Interconnection Feasibility Study Report
GIP-151-FEAS-R1

Generator Interconnection Request #151

50 MW Steam Generating Facility

Halifax County, NS (91H)

May 30, 2008

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

Interconnection Request (IR) #151 is a 50 MW steam extension to a pair of 50MW combustion turbine generators at the Tuft's Cove generating station in Dartmouth Nova Scotia. The generator is a conventional synchronous generator capable of providing standard ancillary services such as voltage control, load following, regulation, and synchronized reserve.

IR #151 is not expected to cause concern for voltage control, flicker, or short circuit duty on nearby breakers.

There is an existing thermal limit concern for the single contingency loss of both circuits between 91H-Tuft's Cove and 90H-Sackville:

- Fault on breaker 91H-605 trips L-6003 plus L-6007.
- Fault on either L-6003 or L-6007 with failure of 91H-605 (BBU) trips L-6003 plus L-6007.
- Double-circuit tower faults on L-6003 plus L-6007 between 91H-Tuft's Cove and 108H-Burnside trips both circuits
- Double-circuit tower faults on L-6003 plus L-6009 between 90H-Sackville and 108H-Burnside trips both circuits

Each of these contingencies results in severe over-loading of L-5003 between 90H-Sackville and 99H-Farrell St. The addition of IR#151 does not relieve this existing condition, which can be mitigated by uprating switches at 124H-Akerley Blvd and 99H-Farrell St.

However, those upgrades are insufficient to provide for the addition of IR#151 under the provisions of Network Resource Interconnection Service. To provide for sufficient thermal capacity under the above contingencies, two options were investigated.

Option 1 involves the uprating of L-5003 from a design temperature of 50°C to an operating temperature of 55 - 60°C, providing a summer rating of 64 - 71 MVA. It is estimated that the cost of these network upgrades is approximately $1.75M, of which $1.47M would be the responsibility of IR#151.

Option 2 involves the installation of a generation run-back Special Protection System (SPS) which trips the duct-firing portion of IR#151 and reduces the output of Tuft's Cove Units 4 and 5 to 50% load within 5 minutes. The capital cost of this option is estimated to be approximately $220,000 and eliminates the need to replace the switches at 124H-Akerley Blvd and 99H-Farrell St. This SPS would be presented to NPCC for their approval.

For either option, a detail survey of L-5003 must be conducted to verify the present ampacity of the line, and determine the number of structures that must potentially be uprated or the setting of the proposed SPS. The cost of this survey is included in the above estimates.

As there is the potential for stability concerns at this plant, the System Impact Study may indicate additional transmission reinforcement requirements and/or additional SPS functionality.

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1 Introduction

The Interconnection Customer submitted an Interconnection Request (IR) to Nova Scotia Power Inc. (NSPI) for a proposed 50 MW Steam Generation Facility interconnected to the NSPI system at 91H-Tuft's Cove. The Interconnection Customer signed a Feasibility Study Agreement to study the connection of their proposed generation to the NSPI transmission system. This report is the result of that Agreement. This generating unit, to be referenced as IR#151 throughout this report, utilizes the exhaust heat from existing combustion turbines in a combined-cycle configuration, and can therefore only operate with 91H-Tuft's Cove Unit 4 and/or 91H-Tuft's Cove Unit 5 operating. Total operating capacity of the combined-cycle configuration is 150 MW.

2 Scope

The Interconnection Feasibility Study (FEAS) report shall provide the following information:

i. Preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection.

ii. Preliminary identification of any thermal overload or voltage limit violations resulting from the interconnection.

iii. Preliminary description and non-binding estimated cost of facilities required to interconnect the Generating Facility to the NSPI Transmission System, the time to construct such facilities, and to address any identified short circuit and power flow issues

The Scope of this FEAS includes modeling the power system in normal state (with all transmission elements in service) under anticipated load and generation dispatch conditions.

For Network Resources Integration Service (NRIS), the FEAS will identify any transmission upgrades required as the result of thermal overload, voltage violation, or equipment rating. The FEAS will attempt to provide high level cost estimates for such upgrades and direct interconnection costs.

A more detailed analysis of the technical implications of this development will be included in the System Impact Study (SIS) report. This may include system stability analysis, single contingencies (single or multiple elements as defined by the Northeast Power Coordinating Council), off-nominal frequency operation, off-nominal voltage operation, low voltage ride through, harmonic current distortion, harmonic voltage distortion, system protection, special protection systems (SPS), automatic general control (AGC) and islanded operation. The impacts on neighbouring power systems and the requirements set by reliability authorities such as Northeast Power Coordinating Council

(NPCC), North American Electric Reliability Corporation (NERC), and NSPI will be addressed at that time. The SIS may identify additional costs and upgrades that were not identified in this FEAS.

A separate Facilities Study will follow the SIS in order to ascertain the final cost estimate for the transmission upgrade requirements.

3 Assumptions

The configuration studied is as follows:

i. 50 MW synchronous generating unit powered by a steam-driven turbine in a combined-cycle arrangement. The steam will be provided by a Heat Recovery Steam Generator extracting exhaust heat from the existing Combustion Turbines 91H-G4 and 91H-G5, plus a "duct-fired" auxiliary heat source. It is also assumed that the resulting combined cycle unit (Units 4, 5, 6) are not restricted to base-load operation.

ii. NRIS

iii. The Steam Generating Facility will be located at the 91H-Tuft's Cove Generating Station in Dartmouth NS.

iv. Point of Interconnection will be on the 138kV bus node between 91H-611B and 91H-612B via a new transformer

v. The results of the analysis in this FEAS are based on the assumption that IRs higher in the Generation Interconnection Queue (Queue) will not proceed, but the impacts of higher Queued IRs are reviewed qualitatively.

vi. The existing generation at the 91H-Tuft's Cove is net 419 MW.

vii. IR#151 is proposed to displace more expensive energy such as Burnside Combustion Turbines or Tuft's Cove Unit 1. Although it is not needed to meet system firm load capacity requirements, it will increase the installed accredited capacity at 91H-Tuft's Cove since no generation at that plant is scheduled to be retired in the time frame under consideration.

4 Projects with Higher Queue Positions

As of May 2008, the following IRs can proceed ahead of this project due to their position in the Queue and have the status indicated.

<u>Generation projects with a higher Queue position, not yet committed</u>
IR 008 Wind – Guysborough, L-5527B, 15 MW – FAC Complete
IR 017 Wind – Lunenburg, L-6004, 100MW – FEAS Completed

IR 023 Wind – Inverness, L-6549, 100MW – FEAS Completed
IR 042 Wind – Cape Breton, New 138kV line, 100MW – FEAS Completed
IR 045 Wind – Cumberland, L-6535, 35MW – SIS Complete
IR 046 Wind – Colchester, L-6513, 32MW – FEAS Completed
IR 056 Wind – Cumberland, L-5058, 34MW – FEAS Completed
IR 067 Wind – Annapolis, L-5026, 40MW – FEAS Completed
IR 068 Wind – Digby, L-5533, 35MW – FEAS Completed
IR 082 Wind – Colchester, L-5040, 45MW – FEAS Completed
IR 084 Wind – Pictou, L-7004, 50MW – FEAS Completed
IR 086 Wind – Pictou, L-7003, 50MW – FEAS Completed
IR 114 Wind – Pictou, L-6511, 60MW – FEAS Completed
IR 115 Wind – Pictou, L-7003, 120MW – FEAS Completed
IR 117 Wind – Shelburne, L-5027, 10MW – FEAS Completed
IR 126 Wind – Cumberland, L-6513, 70MW – FEAS Completed
IR 128 Wind – Cumberland, L-6536, 40.5MW – FEAS Completed
IR 130 Wind/Water pumped storage– Cape Breton, L-6516, 200MW – FEAS Completed
IR 131 Wind – Cape Breton, L-5580, 11.5MW – FEAS Completed
IR 137 Wind – Richmond, 1C-T61, 10MW – FEAS Completed
IR 140 Wind – Antigonish, L-7004, 30MW – FEAS Completed
IR 141 Wind – Digby, 77V, 30MW – FEAS Completed
IR 149 Wind – Cumberland, L-6536, 70MW – FEAS in progress
IR 150 Wind – Richmond, 1C-T61, incremental 10 MW – FEAS Completed

All of the above projects (with the exception of the Water Pumped Storage) can have an impact on the management of the inter-provincial ties (balancing load and generation in the NSPI system), since such generation is considered to be variable and non-dispatchable. The design of IR#151 is such that it can be used to control inter-provincial ties and thus can assist in the mitigation of such issues.

Unlike this FEAS, the SIS will be based on the assumption that all projects that are ahead of this project in the Queue are in-service. However, because this IR#151 is located in the load centre, it is not expected to be adversely affected by projects ahead in the Queue.

5 Flicker Levels

This generator is a conventional synchronous machine with high-speed voltage control (automatic voltage regulator) connected to a strong 138kV bus, and therefore is not expected to result in voltage flicker issues.

6 Short-Circuit Duties

The maximum (future) expected short-circuit levels on 138kV system is 5,000 MVA.

The short-circuit levels in the area before and after this development are provided in Table 6-1.

Table 6-1: Short-Circuit Levels. Three-phase MVA (kA)		
Location	**This Generating Facility in service**	**This Generating Facility not in service**
All transmission facilities in service		
91H-Tuft's Cove 138kV	3069 (12.8)	2931 (12.3)
91H-Tuft's Cove 69kV	1864	1845
108H-Burnside 138kV	2813 (11.8)	2726 (11.4)
90H-Sackville 138kV	2958 (12.4)	2885 (12.0)
104H-Kempt Rd. 138kV	2381 (10)	2300 (9.6)
Minimum Conditions (Units 1, 2, 3, 4, 5 at 91H Off)		
91H-Tuft's Cove 138kV	N/A	1787

All 69kV circuit breakers at 91H-Tuft's Cove are rated at least 3000 MVA, and all 138kV breakers at that station are rated at least 5000 MVA, so the addition of IR#151 will not exceed the duty of those circuit breakers. The minimum breaker rating at 108H-Burnside 138kV and 104H-Kempt Rd is 3100 MVA, so IR#151 will not exceed breaker duty at those stations. All 69kV circuit breakers at 91H-Tuft's Cove are rated at least 3100 MVA, higher than the 1864 MVA with IR#151 in service.

Circuit breakers at 90H-Sackville were uprated in 2007, and therefore IR#151 will not impact circuit breakers at that station.

7 Thermal Limits

Steady-state (load flow) analysis has been conducted with all lines in service and for all single contingencies required by NERC and NPCC. Consistent with the requirement for NRIS, dispatch conditions included all units at Tuft's Cove operating at full load for system load levels above 70% of winter peak load and at 100% of summer peak load, based on historical dispatch patterns. Total plant generation is reduced for load levels below that indicated above.

Single contingencies are defined as the loss of any single element (generator, transformer, transmission line or bus section), or multiple elements that share a common element (circuit breaker or multiple-circuit tower).

Two contingencies result in thermal overloads. Lines L-6003 and L-6007/L-6009 share common towers between 90H-Sackville and 91H-Tuft's Cove. In addition, L-6003 shares

a common circuit breaker (91H-605) with L-6007 at 91H-Tuft's Cove. Therefore, simultaneous loss of L-6003 plus L-6007 or simultaneous loss of L-6003 plus L-6009 are considered to be single contingencies. These latter contingencies result in high flow across the 69kV line L-5003 from 99H-Farrell St. to 90H-Sackville via 124H-Akerley Blvd. This line is currently rated at 48 MVA summer and winter due to the switches at 124H-Akerley Blvd. The switch at 99H-Farrell St. is rated at 72 MVA and the one at 90H-Sackville is rated for 96 MVA. The conductor for L-5003 is rated 55 MVA summer and 82 MVA winter. If the switches at 124H-Akerley Blvd. and 99H-Farrell St are uprated to 96 MVA (800A), then the overall line rating would be raised to 55 MVA summer and 82 MVA winter.

Generation at the Tuft's Cove plant historically operates at full load only when system load levels are above 1700 MW. Figure 1 shows the system conditions with current summer transmission rating (48 MVA), all lines in service, and IR#151 not in service. Figure 2 shows power flow with the simultaneous loss of L-6003 and L-6007, again with IR#151 not in service. Line L-5003 is loaded to 58 MVA (120% of its current summer rating) which is above the acceptable limit of 110% of rating. If the upgrades to the switches of L-5003 mentioned above are made, the loading on L-5003 will be brought down to 106% of rating, as shown in Figure 3. This is an existing condition that is not improved with the addition of IR#151, but is also not caused by IR#151 and therefore any costs associated with correcting this situation would not be assigned to IR#151.

The addition of IR#151 will result in L-5003 to be loaded to 68 MVA for the double-circuit outage, as shown in Figure 4. This load is 140% of the present rating of 48 MVA and 124% of the summer rating of the conductor (if the switches at 124H-Akerley Blvd. and 99H-Farrell St. are uprated). Similarly, L-5003 is loaded to 57 MVA (116% of present line rating) for the simultaneous loss of L-6003 and L-6009, as shown in Figure 5. Two alternatives are proposed to remedy this condition as required by an NRIS FEAS.

Option 1 – Uprate L5003 Conductor Operating Temperature

If the summer rating of L-5003 is raised from 55 MVA to 62 MVA, then the flow on that circuit for the double-circuit contingency will be under 110% of the new summer rating. This means that the conductor should be capable of an operating temperature of at least 55°C. Figure 6 shows the result of this uprating for loss of L-6003/L-6007 and Figure 7 shows the result of the uprating for loss of L-6003/L-6009.

Option 2 – Install Generation – Run-back Special Protection System (SPS)

Since the overload condition on L5003 is experienced only under the condition of simultaneous loss of L-6003/L-6007 or L-6003/L6009, it would be feasible to install a generation – run-back scheme to detect the conditions and automatically adjust generation at 91H-Tuft's Cove after the contingency has occurred. The SPS would be armed by total generation at 91H-Tuft's Cove in combination with load in the area and local ambient temperature. The SPS would select the amount of generation to be "run back" when protection detected the simultaneous loss of

multiple 138kV circuits between 91H-Tuft's Cove and 90H-Sackville. Alternately, the SPS could operate on detection of overload on L-5003 for a pre-set period of time. The action of the SPS would reduce the output of the generating units 4, 5 and 6 at 91H-Tuft's Cove within five minutes of the event (allowing time for attempted reclosing of the circuits), followed by a trip of the units if run-back does not achieve load relief. The scheme would reduce Units 4 and 5 by 50% (24 MW each) and remove duct-firing in Unit 6 (13 MW). Run-back would retain the reactive capabilities of the generating units on the system through the event. All SPS's must be approved by NPCC.

Figure 8 shows the effect of the proposed SPS with the present rating of L-5003. This demonstrates that the SPS would eliminate the need for uprating the switches at 124H-Akerley Blvd and 99H-Farrell St.

In the case of either Option, a detailed survey of L-5003 is required to verify the present operating capability. This will provide input to the determination of the number of structures which must be uprated to provide 55 - 60°C operating capability for Option 1, or the settings of the SPS for Option 2.

It should be noted that the viability of either option is contingent on the outcome of the SIS, and in the case of Option 2, the approval of NPCC.

8 Voltage Control

This generator must be supplied with high-speed excitation system capable of responding to system disturbances that result in step changes to the voltage detected at the machine terminals within 100ms.

9 System Limitations (System Security)

This project will increase the amount of generation in the load centre. Assuming other units at Tuft's Cove are not reduced to accommodate IR#151 (a valid assumption for an NRIS study), the operation of this unit (in conjunction with 91H-G4 and 91H-G5 as is necessary for operation), flow into the load centre is reduced, which improves system losses and relieves transmission of reactive power demands. Since this unit is "dispatchable", it can provide ancillary services such as spinning reserve, load following, and tie-line regulation. However, there is the potential for stability issues due to the contingencies which result in the loss of two circuits between 91H-Tuft's Cove and 90H-Sackville, which may require additional transmission and/or additional SPS functionality. These impacts will be determined during the SIS.

10 Expected Facilities Required for Interconnection

The following additions/changes to the Transmission Provider's Interconnection Facilities are required:

Option 1

i. Install new switches on L-5003 at 124H-Akerly Boulevard rated to at least 800A. Uprate switches 99H-506A and 99H-506B at 99H-Farrell St. to at least 800A.[1]

ii. Uprate L-5003 to 55°C, including detailed line survey of L-5003 to determine number of structures to be uprated.

iii. Control and communications between this Generating Facility and NSPI Supervisory Control and Data Acquisition (SCADA) system (to be specified)

Option 2

i. Install generation run-back SPS, including detailed line survey of L-5003 to determine settings of SPS.

ii. Control and communications between this Generating Facility and NSPI Supervisory Control and Data Acquisition (SCADA) system (to be specified)

The Interconnection Customer's Interconnection Facility is to include:

i. Steam turbine generators to provide 0.95 leading and lagging power factor when delivering rated output (50 MW) measured at the Interconnection Point.

ii. High-speed voltage control.

iii. Real-time monitoring and control RTUs of the Interconnection Facility, with the capability of the NSPI System Operator to curtail part or all of the Interconnection Facility output.

iv. Transformer, switchgear, buswork to connect to 91H-Tuft's Cove 138kV.

[1] Existing limitations requiring these upgrades are not the responsibility of IR#151, but are listed as necessary upgrades for Option 1.

11 Magnitude of NSPI Interconnection Facilities Cost Estimate

Estimates for NSPI Interconnection Facilities for Options 1 and 2 are included in Table 11-1, and Table 11-2 respectively:

Table 11-1: Cost Estimates for Option 1		
	Determined Cost Items	**Estimate**
i	Replace two switches at 124H-Akerley Blvd.(Note 1)	$167,000
ii	Replace two switches at 99H-Farrell St. (Note 1)	$121,000
iii	Survey L-5003 ground clearance	$50,000
iv	Uprate L-5003 to 55°C (Note 2)	$1,235,000
v	Control and communications (Note 3)	$50,000
vi	Contingency (10%)	$133,500
	Total of Determined Cost Items (Items iii – vi)	$1,468,500
	Total Cost, including costs for prior limitations	$1,751,530
	To be Determined Costs	
vii	System upgrades to meet stability criteria	TBD (SIS)

Note 1: Upgrades necessary for existing limitations, which must be completed by NSPI before other proposed network upgrades.

Note 2: Line uprate estimate highly dependent on outcome of line survey. Cost estimates include 25% new structures, foundations to increase clearances, reuse existing conductor, insulators, and hardware on existing ROW/ easements. No distribution underbuild costs are included.

Note 3: This estimate assumes there is spare capacity on existing SCADA/RTU equipment. To be confirmed.

Table 11-2: Cost Estimates for Option 2		
	Determined Cost Items	**Estimate**
i	Survey L-5003 ground clearance	$50,000
ii	Install generation run-back SPS	$100,000
iii	Control and communications (Note 4)	$50,000
iv	Contingency (10%)	$20,000
	Total of Determined Cost Items	$220,000
	To be Determined Costs	
v	System upgrades to meet stability criteria	TBD (SIS)

Note 4: This estimate assumes there is spare capacity on existing SCADA/RTU equipment. To be confirmed.

The TBD costs may exceed the total of the determined cost items.

The above estimate includes the additions/changes to NSPI systems only. All costs of associated facilities required at the Generating Facility are in addition to the above estimate. Items identified as TBD will be assessed in the SIS. The estimated time to construct the "Determined Cost Items" will be 12 to 24 months.

12 Preliminary Scope of System Impact Study

The SIS must determine the facilities required to operate this facility at full capacity, withstand the contingencies as defined by NPCC/NERC and identify any restrictions that must be placed on the system, following a first contingency loss. The SIS will be conducted with the assumption that all projects higher Queued will proceed and the facilities associated with those projects are in service.

Some of the interfaces that may be constrained and should be included in the assessment are as follows:

i. Cape Breton Export
ii. Onslow Import
iii. Onslow South
iv. Maximum flow away from Tuft's Cove

Steady-state and post contingency analysis will have all elements within acceptable voltage and thermal limits under the following single contingencies, in accordance with NPCC/NERC criteria:

i. L-8003
ii. Hopewell transformer 79N-T81
iii. L-8002
iv. Loss of double circuit tower line L-6003 and L-6007
v. Loss of double circuit tower line L-6003 and L-6009

System stability will be assessed for the following faults:

i. Loss of any element without a fault
    a. L-8002
    b. Hopewell transformer 79N-T81
    c. L-8003

ii. Three-phase fault cleared in normal time

a. L-8003 at Onslow end
b. L-8002 at Lakeside end
c. High Voltage side of 79N-T81
d. L-6014 at Tuft's Cove end.
e. L-6003 at Tuft's Cove end.

iii. Single-phase to ground fault cleared in backup time (Breaker failure)

a. L-8003 at Onslow with failure of 67N-812 (lose L-8002)
b. L-6007 at Tuft's Cove end with failure of 91H-605 (lose L-6003)
c. L-6005 at Sackville end with failure of 90H-608 (lose L-6010)

iv. Single-phase to ground fault on separated circuits of double circuit tower

a. L-8004 plus L-7005 at Canso Crossing
b. L-6007 plus L-6003 at Tuft's Cove
c. L-6003 plus L-6009 at Burnside
d. L-6010 plus L-6005 at Sackville

Any changes to existing SPS schemes required for operation of this Generating Facility, in addition to existing generation and facilities that can proceed before this project, will be determined by the SIS as well as any required additional transmission facilities. The determination will be based on NERC and NPCC criteria as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility may be curtailed.

Figures

Figure 1

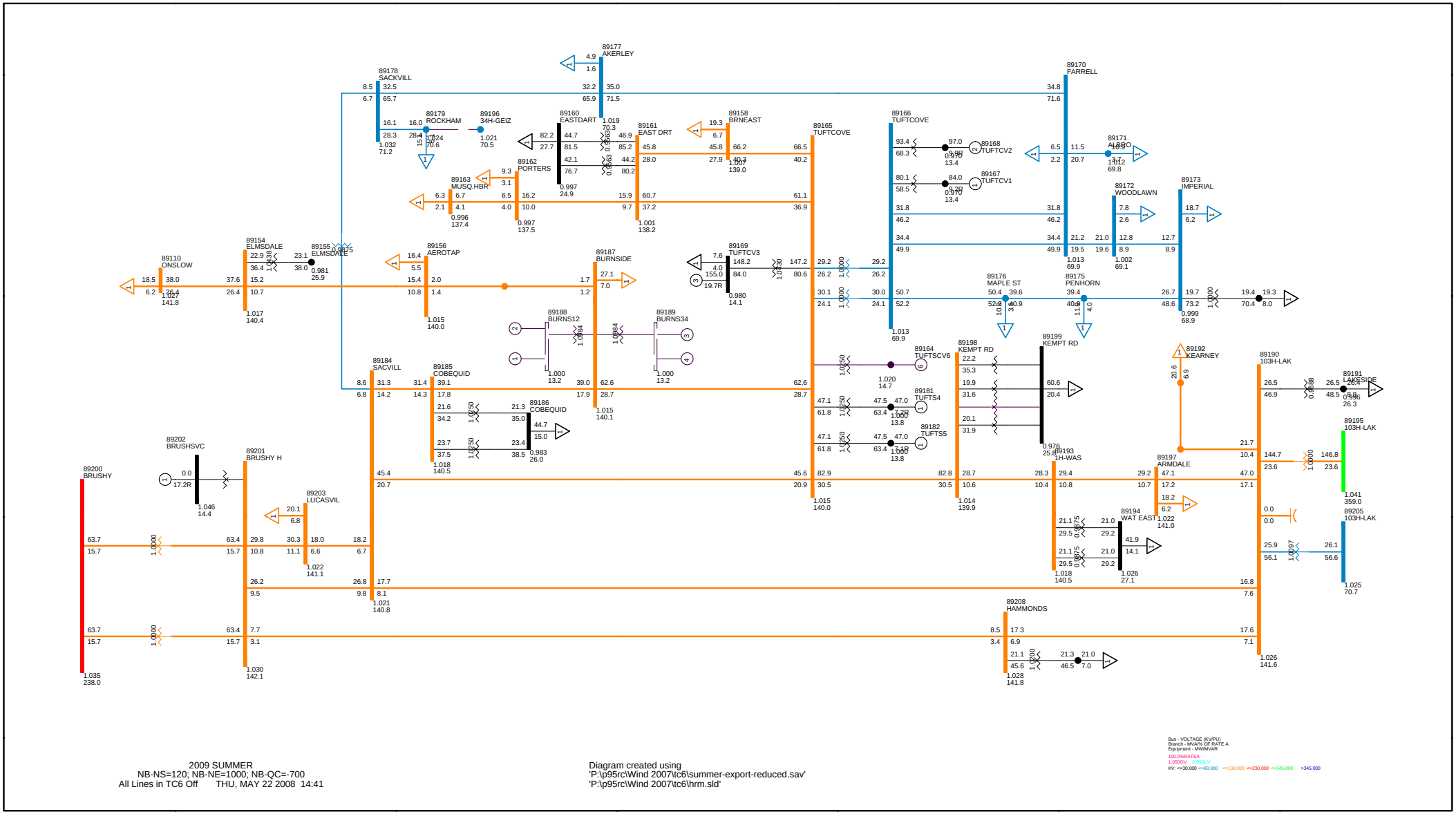

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Figure 2

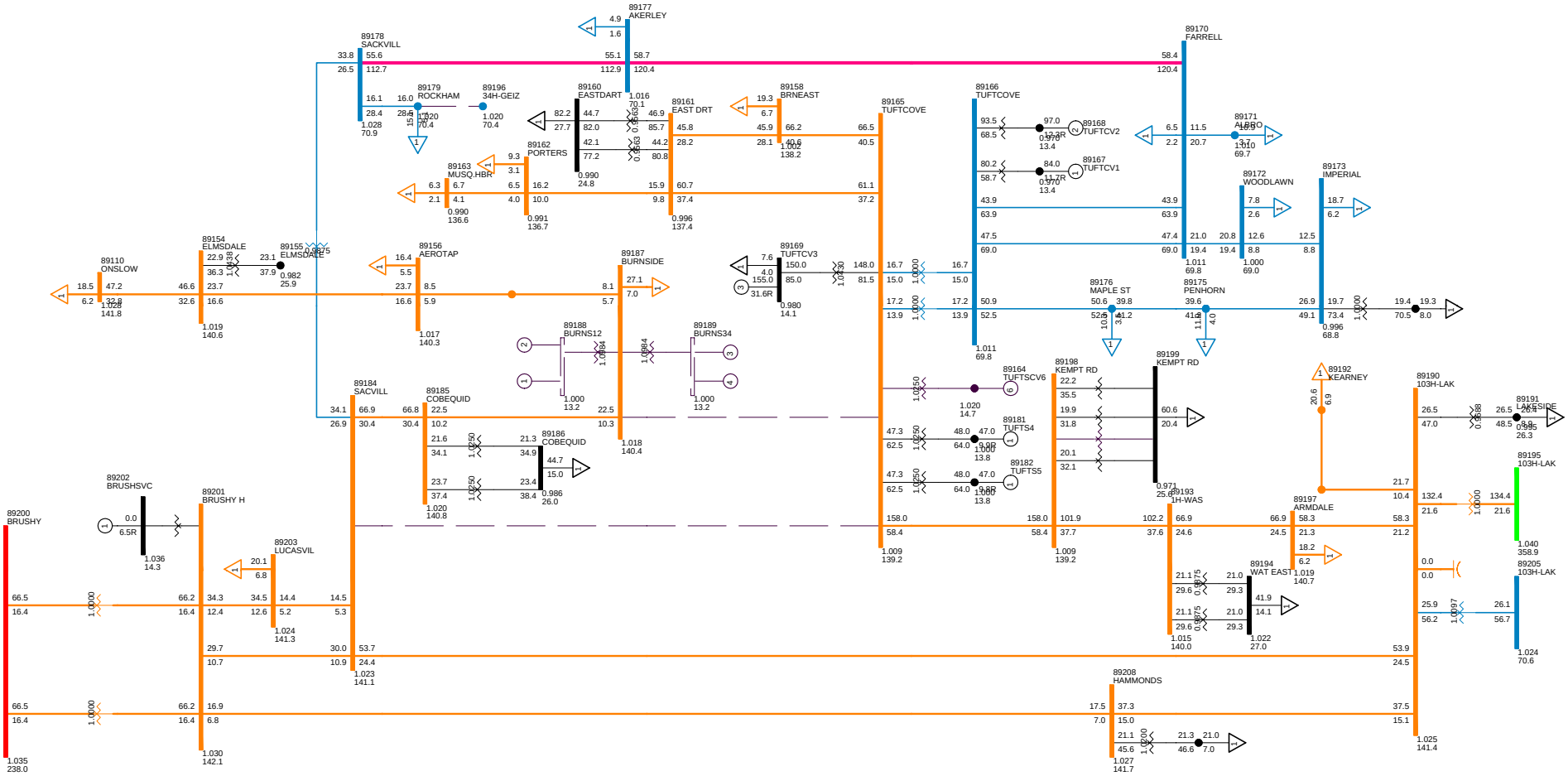

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Figure 3

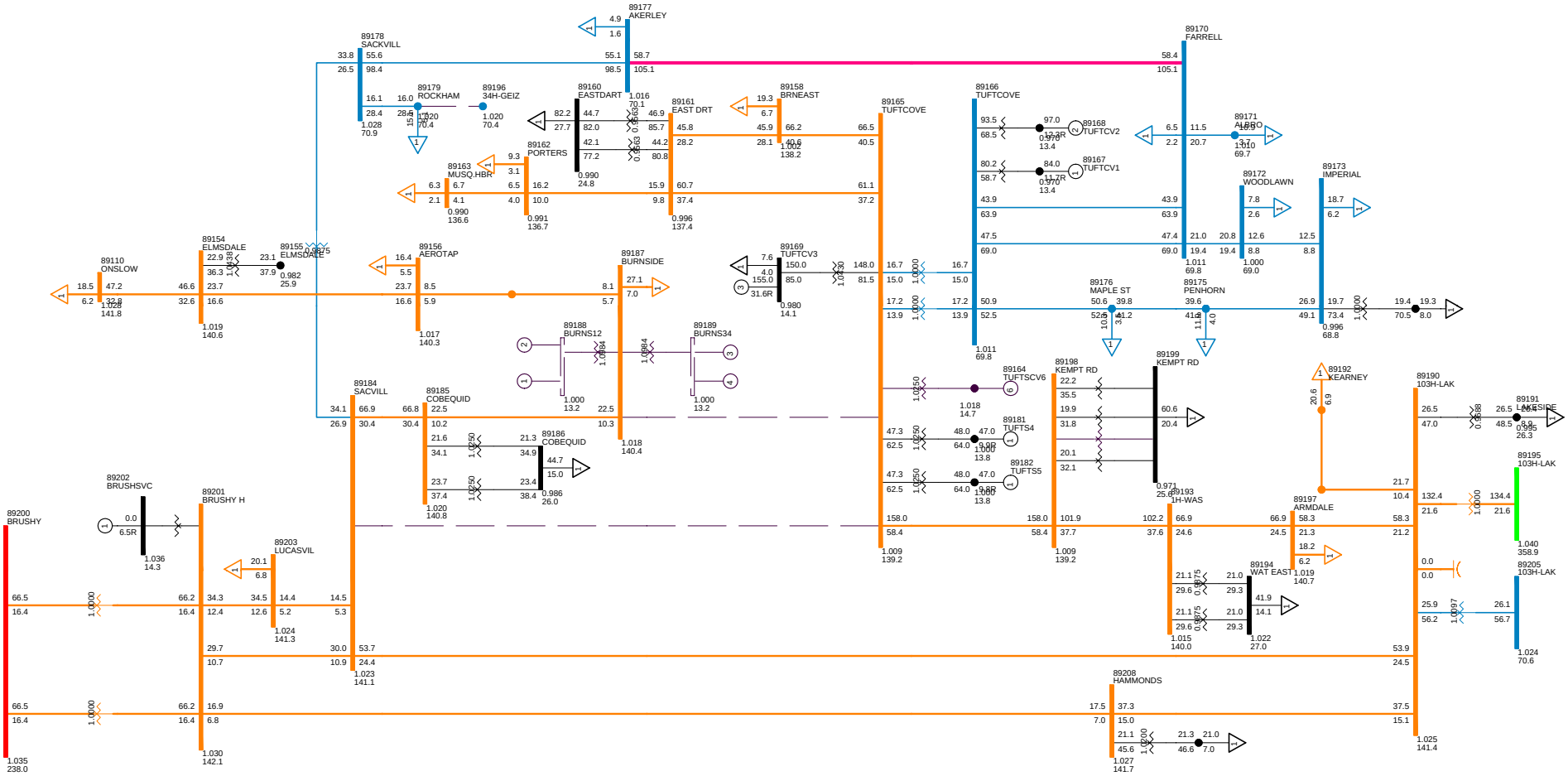

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Figure 4

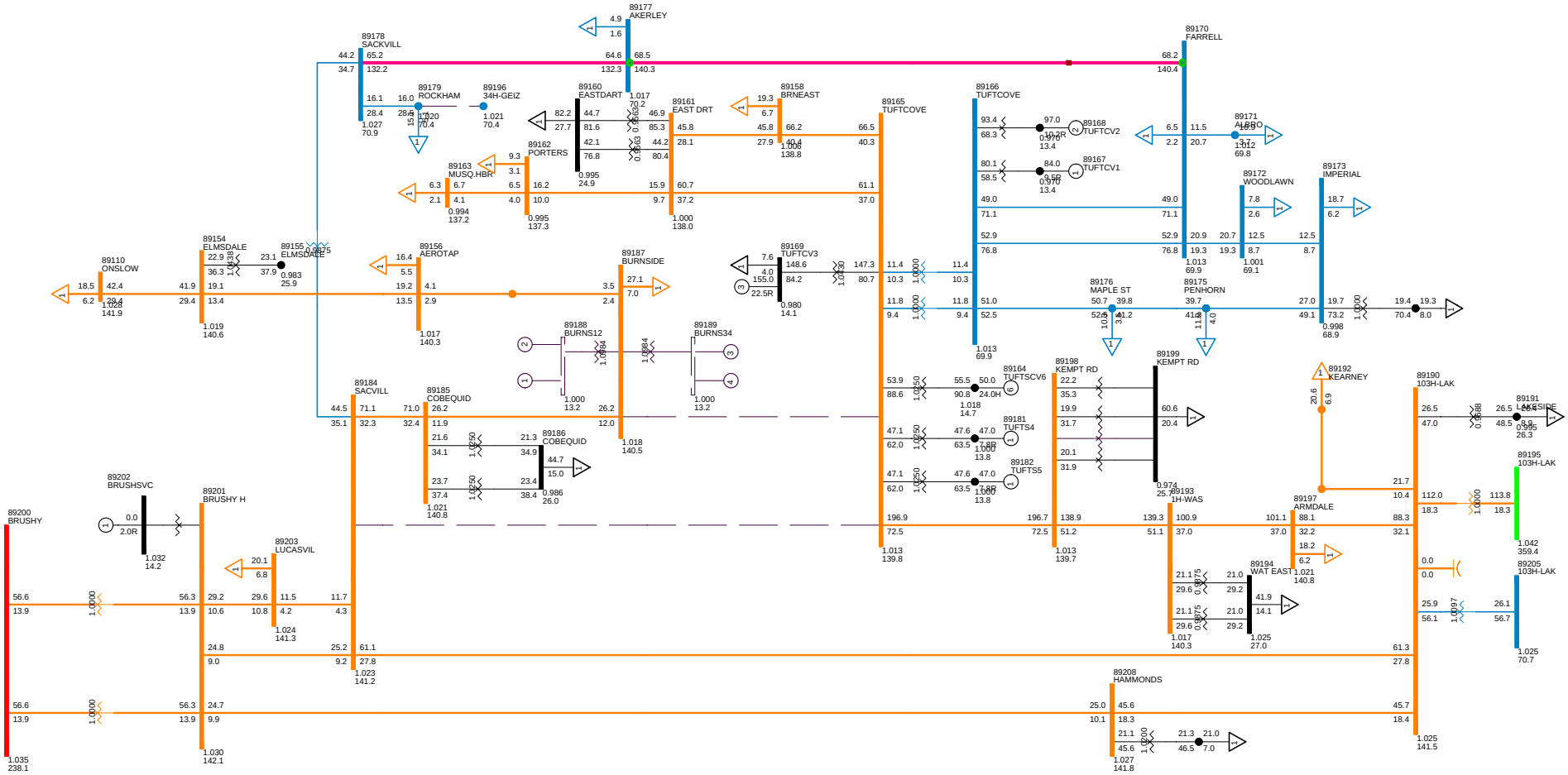

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Figure 5

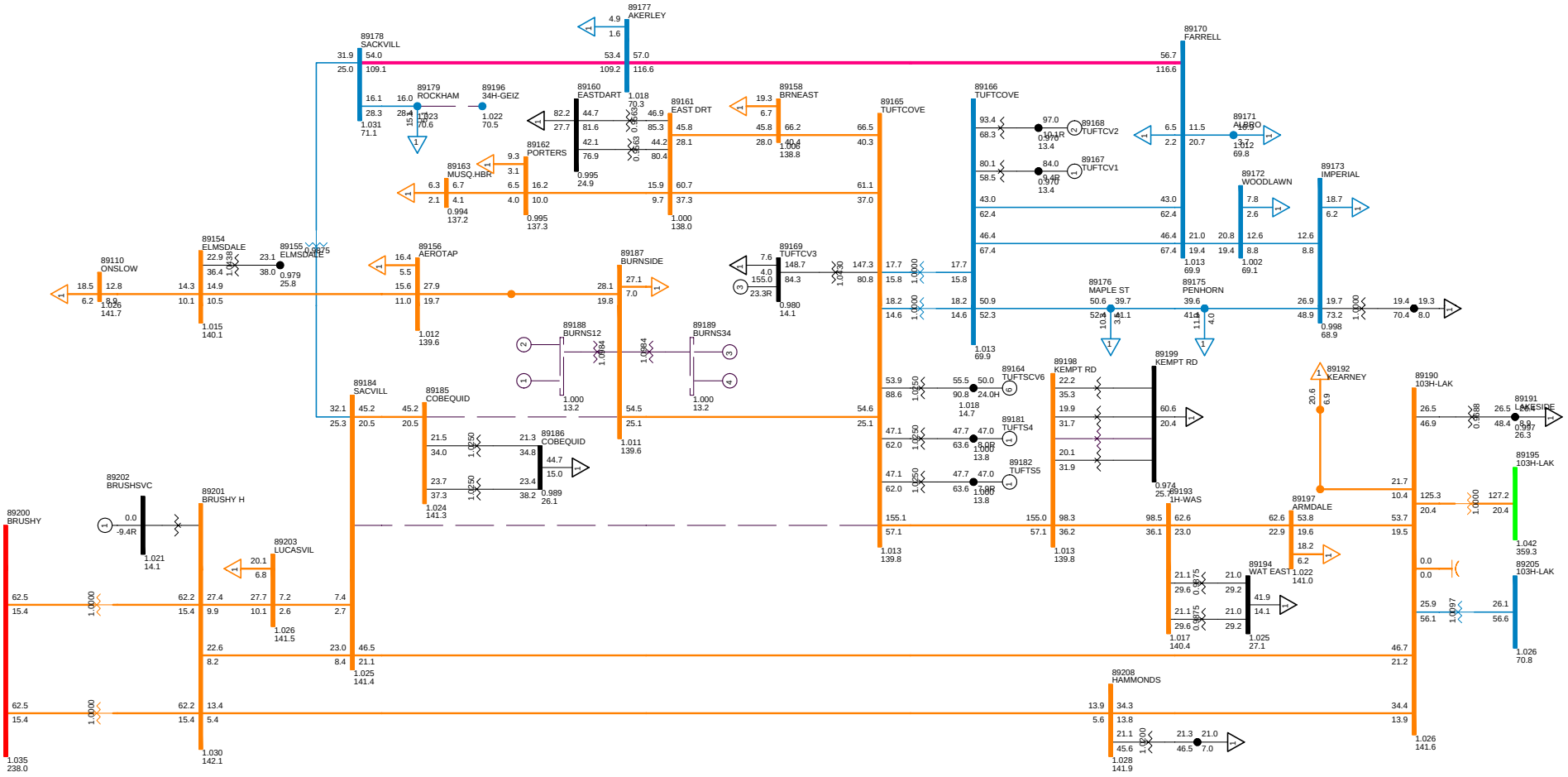

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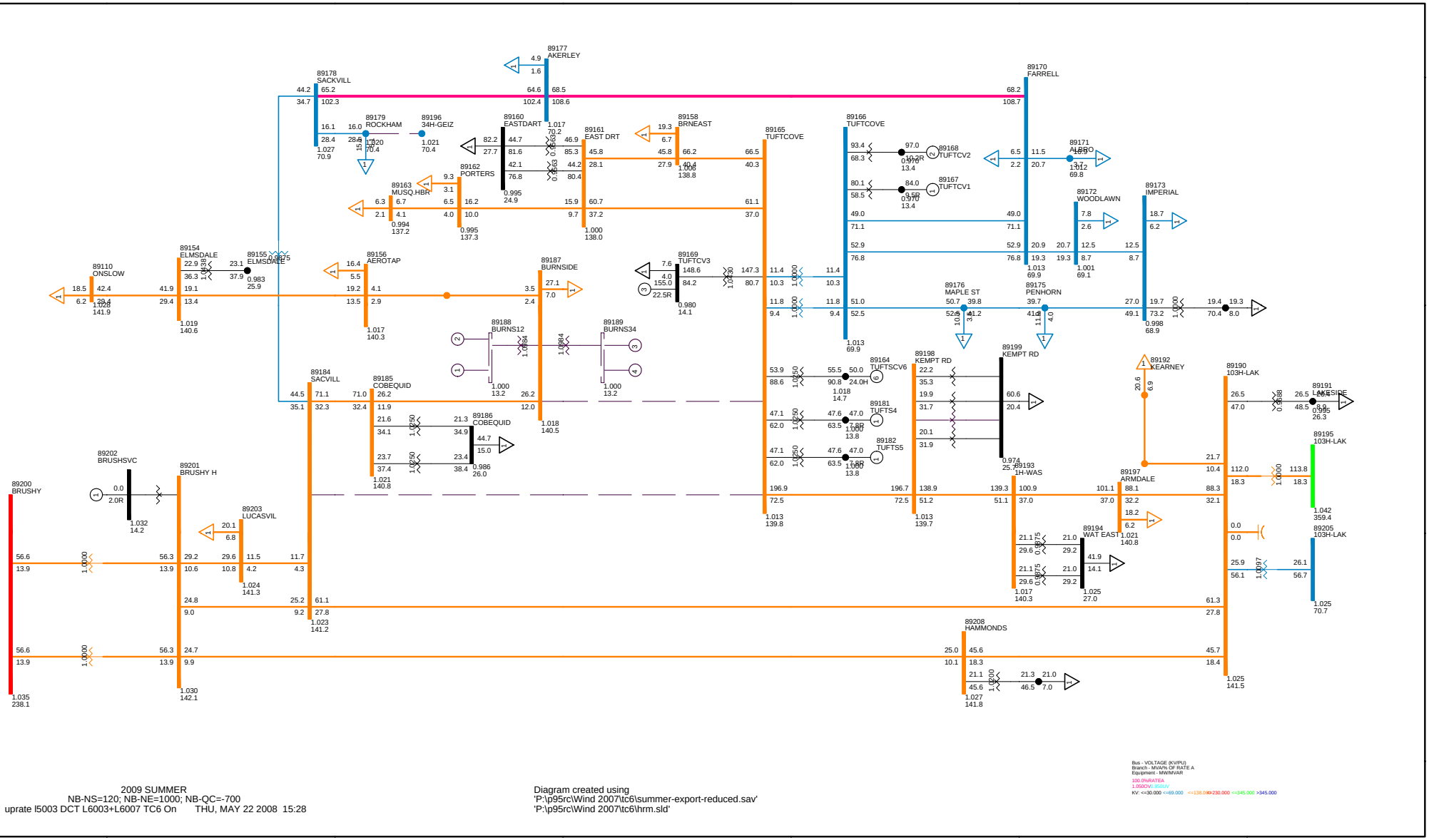
Figure 6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89168 TUFTCV2
89167 TUFTCV1
89170 FARRELL
89171 ALBRO
89172 WOODLAWN
89173 IMPERIAL
89162 PORTERS
89163 MUSQ.HBR
89110 ONSLOW
89154 ELMSDALE
89155 ELMSDALE
89156 AEROTAP
89187 BURNSIDE
89169 TUFTCV3
89176 MAPLE ST
89175 PENHORN
89188 BURNS12
89189 BURNS34
89184 SACVILL
89185 COBEQUID
89186 COBEQUID
89164 TUFTSCV6
89181 TUFTS4
89182 TUFTS5
89198 KEMPT RD
89199 KEMPT RD
89192 KEARNEY
89190 103H-LAK
89191 LAKESIDE
89195 103H-LAK
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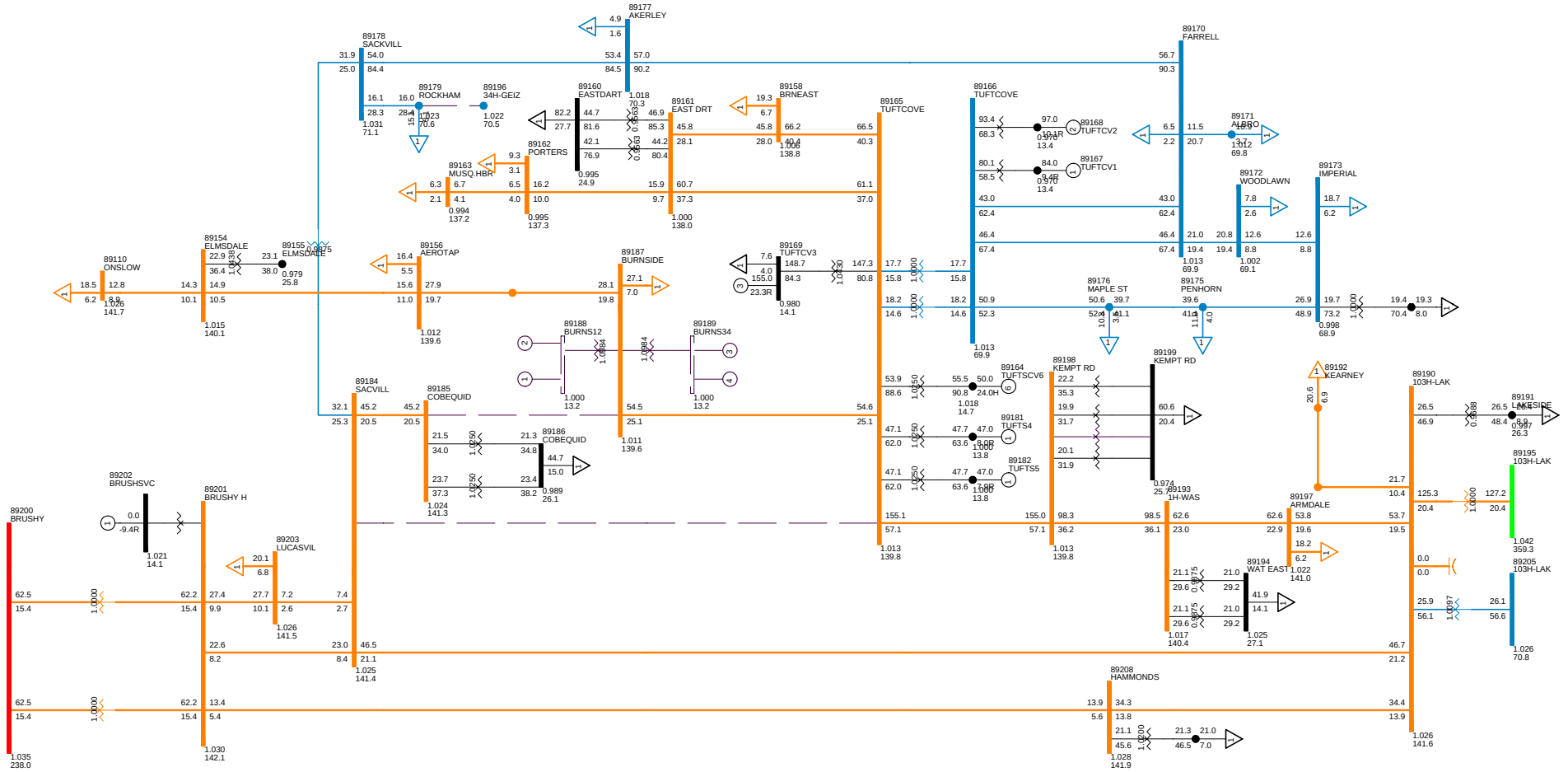
Figure 7



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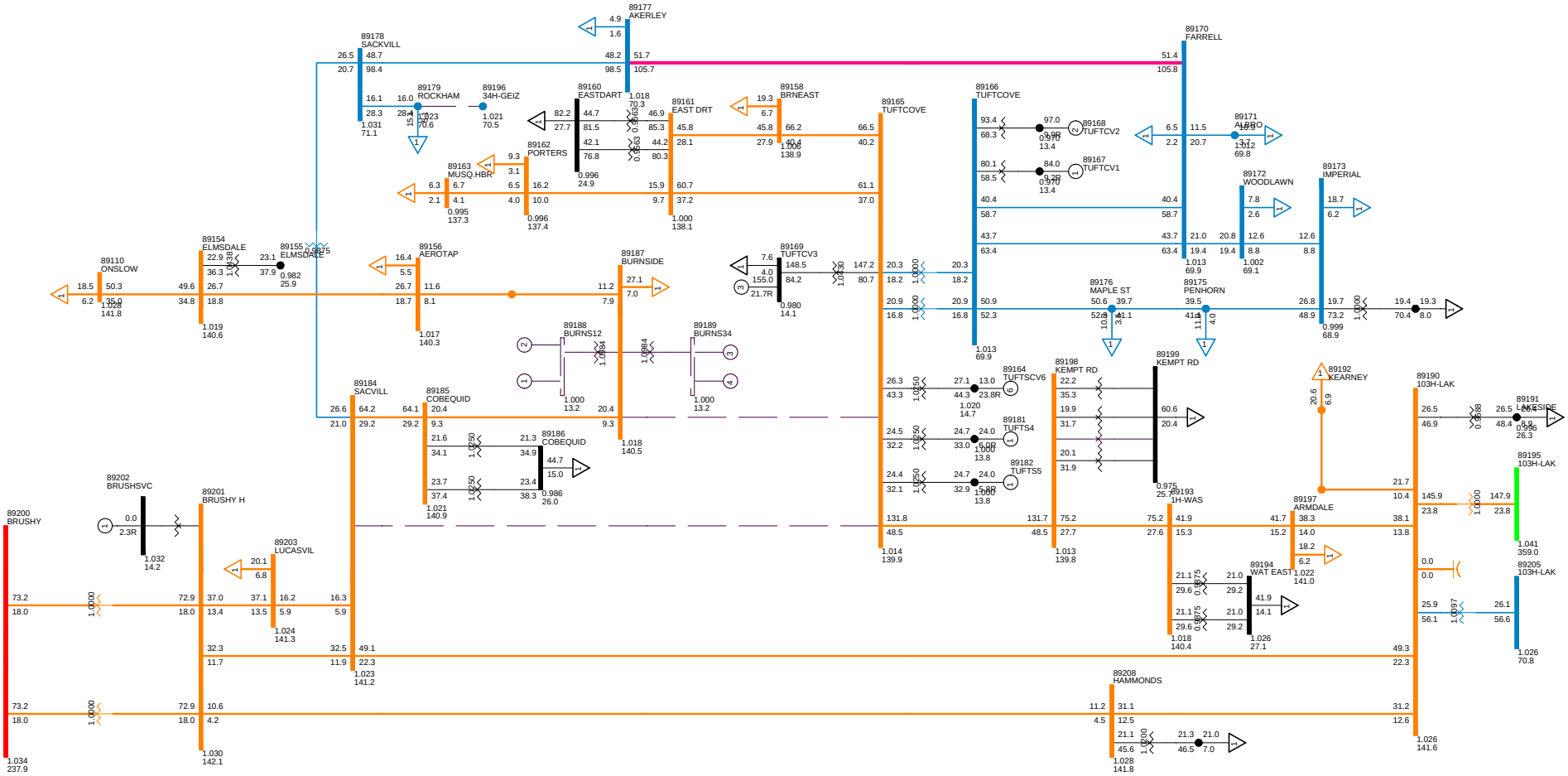
'P:\p95rc\Wind 2007\tc6\hrm.sld'

Figure 8



2009 SUMMER
NB-NS=120; NB-NE=1000; NB-QC=-700
DCT fault, SPS runback TC 4,5,6 THU, MAY 22 2008 16:00

Diagram created using
'P:\p95rc\Wind 2007\tc6\summer-export-reduced.sav'
'P:\p95rc\Wind 2007\tc6\hrm.sld'