Q. It is understood that the 200ms shutdown time for a three phase or single phase short circuit in the ac network near Soldiers Pond and near Muskrat Falls is based on the use of a dual protection system. Please explain what would happen if the breaker does not open, e.g. due to a breaker failure and the consequence on the power supply to the Island Interconnected System including whether load shedding will be required and if so, what magnitude of load shedding would be required.

A. Table 1 provides the fault clearing times for the 230 kV and 315 kV stations and Soldiers Pond and Muskrat Falls respectively.

Table 1: Fault Clearing Times - MFA and SOP 315/230 kV ac Systems

Circuit	Nature of Fault	Time (cycles)
Overhead Line and Feeder Protection	Fault close to one end of the line. Clearance at the end nearest to the fault.	5
Overhead Line and Feeder Protection	Fault in the transformer zone or close to one end of a line with clearance of the end remote from fault using protection signaling.	5.5
Transformer HV Side	All faults, maximum	5
General - Backup	Clearance, from the remote end of the line, of a fault with a protection signaling failure (zone 2).	24
All Zones	Breaker failure trip and faults between the circuit breaker and the associated CT: • Local • Remote	 12-18 13-19

In the event of a breaker failure, a breaker adjacent to the failed unit will trip in 200 to 300ms.

Tables 2 and 3 outline the equipment forced out of service at the Muskrat Falls and Soldiers Pond switchyards, respectively, for a three phase fault with stuck breaker protection operated to clear the fault. Please refer to attached single line diagrams (PUB-NLH-241 Attachments 1 and 2) for clarification.

Table 2: Muskrat Falls ac Switchyard - Local Breaker Fail Protection

Case	Faulted Bus	Failed Breaker	Forced Equipment Outages	
1	B12 or B32	B12B32	G1	P1
	B32 or B22	B22B32	G2	P1
2	B11 or B31	B11B31	G3	F1
	B21 or B31	B21B31	G4	F1
3	B24 or B34	B24B34	T5	F2
4	B14 or B34	B14B34	T5	L3101
5	B34	B41T5	T5	L1301
6	B23 or B33	B23B33	P2	L3102
7	B13	B41T6	T6	L1301
8	B13 or B33	B13B33	T6	L3102

Table 3: Soldiers Pond ac Switchyard - Local Breaker Fail Protection

Case	Faulted Bus	Failed Breaker	Forced Equipment Outages	
1	B24 or B34	B24B34	TL201	P1
2	B15 or B35	B15B35	TL217	F1
3	B11 or B21	B11B21	TL242	SC1
4	B14 or B34	B14L34	TL265	P1
5	B12 or B32	B12B32	TL266	SC2
	B22 or B32	B22B32	TL266	SC3
6	B23 or B33	B23B33	TL268	F2
7	B13 or B33	B13B33	TL268	P2

For the purposes of this analysis, the following circuit breaker fail scenarios were dynamically simulated in PSS®E version 32 for winter peak, intermediate, light and extreme light load cases:

1. 3Φ Fault MFA B23 – Trip HVdc Converter Pole and L3102 in 200ms;
2. 3Φ Fault MFA B12 – Trip HVdc Converter Pole and G2 in 200ms;
3. 3Φ Fault MFA B31 - Trip 72 MVAR filter bank and G3 or G4 in 200ms;
4. 3Φ Fault SOP B35 – Trip 75 MVAR filter bank and TL217 (WAV-SOP) in 200ms;
5. 3Φ Fault SOP B14 – HVdc Converter Pole and TL265 (HRD to SOP) in 200ms;
6. 3Φ Fault SOP B24 – HVdc Converter Pole and TL201 (WAV to SOP) in 200ms;
7. 3Φ Fault SOP B23 – Trip 75 MVAR filter bank and TL268 (HRD-SOP) in 200ms;
8. 3Φ Fault SOP B12 – Trip SC2 and TL266 (HWD-SOP) in 200ms; and
9. 3Φ Fault SOP B11 – Trip SC1 and TL242 (HWD-SOP) in 200ms.

The dynamic analysis has indicated the worst-case stuck/failed breaker scenario is a fault on Muskrat Falls bus B23 or B33 with a stuck circuit breaker resulting in the trip of both an HVdc pole and a 315 kVac transmission line (i.e., L3102) between Churchill Falls and Muskrat Falls during winter peak operation. This is case 6 in Table 2 "*Muskrat Falls ac Switchyard - Local Breaker Fail Protection"* above. In this case the converter station at Muskrat Falls will experience multiple commutation failures and does not recover. For this scenario, the HVdc protection would trip both poles of the Labrador Island Link resulting in a total loss of supply from Labrador. This case can be considered a permanent bipole failure, and as such, is expected to result in scheduled load shedding on the Island Interconnected System. The detailed load shedding schedule is to be developed during the operational studies in the 2015/2016 timeframe following the detailed design phase of the integrated transmission system with the HVdc vendors and completion of the detailed PSS®E and PSCAD™ models.

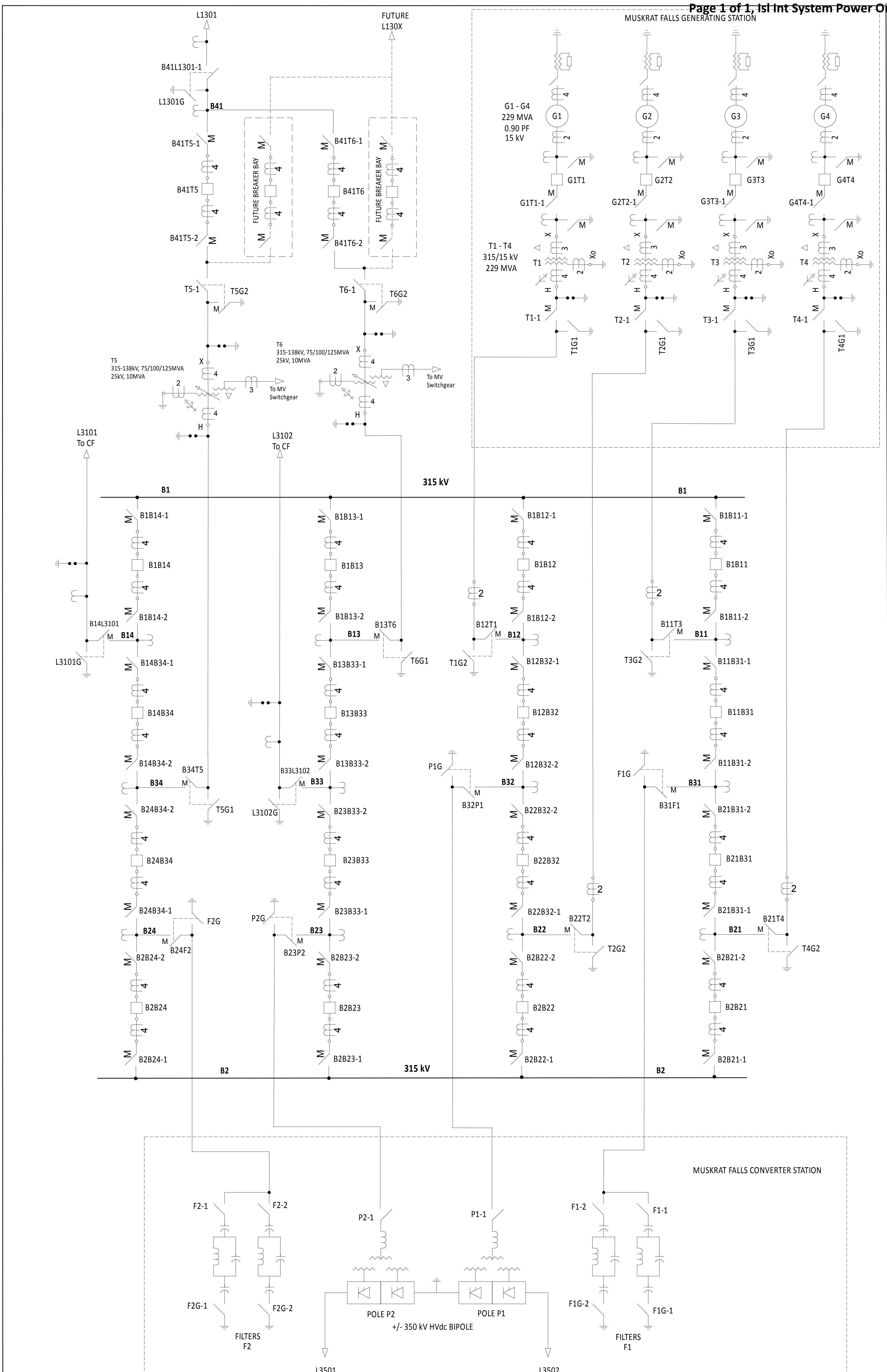
While the Island Interconnected System is not NERC compliant at this point in time, it is prudent to compare the results of the analysis of the failed breaker scenario above with the applicable NERC Reliability Standards for Bulk Electric Systems in North America. Referencing standard *TPL-001-0.1, Table 1 – Transmission System Standards – Normal and Emergency Conditions*, categories C and D define the system limits or impacts for:

- Category C - Event(s) resulting in the loss of two or more (multiple) elements; and
- Category D - Extreme event resulting in two or more (multiple) elements removed or cascading out of service.

A single line to ground fault with delayed clearing due to a stuck breaker falls under NERC contingency category C for a generator, transformer, transmission circuit and/or bus section. In this case, the power system must remain stable with both thermal and voltage limits within applicable ratings and the loss of demand or curtailed firm transfers must be planned and controlled.

A three-phase fault with delayed clearing due to a stuck breaker falls under NERC contingency category D for a generator, transformer, transmission circuit and/or bus section. In this case, the contingency should be evaluated for risks and consequences as it may "*involve substantial loss of customer demand and generation in a widespread area or areas. Portions or all of the interconnected systems may or may not achieve a new, stable operating point. Evaluation of these events may require joint studies with neighboring systems.*"

It appears that the impacts observed during the analysis of a stuck/failed circuit breaker associated with the Labrador – Island HVdc Link is consistent with the expectations of the NERC standards.



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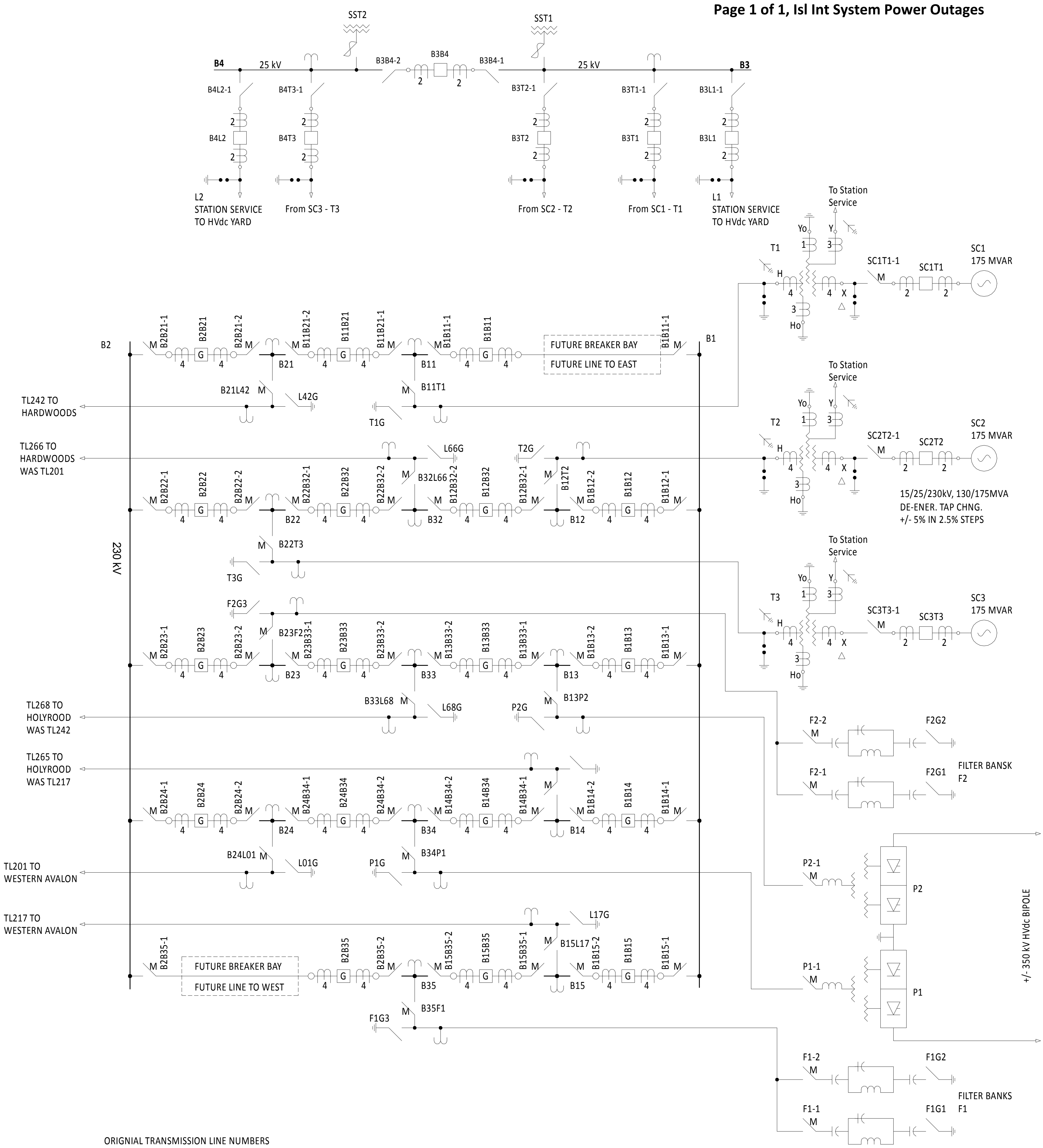
MUSKRAT FALLS AC SWITCHYARD
315 kV SINGLE LINE DIAGRAM

SYS PLAN: PWT	SHEET 1 OF 1
SYS OP: RB / JT	DATE: Apr. 23, 2012
ELEC:	DRAWN BY: JPF
P&C:	REVISION: 4
FILE: muskrat falls ac yard_Apr23_Rev4.SKF	



ORIGNIAL TRANSMISSION LINE NUMBERS
TL201 (H-FRAME WOOD) WESTERN AVALON TO HARDWOODS
TL217 (GUYED V STEEL) WESTERN AVALON TO HOLYROOD
TL218 (H-FRAME WOOD) HOLYROOD TO OXEN POND
TL236 (SELF SUPPORT STEEL) HARDWOODS TO OXEN POND
TL242 (GUYED V STEEL) HOLYROOD TO HARDWOODS

NEW TRANSMISSION LINE NUMBERS
TL201 (H-FRAME WOOD) WESTERN AVALON TO SOLDIERS POND
TL217 (GUYED V STEEL) WESTERN AVALON TO SOLDIERS POND
TL218 (H-FRAME WOOD) HOLYROOD TO OXEN POND - DOES NOT ENTER/EXIT SOLDIERS POND
TL236 (SELF SUPPORT STEEL) HARDWOODS TO OXEN POND
TL242 (GUYED V STEEL) SOLDIERS POND TO HARDWOODS
TL265 (GUYED V STEEL) SOLDIERS POND TO HOLYROOD - WAS PART OF TL217
TL266 (H-FRAME WOOD) SOLDIERS POND TO HARDWOODS - WAS PART OF TL201
TL268 (GUYED V STEEL) SOLDIERS POND TO HOLYROOD - WAS PART OF TL242

TL267 (STEEL) BAY d'ESPOIR TO WESTERN AVALON
TL269 (HYBRID) GRANITE CANAL TAP TO BOTTOM BROOK
TL270 (HYBRID) GRANITE CANAL TO GRANITE CANAL TAP

SYNCHONOUS CONDENSER TRANSFORMERS T1, T2, T3
15/25/230 kV
LV1 - 15 kV, DELTA, 175 MVA
LV2 - 25 kV, WYE-GND, 15/20/25 MVA
HV - 230 kV, WYE-GND, 120/150/200 MVA
SIMULTANEOUS LOADING OF ALL WINDINGS
DE-ENERGIZED TAP CHANGER OF HV WINDING
+/- 5% IN2.5% STEPS

HVdc STATION EQUIPMENT NUMBERS TO BE REFINED BY HYDRO SYSTEM OPERATIONS AND PLANNING IN FINAL DESIGN WITH MANUFACTURER

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SOLDIERS POND TERMINAL STATION
230 kV SINGLE LINE DIAGRAM

SYS PLANNING:	SHEET 1 OF 1
SYS OPERATIONS:	DATE: APRIL 8, 2013 Rev. 3
TERM DESIGN:	DRAWN BY: PWT
PROTECTION:	FILE: soldiers pond 230 kv ac_apr 8 2013.SKF