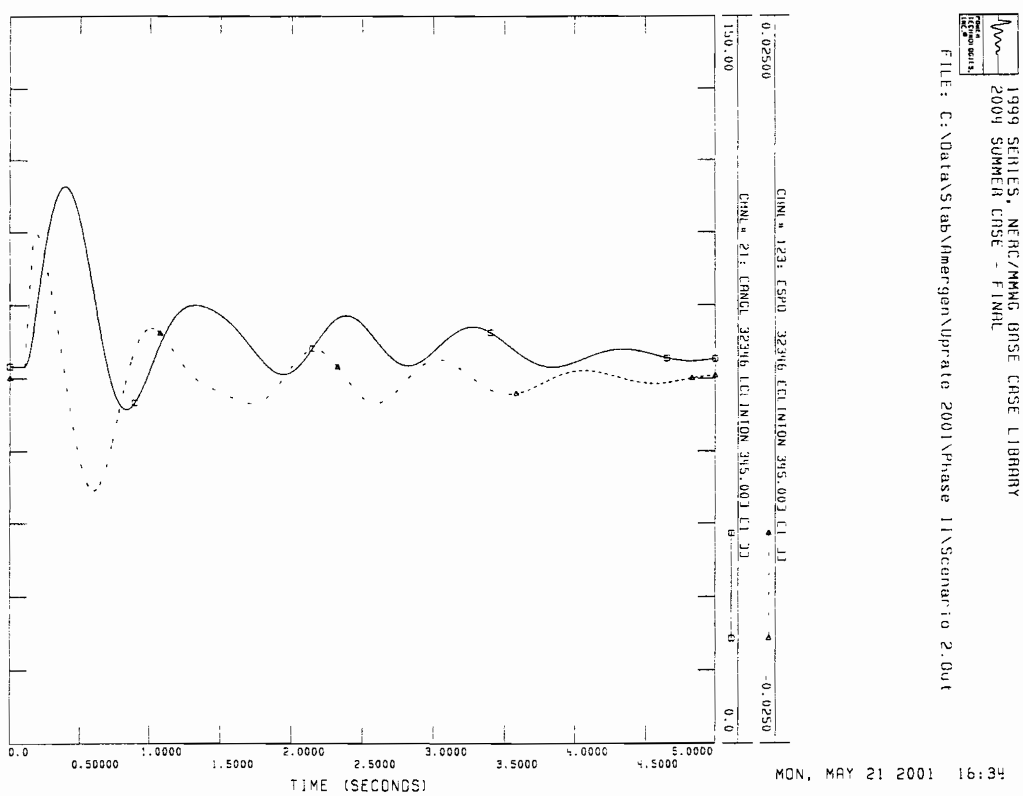
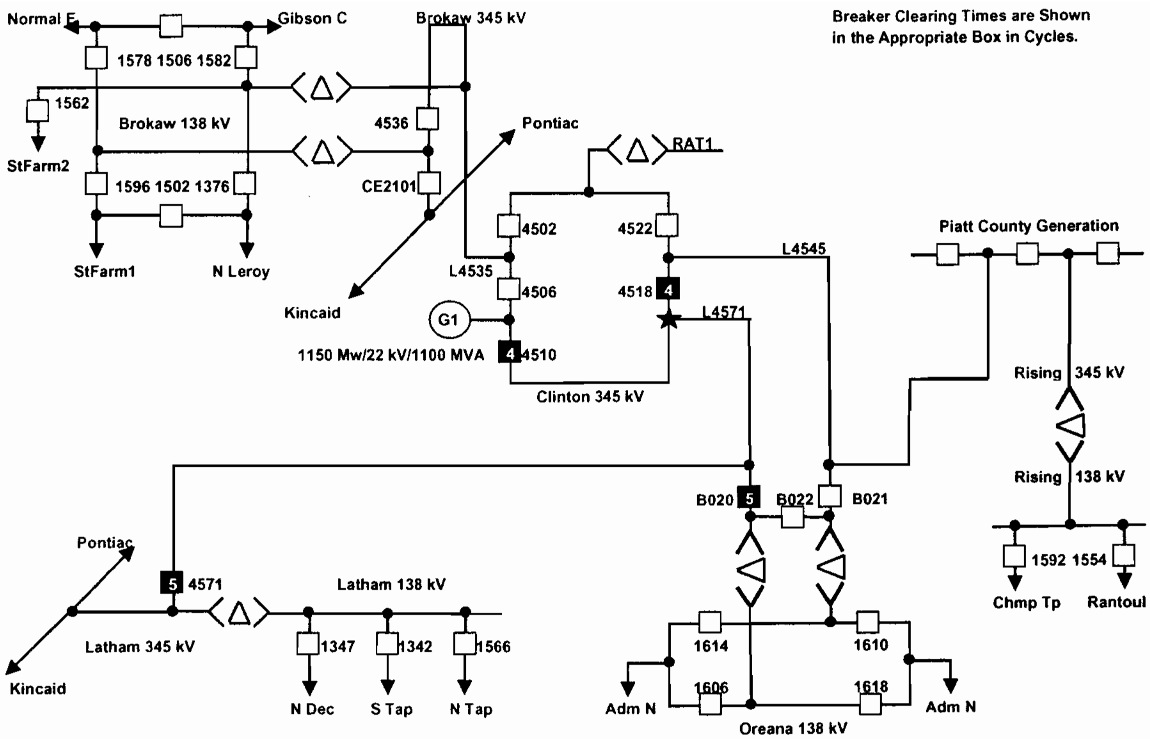


Exhibit 34: 3-Phase fault on the Clinton to Brokaw 345 kV line at CPS, Case 4.



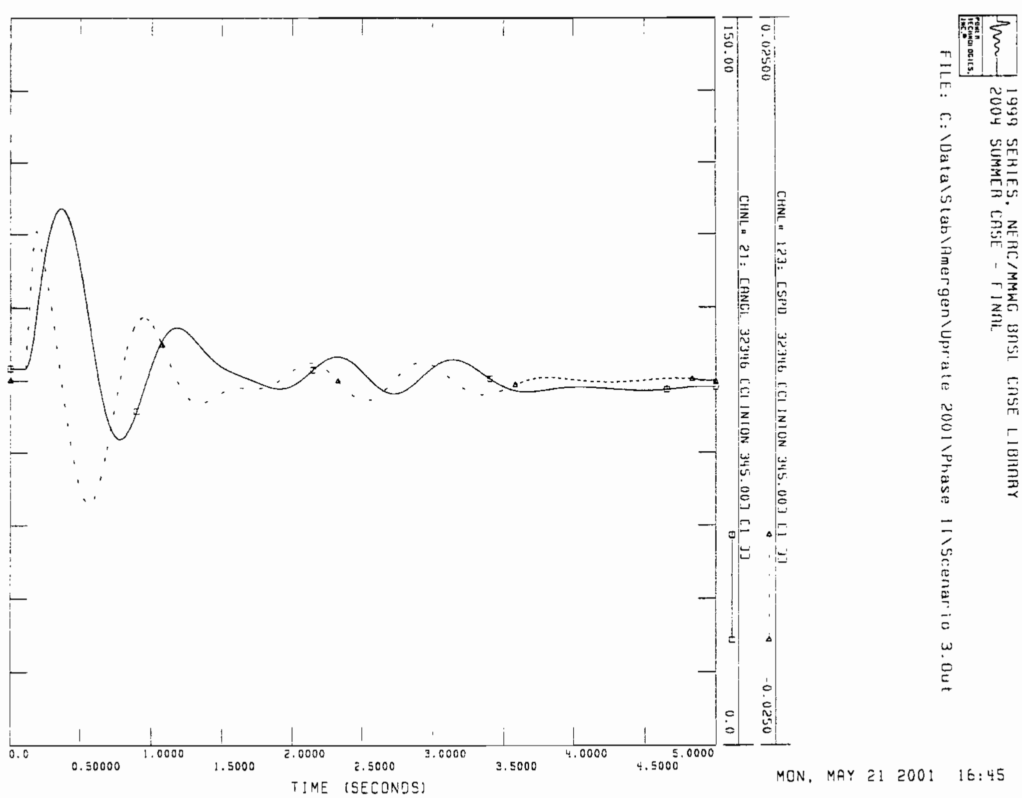


Exhibit 35: 3-Phase fault on the Clinton to Latham 345 kV line at CPS, Case 4.

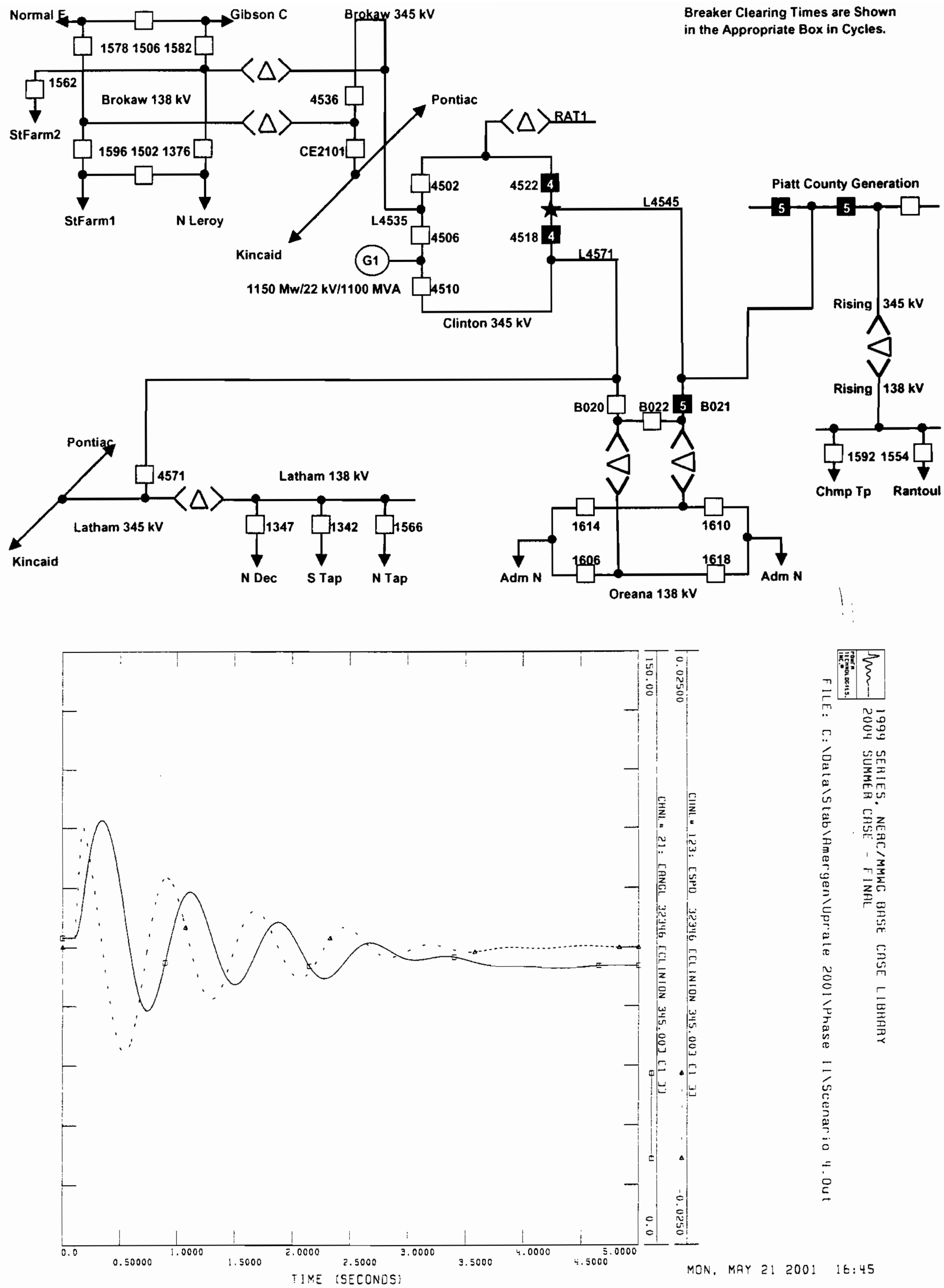
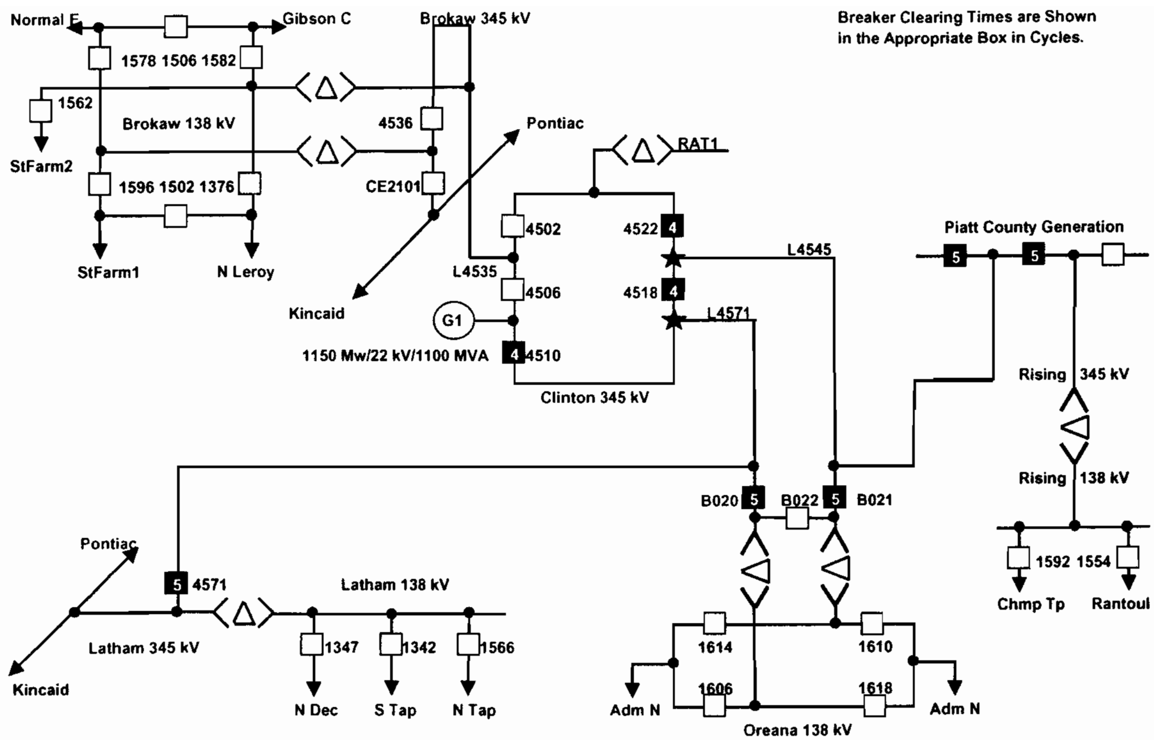


Exhibit 36: 3-Phase fault on the Clinton to Oreana to Rising 345 kV line at CPS, Case 4.



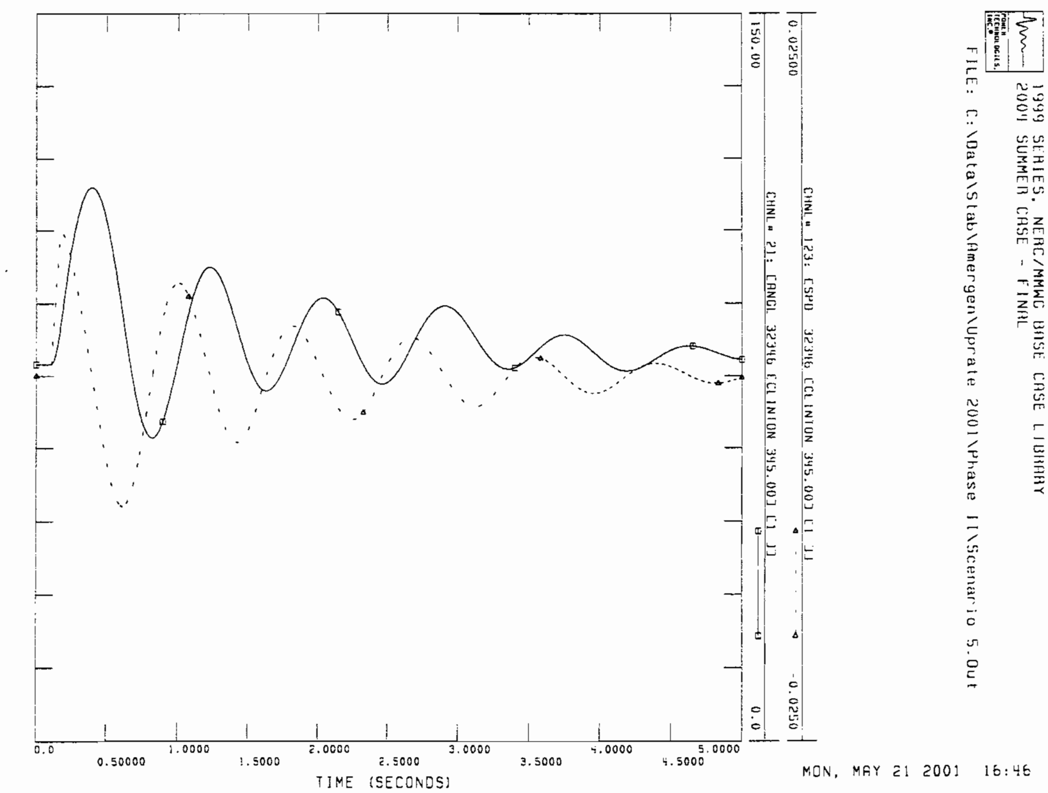
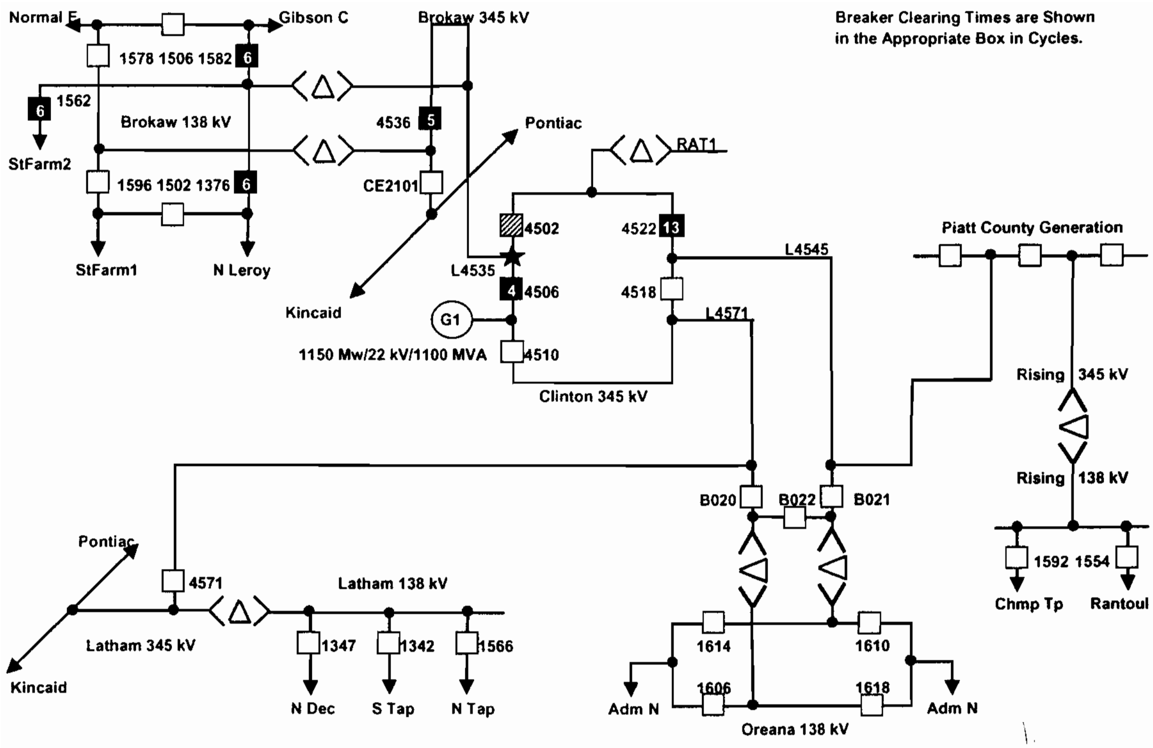


Exhibit 37: 3-Phase simultaneous fault on the double circuit Clinton to Latham and Clinton to Oreana to Rising 345 kV lines at CPS, Case 4.



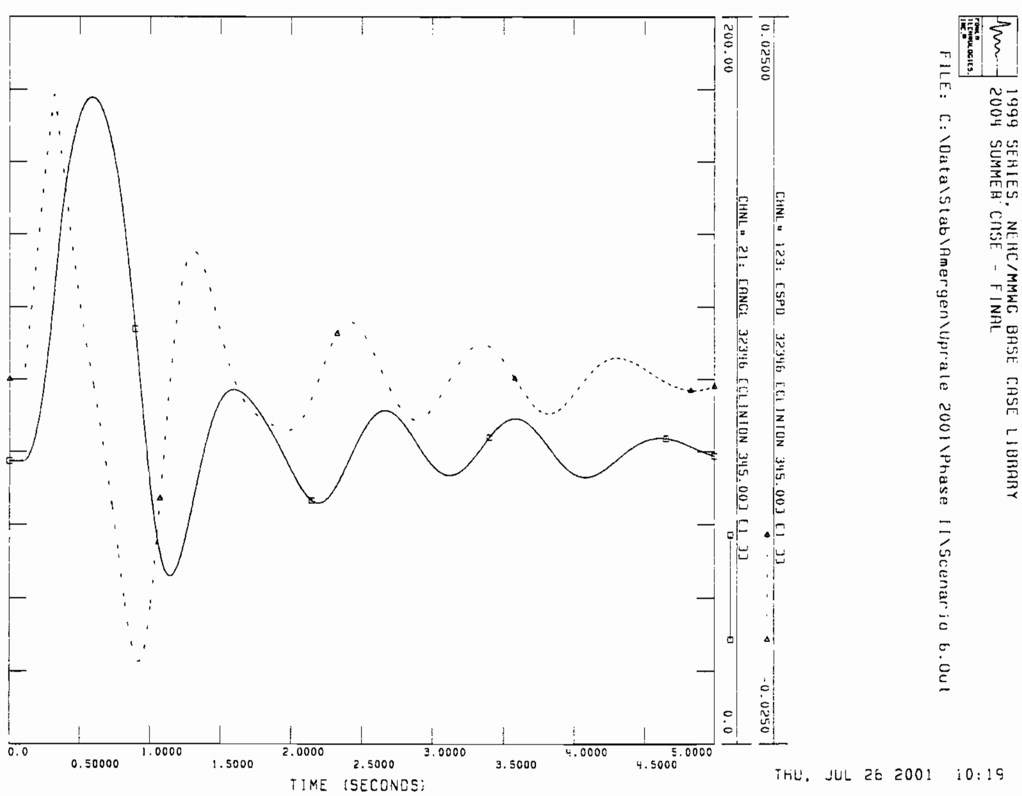
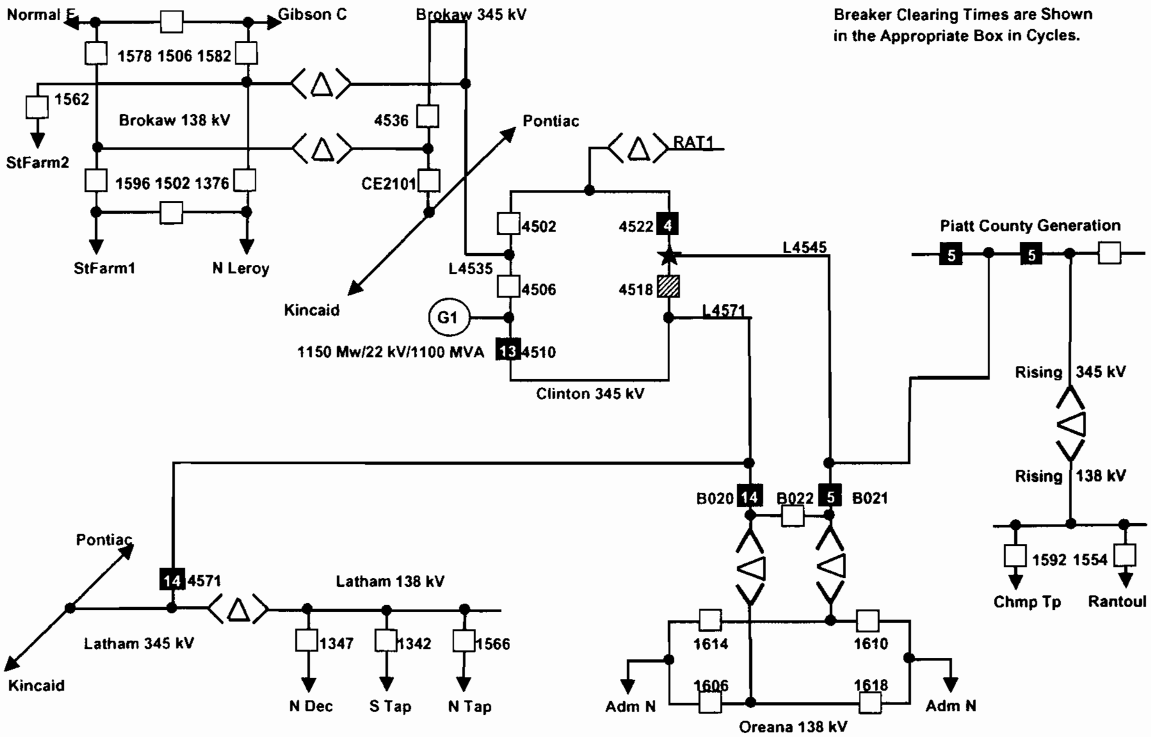


Exhibit 38: Double-line-ground fault on the Clinton to Brokaw 345 kV line at CPS with failure of Breaker 4502, Case 4.



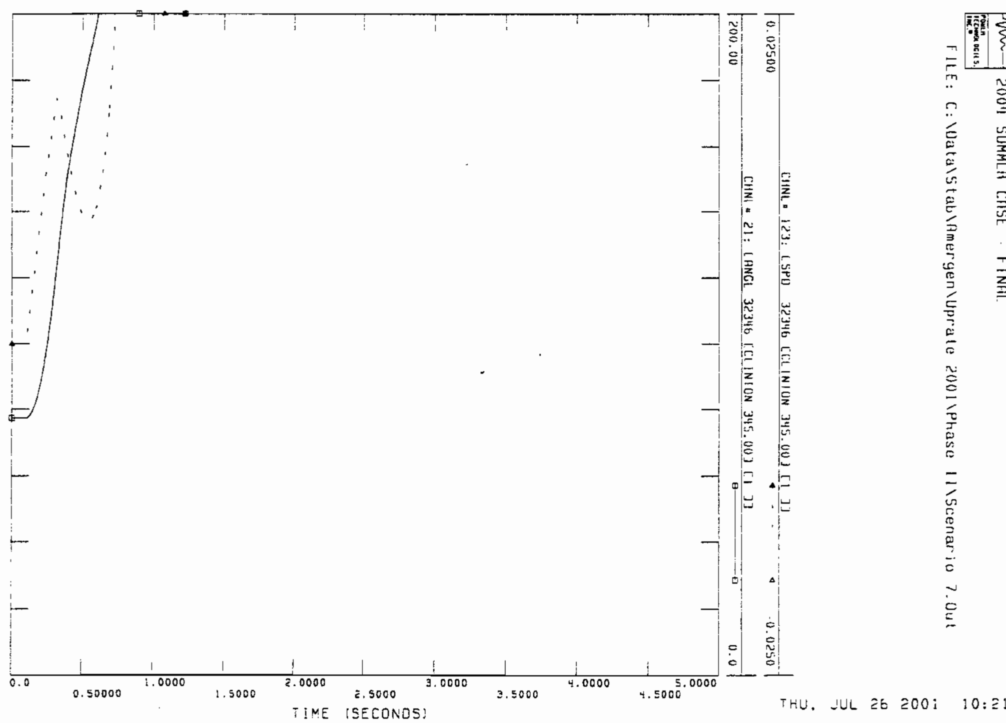
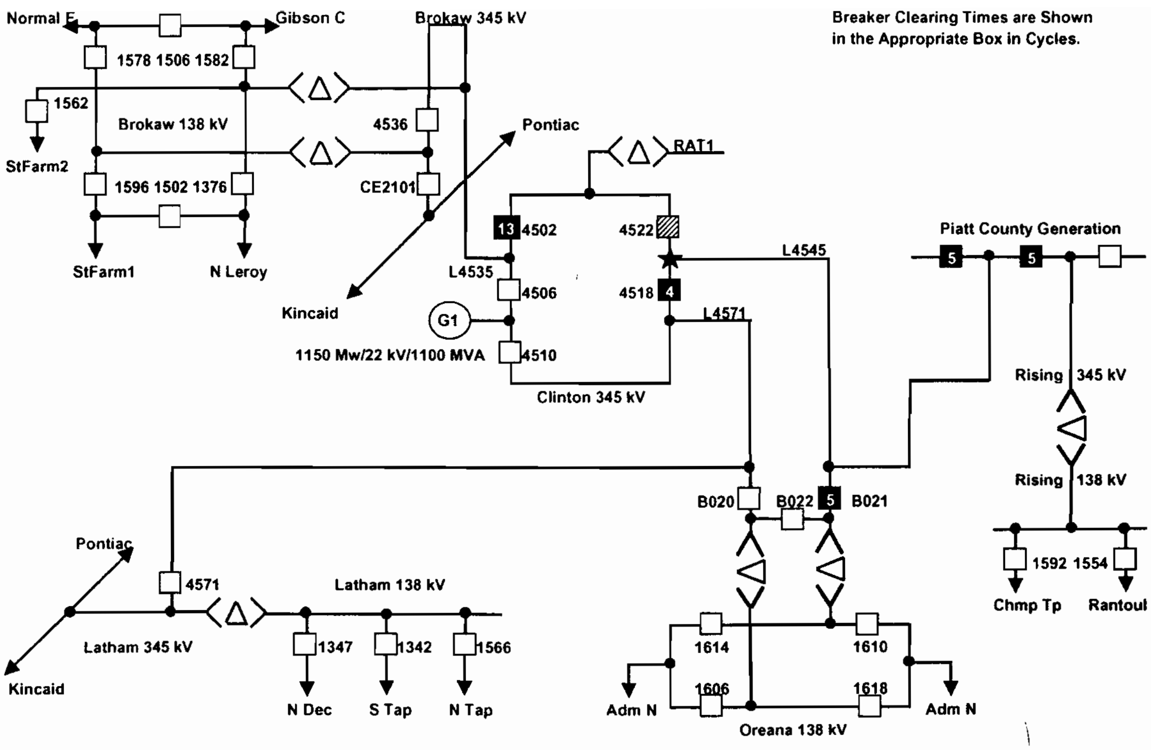


Exhibit 39: Double-line-ground fault on the Clinton to Oreana to Rising 345 kV line at CPS with failure of Breaker 4518, Case 4.



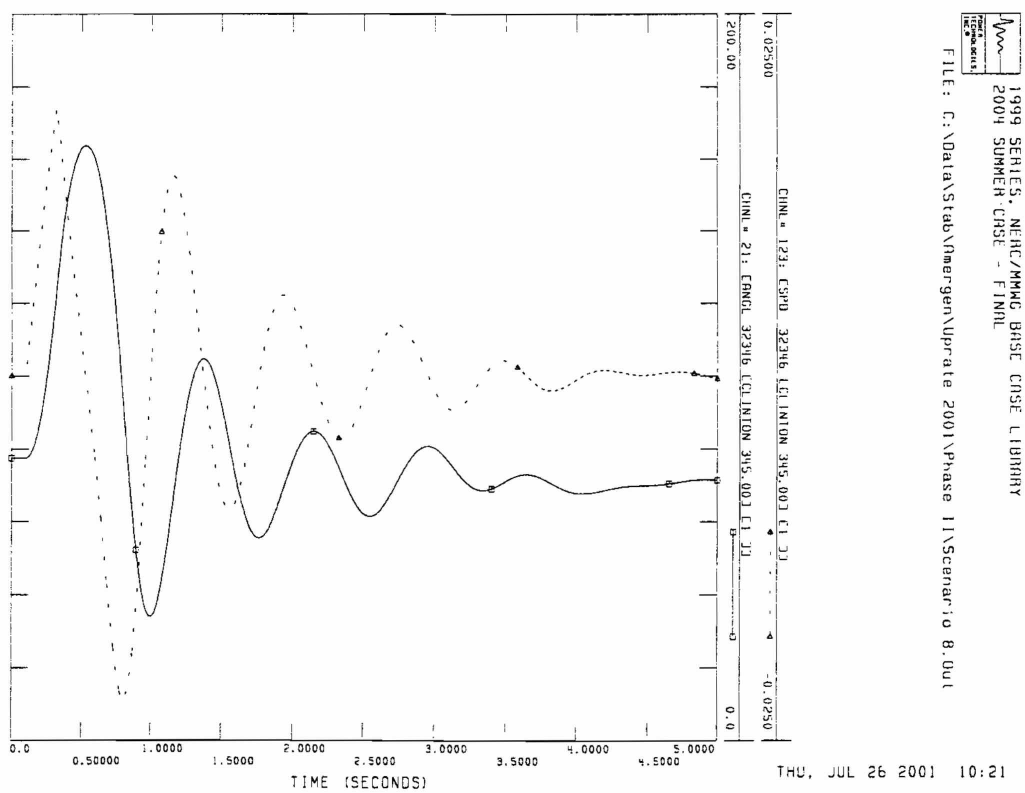
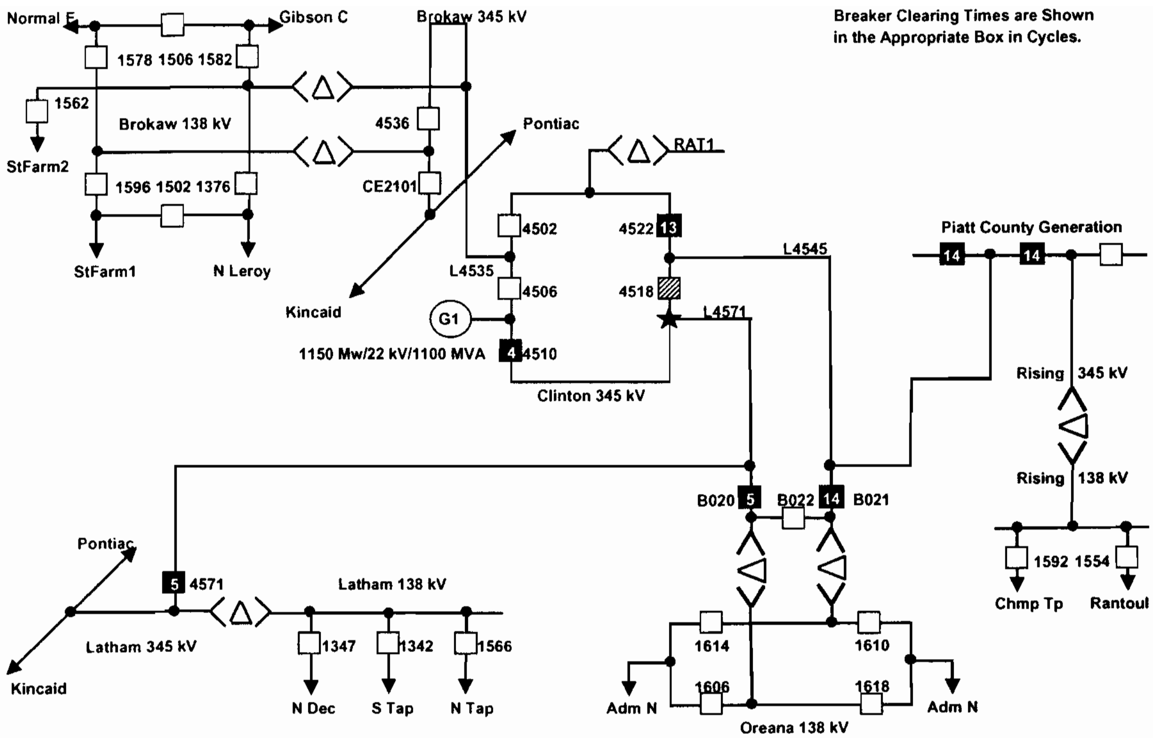


Exhibit 40: Double-line-ground fault on the Clinton to Oreana to Rising 345 kV line at CPS with failure of Breaker 4522, Case 4.



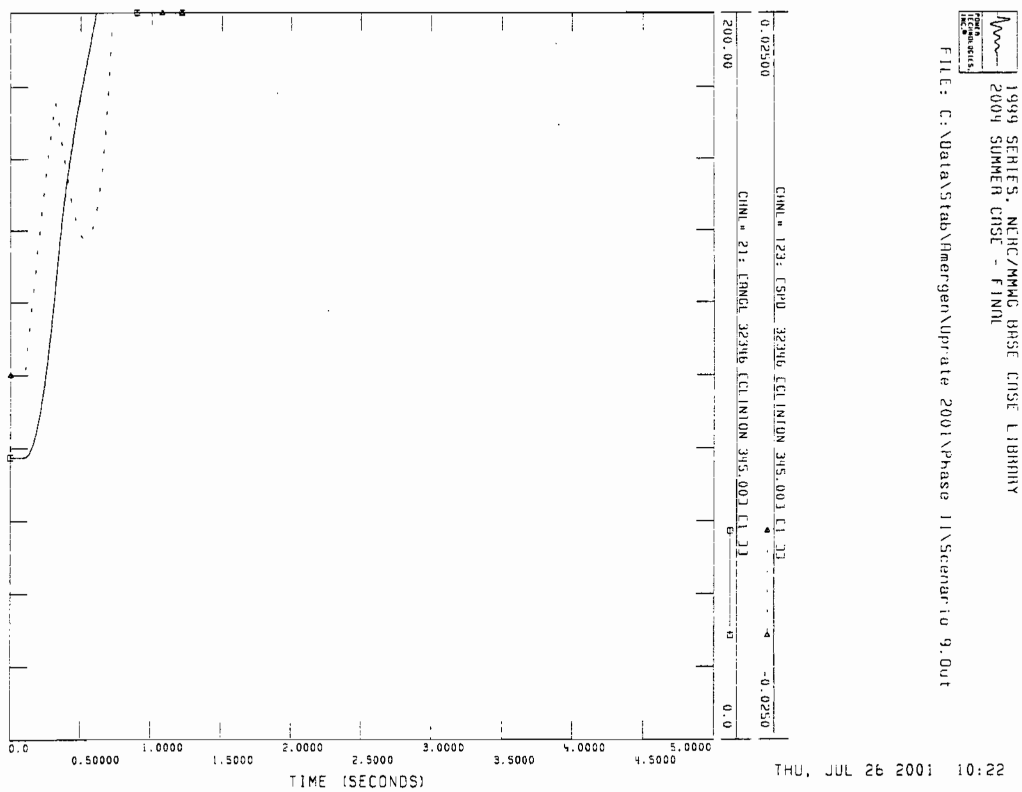
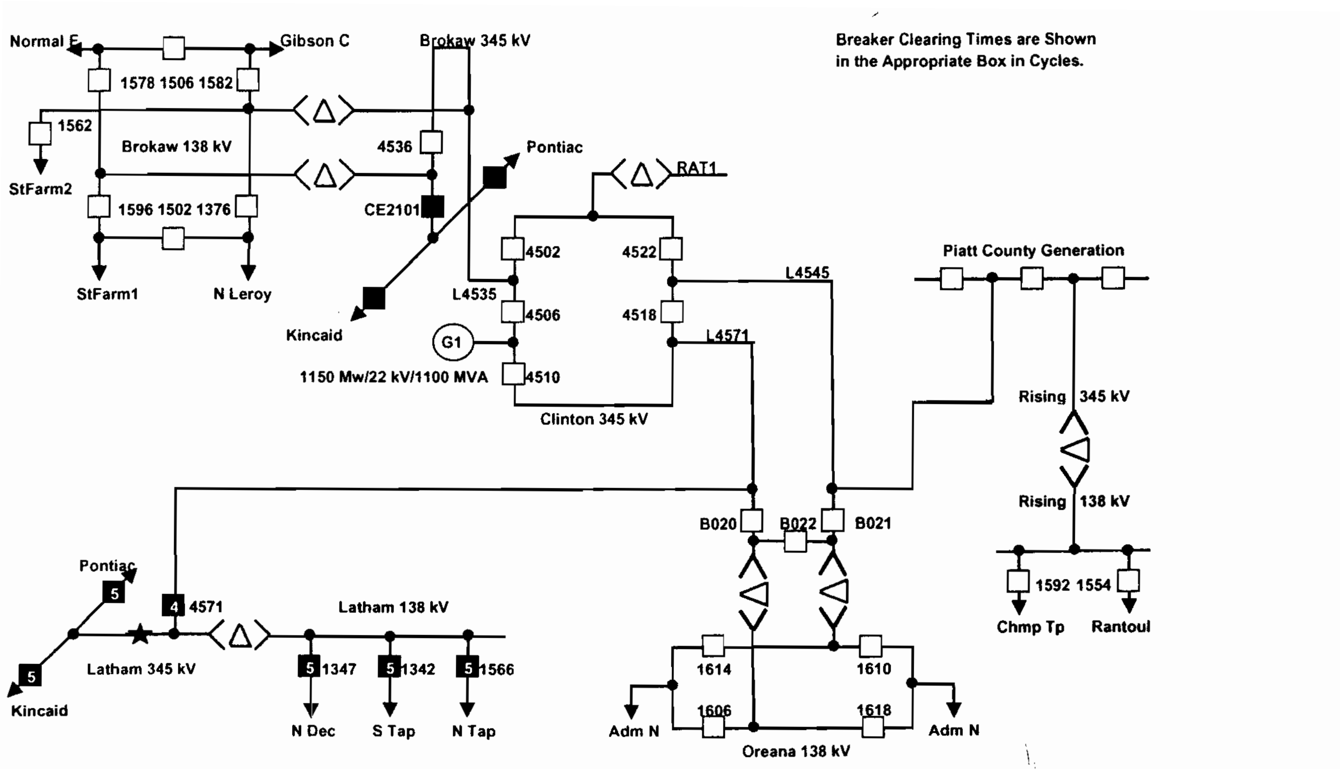


Exhibit 41: Double-line-ground fault on the Clinton to Latham 345 kV line at CPS with failure of Breaker 4518, Case 4.



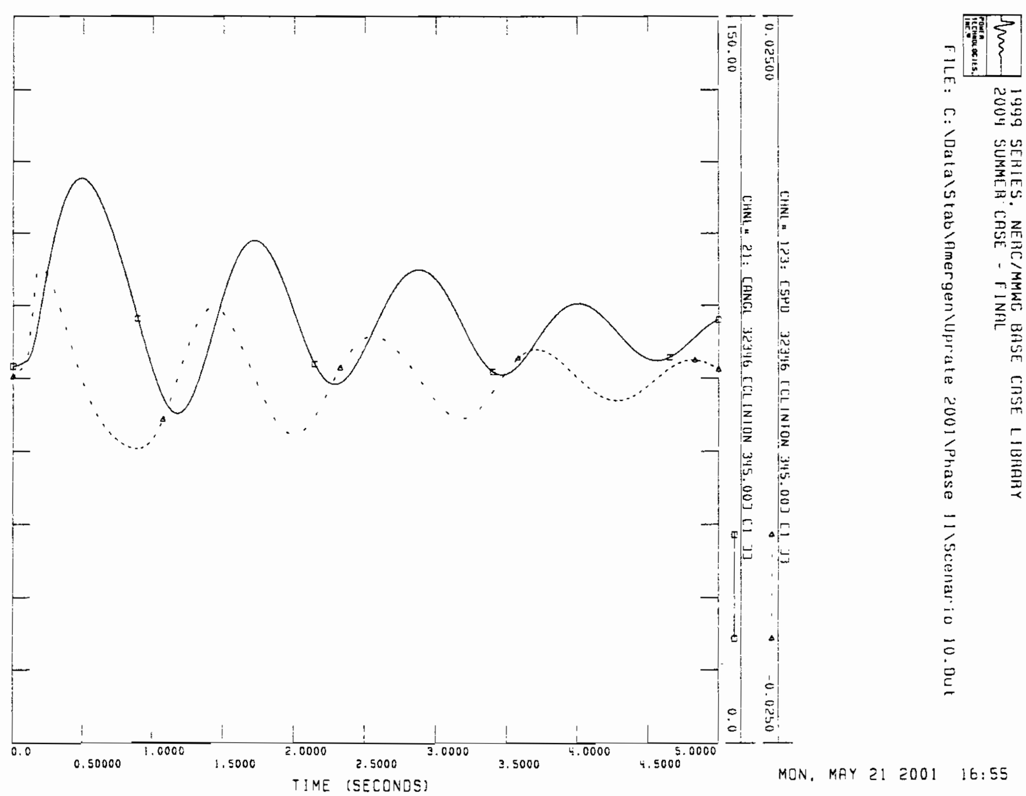
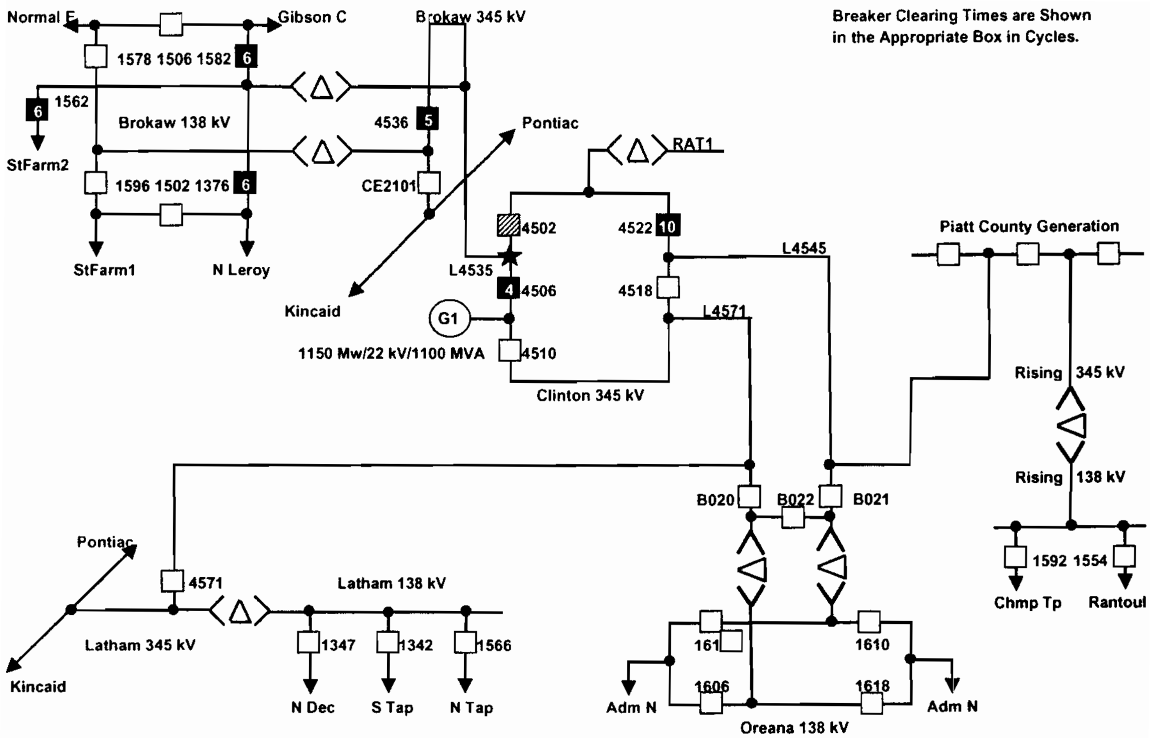


Exhibit 42: 3-Phase fault on the Kincaid to Latham to Pontiac 345 kV line at Latham with the Kincaid to Brokaw to Pontiac 345 kV line out of service, Case 4.



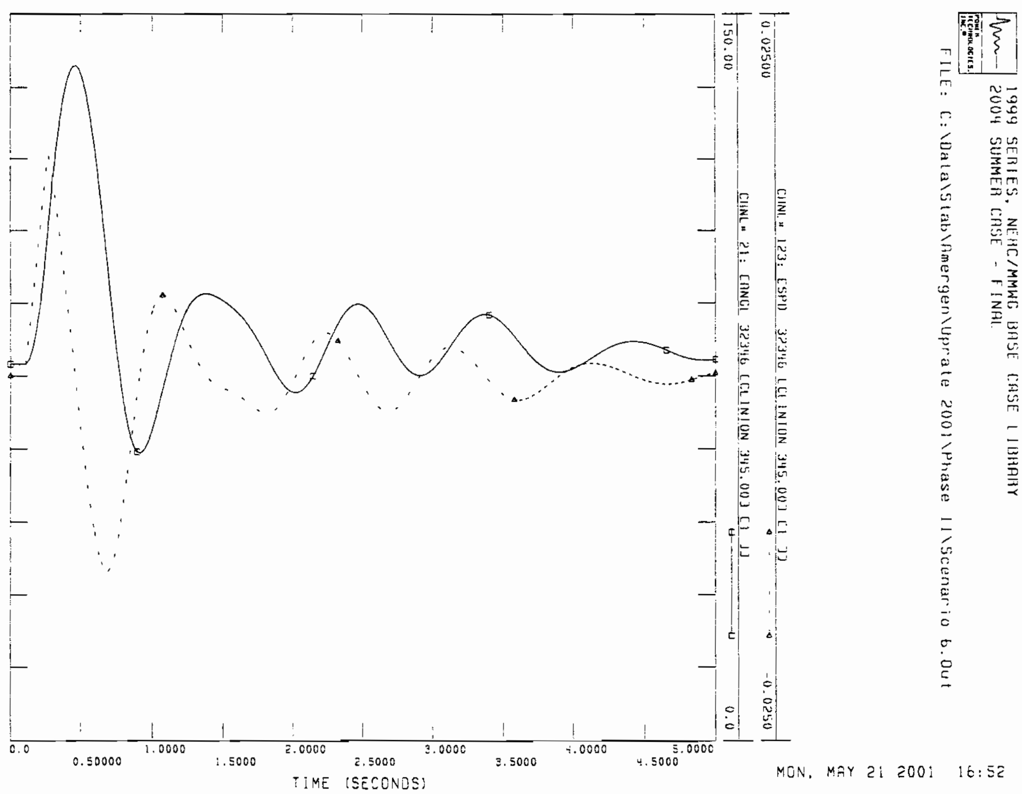


Exhibit 43: Double-line-ground fault on the Clinton to Brokaw 345 kV line at CPS with failure of Breaker 4502, Case 4 with system upgrades.

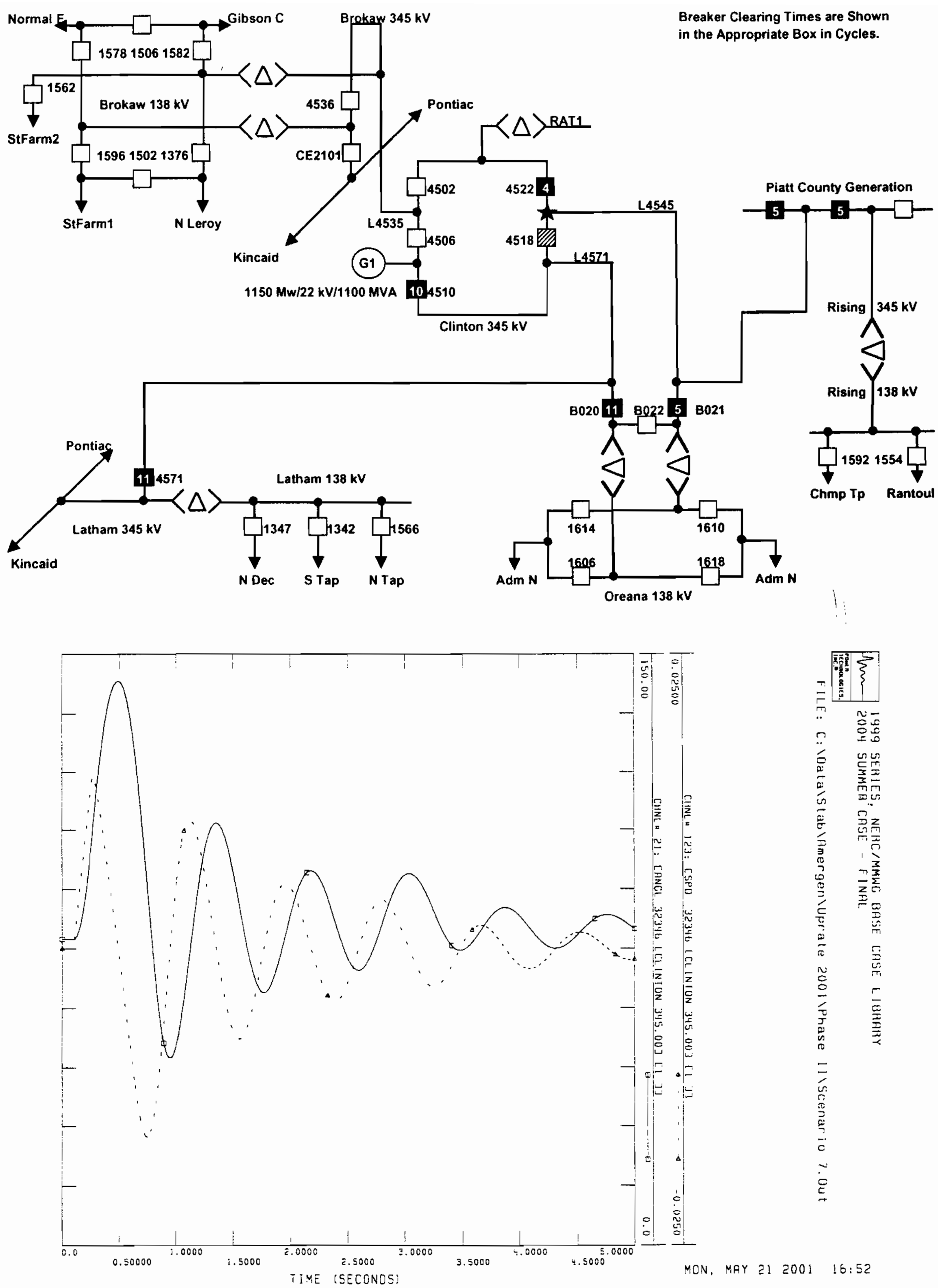
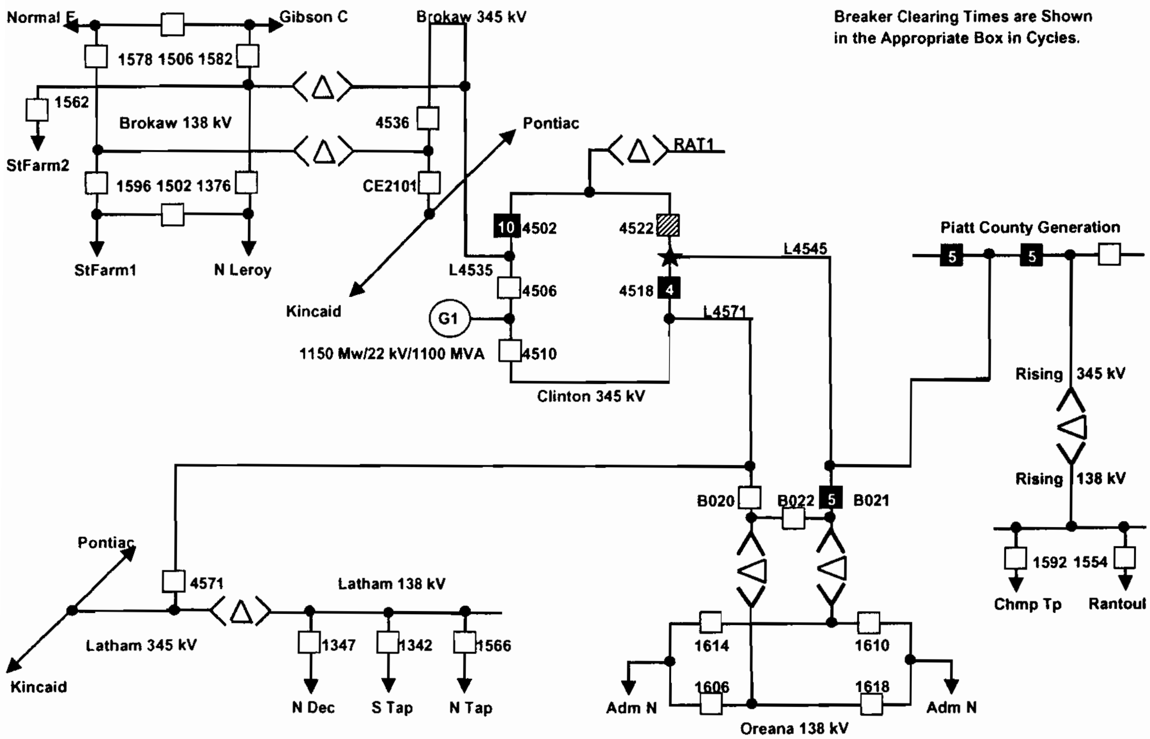


Exhibit 44: Double-line-ground fault on the Clinton to Oreana to Rising 345 kV line at CPS with failure of Breaker 4518, Case 4 with system upgrades.



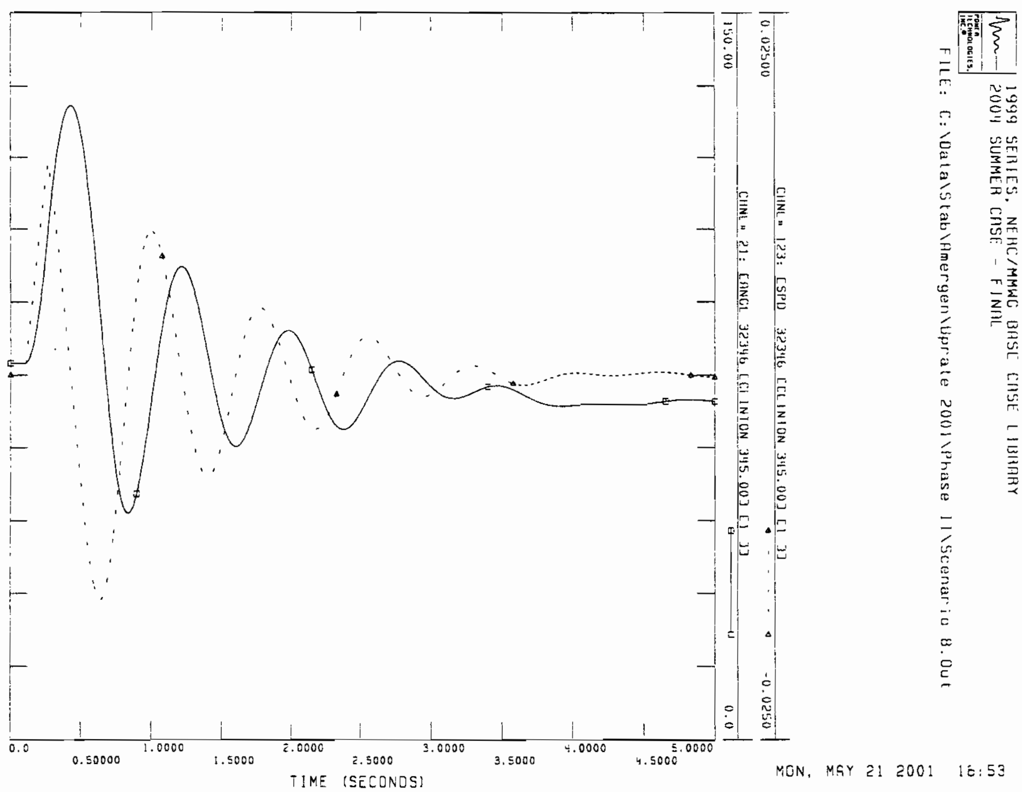
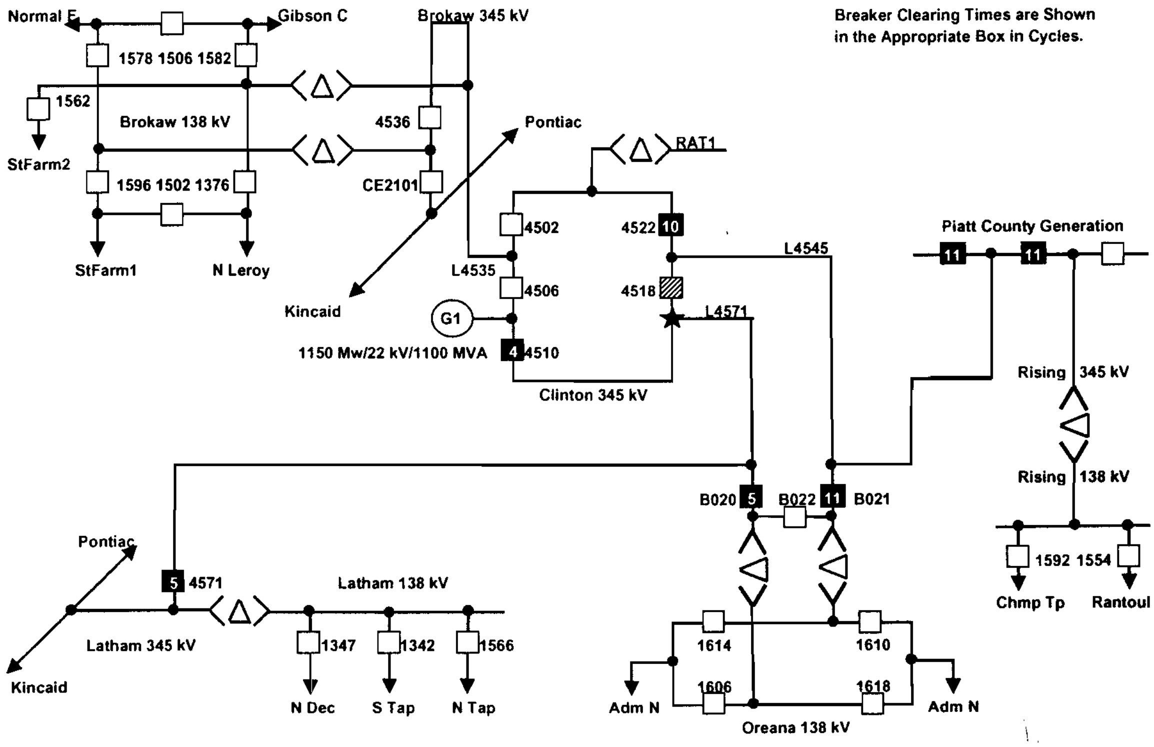


Exhibit 45: Double-line-ground fault on the Clinton to Oreana to Rising 345 kV line at CPS with failure of Breaker 4522, Case 4 with system upgrades.



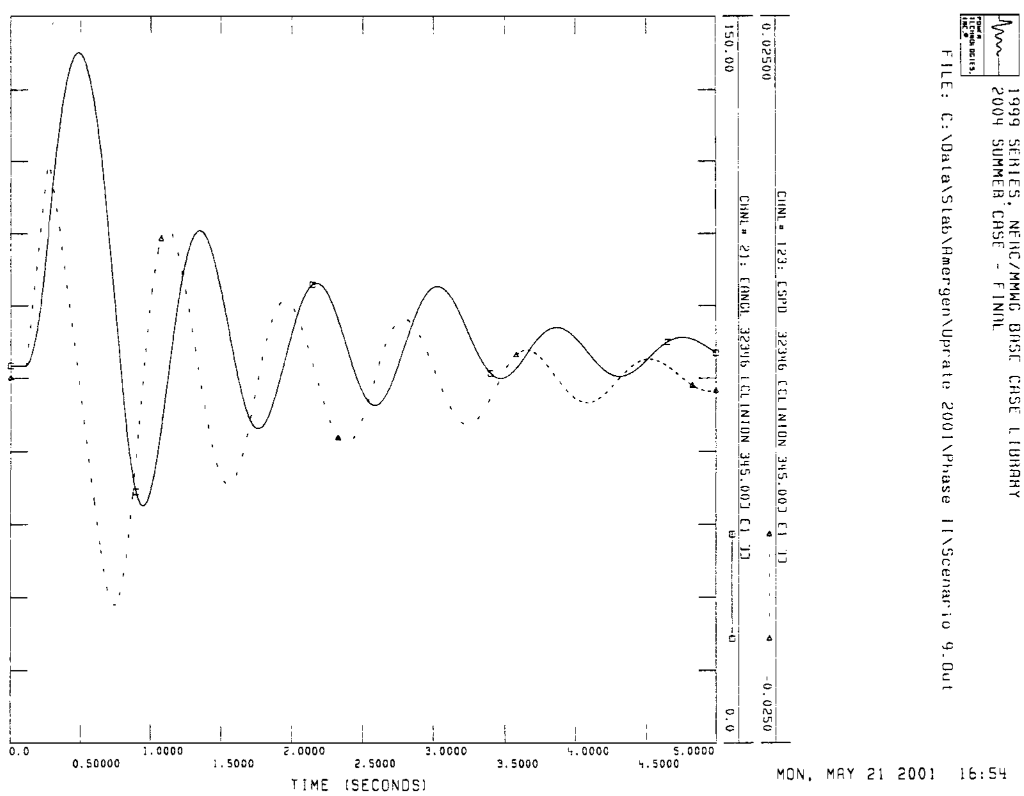


Exhibit 46: Double-line-ground fault on the Clinton to Latham 345 kV line at CPS with failure of Breaker 4518, Case 4 with system upgrades.

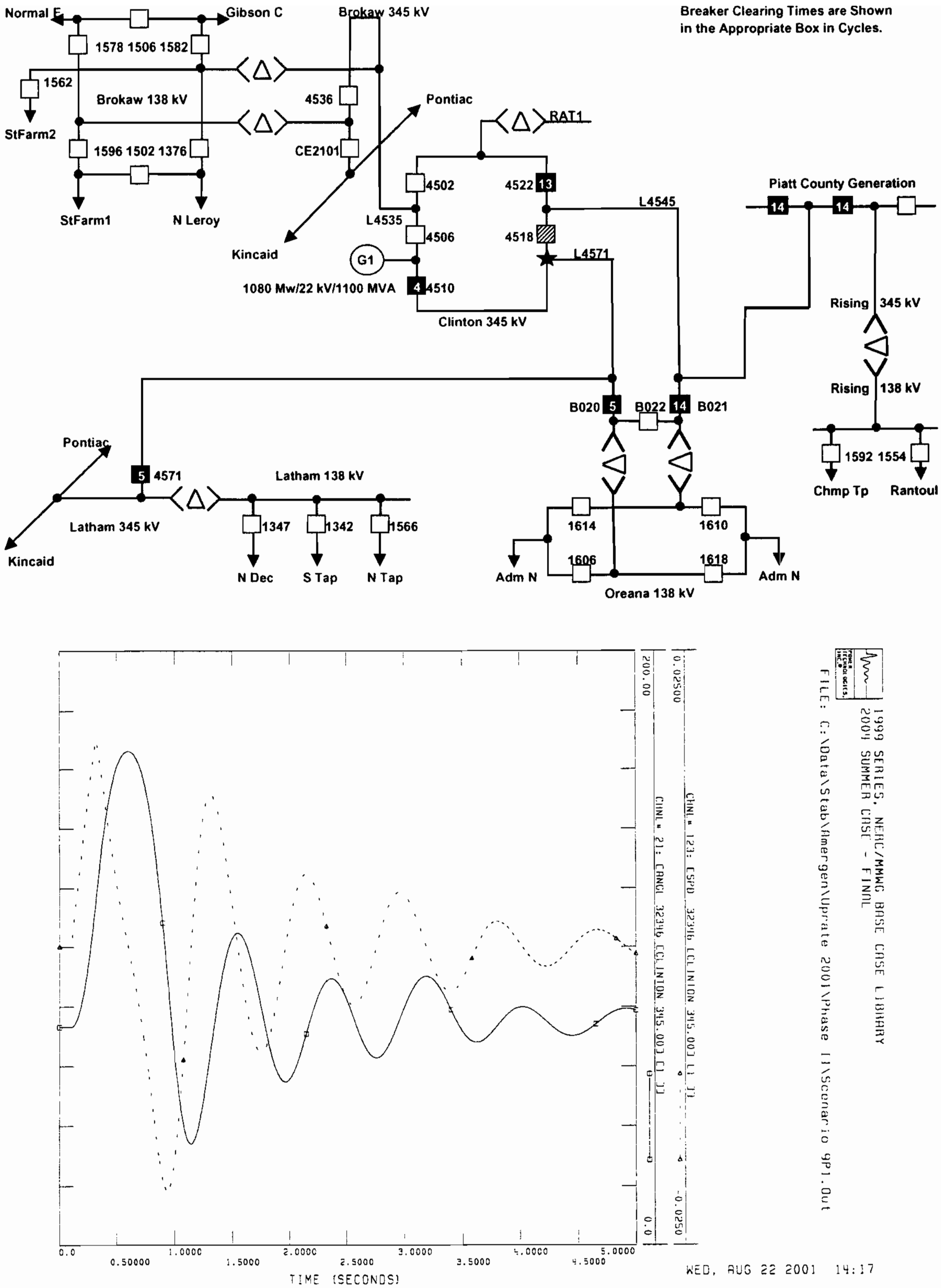
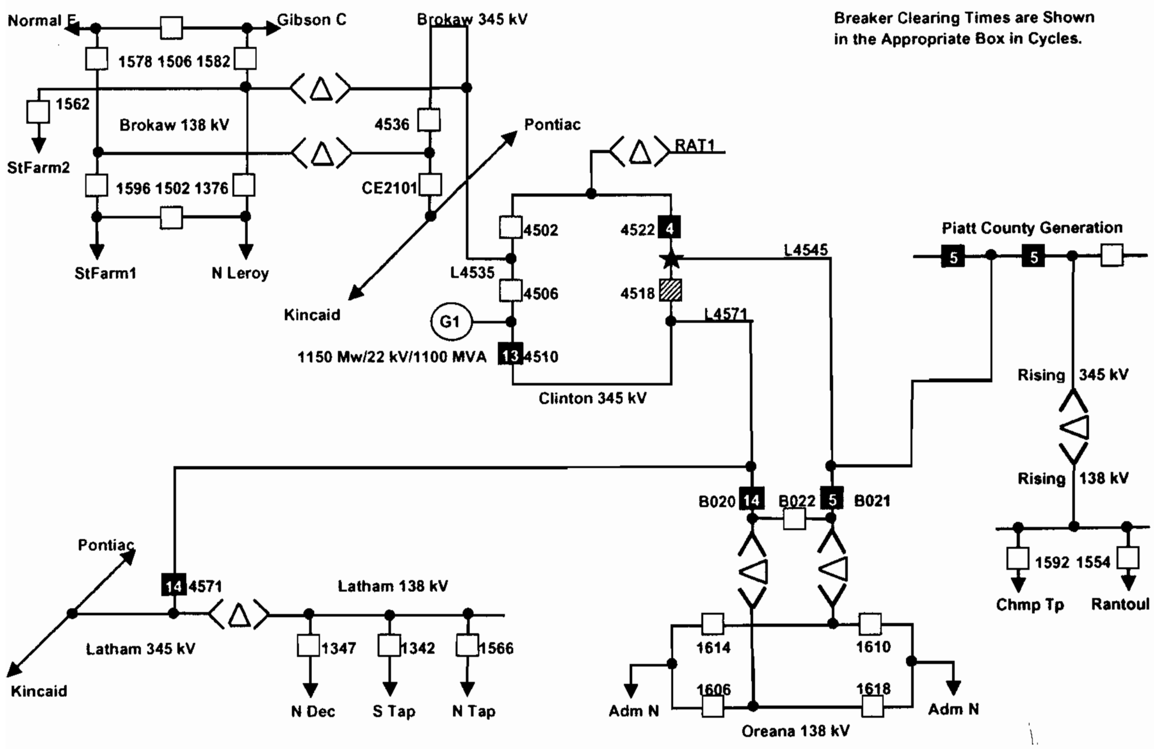


Exhibit 47: Double-line-ground fault on the Clinton to Latham 345 kV line at CPS with failure of Breaker 4518, Case 5.



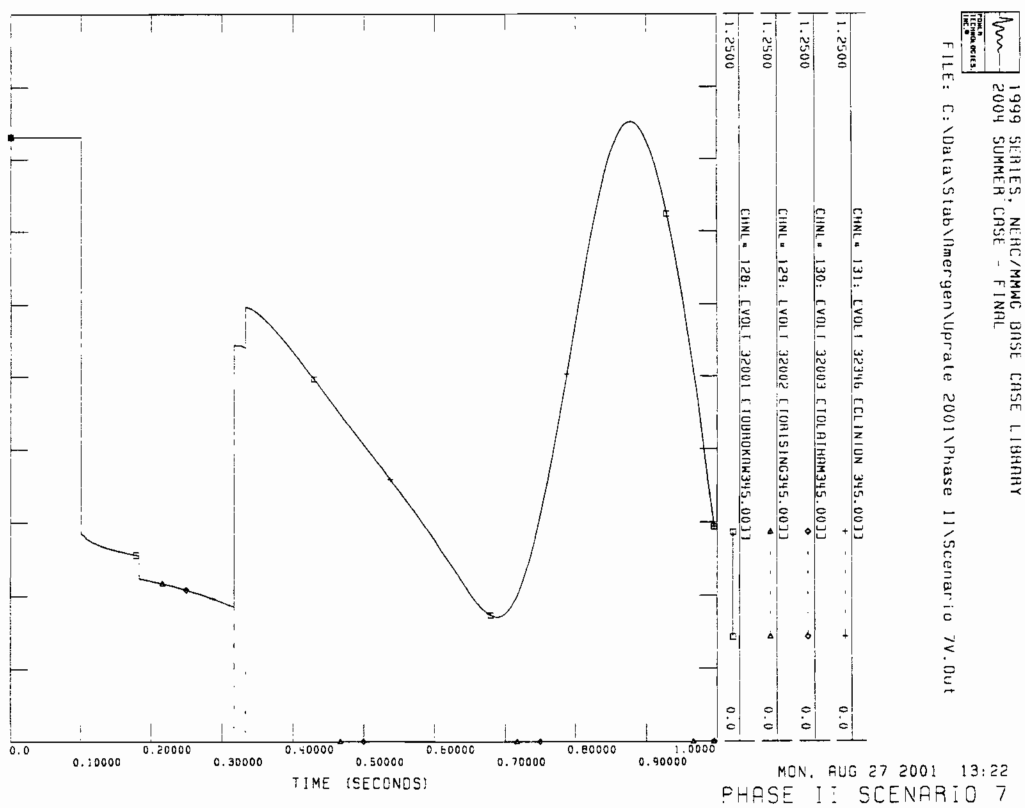


Exhibit 48 - Clinton Voltage

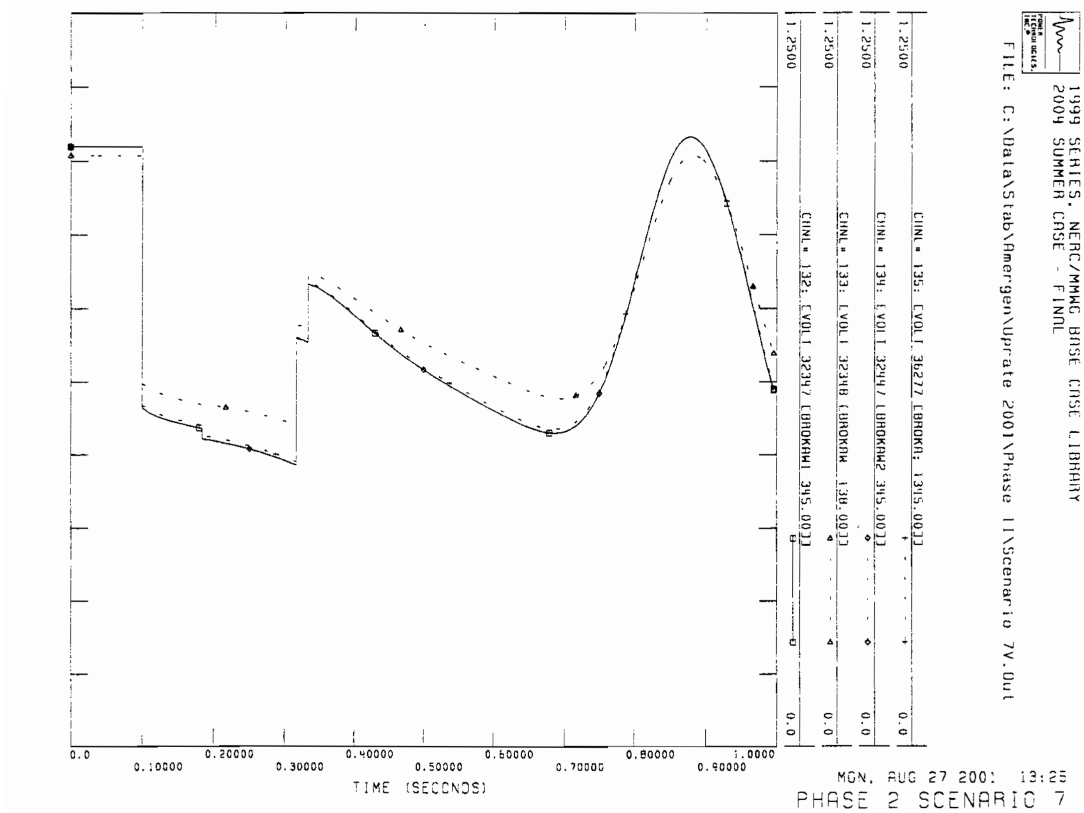


Exhibit 49 - Brokaw Voltage

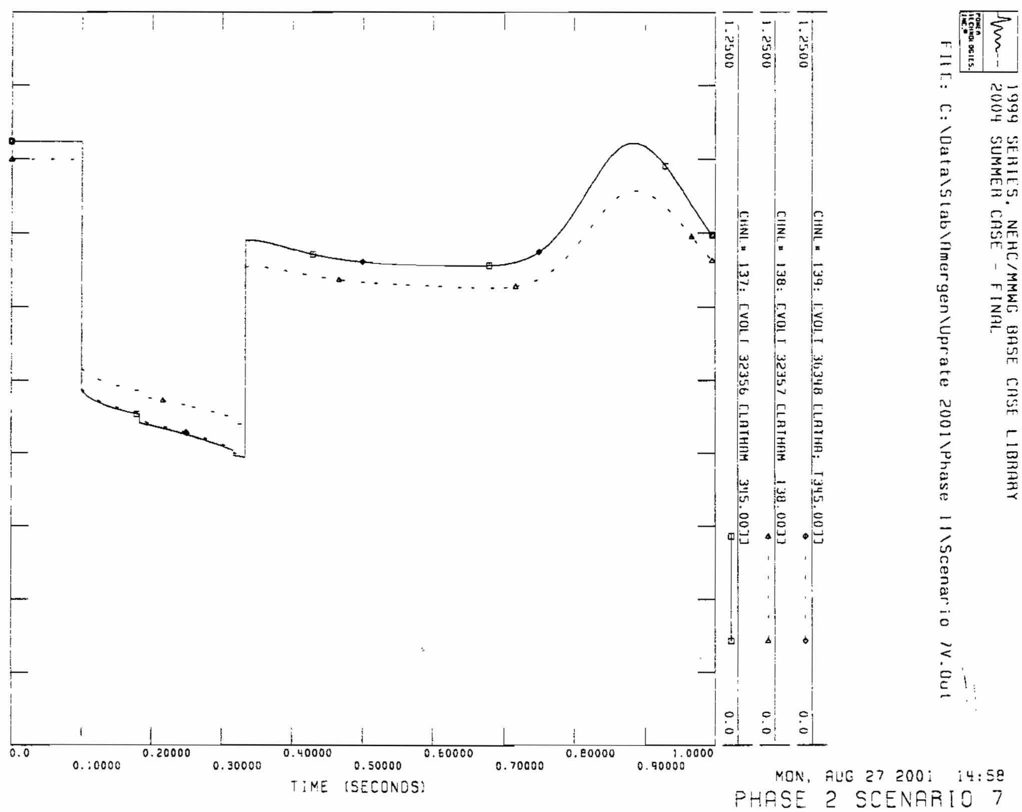


Exhibit 50 - Latham Voltage

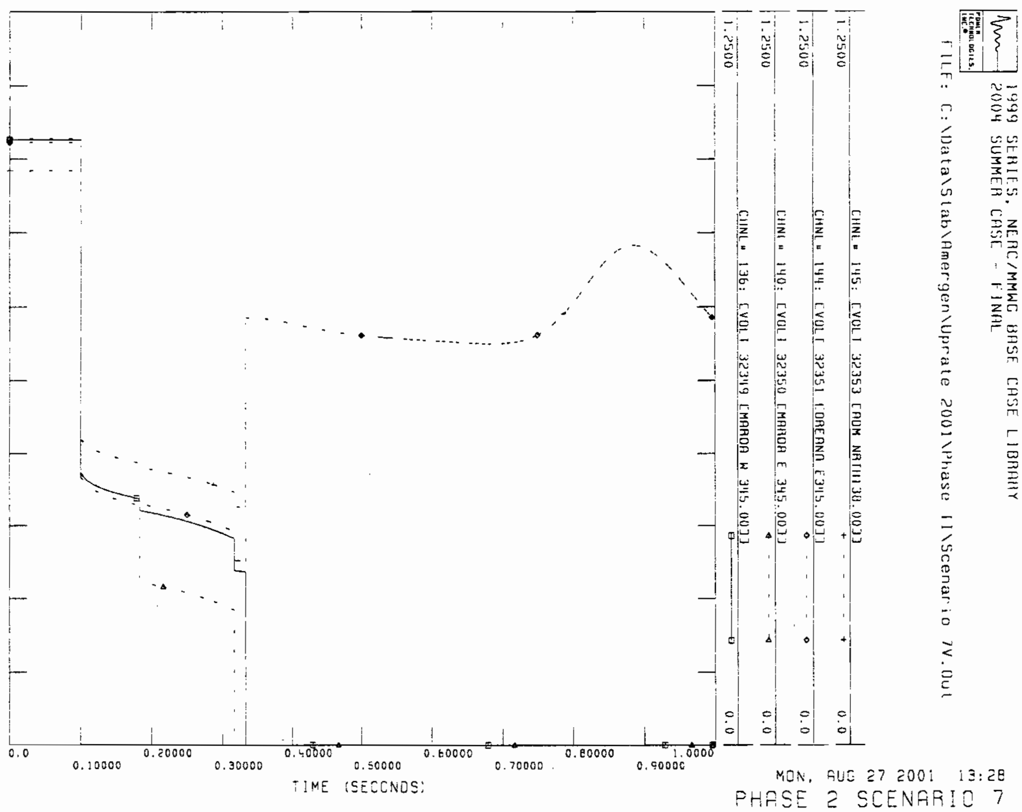


Exhibit 51 – Oreana Voltage

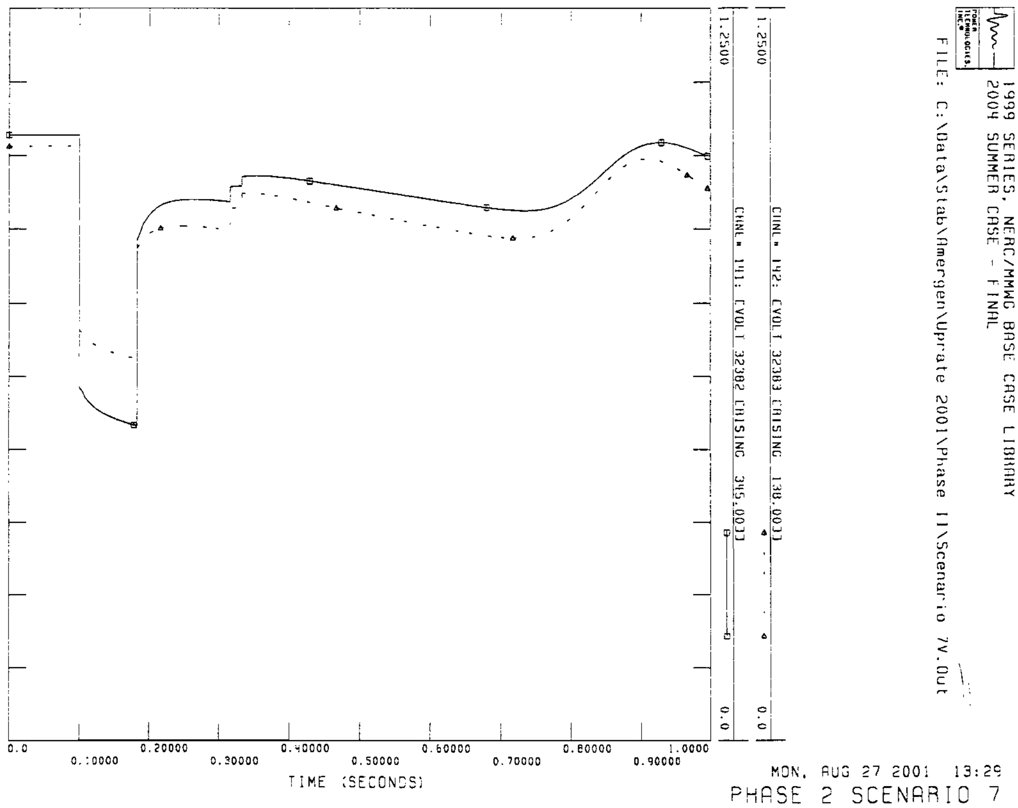
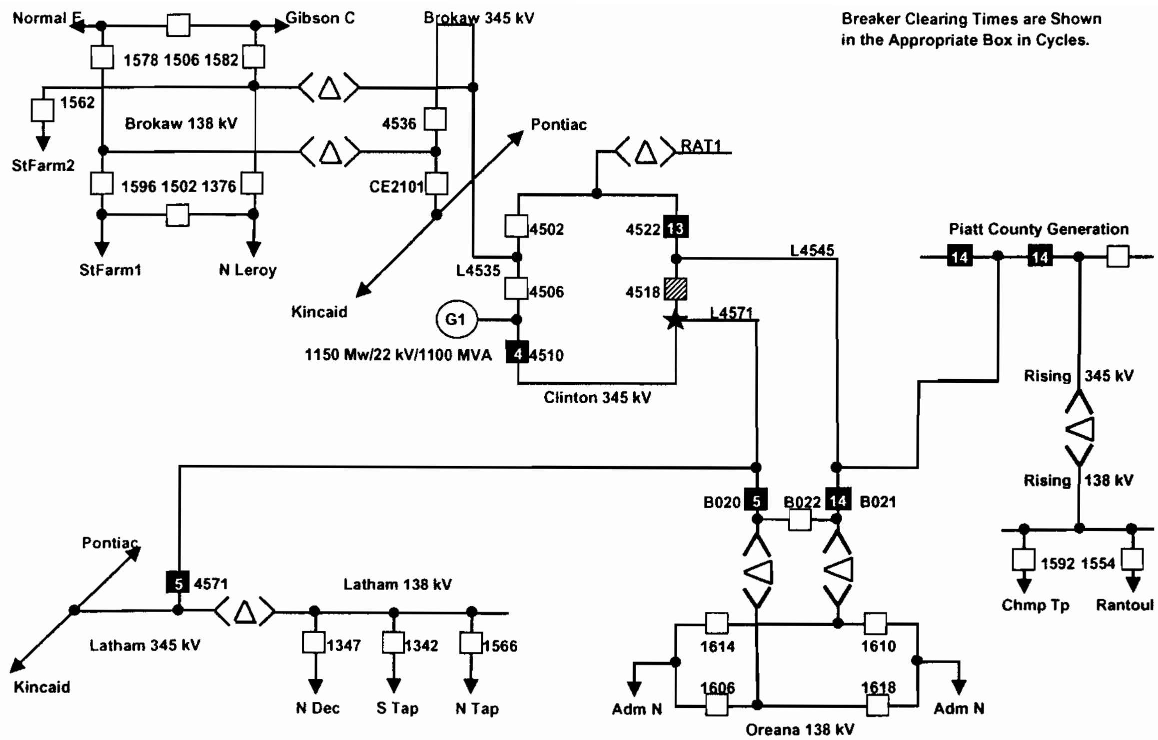


Exhibit 52 - Rising Voltage



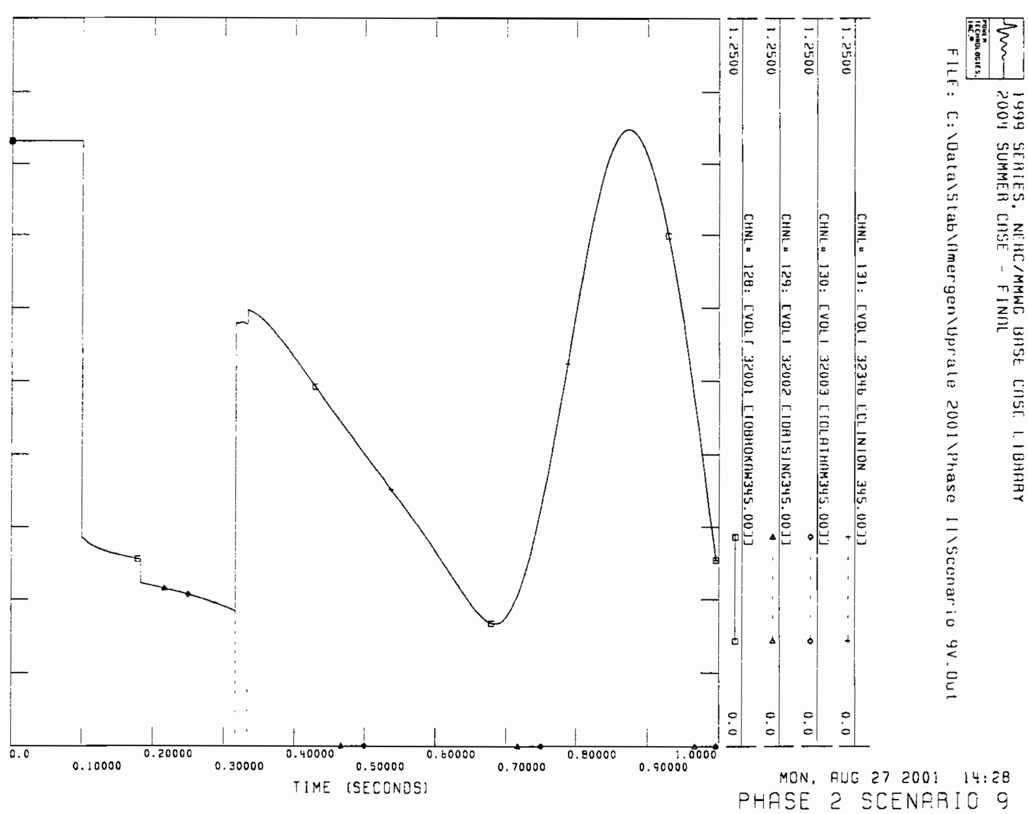


Exhibit 53 - Clinton Voltage

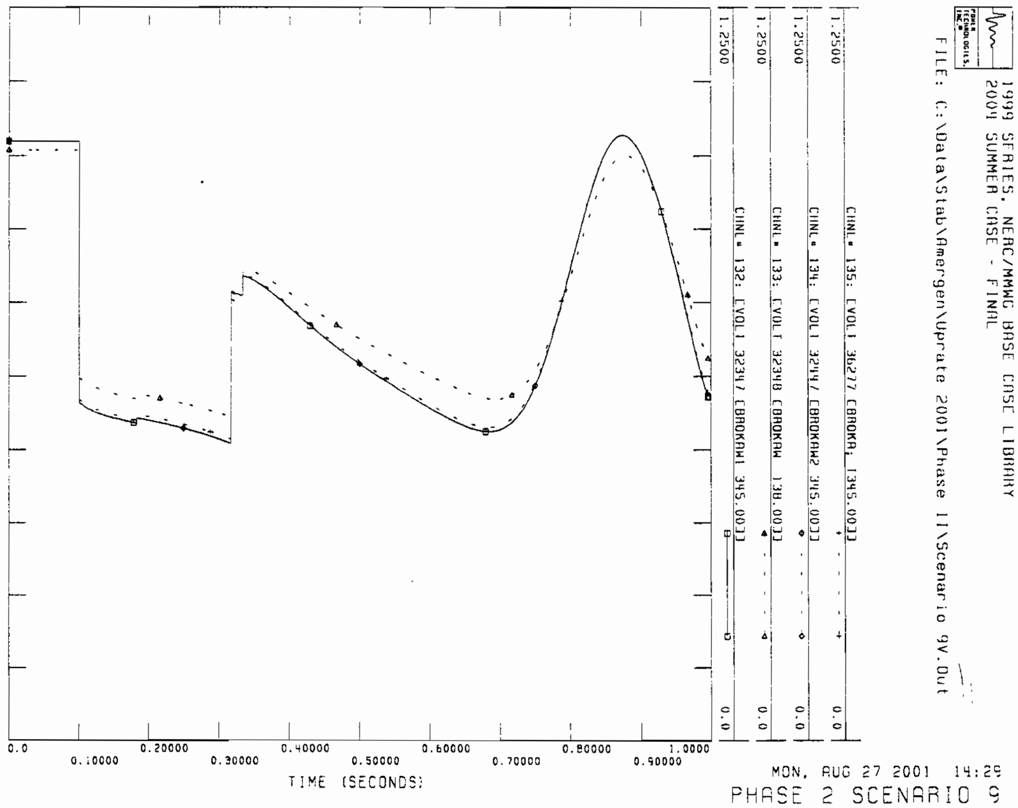


Exhibit 54 - Brokaw Voltage

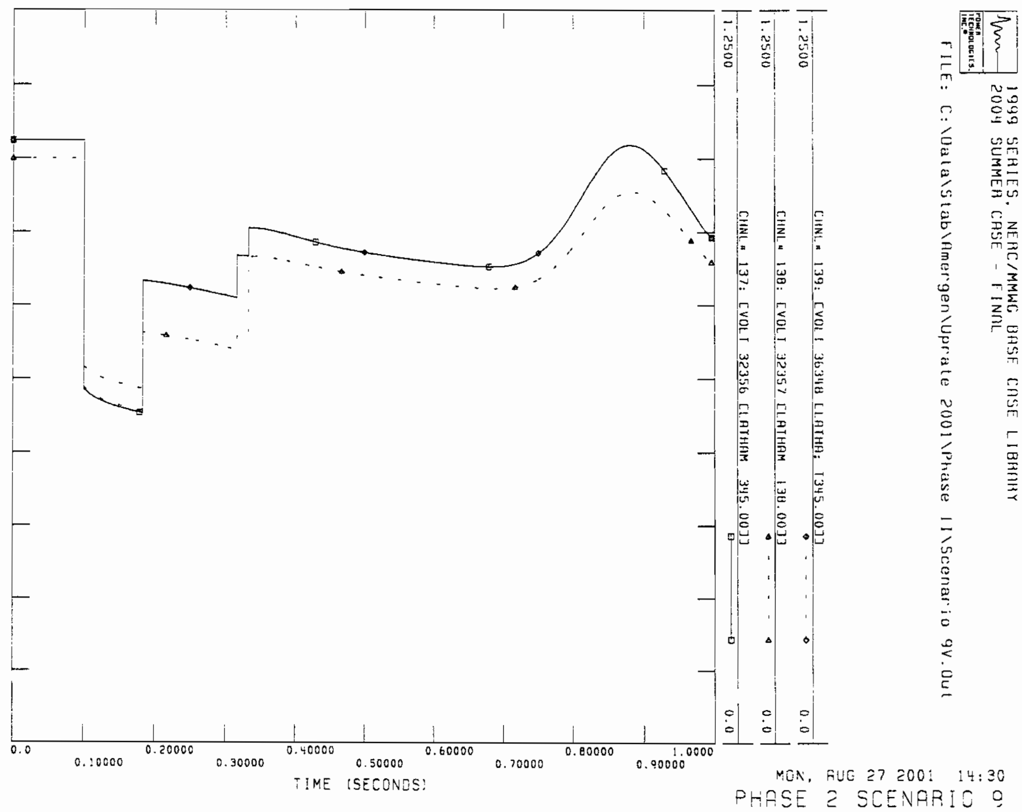


Exhibit 55 - Latham Voltage

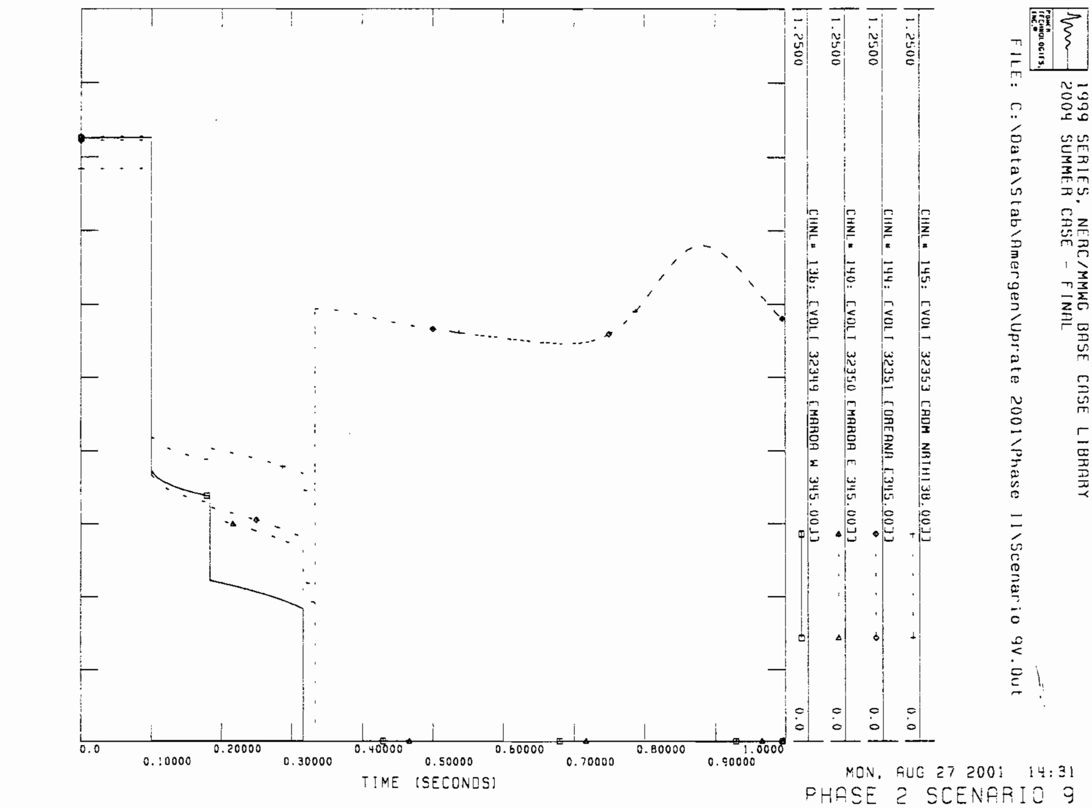


Exhibit 56 - Oreana Voltage

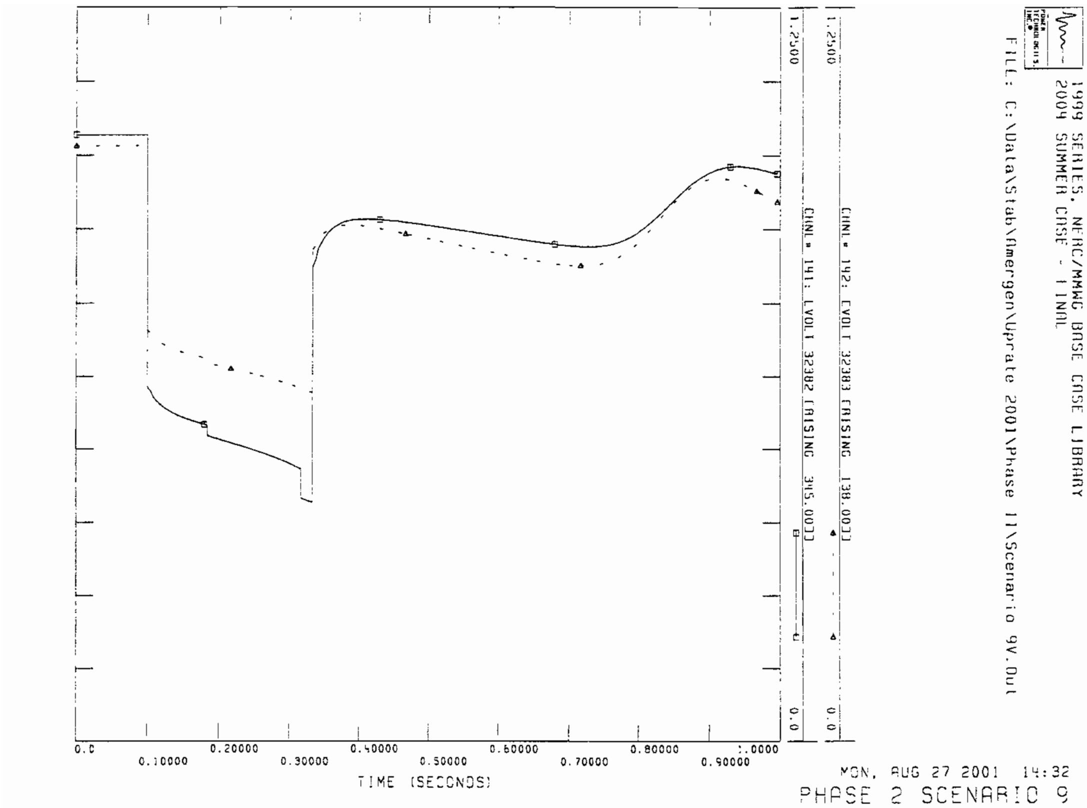


Exhibit 57 - Rising Voltage