APPENDIX B – CITY OF WINNIPEG – CLIFTON FLOOD PUMPING STATION AND WASTEWATER LIFT PUMPING STATION ARC FLASH STUDY – 1256 WOLSELEY AVENUE - MAY 2011

SNC·LAVALIN

City of Winnipeg

Clifton Flood Pumping Station and Lift Pumping Station Arc Flash Study

1256 Wolseley Avenue

PROVINCE OF MANITOBA
C. J. REIMER
Member
21968
REGISTERED PROFESSIONAL ENGINEER

2011/05/19
Rev 00

PREPARED BY :	D. Ramjeet
REVIEWED BY :	C. Reimer
APPROVED BY :	C. Reimer

May 2011
Revision 00

SNC • LAVALIN

NOTICE

This document contains the expression of the professional opinion of SNC-Lavalin Inc. (SLI) as to the matters set out herein, using its professional judgment and reasonable care. It is to be read in the context of the agreement between SLI and the City of Winnipeg, and the methodology, procedures and techniques used, SLI's assumptions, and the circumstances and constraints under which its mandate was performed. This document is written solely for the purpose stated in the agreement, and for the sole and exclusive benefit of the City of Winnipeg, whose remedies are limited to those set out in the agreement. This document is meant to be read as a whole, and sections or parts thereof should thus not be read or relied upon out of context.

SLI disclaims any liability to the City of Winnipeg and to third parties in respect of the publication, reference, quoting, or distribution of this report or any of its contents to and reliance thereon by any third party.

Table of Contents

1.0 INTRODUCTION

1.1 Background

Clifton Pumping Station is located at 1256 Wolseley Avenue, at the end of Clifton Street on the North side of the Assiniboine River. There are two buildings at this location – one for flood pumping and one for wastewater lift pumping. The flood pumps are operated by the City of Winnipeg to provide additional pumping capacity during high river levels. As excess flows can not flow by gravity during high river levels, the flood pumping station is utilized to pump the excess flow, not handled by the lift pumps, to the river.

Clifton Flood Pumping Station is powered via a bank of three 333 kVA, City of Winnipeg owned transformers, located within a vault. There is also a 120/240 V service to the station. The pumping at the station is comprised of four 250 HP flood pumps, and one 10HP pumpout pump.

Clifton Wastewater Lift Pumping Station is powered via three 37.5 kVA, utility-owned, pole-mount transformers. The pumping at the station is comprised of two pumps, both rated at 30 HP.

1.2 Objective

The City of Winnipeg's flood pumping stations and wastewater lift stations utilize electrical power, which is supplied by Manitoba Hydro, and then distributed to various loads in the facilities. City personnel are responsible for operating and maintaining the electrical distribution equipment and must be provided safe working guidelines to perform work on or near the equipment.

The purpose of an arc flash study is to identify and quantify potential arc flash hazards associated with electrical distribution equipment, and establish safe working guidelines for personnel. The safe working guidelines consist of identifying arc flash protection boundaries and the personnel protective equipment (PPE) required for each piece of electrical equipment. This information is identified on a label, which is to be applied to each piece of electrical equipment.

The arc flash hazard analysis is performed in association with a short circuit study and protection device coordination study. Results of the short circuit study are used to determine the available fault current levels at each piece of equipment and results from the coordination study determine the time required for the electrical circuit protective devices to clear the fault condition. The results of these two studies are combined to calculate the incident energy at assigned working positions from the electrical equipment and categorize the arc flash hazard to determine the required PPE to provide adequate protection.

1.3 Scope of Study

The scope of this study is to analyze the electrical distribution as detailed below:

- Investigate the facility to collect data regarding the electrical distribution, equipment nameplate data, and existing protection settings.
- Create or update the electrical system single line diagram to accurately represent the installed electrical system. The drawings will be in AutoCAD format, and transferred to the City for ownership.
- Contact Manitoba Hydro for available utility fault current to the facility.
- Create a software model of the electrical distribution at the station, using the SKM Power Tools software.
- Obtain or create software libraries for protective devices to be utilized in the model.
- Perform a short-circuit study to determine the available fault current at each relevant point within the electrical distribution.
- Perform a coordination study to determine if the existing protection settings of the main distribution breakers are adequate.
- Make recommendations regarding the electrical distribution configuration and protection settings, where required to improve device coordination, or reduce arc flash energies. These recommendations are provided in two phases. Phase 1 recommendations will include minor changes to protective device settings, which can be implemented immediately. Phase 2 recommendations will be comprised of upgrade work to the electrical distribution system.
- Perform an arc flash study to determine the existing potential arc energy levels at the various distribution points, incorporating the proposed Phase 1 recommendations.
- Provide capital costs to perform equipment upgrades to lower fault energies where necessary and practical.
- Provide arc flash labels for electrical equipment.

2.0 METHOD OF STUDY

2.1 Standards

The study is based upon the guidelines specified in the following standards:

- IEEE-1584 – IEEE Guide for Performing Arc-Flash Hazard Calculations
- NFPA-70E – Standard for Electrical Safety In the Workplace
- CSA-Z462 – Workplace Electrical Safety
- IEEE 242 – IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
- IEEE 141 – IEEE Recommended Practice for Electric Power Distribution for Industrial Plants

2.2 System Model

The facility electrical distribution was modelled in software, to allow for software calculation of the study results. This study utilizes software from SKM Systems Analysis Inc. (SKM Power Tools Version 6.5.2.4 - Build 1) to perform the fault current calculations, to produce the required protection coordination curves, and to calculate arc flash energy levels.

Following are the methods utilized in developing the system model.

2.2.1 Utility Contribution

The utility fault levels are provided by Manitoba Hydro at the primary terminals of the supply transformers. Refer to Appendix B for the actual fault reports provided by Manitoba Hydro.

2.2.2 Feeder Conductors

Parameters used in modeling the feeder conductors include: cable type, size, length, conductors per phase, conduit type (magnetic or nonmagnetic), and conductor material. All data was based on available existing single line diagrams, site layout drawings, and visual inspections.

2.2.3 Transformers

Parameters used in modeling the transformers include: transformer type, winding connection, secondary neutral-ground connection, primary and secondary voltage rating, kVA rating, and impedance. Transformer taps and phase shift were unknown and default values are used. Utility transformer data is based as per information provided by Manitoba Hydro. City owned transformer data is based upon visible nameplates. Where transformer impedance data is not available and cannot be determined from site inspections, values from Table 1, in IEEE Std 242, are used.

2.2.4 Motor Contribution

This short circuit study takes into account the continuous sub-transient fault current contribution of induction motors within the system. The large flood pumping motors are modeled individually in order to accurately determine the motor's fault current contribution. Parameters used in the modeling of induction motors include: operating voltage, horsepower, full-load amps, power factor, efficiency and RPM. Where data was not available, default values (based on similar conditions found at another station) were used.

2.2.5 Assumptions

The following is a list of assumptions that were made about the electrical distribution:

- A Manitoba Hydro owned fused cutout is feeding the three 333 kVA transformers. The type and rating of this fuse is unknown, but it is assumed to be an S&C SM-5 200E fuse.
- A nominal impedance of 4.8% was utilized for the city owned flood pumping station transformer, based upon nameplate information. A minimum impedance of 4.3% was utilized based upon the criterion that for City owned transformers, the minimum impedance would be taken to be the nominal value less 10%. Typical X/R transformer ratios were utilized.
- A nominal impedance of 2.0% was utilized for the wastewater lift station utility transformer. A minimum impedance of 1.5% was utilized based on Manitoba Hydro data.
- The flood pump motor cable size could not be confirmed through site investigations as it is installed in rigid conduit and the exposed cable in the starters did not have markings.
- Cable lengths were measured on site, however they can only be considered as approximations with a tolerance of ±(1.0m +5%).
- The distance from the 600V secondary of XFMR-F1, to the pumping station's main splitter (SPL-F1) was estimated to be 1.8m. The cable is assumed to be 3-2C, 500 MCM, aluminum.
- The flood pump reduced voltage starters (primary resistance) are assumed to limit the starting inrush to less than 4.5x FLA.
- A software model of the Royal Electric (60A) fuse (FDS-SPL-F10) found on site is not available. A Gould Shawmut NRS, type P (60A) non-time delay fuse was used to model the existing scenario.

- A software model of the Royal Electric (30A) fuse (FDS-P-F5) found on site is not available. A Gould Shawmut NRS, type P (30A) non-time delay fuse was used to model the existing scenario.
- A software model of the Shawmut VM-31 (15A) fuse (FDS-P-F7) found on site is not available. A Gould Shawmut NRS, type P (15A) non-time delay fuse was used to model the existing scenario.
- The 400A ITE JKL frame breakers were modeled as Siemens JJ Series breakers. The curves were compared, and the Siemens JJ curve is deemed to be a similar, conservative curve compared to the ITE breaker.
- The size of the cables CP-P-P5 and CP-EF-F7, was not confirmed but was assumed to be 12 AWG, based on the Canadian Electrical Code.
- The exhaust fan motor rating was not confirmed on site and is assumed to be 1 HP. As this motor is small, it will not have a significant contribution to the incident energy found at MS-EF-F7.
- The power fail relay is assumed to contain 15A midget type fuses.
- The size of the wire to the power fail voltage monitor is assumed to be 12 AWG.
- A ground fault detection system is not present.
- The length of CP-P-L1 and CP-P-L2 were estimated to be 29.0 m.
- The 25 kVA, 120/240V utility pole-top transformer, XFMR-UTIL-240V, was modeled as a three phase transformer, which produces the same full load secondary current, in order to conduct a balanced system analysis.
- The 25 kVA, 120/240V utility pole-top transformer, XFMR-UTIL-240V, is assumed to have an impedance of 1.5% based on the Winnipeg Electrical By-Law No. 74/2009.
- The size of the cable CP-CB-PNL-F10-1, could not be confirmed but was assumed to be 3C, 2 AWG aluminum, NS75.
- The size of the cable CP-CB-PNL-F10-2, could not be confirmed but was assumed to be 3-1C, 2/0 AWG.
- The size of the cables CP-CON-F11 and CP-PNL-F11, could not be confirmed but was assumed to be 3 AWG.
- An infinite utility bus was used to model the utility contribution to the Wastewater Lift Station.
- Conductors with a size of 3 AWG are modelled as 2 AWG, due to the lack of 3 AWG conductors in the software utilized.

2.3 Configuration Scenarios

Worst case incident energy levels do not necessarily occur when fault current levels are the highest. Circuit protection normally consists of a combination of time overcurrent and instantaneous overcurrent where lower level fault currents can cause longer clearing times that may result in higher incident energy levels. The additional clearing time may offset the lower arcing current to produce higher incident energy and consequently a more hazardous condition.

Therefore, different possible electrical distribution configuration scenarios must be analyzed to determine which scenario produces the worst-case arc flash safety hazard and each piece of electrical equipment must be categorized based on the worst-case result.

The following are the electrical distribution configurations at the flood pumping stations that are analyzed as part of this study.

2.3.1 Scenario A – Baseline Fault Level (Normal Operation)

Scenario A is based upon a system configuration which would generate typical short circuit fault levels. The system configuration includes:

- Normal utility fault level.
- Nominal utility transformer impedance.
- The pump motors are not operating.

2.3.2 Scenario B – Maximum Fault Level

Scenario B is based upon a system configuration which would generate maximum short circuit fault levels. The system configuration includes:

- Maximum (horizon) utility fault level.
- Minimum utility transformer impedance.
- The pump motors are running.

3.0 SHORT CIRCUIT STUDY

3.1 Short Circuit Calculation Method

A short circuit study is performed to determine the available fault levels for the major 600V, 240V and 208V busses within the pumping station's electrical distribution. This study is necessary in order to find the symmetrical RMS bolted fault current at each point of concern in the electrical distribution, which is then used to calculate the arc fault current. Arc currents are lower than bolted fault currents due to the arc impedance, however they can persist longer than the full bolted fault depending on the protective device time current curves. The results of this study are also used to ensure that interrupting current ratings of the equipment exceeds the calculated maximum available fault current and in determining selectivity and protection settings, as part of the coordination study.

The calculations were performed using the *A_FAULT* module from SKM Systems Analysis Inc. This module follows the specifications of the ANSI standard C37.010, C37.5 and C37.13 and IEEE Standard 141 (Red Book).

The short circuit calculations are based upon Scenario B, described in Section 2.3.2. Note that the Winnipeg Electrical Bylaw requires that an infinite bus be assumed at the primary of the utility transformer, when calculating short circuit currents for equipment ratings of new construction. The requirement of this clause, in the bylaw, is based upon the authority's desire to avoid the case where changes in the utility's distribution system will cause equipment within a customer's facility to be incorrectly rated. However, in this case, the installation is existing. By assuming a minimum transformer impedance and horizon utility fault levels, the short circuit values produced in this study are deemed to be safe and conservative, for evaluation of equipment ratings. However, for any new construction within the facility, the requirement to assume an infinite utility bus would apply, which would increase the short circuit currents and potentially the required equipment ratings.

3.2 Utility Contribution

3.2.1 Flood Pumping Station

The following table is a summary of the available fault levels at the flood pumping station provided by Manitoba Hydro. Refer to Appendix B for the official fault study report.

	Normal (Amps)	Horizon (Amps)
3 Phase (L-L-L)	6586	8938
Single Phase – GND (S-L-G)	2151	4644
System Impedances (ohms)	**Pos.** 1.2237 + j 1.7155 pu **Zero.** 15.6449 + j 3.4461 pu	**Pos.** 0.6678 + j 1.4019 pu **Zero.** 4.8630 + j 3.6744 pu

Table 3-1: Clifton Flood Pumping Station - Manitoba Hydro Fault Level Summary

3.2.2 Wastewater Lift Station

The following table is a summary of the available fault levels at the flood pumping station provided by Manitoba Hydro. Refer to Appendix C for the official fault study report.

	Normal (Amps)	Horizon (Amps)
3 Phase (L-L-L)	8523	9548
Single Phase – GND (S-L-G)	4479	4758
System Impedances (ohms)	**Pos.** 0.6996 + j 1.4703 pu **Zero.** 4.9649 + j 3.8336 pu	**Pos.** 0.6531 + j 1.2986 pu **Zero.** 4.8977 + j 3.5739 pu

Table 3-2: Clifton Wastewater Lift Station - Manitoba Hydro Fault Level Summary

3.3 Short Circuit Fault Levels

The following table summarizes the calculated short circuit fault levels at the electrical equipment in the flood pumping station. The fault levels presented are based on the calculations for the maximum fault level scenario.

ID	Description	3P		SLG	
		I_{SC} (Amps)	X/R	I_{SC} (Amps)	X/R
SPL-F1	Flood Pump Station – Splitter	21,499	5.3	0	1.0
CB-P-F1	Flood Pump Station – P-F1 Motor Circuit Protector	21,343	5.1	0	1.0
CB-P-F2	Flood Pump Station – P-F2 Motor Circuit Protector	21,343	5.1	0	1.0
CB-P-F3	Flood Pump Station – P-F3 Motor Circuit Protector	21,343	5.1	0	1.0
CB-P-F4	Flood Pump Station – P-F4 Motor Circuit Protector	21,343	5.1	0	1.0
FDS-SPL-F10	Flood Pump Station – Fused Disconnect	20,394	3.0	0	1.0
MS-P-F1	Flood Pump Station – P-F1 Motor Starter	21,036	4.8	0	1.0
MS-P-F2	Flood Pump Station – P-F2 Motor Starter	21,036	4.8	0	1.0
MS-P-F3	Flood Pump Station – P-F3 Motor Starter	21,036	4.8	0	1.0
MS-P-F4	Flood Pump Station – P-F4 Motor Starter	21,036	4.8	0	1.0
SPL-F10	Flood Pump Station – Splitter	19,976	2.6	0	1.0
FDS-P-F5	Flood Pump Station – Fused Disconnect	18,736	1.9	0	1.0
FDS-SP-F6	Flood Pump Station – Fused Disconnect	18,728	1.9	0	1.0
FDS-EF-F7	Flood Pump Station – Fused Disconnect	18,728	1.9	0	1.0
RLY-F1	Flood Pump Station – Power Fail Voltage Monitor	19,184	2.1	0	1.0
MS-P-F5	Flood Pump Station – P-F5 Manual Motor Starter	8,590	0.5	0	1.0
MS-EF-F7	Flood Pump Station – EF-F7 Manual Motor Starter	7,052	0.4	0	1.0
PNL-F10	Flood Pump Station – 120/240V Panelboard	1,829	0.4	1,534	0.4
PNL-F11	Flood Pump Station – 120/240V Panelboard	1,816	0.4	1,518	0.4

ID	Description	3P		SLG	
		I_{SC} (Amps)	X/R	I_{SC} (Amps)	X/R
CB-MCC-L1	Wastewater Lift Station – MCC-L1 Main Circuit Breaker	6,280	2.2	6,180	2.0
MCC-L1	Wastewater Lift Station – Motor Control Centre	6,261	2.1	6,154	2.0

Table 3-3: Clifton Station - Short Circuit Currents

The short circuit currents were compared against the interrupting ratings of the protective equipment. The existing equipment ratings exceeded the available short circuit current except for the following:

- The fuses in FDS-SPL-F10, FDS-P-F5, FDS-EF-F7, are assumed to be Class H, Type P, which have a 10KA interrupting rating. This fuse rating is below the available fault current. It is recommended to replace the fuses as required to achieve sufficient interrupting capacity. For any new equipment, a minimum 25KA interrupting rating is recommended.
- The power fail relay, RLY-F1, is assumed to be protected by 15A midget fuses, which have a 10KA interrupting rating. The fault current is above this rating therefore, it is recommended to install appropriately rated branch circuit protection upstream of the power fail relay and connected to SPL-F1.
- The 400A ITE circuit breakers do not have an interrupting rating indicated, and thus are assumed to be rated at 10KA. It is recommended that these breakers be rated at a minimum of 25KA.

4.0 COORDINATION STUDY

4.1 Objectives

A review of the protection settings is performed to ensure that protection devices are set properly for the supplied loads, and to minimize arc flash and potential equipment damage in the event that a fault occurs.

There are three main objectives, in order of priority, to the selective coordination of overcurrent protection devices:

- The first objective is life safety. If reasonable, protective devices should be set at the lowest possible setting that allows normal operation of the connected loads. In the event that a fault does occur, lower protection settings will often provide faster pickup of the fault condition, and consequently reduce the resultant arc fault energy levels.
- The second objective is equipment protection. Protection requirements are met if overcurrent devices are set above load operating levels and below equipment damage curves. This allows normal operation without causing nuisance trips while still protecting equipment against damage should a fault occur.
- The third objective is selective coordination. Where possible, overcurrent protection devices are coordinated such that in the event of a fault, the smallest possible distribution area is removed from service.

Often it is impossible to meet all three objectives because they have conflicting requirements. In order to reduce arc flash energies, protection settings must be set to pickup as fast as possible and clear the fault quickly. However, coordinating upstream breakers with downstream breakers is often achieved by introducing time delays in the upstream breakers to allow the downstream breakers time to trip first. This results in longer fault clearing times for the upstream equipment and increased arc fault energies.

This study attempts to meet all three objectives, but where it is not possible, life safety and equipment protection requirements take precedence.

4.2 Utility Services

Currently, Clifton Flood Pumping Station has two utility services. A 600V service powers the pumps and a 120/240V service powers miscellaneous loads including lighting and pump controls. The 600V service is dedicated to the pumping station, but the 120/240V service is shared with nearby residential customers. It is possible, although not a frequent situation, that an event on a nearby residential property could cause the 120/240V utility transformer fuse to blow, resulting in a power failure for the pumping station 120/240V loads.

It is also noted that the 600V distribution system is a delta connected system and no ground fault detection device is installed. As per CEC 10-106(2), ungrounded (delta) systems require a suitable ground detection device to indicate the presences of a ground fault. A ground fault detection device would allow maintenance electricians to identify that a ground fault has occurred, and make repairs before a second ground fault takes place. Should a second ground fault occur on a different phase from the first, there is the possibility of disruption in station operation due to an overcurrent device opening. In some installations, a simple three-light ground fault detection system is utilized. However, give that this facility is unmanned, it is recommended to provide ground fault alarming through the SCADA system. Alternatively, the 4160V-600V transformer could be replaced with a delta-wye transformer, which does not require ground fault detection.

4.3 Flood Pump Coordination

4.3.1 Existing

The selective coordination of the protective devices associated with the flood pumps was accessed. The existing time current curves are shown in Figure 4-1.

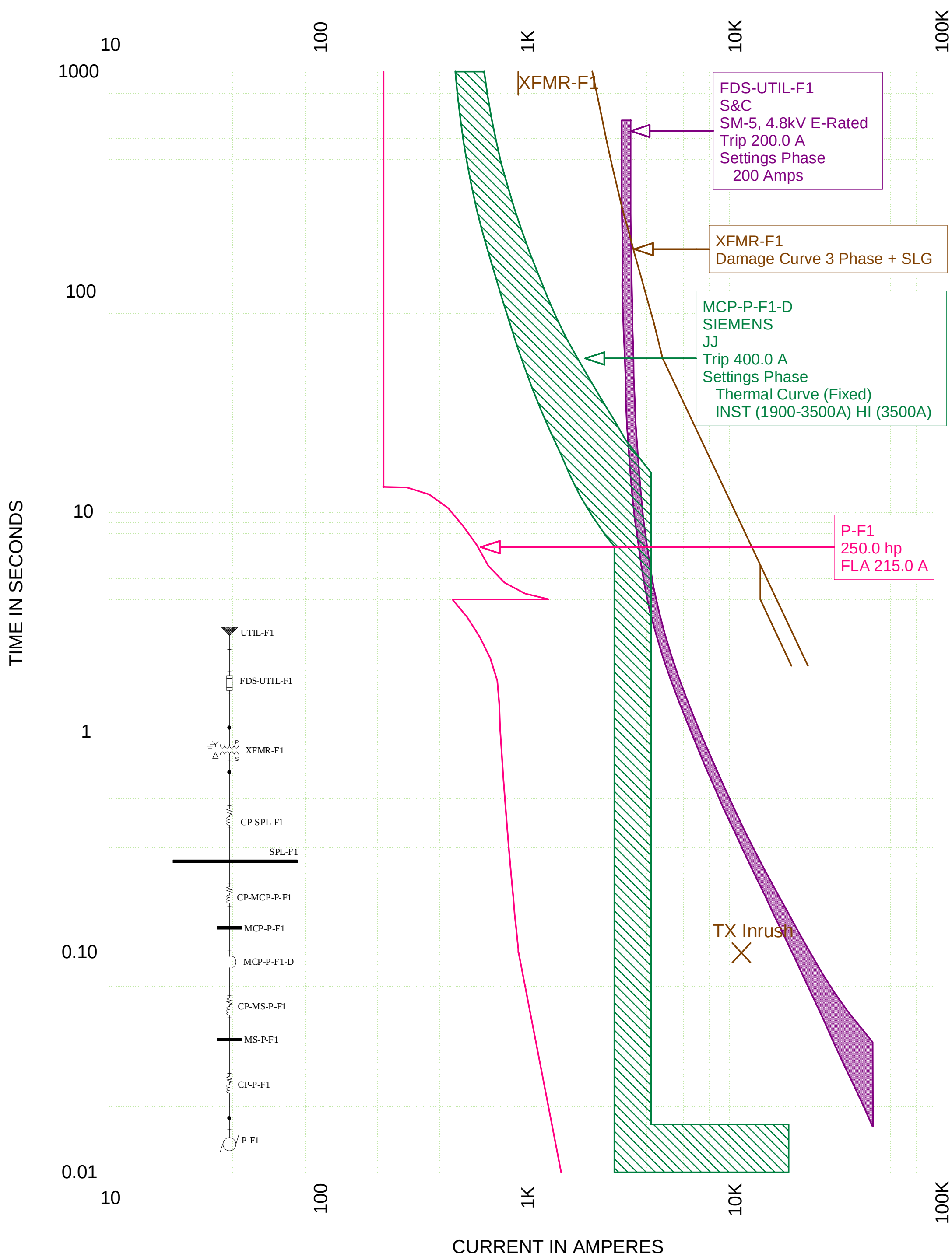
4.3.2 Proposed Phase 1

There are no proposed Phase 1 changes to the protective device configuration of the flood pump.

4.3.3 Proposed Phase 2

Additional work proposed is as follows:

- Given the interrupting rating issue with the ITE circuit breaker discussed in Section 3.3, it is recommended to replace CB-P-F1, CB-P-F2 and CB-P-F3 with appropriate molded case circuit breakers that provide selective coordination.



TCC Name: Flood Pump
Scenario: Existing

Current Scale x 1

Reference Voltage: 600

Figure 4-1 - Clifton Flood Pump – Existing TCC Curve

4.4 FDS-SPL-F10 Code Violation

The existing wiring contains a code violation in that the ampacity of the 8 AWG feeder and load conductors associated with FDS-SPL-F10 are less than the 60A fuses in the fused disconnect.

4.4.1 Proposed Phase 1

There are no proposed Phase 1 changes.

4.4.2 Proposed Phase 2

It is proposed to replace the associated conductors (CP-FDS-SPL-F10 and CP-SPL-F10) with 6 AWG conductors.

4.5 Pumpout Pump P-F5 Coordination

The selective coordination of the protective devices associated with P-F5 was assessed. The existing time current curves are shown in Figure 4-2.

The existing coordination is acceptable for this installation and no additional work is proposed.

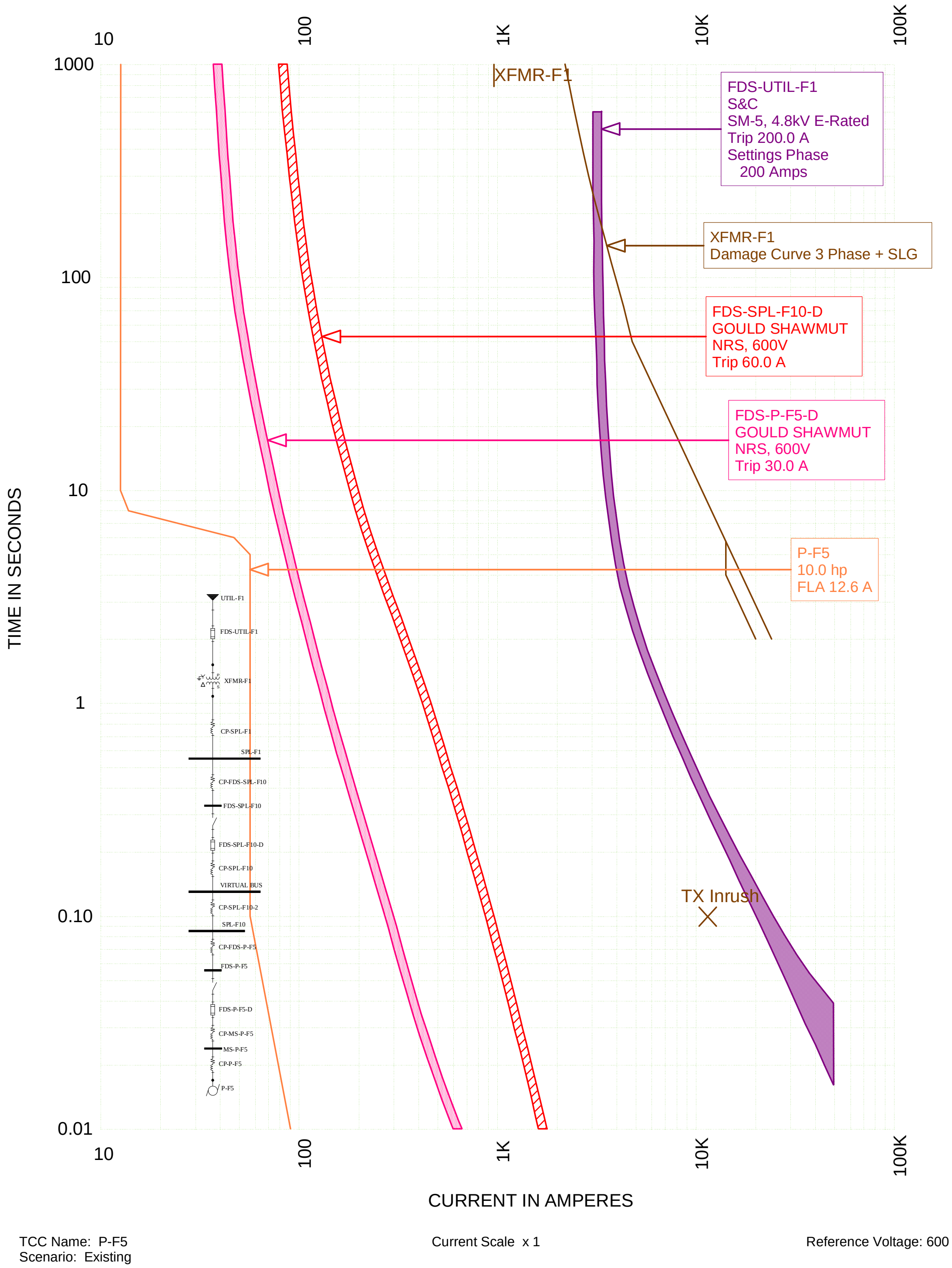


Figure 4-2 - Clifton Pumpout Pump P-F5– Existing TCC Curve

4.6 PNL-F10 Coordination

4.6.1 Existing

The selective coordination of the protective devices associated with PNL-F10 was assessed. The existing time current curves are shown in Figure 4-3.

The existing coordination is acceptable for this installation and no additional work is proposed.

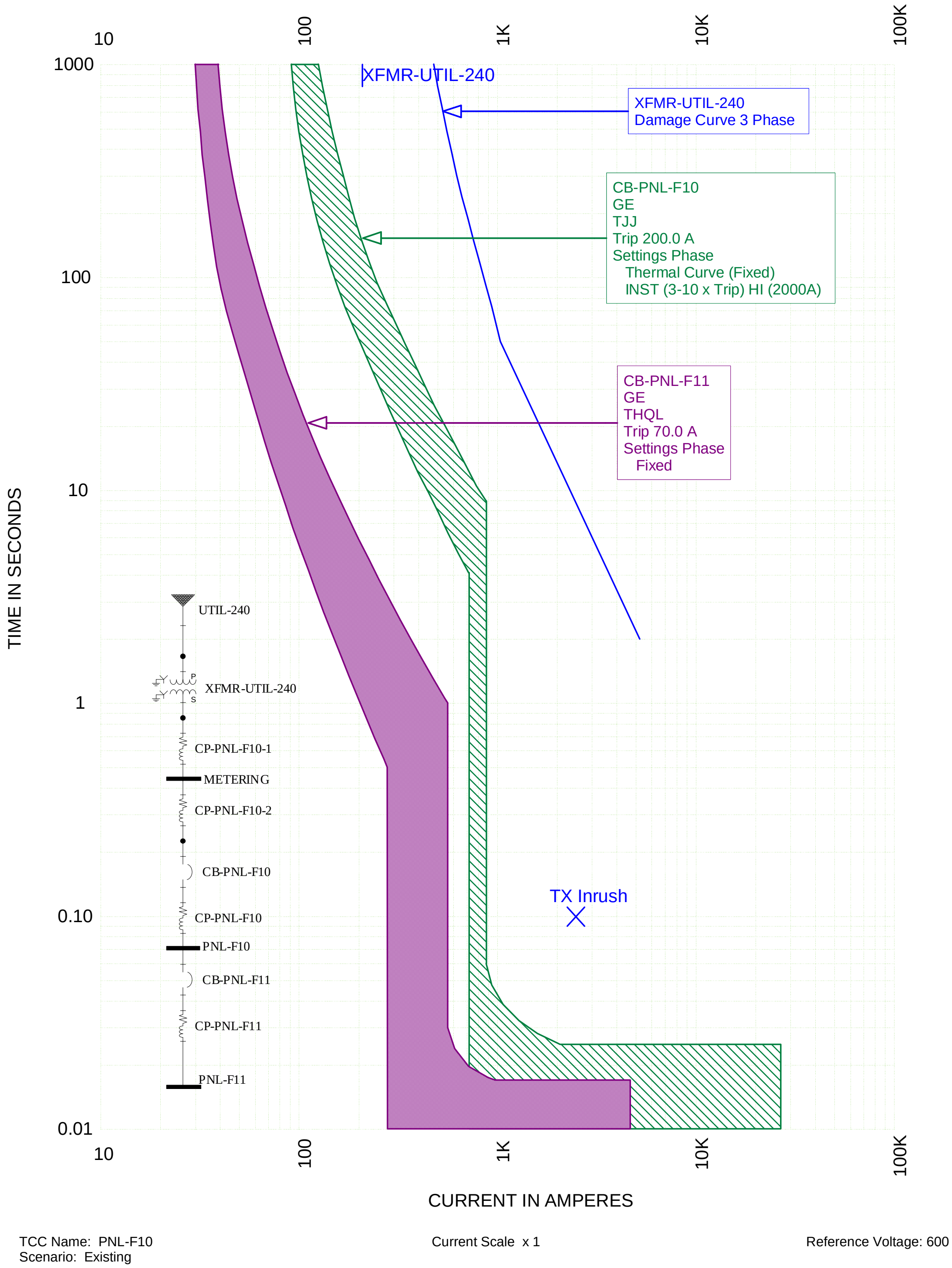


Figure 4-3 - Clifton PNL-F10– Existing TCC Curve

4.7 Wastewater Lift Pump Coordination

4.7.1 Existing

The selective coordination of the protective devices associated with the wastewater lift pumps were assessed. The existing time current curves are shown in Figure 4-4. The existing trip rating of MCP-P-L1 and MCP-P-L2, are in violation of the Canadian Electrical Code which states that motor overcurrent protection can not be rated higher than 2.5X the FLA of the motor it is protecting.

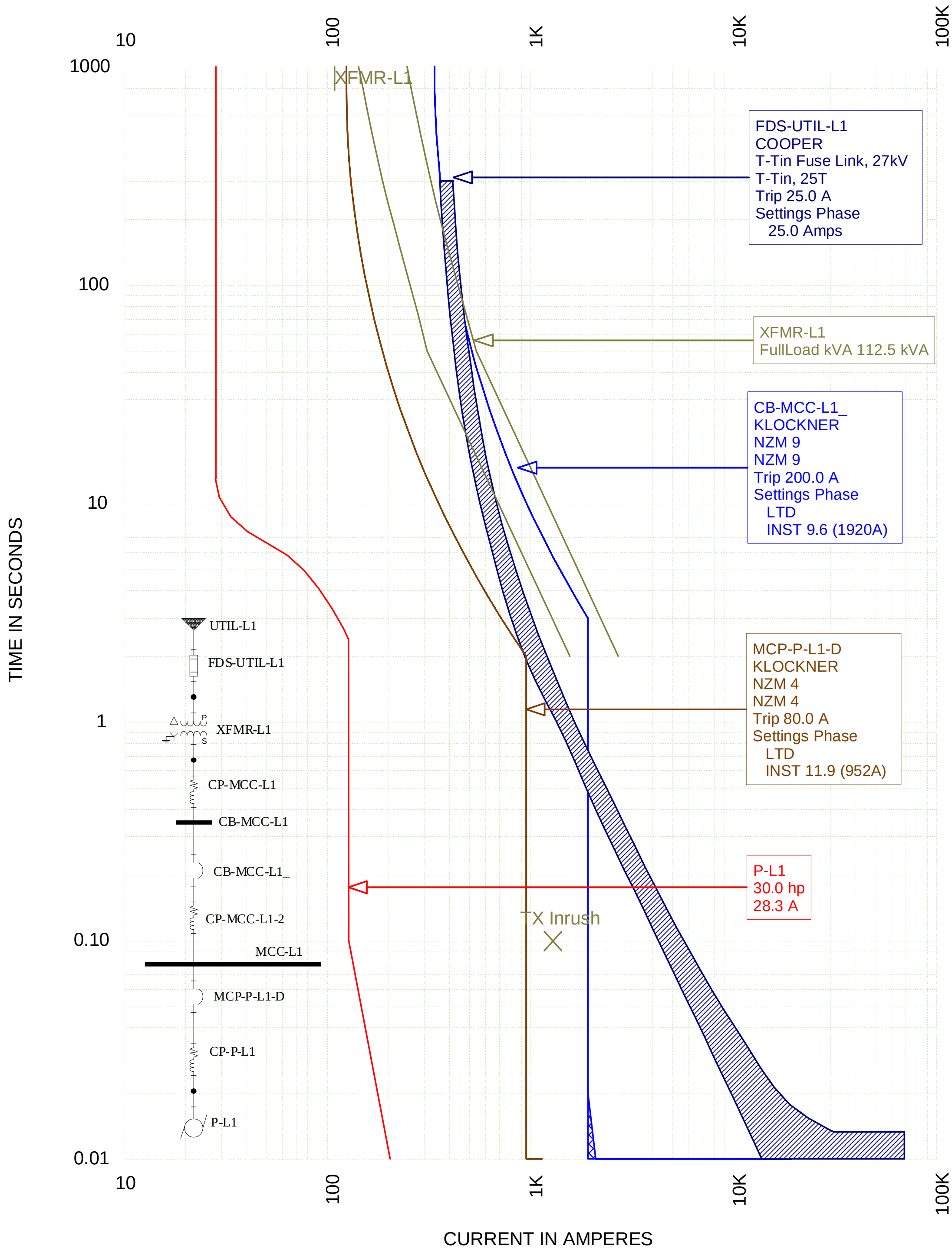
4.7.2 Proposed Phase 1

It is proposed to reduce the instantaneous setting of MCP-P-L1 and MCP-P-L2 to 8X (640A), which is the minimum setting. This modification does not meet code, but is the best setting possible until the breaker can be replaced.

It is also proposed to reduce the instantaneous setting of CB-MCC-L1 from 2000A to 1600A to improve the coordination with the utility fuse.

4.7.3 Proposed Phase 2

It is proposed to change pump P-L1 and P-L2 motor circuit protectors with ones rated at 40A, and set the instantaneous rating to be 320A.

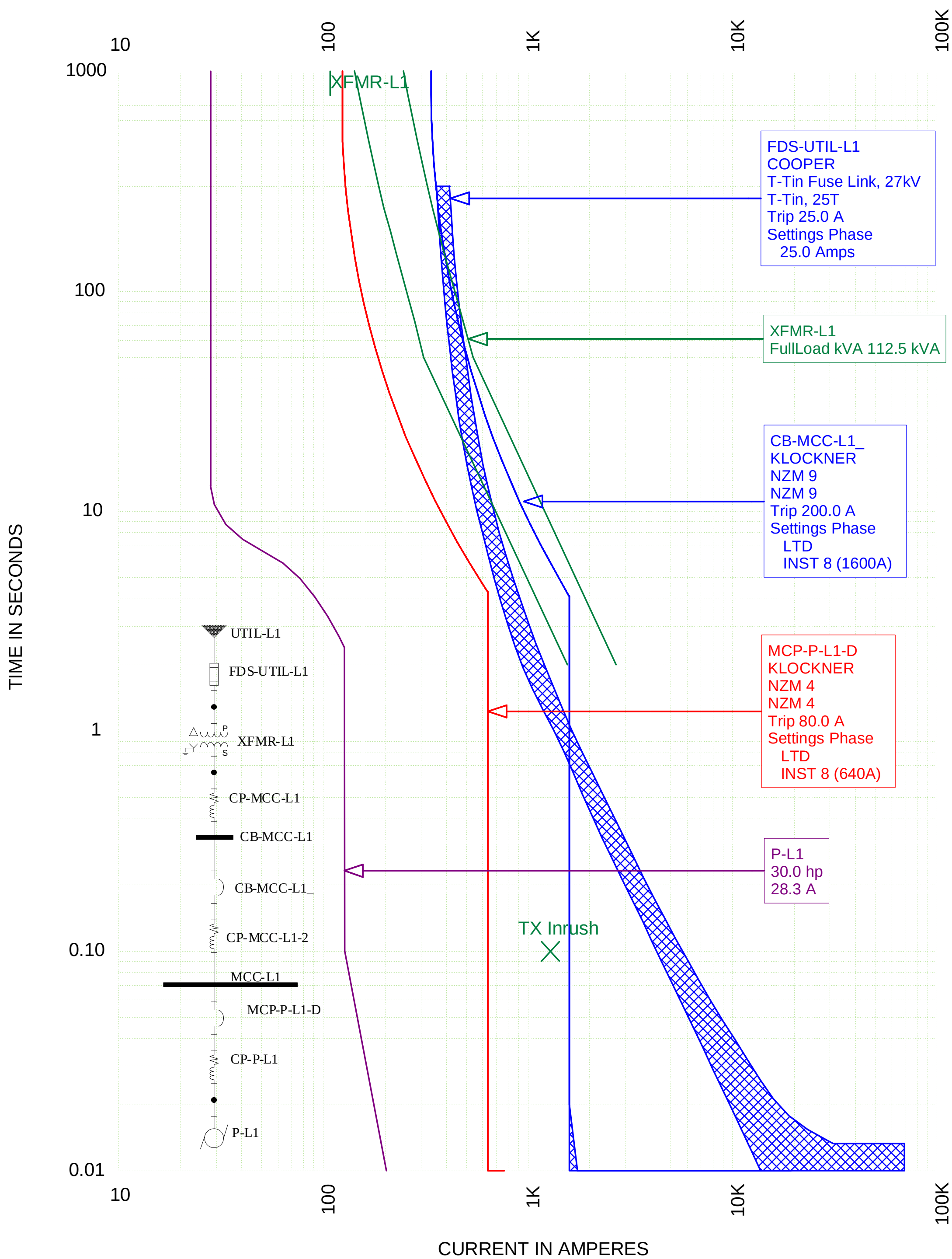


TCC Name: Lift Pump
Scenario: Existing

Current Scale x 1

Reference Voltage: 600

Figure 4-4 - Clifton Lift Pump – Existing TCC Curve



TCC Name: Lift Pump
Scenario: Phase1 - Maximum Fault Level

Current Scale x 1

Reference Voltage: 600

Figure 4-5 - Clifton Lift Pump – Phase 1 TCC Curve

4.8 XFMR-L10 Protection

4.8.1 Existing

XFMR-L10 is currently protected by a motor circuit protector which offers no thermal protection to XFMR-L10, and is therefore a code violation.

4.8.2 Proposed Phase 1

There is no proposed Phase 1 work.

4.8.3 Proposed Phase 2

It is proposed to replace MCP-XFMR-L10 with a thermal magnetic circuit breaker.

5.0 ARC FLASH STUDY

5.1 Arc Flash Method

The arc flash calculations are calculated utilizing

- The arc flash analysis methodology is based on IEEE Standard 1584-2002.
- The arc flash results are based on worst case incident energies calculated from the scenarios established in Section 2.3.

The results of the arc flash study are based on the available fault currents calculated at each piece of equipment and the coordination study results which determine the time required for the electrical circuit protective devices to clear the fault condition. The worst case arc flash energies calculated from the two scenarios identified in Section 2.3 were used to classify the arc flash hazard for each piece of equipment.

Mitigation to reduce the arc flash hazard is presented for each station, if required, and the resulting arc flash hazard classification as a result of the mitigation.

Safe working guidelines and recommended personnel protective equipment (PPE) required for each arc flash category are given.

5.1.1 Assumptions

The following assumptions were used in the arc flash analysis:

- Electrical equipment, 240V and less, that is fed from a single transformer less than 125 kVA is assumed to have a classification of Category 0, as per IEEE Std 1584.
- The maximum arcing time duration is 2 seconds for incident energy calculations as per IEEE Std 1584. This is a reasonable time to expect a person exposed to an arc flash to move away from the location.
- The cleared fault threshold is 80% of the total arcing fault current. In other words, for busses with multiple sources of fault current, the fault is considered cleared when protection devices have clear 80% of the total arcing fault.
- Arc fault tolerances are defined as -15% and 0% as per IEEE Std 1584. Incident energies are calculated at the low and high tolerances to account for arcing fault current variability which can produce varying protection trip times. The largest incident energy is reported.

5.2 Arc Flash Results

The following arc flash results are based on a system model configured with the proposed Phase 1 settings. The arc flash levels were considered while developing the proposed settings, and arc flash energies are set as low as possible without compromising facility operation. As described in Section 2.3, the presented incident energy is the higher of two scenarios analyzed. The arc flash results are shown in Table 5-1:

ID	Description	Incident Energy (cal/cm^2)	Required PPE
XFMR-F1	Flood Pump Station – Incoming Transformer (Located in the Vault)	23.6	Category 3
SPL-F1	Flood Pump Station – Splitter	23.7	Category 3
CB-P-F1	Flood Pump Station – P-F1 Motor Circuit Protector	23.9	Category 3
CB-P-F2	Flood Pump Station – P-F2 Motor Circuit Protector	23.9	Category 3
CB-P-F3	Flood Pump Station – P-F3 Motor Circuit Protector	23.9	Category 3
CB-P-F4	Flood Pump Station – P-F4 Motor Circuit Protector	23.9	Category 3
FDS-SPL-F10	Flood Pump Station – Fused Disconnect	24.8	Category 3
MS-P-F1	Flood Pump Station – P-F1 Motor Starter	1.1	Category 0
MS-P-F2	Flood Pump Station – P-F2 Motor Starter	1.1	Category 0
MS-P-F3	Flood Pump Station – P-F3 Motor Starter	1.1	Category 0
MS-P-F4	Flood Pump Station – P-F4 Motor Starter	1.1	Category 0
SPL-F10	Flood Pump Station – Splitter	0.7	Category 0
FDS-P-F5	Flood Pump Station – Fused Disconnect	0.6	Category 0
FDS-SP-F6	Flood Pump Station – Fused Disconnect	0.6	Category 0
FDS-EF-F7	Flood Pump Station – Fused Disconnect	0.6	Category 0
RLY-F1	Flood Pump Station – Power Fail Voltage Monitor	0.6	Category 0
MS-P-F5	Flood Pump Station – P-F5 Manual Motor Starter	0.3	Category 0
MS-EF-F7	Flood Pump Station – EF-F7 Manual Motor Starter	0.2	Category 0
PNL-F10	Flood Pump Station – 120/240V Panelboard	- (See Note 1)	Category 0
CON-F11	Flood Pump Station – Thermostat	- (See Note 1)	Category 0

ID	Description	Incident Energy (cal/cm^2)	Required PPE
PNL-F11	Flood Pump Station – 120/240V Panelboard	- (See Note 1)	Category 0
CB-MCC-L1	Wastewater Lift Station – MCC-L1 Main Circuit Breaker	2.7	Category 1
MCC-L1	Wastewater Lift Station – Motor Control Centre	0.2	Category 0

Table 5-1: Clifton Station - Arc Flash Hazard Classification

Notes:

1. Equipment is Category 0 as it is fed by one transformer rated less than 125 kVA.

5.2.1 Proposed Phase 2 Mitigation

It is recommended that a main incoming breaker that offers adjustable LSI trip settings be introduced into the existing distribution in order to reduce the Category 3 arc flash hazard found within the flood pump station. A new distribution panel, which also addresses the interrupting ratings of the fused disconnects, as discussed in Section 3.0, is recommended. Appropriate settings to provide protection, coordination and lowest possible arc flash energies would be determined as part of detailed design.

5.3 Recommended Personal Protective Equipment (PPE)

The following is a summary of the personal protective equipment recommended by CSA Z462-08 for each hazard category. Refer to the CSA Z462-08 standard for more detailed information.

Category 0 PPE requirements:

- Natural fibre long sleeve shirt and pants (no synthetic shirts, pants, or undergarments)
- Safety glasses or safety goggles
- Hearing protection (ear canal inserts)
- Leather gloves as needed (optional)

Category 1 PPE requirements:

- Arc-rated long sleeve shirt and pants or arc-rated coverall (minimum arc rating of 4 cal/cm2)
- Hard hat with arc-rated face shield or arc flash suit hood (minimum arc rating of 4 cal/cm2)

- Arc-rated jacket, parka, or rainwear as needed
- Safety glasses or safety goggles
- Hearing protection (ear canal inserts)
- Leather gloves
- CSA approved safety boots with dielectric rating and leather uppers as needed (for work with exposed live conductors)

Category 2 PPE requirements:

- Arc-rated long sleeve shirt and pants or arc-rated coverall (minimum arc rating of 8 cal/cm2)
- Hard hat with arc-rated face shield or arc flash suit hood (minimum arc rating of 8 cal/cm2)
- Arc-rated jacket, parka, or rainwear as needed
- Safety glasses or safety goggles
- Hearing protection (ear canal inserts)
- Leather gloves
- CSA approved safety boots with dielectric rating and leather uppers

Category 3 PPE requirements:

- Total FR clothing system and hood (minimum arc rating of 25 cal/cm2)
- Hard hat
- Hearing protection (ear canal inserts)
- Arc flash rated gloves
- CSA approved safety boots with dielectric rating and leather uppers

Rubber gloves with leather protectors are required for work near exposed energized conductors. Ensure that the rubber gloves are voltage rated to a minimum of 1000V. Non-rated rubber gloves should not be used around electrical equipment as the perceived safety may not be provided.

6.0 RECOMMENDATIONS

6.1 Phase 1 Required Work

The following work is required to achieve the goals set forth in this study:

- Set the instantaneous setting of MCP-P-L1 to 8X (640A).
- Set the instantaneous setting of MCP-P-L2 to 8X (640A).
- Set the instantaneous setting of CB-MCC-L1 to 1600A.
- Install new identification lamacoids.
- Apply the arc flash labels provided as part of this study.

6.1.1 Cost Estimate

A cost estimate for the Phase 1 work is shown below:

Description	Cost
Install identification lamacoids	$ 100
Total	**$ 100**

Notes:

1. *It is assumed that the work will be performed by City forces, and thus no cost allowance for labour or field materials has been included.*

6.2 Phase 2 Recommendations – Flood Pumping Station

It is recommended that the City initiate a project to perform the following additional work. Note that the provided arc flash stickers do not include these Phase 2 recommendations, and updated arc flash stickers will be required as part of the proposed Phase 2 work.

1. Install a new 600V distribution panel with a main incoming breaker that offers adjustable LSI trip settings. Appropriate settings to provide protection, coordination and lowest possible arc flash energies will have to be determined.
2. Replace the separate 120/240V service with a 600V-120/240V dry type transformer within the station.
3. Replace the existing vault containing three transformers with a single delta-wye padmount transformer.

4. If the ungrounded 600V system is retained, install a ground fault detection system with a connected SCADA alarm.
5. Replace overcurrent protection for the power fail relay.
6. Replace the conductors associated with FDS-SPL-F10 with 6 AWG conductors.

6.2.1 Cost Estimate

A cost estimate for the Phase 2 work is shown below:

Description	Cost
Install new 600 V distribution panel	$ 100,000
Install 600V-120/240V transformer	$ 5,000
Install new padmount distribution transformer	See Note 3
Install ground fault detection	See Note 4
Replace FDS-SPL-F10 conductors with 6 AWG conductors	See Note 5
Total	**$ 105,500**

Notes:

1. *The above cost estimate is a Class C estimate and includes contractor costs and a 20% contingency factor. Taxes and City Finance and Admin charges are extra.*
2. *It is assumed that the work will be performed by City forces, and thus no cost allowance for labour or field materials has been included.*
3. *Costs for the 4160 V transformer replacement are dependant on many factors, and have not been estimated as part of this study.*
4. *A ground fault detection system is only required if the 4160V-600V transformers are retained. Approximate cost would be $5000.*
5. *The costs for the 6 AWG conductors are not included as this would be replaced by the proposed new 600V distribution panel.*

6.3 Phase 2 Recommendations – Wastewater Lift Pumping Station

It is recommended that the City initiate a project to perform the following additional work. Note that the provided arc flash stickers do not include these Phase 2 recommendations, and updated arc flash stickers will be required as part of the proposed Phase 2 work.

1. Replace the motor circuit protector for lift pump P-L1 and P-L2 with 40A rated models that have an instantaneous setting of 320A.
2. Replace the transformer primary protection with an appropriately rated thermal-magnetic breaker.

6.3.1 Cost Estimate

A cost estimate for the Phase 2 work is shown below:

Description	Cost
Replace Motor Circuit Protectors & Transformer breaker	$ 1500
Total	**$ 1500**

Notes:

1. *The above cost estimate is a Class C estimate and includes contractor costs and a 20% contingency factor. Taxes and City Finance and Admin charges are extra.*
2. *It is assumed that the work will be performed by City forces, and thus no cost allowance for labour or field materials has been included.*

APPENDIX A : LIST OF ASSOCIATED DRAWINGS

Drawing Number	Title
1-0125F-E0001	Clifton Flood Pumping Station - Single Line Diagram
1-0125L-E0001	Clifton Wastewater Lift Station - Single Line Diagram

SNC·LAVALIN

APPENDIX B : MANITOBA HYDRO FAULT LEVEL REPORTS – FLOOD PUMPING STATION

MANITOBA HYDRO
INTEROFFICE MEMORANDUM

FROM Marc Robert
Distribution Engineering - Winnipeg
Customer Service & Distribution
1120 Waverley Street, Winnipeg, MB

TO Brian Adamyk
South East Energy Services Advisor
Major Account Department
Customer Care & Marketing
360 Portage Ave (6), Winnipeg MB

DATE 2009 08 12
SUBJECT UTILITY INFORMATION REQUIRED FOR CLIFTON PUMPING STATION

Customer Information
Name: City of Winnipeg Water & Waste
Address: **1256 Wolseley Ave**

Source Information
Station: **Arlington & Empress**
Feeder: **409N20**

Fault Levels at Point of Delivery[1, 2]

Switching Configuration	Voltage (kV)	LLL (Amps)	LG (Amps)	R1 (pu)	X1 (pu)	R0 (pu)	X0 (pu)
Normal System Operation[3]	4.16	6586	2151	1.2237	1.7155	15.6449	3.4461
Empress Stn Banks 1 & 2 Paralleled - FNET Source	4.16	8938	4644	0.6678	1.4019	4.8630	3.6744

Impedances are per unit on a 100MVA base

Notes
1. These values are reflective of the normal and expected maximum available fault levels at the customer location, depending on the configuration of the supply, and can be used for arc flash hazard calculation.
2. These values are valid for the system configuration at the time of this study. These fault levels and impedances can change in the future as a result of changes to the Manitoba Hydro system, including feeder reconfiguration or reconductoring, increasing the size of substation transformers and from new or reconductored subtransmission lines. While these changes are infrequent in nature, they are not uncommon and Manitoba Hydro does not communicate changes in fault level or impedance information to customers unless a new request is initiated.
3. The Normal switching configuration is intended for overcurrent protection coordination studies, power quality studies, harmonic assessment and mitigation reports, or power factor correction studies only. The normal fault level information is not to be used for equipment rating purposes.

Yours truly,

Marc Robert

PROVINCE OF MANITOBA
2009-08-13
D. N. SHELVEY
Member
24784
REGISTERED PROFESSIONAL ENGINEER

APEGM
Certificate of Authorization
Manitoba Hydro
No. 38 Date: 2009 08 12

MR/mr/409N20_1256 Wolseley Ave_Arc Fault Memo_2009 08 12.doc

SNC·LAVALIN

APPENDIX C : MANITOBA HYDRO FAULT LEVEL REPORTS – WASTEWATER LIFT STATION

MANITOBA HYDRO
INTEROFFICE MEMORANDUM

FROM R. P. Peech C.E.T.
Technical Assistant - Protection
Distribution Planning & Protection
Distribution Engineering - Winnipeg Dept.
820 Taylor Ave. (1), Winnipeg, MB

TO Brian Adamyk
South East Energy Services Advisor
Major Account Department
Customer Care & Marketing
360 Portage Ave (6), Winnipeg MB

DATE 2010 12 10

SUBJECT UTILITY INFORMATION REQUIRED FOR CLIFTON PUMPING STATION

Customer Information
Name: City of Winnipeg Water & Waste
Address: **1256 Wolseley Ave**

Source Information
Station: **Arlington & Empress**
Feeder: **409N20**

347/600V Supply Transformer Information
kVA: 3 X 37.5 = 112.5 kVA
Secondary Voltage: 600V
Connection: Wye - Delta
Minimum Impedance: 1.5%
Primary Protection[1]: Cooper T-Tin 25T Fuses

PROVINCE OF MANITOBA K. J. BRAID Member 22259 REGISTERED PROFESSIONAL ENGINEER

Fault Levels at Point of Delivery[2, 3]

Switching Configuration	Voltage (kV)	LLL (Amps)	LG (Amps)	R1 (pu)	X1 (pu)	R0 (pu)	X0 (pu)
Normal System Operation[4]	4.16	8523	4479	0.6996	1.4703	4.9649	3.8336
Empress & Arlington Stn Banks Paralleled - FNET Source	4.16	9548	4758	0.6531	1.2986	4.8977	3.5739

Impedances are per unit on a 100MVA base

Notes
1. Manitoba Hydro sources replacement fuses from various manufacturers, therefore the fuse stated above is only representative of the fuse installed
2. These values are reflective of the normal and expected maximum available fault levels at the customer location, depending on the configuration of the supply, and can be used for arc flash hazard calculation.
3. These values are valid for the system configuration at the time of this study. These fault levels and impedances can change in the future as a result of changes to the Manitoba Hydro system, including feeder reconfiguration or reconductoring, increasing the size of substation transformers and from new or reconductored subtransmission lines. While these changes are infrequent in nature, they are not uncommon and Manitoba Hydro does not communicate changes in fault level or impedance information to customers unless a new request is initiated.
4. The Normal switching configuration is intended for overcurrent protection coordination studies, power quality studies, harmonic assessment and mitigation reports, or power factor correction studies only. The normal fault level information is not to be used for equipment rating purposes.

R. P. Peech

APEGM
Certificate of Authorization
Manitoba Hydro
No. 38 Date: December 10, 2010

RPP/rpp/409N20_1256 Wolseley Ave_Arc Fault Memo_2010 12 10.doc

APPENDIX D : SKM INPUT DATA

ALL PU VALUES ARE EXPRESSED ON A 100 MVA BASE.

```
                                          FEEDER  INPUT  DATA
===============================================================================================================
CABLE         FEEDER FROM     FEEDER TO       QTY  VOLTS   LENGTH            FEEDER
NAME          NAME            NAME            /PH  L-L                   SIZE       TYPE
===============================================================================================================
CP-CB-P-F1    SPL-F1          CB-P-F1          1    600  0.900 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                 Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m        0.0377 + J  0.0291  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m        0.1186 + J  0.0717  PU

CP-CB-P-F2    SPL-F1          CB-P-F2          1    600  0.900 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                 Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m        0.0377 + J  0.0291  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m        0.1186 + J  0.0717  PU

CP-CB-P-F3    SPL-F1          CB-P-F3          1    600  0.900 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                 Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m        0.0377 + J  0.0291  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m        0.1186 + J  0.0717  PU

CP-CB-P-F4    SPL-F1          CB-P-F4          1    600  0.900 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                 Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m        0.0377 + J  0.0291  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m        0.1186 + J  0.0717  PU

CP-CON-F11    PNL-F10         CON-f11          1    240  0.500 METER       2     Copper
              Duct Material:     Magnetic     Insulation Type:                 Insulation Class:       THWN
              +/-  Impedance: 0.6627 + J  0.1919  Ohms/1000 m        0.5753 + J  0.1666  PU
              Z0   Impedance:   2.09 + J  0.4724  Ohms/1000 m          1.81 + J  0.4101  PU

CP-EF-F7      MS-EF-F7        BUS-0025         1    600    3.0 METER      12     Copper
              Duct Material:     Magnetic     Insulation Type:                 Insulation Class:       THWN
              +/-  Impedance:   6.14 + J  0.2986  Ohms/1000 m          5.11 + J  0.2488  PU
              Z0   Impedance:  19.34 + J  0.7352  Ohms/1000 m         16.11 + J  0.6127  PU

CP-FDS-EF-F7  SPL-F10         FDS-EF-F7        1    600  0.600 METER      10     Copper
              Duct Material:     Magnetic     Insulation Type:                 Insulation Class:       THWN
              +/-  Impedance:   3.87 + J  0.2802  Ohms/1000 m        0.6452 + J  0.0467  PU
              Z0   Impedance:  12.20 + J  0.6900  Ohms/1000 m          2.03 + J  0.1150  PU

CP-FDS-P-F5   SPL-F10         FDS-P-F5         1    600  0.600 METER      10     Copper
              Duct Material:     Magnetic     Insulation Type:                 Insulation Class:       THWN
              +/-  Impedance:   3.87 + J  0.2802  Ohms/1000 m        0.6452 + J  0.0467  PU
              Z0   Impedance:  12.20 + J  0.6900  Ohms/1000 m          2.03 + J  0.1150  PU

CP-FDS-SP-F6  SPL-F10         FDS-SP-F6        1    600  0.600 METER      10     Copper
              Duct Material:     Magnetic     Insulation Type:                 Insulation Class:       THWN
              +/-  Impedance:   3.87 + J  0.2802  Ohms/1000 m        0.6452 + J  0.0467  PU
              Z0   Impedance:  12.20 + J  0.6900  Ohms/1000 m          2.03 + J  0.1150  PU


                                          FEEDER  INPUT  DATA
===============================================================================================================
CABLE         FEEDER FROM     FEEDER TO       QTY  VOLTS   LENGTH            FEEDER
NAME          NAME            NAME            /PH  L-L                   SIZE       TYPE
===============================================================================================================
CP-FDS-SPL-F10SPL-F1          FDS-SPL-F10      1    600  0.900 METER       8     Copper
              Duct Material:     Magnetic     Insulation Type:                 Insulation Class:       THWN
              +/-  Impedance:   2.66 + J  0.2474  Ohms/1000 m        0.6652 + J  0.0619  PU
              Z0   Impedance:   8.39 + J  0.6089  Ohms/1000 m          2.10 + J  0.1522  PU

CP-MCC-L1     BUS-0045        CB-MCC-L1        1    600   16.7 METER     2/0   Aluminum
              Duct Material: Non-Magnetic     Insulation Type:                 Insulation Class:       THHN
              +/-  Impedance: 0.5479 + J  0.1083  Ohms/1000 m          2.54 + J  0.5024  PU
              Z0   Impedance: 0.8710 + J  0.2755  Ohms/1000 m          4.04 + J    1.28  PU

CP-MCC-L1-2   CB-MCC-L1       MCC-L1           1    600  0.900 METER     3/0     Copper
              Duct Material: Non-Magnetic     Insulation Type:         PVC     Insulation Class:       XLPE
              +/-  Impedance: 0.2743 + J  0.0965  Ohms/1000 m        0.0686 + J  0.0241  PU
              Z0   Impedance: 0.4363 + J  0.2454  Ohms/1000 m        0.1091 + J  0.0614  PU

CP-MCP-XFMR-L1MCC-L1          MCP-XFMR-L10     1    600    1.0 METER      10     Copper
              Duct Material: Non-Magnetic     Insulation Type:                 Insulation Class:       THWN
              +/-  Impedance:   3.87 + J  0.2700  Ohms/1000 m          1.08 + J  0.0750  PU
              Z0   Impedance:   6.15 + J  0.6867  Ohms/1000 m          1.71 + J  0.1908  PU
```

```
CP-MS-EF-F7   FDS-EF-F7       MS-EF-F7         1    600    6.0 METER      12     Copper
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance:   6.14 + J  0.2986  Ohms/1000 m        10.23 + J  0.4977  PU
              Z0   Impedance:  19.34 + J  0.7352  Ohms/1000 m        32.23 + J    1.23  PU

CP-MS-P-F1    CB-P-F1         MS-P-F1          1    600    1.8 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m       0.0753 + J  0.0582  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m       0.2373 + J  0.1434  PU

CP-MS-P-F2    CB-P-F2         MS-P-F2          1    600    1.8 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m       0.0753 + J  0.0582  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m       0.2373 + J  0.1434  PU

CP-MS-P-F3    CB-P-F3         MS-P-F3          1    600    1.8 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m       0.0753 + J  0.0582  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m       0.2373 + J  0.1434  PU

CP-MS-P-F4    CB-P-F4         MS-P-F4          1    600    1.8 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m       0.0753 + J  0.0582  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m       0.2373 + J  0.1434  PU


                                          FEEDER  INPUT  DATA
===============================================================================================================
CABLE         FEEDER FROM     FEEDER TO       QTY  VOLTS   LENGTH            FEEDER
NAME          NAME            NAME            /PH  L-L                   SIZE       TYPE
===============================================================================================================
CP-MS-P-F5    FDS-P-F5        MS-P-F5          1    600    4.5 METER      12     Copper
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance:   6.14 + J  0.2986  Ohms/1000 m         7.67 + J  0.3732  PU
              Z0   Impedance:  19.34 + J  0.7352  Ohms/1000 m        24.17 + J  0.9190  PU

CP-P-F1       MS-P-F1         BUS-0032         1    600    4.5 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m       0.1883 + J  0.1456  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m       0.5932 + J  0.3585  PU

CP-P-F2       MS-P-F2         BUS-0036         1    600    4.5 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m       0.1883 + J  0.1456  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m       0.5932 + J  0.3585  PU

CP-P-F3       MS-P-F3         BUS-0037         1    600    4.5 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m       0.1883 + J  0.1456  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m       0.5932 + J  0.3585  PU

CP-P-F4       MS-P-F4         BUS-0038         1    600    4.5 METER     500   Aluminum
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.1506 + J  0.1165  Ohms/1000 m       0.1883 + J  0.1456  PU
              Z0   Impedance: 0.4746 + J  0.2868  Ohms/1000 m       0.5932 + J  0.3585  PU

CP-P-F5       MS-P-F5         BUS-0023         1    600    2.7 METER      12     Copper
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance:   6.14 + J  0.2986  Ohms/1000 m         4.60 + J  0.2239  PU
              Z0   Impedance:  19.34 + J  0.7352  Ohms/1000 m        14.50 + J  0.5514  PU

CP-P-L1       MCC-L1          BUS-0019         1    600   10.0 METER       6     Copper
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance:   1.67 + J  0.2247  Ohms/1000 m         4.65 + J  0.6242  PU
              Z0   Impedance:   5.27 + J  0.5535  Ohms/1000 m        14.65 + J    1.54  PU

CP-P-L2       MCC-L1          BUS-0021         1    600   10.0 METER       6     Copper
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance:   1.67 + J  0.2247  Ohms/1000 m         4.65 + J  0.6242  PU
              Z0   Impedance:   5.27 + J  0.5535  Ohms/1000 m        14.65 + J    1.54  PU

CP-PNL-F10    CB-PNL-F10      PNL-F10          1    240  0.500 METER     4/0   Aluminum
              Duct Material: Non-Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.3445 + J  0.1017  Ohms/1000 m       0.2990 + J  0.0883  PU
              Z0   Impedance: 0.5477 + J  0.2588  Ohms/1000 m       0.4754 + J  0.2247  PU

                                          FEEDER  INPUT  DATA
===============================================================================================================
CABLE         FEEDER FROM     FEEDER TO       QTY  VOLTS   LENGTH            FEEDER
NAME          NAME            NAME            /PH  L-L                   SIZE       TYPE
===============================================================================================================
CP-PNL-F10-1  BUS-0034        METERING         1    240   56.0 METER       2   Aluminum
              Duct Material: Non-Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance:   1.10 + J  0.1214  Ohms/1000 m       106.86 + J   11.80  PU
              Z0   Impedance:   1.75 + J  0.3089  Ohms/1000 m       169.88 + J   30.03  PU
```

```
CP-PNL-F10-2  METERING        CB-PNL-F10       1    240    5.0 METER     2/0   Aluminum
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.5479 + J  0.1345  Ohms/1000 m         4.76 + J    1.17  PU
              Z0   Impedance:   1.73 + J  0.3313  Ohms/1000 m        14.99 + J    2.88  PU

CP-PNL-F11    CON-f11         PNL-F11          1    240  0.300 METER       2     Copper
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.6627 + J  0.1919  Ohms/1000 m       0.3452 + J  0.1000  PU
              Z0   Impedance:   2.09 + J  0.4724  Ohms/1000 m         1.09 + J  0.2461  PU

CP-PNL-L10    XFMR-L10-S      PNL- L10         1    208  0.900 METER       2     Copper
              Duct Material: Non-Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.6627 + J  0.1532  Ohms/1000 m         1.38 + J  0.3187  PU
              Z0   Impedance:   1.05 + J  0.3898  Ohms/1000 m         2.19 + J  0.8108  PU

CP-RLY-F1     FDS-SPL-F10.L   RLY-F1           1    600  0.300 METER      12     Copper
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance:   6.14 + J  0.2986  Ohms/1000 m       0.5113 + J  0.0249  PU
              Z0   Impedance:  19.34 + J  0.7352  Ohms/1000 m         1.61 + J  0.0613  PU

CP-SPL-F1     XFMR-F1-S       SPL-F1           2    600    1.8 METER     500     Copper
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance: 0.0965 + J  0.1529  Ohms/1000 m       0.0241 + J  0.0382  PU
              Z0   Impedance: 0.3038 + J  0.3763  Ohms/1000 m       0.0759 + J  0.0941  PU

CP-SPL-F10-2  FDS-SPL-F10.L   SPL-F10          1    600  0.100 METER       8     Copper
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance:   2.66 + J  0.2474  Ohms/1000 m       0.0739 + J  0.0069  PU
              Z0   Impedance:   8.39 + J  0.6089  Ohms/1000 m       0.2329 + J  0.0169  PU

CP-XFMR-L10   MCP-XFMR-L10    XFMR-L10-P       1    600  0.300 METER      10     Copper
              Duct Material: Non-Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance:   3.87 + J  0.2700  Ohms/1000 m       0.3226 + J  0.0225  PU
              Z0   Impedance:   6.15 + J  0.6867  Ohms/1000 m       0.5129 + J  0.0572  PU

FDS-SPL-F10.CPFDS-SPL-F10     FDS-SPL-F10.L    1    600  0.200 METER       8     Copper
              Duct Material:     Magnetic     Insulation Type:                Insulation Class:       THWN
              +/-  Impedance:   2.66 + J  0.2474  Ohms/1000 m       0.1478 + J  0.0137  PU
              Z0   Impedance:   8.39 + J  0.6089  Ohms/1000 m       0.4659 + J  0.0338  PU

                           TRANSFORMER  INPUT  DATA
============================================================================================
TRANSFORMER    PRIMARY RECORD      VOLTS   * SECONDARY RECORD    VOLTS   FULL-LOAD    NOMINAL
NAME           NO NAME             L-L       NO NAME             L-L     KVA          KVA
============================================================================================
XFMR-F1        XFMR-F1-P       YG 4160.00   XFMR-F1-S      D    600.00 1000.00       999.00
               Pos. Seq. Z%:     0.741 + J   4.24    (Zpu  0.742 + j   4.24 )    Shell Type
               Zero Seq. Z%:     0.741 + J   4.24    (Pri  0.742 + j   4.24 Sec  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leading Sec.):  -30.0 Deg.

XFMR-L1        BUS-0009        D  4157.00   BUS-0045       YG    600.00  112.50       112.50
               Pos. Seq. Z%:     0.423 + J   1.44    (Zpu   3.77 + j  12.79 )    Shell Type
               Zero Seq. Z%:     0.423 + J   1.44    (Sec   3.77 + j  12.79 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leading Sec.):  30.00 Deg.

XFMR-L10-D     XFMR-L10-P      D   600.00   XFMR-L10-S     YG    208.00    9.00         9.00
               Pos. Seq. Z%:      1.31 + J   3.24    (Zpu  145.9 + j  360.4 )    Shell Type
               Zero Seq. Z%:      1.31 + J   3.24    (Sec  145.9 + j  360.4 Pri  Open)
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leading Sec.):  30.00 Deg.

XFMR-UTIL-240  BUS-0033        YG 4160.00   BUS-0034       YG    240.00   43.30        43.30
               Pos. Seq. Z%:     0.491 + J   1.42    (Zpu  11.35 + j  32.73 )    Shell Type
               Zero Seq. Z%:     0.491 + J   1.42    (      Pri - Sec: 11.35 + j  32.73 )
               Taps  Pri. 0.000 %  Sec. 0.000 %  Phase Shift (Pri. Leading Sec.):  0.000 Deg.


                       GENERATION  CONTRIBUTION  DATA
====================================================================================
BUS            CONTRIBUTION    VOLTAGE
NAME           NAME              L-L     MVA      X"d    X/R
====================================================================================
BUS-0009       UTIL-L1         4160.00   68.80
                  Three Phase           Contribution:    9547.87 AMPS       1.99
                  Single Line to Ground Contribution:    4758.12 AMPS     0.9947
                  Pos  Sequence Impedance (100 MVA Base)  0.6531 + J     1.30 PU
                  Zero Sequence Impedance (100 MVA Base)    4.90 + J     3.57 PU

BUS-0033       UTIL-240        4160.00 5177.59
                  Three Phase           Contribution:    718577. AMPS       1.74
                  Single Line to Ground Contribution:    484783. AMPS     0.9365
                  Pos  Sequence Impedance (100 MVA Base)  0.0096 + J   0.0167 PU
                  Zero Sequence Impedance (100 MVA Base)  0.0434 + J   0.0252 PU

XFMR-F1-P      UTIL-F1         4160.00   64.40
                  Three Phase           Contribution:    8937.63 AMPS       2.10
                  Single Line to Ground Contribution:    4643.73 AMPS       1.05
                  Pos  Sequence Impedance (100 MVA Base)  0.6678 + J     1.40 PU
                  Zero Sequence Impedance (100 MVA Base)    4.86 + J     3.67 PU
```

MOTOR CONTRIBUTION DATA

```
                            MOTOR  CONTRIBUTION  DATA
=====================================================================================
BUS            CONTRIBUTION      VOLTAGE    BASE                               Motor
NAME           NAME                L-L      kVA        X"d    X/R          Number
=====================================================================================
BUS-0019       P-L1                 600   29.41      0.1622    3.18  1.00
                  Pos  Sequence Impedance (100 MVA Base)  173.44 + j  551.51 PU

BUS-0021       P-L2                 600   29.41      0.1622    3.18  1.00
                  Pos  Sequence Impedance (100 MVA Base)  173.44 + j  551.51 PU

BUS-0023       P-F5                 600   13.10      0.1622    3.18  1.00
                  Pos  Sequence Impedance (100 MVA Base)  389.53 + j 1238.63 PU

BUS-0025       EF-F7                600    1.00      0.1692    10.0  1.00
                  Pos  Sequence Impedance (100 MVA Base) 1687.46 + j 16874.6 PU

BUS-0032       P-F1                 600  223.44      0.1692    10.0  1.00
                  Pos  Sequence Impedance (100 MVA Base)    7.57 + j   75.72 PU

BUS-0036       P-F2                 600  223.09      0.1692    10.0  1.00
                  Pos  Sequence Impedance (100 MVA Base)    7.58 + j   75.85 PU

BUS-0037       P-F3                 600  223.09      0.1692    10.0  1.00
                  Pos  Sequence Impedance (100 MVA Base)    7.58 + j   75.85 PU

BUS-0038       P-F4                 600  223.09      0.1692    10.0  1.00
                  Pos  Sequence Impedance (100 MVA Base)    7.58 + j   75.85 PU
```

APPENDIX E : ANSI FAULT SUMMARY

F A U L T S T U D Y S U M M A R Y
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

BUS RECORD NO NAME	VOLTAGE L-L	A V A I L A B L E F A U L T D U T I E S (KA) 3 PHASE	X/R	LINE/GRND	X/R
CB-MCC-L1	600.	6.280	2.15	6.180	2.02
CB-P-F1	600.	21.343	5.11	0.000	1.00
CB-P-F2	600.	21.343	5.11	0.000	1.00
CB-P-F3	600.	21.343	5.11	0.000	1.00
CB-P-F4	600.	21.343	5.11	0.000	1.00
CON-f11	240.	1.821	0.37	1.524	0.35
FDS-EF-F7	600.	18.728	1.91	0.000	1.00
FDS-P-F5	600.	18.736	1.91	0.000	1.00
FDS-SP-F6	600.	18.728	1.91	0.000	1.00
FDS-SPL-F10	600.	20.394	2.97	0.000	1.00
FDS-SPL-F10.L	600.	20.117	2.71	0.000	1.00
MCC-L1	600.	6.261	2.13	6.154	2.00
MCP-XFMR-L10	600.	6.043	1.84	5.885	1.70
METERING	240.	1.904	0.38	1.624	0.36
MS-EF-F7	600.	7.052	0.40	0.000	1.00
MS-P-F1	600.	21.036	4.84	0.000	1.00
MS-P-F2	600.	21.036	4.84	0.000	1.00
MS-P-F3	600.	21.036	4.84	0.000	1.00
MS-P-F4	600.	21.036	4.84	0.000	1.00
MS-P-F5	600.	8.590	0.50	0.000	1.00
PNL- L10	208.	0.684	2.41	0.693	2.42
PNL-F10	240.	1.829	0.37	1.534	0.36
PNL-F11	240.	1.816	0.37	1.518	0.35
RLY-F1	600.	19.184	2.08	0.000	1.00
SPL-F1	600.	21.499	5.26	0.000	1.00
SPL-F10	600.	19.976	2.60	0.000	1.00
XFMR-F1-S	600.	21.611	5.26	0.000	1.00
XFMR-L10-P	600.	5.977	1.77	5.804	1.63
XFMR-L10-S	208.	0.686	2.43	0.695	2.45

APPENDIX F : ARC FLASH OPTIONS

Arc Flash Options Report

Client	SKM Systems Analysis, Inc.				
Location	Main Plant				
Project	Clifton - Scenario(1): Phase1 - Maximum Fault Level				
Job #	SAMPLE	Date	08/05/02	Engineer	SKM
Standard	IEEE 1584 - 2002/2004a Edition				
Unit	English				

Flash Boundary Calculation Adjustments
Equipment above 1 kV and Trip Time <= 0.1 seconds, use 1.5 cal/cm^2 (6.276 J/cm^2) for flash boundary calculation

Equipment 240 V and Below
Report as category 0 if fed by one transformer size < 125 kVA

Short Circuit Options

Include Transformer Tap	Yes	Pre-Fault Option	No Load with Tap
Include Transformer Phase Shift	No	Define Grounded as SLG/3P Fault >=	5 %
Include Induction Motor Contribution	5.0 cycles	Current Limiting Fuse	Specified in library
Reduce Generator/Synch. Motor Contribution to	Do not represent generator and synchronous motor decay		
Line Side Incident Energy Calculation	Include line side + load side fault contributions		
Recalculate Trip Time Using Reduced Current	No	Mis-Coordination Levels to search	1
Use Arc Flash Equations for Breakers and Fuses	Yes	Mis-Coordination Ratio	80 %

Report Options

Report Option	Bus Report	Arcing Fault Tolerance		
Label and Summary View	Report Main Device	Low Voltage In Box	(-15%)	(0%)
Check Upstream Device for Mis-Coordination	Yes	Low Voltage Open Air	(-15%)	(0%)
Cleared Fault Threshold	80.0 %	HV/MV In Box	(0%)	(0%)
Max Arcing Duration	2 seconds	HV/MV Open Air	(0%)	(0%)
Increase PPE Category by 1 for high marginal IE	No			

Notes

APPENDIX G : ARC FLASH RESULTS (PHASE 1 MITIGATION)

Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category
CB-MCC-L1	FDS-UTIL-L1	0.600	4.64	3.29	4.64	3.3	0.27	0	PNL	25	30	18	2.7	Category 1 (*N3) (*S5)
CB-P-F1	FDS-UTIL-F1	0.600	14.1	9.14	14.1	9.14	0.612	0	PNL	25	112	18	23.9	Category 3 (*N3) (*S5)
CB-P-F2	FDS-UTIL-F1	0.600	14.1	9.14	14.1	9.14	0.612	0	PNL	25	112	18	23.9	Category 3 (*N3) (*S5)
CB-P-F3	FDS-UTIL-F1	0.600	14.1	9.14	14.1	9.14	0.612	0	PNL	25	112	18	23.9	Category 3 (*N3) (*S5)
CB-P-F4	FDS-UTIL-F1	0.600	14.1	9.14	14.1	9.14	0.612	0	PNL	25	112	18	23.9	Category 3 (*N3) (*S5)
CON-f11	CB-PNL-F11	0.240	1.82	1.34	1.82	1.34	1.078	0	PNL	25	18	18	1.2	Category 0 (*N15) (*S1)
FDS-EF-F7	FDS-SPL-F10-D	0.600	18.7	14	18.7	14	0.01	0	PNL	25	12	18	0.6	Category 0 (*S1)
FDS-P-F5	FDS-SPL-F10-D	0.600	18.7	14	18.7	14	0.01	0	PNL	25	12	18	0.6	Category 0 (*S1)
FDS-SP-F6	FDS-SPL-F10-D	0.600	18.7	14	18.7	14	0.01	0	PNL	25	12	18	0.6	Category 0 (*S1)
FDS-SPL-F10	FDS-UTIL-F1	0.600	13.6	8.84	13.6	8.84	0.657	0	PNL	25	114	18	24.8	Category 3 (*N3) (*S5)
FDS-SPL-F10.L	FDS-SPL-F10-D	0.600	20.1	15	20	14.9	0.01	0	PNL	25	13	18	0.7	Category 0 (*S1)
MCC-L1	CB-MCC-L1_	0.600	6.27	5.11	5.94	4.84	0.01	0	PNL	25	5	18	0.2	Category 0 (*S1)
MCP-XFMR-L10	CB-MCC-L1_	0.600	6.05	4.94	5.73	4.69	0.01	0	PNL	25	5	18	0.2	Category 0 (*S1)
METERING	CB-PNL-F10-D	0.240	1.90	1.38	0.00	0.00	2	0	PNL	25	18	18	1.2	Category 0 (*N2) (*N9) (*N15) (*S1)
MS-EF-F7	FDS-EF-F7-D	0.600	7.05	5.70	7.05	5.69	0.01	0	PNL	25	7	18	0.2	Category 0 (*S1)
MS-P-F1	CB-P-F1-D	0.600	21.04	15.59	19.79	14.67	0.016	0	PNL	25	18	18	1.1	Category 0 (*S1)
MS-P-F2	CB-P-F2-D	0.600	21.04	15.59	19.79	14.67	0.016	0	PNL	25	18	18	1.1	Category 0 (*S1)
MS-P-F3	CB-P-F3-D	0.600	21.04	15.59	19.79	14.67	0.016	0	PNL	25	18	18	1.1	Category 0 (*S1)
MS-P-F4	CB-P-F4-D	0.600	21.04	15.59	19.79	14.67	0.016	0	PNL	25	18	18	1.1	Category 0 (*S1)
MS-P-F5	FDS-P-F5-D	0.600	8.59	6.83	8.54	6.79	0.01	0	PNL	25	8	18	0.3	Category 0 (*S1)
PNL- L10	MCP-XFMR-L10-D	0.208	0.68	0.68	0.68	0.68	0.01	0	PNL	25	1	18	0.0	Category 0 (*N11) (*N15) (*S1)
PNL-F10	CB-PNL-F10-D	0.240	1.83	1.34	1.83	1.34	2	0	PNL	25	18	18	1.2	Category 0 (*N9) (*N15) (*S1)
PNL-F11	CB-PNL-F11	0.240	1.82	1.34	1.82	1.34	1.081	0	PNL	25	18	18	1.2	Category 0 (*N15) (*S1)

SNC·LAVALIN

Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category
RLY-F1	FDS-SPL-F10-D	0.600	19.18	14.32	19.11	14.27	0.01	0	PNL	25	12	18	0.6	Category 0 (*S1)
SPL-F1	FDS-UTIL-F1	0.600	14.13	9.19	14.13	9.19	0.605	0	PNL	25	111	18	23.7	Category 3 (*N3) (*S5)
SPL-F10	FDS-SPL-F10-D	0.600	19.98	14.87	19.90	14.81	0.01	0	PNL	25	13	18	0.7	Category 0 (*S1)
XFMR-F1-P	FDS-UTIL-F1	4.160	9.51	9.24	8.94	8.68	0.032	0	SWG	104	8	36	0.3	Category 0 (*S1)
XFMR-F1-S	FDS-UTIL-F1	0.600	14.22	9.24	14.22	9.24	0.597	0	PNL	25	111	18	23.6	Category 3 (*N3) (*S5)
XFMR-L10-P	MCP-XFMR-L10-D	0.600	5.98	4.89	5.98	4.89	0.01	0	PNL	25	5	18	0.2	Category 0 (*S1)
XFMR-L10-S	MCP-XFMR-L10-D	0.208	0.69	0.69	0.69	0.69	0.01	0	PNL	25	1	18	0.0	Category 0 (*N11) (*N15) (*S1)
Category 0: Untreated Cotton	0.0 - 1.2 cal/cm^2												#Cat 0 = 22	(*N11) - Out of IEEE 1584 Range, Lee Equation Used. Applicable for Open Air only. Existing Equipment type is not Open Air!
Category 1: FR Shirt & Pants	1.2 - 4.0 cal/cm^2												#Cat 1 = 1	(*N2) < 80% Cleared Fault Threshold
Category 2: Cotton Underwear + FR Shirt & Pants	4.0 - 8.0 cal/cm^2												#Cat 2 = 0	(*N3) - Arcing Current Low Tolerances Used
Category 3: Cotton Underwear + FR Shirt & Pant + FR Coverall	8.0 - 25.0 cal/cm^2												#Cat 3 = 7	(*N9) - Max Arcing Duration Reached
Category 4: Cotton Underwear + FR Shirt & Pant + Multi Layer Flash Suit	25.0 - 40.0 cal/cm^2												#Cat 4 = 0	(*N15) - Report as category 0 if fed by one transformer size < 125 kVA

Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category
Category Dangerous!: No FR Category Found	40.0 - 999.0 cal/cm^2												#Danger = 0	IEEE 1584 - 2002/2004a Edition Bus Report (80% Cleared Fault Threshold, mis-coordination checked
													Worst Case	(*S1) - Phase1 - Maximum Fault Level
														(*S5) - Phase1 - Baseline Fault Level

LEGEND:

PPE: 4 — HAZARD/RISK CATEGORY
29 CAL/CM² — INCIDENT ENERGY

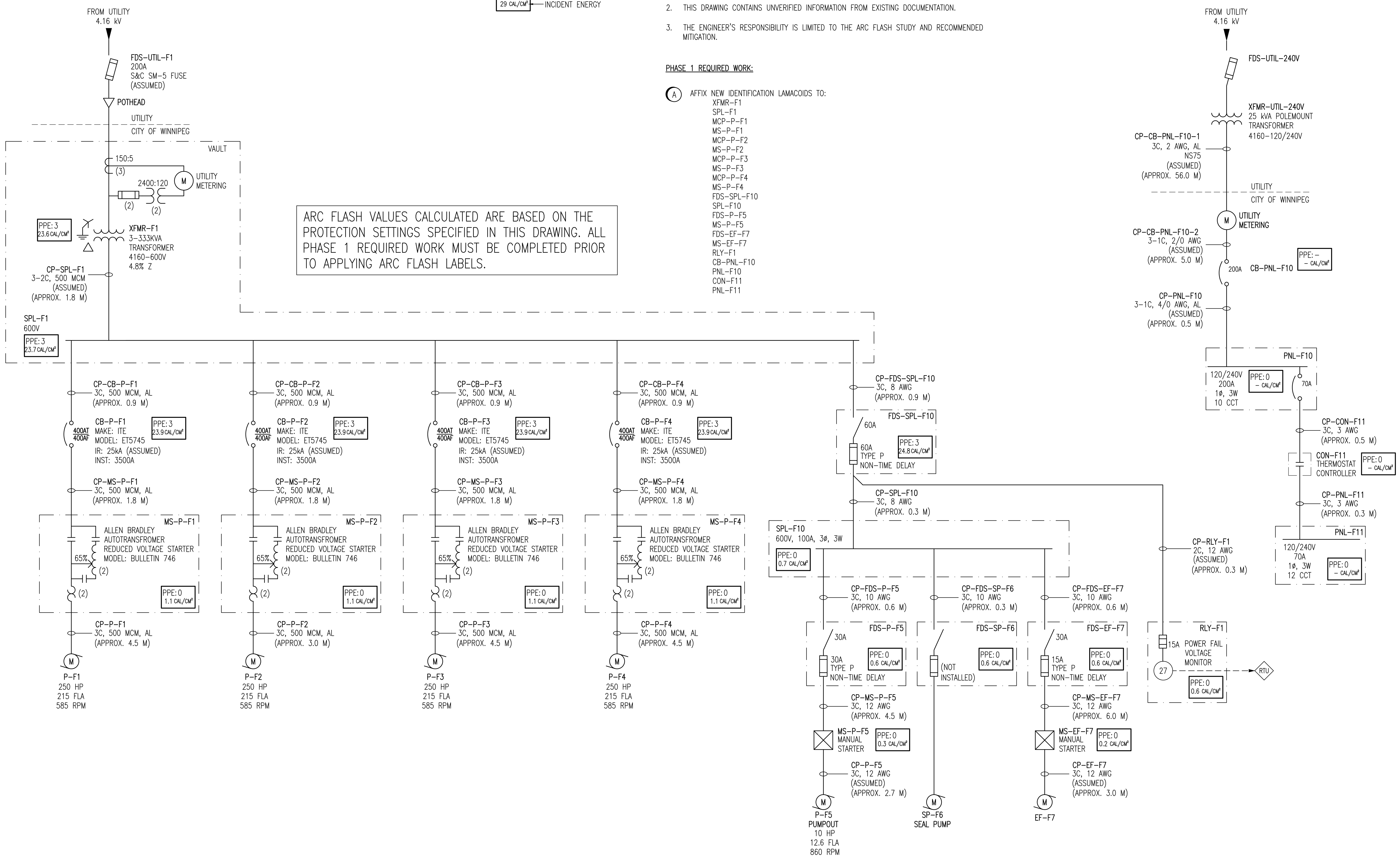
NOTES:

1. THIS DRAWING SUPERCEDES KGS DRAWING (DOES NOT HAVE A NUMBER).
2. THIS DRAWING CONTAINS UNVERIFIED INFORMATION FROM EXISTING DOCUMENTATION.
3. THE ENGINEER'S RESPONSIBILITY IS LIMITED TO THE ARC FLASH STUDY AND RECOMMENDED MITIGATION.

PHASE 1 REQUIRED WORK:

(A) AFFIX NEW IDENTIFICATION LAMACOIDS TO:
XFMR-F1
SPL-F1
MCP-P-F1
MS-P-F1
MCP-P-F2
MS-P-F2
MCP-P-F3
MS-P-F3
MCP-P-F4
MS-P-F4
FDS-SPL-F10
SPL-F10
FDS-P-F5
MS-P-F5
FDS-EF-F7
MS-EF-F7
RLY-F1
CB-PNL-F10
PNL-F10
CON-F11
PNL-F11

ARC FLASH VALUES CALCULATED ARE BASED ON THE PROTECTION SETTINGS SPECIFIED IN THIS DRAWING. ALL PHASE 1 REQUIRED WORK MUST BE COMPLETED PRIOR TO APPLYING ARC FLASH LABELS.



NO.	REVISIONS	DATE	DESIGN	CHECK
00	ISSUED FOR CITY USE	2011/05/19	APS	CJR

SNC·LAVALIN
SNC-LAVALIN INC.
148 Nature Park Way
Winnipeg, MB, Canada R3P 0X7
204-786-8080

DESIGNED BY: D. RAMJEET	CHECKED BY: C. REIMER
DRAWN BY: D. RAMJEET	APPROVED BY: C. REIMER
SCALE: NTS	RELEASED FOR CONSTRUCTION BY:
DATE: 2010/03/19	DATE:
CONSULTANT NO.:	

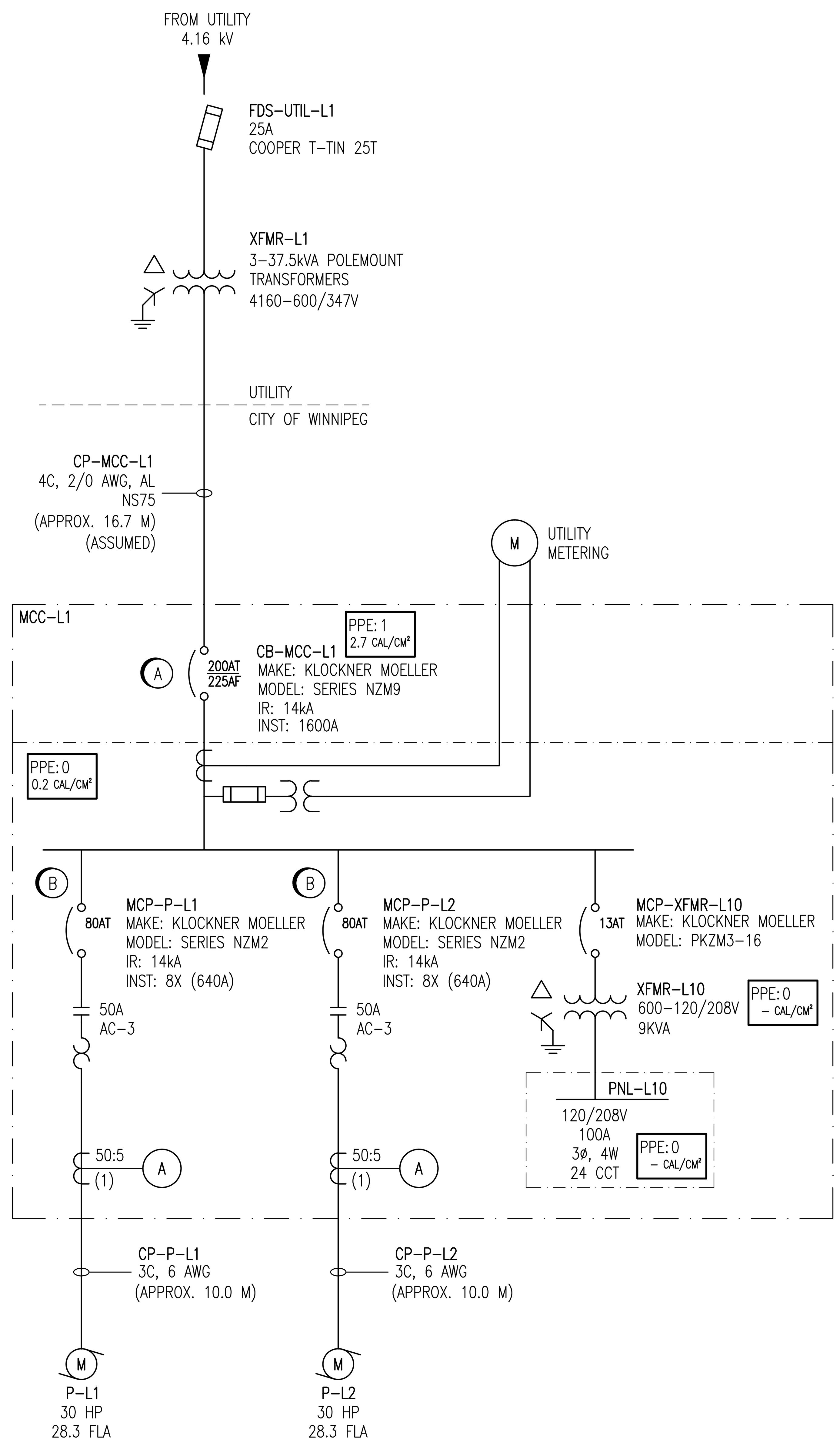
ENGINEER'S SEAL

ORIGINAL DRAWING SEALED BY:
C. J. REIMER
SNC-LAVALIN
MEMBER #21968
2011/05/19
REV. 00

Winnipeg
THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

CLIFTON FLOOD PUMPING STATION
ARC FLASH STUDY
SINGLE LINE DIAGRAM

CITY DRAWING NUMBER	SHEET	REV.	SIZE
1-0125F-E0001	001	00	A1



LEGEND:

PPE: 4 — HAZARD/RISK CATEGORY
29 CAL/CM² — INCIDENT ENERGY

NOTES:

1. THIS DRAWING CONTAINS UNVERIFIED INFORMATION FROM EXISTING DOCUMENTATION.
2. THE ENGINEER'S RESPONSIBILITY IS LIMITED TO THE ARC FLASH STUDY AND RECOMMENDED MITIGATION.
3. THE NEUTRAL CONDUCTOR IS NOT TERMINATED AT THE MASTHEAD.

PHASE 1 REQUIRED WORK:

(A) ADJUST THE CB-MCC-L1 INSTANTANEOUS SETTING TO 1600A.

(B) ADJUST THE INSTANTANEOUS SETTING OF MCP-P-L1 AND MCP-P-L2 TO IT'S MINIMUM SETTING (8X).

(C) AFFIX NEW IDENTIFICATION LAMACOIDS TO:
CB-MCC-L1
MCC-L1

ARC FLASH VALUES CALCULATED ARE BASED ON THE PROTECTION SETTINGS SPECIFIED IN THIS DRAWING. ALL PHASE 1 REQUIRED WORK MUST BE COMPLETED PRIOR TO APPLYING ARC FLASH LABELS.

NO.	REVISIONS	DATE	DESIGN	CHECK
00	ISSUED FOR CITY USE	2011/05/19	APS	CJR

SNC·LAVALIN
SNC-LAVALIN INC.
148 Nature Park Way
Winnipeg, MB, Canada R3P 0X7
204-786-8080

DESIGNED BY: EXISTING	CHECKED BY: C. REIMER
DRAWN BY: D. RAMJEET	APPROVED BY: C. REIMER
SCALE: NTS	RELEASED FOR CONSTRUCTION BY:
DATE: 2010/03/19	DATE:
CONSULTANT NO.:	

ENGINEER'S SEAL

ORIGINAL DRAWING
SEALED BY:
C. J. REIMER
SNC-LAVALIN
MEMBER #21968
2011/05/19
REV. 00

Winnipeg
THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

CLIFTON WASTEWATER LIFT STATION
ARC FLASH STUDY
SINGLE LINE DIAGRAM

CITY DRAWING NUMBER	SHEET	REV.	SIZE
1-0125L-E0001	001	00	A1

1-0125L-E0001-001-00.dwg

A1 SIZE - 594mm x 841mm

LAST SAVE: 2011/05/20 - 11:19am
PATH: M:\113286\4ENG\47ELE\00 - General DWG\1-0125L-E0001-001-00.dwg