Q. **(Reference Application Schedule B, St. John's Teleprotection System Replacement, page 76 of 99)**

a) Has the system operator (NLSO) verified that this project is needed? Please provide a copy of all communications between NLSO and Newfoundland Power concerning whether this project is needed.
b) Has the NLSO verified that it can operate the power system in a reliable manner once the proposed system is in place, and that the proposed system is the least cost solution?
c) What entity in the Province is responsible for reliability of the bulk power system?

A. a) The Newfoundland and Labrador System Operator ("NLSO"), through Newfoundland and Labrador Hydro's ("Hydro's") transmission planning department, determines the transmission system critical clearing time requirements to meet the bulk power system planning criteria. The critical clearing time requirements are set out in Attachment A of this response.[1]

Newfoundland Power is required to meet the critical clearing time requirements, as set out by the NLSO, and is responsible for determining which projects are needed in order to meet these requirements.

In Attachment A, the report author, TransGrid Solutions, states "*The replacement teleprotection system will allow Newfoundland Power to continue to meet the critical clearing times into the future.*"[2]

b) It is Newfoundland Power's obligation to provide reliable electrical service to customers at the lowest possible cost. Newfoundland Power can confirm that the *St. John's Teleprotection System Replacement* project proposed in the *2022 Capital Budget Application* will be able to meet the critical clearing time requirements and that it is the least cost solution to maintain the required critical clearing times for its 66 kV transmission systems in the St. John's area.

c) The NLSO is responsible for reliability of the bulk power system in the province operating at a voltage of 230 kV or higher.

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[1] Hydro filed this study with the Board as part of the *Reliability and Resource Adequacy Study* proceeding on March 31, 2021.
[2] See Attachment A, page 9 of 14, to this response to Request for Information.

TransGrid Solutions
Technical Note TN1205.81.06

Engineering Support Services for:

RFI Studies

Newfoundland and Labrador Hydro

Attention: Mr. Rob Collett

Critical Clearing Time Study (138 kV / 66 kV Systems)

Technical Note: TN1205.81.06
Date of issue: March 20, 2021

Prepared By:
TransGrid Solutions Inc.
100-78 Innovation Dr.
Winnipeg, MB R3T 6C2
CANADA

Disclaimer

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Revisions

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01	DFC	R. Ostash / R. Brandt		November 16, 2020	Draft report updated with results for CCT for SLGFs
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03	IFA	R. Ostash / R. Brandt		February 18, 2021	Report updated based on comments received Feb 18.
04	IFA	R. Ostash / R. Brandt		February 19, 2021	Report updated based on comments received Feb 19.
05	IFA	R. Ostash / R. Brandt		March 17, 2021	Report updated to include NL Hydro's 66 kV and 138 kV buses.
06	ABC	R. Ostash / R. Brandt		March 20, 2021	Report finalized based on comments from Executive review.

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Approved by Client	ABC	Issued for Approval	IFA
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Table of Contents

1. Summary

The purpose of this study is to identify the critical clearing times (“CCT”) on all 138 kV and 66 kV buses within the Island Interconnected System (“IIS”). Critical clearing times are the longest duration a fault can be present at a certain location before Transmission Planning Criteria on the bulk IIS is violated.

This technical note provides:

- A table of CCT results for each bus (Table 3-1 in Section 3)
- The criteria applicable to the bulk IIS that was used to determine the CCT (Section 2.2)
- The study procedure used to determine the CCTs (Section 2.3)
- The PSSE base cases used to perform the study (Section 2.1).

2. Study Methodology

2.1 Base Cases

The 230 kV network of the IIS is shown in Figure 2–1.

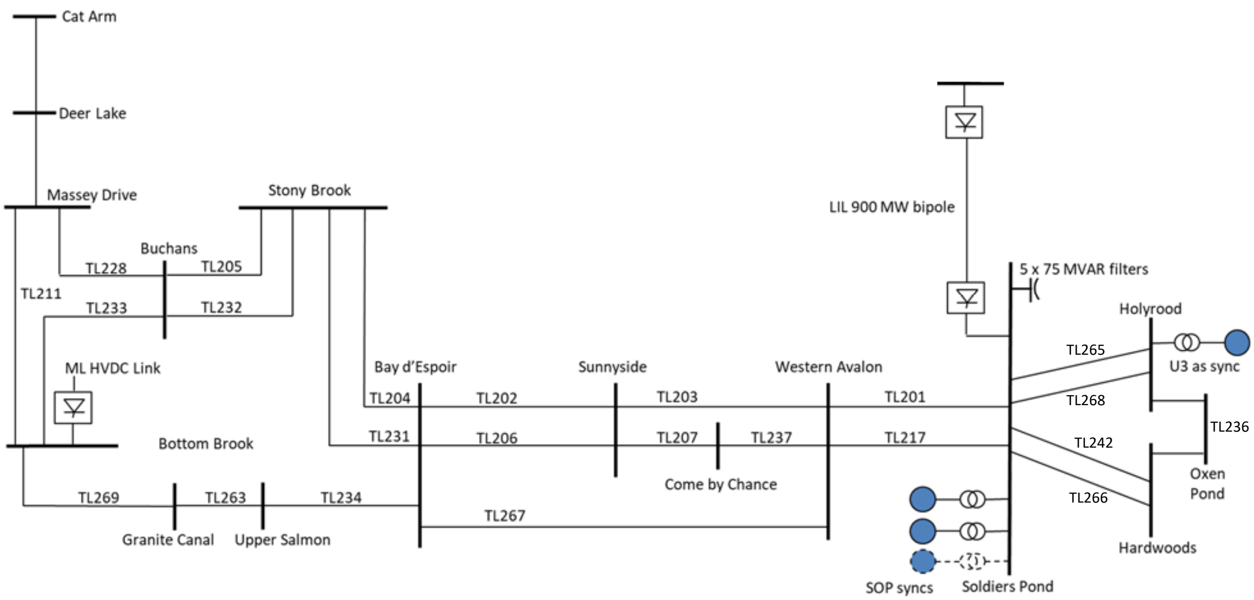

Figure 2–1. Interconnected Island System 230 kV grid

Three base cases were used to perform this study: Light, Intermediate and Peak demand scenarios as summarized in Table 2-1. A variety of LIL and ML transfers were considered.

Table 2-1. Base cases

Load Condition	Island Demand (MW)[1]	Island Generation (MW)	LIL Power Transfer (at MFA) (MW)	ML Power Transfer (at BBK) (MW)
Peak	1802	993	870	0
Intermediate	1391	536	560	-320
Light	811	478	900	500

2.2 Study Assumptions

The following assumptions are made for this study:

- Thermal generation from HRD units (1,2,3) is decommissioned. HRD unit 3 is operating as a synchronous condenser.
- Two Soldiers Pond synchronous condensers are in-service.

[1] Island Demand includes load and losses.

- LIL frequency controller is in-service.
- ML frequency controller is in-service.
- A new Newfoundland Power substation near the airport was not included in the cases in this study. AIR station is proposed to be installed between OPD (195654) and KEN (196565) stations, tapping off of 35L. Analysis for the CCT of this station can be performed at the time of approval. The analysis provided in this report for the OPD and KEN stations can provide a good indication of the expected CCT at the AIR station.
- The study was performed with the power system stabilizers (PSSes) in the system enabled. Sensitivity analysis was performed without the PSSes on select CCTs, and the impact of the PSSes on these CCTs was observed to be minimal.

2.3 Study Criteria

The following Transmission Planning Criteria are applicable to this study and are monitored for the bulk transmission system (230 kV).

- Post fault recovery voltages on the ac system shall be as follows:
  - Transient undervoltages following fault clearing should not drop below 70%
  - The duration of the voltage below 80% following fault clearing should not exceed 20 cycles
- Post fault system frequencies shall not drop below 58 Hz and shall not rise above 62 Hz
- Voltage variations should remain within the criteria defined in Table 2-2.

Table 2-2. Power Frequency Voltage Variations During Transient Conditions

Power Frequency Voltage Variations During Transient Conditions – Island of Newfoundland	
Voltage (pu)	**Duration**
V = 0.00	0.15 seconds
0. 0 ≤ V < 0.80	1 second
0.85 ≤ V < 0.90	300 seconds
0.90 ≤ V < 1.10	Steady State
1.10 ≤ V < 1.20	3 seconds
1.10 ≤ V < 1.30	0.5 seconds
1.30 ≤ V < 1.50	0.1 seconds

2.4 Study Procedure

Typically, the critical clearing time (CCT) is defined as the longest fault clearing time for a particular contingency in order to maintain transient stability of the system (i.e. stable recovery from fault). However, limits for reliable operation as specified in the system performance criteria defined in Section

2.3 force the CCT to be more stringent. In this study, the CCT values were determined in order to ensure Transmission Planning Criteria is met on the 230 kV bulk system.

Typically, the CCT would be defined for a particular contingency, for example a 66 kV line fault. However, this study is looking at the impact on the 230 kV bulk system from faults on the 66 kV or 138 kV network, and it was found that whether the fault is a 138 kV or 66 kV bus fault or whether is it a 138 kV or 66 kV line fault, the fault had the same impact on the bulk system (i.e. whether the 66 kV line was tripped to clear the fault, or whether the fault was applied to a bus and cleared without tripping a line had the same impact on the bulk system). Therefore, the CCT was calculated by applying a fault on each of the 66 kV and 138 kV buses, and not on specific lines.

A custom python script was created to run faults at each 66 kV and 138 kV bus for increasing fault durations. The IIS bulk system buses were monitored during the simulations to check each of the criteria listed in Section 2.3. Once the first criteria violation was flagged, the CCT was determined.

Typically, the weakest system conditions are most determining for CCTs. Therefore, the light load case was first used as the basis for determining the CCT at each 138 kV and 66 kV bus. Once the CCT was determined for the light load case, the faults with those CCT durations were simulated in the intermediate and peak load cases to ensure Transmission Planning Criteria was met. If criteria violations were found using the intermediate or peak load cases for those CCT durations, a more limiting CCT duration was determined to meet criteria for all IIS demand scenarios studied.

3. Study Results

The CCT for three-phase faults ("3PF") and single-line-to-ground faults ("SLGF") for each 66 kV and 138 kV bus is listed in Table 3-1, along with the criteria that determined the CCT. If the fault were to be sustained longer than the CCT duration listed, the criteria stated in the 'Limiting Factor' column was violated.

There were three main criteria violations that came up in the study:

1) **Voltage < 0.8 pu for 1 sec**
   The fault on the 66 kV or 138 kV bus caused the voltage at a IIS bulk system bus(es) to be less than 0.8 pu > 1 second.

2) **Frequency < 59 Hz**
   If the location of the 66 kV or 138 kV bus is close enough to the SOP (LIL inverter) bus, it causes the LIL to experience commutation failures during the fault, which reduces LIL infeed and causes the IIS frequency to drop. If the fault is too long, the IIS frequency can drop below 59 Hz and cause underfrequency load shedding (UFLS).

3) **Oscillations**
   In a few 66 kV or 138 kV bus locations an excessively long duration fault resulted in poorly damped oscillations in the IIS bulk system after the fault was cleared.

The 66 kV and 138 kV locations that did not result in violations were tested up to a maximum fault duration of 5 seconds.

It is noted that the CCTs at OPD/HWD and in the nearby 66 kV area are limited by the "Frequency < 59 Hz" criteria explained above. In this area, the CCTs become shorter in duration as the fault location moves further down the 66 kV network even though the 66 kV buses are becoming further away electrically from SOP (the LIL inverter bus). For example, from Table 3-1, PUL (CCT = 0.31s) is electrically further away from SOP than VIR (CCT = 0.43s), but has a shorter CCT. This is because the faults that are farther away from the SOP bus result in less of a voltage drop at SOP (LIL inverter) during the fault. However, the voltage drop at SOP is still enough to cause the LIL to fail commutation resulting in temporary loss/reduction of power infeed at SOP, which causes the IIS frequency to start dropping. In the case that has a higher SOP voltage during the fault (e.g. if the fault is at PUL) during the time when LIL power infeed feed is interrupted, the loads in the IIS draw more power during the fault than if the SOP voltage were lower (e.g. if the fault is at VIR), therefore the fault at PUL results in more of a frequency drop and therefore has a shorter CCT than a fault at VIR.

Newfoundland Power and Newfoundland and Labrador Hydro confirm that the critical clearing times established in this report are met. In all cases, the updated critical clearing times have increased slightly from where they were previously[2]. Therefore, the existing critical clearing times will not need to be modified as their operation will be slightly faster than the critical clearing times established in the report. Protection systems are reviewed on a regular basis and updates are applied as required.

[2] All buses supplying Hydro customers have a critical clearing time greater than 5 seconds.

Newfoundland Power has identified in its 2022 Capital Budget Application a 2-year project to replace the existing St. John's Teleprotection System used to provide telecommunications for its differential protection relays used to protect its 66 kV transmission network in St. John's and surrounding areas. The differential protection relays are key to meeting the critical clearing time specifications. The existing teleprotection system installed in 2002 has become obsolete with increasing failures, which have depleted the supply of spare parts. The replacement teleprotection system will allow Newfoundland Power to continue to meet the critical clearing times into the future.

Table 3-1. CCT at 138 kV and 66 kV Buses

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
BBK B2	195177	>5.0	-	>5.0	
BBK B3	195178	>5.0	-	>5.0	
BBK T2	195636	>5.0	-	>5.0	
BCV B1	195106	>5.0	-	>5.0	-
BCV NP	196562	0.32	frequency < 59.0 Hz	>5.0	
BCV R1	196362	>5.0	-	>5.0	-
BCX L20	195648	>5.0	-	>5.0	-
BDE B13	195645	>5.0	-	>5.0	-
BFS NP	195127	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
BHL B1	195100	>5.0	-	>5.0	-
BHL T1	195606	>5.0	-	>5.0	-
BIG NP	196575	0.32	frequency < 59.0 Hz	>5.0	
BLA L12	195154	>5.0	-	>5.0	
BLA NLH WHLD	195156	>5.0	-	>5.0	-
BLK NP	195165	0.4	frequency < 59.0 Hz	>5.0	
BLK NPT3	196546	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
BOY NP	196526	>5.0	-	>5.0	
BRB NP	195167	0.33	frequency < 59.0 Hz	>5.0	
BRB T2T3	196556	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
BUC B2	195639	>5.0	-	>5.0	
BVA NP	195146	>5.0	-	>5.0	
BWT L60	195118	>5.0	-	>5.0	-
CAB NP	196582	>5.0	-	>5.0	-
CAM L53	196516	>5.0	-	>5.0	
CAR NP	196552	>5.0	-	>5.0	
CAT NP	195145	>5.0	-	>5.0	
CAT NPT1	196539	>5.0	-	>5.0	

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
CHA NP	196561	0.38	frequency < 59.0 Hz	>5.0	
CHD B1	195608	>5.0	-	>5.0	-
CLK NP	196525	>5.0	-	>5.0	
CLV NP	195144	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
CLV NPT1	196533	>5.0	-	>5.0	
COB NP	195130	>5.0	-	>5.0	
COB NPT2	196524	>5.0	-	>5.0	
COL NP	195171	0.33	frequency < 59.0 Hz	>5.0	
CRV L20	195646	>5.0	-	>5.0	-
DHR B1B2	195610	>5.0	-	>5.0	-
DLK B1	195111	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
DLK B2	195600	0.26	Oscillations	>5.0	
DLK NP	196500	0.23	Oscillations	>5.0	
DLS B1	195637	>5.0	-	>5.0	
DLS L14	195179	>5.0	-	>5.0	
DPD L64	195640	>5.0	-	>5.0	
EHW L20	195647	>5.0	-	>5.0	-
FER NP	196583	>5.0	-	>5.0	-
FER WIND	196584	>5.0	-	>5.0	-
FHD L54	196527	>5.0	-	>5.0	
GAL NP	196504	>5.0	-	>5.0	
GAM NP	195133	>5.0	-	>5.0	
GAM NPT2	196528	>5.0	-	>5.0	
GAN NP	195132	>5.0	-	>5.0	
GAN NPT2	196523	>5.0	-	>5.0	
GAR NP	196545	>5.0	-	>5.0	
GBK L50	195182	>5.0	-	>5.0	
GBY NP	196507	>5.0	-	>5.0	
GDL NP	196563	0.38	frequency < 59.0 Hz	>5.0	
GFS NP	195126	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
GFS NPT1	196517	>5.0	-	>5.0	
GLB L29	195603	>5.0	-	>5.0	-
GLN NP	195129	>5.0	-	>5.0	
GLV NP	195135	>5.0	-	>5.0	

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
GOU NP	196564	0.37	frequency < 59.0 Hz	>5.0	
GPD NP	196531	>5.0	-	>5.0	
GRH NP	196544	>5.0	-	>5.0	
HAR NP	196503	>5.0	-	>5.0	
HBS NP	196529	>5.0	-	>5.0	
HBY B1	195612	>5.0	-	>5.0	-
HCP NP	196581	>5.0	-	>5.0	-
HCP TAP NP	196580	>5.0	-	>5.0	
HCT NP	196549	>5.0	-	>5.0	
HDN L51	196512	>5.0	-	>5.0	-
HGR NP	196554	>5.0	-	>5.0	
HLK L43	195113	>5.0	-	>5.0	
HLY B1	195112	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
HLY L51	196510	>5.0	-	>5.0	
HOL NP	195173	0.39	frequency < 59.0 Hz	>5.0	
HRD B6B7	195652	0.32	frequency < 59.0 Hz	>5.0	
HRD B8	195175	0.33	frequency < 59.0 Hz	0.33	frequency < 59.0 Hz
HRD OUTS	196587	0.32	frequency < 59.0 Hz	>5.0	
HWD B7B8	195655	0.33	frequency < 59.0 Hz	0.33	frequency < 59.0 Hz
ILC NP	196555	>5.0	-	>5.0	
IRV B1	195115	>5.0	-	>5.0	
ISL NP	196548	>5.0	-	>5.0	
JAM L52	196514	>5.0	-	>5.0	-
KBR NP	196570	0.42	frequency < 59.0 Hz	>5.0	
KEL NP	196560	0.32	frequency < 59.0 Hz	>5.0	
KEN NP	196565	0.43	frequency < 59.0 Hz	>5.0	
LAU NP	196541	>5.0	-	>5.0	
LET NP	196535	>5.0	-	>5.0	
LEW NP	195134	>5.0	-	>5.0	
LEW NP	196522	>5.0	-	>5.0	
LGL NP	196509	>5.0	-	>5.0	
LLK NP	195155	>5.0	-	>5.0	
LOK NP	196537	>5.0	-	>5.0	
MBK L57	195617	>5.0	-	>5.0	-

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
MDR B2B3	195624	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
MIL NP	196534	>5.0	-	>5.0	
MKS L12	195153	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
MMT NP	195622	0.21	Oscillations	>5.0	
MOB NP	196576	>5.0	-	>5.0	
MOL NP	196566	0.38	frequency < 59.0 Hz	>5.0	
MRP NP	196579	>5.0	-	>5.0	
MSY NP	195157	>5.0	-	>5.0	
MUN NP	196569	0.42	frequency < 59.0 Hz	0.99	Voltage < 0.8 pu for 1 sec
NCH NP	196550	>5.0	-	>5.0	
NDJ NP	196521	>5.0	-	>5.0	
NHR NP	196547	>5.0	-	>5.0	
NWB NP	195151	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
OPD B2B5	195654	0.33	frequency < 59.0 Hz	0.33	frequency < 59.0 Hz
OPL NP	196551	>5.0	-	>5.0	
PAB NP	196508	>5.0	-	>5.0	
PAS B1	195621	0.55	Oscillations	>5.0	
PBD NP	195141	>5.0	-	>5.0	
PBD TAP	195140	>5.0	-	>5.0	
PBN B1	195102	>5.0	-	>5.0	-
PBN B2	195611	>5.0	-	>5.0	-
PEP NP	196571	0.44	frequency < 59.0 Hz	>5.0	
PPD L27	195609	>5.0	-	>5.0	-
PPT B1	195104	>5.0	-	>5.0	-
PPT R1	196360	>5.0	-	>5.0	-
PPT R2	196361	>5.0	-	>5.0	-
PUL NP	196574	0.31	frequency < 59.0 Hz	>5.0	
PUN NP	196538	>5.0	-	>5.0	
RBK L53	196515	>5.0	-	>5.0	
RBK NP	196520	>5.0	-	>5.0	
RHR B1	195605	>5.0	-	>5.0	-
RHR TAP	195604	>5.0	-	>5.0	-
ROP NP	196578	>5.0	-	>5.0	

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
RRD NP	196572	0.43	frequency < 59.0 Hz	0.99	Voltage < 0.8 pu for 1 sec
RUS NP	196518	>5.0	-	>5.0	
RWC B1	195618	>5.0	-	>5.0	-
SBK NP	196519	>5.0	-	>5.0	
SCR NLH WHLD	195116	>5.0	-	>5.0	-
SCR NP	195117	>5.0	-	>5.0	
SCV L27	195607	>5.0	-	>5.0	-
SCV NP	196559	0.32	frequency < 59.0 Hz	>5.0	
SDP L61	195616	>5.0	-	>5.0	-
SJM NP	196568	0.39	frequency < 59.0 Hz	>5.0	
SLA NP	196567	0.34	frequency < 59.0 Hz	0.34	frequency < 59.0 Hz
SLK L80	195641	>5.0	-	>5.0	
SMV NP	196536	>5.0	-	>5.0	
SOK L22	195122	4.36	frequency < 59.0 Hz	>5.0	
SPF NP	195169	0.32	frequency < 59.0 Hz	>5.0	
SPL B1	195120	4.7	frequency < 59.0 Hz	>5.0	
SPL NLH WHLD	195121	>5.0	-	>5.0	-
SPO NP	195159	>5.0	-	>5.0	
SPT NP	196540	>5.0	-	>5.0	
SSD B2B3	195152	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
STA B1	195615	>5.0	-	>5.0	-
STA L58	195108	>5.0	-	>5.0	-
STB B3	195124	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
STG NP	196502	>5.0	-	>5.0	
STL WIND	196542	>5.0	-	>5.0	
STX NP	196501	>5.0	-	>5.0	
SUM NP	196585	>5.0	-	>5.0	-
SVL B2	195635	>5.0	-	>5.0	
TCV NP	196577	>5.0	-	>5.0	
TL252TAP	196511	>5.0	-	>5.0	
TL253TAP	196513	>5.0	-	>5.0	
TNS NP	195136	>5.0	-	>5.0	

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
TRN NP	196530	>5.0	-	>5.0	
TWG NP	196586	>5.0	-	>5.0	-
ULT NP	196558	0.34	frequency < 59.0 Hz	>5.0	
ULT TAP	196557	0.32	frequency < 59.0 Hz	>5.0	
VIC NP	196553	>5.0	-	>5.0	
VIR NP	196573	0.43	frequency < 59.0 Hz	>5.0	
WAV B2	195650	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
WAV B4	195163	0.48	frequency < 59.0 Hz	0.99	Voltage < 0.8 pu for 1 sec
WDL B1	195602	>5.0	-	>5.0	-
WDL TAP	195601	>5.0	-	>5.0	-
WEBCV_NP	196543	>5.0	-	>5.0	
WES NP	196532	>5.0	-	>5.0	
WHE NP	196506	>5.0	-	>5.0	
WHE TAP	196505	>5.0	-	>5.0	