

August 14, 2003 System Disturbance Sequence of Events

Presentation to the IEEE, Toronto Section

by

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October 3, 2003.

12:05 PM to 1:31 PM:

Generation trips in the US

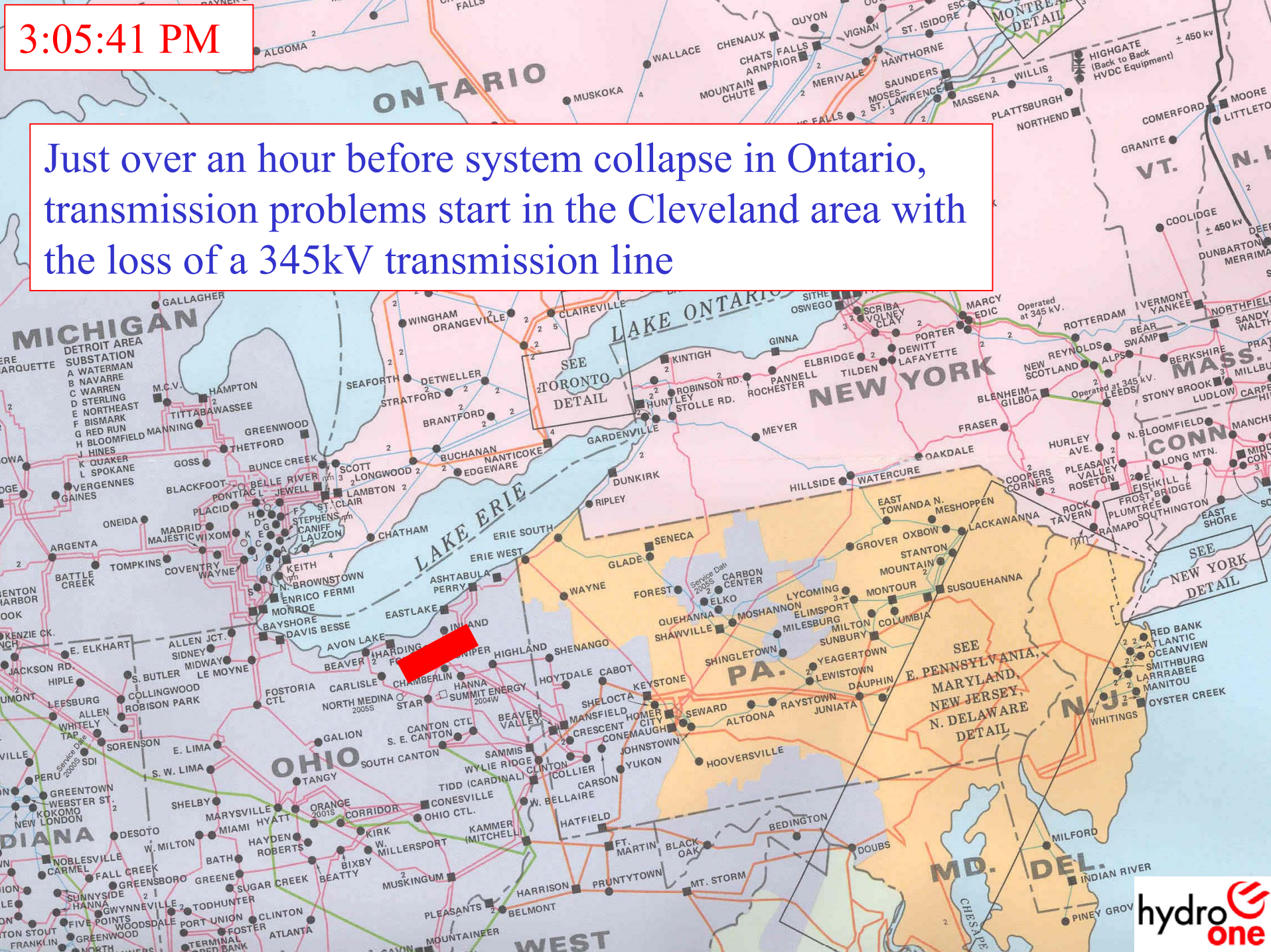
1:14 PM
Greenwood #1 (785 MW)

1:31 PM
Eastlake #5 (597 MW)

12:05 PM
Conesville #5 (375 MW)

3:05:41 PM

Just over an hour before system collapse in Ontario, transmission problems start in the Cleveland area with the loss of a 345kV transmission line



4:00 PM

System appears normal in Ontario with system demand at 24,000MW

1000 MW import from New York

340 MW import from Michigan

Additional 345kV circuits has tripped in the Cleveland area

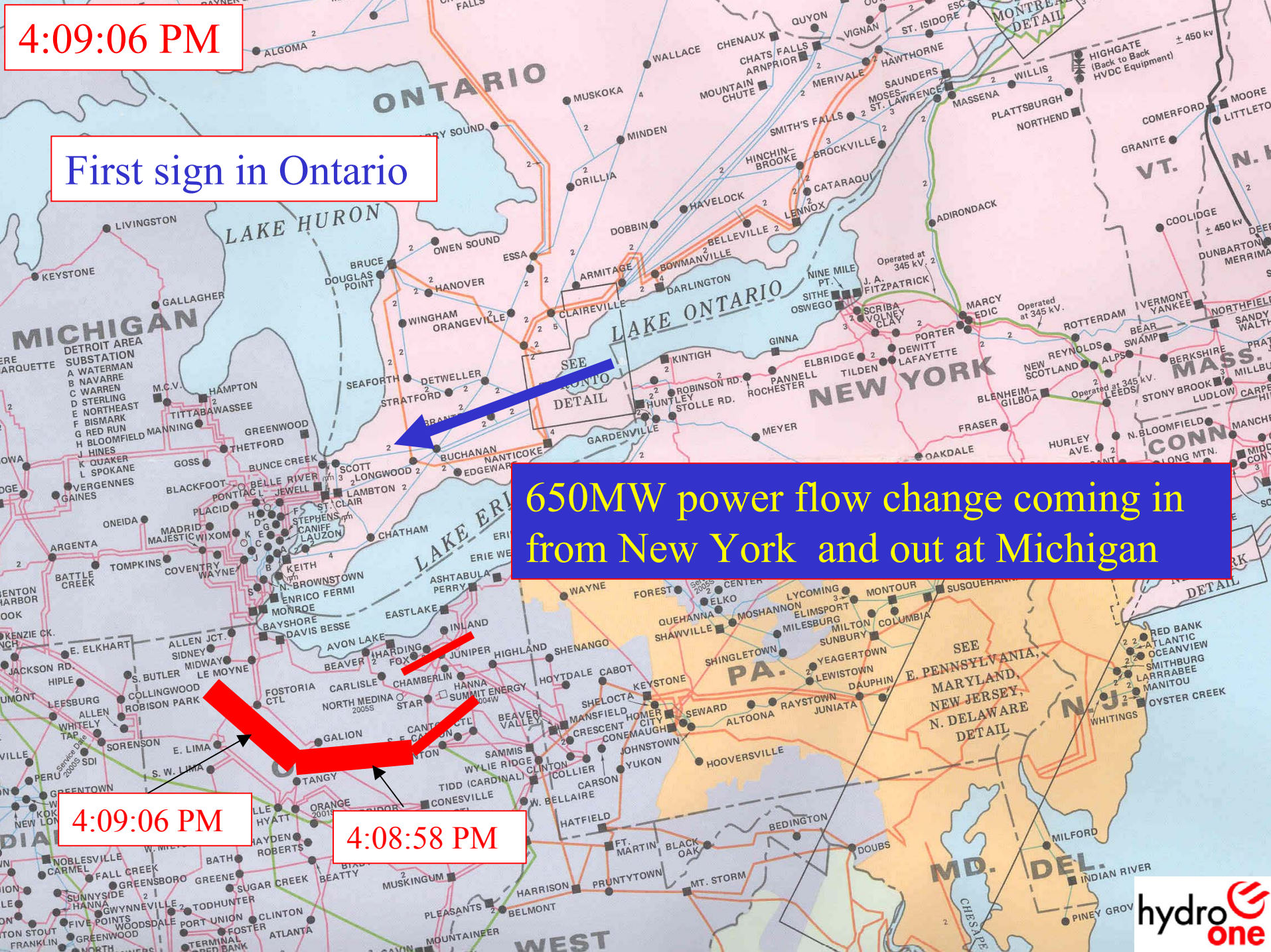
4:09:06 PM

First sign in Ontario

650MW power flow change coming in from New York and out at Michigan

4:09:06 PM

4:08:58 PM

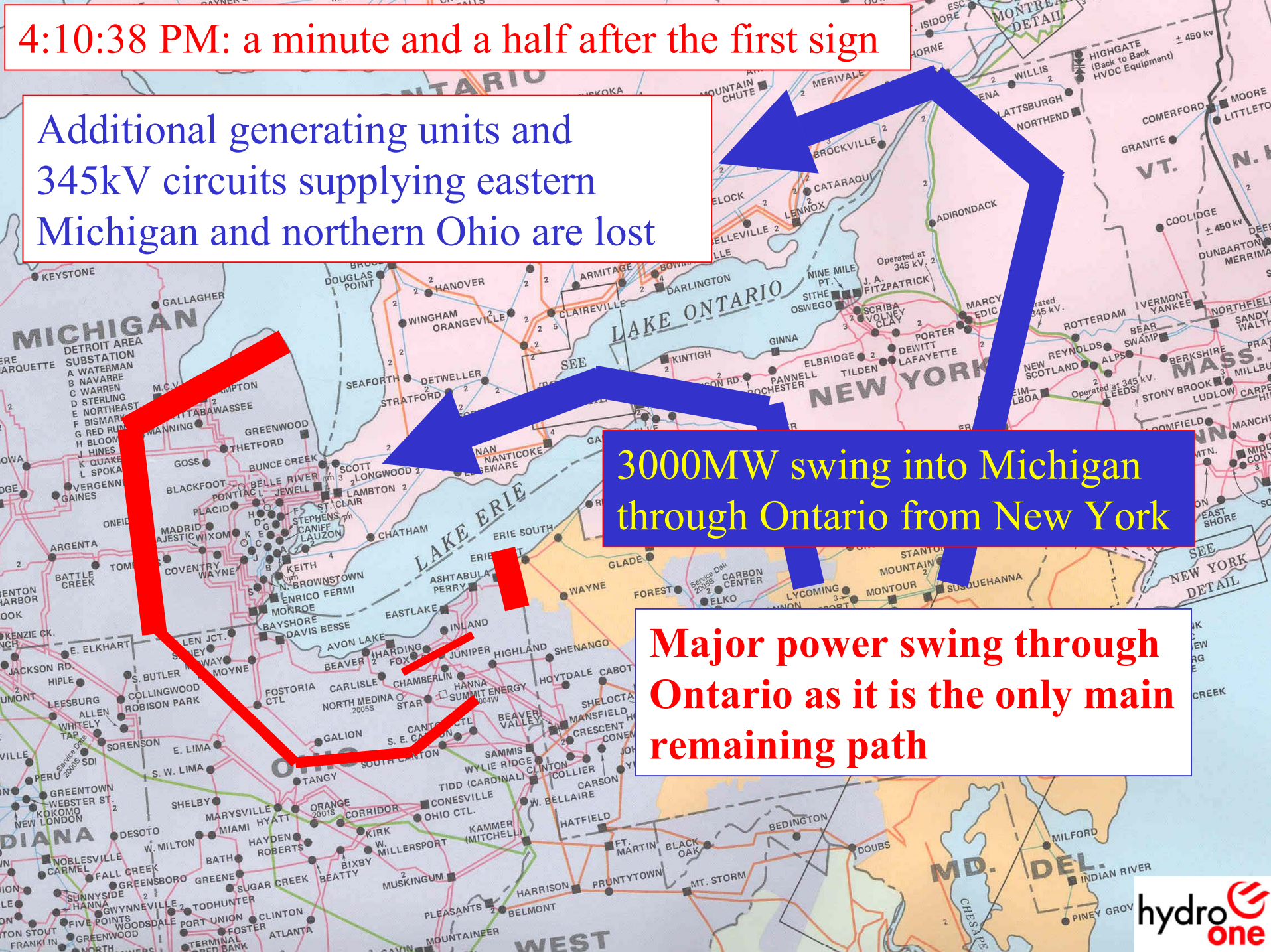


4:10:38 PM: a minute and a half after the first sign

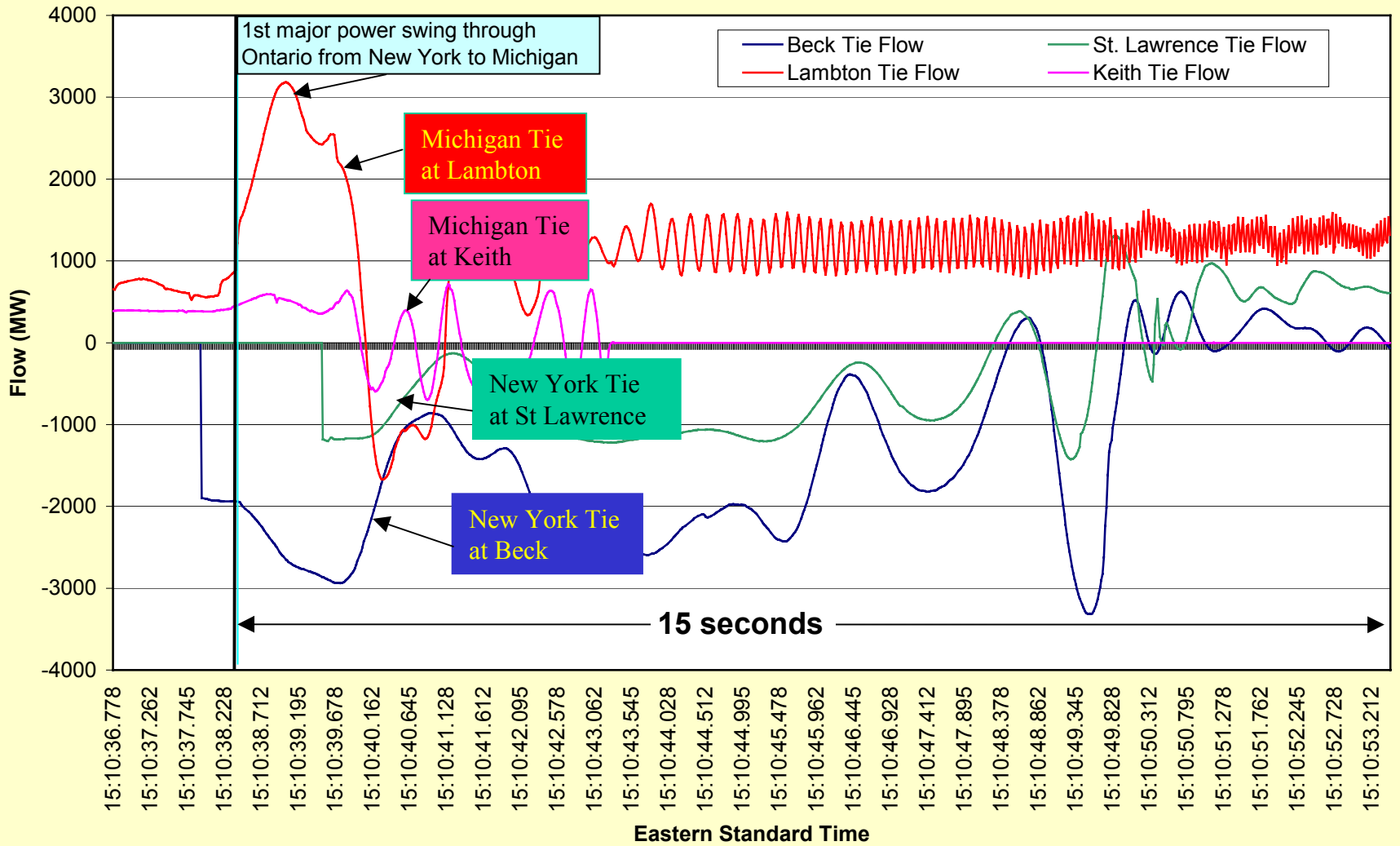
Additional generating units and 345kV circuits supplying eastern Michigan and northern Ohio are lost

3000MW swing into Michigan through Ontario from New York

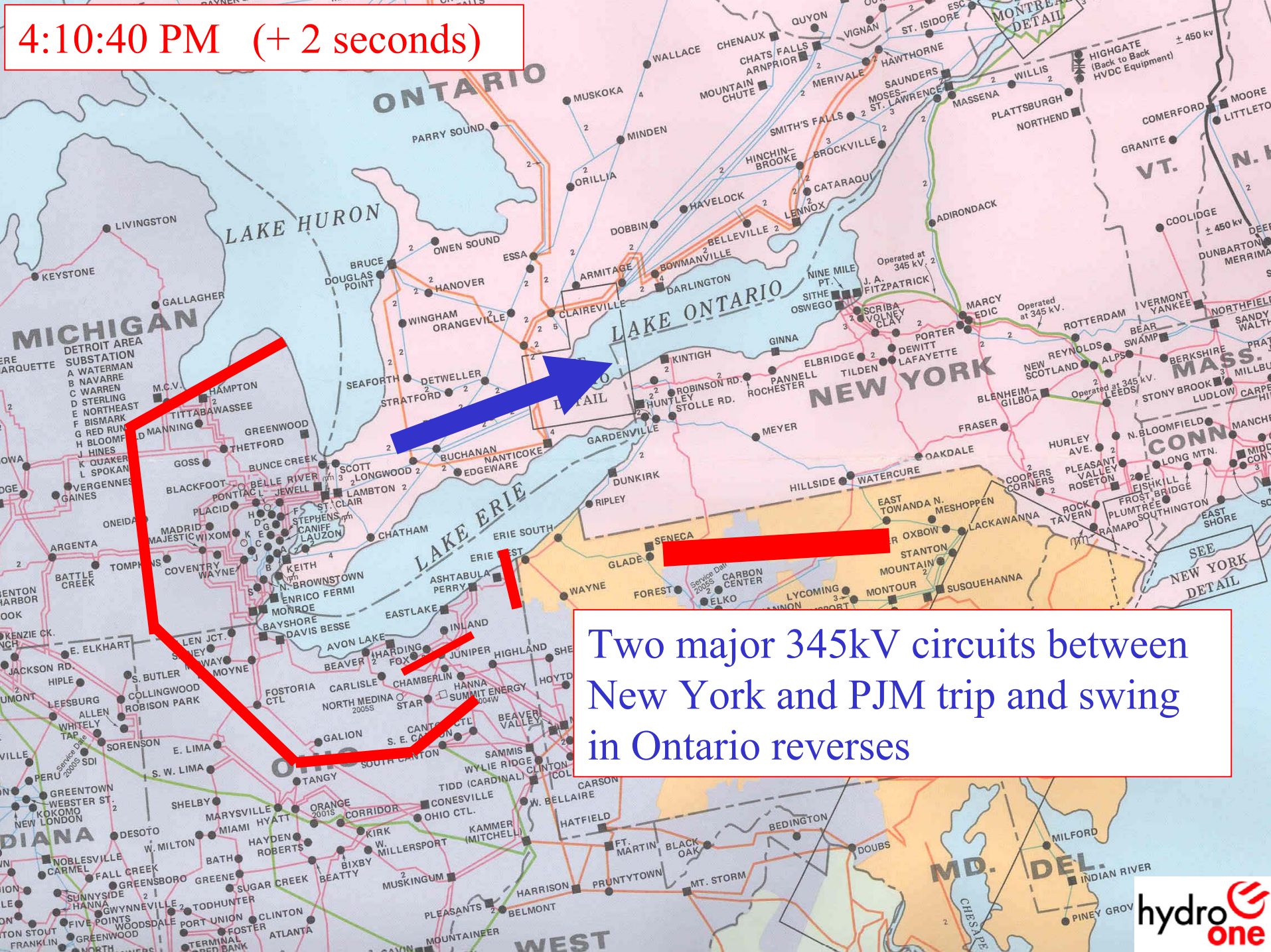
Major power swing through Ontario as it is the only main remaining path



New York and Michigan Tie Flows

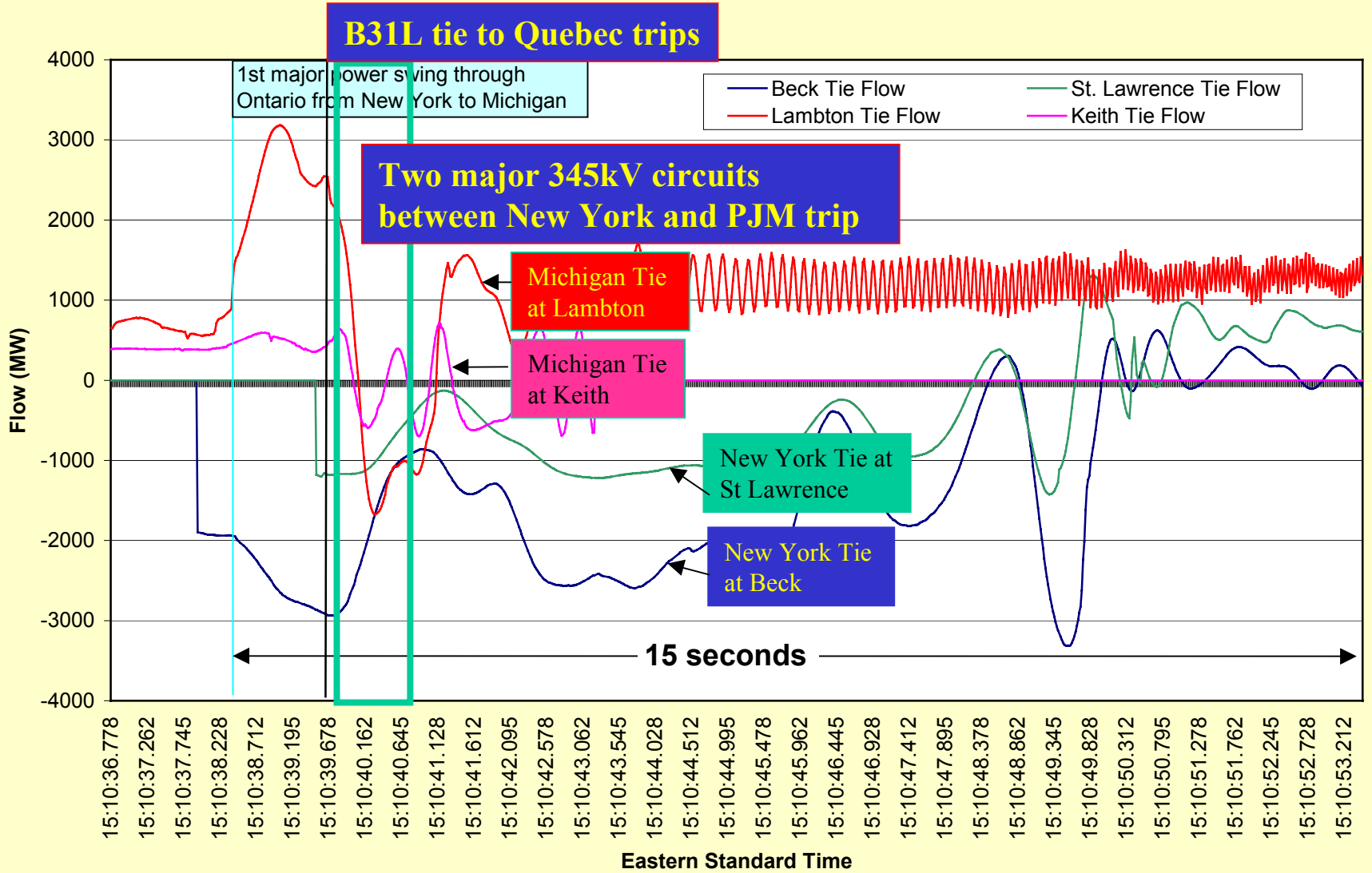


4:10:40 PM (+ 2 seconds)

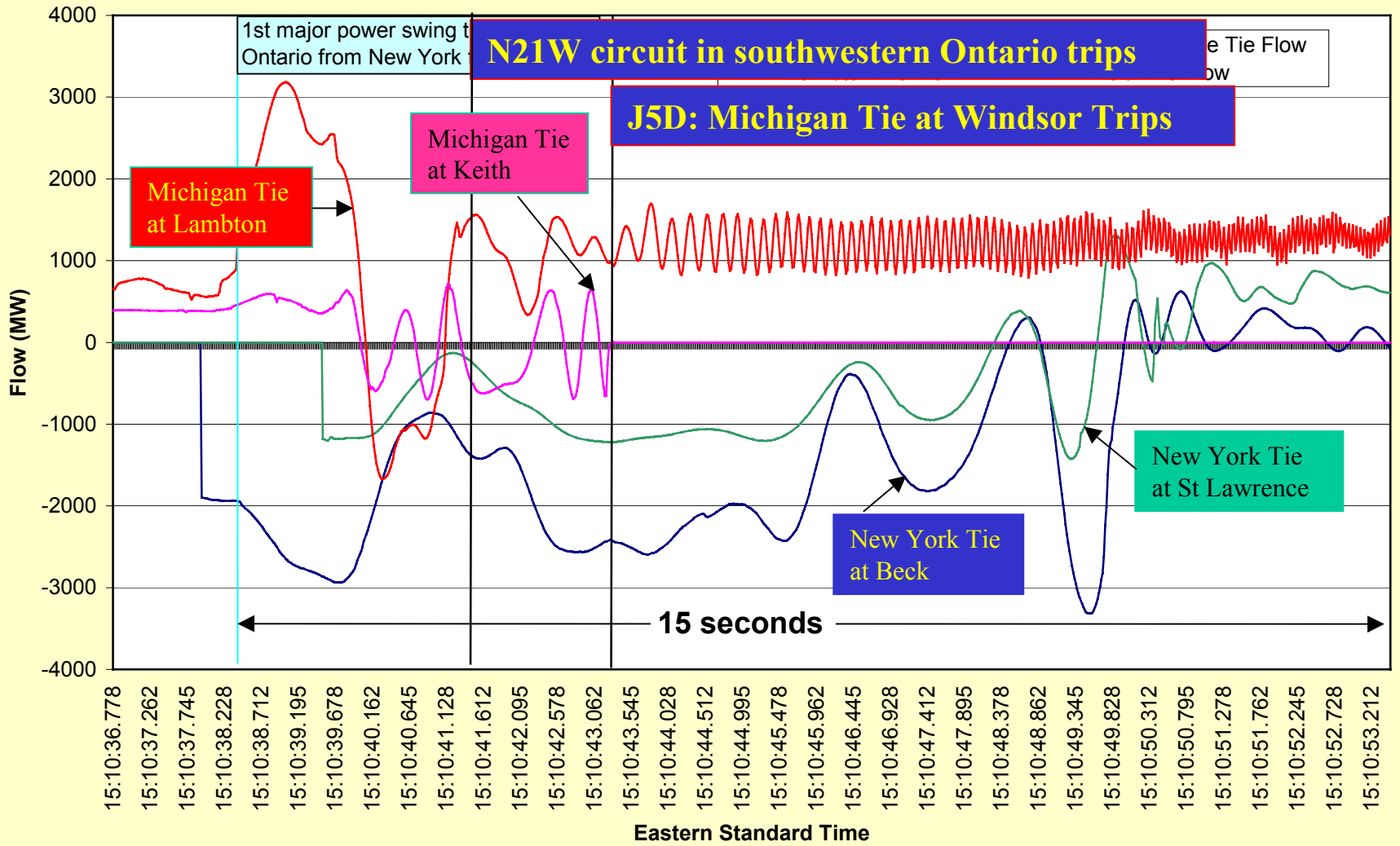


Two major 345kV circuits between New York and PJM trip and swing in Ontario reverses

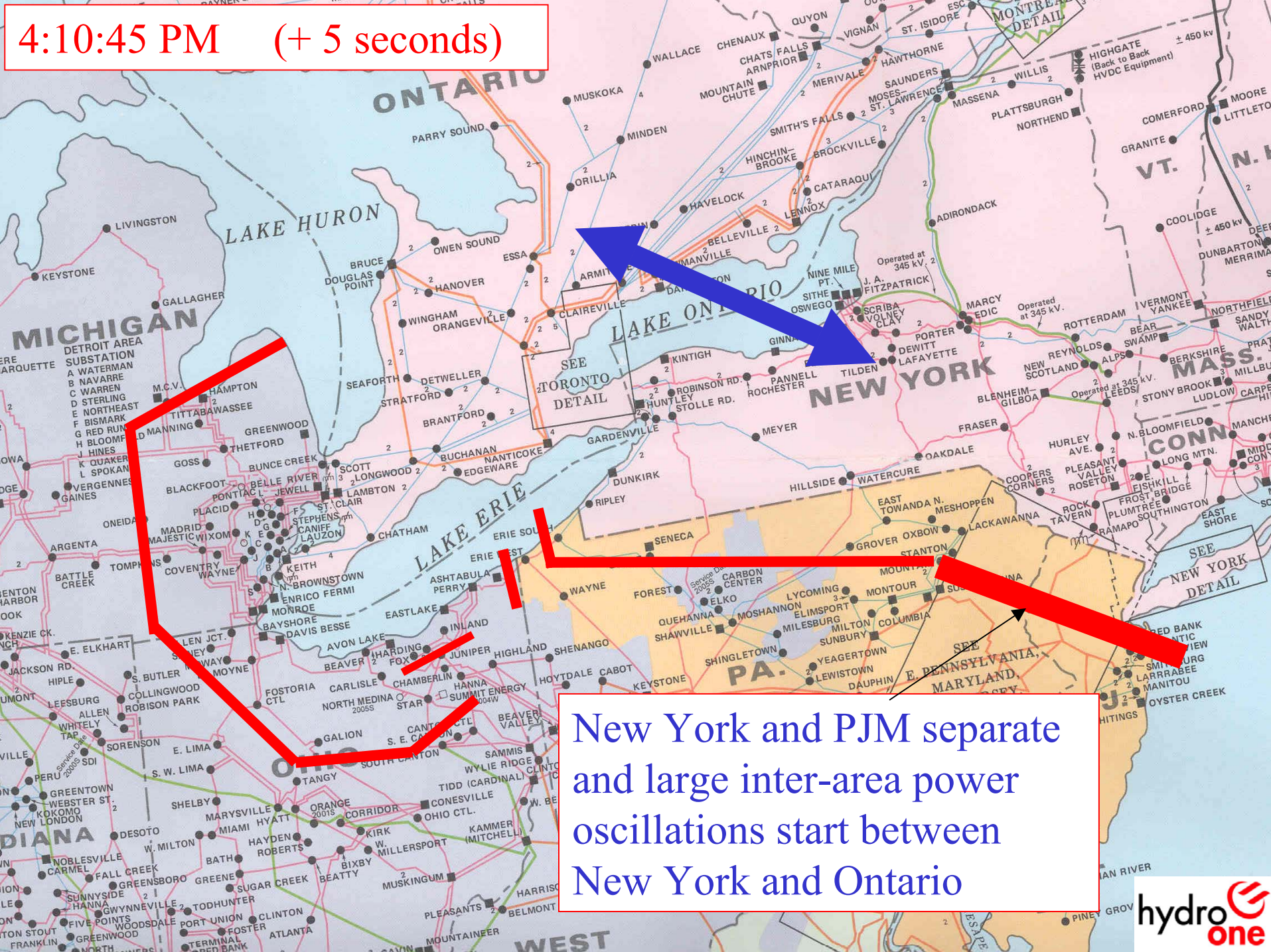
New York and Michigan Tie Flows



New York and Michigan Tie Flows

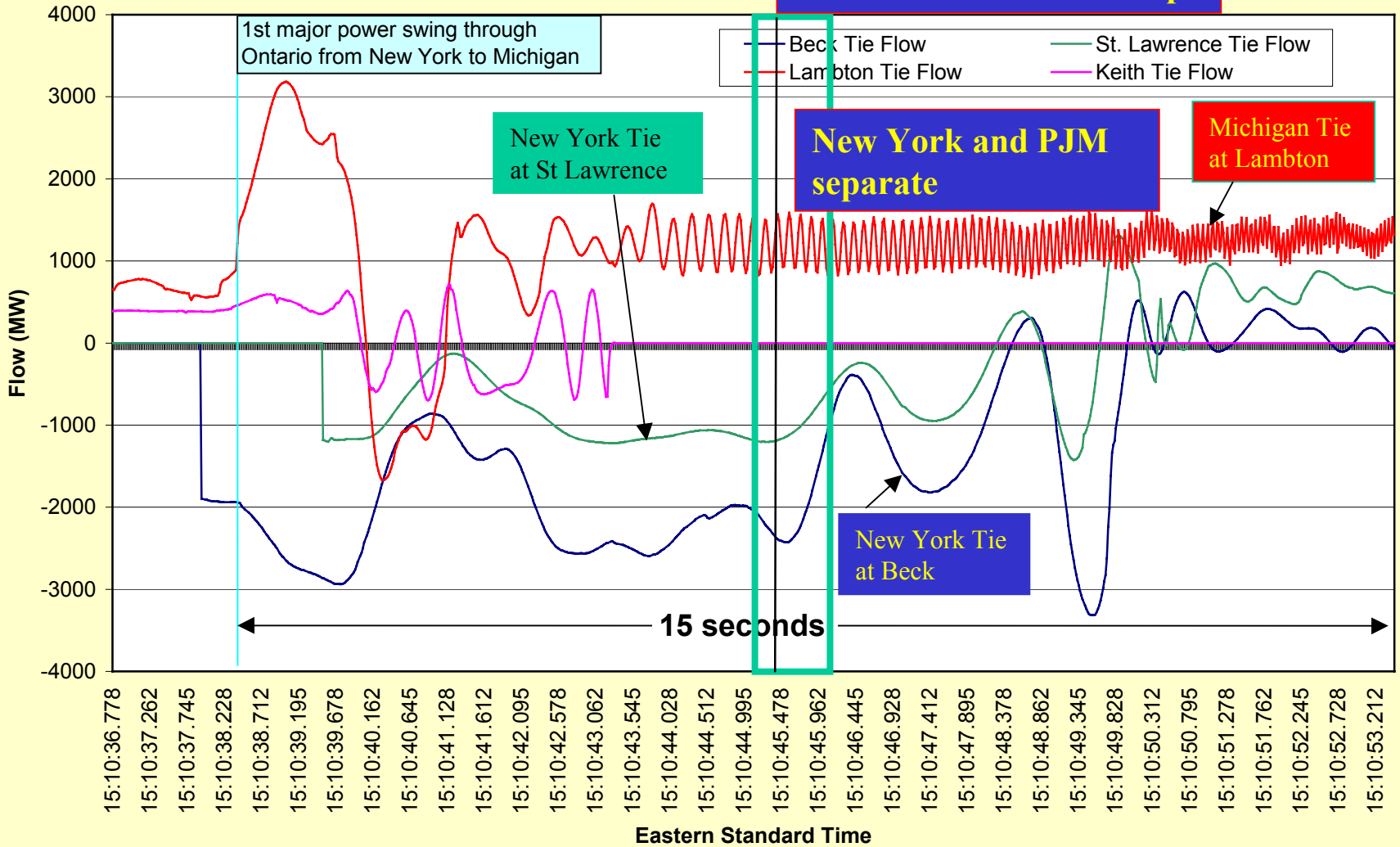


4:10:45 PM (+ 5 seconds)



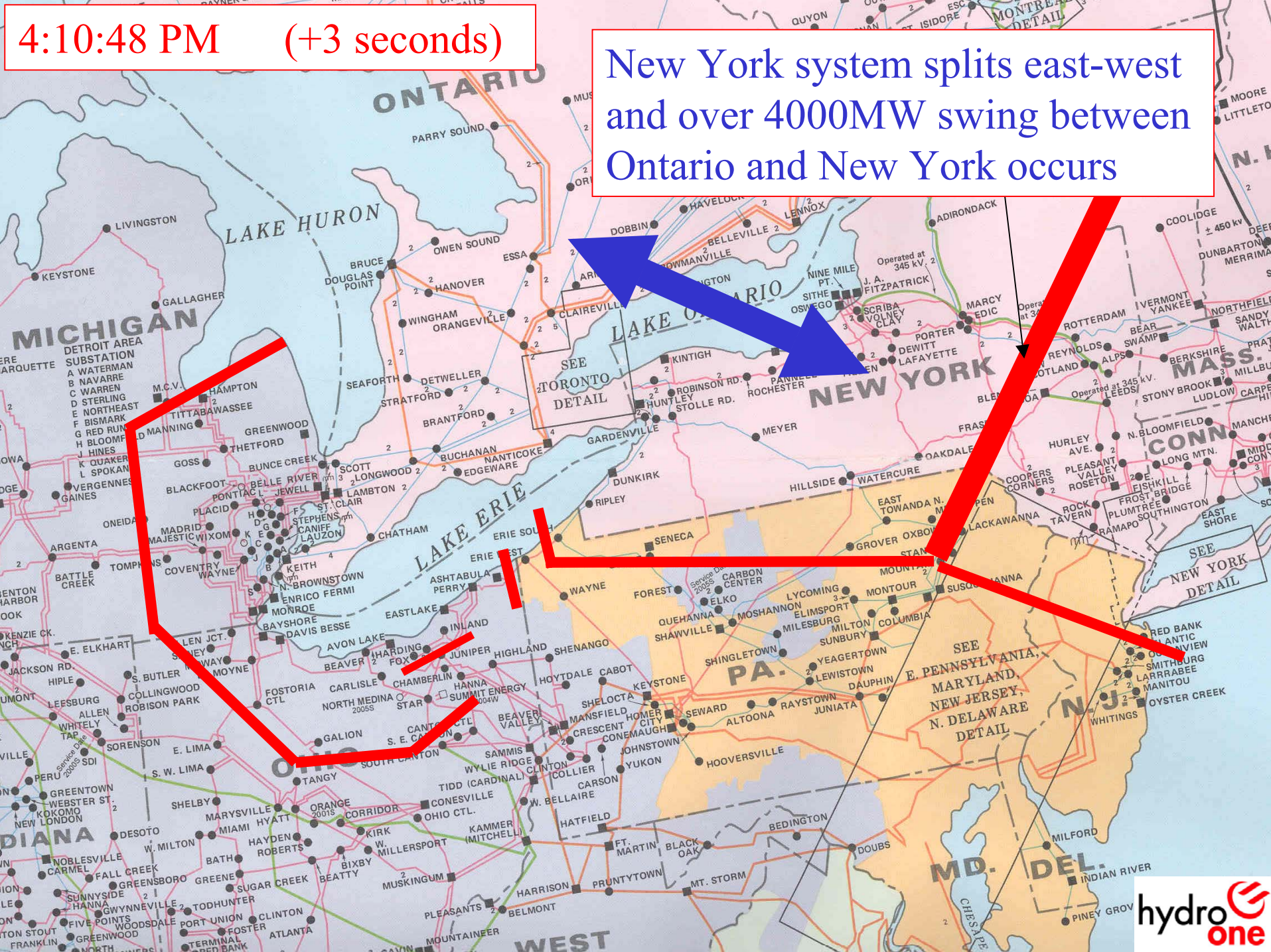
New York and PJM separate and large inter-area power oscillations start between New York and Ontario

New York and Michigan Tie Flows

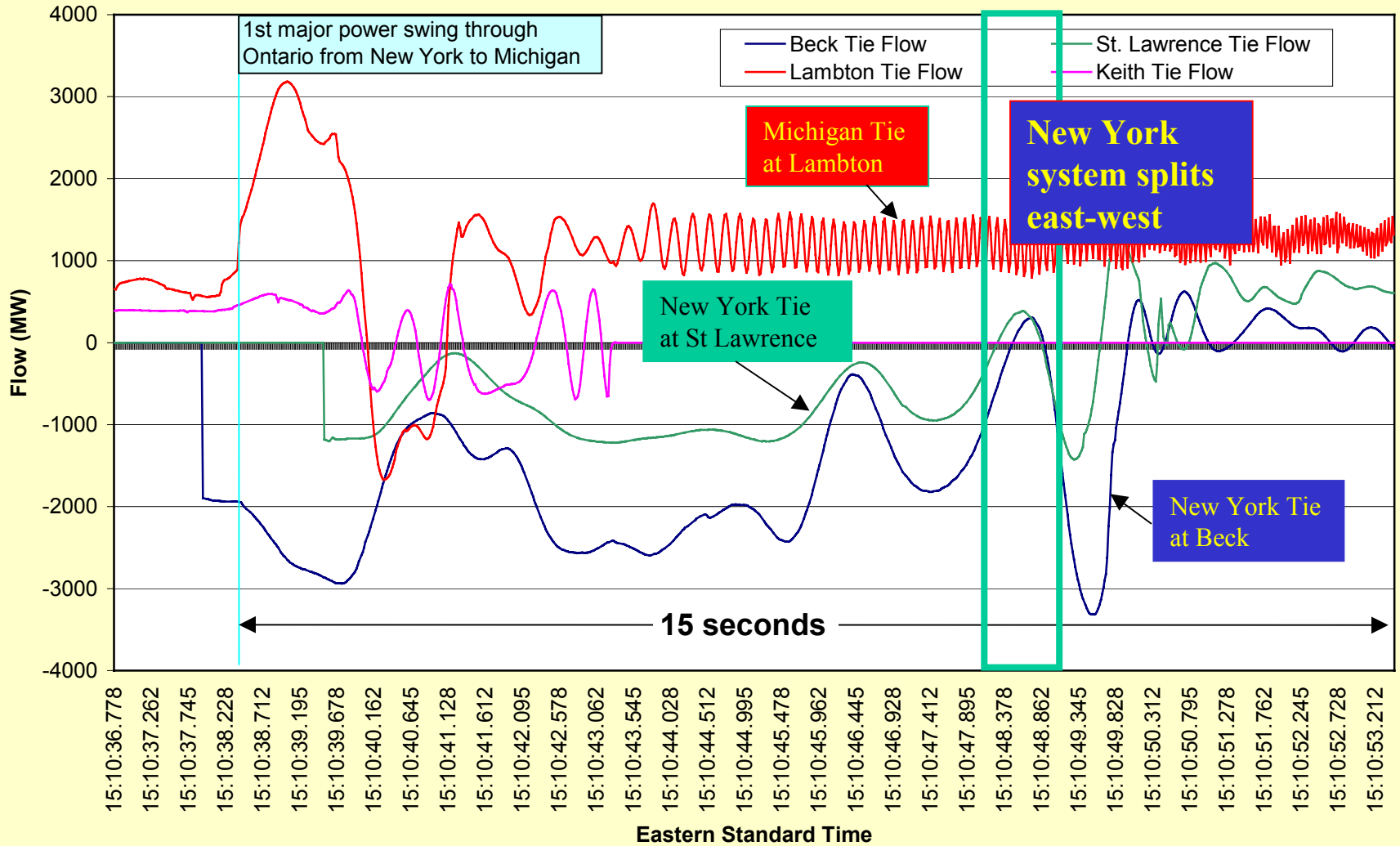


4:10:48 PM (+3 seconds)

New York system splits east-west and over 4000MW swing between Ontario and New York occurs

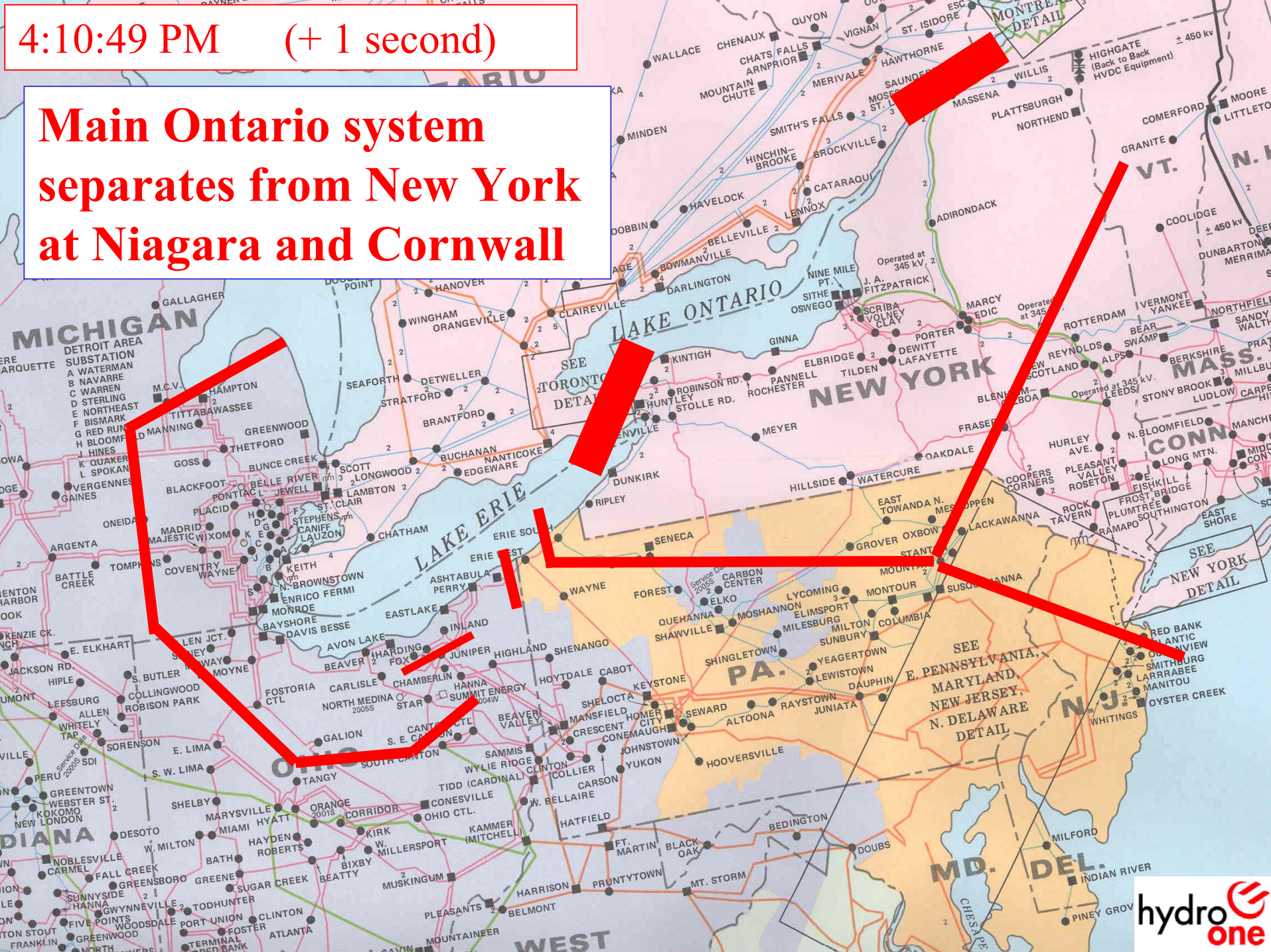


New York and Michigan Tie Flows

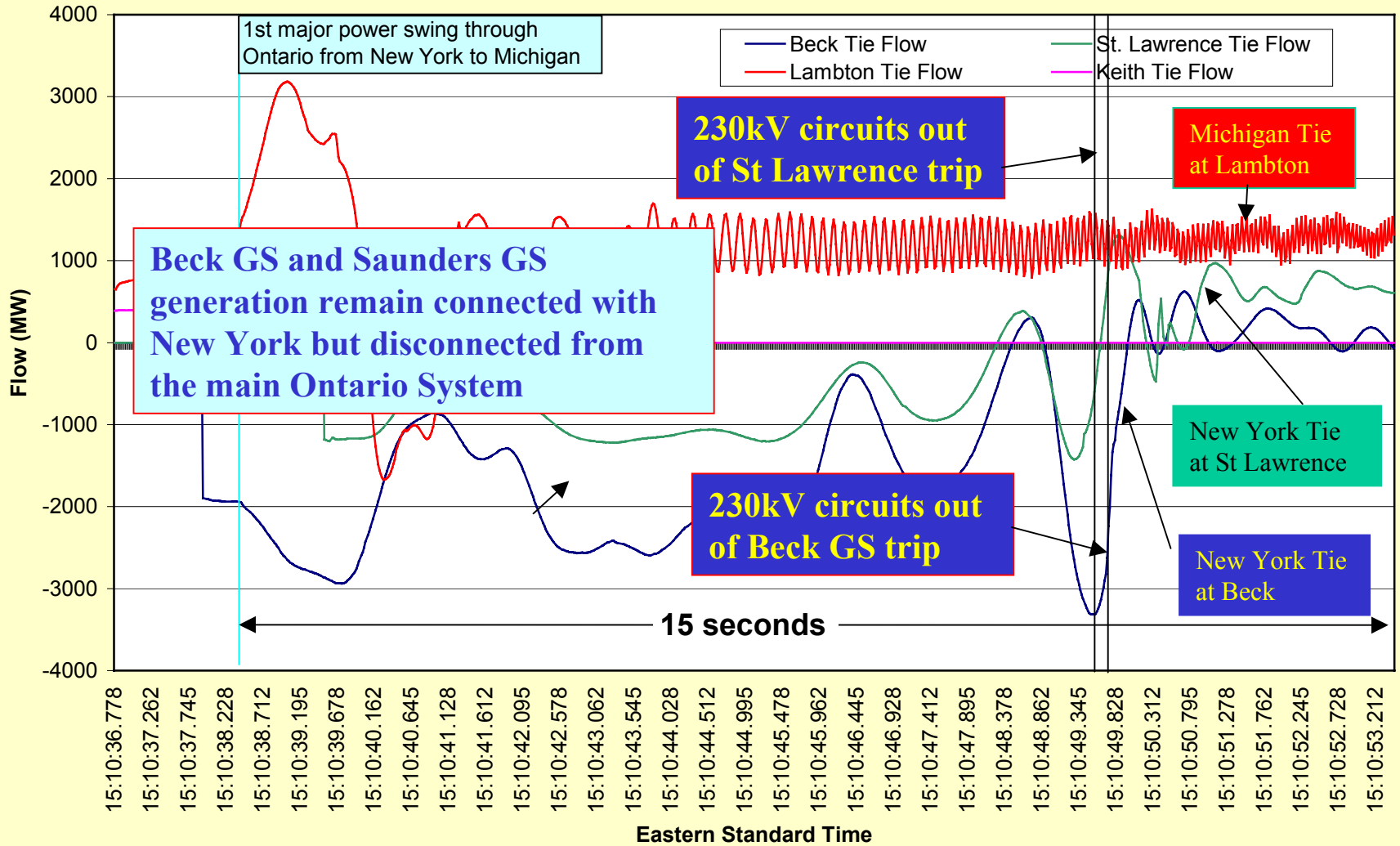


4:10:49 PM (+ 1 second)

Main Ontario system separates from New York at Niagara and Cornwall

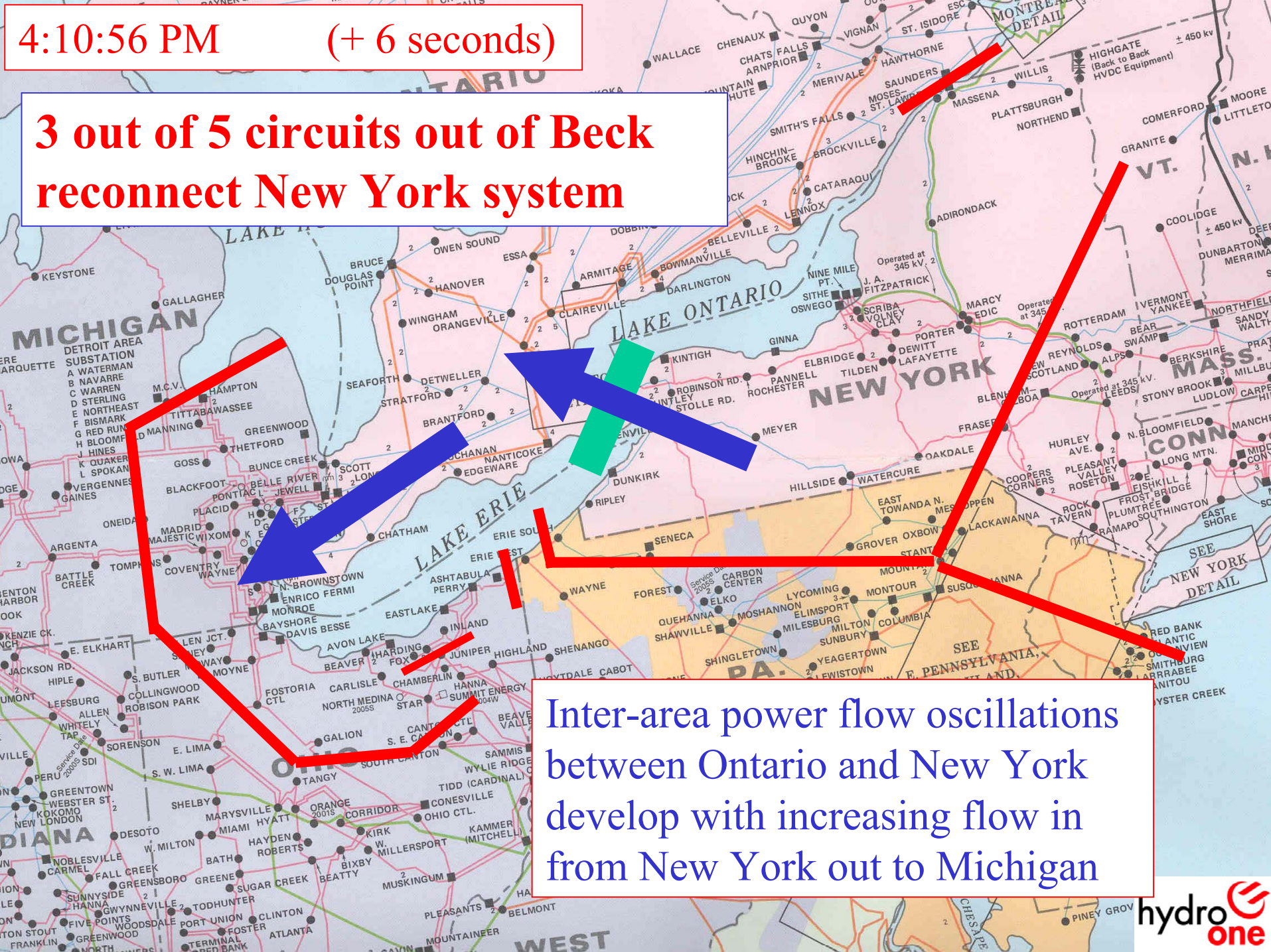


New York and Michigan Tie Flows



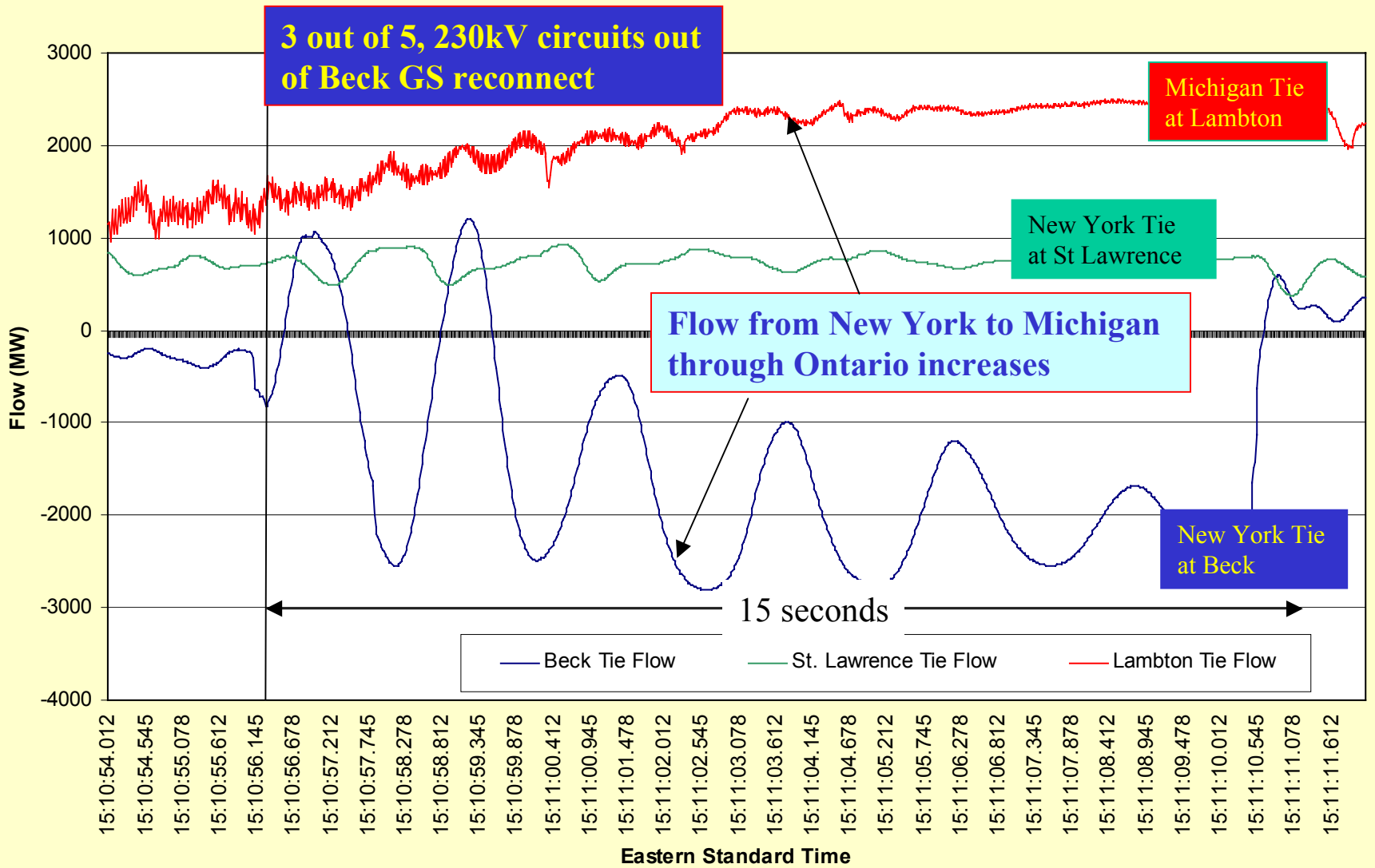
4:10:56 PM (+ 6 seconds)

3 out of 5 circuits out of Beck
reconnect New York system



Inter-area power flow oscillations between Ontario and New York develop with increasing flow in from New York out to Michigan

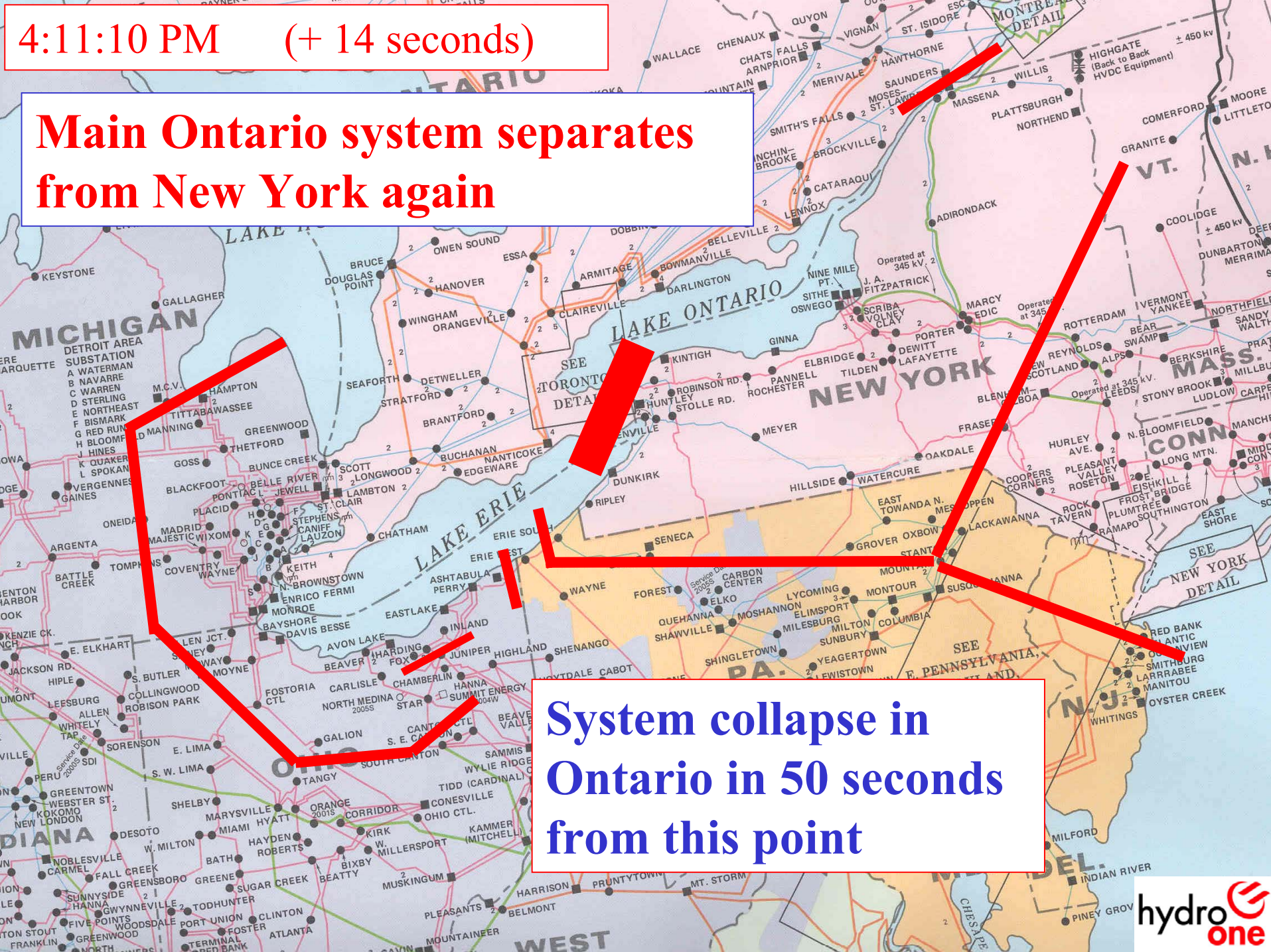
New York and Michigan Tie Flows



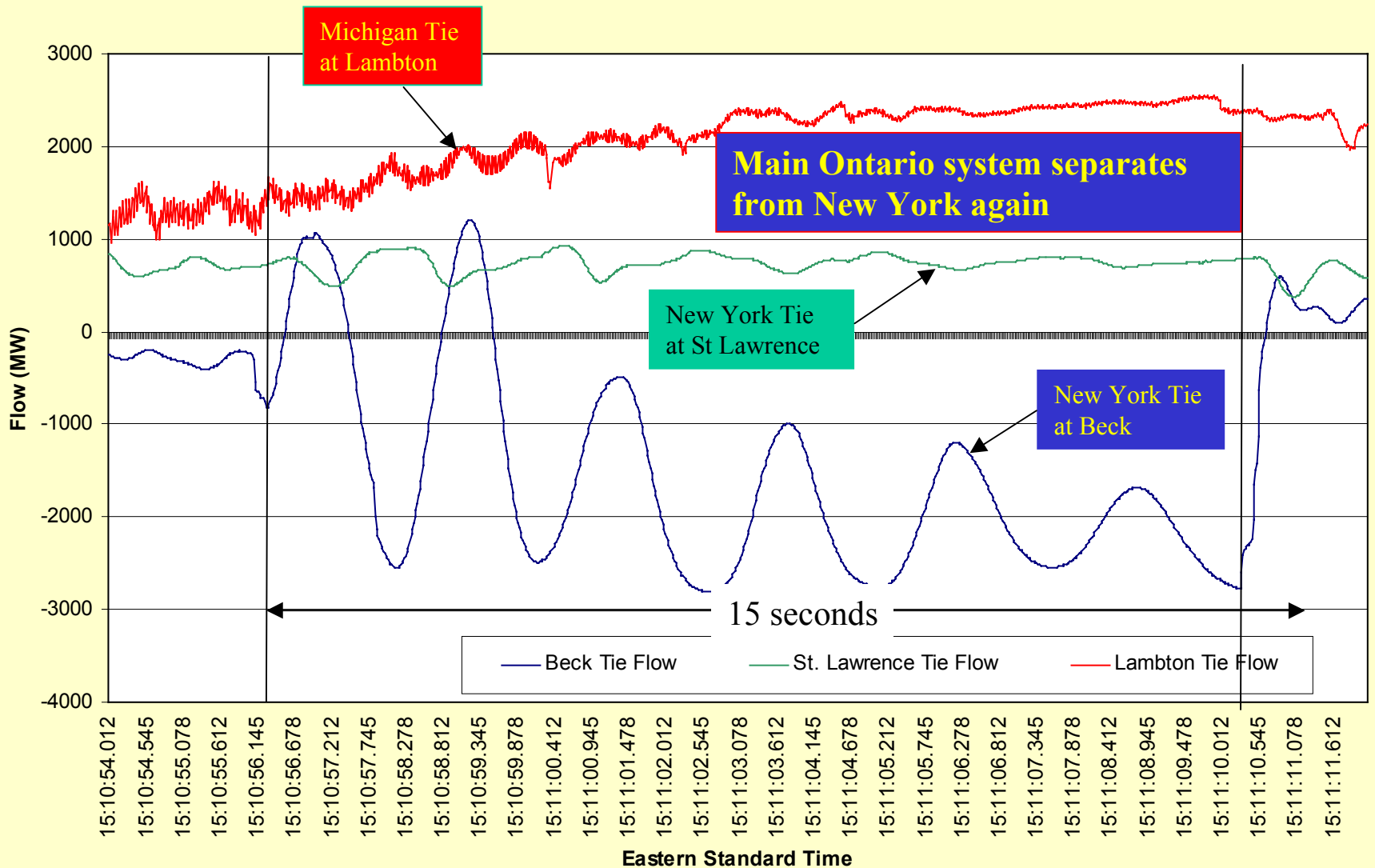
4:11:10 PM (+ 14 seconds)

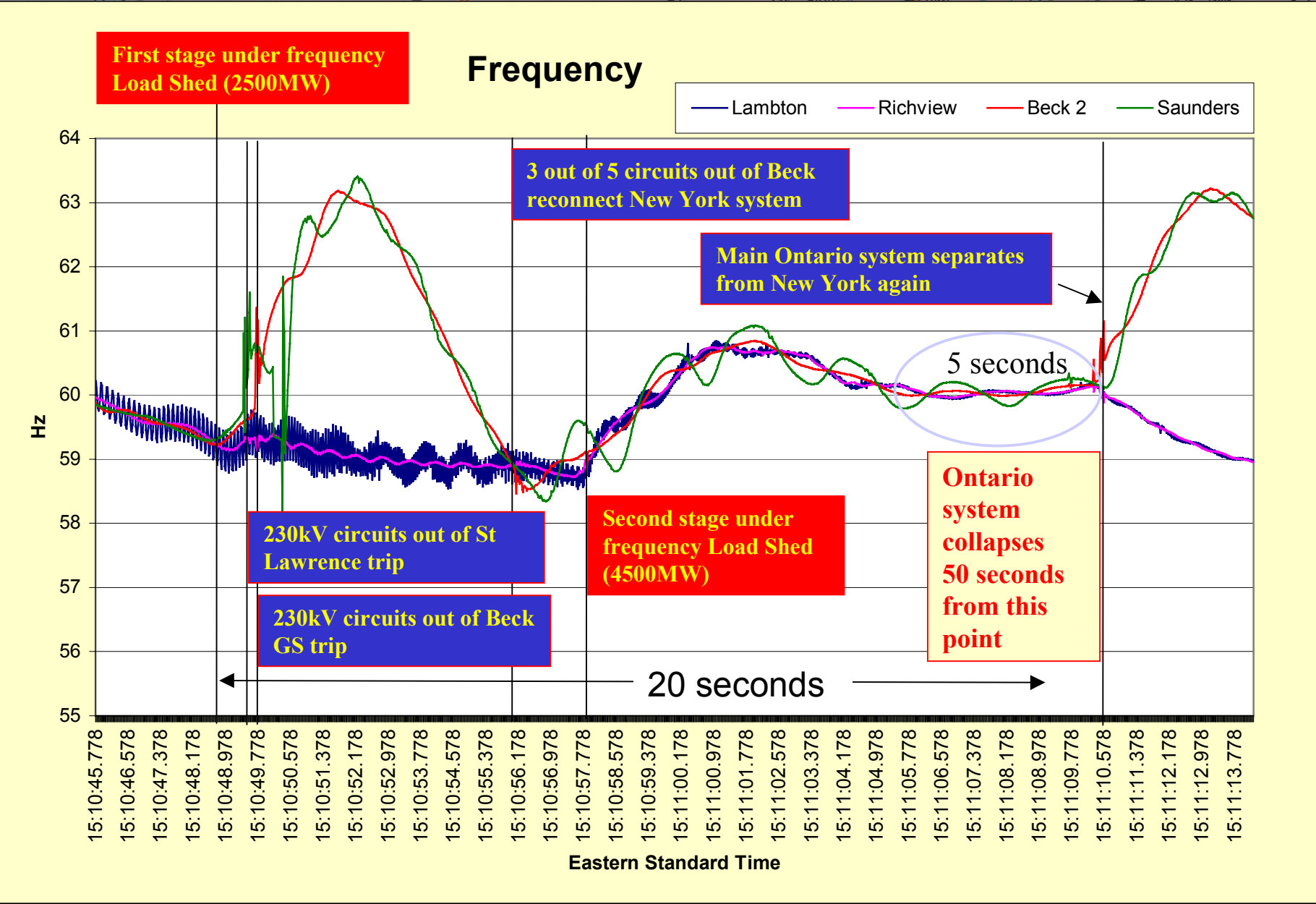
Main Ontario system separates from New York again

System collapse in Ontario in 50 seconds from this point



New York and Michigan Tie Flows

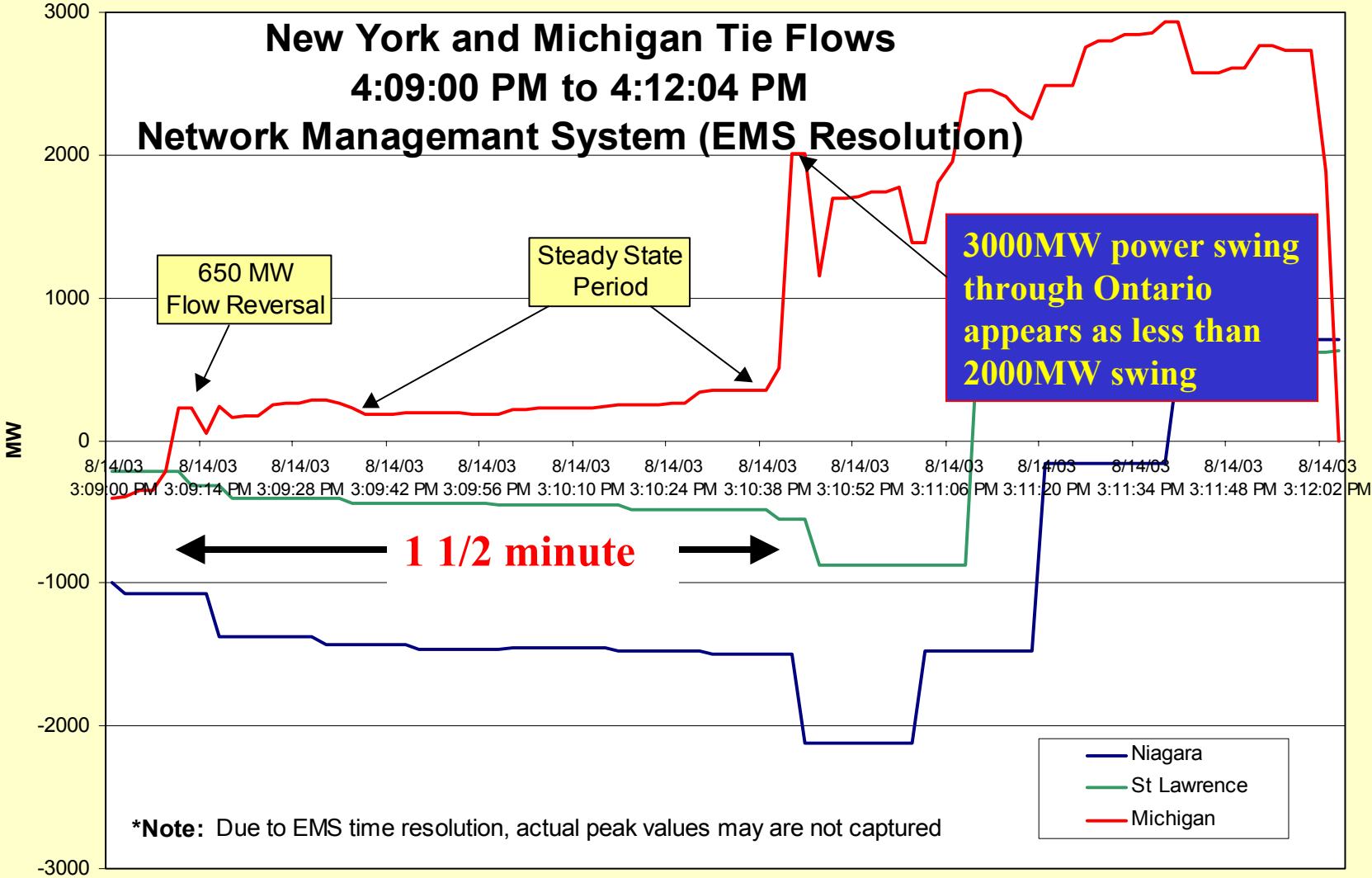




What the operators in Ontario saw

New York and Michigan Tie Flows 4:09:00 PM to 4:12:04 PM

Network Management System (EMS Resolution)



*Note: Due to EMS time resolution, actual peak values may are not captured

- Niagara
- St. Lawrence
- Michigan

Conclusion

- All Hydro One Networks' automatic protection systems worked as designed.
- The system collapse in Ontario occurred within 3 minutes from the first sign, 1 1/2 minutes from the first major power swing.