

**EXHIBIT 10 - INTERROGATORY RESPONSES**

Exhibit 10, Tab 1, Schedule 2

Appendices to the Responses to Interrogatories from Board Staff

June 14, 2004

Great Lakes Power Limited  
2 Sackville Road  
Sault Ste. Marie, ON., P6B 6J6

**Attention: Berk Gursoy**  
**Title: Sr. Transmission Engineer**

Dear Sir

**Re: Transmission Station Grounding Grid  
Assessment and Measurements – Final Report  
GLP Contract No.: NEAM 2003-0028  
PwrTech Project No. : 03-014-02**

We are pleased to submit two (2) copies of the completed study report "Transmission Station Grounding Grid Assessment and Measurements, Final Report".

Should you wish further clarification of any information contained in this report, we would welcome the opportunity to be of service.

Yours truly,

**PwrTech Designs**



Barry Bingeman  
Lead Designer

BWB/bwb

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**Great Lakes Power Limited**  
**Sault Ste. Marie, ON**

**Transmission Station Grounding Grid**  
**Assessment and Measurements**

**FINAL REPORT**

**GLP Contract No.: NEAM 2003-0028**

**PwrTech Designs Project No.: 03014-02**

**June 14, 2004**



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## 1.0 INTRODUCTION AND SCOPE OF WORK

Great Lakes Power Limited retained the services of PwrTech Designs of Thunder Bay to perform additional grounding measurements and documentation of eight transmission substations. This follows the initial four transmission substations which were completed under PTD project 03014-01. The additional transmission substations studied are:

1. Anjigami TS
2. Clerque TS
3. Echo River TS
4. Hollingsworth TS
5. Magpie TS
6. Northern Ave TS
7. Patrick St./Steelton TS
8. Watson TS

PwrTech Designs retained the services of Procomm T.S.I. to provide grounding measurements and assist in the overall study objectives and analysis. KMH Engineering was retained to provide a technical review of modeled results and endorse the final report.

The objectives of the study are to measure and document the following:

1. Stone coverage of the area
2. Stone quality (measure resistivity of existing stone)
3. Inventory of #2/0 awg. single conductor loops or connections above ground occurrences.
4. Continuity of the main grounding grid and possible measuring of the grounding conductor size integrity of the grounding connections for all free-standing equipment or structures in switchyard (including fence grounding).
5. Confirmation of grid wire size in selected areas.
6. Soil resistivity.
7. Measured/calculated grid resistance to remote earth.
8. Measured/ calculated potential rise and comparison to modeled values.

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9. Calculated ground potential rise for a remote fault.
  10. Connection resistances between grid and fence, integrity along fence and integrity of gates.
  11. Ensure that all accessible non-current-carrying metal structures and equipment are maintained at the same potential.
  12. All measurements and calculations will be in accordance with IEEE 80.



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## 2.0 EXECUTIVE SUMMARY

Great Lakes Power Limited retained the services of PwrTech Designs of Thunder Bay to perform additional grounding measurements and documentation of eight transmission substations. This follows the initial four transmission substations which were completed throughout the summer and fall of 2003; PTD project 03014-01.

PwrTech Designs retained the services of Procomm T.S.I. to provide grounding measurements and assist in the overall study objectives and analysis. KMH Engineering was retained to provide a technical review of modeled results and endorse the final report.

Section 1.0 details the requirements and objectives of the study. Generally these may be summarized as: condition of the grid and fenced enclosure, soil resistivity measurements, grid resistance to remote earth and ground potential rise for existing short circuit values and for future distant short circuit values.

Field measurements were made during a three week period from October 20<sup>th</sup> through to November 6<sup>th</sup>, 2003. Environmental conditions during this period were near freezing temperatures with precipitation occurring most days. This has an effect on measured results. Extracted from IEEE standard 80-2000, contained in Appendix 9.4, is a summary chart indicating the effects of moisture, temperature and salt upon soil resistivity. We have not biased our measurements based on temperature and moisture.

Engineering drawings of the installed ground grid were provided to PwrTech Designs for each station examined. The drawings for recently reworked ground grids accurately reflected the installed system, older stations, such as Northern Ave., were more generalized and assumptions as to the installed system had to be made. We attempted to obtain the generation station ground grid drawings for the transmission stations which are inter-connected to the generation station grids. Drawings that were obtained did not accurately reflect installed grids. Anjigami TS is inter-connected to the adjacent Hydro One Station grid and this drawing was also not obtainable at the time of our analysis (a request is still in progress). For the Patrick

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St./Steelton substation, Algoma Steel was contacted and ground grid drawings were obtained for their portion of the station ground grid.

Ground grid layouts were modeled in computer analysis software: ETAP Power Station by Operation Technology Inc. Soil resistivity measurements were utilized in the computer model to reflect actual conditions. Conductor grid layouts were based on the engineering drawings provided and obtained. Current split factors have been considered based on present installed transmission and distribution circuits.

In our analysis we have compared the computer modeled results to the measured results and also to hand calculated results. Existing short circuit fault values have been considered in the initial analysis. These values, provided by GLP, are summarized in Appendix 9.3. The results of this analysis are summarized in "Table 2 - Tabulated Study Results, Existing Fault Considerations". Detail calculations have not been included in this report. Distant Future short circuit values have also been considered. The results of this analysis are summarized in "Table 1 - Tabulated Study Results, Distant Future Fault Considerations".

Transmission stations which are interconnected with the Generating stations could not be modeled accurately because of the unknown systems. We have based our calculations and analysis on the measured values. It is strongly recommended that some stations be revisited for additional measurements. These stations are Anjigami, Clerque, Hollingsworth, Magpie and Watson TS.

Detail comments for each specific Transmission Substation analyzed are contained in section 6.x.14 of the Detail Substation Results.

## DISTANT FUTURE CONSIDERATIONS

LOCATION	Rg Ω		Sf	IG (kA)		GPR (Volts)		Safe Potential		
	Measured	Program		Hand Calc	Program	Hand Calc	Measured	Program	Hand Calc	Touch (V)
Anjigami - 115 kV Future	0.73	18.30	19.40	38%	3.98	3.98	2905	****	631	1858
Clerque - 115 kV Future	1.20	1.47	1.51	22%	3.46	3.46	4153	5094	860	2775
Echo River- 230 kV Future	1.02	0.88	0.91	43%	2.71	2.70	2754	2386	287	480
Hollingsworth- 115 kV Future	13.10	31.10	31.80	20%	0.53	0.53	6943	****	1136	3878
Magpie - 115 kV Future	5.70	6.81	7.37	20%	0.74	0.74	4218	5046	573	1626
Northern Ave. - 115 kV Future	0.62	0.68	0.61	48%	7.41	7.43	4514	5030	308	569
Patrick/Steelton - 115 kV Future	1.51	1.54	1.22	9%	1.86	1.88	2838	2876	1434	5070
Watson - 115 kV Future	8.20	22.14	23.50	15%	0.46	0.46	3772	****	1250	4334

1. Safe Touch and Step Potentials indicated are based on 70 kg body weight and 0.5 sec. clearing time

2. See specific section for determination of Split factor (Sf)

## TABLE 1 - TABULATED STUDY RESULTS DISTANT FUTURE CONSIDERATIONS



## EXISTING FAULT CONSIDERATIONS

LOCATION	Rg Ω		Sf	IG (kA)		GPR (Volts)		Safe Potential		
	Measured	Program		Hand Calc	Program	Measured	Program	Hand Calc	Touch (V)	Step (V)
Anjigami - 115 kV Existing	0.73	18.30	19.40	38%	3.85	3.83	2796	****	631	1858
Clerque - 115 kV Existing	1.20	1.47	1.51	22%	2.23	2.23	2671	3277	860	2775
Echo River - 230 kV Existing	1.02	0.88	0.91	43%	1.72	1.72	1754	1513	287	480
Hollingsworth - 115 kV Existing	13.10	31.10	31.80	20%	0.45	0.45	5960	****	1136	3877
Magpie - 115 kV Existing	5.70	6.81	7.37	20%	0.68	0.68	3858	4607	573	1626
Northern Ave - 115 kV Existing	0.62	0.68	0.61	48%	4.58	4.61	2858	3112	308	569
Patrick/Steelton - 115 kV Existing	1.51	1.54	1.22	9%	1.09	1.09	1639	1681	1434	5070
Watson - 115 kV Existing	8.20	22.14	23.50	15%	0.40	0.40	3243	****	1250	4334

1. Safe Touch and Step Potentials indicated are based on 70 kg body weight and 0.5 sec. clearing time
2. See specific section for determination of Split factor (Sf)

## TABLE 2 - TABULATED STUDY RESULTS EXISTING FAULT CONSIDERATIONS



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## 3.0 MEASUREMENT APPARATUS and METHODOLOGY

Two earth resistance testers were used to measure soil resistivity. Both units are manufactured by Biddle Megger Instruments.

Models used were DET2/2 Auto Earth Tester and ET6/3 Earth Tester.

For all transmission substations measured the "Slope Method" was used. Refer to the Appendix for a description of this methodology. Details of measurements and results are shown in the specific substation tab in Section 6.0.



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## 4.0 ENVIRONMENTAL CONDITIONS

Field measurements were made during a three week period from October 20<sup>th</sup> through to November 6<sup>th</sup>, 2003.

Weather conditions during all three weeks were wet and cold. Temperatures were typically 0°C to +8°C. Precipitation occurred almost every day in the form of rain or snow. Ground conditions were wet but no freezing had occurred.



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## 5.0 COMPUTER SOFTWARE

ETAP Power Station version 4.7.0.C by Operation Technology Inc. was used to perform the grounding calculations and modeling. This program performs calculations based on the following standards and methods:

- IEEE 80-1986
- IEEE 80-2000
- IEEE 665-1995
- Finite Element

The substation grids for all sites studied are of irregular shape and complexity. The Finite Element method has been selected for modeling of the systems.

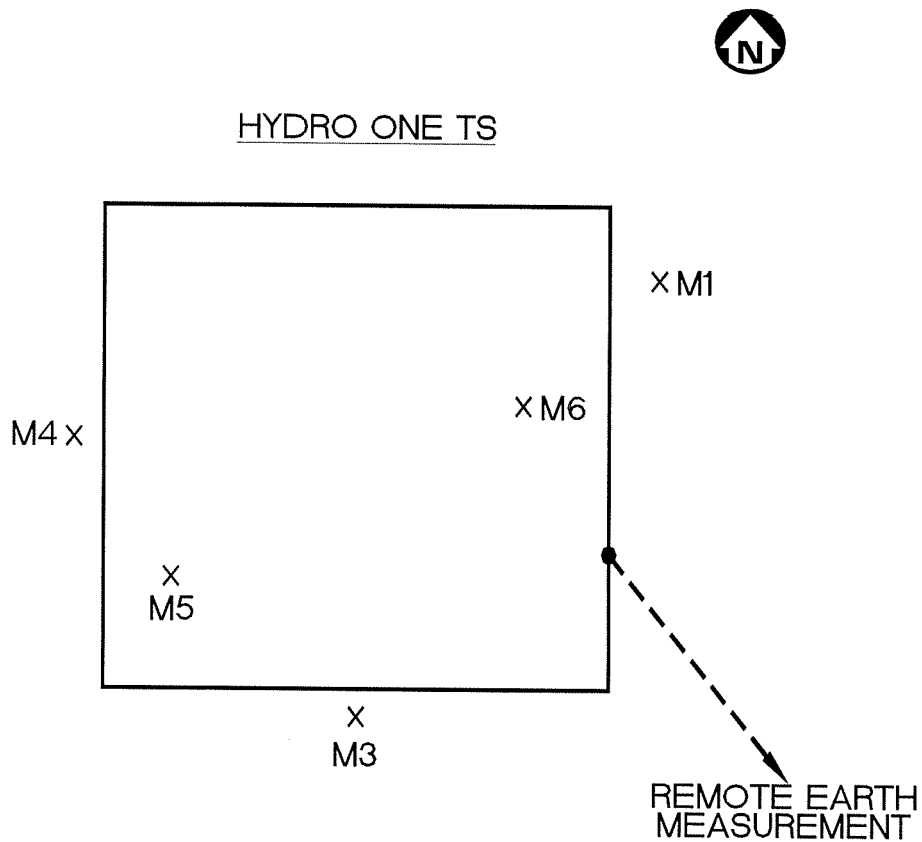




## 6.0 DETAIL SUBSTATION RESULTS

### 6.1 Anjigami TS

#### 6.1.1 Soil Resistivity Measurement Locations



## 6.1.2 Resistivity Measurement

Soil resistivity has been calculated based on the following:

$$P = 2\pi aR$$

$a$  = Rod Spacing

$R$  = Resistivity Measurement

Measurement Location	Probe Spacing	Resistance Measured	Calculated Soil Resistivity
M1	0.76 M	284 $\Omega$	1359 $\Omega \cdot M$
M2	0.91 M	536 $\Omega$	3079 $\Omega \cdot M$
M3	0.91 M	165 $\Omega$	947 $\Omega \cdot M$
M4	0.91 M	381 $\Omega$	2189 $\Omega \cdot M$
M5	0.305 M	556 $\Omega$	1065 $\Omega \cdot M$
M6	0.305 M	490 $\Omega$	939 $\Omega \cdot M$

Modeling Values Used:

1. Surface            Stone            1000  $\Omega \cdot M$
2. Upper Surface    Moist Soil      2000  $\Omega \cdot M$
3. Lower Surface    Moist Soil      2000  $\Omega \cdot M$

## 6.1.3 Ground Resistance Measurements

Measurement Location:

The test ground electrode used is indicated on the measurement location sketch

6.1.1. Current probe C1 was located in a south east direction, 800 ft. from test electrode. Potential probe P1 measurements were made at approximately 100 ft. intervals between test electrode and current probe C1.

Measurements obtained:

Position No.	Distance	Resistance
1	160 ft.	0.358 $\Omega$
2	200 ft.	0.414 $\Omega$
3	320 ft.	0.576 $\Omega$
4	400 ft.	0.732 $\Omega$
5	480 ft.	0.854 $\Omega$
6	600 ft.	1.076 $\Omega$
7	700 ft.	1.339 $\Omega$

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The Slope Method was used to calculate soil resistivity. Refer to Appendix 9.1 for supporting methodology.

Distance calculation for value R

$$R_1 = 0.2 \times 800' = 160'$$

$$R_2 = 0.4 \times 800' = 320'$$

$$R_3 = 0.6 \times 800' = 480'$$

Remote Distance Curve Calculation:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1} = \frac{0.854 - 0.576}{0.576 - 0.358} = 1.27$$

From Table VII in Appendix 9.2:

$$\mu \text{ of } 1.27 = \text{Pt/C of } 0.474$$

Distance of potential probe to represent remote earth soil resistivity  
=  $0.474 \times 800' = 379'$  to Probe P1

**Measured Value = 0.73  $\Omega$**

#### 6.1.4 Stone Coverage Area

On a percentage basis, approximately 100% of the area inside the fenced enclosure does have a stone cover. Stone depth was measured at 0.152 M. The stone cover and sand subsoil contained considerable moisture. This is reflected in the ground resistance measurements.

## 6.1.5 Allowable Safe Step and Touch Potentials

Based on Surface Layer De-rating Factor ( $C_s$ )

$$\begin{aligned} C_s &= 1 - \frac{0.09 \left(1 - \frac{P}{P_s}\right)}{2h_s + 0.09} \\ &= 1 - \left(\frac{-0.09}{0.394}\right) \\ &= 1 - (-)0.228 \\ &= 1.228 \end{aligned}$$

$$P = 2000 \Omega \cdot M$$

$$P_s = 1000 \Omega \cdot M$$

$$h_s = 0.152 M$$

### Safe Step Potential

$$\begin{aligned} E_{Step(50)} &= [1000 + 6C_s P_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 6 * 1.228 * 1000] * \frac{0.116}{\sqrt{0.5}} \\ &= 8368 * 0.164 \\ &= 1372 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Step(70)} &= [1000 + 6C_s P_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 6 * 1.228 * 1000] * \frac{0.157}{\sqrt{0.5}} \\ &= 8368 * 0.222 \\ &= 1858 \text{ Volts} \end{aligned}$$

## Safe Touch Potential

$$\begin{aligned} E_{Touch(50)} &= [1000 + 1.5C_sP_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 1.228 * 1000] * \frac{0.116}{\sqrt{0.5}} \\ &= 2842 * 0.164 \\ &= 466 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Touch(70)} &= [1000 + 1.5C_sP_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 1.228 * 1000] * \frac{0.157}{\sqrt{0.5}} \\ &= 2842 * 0.222 \\ &= 631 \text{ Volts} \end{aligned}$$

### 6.1.6 Total Resistance to Remote Earth

$$\begin{aligned} R_g &= P * \left[ \frac{1}{L_T} + \frac{1}{\sqrt{20A}} \left( 1 + \frac{1}{1 + h\sqrt{\frac{20}{A}}} \right) \right] \\ &= 2000 * \left[ \frac{1}{998} + \frac{1}{\sqrt{20 * 2575}} \left( 1 + \frac{1}{1 + 0.305\sqrt{\frac{20}{2575}}} \right) \right] \\ &= 2000 * [0.0010 + 0.0044 * 1.974] \\ &= 2000 * 0.0097 \\ &= 19.4 \Omega \end{aligned}$$

$L_T$  = Buried conductors and rods

= 988 M

$A$  = Ground grid area

= 2575 M<sup>2</sup>

$h$  = Depth of grid

= 0.305 M

$P$  = Resistivity

= 2000  $\Omega \cdot M$

## 6.1.7 Current Grid Split Factor Determination

To calculate  $S_f$  based on IEEE Std. 80-2000 Annex C.

Based on 5 Transmission / 1 Distribution Lines

$R_g$  Measured = 0.73  $\Omega$  (selected for calculation)

$R_g$  Calculated = 19.4  $\Omega$

$R_g$  Modeled = 18.3  $\Omega$

### Method A

Table C.1    4T / 1D     $R_{tg} = 15 \Omega$      $R_{dg} = 25 \Omega$      $R + jX = 0.45 + j0.16$

$$Z_g = \frac{(0.45 + j0.16)}{(0.73 + 0.45 + j0.16)} = \frac{0.478}{1.191} = 0.40 \Omega$$

### Method B

4T / 1D    100% Remote Contribution     $R_g = 0.73 \Omega$

$R_{tg} = 15 \Omega$      $R_{dg} = 25 \Omega$     Figure C.5

$S_f = 38\%$

$\therefore$  Comparing methods A and B, assign  $S_f$  for 115 kV system of 38%.

## 6.1.8 Symmetrical Grid Current ( $I_g$ )

$$\begin{aligned} I_g &= S_f * I_F \\ &= 0.38 * 10.07 \text{ kA} \\ &= 3.83 \text{ kA} \end{aligned}$$

$$S_f = 38\%$$

$$\begin{aligned} I_F &= L - G \text{ value from G.L.P.} \\ &= 10.07 \text{ kA} \end{aligned}$$

## 6.1.9 Maximum Grid Current ( $I_G$ )

$$\begin{aligned} I_G &= D_f * I_g \\ &= 1.039 * 3.83 \text{ kA} \\ &= 3.98 \text{ kA} \end{aligned}$$

$$D_f = 1.039$$

$$I_g = 3.83 \text{ kA}$$

## 6.1.10 Calculated Ground Potential Rise ( $GPR$ )

$$\begin{aligned} GPR_{Hand} &= R_g * I_G * 10^3 \\ &= 19.4 * 3.98 * 10^3 \\ &= 77212 \text{ Volts} \end{aligned}$$

$$\begin{aligned} GPR_{Measured} &= R_g * I_G * 10^3 \\ &= 0.73 * 3.98 * 10^3 \\ &= 2905 \text{ Volts} \end{aligned}$$

## 6.1.11 Comparison of Modeled Values and Results

Modeled Step and Touch voltage values have not been compared to manual calculated values.

Manual calculated values could not be completed as per the methodologies of IEEE 80-2000 Section 16.5.1 and 16.5.2 due to the irregularity and complexity of the

existing grounding grid layout. Refer to Sections 16.7 and 16.8 of the referenced standard.

Section 6.1.15 contains the detailed computer model output summary report. The Ground Grid Summary Report, usually the final page of the output documents, summarizes the calculated Maximum Touch and Step Potential values based on the grid layout. Calculated values are compared to the Safe Touch and Step potentials.

### 6.1.12 Fence Grounding and Condition Comments

The boundary fence is tied to the substation ground grid. Measured resistance between fence and ground grid is 0.286  $\Omega$ .

A visual inspection of the fence and gate grounding was completed. The condition of each thermoweld was inspected and the continuity of each jumper was confirmed. There were no apparent bonding issues associated with the fence or gates.

### 6.1.13 Above Grade Equipment Ground Audit

An audit of all bonding and grounding associated with electrical distribution equipment, supporting towers and structures, fences and gates was completed. All bare ground wire connections were assessed including both thermoweld and mechanical configurations. Bare ground wire sizes were measured and compared to the engineering drawing provided by Great Lakes Power. For reference, this drawing is 1079701-E-004 rev. 3 (file SD-20203).

At the time of this audit, an installation of a new SF6 circuit breaker was being completed. Grounding conformity to breaker and structure was not confirmed.

### 6.1.14 Comments

1. The ground grid for the GLP Anjigami TS is inter-connected with the adjacent Hydro One Anjigami TS. We did not obtain a ground grid layout drawing for the Hydro One yard at the time of our analysis; however a request has been made to obtain this drawing.



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2. The above referenced drawing indicates a remote ground grid array near Anjigami Lake. This could not be confirmed and has a significant effect on modeled and hand calculations.
  3. An accurate computer model of Anjigami TS could not be constructed because of the issues referenced in items 1 and 2 above. Therefore results have been calculated based on the measured remote earth resistivity.
  4. The incoming structure on the west side of the yard, breakers 843 and 854, does not have the required clearance between the equipment and the fence. It is possible to realize ground grid touch potential at this location.

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## 6.1.15 Computer Model Output Results

### System Data:

Body Weight	70 kg
Fault Current ( $I_F$ )	10.07 kA
X/R ratio	15.18
Division Factor ( $S_F$ )	38%
Projection Factor ( $C_P$ )	100%
Fault Duration ( $T_f, T_c, T_s$ )	0.5 sec.
Plot Step	3 ft.

### Summary Report:

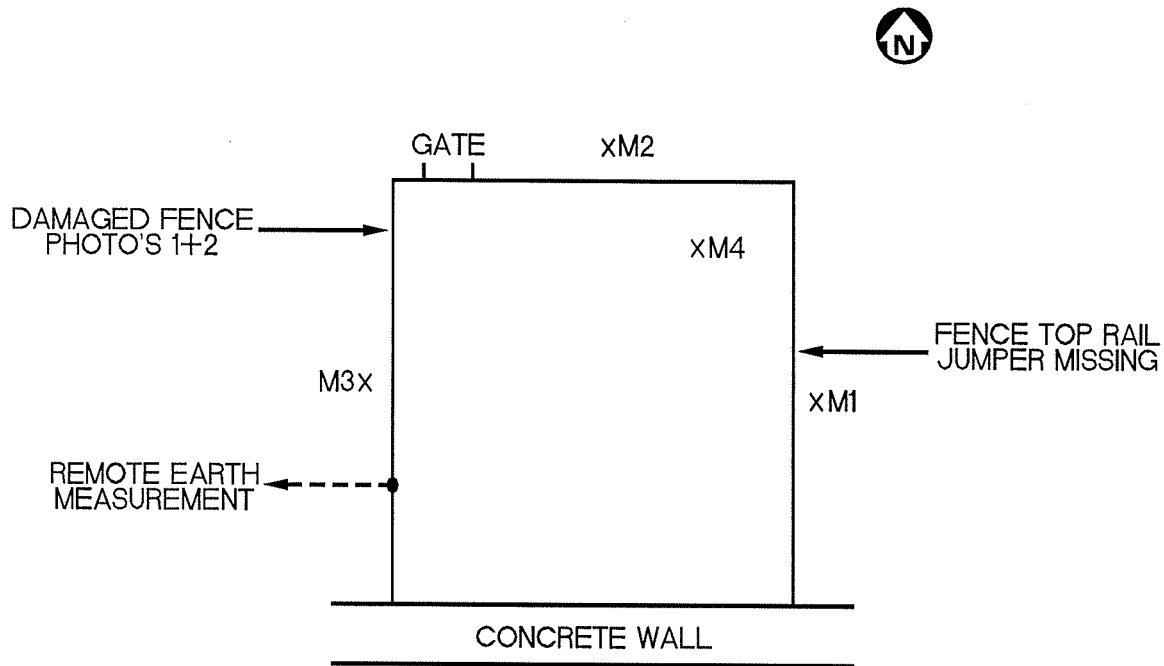
Ground Resistance ( $R_g$ )	N/A $\Omega$
Ground Potential Rise (GPR)	N/A V
Tolerable Touch Potential	631 V
Calculated Touch Potential	N/A V
Tolerable Step Potential	1858 V
Calculated Step Potential	N/A V

### Modeled Results Not Obtainable



## 6.2 Clerque TS

### 6.2.1 Soil Resistivity Measurement Locations



## 6.2.2 Resistivity Measurement

Soil resistivity has been calculated based on the following:

$$P = 2\pi aR$$

$a$  = Rod Spacing

$R$  = Resistivity Measurement

Measurement Location	Probe Spacing	Resistance Measured	Calculated Soil Resistivity
M1	2.0 M	29 $\Omega$	364 $\Omega \cdot M$
M2	2.0 M	146 $\Omega$	1834 $\Omega \cdot M$
M3	2.0 M	10 $\Omega$	126 $\Omega \cdot M$
M4	0.305 M	1171 $\Omega$	2242 $\Omega \cdot M$

Modeling Values Used:

1. Surface            Stone            2242  $\Omega \cdot M$
2. Upper Surface    Moist Soil    250  $\Omega \cdot M$
3. Lower Surface    Moist Soil    250  $\Omega \cdot M$

## 6.2.3 Ground Resistance Measurements

Measurement Location:

The test ground electrode used is indicated on the measurement location sketch

6.2.1. Current probe C1 was located in a westerly direction, 800 ft. from test electrode. Potential probe P1 measurements were made at the required significant locations between test electrode and current probe C1.

Measurements obtained:

Position No.	Distance	Resistance
1	160 ft.	0.336 $\Omega$
2	320 ft.	0.821 $\Omega$
3	480 ft.	1.201 $\Omega$

This was the third measurement that was taken to obtain a remote earth resistance value. The first measurement was taken along the spillway towards the pedestrian walkover and the second measurement was taken in the direction towards the Casino, a north easterly direction. Both measurements failed to resolve into an acceptable value.

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The Slope Method was used to calculate soil resistivity. Refer to Appendix 9.1 for supporting methodology.

Distance calculation for value R

$$R_1 = 0.2 \times 800' = 160'$$

$$R_2 = 0.4 \times 800' = 320'$$

$$R_3 = 0.6 \times 800' = 480'$$

Remote Distance Curve Calculation:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1} = \frac{1.201 - 0.821}{0.821 - 0.336} = 0.784$$

From Table VII in Appendix 9.2:

$$\mu \text{ of } 0.784 = \text{Pt/C of } 0.584$$

Distance of potential probe to represent remote earth soil resistivity  
=  $0.584 \times 800' = 467'$  to Probe P1

**Measured Value = 1.2  $\Omega$**

#### 6.2.4 Stone Coverage Area

On a percentage basis, approximately 100% of the area inside the fenced enclosure does have a stone cover. Stone depth was measured at 0.23 M. The stone cover and sand/gravel subsoil contained considerable moisture. This is reflected in the ground resistance measurements.

## 6.2.5 Allowable Safe Step and Touch Potentials

Based on Surface Layer De-rating Factor ( $C_s$ )

$$\begin{aligned} C_s &= 1 - \frac{0.09 \left(1 - \frac{P}{P_s}\right)}{2h_s + 0.09} \\ &= 1 - \left(\frac{0.080}{0.55}\right) \\ &= 1 - 0.145 \\ &= 0.855 \end{aligned}$$

$$P = 250 \Omega - M$$

$$P_s = 2242 \Omega - M$$

$$h_s = 0.23 M$$

### Safe Step Potential

$$\begin{aligned} E_{Step(50)} &= [1000 + 6C_sP_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 6 * 0.85 * 2242] * \frac{0.116}{\sqrt{0.5}} \\ &= 12501 * 0.164 \\ &= 2050 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Step(70)} &= [1000 + 6C_sP_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 6 * 0.85 * 2242] * \frac{0.157}{\sqrt{0.5}} \\ &= 12501 * 0.222 \\ &= 2775 \text{ Volts} \end{aligned}$$

## Safe Touch Potential

$$\begin{aligned} E_{Touch(50)} &= [1000 + 1.5C_sP_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 0.85 * 2242] * \frac{0.116}{\sqrt{0.5}} \\ &= 3875 * 0.164 \\ &= 636 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Touch(70)} &= [1000 + 1.5C_sP_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 0.85 * 2242] * \frac{0.157}{\sqrt{0.5}} \\ &= 3875 * 0.222 \\ &= 860 \text{ Volts} \end{aligned}$$

## 6.2.6 Total Resistance to Remote Earth

$$\begin{aligned} R_g &= P * \left[ \frac{1}{L_T} + \frac{1}{\sqrt{20A}} \left( 1 + \frac{1}{1 + h\sqrt{\frac{20}{A}}} \right) \right] \\ &= 250 * \left[ \frac{1}{1119} + \frac{1}{\sqrt{20 * 7476}} \left( 1 + \frac{1}{1 + 0.305\sqrt{\frac{20}{7476}}} \right) \right] \\ &= 250 * [0.00089 + 0.0026 * 1.98] \\ &= 250 * 0.0060 \\ &= 1.51 \Omega \end{aligned}$$



$L_T$  = Buried conductors and rods

$$= 1119 \text{ M}$$

$A$  = Ground grid area

$$= 7476 \text{ M}^2$$

$h$  = Depth of grid

$$= 0.305 \text{ M}$$

$P$  = Resistivity

$$= 250 \Omega \cdot \text{M}$$

## 6.2.7 Current Grid Split Factor Determination

To calculate  $S_r$  based on IEEE Std. 80-2000 Annex C.

Based on 6 Transmission / 0 Distribution Lines

$$R_g \text{ Measured} = 1.2 \Omega \text{ (selected for calculation)}$$

$$R_g \text{ Calculated} = 1.51 \Omega$$

$$R_g \text{ Modeled} = 1.47 \Omega$$

### Method B (Interpolation Required)

$$4T / 0D \quad 25\% \text{ Local} / 75\% \text{ Remote Contribution} \quad R_g = 1.2 \Omega$$

$$R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad \text{Figure C.17}$$

$$S_r = 26\%$$

$$8T / 0D \quad 25\% \text{ Local} / 75\% \text{ Remote Contribution} \quad R_g = 1.2 \Omega$$

$$R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad \text{Figure C.17}$$

$$S_r = 17\%$$

$$\text{Approximate Split Factor} = \frac{17 + 26}{2} = 21.5\%$$

$\therefore$  Assign  $S_r$  for 115 kV system of 22%.

## 6.2.8 Symmetrical Grid Current ( $I_g$ )

$$\begin{aligned} I_g &= S_f * I_F \\ &= 0.22 * 15.44 \text{ kA} \\ &= 3.40 \text{ kA} \end{aligned}$$

$$S_f = 22\%$$

$$\begin{aligned} I_F &= L - G \text{ value from G.L.P.} \\ &= 15.44 \text{ kA} \end{aligned}$$

## 6.2.9 Maximum Grid Current ( $I_G$ )

$$\begin{aligned} I_G &= D_f * I_g \\ &= 1.019 * 3.40 \text{ kA} \\ &= 3.46 \text{ kA} \end{aligned}$$

$$D_f = 1.019$$

$$I_g = 3.40 \text{ kA}$$

## 6.2.10 Calculated Ground Potential Rise ( $GPR$ )

$$\begin{aligned} GPR_{Hand} &= R_g * I_G * 10^3 \\ &= 1.51 * 3.46 * 10^3 \\ &= 5225 \text{ Volts} \end{aligned}$$

$$\begin{aligned} GPR_{Measured} &= R_g * I_G * 10^3 \\ &= 1.2 * 3.46 * 10^3 \\ &= 4152 \text{ Volts} \end{aligned}$$

## 6.2.11 Comparison of Modeled Values and Results

Modeled Step and Touch voltage values have not been compared to manual calculated values.

Manual calculated values could not be completed as per the methodologies of IEEE 80-2000 Section 16.5.1 and 16.5.2 due to the irregularity and complexity of the

existing grounding grid layout. Refer to Sections 16.7 and 16.8 of the referenced standard.

Section 6.2.15 contains the detailed computer model output summary report. The Ground Grid Summary Report, usually the final page of the output documents, summarizes the calculated Maximum Touch and Step Potential values based on the grid layout. Calculated values are compared to the Safe Touch and Step potentials.

### 6.2.12 Fence Grounding and Condition Comments

The boundary fence is tied to the substation ground grid. Measured resistance between fence and ground grid is  $0.35 \Omega$ .

A visual inspection of the fence and gate grounding was completed. The condition of each thermoweld was inspected and the continuity of each jumper was confirmed. A top rail jumper is missing on the east side midway of the fence length.

As observed in the following photographs the fence is damaged for approximately 6 sections. Refer to measurement location sketch, section 6.2.1 for fence damage location.



Photo #1 Looking North



Photo #2 Looking South

### 6.2.13 Above Grade Equipment Ground Audit

An audit of all bonding and grounding associated with electrical distribution equipment, supporting towers and structures, fences and gates was completed. All

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bare ground wire connections were assessed including both thermoweld and mechanical configurations. Bare ground wire sizes were measured and compared to the engineering drawing provided by Great Lakes Power. For reference, these drawing are: SH-3 9603 rev. 4, SE-3 9601 rev. 4 and 9862-SD-39650 rev. 2.

No issues were observed. We did not inspect the service platform on top of the dam nor any of the Generating Station grid. Limits of inspection were confined to the substation yard.

## 6.2.14 Comments

1. The remote earth measurement proved to be difficult. The only successful measurement was obtained by following the earth berm behind St. Marys Paper Administration Building and along the roadway next to the Greenwood Building.
2. The Powerhouse ground grid is interconnected with the substation yard grid. The copper conductors associated with the Powerhouse, generators and maintenance platforms have not been entered into the model, they are however included in the field measurement.
3. It is recommended additional site measurements be taken to confirm the validity of the initial site measurements.
4. Considering existing fault values, the Safe Touch Potential exceeds tolerable limits (142%).
5. Considering distant future fault values, the Safe Touch Potential exceeds tolerable limits (220%).

## 6.2.15 Computer Model Output Results

### System Data:

Body Weight	70 kg
Fault Current ( $I_F$ )	14.44 kA
X/R ratio	7.10
Division Factor ( $S_F$ )	22%
Projection Factor ( $C_P$ )	100%
Fault Duration ( $T_f, T_c, T_s$ )	0.5 sec.
Plot Step	3 ft.

### Summary Report:

Ground Resistance ( $R_g$ )	1.47 $\Omega$
Ground Potential Rise (GPR)	5094 V
Tolerable Touch Potential	860 V
Calculated Touch Potential	1899 V
Tolerable Step Potential	2772 V
Calculated Step Potential	1177 V

### Touch Voltage Exceeds Tolerable Limits

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Location: Clerque TS  
Contract: PTD Project 03014-02  
Engineer: Bingeman

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Distant Future 115 kV Consideration

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Electrical Transient Analyzer Program

ETAP PowerStation

Ground Grid Systems

Finite Element Method

Number of Ground Conductors: 48  
Number of Ground Rods: 49  
Total Length of Ground Conductors: 3182.00 ft  
Total Length of Ground Rods: 490.00 ft

Frequency: 60.0  
Unit System: English  
Project Filename: GLP-Clergue

Output Filename: C:\Documents and Settings\Barry Bingeman\My Documents\Great Lakes  
Power\Models\GLP-CLERQUE\Grid1\_Untitled.GR1

Project: Ground Grid Assessment  
Location: Clerque TS  
Contract: PTD Project 03014-02  
Engineer: Bingeman

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**Ground Grid Input Data**

**System Data:**

Freq. Hz	Weight kg	Ambient Temp. °C	Short-Circuit Current			Fault Duration (Seconds)			Plot Step ft	Extended Boundary Length ft	
			Total Fault Current kA	Sf Division Factor %	Cp Projection Factor %	Tf for Total Fault Duration	Tc for Sizing Ground Conductors	Ts for Available Body Current			
60.0	70	40.00	15.438	7.10	22.0	100.0	0.50	0.50	0.50	3.0	0.0

**Soil Data:**

Surface Material			Upper Layer Soil			Lower Layer Soil	
Material Type	Resistivity .m	Depth ft	Material Type	Resistivity .m	Depth ft	MaterialType	Resistivity .m
Crushed rock	2242.0	0.75	Moist soil	250.0	5.00	Moist soil	250.0

**Material Constants:**

Conductor/Rod	Type	Conductivity %	r Factor @ 20 °C 1/°C	K0 @ 0 °C	Fusing Temperature °C	Resistivity of Ground Conductor @ 20°C .cm	Thermal Capacity Per Unit Volume J/(cm³.°C)
Conductor	Copper, annealed soft-drawn	100.0	0.00393	234.0	1083.0	1.72	3.42
Rod	Copper, annealed soft-drawn	100.0	0.00393	234.0	1083.0	1.72	3.42

**Conductor Data:**

Label	Type	Size AWG/kemil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C3	Copper, annealed soft-drawn	500	171.9	112.7	1.0	171.9	77.2	1.0	35.5	NO	\$3
C4	Copper, annealed soft-drawn	500	167.0	113.0	1.0	245.2	113.0	1.0	78.2	NO	\$3
C5	Copper, annealed soft-drawn	500	244.2	112.7	1.0	244.0	177.0	1.0	64.3	NO	\$3
C6	Copper, annealed soft-drawn	500	244.7	176.7	1.0	268.7	176.5	1.0	24.0	NO	\$3
C7	Copper, annealed soft-drawn	500	268.0	177.0	1.0	268.0	193.0	1.0	16.0	NO	\$3
C8	Copper, annealed soft-drawn	500	269.2	192.7	1.0	340.5	198.5	1.0	71.5	NO	\$3
C17	Copper, annealed soft-drawn	2/0	244.5	151.5	1.0	449.0	151.0	1.0	204.5	NO	\$3
C19	Copper, annealed soft-drawn	500	166.5	127.0	1.0	231.5	127.0	1.0	65.0	NO	\$3
C20	Copper, annealed soft-drawn	500	231.0	127.0	1.0	231.0	209.5	1.0	82.5	NO	\$3
C21	Copper, annealed soft-drawn	500	167.5	209.0	1.0	231.5	209.0	1.0	64.0	NO	\$3
C24	Copper, annealed soft-drawn	500	368.0	28.5	1.0	440.5	28.5	1.0	72.5	NO	\$3
C25	Copper, annealed soft-drawn	500	440.5	28.5	1.0	440.5	75.5	1.0	47.0	NO	\$3
C26	Copper, annealed soft-drawn	500	368.0	75.5	1.0	368.0	27.5	1.0	48.0	NO	\$3
C27	Copper, annealed soft-drawn	500	430.0	74.5	1.0	440.5	74.5	1.0	10.5	NO	\$3
C29	Copper, annealed soft-drawn	500	352.5	45.5	1.0	369.0	45.5	1.0	16.5	NO	\$3
C44	Copper, annealed soft-drawn	2/0	163.0	14.0	0.6	455.3	14.5	0.6	292.3	NO	\$3
C45	Copper, annealed soft-drawn	2/0	454.5	15.0	0.6	454.0	270.0	0.6	255.0	NO	\$3

Project: Ground Grid Assessment  
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 Engineer: Bingeman

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**Conductor Data:**

Label	Type	Size AWG/kemil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C46	Copper, annealed soft-drawn	2/0	161.5	313.5	0.6	454.8	270.0	0.6	296.5	NO	\$3
C47	Copper, annealed soft-drawn	2/0	162.0	14.0	0.6	162.0	313.5	0.6	299.5	NO	\$3
C0	Copper, annealed soft-drawn	500	185.5	39.5	1.0	185.5	76.0	1.0	36.5	NO	\$3
C1	Copper, annealed soft-drawn	500	197.5	40.0	1.0	197.5	76.0	1.0	36.0	NO	\$3
C2	Copper, annealed soft-drawn	500	184.5	76.0	1.0	199.0	76.2	1.0	14.5	NO	\$3
C28	Copper, annealed soft-drawn	500	197.5	47.0	1.0	245.0	47.0	1.0	47.5	NO	\$3
C22	Copper, annealed soft-drawn	500	438.0	130.5	1.0	438.0	167.0	1.0	36.5	NO	\$3
C23	Copper, annealed soft-drawn	500	438.5	131.0	1.0	471.5	145.5	1.0	36.0	NO	\$3
C9	Copper, annealed soft-drawn	500	340.5	198.7	1.0	340.5	220.0	1.0	21.3	NO	\$3
C10	Copper, annealed soft-drawn	500	340.6	219.7	1.0	411.8	219.5	1.0	71.2	NO	\$3
C11	Copper, annealed soft-drawn	500	411.6	219.5	1.0	411.6	243.2	1.0	23.7	NO	\$3
C12	Copper, annealed soft-drawn	500	411.3	242.0	1.0	423.6	242.2	1.0	12.3	NO	\$3
C13	Copper, annealed soft-drawn	500	424.0	241.5	1.0	424.3	212.0	1.0	29.5	NO	\$3
C14	Copper, annealed soft-drawn	500	424.1	212.2	1.0	434.1	212.2	1.0	10.0	NO	\$3
C15	Copper, annealed soft-drawn	500	434.0	212.5	1.0	434.1	196.7	1.0	15.8	NO	\$3
C16	Copper, annealed soft-drawn	500	434.3	196.5	1.0	467.3	196.5	1.0	33.0	NO	\$3
C18	Copper, annealed soft-drawn	500	387.0	197.5	1.0	387.0	219.5	1.0	22.0	NO	\$3
C30	Copper, annealed soft-drawn	4/0	384.5	251.7	1.0	411.5	242.2	1.0	28.6	NO	\$3
C31	Copper, annealed soft-drawn	4/0	384.1	227.9	1.0	383.8	263.2	1.0	35.3	NO	\$3
C32	Copper, annealed soft-drawn	4/0	302.2	228.2	1.0	384.5	228.2	1.0	82.3	NO	\$3
C33	Copper, annealed soft-drawn	4/0	302.0	273.2	1.0	302.2	227.9	1.0	45.3	NO	\$3
C34	Copper, annealed soft-drawn	4/0	301.6	273.5	1.0	384.9	262.7	1.0	84.0	NO	\$3
C35	Copper, annealed soft-drawn	4/0	302.7	258.3	1.0	384.9	258.0	1.0	82.2	NO	\$3
C36	Copper, annealed soft-drawn	4/0	302.2	247.5	1.0	384.7	247.5	1.0	82.5	NO	\$3
C37	Copper, annealed soft-drawn	4/0	302.3	236.7	1.0	384.7	236.5	1.0	82.4	NO	\$3
C38	Copper, annealed soft-drawn	4/0	317.2	264.7	1.0	317.0	197.5	1.0	67.2	NO	\$3
C39	Copper, annealed soft-drawn	4/0	346.5	266.7	1.0	346.5	227.9	1.0	38.8	NO	\$3
C40	Copper, annealed soft-drawn	4/0	369.5	247.5	1.0	369.5	236.5	1.0	11.0	NO	\$3
C41	Copper, annealed soft-drawn	4/0	313.2	247.5	1.0	313.2	236.5	1.0	11.0	NO	\$3
C42	Copper, annealed soft-drawn	4/0	326.8	270.3	1.0	333.5	291.0	1.0	21.8	NO	\$3
C43	Copper, annealed soft-drawn	4/0	367.1	265.0	1.0	374.1	283.7	1.0	20.0	NO	\$3

**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R0	Copper, annealed soft-drawn	0.75	260.5	59.0	0.5	260.5	59.0	10.5	10.0	NO	\$100
R1	Copper, annealed soft-drawn	0.75	279.5	59.0	0.5	279.5	59.0	10.5	10.0	NO	\$100
R2	Copper, annealed soft-drawn	0.75	296.5	59.5	0.5	296.5	59.5	10.5	10.0	NO	\$100
R3	Copper, annealed soft-drawn	0.75	269.5	41.5	0.5	269.5	41.5	10.5	10.0	NO	\$100
R4	Copper, annealed soft-drawn	0.75	291.0	41.0	0.5	291.0	41.0	10.5	10.0	NO	\$100
R5	Copper, annealed soft-drawn	0.75	260.0	75.0	0.5	260.0	75.0	10.5	10.0	NO	\$100



Project: Ground Grid Assessment  
 Location: Clergue TS  
 Contract: PTD Project 03014-02  
 Engineer: Bingeman

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**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R6	Copper, annealed soft-drawn	0.75	279.0	75.5	0.5	279.0	75.5	10.5	10.0	NO	\$100
R7	Copper, annealed soft-drawn	0.75	296.0	75.0	0.5	296.0	75.0	10.5	10.0	NO	\$100
R8	Copper, annealed soft-drawn	0.75	260.0	91.0	0.5	260.0	91.0	10.5	10.0	NO	\$100
R9	Copper, annealed soft-drawn	0.75	278.5	91.5	0.5	278.5	91.5	10.5	10.0	NO	\$100
R10	Copper, annealed soft-drawn	0.75	297.5	91.5	0.5	297.5	91.5	10.5	10.0	NO	\$100
R11	Copper, annealed soft-drawn	0.75	320.5	59.0	0.5	320.5	59.0	10.5	10.0	NO	\$100
R12	Copper, annealed soft-drawn	0.75	333.5	59.0	0.5	333.5	59.0	10.5	10.0	NO	\$100
R13	Copper, annealed soft-drawn	0.75	343.5	58.5	0.5	343.5	58.5	10.5	10.0	NO	\$100
R14	Copper, annealed soft-drawn	0.75	356.0	59.0	0.5	356.0	59.0	10.5	10.0	NO	\$100
R15	Copper, annealed soft-drawn	0.75	320.0	74.0	0.5	320.0	74.0	10.5	10.0	NO	\$100
R16	Copper, annealed soft-drawn	0.75	333.5	73.5	0.5	333.5	73.5	10.5	10.0	NO	\$100
R17	Copper, annealed soft-drawn	0.75	345.0	73.5	0.5	345.0	73.5	10.5	10.0	NO	\$100
R18	Copper, annealed soft-drawn	0.75	357.5	74.0	0.5	357.5	74.0	10.5	10.0	NO	\$100
R19	Copper, annealed soft-drawn	0.75	319.5	91.0	0.5	319.5	91.0	10.5	10.0	NO	\$100
R20	Copper, annealed soft-drawn	0.75	340.0	90.5	0.5	340.0	90.5	10.5	10.0	NO	\$100
R21	Copper, annealed soft-drawn	0.75	357.5	90.5	0.5	357.5	90.5	10.5	10.0	NO	\$100
R22	Copper, annealed soft-drawn	0.75	368.0	76.5	0.5	368.0	76.5	10.5	10.0	NO	\$100
R23	Copper, annealed soft-drawn	0.75	351.3	45.5	0.5	351.3	45.5	10.5	10.0	NO	\$100
R24	Copper, annealed soft-drawn	0.75	428.5	74.0	0.5	428.5	74.0	10.5	10.0	NO	\$100
R36	Copper, annealed soft-drawn	0.75	246.5	47.5	0.5	246.5	47.5	10.5	10.0	NO	\$100
R37	Copper, annealed soft-drawn	0.75	239.5	200.0	0.5	239.5	200.0	10.5	10.0	NO	\$100
R47	Copper, annealed soft-drawn	0.75	324.3	40.8	0.5	324.3	40.8	10.5	10.0	NO	\$100
R48	Copper, annealed soft-drawn	0.75	343.2	40.6	0.5	343.2	40.6	10.5	10.0	NO	\$100
R26	Copper, annealed soft-drawn	0.75	185.5	37.5	0.5	185.5	37.5	10.5	10.0	NO	\$100
R27	Copper, annealed soft-drawn	0.75	197.5	38.0	0.5	197.5	38.0	10.5	10.0	NO	\$100
R28	Copper, annealed soft-drawn	0.75	185.0	74.0	0.5	185.0	74.0	10.5	10.0	NO	\$100
R29	Copper, annealed soft-drawn	0.75	198.0	77.5	0.5	198.0	77.5	10.5	10.0	NO	\$100
R30	Copper, annealed soft-drawn	0.75	256.5	118.0	0.5	256.5	118.0	10.5	10.0	NO	\$100
R31	Copper, annealed soft-drawn	0.75	284.0	133.0	0.5	284.0	133.0	10.5	10.0	NO	\$100
R32	Copper, annealed soft-drawn	0.75	343.0	133.0	0.5	343.0	133.0	10.5	10.0	NO	\$100
R33	Copper, annealed soft-drawn	0.75	283.0	117.0	0.5	283.0	117.0	10.5	10.0	NO	\$100
R34	Copper, annealed soft-drawn	0.75	343.5	115.0	0.5	343.5	115.0	10.5	10.0	NO	\$100
R35	Copper, annealed soft-drawn	0.75	368.0	124.0	0.5	368.0	124.0	10.5	10.0	NO	\$100
R25	Copper, annealed soft-drawn	0.75	439.0	130.0	0.5	439.0	130.0	10.5	10.0	NO	\$100
R39	Copper, annealed soft-drawn	0.75	317.5	168.0	0.5	317.5	168.0	10.5	10.0	NO	\$100
R40	Copper, annealed soft-drawn	0.75	343.5	168.0	0.5	343.5	168.0	10.5	10.0	NO	\$100
R43	Copper, annealed soft-drawn	0.75	385.5	170.0	0.5	385.5	170.0	10.5	10.0	NO	\$100
R45	Copper, annealed soft-drawn	0.75	420.5	169.5	0.5	420.5	169.5	10.5	10.0	NO	\$100
R46	Copper, annealed soft-drawn	0.75	438.5	166.5	0.5	438.5	166.5	10.5	10.0	NO	\$100
R38	Copper, annealed soft-drawn	0.75	317.0	196.5	0.5	317.0	196.5	10.5	10.0	NO	\$100
R41	Copper, annealed soft-drawn	0.75	343.5	196.0	0.5	343.5	196.0	10.5	10.0	NO	\$100
R42	Copper, annealed soft-drawn	0.75	387.5	195.0	0.5	387.5	195.0	10.5	10.0	NO	\$100

Project: Ground Grid Assessment  
 Location: Clerque TS  
 Contract: PTD Project 03014-02  
 Engineer: Bingeman

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**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R44	Copper, annealed soft-drawn	0.75	421.5	196.0	0.5	421.5	196.0	10.5	10.0	NO	\$100

**Cost:**

Conductor			Rod			Total Cost
Total No.	Total Length ft	Cost	Total No.	Total Length ft	Cost	
48	3,181.5	\$10,499	49	490.0	\$49,000	\$59,499

Project: Ground Grid Assessment  
 Location: Clerque TS  
 Contract: PTD Project 03014-02  
 Engineer: Bingeman

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**Ground Grid Summary Report**

Rg Ground Resistance Ohm	GPR Ground Potential Rise Volts	Maximum Touch Potential					Maximum Step Potential				
		Tolerable Volts	Calculated Volts	Calculated %	Coordinates (ft)		Tolerable Volts	Calculated Volts	Calculated %	Coordinates (ft)	
					X	Y				X	Y
1.47	5,093.9	859.6	1,895.9	220.5	198.1	274.6	2,772.3	1,176.7	42.4	162.00	313.22

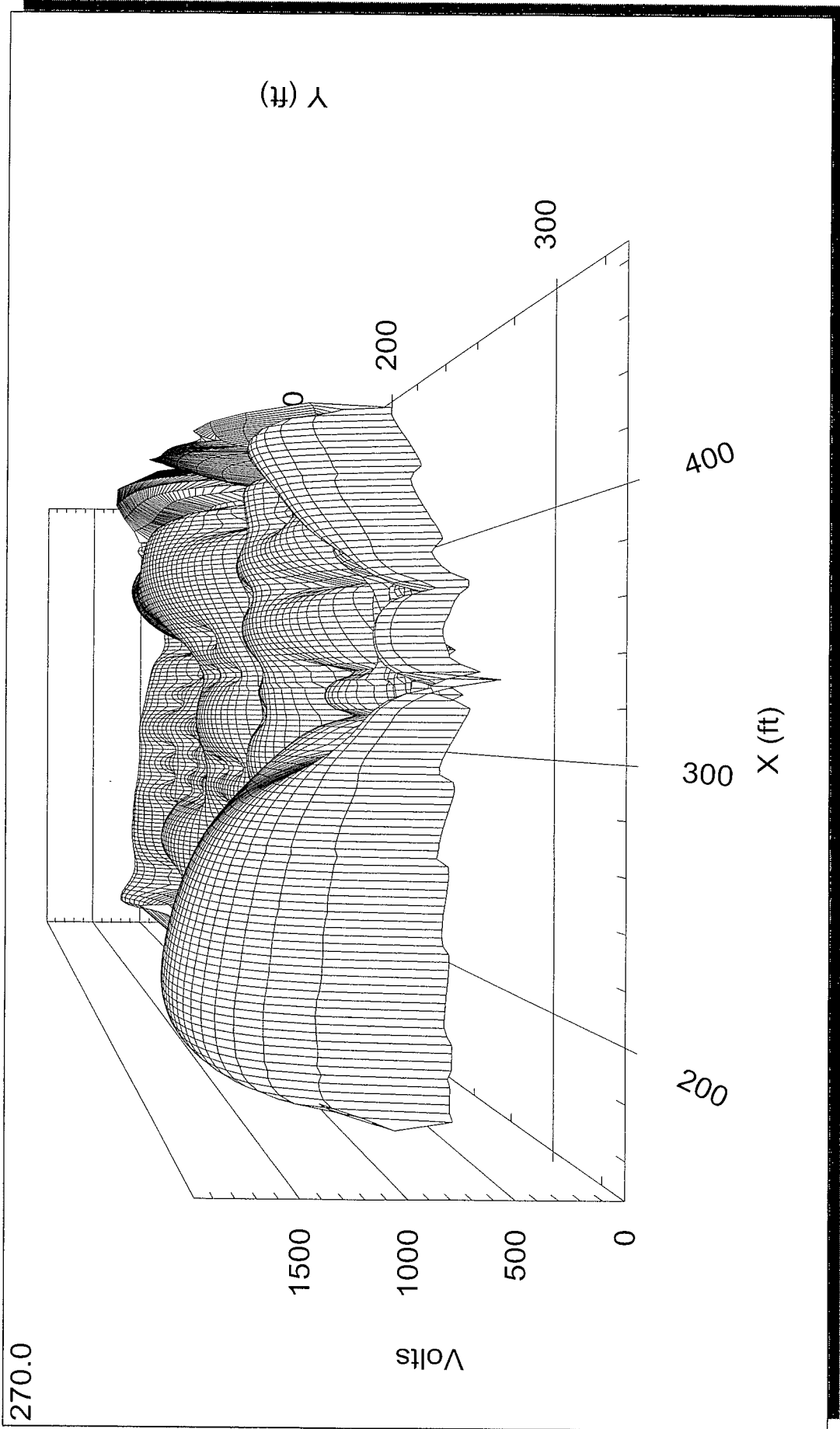
Total Fault Current	15.438 kA	Reflection Factor (K):	-0.799
Maximum Grid Current:	3.460 kA	Surface Layer Derating Factor (Cs):	0.854
		Decrement Factor (Df):	1.019

**Warnings:**

The maximum Touch Voltage exceeds the tolerable limits

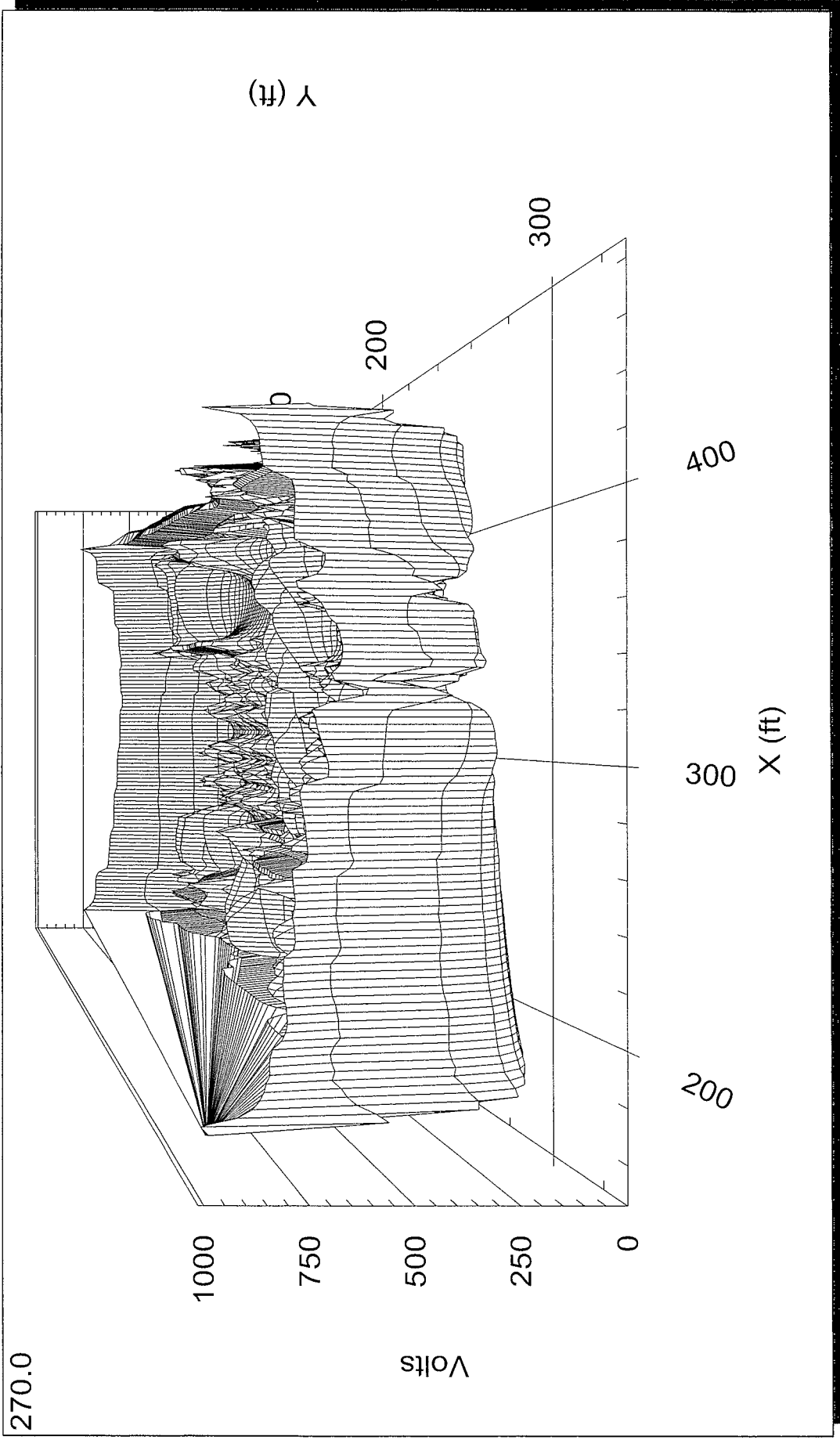
# Clergue TS

Touch Potential Profile



# Clergue TS

Step Potential Profile



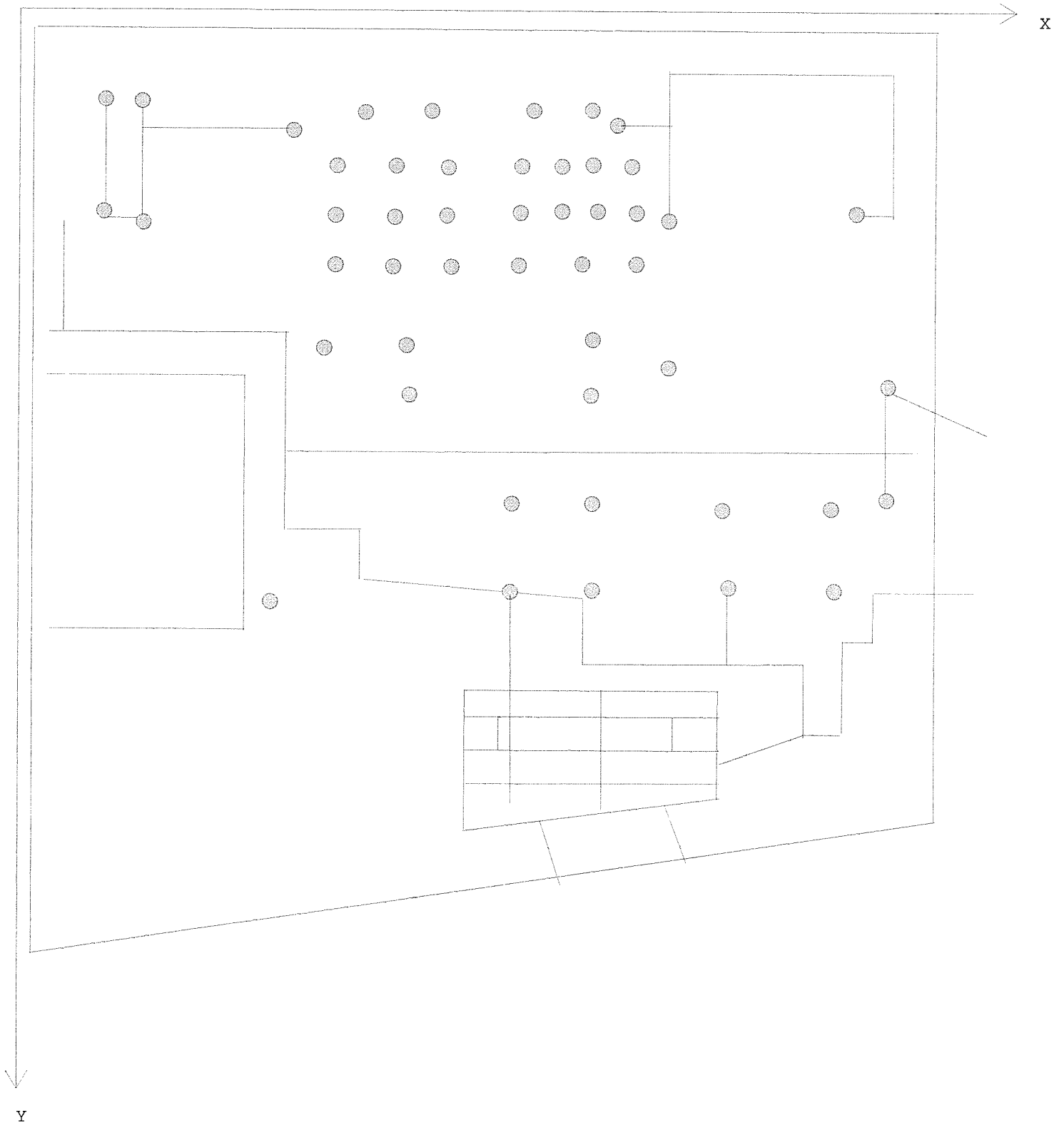
270.0

Project:  
Location:  
Contract:  
Engineer:  
Filename: GLP-Clergue

ETAP PowerStation  
4.7.4C  
Study Case: GRD1

Date: Feb-20-2004  
SN: PROCOMMTSI  
Revision: Base

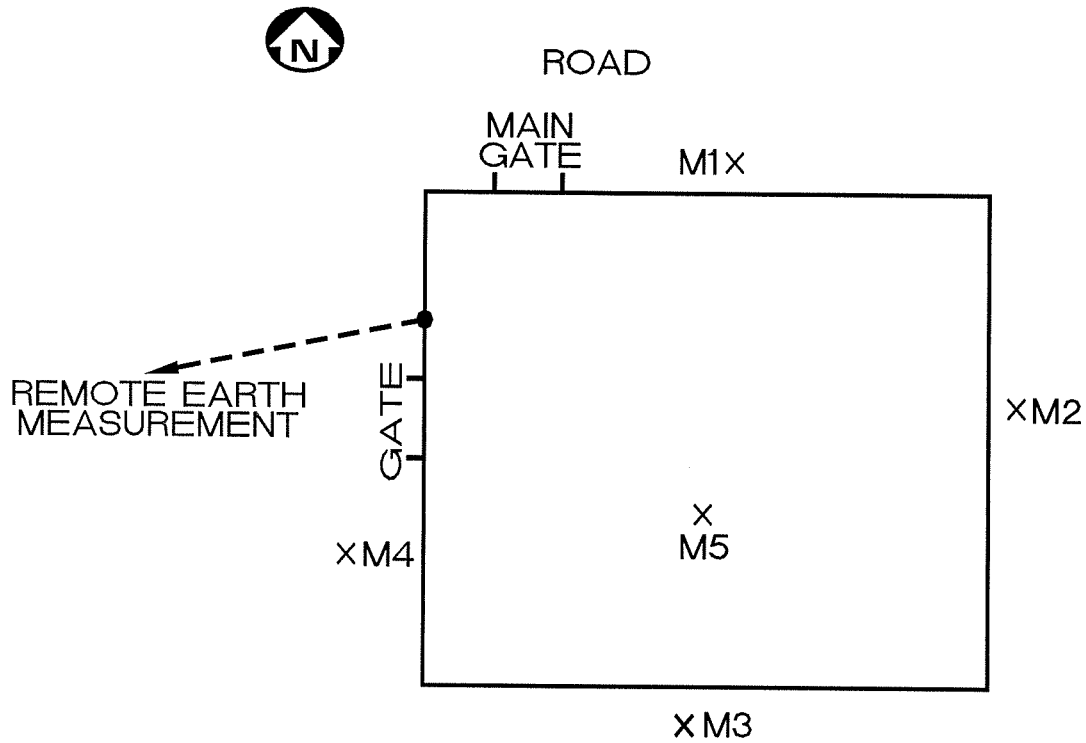
Grid1 - Top View





## 6.3 Echo River TS

### 6.3.1 Soil Resistivity Measurement Locations





## 6.3.2 Resistivity Measurement

Soil resistivity has been calculated based on the following:

$$P = 2\pi aR$$

$a$  = Rod Spacing

$R$  = Resistivity Measurement

Measurement Location	Probe Spacing	Resistance Measured	Calculated Soil Resistivity
M1	2.0 M	12.3 $\Omega$	154 $\Omega \cdot M$
M2	2.0 M	2.6 $\Omega$	33 $\Omega \cdot M$
M3	2.0 M	1.8 $\Omega$	23 $\Omega \cdot M$
M4	2.0 M	36.2 $\Omega$	455 $\Omega \cdot M$
M5	0.305 M	106 $\Omega$	202 $\Omega \cdot M$

Modeling Values Used:

1. Surface                      Stone              200  $\Omega \cdot M$
2. Upper Surface            Moist Soil        175  $\Omega \cdot M$
3. Lower Surface            Moist Soil        175  $\Omega \cdot M$

## 6.3.3 Ground Resistance Measurements

Measurement Location:

The test ground electrode used is indicated on the measurement location sketch

6.3.1. Current probe C1 was located in a westerly direction, 800 ft. from test electrode. Potential probe P1 measurements were made at 100 ft. intervals between test electrode and current probe C1.

Measurements obtained:

Position No.	Distance	Resistance
1	100 ft.	0.876 $\Omega$
2	200 ft.	0.947 $\Omega$
3	300 ft.	1.015 $\Omega$
4	400 ft.	1.020 $\Omega$
5	500 ft.	1.099 $\Omega$
6	600 ft.	1.233 $\Omega$
7	700 ft.	1.320 $\Omega$

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The Slope Method was used to calculate soil resistivity. Refer to Appendix 9.1 for supporting methodology.

Distance calculation for value R

$$R_1 = 0.2 \times 800' = 160'$$

$$R_2 = 0.4 \times 800' = 320'$$

$$R_3 = 0.6 \times 800' = 480'$$

Remote Distance Curve Calculation:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1} = \frac{1.099 - 1.015}{1.015 - 0.947} = 1.24$$

From Table VII in Appendix 9.2:

$$\mu \text{ of } 1.24 = \text{Pt/C of } 0.483$$

Distance of potential probe to represent remote earth soil resistivity  
=  $0.483 \times 800' = 386'$  to Probe P1

**Measured Value = 1.02  $\Omega$**

#### 6.3.4 Stone Coverage Area

On a percentage basis, approximately 100% of the area inside the fenced enclosure does have a stone cover. Stone depth was measured at 0.152 M. The stone cover and gravel subsoil contained moisture and was damp.

## 6.3.5 Allowable Safe Step and Touch Potentials

Based on Surface Layer De-rating Factor ( $C_s$ )

$$\begin{aligned} C_s &= 1 - \frac{0.09 \left(1 - \frac{P}{P_s}\right)}{2h_s + 0.09} \\ &= 1 - \left(\frac{0.011}{0.394}\right) \\ &= 1 - 0.028 \\ &= 0.97 \end{aligned}$$

$$P = 175 \Omega \cdot M$$

$$P_s = 200 \Omega \cdot M$$

$$h_s = 0.152 M$$

### Safe Step Potential

$$\begin{aligned} E_{Step(50)} &= [1000 + 6C_s P_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 6 * 0.97 * 200] * \frac{0.116}{\sqrt{0.5}} \\ &= 2164 * 0.164 \\ &= 355 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Step(70)} &= [1000 + 6C_s P_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 6 * 0.97 * 200] * \frac{0.157}{\sqrt{0.5}} \\ &= 2164 * 0.222 \\ &= 480 \text{ Volts} \end{aligned}$$

## Safe Touch Potential

$$\begin{aligned} E_{Touch(50)} &= [1000 + 1.5C_sP_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 0.97 * 200] * \frac{0.116}{\sqrt{0.5}} \\ &= 1291 * 0.164 \\ &= 212 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Touch(70)} &= [1000 + 1.5C_sP_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 0.97 * 200] * \frac{0.157}{\sqrt{0.5}} \\ &= 1291 * 0.222 \\ &= 287 \text{ Volts} \end{aligned}$$

### 6.3.6 Total Resistance to Remote Earth

$$\begin{aligned} R_g &= P * \left[ \frac{1}{L_T} + \frac{1}{\sqrt{20A}} \left( 1 + \frac{1}{1 + h\sqrt{\frac{20}{A}}} \right) \right] \\ &= 175 * \left[ \frac{1}{2292} + \frac{1}{\sqrt{20 * 8370}} \left( 1 + \frac{1}{1 + 0.305\sqrt{\frac{20}{8370}}} \right) \right] \\ &= 175 * [0.00044 + 0.0024 * 1.985] \\ &= 175 * 0.0052 \\ &= 0.91 \Omega \end{aligned}$$

$L_T$  = Buried conductors and rods

$$= 2292 \text{ M}$$

$A$  = Ground grid area

$$= 8370 \text{ M}^2$$

$h$  = Depth of grid

$$= 0.305 \text{ M}$$

$P$  = Resistivity

$$= 175 \Omega \cdot \text{M}$$

### 6.3.7 Current Grid Split Factor Determination

To calculate  $S_f$  based on IEEE Std. 80-2000 Annex C.

Based on 1 Transmission / 2 Distribution Lines

$$R_g \text{ Measured} = 1.02 \Omega$$

$$R_g \text{ Calculated} = 0.91 \Omega$$

$$R_g \text{ Modeled} = 0.88 \Omega \text{ (selected for calculation)}$$

#### Method A

$$\text{Table C.1} \quad 1T / 2D \quad R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad R + jX = 0.54 + j0.33$$

$$Z_g = \frac{(0.54 + j0.33)}{(0.88 + 0.54 + j0.33)} = \frac{0.633}{1.458} = 0.43 \Omega$$

#### Method B

$$1T / 2D \quad 100\% \text{ Remote Contribution} \quad R_g = 0.88 \Omega$$

$$R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad \text{Figure C.1}$$

$$S_f = 43\%$$

$\therefore$  Comparing methods A and B, assign  $S_f$  for 230 kV system of 43%.

### 6.3.8 Symmetrical Grid Current ( $I_g$ )

$$\begin{aligned} I_g &= S_f * I_F \\ &= 0.43 * 6.22 \text{ kA} \\ &= 2.67 \text{ kA} \end{aligned}$$

$$S_f = 43\%$$

$$\begin{aligned} I_F &= L - G \text{ value from G.L.P.} \\ &= 6.22 \text{ kA} \end{aligned}$$

### 6.3.9 Maximum Grid Current ( $I_G$ )

$$\begin{aligned} I_G &= D_f * I_g \\ &= 1.01 * 2.67 \text{ kA} \\ &= 2.70 \text{ kA} \end{aligned}$$

$$D_f = 1.01$$

$$I_g = 2.67 \text{ kA}$$

### 6.3.10 Calculated Ground Potential Rise ( $GPR$ )

$$\begin{aligned} GPR_{Hand} &= R_g * I_G * 10^3 \\ &= 0.91 * 2.70 * 10^3 \\ &= 2457 \text{ Volts} \end{aligned}$$

$$\begin{aligned} GPR_{Measured} &= R_g * I_G * 10^3 \\ &= 1.02 * 2.70 * 10^3 \\ &= 2754 \text{ Volts} \end{aligned}$$

### 6.3.11 Comparison of Modeled Values and Results

Modeled Step and Touch voltage values have not been compared to manual calculated values.

Manual calculated values could not be completed as per the methodologies of IEEE 80-2000 Section 16.5.1 and 16.5.2 due to the irregularity and complexity of the

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existing grounding grid layout. Refer to Sections 16.7 and 16.8 of the referenced standard.

Section 6.3.15 contains the detailed computer model output summary report. The Ground Grid Summary Report, usually the final page of the output documents, summarizes the calculated Maximum Touch and Step Potential values based on the grid layout. Calculated values are compared to the Safe Touch and Step potentials.

### 6.3.12 Fence Grounding and Condition Comments

The boundary fence is tied to the substation ground grid. Measured resistance between fence and ground grid is 0.435  $\Omega$ .

A visual inspection of the fence and gate grounding was completed. The condition of each thermoweld was inspected and the continuity of each jumper was confirmed. There were no apparent bonding issues associated with the fence or gates.

### 6.3.13 Above Grade Equipment Ground Audit

An audit of all bonding and grounding associated with electrical distribution equipment, supporting towers and structures, fences and gates was completed. All bare ground wire connections were assessed including both thermoweld and mechanical configurations. Bare ground wire sizes were measured and compared to the engineering drawing provided by Great Lakes Power. For reference, this drawing is SG-30760 rev. 5

This is a relatively new ground grid. We found no issues with the above ground audit.

### 6.3.14 Comments

1. Soil conditions surrounding this substation were very moist almost bordering on swampy conditions. This is reflected in the soil resistivity measurements.
2. Considering existing fault values, the Safe Touch Potential exceeds tolerable limits (151%).
3. Considering future distant fault values, the Safe Touch Potential exceeds tolerable limits (239%).

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## 6.3.15 Computer Model Output Results

### System Data:

Body Weight	70 kg
Fault Current ( $I_F$ )	6.22 kA
X/R ratio	5.68
Division Factor ( $S_F$ )	43%
Projection Factor ( $C_P$ )	100%
Fault Duration ( $T_f, T_c, T_s$ )	0.5 sec.
Plot Step	3 ft.

### Summary Report:

Ground Resistance ( $R_g$ )	0.88 $\Omega$
Ground Potential Rise (GPR)	2386 V
Tolerable Touch Potential	287 V
Calculated Touch Potential	685 V
Tolerable Step Potential	481 V
Calculated Step Potential	319 V

### Touch Voltage Exceeds Tolerable Limits



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Distant Future 230 kV Consideration

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Electrical Transient Analyzer Program

ETAP PowerStation

Ground Grid Systems

Finite Element Method

Number of Ground Conductors: 51  
Number of Ground Rods: 88  
Total Length of Ground Conductors: 6641.00 ft  
Total Length of Ground Rods: 880.00 ft

Frequency: 60.0  
Unit System: English  
Project Filename: GLP-EchoRiver

Output Filename: C:\Documents and Settings\Barry Bingeman\My Documents\Great Lakes Power\Models  
03-014-02\GLP-ECHO\_RIVER\Grid1\_Untitled.GRI

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**Ground Grid Input Data**

**System Data:**

Freq. Hz	Weight kg	Ambient Temp. °C	Short-Circuit Current			Fault Duration (Seconds)			Plot Step ft	Extended Boundary Length ft	
			Total Fault Current kA	Sf Division Factor %	Cp Projection Factor %	Tf for Total Fault Duration	Tc for Sizing Ground Conductors	Ts for Available Body Current			
60.0	70	40.00	6.220	5.68	43.0	100.0	0.50	0.50	0.50	3.0	0.0

**Soil Data:**

Surface Material			Upper Layer Soil			Lower Layer Soil	
Material Type	Resistivity .m	Depth ft	Material Type	Resistivity .m	Depth ft	Material Type	Resistivity .m
Gravel	200.0	0.50	Moist soil	175.0	1.00	Moist soil	175.0

**Material Constants:**

Conductor/Rod	Type	Conductivity %	r Factor @ 20 °C 1/°C	K0 @ 0 °C	Fusing Temperature °C	Resistivity of Ground Conductor @ 20°C .cm	Thermal Capacity Per Unit Volume J/(cm³.°C)
Conductor	Copper, annealed soft-drawn	100.0	0.00393	234.0	1083.0	1.72	3.42
Rod	Zinc-coated steel rod	8.6	0.00320	293.0	419.0	20.10	3.93

**Conductor Data:**

Label	Type	Size AWG/kemil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
---	Copper, annealed soft-drawn	4/0	199.4	204.7	1.0	541.0	204.7	1.0	341.6	NO	\$3
---	Copper, annealed soft-drawn	4/0	541.0	204.7	1.0	541.0	471.8	1.0	267.1	NO	\$3
---	Copper, annealed soft-drawn	4/0	199.4	471.8	1.0	541.0	471.8	1.0	341.6	NO	\$3
---	Copper, annealed soft-drawn	4/0	199.4	204.7	1.0	199.4	471.8	1.0	267.1	NO	\$3
C0	Copper, annealed soft-drawn	4/0	206.0	209.0	1.0	542.0	210.2	1.0	336.0	NO	\$3
C1	Copper, annealed soft-drawn	4/0	535.0	209.0	1.0	535.0	464.0	1.0	255.0	NO	\$3
C2	Copper, annealed soft-drawn	4/0	198.0	464.4	1.0	541.0	464.4	1.0	343.0	NO	\$3
C3	Copper, annealed soft-drawn	4/0	205.0	209.0	1.0	205.0	464.0	1.0	255.0	NO	\$3
C4	Copper, annealed soft-drawn	4/0	237.5	204.7	1.0	237.5	471.9	1.0	267.2	NO	\$3
C5	Copper, annealed soft-drawn	4/0	270.5	204.7	1.0	270.5	472.4	1.0	267.7	NO	\$3
C6	Copper, annealed soft-drawn	4/0	303.0	204.7	1.0	303.0	472.9	1.0	268.2	NO	\$3
C7	Copper, annealed soft-drawn	4/0	337.5	204.2	1.0	338.0	471.9	1.0	267.7	NO	\$3
C8	Copper, annealed soft-drawn	4/0	369.5	204.7	1.0	370.5	472.4	1.0	267.7	NO	\$3
C9	Copper, annealed soft-drawn	4/0	403.0	205.2	1.0	403.0	472.9	1.0	267.7	NO	\$3
C10	Copper, annealed soft-drawn	4/0	436.0	205.2	1.0	436.5	304.7	1.0	99.5	NO	\$3
C11	Copper, annealed soft-drawn	4/0	468.5	204.7	1.0	469.5	305.2	1.0	100.5	NO	\$3
C12	Copper, annealed soft-drawn	4/0	502.0	205.2	1.0	502.5	304.7	1.0	99.5	NO	\$3

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**Conductor Data:**

Label	Type	Size AWG/kcmil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C13	Copper, annealed soft-drawn	4/0	198.0	240.9	1.0	535.0	240.9	1.0	337.0	NO	\$3
C14	Copper, annealed soft-drawn	4/0	199.0	273.4	1.0	535.0	272.8	1.0	336.0	NO	\$3
C15	Copper, annealed soft-drawn	4/0	198.5	304.4	1.0	541.0	303.9	1.0	342.5	NO	\$3
C16	Copper, annealed soft-drawn	4/0	197.0	337.4	1.0	403.5	337.2	1.0	206.5	NO	\$3
C17	Copper, annealed soft-drawn	4/0	199.0	367.9	1.0	339.0	366.7	1.0	140.0	NO	\$3
C18	Copper, annealed soft-drawn	4/0	198.5	401.4	1.0	405.0	400.7	1.0	206.5	NO	\$3
C19	Copper, annealed soft-drawn	4/0	197.5	432.9	1.0	403.5	432.2	1.0	206.0	NO	\$3
C20	Copper, annealed soft-drawn	4/0	337.0	377.2	1.0	371.0	377.2	1.0	34.0	NO	\$3
C21	Copper, annealed soft-drawn	4/0	371.5	368.7	1.0	404.0	368.7	1.0	32.5	NO	\$3
---	Copper, annealed soft-drawn	4/0	440.0	265.2	1.0	479.5	265.2	1.0	39.5	NO	\$3
---	Copper, annealed soft-drawn	4/0	479.5	265.2	1.0	479.5	284.7	1.0	19.5	NO	\$3
---	Copper, annealed soft-drawn	4/0	440.0	284.7	1.0	479.5	284.7	1.0	39.5	NO	\$3
---	Copper, annealed soft-drawn	4/0	440.0	265.2	1.0	440.0	284.7	1.0	19.5	NO	\$3
---	Copper, annealed soft-drawn	4/0	445.0	268.7	1.0	475.0	268.7	1.0	30.0	NO	\$3
---	Copper, annealed soft-drawn	4/0	475.0	268.7	1.0	475.0	279.7	1.0	11.0	NO	\$3
---	Copper, annealed soft-drawn	4/0	445.0	279.7	1.0	475.0	279.7	1.0	30.0	NO	\$3
---	Copper, annealed soft-drawn	4/0	445.0	268.7	1.0	445.0	279.7	1.0	11.0	NO	\$3
---	Copper, annealed soft-drawn	4/0	348.5	389.2	1.0	366.5	389.2	1.0	18.0	NO	\$3
---	Copper, annealed soft-drawn	4/0	366.5	389.2	1.0	366.5	420.2	1.0	31.0	NO	\$3
---	Copper, annealed soft-drawn	4/0	348.5	420.2	1.0	366.5	420.2	1.0	18.0	NO	\$3
---	Copper, annealed soft-drawn	4/0	348.5	389.2	1.0	348.5	420.2	1.0	31.0	NO	\$3
---	Copper, annealed soft-drawn	4/0	351.5	393.2	1.0	362.5	393.2	1.0	11.0	NO	\$3
---	Copper, annealed soft-drawn	4/0	362.5	393.2	1.0	362.5	415.7	1.0	22.5	NO	\$3
---	Copper, annealed soft-drawn	4/0	351.5	415.7	1.0	362.5	415.7	1.0	11.0	NO	\$3
---	Copper, annealed soft-drawn	4/0	351.5	393.2	1.0	351.5	415.7	1.0	22.5	NO	\$3
---	Copper, annealed soft-drawn	4/0	298.0	400.7	1.0	310.5	400.7	1.0	12.5	NO	\$3
---	Copper, annealed soft-drawn	4/0	310.5	400.7	1.0	310.5	421.2	1.0	20.5	NO	\$3
---	Copper, annealed soft-drawn	4/0	298.0	421.2	1.0	310.5	421.2	1.0	12.5	NO	\$3
---	Copper, annealed soft-drawn	4/0	298.0	400.7	1.0	298.0	421.2	1.0	20.5	NO	\$3
C23	Copper, annealed soft-drawn	4/0	534.5	255.4	1.0	541.0	255.4	1.0	6.5	NO	\$3
C24	Copper, annealed soft-drawn	4/0	536.0	283.9	1.0	542.0	283.9	1.0	6.0	NO	\$3
C25	Copper, annealed soft-drawn	4/0	534.0	430.9	1.0	542.0	431.4	1.0	8.0	NO	\$3
C26	Copper, annealed soft-drawn	4/0	536.5	367.9	1.0	542.0	368.4	1.0	5.5	NO	\$3
C27	Copper, annealed soft-drawn	4/0	327.0	367.3	1.0	327.0	336.8	1.0	30.5	NO	\$3

**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R0	Zinc-coated steel rod	0.75	536.0	210.7	1.0	536.0	210.7	11.0	10.0	NO	\$100
R1	Zinc-coated steel rod	0.75	535.5	230.7	1.0	535.5	230.7	11.0	10.0	NO	\$100
R2	Zinc-coated steel rod	0.75	502.0	210.2	1.0	502.0	210.2	11.0	10.0	NO	\$100

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Distant Future 230 kV Consideration

**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R3	Zinc-coated steel rod	0.75	469.0	209.7	1.0	469.0	209.7	11.0	10.0	NO	\$100
R4	Zinc-coated steel rod	0.75	435.5	209.2	1.0	435.5	209.2	11.0	10.0	NO	\$100
R5	Zinc-coated steel rod	0.75	403.5	209.2	1.0	403.5	209.2	11.0	10.0	NO	\$100
R6	Zinc-coated steel rod	0.75	317.0	209.7	1.0	317.0	209.7	11.0	10.0	NO	\$100
R7	Zinc-coated steel rod	0.75	281.0	209.2	1.0	281.0	209.2	11.0	10.0	NO	\$100
R8	Zinc-coated steel rod	0.75	245.0	209.2	1.0	245.0	209.2	11.0	10.0	NO	\$100
R9	Zinc-coated steel rod	0.75	206.0	209.2	1.0	206.0	209.2	11.0	10.0	NO	\$100
R10	Zinc-coated steel rod	0.75	353.5	209.7	1.0	353.5	209.7	11.0	10.0	NO	\$100
R11	Zinc-coated steel rod	0.75	503.0	241.2	1.0	503.0	241.2	11.0	10.0	NO	\$100
R12	Zinc-coated steel rod	0.75	469.5	241.7	1.0	469.5	241.7	11.0	10.0	NO	\$100
R13	Zinc-coated steel rod	0.75	436.0	241.2	1.0	436.0	241.2	11.0	10.0	NO	\$100
R14	Zinc-coated steel rod	0.75	404.0	241.2	1.0	404.0	241.2	11.0	10.0	NO	\$100
R15	Zinc-coated steel rod	0.75	370.0	241.2	1.0	370.0	241.2	11.0	10.0	NO	\$100
R16	Zinc-coated steel rod	0.75	337.5	241.2	1.0	337.5	241.2	11.0	10.0	NO	\$100
R17	Zinc-coated steel rod	0.75	270.5	241.7	1.0	270.5	241.7	11.0	10.0	NO	\$100
R18	Zinc-coated steel rod	0.75	239.0	241.2	1.0	239.0	241.2	11.0	10.0	NO	\$100
R19	Zinc-coated steel rod	0.75	271.5	273.2	1.0	271.5	273.2	11.0	10.0	NO	\$100
R20	Zinc-coated steel rod	0.75	337.5	272.7	1.0	337.5	272.7	11.0	10.0	NO	\$100
R21	Zinc-coated steel rod	0.75	370.0	273.7	1.0	370.0	273.7	11.0	10.0	NO	\$100
R22	Zinc-coated steel rod	0.75	403.0	272.7	1.0	403.0	272.7	11.0	10.0	NO	\$100
R23	Zinc-coated steel rod	0.75	445.5	262.7	1.0	445.5	262.7	11.0	10.0	NO	\$100
R24	Zinc-coated steel rod	0.75	445.0	286.7	1.0	445.0	286.7	11.0	10.0	NO	\$100
R25	Zinc-coated steel rod	0.75	481.5	262.2	1.0	481.5	262.2	11.0	10.0	NO	\$100
R26	Zinc-coated steel rod	0.75	482.0	286.7	1.0	482.0	286.7	11.0	10.0	NO	\$100
R27	Zinc-coated steel rod	0.75	501.5	273.7	1.0	501.5	273.7	11.0	10.0	NO	\$100
R28	Zinc-coated steel rod	0.75	535.0	293.7	1.0	535.0	293.7	11.0	10.0	NO	\$100
R29	Zinc-coated steel rod	0.75	535.0	260.7	1.0	535.0	260.7	11.0	10.0	NO	\$100
R30	Zinc-coated steel rod	0.75	502.0	304.7	1.0	502.0	304.7	11.0	10.0	NO	\$100
R31	Zinc-coated steel rod	0.75	469.5	304.7	1.0	469.5	304.7	11.0	10.0	NO	\$100
R32	Zinc-coated steel rod	0.75	437.0	303.7	1.0	437.0	303.7	11.0	10.0	NO	\$100
R33	Zinc-coated steel rod	0.75	403.0	304.2	1.0	403.0	304.2	11.0	10.0	NO	\$100
R34	Zinc-coated steel rod	0.75	370.5	304.7	1.0	370.5	304.7	11.0	10.0	NO	\$100
R35	Zinc-coated steel rod	0.75	337.5	304.2	1.0	337.5	304.2	11.0	10.0	NO	\$100
R36	Zinc-coated steel rod	0.75	304.5	304.7	1.0	304.5	304.7	11.0	10.0	NO	\$100
R37	Zinc-coated steel rod	0.75	271.0	304.2	1.0	271.0	304.2	11.0	10.0	NO	\$100
R38	Zinc-coated steel rod	0.75	237.5	304.2	1.0	237.5	304.2	11.0	10.0	NO	\$100
R39	Zinc-coated steel rod	0.75	238.5	335.2	1.0	238.5	335.2	11.0	10.0	NO	\$100
R40	Zinc-coated steel rod	0.75	271.5	336.2	1.0	271.5	336.2	11.0	10.0	NO	\$100
R41	Zinc-coated steel rod	0.75	304.5	335.7	1.0	304.5	335.7	11.0	10.0	NO	\$100
R42	Zinc-coated steel rod	0.75	337.5	336.7	1.0	337.5	336.7	11.0	10.0	NO	\$100
R43	Zinc-coated steel rod	0.75	375.5	337.2	1.0	375.5	337.2	11.0	10.0	NO	\$100
R44	Zinc-coated steel rod	0.75	402.5	336.2	1.0	402.5	336.2	11.0	10.0	NO	\$100

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**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R45	Zinc-coated steel rod	0.75	403.0	369.2	1.0	403.0	369.2	11.0	10.0	NO	\$100
R46	Zinc-coated steel rod	0.75	369.0	369.2	1.0	369.0	369.2	11.0	10.0	NO	\$100
R47	Zinc-coated steel rod	0.75	337.5	373.2	1.0	337.5	373.2	11.0	10.0	NO	\$100
R48	Zinc-coated steel rod	0.75	348.5	390.7	1.0	348.5	390.7	11.0	10.0	NO	\$100
R49	Zinc-coated steel rod	0.75	370.5	387.2	1.0	370.5	387.2	11.0	10.0	NO	\$100
R50	Zinc-coated steel rod	0.75	403.0	400.7	1.0	403.0	400.7	11.0	10.0	NO	\$100
R51	Zinc-coated steel rod	0.75	403.0	431.7	1.0	403.0	431.7	11.0	10.0	NO	\$100
R52	Zinc-coated steel rod	0.75	370.5	417.2	1.0	370.5	417.2	11.0	10.0	NO	\$100
R53	Zinc-coated steel rod	0.75	348.5	409.2	1.0	348.5	409.2	11.0	10.0	NO	\$100
R54	Zinc-coated steel rod	0.75	403.5	464.7	1.0	403.5	464.7	11.0	10.0	NO	\$100
R55	Zinc-coated steel rod	0.75	370.0	463.2	1.0	370.0	463.2	11.0	10.0	NO	\$100
R56	Zinc-coated steel rod	0.75	437.5	464.7	1.0	437.5	464.7	11.0	10.0	NO	\$100
R57	Zinc-coated steel rod	0.75	470.5	464.7	1.0	470.5	464.7	11.0	10.0	NO	\$100
R58	Zinc-coated steel rod	0.75	505.5	464.7	1.0	505.5	464.7	11.0	10.0	NO	\$100
R59	Zinc-coated steel rod	0.75	535.5	448.2	1.0	535.5	448.2	11.0	10.0	NO	\$100
R60	Zinc-coated steel rod	0.75	535.5	415.2	1.0	535.5	415.2	11.0	10.0	NO	\$100
R61	Zinc-coated steel rod	0.75	535.5	369.7	1.0	535.5	369.7	11.0	10.0	NO	\$100
R62	Zinc-coated steel rod	0.75	535.5	335.2	1.0	535.5	335.2	11.0	10.0	NO	\$100
R63	Zinc-coated steel rod	0.75	540.5	204.2	1.0	540.5	204.2	11.0	10.0	NO	\$100
R64	Zinc-coated steel rod	0.75	541.0	237.7	1.0	541.0	237.7	11.0	10.0	NO	\$100
R65	Zinc-coated steel rod	0.75	541.0	278.2	1.0	541.0	278.2	11.0	10.0	NO	\$100
R66	Zinc-coated steel rod	0.75	540.5	314.2	1.0	540.5	314.2	11.0	10.0	NO	\$100
R67	Zinc-coated steel rod	0.75	540.5	353.7	1.0	540.5	353.7	11.0	10.0	NO	\$100
R68	Zinc-coated steel rod	0.75	540.0	394.2	1.0	540.0	394.2	11.0	10.0	NO	\$100
R69	Zinc-coated steel rod	0.75	541.0	427.7	1.0	541.0	427.7	11.0	10.0	NO	\$100
R70	Zinc-coated steel rod	0.75	540.0	469.2	1.0	540.0	469.2	11.0	10.0	NO	\$100
R71	Zinc-coated steel rod	0.75	520.5	469.7	1.0	520.5	469.7	11.0	10.0	NO	\$100
R72	Zinc-coated steel rod	0.75	489.5	470.7	1.0	489.5	470.7	11.0	10.0	NO	\$100
R73	Zinc-coated steel rod	0.75	456.5	470.2	1.0	456.5	470.2	11.0	10.0	NO	\$100
R74	Zinc-coated steel rod	0.75	420.0	470.2	1.0	420.0	470.2	11.0	10.0	NO	\$100
R75	Zinc-coated steel rod	0.75	349.5	470.2	1.0	349.5	470.2	11.0	10.0	NO	\$100
R76	Zinc-coated steel rod	0.75	201.0	468.7	1.0	201.0	468.7	11.0	10.0	NO	\$100
R77	Zinc-coated steel rod	0.75	206.0	468.7	1.0	206.0	468.7	11.0	10.0	NO	\$100
R78	Zinc-coated steel rod	0.75	200.0	205.7	1.0	200.0	205.7	11.0	10.0	NO	\$100
R79	Zinc-coated steel rod	0.75	229.0	204.7	1.0	229.0	204.7	11.0	10.0	NO	\$100
R80	Zinc-coated steel rod	0.75	263.5	204.7	1.0	263.5	204.7	11.0	10.0	NO	\$100
R81	Zinc-coated steel rod	0.75	304.0	204.2	1.0	304.0	204.2	11.0	10.0	NO	\$100
R82	Zinc-coated steel rod	0.75	344.0	204.2	1.0	344.0	204.2	11.0	10.0	NO	\$100
R83	Zinc-coated steel rod	0.75	387.0	204.7	1.0	387.0	204.7	11.0	10.0	NO	\$100
R84	Zinc-coated steel rod	0.75	421.0	204.7	1.0	421.0	204.7	11.0	10.0	NO	\$100
R85	Zinc-coated steel rod	0.75	458.5	204.2	1.0	458.5	204.2	11.0	10.0	NO	\$100
R86	Zinc-coated steel rod	0.75	508.0	205.2	1.0	508.0	205.2	11.0	10.0	NO	\$100

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**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R87	Zinc-coated steel rod	0.75	272.0	378.7	1.0	272.0	378.7	11.0	10.0	NO	\$100

**Cost:**

Conductor			Rod			Total Cost
Total No.	Total Length ft	Cost	Total No.	Total Length ft	Cost	
51	6,640.7	\$21,914	88	880.0	\$88,000	\$109,914

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Distant Future 230 kV Consideration

Ground Grid Summary Report

Rg Ground Resistance Ohm	GPR Ground Potential Rise Volts	Maximum Touch Potential					Maximum Step Potential				
		Tolerable Volts	Calculated Volts	Calculated %	Coordinates (ft)		Tolerable Volts	Calculated Volts	Calculated %	Coordinates (ft)	
					X	Y				X	Y
0.88	2,386.4	286.7	684.7	238.8	484.1	403.9	480.9	318.7	66.3	541.00	471.41

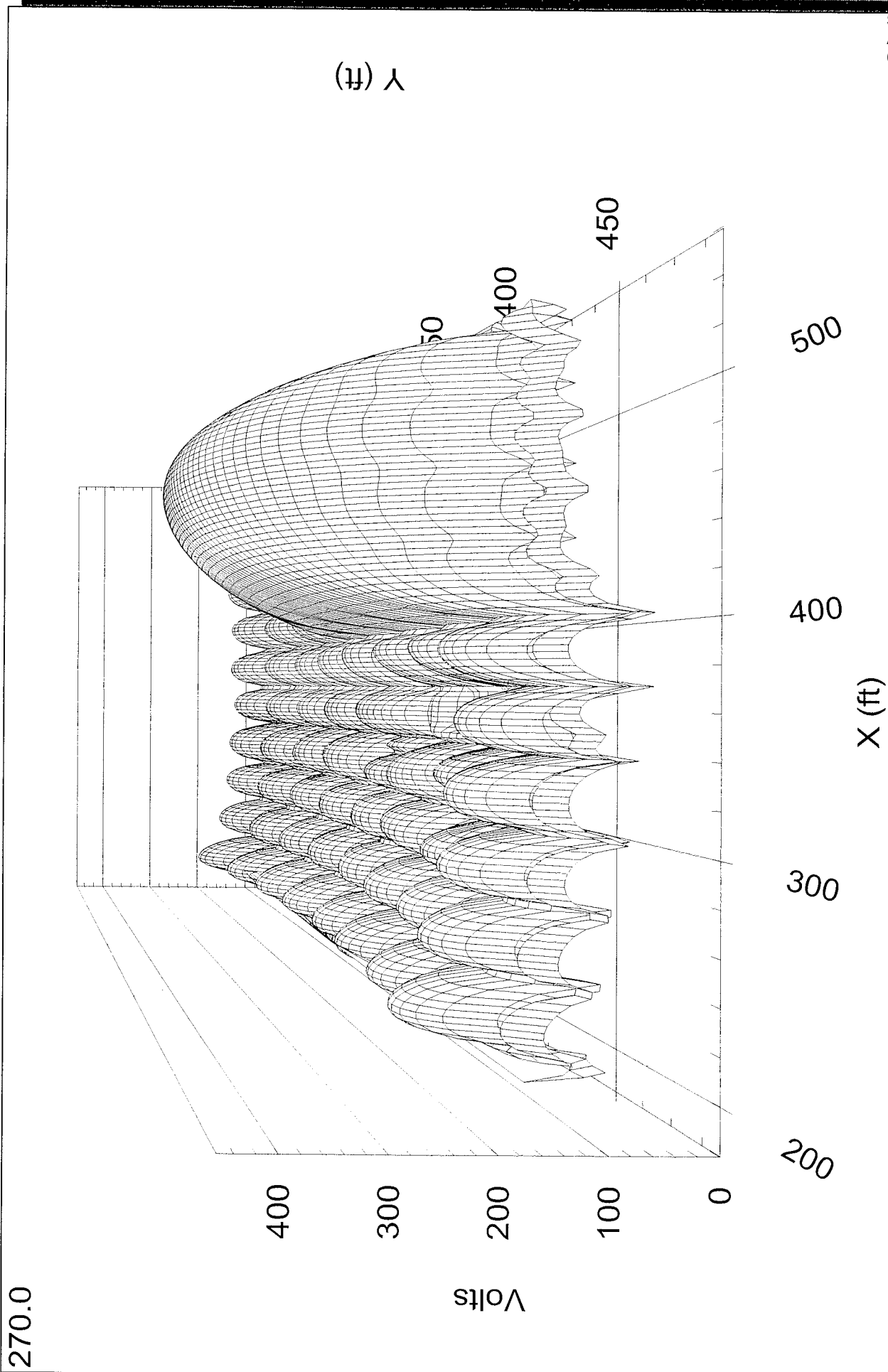
Total Fault Current	6.220 kA	Reflection Factor (K):	-0.067
Maximum Grid Current:	2.715 kA	Surface Layer Derating Factor (Cs):	0.972
		Decrement Factor (DF):	1.015

Warnings:

The maximum Touch Voltage exceeds the tolerable limits

# Echo Over TS

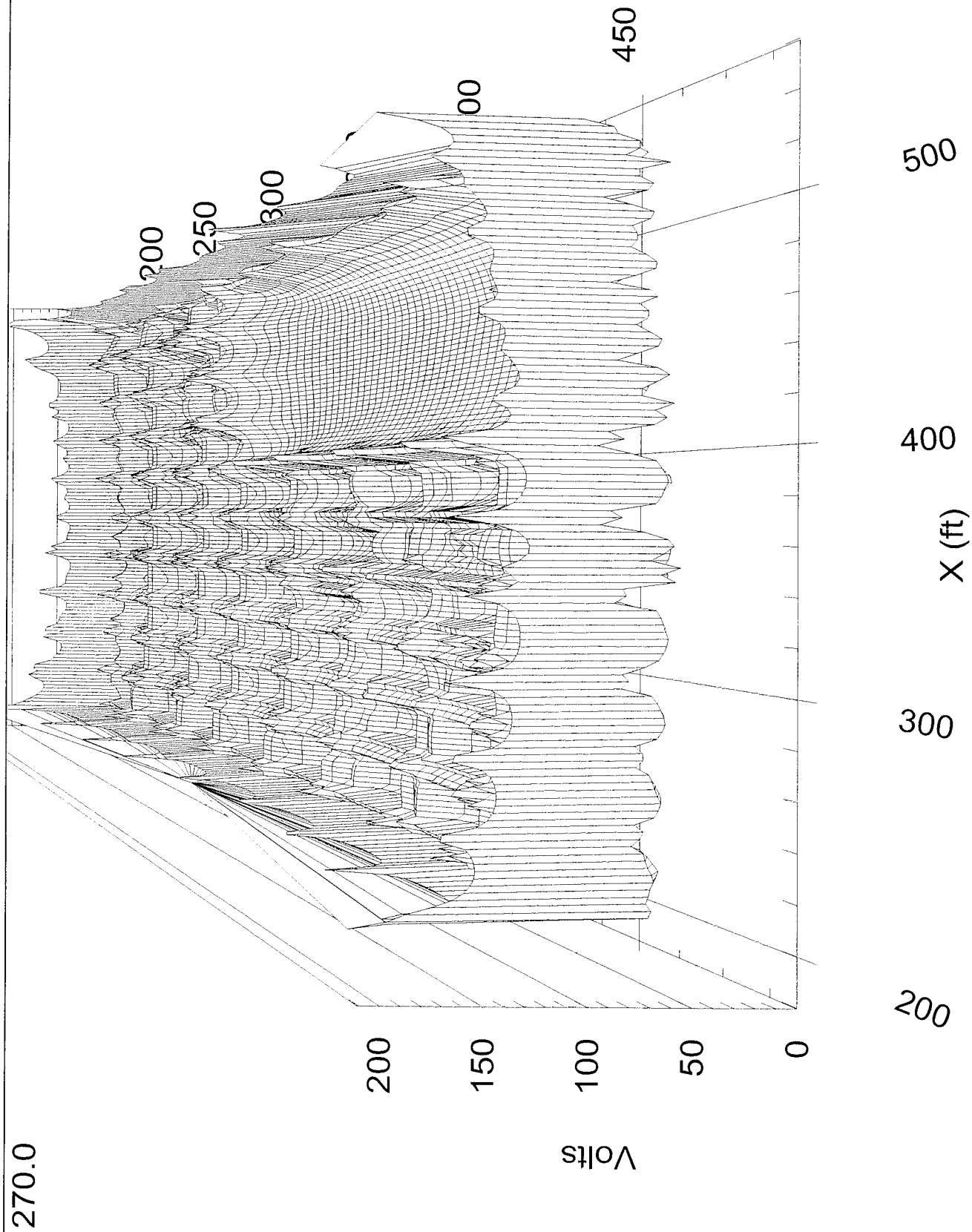
Touch Potential Profile





# EchORiver

## Step Potential Profile



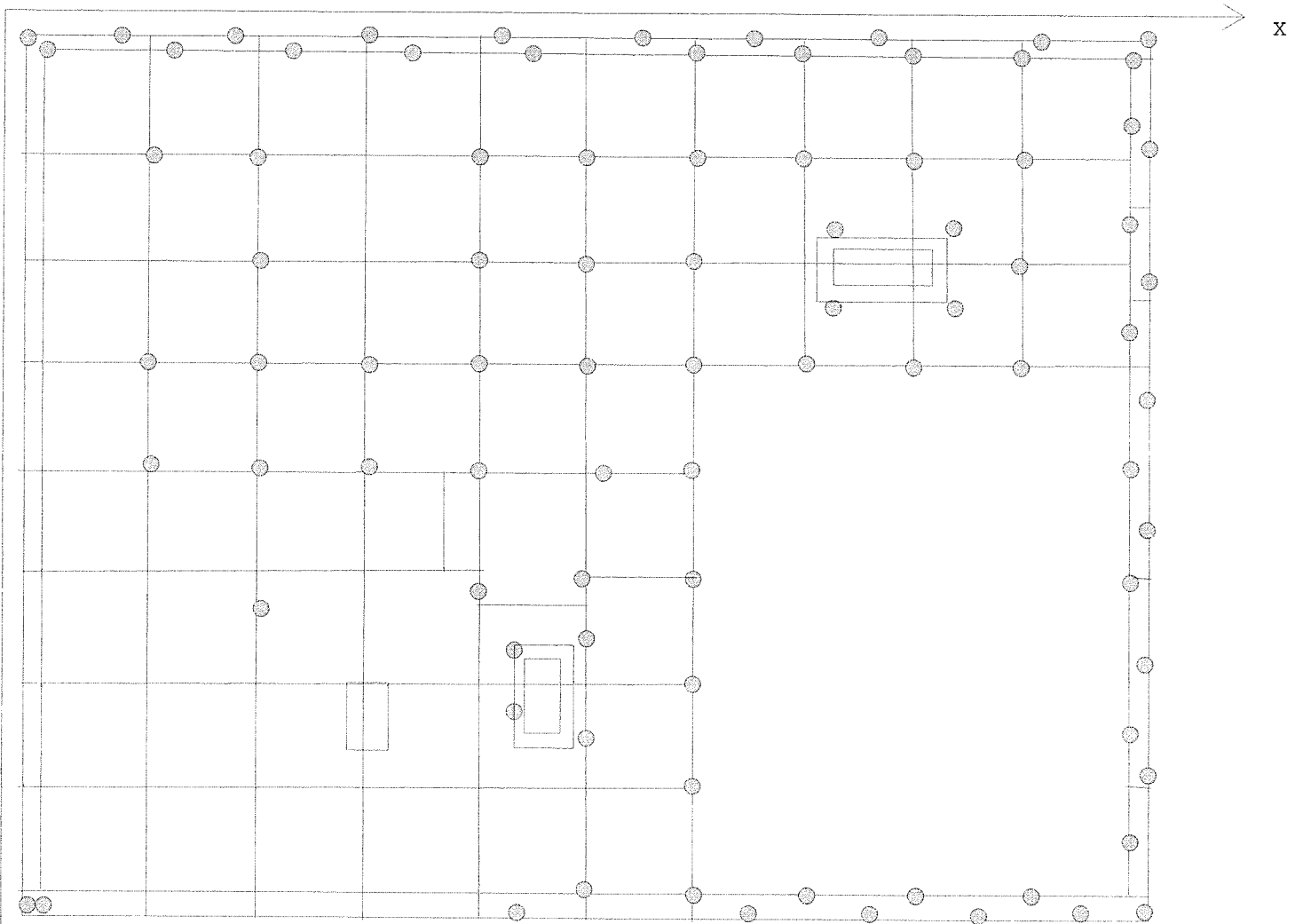
Y (ft)

Project:  
Location:  
Contract:  
Engineer:  
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Revision: Base

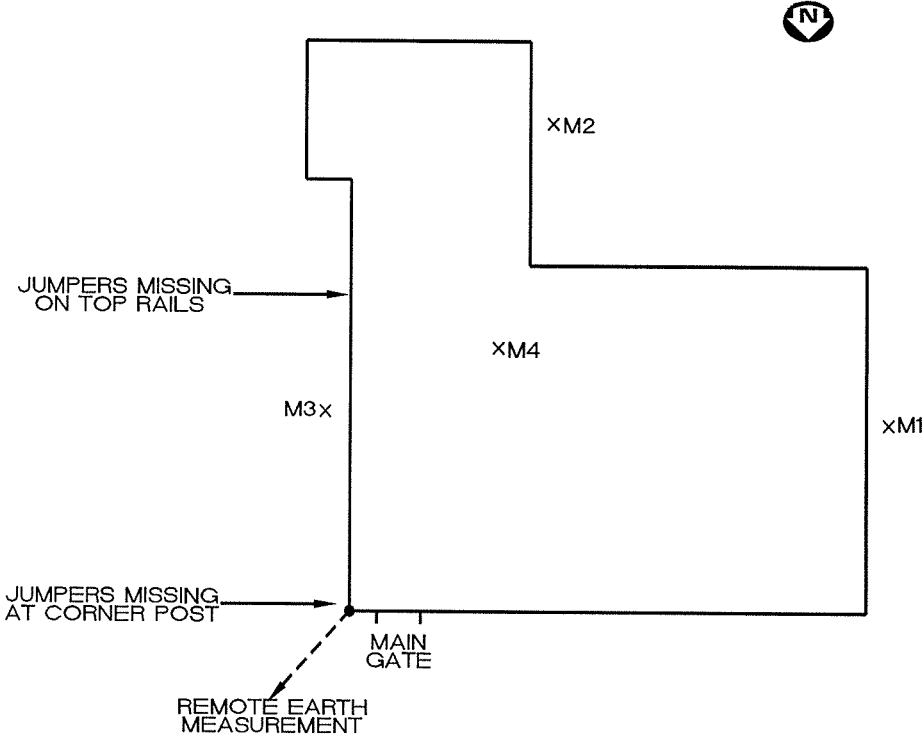
Grid1 - Top View





**6.4 Hollingsworth TS**

**6.4.1 Soil Resistivity Measurement Locations**



## 6.4.2 Resistivity Measurement

Soil resistivity has been calculated based on the following:

$$P = 2\pi aR$$

$a$  = Rod Spacing

$R$  = Resistivity Measurement

Measurement Location	Probe Spacing	Resistance Measured	Calculated Soil Resistivity
M1	0.91 M	267 $\Omega$	1533 $\Omega \cdot M$
M2	0.91 M	354 $\Omega$	2033 $\Omega \cdot M$
M3	0.91 M	1398 $\Omega$	7993 $\Omega \cdot M$
M4	0.305 M	256 $\Omega$	4902 $\Omega \cdot M$

Modeling Values Used:

1. Surface            Stone            4902  $\Omega \cdot M$
2. Upper Surface    Gravel           1500  $\Omega \cdot M$
3. Lower Surface    Bedrock          1500  $\Omega \cdot M$

## 6.4.3 Ground Resistance Measurements

Measurement Location:

The test ground electrode used is indicated on the measurement location sketch 6.4.1. Current probe C1 was located in a northerly direction, 800 ft. from test electrode. Potential probe P1 measurements were made at approximately 100 ft. intervals between test electrode and current probe C1.

Measurements obtained:

Position No.	Distance	Resistance
1	100 ft.	3.5 $\Omega$
2	160 ft.	4.1 $\Omega$
3	200 ft.	4.6 $\Omega$
4	320 ft.	9.6 $\Omega$
5	400 ft.	11.0 $\Omega$
6	480 ft.	12.5 $\Omega$
7	600 ft.	14.0 $\Omega$

---

The Slope Method was used to calculate soil resistivity. Refer to Appendix 9.1 for supporting methodology.

Distance calculation for value R

$$R_1 = 0.2 \times 800' = 160'$$

$$R_2 = 0.4 \times 800' = 320'$$

$$R_3 = 0.6 \times 800' = 480'$$

Remote Distance Curve Calculation:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1} = \frac{12.5 - 9.6}{9.6 - 4.1} = 0.527$$

From Table VII in Appendix 9.2:

$$\mu \text{ of } 0.527 = \text{Pt/C of } 0.624$$

Distance of potential probe to represent remote earth soil resistivity  
=  $0.624 \times 800' = 499'$  to Probe P1

**Measured Value = 13.1  $\Omega$**

#### 6.4.4 Stone Coverage Area

On a percentage basis, approximately 100% of the area inside the fenced enclosure does have a stone cover. Stone depth was measured at 0.025 M. The stone cover and sand/gravel subsoil contained moisture and was damp. This is reflected in the ground resistance measurements. The surrounding area was mostly bedrock with gravel cover.

## 6.4.5 Allowable Safe Step and Touch Potentials

Based on Surface Layer De-rating Factor ( $C_s$ )

$$\begin{aligned} C_s &= 1 - \frac{0.09 \left(1 - \frac{P}{P_s}\right)}{2h_s + 0.09} \\ &= 1 - \left(\frac{0.062}{0.141}\right) \\ &= 1 - 0.4397 \\ &= 0.56 \end{aligned}$$

$$P = 1500 \Omega \cdot M$$

$$P_s = 4902 \Omega \cdot M$$

$$h_s = 0.0254 M$$

### Safe Step Potential

$$\begin{aligned} E_{Step(50)} &= [1000 + 6C_sP_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 6 * 0.56 * 4902] * \frac{0.116}{\sqrt{0.5}} \\ &= 17470 * 0.164 \\ &= 2865 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Step(70)} &= [1000 + 6C_sP_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 6 * 0.56 * 4902] * \frac{0.157}{\sqrt{0.5}} \\ &= 17470 * 0.222 \\ &= 3878 \text{ Volts} \end{aligned}$$

## Safe Touch Potential

$$\begin{aligned} E_{Touch(50)} &= [1000 + 1.5C_sP_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 0.56 * 4902] * \frac{0.116}{\sqrt{0.5}} \\ &= 5118 * 0.164 \\ &= 839 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Touch(70)} &= [1000 + 1.5C_sP_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 0.56 * 4902] * \frac{0.157}{\sqrt{0.5}} \\ &= 5118 * 0.222 \\ &= 1136 \text{ Volts} \end{aligned}$$

## 6.4.6 Total Resistance to Remote Earth

$$\begin{aligned} R_g &= P * \left[ \frac{1}{L_r} + \frac{1}{\sqrt{20A}} \left( 1 + \frac{1}{1 + h\sqrt{\frac{20}{A}}} \right) \right] \\ &= 1500 * \left[ \frac{1}{482} + \frac{1}{\sqrt{20 * 544}} \left( 1 + \frac{1}{1 + 0.025\sqrt{\frac{20}{544}}} \right) \right] \\ &= 1500 * [0.0021 + 0.00958 * 1.995] \\ &= 1500 * 0.0212 \\ &= 31.8 \Omega \end{aligned}$$



$L_T$  = Buried conductors and rods

$$= 482 \text{ M}$$

$A$  = Ground grid area

$$= 544 \text{ M}^2$$

$h$  = Depth of grid

$$= 0.025 \text{ M}$$

$P$  = Resistivity

$$= 1500 \Omega \cdot \text{M}$$

## 6.4.7 Current Grid Split Factor Determination

To calculate  $S_f$  based on IEEE Std. 80-2000 Annex C.

Based on 1 Transmission / 1 Distribution Lines

$$R_g \text{ Measured} = 13.1 \Omega \text{ (selected for calculation)}$$

$$R_g \text{ Calculated} = 31.8 \Omega$$

$$R_g \text{ Modeled} = 31.1 \Omega$$

Hollingsworth Generation comprised 3% of Local fault current, we therefore have considered contribution to be 100% Remote.

### Method A

$$\text{Table C.1} \quad 1T / 1D \quad R_{tg} = 100 \Omega \quad R_{dg} = 200 \Omega \quad R + jX = 3.27 + j0.652$$

$$Z_g = \frac{(3.27 + j0.652)}{(13.1 + 3.27 + j0.652)} = \frac{3.334}{16.383} = 0.203 \Omega$$

### Method B

$$1T / 1D \quad 100\% \text{ Remote Contribution} \quad R_g = 13.1 \Omega$$

$$R_{tg} = 100 \Omega \quad R_{dg} = 200 \Omega \quad \text{Figure C.2}$$

$$S_f = 20\%$$

$\therefore$  Comparing methods A and B, assign  $S_f$  for 12.0 kV system of 20%.

## 6.4.8 Symmetrical Grid Current ( $I_g$ )

$$\begin{aligned} I_g &= S_f * I_F \\ &= 0.20 * 2.622 \text{ kA} \\ &= 0.52 \text{ kA} \end{aligned}$$

$$\begin{aligned} S_f &= 20\% \\ I_F &= L - G \text{ value from G.L.P.} \\ &= 2.622 \text{ kA} \end{aligned}$$

## 6.4.9 Maximum Grid Current ( $I_G$ )

$$\begin{aligned} I_G &= D_f * I_g \\ &= 1.012 * 0.52 \text{ kA} \\ &= 0.53 \text{ kA} \end{aligned}$$

$$\begin{aligned} D_f &= 1.012 \\ I_g &= 0.52 \text{ kA} \end{aligned}$$

## 6.4.10 Calculated Ground Potential Rise ( $GPR$ )

$$\begin{aligned} GPR_{Hand} &= R_g * I_G * 10^3 \\ &= 31.8 * 0.53 * 10^3 \\ &= 16854 \text{ Volts} \end{aligned}$$

$$\begin{aligned} GPR_{Measured} &= R_g * I_G * 10^3 \\ &= 13.1 * 0.53 * 10^3 \\ &= 6943 \text{ Volts} \end{aligned}$$

## 6.4.11 Comparison of Modeled Values and Results

Modeled Step and Touch voltage values have not been compared to manual calculated values.

Manual calculated values could not be completed as per the methodologies of IEEE 80-2000 Section 16.5.1 and 16.5.2 due to the irregularity and complexity of the

existing grounding grid layout. Refer to Sections 16.7 and 16.8 of the referenced standard.

Section 6.4.15 contains the detailed computer model output summary report. The Ground Grid Summary Report, usually the final page of the output documents, summarizes the calculated Maximum Touch and Step Potential values based on the grid layout. Calculated values are compared to the Safe Touch and Step potentials.

#### 6.4.12 Fence Grounding and Condition Comments

The boundary fence is tied to the substation ground grid. Measured resistance between fence and ground grid is 0.100  $\Omega$ .

A visual inspection of the fence and gate grounding was completed. The condition of each thermoweld was inspected and the continuity of each jumper was confirmed.

Bonding jumpers were missing at the north east corner post and two bonding jumpers were missing from the top rail on the east side of the yard. Refer to measurement location sketch, section 6.4.1, for fence damage location.

#### 6.4.13 Above Grade Equipment Ground Audit

An audit of all bonding and grounding associated with electrical distribution equipment, supporting towers and structures, fences and gates was completed. All bare ground wire connections were assessed including both thermoweld and mechanical configurations. Bare ground wire sizes were measured and compared to the engineering drawing provided by Great Lakes Power. For reference, this drawing is SD-30302 rev. 1.

This drawing was not a complete ground grid drawing as the original ground grid was not indicated. We did confirm the grounding of equipment and conductor sizes conformed to acceptable standards. Most of the older grid however, is not buried and generally, is exposed to damage.

---

## 6.4.14 Comments

1. The Hollingsworth T.S. ground grid is interconnected to the Hollingsworth G.S. ground grid via an overhead ACSR conductor. We have obtained the generating station ground grid drawings from 1958 and these drawings do not conform to the installed system grid. In our analysis we have attempted to replicate the ground grid in the computer model but were unsuccessful.
2. The structure at the south end of the existing yard, near circuit breaker 993, does not have the required clearance between the fence and equipment. It is possible to realize ground grid touch potential at this location. This possibly is a moot point because the ground grid is exposed at many locations within the older substation area; no soil cover.
3. In our analysis we used the measured value of remote earth resistance to establish ground potential rise.
4. It is recommended that this site be re-measured.

---

## 6.4.15 Computer Model Output Results

### System Data:

Body Weight	70 kg
Fault Current ( $I_F$ )	2.622 kA
X/R ratio	4.4
Division Factor ( $S_F$ )	20%
Projection Factor ( $C_P$ )	100%
Fault Duration ( $T_f, T_c, T_s$ )	0.5 sec.
Plot Step	3 ft.

### Summary Report:

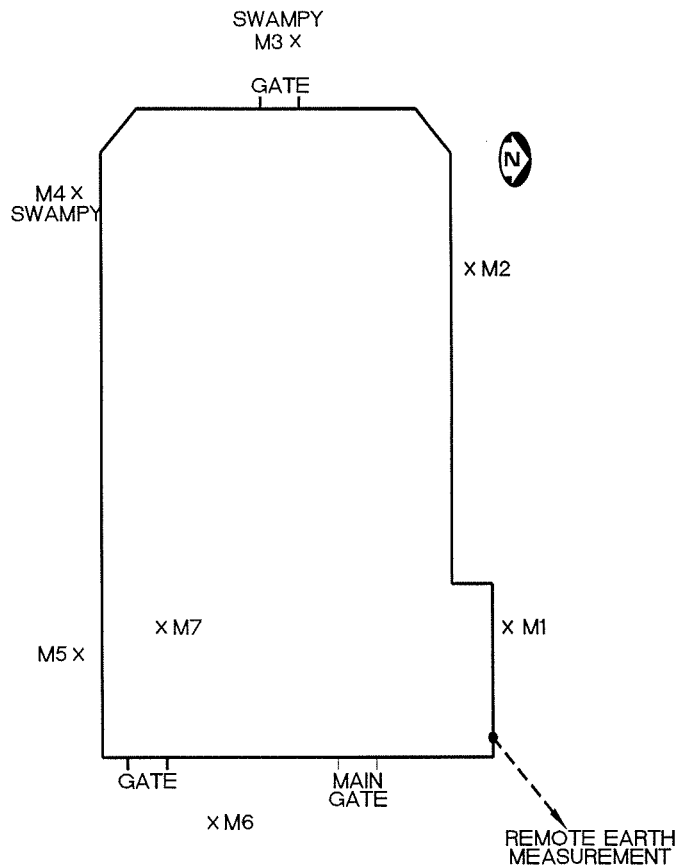
Ground Resistance ( $R_g$ )	N/A $\Omega$
Ground Potential Rise (GPR)	N/A V
Tolerable Touch Potential	1129 V
Calculated Touch Potential	N/A V
Tolerable Step Potential	3851 V
Calculated Step Potential	N/A V

### Modeled Results Not Obtainable



## 6.5 MAGPIE TS

### 6.5.1 Soil Resistivity Measurement Locations



## 6.5.2 Resistivity Measurement

Soil resistivity has been calculated based on the following:

$$P = 2\pi aR$$

$a$  = Rod Spacing

$R$  = Resistivity Measurement

Measurement Location	Probe Spacing	Resistance Measured	Calculated Soil Resistivity
M1	0.91 M	359 $\Omega$	2063 $\Omega \cdot M$
M2	0.91 M	582 $\Omega$	3344 $\Omega \cdot M$
M3	0.91 M	54.8 $\Omega$	315 $\Omega \cdot M$
M4	0.91 M	69.5 $\Omega$	399 $\Omega \cdot M$
M5	0.91 M	608 $\Omega$	3493 $\Omega \cdot M$
M6	0.91 M	455 $\Omega$	2614 $\Omega \cdot M$
M7	0.46 M	345 $\Omega$	990 $\Omega \cdot M$

Modeling Values Used:

1. Surface            Stone            990  $\Omega \cdot M$
2. Upper Surface    Sand/Gravel    1200  $\Omega \cdot M$
3. Lower Surface    Sand/Gravel    1200  $\Omega \cdot M$

## 6.5.3 Ground Resistance Measurements

Measurement Location:

The test ground electrode used is indicated on the measurement location sketch

6.5.1. Current probe C1 was located in a northerly direction, 800 ft. from test electrode. Potential probe P1 measurements were made at approximately 100 ft. intervals between test electrode and current probe C1.

Measurements obtained:

Position No.	Distance	Resistance
1	160 ft.	3.62 $\Omega$
2	200 ft.	4.11 $\Omega$
3	320 ft.	4.74 $\Omega$
4	400 ft.	5.61 $\Omega$
5	480 ft.	5.91 $\Omega$
6	600 ft.	7.11 $\Omega$
7	700 ft.	9.25 $\Omega$



The Slope Method was used to calculate soil resistivity. Refer to Appendix 9.1 for supporting methodology.

Distance calculation for value R

$$R_1 = 0.2 \times 800' = 160'$$

$$R_2 = 0.4 \times 800' = 320'$$

$$R_3 = 0.6 \times 800' = 480'$$

Remote Distance Curve Calculation:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1} = \frac{5.91 - 4.74}{4.74 - 3.62} = 1.04$$

From Table VII in Appendix 9.2:

$$\mu \text{ of } 1.04 = \text{Pt/C of } 0.533$$

Distance of potential probe to represent remote earth soil resistivity

$$= 0.533 \times 800' = 426' \text{ to Probe P1}$$

**Measured Value = 5.70  $\Omega$**

#### 6.5.4 Stone Coverage Area

On a percentage basis, approximately 100% of the area inside the fenced enclosure does have a stone cover. Stone depth was measured at 0.102 M. The stone cover and sand/gravel subsoil contained moisture and was very damp. This is reflected in the ground resistance measurements.

## 6.5.5 Allowable Safe Step and Touch Potentials

Based on Surface Layer De-rating Factor ( $C_s$ )

$$\begin{aligned} C_s &= 1 - \frac{0.09 \left(1 - \frac{P}{P_s}\right)}{2h_s + 0.09} \\ &= 1 - \left(\frac{-0.019}{0.294}\right) \\ &= 1 - (-)0.0646 \\ &= 1.065 \end{aligned}$$

$$P = 1200 \Omega \cdot M$$

$$P_s = 990 \Omega \cdot M$$

$$h_s = 0.102 M$$

### Safe Step Potential

$$\begin{aligned} E_{Step(50)} &= [1000 + 6C_s P_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 6 * 1.065 * 990] * \frac{0.116}{\sqrt{0.5}} \\ &= 7326 * 0.164 \\ &= 1201 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Step(70)} &= [1000 + 6C_s P_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 6 * 1.065 * 990] * \frac{0.157}{\sqrt{0.5}} \\ &= 7326 * 0.222 \\ &= 1626 \text{ Volts} \end{aligned}$$

## Safe Touch Potential

$$\begin{aligned} E_{Touch(50)} &= [1000 + 1.5C_sP_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 1.065 * 990] * \frac{0.116}{\sqrt{0.5}} \\ &= 2582 * 0.164 \\ &= 423 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Touch(70)} &= [1000 + 1.5C_sP_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 1.065 * 990] * \frac{0.157}{\sqrt{0.5}} \\ &= 2582 * 0.222 \\ &= 573 \text{ Volts} \end{aligned}$$

## 6.5.6 Total Resistance to Remote Earth

$$\begin{aligned} R_g &= P * \left[ \frac{1}{L_\tau} + \frac{1}{\sqrt{20A}} \left( 1 + \frac{1}{1 + h\sqrt{\frac{20}{A}}} \right) \right] \\ &= 1200 * \left[ \frac{1}{1883} + \frac{1}{\sqrt{20 * 6203}} \left( 1 + \frac{1}{1 + 0.406\sqrt{\frac{20}{6203}}} \right) \right] \\ &= 1200 * [0.00053 + 0.0028 * 1.977] \\ &= 1200 * 0.00614 \\ &= 7.37 \Omega \end{aligned}$$

$L_T$  = Buried conductors and rods

$$= 1883 \text{ M}$$

$A$  = Ground grid area

$$= 6203 \text{ M}^2$$

$h$  = Depth of grid

$$= 0.406 \text{ M}$$

$P$  = Resistivity

$$= 1200 \Omega \cdot \text{M}$$

## 6.5.7 Current Grid Split Factor Determination

To calculate  $S_f$  based on IEEE Std. 80-2000 Annex C.

Based on 1 Transmission / 0 Distribution Lines

$$R_g \text{ Measured} = 5.70 \Omega$$

$$R_g \text{ Calculated} = 7.37 \Omega$$

$$R_g \text{ Modeled} = 6.81 \Omega \text{ (selected for calculation)}$$

### Method B

$$1T / 0D \quad 25\% \text{ Local Contribution} / 75\% \text{ Remote Contribution} \quad R_g = 6.8 \Omega$$

$$R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad \text{Figure C.17}$$

$$S_f = 20\%$$

Assign a Current Split Factor  $S_f$  for 115 kV system of 20%.

## 6.5.8 Symmetrical Grid Current ( $I_g$ )

$$\begin{aligned} I_g &= S_f * I_F \\ &= 0.20 * 3.62 \text{ kA} \\ &= 0.72 \text{ kA} \end{aligned}$$

$$\begin{aligned} S_f &= 20\% \\ I_F &= L - G \text{ value from G.L.P.} \\ &= 3.62 \text{ kA} \end{aligned}$$

## 6.5.9 Maximum Grid Current ( $I_G$ )

$$\begin{aligned} I_G &= D_f * I_g \\ &= 1.024 * 0.72 \text{ kA} \\ &= 0.74 \text{ kA} \end{aligned}$$

$$\begin{aligned} D_f &= 1.024 \\ I_g &= 0.72 \text{ kA} \end{aligned}$$

## 6.5.10 Calculated Ground Potential Rise ( $GPR$ )

$$\begin{aligned} GPR_{Hand} &= R_g * I_G * 10^3 \\ &= 7.37 * 0.74 * 10^3 \\ &= 5454 \text{ Volts} \end{aligned}$$

$$\begin{aligned} GPR_{Measured} &= R_g * I_G * 10^3 \\ &= 5.7 * 0.74 * 10^3 \\ &= 4218 \text{ Volts} \end{aligned}$$

## 6.5.11 Comparison of Modeled Values and Results

Modeled Step and Touch voltage values have not been compared to manual calculated values.

Manual calculated values could not be completed as per the methodologies of IEEE 80-2000 Section 16.5.1 and 16.5.2 due to the irregularity and complexity of the

existing grounding grid layout. Refer to Sections 16.7 and 16.8 of the referenced standard.

Section 6.5.15 contains the detailed computer model output summary report. The Ground Grid Summary Report, usually the final page of the output documents, summarizes the calculated Maximum Touch and Step Potential values based on the grid layout. Calculated values are compared to the Safe Touch and Step potentials.

### 6.5.12 Fence Grounding and Condition Comments

The boundary fence is tied to the substation ground grid. Measured resistance between fence and ground grid is 0.422  $\Omega$ .

A visual inspection of the fence and gate grounding was completed. The condition of each thermoweld was inspected and the continuity of each jumper was confirmed.

This is a relatively new ground grid installation. We found no issues with the fence and fence grounding.

### 6.5.13 Above Grade Equipment Ground Audit

An audit of all bonding and grounding associated with electrical distribution equipment, supporting towers and structures, fences and gates was completed. All bare ground wire connections were assessed including both thermoweld and mechanical configurations. Bare ground wire sizes were measured and compared to the engineering drawing provided by Great Lakes Power. For reference, this drawing is number 38019 (SE-39501) rev. 7.

This is a relatively new ground grid installation. We found no issues with the above ground audit.

### 6.5.14 Comments

1. Soil resistivity values in this area ranged over a large spectrum. Values ranged from 315  $\Omega\cdot M$  to 3500  $\Omega\cdot M$ . This was reflective of surface conditions; a mixture of

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gravel, sand and rock. We have selected an intermediate value of soil resistivity to align with the actual measured value of remote earth resistivity ( $R_g$ ).

It is recommended additional site measurements be taken to confirm validity of initial site measurements.

2. Considering existing fault values, the Safe Touch Potential has exceeded safe limits (156%).
3. Considering future distant fault values, the Safe Touch Potential has exceeded safe limits (171%).

## 6.5.15 Computer Model Output Results

### System Data:

Body Weight	70 kg
Fault Current ( $I_F$ )	3.62 kA
X/R ratio	9.10
Division Factor ( $S_F$ )	20%
Projection Factor ( $C_P$ )	100%
Fault Duration ( $T_f, T_c, T_s$ )	0.5 sec.
Plot Step	3 ft.

### Summary Report:

Ground Resistance ( $R_g$ )	6.81 $\Omega$
Ground Potential Rise (GPR)	5046 V
Tolerable Touch Potential	573 V
Calculated Touch Potential	978 V
Tolerable Step Potential	1627 V
Calculated Step Potential	800 V

### Touch Voltage Exceeds Tolerable Limits



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Electrical Transient Analyzer Program

ETAP PowerStation

Ground Grid Systems

Finite Element Method

Number of Ground Conductors: 60  
Number of Ground Rods: 72  
Total Length of Ground Conductors: 5458.00 ft  
Total Length of Ground Rods: 720.00 ft

Frequency: 60.0

Unit System: English

Project Filename: GLP-MAGPIE

Output Filename: C:\Documents and Settings\Barry Bingeman\My Documents\Great Lakes  
Power\Models\GLP-MAGPIE\Grid1\_Untitled.GR1

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**Ground Grid Input Data**

**System Data:**

Freq. Hz	Weight kg	Ambient Temp. °C	Short-Circuit Current			Fault Duration (Seconds)			Plot Step ft	Extended Boundary Length ft	
			Total Fault Current kA	Sf Division Factor %	Cp Projection Factor %	Tf for Total Fault Duration	Tc for Sizing Ground Conductors	Ts for Available Body Current			
60.0	70	40.00	3.620	9.10	20.0	100.0	0.50	0.50	0.50	3.0	0.0

**Soil Data:**

Surface Material			Upper Layer Soil			Lower Layer Soil	
Material Type	Resistivity .m	Depth ft	Material Type	Resistivity .m	Depth ft	MaterialType	Resistivity .m
Crushed rock	990.0	0.33	Moist soil	1200.0	5.00	Moist soil	1200.0

**Material Constants:**

Conductor/Rod	Type	Conductivity %	r Factor @ 20 °C 1/°C	K0 @ 0 °C	Fusing Temperature °C	Resistivity of Ground Conductor @ 20°C .cm	Thermal Capacity Per Unit Volume J/(cm³.°C)
Conductor	Copper, annealed soft-drawn	100.0	0.00393	234.0	1083.0	1.72	3.42
Rod	Copper, annealed soft-drawn	100.0	0.00393	234.0	1083.0	1.72	3.42

**Conductor Data:**

Label	Type	Size AWG/kcmil	From			To			Length ft	Insulated Ycs/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C0	Copper, annealed soft-drawn	2/0	1931.4	1296.9	1.0	2297.4	1296.9	1.0	366.0	NO	\$3
C3	Copper, annealed soft-drawn	2/0	1906.2	1250.4	1.0	1931.8	1296.8	1.0	53.0	NO	\$3
C4	Copper, annealed soft-drawn	2/0	1906.4	1175.8	1.0	1943.9	1135.5	1.0	55.0	NO	\$3
C5	Copper, annealed soft-drawn	2/0	1906.3	1250.2	1.0	1906.3	1175.2	1.0	75.0	NO	\$3
C6	Copper, annealed soft-drawn	2/0	1943.6	1135.5	1.0	2189.6	1135.5	1.0	246.0	NO	\$3
C7	Copper, annealed soft-drawn	2/0	2189.2	1135.1	1.0	2189.2	1097.1	1.0	38.0	NO	\$3
C8	Copper, annealed soft-drawn	2/0	2188.9	1097.4	1.0	2297.9	1097.4	1.0	109.0	NO	\$3
C9	Copper, annealed soft-drawn	2/0	2297.3	1097.1	1.0	2297.3	1296.1	1.0	199.0	NO	\$3
C10	Copper, annealed soft-drawn	4/0	1955.6	1136.0	1.3	1955.6	1298.0	1.3	162.0	NO	\$3
C11	Copper, annealed soft-drawn	4/0	2034.0	1247.1	1.3	2034.0	1246.8	1.3	0.3	NO	\$3
C12	Copper, annealed soft-drawn	4/0	1994.2	1135.8	1.3	1994.2	1297.8	1.3	162.0	NO	\$3
C13	Copper, annealed soft-drawn	4/0	2032.2	1135.8	1.3	2032.2	1297.8	1.3	162.0	NO	\$3
C14	Copper, annealed soft-drawn	4/0	2071.7	1135.5	1.3	2071.7	1297.5	1.3	162.0	NO	\$3
C15	Copper, annealed soft-drawn	4/0	2110.3	1135.7	1.3	2110.3	1297.7	1.3	162.0	NO	\$3
C16	Copper, annealed soft-drawn	4/0	2149.9	1135.5	1.3	2149.9	1297.5	1.3	162.0	NO	\$3
C17	Copper, annealed soft-drawn	4/0	2194.2	1097.5	1.3	2194.2	1296.5	1.3	199.0	NO	\$3
C18	Copper, annealed soft-drawn	4/0	2233.9	1097.8	1.3	2233.9	1296.8	1.3	199.0	NO	\$3

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**Conductor Data:**

Label	Type	Size AWG/kemil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C19	Copper, annealed soft-drawn	4/0	2272.5	1097.5	1.3	2272.5	1296.5	1.3	199.0	NO	\$3
C20	Copper, annealed soft-drawn	4/0	2194.6	1135.3	1.3	2297.2	1135.3	1.3	102.6	NO	\$3
C21	Copper, annealed soft-drawn	4/0	2233.6	1117.1	1.3	2272.6	1117.1	1.3	39.0	NO	\$3
C22	Copper, annealed soft-drawn	4/0	1916.3	1268.8	1.3	2297.6	1268.6	1.3	381.3	NO	\$3
C23	Copper, annealed soft-drawn	4/0	1906.5	1235.2	1.3	2297.5	1235.2	1.3	391.0	NO	\$3
C24	Copper, annealed soft-drawn	4/0	1906.6	1201.9	1.3	2297.6	1201.9	1.3	391.0	NO	\$3
C25	Copper, annealed soft-drawn	4/0	1912.6	1169.1	1.3	2297.9	1168.7	1.3	385.3	NO	\$3
C26	Copper, annealed soft-drawn	4/0	2032.6	1253.2	1.3	2234.6	1253.2	1.3	202.0	NO	\$3
C27	Copper, annealed soft-drawn	4/0	2032.5	1183.3	1.3	2234.5	1183.3	1.3	202.0	NO	\$3
C28	Copper, annealed soft-drawn	4/0	2043.2	1202.2	1.3	2043.2	1235.2	1.3	33.0	NO	\$3
C29	Copper, annealed soft-drawn	4/0	2058.0	1202.2	1.3	2058.0	1235.2	1.3	33.0	NO	\$3
C30	Copper, annealed soft-drawn	4/0	2082.8	1202.2	1.3	2082.8	1235.2	1.3	33.0	NO	\$3
C31	Copper, annealed soft-drawn	4/0	2097.6	1202.2	1.3	2097.6	1235.2	1.3	33.0	NO	\$3
C32	Copper, annealed soft-drawn	4/0	2122.2	1202.2	1.3	2122.2	1235.2	1.3	33.0	NO	\$3
C33	Copper, annealed soft-drawn	4/0	2137.0	1202.2	1.3	2137.0	1235.2	1.3	33.0	NO	\$3
C34	Copper, annealed soft-drawn	4/0	2164.0	1202.0	1.3	2164.0	1235.0	1.3	33.0	NO	\$3
C35	Copper, annealed soft-drawn	4/0	2180.8	1202.4	1.3	2180.8	1235.4	1.3	33.0	NO	\$3
C36	Copper, annealed soft-drawn	4/0	2025.3	1202.0	1.3	2025.3	1187.0	1.3	15.0	NO	\$3
C37	Copper, annealed soft-drawn	4/0	2046.1	1183.4	1.3	2046.1	1197.8	1.3	14.4	NO	\$3
C38	Copper, annealed soft-drawn	4/0	2060.0	1183.6	1.3	2060.0	1198.6	1.3	15.0	NO	\$3
C39	Copper, annealed soft-drawn	4/0	2078.5	1201.8	1.3	2078.5	1186.8	1.3	15.0	NO	\$3
C40	Copper, annealed soft-drawn	4/0	2091.8	1201.8	1.3	2091.8	1186.8	1.3	15.0	NO	\$3
C41	Copper, annealed soft-drawn	4/0	2103.8	1183.6	1.3	2103.8	1198.6	1.3	15.0	NO	\$3
C42	Copper, annealed soft-drawn	4/0	2117.3	1183.6	1.3	2117.3	1198.6	1.3	15.0	NO	\$3
C43	Copper, annealed soft-drawn	4/0	2126.0	1183.6	1.3	2126.1	1198.6	1.3	15.0	NO	\$3
C44	Copper, annealed soft-drawn	4/0	2134.3	1183.4	1.3	2134.3	1198.4	1.3	15.0	NO	\$3
C45	Copper, annealed soft-drawn	4/0	2142.5	1183.4	1.3	2142.5	1198.4	1.3	15.0	NO	\$3
C46	Copper, annealed soft-drawn	4/0	2159.4	1201.8	1.3	2159.4	1186.8	1.3	15.0	NO	\$3
C47	Copper, annealed soft-drawn	4/0	2172.7	1201.8	1.3	2172.6	1186.8	1.3	15.0	NO	\$3
C48	Copper, annealed soft-drawn	4/0	2184.5	1202.0	1.3	2184.5	1187.0	1.3	15.0	NO	\$3
C49	Copper, annealed soft-drawn	4/0	2225.4	1183.6	1.3	2225.5	1198.6	1.3	15.0	NO	\$3
C50	Copper, annealed soft-drawn	4/0	2024.3	1235.4	1.3	2024.3	1250.4	1.3	15.0	NO	\$3
C51	Copper, annealed soft-drawn	4/0	2046.2	1235.4	1.3	2046.3	1250.4	1.3	15.0	NO	\$3
C52	Copper, annealed soft-drawn	4/0	2056.8	1235.4	1.3	2056.8	1250.4	1.3	15.0	NO	\$3
C53	Copper, annealed soft-drawn	4/0	2065.3	1253.2	1.3	2065.3	1238.2	1.3	15.0	NO	\$3
C54	Copper, annealed soft-drawn	4/0	2077.5	1253.2	1.3	2077.5	1238.2	1.3	15.0	NO	\$3
C55	Copper, annealed soft-drawn	4/0	2084.8	1253.0	1.3	2084.8	1238.0	1.3	15.0	NO	\$3
C56	Copper, annealed soft-drawn	4/0	2092.8	1253.0	1.3	2092.9	1238.0	1.3	15.0	NO	\$3
C57	Copper, annealed soft-drawn	4/0	2101.4	1253.0	1.3	2101.4	1238.0	1.3	15.0	NO	\$3
C58	Copper, annealed soft-drawn	4/0	2120.0	1235.2	1.3	2120.1	1250.2	1.3	15.0	NO	\$3
C59	Copper, annealed soft-drawn	4/0	2130.7	1235.4	1.3	2130.7	1250.4	1.3	15.0	NO	\$3
C60	Copper, annealed soft-drawn	4/0	2142.2	1253.2	1.3	2142.3	1238.2	1.3	15.0	NO	\$3

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**Conductor Data:**

Label	Type	Size AWG/kcmil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C61	Copper, annealed soft-drawn	4/0	2227.3	1253.0	1.3	2227.4	1238.0	1.3	15.0	NO	\$3

**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R0	Copper, annealed soft-drawn	0.75	2189.1	1097.4	1.3	2189.1	1097.4	11.3	10.0	NO	\$100
R1	Copper, annealed soft-drawn	0.75	2221.2	1097.5	1.3	2221.2	1097.5	11.3	10.0	NO	\$100
R2	Copper, annealed soft-drawn	0.75	2255.5	1097.5	1.3	2255.5	1097.5	11.3	10.0	NO	\$100
R3	Copper, annealed soft-drawn	0.75	2297.1	1097.1	1.3	2297.1	1097.1	11.3	10.0	NO	\$100
R4	Copper, annealed soft-drawn	0.75	2233.8	1116.7	1.3	2233.8	1116.7	11.3	10.0	NO	\$100
R5	Copper, annealed soft-drawn	0.75	2272.1	1116.7	1.3	2272.1	1116.7	11.3	10.0	NO	\$100
R6	Copper, annealed soft-drawn	0.75	2234.1	1135.1	1.3	2234.1	1135.1	11.3	10.0	NO	\$100
R7	Copper, annealed soft-drawn	0.75	2272.1	1135.1	1.3	2272.1	1135.1	11.3	10.0	NO	\$100
R8	Copper, annealed soft-drawn	0.75	2297.5	1135.1	1.3	2297.5	1135.1	11.3	10.0	NO	\$100
R9	Copper, annealed soft-drawn	0.75	2297.5	1168.4	1.3	2297.5	1168.4	11.3	10.0	NO	\$100
R10	Copper, annealed soft-drawn	0.75	2297.5	1202.1	1.3	2297.5	1202.1	11.3	10.0	NO	\$100
R11	Copper, annealed soft-drawn	0.75	2297.5	1235.4	1.3	2297.5	1235.4	11.3	10.0	NO	\$100
R12	Copper, annealed soft-drawn	0.75	2297.1	1268.4	1.3	2297.1	1268.4	11.3	10.0	NO	\$100
R13	Copper, annealed soft-drawn	0.75	2297.5	1296.4	1.3	2297.5	1296.4	11.3	10.0	NO	\$100
R14	Copper, annealed soft-drawn	0.75	2272.5	1168.4	1.3	2272.5	1168.4	11.3	10.0	NO	\$100
R15	Copper, annealed soft-drawn	0.75	2272.1	1201.7	1.3	2272.1	1201.7	11.3	10.0	NO	\$100
R16	Copper, annealed soft-drawn	0.75	2272.1	1235.1	1.3	2272.1	1235.1	11.3	10.0	NO	\$100
R17	Copper, annealed soft-drawn	0.75	2272.5	1268.4	1.3	2272.5	1268.4	11.3	10.0	NO	\$100
R18	Copper, annealed soft-drawn	0.75	2272.5	1297.1	1.3	2272.5	1297.1	11.3	10.0	NO	\$100
R19	Copper, annealed soft-drawn	0.75	2189.1	1135.1	1.3	2189.1	1135.1	11.3	10.0	NO	\$100
R20	Copper, annealed soft-drawn	0.75	2234.1	1168.4	1.3	2234.1	1168.4	11.3	10.0	NO	\$100
R21	Copper, annealed soft-drawn	0.75	2234.1	1202.1	1.3	2234.1	1202.1	11.3	10.0	NO	\$100
R22	Copper, annealed soft-drawn	0.75	2233.8	1235.4	1.3	2233.8	1235.4	11.3	10.0	NO	\$100
R23	Copper, annealed soft-drawn	0.75	2233.8	1268.7	1.3	2233.8	1268.7	11.3	10.0	NO	\$100
R24	Copper, annealed soft-drawn	0.75	2234.1	1296.7	1.3	2234.1	1296.7	11.3	10.0	NO	\$100
R25	Copper, annealed soft-drawn	0.75	2150.1	1135.7	1.3	2150.1	1135.7	11.3	10.0	NO	\$100
R26	Copper, annealed soft-drawn	0.75	2194.5	1168.4	1.3	2194.5	1168.4	11.3	10.0	NO	\$100
R27	Copper, annealed soft-drawn	0.75	2194.1	1201.7	1.3	2194.1	1201.7	11.3	10.0	NO	\$100
R28	Copper, annealed soft-drawn	0.75	2194.5	1235.1	1.3	2194.5	1235.1	11.3	10.0	NO	\$100
R29	Copper, annealed soft-drawn	0.75	2194.1	1268.4	1.3	2194.1	1268.4	11.3	10.0	NO	\$100
R30	Copper, annealed soft-drawn	0.75	2194.5	1296.7	1.3	2194.5	1296.7	11.3	10.0	NO	\$100
R31	Copper, annealed soft-drawn	0.75	2149.8	1168.4	1.3	2149.8	1168.4	11.3	10.0	NO	\$100
R32	Copper, annealed soft-drawn	0.75	2149.8	1201.7	1.3	2149.8	1201.7	11.3	10.0	NO	\$100
R33	Copper, annealed soft-drawn	0.75	2149.8	1235.1	1.3	2149.8	1235.1	11.3	10.0	NO	\$100
R34	Copper, annealed soft-drawn	0.75	2149.8	1268.4	1.3	2149.8	1268.4	11.3	10.0	NO	\$100
R35	Copper, annealed soft-drawn	0.75	2150.1	1296.7	1.3	2150.1	1296.7	11.3	10.0	NO	\$100

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**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R36	Copper, annealed soft-drawn	0.75	2110.1	1135.7	1.3	2110.1	1135.7	11.3	10.0	NO	\$100
R37	Copper, annealed soft-drawn	0.75	2110.5	1168.4	1.3	2110.5	1168.4	11.3	10.0	NO	\$100
R38	Copper, annealed soft-drawn	0.75	2110.5	1202.1	1.3	2110.5	1202.1	11.3	10.0	NO	\$100
R39	Copper, annealed soft-drawn	0.75	2110.1	1235.1	1.3	2110.1	1235.1	11.3	10.0	NO	\$100
R40	Copper, annealed soft-drawn	0.75	2110.5	1268.4	1.3	2110.5	1268.4	11.3	10.0	NO	\$100
R41	Copper, annealed soft-drawn	0.75	2110.5	1297.1	1.3	2110.5	1297.1	11.3	10.0	NO	\$100
R42	Copper, annealed soft-drawn	0.75	2071.5	1135.7	1.3	2071.5	1135.7	11.3	10.0	NO	\$100
R43	Copper, annealed soft-drawn	0.75	2071.5	1168.7	1.3	2071.5	1168.7	11.3	10.0	NO	\$100
R44	Copper, annealed soft-drawn	0.75	2071.5	1201.7	1.3	2071.5	1201.7	11.3	10.0	NO	\$100
R45	Copper, annealed soft-drawn	0.75	2071.5	1235.1	1.3	2071.5	1235.1	11.3	10.0	NO	\$100
R46	Copper, annealed soft-drawn	0.75	2071.5	1268.4	1.3	2071.5	1268.4	11.3	10.0	NO	\$100
R47	Copper, annealed soft-drawn	0.75	2071.8	1297.1	1.3	2071.8	1297.1	11.3	10.0	NO	\$100
R48	Copper, annealed soft-drawn	0.75	2032.1	1135.7	1.3	2032.1	1135.7	11.3	10.0	NO	\$100
R49	Copper, annealed soft-drawn	0.75	2032.1	1168.7	1.3	2032.1	1168.7	11.3	10.0	NO	\$100
R50	Copper, annealed soft-drawn	0.75	2032.5	1201.7	1.3	2032.5	1201.7	11.3	10.0	NO	\$100
R51	Copper, annealed soft-drawn	0.75	2032.5	1235.1	1.3	2032.5	1235.1	11.3	10.0	NO	\$100
R52	Copper, annealed soft-drawn	0.75	2032.1	1269.1	1.3	2032.1	1269.1	11.3	10.0	NO	\$100
R53	Copper, annealed soft-drawn	0.75	2032.1	1296.7	1.3	2032.1	1296.7	11.3	10.0	NO	\$100
R54	Copper, annealed soft-drawn	0.75	1994.5	1135.4	1.3	1994.5	1135.4	11.3	10.0	NO	\$100
R55	Copper, annealed soft-drawn	0.75	1994.1	1168.7	1.3	1994.1	1168.7	11.3	10.0	NO	\$100
R56	Copper, annealed soft-drawn	0.75	1994.5	1202.1	1.3	1994.5	1202.1	11.3	10.0	NO	\$100
R57	Copper, annealed soft-drawn	0.75	1994.1	1235.4	1.3	1994.1	1235.4	11.3	10.0	NO	\$100
R58	Copper, annealed soft-drawn	0.75	1994.1	1268.7	1.3	1994.1	1268.7	11.3	10.0	NO	\$100
R59	Copper, annealed soft-drawn	0.75	1994.1	1297.1	1.3	1994.1	1297.1	11.3	10.0	NO	\$100
R60	Copper, annealed soft-drawn	0.75	1955.5	1135.7	1.3	1955.5	1135.7	11.3	10.0	NO	\$100
R61	Copper, annealed soft-drawn	0.75	1955.5	1169.1	1.3	1955.5	1169.1	11.3	10.0	NO	\$100
R62	Copper, annealed soft-drawn	0.75	1955.8	1201.7	1.3	1955.8	1201.7	11.3	10.0	NO	\$100
R63	Copper, annealed soft-drawn	0.75	1955.8	1235.1	1.3	1955.8	1235.1	11.3	10.0	NO	\$100
R64	Copper, annealed soft-drawn	0.75	1955.5	1269.1	1.3	1955.5	1269.1	11.3	10.0	NO	\$100
R65	Copper, annealed soft-drawn	0.75	1955.8	1297.1	1.3	1955.8	1297.1	11.3	10.0	NO	\$100
R66	Copper, annealed soft-drawn	0.75	1912.8	1168.7	1.3	1912.8	1168.7	11.3	10.0	NO	\$100
R67	Copper, annealed soft-drawn	0.75	1906.1	1201.7	1.3	1906.1	1201.7	11.3	10.0	NO	\$100
R68	Copper, annealed soft-drawn	0.75	1906.5	1235.1	1.3	1906.5	1235.1	11.3	10.0	NO	\$100
R69	Copper, annealed soft-drawn	0.75	1916.5	1268.7	1.3	1916.5	1268.7	11.3	10.0	NO	\$100
R70	Copper, annealed soft-drawn	0.75	1931.1	1149.1	1.3	1931.1	1149.1	11.3	10.0	NO	\$100
R71	Copper, annealed soft-drawn	0.75	1926.5	1287.7	1.3	1926.5	1287.7	11.3	10.0	NO	\$100

**Cost:**

Conductor			Rod			Total Cost
Total No.	Total Length ft	Cost	Total No.	Total Length ft	Cost	
60	5,457.9	\$18,011	72	720.0	\$72,000	\$90,011

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Ground Grid Summary Report

Rg Ground Resistance Ohm	GPR Ground Potential Rise Volts	Maximum Touch Potential					Maximum Step Potential				
		Tolerable Volts	Calculated Volts	Calculated %	Coordinates (ft)		Tolerable Volts	Calculated Volts	Calculated %	Coordinates (ft)	
					X	Y				X	Y
6.81	5,045.9	573.4	978.2	170.6	1919.3	1185.2	1,627.4	799.6	49.1	2,297.10	1,097.40

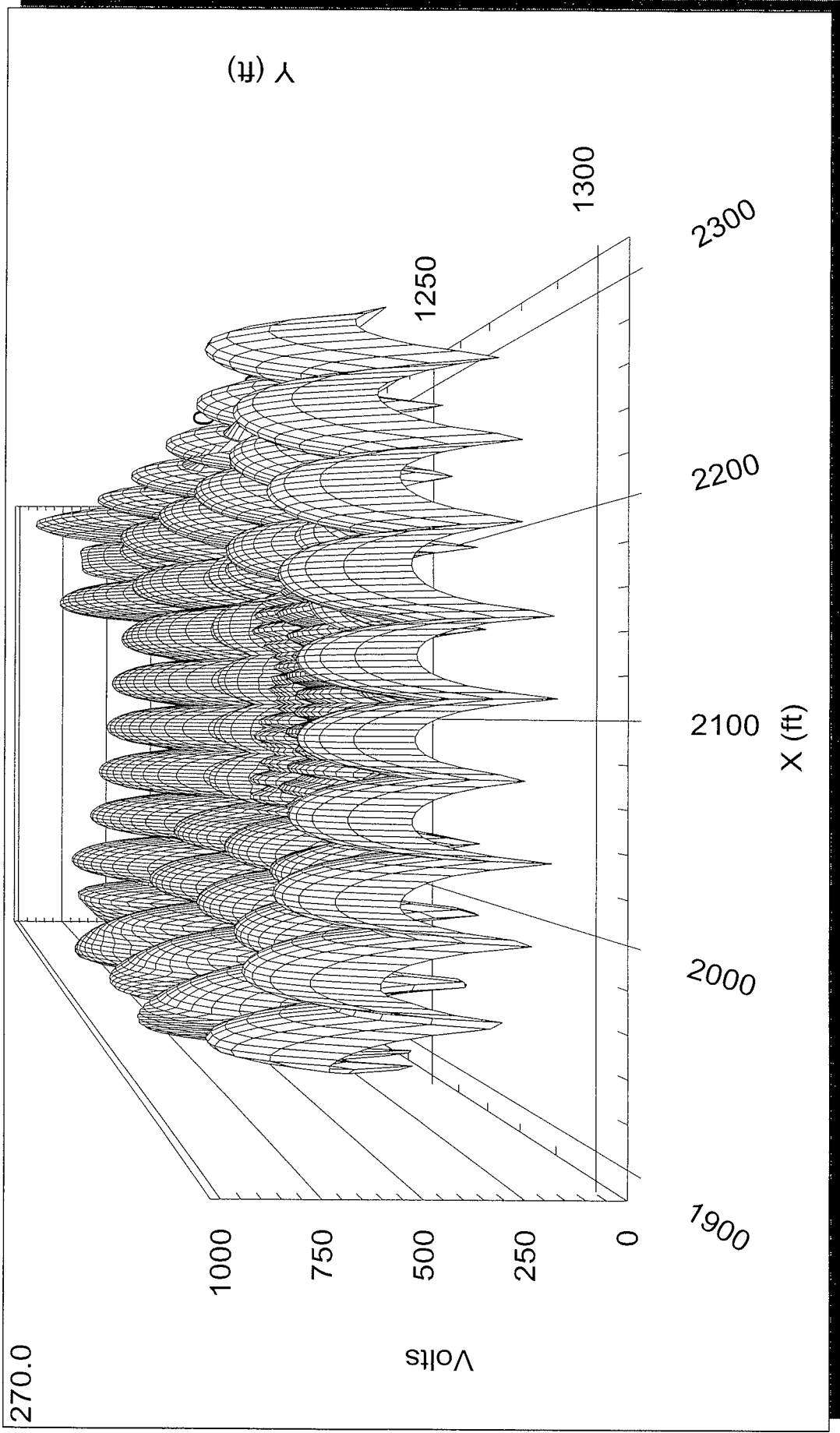
Total Fault Current	3.620 kA	Reflection Factor (K):	0.096
Maximum Grid Current:	0.741 kA	Surface Layer Derating Factor (Cs):	1.066
		Decrement Factor (Df):	1.024

Warnings:

The maximum Touch Voltage exceeds the tolerable limits

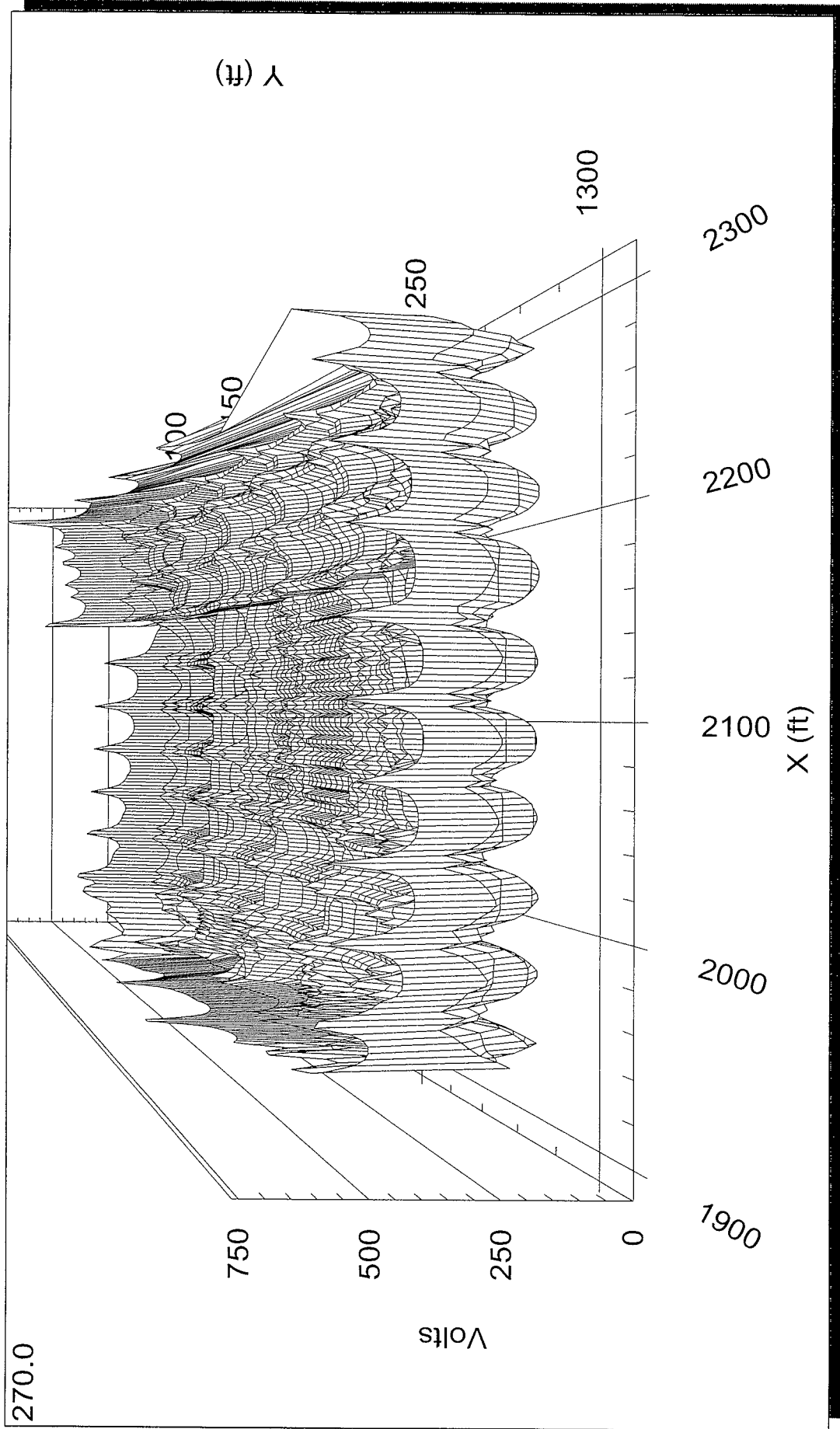
# Magpie TS

Touch Potential Profile



# Magpie TS

Step Potential Profile

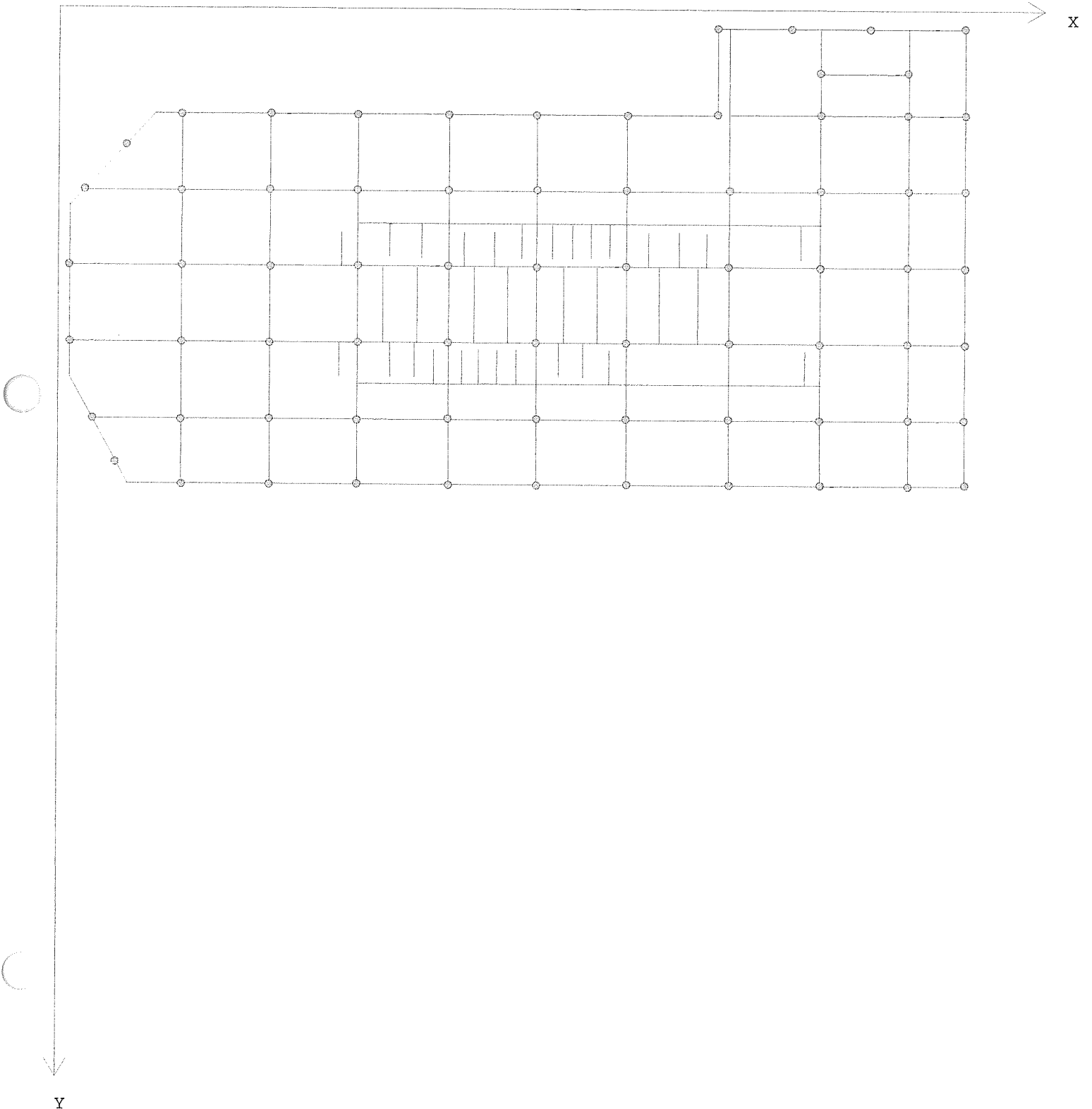




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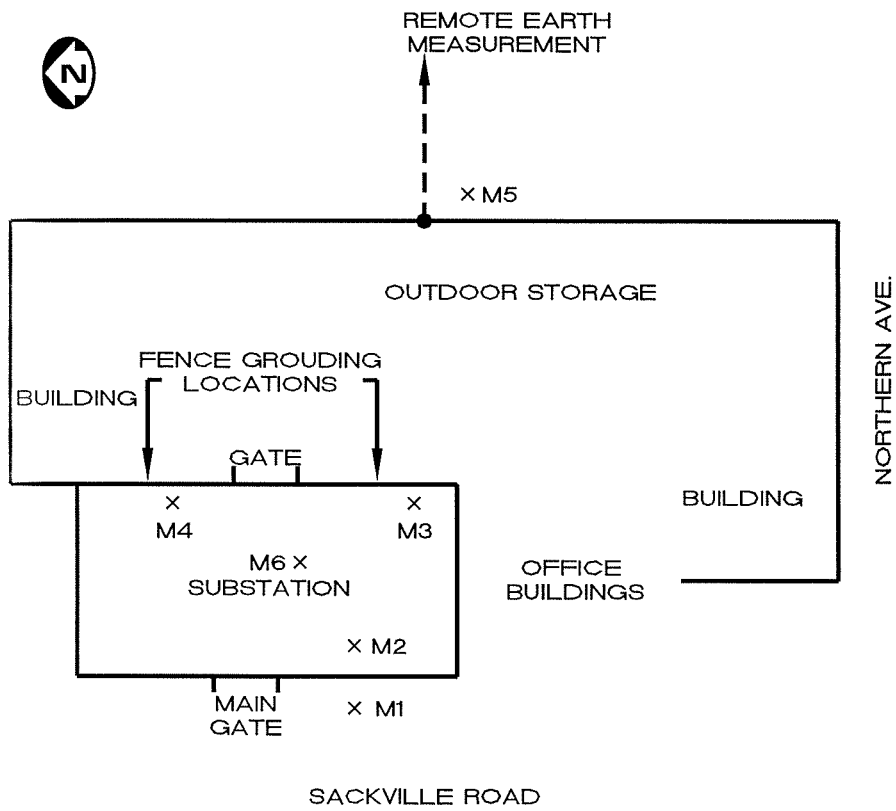
Grid1 - Top View





**6.6 NORTHERN AVE. TS**

**6.6.1 Soil Resistivity Measurement Locations**



## 6.6.2 Resistivity Measurement

Soil resistivity has been calculated based on the following:

$$P = 2\pi aR$$

$a$  = Rod Spacing

$R$  = Resistivity Measurement

Measurement Location	Probe Spacing	Resistance Measured	Calculated Soil Resistivity
M1	2.0 M	15.3 $\Omega$	192 $\Omega \cdot M$
M2	2.0 M	13.5 $\Omega$	170 $\Omega \cdot M$
M3	2.0 M	11.3 $\Omega$	142 $\Omega \cdot M$
M4	2.0 M	7.3 $\Omega$	92 $\Omega \cdot M$
M5	2.0 M	4.0 $\Omega$	50 $\Omega \cdot M$
M6	0.305 M	179 $\Omega$	343 $\Omega \cdot M$

Modeling Values Used:

1. Surface            Stone            343  $\Omega \cdot M$
2. Upper Surface    Sand/Gravel    170  $\Omega \cdot M$
3. Lower Surface    Sand/Gravel    170  $\Omega \cdot M$

## 6.6.3 Ground Resistance Measurements

Measurement Location:

The test ground electrode used is indicated on the measurement location sketch

6.6.1. Current probe C1 was located in a easterly direction, 800 ft. from test electrode. Potential probe P1 measurements were made at approximately 100 ft. intervals between test electrode and current probe C1.

Measurements obtained:

Position No.	Distance	Resistance
1	160 ft.	0.487 $\Omega$
2	200 ft.	0.519 $\Omega$
3	320 ft.	0.568 $\Omega$
4	400 ft.	0.584 $\Omega$
5	480 ft.	0.647 $\Omega$
6	600 ft.	0.894 $\Omega$
7	700 ft.	1.284 $\Omega$

Two measurements were taken to obtain a remote earth resistance value. The first measurement was directly north of the substation. This didn't resolve because of transmission tower grounding. The second measurement was taken on the easterly side of the outside storage area.

The Slope Method was used to calculate soil resistivity. Refer to Appendix 9.1 for supporting methodology.

Distance calculation for value R

$$R_1 = 0.2 \times 800' = 160'$$

$$R_2 = 0.4 \times 800' = 320'$$

$$R_3 = 0.6 \times 800' = 480'$$

Remote Distance Curve Calculation:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1} = \frac{0.647 - 0.568}{0.568 - 0.487} = 0.98$$

From Table VII in Appendix 9.2:

$$\mu \text{ of } 0.98 = \text{Pt/C of } 0.546$$

Distance of potential probe to represent remote earth soil resistivity  
=  $0.545 \times 800' = 437'$  to Probe P1

**Measured Value = 0.62  $\Omega$**

#### 6.6.4 Stone Coverage Area

On a percentage basis, approximately 100% of the area inside the substation fenced enclosure does have a stone cover. Stone depth was measured at 0.05 M. The stone cover and sand/gravel subsoil contained moisture and was damp. This is reflected in the ground resistance measurements.

A low spot in grade existed near the main entrance gate on the west side of the substation. Moisture had collected at this location during our visit to this site.

## 6.6.5 Allowable Safe Step and Touch Potentials

Based on Surface Layer De-rating Factor ( $C_s$ )

$$\begin{aligned} C_s &= 1 - \frac{0.09 \left(1 - \frac{P}{P_s}\right)}{2h_s + 0.09} \\ &= 1 - \left(\frac{0.045}{0.19}\right) \\ &= 1 - 0.242 \\ &= 0.76 \end{aligned}$$

$$P = 170 \Omega \cdot M$$

$$P_s = 343 \Omega \cdot M$$

$$h_s = 0.05 M$$

### Safe Step Potential

$$\begin{aligned} E_{Step(50)} &= [1000 + 6C_s P_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 6 * 0.75 * 343] * \frac{0.116}{\sqrt{0.5}} \\ &= 2544 * 0.164 \\ &= 417 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Step(70)} &= [1000 + 6C_s P_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 6 * 0.75 * 343] * \frac{0.157}{\sqrt{0.5}} \\ &= 2564 * 0.222 \\ &= 569 \text{ Volts} \end{aligned}$$

## Safe Touch Potential

$$\begin{aligned} E_{Touch(50)} &= [1000 + 1.5C_sP_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 0.75 * 343] * \frac{0.116}{\sqrt{0.5}} \\ &= 1386 * 0.164 \\ &= 227 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Touch(70)} &= [1000 + 1.5C_sP_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 0.75 * 343] * \frac{0.157}{\sqrt{0.5}} \\ &= 1386 * 0.222 \\ &= 308 \text{ Volts} \end{aligned}$$

## 6.6.6 Total Resistance to Remote Earth

$$\begin{aligned} R_g &= P * \left[ \frac{1}{L_T} + \frac{1}{\sqrt{20A}} \left( 1 + \frac{1}{1 + h\sqrt{\frac{20}{A}}} \right) \right] \\ &= 170 * \left[ \frac{1}{1443} + \frac{1}{\sqrt{20 * 23302}} \left( 1 + \frac{1}{1 + 0.229\sqrt{\frac{20}{23302}}} \right) \right] \\ &= 170 * [0.00069 + 0.0015 * 1.99] \\ &= 170 * 0.0036 \\ &= 0.61 \Omega \end{aligned}$$

$L_T$  = Buried conductors and rods

$$= 1443 \text{ M}$$

$A$  = Ground grid area

$$= 23302 \text{ M}^2$$

$h$  = Depth of grid

$$= 0.229 \text{ M}$$

$P$  = Resistivity

$$= 170 \Omega \cdot \text{M}$$

## 6.6.7 Current Grid Split Factor Determination

To calculate  $S_f$  based on IEEE Std. 80-2000 Annex C.

Based on 1 Transmission / 2 Distribution Lines

$$R_g \text{ Measured} = 0.62 \Omega$$

$$R_g \text{ Calculated} = 0.61 \Omega$$

$$R_g \text{ Modeled} = 0.68 \Omega \text{ (selected for calculation)}$$

### Method A

$$\text{Table C.1} \quad 1T / 2D \quad R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad R + jX = 0.54 + j0.33$$

$$Z_g = \frac{(0.54 + j0.33)}{(0.68 + 0.54 + j0.33)} = \frac{0.633}{1.26} = 0.50$$

### Method B

$$1T / 2D \quad 100\% \text{ Remote Contribution} \quad R_g = 0.68 \Omega$$

$$R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad \text{Figure C.1}$$

$$S_f = 48\%$$

$\therefore$  Comparing methods A and B, assign  $S_f$  for 115 kV system of 48%.



## 6.6.8 Symmetrical Grid Current ( $I_g$ )

$$\begin{aligned} I_g &= S_f * I_F \\ &= 0.48 * 15.16 \text{ kA} \\ &= 7.28 \text{ kA} \end{aligned}$$

$$\begin{aligned} S_f &= 48\% \\ I_F &= L - G \text{ value from G.L.P.} \\ &= 15.16 \text{ kA} \end{aligned}$$

## 6.6.9 Maximum Grid Current ( $I_G$ )

$$\begin{aligned} I_G &= D_f * I_g \\ &= 1.02 * 7.28 \text{ kA} \\ &= 7.43 \text{ kA} \end{aligned}$$

$$\begin{aligned} D_f &= 1.02 \\ I_g &= 7.28 \text{ kA} \end{aligned}$$

## 6.6.10 Calculated Ground Potential Rise ( $GPR$ )

$$\begin{aligned} GPR_{Hand} &= R_g * I_G * 10^3 \\ &= 0.61 * 7.28 * 10^3 \\ &= 4441 \text{ Volts} \end{aligned}$$

$$\begin{aligned} GPR_{Measured} &= R_g * I_G * 10^3 \\ &= 0.62 * 7.28 * 10^3 \\ &= 4514 \text{ Volts} \end{aligned}$$

## 6.6.11 Comparison of Modeled Values and Results

Modeled Step and Touch voltage values have not been compared to manual calculated values.

Manual calculated values could not be completed as per the methodologies of IEEE 80-2000 Section 16.5.1 and 16.5.2 due to the irregularity and complexity of the

existing grounding grid layout. Refer to Sections 16.7 and 16.8 of the referenced standard.

Section 6.6.15 contains the detailed computer model output summary report. The Ground Grid Summary Report, usually the final page of the output documents, summarizes the calculated Maximum Touch and Step Potential values based on the grid layout. Calculated values are compared to the Safe Touch and Step potentials.

### 6.6.12 Fence Grounding and Condition Comments

The boundary fence is tied to the substation ground grid. Measured resistance between fence and ground grid is 0.627  $\Omega$ .

A visual inspection of the fence and gate grounding was completed. This includes the entire perimeter of the fenced enclosure, i.e. along Northern Ave. etc. The condition of each thermoweld was inspected and the continuity of each jumper was confirmed.

Two fence bonding issues have been identified and the locations are indicated on the measurement location sketch, section 6.6.1. The first conditions identified the bonding of the ground conductor to the fence and the second condition identified a missing ground jumper.

A new fence and gate have recently been installed near the T & D Receiving Building. No grounding exists on this new fence.

### 6.6.13 Above Grade Equipment Ground Audit

An audit of all bonding and grounding associated with electrical distribution equipment, supporting towers and structures, fences and gates was completed. All bare ground wire connections were assessed including both thermoweld and mechanical configurations. Bare ground wire sizes were measured and compared to the engineering drawing provided by Great Lakes Power. For reference, these drawings are numbers AB-32206 rev.1 and SD-33020 rev. 0. Please note that the documentation did not accurately reflect installed conditions.

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There were no ground grid connections on the supporting tower columns located at the south east corner of the substation yard near transformer T7. Even though these two specific columns weren't bonded, the entire structure was grounded through other structural columns

#### 6.6.14 Comments

1. Considering existing fault values, both Safe Step and Safe Touch values have been exceeded, 114% and 625% respectively.
2. Considering future distant fault values, both Safe Step and Safe Touch values have been exceeded, 184% and 1010% respectively.

## 6.6.15 Comments

### System Data:

Body Weight	70 kg
Fault Current ( $I_F$ )	15.16 kA
X/R ratio	6.80
Division Factor ( $S_F$ )	48%
Projection Factor ( $C_P$ )	100%
Fault Duration ( $T_f, T_c, T_s$ )	0.5 sec.
Plot Step	3 ft.

### Summary Report:

Ground Resistance ( $R_g$ )	0.68 $\Omega$
Ground Potential Rise (GPR)	5030 V
Tolerable Touch Potential	309 V
Calculated Touch Potential	3119 V
Tolerable Step Potential	568 V
Calculated Step Potential	1044 V

**Safe Step and Touch Voltage Exceeds Tolerable Limits**

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Electrical Transient Analyzer Program

ETAP PowerStation

Ground Grid Systems

Finite Element Method

Number of Ground Conductors: 56  
Number of Ground Rods: 53  
Total Length of Ground Conductors: 4204.00 ft  
Total Length of Ground Rods: 530.00 ft

Frequency: 60.0  
Unit System: English  
Project Filename: GLP-NORTHERN\_AVE

Output Filename: C:\Documents and Settings\Barry Bingeman\My Documents\Great Lakes Power\Models  
03-014-02\GLP-NORTHERN\_AVE\Grid1\_Untitled.GRI

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**Ground Grid Input Data**

**System Data:**

Freq. Hz	Weight kg	Ambient Temp. °C	Short-Circuit Current			Fault Duration (Seconds)			Plot Step ft	Extended Boundary Length ft	
			Total Fault Current kA	X/R	Sf Division Factor %	Cp Projection Factor %	Tf for Total Fault Duration	Tc for Sizing Ground Conductors			Ts for Available Body Current
60.0	70	40.00	15.160	6.80	48.0	100.0	0.50	0.50	0.50	3.0	0.0

**Soil Data:**

Surface Material			Upper Layer Soil			Lower Layer Soil	
Material Type	Resistivity .m	Depth ft	Material Type	Resistivity .m	Depth ft	MaterialType	Resistivity .m
Gravel	343.0	0.16	Moist soil	170.0	3.00	Moist soil	170.0

**Material Constants:**

Conductor/Rod	Type	Conductivity %	r Factor @ 20 °C 1/°C	K0 @ 0 °C	Fusing Temperature °C	Resistivity of Ground Conductor @ 20°C .cm	Thermal Capacity Per Unit Volume J/(cm <sup>3</sup> .°C)
Conductor	Copper, annealed soft-drawn	100.0	0.00393	234.0	1083.0	1.72	3.42
Rod	Copper, annealed soft-drawn	100.0	0.00393	234.0	1083.0	1.72	3.42

**Conductor Data:**

Label	Type	Size AWG/kemil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C0	Copper, annealed soft-drawn	2/0	412.7	125.2	0.8	1147.7	125.2	0.8	735.0	NO	\$3
C1	Copper, annealed soft-drawn	2/0	412.7	125.5	0.8	412.7	307.5	0.8	182.0	NO	\$3
C2	Copper, annealed soft-drawn	2/0	412.7	307.0	0.8	447.7	307.0	0.8	35.0	NO	\$3
C3	Copper, annealed soft-drawn	2/0	447.2	307.5	0.8	447.2	504.5	0.8	197.0	NO	\$3
C4	Copper, annealed soft-drawn	2/0	447.2	504.0	0.8	757.2	504.0	0.8	310.0	NO	\$3
C5	Copper, annealed soft-drawn	2/0	757.0	503.0	0.8	757.0	306.0	0.8	197.0	NO	\$3
C7	Copper, annealed soft-drawn	2/0	1147.0	125.0	0.8	1147.0	438.0	0.8	313.0	NO	\$3
C8	Copper, annealed soft-drawn	2/0	1083.0	437.0	0.8	1147.0	437.0	0.8	64.0	NO	\$3
C9	Copper, annealed soft-drawn	2/0	448.0	307.0	0.8	758.0	307.0	0.8	310.0	NO	\$3
C10	Copper, annealed soft-drawn	2/0	485.1	491.9	0.8	485.1	371.9	0.8	120.0	NO	\$3
C11	Copper, annealed soft-drawn	2/0	534.5	491.5	0.8	534.5	326.5	0.8	165.0	NO	\$3
C12	Copper, annealed soft-drawn	2/0	604.0	491.0	0.8	604.0	326.0	0.8	165.0	NO	\$3
C13	Copper, annealed soft-drawn	2/0	666.5	491.0	0.8	666.5	326.0	0.8	165.0	NO	\$3
C14	Copper, annealed soft-drawn	2/0	723.0	492.0	0.8	723.0	375.0	0.8	117.0	NO	\$3
C15	Copper, annealed soft-drawn	2/0	484.6	491.3	0.8	723.5	491.5	0.8	238.9	NO	\$3
C16	Copper, annealed soft-drawn	2/0	484.6	372.1	0.8	534.6	372.1	0.8	50.0	NO	\$3
C17	Copper, annealed soft-drawn	2/0	535.0	327.0	0.8	745.0	327.0	0.8	210.0	NO	\$3

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**Conductor Data:**

Label	Type	Size AWG/kemil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C18	Copper, annealed soft-drawn	2/0	604.0	375.0	0.8	745.0	375.0	0.8	141.0	NO	\$3
C19	Copper, annealed soft-drawn	2/0	745.1	327.5	0.8	745.1	375.5	0.8	48.0	NO	\$3
C20	Copper, annealed soft-drawn	4/0	475.6	480.2	0.8	485.6	480.2	0.8	10.0	NO	\$3
C21	Copper, annealed soft-drawn	4/0	475.7	456.9	0.8	485.7	456.9	0.8	10.0	NO	\$3
C22	Copper, annealed soft-drawn	4/0	475.4	426.6	0.8	485.4	426.6	0.8	10.0	NO	\$3
C23	Copper, annealed soft-drawn	4/0	475.6	389.0	0.8	485.6	389.0	0.8	10.0	NO	\$3
C24	Copper, annealed soft-drawn	4/0	514.0	403.0	0.8	534.0	403.3	0.8	20.0	NO	\$3
C25	Copper, annealed soft-drawn	4/0	534.3	335.3	0.8	544.3	335.3	0.8	10.0	NO	\$3
C26	Copper, annealed soft-drawn	4/0	534.9	354.1	0.8	544.9	354.1	0.8	10.0	NO	\$3
C27	Copper, annealed soft-drawn	4/0	535.0	372.0	0.8	545.0	372.0	0.8	10.0	NO	\$3
C28	Copper, annealed soft-drawn	4/0	535.0	388.6	0.8	545.0	388.6	0.8	10.0	NO	\$3
C29	Copper, annealed soft-drawn	4/0	534.6	410.3	0.8	544.6	410.3	0.8	10.0	NO	\$3
C30	Copper, annealed soft-drawn	2/0	604.3	336.3	0.8	614.3	336.3	0.8	10.0	NO	\$3
C31	Copper, annealed soft-drawn	2/0	604.3	356.6	0.8	614.3	356.6	0.8	10.0	NO	\$3
C32	Copper, annealed soft-drawn	2/0	604.6	382.6	0.8	614.6	382.6	0.8	10.0	NO	\$3
C33	Copper, annealed soft-drawn	2/0	604.4	401.3	0.8	614.4	401.3	0.8	10.0	NO	\$3
C34	Copper, annealed soft-drawn	2/0	604.1	420.3	0.8	614.1	420.3	0.8	10.0	NO	\$3
C35	Copper, annealed soft-drawn	2/0	604.3	438.3	0.8	614.3	438.3	0.8	10.0	NO	\$3
C36	Copper, annealed soft-drawn	2/0	604.3	457.3	0.8	614.3	457.3	0.8	10.0	NO	\$3
C37	Copper, annealed soft-drawn	2/0	604.4	474.9	0.8	614.4	474.9	0.8	10.0	NO	\$3
C38	Copper, annealed soft-drawn	2/0	656.6	336.0	0.8	666.6	336.0	0.8	10.0	NO	\$3
C39	Copper, annealed soft-drawn	2/0	656.0	356.0	0.8	666.0	356.0	0.8	10.0	NO	\$3
C40	Copper, annealed soft-drawn	2/0	656.3	382.0	0.8	666.3	382.0	0.8	10.0	NO	\$3
C41	Copper, annealed soft-drawn	2/0	666.6	382.0	0.8	676.6	382.0	0.8	10.0	NO	\$3
C42	Copper, annealed soft-drawn	2/0	666.6	401.0	0.8	676.6	401.0	0.8	10.0	NO	\$3
C43	Copper, annealed soft-drawn	2/0	666.3	420.0	0.8	676.3	420.0	0.8	10.0	NO	\$3
C44	Copper, annealed soft-drawn	2/0	666.6	438.3	0.8	676.6	438.3	0.8	10.0	NO	\$3
C45	Copper, annealed soft-drawn	2/0	666.6	456.3	0.8	676.6	456.3	0.8	10.0	NO	\$3
C46	Copper, annealed soft-drawn	2/0	666.6	474.0	0.8	676.6	474.0	0.8	10.0	NO	\$3
C47	Copper, annealed soft-drawn	2/0	676.0	375.0	0.8	676.0	365.0	0.8	10.0	NO	\$3
C48	Copper, annealed soft-drawn	2/0	688.2	374.7	0.8	688.2	364.7	0.8	10.0	NO	\$3
C49	Copper, annealed soft-drawn	2/0	699.0	375.3	0.8	699.0	350.3	0.8	25.0	NO	\$3
C50	Copper, annealed soft-drawn	2/0	713.7	375.6	0.8	713.7	350.3	0.8	25.3	NO	\$3
C51	Copper, annealed soft-drawn	2/0	729.6	375.6	0.8	729.9	350.3	0.8	25.3	NO	\$3
C52	Copper, annealed soft-drawn	2/0	739.0	375.0	0.8	739.2	365.0	0.8	10.0	NO	\$3
C53	Copper, annealed soft-drawn	2/0	675.0	327.0	0.8	675.0	337.0	0.8	10.0	NO	\$3
C54	Copper, annealed soft-drawn	2/0	688.3	327.0	0.8	688.3	337.0	0.8	10.0	NO	\$3
C55	Copper, annealed soft-drawn	2/0	738.6	327.6	0.8	738.6	337.6	0.8	10.0	NO	\$3
C56	Copper, annealed soft-drawn	2/0	682.3	326.9	0.8	682.3	351.9	0.8	25.0	NO	\$3

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Rod Data:

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R0	Copper, annealed soft-drawn	0.75	422.0	125.0	0.8	422.0	125.0	10.8	10.0	NO	\$100
R1	Copper, annealed soft-drawn	0.75	459.0	126.0	0.8	459.0	126.0	10.8	10.0	NO	\$100
R2	Copper, annealed soft-drawn	0.75	504.0	126.0	0.8	504.0	126.0	10.8	10.0	NO	\$100
R3	Copper, annealed soft-drawn	0.75	547.0	126.0	0.8	547.0	126.0	10.8	10.0	NO	\$100
R4	Copper, annealed soft-drawn	0.75	585.0	126.0	0.8	585.0	126.0	10.8	10.0	NO	\$100
R5	Copper, annealed soft-drawn	0.75	621.0	126.0	0.8	621.0	126.0	10.8	10.0	NO	\$100
R6	Copper, annealed soft-drawn	0.75	656.0	126.0	0.8	656.0	126.0	10.8	10.0	NO	\$100
R7	Copper, annealed soft-drawn	0.75	696.0	126.0	0.8	696.0	126.0	10.8	10.0	NO	\$100
R8	Copper, annealed soft-drawn	0.75	735.0	126.0	0.8	735.0	126.0	10.8	10.0	NO	\$100
R9	Copper, annealed soft-drawn	0.75	777.0	126.0	0.8	777.0	126.0	10.8	10.0	NO	\$100
R10	Copper, annealed soft-drawn	0.75	834.0	126.0	0.8	834.0	126.0	10.8	10.0	NO	\$100
R11	Copper, annealed soft-drawn	0.75	874.0	126.0	0.8	874.0	126.0	10.8	10.0	NO	\$100
R12	Copper, annealed soft-drawn	0.75	917.0	126.0	0.8	917.0	126.0	10.8	10.0	NO	\$100
R13	Copper, annealed soft-drawn	0.75	964.0	126.0	0.8	964.0	126.0	10.8	10.0	NO	\$100
R14	Copper, annealed soft-drawn	0.75	1005.0	125.0	0.8	1005.0	125.0	10.8	10.0	NO	\$100
R15	Copper, annealed soft-drawn	0.75	1050.0	126.0	0.8	1050.0	126.0	10.8	10.0	NO	\$100
R16	Copper, annealed soft-drawn	0.75	1091.0	126.0	0.8	1091.0	126.0	10.8	10.0	NO	\$100
R17	Copper, annealed soft-drawn	0.75	1135.0	125.0	0.8	1135.0	125.0	10.8	10.0	NO	\$100
R18	Copper, annealed soft-drawn	0.75	1147.0	165.0	0.8	1147.0	165.0	10.8	10.0	NO	\$100
R19	Copper, annealed soft-drawn	0.75	1147.0	199.0	0.8	1147.0	199.0	10.8	10.0	NO	\$100
R20	Copper, annealed soft-drawn	0.75	1147.0	242.0	0.8	1147.0	242.0	10.8	10.0	NO	\$100
R21	Copper, annealed soft-drawn	0.75	1147.0	284.0	0.8	1147.0	284.0	10.8	10.0	NO	\$100
R22	Copper, annealed soft-drawn	0.75	1147.0	331.0	0.8	1147.0	331.0	10.8	10.0	NO	\$100
R23	Copper, annealed soft-drawn	0.75	1147.0	373.0	0.8	1147.0	373.0	10.8	10.0	NO	\$100
R24	Copper, annealed soft-drawn	0.75	1147.0	415.0	0.8	1147.0	415.0	10.8	10.0	NO	\$100
R25	Copper, annealed soft-drawn	0.75	1116.0	437.0	0.8	1116.0	437.0	10.8	10.0	NO	\$100
R26	Copper, annealed soft-drawn	0.75	411.0	157.0	0.8	411.0	157.0	10.8	10.0	NO	\$100
R27	Copper, annealed soft-drawn	0.75	412.0	202.0	0.8	412.0	202.0	10.8	10.0	NO	\$100
R28	Copper, annealed soft-drawn	0.75	412.0	243.0	0.8	412.0	243.0	10.8	10.0	NO	\$100
R29	Copper, annealed soft-drawn	0.75	412.0	286.0	0.8	412.0	286.0	10.8	10.0	NO	\$100
R30	Copper, annealed soft-drawn	0.75	433.0	308.0	0.8	433.0	308.0	10.8	10.0	NO	\$100
R31	Copper, annealed soft-drawn	0.75	481.0	307.0	0.8	481.0	307.0	10.8	10.0	NO	\$100
R32	Copper, annealed soft-drawn	0.75	521.0	307.0	0.8	521.0	307.0	10.8	10.0	NO	\$100
R33	Copper, annealed soft-drawn	0.75	557.0	307.0	0.8	557.0	307.0	10.8	10.0	NO	\$100
R34	Copper, annealed soft-drawn	0.75	600.0	308.0	0.8	600.0	308.0	10.8	10.0	NO	\$100
R35	Copper, annealed soft-drawn	0.75	640.0	307.0	0.8	640.0	307.0	10.8	10.0	NO	\$100
R36	Copper, annealed soft-drawn	0.75	681.0	308.0	0.8	681.0	308.0	10.8	10.0	NO	\$100
R37	Copper, annealed soft-drawn	0.75	726.0	307.0	0.8	726.0	307.0	10.8	10.0	NO	\$100
R38	Copper, annealed soft-drawn	0.75	469.0	504.0	0.8	469.0	504.0	10.8	10.0	NO	\$100
R39	Copper, annealed soft-drawn	0.75	514.0	504.0	0.8	514.0	504.0	10.8	10.0	NO	\$100
R40	Copper, annealed soft-drawn	0.75	559.0	504.0	0.8	559.0	504.0	10.8	10.0	NO	\$100
R41	Copper, annealed soft-drawn	0.75	604.0	504.0	0.8	604.0	504.0	10.8	10.0	NO	\$100



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**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R42	Copper, annealed soft-drawn	0.75	641.0	505.0	0.8	641.0	505.0	10.8	10.0	NO	\$100
R43	Copper, annealed soft-drawn	0.75	685.0	505.0	0.8	685.0	505.0	10.8	10.0	NO	\$100
R44	Copper, annealed soft-drawn	0.75	729.0	505.0	0.8	729.0	505.0	10.8	10.0	NO	\$100
R45	Copper, annealed soft-drawn	0.75	757.0	333.0	0.8	757.0	333.0	10.8	10.0	NO	\$100
R46	Copper, annealed soft-drawn	0.75	757.0	376.0	0.8	757.0	376.0	10.8	10.0	NO	\$100
R47	Copper, annealed soft-drawn	0.75	757.0	418.0	0.8	757.0	418.0	10.8	10.0	NO	\$100
R48	Copper, annealed soft-drawn	0.75	758.0	468.0	0.8	758.0	468.0	10.8	10.0	NO	\$100
R49	Copper, annealed soft-drawn	0.75	447.0	342.0	0.8	447.0	342.0	10.8	10.0	NO	\$100
R50	Copper, annealed soft-drawn	0.75	447.0	380.0	0.8	447.0	380.0	10.8	10.0	NO	\$100
R51	Copper, annealed soft-drawn	0.75	447.0	432.0	0.8	447.0	432.0	10.8	10.0	NO	\$100
R52	Copper, annealed soft-drawn	0.75	448.0	473.0	0.8	448.0	473.0	10.8	10.0	NO	\$100

**Cost:**

Conductor			Rod			Total Cost
Total No.	Total Length ft	Cost	Total No.	Total Length ft	Cost	
56	4,203.5	\$13,872	53	530.0	\$53,000	\$66,872

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Distant Future 115 kV Considerations

**Ground Grid Summary Report**

Rg Ground Resistance Ohm	GPR Ground Potential Rise Volts	Maximum Touch Potential					Maximum Step Potential				
		Tolerable Volts	Calculated Volts	Calculated %	Coordinates (ft)		Tolerable Volts	Calculated Volts	Calculated %	Coordinates (ft)	
					X	Y				X	Y
0.68	5,029.8	308.6	3,119.3	1,010.8	987.0	465.1	568.4	1,044.4	183.8	1,147.00	437.00

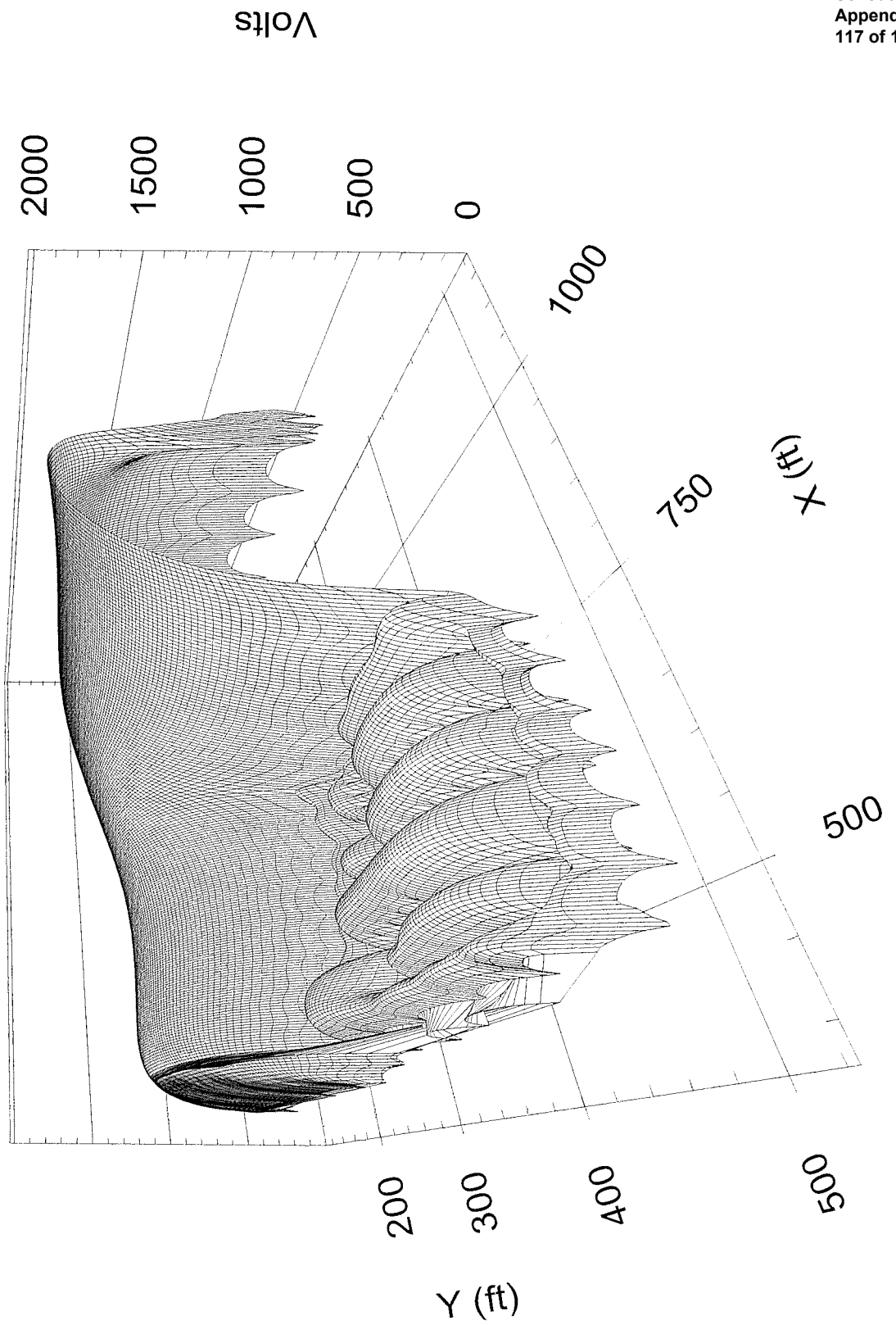
Total Fault Current: 15.160 kA      Reflection Factor (K): -0.337  
 Maximum Grid Current: 7.407 kA      Surface Layer Derating Factor (Cs): 0.758  
    Decrement Factor (Df): 1.018

**Warnings:**

- The maximum Touch Voltage exceeds the tolerable limits
- The maximum Step Voltage exceeds the tolerable limits

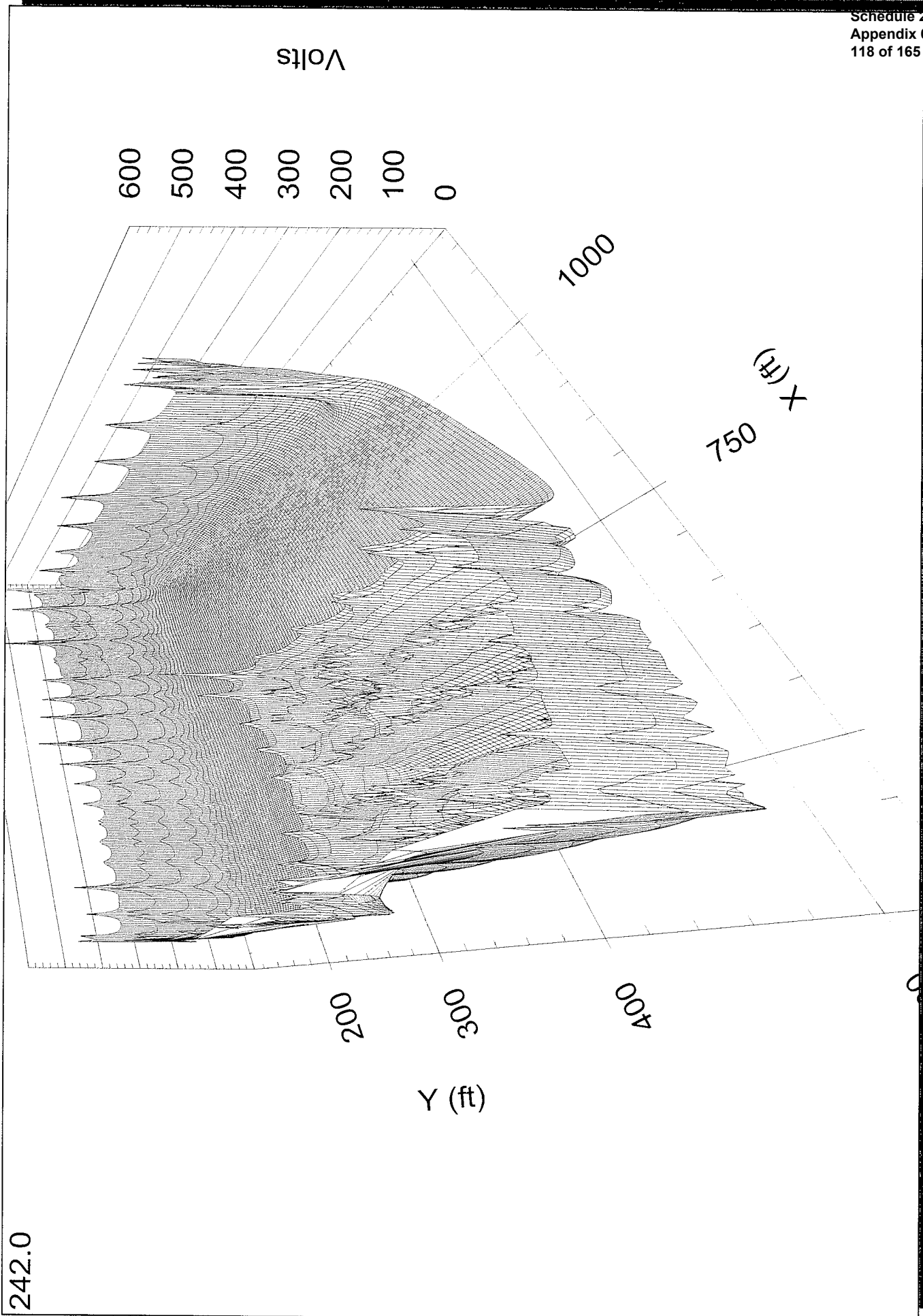
# NorthOn Ave. Touch Potential Profile

242.0



# North On Ave

Step Potential Profile



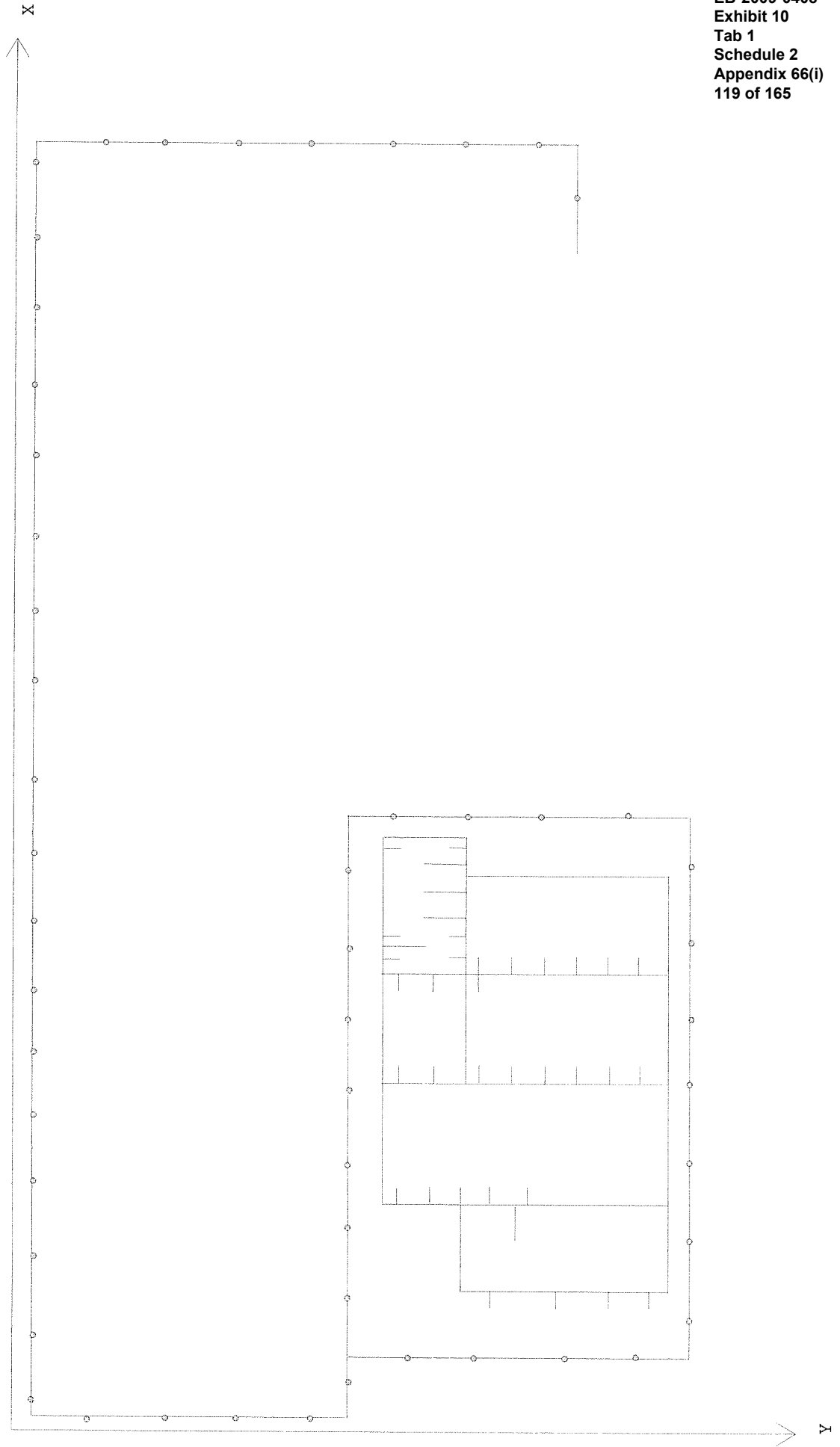
242.0

ETNP PowerStation  
4.7.4C  
Study Case: GR02

Date: Feb-20-2004  
SN: PROCOMTISI  
Revision: Base

Project:  
Location:  
Contract:  
Engineer:  
Filename: GLP-NORTHERN\_AVE

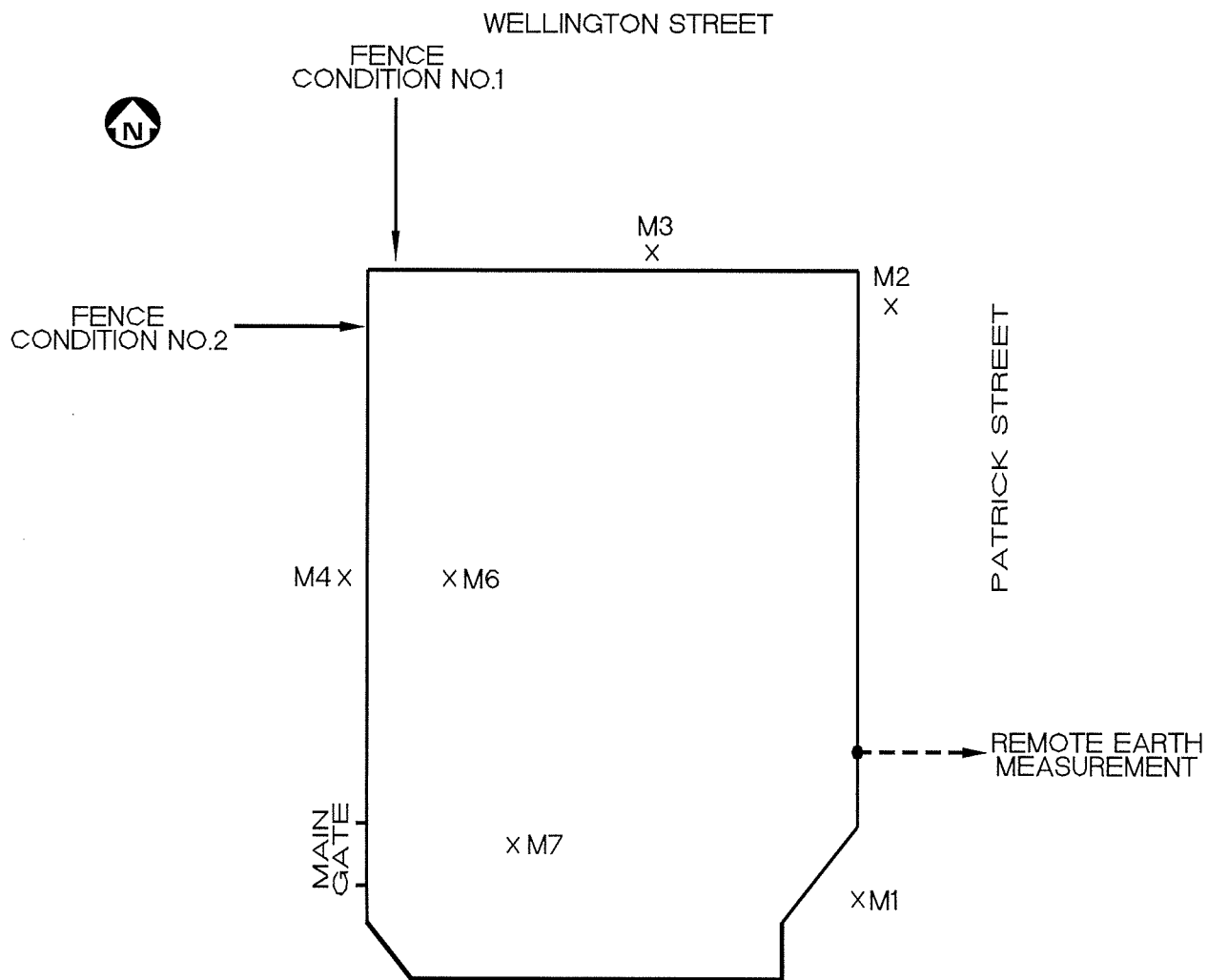
Grid1 - Top View





## 6.7 PATRICK ST/STEELTON TS

### 6.7.1 Soil Resistivity Measurement Locations



## 6.7.2 Resistivity Measurement

Soil resistivity has been calculated based on the following:

$$P = 2\pi aR$$

$a$  = Rod Spacing

$R$  = Resistivity Measurement

Measurement Location	Probe Spacing	Resistance Measured	Calculated Soil Resistivity
M1	2.0 M	57 $\Omega$	328 $\Omega \cdot M$
M2	2.0 M	114 $\Omega$	655 $\Omega \cdot M$
M3	2.0 M	45 $\Omega$	257 $\Omega \cdot M$
M4	2.0 M	605 $\Omega$	3475 $\Omega \cdot M$
M5	0.305 M	2290 $\Omega$	4386 $\Omega \cdot M$
M6	0.305 M	2130 $\Omega$	4079 $\Omega \cdot M$
M7	0.305 M	1975 $\Omega$	3782 $\Omega \cdot M$

Modeling Values Used:

1. Surface            Stone            4000  $\Omega \cdot M$
2. Upper Surface    Stone/Gravel    300  $\Omega \cdot M$
3. Lower Surface    Stone/Gravel    300  $\Omega \cdot M$

## 6.7.3 Ground Resistance Measurements

Measurement Location:

The test ground electrode used is indicated on the measurement location sketch

6.7.1. Current probe C1 was located in a easterly direction along Bloor Street, 700 ft. from test electrode. Potential probe P1 measurements were made at the significant intervals between test electrode and current probe C1.

Measurements obtained:

Position No.	Distance	Resistance
1	140 ft.	1.481 $\Omega$
2	280 ft.	1.499 $\Omega$
3	420 ft.	1.518 $\Omega$



The Slope Method was used to calculate soil resistivity. Refer to Appendix 9.1 for supporting methodology.

Distance calculation for value R

$$R_1 = 0.2 \times 700' = 140'$$

$$R_2 = 0.4 \times 700' = 280'$$

$$R_3 = 0.6 \times 700' = 420'$$

Remote Distance Curve Calculation:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1} = \frac{1.518 - 1.499}{1.499 - 1.481} = 1.05$$

From Table VII in Appendix 9.2:

$$\mu \text{ of } 1.05 = Pt/C \text{ of } 0.531$$

Distance of potential probe to represent remote earth soil resistivity  
=  $0.531 \times 700' = 371'$  to Probe P1

**Measured Value = 1.51  $\Omega$**

#### 6.7.4 Stone Coverage Area

On a percentage basis, approximately 100% of the area inside the substation fenced enclosure does have a stone cover. Stone depth was measured at 0.406 M. The stone cover and sand/gravel subsoil contained moisture and was damp. This is reflected in the ground resistance measurements.

## 6.7.5 Allowable Safe Step and Touch Potentials

Based on Surface Layer De-rating Factor ( $C_s$ )

$$\begin{aligned} C_s &= 1 - \frac{0.09 \left(1 - \frac{P}{P_s}\right)}{2h_s + 0.09} \\ &= 1 - \left(\frac{0.083}{0.902}\right) \\ &= 1 - 0.092 \\ &= 0.91 \end{aligned}$$

$$P = 300 \Omega \cdot M$$

$$P_s = 4000 \Omega \cdot M$$

$$h_s = 0.406 M$$

### Safe Step Potential

$$\begin{aligned} E_{Step(50)} &= [1000 + 6C_s P_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 6 * 0.91 * 4000] * \frac{0.116}{\sqrt{0.5}} \\ &= 22840 * 0.164 \\ &= 3745 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Step(70)} &= [1000 + 6C_s P_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 6 * 0.91 * 4000] * \frac{0.157}{\sqrt{0.5}} \\ &= 22840 * 0.222 \\ &= 5070 \text{ Volts} \end{aligned}$$

## Safe Touch Potential

$$\begin{aligned} E_{Touch(50)} &= [1000 + 1.5C_sP_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 0.91 * 4000] * \frac{0.116}{\sqrt{0.5}} \\ &= 6460 * 0.164 \\ &= 1059 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Touch(70)} &= [1000 + 1.5C_sP_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 0.91 * 4000] * \frac{0.157}{\sqrt{0.5}} \\ &= 6460 * 0.222 \\ &= 1434 \text{ Volts} \end{aligned}$$

## 6.7.6 Total Resistance to Remote Earth

$$\begin{aligned} R_g &= P * \left[ \frac{1}{L_T} + \frac{1}{\sqrt{20A}} \left( 1 + \frac{1}{1 + h\sqrt{\frac{20}{A}}} \right) \right] \\ &= 300 * \left[ \frac{1}{1519} + \frac{1}{\sqrt{20 * 16999}} \left( 1 + \frac{1}{1 + 0.457\sqrt{\frac{20}{16999}}} \right) \right] \\ &= 300 * [0.00066 + 0.0017 * 1.984] \\ &= 300 * 0.00405 \\ &= 1.22 \Omega \end{aligned}$$

$L_T$  = Buried conductors and rods

$$= 1519 \text{ M}$$

$A$  = Ground grid area

$$= 16,999 \text{ M}^2$$

$h$  = Depth of grid

$$= 0.457 \text{ M}$$

$P$  = Resistivity

$$= 300 \Omega \cdot \text{M}$$

## 6.7.7 Current Grid Split Factor Determination

To calculate  $S_r$  based on IEEE Std. 80-2000 Annex C.

Based on 6 Transmission / 6 Distribution Lines

$$R_g \text{ Measured} = 1.51 \Omega$$

$$R_g \text{ Calculated} = 1.22 \Omega$$

$$R_g \text{ Modeled} = 1.54 \Omega \text{ (selected for calculation)}$$

### Method A (Interpolation Required)

$$\text{Table C.1} \quad 4T / 8D \quad R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad R + jX = 0.134 + j0.083$$

$$Z_g = \frac{(0.134 + j0.083)}{(1.54 + 0.134 + j0.083)} = \frac{0.158}{1.676} = 0.094 \Omega$$

$$\text{Table C.1} \quad 8T / 8D \quad R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad R + jX = 0.114 + j0.061$$

$$Z_g = \frac{(0.114 + j0.061)}{(1.54 + 0.114 + j0.061)} = \frac{0.129}{1.655} = 0.080 \Omega$$

$$\text{Approximate Split Factor} = \frac{0.094 + 0.080}{2} = 9\%$$

### Method B (Interpolation Required)

$$4T / 8D \quad 100\% \text{ Remote Contribution} \quad R_g = 1.54 \Omega$$

$$R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad \text{Figure C.5}$$

$$S_f = 9\%$$

$$8T / 8D \quad 100\% \text{ Remote Contribution} \quad R_g = 1.54 \Omega$$

$$R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad \text{Figure C.7}$$

$$S_f = 8\%$$

$$\text{Approximate Split Factor} = \frac{9 + 8}{2} = 8.5\%$$

$\therefore$  Comparing methods A and B, assign  $S_f$  for 115 kV system of 9%.

### 6.7.8 Symmetrical Grid Current ( $I_g$ )

$$\begin{aligned} I_g &= S_f * I_F \\ &= 0.09 * 20.11 \text{ kA} \\ &= 1.81 \text{ kA} \end{aligned}$$

$$S_f = 9\%$$

$$\begin{aligned} I_F &= L - G \text{ value from G.L.P.} \\ &= 20.11 \text{ kA} \end{aligned}$$

### 6.7.9 Maximum Grid Current ( $I_G$ )

$$\begin{aligned} I_G &= D_f * I_g \\ &= 1.039 * 1.81 \text{ kA} \\ &= 1.88 \text{ kA} \end{aligned}$$

$$D_f = 1.039$$

$$I_g = 1.81 \text{ kA}$$

## 6.7.10 Calculated Ground Potential Rise (*GPR*)

$$\begin{aligned} GPR_{Hand} &= R_g * I_G * 10^3 \\ &= 1.22 * 1.88 * 10^3 \\ &= 2294 \text{ Volts} \end{aligned}$$

$$\begin{aligned} GPR_{Measured} &= R_g * I_G * 10^3 \\ &= 1.51 * 1.88 * 10^3 \\ &= 2838 \text{ Volts} \end{aligned}$$

## 6.7.11 Comparison of Modeled Values and Results

Modeled Step and Touch voltage values have not been compared to manual calculated values.

Manual calculated values could not be completed as per the methodologies of IEEE 80-2000 Section 16.5.1 and 16.5.2 due to the irregularity and complexity of the existing grounding grid layout. Refer to Sections 16.7 and 16.8 of the referenced standard.

Section 6.6.15 contains the detailed computer model output summary report. The Ground Grid Summary Report, usually the final page of the output documents, summarizes the calculated Maximum Touch and Step Potential values based on the grid layout. Calculated values are compared to the Safe Touch and Step potentials.

## 6.7.12 Fence Grounding and Condition Comments

The boundary fence is tied to the substation ground grid. Measured resistance between fence and ground grid is 1.51  $\Omega$ .

A visual inspection of the fence and gate grounding was completed. The condition of each thermoweld was inspected and the continuity of each jumper was confirmed.

As observed in the both of the following photographs the fence and top rail are damaged. Refer to the measurement location sketch, section 6.7.1, for locations.

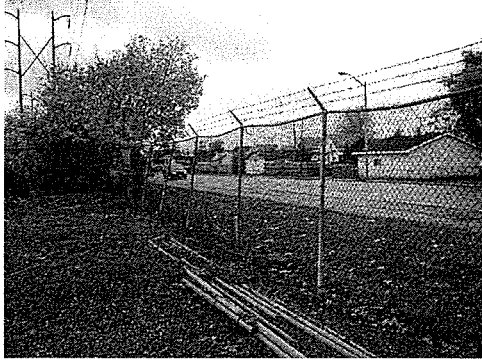


Photo #1 Looking West



Photo #2 Looking South

### 6.7.13 Above Grade Equipment Ground Audit

An audit of all bonding and grounding associated with electrical distribution equipment, supporting towers and structures, fences and gates was completed. All bare ground wire connections were assessed including both thermoweld and mechanical configurations. Bare ground wire sizes were measured and compared to the engineering drawings provided by Great Lakes Power. For reference, these drawings are numbers SD-34902 rev.0 and SD-34512 rev. 2. Please note that the documentation did not accurately reflect installed conditions. Algoma Steel also provided ground grid and fence drawings. These are drawings C-360 Sheet 1 rev. 5, C-360 Sheet 2 rev. 8 and C-298 rev. 1.

### 6.7.14 Comments

1. Algoma Steel has distribution transformers and breakers in the substation yard. We have obtained the ground grid drawings which incorporate changes made up to 1997 and have included them in our ground grid analysis.
2. Considering existing fault values, the Safe Touch and Step Potential values are within tolerable limits, 73% and 5% respectively.
3. Considering future distant fault values, the Touch Potential exceeds tolerable limits (126%).

---

## 6.7.15 COMPUTER MODEL OUTPUT RESULTS

### System Data:

Body Weight	70 kg
Fault Current ( $I_F$ )	20.11 kA
X/R ratio	11.65
Division Factor ( $S_F$ )	9%
Projection Factor ( $C_P$ )	100%
Fault Duration ( $T_f, T_c, T_s$ )	0.5 sec.
Plot Step	3 ft.

### Summary Report:

Ground Resistance ( $R_g$ )	1.54 $\Omega$
Ground Potential Rise (GPR)	2876 V
Tolerable Touch Potential	1429 V
Calculated Touch Potential	1795 V
Tolerable Step Potential	5048 V
Calculated Step Potential	444 V

### Touch Voltage Exceeds Tolerable Limits



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Electrical Transient Analyzer Program

ETAP PowerStation

Ground Grid Systems

Finite Element Method

Number of Ground Conductors: 117  
Number of Ground Rods: 123  
Total Length of Ground Conductors: 3755.00 ft  
Total Length of Ground Rods: 1230.00 ft

Frequency: 60.0  
Unit System: English  
Project Filename: GLP-Patrick-Steelton

Output Filename: C:\Documents and Settings\Barry Bingeman\My Documents\Great Lakes  
Power\Models\GLP-PATRICK-STEELTON\Grid1\_Untitled.GRI

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**Ground Grid Input Data**

**System Data:**

Freq. Hz	Weight kg	Ambient Temp. °C	Short-Circuit Current			Fault Duration (Seconds)			Plot Step ft	Extended Boundary Length ft	
			Total Fault Current kA	Sf Division Factor %	Cp Projection Factor %	Tf for Total Fault Duration	Tc for Sizing Ground Conductors	Ts for Available Body Current			
60.0	70	40.00	20.110	11.65	9.0	100.0	0.50	0.50	0.50	3.0	0.0

**Soil Data:**

Surface Material			Upper Layer Soil			Lower Layer Soil	
Material Type	Resistivity .m	Depth ft	Material Type	Resistivity .m	Depth ft	Material Type	Resistivity .m
Crushed rock	4000.0	1.30	Moist soil	300.0	5.00	Moist soil	300.0

**Material Constants:**

Conductor/Rod	Type	Conductivity %	r Factor @ 20 °C 1/°C	K0 @ 0 °C	Fusing Temperature °C	Resistivity of Ground Conductor @ 20°C .cm	Thermal Capacity Per Unit Volume J/(cm³.°C)
Conductor	Copper, annealed soft-drawn	100.0	0.00393	234.0	1083.0	1.72	3.42
Rod	Copper, annealed soft-drawn	100.0	0.00393	234.0	1083.0	1.72	3.42

**Conductor Data:**

Label	Type	Size AWG/kemil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C8	Copper, annealed soft-drawn	4/0	509.4	73.0	1.5	509.3	59.6	1.5	13.4	NO	\$3
C9	Copper, annealed soft-drawn	4/0	518.8	77.3	1.5	518.8	59.6	1.5	17.7	NO	\$3
C10	Copper, annealed soft-drawn	4/0	528.3	77.2	1.5	528.4	59.7	1.5	17.5	NO	\$3
C11	Copper, annealed soft-drawn	4/0	535.4	74.2	1.5	535.4	91.6	1.5	17.4	NO	\$3
C12	Copper, annealed soft-drawn	4/0	493.2	108.7	1.5	493.2	91.7	1.5	17.0	NO	\$3
C13	Copper, annealed soft-drawn	4/0	506.4	109.2	1.5	506.4	91.6	1.5	17.6	NO	\$3
C14	Copper, annealed soft-drawn	4/0	520.4	109.2	1.5	520.4	91.7	1.5	17.5	NO	\$3
C15	Copper, annealed soft-drawn	4/0	484.4	113.5	1.5	491.4	113.6	1.5	7.0	NO	\$3
C16	Copper, annealed soft-drawn	4/0	496.2	114.4	1.5	496.2	129.0	1.5	14.6	NO	\$3
C17	Copper, annealed soft-drawn	4/0	509.4	114.8	1.5	509.3	128.9	1.5	14.1	NO	\$3
C18	Copper, annealed soft-drawn	4/0	518.7	114.3	1.5	518.8	129.2	1.5	14.9	NO	\$3
C19	Copper, annealed soft-drawn	4/0	532.0	121.6	1.5	542.0	121.6	1.5	10.0	NO	\$3
C20	Copper, annealed soft-drawn	4/0	532.1	111.0	1.5	546.8	111.0	1.5	14.7	NO	\$3
C21	Copper, annealed soft-drawn	4/0	546.7	111.1	1.5	552.5	116.3	1.5	7.8	NO	\$3
C22	Copper, annealed soft-drawn	4/0	541.8	121.7	1.5	545.7	118.3	1.5	5.2	NO	\$3
C23	Copper, annealed soft-drawn	4/0	538.2	59.5	1.5	538.3	54.5	1.5	5.0	NO	\$3
C24	Copper, annealed soft-drawn	4/0	537.9	54.8	1.5	547.8	54.9	1.5	9.9	NO	\$3

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**Conductor Data:**

Label	Type	Size AWG/kcmil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C25	Copper, annealed soft-drawn	4/0	547.6	55.1	1.5	550.4	58.2	1.5	4.2	NO	\$3
C26	Copper, annealed soft-drawn	4/0	322.7	79.3	1.5	322.7	69.3	1.5	10.0	NO	\$3
C28	Copper, annealed soft-drawn	4/0	333.4	69.4	1.5	333.5	79.3	1.5	9.9	NO	\$3
C29	Copper, annealed soft-drawn	4/0	343.6	79.2	1.5	343.7	69.6	1.5	9.6	NO	\$3
C30	Copper, annealed soft-drawn	4/0	355.1	79.3	1.5	355.1	69.7	1.5	9.6	NO	\$3
C31	Copper, annealed soft-drawn	4/0	368.4	79.3	1.5	368.4	69.7	1.5	9.6	NO	\$3
C32	Copper, annealed soft-drawn	4/0	380.7	79.5	1.5	380.8	69.6	1.5	9.9	NO	\$3
C33	Copper, annealed soft-drawn	4/0	393.3	79.3	1.5	393.3	69.6	1.5	9.7	NO	\$3
C34	Copper, annealed soft-drawn	4/0	403.7	79.0	1.5	403.6	69.6	1.5	9.4	NO	\$3
C35	Copper, annealed soft-drawn	4/0	413.9	79.6	1.5	413.9	69.6	1.5	10.0	NO	\$3
C36	Copper, annealed soft-drawn	4/0	427.5	79.3	1.5	427.4	69.6	1.5	9.7	NO	\$3
C37	Copper, annealed soft-drawn	4/0	439.2	79.2	1.5	439.2	69.5	1.5	9.7	NO	\$3
C38	Copper, annealed soft-drawn	4/0	450.2	79.5	1.5	450.2	69.5	1.5	10.0	NO	\$3
C39	Copper, annealed soft-drawn	4/0	461.4	79.9	1.5	461.4	69.6	1.5	10.3	NO	\$3
C40	Copper, annealed soft-drawn	4/0	474.1	79.3	1.5	474.1	69.4	1.5	9.9	NO	\$3
C41	Copper, annealed soft-drawn	4/0	303.1	78.7	1.5	303.1	69.6	1.5	9.1	NO	\$3
C42	Copper, annealed soft-drawn	4/0	332.3	106.5	1.5	332.4	96.3	1.5	10.2	NO	\$3
C43	Copper, annealed soft-drawn	4/0	344.7	107.0	1.5	344.8	96.6	1.5	10.4	NO	\$3
C44	Copper, annealed soft-drawn	4/0	391.1	106.7	1.5	391.1	96.5	1.5	10.2	NO	\$3
C45	Copper, annealed soft-drawn	4/0	404.3	106.6	1.5	404.3	96.3	1.5	10.3	NO	\$3
C46	Copper, annealed soft-drawn	4/0	418.5	106.6	1.5	418.5	96.5	1.5	10.1	NO	\$3
C47	Copper, annealed soft-drawn	4/0	442.8	106.4	1.5	442.8	94.9	1.5	11.5	NO	\$3
C48	Copper, annealed soft-drawn	4/0	452.8	106.5	1.5	452.8	95.2	1.5	11.3	NO	\$3
C49	Copper, annealed soft-drawn	4/0	485.0	84.9	1.5	485.0	69.7	1.5	15.2	NO	\$3
C50	Copper, annealed soft-drawn	4/0	438.3	106.7	1.5	438.3	116.9	1.5	10.2	NO	\$3
C51	Copper, annealed soft-drawn	4/0	464.1	106.8	1.5	464.2	116.7	1.5	9.9	NO	\$3
C52	Copper, annealed soft-drawn	4/0	454.3	116.6	1.5	464.3	116.5	1.5	10.0	NO	\$3
C53	Copper, annealed soft-drawn	4/0	339.5	147.9	1.5	339.5	106.9	1.5	41.0	NO	\$3
C54	Copper, annealed soft-drawn	4/0	422.8	147.9	1.5	422.8	106.9	1.5	41.0	NO	\$3
C55	Copper, annealed soft-drawn	350	337.3	148.0	1.5	467.3	148.0	1.5	130.0	NO	\$3
C56	Copper, annealed soft-drawn	500	493.2	59.7	1.5	541.2	59.7	1.5	48.0	NO	\$3
C57	Copper, annealed soft-drawn	500	541.2	59.7	1.5	541.2	91.7	1.5	32.0	NO	\$3
C58	Copper, annealed soft-drawn	500	532.0	91.9	1.5	541.6	91.8	1.5	9.6	NO	\$3
C60	Copper, annealed soft-drawn	500	484.4	92.0	1.5	532.4	92.0	1.5	48.0	NO	\$3
C61	Copper, annealed soft-drawn	500	532.0	91.7	1.5	532.0	129.2	1.5	37.5	NO	\$3
C62	Copper, annealed soft-drawn	500	484.0	129.2	1.5	532.0	129.2	1.5	48.0	NO	\$3
C63	Copper, annealed soft-drawn	500	484.0	91.7	1.5	484.0	129.2	1.5	37.5	NO	\$3
C64	Copper, annealed soft-drawn	500	293.7	69.6	1.5	312.2	69.6	1.5	18.5	NO	\$3
C66	Copper, annealed soft-drawn	500	293.7	85.6	1.5	312.2	85.6	1.5	18.5	NO	\$3
C67	Copper, annealed soft-drawn	500	293.7	69.6	1.5	293.7	85.6	1.5	16.0	NO	\$3
C68	Copper, annealed soft-drawn	350	295.5	175.0	1.5	337.9	148.0	1.5	50.3	NO	\$3
C69	Copper, annealed soft-drawn	350	209.0	175.2	1.5	295.5	175.0	1.5	86.5	NO	\$3

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**Conductor Data:**

Label	Type	Size AWG/kemil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C70	Copper, annealed soft-drawn	350	244.4	249.7	1.5	244.4	175.0	1.5	74.7	NO	\$3
C71	Copper, annealed soft-drawn	350	209.3	282.2	1.5	209.3	157.2	1.5	125.0	NO	\$3
C72	Copper, annealed soft-drawn	350	208.7	249.4	1.5	294.0	249.6	1.5	85.3	NO	\$3
C73	Copper, annealed soft-drawn	350	293.6	284.3	1.5	293.6	249.3	1.5	35.0	NO	\$3
C74	Copper, annealed soft-drawn	350	293.9	284.4	1.5	501.6	284.6	1.5	207.7	NO	\$3
C75	Copper, annealed soft-drawn	350	501.6	249.6	1.5	501.4	284.7	1.5	35.1	NO	\$3
C76	Copper, annealed soft-drawn	4/0	501.3	249.0	1.5	514.6	249.0	1.5	13.3	NO	\$3
C77	Copper, annealed soft-drawn	4/0	514.0	249.0	1.5	525.6	237.0	1.5	16.7	NO	\$3
C78	Copper, annealed soft-drawn	350	466.9	147.7	1.5	467.0	165.3	1.5	17.6	NO	\$3
C79	Copper, annealed soft-drawn	350	434.0	165.3	1.5	479.0	165.1	1.5	45.0	NO	\$3
C80	Copper, annealed soft-drawn	350	479.0	165.0	1.5	491.6	216.0	1.5	52.5	NO	\$3
C81	Copper, annealed soft-drawn	350	502.3	192.0	1.5	502.3	226.6	1.5	34.6	NO	\$3
C82	Copper, annealed soft-drawn	350	491.7	215.7	1.5	502.0	226.4	1.5	14.9	NO	\$3
C83	Copper, annealed soft-drawn	350	502.6	192.3	1.5	517.3	195.6	1.5	15.1	NO	\$3
C84	Copper, annealed soft-drawn	350	516.3	195.3	1.5	525.6	238.3	1.5	44.0	NO	\$3
C85	Copper, annealed soft-drawn	350	434.0	179.3	1.5	434.0	165.0	1.5	14.3	NO	\$3
C86	Copper, annealed soft-drawn	350	267.3	249.7	1.5	267.0	175.3	1.5	74.4	NO	\$3
C87	Copper, annealed soft-drawn	350	266.3	214.6	1.5	326.6	214.6	1.5	60.3	NO	\$3
C88	Copper, annealed soft-drawn	350	295.3	214.6	1.5	295.3	175.0	1.5	39.6	NO	\$3
C89	Copper, annealed soft-drawn	350	326.6	214.3	1.5	326.6	176.0	1.5	38.3	NO	\$3
C90	Copper, annealed soft-drawn	350	326.6	176.0	1.5	341.3	176.0	1.5	14.7	NO	\$3
C91	Copper, annealed soft-drawn	350	341.4	176.3	1.5	341.6	164.3	1.5	12.0	NO	\$3
C92	Copper, annealed soft-drawn	350	341.9	164.9	1.5	387.9	164.9	1.5	46.0	NO	\$3
C93	Copper, annealed soft-drawn	350	387.7	164.9	1.5	388.0	214.6	1.5	49.7	NO	\$3
C94	Copper, annealed soft-drawn	350	387.6	214.3	1.5	408.0	214.0	1.5	20.4	NO	\$3
C95	Copper, annealed soft-drawn	350	407.7	214.0	1.5	408.0	178.6	1.5	35.4	NO	\$3
C96	Copper, annealed soft-drawn	350	408.0	179.3	1.5	434.3	179.3	1.5	26.3	NO	\$3
C97	Copper, annealed soft-drawn	350	398.3	214.3	1.5	398.0	284.0	1.5	69.7	NO	\$3
C98	Copper, annealed soft-drawn	350	189.3	285.3	1.5	189.3	152.6	1.5	132.7	NO	\$3
C99	Copper, annealed soft-drawn	350	189.0	157.0	1.5	209.9	157.0	1.5	20.9	NO	\$3
C100	Copper, annealed soft-drawn	350	189.3	282.3	1.5	208.6	282.0	1.5	19.3	NO	\$3
C101	Copper, annealed soft-drawn	350	150.0	271.0	1.5	190.0	271.0	1.5	40.0	NO	\$3
C102	Copper, annealed soft-drawn	350	150.0	271.0	1.5	149.6	236.3	1.5	34.7	NO	\$3
C103	Copper, annealed soft-drawn	350	149.3	236.0	1.5	189.3	236.3	1.5	40.0	NO	\$3
C104	Copper, annealed soft-drawn	350	177.4	164.7	1.5	254.4	164.7	1.5	77.0	NO	\$3
C105	Copper, annealed soft-drawn	350	254.4	165.0	1.5	254.6	258.3	1.5	93.3	NO	\$3
C106	Copper, annealed soft-drawn	350	209.0	258.0	1.5	254.7	258.3	1.5	45.7	NO	\$3
C107	Copper, annealed soft-drawn	350	177.0	199.3	1.5	177.3	164.6	1.5	34.7	NO	\$3
C108	Copper, annealed soft-drawn	350	147.3	199.0	1.5	189.6	199.2	1.5	42.3	NO	\$3
C109	Copper, annealed soft-drawn	350	147.0	199.1	1.5	147.0	172.3	1.5	26.8	NO	\$3
C110	Copper, annealed soft-drawn	350	147.3	172.6	1.5	177.3	172.6	1.5	30.0	NO	\$3
C111	Copper, annealed soft-drawn	350	146.6	180.0	1.5	177.6	180.0	1.5	31.0	NO	\$3

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**Conductor Data:**

Label	Type	Size AWG/kemil	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
C112	Copper, annealed soft-drawn	350	146.9	187.0	1.5	177.3	187.3	1.5	30.4	NO	\$3
C113	Copper, annealed soft-drawn	350	254.3	193.0	1.5	287.0	193.3	1.5	32.7	NO	\$3
C114	Copper, annealed soft-drawn	350	287.0	193.0	1.5	287.0	213.3	1.5	20.3	NO	\$3
C115	Copper, annealed soft-drawn	4/0	475.6	165.3	1.5	475.6	156.0	1.5	9.3	NO	\$3
C116	Copper, annealed soft-drawn	4/0	475.4	156.6	1.5	485.4	156.6	1.5	10.0	NO	\$3
C117	Copper, annealed soft-drawn	4/0	485.4	156.6	1.5	485.6	152.6	1.5	4.0	NO	\$3
C118	Copper, annealed soft-drawn	4/0	485.6	152.6	1.5	528.6	142.6	1.5	44.1	NO	\$3
C119	Copper, annealed soft-drawn	4/0	480.6	156.3	1.5	480.6	140.0	1.5	16.3	NO	\$3
C124	Copper, annealed soft-drawn	500	312.6	70.3	1.5	312.6	107.0	1.5	36.7	NO	\$3
C125	Copper, annealed soft-drawn	500	312.6	69.7	1.5	493.9	70.0	1.5	181.3	NO	\$3
C126	Copper, annealed soft-drawn	500	493.0	60.0	1.5	493.0	91.7	1.5	31.7	NO	\$3
C127	Copper, annealed soft-drawn	500	312.6	106.6	1.5	471.6	106.6	1.5	159.0	NO	\$3
C128	Copper, annealed soft-drawn	4/0	471.6	106.6	1.5	484.6	98.6	1.5	15.3	NO	\$3
C129	Copper, annealed soft-drawn	4/0	493.0	66.0	1.5	501.0	66.0	1.5	8.0	NO	\$3
C130	Copper, annealed soft-drawn	4/0	493.6	75.6	1.5	501.6	75.6	1.5	8.0	NO	\$3
C131	Copper, annealed soft-drawn	4/0	493.3	84.6	1.5	501.3	84.6	1.5	8.0	NO	\$3

**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Ycs/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R0	Copper, annealed soft-drawn	0.75	189.0	151.6	1.5	189.0	151.6	11.5	10.0	NO	\$100
R1	Copper, annealed soft-drawn	0.75	189.3	174.6	1.5	189.3	174.6	11.5	10.0	NO	\$100
R2	Copper, annealed soft-drawn	0.75	189.3	208.6	1.5	189.3	208.6	11.5	10.0	NO	\$100
R3	Copper, annealed soft-drawn	0.75	189.3	240.6	1.5	189.3	240.6	11.5	10.0	NO	\$100
R4	Copper, annealed soft-drawn	0.75	189.3	285.0	1.5	189.3	285.0	11.5	10.0	NO	\$100
R5	Copper, annealed soft-drawn	0.75	171.0	271.0	1.5	171.0	271.0	11.5	10.0	NO	\$100
R6	Copper, annealed soft-drawn	0.75	149.6	268.3	1.5	149.6	268.3	11.5	10.0	NO	\$100
R7	Copper, annealed soft-drawn	0.75	149.6	238.3	1.5	149.6	238.3	11.5	10.0	NO	\$100
R8	Copper, annealed soft-drawn	0.75	170.0	236.6	1.5	170.0	236.6	11.5	10.0	NO	\$100
R9	Copper, annealed soft-drawn	0.75	209.3	159.6	1.5	209.3	159.6	11.5	10.0	NO	\$100
R10	Copper, annealed soft-drawn	0.75	209.3	168.3	1.5	209.3	168.3	11.5	10.0	NO	\$100
R11	Copper, annealed soft-drawn	0.75	209.3	175.0	1.5	209.3	175.0	11.5	10.0	NO	\$100
R12	Copper, annealed soft-drawn	0.75	209.6	186.3	1.5	209.6	186.3	11.5	10.0	NO	\$100
R13	Copper, annealed soft-drawn	0.75	209.3	200.3	1.5	209.3	200.3	11.5	10.0	NO	\$100
R14	Copper, annealed soft-drawn	0.75	209.0	213.0	1.5	209.0	213.0	11.5	10.0	NO	\$100
R15	Copper, annealed soft-drawn	0.75	209.3	231.3	1.5	209.3	231.3	11.5	10.0	NO	\$100
R16	Copper, annealed soft-drawn	0.75	209.3	279.3	1.5	209.3	279.3	11.5	10.0	NO	\$100
R17	Copper, annealed soft-drawn	0.75	209.3	263.0	1.5	209.3	263.0	11.5	10.0	NO	\$100
R18	Copper, annealed soft-drawn	0.75	244.3	188.0	1.5	244.3	188.0	11.5	10.0	NO	\$100
R19	Copper, annealed soft-drawn	0.75	244.3	202.0	1.5	244.3	202.0	11.5	10.0	NO	\$100
R20	Copper, annealed soft-drawn	0.75	244.6	220.3	1.5	244.6	220.3	11.5	10.0	NO	\$100

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**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R21	Copper, annealed soft-drawn	0.75	244.6	235.3	1.5	244.6	235.3	11.5	10.0	NO	\$100
R22	Copper, annealed soft-drawn	0.75	258.6	182.3	1.5	258.6	182.3	11.5	10.0	NO	\$100
R23	Copper, annealed soft-drawn	0.75	262.6	182.0	1.5	262.6	182.0	11.5	10.0	NO	\$100
R24	Copper, annealed soft-drawn	0.75	258.3	211.6	1.5	258.3	211.6	11.5	10.0	NO	\$100
R25	Copper, annealed soft-drawn	0.75	262.3	211.0	1.5	262.3	211.0	11.5	10.0	NO	\$100
R26	Copper, annealed soft-drawn	0.75	275.6	182.3	1.5	275.6	182.3	11.5	10.0	NO	\$100
R27	Copper, annealed soft-drawn	0.75	275.0	196.3	1.5	275.0	196.3	11.5	10.0	NO	\$100
R28	Copper, annealed soft-drawn	0.75	275.3	210.3	1.5	275.3	210.3	11.5	10.0	NO	\$100
R29	Copper, annealed soft-drawn	0.75	286.6	196.3	1.5	286.6	196.3	11.5	10.0	NO	\$100
R30	Copper, annealed soft-drawn	0.75	286.3	210.3	1.5	286.3	210.3	11.5	10.0	NO	\$100
R31	Copper, annealed soft-drawn	0.75	292.6	210.0	1.5	292.6	210.0	11.5	10.0	NO	\$100
R32	Copper, annealed soft-drawn	0.75	274.6	218.6	1.5	274.6	218.6	11.5	10.0	NO	\$100
R33	Copper, annealed soft-drawn	0.75	275.0	246.0	1.5	275.0	246.0	11.5	10.0	NO	\$100
R34	Copper, annealed soft-drawn	0.75	282.3	231.0	1.5	282.3	231.0	11.5	10.0	NO	\$100
R35	Copper, annealed soft-drawn	0.75	286.3	231.0	1.5	286.3	231.0	11.5	10.0	NO	\$100
R36	Copper, annealed soft-drawn	0.75	291.6	219.0	1.5	291.6	219.0	11.5	10.0	NO	\$100
R37	Copper, annealed soft-drawn	0.75	289.6	246.3	1.5	289.6	246.3	11.5	10.0	NO	\$100
R38	Copper, annealed soft-drawn	0.75	261.6	253.6	1.5	261.6	253.6	11.5	10.0	NO	\$100
R39	Copper, annealed soft-drawn	0.75	273.3	253.3	1.5	273.3	253.3	11.5	10.0	NO	\$100
R40	Copper, annealed soft-drawn	0.75	284.3	253.3	1.5	284.3	253.3	11.5	10.0	NO	\$100
R41	Copper, annealed soft-drawn	0.75	273.3	264.6	1.5	273.3	264.6	11.5	10.0	NO	\$100
R42	Copper, annealed soft-drawn	0.75	284.6	264.6	1.5	284.6	264.6	11.5	10.0	NO	\$100
R43	Copper, annealed soft-drawn	0.75	284.0	274.6	1.5	284.0	274.6	11.5	10.0	NO	\$100
R44	Copper, annealed soft-drawn	0.75	299.6	181.6	1.5	299.6	181.6	11.5	10.0	NO	\$100
R45	Copper, annealed soft-drawn	0.75	305.0	181.3	1.5	305.0	181.3	11.5	10.0	NO	\$100
R46	Copper, annealed soft-drawn	0.75	299.6	197.0	1.5	299.6	197.0	11.5	10.0	NO	\$100
R47	Copper, annealed soft-drawn	0.75	304.3	197.0	1.5	304.3	197.0	11.5	10.0	NO	\$100
R48	Copper, annealed soft-drawn	0.75	299.3	209.6	1.5	299.3	209.6	11.5	10.0	NO	\$100
R49	Copper, annealed soft-drawn	0.75	304.0	209.6	1.5	304.0	209.6	11.5	10.0	NO	\$100
R50	Copper, annealed soft-drawn	0.75	305.0	227.6	1.5	305.0	227.6	11.5	10.0	NO	\$100
R51	Copper, annealed soft-drawn	0.75	304.6	240.0	1.5	304.6	240.0	11.5	10.0	NO	\$100
R52	Copper, annealed soft-drawn	0.75	299.6	253.0	1.5	299.6	253.0	11.5	10.0	NO	\$100
R53	Copper, annealed soft-drawn	0.75	305.0	253.0	1.5	305.0	253.0	11.5	10.0	NO	\$100
R54	Copper, annealed soft-drawn	0.75	299.0	266.0	1.5	299.0	266.0	11.5	10.0	NO	\$100
R55	Copper, annealed soft-drawn	0.75	304.6	266.0	1.5	304.6	266.0	11.5	10.0	NO	\$100
R56	Copper, annealed soft-drawn	0.75	299.0	277.3	1.5	299.0	277.3	11.5	10.0	NO	\$100
R57	Copper, annealed soft-drawn	0.75	304.6	277.3	1.5	304.6	277.3	11.5	10.0	NO	\$100
R58	Copper, annealed soft-drawn	0.75	321.0	161.6	1.5	321.0	161.6	11.5	10.0	NO	\$100
R59	Copper, annealed soft-drawn	0.75	321.3	165.0	1.5	321.3	165.0	11.5	10.0	NO	\$100
R60	Copper, annealed soft-drawn	0.75	342.0	148.3	1.5	342.0	148.3	11.5	10.0	NO	\$100
R61	Copper, annealed soft-drawn	0.75	346.3	148.3	1.5	346.3	148.3	11.5	10.0	NO	\$100
R62	Copper, annealed soft-drawn	0.75	350.3	148.3	1.5	350.3	148.3	11.5	10.0	NO	\$100

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**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R63	Copper, annealed soft-drawn	0.75	354.0	148.3	1.5	354.0	148.3	11.5	10.0	NO	\$100
R64	Copper, annealed soft-drawn	0.75	348.3	162.3	1.5	348.3	162.3	11.5	10.0	NO	\$100
R65	Copper, annealed soft-drawn	0.75	348.0	157.6	1.5	348.0	157.6	11.5	10.0	NO	\$100
R66	Copper, annealed soft-drawn	0.75	367.6	162.0	1.5	367.6	162.0	11.5	10.0	NO	\$100
R67	Copper, annealed soft-drawn	0.75	367.3	157.0	1.5	367.3	157.0	11.5	10.0	NO	\$100
R68	Copper, annealed soft-drawn	0.75	390.0	148.3	1.5	390.0	148.3	11.5	10.0	NO	\$100
R69	Copper, annealed soft-drawn	0.75	394.3	148.0	1.5	394.3	148.0	11.5	10.0	NO	\$100
R70	Copper, annealed soft-drawn	0.75	398.6	148.3	1.5	398.6	148.3	11.5	10.0	NO	\$100
R71	Copper, annealed soft-drawn	0.75	402.6	148.0	1.5	402.6	148.0	11.5	10.0	NO	\$100
R72	Copper, annealed soft-drawn	0.75	399.6	158.0	1.5	399.6	158.0	11.5	10.0	NO	\$100
R73	Copper, annealed soft-drawn	0.75	399.6	162.6	1.5	399.6	162.6	11.5	10.0	NO	\$100
R74	Copper, annealed soft-drawn	0.75	429.6	158.6	1.5	429.6	158.6	11.5	10.0	NO	\$100
R75	Copper, annealed soft-drawn	0.75	429.6	162.6	1.5	429.6	162.6	11.5	10.0	NO	\$100
R76	Copper, annealed soft-drawn	0.75	460.3	148.0	1.5	460.3	148.0	11.5	10.0	NO	\$100
R77	Copper, annealed soft-drawn	0.75	454.0	148.0	1.5	454.0	148.0	11.5	10.0	NO	\$100
R78	Copper, annealed soft-drawn	0.75	449.3	148.0	1.5	449.3	148.0	11.5	10.0	NO	\$100
R79	Copper, annealed soft-drawn	0.75	443.6	147.6	1.5	443.6	147.6	11.5	10.0	NO	\$100
R80	Copper, annealed soft-drawn	0.75	470.0	156.3	1.5	470.0	156.3	11.5	10.0	NO	\$100
R81	Copper, annealed soft-drawn	0.75	470.6	160.0	1.5	470.6	160.0	11.5	10.0	NO	\$100
R82	Copper, annealed soft-drawn	0.75	308.6	287.3	1.5	308.6	287.3	11.5	10.0	NO	\$100
R83	Copper, annealed soft-drawn	0.75	308.3	291.0	1.5	308.3	291.0	11.5	10.0	NO	\$100
R84	Copper, annealed soft-drawn	0.75	337.0	288.3	1.5	337.0	288.3	11.5	10.0	NO	\$100
R85	Copper, annealed soft-drawn	0.75	337.0	291.6	1.5	337.0	291.6	11.5	10.0	NO	\$100
R86	Copper, annealed soft-drawn	0.75	369.3	288.3	1.5	369.3	288.3	11.5	10.0	NO	\$100
R87	Copper, annealed soft-drawn	0.75	369.0	292.3	1.5	369.0	292.3	11.5	10.0	NO	\$100
R88	Copper, annealed soft-drawn	0.75	392.6	287.6	1.5	392.6	287.6	11.5	10.0	NO	\$100
R89	Copper, annealed soft-drawn	0.75	392.3	291.3	1.5	392.3	291.3	11.5	10.0	NO	\$100
R90	Copper, annealed soft-drawn	0.75	416.0	287.3	1.5	416.0	287.3	11.5	10.0	NO	\$100
R91	Copper, annealed soft-drawn	0.75	416.3	292.0	1.5	416.3	292.0	11.5	10.0	NO	\$100
R92	Copper, annealed soft-drawn	0.75	462.0	287.3	1.5	462.0	287.3	11.5	10.0	NO	\$100
R93	Copper, annealed soft-drawn	0.75	462.3	291.0	1.5	462.3	291.0	11.5	10.0	NO	\$100
R94	Copper, annealed soft-drawn	0.75	402.0	277.0	1.5	402.0	277.0	11.5	10.0	NO	\$100
R95	Copper, annealed soft-drawn	0.75	406.6	277.0	1.5	406.6	277.0	11.5	10.0	NO	\$100
R96	Copper, annealed soft-drawn	0.75	402.0	262.3	1.5	402.0	262.3	11.5	10.0	NO	\$100
R97	Copper, annealed soft-drawn	0.75	406.3	262.3	1.5	406.3	262.3	11.5	10.0	NO	\$100
R98	Copper, annealed soft-drawn	0.75	401.6	251.3	1.5	401.6	251.3	11.5	10.0	NO	\$100
R99	Copper, annealed soft-drawn	0.75	405.3	251.3	1.5	405.3	251.3	11.5	10.0	NO	\$100
R100	Copper, annealed soft-drawn	0.75	162.0	7.0	0.5	162.0	7.0	10.5	10.0	NO	\$100
R101	Copper, annealed soft-drawn	0.75	220.0	6.0	0.5	220.0	6.0	10.5	10.0	NO	\$100
R102	Copper, annealed soft-drawn	0.75	272.0	7.0	0.5	272.0	7.0	10.5	10.0	NO	\$100
R103	Copper, annealed soft-drawn	0.75	328.0	8.0	0.5	328.0	8.0	10.5	10.0	NO	\$100
R104	Copper, annealed soft-drawn	0.75	397.0	6.0	0.5	397.0	6.0	10.5	10.0	NO	\$100

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**Rod Data:**

Label	Type	Diameter inch	From			To			Length ft	Insulated Yes/No	Cost \$/ft
			X	Y	Z	X	Y	Z			
R105	Copper, annealed soft-drawn	0.75	459.0	14.0	0.5	459.0	14.0	10.5	10.0	NO	\$100
R106	Copper, annealed soft-drawn	0.75	516.0	20.0	0.5	516.0	20.0	10.5	10.0	NO	\$100
R107	Copper, annealed soft-drawn	0.75	575.0	30.0	0.5	575.0	30.0	10.5	10.0	NO	\$100
R108	Copper, annealed soft-drawn	0.75	594.0	50.0	0.5	594.0	50.0	10.5	10.0	NO	\$100
R109	Copper, annealed soft-drawn	0.75	606.0	77.0	0.5	606.0	77.0	10.5	10.0	NO	\$100
R110	Copper, annealed soft-drawn	0.75	606.0	112.0	0.5	606.0	112.0	10.5	10.0	NO	\$100
R111	Copper, annealed soft-drawn	0.75	607.0	152.0	0.5	607.0	152.0	10.5	10.0	NO	\$100
R112	Copper, annealed soft-drawn	0.75	605.0	195.0	0.5	605.0	195.0	10.5	10.0	NO	\$100
R113	Copper, annealed soft-drawn	0.75	606.0	268.0	0.5	606.0	268.0	10.5	10.0	NO	\$100
R114	Copper, annealed soft-drawn	0.75	604.0	324.0	0.5	604.0	324.0	10.5	10.0	NO	\$100
R115	Copper, annealed soft-drawn	0.75	606.0	392.0	0.5	606.0	392.0	10.5	10.0	NO	\$100
R116	Copper, annealed soft-drawn	0.75	223.0	345.0	0.5	223.0	345.0	10.5	10.0	NO	\$100
R117	Copper, annealed soft-drawn	0.75	226.0	410.0	0.5	226.0	410.0	10.5	10.0	NO	\$100
R118	Copper, annealed soft-drawn	0.75	119.0	343.0	0.5	119.0	343.0	10.5	10.0	NO	\$100
R119	Copper, annealed soft-drawn	0.75	120.0	246.0	0.5	120.0	246.0	10.5	10.0	NO	\$100
R120	Copper, annealed soft-drawn	0.75	122.0	224.0	0.5	122.0	224.0	10.5	10.0	NO	\$100
R121	Copper, annealed soft-drawn	0.75	120.0	56.0	0.5	120.0	56.0	10.5	10.0	NO	\$100
R122	Copper, annealed soft-drawn	0.75	258.0	411.0	0.5	258.0	411.0	10.5	10.0	NO	\$100

**Cost:**

Conductor			Rod			Total Cost
Total No.	Total Length ft	Cost	Total No.	Total Length ft	Cost	
117	3,754.6	\$12,390	123	1,230.0	\$123,000	\$135,390



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Ground Grid Summary Report

Rg Ground Resistance Ohm	GPR Ground Potential Rise Volts	Maximum Touch Potential					Maximum Step Potential				
		Tolerable Volts	Calculated Volts	Calculated %	Coordinates (ft)		Tolerable Volts	Calculated Volts	Calculated %	Coordinates (ft)	
					X	Y				X	Y
1.54	2,875.9	1,428.5	1,794.6	125.6	563.3	392.1	5,048.1	444.5	8.8	606.00	392.00

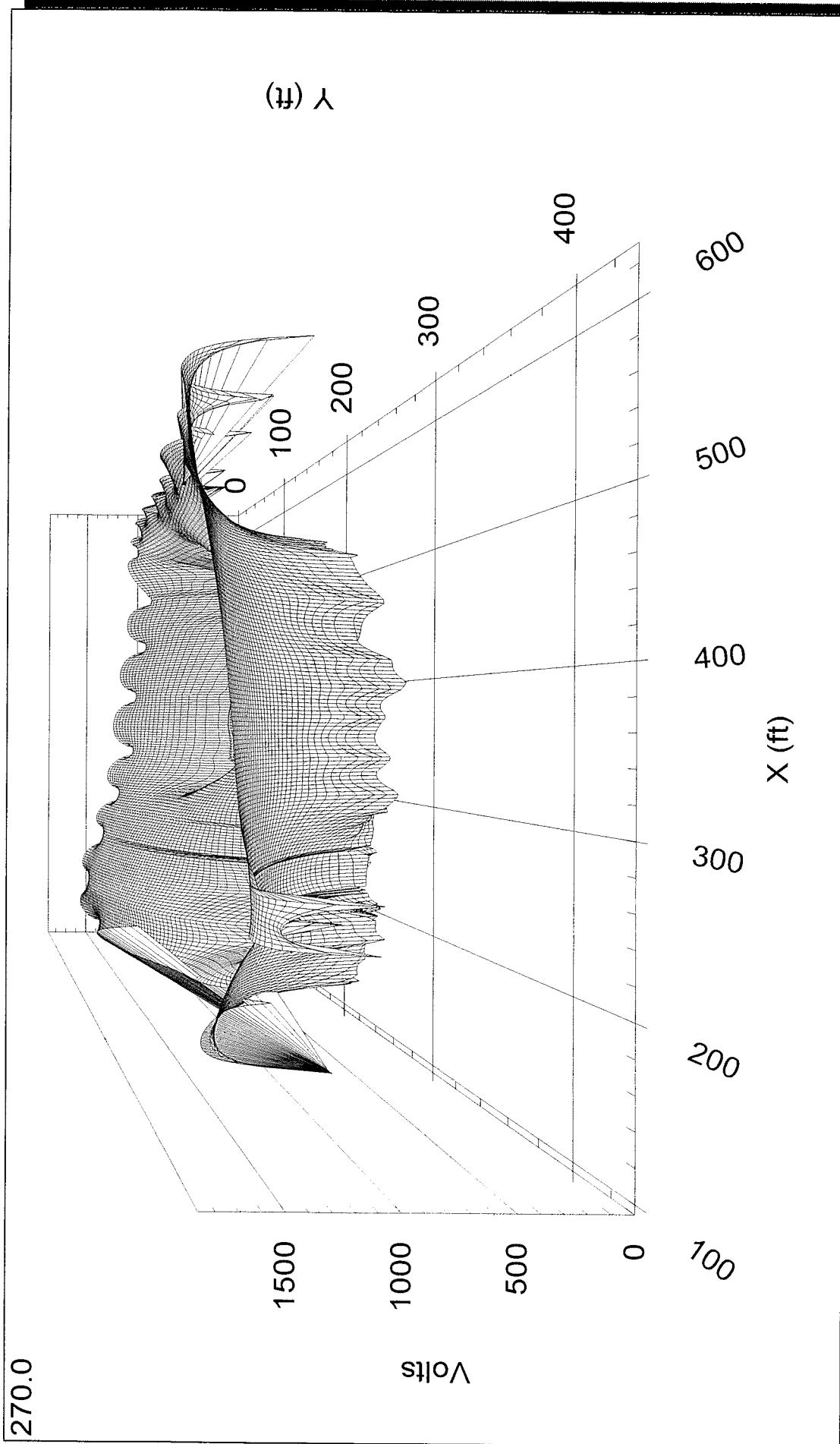
Total Fault Current: 20.110 kA      Reflection Factor (K): -0.860  
 Maximum Grid Current: 1.865 kA      Surface Layer Derating Factor (Cs): 0.906  
    Decrement Factor (Df): 1.030

Warnings:

The maximum Touch Voltage exceeds the tolerable limits

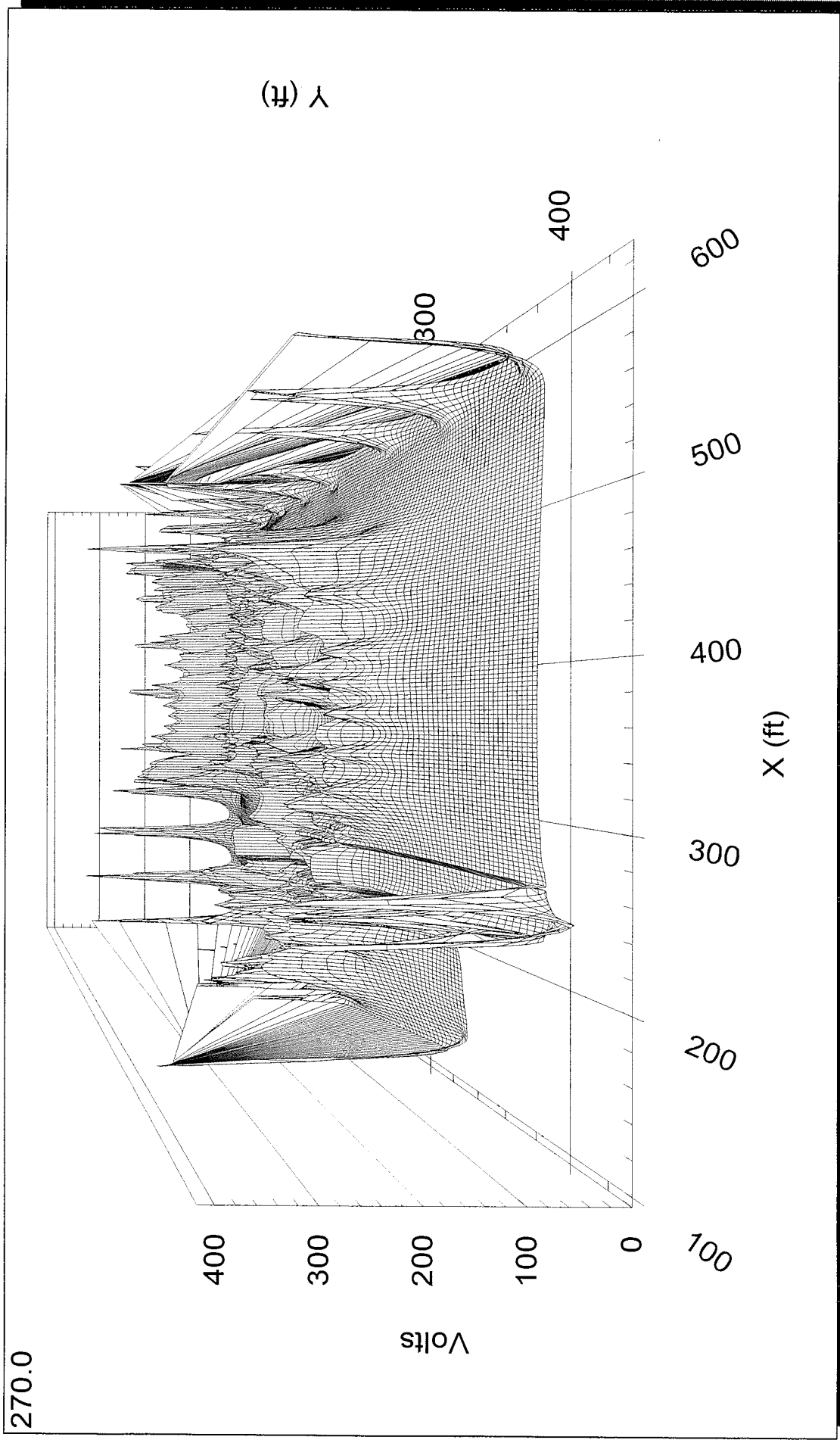
# Patrick Steelton TS

Touch Potential Profile



# Patrick Steelton TS

Step Potential Profile

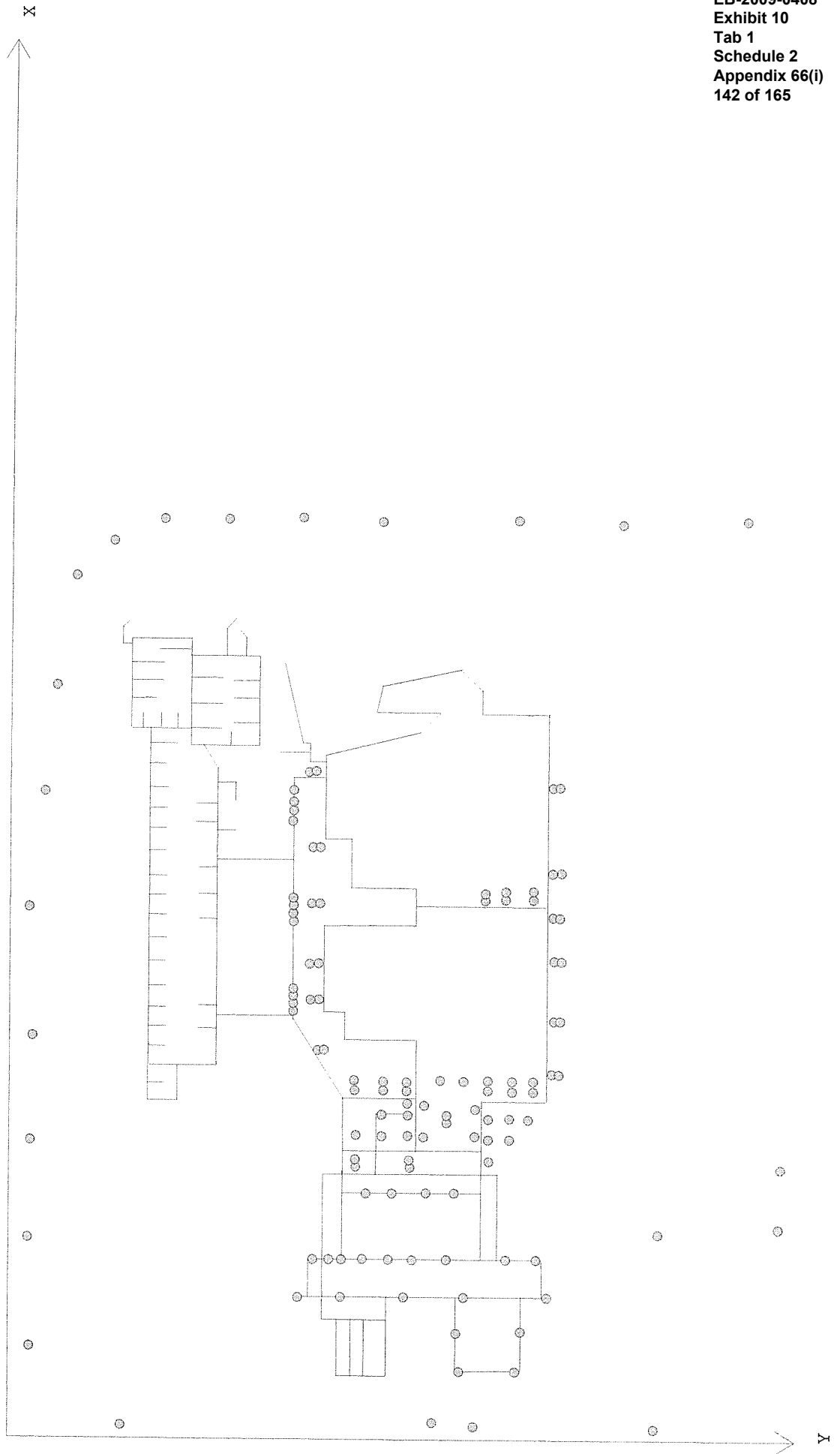


ETAP PowerStation  
4.7.AC  
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Contract:  
Engineer:  
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SN: PROCOMMTSI  
Revision: Base

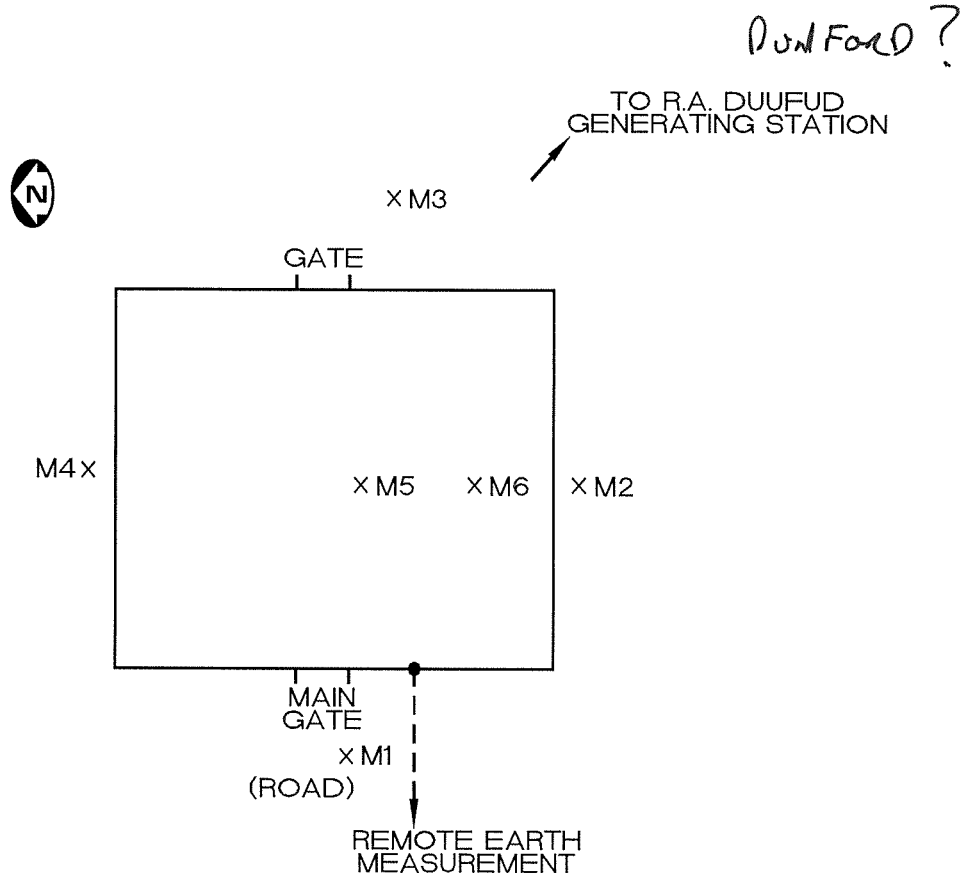
Grid1 - Top View





## 6.8 WATSON TS

### 6.8.1 Soil Resistivity Measurement Locations



## 6.8.2 Resistivity Measurement

Soil resistivity has been calculated based on the following:

$$P = 2\pi aR$$

$a$  = Rod Spacing

$R$  = Resistivity Measurement

Measurement Location	Probe Spacing	Resistance Measured	Calculated Soil Resistivity
M1	2.0 M	114 $\Omega$	1432 $\Omega \cdot M$
M2	2.0 M	389 $\Omega$	4888 $\Omega \cdot M$
M3	2.0 M	479 $\Omega$	6019 $\Omega \cdot M$
M4	2.0 M	322 $\Omega$	4046 $\Omega \cdot M$
M5	0.305 M	244 $\Omega$	467 $\Omega \cdot M$
M6	0.305 M	764 $\Omega$	1463 $\Omega \cdot M$

Modeling Values Used:

- |                  |             |                       |
|------------------|-------------|-----------------------|
| 1. Surface       | Stone       | 1463 $\Omega \cdot M$ |
| 2. Upper Surface | Sand/Gravel | 4000 $\Omega \cdot M$ |
| 3. Lower Surface | Sand/Rock   | 4000 $\Omega \cdot M$ |

## 6.8.3 Ground Resistance Measurements

Measurement Location:

The test ground electrode used is indicated on the measurement location sketch 6.8.1. Current probe C1 was located in a westerly direction along roadway, 800 ft. from test electrode. Potential probe P1 measurements were made at the significant intervals between test electrode and current probe C1.

Measurements obtained:

Position No.	Distance	Resistance
1	160 ft.	3.50 $\Omega$
2	200 ft.	4.27 $\Omega$
3	320 ft	6.66 $\Omega$
4	400 ft	7.28 $\Omega$
5	480 ft	9.98 $\Omega$
6	600 ft	16.70 $\Omega$
7	700 ft	25.00 $\Omega$

The Slope Method was used to calculate soil resistivity. Refer to Appendix 9.1 for supporting methodology.

Distance calculation for value R

$$R_1 = 0.2 \times 800' = 160'$$

$$R_2 = 0.4 \times 800' = 320'$$

$$R_3 = 0.6 \times 800' = 480'$$

Remote Distance Curve Calculation:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1} = \frac{9.98 - 6.66}{6.66 - 3.50} = 1.05$$

From Table VII in Appendix 9.2:

$$\mu \text{ of } 1.05 = \text{Pt/C of } 0.531$$

Distance of potential probe to represent remote earth soil resistivity

$$= 0.531 \times 800' = 425' \text{ to Probe P1}$$

**Measured Value = 8.2  $\Omega$**

#### 6.8.4 Stone Coverage Area

On a percentage basis, approximately 100% of the area inside the substation fenced enclosure does have a stone cover. Stone depth was measured at 0.0254 M. The stone cover and sand/gravel/rock subsoil contained moisture and was damp. This is reflected in the ground resistance measurements.



## 6.8.5 Allowable Safe Step and Touch Potentials

Based on Surface Layer De-rating Factor ( $C_s$ )

$$\begin{aligned} C_s &= 1 - \frac{0.09 \left(1 - \frac{P}{P_s}\right)}{2h_s + 0.09} \\ &= 1 - \left(\frac{-0.156}{0.140}\right) \\ &= 1 - (-)1.114 \\ &= 2.11 \end{aligned}$$

$$P = 4000 \Omega \cdot M$$

$$P_s = 1463 \Omega \cdot M$$

$$h_s = 0.0254 M$$

### Safe Step Potential

$$\begin{aligned} E_{Step(50)} &= [1000 + 6C_s P_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 6 * 2.11 * 1463] * \frac{0.116}{\sqrt{0.5}} \\ &= 19522 * 0.164 \\ &= 3202 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Step(70)} &= [1000 + 6C_s P_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 6 * 2.11 * 1463] * \frac{0.157}{\sqrt{0.5}} \\ &= 19522 * 0.222 \\ &= 4334 \text{ Volts} \end{aligned}$$

## Safe Touch Potential

$$\begin{aligned} E_{Touch(50)} &= [1000 + 1.5C_sP_s] * \frac{0.116}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 2.11 * 1463] * \frac{0.116}{\sqrt{0.5}} \\ &= 5630 * 0.164 \\ &= 923 \text{ Volts} \end{aligned}$$

$$\begin{aligned} E_{Touch(70)} &= [1000 + 1.5C_sP_s] * \frac{0.157}{\sqrt{t_s}} \\ &= [1000 + 1.5 * 2.11 * 1463] * \frac{0.157}{\sqrt{0.5}} \\ &= 5630 * 0.222 \\ &= 1250 \text{ Volts} \end{aligned}$$

## 6.8.6 Total Resistance to Remote Earth

$$\begin{aligned} R_g &= P * \left[ \frac{1}{L_T} + \frac{1}{\sqrt{20A}} \left( 1 + \frac{1}{1 + h\sqrt{\frac{20}{A}}} \right) \right] \\ &= 4000 * \left[ \frac{1}{7643} + \frac{1}{\sqrt{20 * 5923}} \left( 1 + \frac{1}{1 + 0.381\sqrt{\frac{20}{5923}}} \right) \right] \\ &= 4000 * [0.00013 + 0.0029 * 1.978] \\ &= 4000 * 0.0059 \\ &= 23.5 \Omega \end{aligned}$$

$L_T$  = Buried conductors and rods

$$= 7643 \text{ M}$$

$A$  = Ground grid area

$$= 5923 \text{ M}^2$$

$h$  = Depth of grid

$$= 0.381 \text{ M}$$

$P$  = Resistivity

$$= 4000 \Omega \cdot \text{M}$$

## 6.8.7 Current Grid Split Factor Determination

To calculate  $S_f$  based on IEEE Std. 80-2000 Annex C.

Based on 2 Transmission / 3 Distribution Lines

$$R_g \text{ Measured} = 8.2 \Omega \text{ (selected for calculation)}$$

$$R_g \text{ Calculated} = 23.5 \Omega$$

$$R_g \text{ Modeled} = 22.14 \Omega$$

### Method A (Interpolation Required)

$$\text{Table C.1} \quad 2T / 2D \quad R_{tg} = 100 \Omega \quad R_{dg} = 200 \Omega \quad R + jX = 1.63 + j0.324$$

$$Z_g = \frac{(1.63 + j0.324)}{(8.2 + 1.63 + j0.324)} = \frac{1.662}{9.835} = 0.169 \Omega$$

$$\text{Table C.1} \quad 2T / 4D \quad R_{tg} = 100 \Omega \quad R_{dg} = 200 \Omega \quad R + jX = 1.09 + j0.208$$

$$Z_g = \frac{(1.09 + j0.208)}{(8.2 + 1.09 + j0.208)} = \frac{1.110}{9.292} = 0.119 \Omega$$

$$\text{Approximate Split Factor} = \frac{0.169 + 0.119}{2} = 14\%$$

### Method B (Interpolation Required)

$$2T / 2D \quad 100\% \text{ Remote Contribution} \quad R_g = 8.2 \Omega$$

$$R_{tg} = 100 \Omega \quad R_{dg} = 200 \Omega \quad \text{Figure C.4}$$

$$S_f = 17\%$$

2T / 4D      100% Remote Contribution       $R_g = 8.2 \Omega$

$$R_{tg} = 100 \Omega \quad R_{dg} = 200 \Omega \quad \text{Figure C.4}$$

$$S_f = 13\%$$

$$\text{Approximate Split Factor} = \frac{17 + 13}{2} = 15\%$$

$\therefore$  Comparing methods A and B, assign  $S_f$  for 115 kV system of 15%.

### 6.8.8 Symmetrical Grid Current ( $I_g$ )

$$\begin{aligned} I_g &= S_f * I_F \\ &= 0.15 * 2.983 \text{ kA} \\ &= 0.447 \text{ kA} \end{aligned}$$

$$S_f = 15\%$$

$$\begin{aligned} I_F &= L - G \text{ value from G.L.P.} \\ &= 2.983 \text{ kA} \end{aligned}$$

### 6.8.9 Maximum Grid Current ( $I_G$ )

$$\begin{aligned} I_G &= D_f * I_g \\ &= 1.026 * 0.447 \text{ kA} \\ &= .46 \text{ kA} \end{aligned}$$

$$D_f = 1.026$$

$$I_g = 0.447 \text{ kA}$$

## 6.8.10 Calculated Ground Potential Rise (GPR)

$$\begin{aligned} GPR_{Hand} &= R_g * I_G * 10^3 \\ &= 23.5 * 0.46 * 10^3 \\ &= 10810 \text{ Volts} \end{aligned}$$

$$\begin{aligned} GPR_{Measured} &= R_g * I_G * 10^3 \\ &= 8.2 * 0.46 * 10^3 \\ &= 3772 \text{ Volts} \end{aligned}$$

## 6.8.11 Comparison of Modeled Values and Results

Modeled Step and Touch voltage values have not been compared to manual calculated values.

Manual calculated values could not be completed as per the methodologies of IEEE 80-2000 Section 16.5.1 and 16.5.2 due to the irregularity and complexity of the existing grounding grid layout. Refer to Sections 16.7 and 16.8 of the referenced standard. Additionally, the R.A.Dunford Generating Station yard grid and Powerhouse grid are interconnected to the Watson TS ground grid. Also a separate grounding plate has been located in the Dunford GS head pond.

## 6.8.12 Fence Grounding and Condition Comments

The boundary fence is tied to the substation ground grid. Measured resistance between fence and ground grid is 0.522  $\Omega$ .

A visual inspection of the fence and gate grounding was completed. The condition of each thermoweld was inspected and the continuity of each jumper was confirmed.

This is a relatively new ground grid installation. We found no issues with the fence and fence grounding.

---

## 6.8.13 Above Grade Equipment Ground Audit

An audit of all bonding and grounding associated with electrical distribution equipment, supporting towers and structures, fences and gates was completed. All bare ground wire connections were assessed including both thermoweld and mechanical configurations. Bare ground wire sizes were measured and compared to the engineering drawing provided by Great Lakes Power. For reference, this drawing is number SD-20620 rev.0. We have also obtained the R.A. Dunford Generating Station ground grid drawings. For reference, these drawings are KD-379001, KD-309001 and KD-309002 all rev. 0

## 6.8.14 Comments

1. An accurate computer model of the Watson TS could not be constructed for analysis. Factors affecting model integrity include interconnection of the Dunford GS transformer yard and associated Powerhouse grid, remote grounding plate in the head pond.
2. We have calculated the Ground Potential Rise based on measured remote earth resistance.
3. It is recommended that additional site measurements be taken to confirm the validity of the initial site measurements.

---

## 6.8.15 COMPUTER MODEL OUTPUT RESULTS FOR THE 115 kV SYSTEM

### System Data:

Body Weight	70 kg
Fault Current ( $I_F$ )	2.983 kA
X/R ratio	9.87
Division Factor ( $S_F$ )	15%
Projection Factor ( $C_P$ )	100%
Fault Duration ( $T_f, T_c, T_s$ )	0.5 sec.
Plot Step	3 ft.

### Summary Report:

Ground Resistance ( $R_g$ )	N/A $\Omega$
Ground Potential Rise (GPR)	N/A V
Tolerable Touch Potential	1250 V
Calculated Touch Potential	N/A V
Tolerable Step Potential	4335V
Calculated Step Potential	N/A V

**Modeled Results Not Obtainable.**

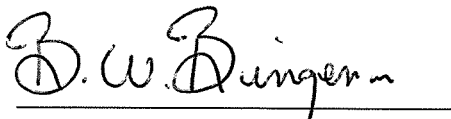




## 7.0 SIGNATURES AND ACKNOWLEDGEMENTS


PwrTech Designs wishes to acknowledge Alex Turpine of Great Lakes Power for his assistance during the field measurement tasks.

Report Prepared by:



Barry Bingeman  
Lead Designer

Report Endorsed by:



Harold Harkonen, P. Eng.  
Senior Electrical Engineer



---

## 8.0 References

1. Westinghouse Electrical Transmission & Distribution,  
Reference Book  
Fourth Edition, 1964
2. IEEE STD. 80-2000  
IEEE Guide for Safety in AC Substation Grounding
3. IEEE STD. 367-1996 (R2002)  
IEEE Recommended Practice for Determining the Electric Power Station Ground  
Potential Rise and Induced Voltage from a Power Fault.

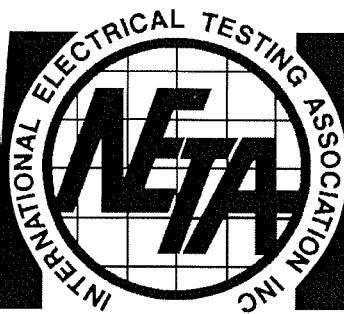


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## 9.0 Appendix

1. Appendix 9.1 NETA World – Slope Method
2. Appendix 9.2 Selected pages from “Getting Down to Earth” – Biddle Megger Instruments.
3. Appendix 9.3 Fault Levels for Grounding Measurements
4. Appendix 9.4 Selected page from IEEE Std 80-2000

# NETA WORLD



The Official Publication of the InterNational Electrical Testing Association

Summer 2002

## Tech Tips

# Slope Method

The fall-of-potential method described in the previous column is the most general and most thorough way to perform a ground test. However, while this method has a sound theoretical base, it may suffer from physical limitations when applied to the practical world. One of the most common limitations is the frequent necessity, depending on size of the ground grid and other site considerations, to employ test leads that are too long. The theory supporting the fall-of-potential method is based on "ideal" test conditions, which include the separation of the electrical fields surrounding the test ground and the separation of the current probes from each other. If the test is being performed on a single-rod residential ground in a suburban neighborhood with plenty of yard space and not too many fences, the ideal test conditions can be accomplished without even pondering it. The graph of the readings obtained by walking the potential probe at regular intervals toward the current probe will reveal the extent of the two respective fields of influence. If it does not, there is no serious problem. The tester will just need to get some more lead wire, extend the current probe into the neighbor's yard, and repeat the procedure. The measurement and the proof of its validity are self-contained.

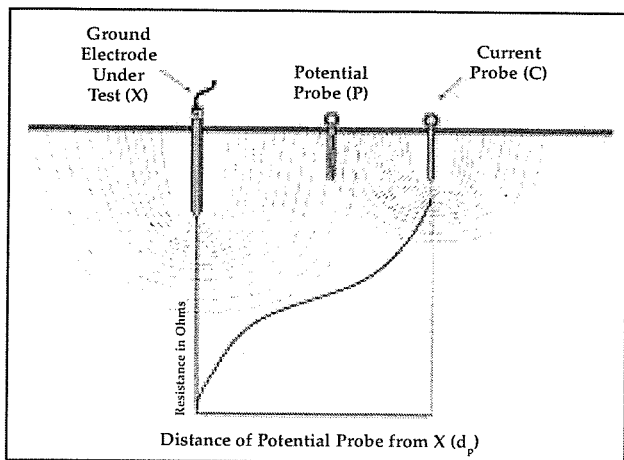
But, suppose the test technician is faced with one or both of two common situations — an enormous ground grid and little or no room. A large grid, such as the type that underlies a substation or encircles a transmission tower, will have a proportionately large electrical field in the soil. Getting the current test probe placed beyond this influence typically takes several multiples of the diagonal dimension. This can come out to several hundred feet and be prohibitive. Also, the environment might not even allow reasonable space since the site could be in a downtown area, surrounded by interstate highways, or contain a neighbor who is a psycho known to shoot trespassers! What then? Are you out of business? Not at all! Rest assured, many test technicians have encountered these and other daunting situations, and methods have been devised to complete the test so they could proceed with business as usual.

The most tried-and-true of these methods is known as the slope method. It was first described by Dr. G. F. Tagg in Paper #62975, Institution of Electrical Engineers (IEE) Proceedings, Volume 117, No. 11, November 1970. The method is based on calculus and the "rate of change of slope." The slope method simplifies the mathematical theory.



by Jeff Jowett  
AVO International

Picture this: A substation grid is to be tested in an industrial area encircled by railroad tracks, busy highways, and fenced properties. Perhaps even a river flows by cutting off a whole side. It appears to be a nightmare! The technician follows standard operating procedures and does a fall-of-potential test by staking out whatever limited room he or she can manage in the most open direction. But the current probe isn't far enough away. As the graph is plotted, the rising resistance curve associated with the grid runs directly into the curve from the test probe. The two "ends" of the fall-of-potential graph have been compressed together, thereby eliminating the plateau between which marks the desired measurement. The point at which the limit of resistance associated with the grid occurs may be somewhere in the graph, but no amount of eyeballing will distin-



guish where grid resistance stops and probe resistance begins. However, the slope method can make this distinction!

The critical data points will be measurements made with the potential probe placed at 0.2, 0.4, and 0.6 times the distance to the current probe. These points are called  $R_1$ ,  $R_2$ , and  $R_3$ , respectively. These positions are chosen because readings taken too close to the grid will have errors since the current flow can not be approximated to that from a hemisphere, upon which the theory is based. Too great a distance will bring errors from the influence of the current spike. The latter is positioned somewhat arbitrarily, but it is best to obtain as much distance as the site will allow.

While these three readings are the ones that will be put through the mathematical exercise, the operator may find it useful to take additional readings and to construct a partial graph. Since the electrical center of the grid is not known, precise measurements and a neat graph, such as could be obtained from a single ground rod, are not possible. Rather, any graph will begin somewhere along the rising curve from the test electrode. Plotting a number of additional points may seem pointless, but, in fact, it serves as a safety net to eliminate localized abnormal highs and lows that could make the subsequent calculation unintelligible or even result in a negative value. This additional step helps to eliminate obviously "bad" readings from further consideration and can be of use in final analysis, as will be explained.

Next, the slope coefficient ( $\mu$ ), showing the rate of change of slope, can be calculated from the formula:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1}$$

A relationship can be derived between the slope coefficient, the distance to the current probe ( $d_c$ ), and the distance at which the potential probe would measure the true earth resistance ( $d_{PT}$ ). A table can be commonly found in the literature,

which gives the value of  $d_{PT}/d_c$  for various values of  $\mu$ . From this table a simple equation yields the distance at which the potential probe should be placed using the known distance to the current probe. Supposing that the critical measurements are 2.1, 4.8, and 6.6 ohms, and the distance to the "C" probe is 100 feet, let's look at a sample calculation:

$$\frac{6.6 - 4.8}{4.8 - 2.1} = \frac{1.8}{2.7} = 0.667$$

Looking up the  $\mu$  value of 0.667 from the standard table yields a slope coefficient ( $d_{PT}/d_c$ ) of 0.6027. As the distance to the current probe ( $d_c$ ) is known, we can solve for  $d_{PT}$ :

$$d_{PT}/d_c = 0.667 \quad d_{PT} = 0.667 \times 100 = 66.7 \text{ feet to P probe}$$

Therefore, if the potential probe were placed at this distance, the reading would indicate the measurement of ground resistance. Finding the measurement of ground resistance could be accomplished by physically moving the probe to that point or if a partial graph had been constructed, as was mentioned earlier, the reading could be taken from the graph. If the crew isn't especially fond of math they could take a sufficient number of data points back to the lab for a supervisor or engineer to analyze. Note that our example also coincided nicely with the well known "62 percent rule" for potential probe spacing, which will be discussed in a future column.

But the crew is not done yet. Recall that the method "may" find the point at which ground resistance ceases to increase. There are a number of problems even this specialized technique may not address. For example, what if the current probe is within the ground field? For large grids, this may well be so. An obvious indication is when the calculated  $\mu$  value cannot be found on the table. If this happens, some more room must be found in order to move the current probe further.

Even when an intelligible calculation is achieved from this method, however, it is still risky to rely on a single test. In order to eliminate localized effects and uncharacteristic readings, it is better to proof the reading through additional tests taken in other directions and at greater probe distances. It may be found that the readings get lower with distance, but this is only because the shorter tests were performed too close. With increasing distances, readings will begin to come together. That agreement provides assurance the measurement is reliable.

Although the slope method requires extra work one will find that this method is an indispensable ally for the most difficult test sites.

In the next issue we will examine some additional methods for handling tight spaces. ☺

---

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Table VII: Values of  $P_T/C$  for Various Values of  $\mu$

$\mu$	$P_T/C$	$\mu$	$P_T/C$	$\mu$	$P_T/C$
0.40	0.643	0.80	0.580	1.20	0.494
0.41	0.642	0.81	0.579	1.21	0.491
0.42	0.640	0.82	0.577	1.22	0.488
0.43	0.639	0.83	0.575	1.23	0.486
0.44	0.637	0.84	0.573	1.24	0.483
0.45	0.636	0.85	0.571	1.25	0.480
0.46	0.635	0.86	0.569	1.26	0.477
0.47	0.633	0.87	0.567	1.27	0.474
0.48	0.632	0.88	0.566	1.28	0.471
0.49	0.630	0.89	0.564	1.29	0.468
0.50	0.629	0.90	0.562	1.30	0.465
0.51	0.627	0.91	0.560	1.31	0.462
0.52	0.626	0.92	0.558	1.32	0.458
0.53	0.624	0.93	0.556	1.33	0.455
0.54	0.623	0.94	0.554	1.34	0.452
0.55	0.621	0.95	0.552	1.35	0.448
0.56	0.620	0.96	0.550	1.36	0.445
0.57	0.618	0.97	0.548	1.37	0.441
0.58	0.617	0.98	0.546	1.38	0.438
0.59	0.615	0.99	0.544	1.39	0.434
0.60	0.614	1.00	0.542	1.40	0.431
0.61	0.612	1.01	0.539	1.41	0.427
0.62	0.610	1.02	0.537	1.42	0.423
0.63	0.609	1.03	0.535	1.43	0.418
0.64	0.607	1.04	0.533	1.44	0.414
0.65	0.606	1.05	0.531	1.45	0.410
0.66	0.604	1.06	0.528	1.46	0.406
0.67	0.602	1.07	0.526	1.47	0.401
0.68	0.601	1.08	0.524	1.48	0.397
0.69	0.599	1.09	0.522	1.49	0.393
0.70	0.597	1.10	0.519	1.50	0.389
0.71	0.596	1.11	0.517	1.51	0.384
0.72	0.594	1.12	0.514	1.52	0.379
0.73	0.592	1.13	0.512	1.53	0.374
0.74	0.591	1.14	0.509	1.54	0.369
0.75	0.589	1.15	0.507	1.55	0.364
0.76	0.587	1.16	0.504	1.56	0.358
0.77	0.585	1.17	0.502	1.57	0.352
0.78	0.584	1.18	0.499	1.58	0.347
0.79	0.582	1.19	0.497	1.59	0.341





**Line-to-ground Fault Current Contributions from Remote Source**

March 28, 2004

System	Station	Fault Location	Remote Source(s)	Station Ground Grid Resistance	Total Fault Current	Contribution from Remote Source(s)	X/R Ratio
Existing	Hollingsworth TS	115 kV terminals of T1	Anjigami TS 115 kV	13.10 ohm	3030 A	2248 A	
Distant Future	Hollingsworth TS	115 kV terminals of T1	Anjigami TS 115 kV	13.10 ohm	3541 A	2622 A	
Existing	Magpie TS	115 kV Bus		5.7 ohm	3305 A	3305 A	9.1
Distant Future	Magpie TS	115 kV Bus		5.7 ohm	3621 A	3621 A	9.1
Existing	Clergue TS	HV side of MT1	LSP, Steelton TS	-	9882 A	9882 A	9.0
Distant Future	Clergue TS	HV side of MT1	LSP, Steelton TS	-	15438 A	15438 A	7.1
Existing	Watson TS	115 kV terminals of T1	Magpie TS, Anjigami TS	8.2 ohm	4209 A	2570 A	9.8
Distant Future	Watson TS	115 kV terminals of T1	Magpie TS, Anjigami TS	8.2 ohm	4763 A	2983 A	9.87

### 12.3 Effect of current magnitude

Soil resistivity in the vicinity of ground electrodes may be affected by current flowing from the electrodes into the surrounding soil. The thermal characteristics and the moisture content of the soil will determine if a current of a given magnitude and duration will cause significant drying and thus increase the effective soil resistivity. A conservative value of current density, as given by Armstrong [B4], is not to exceed  $200 \text{ A/m}^2$  for 1 s.

### 12.4 Effect of moisture, temperature, and chemical content

Electrical conduction in soils is essentially electrolytic. For this reason the resistivity of most soils rises abruptly whenever the moisture content accounts for less than 15% of the soil weight. The amount of moisture further depends upon the grain size, compactness, and variability of the grain sizes. However, as shown in curve 2 of Figure 18, the resistivity is little affected once the moisture content exceeds approximately 22%, as shown in IEEE Std 142-1991.

The effect of temperature on soil resistivity is nearly negligible for temperatures above the freezing point. At  $0^\circ\text{C}$ , the water in the soil starts to freeze and the resistivity increases rapidly. Curve 3 shows this typical variation for a sandy loam soil containing 15.2% of moisture by weight.

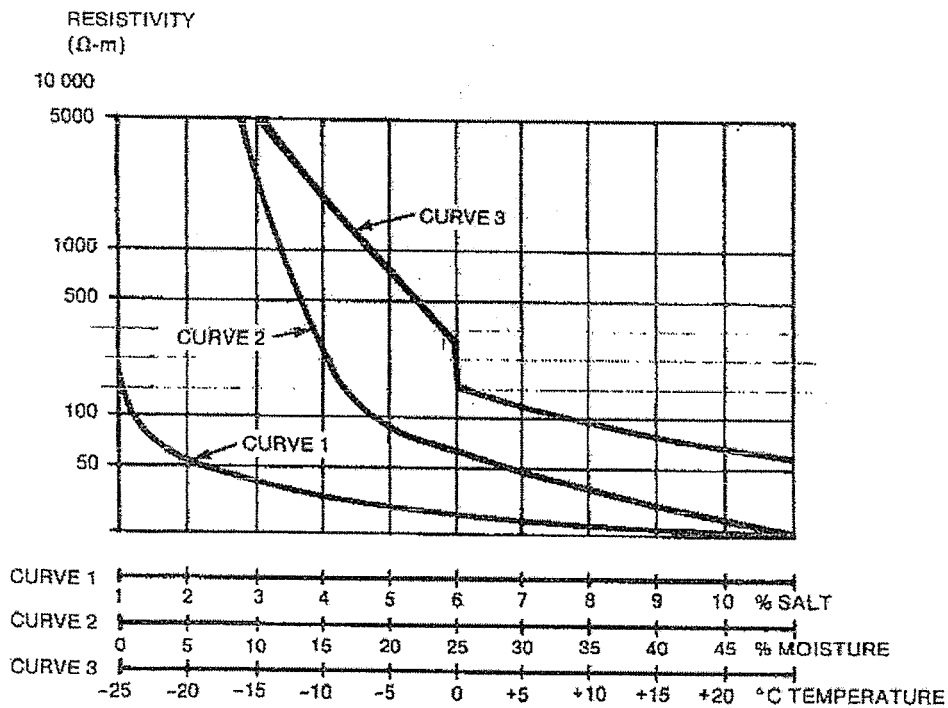


Figure 18—Effects of moisture, temperature, and salt upon soil resistivity



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# **Great Lakes Power Limited**

**Sault Ste. Marie, ON**

## **Transmission Station Grounding Grid Assessment and Measurements**

### **FINAL REPORT**

**GLP Purchase Order: 33362-000**

**ABB Inc. Project No.: 265559**

**February 22, 2008**



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## 1.0 INTRODUCTION AND SCOPE OF WORK

Great Lakes Power Limited retained the services of ABB Inc, Power Technology Services, located in Thunder Bay to perform Ground Grid Measurements and Assessment of three transmission stations. The transmission substations to be studied are:

1. Goulais TS
2. Batchawana TS
3. Northern TS

KMH Engineering was retained by ABB Inc. to provide computer modeling analysis and technical review of results.

The objectives of the study are to measure and document the following:

- Stone coverage of the area
- Stone quality
- Inventory of single conductor loops or connections above ground occurrences.
- Confirmation of grid wire size in selected areas.
- Soil resistivity.
- Measured/calculated grid resistance to remote earth.
- Measured/calculated potential rise and comparison to modeled values.
- Connection resistances between grid and fence, integrity along fence and integrity of gates.
- Ensure that all accessible non-current carrying metal structures and equipment are maintained at the same potential.
- All measurements and calculations will be in accordance with the standard IEEE 80-2000.



## 2.0 EXECUTIVE SUMMARY

Great Lakes Power Limited retained the services of ABB Inc., Power Technology Services, located in Thunder Bay to perform Ground Grid Measurements and Assessments of Goulais TS, Batchawana TS and Northern TS.

KMH Engineering was retained by ABB Inc. to provide computer modeling analysis and technical review of the results.

Section 1.0 details the requirements and objectives of the study. Generally these may be summarized as: 1) Measurement of resistance to remote earth 2) Soil resistivity measurements 3) Physical condition of the fence, bonding connections and other above grade concerns 4) calculated step, touch and GPR values in comparison to tolerable potentials 5) Recommendations to rectify deficiencies.

Field measurements were made on October 24<sup>th</sup> and 25<sup>th</sup>, 2007. Environmental conditions for the preceding week and measurement dates averaged 10°C and precipitation for the week was 54mm.

Engineering drawings of the installed ground grids were provided to ABB by Great Lakes Power. These drawings were of the new modifications only. The original installed grid was generally a point to point system and step and touch analysis would not conform to the methodologies of IEEE standard 80-2000. We have ignored the original grid in our analysis and calculations, however if connected to the new grid will prove beneficial. Fault values as provided by Great Lakes Power are based on the 2007 distribution system.

The analysis and recommendations are detailed in Section 6.0 of the report but are consolidated in this section:

### **Goulais TS:**

- Calculated Touch, Step and Ground Potential Rise are within tolerable levels.
- Surface material throughout the substation is of variable type and quality. Add a uniform layer of washed crushed stone across the grounding electrode area and 1 meter on both sides of the substation fence.



- Erosion occurring because of runoff crossing yard. Restore drainage ditch to prevent erosion.
- Ensure 230kV skywire is not bonded to ground grid.

**Batchawana TS:**

- Tolerable Touch Potentials have been exceeded at the eastern boundary line of the fence enclosure. We recommend extending the buried ground grid to the south and east and connect to the existing fence ground loop. A new fence loop should be installed 1 meter outside the fence along with the washed crushed stone covering.
- Surface material throughout the substation is of variable type and quality. Add a uniform layer of washed crushed stone across the grounding electrode area and 1 meter on both sides of the substation fence.

**Northern TS:**

- Calculated Touch, Step and Ground Potential Rise values are within tolerable levels.
- The metal storage building adjacent to the substation appears to be connected to the ground grid. The transfer potential to the building is quite high. If building isolation is deemed not to be a requirement then install a building perimeter ground loop and crushed stone to achieve safe touch potential.
- Investigate the interconnection tie between the substation and metal storage building. If required ensure two separate connections exist.
- Extended the crushed stone covering layer to 0.3M beyond the extent of the grounding grid conductors.





---

### 3.0 MEASUREMENT APPARATUS and METHODOLOGY

The earth resistance tester used to measure soil resistivity is manufactured by Bidle Megger Instruments; model DET2/2 Auto Earth Tester.

For all transmission substations measured, the “Tagg Slope Method” was used. Refer to the Appendix for a description of this methodology. Details of measurements and results are shown in the specific substation tab in Section 6.0.



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## 4.0 ENVIRONMENTAL CONDITIONS

Field measurements were made on October 24<sup>th</sup> and 25<sup>th</sup> 2007.

Weather conditions for the preceding week in the Sault Ste Marie area averaged 10°C with the average low being 6°C. The total precipitation for the week was 54mm.

Environmental conditions were not a significant factor in measured results.



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## 5.0 COMPUTER SOFTWARE

Safe Engineering Services (SES) AutoGrid Pro, application version 13.1.61.0 was used for the analysis. Methodologies of IEEE Standard 80-2000 are considered in modeled methodologies and reported results.



## 6.0 DETAIL SUBSTATION RESULTS

### 6.1 Goulais TS

#### 6.1.1 Resistivity Measurements

Two soil measurements were obtained. We selected the measurement along Highway 17 as being reflective of conditions. Soil resistivity has been calculated based on the following:

$$P = 2\pi aR$$

$a$  = Rod Spacing

$R$  = Resistivity Measurement

Measurement Location	Probe Spacing	Resistance Measured	Calculated Soil Resistivity
M1	1.52 M	2.26 $\Omega$	21.6 $\Omega \cdot M$
M1	3.04 M	0.958 $\Omega$	18.5 $\Omega \cdot M$
M1	6.08 M	0.606 $\Omega$	23.2 $\Omega \cdot M$
M1	15.24 M	0.35 $\Omega$	33.5 $\Omega \cdot M$
M1	30.48 M	0.199 $\Omega$	38.1 $\Omega \cdot M$

#### 6.1.2 Total Resistance to Remote Earth Measurement ( $R_g$ )

One measurement for Total Resistance to Remote Earth was obtained. No additional measurements were obtained due to interference or obstructions around the substation. The measurement was taken in a northerly direction almost parallel with Highway 17. The test electrode was located at the corner of the substation fence closest to the road.

Current probe C2 was located 800 ft. from the test electrode. Potential probe P2 measurements were made at significant intervals between test electrode and current probe C2.

Measurements obtained:

Position No.	Distance	Resistance
1	160 ft.	0.238 $\Omega$
2	320 ft.	0.275 $\Omega$
3	480 ft.	0.340 $\Omega$

The Tagg Slope Method was used to calculate remote earth resistance. Refer to Appendix for supporting methodology.

Distance calculation for value R

$$R_1 = 0.2 \times 800' = 160'$$

$$R_2 = 0.4 \times 800' = 320'$$

$$R_3 = 0.6 \times 800' = 480'$$

Remote Distance Curve Calculation:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1} = \frac{0.340 - 0.275}{0.309 - 0.238} = 0.915$$

From Tagg Slope Method tables in Appendix:

$$\mu \text{ of } 0.915 = \text{Pt/C of } 0.559$$

Distance of potential probe to represent remote earth resistance  
=  $0.559 \times 800' = 447'$  to Probe P2

**Measured Value = 0.289  $\Omega$**

### 6.1.3 Allowable Safe Step and Touch Potentials

Tolerable Step and Touch Potentials have been obtained from the SES technical report at the end of this section. These results are based on a surface covering layer throughout the substation of gravel which we have assigned a resistivity value of  $2000 \Omega \cdot \text{M}$ . The methodologies of IEEE Std. 80-2000 have been used to establish these tolerable limits. Tolerable Step Potential limits are 2268V and tolerable Touch Potentials are 725V.

The Ontario Electrical Safety Code Rule 36-304 indicates Tolerable Step potentials of 3143V and Tolerable Touch potentials of 885V. These are based on a  $3000 \Omega \cdot \text{M}$  covering layer of crushed stone, 150 mm deep and a fault clearing time of 0.5 seconds. Calculated values, based on present conditions, are different than values as indicated in the Code above. Analysis has been considered on actual installed conditions.



## 6.1.4 Ground Potential Rise Calculation

### Current Grid Split Factor Determination

To calculate  $S_f$  based on IEEE Std. 80-2000 Annex C Figure C-2.

Based on 1 Transmission / 1 Distribution Lines

$$R_g \text{ Measured} = 0.289 \Omega$$

100% Remote Contribution

$$R_{tg} = 100 \Omega \quad R_{dg} = 200 \Omega \quad \text{Figure C.2}$$

$$S_f = 90\%$$

We have assigned a split factor of 90%.

### Symmetrical Grid Current ( $I_g$ )

$$\begin{aligned} I_g &= S_f * I_F \\ &= 0.90 * 3.77 \text{ kA} \\ &= 3.39 \text{ kA} \end{aligned}$$

$$S_f = 90\%$$

$$\begin{aligned} I_F &= L - G \text{ value from G.L.P.} \\ &= 3.77 \text{ kA} \end{aligned}$$

### Maximum Grid Current ( $I_G$ )

$$\begin{aligned} I_G &= D_f * I_g \\ &= 1.052 * 3.39 \text{ kA} \\ &= 3.57 \text{ kA} \end{aligned}$$

$$D_f = 1.052$$

$$I_g = 3.39 \text{ kA}$$



## Calculated Ground Potential Rise (*GPR*)

$$\begin{aligned}GPR_{Measured} &= R_g * I_G * 10^3 \\ &= 0.289 * 3.57 * 10^3 \\ &= 1032 \text{ Volts}\end{aligned}$$

### 6.1.5 Substation Condition Report

#### Fence Grounding and Condition Comments

A visual inspection of the fence and gate grounding was completed. The condition of each thermoweld was inspected and the continuity of each jumper was confirmed. There were no apparent bonding issues associated with the fence or gate.

The fence needs to be straightened and aligned in certain areas. Additionally, some vegetation is growing over/through the fence and should be removed.

We have confirmed that the boundary fence is tied to the substation ground grid.

#### Above Grade Equipment Ground Audit

An audit of all bonding and grounding associated with the electrical distribution equipment, supporting towers and structures, fences and gates was completed. All bare ground wire connections were assessed including both thermoweld and mechanical configurations. Bare ground wire sizes were compared to the engineering drawings provided by Great Lakes Power. For reference, these drawings are SD-27105 Rev. 3 and C-90306-G Rev.1.

We did not find issues of equipment not being bonded throughout the substation. The gradient control mats for disconnects 587, 585 and 583 had only one tie point which is contrary to the Ontario Electrical Safety Code rule 360310 (2) (a) which requires two.

#### Surface Conditions

The surface covering throughout the majority of the substation yard consisted of gravel and rock. We have considered this material to have a resistivity of 2000  $\Omega \cdot M$ . There are areas at the south end of the yard where the surface covering material is



not gravel and the resistivity will be substantially lower and subsequently the tolerable touch and step potentials will decrease.

Drainage is also a major problem in this yard. Water flowing off of the rock structure on the east side of the yard has washed away all of the gravel and surface covering over the gradient control mates. Erosion around the structures is apparent. Drawing C-90306-G indicates a drainage ditch surrounding the electrical equipment. This is not present and should be reviewed.

### 6.1.6 Computer Model Output Results

#### System Data:

Body Weight	70 kg
Fault Current ( $I_F$ )	3.77 kA
X/R ratio	20
Division Factor ( $S_F$ )	90%
Fault Duration ( $T_f, T_c, T_s$ )	0.5 sec.
Plot Step	3 ft.

#### Summary Report:

Ground Resistance ( $R_g$ )	0.26 $\Omega$
Ground Potential Rise (GPR)	867 V
Tolerable Touch Potential	725 V
Calculated Maximum Touch Potential	407 V
Tolerable Step Potential	2268 V
Calculated Maximum Step Potential	90 V

### 6.1.7 Analysis and Recommendations

1. The surface material throughout the substation varies. Present Code requirements, specifically rule 36-304 (5), indicates “ the ground surface covering layer shall exist throughout the station grounding electrode area, including all areas in which metallic structures electrically connected to the station are to be found and shall extend at least 1 meter beyond the station grounding electrode area on all sides”. We recommend adding a uniform layer of washed crushed





---

stone across grounding electrode area and 1 meter on both sides of substation fence.

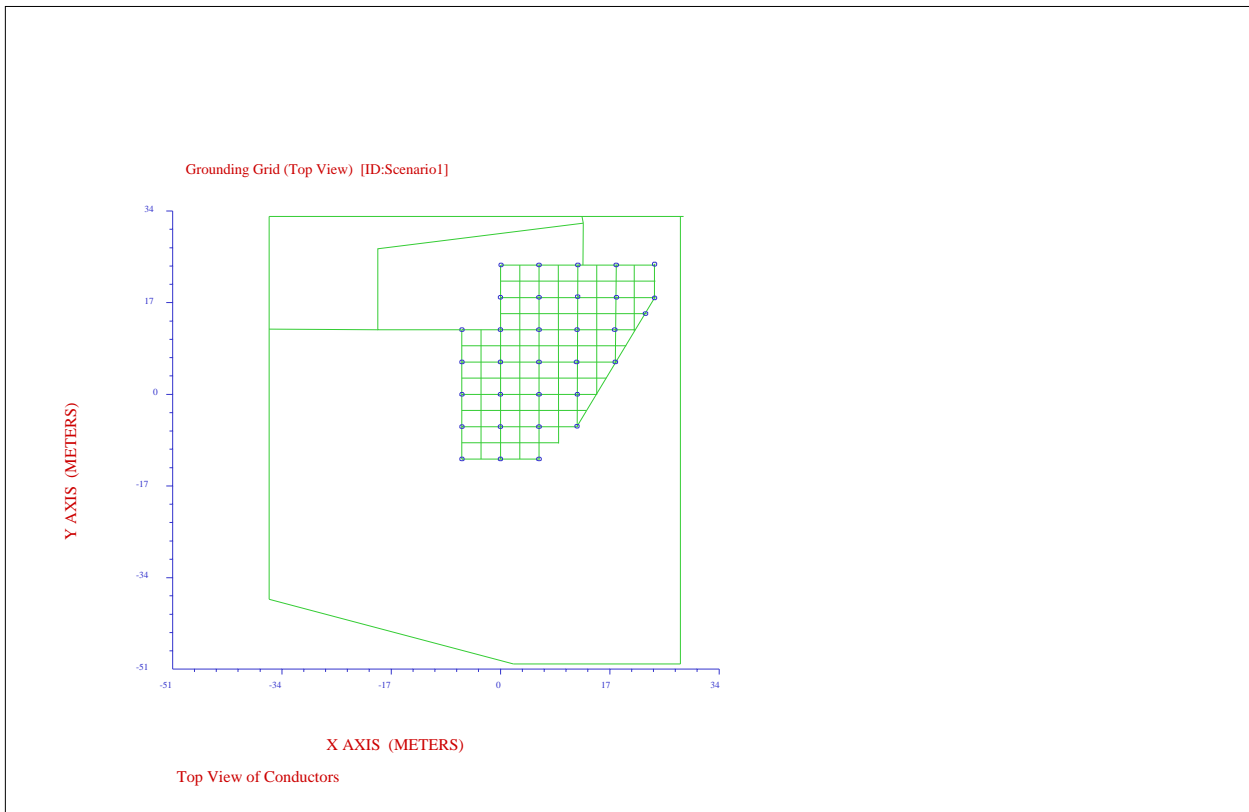
2. Restore drainage ditch to prevent erosion in yard.
3. Ensure 230KV skywire is not bonded to ground grid. We have not considered this connection and impact in our assessment.
4. Calculated Touch, Step and Ground Potential Rise values are within tolerable levels.

#### **6.1.8 Computer Model Plots**

1. Grounding grid layout
2. Touch Voltages – all points
3. Touch Voltages – unsafe points
4. Step Voltages – all points
5. Step Voltages – unsafe points
6. Ground grid performance report

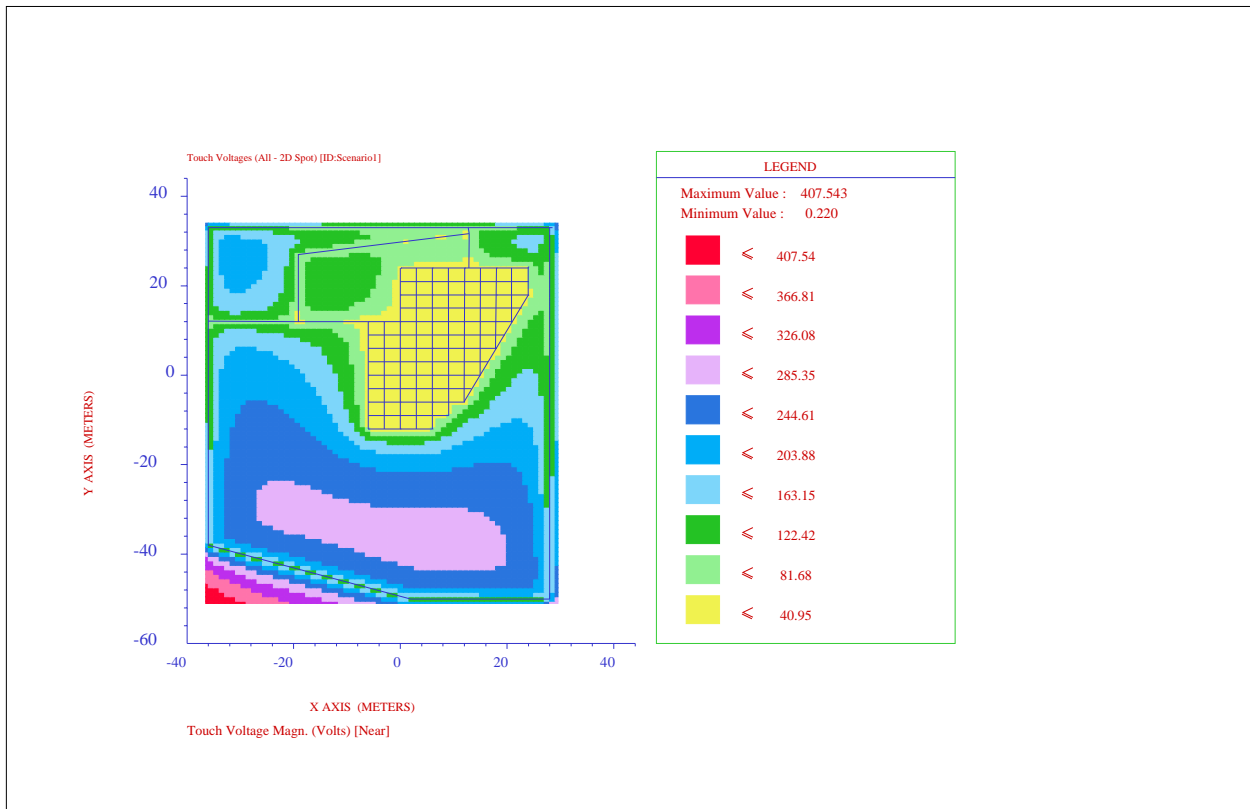
Auto Grid Pro [Project: Goulais TS; Scenario: Scenario1]  
Grounding Grid (Top View)

12-December-2007 2:00:47 PM



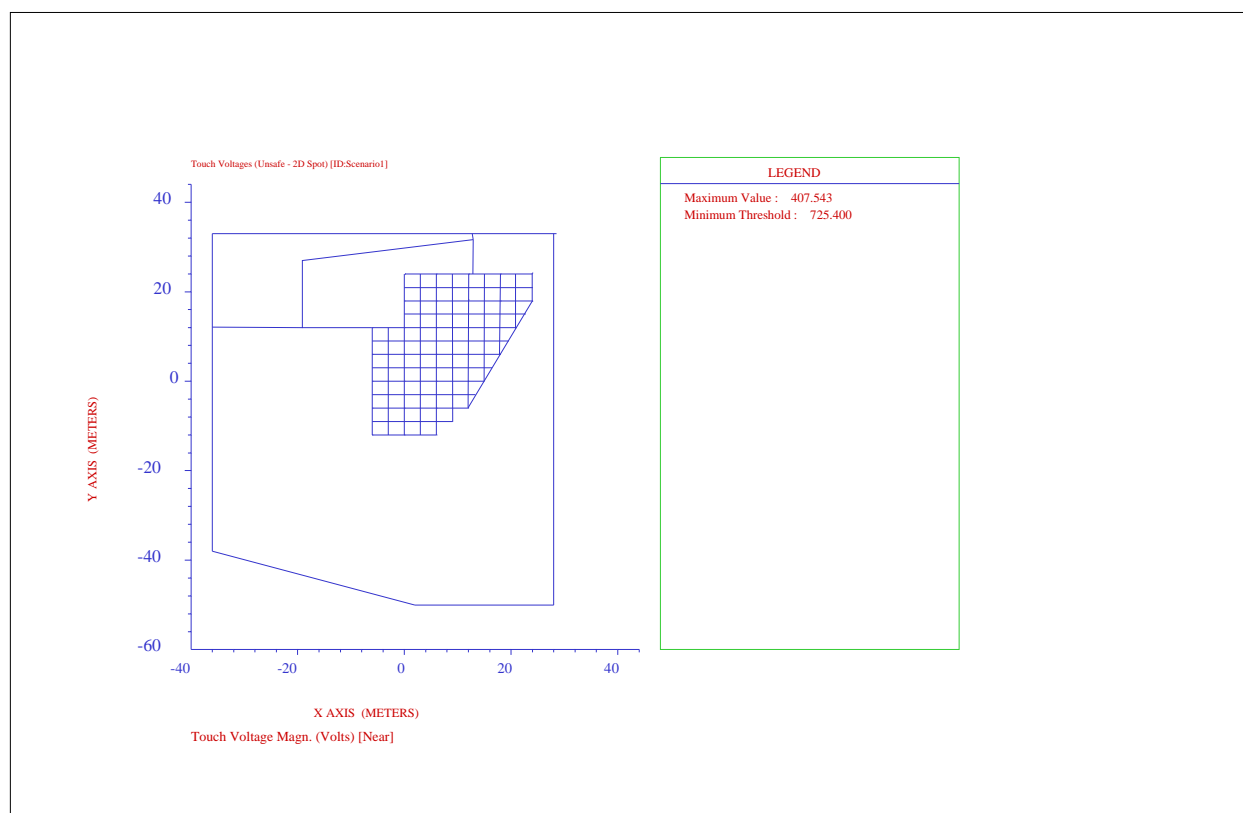
Auto Grid Pro [Project: Goulais TS; Scenario: Scenario1]  
Touch Voltages (All - 2D Spot)

22-February-2008 11:23:07 AM



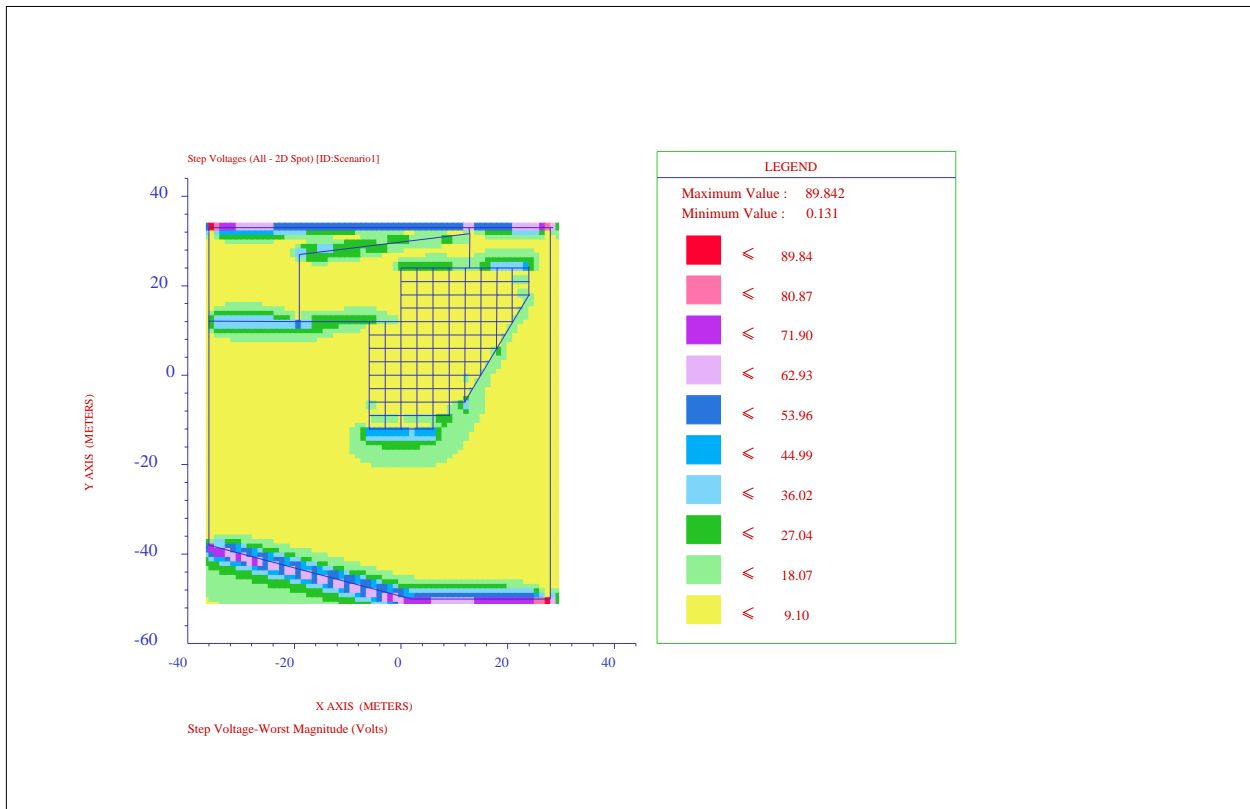
Auto Grid Pro [Project: Goulais TS; Scenario: Scenario1]  
Touch Voltages (Unsafe - 2D Spot)

22-February-2008 1:41:27 PM



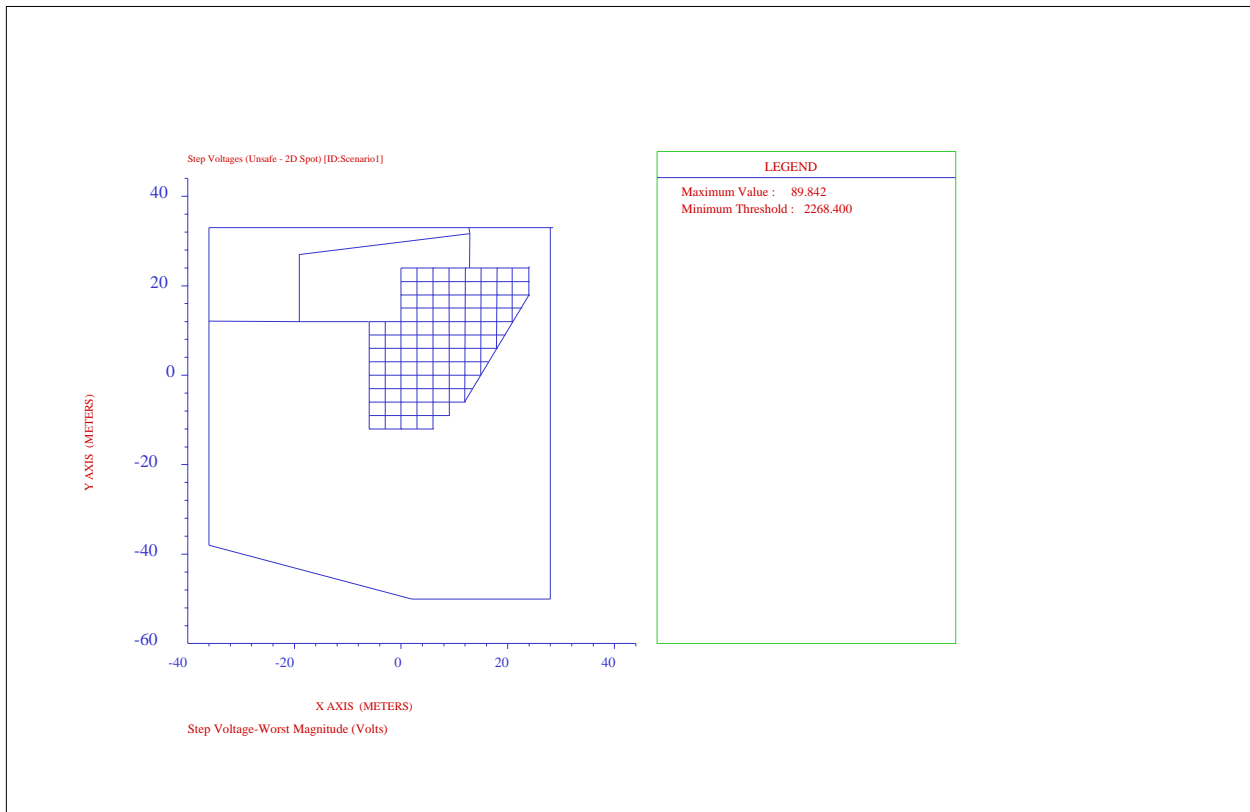
Auto Grid Pro [Project: Goulais TS; Scenario: Scenario1]  
Step Voltages (All - 2D Spot)

22-February-2008 11:23:32 AM



Auto Grid Pro [Project: Goulais TS; Scenario: Scenario1]  
Step Voltages (Unsafe - 2D Spot)

22-February-2008 1:41:06 PM



Report #1:

```
*****  
*****  
AUTOGRID PRO USER INPUT DATA REPORT  
Creation Date/Time: 22 Feb 2008/11:22:13  
*****  
*****
```

-----  
Input Data Summary Reports  
-----

System Data Summary

C:\Program Files\SESSoftware 2005\Goulais TS\Scenario1\Results\System  
Input.rep  
Requested Computation Reports and Plots  
C:\Program Files\SESSoftware 2005\Goulais TS\Scenario1\Results\User  
Input.rep

-----  
Graphics option chosen  
-----

Computation Plots

Touch Voltages  
    Show All Values  
    Show Unsafe Values Above Selected Safety Threshold

Step Voltages  
    Show All Values  
    Show Unsafe Values Above Selected Safety Threshold

Electric Network Configuration

Soil Resistivity Measurement Interpretation

Fault Current Distribution  
    Section Span Currents  
    Shunt Tower Currents  
    Shunt Tower Potentials  
    One Terminal Plot  
    Terminal Number ..... 1  
    All Sections Selected

Configuration Plots

    Grounding System Configuration

-----  
Types of plot selected  
-----

Computation Plots

    2D Spot  
    2D Contour  
    3D Perspective

Configuration Plots

    3D Perspective  
    Top View

End of Report #1

Report #2:

```
*****
*****
AUTOGRID PRO SYSTEM INPUT DATA REPORT
Creation Date/Time:      22 Feb 2008/11:22:13
*****
*****
```

-----  
 Project Summary  
 -----

```
Run Identification ..... Scenario1
System of Units ..... Metric
Radius Measured in ..... Meters
Frequency ..... 60 Hz
```

-----  
 Soil Structure (deduce soil structure from field resistivity measurements)  
 -----

```
Measurement method.....Wenner
Type of measurement.....Resistance
Probe depth option.....Account for Probe Depth
```

Measurement Number	Spacing S (Meters)	Apparent Resistance R (Ohms)	Depth of Current Probes Do (Meters)	Depth of Potential Probes Di (Meters)
R1	1.52	2.26	0.152	0.152
R2	3.04	0.958	0.152	0.152
R3	6.08	0.606	0.152	0.152
R4	15.24	0.35	0.152	0.152
R5	30.48	0.199	0.152	0.152

-----  
 Network Fault Current Distribution  
 -----

```
Average soil characteristics along electric lines:
  Resistivity(Ohm-m) ..... 100
  Relative Permeability (p.u.) ..... 1
```

```
Central site definition:
  Name .....
```



Ground Impedance (To be deduced from grounding computations)

-----  
 Safety  
 -----

Determine Safety Limits for Touch and Step Voltages  
 Maximum GPR of Grid (Volts) ..... 5000  
     Safety Threshold for Touch Voltages ..... 725.4 V  
     Safety Threshold for Step Voltages ..... 2268.4 V  
 Generation of observation points is user-defined.  
     Grid Border Offset for Touch Voltages ..... 1 m  
     Grid Border Offset for Step Voltages ..... 3 m

-----  
 The computation results are written in the following reports:  
 -----

Soil Resistivity Measurement Interpretation  
     C:\Program Files\SESSoftware 2005\Goulais TS\Scenariol\Results\Soil  
 Structure.rep  
 Ground Grid Perfomance  
     C:\Program Files\SESSoftware 2005\Goulais TS\Scenariol\Results\Ground  
 Grid Performance.rep  
 Safety Assessment  
     C:\Program Files\SESSoftware 2005\Goulais TS\Scenariol\Results\Safety.rep  
 Resistivity Comparison  
     C:\Program Files\SESSoftware 2005\Goulais  
 TS\Scenariol\Results\Resistivity Comparison.rep  
 List of Materials  
     C:\Program Files\SESSoftware 2005\Goulais TS\Scenariol\Results\Bill of  
 Materials.rep

End of Report #2

Report #3:

=====  
 < R E S I S T I V I T Y ( SYSTEM INFORMATION SUMMARY ) >=====  
 =====

Run ID.....: Scenariol  
 System of Units .....: Meters  
 Soil Type Selected.....: Multi-Layer Horizontal  
 RMS error between measured and calculated...: 9.66626 in percent  
 resistivities (Note RMS=SQRT(average(Di\*\*2))).

Layer Number	<--- LAYER CHARACTERISTICS --->		Reflection Coefficient (p.u.)	Resistivity Contrast Ratio
	Resistivity (ohm-m)	Thickness (Meters)		
1	infinite	infinite	0.0	1.0
2	21.70898	7.367156	-1.0000	0.21709E-18
3	46.62044	infinite	0.36458	2.1475

\*\*WARNING\*\* MORE THAN ONE SOIL MODEL CAN PRODUCE SIMILAR APPARENT RESISTIVITY  
 MEASUREMENT CURVES. IF YOU USE THE DEFAULT STEEPEST-DESCENT  
 METHOD,  
 THEN YOU WILL MOST OFTEN OBTAIN DECENT AGREEMENT BETWEEN MEASURED

VALUES AND THE COMPUTED CURVE, WITH A REALISTIC SOIL MODEL;  
 HOWEVER, THE FIT MAY OCCASIONALLY BE SUB-OPTIMAL. IN SUCH CASES, THE  
 MARQUARDT METHOD WILL USUALLY YIELD AN EXCELLENT FIT, BUT MAY SOMETIMES  
 SUGGEST EXTREME RESISTIVITY VALUES. NOTE THAT DIFFERENT SOIL MODELS WILL  
 USUALLY YIELD SIMILAR RESULTS FOR YOUR GROUNDING SYSTEM MODELS (I.E.,  
 GPR, TOUCH & STEP VOLTAGES), PROVIDED THAT THE GROUNDING SYSTEM IS LOCATED  
 CLOSE TO THE EARTH SURFACE. IF IN DOUBT, CHECK YOUR RESULTS WITH BOTH SOIL  
 MODELS.

End of Report #3

Report #4:

\*\*\*\*\*  
 Resistivity Comparison  
 Creation Date/Time: 22 Feb 2008/11:22:14  
 \*\*\*\*\*

Comparison of Measured & Computed Apparent Resistivities

=====

POINT	C1-C2 SPACING (meters)	APPARENT MEASURED	RESISTIVITY COMPUTED	DISCREPANCY Di (percent)
1	4.56000	21.71	21.76	0.23
2	9.12000	18.33	22.09	20.53
3	18.2400	23.16	23.85	3.00
4	45.7200	33.52	31.59	5.76
5	91.4400	38.11	38.81	1.84

=====  
 Average discrepancy: 6.27%

RMS ERROR BETWEEN MEASURED AND CALCULATED RESISTIVITIES :

9.67 percent

\*NOTE\* RMS = SQRT( average(Di\*\*2) )

End of Report #4

Report #5:

\*\*\*\*\*  
 List of Materials  
 Creation Date/Time: 22 Feb 2008/11:22:14  
 \*\*\*\*\*

Interconnection / Bonding Nodes ..... 87  
 Extent of Grounding System ..... 5104.75 (Square Meters)  
 Surface Layer Thickness ..... 15 (Centimeters)  
 Volume of Insulating Layer ..... 765.713 (Cubic meters)  
 Wet Resistivity of Insulating Surface Layer ..... 2000 (Ohm-m)

Grounding System Data

Number of Rods	Length (m)	Diameter (m)
32	3	0.019

Number of Grid Conductors	Length (m)	Diameter (m)
1	21.031	0.0134
1	22.5834	0.0134
3	24.1112	0.0134
1	23.8979	0.0134
4	12	0.0134
1	33.1065	0.0134
1	29.9111	0.0134
1	24.0576	0.0134
1	15.086	0.0134
1	18.045	0.0134
1	19.3467	0.0134
1	20.9497	0.0134
1	22.4609	0.0134
1	25.5626	0.0134
1	6	0.0134
5	24	0.0134
1	18.0028	0.0134
1	12.2826	0.0134
1	7.73762	0.0134
1	26.673	0.0134
1	6.26506	0.0134
1	13	0.0134
1	15	0.0134
1	32.3397	0.0134
1	64.5	0.0134
1	83	0.0134
1	71	0.0134
1	26	0.0134
1	39.8497	0.0134
1	1.28706	0.0134
1	16.9003	0.0134

Total Length of Grid Conductors (m)	Diameter (m)
956.21	0.0134
96	0.019

End of Report #5

Report #6:  
 Date of run (Start) = Friday, 22 February 2008  
 Starting Time = 11:22:15 AM

>>Safety Calculation Table

System Frequency.....: 60.000(Hertz)  
 System X/R.....: 20.000  
 Surface Layer Thickness.....: 15.000(cm)  
 Number of Surface Layer Resistivities.....: 8  
 Starting Surface Layer Resistivity.....: NONE  
 Incremental Surface Layer Resistivity.....: 500.00(ohm-m)  
 Equivalent Sub-Surface Layer Resistivity..... : 21.709(ohm-m)

Body Resistance Calculation.....: IEEE Std.80-2000  
 Fibrillation Current Calculation.....: IEEE Std.80-2000 (70kg)  
 Foot Resistance Calculation.....: IEEE Std.80-2000  
 User Defined Extra Foot Resistance.....: 0.0000 ohms

Fault Clearing Time (sec)	0.125	0.250	0.500
Decrement Factor	1.192	1.101	1.052
Fibrillation Current (amps)	0.444	0.314	0.222
Body Resistance (ohms)	1000.00	1000.00	1000.00

Surface Layer Resistivity (ohm-m)	Fault Clearing Time						Foot Resistance 1 Foot (ohms)
	0.125 sec.		0.250 sec.		0.500 sec.		
	Step Voltage (Volts)	Touch Voltage (Volts)	Step Voltage (Volts)	Touch Voltage (Volts)	Step Voltage (Volts)	Touch Voltage (Volts)	
NONE	423.1	385.2	323.9	294.9	239.8	218.3	67.8
500.0	1292.0	602.4	989.0	461.1	732.1	341.4	1233.9
1000.0	2195.8	828.4	1680.9	634.1	1244.2	469.4	2446.8
1500.0	3099.5	1054.3	2372.6	807.1	1756.3	597.4	3659.6
2000.0	4003.2	1280.2	3064.4	980.0	2268.4	725.4	4872.4
2500.0	4906.9	1506.1	3756.1	1152.9	2780.4	853.4	6085.1
3000.0	5810.5	1732.1	4447.9	1325.9	3292.5	981.5	7297.9
3500.0	6714.2	1958.0	5139.6	1498.8	3804.5	1109.5	8510.6

\* Note \* Listed values account for short duration asymmetric waveform decrement factor listed at the top of each column.

End of Report #6

Report #7:

DATE OF RUN (Start)= DAY 22 / Month 2 / Year 2008

STARTING TIME= 11:22:15:27

=====< G R O U N D I N G ( SYSTEM INFORMATION SUMMARY ) >=====

Run ID.....: Scenario1  
 System of Units .....: Metric  
 Earth Potential Calculations.....: Single Electrode Case  
 Type of Electrodes Considered.....: Main Electrode ONLY  
 Soil Type Selected.....: Multi-Layer Horizontal  
 SPLITS/FCDIST Scaling Factor.....: 0.90000

1  
 1

MULTI-LAYER EARTH CHARACTERISTICS USED BY PROGRAM

LAYER No.	TYPE	REFLECTION COEFFICIENT	RESISTIVITY (ohm-meter)	HEIGHT METERS
1	Air	0.00000	0.100000E+21	100000.
2	Soil	-0.999990	21.7090	7.36716
3	Soil	0.364579	46.6204	0.100000E+11

1

CONFIGURATION OF MAIN ELECTRODE

=====

Original Electrical Current Flowing In Electrode...: 3771.0 amperes  
 Current Scaling Factor (SPLITS/FCDIST/specified)...: 0.90000  
 Adjusted Electrical Current Flowing In Electrode...: 3393.9 amperes  
 Number of Conductors in Electrode.....: 72  
 Resistance of Electrode System.....: 0.25557 ohms

SUBDIVISION

=====

Grand Total of Conductors After Subdivision.: 262

Total Current Flowing In Main Electrode.....: 3393.9 amperes  
 Total Buried Length of Main Electrode.....: 1052.2 meters

EARTH POTENTIAL COMPUTATIONS

=====

Main Electrode Potential Rise (GPR).....: 867.40 volts

End of Report #7



## 6.2 Batchawana TS

### 6.2.1 Resistivity Measurements

One soil measurement was obtained. Conditions were the same on both the east and west side of the substation, the only areas suitable for measurement.

Soil resistivity has been calculated based on the following:

$$P = 2\pi aR$$

$a$  = Rod Spacing

$R$  = Resistivity Measurement

Measurement Location	Probe Spacing	Resistance Measured	Calculated Soil Resistivity
M1	1.52 M	17.3 $\Omega$	166.0 $\Omega \cdot M$
M1	3.04 M	3.25 $\Omega$	62.2 $\Omega \cdot M$
M1	6.08 M	1.04 $\Omega$	39.9 $\Omega \cdot M$
M1	15.24 M	0.52 $\Omega$	49.4 $\Omega \cdot M$
M1	30.48 M	0.29 $\Omega$	56.1 $\Omega \cdot M$

### 6.2.2 Total Resistance to Remote Earth Measurement ( $R_g$ )

One measurement for Total Resistance to Remote Earth was obtained. No additional measurements were obtained due to interference or obstructions around the substation. The measurement was taken in an easterly direction almost parallel with Highway 17. The test electrode was located at the corner of the substation fence closest to the road (south east corner).

Current probe C2 was located 800 ft. from the test electrode. Potential probe P2 measurements were made at significant intervals between test electrode and current probe C2.

Measurements obtained:

Position No.	Distance	Resistance
1	160 ft.	0.32 $\Omega$
2	320 ft.	0.38 $\Omega$
3	480 ft.	0.44 $\Omega$

The Tagg Slope Method was used to calculate remote earth resistance. Refer to Appendix for supporting methodology.



Distance calculation for value R

$$R_1 = 0.2 \times 800' = 160'$$

$$R_2 = 0.4 \times 800' = 320'$$

$$R_3 = 0.6 \times 800' = 480'$$

Remote Distance Curve Calculation:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1} = \frac{0.44 - 0.38}{0.38 - 0.32} = 1.0$$

From Tagg Slope Method tables in Appendix:

$$\mu \text{ of } 1.0 = \text{Pt/C of } 0.542$$

Distance of potential probe to represent remote earth resistance

$$= 0.542 \times 800' = 433' \text{ to Probe P2}$$

**Measured Value = 0.43  $\Omega$**

### 6.2.3 Allowable Safe Step and Touch Potentials

Tolerable Step and Touch Potentials have been obtained from the SES technical report at the end of this section. These results are based on a surface covering layer throughout the substation of gravel which we have assigned a resistivity value of 2000  $\Omega \cdot \text{M}$ . The methodologies of IEEE Std. 80-2000 have been used to establish these tolerable limits. Tolerable Step Potential limits are 2435V and tolerable Touch Potentials are 767V.

The Ontario Electrical Safety Code Rule 36-304 indicates Tolerable Step potentials of 3143V and Tolerable Touch potentials of 885V. These are based on a 3000  $\Omega \cdot \text{M}$  covering layer of crushed stone, 150 mm deep and a fault clearing time of 0.5 seconds. Calculated values, based on present conditions, are different than values as indicated in the Code above and are more stringent. Analysis has been considered on actual installed conditions.



## 6.2.4 Ground Potential Rise Calculation

### Current Grid Split Factor Determination

To calculate  $S_f$  based on IEEE Std. 80-2000 Annex C Figure C-2.

Based on 1 Transmission / 1 Distribution Lines

$$R_g \text{ Measured} = 0.43 \Omega$$

100% Remote Contribution

$$R_{tg} = 100 \Omega \quad R_{dg} = 200 \Omega \quad \text{Figure C.2}$$

$$S_f = 90\%$$

We have assigned a split factor of 90%.

### Symmetrical Grid Current ( $I_g$ )

$$\begin{aligned} I_g &= S_f * I_F \\ &= 0.90 * 3.05 \text{ kA} \\ &= 2.75 \text{ kA} \end{aligned}$$

$$S_f = 90\%$$

$$\begin{aligned} I_F &= L - G \text{ value from G.L.P.} \\ &= 3.05 \text{ kA} \end{aligned}$$

### Maximum Grid Current ( $I_G$ )

$$\begin{aligned} I_G &= D_f * I_g \\ &= 1.052 * 2.75 \text{ kA} \\ &= 2.89 \text{ kA} \end{aligned}$$

$$D_f = 1.052$$

$$I_g = 2.75 \text{ kA}$$





## Calculated Ground Potential Rise (*GPR*)

$$\begin{aligned}GPR_{Measured} &= R_g * I_G * 10^3 \\ &= 0.43 * 2.89 * 10^3 \\ &= 1243 \text{ Volts}\end{aligned}$$

### 6.2.5 Substation Condition Report

#### Fence Grounding and Condition Comments

A visual inspection of the fence and gate grounding was completed. The condition of each thermoweld was inspected and the continuity of each jumper was confirmed. There were no apparent bonding issues associated with the fence or gate.

We have confirmed that the boundary fence is tied to the substation ground grid.

The man gate within the vehicle gate at the main entrance does not have a flexible bonding jumper.

#### Above Grade Equipment Ground Audit

An audit of all bonding and grounding associated with the electrical distribution equipment, supporting towers and structures, fences and gates was completed. All bare ground wire connections were assessed including both thermoweld and mechanical configurations. Bare ground wire sizes were compared to the engineering drawing provided by Great Lakes Power. For reference, this drawing is SD-27508 Rev. 2.

We did not find issues of equipment not being bonded throughout the substation. The gradient control mats for some disconnects were not adequately covered with surface material. A #6 SDBC conductor on a skywire connection near grounding switch 594GR was broken. This was a looped connection and the other side was still connected to the skywire (maintenance item).

#### Surface Conditions

The surface covering throughout the majority of the substation yard consisted of gravel, rock and sand. We have considered this material to have a resistivity of 2000  $\Omega \cdot M$ . The entire area under the HV disconnects had a covering of sand. It was also

lower than the remaining yard and obviously an area for water to flow to and collect. The buried ground grid in this area was only 150mm below grade contrary to the 450mm burial depth required on the engineering drawing.

## 6.2.6 Computer Model Output Results

### System Data:

Body Weight	70 kg
Fault Current ( $I_F$ )	3.05 kA
X/R ratio	20
Division Factor ( $S_F$ )	90%
Fault Duration ( $T_f, T_c, T_s$ )	0.5 sec.
Plot Step	3 ft.

### Summary Report:

Ground Resistance ( $R_g$ )	0.61 $\Omega$
Ground Potential Rise (GPR)	1687 V
Tolerable Touch Potential	767 V
Calculated Maximum Touch Potential	1182 V
Tolerable Step Potential	2435 V
Calculated Maximum Step Potential	292 V

## 6.2.7 Analysis and Recommendations

1. The surface material throughout the substation varies. Present Code requirements, specifically rule 36-304 (5), indicates “ the ground surface covering layer shall exist throughout the station grounding electrode area, including all areas in which metallic structures electrically connected to the station are to be found and shall extend at least 1 meter beyond the station grounding electrode area on all sides”. We recommend adding a uniform layer of washed crushed stone across grounding electrode area and 1 meter on both sides of substation fence.
2. Tolerable Touch Potentials have been exceeded. The areas of concern are generally on the east side of the yard. The touch potential increases from the



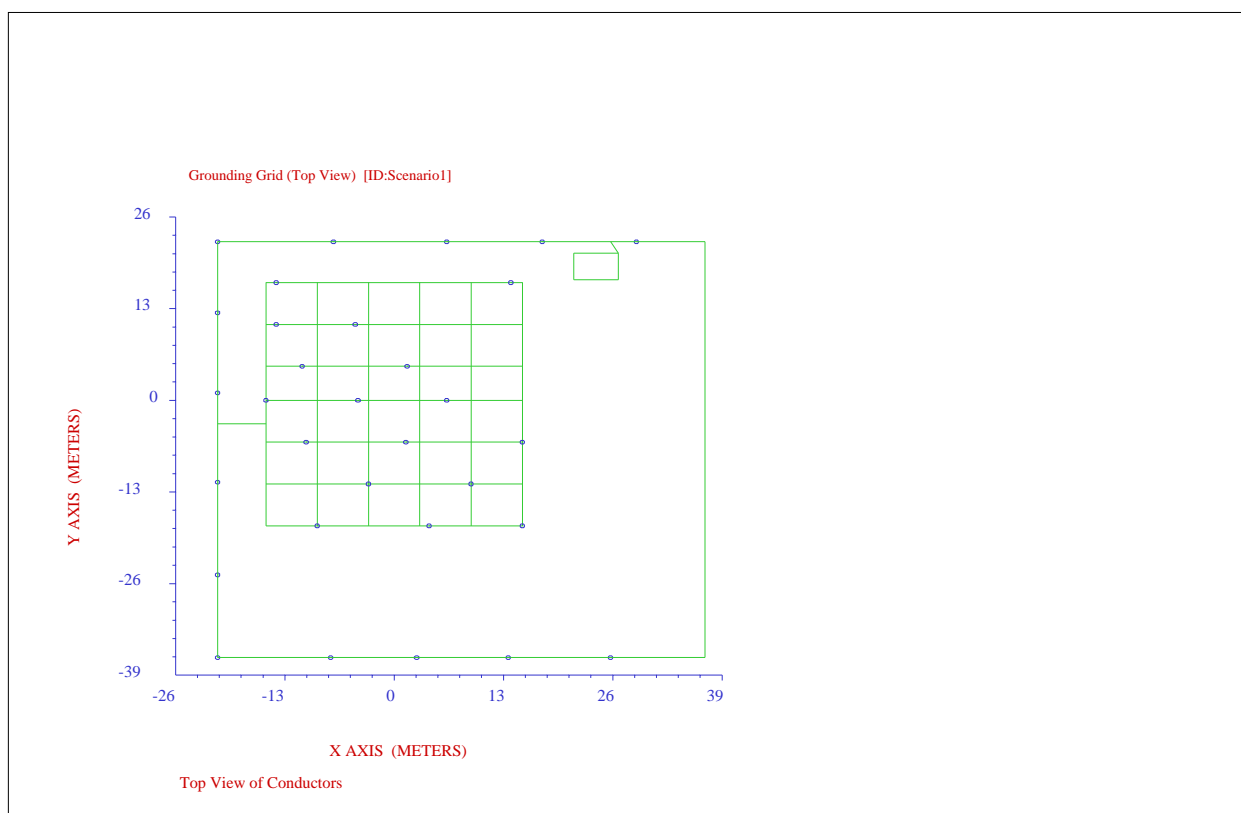
- 
- main grid easterly towards the area of the boundary fence which is the highest potential. We recommend extending the buried ground grid to the south east and connecting to the existing fence loop and to the new recommended loop.
3. The present fence ground loop is installed inside the fence. We recommend installing a ground loop 1 meter outside the fence with the appropriate surface covering layer.
  4. Ensure 230KV skywire is not bonded to ground grid. We have not considered this connection and impact in our assessment.

### **Computer Model Plots**

1. Grounding grid layout
2. Touch Voltages – all points
3. Touch Voltages – unsafe points
4. Step Voltages – all points
5. Step Voltages – unsafe points
6. Ground grid performance report

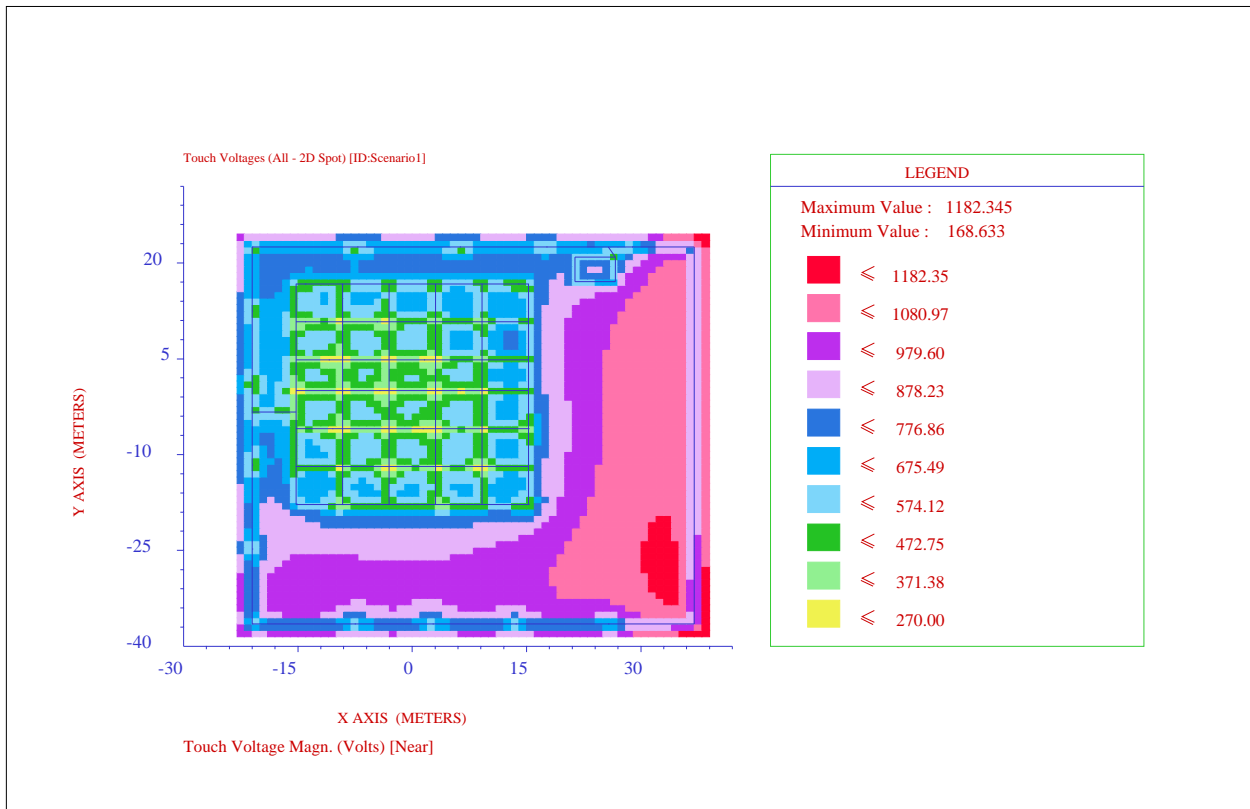
Auto Grid Pro [Project: Batchawana TS; Scenario: Scenario1]  
Grounding Grid (Top View)

09-December-2007 8:09:05 PM



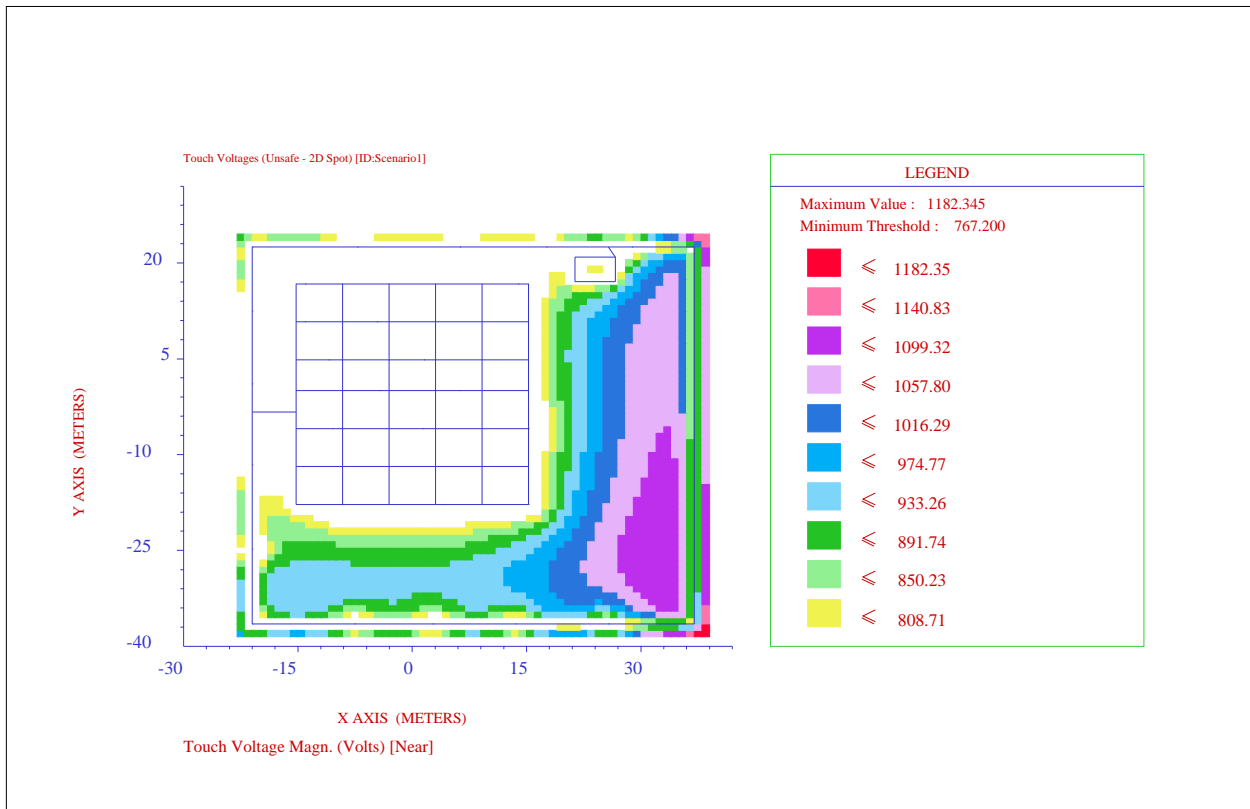
Auto Grid Pro [Project: Batchawana TS; Scenario: Scenario1]  
Touch Voltages (All - 2D Spot)

20-February-2008 5:31:39 PM



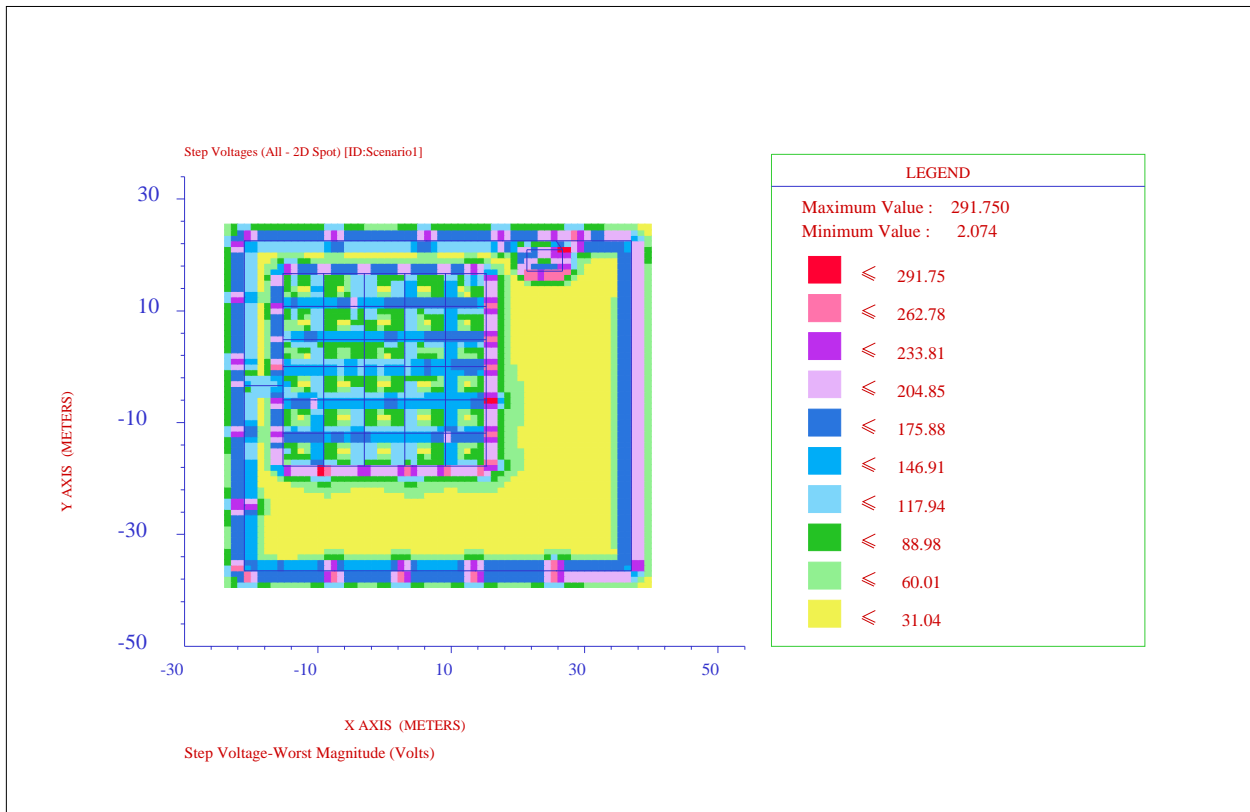
Auto Grid Pro [Project: Batchawana TS; Scenario: Scenario1]  
Touch Voltages (Unsafe - 2D Spot)

20-February-2008 5:32:05 PM



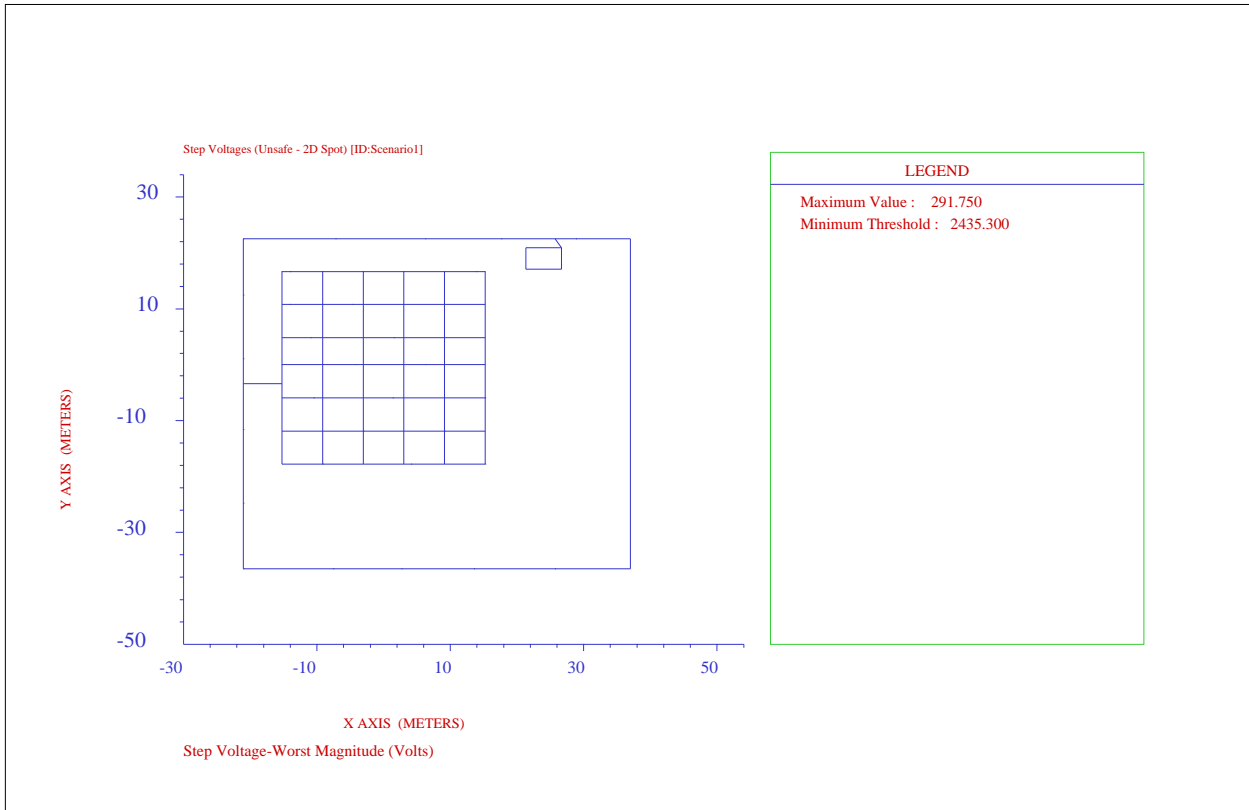
Auto Grid Pro [Project: Batchawana TS; Scenario: Scenario1]  
Step Voltages (All - 2D Spot)

20-February-2008 5:32:16 PM



Auto Grid Pro [Project: Batchawana TS; Scenario: Scenario1]  
Step Voltages (Unsafe - 2D Spot)

20-February-2008 5:32:40 PM





Report #1:

```
*****
*****
AUTOGRID PRO USER INPUT DATA REPORT
Creation Date/Time:    20 Feb 2008/17:31:20
*****
*****
```

-----  
Input Data Summary Reports  
-----

System Data Summary

C:\Program Files\SESSoftware 2005\Batchawana TS\Scenario1\Results\System  
Input.rep  
Requested Computation Reports and Plots  
C:\Program Files\SESSoftware 2005\Batchawana TS\Scenario1\Results\User  
Input.rep

-----  
Graphics option chosen  
-----

Computation Plots

Touch Voltages  
    Show All Values  
    Show Unsafe Values Above Selected Safety Threshold

Step Voltages

    Show All Values  
    Show Unsafe Values Above Selected Safety Threshold

Soil Resistivity Measurement Interpretation

Configuration Plots

    Grounding System Configuration

-----  
Types of plot selected  
-----

Computation Plots

    2D Spot

Configuration Plots

    Top View

End of Report #1

Report #2:

```
*****
*****
AUTOGRID PRO SYSTEM INPUT DATA REPORT
Creation Date/Time:    20 Feb 2008/17:31:20
*****
*****
```

Auto Grid Pro [Project: Batchawana TS; Scenario Page  
 Scenario1]

-----  
 Project Summary  
 -----

Run Identification ..... Scenario1  
 System of Units ..... Metric  
 Radius Measured in ..... Meters  
 Frequency ..... 60 Hz

-----  
 Soil Structure (deduce soil structure from field resistivity measurements)  
 -----

Measurement method.....Wenner  
 Type of measurement.....Resistance  
 Probe depth option.....Account for Probe Depth

Measurement Number	Spacing S (Meters)	Apparent Resistance R (Ohms)	Depth of Current Probes Do (Meters)	Depth of Potential Probes Di (Meters)
R1	1.52	17.34	0.152	0.152
R2	3.04	3.25	0.152	0.152
R3	6.08	1.042	0.152	0.152
R4	15.24	0.516	0.152	0.152
R5	30.48	0.293	0.152	0.152

-----  
 Network Fault Current Distribution  
 -----

Average soil characteristics along electric lines:  
 Resistivity(Ohm-m) ..... 100  
 Relative Permeability (p.u.) ..... 1

Central site definition:  
 Name .....  
 Ground Impedance (To be deduced from grounding computations)

-----  
 Safety  
 -----

Determine Safety Limits for Touch and Step Voltages  
 Maximum GPR of Grid (Volts) ..... 5000  
 Safety Threshold for Touch Voltages ..... 767.2 V

Auto Grid Pro [Project: Batchawana TS; Scenario Page  
 Scenario1]

Safety Threshold for Step Voltages ..... 2435.3 V  
 Automatic Generation of Observation Points.  
 Grid Border Offset for Touch Voltages ..... 2 m  
 Grid Border Offset for Step Voltages ..... 3 m

-----  
 The computation results are written in the following reports:  
 -----

Soil Resistivity Measurement Interpretation  
 C:\Program Files\SESSoftware 2005\Batchawana TS\Scenario1\Results\Soil  
 Structure.rep  
 Ground Grid Performance  
 C:\Program Files\SESSoftware 2005\Batchawana TS\Scenario1\Results\Ground  
 Grid Performance.rep  
 Safety Assessment  
 C:\Program Files\SESSoftware 2005\Batchawana  
 TS\Scenario1\Results\Safety.rep  
 Resistivity Comparison  
 C:\Program Files\SESSoftware 2005\Batchawana  
 TS\Scenario1\Results\Resistivity Comparison.rep  
 List of Materials  
 C:\Program Files\SESSoftware 2005\Batchawana TS\Scenario1\Results\Bill of  
 Materials.rep

End of Report #2

Report #3:

=====< R E S I S T I V I T Y ( SYSTEM INFORMATION SUMMARY ) >=====

Run ID.....: Scenario1  
 System of Units .....: Meters  
 Soil Type Selected.....: Multi-Layer Horizontal  
 RMS error between measured and calculated...: 12.2392 in percent  
 resistivities (Note RMS=SQRT(average(Di\*\*2))).

Layer Number	<--- LAYER CHARACTERISTICS ---> Resistivity (ohm-m)	Thickness (Meters)	Reflection Coefficient (p.u.)	Resistivity Contrast Ratio
1	infinite	infinite	0.0	1.0
2	462.7040	0.8005510	-1.0000	0.46270E-17
3	37.43818	0.2034501	-0.85029	0.80912E-01
4	45.87112	infinite	0.10122	1.2252

**\*\*WARNING\*\*** MORE THAN ONE SOIL MODEL CAN PRODUCE SIMILAR APPARENT RESISTIVITY MEASUREMENT CURVES. IF YOU USE THE DEFAULT STEEPEST-DESCENT METHOD, THEN YOU WILL MOST OFTEN OBTAIN DECENT AGREEMENT BETWEEN MEASURED VALUES AND THE COMPUTED CURVE, WITH A REALISTIC SOIL MODEL; HOWEVER, THE FIT MAY OCCASIONALLY BE SUB-OPTIMAL. IN SUCH CASES, THE MARQUARDT METHOD WILL USUALLY YIELD AN EXCELLENT FIT, BUT MAY SOMETIMES SUGGEST EXTREME RESISTIVITY VALUES. NOTE THAT DIFFERENT SOIL MODELS WILL USUALLY YIELD SIMILAR RESULTS FOR YOUR GROUNDING SYSTEM MODELS (I.E., GPR, TOUCH & STEP VOLTAGES), PROVIDED THAT THE GROUNDING SYSTEM IS LOCATED

Auto Grid Pro [Project: Batchawana TS; Scenario Page 1  
 Scenario1]

CLOSE TO THE EARTH SURFACE. IF IN DOUBT, CHECK YOUR RESULTS WITH BOTH SOIL MODELS.

End of Report #3

Report #4:

\*\*\*\*\*  
 Resistivity Comparison  
 Creation Date/Time: 20 Feb 2008/17:31:20  
 \*\*\*\*\*

Comparison of Measured & Computed Apparent Resistivities  
 =====

POINT	C1-C2 SPACING (meters)	APPARENT RESISTIVITY MEASURED	DISCREPANCY COMPUTED	Di (percent)
1	4.56000	166.6	166.7	0.08
2	9.12000	62.17	61.05	1.81
3	18.2400	39.82	47.47	19.21
4	45.7200	49.41	46.02	6.87
5	91.4400	56.11	45.93	18.15
				=====
Average discrepancy:				9.22%

RMS ERROR BETWEEN MEASURED AND CALCULATED RESISTIVITIES :

12.24 percent

\*NOTE\* RMS = SQRT( average(Di\*\*2) )

End of Report #4

Report #5:

\*\*\*\*\*  
 List of Materials  
 Creation Date/Time: 20 Feb 2008/17:31:20  
 \*\*\*\*\*

Interconnection / Bonding Nodes ..... 76  
 Extent of Grounding System ..... 3422 (Square Meters)  
 Surface Layer Thickness ..... 15 (Centimeters)  
 Volume of Insulating Layer ..... 513.3 (Cubic meters)  
 Wet Resistivity of Insulating Surface Layer ..... 2000 (Ohm-m)

Grounding System Data

Number of Rods                      Length (m)                      Diameter (m)  
 -----

Auto Grid Pro [Project: Batchawana TS; Scenario Page  
 Scenario1]

30 3 0.019  
 1 3 0.038

Number of Grid Conductors	Length (m)	Diameter (m)
2	58	0.0106
2	59	0.0106
2	5.3	0.0134
2	3.8	0.0134
7	30.5	0.0134
6	34.532	0.0134
1	5.75	0.0106
1	1.84117	0.0106

Total Length of Grid Conductors (m)	Diameter (m)
241.591	0.0106
438.892	0.0134
90	0.019
3	0.038

End of Report #5

Report #6:  
 Date of run (Start) = Wednesday, 20 February 2008  
 Starting Time = 5:31:20 PM

>>Safety Calculation Table

System Frequency.....: 60.000(Hertz)  
 System X/R.....: 20.000  
 Surface Layer Thickness.....: 15.000(cm)  
 Number of Surface Layer Resistivities.....: 10  
 Starting Surface Layer Resistivity.....: NONE  
 Incremental Surface Layer Resistivity.....: 500.00(ohm-m)  
 Equivalent Sub-Surface Layer Resistivity.....: 463.28(ohm-m)

Body Resistance Calculation.....: IEEE Std.80-2000  
 Fibrillation Current Calculation.....: IEEE Std.80-2000 (70kg)  
 Foot Resistance Calculation.....: IEEE Std.80-2000  
 User Defined Extra Foot Resistance.....: 0.0000 ohms

Fault Clearing Time (sec)	0.125	0.250	0.500
Decrement Factor	1.192	1.101	1.052
Fibrillation Current (amps)	0.444	0.314	0.222
Body Resistance (ohms)	1000.00	1000.00	1000.00

Surface Layer Resist	Fault Clearing Time			Foot Resist ance
	0.125 sec.	0.250 sec.	0.500 sec.	

Auto Grid Pro [Project: Batchawana TS; ScenarioPage  
 Scenario1]

ivity (ohm-m)	Step Voltage (Volts)	Touch Voltage (Volts)	Step Voltage (Volts)	Touch Voltage (Volts)	Step Voltage (Volts)	Touch Voltage (Volts)	1 Foot (ohms)
NONE	1451.4	642.3	1111.0	491.6	822.4	363.9	1447.8
500.0	1522.6	660.1	1165.6	505.3	862.8	374.0	1543.4
1000.0	2464.6	895.6	1886.6	685.5	1396.5	507.5	2807.5
1500.0	3384.8	1125.6	2591.0	861.7	1918.0	637.8	4042.5
2000.0	4297.8	1353.9	3289.9	1036.4	2435.3	767.2	5267.7
2500.0	5207.4	1581.3	3986.2	1210.4	2950.7	896.0	6488.4
3000.0	6115.2	1808.2	4681.1	1384.2	3465.1	1024.6	7706.7
3500.0	7021.9	2034.9	5375.1	1557.7	3978.9	1153.1	8923.5
4000.0	7927.9	2261.4	6068.6	1731.1	4492.2	1281.4	10139.4
4500.0	8833.4	2487.8	6761.8	1904.3	5005.3	1409.7	11354.6

\* Note \* Listed values account for short duration asymmetric waveform decrement factor listed at the top of each column.

End of Report #6

Report #7:

DATE OF RUN (Start)= DAY 20 / Month 2 / Year 2008  
 STARTING TIME= 17:31:21: 3

=====< G R O U N D I N G ( SYSTEM INFORMATION SUMMARY ) >=====

Run ID.....: Scenario1  
 System of Units .....: Metric  
 Earth Potential Calculations.....: Single Electrode Case  
 Type of Electrodes Considered.....: Main Electrode ONLY  
 Soil Type Selected.....: Multi-Layer Horizontal  
 SPLITS/FCDIST Scaling Factor.....: 0.90000

1  
 1

MULTI-LAYER EARTH CHARACTERISTICS USED BY PROGRAM

LAYER No.	TYPE	REFLECTION COEFFICIENT	RESISTIVITY (ohm-meter)	HEIGHT METERS
1	Air	0.00000	0.100000E+21	100000.
2	Soil	-0.999990	462.704	0.800551
3	Soil	-0.850290	37.4382	0.203450

Auto Grid Pro [Project: Batchawana TS; Scenario Page  
Scenario1]

1           4   Soil   0.101224       45.8711       0.100000E+11

CONFIGURATION OF MAIN ELECTRODE  
=====

Original Electrical Current Flowing In Electrode..:   3050.0       amperes  
Current Scaling Factor (SPLITS/FCDIST/specified)..:   0.90000  
Adjusted Electrical Current Flowing In Electrode..:   2745.0       amperes  
Number of Conductors in Electrode.....:           54  
Resistance of Electrode System.....:   0.61423       ohms

SUBDIVISION  
=====

Grand Total of Conductors After Subdivision.:   320

Total Current Flowing In Main Electrode.....:   2745.0       amperes  
Total Buried Length of Main Electrode.....:   773.48       meters

EARTH POTENTIAL COMPUTATIONS  
=====

Main Electrode Potential Rise (GPR).....:   1686.1       volts

End of Report #7



### 6.3 Northern TS

#### 6.3.1 Resistivity Measurements

Two soil measurements were obtained. The first was located adjacent to the parking lot and the second was located to the north of the substation. We have selected the second measurement to be representative of conditions.

Soil resistivity has been calculated based on the following:

$$P = 2\pi aR$$

$a$  = Rod Spacing

$R$  = Resistivity Measurement

Measurement Location	Probe Spacing	Resistance Measured	Calculated Soil Resistivity
M1	1.52 M	4.07 $\Omega$	38.9 $\Omega \cdot M$
M1	3.04 M	1.24 $\Omega$	23.7 $\Omega \cdot M$
M1	4.56 M	0.85 $\Omega$	24.3 $\Omega \cdot M$
M1	9.12 M	0.67 $\Omega$	38.4 $\Omega \cdot M$
M1	15.24 M	0.53 $\Omega$	50.8 $\Omega \cdot M$

#### 6.3.2 Total Resistance to Remote Earth Measurement ( $R_g$ )

One measurement for Total Resistance to Remote Earth was obtained. No additional measurements were obtained due to interference or obstructions around the substation. The measurement was taken in an easterly direction directly towards the high school football field. The test electrode was located at the north east corner of the substation yard.

Current probe C2 was located 800 ft. from the test electrode. Potential probe P2 measurements were made at significant intervals between test electrode and current probe C2.

Measurements obtained:

Position No.	Distance	Resistance
1	160 ft.	0.497 $\Omega$
2	320 ft.	0.571 $\Omega$
3	480 ft.	0.655 $\Omega$





The Tagg Slope Method was used to calculate remote earth resistance. Refer to Appendix for supporting methodology.

Distance calculation for value R

$$R_1 = 0.2 \times 800' = 160'$$

$$R_2 = 0.4 \times 800' = 320'$$

$$R_3 = 0.6 \times 800' = 480'$$

Remote Distance Curve Calculation:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1} = \frac{0.655 - 0.571}{0.571 - 0.497} = 1.135$$

From Tagg Slope Method tables in Appendix:

$$\mu \text{ of } 1.135 = \text{Pt/C of } 0.510$$

Distance of potential probe to represent remote earth resistance  
=  $0.510 \times 800' = 408'$  to Probe P2

**Measured Value = 0.604  $\Omega$**

### 6.3.3 Allowable Safe Step and Touch Potentials

Tolerable Step and Touch Potentials have been obtained from the SES technical report at the end of this section. These results are based on a surface covering layer throughout the substation of crushed stone which we have assigned a resistivity value of  $2000 \Omega \cdot \text{M}$ . The methodologies of IEEE Std. 80-2000 have been used to establish these tolerable limits. Tolerable Step Potential limits are 3300V and tolerable Touch Potentials are 983V.



### 6.3.4 Ground Potential Rise Calculation

#### Current Grid Split Factor Determination

To calculate  $S_f$  based on IEEE Std. 80-2000 Annex C Figure C-1.

Based on 1 Transmission / 2 Distribution Lines

$$R_g \text{ Measured} = 0.60 \Omega$$

100% Remote Contribution

$$R_{tg} = 15 \Omega \quad R_{dg} = 25 \Omega \quad \text{Figure C.1}$$

$$S_f = 50\%$$

We have assigned a split factor of 50%.

#### Symmetrical Grid Current ( $I_g$ )

$$\begin{aligned} I_g &= S_f * I_F \\ &= 0.50 * 12.99 \text{ kA} \\ &= 6.50 \text{ kA} \end{aligned}$$

$$S_f = 50\%$$

$$\begin{aligned} I_F &= L - G \text{ value from G.L.P.} \\ &= 12.99 \text{ kA} \end{aligned}$$

#### Maximum Grid Current ( $I_G$ )

$$\begin{aligned} I_G &= D_f * I_g \\ &= 1.052 * 6.52 \text{ kA} \\ &= 6.83 \text{ kA} \end{aligned}$$

$$D_f = 1.052$$

$$I_g = 6.50 \text{ kA}$$



## Calculated Ground Potential Rise (*GPR*)

$$\begin{aligned}GPR_{Measured} &= R_g * I_G * 10^3 \\ &= 0.60 * 6.83 * 10^3 \\ &= 4098 \text{ Volts}\end{aligned}$$

## Substation Condition Report

### Fence Grounding and Condition Comments

A visual inspection of the fence and gate grounding was completed. The condition of each thermoweld was inspected and the continuity of each jumper was confirmed. There were no apparent bonding issues associated with the fence or gate.

We have confirmed that the boundary fence is tied to the substation ground grid. We also confirm that the fence surrounding the substation yard is isolated from the fence surrounding the maintenance yard.

### Above Grade Equipment Ground Audit

An audit of all bonding and grounding associated with the electrical distribution equipment, supporting towers and structures, fences and gates was completed. All bare ground wire connections were assessed including both thermoweld and mechanical configurations. Bare ground wire sizes were compared to the engineering drawing provided by Great Lakes Power. For reference, this drawing is SD-23009 Rev. 0.

We found no issues with equipment bonding.

Of concern however is the transfer potential to the metal storage building adjacent to the substation yard. The main building ground conductor consists of a #2/0 awg bare copper conductor being secured to a structural member within the building. We confirmed the continuity of this ground conductor to the main substation grid (measured  $0.19 \Omega$ ). If the building ground is to be connected to the substation grid, as indicated on note 4 on the engineering drawing, then a building perimeter ground must be installed and a layer of crushed stone to be added and this will reduce the touch potentials.



### Surface Conditions

The surface covering throughout the substation yard consisted of washed crushed stone. We have considered this material to have a resistivity of 3000  $\Omega \cdot M$ .

This layer of stone needs to be extended 0.3 M past the extent of the grounding grid conductors. This is also referenced in note 3 on the engineering drawing.

### Computer Model Output Results

#### System Data:

Body Weight	70 kg
Fault Current ( $I_F$ )	12.99 kA
X/R ratio	20
Division Factor ( $S_F$ )	50%
Fault Duration ( $T_f, T_c, T_s$ )	0.5 sec.
Plot Step	3 ft.

#### Summary Report:

Ground Resistance ( $R_g$ )	0.35 $\Omega$
Ground Potential Rise (GPR)	2278 V
Tolerable Touch Potential	983 V
Calculated Maximum Touch Potential	581 V
Tolerable Step Potential	3300 V
Calculated Maximum Step Potential	214 V

### 6.3.7 Analysis and Recommendations

1. Calculated Touch, Step and Ground Potential Rise values are within tolerable levels.
2. The transfer potential to the metal storage building is of concern. We recommend further investigation into the tie between the building ground and the substation ground grid. If building isolation is deemed not to be a requirement then install the building perimeter loop and crushed stone to achieve safe touch potential. Ensure two separate connections exist if required.



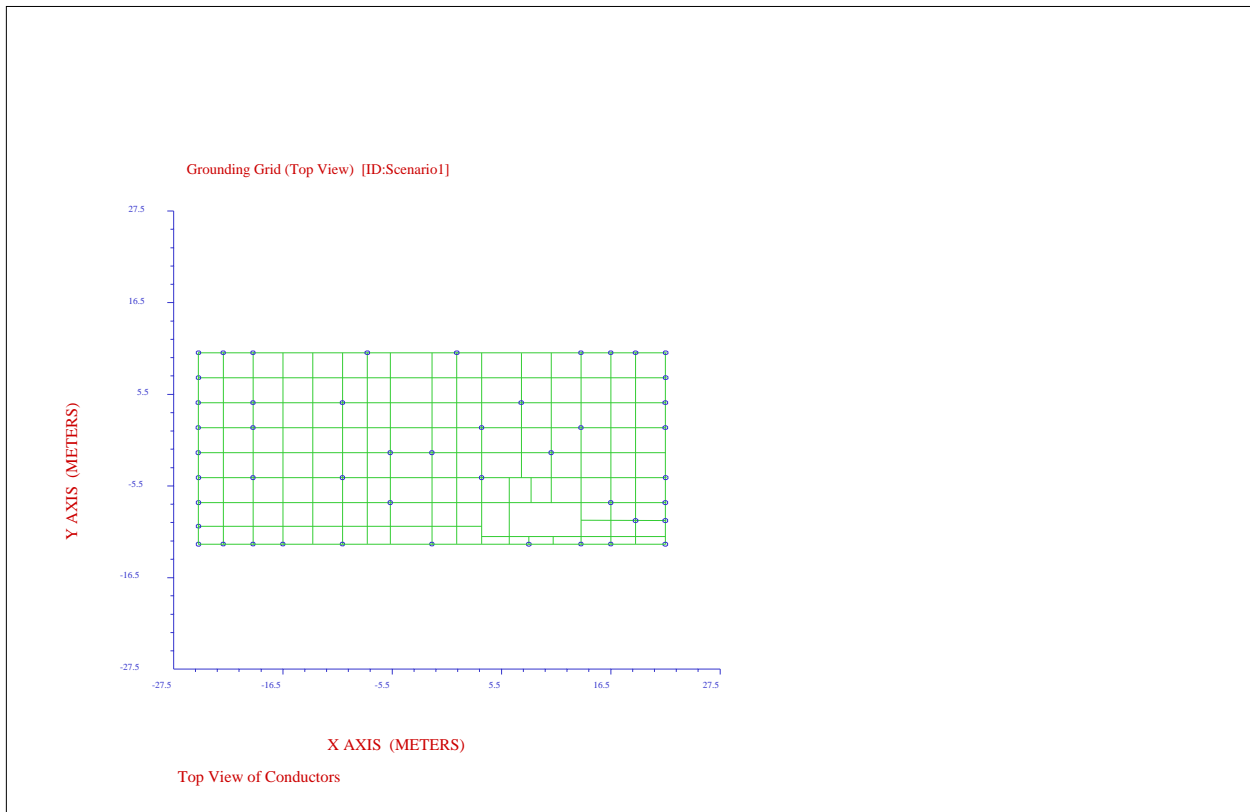
- 
3. Extend the crushed stone 0.3 M beyond the extent of the grounding grid conductors.

### **6.3.8 Computer Model Plots**

1. Grounding grid layout
2. Touch Voltages – all points
3. Touch Voltages – unsafe points
4. Step Voltages – all points
5. Step Voltages – unsafe points
6. Ground grid performance report

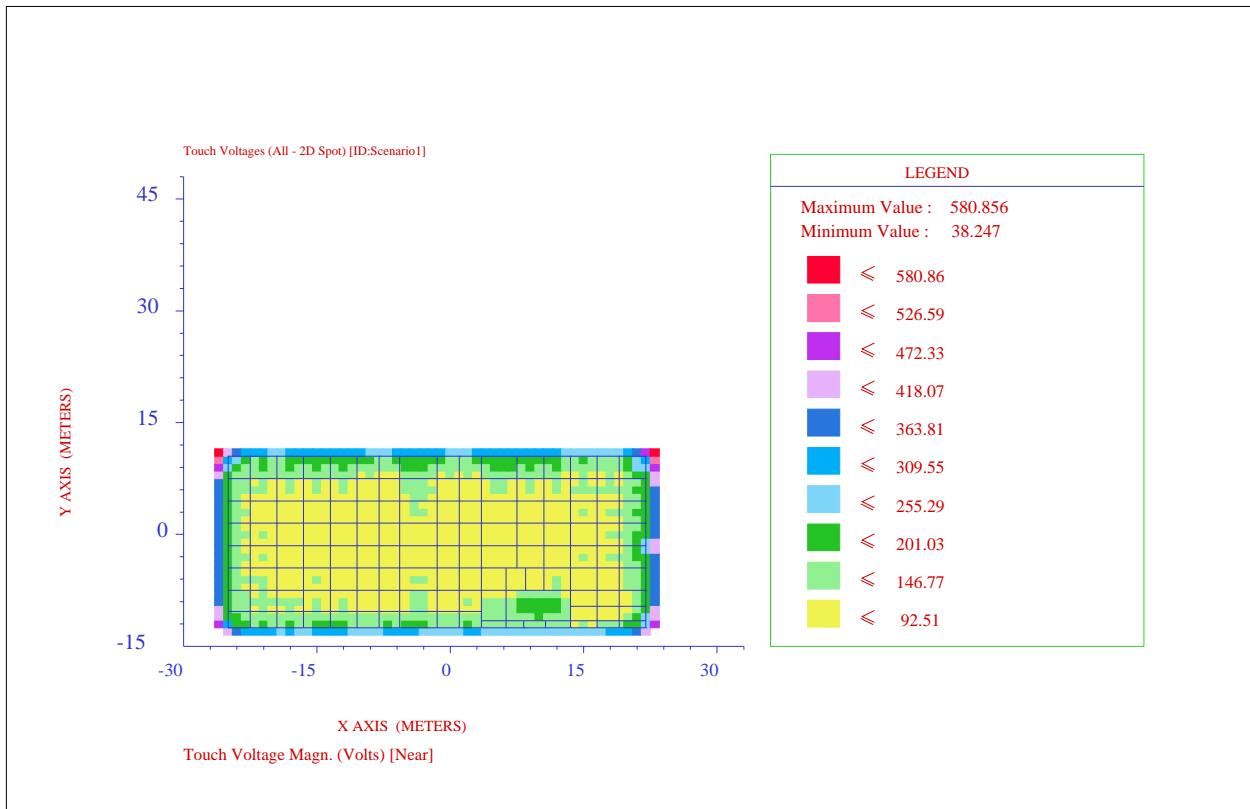
Auto Grid Pro [Project: Northern Ave TS; Scenario: Scenario1]  
Grounding Grid (Top View)

13-December-2007 11:16:07 AM



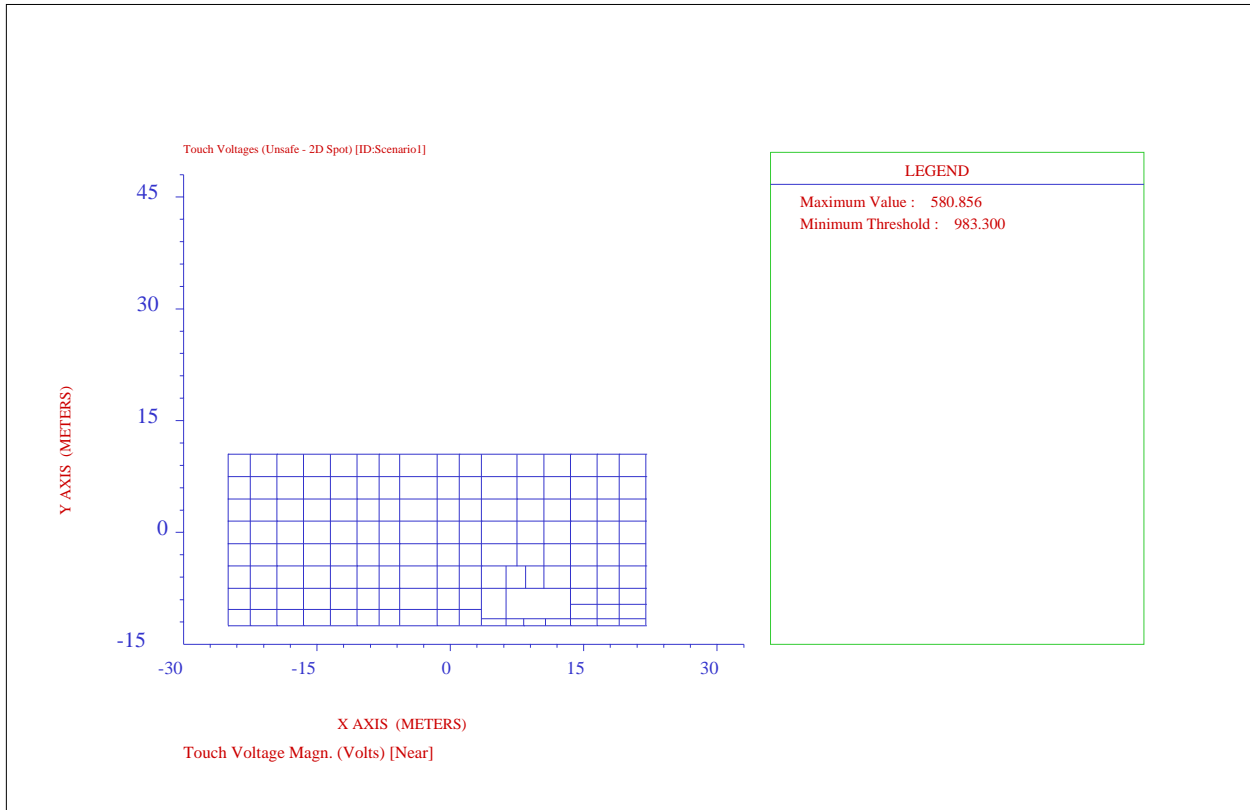
Auto Grid Pro [Project: Northern Ave TS; Scenario: Scenario1]  
Touch Voltages (All - 2D Spot)

22-February-2008 11:25:49 AM



Auto Grid Pro [Project: Northern Ave TS; Scenario: Scenario1]  
Touch Voltages (Unsafe - 2D Spot)

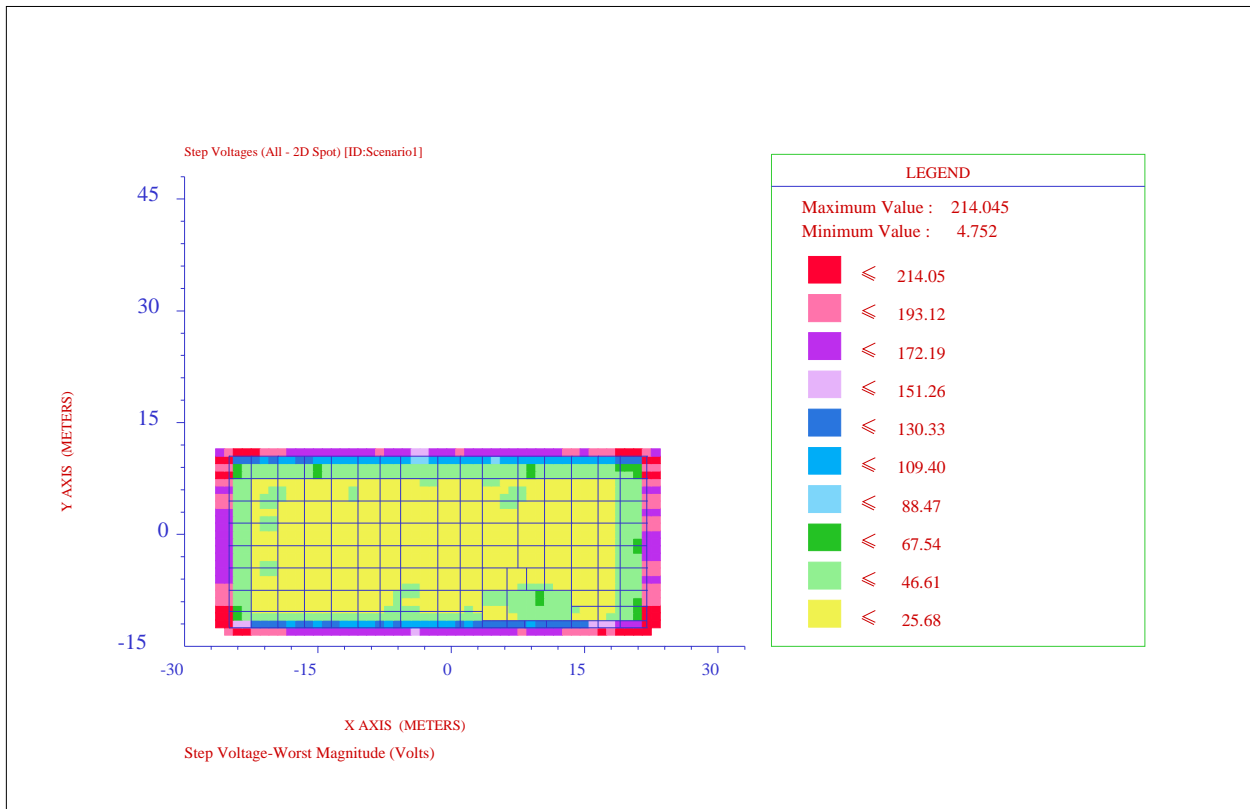
22-February-2008 11:25:57 AM





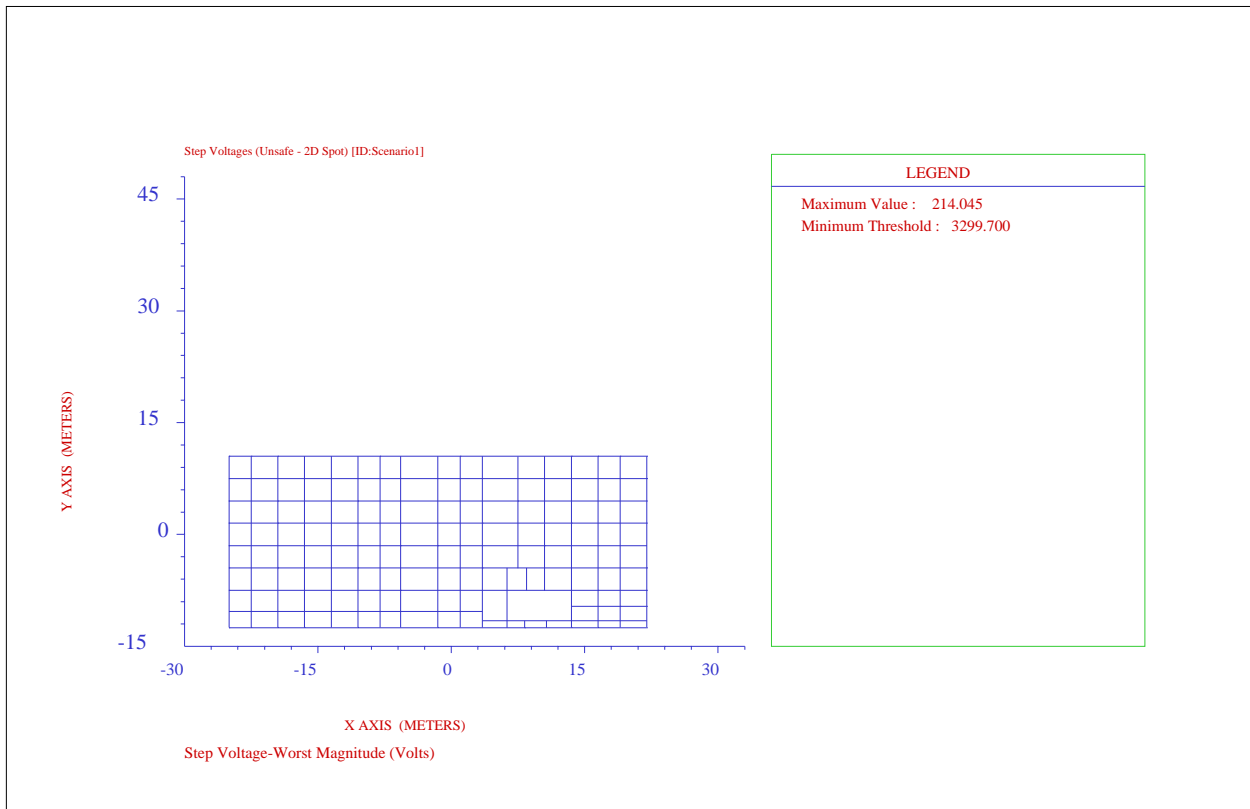
Auto Grid Pro [Project: Northern Ave TS; Scenario: Scenario1]  
Step Voltages (All - 2D Spot)

22-February-2008 11:26:06 AM



Auto Grid Pro [Project: Northern Ave TS; Scenario: Scenario1]  
Step Voltages (Unsafe - 2D Spot)

22-February-2008 11:26:17 AM



Report #1:

```
*****  
*****  
AUTOGRID PRO USER INPUT DATA REPORT  
Creation Date/Time: 22 Feb 2008/11:25:24  
*****  
*****
```

-----  
Input Data Summary Reports  
-----

System Data Summary

C:\Program Files\SESSoftware 2005\Northern Ave  
TS\Scenario1\Results\System Input.rep  
Requested Computation Reports and Plots  
C:\Program Files\SESSoftware 2005\Northern Ave TS\Scenario1\Results\User  
Input.rep

-----  
Graphics option chosen  
-----

Computation Plots

Touch Voltages  
    Show All Values  
    Show Unsafe Values Above Selected Safety Threshold

Step Voltages  
    Show All Values  
    Show Unsafe Values Above Selected Safety Threshold

Electric Network Configuration

Soil Resistivity Measurement Interpretation

Fault Current Distribution  
    Section Span Currents  
    Shunt Tower Currents  
    Shunt Tower Potentials  
    One Terminal Plot  
    Terminal Number ..... 1  
    All Sections Selected

Configuration Plots

    Grounding System Configuration

-----  
Types of plot selected  
-----

Computation Plots

    2D Spot  
    2D Contour  
    3D Perspective

Configuration Plots

    3D Perspective  
    Top View

Auto Grid Pro [Project: Northern Ave TS; Scenario1] Scenario1

End of Report #1

Report #2:

```
*****
*****
AUTOGRID PRO SYSTEM INPUT DATA REPORT
Creation Date/Time:      22 Feb 2008/11:25:24
*****
*****
```

-----  
 Project Summary  
 -----

```
Run Identification ..... Scenario1
System of Units ..... Metric
Radius Measured in ..... Meters
Frequency ..... 60 Hz
```

-----  
 Soil Structure (deduce soil structure from field resistivity measurements)  
 -----

```
Measurement method.....Wenner
Type of measurement.....Resistance
Probe depth option.....Account for Probe Depth
```

Measurement Number	Spacing S (Meters)	Apparent Resistance R (Ohms)	Depth of Current Probes Do (Meters)	Depth of Potential Probes Di (Meters)
R1	1.52	4.07	0.152	0.152
R2	3.04	1.236	0.152	0.152
R3	4.56	0.853	0.152	0.152
R4	9.12	0.67	0.152	0.152
R5	15.24	0.529	0.152	0.152

-----  
 Network Fault Current Distribution  
 -----

```
Average soil characteristics along electric lines:
  Resistivity(Ohm-m) ..... 100
  Relative Permeability (p.u.) ..... 1
```

```
Central site definition:
  Name .....
```

Auto Grid Pro [Project: Northern Ave TS; Scenario1] Scenario1

Ground Impedance (To be deduced from grounding computations)

-----  
 Safety  
 -----

Determine Safety Limits for Touch and Step Voltages  
 Maximum GPR of Grid (Volts) ..... 5000  
     Safety Threshold for Touch Voltages ..... 983.3 V  
     Safety Threshold for Step Voltages ..... 3299.7 V  
 Automatic Generation of Observation Points.  
     Grid Border Offset for Touch Voltages ..... 1 m  
     Grid Border Offset for Step Voltages ..... 1 m

-----  
 The computation results are written in the following reports:  
 -----

Soil Resistivity Measurement Interpretation  
     C:\Program Files\SESSoftware 2005\Northern Ave TS\Scenario1\Results\Soil  
 Structure.rep  
 Ground Grid Performance  
     C:\Program Files\SESSoftware 2005\Northern Ave  
 TS\Scenario1\Results\Ground Grid Performance.rep  
 Safety Assessment  
     C:\Program Files\SESSoftware 2005\Northern Ave  
 TS\Scenario1\Results\Safety.rep  
 Resistivity Comparison  
     C:\Program Files\SESSoftware 2005\Northern Ave  
 TS\Scenario1\Results\Resistivity Comparison.rep  
 List of Materials  
     C:\Program Files\SESSoftware 2005\Northern Ave TS\Scenario1\Results\Bill  
 of Materials.rep

End of Report #2

Report #3:

=====< R E S I S T I V I T Y ( SYSTEM INFORMATION SUMMARY ) >=====

Run ID.....: Scenario1  
 System of Units .....: Meters  
 Soil Type Selected.....: Multi-Layer Horizontal  
 RMS error between measured and calculated...: 27.6903 in percent  
 resistivities (Note RMS=SQRT(average(Di\*\*2))).

Layer Number	<--- LAYER CHARACTERISTICS ---> Resistivity (ohm-m)	Thickness (Meters)	Reflection Coefficient (p.u.)	Resistivity Contrast Ratio
1	infinite	infinite	0.0	1.0
2	39.09538	0.5986753	-1.0000	0.39095E-18
3	28.87995	infinite	-0.15028	0.73870

\*\*WARNING\*\* MORE THAN ONE SOIL MODEL CAN PRODUCE SIMILAR APPARENT RESISTIVITY  
 MEASUREMENT CURVES. IF YOU USE THE DEFAULT STEEPEST-DESCENT  
 METHOD,

Auto Grid Pro [Project: Northern Ave TS; Scenario1] Page 4  
 Scenario1]

THEN YOU WILL MOST OFTEN OBTAIN DECENT AGREEMENT BETWEEN MEASURED VALUES AND THE COMPUTED CURVE, WITH A REALISTIC SOIL MODEL; HOWEVER, THE FIT MAY OCCASIONALLY BE SUB-OPTIMAL. IN SUCH CASES, THE MARQUARDT METHOD WILL USUALLY YIELD AN EXCELLENT FIT, BUT MAY SOMETIMES SUGGEST EXTREME RESISTIVITY VALUES. NOTE THAT DIFFERENT SOIL MODELS WILL USUALLY YIELD SIMILAR RESULTS FOR YOUR GROUNDING SYSTEM MODELS (I.E., GPR, TOUCH & STEP VOLTAGES), PROVIDED THAT THE GROUNDING SYSTEM IS LOCATED CLOSE TO THE EARTH SURFACE. IF IN DOUBT, CHECK YOUR RESULTS WITH BOTH SOIL MODELS.

End of Report #3

Report #4:

\*\*\*\*\*  
 Resistivity Comparison  
 Creation Date/Time: 22 Feb 2008/11:25:24  
 \*\*\*\*\*

Comparison of Measured & Computed Apparent Resistivities  
 =====

POINT	C1-C2 SPACING (meters)	APPARENT MEASURED	RESISTIVITY COMPUTED	DISCREPANCY Di (percent)
=====	=====	=====	=====	=====
1	4.56000	39.10	32.04	18.05
2	9.12000	23.64	29.78	25.97
3	13.6800	24.46	29.28	19.73
4	27.3600	38.40	28.98	24.54
5	45.7200	50.66	28.91	42.92
				=====
		Average discrepancy:		26.24%

RMS ERROR BETWEEN MEASURED AND CALCULATED RESISTIVITIES :

27.69 percent

\*NOTE\* RMS = SQRT( average(Di\*\*2) )

End of Report #4

Report #5:

\*\*\*\*\*  
 List of Materials  
 Creation Date/Time: 22 Feb 2008/11:25:24  
 \*\*\*\*\*

Auto Grid Pro [Project: Northern Ave TS; Scenario1] Page 1

Interconnection / Bonding Nodes ..... 162  
 Extent of Grounding System ..... 1082.16 (Square Meters)  
 Surface Layer Thickness ..... 15 (Centimeters)  
 Volume of Insulating Layer ..... 162.324 (Cubic meters)  
 Wet Resistivity of Insulating Surface Layer ..... 3000 (Ohm-m)

Grounding System Data

Number of Rods	Length (m)	Diameter (m)
47	3	0.019

Number of Grid Conductors	Length (m)	Diameter (m)
8	47.0566	0.0106
15	22.9725	0.0106
1	14.9703	0.0106
1	18.049	0.0106
1	8	0.0106
1	28.5	0.0106
1	18.5	0.0106
1	8.50007	0.0106
1	3	0.0106
2	0.92129	0.0106

Total Length of Grid Conductors (m)	Diameter (m)
822.402	0.0106
141	0.019

End of Report #5

Report #6:  
 Date of run (Start) = Friday,22 February 2008  
 Starting Time = 11:25:25 AM

>>Safety Calculation Table

System Frequency.....: 60.000(Hertz)  
 System X/R.....: 20.000  
 Surface Layer Thickness.....: 15.000(cm)  
 Number of Surface Layer Resistivities.....: 8  
 Starting Surface Layer Resistivity.....: NONE  
 Incremental Surface Layer Resistivity.....: 500.00(ohm-m)  
 Equivalent Sub-Surface Layer Resistivity.....: 39.095(ohm-m)

Body Resistance Calculation.....: IEEE Std.80-2000  
 Fibrillation Current Calculation.....: IEEE Std.80-2000 (70kg)  
 Foot Resistance Calculation.....: IEEE Std.80-2000  
 User Defined Extra Foot Resistance.....: 0.0000 ohms

Fault Clearing Time (sec)	0.125	0.250	0.500
+	+	+	+

Auto Grid Pro [Project: Northern Ave TS; Scenario1] Page 1  
 Scenario1]

Decrement Factor	1.192	1.101	1.052
Fibrillation Current (amps)	0.444	0.314	0.222
Body Resistance (ohms)	1000.00	1000.00	1000.00

Surface Layer Resistivity (ohm-m)	Fault Clearing Time						Foot Resistance 1 Foot (ohms)
	0.125 sec.		0.250 sec.		0.500 sec.		
	Step Voltage (Volts)	Touch Voltage (Volts)	Step Voltage (Volts)	Touch Voltage (Volts)	Step Voltage (Volts)	Touch Voltage (Volts)	
NONE	463.6	395.3	354.9	302.6	262.7	224.0	122.2
500.0	1304.2	605.5	998.3	463.5	739.0	343.1	1250.3
1000.0	2208.4	831.5	1690.5	636.5	1251.3	471.2	2463.7
1500.0	3112.2	1057.5	2382.3	809.5	1763.5	599.2	3676.6
2000.0	4015.9	1283.4	3074.1	982.4	2275.6	727.2	4889.5
2500.0	4919.6	1509.3	3765.9	1155.4	2787.7	855.3	6102.3
3000.0	5823.3	1735.3	4457.6	1328.3	3299.7	983.3	7315.0
3500.0	6727.0	1961.2	5149.4	1501.2	3811.8	1111.3	8527.8

\* Note \* Listed values account for short duration asymmetric waveform decrement factor listed at the top of each column.

End of Report #6

Report #7:

DATE OF RUN (Start)= DAY 22 / Month 2 / Year 2008  
 STARTING TIME= 11:25:25:15

=====< G R O U N D I N G ( SYSTEM INFORMATION SUMMARY ) >=====

Run ID.....: Scenario1  
 System of Units .....: Metric  
 Earth Potential Calculations.....: Single Electrode Case  
 Type of Electrodes Considered.....: Main Electrode ONLY  
 Soil Type Selected.....: Multi-Layer Horizontal  
 SPLITS/FCDIST Scaling Factor.....: 0.50000

1  
 1

MULTI-LAYER EARTH CHARACTERISTICS USED BY PROGRAM



Auto Grid Pro [Project: Northern Ave TS; Scenario1] Scenario1]

LAYER No.	TYPE	REFLECTION COEFFICIENT	RESISTIVITY (ohm-meter)	HEIGHT METERS
1	Air	0.00000	0.100000E+21	100000.
2	Soil	-0.999990	39.0954	0.598675
3	Soil	-0.150281	28.8799	0.100000E+11

1

CONFIGURATION OF MAIN ELECTRODE

=====

Original Electrical Current Flowing In Electrode...: 12990. amperes  
 Current Scaling Factor (SPLITS/FCDIST/specified)...: 0.50000  
 Adjusted Electrical Current Flowing In Electrode...: 6495.0 amperes  
 Number of Conductors in Electrode.....: 79  
 Resistance of Electrode System.....: 0.35070 ohms

SUBDIVISION

=====

Grand Total of Conductors After Subdivision.: 373

Total Current Flowing In Main Electrode.....: 6495.0 amperes  
 Total Buried Length of Main Electrode.....: 963.34 meters

EARTH POTENTIAL COMPUTATIONS

=====

Main Electrode Potential Rise (GPR).....: 2277.8 volts

End of Report #7



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## 7.0 SIGNATURES AND ACKNOWLEDGEMENTS

Report Prepared by:

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Barry Bingeman  
Power Systems Analyst

Report Endorsed by:

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Harold Harkonen, P. Eng.  
Senior Electrical Engineer



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## 8.0 References

1. Westinghouse Electrical Transmission & Distribution,  
Reference Book  
Fourth Edition, 1964
2. IEEE STD. 80-2000  
IEEE Guide for Safety in AC Substation Grounding
3. IEEE STD. 367-1996 (R2002)  
IEEE Recommended Practice for Determining the Electric Power Station Ground  
Potential Rise and Induced Voltage from a Power Fault.



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## 9.0 Appendix

1. Appendix 9.1 Summary of Fault Levels for Grounding Measurements
2. Appendix 9.2 Tagg Tables
3. Appendix 9.3 NETA World – Slope Method

Three Phase Fault Levels

<b>Station</b>	<b>Pre Fault Voltage (kV)</b>	<b>Three Phase Fault</b>	<b>X/R</b>
Northern Ave	13.2	2.4	10.04
Northern Ave	37.95	4.5	11.4
Northern Ave	121	11.8	8.9
Goulais	13.75	8.58	12.66
Goulais	121	5.24	3.18
Batchawana	7.92	4.5	17.31
Batchawana	121	4.3	3.07

Line to Ground Fault Levels

<b>Station</b>	<b>Pre Fault Voltage (kV)</b>	<b>L-gnd Fault</b>	<b>X/R</b>
Northern Ave	13.2	2.55	9.96
Northern Ave	37.95	4.6	11.47
Northern Ave	121	12.99	7.48
Goulais	13.75	9.14	15.75
Goulais	121	3.771	3.18
Batchawana	7.92	4.625	19.2
Batchawana	121	3.05	3.12

### Tagg Slope Method Tables

(Values of  $P_f/EC$  for Values of  $\mu$ )

$\mu$	0	1	2	3	4	5	6	7	8	9
0.40	0.6432	6431	6429	6428	6426	6425	6423	6422	6420	6419
0.41	0.6418	6416	6415	6413	6412	6410	6409	6408	6406	6405
0.42	0.6403	6402	6400	6399	6397	6396	6395	6393	6392	6390
0.43	0.6389	6387	6386	6384	6383	6382	6380	6379	6377	6376
0.44	0.6374	6373	6372	6370	6369	6367	6366	6364	6363	6361
0.45	0.6360	6359	6357	6356	6354	6353	6351	6350	6348	6347
0.46	0.6346	6344	6343	6341	6340	6338	6337	6336	6334	6333
0.47	0.6331	6330	6328	6327	6325	6324	6323	6321	6320	6318
0.48	0.6317	6315	6314	6312	6311	6310	6308	6307	6305	6304
0.49	0.6302	6301	6300	6298	6297	6295	6294	6292	6291	6289
0.50	0.6288	6286	6285	6283	6282	6280	6279	6277	6276	6274
0.51	0.6273	6271	6270	6268	6267	6265	6264	6262	6261	6259
0.52	0.6258	6256	6255	6253	6252	6250	6248	6247	6245	6244
0.53	0.6242	6241	6239	6238	6236	6235	6233	6232	6230	6229
0.54	0.6227	6226	6224	6223	6221	6220	6218	6217	6215	6214
0.55	0.6212	6210	6209	6207	6206	6204	6203	6201	6200	6198
0.56	0.6197	6195	6194	6192	6191	6189	6188	6186	6185	6183
0.57	0.6182	6180	6179	6177	6176	6174	6172	6171	6169	6168
0.58	0.6166	6165	6163	6162	6160	6159	6157	6156	6154	6153
0.59	0.6151	6150	6148	6147	6145	6144	6142	6141	6139	6138
0.60	0.6136	6134	6133	6131	6130	6128	6126	6125	6123	6121
0.61	0.6120	6118	6117	6115	1663	6112	6110	6108	6107	6105
0.62	0.6104	6102	6100	6099	6097	6096	6094	6092	6091	6089
0.63	0.6087	6086	6084	6083	6081	6079	6077	6076	6074	6073
0.64	0.6071	6070	6068	6066	6065	6063	6061	6060	6058	6057
0.65	0.6055	6053	6052	6050	6049	6047	6045	6044	6042	6040
0.66	0.6039	6037	6036	6034	6032	6031	6029	6027	6026	6024
0.67	0.6023	6021	6019	6018	6016	6015	6013	6011	6010	6008
0.68	0.6006	6005	6003	6002	6000	5998	5997	5995	5993	5992
0.69	0.5990	5989	5987	5985	5984	5982	5980	5979	5977	5975

$\mu$	0	1	2	3	4	5	6	7	8	9
0.70	0.5974	5973	5971	5969	5967	5965	5964	5962	5960	5959
0.71	0.5957	5955	5953	5952	5950	5948	5947	5945	5943	5942
0.72	0.5940	5938	5936	5935	5933	5931	5930	5928	5926	5924
0.73	0.5923	5921	5920	5918	5916	5914	5912	5911	5909	5907
0.74	0.5906	5904	5902	5900	5899	5897	5895	5894	5892	5890
0.75	0.5889	5887	5885	5883	5882	5880	5878	5877	5875	5873
0.76	0.5871	5870	5868	5866	5865	5863	5861	5859	5858	5856
0.77	0.5854	5853	5851	5849	5847	5846	5844	5842	5841	5839
0.78	0.5837	5835	5834	5832	5830	5829	5827	5825	5824	5822
0.79	0.5820	5818	5817	5815	5813	5812	5810	5808	5806	5805
0.80	0.5803	5801	5799	5797	5796	5794	5792	5790	5788	5786
0.81	0.5785	5783	5781	5779	5777	5775	5773	5772	5770	5768
0.82	0.5766	5764	5762	5760	5759	5757	5755	5753	5751	5749
0.83	0.5748	5746	5744	5742	5740	5738	5736	5735	5733	5731
0.84	0.5729	5727	5725	5723	5722	5720	5718	5716	5714	5712
0.85	0.5711	5709	5707	5705	5703	5701	5699	5698	5696	5694
0.86	0.5692	5690	5688	5686	5685	5683	5681	5679	5677	5675
0.87	0.5674	5672	5670	5668	5666	5664	5662	5661	5659	5657
0.88	0.5655	5653	5651	5650	5648	5646	5644	5642	5640	5638
0.89	0.5637	5635	5633	5631	5629	5627	5625	5624	5622	5620
0.90	0.5618	5616	5614	5612	5610	5608	5606	5604	5602	5600
0.91	0.5598	5596	5594	5592	5590	5588	5586	5584	5582	5580
0.92	0.5578	5576	5574	5572	5570	5568	5565	5563	5561	5559
0.93	0.5557	5555	5553	5551	5549	5547	5545	5543	5541	5539
0.94	0.5537	5535	5533	5531	5529	5527	5525	5523	5521	5519
0.95	0.5517	5515	5513	5511	5509	5507	5505	5503	5501	5499
0.96	0.5497	5495	5493	5491	5489	5487	5485	5483	5481	5479
0.97	0.5477	5475	5473	5471	5469	5467	5464	5462	5460	5458
0.98	0.5456	5454	5452	5450	5448	5446	5444	5442	5440	5438
0.99	0.5436	5434	5432	5430	5428	5426	5424	5422	5420	5418

### Tagg Slope Method Tables (concluded)

(Values of  $P_t/EC$  for Values of  $\mu$ )

$\mu$	0	1	2	3	4	5	6	7	8	9
1.00	0.5416	5414	5412	5409	5407	5405	5403	5400	5398	5396
1.01	0.5394	5391	5389	5387	5385	5383	5380	5378	5376	5374
1.02	0.5371	5369	5367	5365	5362	5360	5358	5356	5354	5351
1.03	0.5349	5347	5345	5342	5340	5338	5336	5333	5331	5329
1.04	0.5327	5325	5322	5320	5318	5316	5131	5311	5309	5307
1.05	0.5305	5302	5300	5298	5296	5293	5291	5289	5287	5284
1.06	0.5282	5280	5278	5276	5273	5271	5269	5267	5264	5262
1.07	0.5260	5258	5255	5253	5251	5249	5247	5244	5242	5240
1.08	0.5238	5235	5233	5231	5229	5226	5224	5222	5219	5217
1.09	0.5215	5213	5211	5209	5206	5204	5202	5200	5197	5195
1.10	0.5193	5190	5188	5185	5183	5180	5178	5175	5173	5170
1.11	0.5168	5165	5163	5160	5158	5155	5153	5150	5148	5145
1.12	0.5143	5140	5137	5135	5132	5130	5127	5125	5122	5120
1.13	0.5118	5115	5113	5110	5108	5105	5103	5100	5098	5095
1.14	0.5093	5090	5088	5085	5083	5080	5078	5075	5073	5070
1.15	0.5068	5065	5062	5060	5057	5055	5052	5050	5047	5045
1.16	0.5042	5040	5037	5035	5032	5030	5027	5025	5022	5020
1.17	0.5017	5015	5012	5010	5007	5005	5002	5000	4997	4995
1.18	0.4992	4990	4987	4985	4982	4980	4977	4975	4972	4970
1.19	0.4967	4965	4962	4960	4957	4955	4952	4950	4947	4945
1.20	0.4942	4939	4936	4933	4930	4928	4925	4922	4919	4915
1.21	0.4913	4910	4907	4904	4901	4899	4896	4893	4890	4887
1.22	0.4884	4881	4878	4875	4872	4870	4867	4864	4861	4858
1.23	0.4855	4852	4849	4846	4843	4841	4838	4835	4832	4829
1.24	0.4825	4823	4820	4817	4814	4812	4809	4806	4803	4800
1.25	0.4797	4794	4791	4788	4785	4783	4780	4777	4774	4771
1.26	0.4768	4765	4762	4759	4756	4754	4751	4748	4745	4742
1.27	0.4739	4736	4733	4730	4727	4725	4722	4719	4716	4713
1.28	0.4710	4707	4704	4701	4698	4696	4693	4690	4687	4684
1.29	0.4681	4678	4675	4672	4669	4667	4664	4661	4658	4655

$\mu$	0	1	2	3	4	5	6	7	8	9
1.30	0.4652	4649	4645	4642	4638	4635	4631	4628	4625	4621
1.31	0.4618	4614	4611	4607	4604	4601	4597	4594	4590	4586
1.32	0.4583	4580	4577	4573	4570	4566	4563	4559	4556	4553
1.33	0.4549	4546	4542	4539	4535	4532	4529	4525	4522	4518
1.34	0.4515	4511	4508	4505	4501	4498	4494	4491	4487	4484
1.35	0.4481	4477	4474	4470	4467	4463	4460	4457	4453	4450
1.36	0.4446	4443	4439	4436	4432	4429	4426	4422	4419	4415
1.37	0.4412	4408	4405	4402	4398	4395	4391	4388	4384	4381
1.38	0.4378	4374	4371	4367	4364	4360	4357	4354	4350	4347
1.39	0.4343	4340	4336	4333	4330	4326	4323	4319	4316	4312
1.40	0.4309	4305	4301	4296	4292	4288	4284	4280	4275	4271
1.41	0.4267	4263	4258	4254	4250	4246	4242	4237	4233	4229
1.42	0.4225	4221	4216	4212	4208	4204	4200	4195	4191	4187
1.43	0.4183	4178	4174	4170	4166	4162	4157	4153	4149	4145
1.44	0.4141	4136	4132	4128	4124	4210	4115	4111	4107	4103
1.45	0.4099	4094	4090	4086	4082	4077	4073	4069	4065	4061
1.46	0.4056	4052	4048	4044	4040	4035	4031	4027	4023	4018
1.47	0.4014	4010	4005	4001	3997	3993	3989	3985	3980	3976
1.48	0.3972	3968	3964	3959	3955	3951	3947	3943	3938	3934
1.49	0.3930	3926	3921	3917	3913	3909	3905	3900	3896	3892
1.50	0.3888	3883	3878	3874	3869	3864	3859	3854	3850	3845
1.51	0.3840	3835	3830	3825	3820	3816	3811	3806	3801	3796
1.52	0.3791	3786	3781	3776	3771	3766	3760	3755	3750	3745
1.53	0.3740	3735	3730	3724	3719	3714	3709	3704	3698	3693
1.54	0.3688	3683	3677	3672	3667	3662	3656	3651	3646	3640
1.55	0.3635	3630	3624	3619	3613	3608	3602	3597	3591	3586
1.56	0.3580	3574	3569	3563	3557	3552	3546	3540	3534	3528
1.57	0.3523	3517	3511	3506	3500	3494	3488	3482	3477	3471
1.58	0.3465	3459	3453	3447	3441	3435	3429	3423	3417	3411
1.59	0.3405	3399	3393	3386	3380	3374	3368	3362	3355	3349

# NETA WORLD



The Official Publication of the InterNational Electrical Testing Association

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## Tech Tips

# Slope Method

The fall-of-potential method described in the previous column is the most general and most thorough way to perform a ground test. However, while this method has a sound theoretical base, it may suffer from physical limitations when applied to the practical world. One of the most common limitations is the frequent necessity, depending on size of the ground grid and other site considerations, to employ test leads that are too long. The theory supporting the fall-of-potential method is based on "ideal" test conditions, which include the separation of the electrical fields surrounding the test ground and the separation of the current probes from each other. If the test is being performed on a single-rod residential ground in a suburban neighborhood with plenty of yard space and not too many fences, the ideal test conditions can be accomplished without even pondering it. The graph of the readings obtained by walking the potential probe at regular intervals toward the current probe will reveal the extent of the two respective fields of influence. If it does not, there is no serious problem. The tester will just need to get some more lead wire, extend the current probe into the neighbor's yard, and repeat the procedure. The measurement and the proof of its validity are self-contained.

But, suppose the test technician is faced with one or both of two common situations — an enormous ground grid and little or no room. A large grid, such as the type that underlies a substation or encircles a transmission tower, will have a proportionately large electrical field in the soil. Getting the current test probe placed beyond this influence typically takes several multiples of the diagonal dimension. This can come out to several hundred feet and be prohibitive. Also, the environment might not even allow reasonable space since the site could be in a downtown area, surrounded by interstate highways, or contain a neighbor who is a psycho known to shoot trespassers! What then? Are you out of business? Not at all! Rest assured, many test technicians have encountered these and other daunting situations, and methods have been devised to complete the test so they could proceed with business as usual.

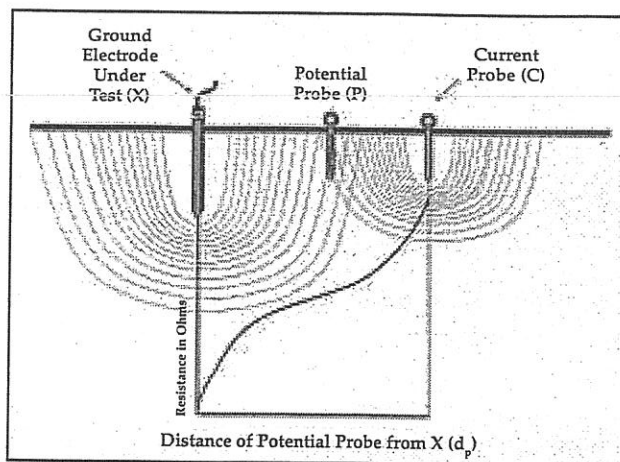
The most tried-and-true of these methods is known as the slope method. It was first described by Dr. G. F. Tagg in Paper #62975, Institution of Electrical Engineers (IEE) Proceedings, Volume 117, No. 11, November 1970. The method is based on calculus and the "rate of change of slope." The slope method simplifies the mathematical theory.



by Jeff Jowett  
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Picture this: A substation grid is to be tested in an industrial area encircled by railroad tracks, busy highways, and fenced properties. Perhaps even a river flows by cutting off a whole side. It appears to be a nightmare! The technician follows standard operating procedures and does a fall-of-potential test by staking out whatever limited room he or she can manage in the most open direction. But the current probe isn't far enough away. As the graph is plotted, the rising resistance curve associated with the grid runs directly into the curve from the test probe. The two "ends" of the fall-of-potential graph have been compressed together, thereby eliminating the plateau between which marks the desired measurement. The point at which the limit of resistance associated with the grid occurs may be somewhere in the graph, but no amount of eyeballing will distin-





which gives the value of  $d_{PT}/d_C$  for various values of  $\mu$ . From this table a simple equation yields the distance at which the potential probe should be placed using the known distance to the current probe. Supposing that the critical measurements are 2.1, 4.8, and 6.6 ohms, and the distance to the "C" probe is 100 feet, let's look at a sample calculation:

$$\frac{6.6 - 4.8}{4.8 - 2.1} = \frac{1.8}{2.7} = 0.667$$

Looking up the  $\mu$  value of 0.667 from the standard table yields a slope coefficient ( $d_{PT}/d_C$ ) of 0.6027. As the distance to the current probe ( $d_C$ ) is known, we can solve for  $d_{PT}$ :

$$d_{PT}/d_C = 0.667 \quad d_{PT} = 0.667 \times 100 = 66.7 \text{ feet to P probe}$$

guish where grid resistance stops and probe resistance begins. However, the slope method can make this distinction!

The critical data points will be measurements made with the potential probe placed at 0.2, 0.4, and 0.6 times the distance to the current probe. These points are called  $R_1$ ,  $R_2$ , and  $R_3$ , respectively. These positions are chosen because readings taken too close to the grid will have errors since the current flow can not be approximated to that from a hemisphere, upon which the theory is based. Too great a distance will bring errors from the influence of the current spike. The latter is positioned somewhat arbitrarily, but it is best to obtain as much distance as the site will allow.

While these three readings are the ones that will be put through the mathematical exercise, the operator may find it useful to take additional readings and to construct a partial graph. Since the electrical center of the grid is not known, precise measurements and a neat graph, such as could be obtained from a single ground rod, are not possible. Rather, any graph will begin somewhere along the rising curve from the test electrode. Plotting a number of additional points may seem pointless, but, in fact, it serves as a safety net to eliminate localized abnormal highs and lows that could make the subsequent calculation unintelligible or even result in a negative value. This additional step helps to eliminate obviously "bad" readings from further consideration and can be of use in final analysis, as will be explained.

Next, the slope coefficient ( $\mu$ ), showing the rate of change of slope, can be calculated from the formula:

$$\mu = \frac{R_3 - R_2}{R_2 - R_1}$$

A relationship can be derived between the slope coefficient, the distance to the current probe ( $d_C$ ), and the distance at which the potential probe would measure the true earth resistance ( $d_{PT}$ ). A table can be commonly found in the literature,

Therefore, if the potential probe were placed at this distance, the reading would indicate the measurement of ground resistance. Finding the measurement of ground resistance could be accomplished by physically moving the probe to that point or if a partial graph had been constructed, as was mentioned earlier, the reading could be taken from the graph. If the crew isn't especially fond of math they could take a sufficient number of data points back to the lab for a supervisor or engineer to analyze. Note that our example also coincided nicely with the well known "62 percent rule" for potential probe spacing, which will be discussed in a future column.

But the crew is not done yet. Recall that the method "may" find the point at which ground resistance ceases to increase. There are a number of problems even this specialized technique may not address. For example, what if the current probe is within the ground field? For large grids, this may well be so. An obvious indication is when the calculated  $\mu$  value cannot be found on the table. If this happens, some more room must be found in order to move the current probe further.

Even when an intelligible calculation is achieved from this method, however, it is still risky to rely on a single test. In order to eliminate localized effects and uncharacteristic readings, it is better to proof the reading through additional tests taken in other directions and at greater probe distances. It may be found that the readings get lower with distance, but this is only because the shorter tests were performed too close. With increasing distances, readings will begin to come together. That agreement provides assurance the measurement is reliable.

Although the slope method requires extra work one will find that this method is an indispensable ally for the most difficult test sites.

In the next issue we will examine some additional methods for handling tight spaces. Ⓞ

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**36-300 Material and minimum size of grounding conductor and ground grid conductor and connections (see Appendix B)**

(1) Except as provided for in Subrule (2), bare copper conductors shall be used for grounding purposes and shall be not smaller than those specified in Rules 36-302 to 36-310 and Table 51.

Δ (2) Notwithstanding the requirement of Subrule (1), a galvanized steel, copper-weld, or other conductor shall be permitted for grounding purposes, provided that

(a) its current-carrying rating is equal to or greater than that of the copper conductor specified in Rules 36-302 to 36-310;

(b) consideration is given to galvanic action if such conductors are buried in the ground or come in contact with dissimilar metals; and

(c) the method of bolting or connecting such conductors to each other and to other surfaces is such as to maintain the required current-carrying capacity for the life of the electrode design.

**36-302 Station ground electrode (see Appendix B)**

(1) Every outdoor station shall be grounded by means of a station ground electrode that shall meet the requirements of Rule 36-304 and shall

(a) consist of a minimum of four driven ground rods not less than 3 m long and 19.0 mm in diameter spaced at least the rod length apart and, where practicable, located adjacent to the equipment to be grounded;

(b) have the ground rods interconnected by ground grid conductors not less than No. 2/0 AWG bare copper buried to a maximum depth of 600 mm below the rough station grade and a minimum depth of 150 mm below the finished station grade; and

(c) have the station ground grid conductors in Item (b) connected to all non-current-carrying metal parts of equipment and structures and shall form a loop around the equipment to be grounded, except that

(i) a portion of the loop shall be permitted to be omitted where an obstacle such as a wall prevents a person from standing on the corresponding side or sides of the equipment; and

(ii) loops formed by the rebar in a reinforced concrete slab are adequate when the rebar members are interconnected and reliably connected to all other parts of the station ground electrode.

(2) Where a deviation has been allowed in accordance with Rule 2-030, a buried station ground electrode other than that described in Subrule (1) shall be permitted to be used.

(3) Where it is not practicable to locate the station ground electrode adjacent to the station as described in Subrule (1), the station ground electrode shall be permitted to be remote from the station, and

(a) two grounding conductors of a minimum of No. 2/0 AWG copper shall connect the ground electrode to the station equipment in such a way that should one grounding conductor or ground electrode be damaged, no single metal structure or equipment frame may become isolated; and

(b) in locations with system short-circuit currents exceeding 30 000 A, the grounding conductor wire size shall be increased and shall be such that it will not suffer thermal damage or be a fire hazard under the severest fault conditions occurring on the system.

(4) Every indoor station shall be grounded by means of a station ground electrode

(a) in accordance with Subrule (1), (2), or (3); or

(b) if it is not practicable to ground an indoor station in accordance with Subrule (1), (2), or (3) and the indoor station receives its supply from a main station on the same property, the station equipment shall be connected to the main station ground electrode in accordance with Subrule (3).

(5) All parts of the indoor station that are required to be grounded shall be connected together by copper conductors of not less than No. 2/0 AWG.

- (6) The reinforcing steel members to be found in building foundations and concrete platforms shall be permitted to be included as part of the station ground electrode design, provided that
- (a) no insulating film separates the concrete from the surrounding soil;
  - (b) the maximum expected fault current magnitude and duration will not result in thermal damage to the steel members or the concrete structure;
  - (c) the steel members are connected to the rest of the station ground electrode with not less than 2 copper conductors of not less than No. 2/0 AWG in such a way that, should one grounding conductor or ground electrode be damaged, no single metal structure or equipment frame may become isolated; and
  - (d) the ground electrode design is based on the assumption that the concrete resistivity is greater than or equal to that of the surrounding soil.

**36-304 Station ground resistance** (see Appendix B)

- (1) The maximum permissible resistance of the station ground electrode shall be determined by the maximum available ground fault current injected into the ground by the station ground electrode or by the maximum fault current in the station, and the ground resistance shall be such that under all soil conditions that exist in practice (e.g., wet, dry, and frozen conditions), the maximum ground fault current conditions shall limit the potential rise of all parts of the station ground grid to 5000 V; whereas in special circumstances where this level cannot be reasonably achieved, a higher voltage up to the maximum insulation level of the communication equipment shall be permitted where a deviation has been allowed in accordance with Rule 2-030.
- (2) In addition to the requirements of Subrule (1), the touch and step voltage at the edge, within, and around the station grounding electrode, including all areas in which metallic structures electrically connected to the station are to be found, shall not exceed the tolerable values specified in Table 52.
- (3) When a station ground electrode design is selected according to the procedure delineated in Appendix B and when it is proven that the station parameters used in the procedure are valid, this electrode design shall be deemed to meet the requirements of Subrules (1) and (2).
- (4) After completion of construction, the resistance of the station ground electrode at each station shall be measured and changes shall be made if necessary to verify and ensure that the maximum permissible resistance of Subrule (1) is not exceeded.
- (5) Where the safety of persons depends on the integral presence of a ground surface covering layer, such as crushed rock or asphalt, the ground surface covering layer shall exist throughout the station grounding electrode area, including all areas in which metallic structures electrically connected to the station are to be found and shall extend at least 1 m beyond the station grounding electrode area on all sides.

**36-306 Station exemption**

Where the phase-to-phase voltage is less than or equal to 7500 V and a ground surface covering layer with a minimum thickness of 150 mm is installed and maintained as specified in Rule 36-304(5) and it can be demonstrated that the potential rise (GPR) of a station shall not exceed the tolerable touch and step voltages specified in Table 52 during the lifetime of the station, the following exemptions shall apply:

- (a) no soil resistivity measurements need be made at the station site;
- (b) notwithstanding Rule 36-304(2), no analysis is required to prove that touch and step voltages within the station grounding electrode area shall not exceed tolerable values; and
- (c) notwithstanding Rule 36-304(4), neither the resistance of the station ground electrode nor the touch voltage near the centre or corner of the ground electrode need be measured after completion of construction.

**36-308 Connections to the station ground electrode** (see Appendix B)

- (1) All non-current-carrying metal equipment and structures forming part of the station shall

be grounded to the station ground electrode to prevent the buildup of dangerous potential differences between the equipment or structures and the nearby earth.

- (2) All metal items forming part of the station shall be connected to the station ground electrode as follows:
- (a) metal structures:
    - (i) single columns or pedestal-type (pipe, etc.) structures shall be grounded by a grounding conductor not less than No. 2/0 AWG copper; and
    - (ii) single and multi-bay structures shall be bonded to ground at each column by a bonding conductor not less than No. 2/0 AWG copper;
  - (b) apparatus mounted on metallic or non-metallic structures:
    - (i) tanks or frames of transformers, generators, motors, circuit breakers, reclosers, instrument transformers, switchgear, and other equipment shall be grounded by grounding conductors of not less than No. 2/0 AWG copper;
    - (ii) metal bases of all gang-operated switches shall be grounded by a grounding conductor of not less than No. 2/0 AWG copper (for switch handles see Rule 36-310); and
    - (iii) the grounding of metal bases of single-pole fuse cut-outs and isolating switches on wood structures is optional;
  - (c) lightning arresters:
    - (i) the lightning arresters shall be connected to the station ground electrode by a conductor of not less than No. 2/0 AWG copper;
    - (ii) lightning arrester grounding conductors shall be as short, straight, and direct as practicable; and
    - (iii) where lightning arresters are for the protection of high-voltage cable and cable sheath, the lightning arrester grounding conductor shall be connected to metal potheads and/or metal sheath or armour or shielding of all cables;
  - (d) a metal water main inside or adjacent to the station ground electrode area shall be grounded by at least one copper conductor of not less than No. 2/0 AWG copper, at intervals not exceeding 12 m;
  - (e) the non-current-carrying parts of metal equipment, such as
    - (i) cable sheaths, cable armour, shield, ground wires, potheads, raceways, pipe work, screen guards, and switchboards, shall be grounded by copper conductor of not less than No. 4 AWG;
    - (ii) meter, instrument, and relay cases, when mounted on insulated panels, shall be grounded by a copper conductor of not less than No. 10 AWG; and
    - (iii) the metal frame and all exposed metal work on buildings within or forming part of the station, shall be grounded to the station ground electrode by a minimum of No. 2/0 AWG copper in at least two places and at intervals not exceeding 12 m along the building perimeter;
  - (f) steel rails of railway spur tracks entering an outdoor station ground electrode area by a copper conductor of not less than No. 2/0 AWG with the part of the spur track located outside the station ground electrode area properly isolated from the station ground electrode or grounded or both in order that touch voltages along the track not exceed the tolerable values specified in Table 52.
- (3) Where it is proven that touch and step potentials around a building shall not exceed the tolerable values specified in Table 52, no loop need be installed around the building.
- (4) A transmission line overhead ground wire shall be connected to the station ground electrode with a grounding conductor of not less than No. 2/0 AWG copper that, notwithstanding Rule 36-300(1), shall be permitted to be insulated.
- (5) A line neutral conductor on grounded neutral systems shall be connected to the station ground electrode by a grounding conductor having an ampacity not less than the neutral conductor.
- Δ (6) A transformer neutral on solidly grounded neutral systems shall be connected to the station ground electrode by a copper conductor sized as follows:
- (a) conductors for grounding primary and secondary neutrals shall be not less than No. 2/0

AWG and have sufficient ampacity to carry the maximum ground fault current of the transformer in accordance with Table 51, and this grounding conductor shall be in addition to the requirement of Subrule (2)(b)(i); and

(b) notwithstanding Subrule (6)(a), conductors for grounding low-voltage secondary neutrals shall be sized in accordance with Section 10, provided that the size selected is suitable for the maximum ground fault current on the transformer secondary.

(7) Connections to the items in Subrules (2)(d), (4), and (5) shall be made through removable connectors that will permit isolation from the station ground electrode for the purpose of station ground grid resistance measurement.

### **36-310 Gang-operated switch handle grounds**

(1) The operating handle of all gang-operated switches not enclosed in metal housings shall be grounded by one of the following methods:

(a) an approved, multi-revolution grounding device shall be connected to the station ground electrode by a conductor having a current-carrying capacity of not less than No. 2/0 AWG copper; or

(b) the operating shaft shall be grounded to the station ground electrode by a combination of extra-flexible conductor, braid, and/or stranded conductor of not less than No. 2/0 AWG copper.

(2) In addition to the requirements of Subrule (1), the touch voltage shall be maintained at a tolerable level as specified in Table 52 at the location where the operator is normally standing and shall be done as follows:

(a) by the use of a metallic gradient control mat connected to the operating handle grounding conductor as required in Subrule (1) by two separate conductors, each not less than No. 2/0 AWG copper; and

(b) the gradient control mat shall

(i) be positioned so that the operator will not be required to step from the mat during the operation of the switch;

(ii) be placed on a minimum of 150 mm of crushed stone on the ground;

(iii) have dimensions approximately 1.2 m × 1.8 m; and

(iv) be permitted to be covered by a layer of crushed stone, asphalt, or concrete not exceeding 150 mm in depth.

### **36-312 Grounding of metallic fence enclosures of outdoor stations**

(1) The fence shall be located at least 1 m inside the perimeter of the station ground electrode area.

(2) The station ground electrode shall be connected to the fence by a tap conductor at each end post, corner post, and gate post, and at intermediate posts at intervals not exceeding 12 m by a conductor of not less than No. 2/0 AWG copper.

(3) The tap conductor at each hinge gate post shall be clamped or bonded to the gate frame by a copper braid or a flexible copper conductor of at least No. 2/0 AWG.

(4) The tap conductor shall be connected to the fence post, the bottom tension wire, the fence fabric (for which the conductor may be woven in at least two places), the top rail, and each strand of barbed wire, with the connection to the bottom tension wire, the fence fabric, and barbed wire strands made with bolted or equivalent connectors, and with the top rail connections bonded at every joint by a jumper equivalent to No. 2/0 AWG copper.

(5) When there is a metal boundary fence in proximity to the station fence, the touch voltages within 1 m of all parts of the boundary fence shall not exceed the tolerable values specified in Table 52.

## **Section 38 — Elevators, dumbwaiters, material lifts, escalators, moving walks, lifts for persons with physical disabilities, and**



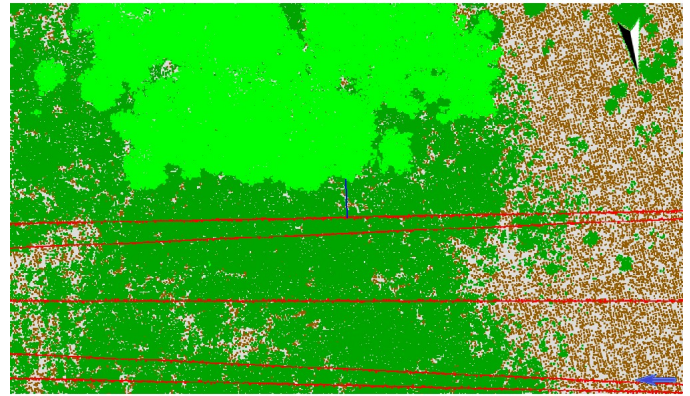
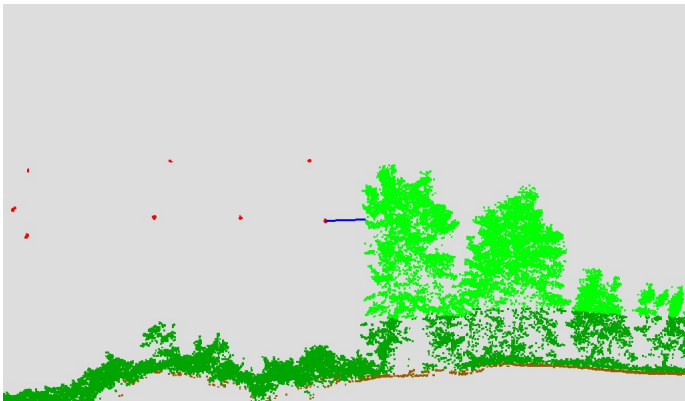
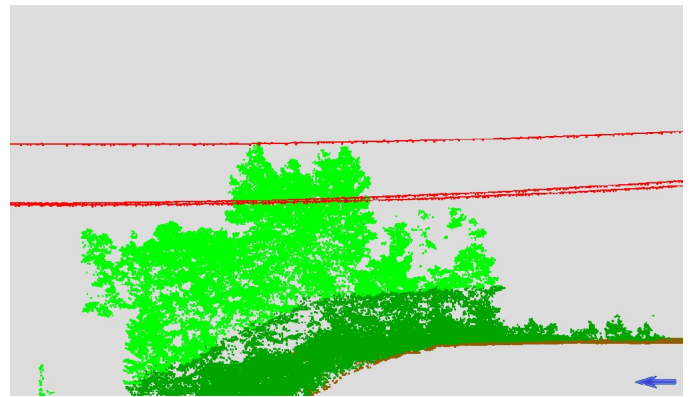


Line Name: **K24G Third line TS - Junction1**

Date Surveyed: **10-Aug-2009**

Situation ID	<b>veg_00002</b>
SituationType	<b>Vegetation Clearance</b>
Latitude	<b>46.556126</b>
Longitude	<b>-84.330289</b>
Distance to Wire (m)	<b>3.43</b>
Object Height (m)	<b>14.03</b>
Distance From 1st Structure in Span (m)	<b>71.50</b>
Clearance Criteria (m)	<b>4.57</b>
Conductor Condition	<b>As surveyed</b>
Line Voltage (kV)	<b>230</b>
Comment	

Spanning	Between	And
Structure ID	<b>2</b>	<b>3</b>
Latitude	<b>46.556083</b>	<b>46.556335</b>
Longitude	<b>-84.329359</b>	<b>-84.330989</b>
Span Length (m)	<b>128.01</b>	



**GREAT LAKES POWER LIMITED**

**- and -**

**CIBC MELLON TRUST COMPANY**

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**DEED OF TRUST**  
**Made as of March 12, 2008**

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**Providing for the issue  
of Senior Secured Bonds and  
Subordinate Secured Bonds**

**McCarthy Tétrault LLP**

**Torys LLP**



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THIS INDENTURE made as of the 12<sup>th</sup> day of March, 2008.

BETWEEN:

**GREAT LAKES POWER LIMITED**, a corporation  
incorporated under the laws of Ontario,

(hereinafter called the “**Company**”)

OF THE FIRST PART

- and -

**CIBC MELLON TRUST COMPANY**, a trust corporation  
existing under the laws of Canada and duly authorized to carry on  
the business of a trust company in the Provinces and Territories of  
Canada,

(hereinafter called the “**Trustee**”)

OF THE SECOND PART

**WITNESSES THAT:**

**WHEREAS** as of the date hereof the Company holds good title in fee simple to  
the Lands;

**AND WHEREAS** the Company is desirous of issuing Bonds for the purposes of  
replacing certain outstanding bonds issued by the Company and raising money from time to time  
through the issuance of additional Bonds for general corporate purposes, the issuance of which  
Bonds is provided for by this indenture;

**AND WHEREAS** all necessary by-laws and resolutions of the directors and  
shareholders of the Company have been duly enacted and passed and other proceedings taken  
and conditions complied with to make the creation and issue of the Bonds proposed to be issued  
under this indenture and the execution thereof legal and valid and in accordance with the laws  
relating to the Company and with all other laws and regulations in that behalf;

**AND WHEREAS** the foregoing recitals are made as representations and  
statements of fact by the Company and not by the Trustee;

**NOW THEREFORE IT IS HEREBY AGREED AS FOLLOWS:**

**ARTICLE 1**  
**INTERPRETATION**

**Section 1.1 Definitions**

In this indenture, unless there is something in the subject matter or context inconsistent therewith:

- (a) **“Accounts Receivable”** means indebtedness owing by a person to the Company in respect to inventory sold (including, without limitation, electricity) or services provided in connection with the Transmission Business;
- (b) **“Acknowledgement and Consent”** means an acknowledgement and consent agreement executed and delivered in favour of the Trustee by (i) a party to a Material Contract (other than the Company), (ii) GLPL with respect to the purchase and sale agreement between GLPL and GLPT dated December 11, 2007, in each case acknowledging and consenting to the assignment of such agreement in favour of the Trustee pursuant to the Assignment of Material Contracts;
- (c) **“Addition”** means any buildings, erections, improvements, fixtures, machinery, equipment, plant, construction or development owned, leased or licensed by the Company, constructed or acquired after the date hereof and used in connection with the Transmission Business and located on the Power Real Estate (in addition to the Existing Improvements) including, without limitation, any expansion, renovation, replacement, redevelopment and/or refurbishing of the Existing Improvements and, in the case of demolition of existing structures, includes any Addition or any reconstruction or development in connection therewith;
- (d) **“Additional Bonds”** means Senior Bonds issued in one or more series hereunder from time to time hereunder in addition to the Series 1 Senior Bonds;
- (e) **“Affiliate”** means, with respect to any person, any person directly or indirectly controlled by, controlling or under common control with such person; where **“control”** includes (i) the ownership of or power to vote, directly or indirectly, shares, or the equivalent, representing 50% or more of the power to vote in the election of directors, managers, trustees or persons performing similar functions for that person, (ii) the ownership of 50% or more of the equity or beneficial interest in that person, (iii) the ownership of or power to vote directly or indirectly, shares or the equivalent, representing at least 20% of the voting rights attributable to the shares or interests in such other person, which enables the first person to, directly or indirectly, direct or cause the direction of the management or policies of such person, or (iv) with

respect to a partnership, control (as otherwise determined in accordance with this definition) of a general partner of such partnership;

- (f) **“Affiliate Debt”** means any indebtedness or obligations of any nature or kind owing by the Company to any Affiliate of the Company, including obligations in respect of any swap or hedging agreement or derivative transaction;
- (g) **“Annual Operating Report”** means the management report to be prepared annually by the Company and submitted to the bondholders in respect of each of its Fiscal Years, which will include without limitation, for the relevant Fiscal Year, an analysis of the actual performance against that set forth in the applicable Operating Plan, together with such explanations and supporting data as is reasonably necessary to inform the bondholders of the reasons for deviations from the applicable Operating Plan, the ongoing implications to the Company for such deviations, an outline of capital expenditures (including, without limitation, maintenance capital expenditures) incurred, a description of any material operational, contractual and environmental issues the Company had dealt with during such Fiscal Year and the impact of same upon the Company’s performance;
- (h) **“Applicable Law”** means, in respect of any person, property, transaction or event, all applicable laws, statutes, common law, ordinances, rules, by-laws, treaties and Regulations, and all applicable directives, rules, guidelines, standards, requirements, policies, Orders, judgments, injunctions, awards and decrees of Governmental Authorities having the force of law;
- (i) **“Arm’s Length”** has the meaning ascribed to it, as of the date hereof, in the *Income Tax Act* (Canada);
- (j) **“Assignment of Insurance”** means the assignment of insurance dated as of March 12, 2008 made by the Company in favour of the Trustee, as such assignment may be amended, restated or replaced from time to time;
- (k) **“Assignment of Material Contracts”** means the assignment of material contracts dated as of March 12, 2008 made by the Company in favour of the Trustee, as such assignment may be amended, restated or replaced from time to time;
- (l) **“Bond Purchase Agreements”** means the purchase agreements in respect of any Bonds between the Company and the relevant bondholders, as such agreements may be amended, modified, supplemented, restated or replaced from time to time;
- (m) **“bondholders”** or **“holders”** means those persons from time to time entered in the register or registers hereinafter mentioned as holders of any of the Bonds;

- (n) **“Bondholders’ Request”** means, at any time, an instrument signed in one or more counterparts by the holders of not less than 35% in principal amount of the Senior Bonds, Subordinate Bonds or all Bonds (as applicable) outstanding at such time requesting the Trustee to take the action or proceeding specified therein;
- (o) **“Bonds”** means, collectively, the Senior Bonds and the Subordinate Bonds;
- (p) **“Business”** or **“Transmission Business”** means the business carried on by the Company consisting of the owning, operating and maintaining of electricity transmission facilities in the Province of Ontario and the transmission of electricity by way of such facilities, and all matters incidental and/or ancillary thereto;
- (q) **“business day”** means a day other than a Saturday, Sunday or a statutory holiday in the Province of Ontario;
- (r) **“Canadian Dollars”** or **“\$”** means lawful money of Canada;
- (s) **“Capital Lease Obligations”** means the obligations of the Company (specifically relating to the Transmission Business) to pay rent or other amounts under a lease of (or other agreement conveying the right to use) real or personal property, which obligations are required to be classified and accounted for as a capital lease on a balance sheet of the Transmission Business under GAAP and, for purposes of this indenture, the amount of such obligations will in each case be the capitalized amount thereof, determined in accordance with GAAP;
- (t) **“Certified Resolution”** means a copy of a resolution of the directors of the Company certified by the Secretary or an Assistant Secretary of the Company, have been duly passed by the directors of the Company and to be in full force and effect on the date of such certification;
- (u) **“Chartered Accountant”** means any Arm’s Length firm of chartered accountants (whether or not such firm of accountants regularly acts for the Company), selected by the Company, licensed under the *Public Accountancy Act* (Ontario) and of nationally recognized standing and reputation;
- (v) **“Chartered Accountant’s Certificate”** means a certificate conforming to the requirements of Section 17.12, signed by a Chartered Accountant;
- (w) **“Collateral”** means cash, a certified cheque or official bank draft of a Permitted Financial Institution, a Letter of Credit or Permitted Investments;
- (x) **“Company”** means Great Lakes Power Limited and any successor permitted hereunder, including, without limiting the foregoing, GLPT if it acquires the Secured Assets as permitted by Section 6.10; provided that if GLPT becomes the Company for purposes of this indenture and the Operative Documents,



the “Company” shall no longer include GLPL and references to resolutions, officers or directors of the Company will be to resolutions, officers or directors of the general partner of GLPT;

- (y) “**Company Counsel**” means Torys LLP or any other firm appointed by the Company;
- (z) “**Contingent Obligations**” means, as to any person, any obligation, whether secured or unsecured, of such person guaranteeing or indemnifying, or in effect guaranteeing or indemnifying, any indebtedness, leases, dividends, letters of credit or other obligations of any other person in any manner, whether directly or indirectly;
- (aa) “**Conversion Representation Agreement**” means the representation and warranty agreement to be executed by GLPT in favour of each holder of a Series 1 Senior Bond as of the date such Bond was issued to such holder upon the conversion of its Series 1 Senior Bond issued pursuant to the trust indenture dated as of June 16, 2003 between the Company, as issuer, and CIBC Mellon Trust Company, as trustee, as the same has been amended or supplemented to the date hereof;
- (bb) “**Counsel**” means any firm of solicitors retained by the Trustee or retained by the Company and acceptable to the Trustee from time to time, acting reasonably, to act on behalf of the Trustee and the bondholders, and may be a person or firm regularly retained by the Company and, as of the date hereof, is McCarthy Tétrault LLP; notwithstanding the foregoing, the holders of the Senior Bonds (and the holders of Subordinate Bonds if there are no Senior Bonds) may, from time to time and by Ordinary Resolution, direct the Trustee to retain such firm of solicitors to act on behalf of the Trustee and the bondholders as is acceptable to them and to the Trustee;
- (cc) “**D&C Assets**” means, collectively, all property, assets, contracts, permits, rights, licenses, franchises and undertaking of GLPL, whether real, personal or mixed, tangible or intangible, of every nature, kind and description, wherever located, that are owned, leased or licensed by GLPL and are used solely in connection with the D&C Business, including GLPL’s low-voltage distribution system, its 11 distribution stations, approximately 1,700 km of low voltage lines and its office building and control centre located in Sault Ste. Marie, Ontario, provided that to the extent that GLPL has only a co-ownership interest in any such property, asset, contract, permit, right, licence, franchise or undertaking, it is such co-ownership interest that constitutes a D&C Asset;
- (dd) “**D&C Business**” means the business carried on by GLPL consisting of owning, operating and maintaining low-voltage electricity distribution and telecommunications facilities and all matters incidental and/or ancillary thereto;

- (ee) **"DBRS"** means DBRS Limited and its successors and assigns;
- (ff) **"Debenture"** means the \$1,000,000,000 demand debenture dated as of March 12, 2008 made on behalf of the Company by the Nominee in favour of the Trustee, as such debenture may be amended, restated or replaced from time to time;
- (gg) **"Debt Service"** means the aggregate amount of interest and principal paid or required to be paid by the Company in connection with all Bonds and other Indebtedness of the Company;
- (hh) **"Debt Service Reserve Account"** means the account in the name of the Trustee in trust for the Company established pursuant to Section 6.23 of this indenture and maintained and held as security for the benefit of the holders of Senior Bonds by the Trustee at a Permitted Financial Institution;
- (ii) **"Default"** means an event or condition, the occurrence of which would, with the lapse of time or the giving of notice, or both, become an Event of Default;
- (jj) **"directors"** means the board of directors of the Company, or whenever duly empowered, the executive committee (if any) of the board of directors of the Company, and reference without more to action by the directors or by the board of directors means action by the directors as a board or by the executive committee as such;
- (kk) **"Distribution"** means, in respect of the Company, any (i) distribution of any nature or kind, either directly or indirectly, to any Affiliate, partner or shareholder of the Company or to any Non-Arm's Length Person including without limitation, a dividend or distribution in cash or specie; a purchase, redemption, reduction, return or any other payment of capital; or any repayment or reduction of loans or other indebtedness owing to an Affiliate, partner or shareholder of the Company or to any Non-Arm's Length Person; (ii) loans or other payments to an Affiliate, partner or shareholder of the Company or to any Non-Arm's Length Person, and (iii) payment for or on behalf of an Affiliate, partner or shareholder of the Company or on behalf of any Non-Arm's Length Person by way of guaranty, indemnity or otherwise including in connection with any Affiliate Debt; but will not include any payments made to any shareholder, Affiliate or partner of the Company or to any Non-Arm's Length Person under any services, advisory or agency agreement disclosed to the Trustee and entered into on commercially reasonable terms and conditions and will not include the issuance of shares or partnership units by the Company to an Affiliate or partner in satisfaction of indebtedness owing by the Company to such Affiliate or partner;
- (ll) **"EBITDA"** of the Transmission Business for any period means the net income of the Transmission Business for such period before extraordinary gains or losses (such extraordinary gains to include, without limitation, (a)

any gains in excess of losses resulting from the sale, conversion or other disposition of capital assets (i.e., assets other than current assets), (b) any gains resulting from the write-up of assets, (c) any earnings of any person acquired by the Company through purchase, merger or consolidation or otherwise for any period prior to the date of acquisition, (d) any gains from the acquisition of securities or the retirement or extinguishment of Indebtedness, (e) any gains on collections from the proceeds of insurance policies or settlements, (f) any restoration to income of any contingency reserve, except to the extent that provision for such reserve was made out of income accrued during such period, or (g) any income or gain during such period from any change in accounting principles, from any discontinued operations or the disposition thereof, from any extraordinary items or from any prior period adjustments, which in the aggregate will be deducted only to the extent they are positive) and before deducting interest, taxes (whether current or deferred), depreciation, amortization and other non-cash deductions deducted in calculating such net income of the Transmission Business, all as determined in accordance with GAAP;

- (mm) “**Environmental Laws**” means all Applicable Laws, Notices and Permits in effect as at the date hereof and as may be brought into effect at a future date, with respect to environmental matters;
- (nn) “**Event of Default**” means an Event of Default as defined in Section 9.1 and includes an Event of Default as defined in and created by any indenture supplemental hereto;
- (oo) “**Excluded Assets**” means, collectively, (i) the Excluded Subsidiaries and the Company’s interests therein (including, for so long as the Company is GLPL, any receivables owed to the Company by any Excluded Subsidiary), (ii) the businesses carried on by the Excluded Subsidiaries, (iii) the assets possessed by the Excluded Subsidiaries, (iv) the Generation Business and the Generation Assets, and (v) the D&C Business and the D&C Assets;
- (pp) “**Excluded Subsidiaries**” means, collectively, (i) BrasPower Equity Inc., First Toronto Equities Inc., Lake Superior Power Inc., Lake Superior Power Limited Partnership, Valerie Falls General Partner Limited, Valerie Falls Power Limited Partnership, Western Pacific Powergen Corp., Harmony Wind Energy Inc. and Brookfield Power Wind Corporation, (ii) any corporation or partnership acquired by the Company in consideration or substitution for, or as a successor of, any of the foregoing, and (iii) each corporation or partnership that is directly or indirectly owned by any person described in subparagraphs (i) or (ii) of this definition.
- (qq) “**Existing Improvements**” means all sub-stations and all other buildings and Improvements in each case owned, licensed or leased by the Company and located on the Power Real Estate on the date hereof and used in connection with the Transmission Business;

- (rr) “**Extraordinary Resolution**” has the meaning ascribed thereto by Section 16.2;
- (ss) “**Fiscal Year**” means, in respect to the Company, each consecutive period of days commencing on January 1st in each year and ending on the last day of December next following, provided that the commencement date and expiry date of a fiscal year may be changed by the Company from time to time;
- (tt) “**Fitch**” means Fitch Ratings Ltd. and its successors and assigns;
- (uu) “**Future Sites**” means any real property of which the Company becomes the owner or in which it acquires rights, in each case after the date hereof, where such property or rights are used in connection with the Transmission Business;
- (vv) “**GAAP**” means generally accepted accounting principles in Canada consistently applied which are in effect from time to time;
- (ww) “**Generation Assets**” means, collectively, all property, assets, contracts, permits, rights, licenses, franchises and undertaking of GLPL, whether real, personal or mixed, tangible or intangible, of every nature, kind and description, wherever located, that are owned, leased or licensed by GLPL and are used in connection with the Generation Business, provided that to the extent that GLPL has only a co-ownership interest in any such property, asset, contract, permit, right, licence, franchise or undertaking, it is such co-ownership interest that constitutes a Generation Asset;
- (xx) “**Generation Business**” means the business carried on by GLPL consisting of owning, operating and maintaining hydro electric generating facilities in the Province of Ontario and the sale of electricity generated therefrom, and all matters incidental and/or ancillary thereto;
- (yy) “**GLPL**” means Great Lakes Power Limited and its successors;
- (zz) “**GLPT**” means Great Lakes Power Transmission LP, a limited partnership formed under the laws of Ontario and its successors;
- (aaa) “**GLPT GP**” means Great Lakes Power Transmission Inc., the general partner of the GLPT, or any successor thereto in such capacity;
- (bbb) “**Good Utility Practices**” means the practices, methods and acts engaged in or adopted by a significant portion of the electric transmission industry in Canada during the relevant time period as good practices applicable to electric transmission facilities of similar design, size and capacity as those of the Company, or any of the practices, methods and acts which, in the exercise of reasonable judgment by a prudent electric transmission facility owner in light of the facts known at the time the decision was made, would reasonably have been expected to accomplish the desired result at a reasonable cost

consistent with good business practices, reliability, safety, environmental protection, economy, and expedition. Good Utility Practices are not intended to be limited to the optimal practices, methods or acts to the exclusion of all others, but rather practices, methods or acts generally accepted in the Canadian electric transmission industry having regard to Applicable Laws;

- (ccc) **“Governmental Authority”** means any government, parliament, legislature, or any regulatory authority, agency, commission or board of any government, parliament or legislature, or any subdivision thereof, or any court or (without limitation to the foregoing) any other law, regulation or rule-making entity, having or purporting to have jurisdiction in the relevant circumstances, or any person acting under the authority of any of the foregoing (including, without limitation, any arbitrator with the authority to bind the parties at law) or any other authority charged with the administration or enforcement of Applicable Laws;
- (ddd) **“GSA”** means the general security agreement dated as of March 12, 2008 made by the Company in favour of the Trustee, as such agreement may be amended, restated or replaced from time to time;
- (eee) **“Hazardous Substance”** means any substance or material that is prohibited, controlled or regulated by any Governmental Authority pursuant to Environmental Laws, including, but not limited to, any contaminants, pollutants, petroleum and other hydrocarbons and their derivatives and by-products, dangerous substances or goods, including asbestos, gaseous, solid and liquid wastes, special wastes, toxic substances, hazardous or toxic chemicals, hazardous wastes, hazardous materials or hazardous substances as defined in or pursuant to any Environmental Law;
- (fff) **“Impair the Security”** means, in the case of Permitted Encumbrances, encumbrances which individually or in the aggregate will materially adversely impair the value of the Transmission Business or the Power Assets or materially interfere with the use of the Power Assets for the purposes for which they are held;
- (ggg) **“Improvements”** means, collectively, the Existing Improvements and any Additions and includes all fixed machinery, plant, equipment, apparatus and fittings and other fixtures now or at any time hereafter owned by the Company and constructed, brought or placed upon the Power Real Estate or incorporated into the Existing Improvements or Additions, but excluding any part or parts thereof released, from time to time, from the Liens created by the Security;
- (hhh) **“Included Subsidiaries”** means, collectively, 1228185 Ontario Limited and the Nominee;

- (iii) **“Indebtedness”** of any person means (i) any indebtedness for money borrowed or raised and any interest thereon, (ii) any liability under any bond, note or other security or under any credit facility, (iii) accounts payable that are greater than 90 days in arrears and which are not being contested in good faith, (iv) any Capital Lease Obligation, (v) any Contingent Obligations, (vi) for the purpose of determining Indebtedness of the Company, any indebtedness, liability or obligation secured by a Lien on all or any of the Secured Assets whether or not the Company has assumed or become liable for the payment or performance thereof and (vii) any other obligation arising under arrangements or agreements that, in substance, provide financing to such person and which, in accordance with GAAP, would be classified upon a balance sheet as a liability (absolute or contingent) of such person; but, for greater certainty, does not include deferred taxes, trade or account payables (other than as provided for in (iii) above) and accrued liabilities;
- (jjj) **“Independent Engineers’ Certificate”** means a certificate of an engineer duly licensed and qualified in the Province of Ontario and in the employ of an engineering firm of nationally recognized standing and reputation, selected by the Company, which engineer must not be a director, officer or employee of the Company or any of the Company’s Affiliates and must be at Arm’s Length with the Company;
- (kkk) **“Insurance Consultant”** means In Tech Risk Management Inc. or such other insurance consultant retained from time to time by the Trustee;
- (lll) **“Investment Dealer”** means any of Scotia Capital Inc., TD Securities Inc., CIBC World Markets Inc., RBC Dominion Securities Inc., BMO Nesbitt Burns Inc. or any of their respective successors, or any other recognized investment dealer who is a member of the Investment Dealers’ Association of Canada (or any successor association thereto) selected by the Trustee and approved by the bondholders, as evidenced by an Ordinary Resolution of the holders of the Senior Bonds (or, if no Senior Bonds are then outstanding, by an Ordinary Resolution of the holders of the Subordinate Bonds);
- (mmm) **“Investment Dealer’s Certificate”** means a certificate conforming to the requirements of Section 17.12, signed by an Investment Dealer;
- (nnn) **“Lands”** means the real property described in Schedule “A” upon which the Transmission Assets are located;
- (ooo) **“Letter of Credit”** means an irrevocable and unconditional letter of credit in form and substance acceptable to the Trustee, upon receipt of advice of Counsel, issued by one of the Permitted Financial Institutions naming the Trustee as beneficiary thereunder on behalf of the holders of the Senior Bonds, in the case of the Debt Service Reserve Account, and the holders of all Bonds, in any other case;

- (ppp) “**Lien**” means, with respect to any person, any mortgage, lien, pledge, adverse claim, charge, deed of trust, lis pendens, security interest, hypothec or other encumbrance, or any interest or title of any vendor, lessor, lender or other secured party to or of such person under any conditional sale or other title retention agreement or capital lease or any similar type of agreement, upon or with respect to any property or asset of such person;
- (qqq) “**Major Rating Agency**” means, any of S&P, DBRS, Moody’s or Fitch or any of their respective successors or, if such rating agencies or their successors do not remain in existence, such nationally recognized statistical rating agency or other comparable person designated by the Trustee and approved by Ordinary Resolution of the holders of the Senior Bonds (and if no Senior Bonds are outstanding, by the holders of Subordinate Bonds);
- (rrr) “**Make-Whole Amount**” means, with respect to any Bond, the excess, if any, of the then applicable Redemption Price of such Bond over the principal amount of such Bond;
- (sss) “**Manager**” means GLPL as manager pursuant to the Operation, Maintenance and Administration Agreement, any other person that is then party to the Operation, Maintenance and Administration Agreement as the manager in replacement of GLPL and any person who provides services to the Company of the nature of those provided by GLPL pursuant to the Operation, Maintenance and Administration Agreement.
- (ttt) “**Material Adverse Change**” means any event or occurrence that would reasonably be expected to result in a material adverse change to the financial condition or operation of the Transmission Business or the Power Assets or the Company’s ability to perform any of its obligations under this indenture or the Bonds, including any such loss resulting from the expropriation of any material portion of the Power Assets;
- (uuu) “**Material Contracts**” means the contracts and agreements set out in Schedule “B” to this indenture and any other contracts and agreements (other than those constituting Transmission Property Rights) entered into by the Company from time to time that are material to the operation or profitability of the Transmission Business, as the same may be amended, restated or replaced from time to time in compliance with Section 6.17 of this indenture;
- (vvv) “**Maturity Date**” for any Senior Bond means June 16, 2023 and, for any Subordinate Bond, means the maturity date applicable thereto specified in the indenture supplemental hereto creating such Subordinate Bond;
- (www) “**Minor Title Defects**” means title defects or irregularities which, (i) do not affect the validity of the Security, and (ii) are of a minor nature and, in the aggregate, will not materially impair the use of the Power Assets for the

purpose for which they are held by the Company or materially impair the value of the Power Asset that is affected by such defects or irregularities;

- (xxx) “**Moody’s**” means Moody’s Investors Service, Inc. and its successors and assigns;
- (yyy) “**Nominee**” means Great Lakes Power Transmission Holding Corp. and its successors and assigns;
- (zzz) “**Nominee Agreement**” means the nominee agreement between GLPL and the Nominee dated as of February 21, 2008, as the same may be amended, restated or replaced from time to time;
- (aaaa) “**Nominee Direction**” means the Nominee Direction and Acknowledgement dated as of March 12, 2008 made between GLPL, the Nominee and the Trustee, as the same may be amended, restated or replaced from time to time;
- (bbbb) “**Non-Arm’s Length Person**” means any person who does not deal at Arm’s Length with the Company within the meaning of such concept as used in the *Income Tax Act* (Canada).
- (cccc) “**Notice**” means any citation, Order, claim, litigation, inspection report, investigation report, complaint, proceeding, judgment, letter or other communication, written or oral, from any Governmental Authority;
- (dddd) “**Officers’ Certificate**” means a certificate in writing signed by any two of the Chairman of the Board, the President, Chief Financial Officer, Chief Executive Officer, a director, a Vice-President, the Treasurer, the Secretary, an Assistant Secretary or an Assistant Treasurer, in each case of the Company, and conforming *mutatis mutandis* to Section 17.12 of this indenture;
- (eeee) “**Operating Plan**” means, at any time, the Company’s operating plan for the forthcoming Fiscal Year in respect of the Transmission Business which will include for such Fiscal Year each of the following:
- (i) an annual budget including a forecast of projected revenues, expenses and capital expenditures;
  - (ii) an annual forecast of the capital expenditure projects, on a project-by-project basis, including the name of each capital expenditure project to be undertaken that has a cost in excess of \$250,000 and the estimated cost thereof, and the estimated total cost of all other capital expenditure projects; and
  - (iii) a description of the maintenance plan for such Fiscal Year.



- (ffff) **“Operation, Maintenance and Administration Agreement”** means the agreement to be entered into between GLPL and GLPT upon GLPT acquiring the Secured Assets in accordance with Section 6.10, pursuant to which GLPL will perform services required by GLPT in connection with its ownership, operation and maintenance of the Transmission Business and the Transmission Assets, as such agreement may be amended, restated or replaced from time to time in compliance with Section 6.17 of this indenture;
- (gggg) **“Operative Documents”** means:
- (i) this indenture, the Material Contracts, the Bond Purchase Agreements (if any), the Conversion Representation Agreement and the Security Agreements; and
  - (ii) any other indentures, undertakings and other agreements material to the Transmission Business or the Power Assets delivered or to be delivered to the Trustee in accordance with the terms hereof,
- and, when used in relation to any person, the term **“Operative Documents”** means and refers to the Operative Documents executed and delivered by such person;
- (hhhh) **“Opinion of Company Counsel”** means an opinion in writing, conforming to the requirements of Section 17.12, signed by Company Counsel;
- (iiii) **“Opinion of Counsel”** means an opinion or opinions in writing, conforming to the requirements of Section 17.12, signed by Counsel;
- (jjjj) **“Orders”** means all applicable orders, decisions, directives, declarations, decrees, injunctions, writs, judgements, rulings, awards or requirements made or rendered by any Governmental Authority and having the force of law, and includes, without limitation, any environmental orders;
- (kkkk) **“Ordinary Resolution”** means in respect of either the Senior Bonds, the Subordinate Bonds or all Bonds (as may be specified in this indenture), a resolution (i) passed at a duly convened meeting of bondholders by favourable votes of the holder or holders of more than 50% of the outstanding principal amount of such Senior Bonds, Subordinate Bonds or Bonds, respectively, present in person or by proxy, or (ii) evidenced by an instrument in writing signed by the holder or holders of more than 50% of the outstanding principal amount of such Senior Bonds or Subordinate Bonds or Bonds, respectively. An Ordinary Resolution, adopted in accordance with the provisions of this indenture, will be binding upon all the holders of Senior Bonds, Subordinate Bonds or Bonds, as applicable, and the Trustee will be bound to give effect thereto accordingly;
- (llll) **“Permits”** means all permits, consents, waivers, licences, certificates, approvals, authorizations, registrations, franchises, rights, privileges and

exemptions or any item with a similar effect as the foregoing issued or granted by any Governmental Authority or by any other third party, including, without limitation, environmental Permits;

- (mmmm) **“Permitted Encumbrances”**, as of any particular time, constitute any of the following in respect of the Secured Assets or any part thereof:
- (i) liens, charges or prior claims for taxes (which term includes charges, rates and assessments) or utilities (including levies or imposts for sewers and other municipal utility services) not yet due or if due, the validity of which is being contested in good faith and in respect of which the Company has set aside adequate reserves for the payment of such disputed amounts (together with any interest or penalties accrued thereon), and no sale or forfeiture proceedings will have been taken in respect thereof;
  - (ii) the Lien of any judgment for a liquidated amount rendered, or claim filed, against the Company which the Company is contesting in good faith and in respect of which Collateral has been deposited with the Trustee in an amount sufficient to pay such judgment or claim together with any interest thereon and costs in respect thereto;
  - (iii) the rights reserved to or vested in any municipality or Governmental Authority by any statutory provision;
  - (iv) zoning (including, without limitation, airport zoning regulations), use and building by-laws and ordinances and federal, provincial or municipal by-laws and regulations as to the use of the Secured Assets, which do not materially interfere with the use of the Secured Assets for the purposes for which they are held or the value thereof;
  - (v) subdivision, site plan control, development, reciprocal, servicing, facility, facility cost sharing or similar agreements currently existing or entered into with a Governmental Authority, from time to time in respect of the Secured Assets which do not materially interfere with the use of the Secured Assets for the purposes for which they are held; encumbrances respecting encroachments by the Secured Assets or any facilities of or used in connection with the Secured Assets over neighbouring lands and permitted under agreements with the owners of such lands, provided they have been complied with, are in good standing and any security required under the agreements has been given to the municipality;

- (vi) encumbrances respecting encroachments by facilities on neighbouring lands over the Secured Assets which do not materially interfere with the use thereof for the purposes for which the Power Assets are held;
- (vii) permits, licenses, agreements, easements (including, without limitation, heritage easements and agreements relating thereto), restrictions, restrictive covenants, reciprocal rights, rights-of-way, public ways, rights in the nature of an easement and other similar rights in land granted to or reserved by other persons (including, without in any way limiting the generality of the foregoing, permits, licenses, agreements, easements, rights-of-way, sidewalks, public ways, and rights in the nature of easements or servitudes for sewers, drains, steam, gas and water mains or electric light and power or telephone and telegraph conduits, poles, wires and cables) or which are contemplated or provided for or which the Company is bound to enter into pursuant to any subdivision, development, site plan control or similar agreement in respect of any part of the Secured Assets which in the aggregate do not materially impair the value of the Secured Assets or materially interfere with the use thereof for the purposes for which they are held;
- (viii) any encumbrance of any nature whatsoever charging the interest of persons (other than the Company) under any permit, licence, agreement, easement, restriction, restrictive covenant, right-of-way, public way, right in the nature of an easement or other similar rights in land;
- (ix) undetermined or inchoate liens and charges to current construction or current operations, a claim for which will not at the time have been filed against the Lands or of which the Trustee has not received notice;
- (x) any construction, builders', mechanics', labourers', materialmen's, statutory or other similar privileges or Liens in respect of which Collateral in an amount equal to such Liens and all costs required to discharge the same has been deposited with the Trustee or is otherwise provided for in accordance with the *Construction Lien Act* (Ontario);
- (xi) security given to a public utility or any municipality or Governmental Authority when required by the operations of the Company in the ordinary course of business, including, without limitation, the right of the municipality to acquire portions of any Lands for road widening or interchange construction and the right of the municipality to complete improvements, landscaping or

remedy deficiencies in any traffic control or monitoring to be provided to the Power Assets;

- (xii) Minor Title Defects;
- (xiii) any subsisting reservations, limitations, provisions and conditions contained in any original grants from the Crown of any land or interests therein, reservations of undersurface rights to mines and minerals of any kind;
- (xiv) statutory reservations and exceptions to title set forth in Section 44 of the *Land Titles Act* (Ontario) save and except paragraph 11 thereof and otherwise modified as provided in this definition;
- (xv) any and all statutory liens, charges, adverse claims, prior claims, security interests, deemed trusts or other Liens of any nature whatsoever claimed or held by Her Majesty the Queen in Right of Canada, Her Majesty the Queen in Right of the Province of Ontario, or by any other Governmental Authority under or pursuant to any applicable legislation, statute or regulation securing indebtedness not yet due or delinquent which in the aggregate do not materially impair the value of the Secured Assets or materially interfere with the use thereof for the purposes for which they are held;
- (xvi) the reservation of mining rights to the Algoma Central Railway in respect of Parcel 2028 Algoma West Section, Parcel 2029 Algoma West Section, Parcel 2188 Algoma West Section, Parcel 9660 Algoma West Section, Parcel 212 Algoma Central Railway Lands and the right of Algoma Central Railway at any time in the future to take and acquire portions of the said parcels for the right of way of a railway and other railroad purposes;
- (xvii) the right of way to the International Bridge Authority of Michigan over Parts 4 and 8, Plan 1R 4438 and over part of Parcel 996, Algoma West Section;
- (xviii) any reference plans or plans registered pursuant to the Boundaries Act (Ontario);
- (xix) a lease of 1,500 square feet more or less in favour of Her Majesty the Queen in right of Canada represented by the Minister of Transport over part of Parcel 9099, Algoma West Section, for front range light;
- (xx) an easement for a steam transmission line to Lake Superior Power Limited Partnership over, in, under and through a strip of land more particularly described therein and being part of Parcel

996 in the Register for Algoma West Section and parts of St. Mary's Island, the Water Lots adjacent to St. Mary's Island and the Laird and Henderson Mill Site registered as Instrument Numbers 200701 and T-367959, respectively;

- (xxi) an easement for an underwater electricity transmission line to Lake Superior Power Limited Partnership over, in, under and through a strip of land more particularly described therein and being part of Parcels 996, 1954 and 6994 all in the Register for Algoma West Section and part of the Laird and Henderson Mill Site, St. Mary's Island and the Water Lots adjacent to St. Mary's Island registered as Instrument Numbers 200700 and T-367959;
- (xxii) permits, licenses, easements, rights of way, reciprocal rights, rights in the nature of easements, subleases, sublicenses, and other similar rights and entitlements and shared use agreements permitted pursuant to Section 6.10 and Section 7.6 hereunder;
- (xxiii) Purchase Money Security Interests otherwise permitted by this indenture which for greater certainty must not exceed, in the aggregate, \$5,000,000; and
- (xxiv) the Security;
- (nnnn) **"Permitted Financial Institution"** means any of the five largest Canadian chartered banks, provided that the senior unsecured indebtedness of such bank is rated at least AA(low) by the Rating Agency or, if none of such Canadian banks meet such threshold, such lower rating as may be approved from time to time by the holders of Senior Bonds (or if no Senior Bonds are outstanding, holders of Subordinate Bonds) pursuant to an Ordinary Resolution;
- (oooo) **"Permitted Investments"** means any bonds, debentures, notes, bills of exchange, securities or other evidences of indebtedness (including specific interest and principal payments thereof) that have a term to maturity not exceeding 2 years and which are issued or guaranteed by: (i) the Government of Canada; (ii) any Province of Canada, provided that such instruments are rated by DBRS at least AA(low) for long-term debt or R-1(mid) for short-term debt or the equivalent thereof by another Major Rating Agency or such other rating as may be approved by the holders of the Senior Bonds (or if no Senior Bonds are outstanding, holders of the Subordinate Bonds) from time to time pursuant to an Ordinary Resolution; or (iii) any of the five largest Canadian chartered banks, provided that the senior unsecured indebtedness of such bank is rated at least AA(low) by DBRS or the equivalent thereof by another Major Rating Agency or such other rating as may be approved by the holders of the Senior Bonds (or if no Senior Bonds are outstanding, holders

of the Subordinate Bonds) from time to time pursuant to an Ordinary Resolution;

- (pppp) **“person”** means any individual, sole proprietorship, partnership, joint venture, trust, unincorporated organization, association, corporation, limited liability company, institution, public benefit corporation, other entity or government (whether federal, provincial, state, county, city, municipal, local, foreign, or otherwise, including any instrumentality, division, agency, body or department thereof);
- (qqqq) **“Pledge Agreement”** means the share pledge agreement dated as of March 12, 2008 made by the Company in favour of the Trustee, as such agreement may be amended, restated or replaced from time to time;
- (rrrr) **“Power Assets”** means collectively, without duplication, any and all rights of the Company of any nature or kind, whether now or hereafter acquired, in:
- (i) the Power Real Estate;
  - (ii) the Improvements;
  - (iii) the Transmission Assets;
  - (iv) all intellectual property and intangible property (including, without limitation, software) of every nature or kind used in connection with the Transmission Business;
  - (v) all buildings, plants, constructions, sub-stations, equipment, machinery, transformers, motor vehicles, computer hardware and other personal property located from time to time on the Power Real Estate, and all electric transmission systems and lines, poles, wires and all other personal property, in each case owned, leased or licensed by the Company and used in connection with the Transmission Business, whether such interests are now or hereafter acquired by the Company; and
  - (vi) all remaining property, assets, rights, licenses, franchises and undertaking of the Company relating to any of the foregoing and used in connection with the Transmission Business.
- (ssss) **“Power Real Estate”** means, collectively, the Lands, the Future Sites and the Transmission Property Rights;
- (tttt) **“Purchase Money Security Interest”** means a Lien created by the Company securing indebtedness incurred to finance the unpaid acquisition price of personal property provided that (i) such Lien is created prior to or concurrent with the acquisition of such property, (ii) such Lien does not at any time encumber any other property of the Company other than the property so

acquired and the proceeds thereof, (iii) the amount of such indebtedness secured thereby is not increased subsequent to such acquisition, (iv) the principal amount of indebtedness secured by any such Lien at no time exceeds 100% of the original purchase price of such property at the time it was acquired and (v) the asset subject to such Lien, if reclaimed by the person holding such Lien, will not impair the ability of the Company to continue to carry on the Transmission Business;

- (uuuu) **“Rating Agency”** means DBRS, provided that if DBRS or any of its successors does not remain in existence, **“Rating Agency”** will refer to such other Major Rating Agency as is designated by the Trustee, notice of which designation will be given in writing to the Company, and thereafter, the specific ratings referred to herein will be deemed to refer to the equivalent ratings of the Major Rating Agency so designated;
- (vvvv) **“Rating Condition”** means that (i) the Rating Agency has received at least 30 days prior written notice of the proposed action (or such shorter period as it may accept); and (ii) the Trustee has received confirmation in writing from the Rating Agency that, after giving effect to the proposed action, the rating ascribed to the Senior Bonds by such Rating Agency immediately prior to the proposed action will not be qualified, downgraded or withdrawn as a consequence of the proposed action;
- (www) **“Receiver”** has the meaning ascribed to such term in Section 10.2;
- (xxxx) **“Receiver’s Certificate”** has the meaning ascribed to it in Section 10.4(e);
- (yyyy) **“Reciprocal Agreement”** means the reciprocal co-operation and co-ownership agreement to be entered into between GLPL and GLPT upon GLPT acquiring the Secured Assets in accordance with Section 6.10, pursuant to which each will agree to provide to the other such reasonable co-operation and assistance as the other may from time to time reasonably require in order to facilitate its efficient and continuous use, ownership, operation and maintenance of the Secured Assets (in the case of GLPT) and the Excluded Assets (in the case of GLPL), as such agreement may be amended, restated or replaced from time to time in compliance with Section 6.17 of this indenture;
- (zzzz) **“Redemption Date”** means, in respect of any redemption of Bonds, the date (which must be a business day) specified in the notice of such redemption as the date on which such Bonds will be redeemed;
- (aaaa) **“Redemption Price”** means, in respect of any series of Bonds, the redemption price or prices applicable to such Bonds specified in the indenture supplemental hereto creating such Bonds;
- (bbbb) **“Regulations”** means all rules, regulations, by-laws or any requirement with a similar effect as the foregoing promulgated by Governmental Authorities

under or pursuant to Applicable Laws, including, without limitation, environmental and safety regulations;

- (ccccc) **“Release”** means a releasing, adding, spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, migrating, dispersing, dispensing, disposing, depositing, spraying, inoculating, abandoning, throwing, placing, exhausting or dumping, and “Released” has a comparable meaning;
- (ddddd) **“Replacement Cost”** means, with respect to any property, the cost of repairing, replacing or reinstating such property with materials of like kind and quality and for like occupancy (where applicable) on a same or similar site, in accordance with the requirements of any applicable municipal by-law up to a value and condition not less than the value and condition that such property was in prior to the event requiring the repair, replacement or reinstatement (assuming that such property was at such time in the condition required by the terms of this indenture);
- (eeee) **“S&P”** means Standard & Poor’s Rating Service and its successors and assigns;
- (ffff) **“Secured Assets”** means, collectively, at any time and from time to time (subject to the applicable Security Agreements providing for appropriate and necessary terms to address any restrictions that may exist on the ability to grant Liens over such assets), all property, undertaking and assets of the Company (1) for so long as GLPL is the Company, used in connection with the Transmission Business, and (2) in any other circumstance, used in connection with the Transmission Business, and which will, in each case, include (without intending to be limiting);
- (i) the Power Assets and all books and records relating thereto;
  - (ii) all Accounts Receivable or other amounts owing by any person to the Company in connection with the Transmission Business or arising from or relating to any portion of the Power Assets;
  - (iii) any Collateral at any time deposited with the Trustee (or an agent appointed by the Trustee) pursuant to the terms of this indenture or any Security Agreement;
  - (iv) all cash generated at any time or from time to time from the Transmission Business or the use of the Power Assets and all such cash converted into Permitted Investments;
  - (v) all other property or assets of the Company used in connection with the Transmission Business which may at any time or from time to time be mortgaged, pledged and charged pursuant to the terms of the Security Agreements;



- (vi) all Material Contracts;
- (vii) all collateral pledged pursuant to the Pledge Agreement;
- (viii) all leases, licences and permits at any time or from time to time relating to the ownership, operation or maintenance of the Transmission Business and the Power Assets;
- (ix) all cash at any time or from time to time in the Debt Service Reserve Account; and
- (x) all insurance proceeds and expropriation proceeds arising at any time or from time to time from or relating to the Transmission Business and the Power Assets;

, provided that to the extent that GLPT has only a co-ownership interest in any such property, asset, contract, permit, right, licence, franchise, or undertaking, it is such co-ownership interest that constitutes a Secured Asset.

- (ggggg) “**Securities**” has the meaning attributed to such term in the *Securities Act* (Ontario);
- (hhhhh) “**Security**” means the Liens created and the security granted pursuant to the Security Agreements over and in respect to the Secured Assets;
- (iiiiii) “**Security Agreements**” means the Debenture, the Nominee Direction, the GSA, the Pledge Agreement, the Assignment of Material Contracts, the Assignment of Insurance, the Subsidiary Guarantee and all other security (including all cash on deposit and additional letters of credit) now or hereafter delivered to the Trustee by or on behalf of the Company;
- (jjjjj) “**Senior Bonds**” means senior bonds of the Company issued or to be issued hereunder from time to time in one or more series which are outstanding and entitled to the benefit of the Security and includes the Series 1 Senior Bonds and the Additional Bonds;
- (kkkkk) “**Series 1 Senior Bonds**” means the Series 1 Senior Bonds to be issued pursuant to a supplemental indenture immediately subsequent to the execution of this indenture;
- (lllll) “**Subordinate Bond Event of Default**” means the occurrence of any of the events identified in Section 9.1(c), (d), (g), (h), (i), (j) and (k);
- (mmmmm) “**Subordinate Bonds**” means subordinate bonds of the Company issued or to be issued hereunder from time to time in one or more series which are outstanding and entitled to the benefit of the Security but which are subordinated to the Senior Bonds in accordance with the terms hereof;

- (nnnnn) **“Subsidiary Guarantee”** means the guarantee dated as of March 12, 2008 made by the Included Subsidiaries in favour of the Trustee, as such agreement may be amended, restated or replaced from time to time;
- (ooooo) **“this indenture”**, **“this trust indenture”**, **“this deed of trust and mortgage”**, **“hereto”**, **“herein”**, **“hereof”**, **“hereby”**, **“hereunder”**, and similar expressions refer to this deed of trust and not to any particular Article, Section or other portion hereof and include any and every instrument or indenture supplemental or ancillary hereto or in implementation hereof: and references to a particular Schedule, Article or Section mean such Schedule, Article or Section hereof;
- (ppppp) **“Transmission Assets”** means, collectively, all property, assets, contracts, permits, rights, licenses, franchises and undertaking of the Company, whether real, personal or mixed, tangible or intangible, of every nature, kind and description, wherever located, that are owned, leased or licensed by the Company and are related to and used in connection with the Transmission Business, including, without limitation, the Transmission Property Rights, provided that to the extent that the Company has only a co-ownership interest in any such property, asset, contract, permit, right, licence, franchise or undertaking, it is such co-ownership interest that constitutes a Transmission Asset;
- (qqqqq) **“Transmission Property Rights”** means the easements, leases, licenses and other rights in land described in Schedule “D” and any future easements, leases, licences and other rights in land acquired by the Company and used in connection with the Company’s power transmission system;
- (rrrrr) **“Trust Indenture Legislation”** means, at any time, the provisions of any statute of Canada or any province thereof and the Regulations thereunder, relating to trust indentures and the rights, duties and obligations of trustees under trust indentures and of corporations issuing debt obligations under trust indentures, to the extent that such provisions are at such time in force and applicable to this indenture;
- (sssss) **“Trust Moneys”** has the meaning attributed to such term in Section 8.1;
- (ttttt) **“Trustee”** means CIBC Mellon Trust Company, as trustee for the benefit of the bondholders and includes any successor trustee appointed in accordance with the terms of Section 14.1;
- (uuuuu) **“Unanimous Resolution”** means in respect of the Senior Bonds, Subordinate Bonds, all Bonds or any series thereof (as may be specified in this indenture), a resolution (i) passed at a duly convened meeting of bondholders holding such Bonds by favourable votes of the holder or holders of not less than 100% of the outstanding principal amount of such Bonds, present in person or by proxy, or (ii) evidenced by an instrument in writing signed by the

holder or holders of not less than 100% of the outstanding principal amount of such Bonds;

- (vvvvv) “**United States Dollars**” or “**US\$**” means such currency of the United States of America which at the time of payment or determination will be legal tender for the payment of public or private debts in immediately available funds;
- (wwwww) “**United States of America**” means the United States of America (including the states and the District of Columbia), its territories, possession and other areas subject to its jurisdiction; and
- (xxxxx) “**Written Order**”, “**Written Request**” and “**Written Consent**” of the Company means a written order, request or consent signed in the name of the Company by any two of the Chairman of the Board, Chief Financial Officer, Chief Executive Officer, the President, a Vice-President, the Treasurer, the Secretary, an Assistant Treasurer or an Assistant Secretary of the Company, or by any two directors of the Company.

## **Section 1.2 Interpretation**

Words importing the singular number only will include the plural, and vice versa, and words importing the masculine gender includes the feminine gender and words importing persons include firms and corporations, and vice versa. References to any statute herein includes such statute as amended, revised, re-enacted and/or consolidated from time to time and any successor statute thereto, and includes any Regulations promulgated thereunder from time to time.

## **Section 1.3 Headings and Table of Contents**

The headings of all the Articles and Sections hereof and the Table of Contents are inserted for convenience of reference only and do not affect the construction or interpretation of this indenture.

## **Section 1.4 Governing Law**

This indenture and the Bonds will be construed in accordance with the laws of the Province of Ontario and the laws of Canada applicable therein and will be treated in all respects as Ontario contracts.

## **Section 1.5 Amounts of Money Expressed in Lawful Money of Canada**

Unless specifically otherwise provided herein or in any indenture supplemental hereto, all references to dollar amounts herein or other money amounts herein are expressed in terms of lawful money of Canada.

### **Section 1.6 Invalidation of Provisions**

Each of the provisions contained in this indenture or the Bonds and the Liens created by the Security in each parcel of the Power Real Estate is distinct and severable and a declaration of invalidity or unenforceability of any such provision, charge or security interest by a court of competent jurisdiction will not affect the validity or enforceability of any other provision hereof or thereof or any charge or security interest in any other parcel of the Power Real Estate.

### **Section 1.7 Meaning of "outstanding" for Certain Purposes**

Every Bond certified and delivered by the Trustee hereunder will be deemed to be outstanding until it has been cancelled or delivered to the Trustee for cancellation, or a new Bond has been issued in substitution therefor under Section 2.10 provided that:

- (a) where a new Bond has been issued in substitution for a Bond which has been lost, stolen or destroyed, only one of such Bonds will be counted for the purpose of determining the aggregate principal amount of Bonds outstanding; and
- (b) for the purpose of any provision of this indenture entitling bondholders to vote, sign consents, requests or other instruments or take any other action under this indenture, Bonds owned directly or indirectly, legally or equitably, by the Company or any Affiliate will be disregarded provided that:
  - (i) the Trustee has the right to obtain written confirmation from bondholders that they are not an Affiliate of the Company prior to relying on any such vote, consent, request or other instrument or other action; and
  - (ii) Bonds so owned which have been pledged in good faith other than to the Company or an Affiliate will not be so disregarded if the pledgee establishes, to the satisfaction of the Trustee, the pledgee's right to vote such Bonds in his discretion free from the control of the Company or an Affiliate.

### **Section 1.8 Currency Conversion**

Wherever it is necessary or appropriate for the purpose of making any determination or calculation hereunder to notionally convert into Canadian Dollars an amount in United States Dollars, such conversion will be made on the basis of the noon buying rate for United States Dollars with Canadian Dollars as reported by the Federal Reserve Bank in New York on the date as of which such conversion is to be made; provided, however, that if the purpose of such conversion is to determine compliance by the Company with any covenant or limitation contained herein, such conversion will take into account (if, and to the extent, permitted in accordance with GAAP) any hedge contract to which the Company is a party at the date of which such conversion is to be made and which applies to the United States Dollar obligation to be converted; but provided further, however, that with respect to any series of Additional Bonds or Subordinate Bonds in United States Dollars, no contract price may be

applied as aforesaid unless the applicable hedge contract is in place on the date of issue of such Additional Bonds.

## **ARTICLE 2** **THE BONDS**

### **Section 2.1 Limitation on Outstanding Bonds**

The aggregate principal amount of Senior Bonds authorized to be outstanding under this indenture is unlimited. The aggregate principal amount of Subordinate Bonds authorized to be outstanding under this indenture is unlimited. In accordance with Section 6.2(ii)(c), the principal amount of Subordinate Bonds when issued must not be in excess of 30% of the aggregate principal amount of all Senior Bonds then outstanding. All Bonds issued hereunder will be subject to the terms and conditions herein provided.

### **Section 2.2 Issuance in Series and Form**

The Bonds may be issued in one or more series, subject to compliance with the provisions and conditions hereinafter set forth. The Bonds of each such series will bear such date or dates, will bear interest at such rate or rates, may be issued in such denominations, may be redeemable before maturity in such manner and subject to payment of such Make-Whole Amount or premium or without premium, may be payable in lawful money of Canada or such other currencies, may provide for such sinking fund or funds (if any), may contain such provisions for the exchange or transfer of Bonds of differing denominations and forms and may contain such other provisions, not inconsistent with the provisions of this indenture, as may be determined by the Company at or prior to the time of issue thereof and expressed in an indenture supplemental hereto providing for the issuance of the Bonds of such series and (to such extent as the Company may deem appropriate) in the Bonds of such series. At the option of the Company, the maximum principal amount of Bonds of any series may be limited as may be expressed in an indenture supplemental hereto providing for the issuance of the Bonds of such series and in the Bonds of such series.

The Bonds of any series may be of different denominations and forms and may contain such variations of tenor and effect as are incidental to such differences of denomination and form including variations in the provisions for the exchange of Bonds of different denominations or forms and in the provisions for the registration or transfer of Bonds, and any series of Bonds may consist of Bonds having different dates of issue, different rates of interest, different redemption prices (if any), different dates of maturity (subject to no Bonds maturing prior to June 16, 2023), different sinking fund provisions (if any) and may consist partly of Bonds carrying the benefit of a sinking fund or funds (subject to the terms of this indenture) and partly of Bonds with no sinking fund or funds.

Subject to the foregoing provisions, any of the Bonds may be issued as part of any series of Bonds previously issued, in which case they will bear the same designation and designating letters as have been applied to such similar prior issue and will be numbered consecutively upwards in respect of each denomination of Bonds in like manner and following the numbers of the Bonds of such prior issue.

Notwithstanding anything contained herein to the contrary, all of the Senior Bonds will mature on the Maturity Date and all of the Subordinate Bonds will mature on or subsequent to the Maturity Date of the Senior Bonds.

### **Section 2.3 Form of Bonds**

Any series of Bonds which may at any time be issued hereunder, the coupons (if any) appertaining thereto and the certificate of the Trustee endorsed on such Bonds may be in such form or forms as the Company may determine at the time of the first issue of any series or part of any series of such Bonds and as may be approved by the Trustee.

The Bonds of any series may be typewritten, engraved, lithographed, printed or photocopied or partly in one form and partly in another, as the Company may determine.

### **Section 2.4 Signature**

Except as otherwise permitted or required with respect to any Bonds by the indenture supplemental hereto creating such Bonds, all such Bonds must be signed (either manually or by facsimile signature) by the Chairman of the Board, the President, a Vice-President, Senior Vice-President, a director, the Treasurer, the Secretary, an Assistant Treasurer or an Assistant Secretary of the Company holding office at the time of signing. In the event of the Trustee receiving a request for the issue of a new Bond pursuant to Section 2.7 or Section 2.10, if the Trustee has requested signature by the Company of such new Bond and the Company has not signed and delivered the same to the Trustee for certification within 10 days of a request by the Trustee therefor, the Trustee will be entitled (but not obligated) to sign the same by its duly authorized officers on behalf of the Company, the Company hereby irrevocably appointing the Trustee its attorney for such purposes. A facsimile signature upon any of the Bonds will, for all purposes of this indenture, be deemed to be the signature of the person whose signature it purports to be and to have been signed at the time such facsimile signature is reproduced and notwithstanding that any such person whose signature, either manual or in facsimile, may appear on the Bonds is not, at the date of this indenture or at the date of the Bonds or at the date of the certifying and delivery thereof, the Chairman of the Board, the President, a Vice-President, a Senior-Vice President, a director, the Treasurer, the Secretary, an Assistant Treasurer or an Assistant Secretary, as the case may be, of the Company, such Bonds will be valid and binding upon the Company and entitled to the Security.

### **Section 2.5 Certification**

No Bond will be issued until it has been certified by or on behalf of the Trustee in a form referred to in Section 2.3. Such certificate will be conclusive evidence that such Bond is duly issued and is entitled to the benefits hereof and is secured by the Security. The certificate of the Trustee on any Bond will not be construed as a representation or warranty by the Trustee as to the validity of this indenture or of such Bond. The certificate of the Trustee on any Bond will, however, be a representation and warranty by the Trustee that such Bond has been duly certified by or on behalf of the Trustee pursuant to the provisions of this indenture.

## Section 2.6 Bonds Equally Secured by Security

(1) All Senior Bonds as soon as issued and certified in accordance with this indenture will be secured equally and rateably by the Security and will rank *pari passu* in respect to payments upon a distribution of proceeds from any sale or realization of the Secured Assets without discrimination or preference with all other Senior Bonds as if all of the Senior Bonds had been issued and certified simultaneously.

(2) The Subordinate Bonds will be secured by the Security but will be subordinate to the Senior Bonds in accordance with the terms of this indenture. All Subordinate Bonds as soon as issued and certified in accordance with this indenture will be secured equally and rateably by the Security and will rank *pari passu* in respect to payments upon a distribution of proceeds from any sale or realization of the Secured Assets without discrimination or preference with all other Subordinate Bonds, as if all of the Subordinate Bonds had been issued and certified simultaneously.

## Section 2.7 Registration: Transfer: Exchange

The Trustee will keep or cause to be kept by and at the principal office of the Trustee in the City of Toronto, Ontario and at such other place or places or by such other registrar or registrars as the Company may designate or appoint, with the approval of the Trustee, registers in which will be alphabetically entered the names and addresses including the street and number (if any), of the holders of all Bonds and of all transfers of Bonds.

No transfer of a Bond will be valid unless the transferee and the balance of the unpaid principal amount of the Bond on the date of registration of the transfer is noted by the Trustee on the registration panel on the Bond and unless made on such transfer register by the registered holder or his executors or administrators or other legal representatives or his or their attorney duly appointed by an instrument in writing in form and execution satisfactory to the Trustee. The holder of a Bond may at any time and from time to time have such Bond transferred or have such Bond exchanged for Bonds of any other authorized denominations in an equivalent aggregate principal amount, at any of the places where a register of transfers is kept, in accordance with such reasonable regulations as the Trustee may prescribe. Without limiting the foregoing, any transfer of a Bond must be made in accordance with applicable securities legislation. The Trustee may act and rely on a opinion of counsel of the transferor that a transfer of a Bond is in accordance with applicable securities legislation.

Neither the Company nor the Trustee nor any registrar will be required:

- (a) to make transfers or exchanges of any Bonds for a period of 10 business days next preceding any scheduled repayment of principal or interest payment date pertaining to such Bonds;
- (b) to make any transfer or exchange of any Bond to reflect an assignment of such Bond in an amount less than \$200,000 unless such lesser amount reflects all of the bondholders ownership interest in respect to the Bonds;

- (c) to make exchanges of any Bonds on the day of any selection by the Trustee of such Bonds to be redeemed or until the date that the notice of redemption is mailed; or
- (d) to make exchanges of any Bonds which have been selected or called for redemption, unless upon due presentation thereof for redemption such Bonds are not redeemed.

The Trustee, when requested to do so by the Company or a bondholder, upon receipt of such reasonable documentation as the Trustee may require, will furnish the Company or a bondholder with a list of the names alphabetically arranged and the last known address of each person who is a holder of Bonds, and the outstanding principal amount of such Bonds held by each holder. The Trustee will furnish the Company with the date and particulars of the issue and transfer of each Bond as soon as reasonably practicable after the date such transfer is noted by the Trustee.

Such registers will at all reasonable times be open for inspection by the Company, the Trustee, any bondholder and any other person entitled thereto by law. Neither the Trustee nor any registrar for any of the Bonds nor the Company will be charged with notice of or be bound to see the execution of any trust, express, implied or constructive, in respect of any Bond and may transfer the same on the direction of the holder thereof, whether named as trustee or otherwise, as though that person were the beneficial owner thereof.

Except as herein otherwise provided, in every case of exchange of Bonds or any transfer of Bonds, the Trustee or other registrar may, subject to Applicable Law, make a sufficient charge to reimburse it for any stamp tax or other governmental charge required to be paid, and in addition the Company will pay to the Trustee a reasonable charge for its services for every Bond issued upon such exchange or transfer.

## **Section 2.8 Payment**

The person in whose name any Bond is registered will be deemed the owner thereof for all purposes of this indenture. Payment of or on account of the principal, interest and Make-Whole Amount (if any) and premium (if any) of and on such Bond will be made only to such registered holder thereof and such payment will be good and sufficient discharge of the liability of the Company and the Trustee for the amounts paid.

Unless otherwise provided with respect to any particular series of Bonds in the supplemental indenture authorizing the creation and issue of such series of Bonds, as the principal and interest on such Bonds becomes payable (except principal and interest payable at maturity or on redemption, which will be paid on such maturity or redemption upon presentation and surrender of such Bonds for payment) the Company will at the request of the registered holder of Bonds, on the date on which principal and interest on such Bonds becomes due (or if such date is not a business day, the first business day preceding such day) either, (i) forward or cause to be forwarded by prepaid post to the holder for the time being, or, in the case of joint holders, to one of such joint holders, at his address appearing on the appropriate register hereinbefore mentioned one or more cheques (drawn on a Canadian chartered bank) for such



principal or interest (less any tax required to be deducted or withheld plus any gross up required to be paid pursuant to any supplemental indenture) payable to the order of such holder or holders and negotiable at par at each of the places at which interest on the Bonds is payable, or (ii) effect a wire transfer of immediately available funds to the holder or, in the case of joint holders, to one of such joint holders, based on the wire transfer instructions provided by any such holder to the Company in the amount of such principal or interest (less any tax required to be deducted or withheld plus any gross up required to be paid pursuant to any supplemental indenture), in each case in immediately available funds for receipt not later than 12:00 (noon) Toronto time on the date such payment is due. Any amount received after such time will be deemed received on the next business day and interest will accrue on such amount until receipt thereof. The forwarding of such cheque or cheques or implementation of such wire transfer will satisfy and discharge the liability for such payment to the extent of the sums represented thereby unless such cheque is not paid on presentation or is lost or destroyed or such wire transfer is not received on or prior to the applicable payment date. In the event of the non-receipt of any such cheque by the holder, or the loss or destruction thereof, the Company or the Trustee, upon being furnished with evidence of such non-receipt, loss or destruction and indemnity satisfactory to it, acting reasonably, will issue or cause to be issued to such holder a replacement cheque for the same amount. Interest in respect of the principal amount of the Bonds will cease to accrue from the due date thereof unless payment of principal or interest thereon, as the case may be, is improperly withheld or refused.

Subject to Section 2.11, payment of principal at maturity of the Bonds, Make-Whole Amount (if any) and premium (if any) on the Bonds will be made only upon presentation of the Bond to the Trustee for cancellation.

The registered holder for the time being of any Bond will be entitled to the outstanding balance of the principal moneys, interest, Make-Whole Amount (if any) and premium (if any) thereon, free from all equities or rights of set-off or counterclaim between the Company and the original or any intermediate holder thereof (except any equities of which the Company is required to take notice by statute or by order of a court of competent jurisdiction) and all persons may act accordingly, and a transferee of a Bond will, after the appropriate form of transfer is lodged with the registrar and upon compliance with all other conditions in that behalf required by this indenture or by any conditions endorsed on the Bond or by law, be entitled to be entered on any one of the registers as the owner of such Bond free from all equities or rights of set-off or counterclaim between the Company and his transferor or any previous holder thereof, save in respect of equities of which the Company is required to take notice by statute or order of a court of competent jurisdiction. The payment by the Company to any registered holder for the time being of any Bond of any such principal moneys, interest, Make-Whole Amount and premium will be a good discharge to the Company and the Trustee for the same, and neither the Company nor the Trustee nor any registrar will be bound to enquire into the title of any such holder (except as aforesaid).

Where Bonds are registered in more than one name, the principal moneys, Make-Whole Amount (if any), premium (if any) and interest from time to time payable in respect thereof may be paid by cheque or wire transfer payable to one of such holders failing written instructions from them to the contrary and the receipt of any one of such holders thereof will be a valid discharge to the Trustee and any other paying agent and to the Company.

## **Section 2.9 Cancellation**

All Bonds redeemed, purchased or otherwise acquired by the Company or by any other person on its behalf must be forthwith delivered to the Trustee and cancelled and will not be re-issued and may not be used as a credit against sinking fund obligations of the Company except to the extent otherwise provided in the sinking fund or redemption provisions of any supplemental indenture pertaining to any particular series of Bonds. All Bonds which have been delivered to and cancelled by the Trustee will be destroyed by the Trustee and, if required by the Company, the Trustee will furnish to the Company a destruction certificate setting forth the number and denomination of the Bonds so destroyed.

## **Section 2.10 Mutilation, Loss or Destruction**

If any Bonds issued hereunder become mutilated or be lost, destroyed or wrongfully taken, provided the Company or the Trustee has no notice that the Bond has been acquired by a *bona fide* purchaser, the Company in its discretion may issue, and thereupon the Trustee will certify and deliver, a new Bond of like date and tenor, with a notation as to the unpaid principal amount outstanding thereunder on the registration panel thereof, upon surrender and cancellation of the mutilated Bond or, in case of a lost or destroyed or wrongfully taken Bond, in lieu of and in substitution for the same. The substituted Bond will be in a form approved by the Trustee and will be entitled to the benefits of this indenture equally with all other Bonds issued or to be issued hereunder of like tenor. In case of loss or destruction or wrongful taking, the applicant for a substituted Bond will furnish to the Company and to the Trustee evidence satisfactory to the Company and to the Trustee of such loss or destruction or wrongful taking (in their reasonable discretion) and an indemnity satisfactory to them (in their reasonable discretion) and must pay any and all expenses incidental to the issue of such substituted Bond and must satisfy any other reasonable requirements imposed by the Company or the Trustee.

## **Section 2.11 Home Office Payment Agreement**

Notwithstanding anything to the contrary contained in this indenture or in any Bond, the Company may enter into an agreement with the registered holder of any Bond providing for the payment of principal, Make-Whole Amount (if any), premium (if any) and interest on any of the Bonds held by such holder at a place and in the manner other than the place or in the manner of payment specified herein or in such Bond for the making of all payments with respect to such Bonds to such bondholder, whether or not out of sinking funds established for the benefit of bondholders, without presentation or surrender of such Bond so long as such holder will, upon the payment of any principal outstanding hereunder or redemption of such Bond in part only, make notations on such Bond of the part thereof so repaid or redeemed and that as promptly as practicable after the payment or prepayment in whole of any Bond, the holder will surrender such Bond to the Trustee for cancellation. Payment of principal, Make-Whole Amount (if any), premium (if any) and interest on any Bond in accordance with this Section 2.11 will absolutely satisfy and discharge the liability of the Company with respect to such payment under such Bond unless, in the case of payment by cheque, a cheque for payment thereof is not paid on presentation or is lost or destroyed. From time to time the Company will furnish to the

Trustee an Officers' Certificate as to the persons with whom the Company has entered into such an agreement.

### **ARTICLE 3** **SECURITY**

#### **Section 3.1 Security**

As continuing security for the due payment of the principal of, and interest on (including interest on amounts in default) and any Make-Whole Amount on, the Bonds and of all other money for the time being and from time to time owing pursuant to the terms of this indenture, the Bonds and the Security, including any amounts payable by the Company to the Trustee or any bondholders as damages, liquidated or otherwise, as a result of the Company defaulting on its obligations hereunder, and to secure the due performance by the Company of all of its obligations hereunder, the Company will deliver or cause to be delivered to and in favour of the Trustee, the Security Agreements.

#### **Section 3.2 Effect of Security**

The Liens created pursuant to the Security Agreements and all rights thereby conferred unto the Trustee, its successors and assigns, will be held in trust for the benefit and security of the holders of all Bonds. The Security Agreements will secure all indebtedness owing pursuant to the Bonds without any preference or priority of (i) any Senior Bonds over any other Senior Bonds or (ii) any Subordinate Bonds over other Subordinate Bonds, and with the powers and authorities and subject to the terms and conditions mentioned and set forth in this indenture. Payments from proceeds of realization against the Secured Assets will be distributed in accordance with the terms of Section 10.6 hereof.

#### **Section 3.3 Further Assurances**

The Company will, forthwith, and from time to time, execute and do or cause to be executed and done all deeds, documents and things that, in the Opinion of Counsel, are necessary or advisable for giving the Trustee (so far as may be possible under Applicable Law) a valid Lien (subject to Permitted Encumbrances) of the nature specified in the Security Agreements upon the Secured Assets to secure the payment of the principal, interest, Make-Whole Amount and any other amount for the time being and from time to time owing under this indenture, the Bonds, the Bond Purchase Agreements, the Conversion Representation Agreement and the Security Agreements, and for conferring upon the Trustee the power of sale and other powers as are in the Security Agreements expressed to be conferred.

Notwithstanding anything herein contained, the Trustee will not be bound to take any conveyance, assignment or transfer pursuant to the Security Agreements of any property or assets that the Trustee cannot legally take or that, in the opinion of the Trustee, is of an onerous character, but the Company must hold any such property or assets in trust for the Trustee.

### **Section 3.4 Registration**

The Company will record, file, enter or register the Security Agreements, all documents supplemental thereto, and all other instruments of further assurance (including financing statements) without delay under the provisions of those statutes providing for the registration of Liens in Canada and any province or territory of Canada and any other jurisdiction in which the Secured Assets are situated and in which in the Opinion of Counsel such recording, filing, entry or registering is necessary or advisable to establish, preserve and protect the Liens created by the Security, perfect the Liens created thereby and preserve and protect the rights of the Trustee thereunder and the rights of the bondholders under the Bonds, and will provide the Trustee with written confirmation thereof. The Company will renew such recordings, filings or registrations from time to time as and when required to keep them in full force and effect and will provide the Trustee with a copy thereof. The Company will from time to time, if and when requested to do so by the Trustee, furnish the Trustee with an Opinion of Company Counsel that the provisions of this Section 3.4 have been complied with. The Trustee will not be responsible for any failure by the Company to effect any registration provided for herein or any renewal thereof.

### **Section 3.5 Funds Held by Trustee**

All cash that may at any time be deposited with or held by the Trustee in accordance with the provisions of this indenture or the Security Agreements will be held by the Trustee in the Province of Ontario and the Securities representing Permitted Investments will be held by the Trustee in the Province of Ontario. All such cash and Securities will be subject to the Security.

### **Section 3.6 Priority**

Any reference to Permitted Encumbrances contained in this indenture or in the Security Agreements in and of itself will not expressly or by implication result in any Permitted Encumbrance ranking ahead of the Liens created pursuant to the Security Agreements.

### **Section 3.7 Supplemental Indentures**

From time to time the Company (when authorized by a resolution of the directors as evidenced by a Certified Resolution) and the Trustee may and, subject to the provisions of this indenture, when so directed by this indenture, the Company and the Trustee will, without the consent or concurrence of the bondholders, execute, acknowledge and deliver by its proper officers, deeds or indentures supplemental hereto, which thereafter will form part hereof, or do and perform any other acts and things and execute and deliver any other deeds or documents, for any one or more of the following purposes:

- (a) mortgaging, pledging, charging and assigning, assuring, confirming or transferring to, or vesting in, the Trustee any property, real or personal, freehold or leasehold, now owned or hereafter acquired by the Company in connection with the Transmission Business and intended to be charged by the Security Agreements, and providing that the same will become and be part of the Secured Assets;

- (b) correcting or amplifying the description of any property specifically mortgaged, pledged, charged or assigned by the Security Agreements, or intended so to be;
- (c) evidencing the succession, or successive successions, of any other person to the Company and the covenants of and obligations assumed by any such successor in accordance with the provisions of this indenture;
- (d) providing for the issue of Bonds of any one or more series and for establishing the terms, provisions and conditions of a particular series of Bonds, subject to Section 6.2;
- (e) implementing the provisions of any Extraordinary Resolution or Ordinary Resolution passed in accordance with the terms of this indenture;
- (f) giving effect to the provisions of Article 7 and Article 11;
- (g) adding to the limitations or restrictions herein specified, further limitations or restrictions thereafter to be observed by the Company, upon the amount, dates of maturity, issue or the purposes of issue of Bonds hereunder;
- (h) adding to the covenants of the Company herein contained for the protection of the holders of the Bonds or providing for Events of Default in addition to those herein specified;
- (i) consenting to the amendment, revision, extension, amplification, alteration or termination of any lease, easement, servitude, agreement, document or instrument which may at any time form part of the Secured Assets; provided in the reasonable opinion of the Trustee relying, where appropriate, on an Officers' Certificate and the opinion of Counsel that the giving of such consent will not be prejudicial to the interests of the bondholders or that such amendment, revision, extension, amplification, alteration or termination is in accordance with the applicable provisions of Article 7; and
- (j) making such amendments, deletions or alterations hereto that may be considered necessary or desirable by the Company and the Trustee to give effect to any Applicable Laws or Trust Indenture Legislation.

The Trustee may also, without the consent or concurrence of the bondholders, by supplemental indenture or otherwise, concur with the Company in making any changes or corrections in this indenture or any Security Agreement as to which it has been advised by Counsel that the same are non-substantive corrections or changes or are required for the purpose of curing or correcting any ambiguity or defective or inconsistent provisions or clerical omission or mistake or manifest error contained herein or therein or in any deed or indenture supplemental or ancillary hereto or thereto. The Trustee will provide to each bondholder a copy of any indenture or other document entered into pursuant to the terms of this Section 3.7.

### **Section 3.8 Discharge of Security**

(1) If the Company pays or causes to be paid to the Trustee all moneys owed to the bondholders and the Trustee pursuant to this indenture and the Bonds and performs the terms hereof, then this indenture and the rights hereby granted will cease, determine and become void and thereupon the Trustee will, at the Written Request of the Company and at the expense of the Company, cancel and discharge all Security granted in connection herewith by executing and delivering to the Company such deeds or other instruments as are requisite to discharge the Security in favour of the Trustee and to reconvey to the Company (or as the Company may direct in writing) the Secured Assets and to release the Company from the covenants herein contained (other than the provisions relating to indemnification) upon delivery of such Written Request to the Trustee, together with an Officers' Certificate stating that all amounts owed to the bondholders and the Trustee pursuant to this indenture and the Bonds have been paid in full.

The Trustee will execute and deliver to the Company such deeds or other instruments as aforesaid; provided that the Company has first satisfied the Trustee that the Company has paid all the principal moneys, interest, Make-Whole Amount (if any) and premium (if any) due or to become due (and as and when the same shall become due under the terms hereof) on all of the Bonds outstanding hereunder as well as all other sums payable hereunder by the Company.

(2) It is hereby declared and agreed that no purchaser from the Company and no registrar will be obliged to inquire into the necessity, expediency, authority or regularity of or for any such release or reconveyance nor be obliged to inquire into the sufficiency of the performance by the Company of any of the conditions upon which it is or may be entitled to such release or reconveyance or the application of any moneys or securities set apart or provided for the payment of any outstanding Bonds or interest thereon.

(3) The registrar of any registration division in which any of the Power Real Estate are situate will (i) discharge and cancel or (ii) reduce (according to the terms of the instrument of release presented) the registration of any Lien created or hereafter created by the Security Agreements, upon the registration of any acquittance, discharge, release or document to that effect signed by the Trustee, without being obliged to see that any of the conditions of this indenture have been fulfilled.

### **Section 3.9 Subordination of Subordinate Bonds to Senior Bonds**

(1) Subject to the terms of this Agreement and specifically to this Section 3.9, the payment of indebtedness owing by the Company to the holders of Subordinate Bonds will be unconditionally and irrevocably deferred, postponed and subordinated in all respects to the prior indefeasible repayment in full by the Company of all indebtedness owing (whether principal, interest (whether incurred prior to or subsequent to Default), Make-Whole Amount or otherwise) to the holders of Senior Bonds. Notwithstanding the foregoing, during such times as a Default or Event of Default does not exist and is not continuing, the holders of Subordinate Bonds will be entitled to receive scheduled payments of interest on a semi-annual basis on the outstanding principal amounts of Subordinate Bonds. During the existence and continuance of a Default or Event of Default, without the requirement of any further notice or action, the Company will not make any payments on the Subordinate Bonds and the holders of Subordinate Bonds will not

accept any payments in respect to the Subordinate Bonds until all indebtedness and other obligations owing to the holders of the Senior Bonds have been paid in full. Any interest payments that were not made to the holders of Subordinate Bonds as a consequence of the existence of a Default or Event of Default will accrue interest on such unpaid interest at the same rate of interest applicable to such Subordinate Bonds.

(2) During such times as any Senior Bonds remain outstanding and subject to the following, the holders of the Subordinate Bonds will not have the right to take, or direct the Trustee to take, any steps or action to enforce payment of any indebtedness owing by the Company to them or to the Trustee following the occurrence of an Event of Default that is not a Subordinate Bond Event of Default. For a period of 365 days after the occurrence of a Subordinate Bond Event of Default which has not been cured, waived or otherwise revoked, the holders of Subordinate Bonds will not be entitled to direct the Trustee to take any steps or actions to enforce payment of the indebtedness owing by the Company to them or to direct the Trustee to commence realization on the Security including, without limitation, issuance of any demand, acceleration of indebtedness and obligation, issuance of statutorily required notices, exercise of any right of set-off, commencement of bankruptcy proceedings, foreclosure, power of sale, taking of possession, giving in payment, appointing or making an application to court for an order appointing an agent or Receiver or by any other means of enforcement thereof (in each case, an "enforcement action"). The restriction on the ability of the holders of Subordinate Bonds to direct the Trustee to take such enforcement action will apply equally to each holder of Subordinate Bonds. Following the expiration of a 365-day period after the occurrence of a Subordinate Bond Event of Default which has not been cured, waived or otherwise revoked on or prior to the expiry of such 365-day period by the holders of Subordinate Bonds by Ordinary Resolution, the holders of Subordinate Bonds will be entitled to accelerate the indebtedness owing pursuant to the Subordinate Bonds and to take such enforcement actions pursuant to the Security as they may determine. Notwithstanding the foregoing, after the holders of Senior Bonds have directed the Trustee to commence any enforcement action in respect of the Security, the holders of Subordinate Bonds will then be entitled to accelerate the indebtedness owing pursuant to the Subordinate Bonds and to make any filings necessary to protect their claims subject to such filings not constituting an enforcement action.

(3) In the event that the holders of Subordinate Bonds by Ordinary Resolution elect to direct the Trustee to take any enforcement action or otherwise to enforce or realize on the Security, the holders of the Senior Bonds will at any time, upon delivery of notice to the Trustee, be entitled to assume control over the enforcement or realization process so that the Trustee will thereafter take instructions solely from the holders of Senior Bonds in accordance with any Ordinary Resolution passed by the holders of Senior Bonds. Upon receipt of such a request from the holders of Senior Bonds, the holders of Subordinate Bonds agree to accede to such request and thereafter not interfere in any manner or form with the course of action and instructions being put forward by the holders of Senior Bonds in respect to the enforcement and realization of the Security. Once all indebtedness and obligations owing to the holders of Senior Bonds have been paid in full, the holders of Subordinate Bonds will be thereafter entitled to direct the Trustee in respect to enforcement actions by Ordinary Resolution of such holders.

(4) Following the occurrence and continuance of an Event of Default, any holder or holders of Subordinate Bonds (collectively, the "initiating bondholders") will be entitled to

purchase all of the indebtedness owing by the Company to all holders of Senior Bonds (including principal, all accrued interest to the date of purchase and, without duplication, the Make-Whole Amount, (if any)) (collectively, the “**Senior Obligations**”). Should any holder of a Subordinate Bond determine that it wishes to purchase the Senior Obligations, it will provide irrevocable written notice to the Trustee and the other bondholders stating that it is exercising its option to purchase the Senior Obligations in accordance with the terms of this Section 3.9(4). Each holder of a Subordinate Bond will have a right to participate in such purchase by providing written notice to the initiating bondholders of its irrevocable agreement to do so within 10 days from the delivery of the initiating bondholders notice to purchase. Each holder of a Subordinate Bond who elects to participate in such purchase (including the initiating bondholders) will be obliged to purchase its respective *pro rata* share of the Senior Obligations. The notice delivered by the initiating bondholders must provide for the purchase date of the Senior Bonds with such purchase date to be no earlier than 30 days from the date of such notice and no later than 40 days from the date of such notice. The purchase price for the Senior Bonds will be based on the applicable Redemption Price for each series of Senior Bonds and will be calculated in accordance with the terms of the supplemental indentures in respect of which such series of Senior Bonds were issued. Upon those purchasing holders tendering payment of the Senior Obligations to the Trustee on the purchase date, each holder of a Senior Bond will transfer its Bonds to the purchaser(s) without representation or warranty other than as to its ownership of such Bonds and that such Bonds and the obligations owing in connection therewith are not subject to any Liens.

(5) The priorities for payment of the Bonds following an enforcement of Security as provided for in Section 10.6 hereof will apply and be effective notwithstanding:

- (a) the fact that a rule of law or any statute may alter or vary the priorities set forth in such Section;
- (b) the time of the incurrence of any of the indebtedness, obligations or liabilities owing to the holders of Senior Bonds or the holders of Subordinate Bonds;
- (c) the time of the Event of Default in respect of the Senior Bonds or the Subordinate Bonds or the making of any demand or giving of any notice or the prior giving of notice by any of the holders of Senior Bonds or Subordinate Bonds;
- (d) any priority granted by any principle of law or any statute; and
- (e) the filing by or against the Company under or pursuant to any Applicable Law of any procedure relating to bankruptcy, insolvency or reorganization or release of debtors.

(6) The terms of this Section 3.9 will remain in full force and effect without regard to, and the obligations of the holders of the Bonds hereunder will not be released or otherwise affected or impaired by:

- (a) any exercise or non-exercise by the holders of Senior Bonds of any right, remedy, power or privilege in this indenture or the Security Agreements;



- (b) any waiver, consent, extension, indulgence or other action, inaction or admission by the holders of the Senior Bonds under or in respect to this indenture or any of the Security Agreements;
- (c) the failure of the holders of Senior Bonds to file or enforce a payment of any kind;
- (d) any defence based upon an election of remedies by the holders of Senior Bonds which destroys or otherwise impairs the subrogation rights of the holders of Subordinate Bonds;
- (e) any merger, consolidation or amalgamation of the holders of Subordinate Bonds or any of them into or with any other person; or
- (f) any insolvency, bankruptcy, liquidation, reorganization, arrangement, composition, winding-up, dissolution or similar proceeding involving or affecting holders of Subordinate Bonds or any of them or the Company.

(7) In the event of a distribution, division or application, partial or complete, voluntary or involuntary, by operation of law or otherwise, of all or any part of the assets of the Company, or the proceeds thereof, to creditors in connection with the bankruptcy, liquidation or winding-up of the Company or in connection with any composition with creditors or scheme of arrangement of the Company, the holders of Senior Bonds will be entitled to receive payment in full of all the indebtedness owing to them in respect to the Senior Bonds (the “**Senior Bond Obligations**”) before the Subordinate Bonds are entitled to receive any direct or indirect payment or distribution of any cash or other assets of the Company on account of any indebtedness owing in respect to the Subordinate Bonds (the “**Subordinate Bond Obligations**”), and the holders of the Senior Bonds will be entitled to receive directly, for application in payment of the Senior Bond Obligations (to the extent necessary to pay all Senior Bond Obligations in full after giving effect to any substantially concurrent payment or distribution to the Senior Bonds in respect of the Senior Bond Obligations), any payment or distribution of any kind or character, whether in cash or other assets, which is payable or deliverable upon or with respect to the Subordinate Bond Obligations.

(8) Should any payment, distribution or proceeds be received by or on behalf of any holder of a Subordinate Bond upon or with respect to the Subordinate Bond Obligations owing to it in contravention of any provision hereof, the recipient thereof will receive and hold the same or cause same to be received and held in trust, as trustee, for the benefit of the holders of Senior Bonds, and must forthwith deliver the same or cause same to be delivered to the Trustee, in precisely the form received (except for the endorsement or assignment of the recipient where necessary), for application in accordance with Section 10.6 hereof, and, until so delivered, the same will be held by the Trustee, and will form part of the Secured Assets.

**ARTICLE 4**  
**ISSUE OF BONDS**

**Section 4.1 Interest Not to Accrue**

From and after the date of maturity, redemption, exchange or purchase by the Company, as applicable, of any Bonds, or the due date of payment of any part of the principal amount of any Bonds, no further interest will accrue on such Bonds or principal amount, as the case may be, unless payment of the amount then payable has not been made in accordance with the applicable terms of this indenture. If payment has not been made in accordance with the applicable terms of this indenture when due, interest will (i) continue to accrue on such unpaid amount and (ii) accrue on overdue interest, all at the same rate as is payable on the principal of the applicable Bonds.

**Section 4.2 Senior Bonds and Subordinate Bonds**

Senior Bonds and Subordinate Bonds may at any time and from time to time (provided no Default or Event of Default has occurred and is continuing at such time) be created, issued and executed by the Company and delivered to the Trustee and will be certified by the Trustee and delivered to or upon the Written Order of the Company (without the Trustee receiving any consideration therefor) but only if the Company has complied with the provisions of Section 6.2, and the Company has furnished to the Trustee:

- (a) a Written Order for the certification and delivery of, the Series 1 Senior Bonds, Additional Bonds or Subordinate Bonds, as the case may be, and specifying the series number, the aggregate amount, the attributes and the form of the Series 1 Senior Bonds, Additional Bonds or Subordinate Bonds, as the case may be, to be certified and delivered;
- (b) a Certified Resolution authorizing the creation, issue and execution of the Series 1 Senior Bonds, Additional Bonds or Subordinate Bonds, as the case may be, in the principal amount applied for and determining the series and attributes thereof in accordance with this indenture;
- (c) an indenture supplemental hereto, in form and substance satisfactory to Counsel, creating the Series 1 Senior Bonds, such series of Additional Bonds or Subordinate Bonds, as the case may be, duly executed by each of the parties thereto;
- (d) an Officers' Certificate:
  - (i) stating that all conditions provided for in this indenture relating to the issue, certification and delivery of the Series 1 Senior Bonds, Additional Bonds or Subordinate Bonds, as the case may be, applied for have been complied with in accordance with the terms of this indenture;
  - (ii) stating that so far as is known to the signers, after having made due enquiry pursuant to Section 17.12, no Default or Event of Default has

occurred and is continuing or will result from the making or granting of such Written Order; and

- (iii) in the case of any Additional Bonds or Subordinate Bonds, providing reasonable particulars demonstrating compliance by the Company with the covenants in Section 6.2(i)(e) or Section 6.2(ii)(e), as and if applicable (on a *pro forma* basis after giving effect to the issue of such Additional Bonds or Subordinate Bonds, as the case may be, and the application of the proceeds thereof);
- (e) an Opinion of Company Counsel dated the date of such Written Order to the effect that (i) all conditions precedent provided for herein relating to the authorization, execution, certification and delivery of the Bonds applied for have been complied with; and (ii) the Bonds applied for have been duly authorized and executed by the Company and, upon certification thereof by the Trustee and delivery thereof by the Trustee or the Company, will be valid and legally binding obligations of the Company, subject to customary qualifications and assumptions and will be secured by the Security; and
- (f) such other materials and documents as the Trustee or Counsel may reasonably require and as may be provided for in the supplemental indenture creating such issue of Series 1 Senior Bonds, Additional Bonds or Subordinate Bonds, as the case may be.

Upon the issuance of any Additional Bonds or Subordinate Bonds, the Trustee will provide to each bondholder, the supplemental indenture entered into in connection with such Bonds along with all other documentation referred to in this Section 4.2 and required by Section 6.2.

#### **Section 4.3 No Bonds to be Issued During Default**

No Bonds will be certified or delivered if at that time, to the knowledge of the Trustee, a Default or an Event of Default has occurred and is continuing. Any certification and delivery of any Bonds by the Trustee will be conclusive evidence of the absence of knowledge on the part of the Trustee of any such Default or Event of Default at the time of such certification and delivery.

#### **Section 4.4 Concerning Opinions and Certificates**

The Trustee, prior to the certification and delivery of any Bonds under any of the provisions of this Article 4, will not be bound to make any enquiry or investigation as to the correctness of the matters set forth in any of the opinions, certificates or other documents required by the provisions of this Article 4, but will be entitled to accept and act upon the said opinions, certificates and other documents. The Trustee may, in its discretion in cases where it deems further proof desirable and will, upon receipt of an Ordinary Resolution of either the holders of Senior Bonds or Subordinate Bonds, require further proof.

**ARTICLE 5**  
**REDEMPTION, PURCHASE AND EXCHANGE OF BONDS**

**Section 5.1 General**

The Company will have the right, at its option, to redeem either in whole at any time or in part from time to time prior to maturity, provided that no Event of Default is then continuing, Bonds issued hereunder of any series which by their terms are made so redeemable (subject, however, to any applicable restriction on the redemption of Bonds of such series) with such Make-Whole Amounts (if any), at such date or dates, upon such notice, upon such terms respecting payment and otherwise in the manner determined at the time of the issue of such Bonds and as expressed in this indenture or in the supplemental indenture authorizing or providing for the issue of such Bonds or in such Bonds.

**Section 5.2 Partial Redemption of Bonds**

In case less than all of the outstanding Bonds of any series are to be redeemed, the Company will in each such case, at least 15 business days before the notice of redemption is required to be given, notify the Trustee in writing of its intention to redeem Bonds and of the aggregate principal amount of such Bonds to be redeemed. The Bonds to be redeemed will be selected on a *pro rata* basis (to the nearest multiple of \$1,000, in the case of Bonds denominated in Canadian Dollars and US\$1,000, in the case of Bonds denominated in United States Dollars) in accordance with the principal amount of Bonds registered in the name of each holder. In the case of a partial redemption, Bonds denominated in United States Dollars may be redeemed only in denominations of US\$1,000 or any whole multiple thereof and Bonds denominated in Canadian Dollars may be redeemed only in denominations of \$1,000 or any whole multiple thereof. The holder of any Bond called for redemption in part only, upon surrender of such Bond for payment as required by Section 5.8, will be entitled to receive, without expense to such holder, one or more new Bonds of the same series and tenor, for the unredeemed part of the Bond surrendered, and the Trustee will certify and deliver such new Bond or Bonds upon receipt of the Bond so surrendered; or, at the option of such holder, the Trustee will return the Bond to the holder after making notation thereon of the portion of the principal amount thereof so redeemed. In the alternative, payment of the applicable Redemption Price of any portion of any Bond may be made to the registered holder thereof without presentation or surrender thereof to the Trustee and such registered holder may be requested to make the notation thereon if there has been filed with the Trustee a certified copy of, or extract from, an agreement between the Company and such registered holder, (or the owner whose nominee the registered holder is) to the effect thereof. The Trustee will be under no duty to determine that such notations have been made by such registered holder. Unless the context otherwise requires, the word "Bond" or "Bonds" as used in this Article 5 will be deemed to mean and include any part of the principal amount of any Bond which in accordance with the foregoing provisions has become subject to redemption.

**Section 5.3 Notice of Redemption**

Except as otherwise required or permitted with respect to any Bonds by the indenture supplemental hereto creating such Bonds, notice of intention to redeem any Bonds (in

whole or in part) prior to their respective maturity date will be given by or on behalf of the Company to the holders of the Bonds which are to be redeemed, not more than 60 days nor less than 30 days prior to the Redemption Date in the manner provided in Section 15.2. Every notice of redemption must, unless all of the Bonds then outstanding are to be redeemed, state the designating numbers of the Bonds called for redemption and, in case a Bond is to be redeemed in part only, that part of the principal amount thereof to be redeemed. Any notice of intention to redeem must specify the Redemption Date, an example of how the Redemption Price will be calculated and the place of payment and must state that all interest thereon will cease from and after such Redemption Date and must include the name and telephone number of a representative of the Company who can be contacted if a bondholder has further inquiries. The Company will use its best efforts to obtain from the Investment Dealer the applicable Canada Yield Price (as such term is defined in the applicable supplemental indenture hereto), if applicable, necessary to determine the Redemption Price as early as possible on the business day three business days immediately preceding the Redemption Date, and forthwith after determining such Redemption Price will provide the Trustee (by telephone confirmed by facsimile or hand delivery at such numbers or address as may be provided by the Trustee to the Company from time to time) with particulars of the calculation of the Redemption Price.

#### **Section 5.4 Bonds Due on Redemption Dates**

Upon notice having been given as aforesaid, all the Bonds called for redemption (or the portion of such Bonds called for partial redemption) will thereupon be due and payable at the Redemption Price on the Redemption Date specified in such notice, in the same manner and with the same effect as if it were the respective maturity date of such Bonds (or such portion being redeemed), anything in the Bonds or herein to the contrary notwithstanding, and from and after such Redemption Date, if the moneys necessary to redeem such Bonds (or the portion of such Bonds called for partial redemption) has been deposited as hereinafter provided and affidavits or other proof satisfactory to the Trustee as to the mailing of such notices have been lodged with it, such Bonds (or the portions thereof that were to have been redeemed) will not be considered as outstanding hereunder and interest upon such Bonds will cease.

In case any question arises as to whether any notice has been given as above provided and any such deposit made, such question will be decided by the Trustee whose decision will be final and binding upon all parties in interest.

#### **Section 5.5 Deposit of Redemption Moneys**

Upon Bonds having been called for redemption (or partial redemption) as provided in this indenture, the Company will deposit with the Trustee before 1:00 p.m. (Toronto time) the Redemption Date fixed in the notice of redemption thereof, such sums as may be sufficient to pay the Redemption Price of the Bonds (or portions thereof) to be redeemed. From the sums so deposited, the Trustee will pay or cause to be paid to the holders of such Bonds called for redemption, upon surrender of such Bonds at the principal office of the Trustee in the City of Toronto, Ontario, and such other places (if any) as may be specified in the notice of redemption, the Redemption Price.

### **Section 5.6 Failure to Surrender Bonds Called for Redemption**

In case the holder of any Bond so called for redemption in whole or in part fails within 30 days after the date fixed for redemption so to surrender his Bond or does not within such time accept payment of the applicable Redemption Price payable in respect thereof or give such receipt therefor (if any) as the Company or the Trustee may require, if the Company has paid the applicable Redemption Price to the Trustee as provided for in Section 5.5 and directed the Trustee to set it aside in trust for such holder, either in the deposit department of the Trustee or an Affiliated Entity (as such term is defined in Article 12 hereof) of the Trustee or in a Permitted Financial Institution, such setting aside will, for all purposes, be deemed a payment to such bondholder of the sum so set aside, and to that extent the said Bond will thereafter not be considered as outstanding hereunder and the bondholder will have no other right except (upon surrender and delivery up of his Bond) to receive payment out of the moneys so deposited of the applicable Redemption Price of such Bond.

Any moneys so set aside and interest thereon (if any) not claimed by or paid to the holder of the Bonds entitled thereto within 6 years after the date of such setting aside will be repaid to the Company by the Trustee on demand and thereupon the Trustee will be released from all further liability with respect to such moneys and thereafter the holders of the Bonds in respect of which such moneys were so paid to the Company will have no rights in respect thereof except to obtain payment of such moneys from the Company subject to any defence the Company may have and to the provisions of this indenture.

### **Section 5.7 Purchase of Bonds**

With respect to any particular series of Bonds, unless otherwise provided herein or in the supplemental indenture authorizing the creation and issue of such series of Bonds, at any time and from time to time, provided that no Default or an Event of Default has occurred and is continuing at such time, the Company may purchase Bonds:

- (a) by private agreement or in the open market; or
- (b) pursuant to a call for tenders given to all holders of the Bonds or the series of Bonds to be purchased, by notice given in accordance with Section 15.2, which notice must specify the purchase date (which may not be earlier than 15 days after the giving of such notice), the purchase price and the place of payment thereof. In the event that an aggregate principal amount of the Bonds, or the Bonds of the series to be purchased, is tendered which is greater than that offered to be purchased, such tendered Bonds will be purchased on a *pro rata* basis in the proportion, as nearly as practicable, which the principal amount of Bonds or series of Bonds tendered by each holder bears to the principal amount of Bonds or series of Bonds offered to be purchased by the Company.

### **Section 5.8 Cancellation of Bonds**

All Bonds redeemed under this Article 5 or under any indenture supplemental hereto and any Bonds purchased by the Company must be forthwith delivered to the Trustee and will be cancelled by the Trustee and no Bonds will be issued in substitution therefor. All Bonds

which have been delivered to and cancelled by the Trustee will be destroyed by the Trustee and, if required by the Company, the Trustee will furnish to it a destruction certificate setting forth the numbers and denominations of the Bonds so destroyed.

### **Section 5.9 Application to All Series of Bonds**

The provisions of Section 5.2 to Section 5.6, inclusive, will apply to each series of Bonds if by their terms they are redeemable unless otherwise provided in instruments supplemental or ancillary hereto establishing the terms of the Bonds of such series.

### **Section 5.10 Make-Whole Amount on Acceleration**

The Company will pay to each holder of Senior Bonds the Make-Whole Amount (if any) (together with any other amounts due under the Senior Bonds) upon payment of such Senior Bonds in any circumstance giving rise in any manner to the repayment of the Senior Bonds prior to the Maturity Date including, without limitation, acceleration pursuant to Section 9.2 of this indenture.

### **Section 5.11 Redemptions and Purchases of Subordinate Bonds**

Notwithstanding the foregoing or anything contained in this indenture to the contrary, the Company may not at any time or under any circumstances redeem or purchase any Subordinate Bonds while Senior Bonds remain outstanding except pursuant to a Unanimous Resolution passed by the holders of all Senior Bonds. This Section 5.11 will be paramount to all other sections contained in this indenture.

## **ARTICLE 6 CERTAIN COVENANTS**

The Company hereby represents, warrants, covenants and agrees with the Trustee that it will carry out or cause to be carried out each and every covenant to be performed by the Company as hereinafter set forth:

### **Section 6.1 Title to Secured Assets**

The Company has and will have, subject only to the rights of the Nominee and to Permitted Encumbrances and except as set forth on Schedule "F":

- (a) good, valid title in fee simple to the Lands;
- (b) valid and subsisting easements or leasehold interests, as the case may be, necessary for the operation of the Company's transmission system; and
- (c) good title to or interests in all Secured Assets not included in paragraphs (a) and (b) above.

The Company will defend the title of its interest in the Secured Assets for the benefit of the Trustee and the bondholders against all claims and demands of all persons.

## Section 6.2 Limitations on Creation of Additional Indebtedness

### (i) Limitation on Creation of Additional Bonds

The Company covenants that it will not issue Additional Bonds unless:

- (a) there exists no Default or Event of Default that is continuing;
- (b) the Additional Bonds mature on the Maturity Date;
- (c) the terms of the Additional Bonds do not allow for any repayment of principal indebtedness owing thereon (other than repayment resulting subsequent to an acceleration in accordance with the terms hereof or redemption in accordance with the terms hereof or of any applicable supplemental indenture) prior to June 16, 2013;
- (d) any repayments of principal on the Additional Bonds on or subsequent to June 16, 2013 will be based on an amortization period that equals or exceeds the then remaining amortization period of the Series 1 Senior Bonds;
- (e) the Company has provided to the Trustee an Officers' Certificate confirming that:
  - (i) the ratio of the EBITDA for the twelve consecutive calendar months immediately preceding the date of the Company's most recent financial statements, determined from the information disclosed in such financial statements, to the actual Debt Service for such twelve calendar month period was at least 3.0:1.0; and
  - (ii) after giving effect to the proposed issuance of Additional Bonds and the application of the proceeds therefrom (to the extent used to retire existing Indebtedness), the ratio of the projected EBITDA for the twelve consecutive calendar months immediately following the date of the proposed issuance to the projected Debt Service for such period is at least equal to 3.0:1.0,

which Officers' Certificate shall have attached thereto a schedule setting forth the calculation of such amounts in the form attached hereto as Schedule "G" and (A) must be accompanied by a Chartered Accountant's Certificate confirming that the ratio set out in clause (i) above was complied with, and (B) must state that the projected EBITDA was determined with reference to the Company's projected regulated transmission rate base for the relevant period and any approvals given by the Ontario Energy Board;

- (f) the Company has delivered to the Trustee an Officers' Certificate confirming that no Default or Event of Default exists and that no material adverse change has occurred with respect to the Company or the Transmission Business;



- (g) the Rating Condition has been satisfied in connection with proposed issuance of the Additional Bonds and evidence of such has been delivered to the bondholders concurrent with or prior to the issuance of such Additional Bonds;
- (h) after such proposed issuance, the ratings ascribed by the Rating Agency to the Senior Bonds will be BBB or higher and evidence of such has been delivered to the bondholders concurrent with or prior to the issuance of such Additional Bonds; and
- (i) the Company has obtained and delivered to the Trustee an endorsement to the title insurance policy previously delivered to the Trustee (or a replacement policy acceptable to the Trustee) in respect to the Power Real Estate such that the total amount of insurance is at least equal to the aggregate principal amount outstanding under all Bonds after the proposed issuance of Additional Bonds.

**(ii) Limitation on Creation of Subordinate Bonds**

The Company covenants that it will not issue Subordinate Bonds unless:

- (a) there exists no Default or Event of Default that is continuing;
- (b) the Subordinate Bonds mature on or subsequent to the Maturity Date applicable to the Senior Bonds;
- (c) the aggregate principal amount of all of the outstanding Subordinate Bonds following the issuance will not exceed 30% of the aggregate principal amount of all Senior Bonds outstanding at the time of such issuance;
- (d) the terms of the Subordinate Bonds provide that no repayment of principal indebtedness owing thereon will be permitted until all indebtedness owing to the holders of Senior Bonds has been paid in full;
- (e) the Company has provided to the Trustee an Officers' Certificate confirming that:
  - (i) the ratio of the EBITDA for the twelve consecutive calendar months immediately preceding the date of the Company's most recent financial statements, determined from the information disclosed in such financial statements, to the actual Debt Service for such twelve calendar month period was at least 2.0:1.0; and
  - (ii) after giving effect to the proposed issuance of Subordinate Bonds and the application of the proceeds therefrom (to the extent used to retire existing Indebtedness), the ratio of the projected EBITDA for the twelve consecutive calendar months immediately following the date of the proposed issuance to the projected Debt Service for such period is at least equal to 2.0:1.0,

which Officers' Certificate shall have attached thereto a schedule setting forth the calculation of such amounts in the form attached hereto as Schedule "G" and (A) must be accompanied by a Chartered Accountant's Certificate confirming that the ratio set out in clause (i) above was complied with, and (B) must state that the projected EBITDA was determined with reference to the Company's projected regulated transmission rate base for the relevant period and any approvals given by the Ontario Energy Board;

- (f) the Company has delivered to the Trustee an Officers' Certificate confirming that no Default or Event of Default exists and that no material adverse change has occurred with respect to the Company or the Transmission Business;
- (g) the Rating Condition has been satisfied in connection with proposed issuance of the Subordinate Bonds and evidence of such has been delivered to the bondholders concurrent with or prior to the issuance of such Subordinate Bonds;
- (h) after such proposed issuance, the ratings ascribed by the Rating Agency to the Senior Bonds will be BBB or higher and evidence of such has been delivered to the bondholders concurrent with or prior to the issuance of such Subordinate Bonds; and
- (i) the Company has obtained and delivered to the Trustee an endorsement to the title insurance policy previously delivered to the Trustee (or a replacement policy acceptable to the Trustee) in respect to the Power Real Estate such that the total amount of insurance is at least equal to the aggregate principal amount outstanding under all Bonds after the proposed issuance of Subordinate Bonds.

**(iii) Limitation on Incurrence of Affiliate Debt**

The Company covenants that it will not incur any Affiliate Debt unless:

- (a) the Affiliate proposing to hold such Affiliate Debt and the Company have entered into a subordination and postponement agreement in favour of the Trustee in the form attached hereto as Schedule "C", with any amendments to such form that are a matter of substance to be approved by Ordinary Resolution of the holders of Senior Bonds (or, if no Senior Bonds are outstanding, the Subordinate Bonds) and any amendments that are a matter of form and not substance to be in the discretion of Trustee upon receipt of advice of Counsel; and
- (b) the Company provides to the Trustee a certified copy of the loan documentation, if any, evidencing such Affiliate Debt.

**(iv) Limitation on Creation of Indebtedness**

The Company covenants that it will not create or assume or attempt to create or assume any Indebtedness other than (a) in connection with Bonds or Affiliate Debt incurred in accordance with Section 6.2(i), Section 6.2 (ii) or Section 6.2(iii) hereof, and (b) Indebtedness which does not exceed \$5,000,000 in the aggregate. All or any portion of such Indebtedness

permitted in (b) may be secured so long as any Lien granted in respect to such Indebtedness qualifies as a Purchase Money Security Interest.

### **Section 6.3 Negative Pledge**

- (a) The Company covenants that it will not create, assume or attempt to create or assume any Lien on the Secured Assets or any part thereof except for Permitted Encumbrances.
- (b) The Company covenants that it will not permit to be outstanding any Lien on the Secured Assets or any part thereof except for Permitted Encumbrances.

### **Section 6.4 To Pay Principal, Make-Whole Amount and Interest**

The Company will well, duly and punctually pay or cause to be paid to every bondholder the principal of and interest accrued on the Bonds of which it is the holder, and, without duplication, the Make-Whole Amount (if any) on such Bonds, on the dates, at the places, in the moneys, and in the manner specified herein and in the Bonds and any supplemental indentures.

### **Section 6.5 To Pay Taxes, Rents, Etc.**

The Company will from time to time pay or cause to be paid all rents, taxes, rates, levies, duties and assessments, general and special, ordinary or extraordinary of every nature and kind whatsoever, including local improvement taxes, which are levied, assessed or imposed upon the Secured Assets or any part thereof, or upon the Company on account thereof, and will, from time to time as the same are paid, upon the written request of the Trustee, produce for inspection by the Trustee receipts or other reasonable evidence of payment of such amounts, other than such amounts due which are being contested in good faith and that the Company has set aside adequate reserves for the payment of such disputed amount. The Company will provide immediate notice to the Trustee of any failure by it to pay any such amounts of which it becomes aware.

### **Section 6.6 To Effect Necessary Registrations**

The Company will record, register or file the Security Agreements (or a notice, caveat or financing statement in respect hereof) at every public office of record where the recording, registration or filing thereof may be necessary to constitute, perfect and maintain the priority of the Security thereby created or intended so to be other than (i) in land titles offices or land registry offices in respect of permits, right-of-way agreements, licenses or sublicenses of occupation or in respect of transmission lines, poles, wires and equipment used by the Company in the course of the transmission of hydro-electric power which are not situated on the Lands, or Future Sites owned or leased by the Company, (ii) in respect of rights in Power Real Estate that are not registered against title, and (iii) under the *Personal Property Security Act* (Ontario) in respect of motor vehicles. The Company will deliver or exhibit to the Trustee, on demand, certificates or other evidence establishing such filings, recordings and registrations. Notwithstanding the foregoing, the Company will not be required to record, register or file the Security Agreements (or a notice, caveat or financing statement in respect thereof) against any

Power Real Estate or Secured Asset where it is necessary to obtain the consent or approval of the Government of Ontario or other grantor until such consent or approval is obtained. Subject to the foregoing, the Company will also record, register or file all such further mortgages, pledges, charges, assignments, security agreements and hypothecs as the Trustee may from time to time request to better assure and perfect its security on the Secured Assets or any part thereof (or a notice, caveat or financing statement in respect of the foregoing), at every public office of record where such recording, registration or filing is, in the opinion of the Trustee or in the Opinion of Counsel, necessary to constitute, perfect and maintain the priority of the security created by the Security Agreements.

### **Section 6.7 To Maintain Security**

The Company will fully and effectively maintain and keep the security created by the Security Agreements to be maintained and kept as a valid and effective Lien at all times while the Bonds are outstanding and it will not permit or suffer the registration of any debt, Lien or privilege whatsoever, whether of workmen, builders, contractors, engineers, architects or suppliers of material, upon or in respect of any of the Secured Assets, unless any such debt, Lien or privilege constitutes and remains a Permitted Encumbrance.

### **Section 6.8 Operation of Business**

#### **(i) Maintain Existence; Conduct Business**

The Company will do or cause to be done all things necessary to preserve and keep in full force and effect its existence pursuant to the laws of Canada or any province thereof, and all material rights and franchises where needed or necessary to the operation of the Transmission Business, and comply in all material respects with all Applicable Laws and conduct and operate the Transmission Business and maintain the Power Assets in accordance with Good Utility Practices. The Company will at all times maintain, preserve and protect the Power Assets in good repair, working order and condition, and will, from time to time, make, or cause to be made, all necessary and proper repairs, renewals, replacements and improvements thereto, for the necessary and effective operation of the Transmission Business, all in accordance with Good Utility Practices.

#### **(ii) Transmission Business**

- (a)** The Company will carry on no business other than the Transmission Business and, for so long as GLPL is the Company and owns the Transmission Business and Power Assets, the Generation Business and the D&C Business;
- (b)** The Company will not (i) continue or re-domicile into any jurisdiction outside of Canada, or (ii) take any other action that would connect it with any jurisdiction outside of Canada in such a way as to result in withholding taxes being imposed on bondholders who are residents in Canada; and
- (c)** The Company will not carry on any business outside the Province of Ontario.

#### **(iii) Transaction with Affiliates**

The Company covenants that transactions with Affiliates and Non-Arm's Length Persons entered into after the date hereof, other than (a) sales, transfers, leases or other dispositions effected in accordance with Section 6.10, Article 7 or Article 11, and (b) Affiliate Debt, will be entered into only in the ordinary course of the Transmission Business and on terms no less favourable to the Transmission Business than those obtainable in Arm's Length transactions. In this regard the Company will provide to the Trustee, within 15 business days after consummating any such transaction, a copy of any agreement relating thereto and an Officers' Certificate as to any such transaction being in the ordinary course and on terms no less favourable than would be obtainable in an Arm's Length transaction. Notwithstanding the foregoing, employees and officers of the Company may provide, from time to time, services to Affiliates of the Company that are not on terms that are as favourable to the Company as would be in Arm's Length transactions so long as the provision of any such services is not in any manner detrimental to the Company or the Transmission Business. In any such instance, the Company will provide to the Trustee, within 15 business days after consummation of any such transaction an Officers' Certificate as to the provision of such services not being in any manner detrimental to the Company or the Transmission Business.

(iv) **Licenses and Permits**

The Company will maintain, renew, apply and obtain all licences, Permits and other consents as may be required to carry on the Transmission Business from time to time except for those which are immaterial to the Company's ability to carry on the Transmission Business.

**Section 6.9 To Pay Trustee's Remuneration**

The Company will pay the Trustee reasonable remuneration for its services as Trustee hereunder and will repay to the Trustee all moneys which have been paid by the Trustee for premiums of insurance, repairs, renewals, taxes, legal expenses or charges on a solicitor and his own client basis, or any other expenditures whatever which the Trustee may reasonably make in and about the execution of the trust hereby created (including all costs incurred by the Trustee in complying with any Applicable Laws as a result of its duties as trustee hereunder) with interest at the rate per annum that is charged by the Trustee to all of its clients from time to time, from the date of expenditure until repayment, and such moneys and the interest thereon, including the Trustee's remuneration, until paid by the Company, will be secured hereby in priority to the principal, Make-Whole Amount (if any) and interest of and on the Bonds.

**Section 6.10 Not to Sell Assets**

(1) Except as permitted in this Section 6.10, Article 7 and Article 11, the Company will not sell, transfer, lease or otherwise dispose of the Secured Assets or any part thereof or any interest therein, or enter into any arrangement, directly or indirectly, whereby the Company sells or transfers and then or thereafter rents or leases back any of the Secured Assets or any part thereof, or any interest therein. For greater certainty, the Company may transfer, in such manner as it may see fit, the Excluded Assets without the requirement of consent of the Trustee or the bondholders.

(2) Notwithstanding the terms of Section 6.10(1), provided that no Default or Event of Default has occurred and is continuing, the Company will be permitted to transfer the Secured Assets, as a whole, to GLPT, a Canadian Affiliate of the Company or Great Lakes Hydro Income Fund (or its successor), or to a Canadian trust or limited partnership which is controlled by either of them (the “**Related Transferee**”), upon the satisfaction of the following conditions:

- (i) the Company provides evidence to the Trustee that the Related Transferee is GLPT, a Canadian Affiliate of or controlled by the Company or Great Lakes Hydro Income Fund (or its successor);
- (ii) the Related Transferee enters into an agreement pursuant to which the Related Transferee (A) makes customary representations and warranties together with such additional representations and warranties as each bondholder may reasonably require and so advise Counsel within 15 days of their receipt of draft documentation relating to the transfer of the Secured Assets to the Related Transferee, (B) assumes the Company’s obligations under the Bonds then outstanding or subsequently issued, (C) agrees to assume, observe, pay, perform, be liable under and be bound by all of the covenants, terms, conditions and obligations provided for in this indenture and the Operative Documents, (D) acknowledges and agrees that all of its interests in the Secured Assets will be subject to a first ranking Lien in favour of the Trustee subject only to Permitted Encumbrances, and (E) agrees to provide, or cause to be provided, concurrent with the transfer such additional Security Agreements as the Trustee may reasonably require acting on advice of Counsel in order to ensure that the Trustee and the bondholders have retained the same rights and remedies as against the Related Transferee and the Secured Assets as they had against the Company and the Secured Assets prior to completion of the transfer;
- (iii) recourse as against the Related Transferee and the Secured Assets will be limited in the same manner as recourse is limited as against the Company and the Power Assets as provided for in Section 10.1 hereof;
- (iv) the Related Transferee makes a representation and warranty or the Trustee receives an Officers’ Certificate from the Related Transferee and/or an opinion from counsel to the Related Transferee (in form and substance acceptable to the Trustee, acting reasonably), confirming that the Related Transferee (a) has all licences, permits and consents necessary or required (including approvals from the Ontario Energy Board (or its successor)) to acquire, own and operate the Secured Assets and (b) maintains all insurance required to be maintained by the Company pursuant to this indenture in respect to the Secured Assets and itself;
- (v) the Trustee receives legal opinions from Company Counsel with respect to, *inter alia*, the enforceability of all obligations under this indenture and the Security Agreements assumed by the Related Transferee and all agreements entered into by the Related Transferee in connection with the

assumption of the obligations of the Company owing pursuant to the Bonds, this indenture and its acquisition of the Secured Assets, such opinions to be in form and substance acceptable to the holders of Senior Bonds as evidenced by an Ordinary Resolution (or if no Senior Bonds are outstanding, Subordinate Bonds by Ordinary Resolution), acting reasonably;

- (vi) if title to any registered real estate assets changes as part of such transaction, the Trustee receives an endorsement or confirmation from any title insurance company that has issued a policy in favour of the Trustee in respect to all or a portion of the Secured Assets to the effect that such title insurance remains in full force and effect as against the Secured Assets and also receives confirmation that all of the insurance requirements provided for in the indenture in respect to the Company and as against the Power Assets are satisfied as respect to the Related Transferee and the Power Assets;
- (vii) the Rating Condition is satisfied; and
- (viii) the Company and the Related Transferee deliver to the Trustee such other agreements, instruments and documents as may be necessary or required to preserve the Security and the rights of the Trustee and the bondholders as a consequence of the transfer of the Secured Assets in the opinion of the holders of Senior Bonds as evidenced by an Ordinary Resolution (or if no Senior Bonds are outstanding, Subordinate Bonds by Ordinary Resolution), acting reasonably.

(3) The Company will notify the Trustee and the bondholders of any proposed transfer in connection with the terms of Section 6.10(2) and will provide to the Trustee and each bondholder a copy of all documents, agreements and instruments executed or delivered pursuant to the terms of Section 6.10(2).

(4) The Company and any transferee of the Secured Assets will be permitted to grant permits, licenses, easements, rights of way, reciprocal rights, rights in the nature of easements, subleases, sublicenses, and other similar rights or entitlements and enter into shared use agreements in favour of any owner of the Generation Business or D&C Business (or any part thereof) or any other person provided that (i) the same do not (y) impair the value of the Secured Assets or interfere with the use thereof in connection with the Business, other than in an immaterial respect; or (z) negatively impact on the ability of the Trustee, if authorized or direct to do so by the Bondholders, to enforce the Security, (ii) they contain customary terms and conditions (including customary insurance and indemnity provisions) (each a “**Permitted Right**”), including the Permitted Rights contemplated by the Reciprocal Agreement. The Trustee will, at the request of the Company, subordinate and/or postpone the Security to a Permitted Right, or consent to or grant a non-disturbance agreement in favour the holder of such Permitted Right, on such terms as the Company may reasonably require provided that the Company delivers to the Trustee:

- (a) a Written Request setting out the proposed subordination, postponement, consent and/or non-disturbance agreement; and
- (b) an Officers' Certificate providing details of the Permitted Right, stating that the requested subordination, postponement, consent and/or non-disturbance agreement complies with the provisions of this Section 6.10(4), and stating that, so far as is known to the signers, after having made due enquiry pursuant to Section 17.12 of this indenture, no Default or Event of Default has occurred and is continuing or will result from the making or granting of the Written Request.

(5) The Trustee will, at the request of the Company, from time to time, release and discharge the Security in respect of all or any part of the Excluded Assets or execute an acknowledgement to the effect that this indenture, the Operative Documents and/or the Security do not extend to the Excluded Assets (or any part thereof) provided that the Company delivers to the Trustee:

- (a) a Written Request setting out the proposed release, discharge or acknowledgement; and
- (b) an Officers' Certificate stating that the proposed release, discharge or acknowledgement complies with the provisions of this Section 6.10(5), and stating that, so far as is known to the signers, after having made due enquiry pursuant to Section 17.12 of this indenture, no Default or Event of Default has occurred and is continuing or will result from the making or granting of the Written Request.

#### **Section 6.11 Financial Statements**

(1) The Company will furnish to the Trustee and each holder of a Bond or its designated agent:

- (a) within one hundred and twenty (120) days after the end of each Fiscal Year a copy of the annual audited consolidated financial statements of the Company, prepared in accordance with GAAP, which will contain an audited balance sheet, statement of income and retained earnings and statement of cash flow, in each case on a comparative basis with the preceding Fiscal Year, certified by a senior officer of the Company as correctly reflecting the financial condition of the Company in all material respects, together with an Annual Operating Report for such Fiscal Year in respect of the Transmission Business and an Officers' Certificate:
  - (i) certifying that no Default or Event of Default has occurred hereunder or, if any Default or Event of Default has occurred, specifying the relevant particulars and the period of existence thereof and the action taken or proposed to be taken by the Company with respect thereto, and



- (ii) describing the aggregate optional principal repayments, purchases by the Company (whether pursuant to sinking fund obligations or otherwise) and redemptions of each series of Bonds in such Fiscal Year, the date on which such repayments, purchases and redemptions occurred and the aggregate unpaid principal amount of each series of Bonds issued hereunder at the end of such Fiscal Year;
- (b) within sixty (60) days after the end of each of the first three fiscal quarters in each Fiscal Year, a copy of the unaudited consolidated quarterly financial statements of the Company prepared in accordance with GAAP which will contain a balance sheet, statement of income and retained earnings and statement of cash flow, certified by a senior officer of the Company as correctly reflecting the financial condition of the Company in all material respects;
- (c) with reasonable promptness such other information regarding the operations and financial condition of the Company as any bondholder may from time to time reasonably request;
- (d) within 60 days after the end of the first three fiscal quarters of each Fiscal Year, an Officers' Certificate stating that the Company is in compliance with all of its obligations under this indenture and that no Default or Event of Default (including without limitation the Events of Default specified in any indenture supplemental hereto) has occurred or is continuing or, if there exists any such non-compliance or if any Default or Event of Default has occurred or is continuing, specifying the relevant particulars and the period of existence thereof and the action taken or proposed to be taken by the Company in respect thereto;
- (e) on or prior to December 1 of each Fiscal Year of the Company, a copy of the Company's Operating Plan for the subsequent Fiscal Year; and
- (f) on each five year anniversary of this indenture, a copy of a current report assessing the overall condition of the Power Assets with such report being addressed to the bondholders and prepared by a nationally recognized and accredited independent engineering and consulting firm with expertise and experience in reviewing assets of a nature similar to the Power Assets.

## Section 6.12 Insurance

The Company will obtain and maintain property insurance in connection with the Power Assets and the Transmission Business and such other types of insurance, including business interruption insurance, liability insurance with respect to claims for personal injury, death or property damage and boiler and machinery insurance, with respect to the operation of the Transmission Business, all with responsible and reputable insurance companies in such amounts and with such deductibles as are customary in cases of businesses of established reputations engaged in the same or similar businesses provided that the property insurance on the Power Assets must be in amounts not less than the Replacement Cost of the Power Assets. Such insurance must contain a provision that it will not be cancelled without at least 30 days prior

written notice to be given by the insurer(s) to the Trustee, and must contain a standard mortgage clause and contain a waiver by the insurer of all rights of subrogation or indemnity and contain a cross-liability clause and a severability of interests clause. Additionally, such policies of insurance must name the Trustee as first loss payee and mortgagee and, in respect to all third party liability insurance, identify the Trustee as an additional insured. All such insurance will, on the close of the issuance of the Series 1 Senior Bonds, be satisfactory in the view of the Insurance Consultant.

### **Section 6.13 Decisions of the Ontario Energy Board**

The Company will deliver to the Trustee and each holder of a Bond within 30 days of receipt, copies of any Ontario Energy Board decisions relevant to the Transmission Business, including, without limitation, those regarding rates relating to the Transmission Assets.

### **Section 6.14 Notifications**

The Company will notify the Trustee and each holder of a Bond of any event, circumstance or matter which may reasonably be expected to result in a Material Adverse Change and of the occurrence of any Default or Event of Default, forthwith and in any event within five business days after the Company becomes aware of such Material Adverse Change, Default or Event of Default.

### **Section 6.15 Notify Trustee of Change of Name or Change of Chief Executive Office**

(a) The Company will not change its name without giving at least 30 days' prior notice to the Trustee and the bondholders in accordance with Section 15.3 of the new name and the date upon which such change of name is to take effect and, within five business days of the change of name, the Company will provide the Trustee and the bondholders with a copy of the relevant articles of amendment indicating such change of name.

(b) The Company will not move its chief executive office outside of the Province of Ontario except upon 30 days' prior written notice to the Trustee and, in such event, (A) only to another Province in Canada, and (B) only if the Liens created by the Security Agreements continue to constitute a valid, enforceable and perfected first priority security interest in all intangible property of the Company including, without limitation, Accounts Receivable, subject only to Permitted Encumbrances, and in such circumstances the Company will continue to hold and preserve its records concerning Accounts Receivable.

### **Section 6.16 To Charge After-Acquired Property and Execute Further Assurances**

(a) The Company will, whether required by the Trustee or not, mortgage, pledge, charge, assign and grant a security interest in favour of the Trustee in any Addition, as part of the Secured Assets, and will mortgage, pledge, charge, assign and grant a security interest in favour of the Trustee, as part of the Secured Assets, in any Future Sites, and the Company will make the requisite registrations and filings under Section 6.6 with respect thereto. The Company will, whether required by the Trustee or not, assign in favour of the Trustee each Material Contract; subject to using its best efforts to obtain any required consents in this regard and an Acknowledgement and Consent for each such Material Contract (other than the Connection

Facilities Agreement dated July 1, 2002 between Hydro One Networks Inc. and the Company, as successor by assignment and novation to GLPL), and the Company will make the requisite registrations and filings with respect thereto. At any and all times the Company will, do, execute, acknowledge and deliver or will cause to be done, executed, acknowledged and delivered all and every such further acts, deeds, conveyances, mortgages, transfers and assurances as the Trustee may reasonably require, for the purpose of giving the Trustee a valid first ranking Lien (subject to Permitted Encumbrances) upon all Secured Assets and for the better assuring, conveying, mortgaging, assigning, confirming or charging unto the Trustee all other property and assets used in connection with the Transmission Business which the Company may hereafter acquire. The Company will deliver to the Trustee and each bondholder a copy of each Material Contract and each assignment and Acknowledgement and Consent obtained in respect thereof. At the request of the Company, the Trustee will execute confirmations and acknowledgements as may be required and based on the advice of Counsel, from time to time, to confirm and acknowledge that the collateral charged by the Security Agreements relates only to the assets included and used in connection with the Transmission Business and that the Security does not extend to the Excluded Assets or assets disposed of or sold in accordance with this indenture (other than any such disposition or sale completed pursuant to Section 6.10(2)).

(b) The Company will:

- (i) keep all its equipment and all of its other tangible personal property in jurisdictions in which all required filings have been duly made for the perfection of the security interests created hereby and are in full force and effect and in which the Security creates a valid and enforceable first priority security interest in the Secured Assets subject only to Permitted Encumbrances; and
- (ii) with respect to any equipment or inventory in the possession or control of any third party, upon the request of the Trustee, provide written notification to such third party (with a copy to the Trustee) of the Trustee's security interest in such equipment or inventory and, upon the Trustee's request following the occurrence of an Event of Default, direct such third party to hold all such equipment or inventory for the Trustee's account and subject to the Trustee's instructions.

#### **Section 6.17 Not to Cancel or Amend**

So long as any of the Bonds remain outstanding, the Company will not (i) make or permit to be made any amendment, revision, modification or replacement of any Material Contract that is prejudicial in any material way to the interests or rights of the bondholders, (ii) cancel, amend, vary, alter, modify any of the Permitted Encumbrances or Transmission Property Rights in any manner which would result in a Material Adverse Change, or (iii) cancel or terminate any Material Contract if such cancellation or termination could result in a Material Adverse Change.

Without limiting the generality of the foregoing, the Company shall not exercise its right to terminate the Operation, Maintenance and Administration Agreement in accordance

with the terms thereof or accept a voluntary termination by the Manager of the Operation, Maintenance and Administration Agreement on less than 180 days notice unless prior thereto the Company has made arrangements to either: (i) retain the people and acquire any assets that it requires to operate the Transmission Assets on its own behalf; or (ii) replace the services provided pursuant to the Operation, Maintenance and Administration Agreement by retaining a recognized and reputable operator with at least five years' experience in operating transmission assets of a type similar to the Transmission Assets; and in either the case of (i) or (ii) of this paragraph above, such arrangements and agreements are on market terms and conditions, are in accordance with Good Utility Practices and would not result in a Material Adverse Change. The Company shall provide to the Trustee copies of any material amendments to and any replacement of the Operation, Maintenance and Administration Agreement entered into from time to time, and to the extent there is to be a change in the Manager, information relating to the experience and reputation of such person.

### **Section 6.18 Copies**

The Company will deliver to the Trustee from time to time, or to such other person as the Trustee may direct, within five business days of receipt of a written request therefor from the Trustee, a true copy of this indenture and any instrument supplemental or ancillary thereto.

### **Section 6.19 Trustee May Perform Covenants**

If the Company fails to perform any covenant on its part contained in this indenture or any indenture supplemental hereto, the Trustee may, after giving notice to the Company, perform (but will not be obliged to perform) or cause any other person to perform any of such covenants capable of being performed by it and, if any such covenant requires the payment or expenditure of money, the Trustee may make such payment or expenditure with its own funds, or with money borrowed by or advanced to it for such purpose. All sums so expended or advanced will be payable by the Company to the Trustee in accordance with Section 6.9 but no such performance or payment will be deemed to relieve the Company from any Default or Event of Default hereunder.

### **Section 6.20 Concerning Officers' Certificates**

The statements made in all Officers' Certificates which may be executed and filed pursuant to the provisions of this indenture will be true and correct and the Company will duly perform any undertaking set forth on behalf of the Company in any such Officers' Certificates.

### **Section 6.21 Limitations on Distributions**

The Company covenants that it will not declare or make any Distribution unless at the time of such Distribution (i) no Default or Event of Default exists, (ii) the Debt Service Reserve Account is funded to its required level, (iii) the ratio of the EBITDA for the immediately preceding 12 calendar months to Debt Service for such 12-month period is equal to or greater than 1.5:1.0 and (iv) the ratio of the Company's forecast of EBITDA for the immediately following 12-month period to its forecast of Debt Service for such 12-month period is equal to or greater than 1.5:1.0. Evidence of compliance with such ratios will be provided for in an

Officers' Certificate which will provide a reasonable detail of the calculations relating thereto. In addition to the Distributions permitted herein, the Company may distribute to any person the cash amount previously paid by such person to the Company pursuant to a purchase by such person of equity in the Company or contributions to the capital of the Company subject to the following: (i) at the time of such Distribution there exists no Default or Event of Default; (ii) the Distribution to be made is made within 30 days from the date that such person completed such purchase of equity of or contributed capital to the Company and made payment in respect thereof to the Company; (iii) the cash distributed pursuant to such Distribution does not exceed the net cash proceeds received by the Company in respect to such purchase of equity or capital contribution; (iv) the Trustee receives an Officers' Certificate of the Company confirming the truth and accuracy of (i), (ii) and (iii) above along with confirmation of the amount of the equity investment or capital contribution and the amount to be distributed.

### **Section 6.22 Inspection Rights**

The Company will permit any holder or holders of a Bond or Bonds that hold in the aggregate no less than 2.5% of the outstanding obligations owing pursuant to the Bonds to discuss the affairs, finances and accounts, inspect the Power Assets and review the books and records of the Transmission Business with the principal officers of the Company during normal business hours and, after receiving consent from the Company, such consent not to be unreasonably withheld, with the Company's independent chartered accountants (with the Company being entitled, when no Default or Event of Default is in existence, to attend at any such meetings), all at such reasonable times, upon such reasonable notice and as often as such holder of a Bond may reasonably request. While no Default or Event of Default is in existence, a bondholder will only be entitled to discuss with the chartered accountants of the Company the affairs of the Company once in each calendar year. Upon and during the continuance of any Default or Event of Default, the holders of the Bonds may direct the Trustee to appoint an agent to act on behalf of all holders of the Bonds and at the expense of the Company to visit and inspect any of the properties of the Company and review the books and records of the Transmission Business, discuss the affairs, finances and accounts of the Company with the Company's independent chartered accountants and all at such reasonable times, upon such notice as may be reasonable in light of such Default or Event of Default and as often as such agent may reasonably determine; provided, however, that all such rights of the holders of the Bonds will, on the requirement of the Company, be subject to such holders and any such agent entering into a confidentiality agreement in the form of Schedule "E", with respect to information to be disclosed.

### **Section 6.23 Debt Service Reserve Account**

(1) The Company will establish and at all times maintain the Debt Service Reserve Account as a segregated account in the name of the Trustee in trust for the Company for purposes of servicing interest and principal payments on the Senior Bonds. The Company will, at its option, either (i) maintain on deposit in the Debt Service Reserve Account an amount of cash equal to six months interest on the Senior Bonds outstanding from time to time, or (ii) provide to the Trustee a Letter of Credit with a face amount equal to six months interest on the outstanding Senior Bonds. Funds held in the Debt Service Reserve Account may be invested by the Trustee, on written instructions from the Company, in Permitted Investments.

(2) The Company will be entitled to, and the Trustee will allow the Company to, withdraw amounts from the Debt Service Reserve Account to pay amounts of principal and interest due under the Senior Bonds in the event that revenues of the Company are insufficient therefor; provided that the Company will not be entitled to make any Distribution following a withdrawal from the Debt Service Reserve Account until the Debt Service Reserve Account has been funded to its required level. For greater certainty, the Debt Service Reserve Account will at all times be funded to the maximum level required hereunder and should any draw be made on such account, the Company will ensure that the account is re-funded, from time to time, in an amount equal to the withdrawn amount prior to making any Distributions. In the event that the Debt Service Reserve Account is funded in an amount that exceeds that amount representing six months interest on the Senior Bonds, the Company will be entitled to, and the Trustee will allow the Company to, withdraw funds to the extent of such excess amount or reduce the Letter of Credit to, or replace the Letter of Credit held by the Trustee with a Letter of Credit in, the required amount.

(3) During the continuance of a Default or an Event of Default, the Company will have no ability to instruct the Trustee in regards to the Debt Service Reserve Account.

(4) Any Letter of Credit delivered pursuant to this Section 6.23 will be issued to the credit of the Debt Service Reserve Account by a Permitted Financial Institution and must contain, in addition to the requirements provided in this Section, such other terms and provisions as are satisfactory to the Trustee in its sole discretion. Any Letter of Credit delivered will form part of the Security for the Senior Bonds only. If no agreement for a renewal or replacement of any Letter of Credit (with cash or otherwise) is made 15 days prior to the expiration of such Letter of Credit, the Company will immediately notify the Trustee and the bondholders and the Trustee will immediately thereafter draw upon such Letter of Credit and deposit such drawing in the Debt Service Reserve Account.

#### **Section 6.24 No Amalgamation, Etc.**

The Company will not enter into any transaction (whether by way of reorganization, consolidation, amalgamation, winding-up, merger, transfer, sale, lease or otherwise) whereby all or any substantial part of the Secured Assets would become the property of any other person unless (i) no Default or Event of Default exists, (ii) the person continuing from any such transaction is organized and existing under the laws of Canada or any province thereof, (iii) the Rating Condition is satisfied and (iv) the holders of Senior Bonds and the holders of Subordinate Bonds have each passed an Extraordinary Resolution approving such proposed transaction and any terms, conditions and requirements that may be contained in such Extraordinary Resolutions have been met to the satisfaction of the Trustee. Any such Extraordinary Resolutions passed by bondholders approving such a transaction may contain such terms, conditions and other requirements as are deemed appropriate and necessary by the bondholders. The terms of this Section 6.24 will not apply to any transfer of the Power Assets effected pursuant to Section 6.10 of this indenture.

## Section 6.25 Excluded Assets

For greater certainty, the Power Assets do not include the Excluded Assets. The Company represents and warrants in favour of the Trustee and each bondholder that no Excluded Asset is used in connection with the Transmission Business and covenants and agrees that at no time may any property, undertaking or asset of an Excluded Subsidiary be used in connection with the Transmission Business.

## Section 6.26 Included Subsidiaries

The Company will cause each Included Subsidiary at all times:

- (a) to maintain and defend its interest in all property, undertaking and assets that it possesses;
- (b) to have no Indebtedness other than in respect of the obligations under this indenture or the Bonds;
- (c) to have no assets other than (i) in the case of 1228185 Ontario Limited, Permits similar in nature to the permit held by it on the date hereof; and (ii) in the case of the Nominee, legal title to the Power Real Estate as nominee and bare trustee for the Company pursuant to the Nominee Agreement;
- (d) to not create or assume or permit to be outstanding or attempt to create or assume any Lien on its property, undertaking and assets except for the Security or Permitted Encumbrances;
- (e) to pay or cause to be paid all rents, taxes, levies, duties and assessments levied, assessed or imposed upon it;
- (f) to carry on no business of any nature or kind unrelated to the Business;
- (g) to not enter into any transactions with any Affiliate of the Company or any Non-Arm's Length Person other than with the Company and transactions which the Company is permitted to enter into under this indenture;
- (h) to maintain all licences, permits and other consents that it now or hereafter possesses;
- (i) to not dispose of any of its property, undertaking or assets except to the Company or pursuant to a disposition that the Company is permitted to make under this indenture; and
- (j) to not enter into any transaction (whether by way of reorganization, consolidation, amalgamation, winding-up, merger, transfer, sale, lease or otherwise) whereby all or any material part of the property, undertaking or assets of the Included Subsidiary would become the property of any other person other than the Company.

**ARTICLE 7**  
**POSSESSION, USE AND RELEASE OF SECURED ASSETS**

**Section 7.1 General**

Until the occurrence of an Event of Default that is continuing and the Trustee has determined or become bound to enforce the Security, and except as otherwise provided for herein, the Company will be permitted to possess, manage, develop, operate and enjoy the Secured Assets and freely to control the conduct of the Transmission Business and to take and use any income, rents, issues and profits thereof.

**Section 7.2 Release of Secured Assets**

(1) Provided that a Default or Event of Default is not continuing, the Company may at any time and from time to time, without the consent of the Trustee or the bondholders, sell or otherwise dispose of any part of the Secured Assets, so long as the aggregate dollar value of all sales in a given calendar year do not exceed \$1,000,000, and upon receipt by the Trustee of an Officers' Certificate stating in substance as follows:

- (a) that the Company has sold or otherwise disposed of, or has contracted to sell, or otherwise dispose of, the property in question for a consideration, representing, in the opinion of the persons executing the certificate, which is not less than its fair market value (which fair market value must be set out in the Officers' Certificate); and
- (b) that the sale of the property in question will not result in a breach of any of the terms and covenants of this indenture.

In connection with such permitted dispositions, the Trustee will release all Liens on such assets being disposed of upon receipt of an Officers' Certificate confirming compliance with the terms of this Section 7.2.

(2) In addition to sales permitted pursuant to Section 7.2(1), provided that a Default or Event of Default is not continuing, the Company may at any time and from time to time, without the consent of the Trustee or the bondholders sell or otherwise dispose of any part of the Secured Assets constituting equipment (the "sold property") in an amount in excess of the monetary threshold set forth in Section 7.2(1), so long as the Trustee receives an Officers' Certificate stating in substance that (i) the Company has sold or otherwise disposed of, or has contracted to sell, or otherwise dispose of, the sold property for a consideration, representing in the opinion of the persons executing the certificate, which is not less than its fair market value (which fair market value must be set out in the Officers' Certificate); (ii) at the time that the sale was made there existed no Default or Event of Default; (iii) the disposition of the sold property will not negatively impact the ability of the Company to carry on the Transmission Business; (iv) the sale proceeds from the sold property have been deposited with the Trustee (and will, for greater certainty, be subject to the Security) or will, subject to the terms of the next sentence of this subsection (2) be used to concurrently or immediately thereafter purchase new equipment; and (v) the aggregate of (a) proceeds of sale from the sold property and (b) money held by the Trustee at such time in respect of previous sales of equipment, does not exceed \$15,000,000.



Sale proceeds will not be required to be deposited with the Trustee if (A) concurrent with or immediately following the conveyance of the sold property the Company purchases new equipment or Transmission Assets, (B) the provisions of Section 7.2(3)(B),(C) and (D) are complied with on the completion of such purchase, and (C) the purchase price for the new equipment or Transmission Assets to be acquired is no less than the proceeds from the sold property unless the difference is deposited with the Trustee in accordance with the terms of Section 7.2(3). Following any purchase of new equipment or Transmission Assets in accordance with the foregoing terms, the Company will deliver to the Trustee an Officers' Certificate confirming compliance with the foregoing terms.

(3) Proceeds of sale will be released to the Company in an amount not to exceed the purchase price of the equipment or Transmission Assets proposed to be purchased upon delivery to the Trustee of an Officers' Certificate stating in substance that (A) the Company has purchased equipment or Transmission Assets (the "acquired property") and providing for the acquisition price of such acquired property; (B) no Default or Event of Default exists; (C) the acquired property is not subject to a Purchase Money Security Interest; and (D) the Security creates a first ranking Lien against the acquired property subject only to Permitted Encumbrances.

(4) Following the occurrence of a Default or Event of Default which is continuing, sale proceeds may only be released to the Company upon receipt by the Trustee of an Ordinary Resolution authorizing such release from the holders of Senior Bonds (and if no Senior Bonds are outstanding, Subordinate Bonds).

### **Section 7.3 Disposal of Plant, Machinery or Equipment Constituting Part of the Power Assets**

Provided that a Default or Event of Default is not continuing, the Company may at any time and from time to time, without the consent of the Trustee or the bondholders, sell or otherwise dispose of any plant, machinery or equipment forming part of the Power Assets which has become worn out, damaged or obsolete and such assets will, upon being separated from the Power Assets, be released from the Liens created by the Security Agreements. Without limiting the foregoing, the Trustee will, upon the Written Request of the Company and upon delivery by the Company to the Trustee and each bondholder of an Officers' Certificate which (i) provides a reasonable detail of the terms of such sale or disposal, and (ii) states that the assets sold or disposed of were worn out, damaged or obsolete, grant a release of the Liens against such assets.

### **Section 7.4 Expropriation and Insurance Proceeds**

(1) In the event of any expropriation or similar taking of any part of the Power Assets or of any sale by the Company in lieu of such expropriation or similar taking and in reasonable anticipation thereof, the Trustee will release the property so taken or sold (although, for greater certainty, this Section 7.4 will not apply to dispositions otherwise permitted pursuant to Section 7.2 or Section 7.3), upon the deposit with the Trustee of a sum equal to the net proceeds to the Company of any such expropriation, taking or sale (subject to the rights of the holder of any applicable Permitted Encumbrance) together with:

- (a) a Written Request of the Company specifying the terms and conditions of such expropriation, taking or sale and requesting the release of such property from the Security;
- (b) an Officers' Certificate stating:
  - (i) that such property has been lawfully expropriated; or
  - (ii) in the case of a sale, that such sale was in lieu of and in reasonable anticipation of expropriation or similar taking and was in the best interests of the Company having a view to such expropriation or similar taking; and
- (c) an Opinion of Counsel to the effect that such property has been lawfully expropriated, taken or sold as aforesaid, and stating that all covenants or conditions relating to the release of such property have been complied with in accordance with the terms of this indenture.

The amount deposited with the Trustee pursuant to this Section 7.4 will form part of the Secured Assets and, until the occurrence of an Event of Default which is continuing, such moneys will be dealt with in the manner set out in Article 8.

(2) Notwithstanding the foregoing, the Trustee will, so long as no Default or Event of Default exists, pay or return to the Company, or direct any expropriating authority or insurer or purchaser, as applicable, to pay directly to the Company, any proceeds relating to a specific expropriation (including a sale in lieu and in reasonable anticipation of any expropriation or similar taking) or a specific insurance claim in the amount of less than \$937,500. Notwithstanding the foregoing, upon the occurrence of a Default or an Event of Default that is continuing, all expropriation, sale and insurance proceeds must be delivered to the Trustee and may only be released to the Company upon receipt by the Trustee of an Ordinary Resolution authorizing such release from the holders of Senior Bonds (and if no Senior Bonds are outstanding, Subordinate Bonds).

(3) The Company agrees that the occurrence of expropriation or similar taking of any part of the Power Assets or sale by the Company in lieu of such expropriation or similar taking and in reasonable anticipation thereof, or any damage or destruction to all or any part of the Secured Assets in each case resulting in moneys being received by the Trustee in accordance with Section 8.2 will be a triggering event for purposes of this indenture (each a "Triggering Event") and upon the occurrence of any such Triggering Event, the Company will elect to have all proceeds resulting from such Triggering Event applied either:

- (a) to repair, restore or replace the property that was damaged, destroyed or expropriated in accordance with the terms and conditions provided for in Section 8.2 and Section 8.3 subject to the requirement to redeem bonds as provided for, and in accordance with, the terms of Section 8.3; or
- (b) to redeem Bonds in accordance with the provisions of Section 8.3.

The Company will provide to the Trustee and the bondholders written notice of its election within 15 days of receipt of the Trust Moneys by the Trustee.

### **Section 7.5 Additional Construction**

Unless a Default or an Event of Default has occurred and is continuing, the Company may undertake or permit to be undertaken any additional construction or development (including without limitation expansion, renovation, repair and or redevelopment) of the Power Assets without the prior consent or approval of the Trustee or the bondholders, provided that such construction or development will not Impair the Security in any material way and that such additional construction or development is subject to the Liens of the Security.

Construction or development (including, without limitation, expansions, renovations, repairs or redevelopment) in the ordinary course of business by the Company or in the ordinary course of operation of the Power Assets by the Company will be deemed not to constitute an impairment of the Security.

### **Section 7.6 Dealing with the Power Assets**

From time to time the Trustee will execute and deliver to the Company, on Written Request by the Company, accompanied by an Officers' Certificate and/or an Opinion of Counsel, if applicable and as may be required by the Trustee:

- (a) all instruments necessary to evidence the consent of the Trustee to the granting of certain easements, right-of-way, cost sharing and reciprocal arrangements in respect of the Lands, the Power Real Estate and lands adjacent thereto and any site plan agreement required to be entered into in connection therewith, provided such instruments do not materially adversely impact the use or value of the Secured Assets;
- (b) acknowledgements in respect of certain Permitted Encumbrances; and
- (c) all instruments necessary to release the Security from portions of any Lands for road widening, dedication to government or municipal authorities and similar purposes in connection with the development and servicing of such Lands provided such instruments do not adversely impact the use or value of the Secured Assets in any material way.

### **Section 7.7 Proceeds of Released or Sold Property**

Except where expressly provided otherwise, all consideration arising from any release of or other dealings with the Secured Assets received by the Trustee under Section 7.2, Section 7.3 and Section 7.4 will be paid by the Trustee to the Company, upon receipt of an Officers' Certificate stating that so far as is known to the signers after having made due enquiry pursuant to Section 17.12, a Default or an Event of Default has not occurred which is continuing nor will result from the payment requested, and otherwise will form part of the Secured Assets hereunder and, except as otherwise specifically provided herein, all cash forming part of the

consideration received under Section 7.2 through Section 7.4 will be dealt with as provided in Article 8 hereof.

### **Section 7.8 Independent Investigation by Trustee**

The certificates, instruments and opinions provided for in this Article 7 will be full authority to the Trustee for making any release or taking any action provided for in this Article 7; provided that before making any such release or taking any action the Trustee may, in its absolute discretion, and will, if requested to do so by Ordinary Resolution of the holders of the Senior Bonds or Subordinate Bonds and if furnished with security and indemnity satisfactory to it, cause to be made such independent investigations as it, acting reasonably, may see fit, and the reasonable expense thereof will be paid by the Company, or if paid by the Trustee will be repaid by the Company upon reasonable notice given by the Trustee to the Company with interest at the rate per annum that is charged by the Trustee to all of its clients from time to time, from the date of such demand until repayment.

## **ARTICLE 8** **APPLICATION OF MONEYS RECEIVED BY THE TRUSTEE**

### **Section 8.1 Trust Moneys**

- (1) All moneys received by the Trustee:
  - (a) as compensation for, or proceeds of sale of, any part of the Secured Assets taken by expropriation or sold in lieu of and in reasonable anticipation of a taking by expropriation that is in excess of \$937,500 or compensation or proceeds in an amount of less than \$937,500 where there exists a Default or an Event of Default, or
  - (b) as proceeds of insurance upon any part of the Secured Assets for a given claim for property damage in which the insurance proceeds are in excess of \$937,500 or proceeds in an amount of less than \$937,500 where there exists a Default or an Event of Default, (all such moneys being herein sometimes called "**Trust Moneys**")

will be held by the Trustee, except as otherwise provided in this Article, as part of the Secured Assets and, upon any entry upon or sale or realization of the Secured Assets or any part thereof under Article 10, Trust Moneys will be applied in accordance with Section 10.6. Prior to any such entry or sale or realization, all or any part of the Trust Moneys may be withdrawn, and will be paid or applied by the Trustee, from time to time as provided in this Article 8.

(2) Unless a Default or an Event of Default under this indenture exists, Trust Moneys will be invested and reinvested by the Trustee in accordance with Section 12.1. Following the occurrence of a Default or an Event of Default, the Trustee may invest or not invest such moneys as it determines.

## **Section 8.2 Application of Trust Moneys to Restoration or Repair**

All Trust Moneys referred to in subparagraphs (a) and (b) of Section 8.1(1) received by the Trustee:

- (a) under the provisions of this indenture or any instruments supplemental hereto, or
- (b) under any policy or policies of insurance governing the Secured Assets or any part thereof, or
- (c) in connection with the release of such property by reason of the exercise of the power of expropriation,

will be held by the Trustee as part of the Secured Assets and will be paid to the Company from time to time, upon receipt by the Trustee of (i) an Officers' Certificate requesting all or a portion of such moneys and confirming that no Default or Event of Default exists and (ii) an Independent Engineers' Certificate approving the paying to, or reimbursing the Company for the payment of the reasonable cost, as shown by such certificate, of repairing or replacing part or all of the property damaged, destroyed or taken on a cost to complete basis, but only if written application is made therefor within 6 months (or such longer period as is provided for in Section 8.3) of the receipt of such proceeds by the Trustee, and then only for and to the extent that the Company shows by such Independent Engineers' Certificate that the portion of such proceeds remaining on deposit with the Trustee, together with any additional funds irrevocably allocated or otherwise provided for in a manner satisfactory to the Trustee for such purpose, will be sufficient to complete such repairs or replacements in accordance with the requirements of Section 6.8(i), free from Liens except the Security and Permitted Encumbrances. Every such Officers' Certificate requesting the payment of such Trust Moneys must state that no Default or Event of Default then exists and must be accompanied by an Opinion of Company Counsel to the effect that upon completion of the repair or replacement, the property will be subject to the Liens created by the Security Agreements, subject only to Permitted Encumbrances and, to the extent applicable, an endorsement to the title insurance policy confirming that the Debenture creates a secured Lien against the property repaired or replaced. Any insurance proceeds payable in respect to loss of income will, so long as there exists no Default or Event of Default, be immediately released to the Company. Notwithstanding the foregoing, if Trust Moneys in an amount of less than \$937,500 were received by the Trustee during the existence of a Default or an Event of Default and there no longer exists a Default or an Event of Default, such Trust Moneys may be released to the Company without the requirement of delivery of an Independent Engineer's Certificate.

## **Section 8.3 Application of Trust Moneys to Redemption of Bonds**

In the event that the Company has failed to apply the Trust Moneys received in respect of any damage, destruction, loss or expropriation of all or any part of the Secured Assets to the repair, restoration or replacement of the property damaged, destroyed or expropriated within the 6-month period provided for in Section 8.2, then the Company will make an offer to the holders of Bonds in accordance with the terms of this indenture to apply all such Trust Moneys to the redemption of Bonds of all series in an amount sufficient to exhaust such cash and otherwise in accordance with the provisions of this indenture or any indenture supplemental

hereto applicable to the optional redemption of Bonds of each series and at the Redemption Price and if there is more than one series of Bonds outstanding, subject to the provisions herein or in any indenture supplemental hereto contained with respect to the redemption and purchase for cancellation of Bonds or requiring that the Trust Moneys be applied to one but not all series, such moneys will be applied *pro rata* as to the amount of the purchase or redemption of Bonds out of each such series in accordance with the provisions for purchase or redemption (otherwise than out of sinking fund moneys) applicable to such Bonds. Such offer must be made no later than 30 days after the expiration of such 6-month period unless such six month period is extended in accordance with the terms of this Section 8.3 in which case it must be made within 30 days of the expiration of the period so extended if the Trust Moneys remain unapplied. Notwithstanding the foregoing, if the Company has delivered to the Trustee and to each holder of the Bonds an Officers' Certificate and an Independent Engineer's Certificate on or before the last day of such 6-month period to the effect that the repair, restoration or replacement of the property destroyed, damaged or expropriated is being diligently pursued and stating the anticipated completion date of such repair, restoration or replacement, then the Company will not be so obligated to redeem Bonds unless the repair, restoration or replacement is not completed by such stated anticipated completion date; provided, however, that the Company will deliver Officers' Certificates and an Independent Engineer's Certificate on each 6-month anniversary thereafter to the same effect, until such repair, restoration or replacement is complete. All such redemptions will first be in respect of outstanding Senior Bonds and when no Senior Bonds are outstanding, Subordinate Bonds will be redeemed.

## **ARTICLE 9**

### **ENFORCEMENT OF SECURITY**

#### **Section 9.1 Events of Default**

The Security will become enforceable, subject to the terms hereinafter contained, in each and every of the events following, herein sometimes called "Events of Default":

- (a) if, in respect to the holders of Senior Bonds, the Company fails to make payment of any interest, principal or Make-Whole Amount on any of the Senior Bonds when the same become due and such default continues for 3 business days; or
- (b) if, in respect to the holders of Senior Bonds, the Company fails to pay any principal or interest on the applicable Maturity Date; or
- (c) if, in respect to the holders of Subordinate Bonds, the Company fails to make payment of any interest, principal or premium on any of the Subordinate Bonds when the same become due and such default continues for 3 business days; or
- (d) if, in respect to the holders of Subordinate Bonds, the Company fails to pay any principal or interest on the applicable Maturity Date; or
- (e) if the Company fails to pay within three business days of written demand being made therefore, any amount other than principal and interest due pursuant to this indenture or the Security; or

- (f) if the Company fails to pay, or cause to be paid, when due, taxes, rates, levies, duties, public utility charges and assessments, general or special, ordinary or extraordinary, of any nature or kind whatsoever, including local improvement taxes, which are levied, assessed or imposed upon the Company (save and except when and so long as the validity thereof is in good faith contested by the Company and the Company has set aside adequate reserves for the payment of such disputed amounts) and any such Default as aforesaid continues either for a period of 20 days after written notice to the Company from the Trustee or for such shorter period as would at any time, if continued, render the Secured Assets or any part thereof liable to forfeiture or sale; or
- (g) if the Company admits its inability to pay its debts generally as they become due or otherwise acknowledges its insolvency, or if an order is made or an effective resolution passed for the winding-up of the Company, or if the Company makes an assignment for the benefit of its creditors or consents to the appointment of a Receiver or a liquidator or a trustee in bankruptcy in respect of it, or if the Company makes a proposal to its creditors under any bankruptcy or insolvency act or similar legislation including, without limitation, the *Companies' Creditors Arrangement Act* (Canada); or
- (h) if a decree or order of a court having jurisdiction is entered appointing a Receiver of the Company or any substantial part of the Secured Assets; or
- (i) if a Receiver of the Company is appointed by a person other than by a court of competent jurisdiction or in proceedings where the Company has not had prior notice of such proceedings, and such appointment continues unstayed, undischarged and in effect for a period of 60 days after notice of it has been served on the Company provided the Company has been diligently and actively contesting such appointment in good faith by appropriate and timely proceedings; or
- (j) if a decree or order of a court of competent jurisdiction is entered adjudging the Company bankrupt or insolvent or approving a petition seeking the winding-up or liquidation of the Company under the *Companies' Creditors Arrangement Act* (Canada), the *Bankruptcy and Insolvency Act* (Canada) or any other bankruptcy, insolvency or analogous laws; or
- (k) if any proceeding or filing is instituted or made against the Company seeking to have an order for relief entered against it as a debtor or to adjudicate it bankrupt or insolvent, or seeking liquidation, winding-up, reorganization, arrangement, adjustment or composition under any law relating to bankruptcy, insolvency, reorganization or release of debtors, or seeking appointment of a Receiver, trustee, custodian or other similar official for it or for any substantial part of its properties or assets, unless the same is being contested actively and diligently in good faith by appropriate and timely proceedings and is dismissed, vacated or permanently stayed within 60 days of institution; or

- (l) if the Company defaults in observing or performing any other covenant or condition contained in this indenture, any Security Agreement, any Bond Purchase Agreement or any undertaking provided to the Trustee in connection with any Bonds required to be observed or performed and if such default continues for a period of 20 days after a notice in writing has been given by the Trustee to the Company, specifying such default, which notice the Trustee may give on its own initiative and will give when required to do so by an Ordinary Resolution from the holders of Senior Bonds (or, where no Senior Bonds are then outstanding or where the holders of the Subordinate Bonds are permitted to do so hereunder, by an Ordinary Resolution from the holders of the Subordinate Bonds); provided that in the case of a default which is curable but which cannot be remedied simply by payment of money, the Company will have within such 20-day period commenced to remedy such default and continues to diligently pursue the remedy thereof for a period not exceeding 180 days after the occurrence of the default; or
- (m) if the Operation, Maintenance and Administration Agreement is terminated for any reason other than as a result of the Manager exercising its right to terminate on not less than 180 days' prior written notice to the Company or if a decree or order of a court of competent jurisdiction is entered adjudging the Manager bankrupt or insolvent or approving as properly filed a petition seeking the winding up of the Manager under the *Companies' Creditors Arrangement Act* (Canada), the *Bankruptcy and Insolvency Act* (Canada) or the *Winding-Up and Restructuring Act* (Canada) or any other bankruptcy, insolvency or analogous laws or issuing sequestration or process of execution against any substantial part of the assets of the Manager or ordering the winding up or liquidation of the Manager's affairs, and any such decree or order continues unstayed and in effect for a period of 30 days and, in each case, the Company has not, within 60 days (or such longer period, not to exceed 100 days, as the Company may reasonably require provided that the Company is diligently pursuing same and during such period the Business continues to operate in the ordinary course, and there is no material adverse effect on the Business, the Company or the Secured Assets during such period) either: (i) retained the people and acquired any assets that it requires to operate the Transmission Assets on its own behalf; or (ii) replaced the services provided pursuant to the Operation, Maintenance and Administration Agreement by retaining a recognized and reputable operator with at least five years' experience in operating transmission facilities of a type similar to the Transmission Assets; and in either the case of (i) or (ii) above, such arrangements and agreements are on market terms and conditions, are in accordance with Good Utility Practices and would not result in a Material Adverse Change; or
- (n) If the Manager provides notice to the Company of its intention to terminate the Operation, Maintenance and Administration Agreement in accordance with the terms thereof on providing not less than 180 days' prior written notice to the Company, and the Company has not within 100 days of the receipt thereof made arrangements to either: (i) retain the people and acquire any assets that it requires to operate the Transmission Assets on its own behalf; or (ii) replace the services



provided pursuant to the Operation, Maintenance and Administration Agreement by retaining a recognized and reputable operator with at least five years' experience in operating transmission facilities of a type similar to the Transmission Assets; and in either the case of (i) or (ii) above, such arrangements and agreements are on market terms and conditions, are in accordance with Good Utility Practices and would not result in a Material Adverse Change; or

- (o) if any statement contained in an Officers' Certificate delivered hereunder constitutes, at the time the same is made, an intentional, material and adverse misstatement; or
- (p) if a final judgement, execution, writ of seizure and sale, sequestration or decree for the payment of money due has been obtained or entered against the Company in an amount in excess of \$25,000,000 and such judgement, execution, writ of seizure and sale, sequestration or decree will not have been and remain vacated, bonded, paid, discharged or stayed pending appeal within 30 days; or
- (q) if the Company makes a material misrepresentation in any Bond Purchase Agreement or the Conversion Representation Agreement which is not cured (if curable) within 30 days after the earlier of (i) the Company becoming aware of such misrepresentation, and (ii) receipt by the Company of notice thereof; or
- (r) if the Company defaults in observing or performing for a period of five business days the covenant contained in any of Section 6.2, Section 6.3(a), Section 6.10, Section 6.12, Section 6.21 or Section 6.24; or
- (s) if the Company does not make an offer to the holders of Bonds to redeem the Bonds as (i) required pursuant to the terms of Section 8.3 hereof within the 30-day period provided for therein or (ii) elected by it pursuant to the terms of Section 7.4 hereof.

## **Section 9.2 Trustee May Declare Principal and Interest Due**

Subject to the provisions of Section 9.3 and subject to the terms of any indenture supplemental hereto in the case of any Event of Default as defined in and created by such supplemental indenture for the benefit of the holders of any particular series of Additional Bonds, in case an Event of Default occurs and is continuing, the Trustee will upon receipt of an Ordinary Resolution from the holders of Senior Bonds and, subject to the terms of Section 3.9, an Ordinary Resolution from the holders of the Subordinate Bonds in the case of a Subordinate Bond Event of Default or an Event of Default where there are no Senior Bonds outstanding or where the holders of the Senior Bonds have accelerated the amounts owing under the Senior Bonds, declare the principal and interest on the Senior Bonds or the Subordinate Bonds, as applicable, and other moneys secured hereby, to be due and payable and the same, together with the Make-Whole Amount (if any) and premium (if any), will forthwith become immediately due and payable to the Trustee on demand, anything therein or herein contained to the contrary notwithstanding in each case without presentment, protest or further notice, all of which are hereby waived and the Company will pay forthwith to the Trustee on demand for the benefit of

the holders of the Bonds that have been accelerated, the amount of the principal of, Make-Whole Amount (if any) and premium (if any) and interest then accrued on all the Bonds and all other moneys secured hereby together with interest at the respective rates of interest borne by the Bonds on such principal, Make-Whole Amount (if any) and premium (if any) and interest, and interest at the same rate per annum on such other moneys from the date of the said declaration until payment is received by the Trustee, and such payment when made will be deemed to have been made on the Bonds and any moneys so received by the Trustee will be applied in accordance with Section 10.6 in the same manner as if they were proceeds of a sale of the Secured Assets. The Company acknowledges, and the parties hereto agree, that each holder of a Bond has the right to maintain its investment in the Bonds free from prepayment by the Company (except as herein specifically provided for) and that the provision for payment of a Make-Whole Amount by the Company in the event that the Bonds are prepaid or are accelerated as a result of an Event of Default, is intended to provide compensation for the deprivation of such right under such circumstances.

### **Section 9.3 Waiver of Default**

(1) Subject to Section 16.2 and the terms of any indenture supplemental hereto in the case of any Event of Default as defined in and created by such supplemental indenture for the benefit of the holders of any particular series of Additional Bonds or Subordinate Bonds, in the event that an Event of Default has occurred, the holders of Senior Bonds will have the power by Extraordinary Resolution to instruct the Trustee, at any time, to waive such Event of Default or to annul any declaration made by the Trustee at the direction of the holders of the Senior Bonds pursuant to Section 9.2, and the Trustee will thereupon waive such Event of Default or annul such declaration upon such terms and conditions as such holders may prescribe; provided always that no act or omission either of the Trustee or of the holders of Senior Bonds will extend to or be taken in any manner whatsoever to affect any subsequent Event of Default or the rights resulting therefrom. The waiver of a Subordinate Bond Event of Default by the holders of Senior Bonds will not bind the holders of Subordinate Bonds in respect to such Subordinate Bond Event of Default.

(2) Other than in respect to a Subordinate Bond Event of Default, while there are Senior Bonds outstanding, the holders of Subordinate Bonds will have no rights to direct the Trustee at any time to waive an Event of Default and the holders of the Subordinate Bonds will be bound in all respects by any decisions made, resolutions passed or actions taken by the holders of the Senior Bonds or the Trustee at their instruction in respect to the waiver of an Event of Default, the annulling of any declaration made by the Trustee pursuant to Section 9.2 at the direction of the holders of the Senior Bonds or any other matter arising in connection with the actions taken or directed to be taken by the holders of Senior Bonds following the occurrence and during the continuance of an Event of Default. The foregoing sentence is paramount to any other terms contained in this indenture. The holders of the Subordinate Bonds will have the power (i) by Unanimous Resolution to instruct the Trustee, at any time, to waive any Subordinate Bond Event of Default identified in Section 9.1(c) or (d), and (ii) by Extraordinary Resolution to instruct the Trustee, at any time, to waive any other Subordinate Bond Event of Default, and, in each case, to annul any declaration made by the Trustee pursuant to Section 9.2 by the holders of the Subordinate Bonds in respect thereof, provided always that no act or omission either of the Trustee or the holders of the Subordinate Bonds will extend to or be taken

in any manner whatsoever to effect any subsequent Default or the rights resulting therefrom. Such waiver will only be binding on the holders of Senior Bonds if they have also passed an Extraordinary Resolution waiving such default.

#### **Section 9.4 Notice of Default**

The Company will give to the Trustee and each bondholder, within a reasonable time but not exceeding five business days after the Company becomes aware of the occurrence thereof, written notice of every Default or Event of Default arising out of this indenture and continuing at such time as such notice is given. In addition to the Company's obligation to give bondholders notice of every Default and Event of Default, the Trustee will, unless notice has already been provided by the Company in accordance with the terms hereof, give to each bondholder, within the earlier of five business days after the Trustee otherwise becomes aware of the occurrence thereof, notice of every Default or Event of Default arising under this indenture and continuing at the time such notice is given.

### **ARTICLE 10**

#### **REMEDIES IN CASE OF DEFAULT**

#### **Section 10.1 Limited Recourse**

Notwithstanding anything contained herein to the contrary, or in the Security, the Operative Documents or any other documentation entered into pursuant to this indenture, the obligations of the Company to the Trustee and the bondholders will be performed, satisfied and paid only out of, and enforced only against, and recourse will be had only against (i) the Secured Assets, and (ii) the Included Subsidiaries in respect to their obligations under the Subsidiary Guarantee. Except with respect to the recourse of the Trustee pursuant to Section 17.6, Section 19.1 and Section 19.2, no obligation of the Company under this indenture, the Bonds, any Security Agreement or any other document delivered pursuant to this indenture is personally binding upon, nor will any resort or recourse be had, judgment issued or execution or other process levied against the Company (except to the extent necessary for the enforcement of the Security and only for that purpose) or against any assets or revenues of the Company that do not constitute Secured Assets. Notwithstanding the foregoing, the Trustee and each purchaser of a Series 1 Senior Bond will have full recourse against the Company and all of its assets in those circumstances provided for in section 3 of the Conversion Representation Agreement.

#### **Section 10.2 General**

Subject to the provisions of Article 9, Section 3.9 and to the provisions of any Ordinary Resolution, if an Event of Default has occurred and is continuing, all of the Security will become immediately enforceable and, in addition to any rights or remedy provided by law, and upon receipt of an Ordinary Resolution passed in accordance with Article 9 (but, in the case of Subordinate Bonds, subject to the terms of Section 3.9), the Trustee must, subject to compliance with the provisions of Section 17.7, proceed to protect and enforce its rights and the rights of the bondholders under this indenture and the Security, if any, by such appropriate private or judicial proceedings as the Ordinary Resolution may provide in order to protect and enforce such rights, whether for the specific enforcement of any covenant or agreement in this

indenture or the Security Agreements or in aid of the exercise of any power granted herein or therein, or to enforce any other proper remedy. Without limiting the generality of the foregoing, if an Event of Default has occurred and is continuing, the bondholders may, subject to Section 9.3, direct the Trustee by the appropriate Ordinary Resolution to exercise one or more of the following powers (which the Trustee will exercise upon receiving any reasonable indemnity and funding that it might require against all costs, expenses and liabilities to be incurred):

- (a) by appointment in writing appoint a receiver or receiver and manager (each herein referred to as the “Receiver”) of the collateral that is the subject of the Security only (which term when used in this Section 10.2 will include the whole or any part of the Security) and may remove or replace such Receiver from time to time or institute proceedings in any court of competent jurisdiction for the appointment of a Receiver of the collateral that is the subject of the Security; and the term “Trustee” when used in this Section 10.2 will include any Receiver so appointed and the agents, officers and employees of such Receiver. The Trustee will not be in any way responsible for any misconduct or negligence of any such Receiver;
- (b) take possession of the collateral that is the subject of the Security and require the Company to assemble (or cause to be assembled) the collateral that is the subject of the Security and deliver or make such collateral available (or cause it to be made available) to the Trustee at such place or places as may be specified by the Trustee;
- (c) take such steps as are desirable to maintain, preserve or protect the collateral that is the subject of the Security;
- (d) carry on or concur in the carrying on of all or any part of the business of the Company insofar as it relates to the collateral that is the subject of the Security;
- (e) exercise any of the rights of the Company under any Operative Document;
- (f) enforce any rights of the Company in respect of the collateral that is the subject of the Security by any manner permitted by Applicable Law;
- (g) subject to the rights, if any, of third parties, sell, lease or otherwise dispose of the collateral that is the subject of the Security at public auction, by private tender, by private sale or otherwise either for cash or upon credit upon such terms and conditions as the Trustee may determine and without notice to the Company unless required by Applicable Law;
- (h) accept the collateral that is the subject of the Security in satisfaction of the obligations of the Company hereunder and under the Bonds upon notice to the Company of its intention to do so in the manner required by Applicable Law;
- (i) enter upon any of the premises where the collateral that is the subject of the Security is located as the Trustee requires to facilitate the realization of the collateral that is the subject of the Security, free of charge;

- (j) charge on its own behalf and pay to others all reasonable amounts for expenses incurred and for services rendered in connection with the exercise of the rights and remedies of the Trustee hereunder, including, without limiting the generality of the foregoing, reasonable legal, Receiver and accounting fees and expenses, and in every such case the amounts so paid together with all costs, charges and expenses incurred in connection therewith, including interest thereon at such rate as the Trustee deems reasonable, will be added to and form part of the obligations secured by the Security; and
- (k) discharge any Lien that may exist or be threatened against the collateral that is the subject of the Security, and in every such case the amounts so paid together with costs, charges and expenses incurred in connection therewith will be added to the obligations hereby secured by the Security.

On any entry or taking of possession, directly or indirectly, as herein provided by the Trustee, the Trustee will have all of the powers of a Receiver, and in any judicial proceeding relative to the Company, its creditors or its property the Trustee will be authorized to file such proofs of claim and other papers or documents as may be necessary or advisable in order to have the claims of the Trustee and of the bondholders allowed in such judicial proceeding.

The Trustee may not exercise the powers contained in this Section 10.2 except with the prior consent of the Bondholders in accordance with Article 9 and Section 17.7.

Subject to the provisions of this indenture, the Trustee may following an enforcement of the Security, upon receipt of an Ordinary Resolution to this effect (but subject to the terms of Section 3.9 in the case of holders of Subordinate Bonds), (i) grant extensions of time, (ii) take and perfect or abstain from taking and perfecting security, (iii) give up securities, (iv) accept compositions or compromises, (v) grant releases and discharges, and (vi) release any part of the Security or otherwise deal with the Company, debtors of the Company, sureties and others and with the Security and other security as the Trustee sees fit without prejudice to the liability of the Company to the Trustee or the Trustee's rights hereunder.

The Trustee will not be liable or responsible for any failure to seize, collect, realize or obtain payment with respect to the Security and will not be bound to institute proceedings or to take other steps for the purpose of seizing, collecting, realizing or obtaining possession or payment with respect to the Security or for the purpose of preserving any rights of the Trustee, the Company or any other person in respect of the Security unless directed to do so in accordance with this indenture.

The Trustee may, subject to Section 10.6, apply any proceeds of realization of the Security to payment of expenses in connection with the preservation and realization of the Security as above described and the Trustee may apply any balance of such proceeds to payment of the obligations of the Company hereunder and under the Bonds in compliance with the terms hereof and, in the absence of such terms, in such order as the Trustee sees fit but subject to Applicable Laws.

The Trustee, any Receiver or any one or more of the bondholders or any agent or representative thereof, may become purchasers at any sale or other realization of the Security, or any part thereof, whether made under the power of sale herein contained or pursuant to judicial proceedings.

All rights of action hereunder may be enforced by the Trustee without the possession of any of the Bonds or the production thereof on the trial or other proceedings relative thereto.

No course of dealing on the part of the Trustee or any bondholder nor any delay or failure of the Trustee or of the bondholders to exercise any remedy referred to in this Section 10.2 will operate as a waiver of any such remedy or will be construed to be a waiver of any Event of Default hereunder or acquiescence therein or will otherwise prejudice any rights, powers or remedies of the Trustee or such holder.

Unless and until it has been required so to do under the terms hereof, the Trustee is not bound to give any notice or do or take any act, action or proceeding by virtue of the powers conferred on it hereby; nor will the Trustee be required to take notice of an Event of Default or any Default hereunder, other than in payment of any moneys required by any provision hereof to be paid to it, unless and until such time as such Trustee has received notice in writing of such Event of Default or any Default hereunder and in the absence of any such notice and subject as aforesaid, the Trustee may assume that the Company is not in default hereunder.

In the exercise of any remedy herein contained the Trustee will in no event be obliged to marshal the Security in favour of any other creditor of the Company, and the Company waives any right that it may have to require the Trustee to so marshal the Security. The Company further renounces all benefits of discussion and division.

### **Section 10.3 Bondholders May Direct Trustee's Action**

Except as herein otherwise expressly provided and subject to the terms of Section 3.9, the holders of Senior Bonds or the holders of Subordinate Bonds by Ordinary Resolution may, from time to time, direct and control the action of the Trustee in any proceeding under this Article 10.

### **Section 10.4 Appointment of Receiver or Receiver and Manager**

Whenever the Trustee is required under the provisions of Section 10.2 to appoint a Receiver, the following provisions will apply.

- (a) Any such appointment may be limited to any part or parts of the Secured Assets or may extend to the whole thereof.
- (b) Every such Receiver may, in the discretion of the Trustee, be vested with all or any of the powers and discretions of the Trustee.

- (c) The Trustee may from time to time fix the remuneration of every such Receiver and direct the payment thereof out of the Secured Assets, the income therefrom or the proceeds thereof.
- (d) The Trustee may from time to time require any such Receiver to give security for the performance of his duties and may fix the nature and amount thereof, but will not be bound to require such security.
- (e) Every such Receiver may, with the consent in writing of the Trustee, borrow money for the purposes of carrying on and managing the Secured Assets, or for the maintenance, protection or preservation of the Secured Assets or any part thereof, and the receiver may issue certificates (herein call "**Receiver's Certificates**") to evidence such indebtedness, and such Receiver's Certificates may be payable either to order or to bearer and may be payable at such time or times as to the Trustee may deem expedient, and will bear interest as is therein declared, and the Receiver may sell, pledge or otherwise dispose of the same in such manner as the Trustee may deem advisable, and may pay such commission on the sale thereof as the Trustee may deem reasonable, and the amounts from time to time payable by virtue of such Receiver's Certificate will be secured by the Security and will be payable in priority to the Bonds.
- (f) Every such Receiver will, so far as concerns responsibility for his acts or omissions, be deemed the agent of the Company and in no event the agent of the Trustee, and the Trustee will not, in asking or consenting to such appointment, incur any liability to the Receiver for his remuneration or otherwise howsoever.
- (g) Except as may be otherwise directed by the Trustee, all moneys from time to time received by such Receiver must be paid over to the Trustee to be held by it on the trusts of this indenture.
- (h) The Trustee may pay over to such Receiver any moneys constituting part of the Secured Assets to the intent that the same may be applied for the purposes hereof by such Receiver, and the Trustee may from time to time determine what funds the Receiver is at liberty to keep in hand with a view to the performance of his duty as such Receiver.
- (i) The Trustee may appoint a receiver and manager hereunder, or may apply to the court of competent jurisdiction for such appointment, without proceeding to realize upon the Security hereof.

#### **Section 10.5 Surrender by Company**

The Company binds and obliges itself to yield up possession of the Secured Assets to the Trustee on demand whenever the Trustee will have a right of entry under the provisions of this indenture and agrees to put no obstacle in the way of, but to facilitate by all legal means, the actions of the Trustee hereunder and not to interfere with the carrying out of the powers hereby granted to it, and in the event of the Security hereby constituted becoming enforceable, as herein provided, the Company will and hereby does consent to the appointment

in such case of a liquidator or Receiver with all such powers as the Trustee is hereby vested with, if so required by the Trustee and will deliver up all information and documentation relating to the Secured Assets. The Company hereby binds itself in the said event to consent to any petition or application presented to the court by the Trustee in order to effectuate the intent of this indenture, and the Company will not, after receiving due notice from the Trustee that it has taken possession of the Secured Assets by virtue hereof, continue in possession of the Secured Assets unless with the express written consent and authority of the Trustee, and will forthwith by and through its respective officers and directors, execute such documents and transfers as may be necessary to place the Trustee in legal possession of the Secured Assets and after receipt of such notice, all the powers and functions, rights and privileges of each and every of the directors and officers of the Company will cease with respect to the Secured Assets unless specifically continued in writing by the Trustee, or unless the property has been restored to the Company as hereinbefore provided.

### **Section 10.6 Application of Moneys**

The moneys arising from any sale or realization of the Secured Assets will be applied:

- (a) first, to pay or reimburse to the Trustee the costs, charges, expenses, advances and compensation of the Trustee (including any Receiver) in or about the execution of its trust, or otherwise in relation hereto, with interest thereon as herein provided, and all taxes, assessments and other charges ranking in priority to the Bonds;
- (b) second, in or towards payment of interest on overdue principal, interest and Make-Whole Amount (if any) on the Senior Bonds;
- (c) third, in or towards payment of interest on the Senior Bonds;
- (d) fourth, in or towards payment of principal of the Senior Bonds;
- (e) fifth, in or towards payment of the Make-Whole Amount (if any) on any of the Senior Bonds;
- (f) sixth, in or towards payment of any other liabilities or obligations of the Company to the holders of Senior Bonds hereunder;
- (g) seventh, in or towards payment of interest on overdue principal, interest and premium (if any) on the Subordinate Bonds;
- (h) eighth, in or towards payment of interest on the Subordinate Bonds;
- (i) ninth, in or towards payment of principal of the Subordinate Bonds;
- (j) tenth, in or towards payment of any other liabilities or obligations of the Company to the holders of the Subordinate Bonds hereunder;

and the surplus (if any) will be paid to the Company or its assigns.



All payments made to holders of Senior Bonds and Subordinate Bonds, respectively, in accordance with the terms hereof will be made on a *pro rata* basis to the outstanding indebtedness owing to such holders of Senior Bonds and Subordinate Bonds, respectively.

#### **Section 10.7 Limitation of Trustee's Liability**

Subject to the provisions of Article 17, the Trustee will not, nor will any Receiver appointed by it, be responsible or liable, otherwise than as a trustee, for any debts contracted by it, for damages to persons or property, or for salaries or non-fulfillment of contracts during any period during which the Trustee or Receiver manages the Secured Assets upon or after entry, as herein provided, nor will the Trustee or any Receiver be liable to account as mortgagee in possession or for anything except actual receipts, or be liable for any loss on realization or for any default or omission for which a mortgagee in possession might be liable.

#### **Section 10.8 Protection of Persons Dealing with Trustee**

No person dealing with the Trustee or its agents will be concerned to inquire whether the Security hereby constituted has become enforceable, or whether the powers which the Trustee is purporting to exercise have become exercisable, or whether any money remains due upon the security of this indenture or the Bonds, or otherwise as to the propriety or regularity of any sale or of any other dealing by the Trustee with the Secured Assets or to see the application of any money paid to the Trustee; and, in the absence of fraud on the part of such person, such dealing will be deemed, so far as regards the safety and protection of such person, to be within the powers hereby conferred and to be valid and effectual accordingly.

#### **Section 10.9 Remedies Cumulative**

No remedy herein conferred upon or reserved to the Trustee, or upon or to the holders of Bonds, is intended to be exclusive of any other remedy, but each and every such remedy will be cumulative and will be in addition to every other remedy given hereunder or now existing or hereafter to exist by law or by statute.

#### **Section 10.10 Company to Execute Confirmatory Deed**

In case of any sale validly made under the provisions of this Article 10, whether by the Trustee or under judicial proceedings, the Company agrees it will execute to the purchaser on demand any instrument reasonably necessary to confirm to the purchaser the title of the property so sold.

#### **Section 10.11 Trustee Appointed Attorney**

The Company hereby irrevocably appoints the Trustee to be the attorney in its name and on its behalf, to execute and do any deeds, conveyances, assignments, assurances and things which the Company ought to execute and do, and have not executed or done, under the covenants and provisions contained herein and generally to use the name of the Company in the exercise of all or any of the powers hereby conferred on the Trustee. This power of attorney is coupled with an interest and will survive the winding-up, dissolution or bankruptcy of the

Company. This power of attorney will only be exercisable by the Trustee following the occurrence and continuance of a Default or Event of Default.

## **ARTICLE 11** **SALE ETC.**

### **Section 11.1 Consolidation, Amalgamation, Merger or Transfer**

The Company will not resolve or order that the Company be wound up or that other proceedings be taken with a view to the consolidation, amalgamation or merger of the Company with another person or the transfer of the Secured Assets as an entirety or substantially as an entirety to such other person or to a continuing person resulting from any amalgamation or merger except in accordance with the terms of Section 6.24.

Subject to Section 11.3, such consolidation, amalgamation, merger or transfer will not release the Company from its covenants and obligations under this indenture or the Bonds then outstanding or any covenants and obligations to the Trustee in its capacity as trustee hereunder or (subject to the terms thereof) under any other document or agreement.

Subject to and upon compliance by the Company with this Section 11.1 and Section 6.24, the Trustee will consent to the consolidation, amalgamation or merger pursuant to this Section 11.1 and join in such documents and do such acts as, in its discretion, may be thought advisable, subject to such conditions as may be set forth in the Extraordinary Resolution required by Section 6.24.

The terms of this Article 11 will not apply to any transfer of the Power Assets effected pursuant to Section 6.10(2) of this indenture.

### **Section 11.2 Substitution of Successor**

In case of any consolidation, amalgamation, merger or transfer as provided in Section 11.1, the person or persons formed by such consolidation, amalgamation or merger or to which any transfer has been made, upon executing a supplemental indenture or other instrument as provided in Section 11.1 will succeed to and be substituted for the Company in whole or in part according to the terms of such consolidation, amalgamation, merger or transfer.

### **Section 11.3 Issue of Bonds by Successor**

Any successor or assignee hereunder referred to in Section 11.2 may thereupon in place of or together with, as the case may be, the Company cause to be signed and may issue any or all replacement Bonds, the issue of which was authorized hereunder prior to the date of the consolidation, amalgamation, merger or transfer and which were not theretofore signed by the Company and delivered to the Trustee and the Trustee, upon the order of such successor or assignee corporation in lieu of or in addition to, as the case may be, the Company, and subject to all the terms, conditions and restrictions herein prescribed, will certify any and all such Bonds previously signed by the officers of the Company and delivered to the Trustee for certification, and any of such Bonds which such successor or assignee will thereafter cause to be signed and delivered to the Trustee for that purpose. All Bonds so issued will have the same rank and

security as the Bonds theretofore or thereafter issued in accordance with the terms of this indenture as though all such Bonds had actually been issued by the Company as of the date of the execution hereof. Every such successor or assignee will possess and may exercise each and every power of the Company hereunder to the extent necessary in the circumstances.

In the case of a transfer of the Secured Assets pursuant to Section 6.24 (whether pursuant to a winding-up, dissolution or merger of the Company or a transfer of the Power Assets as an entirety), the Trustee, upon being satisfied that the provisions of Section 6.24 have been complied with, will consent to such transfer and join in such documents and do such acts as, in its discretion, may be thought advisable, and upon such consent being given and such transfer being carried out, the Company will be released and discharged from its covenants and obligations under this indenture, the Bonds and the Security Agreements and any other covenants and obligations to the Trustee in its capacity as trustee hereunder or under any other document or agreement, and the Trustee will execute any document or documents which it may be advised is or are necessary or advisable for effecting or evidencing such release and discharge, subject in all respects to such conditions as may be set forth in the Extraordinary Resolution required by Section 6.24.

#### **Section 11.4 Exception**

Notwithstanding anything contained in this Article to the contrary, the Company acknowledges that, in the event of a transaction contemplated by Section 11.1, a continuing or other person or a purchaser or purchasers may be required by the Trustee, on the advice of Counsel, to enter into a replacement indenture to this indenture on substantially the same terms as this indenture, which replacement indenture will authorize the issuance of bonds in replacement of the Bonds, and to execute and deliver all such deeds and documents, including opinions, as the Trustee may be advised by Counsel are necessary or advisable in such circumstances.

### **ARTICLE 12**

#### **INVESTMENT OF TRUST MONEYS**

#### **Section 12.1**

Unless provided to the contrary herein, any moneys held by the Trustee which under the trust hereof may or ought to be invested or which may be on deposit with the Trustee or which may be in the control of the Trustee, may, upon receipt of a written direction of the Company, be invested and reinvested in the name or under the control of the Trustee in Permitted Investments. Any direction from the Company to the Trustee will be in writing and will be provided to the Trustee no later than 9:00 a.m. on the day on which the investment is to be made. Any such direction received by the Trustee after 9:00 a.m. or received on a non-business day, will be deemed to have been given prior to 9:00 a.m. the next business day. For the purpose of this Section, "business day" will not include any day on which banks are not open for business in Toronto, Ontario. No such Permitted Investments may have a maturity greater than 24 months from the date of such investment therein. Pending such investment such moneys may be placed by the Trustee on deposit in any Permitted Financial Institution against demand deposit certificates or with its or an Affiliated Entity's deposit department. The Trustee will, at

any time and from time to time, on the Written Request of the Company, invest such monies in Permitted Investments as are directed by the Company, demand payment of the moneys evidenced by any such certificate or sell such Permitted Investments (unless the Trustee is of the opinion that such action would be prejudicial to the interests of the bondholders). The Trustee will allow interest at the current rate for similar deposits of money remaining on deposit with it and credit the Company with interest and other income received on moneys deposited and other depositaries and all moneys invested as herein provided.

In addition to any written direction to invest cash in a Permitted Investment, the Trustee may hold cash balances and may, but need not invest same in its deposit department or the deposit department of an Affiliated Entity of the Trustee; but the Trustee and each Affiliated Entity of the Trustee will not be liable to account for any profit to any parties to this indenture or to any other person or entity other than at a rate, if any, established from time to time by the Trustee or an Affiliated Entity of the Trustee for similar amounts held on deposit. For the purpose of this Section, "Affiliated Entity" means affiliated companies within the meaning of the *Business Corporations Act* (Ontario) ("OBICA"); and in the case of the Trustee, includes Canadian Imperial Bank of Commerce, CIBC Mellon Global Securities Services Company and Mellon Bank, N.A. and each of their affiliates within the meaning of the OBICA.

The Trustee will not be held liable for any losses incurred in the investment of any funds in Permitted Investments.

### **ARTICLE 13** **SUITS BY BONDHOLDERS AND TRUSTEE**

#### **Section 13.1 Bondholders May Not Sue**

Subject to Section 13.3, no holder of any Bond has the right to institute any suit, action or proceeding or to exercise any other remedy authorized by this indenture or available at law for the purpose of enforcing any right under this indenture, any Security Agreement or Bond on behalf of the bondholders or for the execution of any trust or power hereunder or for the appointment of a liquidator or Receiver or for a receiving order under the *Bankruptcy and Insolvency Act* (Canada) or to have the Company wound up or to file or prove a claim in any liquidation or bankruptcy proceedings, unless an Extraordinary Resolution to this effect has been passed in accordance with the terms of this indenture and such Extraordinary Resolution, along with any indemnity and funding commitment required by the Trustee, has been delivered to the Trustee and there is compliance with the provisions of Section 17.7, and the Trustee has failed to act within 30 days. If the Trustee has so failed to act, but not otherwise, any bondholder acting on behalf of all Senior Bonds or Subordinate Bonds, as applicable, will be entitled to take any of the proceedings that the Trustee might have taken hereunder. No bondholder has any right in any manner whatsoever to effect, disturb or prejudice the rights hereby created by its action or to enforce any right hereunder or under any Bond, except subject to the conditions and in the manner herein provided. Any money received as a result of a proceeding taken by any bondholder hereunder must be forthwith paid to the Trustee and will be distributed in accordance with the terms of this indenture.

### **Section 13.2 Bondholders May Waive Default**

In case any action, suit or other proceeding has been brought by the Trustee or by any bondholder after failure of the Trustee to act, the holders of Senior Bonds and Subordinate Bonds (where permitted pursuant to Section 3.9, Article 9, Article 10 and Section 16.2) may by Extraordinary Resolution direct the Trustee or the bondholder bringing any such action, suit or other proceeding to waive the Event of Default in respect of which any such action, suit or other proceeding has been brought upon payment of the costs, charges and expenses incurred by the Trustee or the bondholder, as the case may be, in connection therewith, and to stay or discontinue or otherwise deal with any such action, suit or other proceeding, and the Trustee or such bondholder, as the case may be, will thereupon do so.

### **Section 13.3 Unconditional Right of Bondholders to Receive Principal and Interest**

Each bondholder will have the right on the terms stated herein, which is absolute and unconditional (but subject to Section 3.9 in the case of Subordinate Bonds), to receive payment of the principal of, and interest on, such Bond when due as expressed in such Bond, and, subject to compliance with Section 13.1 and Section 3.9 (in the case of holders of Subordinate Bonds), to institute suit for the enforcement of any such payment, except if and to the extent that the institution or prosecution of such claim or the entry of judgment therein would result in the surrender, impairment, waiver or loss of the Security or any part thereof.

### **Section 13.4 Payment Free from Equities**

The Bonds will be paid by the Company, and may be assigned by each holder of a Bond, absolutely free and clear of all equities, rights of set-off, claims, defences, counterclaims, rights or other matters whatsoever (collectively, "Claims"), whether existing between a holder and the Company and/or any third parties or intermediate holders, and whether now existing or hereafter arising (before or after notice of any assignment to the Company) which could impair or adversely affect in any way the entitlement of any present or future holder to enforce the Bonds strictly in accordance with the terms and provisions hereof and of the Bonds, and the Company hereby agrees not to assert, as against any assignee or any present or future holder, any Claims arising out of this indenture or any Bond that it had against a predecessor holder (other than the defence that obligations hereunder have been performed or observed by the Company). For greater certainty, but without limiting the generality of the foregoing, the foregoing will apply:

- (a) notwithstanding that such Claim arises due to any act or omission of any holder of a Bond or any intermediate holder of a Bond or any other party;
- (b) regardless of how closely or inseparately connected such Claim is to the obligations or whether it flows out of dealings or transactions related thereto; and
- (c) notwithstanding actual or constructive notice to any assignee or any present or future holder of a Bond, or to any intermediate holder of a Bond or any other third party of such Claim, regardless of when received or deemed to be received.

The foregoing will be without prejudice to the right of the Company to subsequently assert any Claim as against the assignor.

**ARTICLE 14**  
**APPOINTMENT OF NEW TRUSTEE**

**Section 14.1 Resignation, etc. and Appointment of New Trustee**

The Trustee may resign its trust after giving 90 days' notice in writing to the Company and the bondholders and will resign in the event that a material conflict of interest arises in its role as a fiduciary under this indenture and is not eliminated within 90 days after ascertaining that it has such a material conflict of interest and in either case the Trustee will be discharged from all further duties and liabilities hereunder.

In the event of the Trustee resigning or being removed by the bondholders by Extraordinary Resolution or being dissolved, becoming bankrupt, going into liquidation or otherwise becoming incapable of acting hereunder, the Company must forthwith appoint a new trustee; failing such appointment by the Company, the bondholders may by Ordinary Resolution appoint a replacement trustee. If neither the Company nor the bondholders so appoint a replacement trustee, the retiring Trustee or any bondholder may apply to an Ontario court of competent jurisdiction at the Company's expense, on such notice as such court may direct, for the appointment of a new trustee; but any new trustee so appointed by the Company or by the Court will be subject to removal as aforesaid by the bondholders.

Any successor Trustee so appointed must be a trust company qualified and authorized to carry on trust business in the Provinces of Canada, as necessary and applicable, and there must not exist a material conflict of interest in its role as a fiduciary under this indenture. On any new appointment the new Trustee will be vested with the same estates, properties, rights, powers, duties, trusts and responsibilities as its predecessor as if it had been originally named as Trustee, without any further assurance, conveyance, act or deed, but there will be immediately executed, at the expense of the Company, all such instruments (if any) as the new Trustee may be advised by Counsel are necessary or advisable.

Upon payment to the retiring Trustee of all amounts owing or due to the retiring Trustee hereunder, the retiring Trustee will duly assign, transfer and deliver to the new Trustee all property, collateral and money held and all records kept by the retiring Trustee.

Should any deed, conveyance or instrument in writing from the Company be required by any new Trustee for more fully and certainly vesting in and confirming to it such estates, properties, rights, powers and trusts, then any and all such deeds, conveyances and instruments in writing will, on request of said new Trustee, be made, executed, acknowledged and delivered by the Company.

Any company into which the Trustee may be merged or with which it may be consolidated or amalgamated, or any company resulting from any merger, consolidation or amalgamation to which the Trustee is a party, will be the successor Trustee under this indenture without the execution of any instrument or any further act unless in the Opinion of Counsel such

action would be prudent, provided that the Trustee shall give written notice to the Company and the bondholders of any such consolidation, amalgamation or succession..

## **ARTICLE 15** **NOTICES**

### **Section 15.1 Notice to Company**

Any notice to the Company under the provisions hereof must be given by delivery or by facsimile or by registered letter addressed to the Company at:

2 Sackville Road  
Sault Ste. Marie, Ontario  
P6B 6J6

Facsimile No.: (705) 941-5600  
Attention: President

with a copy to:

Suite 300  
Brookfield Place  
181 Bay street  
Toronto, Ontario  
M5J 2T3

Facsimile No.: (416) 363-2856  
Attention: Chairman of the Board

and if so delivered, will be deemed to have been given on the first business day following the date of delivery, if so mailed will, subject to Section 15.4, be deemed to have been given on the fifth business day following such mailing, and if sent by facsimile transmission, will be deemed to have been delivered on the first business day following such facsimile transmission. The Company may from time to time notify the Trustee of a change in address or facsimile number as the case may be in accordance with Section 15.3.

### **Section 15.2 Notice to Bondholders**

Any notice to the holder of any Bond under the provisions hereof must be given by delivery or by first class letter addressed to such holder at its post office address appearing in the register of bondholders and if so delivered, will be deemed to have been given on the first business day following the date of delivery and if so mailed, subject to Section 15.4, will be deemed to have been given on the fifth business day following such mailing. Accidental error or omission in giving notice or accidental failure to mail notice to any holder will not invalidate any action or proceeding founded thereon.

### Section 15.3 Notice to the Trustee

Any notice to the Trustee under the provisions hereof must be given by delivery or by facsimile or by registered letter addressed to the Trustee as follows:

- (a) if mailed or delivered, at:

320 Bay Street  
P.O. Box 1  
Toronto, Ontario  
M5H 4A6

Facsimile No.: (416) 643-5570  
Attention: Executive Director, Corporate Trust Services

and if so delivered, will be deemed to have been given on the first business day following the date of delivery, if so mailed will, subject to Section 15.4, be deemed to have been given on the fifth business day following such mailing and if so facsimiled will be deemed to have been given on the first business day following such facsimile. The Trustee may from time to time notify the Company of a change in address in accordance with Section 15.1.

### Section 15.4 Postal Interruption

Notwithstanding the foregoing provisions of this Article 15, a notice may not be sent by first-class or registered mail but must be delivered by hand (or, if applicable, sent by telecopy) if a strike or lockout of postal employees then in effect or generally known to be pending would delay or would be reasonably likely to delay the receipt of such notice by the party to which it is addressed and any such communication sent by registered mail in such circumstances will be deemed not to have been given.

## ARTICLE 16 BONDHOLDERS' MEETINGS

### Section 16.1 Conduct of Meetings

Meetings of bondholders will be convened, held and conducted in the following manner:

- (a) **Calling of Meetings:** At any time and from time to time the Trustee or the Company may, and the Trustee will on being served with a Bondholders' Request, convene a meeting of the Senior Bonds and/or Subordinate Bonds, depending on who made the request. In the event of the Trustee failing to convene a meeting after a meeting is requested by such a Bondholders' Request or by the Company, the bondholders who made the Bondholders' Request or the Company (as applicable) may themselves convene such meeting and the notice calling such meeting may be signed by such person as such bondholders or the Company (as applicable) may specify. Every such meeting will be held at the City of Toronto or at such other place as the Trustee may, acting reasonably, in



any case determine or approve. A meeting of bondholders may be held by means of such telephone, electronic or other communication facilities as permit all persons participating in the meeting to communicate with each other simultaneously and instantaneously, and each bondholder will be permitted, if it so notifies the Trustee and complies with the requirements of Section 1.7 and provided that such bondholder provides sufficient proof to the Trustee that it is a holder of Bonds or a duly appointed proxy therefor, to participate in any meeting of bondholders by any of the foregoing means as it may elect.

- (b) **Notice of Meetings:** At least 21 days' notice of such meeting must be given to the applicable bondholders and such notice must state the time when, and the place where and the means by which, said meeting is to be held and must specify in general terms the nature of the business to be transacted thereat, but it will not be necessary to specify in the notice the text of the resolutions to be passed.
- (c) **Quorum:** At any meeting of the holders of the Senior Bonds or Subordinate Bonds or all Bonds, as the case may be, subject as herein provided, a quorum will consist of persons present or represented by proxy holding either personally or as proxies for holders not less than 50% in principal amount of the Senior Bonds or Subordinate Bonds or all Bonds, as applicable, then outstanding. In the event of a quorum not being present on the date for which the meeting is called within 30 minutes after the time fixed for the holding of such meeting, the meeting will be adjourned to be held at a place and upon a date and at an hour to be fixed by the Trustee who will give not less than 7 days' notice of the date and time to which such meeting is adjourned and of the place where such adjourned meeting is to be held, and at such adjourned meeting, a quorum will consist of the bondholders there present or represented by proxy.
- (d) **Chairman:** Some person, who need not be a bondholder, nominated in writing by the Trustee, will be Chairman of the meeting but, if no person is so nominated or if the person so nominated is not present within 25 minutes after the time fixed for the holding of the meeting, the bondholders present or represented by proxy will choose some person present to be Chairman.
- (e) **Voting:** Subject to the provisions of Section 16.4, every question submitted to a meeting of holders of the Senior Bonds or Subordinate Bonds or all Bonds, except an Extraordinary Resolution or a Unanimous Resolution, will be decided in the first place by a majority of the votes given on a show of hands or, if any of the bondholders are present by telephone, electronic or other acceptable communication facilities, by any other means by which the vote of such holder may be registered, and will be binding on all bondholders holding Senior Bonds or Subordinate Bonds or all Bonds, as applicable. Upon the request of any bondholder present at a meeting in person or by proxy, a question will be determined by a poll. A poll will be taken on every Extraordinary Resolution. On a poll, each bondholder present or represented at the meeting will have one vote for every \$1,000 principal amount of Bonds of which he is the holder. Votes may be given in person or by proxy and a proxy need not be a bondholder.

- (f) **Regulations:** The Trustee may, from time to time, make and vary such regulations as it thinks fit providing for and governing the conduct at meetings of bondholders.
- (g) **Declaration by Chairman of Result of Vote:** At any meeting of the bondholders, in cases where no poll is required or requested, a declaration made by the Chairman that a resolution has been carried, or carried by a particular majority, or lost, will be conclusive evidence thereof.

## Section 16.2 Extraordinary Resolution

An Extraordinary Resolution, adopted in accordance with the provisions hereof, will be binding upon all the holders of Senior Bonds or Subordinate Bonds or all Bonds, as applicable, and the Trustee will be bound to give effect thereto accordingly.

The term "Extraordinary Resolution" when used in this indenture in respect of the Senior Bonds, the Subordinate Bonds or all Bonds, means (subject to the provisions of Section 16.5 and as hereinafter provided) a resolution adopted at a meeting of the holders of such Bonds then outstanding, duly convened and held in accordance with the provisions herein contained, upon a poll by the affirmative vote of not less than 66% of the principal amount of such Bonds present in person or by proxy then outstanding; provided that no Extraordinary Resolution or Ordinary Resolution may be adopted, without the consent or affirmative vote of 100% of the votes of the holders of the applicable Bonds, which purports to:

- (a) waive a default in the payment of the principal of or interest on such Bonds, release any material part of the Security, or change the stated maturity of or the payment for any instalment of interest and/or principal on such Bonds, or reduce the principal amount thereof or the rate of interest payable thereon, or change the currency in which any such Bond or the interest thereon is payable, or the Redemption Price of any such Bonds, or any change that would permit the Company to create Senior Bonds or Subordinate Bonds in excess than that permitted in Section 2.1 hereof, or to repay any principal under any such Bonds sooner than permitted by the terms of the indenture, or
- (b) reduce the percentage in principal amount of such outstanding Bonds the consent of whose holders is required for any Ordinary Resolution, Extraordinary Resolution or Unanimous Resolution or any modification or amendment to this indenture or to the terms and conditions of such Bonds, or for any waiver of compliance therewith, or reduce the requirements for voting and quorum at any meeting of bondholders at which a resolution is to be adopted, or
- (c) modify, amend or waive Section 3.9, Section 5.11, Section 6.2(i), Section 6.2(ii), Section 6.2(iii), Section 6.8(ii), Section 6.8(iii), Section 6.22, Section 6.24 or Section 10.6 or the definitions of EBITDA, Distribution, Indebtedness, Debt Service or Secured Assets.

Except as otherwise provided for herein, no action will be taken at a meeting of the bondholders which changes any provision of this indenture or changes or prejudices the

exercise of any right of any bondholder except by Extraordinary Resolution as hereinbefore provided or by resolution or written instrument as hereafter provided.

The Company agrees that it will, upon receipt from the Trustee of any Unanimous Resolution of the holders of Senior Bonds or Subordinate Bonds, deliver a copy of such resolution or instrument to the Rating Agency.

### **Section 16.3 Powers Exercisable by Extraordinary Resolution**

(1) The holders of all Bonds (except where otherwise provided herein) will, in addition to any powers hereinbefore given, have the following powers which will be exercisable from time to time by Extraordinary Resolution only (except where otherwise provided herein) and will be subject to the terms of this indenture (including Section 3.9 and Section 9.3):

- (a) power to sanction any change whatsoever in any of the provisions of this indenture and any modification, waiver, abrogation, alteration, compromise or arrangement of the rights of the bondholders against the Company or against the Secured Assets whether such rights arise under this indenture or the Bonds or otherwise and to authorize the Trustee to concur in and execute any indenture supplemental to this indenture embodying any such change, modification, waiver, abrogation, alteration, compromise or arrangement;
- (b) power to sanction any scheme for the reorganization or recapitalization of the Company into or with any other person, or for the transferring, selling or leasing of the Secured Assets or any part thereof, where the consent of the holders of Bonds may be required thereto;
- (c) power by the holders of Subordinate Bonds to sanction the exchange of the Subordinate Bonds for, or the conversion of the Subordinate Bonds into, shares debentures, bonds or any other securities of the Company or any other person formed or to be formed;
- (d) power to assent to any compromise or arrangement with any creditor or creditors or any class or classes of creditors, whether secured or otherwise, and with holders of any shares or securities of the Company;
- (e) power to instruct the Trustee to waive any Event of Default or other Default hereunder or cancel any declaration made pursuant to Section 9.2 either unconditionally or on such terms as are specified in the Extraordinary Resolution (except, for greater certainty, with respect to any Default or Event of Default as defined in and created by any indenture supplemental hereto for the benefit of a holder of any particular series of Additional Bonds or Subordinate Bonds, which will be dealt with as prescribed by such supplemental indenture);
- (f) power to restrain any holder of any Bond from taking or instituting any action or other proceeding for the execution of any trust or power hereunder or for the appointment of a liquidator or Receiver where Section 3.9 or Article 13 have not been complied with, and to require such holder of any Bond to waive any Default

or Event of Default by the Company on which any action or proceeding is founded where such waiver is approved in accordance with this indenture; and, in case any action or other proceeding has been brought by any holder or holders of any Bonds pursuant to Section 13.1 after failure of the Trustee to act, power to direct such holder or holders and the Trustee to waive the Default or Event of Default in respect of which such action or other proceeding has been brought where such waiver is approved in accordance with this indenture, upon payment of the costs, charges and expenses incurred in connection therewith, and to stay or discontinue or otherwise deal with any such action or other proceeding;

- (g) power to require the Trustee to exercise or refrain from exercising any of the powers, rights or authority conferred upon the Trustee under this indenture or to waive any Default or Event of Default on the part of the Company in accordance with Section 9.3 and Article 13, upon such terms as may be provided in the Extraordinary Resolution;
- (h) power to remove the Trustee and to appoint a new Trustee to take the place of the Trustee so removed;
- (i) power to approve any sale, transfer or encumbrance of all or any part of the Secured Assets and any purchaser thereof, where the consent of the holders of Bonds may be required thereto pursuant to this indenture;
- (j) power to consent to a release by the Trustee of the Company hereunder, where the consent of the holders of Bonds may be required thereto; and
- (k) power by the holders of Senior Bonds or the holders of Subordinate Bonds from time to time to appoint a committee with power and authority (subject to such limitations, if any, as may be prescribed in the resolution) to exercise on behalf of the holders of Senior Bonds or Subordinate Bonds, as applicable, such of the powers of such bondholders as are exercisable by Extraordinary Resolution or other resolution as are included in such appointment. The resolution making such appointment may provide for payment of the expenses and disbursements of and remuneration of such committee and of the Trustee. Such committee will consist of such number of persons as may be prescribed in the resolution appointing it, and the members need not be themselves holder of Bonds. Every such committee may elect its chairman, and may make regulations respecting its quorum, the calling of its meetings, the filling of vacancies occurring in its number, and its procedure generally. Such regulations may provide that the committee may act a meeting at which a quorum is present or may act by written resolutions signed by a number of members thereof necessary to constitute a quorum. All acts of any such committee within the authority delegated to it will be binding upon all applicable bondholders and the Company and the Trustee will be entitled to rely on actions taken by such committee. Neither the committee nor any member thereof will be liable for any loss arising from or in connection with any action taken or omitted to be taken by them in good faith. The bondholders creating

such committee will advise the Trustee and the Company of its creation as soon as practicable following its creation.

(2) The foregoing powers will be deemed to be several and cumulative and not dependent on each other and the exercise of any one or more of such powers, or any combination of such powers from time to time will not be deemed to exhaust the rights of the bondholders to exercise such power or powers, or combination of powers, thereafter from time to time. No powers exercisable by Extraordinary Resolution pursuant to this Section will derogate in any way from any rights of the Company under or pursuant to this indenture.

#### **Section 16.4 Serial Meetings**

(1) If any business to be transacted at a meeting of bondholders especially affects the rights of the holders of Senior Bonds or Subordinate Bonds (as applicable) of one or more series (and for the purposes of this Article 16, the word "series" will be deemed, unless the context otherwise requires, to mean any series and also any part of a series) in a manner or to an extent substantially differing from that in or to which it affects the rights of the holders of the other Senior Bonds or Subordinate Bonds (as applicable) of any other series (as to which an Opinion of Counsel will be binding on all bondholders, the Trustee and the Company for all purposes hereof) then:

- (a) reference to such fact, indicating each series so especially affected, must be made in the notice of such meeting and the meeting will be and is herein called a "serial meeting"; and
- (b) the holders of Bonds of a series so especially affected will not be bound by any action taken at a serial meeting unless in addition to compliance with the other provisions of this Article 16 at such meeting:
  - (i) there are represent in person or by proxyholders of at least 50% in principal amount of the outstanding Bonds of such series; and
  - (ii) the resolution is passed by votes of more than 50% (or in the case of an Extraordinary Resolution not less than 66 $\frac{2}{3}$ %) of the principal amount of the Bonds of such series then outstanding.

(2) If in the Opinion of Counsel any business to be transacted at any meeting of bondholders does not affect the rights of the holders of Senior Bonds or Subordinate Bonds (as applicable) of one or more series, the provisions of this Article 16 will apply with respect to such business as if the Bonds of such series were not outstanding and no notice need be given to the holders of Bonds of such series.

(3) Without limiting the generality of the foregoing, a proposal (i) to accelerate or to extend the maturity of Bonds of any particular series or reduce the principal amount thereof or the rate of interest or any Redemption Price thereof, (ii) to modify or terminate any covenant or agreement which by its terms is effective only so long as Bonds of a particular series are outstanding, or (iii) to reduce with respect to holders of Bonds of any particular series any percentage (or corresponding percentage required by an Extraordinary Resolution) stated in

Section 16.1 or Section 16.2 hereof or in this Section 16.4 will be deemed to affect the rights of the holders of Bonds of such series in a manner substantially differing from that in which it affects the rights of holders of Bonds of any other series, whether or not a similar extension, reduction, modification or termination is proposed with respect to Bonds of any or all other series.

### **Section 16.5 Signed Instruments**

Any resolution or instrument signed in one or more counterparts by the holders of a given percentage of the aggregate principal amount of the Senior Bonds, Subordinate Bonds or any series of Bonds if especially affected, as the case may be, then outstanding will have the same force and effect as a resolution duly passed at a meeting of the bondholders by the affirmative vote of such percentage of the votes given upon a poll, subject to the same conditions and requirements, as hereinbefore provided, for a meeting of the bondholders.

## **ARTICLE 17** **THE TRUSTEE**

### **Section 17.1 Duty of Trustee**

In the exercise of the powers, rights, duties and obligations prescribed or conferred by the terms of this indenture, the Trustee must exercise that degree of care, diligence and skill that a reasonably prudent trustee would exercise in comparable circumstances.

### **Section 17.2 Trustee May Deal in Bonds**

Subject to Section 17.5 and Trust Indenture Legislation, the Trustee may buy, lend upon and deal in the Bonds either with the Company or otherwise, and generally contract and enter into financial transactions with the Company or otherwise, without being liable to account for any profit made thereby.

### **Section 17.3 Trustee Not Required to Give Security**

The Trustee will not be required to give security for the execution of the trusts or its conduct or administration hereunder.

### **Section 17.4 Protection of Trustee**

By way of supplement to the provisions of any law for the time being relating to trustees, it is expressly declared and agreed as follows:

- (a) the Trustee will not be liable for or by reason of any statements of facts or recitals in this indenture or in the Bonds (except the representation contained in Section 17.5 and in the certificate of the Trustee on the Bonds) or required to verify the same, but all such statements or recitals are deemed to be made by the Company;
- (b) the Trustee will have no obligation to calculate the amount due on any interest payment date for any Bonds; in this regard, if at any time the Trustee is asked and

if it agrees to make any interest payment, the Company covenants to provide to the Trustee an Officers' Certificate detailing the amount due to each bondholder on the relevant interest payment date, no later than 7 business days prior to the interest payment due date, and it will be able to rely absolutely upon the accuracy and completeness of such Officers' Certificate;

- (c) the Trustee will not be liable for any reason for failure or default of the Company to remove any Lien upon the assets of the Company or for failure to take any action necessary to constitute, perfect or maintain the priority of the Security or for any failure of the Security or any defect in the Security or for the sufficiency, correctness, genuineness, or validity of the Security;
- (d) nothing herein contained will impose any obligation on the Trustee to see or to require evidence of registration or filing (or renewals thereof) of this indenture or any instrument ancillary or supplemental hereto;
- (e) the Trustee will not be bound to give any notice of the execution hereof;
- (f) the Trustee will not incur any liability or responsibility whatever or be in any way responsible for the consequence of any breach on the part of the Company of any of the covenants herein contained or of any act of the agents or servants of the Company;
- (g) upon receipt of reports and financial statements furnished to the Trustee hereunder, the Trustee will, while such reports and statements are current, maintain custody of same and deliver copies to the holders of the Bonds upon request;
- (h) the Trustee will not be obligated to analyze financial statements, auditors' reports or other information relating to the business or financial condition of the Company or the Transmission Business which may come into the Trustee's possession, or to evaluate, at any time in any manner whatsoever, the performance of the Company or the Transmission Business;
- (i) the Trustee will not be required to analyze or evaluate the insurance coverages of the Company; nothing herein will be deemed to hold the Trustee responsible for failure by the Company to maintain insurance coverage or for any loss arising out of any want, defect or insufficiency in any insurance policy, or because of failure of any insurer to pay the full amount of any loss or damage insured against; the Trustee will be entitled to request and rely absolutely upon an Officers' Certificate stating that the Company is in compliance with its covenant in Section 6.12 to maintain adequate insurance coverage; no duty with respect to effecting or maintaining insurance coverage will rest with the Trustee;
- (j) the Trustee will incur no liability with respect to the delivery or non-delivery of any certificate or certificates whether delivered by hand, mail or other means;

- (k) the duties and obligations of the Trustee will be determined solely by the provisions hereof and, accordingly, the Trustee will not be responsible except for the performance of such duties and obligations as it has undertaken herein;
- (l) the Trustee will retain the right not to act and will not be held liable for refusing to act unless it has received clear and reasonable documentation which complies with the terms of this indenture; such documentation must not require the exercise of any discretion or independent judgment;
- (m) in the event of any disagreement arising regarding the terms of this indenture, the Trustee will be entitled at its option to refuse to comply with any or all demands whatsoever until the dispute is settled either by agreement amongst the various parties or by a court of competent jurisdiction; and
- (n) the Trustee will not have any liability whatsoever for maintaining, supervising or reviewing any records relating to beneficial ownership interests in the Bonds.

#### **Section 17.5 Conflict of Interest**

The Trustee represents to the Company and the bondholders that at the time of the execution and delivery hereof no material conflict of interest exists in the Trustee's role as a fiduciary hereunder and agrees that in the event of a conflict of interest arising hereafter, it will, forthwith upon ascertaining that it has such conflict of interest, either eliminate the same or resign its trust hereunder. If at any time a material conflict of interest in the Trustee's role as a fiduciary hereunder arises, the Trustee must, forthwith upon ascertaining that it has such a conflict, either eliminate such conflict or resign in the manner and with the effect specified in Section 14.1.

#### **Section 17.6 Indemnification of Trustee**

The Trustee, in both its individual and trustee capacity and its directors, officers, employees and agents, will at all times be indemnified and saved harmless by the Company from and against all claims, demands, losses, actions, causes of action, costs, charges, expenses, damages and liabilities whatsoever, and, without limiting the generality of the foregoing, such indemnity must include a full indemnity referable to any and all environmental liability, (except to the extent caused by the gross negligence or wilful misconduct of the Trustee, its agents, employees, contractors, representatives, directors or officers) arising in connection with this indenture, including, without limitation, those arising out of or related to actions taken or omitted to be taken by the Trustee contemplated hereby, legal fees and disbursements on a solicitor and client basis and costs and expenses incurred in connection with the enforcement of this indemnity, which the Trustee may suffer or incur, whether at law or in equity, in any way caused by or arising, directly or indirectly, in respect of any act, deed, matter or thing whatsoever made, done, acquiesced in or omitted in or about or in relation to the execution of its duties as Trustee and including any deed, matter or thing in relation to the registration, perfection, release or discharge of the Security. The foregoing provisions of this Section 17.6 do not apply to the extent that in any circumstances there has been a failure by the Trustee or its employees or agents to act honestly and in good faith or to discharge the Trustee's obligations under Section



17.1. This indemnity will survive the termination or discharge of this indenture and the resignation or removal of the Trustee.

### **Section 17.7 Conditions Precedent to Trustee's Obligation to Act**

The Trustee will not be bound to give any notice or do or take any act, action or proceeding by virtue of the powers conferred on it hereby unless and until it has been required so to do under the terms hereof; nor will the Trustee be required to take any notice of any Default or Event of Default hereunder, other than in payment of any monies required by any provision hereof to be paid to it, unless and until notified in writing of such Default or Event of Default, which notice must distinctly specify the Default or Event of Default desired to be brought to the attention of the Trustee and, in the absence of any such notice, the Trustee may for all purposes of this indenture conclusively assume that the Company is not in default hereunder and that no Default or Event of Default has been made with respect to the payment of principal or costs, fees, charges, expenses or interest on the Bonds or in the observance or performance of any of the covenants, agreements or conditions contained herein. Any such notice or request will in no way limit any discretion herein given to the Trustee to determine whether or not the Trustee will take any action with respect to any Default or Event of Default or take action without any such request.

The obligation of the Trustee to commence or continue any act, action or proceeding for the purpose of enforcing any rights of the Trustee or the bondholders hereunder will be conditional upon the bondholders furnishing, when required by notice in writing by the Trustee, (i) sufficient funds to commence or continue such act, action or proceeding and (ii) an indemnity satisfactory to the Trustee to protect and hold harmless the Trustee against the costs, charges and expenses and liabilities arising directly or indirectly by reason therefor or to be incurred thereby and any loss and damage it may suffer by reason thereof (save and except for loss or damage resulting from the Trustee's gross negligence or wilful misconduct) and, without limiting the generality of the foregoing, such indemnity must include a full indemnity referable to any and all environmental liability. The holders of Subordinate Bonds must provide or deliver, as applicable, their *pro rata* share of such funds and/or indemnity, as applicable, as is also provided by the holders of Senior Bonds in connection with any proposed enforcement or realization of the Security.

None of the provisions contained in this indenture will require the Trustee to expend or risk its own funds or otherwise incur financial liability in the performance of any of its duties or in the exercise of any of its rights or powers.

### **Section 17.8 Employ Agents**

The Trustee may employ such agents and other assistants as it may reasonably require for the proper discharge of its duties hereunder, and may pay reasonable remuneration for all services performed for it in the discharge of the trusts hereof. All costs incurred therein will be payable on demand and are hereby declared to be secured hereby and to be a charge upon the Secured Assets prior to the charge of the Bonds.

### **Section 17.9 Reliance on Evidence of Compliance**

In the exercise of its rights, duties and obligations the Trustee may, if it is acting in good faith, rely, as to the truth of the statements and the accuracy of the opinions expressed therein, upon statutory declarations, opinions, reports or certificates furnished pursuant to any covenant, condition or other requirement of this indenture or required by the Trustee to be furnished to it in the exercise of its rights and duties under this indenture where such statutory declarations, opinions, reports or certificates comply with the requirements of this indenture and the Trustee examines such evidence and determines that such evidence indicates compliance with the applicable requirements of this indenture.

### **Section 17.10 Provision of Evidence of Compliance to Trustee**

In addition to any other provisions of this indenture, the Company will furnish to the Trustee evidence of compliance with the conditions precedent provided for in this indenture relating to:

- (a) the certification and delivery of Bonds applied for under any supplemental indenture;
- (b) the release or release and substitution of property subject to any Lien created by the Security;
- (c) the satisfaction and discharge of this indenture; and
- (d) the taking of any other action or step to be taken by the Trustee at the request of or on the application of the Company.

### **Section 17.11 Contents of Evidence of Compliance**

Evidence of compliance required by Section 17.10 will consist of:

- (a) an Officers' Certificate (unless otherwise specifically provided) stating that such conditions precedent have been complied with in accordance with the terms of this indenture;
- (b) in the case of conditions precedent compliance with which are, by this indenture, made subject to review or examination by a solicitor, an Opinion of Company Counsel that such conditions precedent have been complied with in accordance with the terms of this indenture; and
- (c) in the case of conditions precedent compliance with which are subject to the review or examination by auditors or accountants, an opinion or report of a Chartered Accountant or a Chartered Accountant's Certificate that such conditions precedent have been complied within accordance with the terms of this indenture.

### **Section 17.12 General Provisions as to Certificates, Opinions, Etc.**

Each Officers' Certificate, each Opinion of Counsel, each Opinion of Company Counsel, each Investment Dealer's Certificate and each Chartered Accountant's Certificate required under this indenture or furnished in connection with any application, Written Order, Written Request or Written Consent made to the Trustee or any bondholder pursuant to any provisions of this indenture must specify the Section under which such application, Written Order, Written Request or Written Consent is being made and must include a statement that the person signing such certificate or giving such opinion has read and is familiar with those provisions of this indenture relating to the conditions precedent with respect to compliance with which such evidence is being given. Each such certificate and opinion will, in addition include:

- (a) a brief statement of the nature and scope of the examination or investigation upon which the statements or opinions contained in the evidence are based;
- (b) a statement that, in the belief of the person giving the evidence, he has made such examination or investigation as is necessary to enable him to make the statements or give the opinions contained or expressed therein;
- (c) a statement whether in the opinion of such person the conditions precedent, if any, with respect to compliance with which such evidence is being given have been complied with or satisfied; provided that a Chartered Accountant or an Investment Dealer need not include such a statement; and
- (d) a statement that (unless the context otherwise requires) in the case of an Officers' Certificate, so far as known to the signers after having made due enquiry pursuant to this Section 17.12, no Default or Event of Default has occurred and is continuing, or if a Default or an Event of Default has occurred and is continuing, specifying the same.

Whenever the delivery of a certificate, opinion or report is a condition precedent to the taking of any action by the Trustee hereunder, the truth and accuracy of the facts and opinions stated in such certificate, opinion or report will in each case be conditions precedent to the right of the Company to have such action taken.

Any application, written demand, statement, request, notice, designation, direction, nomination or other instrument to be made by the Company under any of the provisions hereof will unless otherwise provided, be deemed sufficiently made and executed if executed by any two of the Chairman of the Board, Chief Financial Officer, Chief Executive Officer, the President, a Vice-President, the Treasurer, the Secretary, an Assistant Treasurer or an Assistant Secretary, or any two directors of the Company. The Trustee will accept a certificate signed by the Secretary or an Assistant Secretary of the Company as sufficient evidence of the passage of any resolution of the directors or of the shareholders of the Company.

The same officer, officers or any directors of the Company, or the same Chartered Accountant, Investment Dealer or other person, as the case may be, may, but need not, certify as to all the matters required to be certified under any provision of this indenture, but different officers, directors, Chartered Accountants, Investment Dealers or other persons may certify to

different facts, respectively. Where any person or persons are required to make, give or execute two or more orders, requests, certificates, statutory declarations, opinions or other instruments under this indenture, any such orders, requests, certificates, statutory declarations, opinions or other instruments may but need not be consolidated and form one instrument. Whenever any Officers' Certificate or other certificate is required to state that the Company is not in default hereunder or to state any such Default or Event of Default, the signers of such certificate may make such statement upon the basis of their best knowledge and belief after reasonable inquiry.

Any Chartered Accountant's Certificate may be based upon such examination of the accounting procedures and records of the Company as such Chartered Accountant considers appropriate in the circumstances and which must be in accordance with generally accepted accounting principles.

Any certificate or Opinion of Counsel or Opinion of Company Counsel may be based, insofar as it relates to factual matters or information in the possession of the Company or another person, upon the certificate or opinion of or representations by an officer or officers of the Company or such other person, unless such Counsel or Company Counsel knows that the certificate or opinion or representations with respect to the matters upon which his certificate or opinion may be based as aforesaid are erroneous.

The Trustee may, where it is reasonable in the circumstances so to do, request an Opinion of Counsel or Opinion of Company Counsel hereunder.

Counsel or Company Counsel in giving any opinion hereunder may rely in whole or in part upon the opinion of other counsel provided that Counsel or Company Counsel, as applicable, considers such other counsel as one upon whom he may properly rely.

Counsel or Company Counsel is giving any opinion hereunder, as to matters of interpretation and fact not within the professional competence of Counsel or Company Counsel, as applicable, may rely upon other experts' certificates.

Any certificate of any expert, insofar as it relates to matters outside of such expert's competence or responsibility, may be based upon a certificate or opinion of or upon representations by Counsel or Company Counsel or some other qualified expert, unless such first-mentioned expert knows that the certificate or opinion or representations with respect to the matters upon which his certificate may be based as aforesaid are erroneous, or in the exercise of reasonable care should have known that the same were erroneous.

## **ARTICLE 18**

### **ACCEPTANCE OF TRUSTS BY THE TRUSTEE**

#### **Section 18.1 General**

The Trustee hereby accepts the trust in this indenture declared and provided and agrees to perform the same upon the terms and conditions hereinbefore set forth.

**ARTICLE 19**  
**INDEMNIFICATION AND LIABILITIES OF THE COMPANY AND OTHERS**

**Section 19.1 Company's General Indemnity**

Without in any way limiting the generality of Section 17.6, the Company agrees to indemnify, protect, save and keep harmless the bondholders and the Trustee and their respective beneficiaries, officers, directors, employees, agents and their successors, assigns, heirs, executors and personal representatives (each of the same being an "Indemnitee"), from and against any and all liabilities, obligations, losses, damages, penalties, claims, actions, suits, costs and expenses, including reasonable legal expenses, of whatsoever kind and nature (but excluding in relation to environmental matters), imposed on, incurred by or asserted against any Indemnitee or imposed on or with respect to the Transmission Business, in any way, either directly or indirectly, relating to, arising out of or connected with:

- (a) any claim for personal injury, death, property damage or other loss or liability that may arise by reason of, result from, be caused by, or relate to the operation of the Transmission Business;
- (b) any fine or penalty arising out of the operation of the Transmission Business in violation of any Applicable Law;
- (c) any claim for infringement of patent, trade mark, industrial design, copyright or other intellectual property right arising out of the operation of the Transmission Business;
- (d) the Company's ownership of the Transmission Business;
- (e) any non-compliance with the terms of any Operative Document; or
- (f) any event of default under any Operative Document,

the whole to the complete exoneration of the Indemnitee, but excluding any and all liabilities, obligations, losses, damages, penalties, claims, actions, suits, costs and expenses arising out of the gross negligence or wilful misconduct of an Indemnitee; provided that the gross negligence or wilful misconduct of an Indemnitee will not prejudice this indemnity as it applies to any other Indemnitee. The indemnity contained herein as it applies to bondholders is subject to the terms of Section 10.1.

**Section 19.2 Environmental Indemnity**

Without in any way limiting the generality of Section 17.6, the Company will indemnify the Indemnitees against and hold them harmless from any claims, actions, Orders, remediation orders, abatement orders, prevention orders and suits, administrative or other proceedings made or brought by any person, any loss, expense, judgment, liability or asserted liability (including strict liability except to the extent caused or contributed to by the negligence or wilful misconduct of the Indemnitees) and including, without limitation, (i) costs and expenses of abatement and remediation of any Release of Hazardous Substances, (ii) liabilities of

the Indemnitees to any person (including any Governmental Authority) in respect of bodily injuries, property damage, damage to or impairment of the environment or any other injury or damage, (iii) liabilities of the Indemnitees to any person (including any Governmental Authority) for its foreseeable and unforeseeable consequential damages; and (iv) the liability of an Indemnitee for court costs, expenses of alternative dispute resolution proceedings and fees and disbursements of expert consultants and legal counsel on a solicitor and client basis, incurred as a result of:

- (a) the administration of the trusts created hereby;
- (b) the exercise by the Trustee of any rights under the Security;
- (c) the Release or presence of any Hazardous Substances or the presence of any Hazardous Substances by any means and for any reason on, above or below the Lands, the Future Sites, or the Improvements, any other property which is subject to the Security, whether or not the Release or presence of any Hazardous Substance is located on, above or below or originates or emanates from the Lands, the Future Sites, or the Improvements or any other real property owned, previously owned or under the care, control and management of the Company;
- (d) any presence of Hazardous Substances on, above or below or Release of Hazardous Substances from or to any property that is contiguous to the Lands, the Future Sites, or the Improvements or any other real property owned or controlled or operated by the Company;
- (e) any costs of removal or remediation or reclamation with respect to the Transmission Business (including well or facility abandonment obligations);
- (f) any non-compliance by the Company under any Environmental Law with respect to the Power Assets or the Transmission Business;
- (g) any step taken by any person to enforce compliance with or to collect or impose penalties, fines, administrative, civil or other sanctions provided by any Environmental Law with respect to the Transmission Business;
- (h) all environmental, health, reclamation and clean-up costs and obligations associated with or pertaining to the closure, abandonment or reclamation of the Power Assets or other locations upon which operations pertaining thereto are conducted, including any wells, facilities, buildings, fixtures or equipment located thereon or therein or utilized in respect thereof; or
- (i) any other activity affecting the Power Assets or the Transmission Business within the jurisdiction of any Governmental Authority pursuant to Environmental Laws.

The indemnity contained herein as it applies to bondholders will be subject to the terms of Section 10.1.

### **Section 19.3 Survival**

The provisions of this Article 19 will survive the termination or discharge of this indenture and the payment of all indebtedness arising in respect to the Bonds.

## **ARTICLE 20** **EXECUTION**

### **Section 20.1 Counterparts**

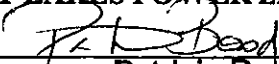
This indenture may be executed in several counterparts, each of which so executed will be deemed to be an original, and such counterparts together will constitute one and the same instrument.

### **Section 20.2 Successors and Assigns**

The protective provisions of this indenture will enure to the benefit of, and be binding upon, the parties and their respective successors and, in the case of the Trustee, assigns, including any company that acquires all or substantially all of the corporate trust business of the Trustee and assumes its obligations hereunder and under the Security Agreements. Any assignment by the Trustee, subject to Section 14.1 will be effective without the necessity for any further notice or advice to or approval of the parties hereto and without any further act or formality whatsoever.

**IN WITNESS WHEREOF** the parties hereto have executed this Indenture.

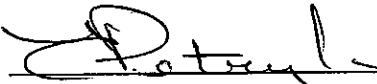
**GREAT LAKES POWER LIMITED**


By:   
Name: Patricia Bood  
Title: Vice-President and Secretary

By: \_\_\_\_\_  
Name:  
Title:



**CIBC MELLON TRUST COMPANY**

By:   
Authorized Signatory

By:   
Authorized Signatory

**SCHEDULE "A"**  
**To Deed of Trust**  
**Transmission Property Rights - fee simple**

**THIRD LINE SUBSTATION (TARENTORUS 19)**

1. PIN 31563-0092(LT) - Lot 66, Registrar's Compiled Plan H739, Tarentorus Section 19, Sault Ste. Marie.

**FOURTH LINE PROPERTY**

2. PIN 31564-0058(LT) - Part of Lot 38, Registrar's Compiled Plan H741, Tarentorus Section 18, as in T220780 (Schedule A 14thly), Sault Ste. Marie.

**FIFTH LINE PROPERTY (TARENTORUS 18)**

3. PIN 31564-0101(LT) - Lot 54, Registrar's Compiled Plan H741, Tarentorus Section 18, together with T220780, Sault Ste. Marie.

**TARENTORUS - SECTION 21**

4. PIN 31506-0125(LT) - Parcel 3329, Algoma West Section, being Part of Section 21, Tarentorus, as in LT29593 amended by LT32324, except LT30035 and Lots 1, 4 and 6, Expropriation Plan M-258, subject to LT40165 and LT70999, Sault Ste. Marie.
5. PIN 31506-0126(LT) - Parcel 3385, Algoma West Section, being Part of Section 21, Tarentorus, as in LT30035, except Lot 2, Expropriation Plan M-258, Sault Ste. Marie.

**PENNEFATHER**

6. PIN 31350-0100(LT) - Part of Section 24, Township of Pennefather as in T220780.

**FENWICK**

7. PIN 31346-0082(LT) - Lot 21, Registrar's Compiled Plan H-812, subject to RB640 and T-15805, District of Algoma.

**TILLEY**

8. PIN 31302-0339(LT) - Part of Section 36 Tilley, designated as Part 1 on Plan 1R-3450, subject to BC97, District of Algoma

**D.A. WATSON TRANSMISSION STATION HIGH FALLS SUBSTATION**

9. PIN 31176-0002(LT) - Parcel 423, Algoma Central Railway Lands, Township of Naveau, designated as Parts 1, 2 and 3, Plan 1R-9587 except an area of land containing 11 acres more or less being a right-of-way for power transmission line of the Great Lakes Power Company; subject to LT68364, LT26454 and LT113588, Michipicoten.

**GARTSHORE TRANSMISSION STATION**

10. **PIN 31231-0019(LT)** - Surface rights only, all of location CL 13852, designated as Part 1, Plan 1R-11005, Township of Peever, District of Algoma as in Crown Patent AL18166.

**ECHO RIVER TRANSMISSION STATION**

11. **PIN 31473-0101(LT)** - Part of Lots 24 and 37, RCP H766, as in T266124 and Parts 1 and 2, Plan 1R-5849, Macdonald, Meredith, Aberdeen Additional.

**SCHEDULE B**  
**MATERIAL CONTRACTS**

1. Reciprocal Agreement.
2. Operation, Maintenance and Administration Agreement.
3. Connection Facilities Agreement between Hydro One Networks Inc. and Great Lakes Power Limited Transmission Division dated July 1, 2002.

## SCHEDULE "C"

### SUBORDINATION AND POSTPONEMENT AGREEMENT

**THIS SUBORDINATION AND POSTPONEMENT AGREEMENT** is made as of the • day of • in favour of CIBC Mellon Trust Company, as trustee for and on behalf of each of the holders of Bonds from time to time under the Trust Indenture (the "Trustee"), by Great Lakes Power Limited (including its successors by amalgamation or otherwise, the "Debtor") and • [Note: identify Affiliate] (including its successors by amalgamation or otherwise, the "Subordinate Creditor");

**WHEREAS** pursuant to a deed of trust dated as of March \_\_, 2008 (such deed of trust and all further amendments, supplements (including all supplemental indentures), modifications, restatements and replacements entered into from time to time being referred to herein as the "Trust Indenture") between the Debtor and the Trustee, the Trustee is empowered and directed to hold the benefit of the Senior Security for and on behalf of the holders of Bonds;

**AND WHEREAS** the Subordinate Creditor has agreed to unconditionally and irrevocably subordinate and postpone the Subordinate Obligations (as hereinafter defined) to the indefeasible repayment in full by the Debtor of the Senior Debt (as hereinafter defined);

**NOW THEREFORE** for good and valuable consideration, the receipt and sufficiency of which is hereby irrevocably acknowledged, the parties hereto make the following covenants, acknowledgments and agreements.

1. **Defined Terms:** Capitalized terms used but not defined elsewhere in this Agreement (including the recitals hereto) shall have the following meanings and if not defined in this Section 1, shall have the meanings ascribed to them in the Trust Indenture:

- (a) "Senior Debt" means all indebtedness, liabilities and obligations, of any nature or kind, present or future, direct or indirect, absolute or contingent, whether as primary debtor or surety, matured or not and at any time owing by the Debtor to the Senior Lenders pursuant to the Trust Indenture and the Senior Security;
- (b) "Senior Security" means all liens, charges, pledges, security interests and other security agreements of any nature or kind, now or hereafter granted by the Debtor to the Senior Lenders through assignment or otherwise which secures payment of the Senior Debt;
- (c) "Senior Lenders" means, collectively, the Trustee and the holders of Bonds (whether Senior Bonds or Subordinate Bonds); and
- (d) "Subordinate Obligations" means all indebtedness, liabilities and obligations, of any nature or kind, present or future, matured or not and at any time owing by the Debtor to the Subordinate Creditor in respect of • [Note: **Contractual agreements to be identified.**].

2. **Subordination and Postponement:** Except as provided in Section 3 below, the Debtor and the Subordinate Creditor hereby covenant and agree that all Subordinate Obligations are hereby unconditionally and irrevocably deferred, postponed and subordinated in all respects to the prior indefeasible repayment in full by the Debtor of all the Senior Debt.

Without limiting the generality of the foregoing, the deferral, postponement and subordination of the Subordinate Obligations contained herein shall be effective notwithstanding:

- (a) the dates of any advances secured by the Senior Security;
- (b) the dates of default or the date or dates of crystallization of any floating charge under the Senior Security; and
- (c) the rules of priority established under applicable law.

3. **Repayment of Subordinate Obligations:** Until the Senior Debt has been indefeasibly paid in full and the Trust Indenture has been terminated, no direct or indirect, distribution, payment (including, but not limited to, principal, interest and fees), prepayment or repayment on account of, or other distribution in respect of, the Subordinate Obligations shall be made by, or on behalf of, the Debtor or received by, or on behalf of, the Subordinate Creditor, except for those payments expressly permitted in this Section 3. Notwithstanding the foregoing, the Debtor may (i) make payments on the Subordinated Obligations, or (ii) exercise rights of set-off in respect of the Subordinate Obligations, or (iii) make payments on the Subordinate Obligations by way of issuance of shares in the Debtor, so long as in each case any such payment constitutes a Distribution that is permitted to be made pursuant to the terms of the first sentence of Section 6.21 of the Trust Indenture.

4. **Restriction on Enforcement:** The Subordinate Creditor shall not take any steps or actions of any nature or kind to enforce payment of the Subordinate Obligations (including, without limitation, notice of default, demand for payment, rights of set-off (subject to set-off being permitted if exercised in accordance with the terms of the last sentence of Section 3 hereof), commencement of bankruptcy proceedings, foreclosure, sale, power of sale, taking of possession, giving in payment, appointing or making application to a court for an order appointing an agent or a receiver or receiver-manager by any other means of enforcement thereof) unless the Senior Debt has been indefeasibly paid in full and the Trust Indenture has been terminated.

5. **Subordinate Security:** The Subordinate Creditor and the Debtor each acknowledges that the Subordinate Creditor has not been granted any security from the Debtor to secure the Subordinated Debt. The Subordinate Creditor covenants in favour of the Senior Lenders that during the term of this Agreement it will not take from the Debtor security for the payment of or performance of obligations in respect of the Subordinate Obligations. The Debtor covenants in favour of the Senior Lenders that during the term of this Agreement, it will not deliver to the Subordinate Creditor any security for the payment of or performance of obligations in respect of the Subordinate Obligations.

6. **No Objection:** The Subordinate Creditor shall not take, or cause or permit any other person to take on its behalf, any steps whatsoever whereby the priority or validity of any of the Senior Security or the rights of the Senior Lenders hereunder or under the Trust Indenture shall be

delayed, defeated, impaired or diminished, and without limiting the generality of the foregoing, the Subordinate Creditor shall not challenge, object to, compete with or impede in any manner any act taken or proceeding commenced by the Senior Lenders in connection with the enforcement by the Senior Lenders of the Senior Security.

7. **Application of Proceeds:** The Subordinate Creditor and the Debtor acknowledge that all and every part of the Senior Security is held by the Senior Lenders as security for all and every part of the Senior Debt and the Senior Lenders may apply as a permanent reduction any monies received, whether from the enforcement of and realization upon any or all of the Senior Security or otherwise, to any part of the Senior Debt as the Senior Lenders, in their sole discretion, may determine appropriate.

8. **Liquidation, Dissolution, Bankruptcy, etc.:**

- (a) In the event of distribution, division or application, partial or complete, voluntary or involuntary, by operation of law or otherwise, of all or any part of the assets of the Debtor, or the proceeds thereof, to creditors in connection with the bankruptcy, liquidation or winding-up of the Debtor or in connection with any composition with creditors or scheme of arrangement to which the Debtor is a party, the Senior Lenders shall be entitled to receive payment in full (including interest accruing to the date of receipt of such payment at the applicable rate whether or not allowed as a claim in any such proceeding) of the Senior Debt before the Subordinate Creditor is entitled to receive any direct or indirect payment or distribution of any cash or other assets of the Debtor on account of the Subordinate Obligations, and the Senior Lenders shall be entitled to receive directly, for application in payment of such Senior Debt (to the extent necessary to pay all Senior Debt in full after giving effect to any substantially concurrent payment or distribution to the Senior Lenders in respect of the Senior Debt), any payment or distribution of any kind or character, whether in cash or other assets, which shall be payable or deliverable upon or with respect to the Subordinate Obligations. To the extent any payment of Senior Debt (whether by or on behalf of the Debtor, as proceeds of security or enforcement of any right of set-off or otherwise) is declared to be a fraudulent preference or otherwise preferential, set aside or required to be paid to a trustee, receiver or other similar person under any bankruptcy, insolvency, receivership or similar law, then if such payment is recoverable by, or paid over to, such trustee, receiver or other person, the Senior Debt or part thereof originally intended to be satisfied shall be deemed to be reinstated and outstanding as if such payment had not occurred.
- (b) In order to enable the Senior Lenders to enforce their rights hereunder in any of the actions or proceedings described in this Section 8, upon the failure of the Subordinate Creditor to make and present on a timely basis a proof of claim against the Debtor on account of the Subordinate Obligations or other motion or pleading as may be expedient or proper to establish the Subordinate Creditor's entitlement to payment of any Subordinate Obligations, the Trustee for and on behalf of the other Senior Lenders is hereby irrevocably authorized and empowered, in its discretion and at its sole expense, to make and present for and on behalf of the Subordinate Creditor such proofs of claims or other motions or pleadings and to demand, receive and collect

any and all dividends or other payments or disbursements made thereon in whatever form the same may be paid or issued and to apply the same on account of the Senior Debt. The Subordinate Creditor hereby covenants and agrees not to exercise any voting right or other privilege that it may have from time to time in any of the actions or proceedings described in this Section 8 in favour of any plan, proposal, compromise, arrangement or similar transaction that would defeat: (i) the right of the Senior Lenders to receive payments and distributions otherwise payable or deliverable upon or with respect to the Subordinate Obligations so long as any Senior Debt remains outstanding; or (ii) the obligation of the Subordinate Creditor to receive, hold in trust, and pay over to the Senior Lenders certain payments and distributions as contemplated by Section 9.

9. **Payments Received by the Subordinate Creditor:** If, prior to the indefeasible payment in full of the Senior Debt, the Subordinate Creditor or any person on its behalf shall receive any payment from or distribution of assets of the Debtor or on account of the Subordinate Obligations in contravention of Section 3, then the Subordinate Creditor shall, and shall cause such other person to, receive and hold such payment or distribution in trust for the benefit of the Senior Lenders and promptly pay the same over or deliver same to the Trustee in precisely the form received by the Subordinate Creditor or such other person on its behalf (except for any necessary endorsement or assignment) and such payment or distribution shall be applied by the Trustee to the repayment of the Senior Debt in such manner as it shall see fit.

10. **Senior Lenders' Rights:** The Subordinate Creditor agrees that the Senior Lenders shall be entitled to deal with the Senior Security as they see fit and nothing herein shall prevent, restrict or limit the Senior Lenders in any manner from exercising all or any part of their rights and remedies otherwise permitted by applicable law upon any default under the Senior Security, and without limiting the generality of the foregoing, the Subordinate Creditor agrees that:

- (a) the Senior Lenders, in their absolute discretion or in the absolute discretion of any authorized officer or agent, and without diminishing the obligations of the Subordinate Creditor hereunder, may grant time or other indulgences to the Debtor and any other person or persons now or hereafter liable to the Senior Lenders in respect of the payment of the Senior Debt, and may give up, modify, vary, exchange, renew or abstain from taking advantage of the Senior Security in whole or in part and may discharge any part or parts of or accept any composition or arrangements or realize upon the Senior Security when and in such manner as the Senior Lenders or any authorized officer or agent thereof may think expedient, and in no such case shall the Senior Lenders be responsible for any neglect or omission with respect to the Senior Security or any part thereof;
- (b) the Subordinate Creditor shall not be released or exonerated from its obligations hereunder by extension of time periods or any other forbearance whatsoever agreed to be the Senior Lenders, whether as to time, performance or otherwise or by any release, discharge, loss or alteration in or dealing with all or any part of the Senior Debt and the Senior Security or any part thereof or by any failure or delay in giving any notice required under this Agreement, the Trust Indenture, Senior Debt or Senior Security or any part thereof, the waiver by the Senior Lenders of compliance with



any conditions precedent to any advance of funds, or by any modification or alteration of the Trust Indenture, Senior Debt or Senior Security or any part thereof, or by anything done, suffered or permitted by the Senior Lenders, or as a result of the method or terms of payment under the Senior Debt or Senior Security or any part thereof or any assignment or other transfer of all or any part of the Trust Indenture, Senior Debt or Senior Security or any part thereof;

- (c) the Senior Lenders shall not be bound to seek or exhaust any recourse against the Debtor or any other person or against the property or assets of the Debtor or any other person or against any security, guarantee or indemnity before being entitled to the benefit of the Subordinate Creditor's obligations hereunder and the Senior Lenders may enforce the various remedies available to them and may realize upon the various security documents, guarantees and indemnities or any part thereof, held by them in such order as the Senior Lenders may determine appropriate;
- (d) the Subordinate Creditor is fully responsible for acquiring and updating information relating to the financial condition of the Debtor and all circumstances relating to the payment or non-payment of the Subordinate Obligations;
- (e) the Senior Lenders shall not be required to marshal in favour of the Subordinate Creditor or any other person the Senior Security or any other securities or any moneys or other assets which the Senior Lenders may be entitled to receive or upon which the Senior Lenders may have a claim; and
- (f) the Senior Lenders shall be entitled to advance their own monies as they see fit in order to preserve or protect the assets of the Debtor or any part thereof, and all such sums advanced pursuant to the Trust Indenture or the Senior Security or any other agreement between the Debtor and the Senior Lenders to the extent reasonably advanced to preserve and protect the assets of the Debtor or any part thereof, shall constitute part of the Senior Debt and shall be secured by the Senior Security.

11. **No Waiver of Subordination Provisions:** No right of the Senior Lenders to enforce the subordination as provided in this Agreement shall at any time in any way be prejudiced or impaired by any act or failure to act on the part of the Debtor or by any act or failure to act by the Senior Lenders or any agent of or trustee for the Senior Lenders, or by any non-compliance by the Debtor with any of the agreements or instruments relating to the Subordinate Obligations or the Senior Debt, regardless of any knowledge thereof which the Senior Lenders may have or be otherwise charged with. Without limitation of the foregoing, but in no way relieving the Debtor of its obligations under this Agreement, the Senior Lenders may, at any time and from time to time, without the consent of the Subordinate Creditor and without impairing or releasing the subordination and other benefits provided in this Agreement or the obligations hereunder of the Subordinate Creditor to the Senior Lenders, do any one or more of the following:

- (a) amend, supplement, modify, restate or replace the Trust Indenture or any of the Senior Security;
- (b) sell, exchange, release, surrender, realize upon, enforce or otherwise deal with in any manner any assets pledged or mortgaged for or otherwise securing the Senior Debt or

any liability of the Debtor or any liability incurred directly or indirectly in respect thereof;

- (c) settle or compromise any Senior Debt or any other liability of the Debtor (other than the Subordinate Obligations) or any security thereof or any liability incurred directly or indirectly in respect thereof, and apply any sums by whomsoever paid and however realized to the Senior Debt in any manner or order; and
- (d) fail to take or to record or otherwise perfect or to preserve the perfection of any liens or security interest securing the Senior Debt, exercise or delay in or refrain from exercising any right or remedy against the Debtor and elect any remedy and otherwise deal freely with the Debtor.

No loss of or in respect of any of the Senior Security or otherwise or any carelessness or neglect by the Senior Lenders in asserting their rights or any other thing whatsoever, including without limitation the loss by operation of law of any right of the Senior Lenders against the Debtor or the loss or destruction of any security, shall in any way impair or release the subordination and other benefits provided by this Agreement.

12. **Waivers of the Subordinate Creditor:** The Subordinate Creditor agrees that the Senior Lenders have made no representations or warranties with respect to the due execution, legality, validity, completeness or enforceability of any agreement or instrument relating to the Trust Indenture or the Senior Debt or the collectibility of the Senior Debt, that the Senior Lenders shall be entitled to manage and supervise their indebtedness and other financial accommodation to the Debtor in accordance with applicable law and their usual practices, modified from time to time as they deem appropriate under the circumstances, or otherwise, without regard to the existence of any rights that the Subordinate Creditor may now or hereafter have in or to any of the assets of the Debtor, and that the Senior Lenders shall have no liability to the Subordinate Creditor for, and the Subordinate Creditor hereby waives any claims which the Subordinate Creditor may now or hereafter have against the Senior Lenders out of, any and all actions which the Senior Lenders take or omit to take (including, without limitation, actions with respect to the creation, perfection or continuation of liens or security interest in any assets at any time securing payment of the Senior Debt, actions with respect to the occurrence of any default under any agreement or instrument relating to the Senior Debt, action with respect to the release or depreciation of, or failure to realize upon, any assets securing payment of the Senior Debt and actions with respect to the collection of any claims or all or any part of the Senior Debt from any account debtor, guarantor or any other person) with respect to the Senior Debt and any agreement or instrument related thereto or with respect to the collection of the Senior Debt or the valuation, use, protection or release of any assets securing payment of the Senior Debt.

13. **No Release:** This Agreement shall remain in full force and effect without regard to, and the obligations of the Subordinate Creditor hereunder shall not be released or otherwise affected or impaired by:

- (a) any exercise or non-exercise by the Senior Lenders of any right, remedy, power or privilege in the Trust Indenture or the Senior Security;

- (b) any waiver, consent, extension, indulgence or other action, inaction or omission by the Senior Lenders under or in respect of this Agreement, the Trust Indenture or the Senior Security;
- (c) any default by the Debtor under, any limitation on the liability of the Debtor on the method or terms of payment under, or any irregularity or other defect in, the Trust Indenture, the Senior Security, other than to the extent of any invalidity or unenforceability of any Senior Security;
- (d) the lack of authority or revocation hereof by any other party;
- (e) the failure of the Senior Lenders to file or enforce a claim of any kind;
- (f) any defence based upon an election of remedies by the Senior Lenders which destroys or otherwise impairs the subrogation rights of the Subordinate Creditor or the right of the Subordinate Creditor to proceed against the Debtor for reimbursement, or both;
- (g) any merger, consolidation or amalgamation of the Subordinate Creditor or the Debtor into or with any other person; or
- (h) any insolvency, bankruptcy, liquidation, reorganization, arrangement, composition, winding-up, dissolution or similar proceeding involving or affecting the Subordinate Creditor or the Debtor.

14. **No Rights to Debtor:** Nothing in this Agreement shall create any rights in favour of, or obligations to the Debtor and the covenants and agreements of the Senior Lenders and the Subordinate Creditor shall not be enforceable by the Debtor. No consent of the Debtor shall be necessary for any amendment to this Agreement by the Senior Lenders and the Subordinate Creditor affecting the covenants between the Senior Lenders and the Subordinate Creditor, provided that the Debtor shall not be bound to give effect to any such amendments until the Debtor receives a copy thereof signed by the Subordinate Creditor and acknowledged by the Trustee and the Debtor shall have no liability for any distributions or payments that are permitted under this Agreement but are not permitted under any such amendment where any such distributions or payments are made prior to actual receipt of any such amendment.

15. **Further Assurances:** The parties hereto shall forthwith, and from time to time, execute and do all deeds, documents and things which may be necessary or advisable, in the reasonable opinion of the Senior Lenders' counsel, to give full effect to the postponement and subordination of the Subordinate Obligations, and the rights and remedies of the Subordinate Creditor thereunder to the Senior Debt and the Senior Security, and the rights and remedies of the Senior Lenders thereunder, in accordance with the intent of this Agreement.

16. **Successors and Assigns:**

- (a) This Agreement is binding upon the Senior Lenders, the Subordinate Creditor and the Debtor and their respective successors and assigns and, subject to subsection

16(b) below, shall enure to the benefit of the Senior Lenders, the Subordinate Creditor, the Debtor, and their respective successors and permitted assigns.

- (b) The Subordinate Creditor shall not be entitled to assign all or any part of its rights and obligations under this Agreement or the Subordinate Obligations unless any prospective assignee enters into an assumption agreement in which it agrees to be bound by the terms of this Agreement as if an original party thereto.

Except in accordance with subsections 16(a) and 16(b) hereof, third parties shall have no rights or benefits under this Agreement.

17. **Rights Accruing to Bondholders.** All rights and benefits provided to the Senior Lenders under this Agreement shall be for the benefit of the holders of the Bonds (along with the Trustee) despite such bondholders not being signatories to this Agreement.

18. **Entire Agreement; Severability:** This Agreement contains the entire subordination agreement among the parties hereto with respect to the obligations, liabilities and assets of the Debtor. If any of the provisions of this Agreement shall be held invalid or unenforceable by any court having jurisdiction, this Agreement shall be construed as if not containing those provisions, and the rights and obligations of the parties hereto should be construed and enforced accordingly.

19. **Acknowledgement:** The Debtor hereby acknowledges receipt of a copy of this Agreement and accepts and further agrees with the Senior Lenders to give effect to all of the provisions of this Agreement subject to Section 14 hereof.

20. **Governing Law:** This Agreement shall be governed and construed in accordance with the laws of the Province of Ontario and the laws of Canada applicable therein.

21. **Termination:** This Agreement shall otherwise terminate upon the earlier of:

- (a) the repayment in full of the Senior Debt; and
- (b) the written agreement of the Trustee and the Subordinate Creditor.

22. **Counterparts:** This Agreement may be executed in any number of counterparts, which when taken together shall constitute one and the same agreement.

IN WITNESS WHEREOF the parties hereto have executed this agreement as of the date first written above.

[AFFILIATE]

By: \_\_\_\_\_  
Name:  
Title:

By: \_\_\_\_\_  
Name:  
Title:

**GREAT LAKES POWER LIMITED**

By: \_\_\_\_\_

By: \_\_\_\_\_

**SCHEDULE "D"**  
**to Deed of Trust**

**TRANSMISSION PROPERTY RIGHTS**

**PART I – Unregistered Leases, Rights-of-Way, Rights of Occupation:**

Each of the following agreements as renewed, amended, assigned, assumed, restated and/or replaced from time to time:

1. Memorandum of Agreement for Electrical Transmission Facilities dated January 1, 2001 between Her Majesty The Queen in right of the Province of Ontario, as represented by the Minister of Natural Resources, and Great Lakes Power Limited.
2. License Agreement made as of November 1, 1994 between Algoma Central Corporation and Great Lakes Power Limited, which was assigned by Algoma to The Corporation of the City of Sault Ste. Marie.
3. Lease of Right-of-Way dated September 1, 1937 between The Algoma Central and Hudson Bay Railway Company, as lessor, and Great Lakes Power Company Limited, as lessee.
4. Lease of Right-of-Way dated May 1, 1956 between The Algoma Central and Hudson Bay Railway, as lessor, and Great Lakes Power Company Limited, as lessee.
5. Lease of Right-of-Way dated September 1, 1957 between The Algoma Central and Hudson Bay Railway Company, as lessor, and Great Lakes Power Corporation Limited, as lessee.
6. Lease of a Right-of-Way dated March 1, 1958 between The Algoma Central and Hudson Bay Railway Company, as lessor, and Great Lakes Power Corporation Limited, as lessee.
7. Lease of Right-of-Way dated May 1, 1987 between Algoma Central Railway, as lessor, and Great Lakes Power Limited, as lessee.
8. Power Transmission Line Amending Agreement – Transferred Lands dated as of November 12, 2002 between 3011650 Nova Scotia Limited, 2016596 Ontario Inc. and Great Lakes Power Limited.
9. Power Transmission Line Amending Agreement – Transferred Lands dated October 27, 2004 between 3011650 Nova Scotia Limited, Interior Fibre Management Inc. and Great Lakes Power Limited.
10. Agreement dated January 1, 1981 between Algoma Central Railway and Great Lakes Power Limited permitting transmission line on railway property in Sault Ste. Marie in respect of transmission line from Clergue GS to Patrick St. TS.

11. License between Algoma Central Corporation and Great Lakes Power Limited dated as of February 1, 1998.
12. License between Barbara Ellen McLeod and David Foster Hales and Great Lakes Power Limited dated as of January 1, 2001.
13. Agreement/Permit dated July 25th, 1984 between Her Majesty the Queen in right of Canada, as represented by the Minister of Indian Affairs and Northern Development, and Great Lakes Power Corporation Limited in respect of constructing, operating and maintaining transmission lines on lands in Rankin Location Indian Reserve No. 15D.
14. 230 KV Right-of-Way Permit effective January 1, 1997 between Her Majesty The Queen in Right of Canada, 1228185 Ontario Limited and Great Lakes Power Limited in respect of transmission lines on lands in Garden River Indian Reserve No. 14.
15. All permits and agreements owned by the Company relating to the crossing by the Transmission Assets over lands, including wire crossing permits authorizing aerial crossings over railway lands, rivers and roads.

**SCHEDULE "D"**  
**to Deed of Trust**  
**Land Titles Pins**

**Part II - Registered Easements, Leases, Rights-of-Way and Rights of Occupation**

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>115 KV LINE</b>	
		<b>MCMURRAY/LENDRUM</b>	
1.	31169-2205(LT) 31169-2206(LT) 31170-0051(LT)	(a) Instrument LT114012 registered August 13, 1981 is an application to rectify and amend 22697 over Parcel 2236, AWS  (b) Caution LT22697 registered April 1, 1939 is an easement from Algoma Ore Properties, Limited to Great Lakes Power Company Limited rectified to be an easement by Instrument LT114012 registered August 13, 1981 over part of mining claim SSM10530 being Part of Part 1, Plan 1R-11226, McMurray	LT113588; LT22697
		<b>NAVEAU</b>	
2.	31176-0001(LT)	Instrument LT56393 registered August 17, 1964 is a lease and grant of right dated December 1, 1963 between The Algoma Central and Hudson Bay Railway Company and Great Lakes Power Corporation Limited over Part of Parcel 12, ACRL	
3.	31176-0001(LT)	(a) Instrument LT114012 registered August 13, 1981 is an application rectifying caution LT26454 to be an easement;  (b) Caution LT26454 is ACRL lease and easement dated September 1, 1937 affects Part of Parcel 12, ACRL	LT26454; LT113588
4.	31176-0001(LT)	Instrument number LT218245 registered June 5, 1998 is an easement from Middle North Contracting Ltd. to Great Lakes Power Limited over Part of Parcel 12, ACRL	



	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>NEBONAIONQUET</b>	
5.	31177-0001(LT)	(a) Instrument LT114012 registered August 13, 1981 is an application rectifying caution LT26454 to be an easement;  (b) Caution LT26454 is ACRL lease and easement dated September 1, 1937 affects Part of Parcel 37, ACRL	LT113588; LT26454
6.	31177-0015(LT)	Instrument LT29914 registered June 5, 1952 is an easement from Olaf Palmgren to Great Lakes Power Corporation Limited over Part of Parcel 1700, AWS, Nebonaionquet	LT113588
		<b>RESTOULE</b>	
7.	31186-0001(LT)	(a) Instrument LT114012 registered August 13, 1981 is an application rectifying caution LT26454 to be an easement;  (b) Caution LT26454 is ACRL lease and easement dated September 1, 1937 affects Part of Parcel 9, ACRL	LT113588; LT26454
		<b>BULLOCK</b>	
8.	31209-0001(LT)	(a) Instrument LT114012 registered August 13, 1981 is an application rectifying caution LT26454 to be an easement;  (b) Caution LT26454 is ACRL lease and easement dated September 1, 1937 affects Part of Parcel 38, ACRL	LT113588; LT26454
		<b>GREENWOOD</b>	
9.	31218-0001(LT)	(a) Instrument LT114012 registered August 13, 1981 is an application rectifying caution LT26454 to be an easement;  (b) Caution LT26454 is ACRL lease and easement dated September 1, 1937 affects Part of Parcel 11, ACRL	LT113588; LT26454
		<b>LARSON</b>	
10.	31223-0020(LT)	(a) Instrument LT114012 registered August 13, 1981 is an application rectifying caution LT26454 to be an easement;  (b) Caution LT26454 is ACRL lease and easement dated September 1, 1937 over Part of Index Plan ACR 25 and 26 being part of the Township of Larson as in LT26454	LT26454; LT113588

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>HOME</b>	
11.	31230-0001(LT)	(a) Instrument LT114012 registered August 13, 1981 is an application rectifying caution LT26454 to be an easement;  (b) Caution LT26454 is ACRL lease and easement dated September 1, 1937 affects Part of Parcel 24, ACRL	LT26454; LT113588
		<b>TOLMONEN</b>	
12.	31234-0001(LT)	(a) Instrument LT114012 registered August 13, 1981 is an application rectifying caution LT26454 to be an easement;  (b) Caution LT26454 is ACRL lease and easement dated September 1, 1937 affects Part of Parcel 30, ACRL	LT113588; LT26454
		<b>TRONSEN</b>	
13.	31235-0001(LT)	(a) Instrument LT114012 registered August 13, 1981 is an application rectifying caution LT26454 to be an easement;  (b) Caution LT26454 is ACRL lease and easement dated September 1, 1937 affects Part of Parcel 28, ACRL	LT113588; LT26454
		<b>ARCHIBALD:</b>	
14.	31301-0053(LT)	Instrument CG12 registered October 1, 1931 is an easement from Wells-Higman Company to The Algoma District Power Company Limited over part of Lot 12, Concession 4, Archibald.	T220780; T445270
15.	31301-0053(LT)	Instrument CG13 registered July 10, 1934 is an easement from Thomas J. McCauley and Sarah M. McCauley to The Algoma District Power Company Limited over Part of Lots 11 and 12, Concession 6 and Part of Lot 12, Concession 5, Archibald.	T220780; T445270
16.	31301-0053(LT)	Instrument T10631 registered June 25, 1957 is an easement from Belco Timber Co. Limited to Great Lakes Power Corporation Limited over Part Lot 12, Concession 5, Archibald.	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
17.	31301-0053(LT)	Instrument T10632 registered June 25, 1957 is an easement from Belco Timber Co. Limited to Great Lakes Power Corporation Limited over part of Lot 11, Concession 6, Archibald.	T220780; T445270
18.	31301-0053(LT)	Instrument T10633 registered June 25, 1957 is an easement from Belco Timber Co. Limited to Great Lakes Power Corporation Limited over Part of Lot 12, Concession 6, Archibald.	T220780; T445270
19.	31301-0053(LT)	Instrument T39697 registered July 13, 1961 is an easement from Roddis Lumber and Veneer Co. of Canada Limited to Great Lakes Power Corporation Limited over Part Lot 12, Concession 4, Archibald.	T220780; T445270
		<b>TILLEY:</b>	
20.	31302-0393(LT)	Instrument BC78 registered October 1, 1931 is an easement from Wells-Higman, Company to The Algoma District Power Company Limited over Part of Sections 13 and 24, Tilley.	T220780; T445270
21.	31302-0208(LT) 31302-0396(LT)	Instrument BC79 registered October 1, 1931 is an easement from Christina S. Seymour to The Algoma District Power Company Limited over Part of the S½ of the SW¼ of Section 25, Tilley.	T220780; T445269; T445270
22.	31302-0209(LT)	Instrument KB1170 registered July 10, 1934 is an easement from Thomas J. McCauley and Sarah M. McCauley to The Algoma District Power Company Limited over Part of Section 25 (known as the Begley Copper location), Tilley.	T220780; T445269; T445270
23.	31302-0208(LT)	Instrument BC96 registered August 24, 1934 is an easement from William Jackson Torrance and Isabelle Mary Torrance to Great Lakes Power Company Limited over Part N ½ of the NW¼ of Section 25, Tilley.	T220780; T445269; T445270
24.	31302-0333(LT) 31302-0334(LT) 31302-0335(LT) 31302-0338(LT) 31302-0340(LT)	Instrument BC97 registered October 1, 1934 is an easement from John B. Cochrane Executor of J.C.T. Cochrane to The Algoma District Power Company Limited over Part of Section 36, Tilley.	T220780; T445269; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
25.	31302-0209(LT)	Instrument T12284 registered September 23, 1957 is an easement from Ethel H. Holgate to Great Lakes Power Corporation Limited over Part of the Begley Copper Location within Section 25, Tilley.	T445269; T445270
26.	31302-0393(LT)	Instrument T39698 registered July 13, 1961 is an easement from Roddis Lumber and Veneer Co. of Canada Limited to Great Lakes Power Corporation Limited over Part of Section 24, Tilley.	T445269; T445270
27.	31302-0393(LT)	Instrument T39699 registered July 13, 1961 is an easement from Roddis Lumber and Veneer Co. of Canada Limited to Great Lakes Power Corporation Limited over Part of Section 13, Tilley.	T445269; T445270
28.	31302-0396(LT) 31302-0208(LT)	Instrument T48442 registered August 10, 1962 is an easement from William Jackson Torrance and Isabelle Mary Torrance to Great Lakes Power Corporation Limited over Part N½ of the NW¼ of Section 25, and Part of the south Part of Section 25, Tilley.	T445269; T445270
29.	31302-0340(LT) 31302-0338(LT) 31302-0333(LT) 31302 0334(LT) 31302-0335(LT)	Instrument T91892 registered February 13, 1968 is an easement from Canada Permanent Trust Company, Executor of the Estate of J.C.T. Cochrane to Great Lakes Power Corporation Limited over Part of Section 36, Tilley.	T445269; T445270
<b>HAVILLAND:</b>			
30.	31306-0374(LT)	Instrument XC226 registered November 30, 1951 is an easement from Humphrey S. Gray and Eleanor Goodenough Gray to Great Lakes Power Company, Limited over part of Broken Section 1, Havilland.	T220780; T445270
31.	31306-0370(LT)	Instrument T12798 registered October 24, 1957 is an easement from Orvil Calvert and Ada M. Calvert to Great Lakes Power Corporation Limited over part of Lot 4, Plan H-413, Havilland.	T445269; T445270
32.	31306-0368(LT)	Instrument T12840 registered October 28, 1957 is an easement from Stanley Kosek and Helena Kosek to Great Lakes Power Corporation Limited over Part of the N½ of Lot 2, Plan H-413, Havilland.	T445269; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
33.	31306-0367(LT)	Instrument T13187 registered November 19, 1957 is an easement from Arthur J. Valenti and Virginia Valenti to Great Lakes Power Corporation Limited over Part of Lot 1, Plan H-413, Havilland.	T445269; T445270
34.	31306-0372(LT)	Instrument T13371 registered December 3, 1957 is an easement from Eber Charles Roberts and Elizabeth Roberts to Great Lakes Power Corporation Limited over Part of Lot 6, Plan H-413, Havilland.	T445269; T445270
35.	31306-0374(LT)	Instrument T13647 registered December 24, 1957 is an easement from Virginia Hetler Globensky and Herbert E. McCauley to Great Lakes Power Corporation Limited over parts of Block D, Plan H-413, Havilland.	T445269; T445270; T467856
36.	31306-0374(LT)	Instrument T13648 registered December 24, 1957 is an easement from Virginia Hetler Globensky and Herbert E. McCauley to Great Lakes Power Corporation Limited over Part of Section 1, Havilland.	T445269; T445270
37.	31306-0366(LT)	Instrument T13649 registered December 24, 1957 is an easement from Virginia Hetler Globensky and Herbert E. McCauley to Great Lakes Power Corporation Limited over Part of Block A, Plan H-413, Havilland.	T445269; T445270
38.	31306-0369(LT) 31306-0370(LT)	Instrument T13839 registered January 9, 1958 is an easement from Leslie W. Gump and Irma O. Gump to Great Lakes Power Corporation Limited over part of Lot 3, Plan H -413, Havilland.	T445269; T445270
39.	31306-0371(LT)	Instrument T17130 registered July 17, 1958 is an easement from Richard N. Heywood and Orpha Heywood to Great Lakes Power Corporation Limited over part of Lot 5, Plan H-413, Havilland.	T445269; T445270
40.	31306-0368(LT)	Instrument T47082 registered June 19, 1962 is an easement from Thomas Stocco and Rina Stocco to Great Lakes Power Corporation Limited over part of the S½ of Lot 2, Plan H-413, Havilland.	T445269; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>TUPPER:</b>	
41.	31307-0061(LT)	Instrument TU12 registered October 1, 1931 is an easement from Samuel Bennett to The Algoma District Power Company Limited over Part S½ of the S½ of Lot 11, Concession 1, Tupper.	T220780; T445269; T445270
42.	31307-0060(LT)	Instrument TU13 registered July 10, 1934 is an easement from Wells-Higman Company to The Algoma District Power Company Limited over Part of Lots 11 and 12, Concession 3 and a part of Lot 12 in the 4th, 5th & 6th Concessions, Tupper.	T220780; T445270
43.	31307-0061(LT)	Instrument TU14 registered August 22, 1934 is an easement from Elmer E. Weed, Lizzie Weed, Joseph E. Devine, Alice E. Devine, Henry J. Vinkemulder, Belle B. Vinkemulder, Thomas J. McCauley and Sarah M. McCauley to Great Lakes Power Company Limited over part of the N½ of S½ and the N½ of Lot 11, Concession 1 and part of Lot 11, Concession 2, Tupper.	T220780; T445269; T445270
44.	31307-0061(LT)	Instrument T12292 registered September 23, 1957 is an easement from Frank M. Lasook and William Smith and Doreen E. Lasook and Annie Smith to Great Lakes Power Corporation Limited over Part of the S½ of the S½ of Lot 11, Concession 1, Tupper.	T445269; T445270
45.	31307-0061(LT)	Instrument T34321 registered November 7, 1960 is an easement from Algoma Forest Products Limited to Great Lakes Power Corporation Limited over part of the N½ of the NW¼ of Section 6, part of Lot 11, Concession 1, and part of Lot 11, Concession 2, Tupper.	T445269; T445270
46.	31307-0060(LT)	Instrument T39695 registered July 13, 1961 is an easement from Roddis Lumber and Veneer Co. of Canada Limited to Great Lakes Power Corporation Limited over part of Lot 12, Concession 3, Tupper.	T445269; T445270
47.	31307-0060(LT)	Instrument T39696 registered July 13, 1961 is an easement from Roddis Lumber and Veneer Co. of Canada Limited to Great Lakes Power Corporation Limited over part of Lot 11, Concession 3, Tupper.	T445269; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
48.	31307-0060(LT)	Instrument T39700 registered July 13, 1961 is an easement from Roddis Lumber and Veneer Co. of Canada Limited to Great Lakes Power Corporation Limited over part of Lot 12, Concession 6, Tupper.	T445269; T445270
49.	31307-0060(LT)	Instrument T39701 registered July 13, 1961 is an easement from Roddis Lumber and Veneer Co. of Canada Limited to Great Lakes Power Corporation Limited over Part of Lot 12, Concession 4, Tupper.	T445269; T445270
50.	31307-0060(LT)	Instrument T39702 registered July 13, 1961 is an easement from Roddis Lumber and Veneer Co. of Canada Limited to Great Lakes Power Corporation Limited over Part of Lot 12, Concession 5, Tupper.	T445269; T445270
<b>VAN KOUGHNET:</b>			
51.	31344-0143(LT) 31344-0144(LT) 31344-0145(LT) 31344-0151(LT)	Instrument LC276 registered July 10, 1934 is an easement from James Nelson McAuley and Robina McAuley to The Algoma District Power Company Limited over Part of the NW¼ of Section 18, Van Koughnet.	T220780; T445270
52.	31344-0135(LT) 31344-0134(LT)	(a) Instrument LC277 registered July 10, 1934 is an easement from Thomas J. McCauley and Sarah M. McCauley to Great Lakes Power Corporation Limited over Part of the N½ of the NW¼ of Section 6, Van Koughnet.  (b) Instrument LC277 registered July 10, 1934 is an easement from Thomas J. McCauley and Sarah M. McCauley Great Lakes Power Corporation Limited over Part of the W½ of the SW¼ of Section 18, Van Koughnet.	T220780; T445270
53.	31344-0162(LT) 31344-0163(LT)	Instrument LC278 registered July 10, 1934 is an easement from Peter A. Jones, Agness Jones and Francis McKie to The Algoma District Power Company Limited over part of the W½ of the SW¼ of Section 7, Van Koughnet.	T220780; T445270
54.	NOT PINNED	Instrument LC281 registered August 22, 1934 is an easement from Elmer E. Weed, Lizzie Weed, Joseph E. Devine, Alice E. Devine, Henry J. Vinkemulder, Belle B. Vinkemulder, Thomas J. McCauley and Sarah M. McCauley to Great Lakes Power Company Limited over part of the NW corner of the E½ of Section 6, Van Koughnet.	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
55.	31344-0176(LT)	Instrument LC411 registered May 18, 1949 is an easement from Thomas Twancheek to The Algoma District Power Company Limited over part of the W½ of the NW¼ of Section 7, Van Koughnet.	T220780; T445270
56.	31344-0162(LT) 31344-0163(LT)	Instrument T8554 registered February 15, 1957 is an easement from Vaino Nikolai Gronroos Green and Margaret Ann Green to Great Lakes Power Corporation Limited over Part of the W½ of the SW¼ of Section 7, Van Koughnet.	T445269; T445270
57.	31344-0143(LT) 31344-0144(LT) 31344-0151(LT)	Instrument T16212 registered June 6, 1958 is an easement from Stanley Belkosky and Cassie Belkosky to Great Lakes Power Corporation Limited over Part of the W½ of the NW¼ of Section 18, Van Koughnet.	T220780; T445270
58.	31344-0176(LT)	Instrument T29147 registered March 15, 1960 is an easement from Stif (Steve) Korytko and Rose Annma Korytko to Great Lakes Power Corporation Limited over Part of the W½ of the NW¼ of Section 7, Van Koughnet.	T445269; T445270
59.	31344-0134(LT) 31344-0135(LT)	Instrument T61246 registered February 26, 1964 is an easement from Lena Johnston (note: Holowachuk) to Great Lakes Power Corporation Limited over Part of the W½ of the SW¼ of Section 18, Van Koughnet.	T220780; T445270
		<b>FENWICK:</b>	
60.	31346-0069(LT) 31346-0070(LT) 31346-0087(LT) 31346-0084(LT) 31346-0308(LT)	Instrument RB480 registered March 5, 1932 is an easement from Lovina Theresa Emily James and Daniel W. James to The Algoma District Power Company Limited over Part N½ of the SE¼ of Section 13, Fenwick.	T220780; T445270
61.	31346-0297(LT) 31346-0298(LT) 31346-0299(LT)	Instrument RB532 registered July 10, 1934 is an easement from Fred Elliott and Laura M. Elliott to The Algoma District Power Company Limited over part of the NE¼ of Section 25, Fenwick.	T220780; T445270
62.	Not PINNED	Instrument RB533 registered July 10, 1934 is an easement from Sylvester T. de Forest, Trustee to Great Lakes Power Company Limited over part of the SE¼ Section 25, Fenwick.	T445269; T445270
63.	31620-0131(LT)	Instrument RB534 registered July 10, 1934 is an easement from Andrew Moskil and Martha Moskil to The Algoma District Power Company Limited over Part of the N½ of the SE¼ of Section 12, Fenwick.	T445269; T445270



	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
64.	not PINNED	Instrument RB535 registered July 10, 1934 is an easement from Hugh M. Dignam and E. Kathleen Dignam to The Algoma District Power Company Limited over Part of the S½ of the SE¼ of Section 36, Fenwick	T220780; T445270
65.	not PINNED	Instrument RB540 registered November 7, 1934 is an Order granting an easement from Isadore Rosenstein and Sarah Rosenstein to Great Lakes Power Company Limited over Part of the NE¼ and the N½ of the SE¼ of Section 36, Fenwick	T220780; T445270
66.	31346-0087(LT) 31346-0078(LT) 31346-0079(LT) 31346-0080(LT) 31346-0081(LT)	Instrument RB640 registered January 23, 1942 is an easement from Nephew Joseph and Nancy Joseph to The Algoma District Power Company Limited over part of the NE¼ of Section 13, Fenwick.	T220780; T445270
67.	31346-0065(LT)	Instrument RB813 registered May 18, 1949 is an easement from Robert H. Somes to The Algoma District Power Company Limited over Part of the S½ of the SE¼ of Section 13, Fenwick.	T220780; T445270
68.	31620-0358(LT)	Instrument RB814 registered May 18, 1949 is an easement from Peter Ossachuck to The Algoma District Power Company Limited over Part of the S½ of the SE¼ of Section 12, Fenwick.	T220780; T445270
69.	31346-0084(LT) 31346-0091(LT) 31346-0093(LT) 31346-0097(LT)	Instrument RB815 registered May 18, 1949 is an easement from Mary Bye, Executrix of the estate of Henry Bye, Mary Bye, William Bye and Alfred Bye to The Algoma District Power Company Limited over Part of the W½ of the E½ of Section 24, Fenwick.	T220780; T445270
70.	31346-0070(LT) 31346-0069(LT) 31346-0084(LT) 31346-0087(LT) 31346-0308(LT)	Instrument RB816 registered May 18, 1949 is an easement from Daniel W. James to The Algoma District Power Company Limited over Part of the N½ of the SE¼ of Section 13, Fenwick.	T220780; T445270
71.	31346-0065(LT)	Instrument T8390 registered January 31, 1957 is an easement from Joseph F. Hill and Doris Hill to Great Lakes Power Corporation Limited over Part of the S½ of the SE¼, Section 13, Fenwick.	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
72.	31620-0358(LT)	Instrument T10248 registered June 6, 1957 is an easement from John Melanchuck and Sally Melanchuck to Great Lakes Power Corporation Limited over part of the S½ of SE¼ of Section 12, Fenwick.	T220780; T445270
73.	31346-0070(LT) 31346-0084(LT) 31346-0087(LT)	Instrument T11899 registered August 30, 1957 is an easement from Melville D. James, Devisee of the late Daniel William James to Great Lakes Power Corporation Limited over Part of the NW¼ of the SE¼ of Section 13, Fenwick.	T220780; T445270
74.	31620-0131(LT)	Instrument T12016 registered September 9, 1957 is an easement from Michael Moskal, Stafford Moskal and Eileen Moskal to Great Lakes Power Corporation Limited over Part of the N½ of the SE¼ of Section 12, Fenwick.	T220780; T445269; T445270
75.	31620-0134(LT)	Instrument T12293 registered September 23, 1957 is an easement from William Smith and Annie Smith to Great Lakes Power Corporation Limited over part of the NE¼ of Section 12, Fenwick.	T220780; T445270
76.	31346-0079(LT) 31346-0078(LT) 31346-0080(LT) 31346-0081(LT) 31346-0087(LT)	Instrument T15805 registered May 20, 1958 is an easement from Nancy Joseph to Great Lakes Power Corporation Limited over Part of the NE¼ of Section 13, Fenwick.	T220780; T445270
77.	31346-0084(LT) 31346-0091(LT) 31346-0093(LT) 31346-0097(LT)	Instrument T15841 registered May 21, 1958 is an easement from Amelia Nardi to Great Lakes Power Corporation Limited over Part of the W½ of the E½ of Section 24, Fenwick.	T220780; T445270
78.	31346-0297(LT) 31346-0299(LT)	Instrument T15842 registered May 22, 1958 is an easement from Amelia Nardi to Great Lakes Power Corporation Limited over Part of the NW¼ of Section 25, Fenwick.	T220780; T445270; T467856
79.	31346-0297(LT) 31346-0298(LT) 31346-0299(LT)	Instrument T15918 registered May 26, 1958 is an easement from Claude Elliott, Thomas Elliott, Harold Elliott, Carl Elliott, Andrew Shearer, Marjorie Elliott, Astrid Elliott, Blanche Elliott, Ivy Elliott and Eleanor Shearer to Great Lakes Power Corporation Limited over Part of the NE¼ of Section 25, Fenwick.	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>PENNEFATHER:</b>	
80.	31350-0104(LT)	Instrument AC162 registered October 1, 1931 is an easement from Elizabeth J. Dunseath to The Algoma District Power Company Limited over Part of the SE¼ of Section 25, Pennefather	T220780; T445270; T467856
81.	31350-0090(LT) 31350-0079(LT)	Instrument AC164 registered March 15, 1932 is an easement from R.J. Loewenthal and Bertha H. Loewenthal to Great Lakes Power Company Limited over Part SE¼ of Section 1 and a portion of the E½ of Section 12, Pennefather	T220780; T445270
82.	31350-0092(LT)	Instrument AC174 registered July 10, 1934 is an easement from Sophia Stewart and George Stewart to Great Lakes Power Company Limited over Part of the N½ of the NE¼ of Section 13, Pennefather.	T220780; T445269; T445270
83.	31350-0097(LT) 31350-0096(LT)	Instrument No. AC176 registered July 10, 1934 is an easement from Thomas J. McCauley and Sarah M. McCauley to The Algoma District Power Company over Part of the S½ of the SE¼ of Section 13 and part of the N½ of the NE¼ of Section 24, Pennefather.	T445270
84.	31350-0105(LT)	Instrument AC185 registered November 24, 1934 is an easement from Fred W. McDowell and Ellen McDowell to The Algoma District Power Company Limited over part of the W½ of the NE¼ of Section 36, Pennefather.	T220780; T445270
85.	31350-0093(LT)	Instrument AC282 registered February 29, 1952 is an easement from Robert J. Running to Great Lakes Power Corporation Limited over Part of the S½ of the NE¼ of Section 13, Pennefather.	T220780; T445270
86.	31350-0105(LT)	Instrument T10287 registered June 7, 1957 is an easement from Norman Scott and Mary Scott to Great Lakes Power Corporation Limited over Part of the W½ of the NE¼ of Section 36, Pennefather.	T220780; T445270
87.	31350-0090(LT)	Instrument T11857 registered August 28, 1957 is an easement from Frank G. Miller, Frank P. Miller, Marion L. Miller and Sidney Miller to Great Lakes Power Corporation Limited over part of the NE¼ of Section 12, Pennefather.	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
88.	31350-0090(LT)	Instrument T11858 registered August 28, 1957 is an easement from Frank G. Miller, Frank P. Miller, Marion L. Miller and Sidney Miller to Great Lakes Power Corporation Limited over Part of the SE¼ of Section 12, Pennefather.	T220780; T445270
89.	31350-0093(LT)	Instrument T12349 registered September 25, 1957 is an easement from George W. Running to Great Lakes Power Corporation Limited over part of the S½ of the NE¼ of Section 13, Pennefather.	T220780; T445270
90.	31350-0079(LT)	Instrument T18479 registered September 19, 1958 is an easement from Esther Schwartz and Hugo Schwartz to Great Lakes Power Corporation Limited over part of the SE¼ of Section 1, Pennefather.	T220780; T445270
91.	31350-0097(LT)	Instrument T37036 registered March 13, 1961 is an easement from Bernard Clay and Annie Clay to Great Lakes Power Corporation Limited over part of the N½ of the NE¼ of Section 24, Pennefather.	T220780; T445270
92.	31350-0096(LT)	Instrument T42924 registered November 23, 1961 is an easement from Howard Percy Lethbridge in favour of Great Lakes Power Corporation Limited over part of the E½ of the S½ of the S½ of Section 13, Pennefather.	T220780; T445270
93.	31350-0092(LT)	Instrument T44361 registered February 8, 1962 is an easement from Earl Stewart and Esther M. Stewart to Great Lakes Power Corporation Limited over part of the N½ of the NE¼ of Section 13, Pennefather.	T220780; T445269; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>TARENTORUS, SECTION 6:</b>	
94.	31508-0020(LT)	<p>(a) Instrument LT114012 registered August 13, 1981 is an application to rectify caution LT19719 to be an easement.</p> <p>(b) Instrument LT19719 registered January 7, 1932 being a caution giving notice of an interest in land pursuant to memorandum of agreement/grant of right of way from Dan Wierzbicki and Annie Wierzbicki to The Algoma District Power Company Limited over Part of the S½ of the NW¼ of Section 6, Tarentoru being Part of Parcel 145, AWS, Tarentorus.</p>	LT113588; LT114012; LT19719
95.	31508-0054(LT)	Instrument B2804 registered July 24, 1934 is an easement from George H. Farmer and Mary J. Farmer to The Algoma District Power Company Limited over Part of the S½ of the SW¼ of Section 6, Tarentorus.	T220780; T445270
96.	31508-0054(LT)	Instrument T8215 registered January 14, 1957 is an easement from Wesley James Farmer and Margaret Farmer to Great Lakes Power Corporation Limited over Part S½ of the SW¼ of Section 6, Tarentorus.	T220780; T445270
97.	31508-0020(LT)	Instrument LT44922 registered February 9, 1960 is an easement from Finlay J. Heacock and Eileen Heacock to Great Lakes Power Corporation Limited over part of the S½ of the NW¼ of Section 6 being Part of Parcel 145, AWS, Tarentorus.	LT113588
98.	31508-0019(LT)	Instrument LT44973 registered February 16, 1960 is an easement from Robert Reid to Great Lakes Power Corporation Limited over part of the N½ of the NW¼ of Section 6 being Part of Parcel 225 Algoma West Section, Tarentorus.	LT113588
99.	31508-0021(LT)	Instrument LT46812 registered October 17, 1960 is an easement from Filicano Manzutti to Great Lakes Power Corporation Limited over part of the N½ of the SW¼ of Section 6 being Part of Parcel 1323, AWS, Tarentorus.	LT113588

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>TARENTORUS, SECTION 7:</b>	
100.	31508-0048(LT)	(a) Instrument LT114012 registered August 13, 1981 is an application to rectify caution LT19717 to be an easement.  (b) Instrument number LT19717 registered January 7, 1933 being a caution giving notice of an interest in land pursuant to memorandum of agreement/ grant of right of way from Robert J. Money and Christien Money to The Algoma District Power Company Limited over part of the N½ of the S½ of the NW¼ of Section 7, Part of Parcel 1869 AWS, Tarentorus.	LT113588; LT114012
101.	31508-0057(LT) 31508-0058(LT) 31508-0059(LT)	Instrument B2790 registered July 24, 1934 is an easement from William J. Money and Elizabeth Money to The Algoma District Power Company Limited over Part of N½ of the NW¼ of Section 7, Tarentorus.	T220780; T445270; T467856
102.	31508-0077(LT) 31508-0161(LT)	Instrument B2805 registered July 24, 1934 is an easement from Henry Selin, John Selin, Anna Selin and Mary Selin to The Algoma District Power Company Limited over part of the W½ of the NE¼ of the SW¼ of Section 7, Tarentorus.	T220780; T445270
103.	31508-0073(LT) 31508-0074(LT) 31508-0075(LT) 31508-0076(LT) 31508-0161(LT)	Instrument B2809 registered August 27, 1934 is an easement from Jane Farquhar executrix and sole devisee of the estate of William Farquhar to The Algoma District Power Company Limited over Part S½ of the E½ of the SW¼ of Section 7, Tarentorus.	T220780; T445270
104.	31508-0057(LT) 31508-0058(LT)	Instrument 8995 registered March 21, 1957 is an easement from Melvin E. Daynard to Great Lakes Power Corporation Limited over Part of N½ of the N½ of the NW¼ of Section 7, Tarentorus.	T220780; T445270
105.	31508-0077(LT)	Instrument T9068 registered March 27, 1957 is an easement from Leonard Gamble to Great Lakes Power Corporation Limited over Part of the W½ of the NE¼ of the SW¼ of Section 7, Tarentorus.	T220780; T445270
106.	31508-0073(LT) 31508-0074(LT) 31508-0075(LT) 31508-0076(LT)	Instrument T20202 registered December 19, 1958 is an easement from Louis Lefebvre and Ida Lefebvre to Great Lakes Power Corporation Limited over Part of the S½ of the E½ of the SW¼ of Section 7, Tarentorus.	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
107.	31508-0077(LT) 31508-0161(LT)	Instrument T20203 registered December 19, 1958 is an easement from Louis Lefebvre and Ida Lefebvre to Great Lakes Power Corporation Limited over Part of the W $\frac{1}{2}$ of the NE $\frac{1}{4}$ of the SW $\frac{1}{4}$ of Section 7, Tarentorus.	T220780; T445270
108.	31508-0048(LT)	Instrument LT45375 registered April 19, 1960 is an easement from Russell Ashmore to Great Lakes Power Corporation Limited over part of the N $\frac{1}{2}$ of the S $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Section 7, Part of Parcel 1869 AWS, Tarentorus.	LT113588
109.	31508-0059(LT)	Instrument T44017 registered January 22, 1962 is an easement from Mary Ernestine Hagen (formerly Mary Ernestine Hillier) to Great Lakes Power Corporation Limited over Part of the N $\frac{1}{2}$ of the N $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Section 7, Tarentorus.	T220780; T445270
110.	31508-0058(LT)	Instrument T45316 registered March 29, 1962 is an easement from Mose J. Ouellette and Lena Ouellette to Great Lakes Power Corporation Limited over Part of the N $\frac{1}{2}$ of the N $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Section 7, Tarentorus.	T220780; T445270
111.	31508-0052(LT) 31508-0049(LT) 31508-0051(LT)	Instrument LT51638 registered July 18, 1962 is an easement from William Lamarche and Loretta Lamarche to Great Lakes Power Corporation Limited over Part of the S $\frac{1}{2}$ of the S $\frac{1}{2}$ of the NW $\frac{1}{4}$ being Part of Parcel 1077 Algoma, Tarentorus.	LT113588
		<b>TARENTORUS, SECTION 18:</b>	
112.	31564-0027(LT)	Instrument B2791 registered June 3, 1929 is an easement from August Saari and Marie Saari to The Algoma District Power Company Limited over part of the N $\frac{1}{2}$ of the SW $\frac{1}{4}$ of Section 18, Tarentorus.	T220780; T445270
113.	31564-0033(LT)	Instrument B2796 registered July 24, 1934 is an easement from John Kaunista and Selina Kaunista to The Algoma District Power Company Limited over part of the S $\frac{1}{2}$ of the SW $\frac{1}{4}$ of Section 18, Tarentorus.	T220780; T445270; T467856
114.	31564-0059(LT)	Instrument B2800 registered July 24, 1934 is an easement from William H. Palmer and Ellen Palmer to The Algoma District Power Company Limited over part of the SE $\frac{1}{4}$ of the SW $\frac{1}{4}$ of Section 18, Tarentorus.	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
115.	31564-0012(LT)	Instrument B2803 registered July 24, 1934 is an easement from Yalmar Maki and Elina Maki to The Algoma District Power Company Limited over part of the E½ of the NW¼ of Section 18, Tarentorus.	T220780; T445270
116.	31564-0028(LT)	Instrument B2812 registered October 1, 1934 is an easement from Gilbert H. Johnston and Lila May Johnston to The Algoma District Power Company Limited over part of the S½ of the SW¼ of Section 18, Tarentorus.	T220780; T445270; T467856
117.	31564-0012(LT)	Instrument T21846 registered April 16, 1959 is an easement from The Director, The Veterans' Land Act to Great Lakes Power Corporation Limited over part of the NW¼ of Section 18, Tarentorus.	T220780; T445270
118.	31564-0033(LT)	Instrument T21880 registered April 17, 1959 is an easement from The Director, The Veterans' Land Act to Great Lakes Power Corporation Limited over part of the SW¼ of Section 18, Tarentorus.	T220780; T445270; T467856
119.	31564-0028(LT)	Instrument T21411 registered May 16, 1959 is an easement from Elizabeth Mathieu to Great Lakes Power Corporation Limited over Part of the S½ of the SW¼ of Section 18, Tarentorus.	T220780; T445270; T403360
120.	31564-0060(LT)	Instrument T77424 registered February 25, 1966 is an easement from W.E. Muncaster to Great Lakes Power Corporation Limited over part of the SE¼ of Section 18, Tarentorus.	
121.	31564-0027(LT)	Instrument T92083 registered February 19, 1968 is an easement from the Montreal Trust Company executors and trustees of the estate of Harold Herbert Moeser to Great Lakes Power Corporation Limited over Part of the SW¼ of Section 18, Tarentorus.	T220780; T445270
		<b>TARENTORUS, SECTION 19:</b>	
122.	31563-0093(LT)	Instrument B2691 registered October 1, 1931 is an easement from Charles Morrison to The Algoma District Power Company Limited over part of the E Part of the SE¼ of the SW¼ of Section 19, Tarentorus.	T220780; T445270
123.	31563-0052(LT)	Instrument B2799 registered July 24, 1934 is an easement from John H. Dumond to The Algoma District Power Company Limited over part of the E½ of the NW¼ of Section 19, Tarentorus.	T220780; T445270



	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
124.	31563-0093(LT)	Instrument T9388 registered April 17, 1957 is an easement from Mike Swazich to Great Lakes Power Corporation Limited over part of the E½ of the E portion of the SE¼ of the SW¼ Section 19, Tarentorus.	T220780; T445270
125.	31563-0052(LT)	Instrument 15756 registered May 16, 1958 is an easement from Andrew Stilin and Enola Ann Stilin to Great Lakes Power Corporation Limited over Part of the E½ of the NW¼ of Section 19, Tarentorus.	T220780; T445270
126.	31563-0093(LT)	Instrument T92084 registered February 27, 1968 is an easement from Mike Swazich to Great Lakes Power Corporation Limited over part of the SW¼ of Section 19, Tarentorus.	T220780; T445270
		<b>TARENTORUS, SECTION 30:</b>	
127.	31561-0118(LT)	Instrument B2783 registered July 12, 1934 is an easement from George A. Dods and Edna Dods to The Algoma District Power Company Limited over part of the S½ of the N½ of the SE¼ of Section 30, Tarentorus, being part of Lot 22, RCP H-744.	T220780; T445270
128.	31561-0090(LT)	Instrument B2788 registered July 24, 1934 is an easement from David W. Euler and Mary Euler to The Algoma District Power Company Limited over part of the N½ of the S½ and the S½ of the N½ of the NE¼ of Section 30, Tarentorus, being part of Lots 1 and 9, RCP H-744.	T220780; T445270
129.	31561-0037(LT) 31561-0041(LT) 31561-0035(LT)	Instrument B2789 registered July 24, 1934 is an easement from Alfred E. Taylor and Elizabeth Taylor to The Algoma District Power Company Limited over part of the N½ of the NW¼ of the SE¼ of Section 30, Tarentorus, being part of Lots 20 and 21, RCP H-744.	T220780; T445270
130.	31561-0090(LT)	Instrument B2792 registered July 24, 1934 is an easement from Wilfred E. Palmer and Lily M. Palmer to The Algoma District Power Company Limited over part of the N½ of the N½ of the NE¼ of Section 30, Tarentorus, being part of Lot 1, RCP H-744.	T220780; T445270
131.	31561-0122(LT)	Instrument B2793 registered July 24, 1934 is an easement from Emma B. Reynolds to Great Lakes Power Company Limited over Part of the S½ of the S½ of the NE¼ Section 30, Tarentorus, being part of Lot 11, RCP H-744.	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
132.	31561-0009(LT) 31561-0008(LT) 31561-0004(LT) 31561-0006(LT) 31561-0003(LT) 31561-0001(LT)	Instrument B2797 registered July 24, 1934 is an easement from Charles Wigmore and Alma Wigmore to The Algoma District Power Company Limited over Part N $\frac{1}{2}$ of the S $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Section 30, Tarentorus, being part of Lot 33, RCP H-744.	T220780; T445270
133.	31561-0003(LT)	Instrument B2798 registered July 24, 1934 is an easement from Charles Wigmore and Alma Wigmore to The Algoma District Power Company Limited over part of the S $\frac{1}{2}$ of the S $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Section 30, Tarentorus, being part of Lot 35, RCP H-744.	T220780; T445270
134.	31561-0122(LT)	Instrument T10313 registered June 10, 1957 is an easement from Valentine D. Euler to Great Lakes Power Corporation Limited over Part of the S $\frac{1}{2}$ of the S $\frac{1}{2}$ of the NE $\frac{1}{4}$ of Section 30, Tarentorus, being part of Lot 11, RCP H-744.	T220780; T445270
135.	31561-0090(LT)	Instrument T10314 registered June 10, 1957 is an easement from Abbie Chappell to Great Lakes Power Corporation Limited over part of the N $\frac{1}{2}$ of the S $\frac{1}{2}$ of the NE $\frac{1}{4}$ of Section 30, Tarentorus being part of Lots 1 and 9 , RCP H-744.	T220780; T445270
136.	31561-0090(LT)	Instrument T10315 registered June 10, 1957 is an easement from Abbie Chappell to Great Lakes Power Corporation Limited over part of the S $\frac{1}{2}$ of the N $\frac{1}{2}$ of the NE $\frac{1}{4}$ of Section 30, Tarentorus, being part of Lot 1, RCP H-744.	T220780; T445270
137.	31561-0037(LT) 31561-0041(LT) 31561-0035(LT)	Instrument T15757 registered May 16, 1958 is an easement from Henry Forsythe and Dorothy Forsythe to Great Lakes Power Corporation Limited over part of the NW $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Section 30, Tarentorus, being part of Lots 20 and 21, RCP H-744.	T220780; T445270
138.	31561-0118(LT)	Instrument T15768 registered May 16, 1958 is an easement from Robert Reid and Viola Reid to Great Lakes Power Corporation Limited over Part of the S $\frac{1}{2}$ of the NW $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Section 30, Tarentorus, being part of Lot 22, RCP H-744.	T220780; T445270
139.	31561-0009(LT) 31561-0008(LT) 31561-0004(LT) 31561-0006(LT) 31561-0003(LT)	Instrument T16210 registered June 6, 1958 is an easement from Wesley Willoughby and Margaret Willoughby to Great Lakes Power Corporation Limited over part of the N $\frac{1}{2}$ of the SW $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Section 30, Tarentorus, being part of Lots 33, 34 and 35, RCP H-744.	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
140.	31561-0003(LT)	Instrument T16211 registered June 6, 1958 is an easement from Wesley Willoughby and Margaret Willoughby to Great Lakes Power Corporation Limited over part of the S½ of the SW¼ of the SE¼ of Section 30, Tarentorus, being part of Lot 35, RCP H-744.	T220780; T445270
141.	31561-0090(LT)	Instrument T17213 registered July 22, 1958 is an easement from Wilfred E. Palmer and Lilly Palmer to Great Lakes Power Corporation Limited over part of the N½ of the NE¼ of the NE¼ of Section 30, Tarentorus, being part of Lot 1 and part of Third Line Road, RCP H-744.	T220780; T445270
142.	31561-0090(LT)	Instrument 93708 registered May 23, 1968 is an easement from Wilfred Earl Palmer to Great Lakes Power Corporation Limited over part of the NE¼ of Broken Section 30, Tarentorus, being part of Lot 1, RCP H-744.	T220780; T445270
		<b>TARENTORUS, SECTION 31</b>	
143.	31559-0065(LT) 31559-0069(LT) 31559-0070(LT) 31559-0087(LT)	Instrument B2938 registered August 24, 1939 is an easement from John Joseph Hussey and Evelyn Hussey to Great Lakes Power Company Limited over parts of Lots 94, 95 and 96, RCP H732 being part of the North West Subdivision of Broken Section 31, Tarentorus	T220780; T445269; T445270
144.	31559-0058(LT) 31559-0059(LT) 31559-0060(LT) 31559-0061(LT) 31559-0062(LT) 31559-0063(LT)	Instrument No. B2939 registered August 24, 1939 is an easement from A.H. Huckson and Zelia Huckson to Great Lakes Power Company Limited over Part of the North West Subdivision of Broken Section 31, Tarentorus, Lots 88, 90, 91, 92 and 93, RCP H732	T220780; T445269; T445270
145.	31559-0070(LT)	Instrument No. T79693 registered June 17, 1966 is an easement from Antonio Calcagnini and Linda Calcagnini to Great Lakes Power Corporation Limited over part of the W½ of Broken Section 31, Part of Lot 96, RCP H732, Tarentorus.	T220780; T445269; T445270
146.	31559-0013(LT)	Instrument T75851 registered November 29, 1965 is an easement from Hollingsworth Investments Limited to Great Lakes Power Corporation Limited over part of Lots 14 and 15, Plan H-565, Commerce Park Subdivision (formerly part of W½ of Tarentorous 31), Sault Ste. Marie.	AL26445

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>KORAH, SECTION 1:</b>	
147.	31599-0063(LT)	Instrument LT29721 registered March 1, 1952 is an easement from Joseph Alfred Jackson to Great Lakes Power Corporation Limited over part of the SE¼ of the NE¼ of Section 1, being Part of Parcel 3347 AWS, Korah.	LT113588
148.	31582-0005(LT) 31582-0006(LT) 31582-0007(LT)	Instrument T7193 registered October 29, 1956 is an easement from Malcolm Harold Dickinson and Lenore Dickinson to Great Lakes Power Corporation Limited over part of Lot 19, Laura Wesley Subdivision 2, Plan 12898	T220780
149.	31582-0003(LT) 31582-0214(LT)	Instrument T7194 registered October 29, 1956 is an easement from Samuel B. Dickinson to Great Lakes Power Corporation Limited over part of Lot 19, Laura Wesley Subdivision 2, Korah, Plan 12898	T220780
150.	31582-0008(LT)	Instrument T7828 registered December 6, 1956 is an easement from Attilio Berardinelli to Great Lakes Power Corporation Limited over part of Lot 19, Laura Wesley Subdivision 2, Korah, Plan 12898	T220780
151.	31568-0094(LT)	Instrument T-8773 registered March 5, 1957 is an easement from William Yureychuk and Rose Yureychuk to Great Lakes Power Corporation Limited over part of Block 14, Stewart Survey, Korah	T220780
152.	31568-0094(LT)	Instrument T-21136 registered February 25, 1959 is an easement from Fred Lawko and Mary Lawko to Great Lakes Power Corporation Limited over part of Block 14, Stewart Survey, Korah	T220780
153.	31584-0126(LT) 31566-0258(LT)	Instrument T39694 registered July 13, 1961 is an easement from Roddis Lumber and Veneer Co. of Canada Limited to Great Lakes Power Corporation Limited over Part of the S½ of the SW¼ of Section 24	T220780
154.	31599-0059(LT)	Instrument LT50016 registered December 27, 1961 is an easement from Vilis Karklins and Elgin Karklins to Great Lakes Power Corporation Limited over part of the N½ of the NE¼ of Section 1, Part Parcel 2976 AWS, Korah.	LT113588

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
155.	31599-0051(LT)	Instrument LT50356 registered February 12, 1962 is an easement from Marion M. Pavelich and Bruna Rose Pavelich to Great Lakes Power Corporation Limited over part of the S½ of the N½ of the NE¼ of Section 1, Part Parcel 1280 AWS, Korah.	LT113588
156.	31570-0210(LT) 31570-0212(LT) 31570-0215(LT)	Instrument T-113556 registered January 5, 1971 is an easement from Lyons Fuel Hardware and Supplies Limited to Great Lakes Power Corporation Limited over all of Lots 58, 98, 215 and 229, Plan 1703; Part of Lot 346, Plan 1703; Part of 30 foot laneway closed by by-law 293, Plan 1703; Part of Lennox Avenue closed by by-law 293, Plan 1703; Part of Shafer Avenue closed by by-law 293, Plan 1703; Part of 12 foot lane between Shafer Avenue and Peoples Road; Part of 12 foot lane between Shafer Avenue and Lennox Avenue	T220780
157.	31609-0104(LT) 31609-0049(LT) 31609-0048(LT) 31609-0047(LT) 31609-0046(LT) 31609-0045(LT) 31609-0044(LT) 31609-0038(LT) 31609-0034(LT) 31609-0001(LT) 31592-0280(LT) 31592-0283(LT) 31613-0308(LT) 31613-0352(LT) 31613-0353(LT)	Instrument LT216273 (Land Titles) and T393141 (Registry) both registered January 20, 1998 is a transfer of easement from Algoma Steel Inc. to Great Lakes Power Limited over Parts 1 and 2, Plan 1R-9347; Parts 1-8 and 15, Plan 1R-9346; Parts 1-11, Plan 1R-9345; Parts 18-27, Plan 1R-9346; Parts 3, 4, 5, 6 and 8-13, Plan 1R-9347, Korah, Sault Ste. Marie, District of Algoma (see Schedule "B" PIN 31609-0176(R) for remaining Registry lands not converted to land titles qualified.  <b>PATRICK STREET TO G.P. FLAKEBOARD</b>	
158.	31568-0025(LT)	Instrument T403789 registered March 30, 1999 is an easement from Rosario Coccimiglio and Mario Coccimiglio to Great Lakes Power Limited over Part of Blocks 13 and 14, Stewart Survey of the Korah Block, Sault Ste. Marie, District of Algoma, described as Part 1, Plan 1R-9735.	T444270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
159.	31592-0280(LT)	Instrument AL9664 registered November 15, 2006 is an easement in gross granted by Algoma Steel Inc. to Great Lakes Power Limited over Part of Section 36, Korah; Part of Lots 19, 20, 21, 22 and 23 (now Part of Carleton Avenue, relocated by By-law 1444, as in Instrument 500); Part of a 14 foot lane and Part of St. Patrick Street, closed by By-law 1444, as in instrument 500, Block 4, Plan 402; designated as Parts 1 to 10 on Plan 1R-11240; Sault Ste. Marie	
		<b>CLERGUE SUBSTATION TO PATRICK STREET SUBSTATION</b>	
160.	31576-0025(LT) 31576-0024(LT) 31578-0250(LT)	Instrument T241680 registered December 19, 1983 is an easement from The Algoma Steel Corporation, Limited to Great Lakes Power Limited over part of Portage Street, Original Town Plot, now described as Part 1, Plan 1R-4611 and part of Portage Street, Original Town Plot, now described as Part 11, Plan 1R-4514	
161.	31592-0280(LT) 31579-0071(LT)	Instrument T241681 registered December 19, 1983 is an easement from The Algoma Steel Corporation, Limited to Great Lakes Power Limited over Part of the Broken South West Quarter of Section 36, Korah, now designated as Parts 4, 5, 6, 7 and 8 on Plan 1R-4612; Sault Ste. Marie	
		<b>KEHOE &amp; COZENS</b>	
162.	31579-0071(LT)	Instrument T241679 registered December 19, 1983 is an easement from Algoma Central Railway to Great Lakes Power Limited over Parts 1, 2 and 3, Plan 1R-4612, Kehoe and Cozens Subdivision.	

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>ST. MARYS PAPER - BLOCK 31577</b>	
163.	31577-0012(LT)	Instrument T454942 registered January 27, 2005 is an easement from St. Marys Paper Ltd. to Great Lakes Power Limited over Part of Hudson's Bay Company's lands, south side of Portage Street, Plan Town Plot of Sault Ste. Marie designated as Parts 1 and 3, Plan 1R-4290; Part of Parcel 1023, AWS	
164.	31577-0035(LT)	Instrument LT254163 registered January 27, 2005 is an easement from St. Marys Paper Ltd. to Great Lakes Power Limited on Part of Hudson's Bay Company's lands, south side of Portage Street, Plan Town Plot of Sault Ste. Marie designated as Part 1 and 3, Plan 1R-4290; Part of Parcel 1023, AWS	
165.	31577-0025(LT)	Instrument T136132E registered July 31, 1985 is a transfer from Great Lakes Power Limited to The Corporation of the City of Sault Ste. Marie which reserves an easement over Part 4, Plan 1R-5809	
166.	31577-0043(LT)	Instrument T136133E registered July 31, 1985 is a transfer from Great Lakes Power Limited to The Corporation of the City of Sault Ste. Marie which reserves an easement over Parts 1 & 4, Plan 1R-5709	
167.	31577-0019(LT)	Instrument T257669E registered July 31, 1985 is a transfer from Great Lakes Power Limited to The Corporation of the City of Sault Ste. Marie which reserves an easement over Parts 2 & 3, Plan 1R-5709	
168.	31577-0019(LT)	Instrument T257670E registered July 31, 1985 is a transfer from Great Lakes Power Limited to The Corporation of the City of Sault Ste. Marie which reserves an easement over Part 11, Plan 1R-5809	

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>230kV TRANSMISSION LINES - THIRD LINE SUB TO MISSISSAGI T. S.</b>	
		<b>TARENTORUS, SECTION 19:</b>	
169.	31563-0082(LT) 31563-0083(LT)	Instrument T17131 registered July 15, 1958 is an easement from Valentine Euler (Valentine David Euler) to Great Lakes Power Corporation Limited over part of the SE¼ of the SE¼ of Section 19, Tarentorus.	T220780; T445270
170.	31563-0093(LT)	Instrument T21301 registered March 9, 1959 is an easement from Mike Swazich to Great Lakes Power Corporation Limited over part of the SE¼ of the SW¼ of Section 19, Tarentorus.	T220780; T445270
171.	31563-0078(LT)	Instrument T169294 registered July 15, 1976 is an easement from Doran's Northern Ontario Breweries Limited to Great Lakes Power Corporation Limited over part of the S½ of the N½ of the SE¼ of Section 19, Part of Lot 60, RCP H739, designated as Part 1, Plan 1R-2569, Tarentorus.	T220780; T445270
172.	31563-0082(LT)	Instrument T172116 registered September 30, 1976 is an easement from Bruce L. Walker and Margaret Walker to Great Lakes Power Corporation Limited over part of the SE¼ of the SE¼ of Section 19, Part of Lot 61, RCP H739, being Part 2, Plan 1R-2569, Tarentorus.	T220780; T445270
173.	31563-0078(LT)	Instrument T211932 registered July 16, 1980 is an easement from Northern Breweries Ltd. to Great Lakes Power Corporation Limited over Part of Lot 60, RCP H-739 being Part 1 on Plan 1R-3800, Section 19, Tarentorus	T445270 T301943
		<b>TARENTORUS, SECTION 20:</b>	
174.	31510-0094(LT)	Instrument T17855 registered August 26, 1958 is an easement from Lorne C. Palmer and Isabel Palmer to Great Lakes Power Corporation Limited over part of the SE¼ of the SW¼ of Section 20, being Part of Lot 45, RCP H737, Tarentorus.	T220780; T445270
175.	31510-0112(LT) 31510-0113(LT)	Instrument T17856 registered August 26, 1958 is an easement from Lorne C. Palmer and Isabel Palmer to Great Lakes Power Corporation Limited over part of the SW¼ of the SW¼ of Section 20, being Part of Lot 38, RCP H737, Tarentorus.	T220780 ; T445270



	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
176.	31510-0110(LT)	Instrument T21412 registered March 16, 1959 is an easement from John Delbert Caul and Alice Marie Caul to Great Lakes Power Corporation Limited over part of SE¼ of the SE¼ of Section 20, being Part of Lot 55, RCP H737, Tarentorus.	T220780; T445270
177.	31510-0099(LT)	Instrument T21598 registered March 31, 1959 is an easement from Lloyd Avery and Mildred Avery to Great Lakes Power Corporation Limited over part of the S½ of Section 20, being Part of Lot 47, RCP H737, Tarentorus	T220780; T445270
178.	31510-0109(LT)	Instrument T21599 registered March 31, 1959 is an easement from Lloyd Avery and Mildred Avery to Great Lakes Power Corporation Limited over part of the SW¼ of the SE¼ and part of the SE¼ of the SE¼, Section 20, being Part of Lot 56, RCP H737, Tarentorus Township.	T220780; T445270
179.	31510-0102(LT) 31510-0103(LT)	Instrument T21600 registered March 31, 1959 is an easement from C. Seaburn Weeks and Margaret Weeks to Great Lakes Power Corporation Limited over Part of Section 20, being Parts of Lots 48 and 50, RCP H737, Tarentorus	T220780; T403337; T445270
180.	31510-0049(LT) 31510-0054(LT) 31510-0057(LT)	Instrument T21667 registered April 2, 1959 is an easement from Edward Yadivisiak and Margaret Yadivisiak to Great Lakes Power Corporation Limited over part of the SE¼ of the SE¼ of Section 20, being Part of 1M-461, Tarentorus	T220780; T445270
181.	31510-0094(LT)	Instrument T169293 registered July 15, 1976 is an easement from Isabel Palmer to Great Lakes Power Corporation Limited over part of the SE¼ of the SW¼, Section 20, being Part of Lot 45, RCP H737, designated as Part 1, Plan 1R-2568, Tarentorus	T220780; T445270
182.	31510-0102(LT)	Instrument T169295 registered July 15, 1976 is an easement from Defazio Enterprises Incorporated to Great Lakes Power Corporation Limited over part of the S½ of the SE¼ of Section 20, being Part 4 on Plan 1R-2568, being Part of Lot 48, RCP H737, Tarentorus.	T22078; T445270
183.	31510-0051(LT) 31510-0052(LT) 31510-0057(LT)	Instrument T169296 registered July 15, 1976 is an easement from Henry Ansel Wightman and Irma Sylvia Wightman to Great Lakes Power Corporation Limited over part of the E part of the N½ of the SE¼ of Section 20, being Part 9, Plan 1R-2568, being Part of Lot 57, RCP H737, Part of 1M-461	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
184.	31510-0099(LT)	Instrument T169878 registered July 29, 1976 is an easement from Kenneth Norman Watkiss and Rosemary Watkiss to Great Lakes Power Corporation Limited over part of the S $\frac{1}{2}$ of the SW $\frac{1}{4}$ of Section 20, being Part 3, Plan 1R-2568, being Part of Lot 47, RCP H737, Tarentorus	T220780; T445270
185.	31510-0110(LT)	Instrument T170070 registered August 4, 1976 is an easement from John Delbert Caul and Alice Marie Caul to Great Lakes Power Corporation Limited over part of the S $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Section 20, being Part 8, Plan 1R-2568, being Part of Lot 55, RCP H737, Tarentorus.	T220780; T445270
186.	31510-0103(LT)	Instrument T170426 registered August 12, 1976 is an easement from Paul Defazio and Carolynn Defazio to Great Lakes Power Corporation Limited over part of the SE $\frac{1}{4}$ of Section 20, now Part 5, Plan 1R-2568, being Part of Lot 50, RCP H737, Tarentorus.	T220780; T445270
187.	31510-0050(LT) 31510-0053(LT) 31510-0057(LT)	Instrument T170759 registered August 23, 1976 is an easement from Gertrud Eisbrenner to Great Lakes Power Corporation Limited over part of the S $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Section 20, being Part 7, Plan 1R-2568, being Part of Lot 54, RCP H737, Part of 1M-461, Tarentorus.	T220780; T445270
188.	31510-0111(LT)	Instrument T283398 registered December 10, 1987 and Instrument T280873 registered September 24, 1987 correct Instrument T172565 registered October 14, 1976 being an easement from Raymond Belkosky and Kenneth Pierman to Great Lakes Power Corporation Limited over part of the N $\frac{1}{2}$ of the SW $\frac{1}{4}$ , Section 20, being Part of Lot 37, RCP H737, being Part 10, Plan 1R-2568, Tarentorus.	T220780; T445270; T280873; T283398
189.	31510-0112(LT)	Instrument T294046 registered October 27, 1988 corrects Instrument T172736 registered October 19, 1976 being an easement from J.H. Ernest Ballentine to Great Lakes Power Corporation Limited over part of the S $\frac{1}{2}$ of the SW $\frac{1}{4}$ and SE $\frac{1}{4}$ of Section 20, part of Lot 38, RCP H737 being Part 1, Plan 1R-2568, Tarentorus.	T220780; T445270
190.	31510-0109(LT)	Instrument T172737 registered October 19, 1976 is an easement from Lloyd Avery Contracting Limited to Great Lakes Power Corporation Limited over part of the S $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Section 20, being part of Lot 56, RCP H736 designated as Part 6, Plan 1R-2568, Tarentorus.	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>TARENTORUS, SECTION 21: (RCP H-736)</b>	
191.	31506-0149(LT) 31506-0146(LT) 31506-0134(LT)	Instrument LT39805 registered July 30, 1958 is an easement from John P. Dunn and Blossom Dunn to Great Lakes Power Corporation Limited over part of the S½ of SE¼ of Section 21, Part of Parcel 3760, AWS, Tarentorus.	LT113588; LT248702
192.	31506-0050(LT)	Instrument T17800 registered August 15, 1958 is an easement from Clair Robert Armstrong and Elsie A. Armstrong to Great Lakes Power Corporation Limited over part of the SW¼ of Section 21, Tarentorus.	T220780; T445270
193.	31506-0038(LT) 31506-0039(LT)	Instrument T17802 registered August 22, 1958 is an easement from Alec Wallenius and Beata Wallenius to Great Lakes Power Corporation Limited over part of the SW¼ of Section 21, Tarentorus	T220780; T445270
194.	31506-0045(LT)	Instrument T17920 registered August 29, 1958 is an easement from Arvo Groondhal to Great Lakes Power Corporation Limited over part of the SW¼ of Section 21, Tarentorus.	T220780; T445270
195.	31506-0134(LT)	Instrument LT64249 registered March 4, 1968 is an easement from John P. Dunn and Blossom Dunn to Great Lakes Power Corporation Limited over part of the SE¼ of Section 21, part of Parcel 3760, Section 21, Tarentorus.	LT113588
196.	31506-0039(LT)	Instrument T169297 registered July 15, 1976 is an easement from Beata Wallenius to Great Lakes Power Corporation Limited over part of the SW¼ of Section 21, Part of Lot 27, RCP H736, being Part 4 on Plan 1R-2567, Tarentorus.	T220780; T445270
197.	31506-0038(LT)	Instrument T170015 registered August 3, 1976 is an easement from Olive Marie Young to Great Lakes Power Corporation Limited over part of the SW¼ of Section 21, part of Lot 26, RCP H736, being Part 3, Plan 1R-2567, Tarentorus.	T220780; T445270
198.	31506-0050(LT)	Instrument T170657 registered August 20, 1976 is an easement from Donald John Van Daele and Gloria Alice Van Daele to Great Lakes Power Corporation Limited over part of the W½ of the W½ of the SW¼ of Section 21, Part of Lot 37, RCP H736, being Part 1, Plan 1R-2567, Tarentorus.	T220780; T445270

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
199.	31506-0149(LT) 31506-0134(LT)	Instrument LT87619 registered September 10, 1976 is an easement from John P. Dunn and Blossom Dunn to Great Lakes Power Corporation Limited over part of the S½ of SE¼ of Section 21, being Parts 3 and 5, Plan 1R-2856, Part of Parcel 3760, AWS, Tarentorus.	LT113588; LT248702
200.	31506-0045(LT)	Instrument T280599 registered September 15, 1987 corrects a Planning Act problem in Instrument T173683 registered November 17, 1976 being an easement from Arvo Groondhal and Anne Groondhal to Great Lakes Power Corporation Limited over part of the SW¼ Section 21, part of Lot 33, RCP H736, being Part 2, Plan 1R-2567, Tarentorus.	T220780; T445270
201.	31506-0121(LT)	Instrument LT149735 registered April 30, 1987 corrects a Planning Act problem in Instrument 89942 registered February 28, 1977 being an easement from The Director, The Veterans' Land Act (Stanley Dominic Fisher) to Great Lakes Power Corporation Limited over part of the SE¼ of Section 21, being Part 4, Plan 1R-2586, Part of Parcel 2652 AWS, Tarentorus.	LT113588
202.	31506-0146(LT)	Instrument LT101116 registered April 12, 1979 is an easement from Charles Dunn and Evelyn Dunn to Great Lakes Power Corporation Limited over part of Parcel 4842 AWS, being Part 2, Plan 1R-2586, Tarentorus.	LT113588

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
209.	31473-0097(LT) 31473-0107(LT)	Instrument T21278 registered March 6, 1959 is an easement from Robert H. Corboy and Kathleen I. Corboy to Great Lakes Power Corporation Limited over part of the S½ of the NE¼ of Section 3, MacDonald, Part Lot 10, RCP H766, Part of Lot 36 RCP H766	T220780; T445270 T403359
210.	31473-0097(LT) 31473-0103(LT)	Instrument T21319 registered March 11, 1959 is an easement from James T. Moss and Clara E. Moss to Great Lakes Power Corporation Limited over part of the S½ of the NW¼, Section 2, MacDonald, Part Lot 20, RCP H766, part of Lot 36 RCP H766	T220780; T445270 T403341
211.	31473-0077(LT)	Instrument T21320 registered March 11, 1959 is an easement from William Cliffe to Great Lakes Power Corporation Limited over part of the S½ of the NE¼ of Section 3 and part of the S½ of the NW¼ of Section 3, MacDonald, Part Lot 9, RCP H766	T220780; T445270 T403358
212.	31473-0098(LT)	Instrument T21352 registered March 12, 1959 is an easement from Robert John Cliffe to Great Lakes Power Corporation Limited over part of the S½ of the NE¼ of Section 2, MacDonald, Part Lot 21, RCP H766	T220780; T445270 T403357
213.	31473-0003(LT)	Instrument LT44594 registered December 18, 1959 is an easement from Edgar L. Arsenault to Great Lakes Power Corporation Limited over part of the S½ of the NW¼ of Section 1, Part of Parcel 4234 AWS, MacDonald.	LT113588
214.	31473-0014(LT) 31473-0016(LT)	Instrument LT46495 registered September 12, 1960 is an easement from Tracey E. Carmichael, Administrator of the estate of Bernice B. Bushong to Great Lakes Power Corporation Limited over part of the S½ of the NE¼ of Section 1, Part of Parcel 947 AWS, Section 1, MacDonald, part of Parcel 4762, Sec AWS SRO	LT113588; LT248072
215.	31473-0097(LT) 31473-0103(LT)	Instrument T85854 registered April 28, 1967 is an easement from James T. Moss and Clara E. Moss to Great Lakes Power Corporation Limited over part of the S½ of the NW¼, Section 2, MacDonald, Part Lot 20, RCP H766, part of Lot 36 RCP H766	T220780; T445270
216.	31473-0003(LT)	Instrument LT61793 registered May 2, 1967 is an easement from Rosa Dupuis to Great Lakes Power Corporation Limited over part of the S½ of the NE¼ of Section 1, Part of Parcel 4234 AWS, Section 1, MacDonald.	LT113588

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
217.	31473-0097(LT) 31473-0107(LT)	Instrument T86024 registered May 5, 1967 is an easement from Francis Leon Lewis to Great Lakes Power Corporation Limited over part of the S½ of the NE¼ of Section 3, MacDonald, Part Lot 10, RCP H766, part of Lot 36 RCP H766	T220780; T445270
218.	31473-0098(LT)	Instrument T90924 registered September 11, 1967 is an easement from Lorne Bain and Edna Bain to Great Lakes Power Corporation Limited over part of the S½ of the NE¼ of Section 2, MacDonald Part Lot 21, RCP H766	T220780; T445270
219.	31473-0014(LT)	Instrument LT63937 registered January 12, 1968 is an easement from L.H. Shay Veneer of Canada Limited to Great Lakes Power Corporation Limited over part of the S½ of the NE¼ of Section 1, Parcel 4762 AWS, SRO, MacDonald	LT113588
220.	31473-0077(LT)	Instrument T94415 registered June 25, 1968 is an easement from Morley Edward Trotter to Great Lakes Power Corporation Limited over part of the S½ of the broken NW¼ of Section 3, and part of the S½ of NE¼, Section 3, MacDonald, Part Lot 9, RCP H766	T220780; T445270
221.	31473-0103(LT)	Instrument T270703 registered October 23, 1986 is an easement from Graham Nelder and Margaret Nelder to Great Lakes Power Limited over part of Lot 20, RCP H-766, being Part 1, Plan 1R-6605, Section 2, MacDonald	

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>MEREDITH:</b>	
222.	31474-0183(LT)	Instrument T17214 registered July 22, 1958 is an easement from Sawyer-Stoll Lumber Company of Canada Limited to Great Lakes Power Corporation Limited over Part of Section 4, Meredith.	T220780; T445270
223.	31474-0183(LT)	Instrument T17215 registered July 22, 1958 is an easement from Sawyer-Stoll Lumber Company of Canada Limited to Great Lakes Power Corporation Limited over a strip between the Township East Line and the East Line of Section 4, Eastern fraction or Gore, Meredith.	T220780; T445270
224.	31474-0074(LT)	Instrument LT46495 registered September 12, 1960 is an easement from Tracey B. Carmichael administrator of the estate of Bernice B. Bushong to Great Lakes Power Corporation Limited over part of the S½ of the NE¼ of Section 1 and parts of Sections 5 and 6, Part of Parcel 948 AWS, Meredith, Part Parcel 4761 AWS, SRO	LT113588; LT248702
225.	31474-0183(LT)	Instrument T86023 registered May 5, 1967 is an easement from Sawyer-Stoll Lumber Company of Canada Limited to Great Lakes Power Corporation Limited over Part of Section 4 and Part of a strip laying immediately E of Section 4, Eastern fraction or Gore, Meredith.	T220780; T445270
226.	31474-0074(LT)	Instrument LT63938 registered January 15, 1968 is an easement from L.H. Shay Veneer of Canada Limited to Great Lakes Power Corporation Limited over part of the S½ of the N½ of Section 5 and part of the S½ of the N½ of Section 6, part of Parcel 4761 AWS, Meredith.	LT113588
		<b>ABERDEEN:</b>	
227.	31386-0329(LT)	Instrument LT42095 registered March 16, 1959 is an easement from Daniel Haines to Great Lakes Power Corporation Limited over part of the N½ of Lot 10, Concession 4, Part of Parcel 168 ACS, Aberdeen.	LT113588
228.	31386-0325(LT)	Instrument LT42501 registered April 30, 1959 is an easement from Martin George Jones and Pearl A. Jones to Great Lakes Power Corporation Limited over part of the N½ of Lot 11, Concession 4, Part of Parcel 275 ACS, Aberdeen.	LT113588

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
229.	31386-0279(LT)	Instrument LT42502 registered April 30, 1959 is an easement from David White and Lillian White to Great Lakes Power Corporation Limited over part of the N½ of Lot 12, Concession 4, Part of Parcel 1412 ACS, Aberdeen.	LT113588
230.	31386-0248(LT)	Instrument LT42503 registered April 30, 1959 is an easement from Charles Gordon Wing and Beatrice Maud Wing to Great Lakes Power Corporation Limited over part of the S½ of the S½ of Lot 4, Concession 4, Part of Parcel 3032 ACS, SRO, Aberdeen.	LT113588
231.	31386-0345(LT)	Instrument LT42619 registered May 13, 1959 is an easement from Lydia Rates to Great Lakes Power Corporation Limited over part of Lot 2, Concession 4, Part of Parcel 1286, Aberdeen	LT113588
232.	31386-0301(LT)	Instrument LT42620 registered May 13, 1959 is an easement from Lydia Rates to Great Lakes Power Corporation Limited over part of the S part of Lot 2, Concession 4, Part of Parcel 833 ACS, Aberdeen	LT113588
233.	31386-0447(LT)	Instrument T22926 registered June 3, 1959 is a Right of Way from Minnie May Cort to Great Lakes Power Corporation Limited over part of the S½ of Lot 1, Concession 4, ACS, Aberdeen, part of Parcel 1403, AWS	T220780; T445270
234.	31386-0325(LT)	Instrument LT62044 registered June 16, 1967 is an easement from Martin George Jones and Pearl Aleene Jones to Great Lakes Power Corporation Limited over part of the N½ of Lot 11, Concession 4, Part of Parcel 275 ACS, Aberdeen.	LT113588
235.	31386-0301(LT) 31386-0345(LT)	Instrument LT62114 registered June 28, 1967 is an easement from Lydia Rates to Great Lakes Power Corporation Limited over part of the S½ of Lot 2, Concession 4, Parcel 833 and Part of Parcel 1286, ACS, Aberdeen	LT113588
236.	31386-0329(LT)	Instrument LT62149 registered July 6, 1967 is an easement from Ethel McClelland to Great Lakes Power Corporation Limited over part of the N½ of Lot 10, Concession 4, Part of Parcel 168 ACS, Aberdeen	LT113588
237.	31386-0279(LT)	Instrument LT62304 registered August 3, 1967 is an easement from Harvey James White to Great Lakes Power Corporation Limited over part of the N½ of Lot 12, Concession 4, Part of Parcel 1412 ACS, Aberdeen	LT113588



	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
238.	31386-0248(LT)	Instrument LT64432 registered April 2, 1968 is an easement from Charles Gordon Wing to Great Lakes Power Corporation Limited over part of the S½ of the S½ of Lot 4, Concession 4, Part of Parcel 3032 ACS, SRO, Aberdeen	LT113588
		<b>GALBRAITH:</b>	
239.	31387-0014(LT)	Instrument LT42846 registered June 3, 1959 is an easement from Minnie May Cort to Great Lakes Power Corporation Limited over part of the S½ of Lot 12, Concession 4, Part of Parcel 668 ACS, Galbraith	LT113588
240.	31387-0147(LT)	Instrument LT42965 registered June 17, 1959 is an easement from Russell Hunter and Eileen Hunter to Great Lakes Power Corporation Limited over part of the N½ of Lot 4, Concession 3, Pt of Parcel 233 Algoma, Galbraith	LT113588
241.	31387-0243(LT) 31387-0244(LT)	Instrument T23265 registered June 17, 1959 is an easement from Robert John Hunter and Ruby Hunter to Great Lakes Power Corporation Limited over part of the N½ of Lot 5, Concession 3, Galbraith.	T220780; T445270
242.	31387-0237(LT)	Instrument T23406 registered June 23, 1959 is an easement from Charles Mitchell to Great Lakes Power Corporation Limited over part of Lot 3, Concession 3, Galbraith.	T220780; T445270
243.	31387-0106(LT) 31387-0046(LT)	Instrument LT43021 registered June 24, 1959 is an easement from Cedric Stone and Edith M. Stone to Great Lakes Power Corporation Limited over part of the S½ of Lot 10, Concession 4, Part of Parcel 1108 ACS, Galbraith, now Parcel 4939, ACS, SRO.	LT113588; LT248702
244.	31387-0045(LT)	Instrument LT43036 registered June 25, 1959 is an easement from Fred Daniel Martin to Great Lakes Power Corporation Limited over part of the N½ of Lot 8, Concession 3, Part of Parcel 1063 ACS, Galbraith.	LT113588
245.	31387-0038(LT)	Instrument LT43845 registered September 28, 1959 is an easement from Frederick William Cort and Minnie May Cort to Great Lakes Power Corporation Limited over part of S½ of Lot 9, Concession 4, Part of Parcel 1005 Algoma Central Section, Galbraith.	LT113588
246.	31387-0146(LT)	Instrument LT44665 registered December 29, 1959 is an easement from Murray Bean to Great Lakes Power Corporation Limited over part of the S½ of Lot 1, Concession 3, Part of Parcel 23 ACS, Galbraith	LT113588

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
247.	31387-0243(LT) 31387-0244(LT)	Instrument T27849 registered December 30, 1959 is an easement from Donald W. Hagerty executor of the estate of Charles Henry Trower to Great Lakes Power Corporation Limited over part of the N½ of Lot 5, Concession 3, Galbraith	T220780; T445270
248.	31387-0047(LT)	Instrument LT44883 registered February 5, 1960 is an easement from James MacLeod, Mildred Mary MacLeod and Charles Shultz to Great Lakes Power Corporation Limited over part of S½ of Lot 11, Concession 4, Part of Parcel 1160 Algoma Central Section, Galbraith	LT113588
249.	31387-0146(LT)	Instrument LT62506 registered August 23, 1967 is an easement from Murray Bean to Great Lakes Power Corporation Limited over part of S½ of Lot 1, Concession 3, Part of Parcel 23 ACS, Galbraith	LT113588
250.	31387-0243(LT) 31387-0244(LT)	Instrument T89369 registered September 28, 1967 is an easement from Charles H. Kulpinski to Great Lakes Power Corporation Limited over part of the N½ of Lot 5, Concession 3, Galbraith.	T220780; T445270
251.	31387-0237(LT)	Instrument T89549 registered October 4, 1967 is an easement from Heinrich Janssen to Great Lakes Power Corporation Limited over part of Lot 3, Concession 3, Galbraith.	T220780; T445270
252.	31387-0147(LT)	Instrument LT63372 registered December 1, 1967 is an easement from Eileen Sarah Hunter to Great Lakes Power Corporation Limited over part of the N½ of Lot 4, Concession 3, Part of Parcel 233 Algoma, Galbraith	LT113588
253.	31387-0045(LT)	Instrument LT63596 registered December 5, 1967 is an easement from John Roderick McKenzie and Gertrude May McKenzie to Great Lakes Power Corporation Limited over part of the N½ of Lot 8, Concession 3, Part of Parcel 1063 ACS, Galbraith.	LT113588
254.	31387-0047(LT)	Instrument LT63784 registered December 20, 1967 is an easement from Harvey James MacLeod and Mildred Mary MacLeod to Great Lakes Power Corporation Limited over part of the S½ of Lot 11, Concession 4, Part of Parcel 1160 Algoma Central Section, Galbraith	LT113588

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
255.	31387-0106(LT)	Instrument LT64137 registered February 12, 1968 is an easement from Sydney Delaney and Marjorie Ann Delaney to Great Lakes Power Corporation Limited over part of the S½ of Lot 10, Concession 4, Part of Parcel 4939 Algoma Central Section, SRO, Galbraith	LT113588
256.	31387-0038(LT)	Instrument LT64980 registered June 17, 1968 is an easement from Howard Erkin McEwen to Great Lakes Power Corporation Limited over part of the S½ of Lot 9, Concession 4, Part of Parcel 1005 ACS, Galbraith	LT113588
		<b>HAUGHTON:</b>	
257.	31388-0009(LT)	Instrument LT45264 registered March 31, 1960 is an easement from Percy Edwin Hamilton to Great Lakes Power Corporation Limited over part of the S½ of Lot 5, Concession 2, Part of Parcel 922 ACS, Haughton	LT113588
258.	31388-0009(LT)	Instrument LT66442 registered December 31, 1968 is an easement from Robert McCort Hamilton and Eva May Hamilton, Executors of the Estate of Percy Edwin Hamilton, to Great Lakes Power Corporation Limited over part of the S½ of Lot 5, Concession 2, Part of Parcel 922 ACS, Haughton	LT113588
		<b>GOULD:</b>	
259.	NOT PINNED	Instrument LT43070 registered June 30, 1959 is an easement from John Stanley William Burrows to Great Lakes Power Corporation Limited over part of the S½ of Lot 10, Concession 1, Gould, Part of Parcel 2125, Section ACS	
260.	31389-0013(LT)	Instrument LT47847 registered March 29, 1961 is an easement from Margaret E. Foster to Great Lakes Power Corporation Limited over part of the N½ of Lot 11, Concession 1, Part of Parcel 1841 ACS, Gould.	LT113588
261.	NOT PINNED	Instrument LT62169 registered July 10, 1967 is an easement from John Stanley William Burrows to Great Lakes Power Corporation Limited over part of the S½ of Lot 10, Concession 1, Gould, Part of Parcel 2125, Section ACS	

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
262.	31389-0013(LT)	Instrument LT63866 registered December 29, 1967 is an easement from Gene Montagnaro and Virginia Stewart McEachern Montagnaro to Great Lakes Power Corporation Limited over part of the N½ of Lot 11, Concession 1, Part of Parcel 1841, ACS, Gould	LT113588
		<b>WELLS:</b>	
263.	31410-0106(LT) 31410-0108(LT)	Instrument LT43645 registered September 2, 1959 is an easement from Douglas Gulley to Great Lakes Power Corporation Limited over part of the N part of Lot 7, Concession 6, part of Parcel 5295 ACS, Wells	LT113588
264.	31410-0181(LT)	Instrument LT60266 registered August 2, 1966 is an easement from Herbert Henry Garrod and Mary L. Garrod to Great Lakes Power Corporation Limited over part of the NE¼ of Lot 8, Concession 6, Part of Parcel 1598 Algoma, Wells	LT113588
265.	31410-0003(LT)	Instrument LT60267 registered August 2, 1966 is an easement from Herbert Henry Garrod and Mary L. Garrod to Great Lakes Power Corporation Limited over part of the NW½ of the N½ of Lot 8, Concession 6, Part of Parcel 65 ACS, Wells	LT113588
266.	31410-0003(LT) 31410-0181(LT)	Instrument LT63597 registered December 5, 1967 is an easement from Herbert Henry Garrod and Mary L. Garrod to Great Lakes Power Corporation Limited over part of the N½ of Lot 8, Concession 6, Part of Parcel 65 and Part of Parcel 1598 ACS, Wells	LT11358
267.	31410-0106(LT) 31410-0108(LT)	Instrument LT64240 registered March 1, 1968 is an easement from Douglas Gulley to Great Lakes Power Corporation Limited over part of the E½ of Lot 7, Concession 6, Part of Parcel 5295 ACS, Wells	LT113588
268.	31410-0181(LT)	Instrument LT69743 registered May 22, 1970 is an easement from Herbert Henry Garrod to Great Lakes Power Corporation Limited over Part of Parcel 1598 Algoma, being Part 1, AR972, Wells.	LT113588
269.	31410-0106(LT)	Instrument LT70960 registered December 9, 1970 is an easement from Douglas Gulley and Verna E. Gulley to Great Lakes Power Corporation Limited over Part of Parcel 5295, ACS, being Part 1, AR972, Wells	LT113588

**SCHEDULE "D"**  
**to Deed of Trust**  
**Registry Pins**

**Part II - Registered Easements, Leases, Rights-of-Way and Rights of Occupation**

	<b>PIN</b>	<b>EASEMENT NUMBERS AND PARTICULARS</b>	<b>Related Instruments</b>
		<b>HAVILLAND</b>	
270.	<b>31306-0373(R)</b>	Instrument T13647 registered December 24, 1957 is an easement from Virginia Hetler Globensky and Herbert E. McCauley to Great Lakes Power Corporation Limited over parts of Block D, Plan H-413, Havilland.	T445269; T445270; T467856
		<b>VAN KOUGHNET</b>	
271.	<b>31344-0164(R)</b>	Instrument LC278 registered July 10, 1934 is an easement from Peter A. Jones, Agness Jones and Francis McKie to The Algoma District Power Company Limited over part of the W½ of the SW¼ of Section 7, Van Koughnet.	T220780; T445270
272.	<b>31344-0188(R)</b>	Instrument LC282 registered November 7, 1934 is an easement from Isadore Rosenstein and Sarah Rosenstein to Great Lakes Power Company Limited over part of the S½ of the NW¼ and part of E½ of the SW¼ of Section 6, Van Koughnet.	T445270; T467856
273.	<b>31344-0188(R)</b>	Instrument LC412 registered May 18, 1949 is an easement from Lynch Timber Company to Great Lakes Power Corporation Limited over part of the E½ of the NW¼ of Section 7, Van Koughnet.	T220780; T445270; T467856
274.	<b>31344-0164(R)</b>	Instrument T8554 registered February 15, 1957 is an easement from Vaino Nikolai Gronroos Green and Margaret Ann Green to Great Lakes Power Corporation Limited over Part of the W½ of the SW¼ of Section 7, Van Koughnet.	T445269; T445270
275.	<b>31344-0188(R)</b>	Instrument T34321 registered November 7, 1960 is an easement from Algoma Forest Products Limited to Great Lakes Power Corporation Limited over part of the N½ of the NW¼ of Section 6, Van Koughnet.	T445269; T445270; T467886;
		<b>FENWICK</b>	
276.	<b>31346-0292(R)</b>	Instrument T15842 registered May 22, 1958 is an easement from Amelia Nardi to Great Lakes Power Corporation Limited over Part of the NW¼ of Section 25, Fenwick.	T220780; T445270; T467856

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>PENNEFATHER</b>	
277.	31350-0233(R)	Instrument AC162 registered October 1, 1931 is an easement from Elizabeth J. Dunseath to The Algoma District Power Company Limited over Part of the SE¼ of Section 25, Pennefather	T220780; T445270; T467856
278.	31350-0232(R)	Instrument AC163 registered March 1, 1932 is an easement from Alfred Benninghaus and Estella Benninghaus to Great Lakes Power Company Limited over Part of the S½ of the NE¼ and the N½ of the SE¼ of Section 24, Pennefather	T220780; T445270; T467856
279.	31350-0230(R)	Instrument No. AC175 registered July 10, 1934 is an easement from Thomas John McCauley and Sarah M. McCauley to Great Lakes Power Company Limited over Part of the NE¼ of Section 1, Pennefather.	T220780; T445269; T445270; T467856
280.	31350-0233(R)	Instrument AC183 registered November 7, 1934 is an easement from Isadore Rosenstein and Sarah Rosenstein to Great Lakes Power Company Limited over part of the S½ of the NE¼ of Section 25, Pennefather.	T445270; T220780; T467856
281.	31350-0235(R)	Instrument AC185 registered November 24, 1934 is an easement from Fred W. McDowell and Ellen McDowell to The Algoma District Power Company Limited over part of the W½ of the NE¼ of Section 36, Pennefather.	T220780; T445270; T467886;
		<b>TARENTORUS, SECTION 7</b>	
282.	31508-0062(R) 31508-0063(R)	Instrument B2790 registered July 24, 1934 is an easement from William J. Money and Elizabeth Money to The Algoma District Power Company Limited over Part of N½ of the NW¼ of Section 7, Tarentorus.	T220780; T445270; T467856
283.	31508-0062(R) 31508-0063(R)	Instrument T11483 registered August 12, 1957 is an easement from Hector C. Maitland and Thelma V. Maitland to Great Lakes Power Corporation Limited over part of the S½ of N½ of the NW¼ of Section 7, Tarentorus.	T220780; T445270; T467856
		<b>TARENTORUS, SECTION 18</b>	
284.	31564-0029(R)	Instrument B2796 registered July 24, 1934 is an easement from John Kaunista and Selina Kaunista to The Algoma District Power Company Limited over part of the S½ of the SW¼ of Section 18, Tarentorus.	T220780; T445270; T467856

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
285.	31564-0029(R)	Instrument B2812 registered October 1, 1934 is an easement from Gilbert H. Johnston and Lila May Johnston to The Algoma District Power Company Limited over part of the S½ of the SW¼ of Section 18, Tarentorus.	T220780; T445270; T467856
286.	31564-0029(R)	Instrument T21880 registered April 17, 1959 is an easement from The Director, The Veterans' Land Act to Great Lakes Power Corporation Limited over part of the SW¼ of Section 18, Tarentorus.	T220780; T445270; T467856
287.	31564-0029(R)	Instrument T43217 registered December 7, 1961 is an easement from Frank Lariviere and Wilhemina Lariviere to Great Lakes Power Corporation Limited over Part of the S½ of the SW¼ of Section 18, Tarentorus.	T220780; T445270; T467856
288.	31564-0029(R)	Instrument T83602 registered December 7, 1966 is a right-of-way from Clifford L. Corbett and Shirley A. Corbett to Great Lakes Power Corporation Limited over part of the S¼ of Section 18, Tarentorus	
		<b>TARENTORUS, SECTION 19</b>	
289.	31563-0038(R)	Instrument B2801 registered July 24, 1934 is an easement from George H. Farmer, Wesley J. Farmer, Margaret I. Farmer and Mary J. Farmer to The Algoma District Power Company Limited over Part N½ of the SW¼ of Section 19, Tarentorus.	T220780; T445270; T467856
290.	31563-0038(R)	Instrument T10417 registered June 14, 1957 is an easement from Wesley J. Farmer and Margaret I. Farmer to Great Lakes Power Corporation Limited over part of the N½ of the SW¼ of Section 19, Tarentorus.	T220780; T445270; T467856

	PIN	EASEMENT NUMBERS AND PARTICULARS	Related Instruments
		<b>KORAH</b>	
291.	31582-0010(R) 31582-0011(R)	Instrument T7682 registered November 28, 1956 is an easement from Alistair Royce Dickinson and Theresa Mary Dickinson to Great Lakes Power Corporation Limited over Part of Lot 19, Laura Wesley Subdivision 2, Plan 12898, Korah	T220780; T467887; T467888 (as to 31582-0010 only) and T467898 (as to 31582-0011 only)
292.	31582-0036(R)	Instrument T7194 registered October 29, 1956 is an easement from Samuel B. Dickinson to Great Lakes Power Corporation Limited over part of Lot 19, Laura Wesley Subdivision 2, Korah, Plan 12898	T220780; T467887; T467888
293.	31609-0176(R)	Instrument T-393141 registered January 20, 1998 is an easement from Algoma Steel Inc. to Great Lakes Power Limited over Parts 9, 10, 11, 12, 13, 14, 16 and 17, Plan 1R-9346 and registered in the Algoma Land Titles division against certain absolute and qualified land titles lands as in instrument LT216273.	
294.	31609-0176(R)	Instrument LT216273 registered January 20, 1998 is an easement from Algoma Steel Inc. to Great Lakes Power Limited over Parts 9, 10, 11, 12, 13, 14, 16 and 17, Plan 1R-9346.	
		<b>GALBRAITH</b>	
295.	31387-0239(R)	Instrument T23264 registered June 17, 1959 is an easement from William C. Foster and Margaret Foster to Great Lakes Power Corporation Limited over part of the S½ of Lot 4, Concession 3 Galbraith.	T220780; T445270
296.	31387-0239(R)	Instrument T90667 registered November 27, 1967 is an easement from William C. Foster to Great Lakes Power Corporation Limited over part of the S½ of Lot 4, Concession 3, Galbraith.	T220780; T445270



## SCHEDULE E

### CONFIDENTIALITY AGREEMENT

THIS CONFIDENTIALITY AGREEMENT is made as of •, 20• between GREAT LAKES POWER LIMITED (the "Company") and •, (the "Recipient").

WHEREAS the Recipient is the holder or the agent of a holder of a Bond issued under and entitled to the benefit of a deed of trust dated as of March \_\_, 2008 (the "**Original Deed of Trust**"), and, as supplemented by the first supplemental trust indenture dated as of March \_\_, 2008 and as each such document may from time to time be amended, modified, supplemented, revised, restated or replaced, collectively, the "**Deed of Trust**") between the Company and CIBC Mellon Trust Company as trustee;

AND WHEREAS pursuant to Section 6.22 of the Original Deed of Trust, the Recipient has certain rights of inspection over the records of the Company, subject, at the Company's request, to signing a confidentiality agreement in the form of this Agreement;

AND WHEREAS the Recipient desires to exercise its rights of inspection and the Company has requested that the Recipient enter into this Agreement;

NOW THEREFORE, in consideration of the premises and the covenants and agreements herein contained, the parties agree as follows:

1. The following terms shall have the meanings herein set forth:

"Agreement" means this agreement, including its recitals, as amended or replaced from time to time.

"Confidential Information" means information provided to the Recipient by or on behalf of the Company specifically in connection with the rights of inspection contemplated by the recitals hereto or otherwise pursuant to this Agreement that is proprietary in nature and that is identified as being confidential information of the Company, provided that such term does not include information that:

- (a) was publicly known or otherwise known to the Recipient prior to the time of such disclosure,
- (b) subsequently becomes publicly known through no act or omission by the Recipient or any person acting on the Recipient's behalf;
- (c) otherwise becomes known to the Recipient other than through disclosure by the Company; or
- (d) constitutes financial statements delivered to the Recipient that are otherwise publicly available.

2. The Recipient will maintain the confidentiality of Confidential Information in accordance with procedures adopted by the Recipient in good faith to protect confidential information of third parties delivered to it, provided that the Recipient may deliver or disclose Confidential Information to:
  - (a) the directors, officers, employees, agents, lawyers and affiliates of the Recipient;
  - (b) its financial advisors and other professional advisors who agree to hold in confidence the Confidential Information substantially in accordance with the terms of this Section 2;
  - (c) any holder of any Bond;
  - (d) any person to which the Recipient sells or offers to sell such Bond or any part thereof or any participation therein (if such person has agreed in writing prior to its receipt of such Confidential Information to be bound by the provisions of this Section 2);
  - (e) any federal, state or provincial regulatory authority having jurisdiction over the Recipient;
  - (f) the National Association of Insurance Commissioners or any similar organization;  
or
  - (g) any other person to which such delivery or disclosure may be necessary or required as a matter of law.
3. Nothing contained herein will be deemed to create any partnership, joint venture or relationship of principal and agent between the parties or to provide either party with the right, power or authority, whether express or implied, to create any duty or obligation on behalf of the other party.
4. This Agreement will enure to the benefit of and be binding upon the respective successors and permitted assigns of the parties.
5. This Agreement is governed by and will be construed in accordance with the laws of the Province of Ontario and the laws of Canada applicable therein.
6. This Agreement may be executed in any number of counterparts, each of which will be deemed to be an original and all of which taken together will be deemed to constitute one and the same instrument.
7. Delivery of an executed signature page to this Agreement by any party by electronic transmission will be as effective as delivery of a manually executed copy of the Agreement by such party.

IN WITNESS WHEREOF the parties have executed this Agreement.

**GREAT LAKES POWER LIMITED**

Per: \_\_\_\_\_  
(Authorized Signatory)

Per: \_\_\_\_\_  
(Authorized Signatory)

•

Per: \_\_\_\_\_  
(Authorized Signatory)

Per: \_\_\_\_\_  
(Authorized Signatory)

**SCHEDULE "F"**  
**to Deed of Trust**  
**Exceptions as to Title**

1. The following Transmission Property Rights which have not been assigned by GLPT but are held by GLPL in trust pending obtaining the necessary consents to assignment:
  - (a) Agreement dated July 25, 1984 between Her Majesty the Queen in Right of Canada, as represented by the Minister of Indian Affairs and Northern Development, and Great Lakes Power Corporation Limited;
  - (b) License originally between Algoma Central Corporation (now Three Lakes Land Company) and GLPL dated as of February 1, 1998; and
  - (c) Certain road, railway and wire crossing permits, licenses or agreements.
2. A proposed sublicense to be granted by GLPL in favour of GLPT of certain lands licensed to GLPL pursuant to a License of Occupation dated January 1, 1989, originally between Algoma Central Railway and GLPL, as assigned, amended, supplemented and restated from time to time (which proposed sublicense may require consent that has not been obtained).
3. Proposed sublicenses from 3011651 Nova Scotia Limited (as successor to Algoma Central Corporation) under Non-Exclusive License Agreements dated February 1, 1993 and September 1, 1988 and all consents required for the creation of such sublicenses and the charging of such sublicenses that have not been obtained.
4. A new license agreement is required to replace the License originally between 3011650 Nova Scotia Limited and GLPL dated as of July 1, 1999 (which will be pursued from the current owner of the affected lands).
5. Other easements, licenses or rights forming part of the Transmission Property Rights which may have issues affecting their validity provided that such issues have not resulted in and do not result in an interruption in GLPT's access to and use of such Transmission Property Rights or GLPT's ability to operate the Transmission Business and provided that neither GLPL nor GLPT has received notice from any other person contesting the validity of thereof.
6. Instrument No. AC176 registered July 10, 1934 is an easement from Thomas J. McCauley and Sarah M. McCauley to The Algoma District Power Company over Part of the S $\frac{1}{2}$  of the SE $\frac{1}{4}$  of Section 13 and part of the N $\frac{1}{2}$  of the NE $\frac{1}{4}$  of Section 24, Pennefather.
7. Instrument T77424 registered February 25, 1966 is an easement from W.E. Muncaster to Great Lakes Power Corporation Limited over part of the SE $\frac{1}{4}$  of Section 18, Tarentorus.

8. Instrument T83602 registered December 7, 1966 is a right-of-way from Clifford L. Corbett and Shirley A. Corbett to Great Lakes Power Corporation Limited over part of the S¼ of Section 18, Tarentorus.
9. Other easements, licenses or rights forming part of the Transmission Property Rights which may have issues affecting their validity provided that such issues have not resulted in and do not result in an interruption in GLPT's ability to operate the Transmission Business and provided that neither GLPL nor GLPT has received notice from any other person contesting the validity of thereof.

**SCHEDULE G  
 CALCULATIONS**

Calendar Month	EBITDA/Projected EBITDA	Debt Service	Coverage
Total			

<b>Senior Debt</b>	
Term	• years
Principal	•
Interest	•%
<b>Subordinate Debt</b>	
Term	• years
Principal	•
Interest	•%
	Annual
Senior Debt	•
Subordinate Debt	•



## REVENUE REQUIREMENT WORK FORM

Name of LDC:  (1)  
File Number:   
Rate Year:  Version: 1.0

### Table of Content

<u>Sheet</u>	<u>Name</u>
A	<a href="#">Data Input Sheet</a>
1	<a href="#">Rate Base</a>
2	<a href="#">Utility Income</a>
3	<a href="#">Taxes/PILS</a>
4	<a href="#">Capitalization/Cost of Capital</a>
5	<a href="#">Revenue Sufficiency/Deficiency</a>
6	<a href="#">Revenue Requirement</a>
7	<a href="#">Bill Impacts</a>

#### Notes:

(1) Pale green cells represent inputs

(2) **Please note that this model uses MACROS. Before starting, please ensure that macros have been enabled.**

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## REVENUE REQUIREMENT WORK FORM

Name of LDC: Great Lakes Power Transmission LP

File Number: EB-2009-0408

Rate Year: 2010

		Data Input				(1)
		Application	Adjustments		Per Board Decision	
<b>1</b>	<b>Rate Base</b>					
	Gross Fixed Assets (average)	\$285,382,423	(4)		\$285,382,423	
	Accumulated Depreciation (average)	(\$76,784,441)	(5)		(\$76,784,441)	
	<b>Allowance for Working Capital:</b>					
	Controllable Expenses	\$11,105,600	(6)		\$11,105,600	
	Cost of Power	\$ -			\$0	
	Working Capital Rate (%)	3.61%			3.61%	
<b>2</b>	<b>Utility Income</b>					
	<b>Operating Revenues:</b>					
	Distribution Revenue at Current Rates	\$34,696,200				
	Distribution Revenue at Proposed Rates	\$39,357,900				
	<b>Other Revenue:</b>					
	Specific Service Charges	\$ -				
	Late Payment Charges	\$ -				
	Other Distribution Revenue	\$ -				
	Other Income and Deductions	\$7,200				
	<b>Operating Expenses:</b>					
	OM+A Expenses	\$11,105,600			\$11,105,600	
	Depreciation/Amortization	\$7,406,900			\$7,406,900	
	Property taxes	\$258,200			\$258,200	
	Capital taxes	\$145,500				
	Other expenses	\$ -			\$0	
<b>3</b>	<b>Taxes/PILs</b>					
	<b>Taxable Income:</b>					
	Adjustments required to arrive at taxable income	(\$2,957,500)	(3)			
	<b>Utility Income Taxes and Rates:</b>					
	Income taxes (not grossed up)	\$1,974,417				
	Income taxes (grossed up)	\$2,861,475				
	Capital Taxes	\$145,500				
	Federal tax (%)	18.00%				
	Provincial tax (%)	13.00%				
	Income Tax Credits	\$ -				
<b>4</b>	<b>Capitalization/Cost of Capital</b>					
	<b>Capital Structure:</b>					
	Long-term debt Capitalization Ratio (%)	57.5%				
	Short-term debt Capitalization Ratio (%)	0.0%	(2)			(2)
	Common Equity Capitalization Ratio (%)	42.5%				
	Preferred Shares Capitalization Ratio (%)	0.0%				
					Capital Structure must total 100%	
	<b>Cost of Capital</b>					
	Long-term debt Cost Rate (%)	6.87%				
	Short-term debt Cost Rate (%)	0.00%				
	Common Equity Cost Rate (%)	10.50%				
	Preferred Shares Cost Rate (%)	0.00%				

**Notes:**

This input sheet provides all inputs needed to complete sheets 1 through 6 (Rate Base through Revenue Requirement), except for Notes that the utility may wish to use to support the components. Notes should be put on the applicable pages to understand the context of each such note.

- (1) All inputs are in dollars (\$) except where inputs are individually identified as percentages (%)
- (2) 4.0% unless an Applicant has proposed or been approved for another amount.
- (3) Net of addbacks and deductions to arrive at taxable income.
- (4) Average of Gross Fixed Assets at beginning and end of the Test Year
- (5) Average of Accumulated Depreciation at the beginning and end of the Test Year. Enter as a negative amount.





## REVENUE REQUIREMENT WORK FORM

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

				Rate Base		
Line No.	Particulars		Application	Adjustments	Per Board Decision	
1	Gross Fixed Assets (average)	(3)	\$285,382,423	\$ -	\$285,382,423	
2	Accumulated Depreciation (average)	(3)	(\$76,784,441)	\$ -	(\$76,784,441)	
3	Net Fixed Assets (average)	(3)	\$208,597,982	\$ -	\$208,597,982	
4	Allowance for Working Capital	(1)	\$401,200	\$ -	\$401,200	
5	<b>Total Rate Base</b>		<b>\$208,999,182</b>	<b>\$ -</b>	<b>\$208,999,182</b>	

(1) Allowance for Working Capital - Derivation					
6	Controllable Expenses		\$11,105,600	\$ -	\$11,105,600
7	Cost of Power		\$ -	\$ -	\$ -
8	Working Capital Base		\$11,105,600	\$ -	\$11,105,600
9	Working Capital Rate %	(2)	3.61%		3.61%
10	Working Capital Allowance		\$401,200	\$ -	\$401,200

**Notes**

- (2) Generally 15%. Some distributors may have a unique rate due as a result of a lead-lag study.
- (3) Average of opening and closing balances for the year.



## REVENUE REQUIREMENT WORK FORM

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

### Utility income

Line No.	Particulars	Application	Adjustments	Per Board Decision
<b>Operating Revenues:</b>				
1	Distribution Revenue (at Proposed Rates)	\$39,357,900	\$ -	\$39,357,900
2	Other Revenue	(1) \$7,200	\$ -	\$7,200
3	<b>Total Operating Revenues</b>	<b>\$39,365,100</b>	<b>\$ -</b>	<b>\$39,365,100</b>
<b>Operating Expenses:</b>				
4	OM+A Expenses	\$11,105,600	\$ -	\$11,105,600
5	Depreciation/Amortization	\$7,406,900	\$ -	\$7,406,900
6	Property taxes	\$258,200	\$ -	\$258,200
7	Capital taxes	\$145,500	\$ -	\$145,500
8	Other expense	\$ -	\$ -	\$ -
9	<b>Subtotal</b>	<b>\$18,916,200</b>	<b>\$ -</b>	<b>\$18,916,200</b>
10	Deemed Interest Expense	\$8,260,797	\$ -	\$8,260,797
11	<b>Total Expenses (lines 4 to 10)</b>	<b>\$27,176,997</b>	<b>\$ -</b>	<b>\$27,176,997</b>
12	<b>Utility income before income taxes</b>	<b>\$12,188,103</b>	<b>\$ -</b>	<b>\$12,188,103</b>
13	Income taxes (grossed-up)	\$2,861,475	\$ -	\$2,861,475
14	<b>Utility net income</b>	<b>\$9,326,628</b>	<b>\$ -</b>	<b>\$9,326,628</b>

**Notes**

(1)	<b>Other Revenues / Revenue Offsets</b>		
	Specific Service Charges	\$ -	\$ -
	Late Payment Charges	\$ -	\$ -
	Other Distribution Revenue	\$ -	\$ -
	Other Income and Deductions	\$7,200	\$7,200
	<b>Total Revenue Offsets</b>	<b>\$7,200</b>	<b>\$7,200</b>



## REVENUE REQUIREMENT WORK FORM

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

Taxes/PILs			
Line No.	Particulars	Application	Per Board Decision
<b><u>Determination of Taxable Income</u></b>			
1	Utility net income	\$9,326,588	\$9,326,588
2	Adjustments required to arrive at taxable utility income	(\$2,957,500)	(\$2,957,500)
3	Taxable income	\$6,369,088	\$6,369,088
<b><u>Calculation of Utility income Taxes</u></b>			
4	Income taxes	\$1,974,417	\$1,974,417
5	Capital taxes	\$145,500	\$145,500
6	Total taxes	\$2,119,917	\$2,119,917
7	Gross-up of Income Taxes	\$887,057	\$887,057
8	Grossed-up Income Taxes	\$2,861,475	\$2,861,475
9	PILs / tax Allowance (Grossed-up Income taxes + Capital taxes)	\$3,006,975	\$3,006,975
10	Other tax Credits	\$ -	\$ -
<b><u>Tax Rates</u></b>			
11	Federal tax (%)	18.00%	18.00%
12	Provincial tax (%)	13.00%	13.00%
13	Total tax rate (%)	31.00%	31.00%

**Notes**



## REVENUE REQUIREMENT WORK FORM

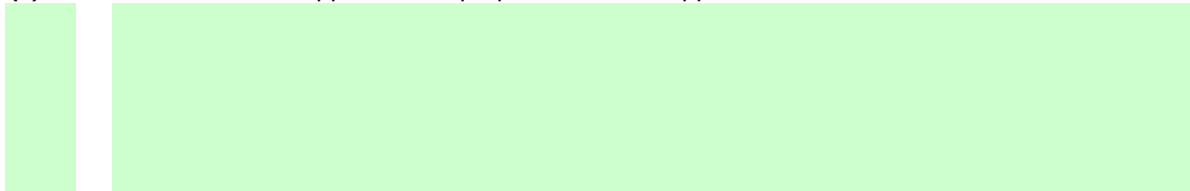
Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

### Capitalization/Cost of Capital

Line No.	Particulars	Capitalization Ratio		Cost Rate	Return
		(%)	(\$)	(%)	(\$)
<b>Application</b>					
<b>Debt</b>					
1	Long-term Debt	57.50%	\$120,174,530	6.87%	\$8,260,797
2	Short-term Debt	0.00%	\$ -	0.00%	\$ -
3	<b>Total Debt</b>	57.50%	\$120,174,530	6.87%	\$8,260,797
<b>Equity</b>					
4	Common Equity	42.50%	\$88,824,652	10.50%	\$9,326,588
5	Preferred Shares	0.00%	\$ -	0.00%	\$ -
6	<b>Total Equity</b>	42.50%	\$88,824,652	10.50%	\$9,326,588
7	<b>Total</b>	100%	\$208,999,182	8.42%	\$17,587,386
<b>Per Board Decision</b>					
<b>Debt</b>					
8	Long-term Debt	57.50%	\$120,174,530	6.87%	\$8,260,797
9	Short-term Debt	0.00%	\$ -	0.00%	\$ -
10	<b>Total Debt</b>	57.50%	\$120,174,530	6.87%	\$8,260,797
<b>Equity</b>					
11	Common Equity	42.5%	\$88,824,652	10.50%	\$9,326,588
12	Preferred Shares	0.0%	\$ -	0.00%	\$ -
13	<b>Total Equity</b>	42.5%	\$88,824,652	10.50%	\$9,326,588
14	<b>Total</b>	100%	\$208,999,182	8.42%	\$17,587,386

**Notes**

(1) 4.0% unless an Applicant has proposed or been approved for another amount.





## REVENUE REQUIREMENT WORK FORM

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

### Revenue Sufficiency/Deficiency

Line No.	Particulars	Per Application		Per Board Decision	
		At Current Approved Rates	At Proposed Rates	At Current Approved Rates	At Proposed Rates
1	Revenue Deficiency from Below		\$4,661,660		\$4,661,660
2	Distribution Revenue	\$34,696,200	\$34,696,240	\$34,696,200	\$34,696,240
3	Other Operating Revenue Offsets - net	\$7,200	\$7,200	\$7,200	\$7,200
4	<b>Total Revenue</b>	<b>\$34,703,400</b>	<b>\$39,365,100</b>	<b>\$34,703,400</b>	<b>\$39,365,100</b>
5	Operating Expenses	\$18,916,200	\$18,916,200	\$18,916,200	\$18,916,200
6	Deemed Interest Expense	\$8,260,797	\$8,260,797	\$8,260,797	\$8,260,797
	<b>Total Cost and Expenses</b>	<b>\$27,176,997</b>	<b>\$27,176,997</b>	<b>\$27,176,997</b>	<b>\$27,176,997</b>
7	<b>Utility Income Before Income Taxes</b>	<b>\$7,526,403</b>	<b>\$12,188,103</b>	<b>\$7,526,403</b>	<b>\$12,188,103</b>
8	Tax Adjustments to Accounting Income per 2009 PILs	(\$2,957,500)	(\$2,957,500)	(\$2,957,500)	(\$2,957,500)
9	<b>Taxable Income</b>	<b>\$4,568,903</b>	<b>\$9,230,603</b>	<b>\$4,568,903</b>	<b>\$9,230,603</b>
10	Income Tax Rate	31.00%	31.00%	31.00%	31.00%
11	<b>Income Tax on Taxable Income</b>	<b>\$1,416,360</b>	<b>\$2,861,487</b>	<b>\$1,416,360</b>	<b>\$2,861,487</b>
12	<b>Income Tax Credits</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>
13	<b>Utility Net Income</b>	<b>\$6,110,043</b>	<b>\$9,326,628</b>	<b>\$6,110,043</b>	<b>\$9,326,628</b>
14	<b>Utility Rate Base</b>	<b>\$208,999,182</b>	<b>\$208,999,182</b>	<b>\$208,999,182</b>	<b>\$208,999,182</b>
	Deemed Equity Portion of Rate Base	\$88,824,652	\$88,824,652	\$88,824,652	\$88,824,652
15	Income/Equity Rate Base (%)	6.88%	10.50%	6.88%	10.50%
16	Target Return - Equity on Rate Base	10.50%	10.50%	10.50%	10.50%
	Sufficiency/Deficiency in Return on Equity	-3.62%	0.00%	-3.62%	0.00%
17	Indicated Rate of Return	6.88%	8.42%	6.88%	8.42%
18	Requested Rate of Return on Rate Base	8.42%	8.42%	8.42%	8.42%
19	Sufficiency/Deficiency in Rate of Return	-1.54%	0.00%	-1.54%	0.00%
20	Target Return on Equity	\$9,326,588	\$9,326,588	\$9,326,588	\$9,326,588
21	Revenue Sufficiency/Deficiency	\$3,216,546	\$40	\$3,216,546	\$40
22	<b>Gross Revenue Sufficiency/Deficiency</b>	<b>\$4,661,660 (1)</b>		<b>\$4,661,660 (1)</b>	

**Notes:**

(1) Revenue Sufficiency/Deficiency divided by (1 - Tax Rate)



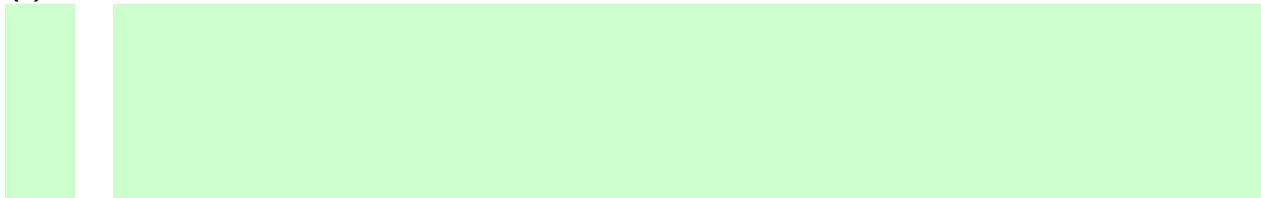
## REVENUE REQUIREMENT WORK FORM

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

Line No.	Particulars	Revenue Requirement	
		Application	Per Board Decision
1	OM&A Expenses	\$11,105,600	\$11,105,600
2	Amortization/Depreciation	\$7,406,900	\$7,406,900
3	Property Taxes	\$258,200	\$258,200
4	Capital Taxes	\$145,500	\$145,500
5	Income Taxes (Grossed up)	\$2,861,475	\$2,861,475
6	Other Expenses	\$ -	\$ -
7	Return		
	Deemed Interest Expense	\$8,260,797	\$8,260,797
	Return on Deemed Equity	\$9,326,588	\$9,326,588
8	Distribution Revenue Requirement before Revenues	<u>\$39,365,060</u>	<u>\$39,365,060</u>
9	Distribution revenue	\$39,357,900	\$39,357,900
10	Other revenue	<u>\$7,200</u>	<u>\$7,200</u>
11	<b>Total revenue</b>	<u>\$39,365,100</u>	<u>\$39,365,100</u>
12	<b>Difference (Total Revenue Less Distribution Revenue Requirement before Revenues)</b>	<u>\$40 (1)</u>	<u>\$40 (1)</u>

**Notes**

(1) Line 11 - Line 8





**REVENUE REQUIREMENT WORK FORM**

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

**Selected Delivery Charge and Bill Impacts  
 Per Draft Rate Order**

		Monthly Delivery Charge				Total Bill			
		Current	Per Draft Rate Order	Change		Current	Per Draft Rate Order	Change	
				\$	%			\$	%
<b>Residential</b>	<b>800 kWh/month</b>			\$ -				\$ -	
<b>GS &lt; 50kW</b>	<b>2000 kWh/month</b>			\$ -				\$ -	

Notes:



## REVENUE REQUIREMENT WORK FORM

Name of LDC:  (1)  
File Number:   
Rate Year:  Version: 1.0

### Table of Content

<u>Sheet</u>	<u>Name</u>
A	<a href="#">Data Input Sheet</a>
1	<a href="#">Rate Base</a>
2	<a href="#">Utility Income</a>
3	<a href="#">Taxes/PILS</a>
4	<a href="#">Capitalization/Cost of Capital</a>
5	<a href="#">Revenue Sufficiency/Deficiency</a>
6	<a href="#">Revenue Requirement</a>
7	<a href="#">Bill Impacts</a>

#### Notes:

(1) Pale green cells represent inputs

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## REVENUE REQUIREMENT WORK FORM

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

		Data Input				(1)
		Application	Adjustments		Per Board Decision	
<b>1</b>	<b>Rate Base</b>					
	Gross Fixed Assets (average)	\$285,382,423	(4)		\$285,382,423	
	Accumulated Depreciation (average)	(\$76,784,441)	(5)		(\$76,784,441)	
	<b>Allowance for Working Capital:</b>					
	Controllable Expenses	\$11,105,600	(6)		\$11,105,600	
	Cost of Power	\$ -			\$0	
	Working Capital Rate (%)	3.61%			3.61%	
<b>2</b>	<b>Utility Income</b>					
	<b>Operating Revenues:</b>					
	Distribution Revenue at Current Rates	\$34,696,200				
	Distribution Revenue at Proposed Rates	\$38,907,826				
	<b>Other Revenue:</b>					
	Specific Service Charges	\$ -				
	Late Payment Charges	\$ -				
	Other Distribution Revenue	\$ -				
	Other Income and Deductions	\$7,200				
	<b>Operating Expenses:</b>					
	OM+A Expenses	\$11,105,600			\$11,105,600	
	Depreciation/Amortization	\$7,406,900			\$7,406,900	
	Property taxes	\$258,200			\$258,200	
	Capital taxes	\$145,500				
	Other expenses	\$ -			\$0	
<b>3</b>	<b>Taxes/PILs</b>					
	<b>Taxable Income:</b>					
	Adjustments required to arrive at taxable income	(\$2,957,500)	(3)			
	<b>Utility Income Taxes and Rates:</b>					
	Income taxes (not grossed up)	\$1,954,981				
	Income taxes (grossed up)	\$2,833,305				
	Capital Taxes	\$145,500				
	Federal tax (%)	18.00%				
	Provincial tax (%)	13.00%				
	Income Tax Credits	\$ -				
<b>4</b>	<b>Capitalization/Cost of Capital</b>					
	<b>Capital Structure:</b>					
	Long-term debt Capitalization Ratio (%)	55.0%				
	Short-term debt Capitalization Ratio (%)	0.0%	(2)			(2)
	Common Equity Capitalization Ratio (%)	45.0%				
	Preferred Shares Capitalization Ratio (%)	0.0%				
					Capital Structure must total 100%	
	<b>Cost of Capital</b>					
	Long-term debt Cost Rate (%)	6.87%				
	Short-term debt Cost Rate (%)	0.00%				
	Common Equity Cost Rate (%)	9.85%				
	Preferred Shares Cost Rate (%)	0.00%				

**Notes:**

This input sheet provides all inputs needed to complete sheets 1 through 6 (Rate Base through Revenue Requirement), except for Notes that the utility may wish to use to support the components. Notes should be put on the applicable pages to understand the context of each such note.

- (1) All inputs are in dollars (\$) except where inputs are individually identified as percentages (%)
- (2) 4.0% unless an Applicant has proposed or been approved for another amount.
- (3) Net of addbacks and deductions to arrive at taxable income.
- (4) Average of Gross Fixed Assets at beginning and end of the Test Year
- (5) Average of Accumulated Depreciation at the beginning and end of the Test Year. Enter as a negative amount.



## REVENUE REQUIREMENT WORK FORM

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

				Rate Base		
Line No.	Particulars		Application	Adjustments	Per Board Decision	
1	Gross Fixed Assets (average)	(3)	\$285,382,423	\$ -	\$285,382,423	
2	Accumulated Depreciation (average)	(3)	(\$76,784,441)	\$ -	(\$76,784,441)	
3	Net Fixed Assets (average)	(3)	\$208,597,982	\$ -	\$208,597,982	
4	Allowance for Working Capital	(1)	\$401,200	\$ -	\$401,200	
5	<b>Total Rate Base</b>		<b>\$208,999,182</b>	<b>\$ -</b>	<b>\$208,999,182</b>	

(1) Allowance for Working Capital - Derivation					
6	Controllable Expenses		\$11,105,600	\$ -	\$11,105,600
7	Cost of Power		\$ -	\$ -	\$ -
8	Working Capital Base		\$11,105,600	\$ -	\$11,105,600
9	Working Capital Rate %	(2)	3.61%		3.61%
10	Working Capital Allowance		\$401,200	\$ -	\$401,200

### Notes

- (2) Generally 15%. Some distributors may have a unique rate due as a result of a lead-lag study.  
 (3) Average of opening and closing balances for the year.



## REVENUE REQUIREMENT WORK FORM

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

### Utility income

Line No.	Particulars	Application	Adjustments	Per Board Decision
<b>Operating Revenues:</b>				
1	Distribution Revenue (at Proposed Rates)	\$38,907,826	\$ -	\$38,907,826
2	Other Revenue	(1) \$7,200	\$ -	\$7,200
3	<b>Total Operating Revenues</b>	<b>\$38,915,026</b>	<b>\$ -</b>	<b>\$38,915,026</b>
<b>Operating Expenses:</b>				
4	OM+A Expenses	\$11,105,600	\$ -	\$11,105,600
5	Depreciation/Amortization	\$7,406,900	\$ -	\$7,406,900
6	Property taxes	\$258,200	\$ -	\$258,200
7	Capital taxes	\$145,500	\$ -	\$145,500
8	Other expense	\$ -	\$ -	\$ -
9	<b>Subtotal</b>	<b>\$18,916,200</b>	<b>\$ -</b>	<b>\$18,916,200</b>
10	Deemed Interest Expense	\$7,901,632	\$ -	\$7,901,632
11	<b>Total Expenses (lines 4 to 10)</b>	<b>\$26,817,832</b>	<b>\$ -</b>	<b>\$26,817,832</b>
12	<b>Utility income before income taxes</b>	<b>\$12,097,194</b>	<b>\$ -</b>	<b>\$12,097,194</b>
13	Income taxes (grossed-up)	\$2,833,305	\$ -	\$2,833,305
14	<b>Utility net income</b>	<b>\$9,263,889</b>	<b>\$ -</b>	<b>\$9,263,889</b>

#### Notes

(1)	<b>Other Revenues / Revenue Offsets</b>		
	Specific Service Charges	\$ -	\$ -
	Late Payment Charges	\$ -	\$ -
	Other Distribution Revenue	\$ -	\$ -
	Other Income and Deductions	\$7,200	\$7,200
	<b>Total Revenue Offsets</b>	<b>\$7,200</b>	<b>\$7,200</b>



## REVENUE REQUIREMENT WORK FORM

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

Taxes/PILs			
Line No.	Particulars	Application	Per Board Decision
<b><u>Determination of Taxable Income</u></b>			
1	Utility net income	\$9,263,889	\$9,263,889
2	Adjustments required to arrive at taxable utility income	(\$2,957,500)	(\$2,957,500)
3	Taxable income	\$6,306,389	\$6,306,389
<b><u>Calculation of Utility income Taxes</u></b>			
4	Income taxes	\$1,954,981	\$1,954,981
5	Capital taxes	\$145,500	\$145,500
6	Total taxes	\$2,100,481	\$2,100,481
7	Gross-up of Income Taxes	\$878,325	\$878,325
8	Grossed-up Income Taxes	\$2,833,305	\$2,833,305
9	PILs / tax Allowance (Grossed-up Income taxes + Capital taxes)	\$2,978,805	\$2,978,805
10	Other tax Credits	\$ -	\$ -
<b><u>Tax Rates</u></b>			
11	Federal tax (%)	18.00%	18.00%
12	Provincial tax (%)	13.00%	13.00%
13	Total tax rate (%)	31.00%	31.00%

**Notes**



## REVENUE REQUIREMENT WORK FORM

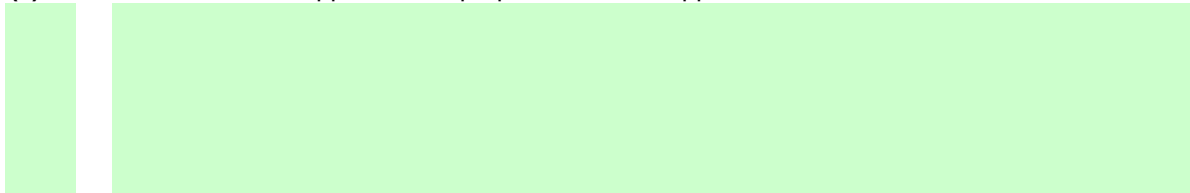
Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

### Capitalization/Cost of Capital

Line No.	Particulars	Capitalization Ratio		Cost Rate	Return
		(%)	(\$)	(%)	(\$)
<b>Application</b>					
<b>Debt</b>					
1	Long-term Debt	55.00%	\$114,949,550	6.87%	\$7,901,632
2	Short-term Debt	0.00%	\$ -	0.00%	\$ -
3	<b>Total Debt</b>	55.00%	\$114,949,550	6.87%	\$7,901,632
<b>Equity</b>					
4	Common Equity	45.00%	\$94,049,632	9.85%	\$9,263,889
5	Preferred Shares	0.00%	\$ -	0.00%	\$ -
6	<b>Total Equity</b>	45.00%	\$94,049,632	9.85%	\$9,263,889
7	<b>Total</b>	100%	\$208,999,182	8.21%	\$17,165,521
<b>Per Board Decision</b>					
<b>Debt</b>					
8	Long-term Debt	55.00%	\$114,949,550	6.87%	\$7,901,632
9	Short-term Debt	0.00%	\$ -	0.00%	\$ -
10	<b>Total Debt</b>	55.00%	\$114,949,550	6.87%	\$7,901,632
<b>Equity</b>					
11	Common Equity	45.0%	\$94,049,632	9.85%	\$9,263,889
12	Preferred Shares	0.0%	\$ -	0.00%	\$ -
13	<b>Total Equity</b>	45.0%	\$94,049,632	9.85%	\$9,263,889
14	<b>Total</b>	100%	\$208,999,182	8.21%	\$17,165,521

**Notes**

(1) 4.0% unless an Applicant has proposed or been approved for another amount.





## REVENUE REQUIREMENT WORK FORM

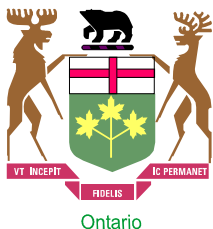
Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

### Revenue Sufficiency/Deficiency

Line No.	Particulars	Per Application		Per Board Decision	
		At Current Approved Rates	At Proposed Rates	At Current Approved Rates	At Proposed Rates
1	Revenue Deficiency from Below		\$4,211,626		\$4,211,626
2	Distribution Revenue	\$34,696,200	\$34,696,200	\$34,696,200	\$34,696,200
3	Other Operating Revenue Offsets - net	\$7,200	\$7,200	\$7,200	\$7,200
4	<b>Total Revenue</b>	<b>\$34,703,400</b>	<b>\$38,915,026</b>	<b>\$34,703,400</b>	<b>\$38,915,026</b>
5	Operating Expenses	\$18,916,200	\$18,916,200	\$18,916,200	\$18,916,200
6	Deemed Interest Expense	\$7,901,632	\$7,901,632	\$7,901,632	\$7,901,632
	<b>Total Cost and Expenses</b>	<b>\$26,817,832</b>	<b>\$26,817,832</b>	<b>\$26,817,832</b>	<b>\$26,817,832</b>
7	<b>Utility Income Before Income Taxes</b>	<b>\$7,885,568</b>	<b>\$12,097,194</b>	<b>\$7,885,568</b>	<b>\$12,097,194</b>
8	Tax Adjustments to Accounting Income per 2009 PILs	(\$2,957,500)	(\$2,957,500)	(\$2,957,500)	(\$2,957,500)
9	<b>Taxable Income</b>	<b>\$4,928,068</b>	<b>\$9,139,694</b>	<b>\$4,928,068</b>	<b>\$9,139,694</b>
10	Income Tax Rate	31.00%	31.00%	31.00%	31.00%
11	<b>Income Tax on Taxable Income</b>	<b>\$1,527,701</b>	<b>\$2,833,305</b>	<b>\$1,527,701</b>	<b>\$2,833,305</b>
12	<b>Income Tax Credits</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>
13	<b>Utility Net Income</b>	<b>\$6,357,867</b>	<b>\$9,263,889</b>	<b>\$6,357,867</b>	<b>\$9,263,889</b>
14	<b>Utility Rate Base</b>	<b>\$208,999,182</b>	<b>\$208,999,182</b>	<b>\$208,999,182</b>	<b>\$208,999,182</b>
	Deemed Equity Portion of Rate Base	\$94,049,632	\$94,049,632	\$94,049,632	\$94,049,632
15	Income/Equity Rate Base (%)	6.76%	9.85%	6.76%	9.85%
16	Target Return - Equity on Rate Base Sufficiency/Deficiency in Return on Equity	9.85% -3.09%	9.85% 0.00%	9.85% -3.09%	9.85% 0.00%
17	Indicated Rate of Return	6.82%	8.21%	6.82%	8.21%
18	Requested Rate of Return on Rate Base	8.21%	8.21%	8.21%	8.21%
19	Sufficiency/Deficiency in Rate of Return	-1.39%	0.00%	-1.39%	0.00%
20	Target Return on Equity	\$9,263,889	\$9,263,889	\$9,263,889	\$9,263,889
21	Revenue Sufficiency/Deficiency	\$2,906,022	\$ -	\$2,906,022	\$ -
22	<b>Gross Revenue Sufficiency/Deficiency</b>	<b>\$4,211,626 (1)</b>		<b>\$4,211,626 (1)</b>	

**Notes:**

(1) Revenue Sufficiency/Deficiency divided by (1 - Tax Rate)



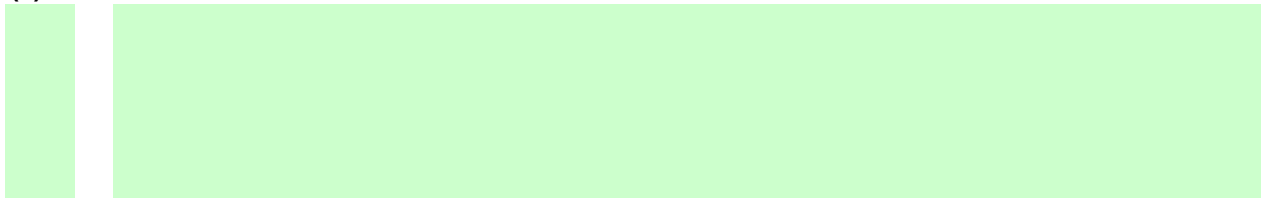
## REVENUE REQUIREMENT WORK FORM

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

Line No.	Particulars	Revenue Requirement	
		Application	Per Board Decision
1	OM&A Expenses	\$11,105,600	\$11,105,600
2	Amortization/Depreciation	\$7,406,900	\$7,406,900
3	Property Taxes	\$258,200	\$258,200
4	Capital Taxes	\$145,500	\$145,500
5	Income Taxes (Grossed up)	\$2,833,305	\$2,833,305
6	Other Expenses	\$ -	\$ -
7	Return		
	Deemed Interest Expense	\$7,901,632	\$7,901,632
	Return on Deemed Equity	\$9,263,889	\$9,263,889
8	Distribution Revenue Requirement before Revenues	<u>\$38,915,026</u>	<u>\$38,915,026</u>
9	Distribution revenue	\$38,907,826	\$38,907,826
10	Other revenue	<u>\$7,200</u>	<u>\$7,200</u>
11	<b>Total revenue</b>	<u>\$38,915,026</u>	<u>\$38,915,026</u>
12	<b>Difference (Total Revenue Less Distribution Revenue Requirement before Revenues)</b>	<u>\$ - (1)</u>	<u>\$ - (1)</u>

**Notes**

(1) Line 11 - Line 8





**REVENUE REQUIREMENT WORK FORM**

Name of LDC: Great Lakes Power Transmission LP  
 File Number: EB-2009-0408  
 Rate Year: 2010

**Selected Delivery Charge and Bill Impacts  
 Per Draft Rate Order**

		Monthly Delivery Charge				Total Bill			
		Current	Per Draft Rate Order	Change		Current	Per Draft Rate Order	Change	
				\$	%			\$	%
<b>Residential</b>	<b>800 kWh/month</b>			\$ -				\$ -	
<b>GS &lt; 50kW</b>	<b>2000 kWh/month</b>			\$ -				\$ -	

Notes:



**Great Lakes Power Transmission LP**  
**EB-2009-0408**  
**Response to Board Staff IR #97**

<b>2004</b>	650 Network		651 Line Connection		652 Transformation Conn.	
	Charge	Demand	Charge	Demand	Charge	Demand
July	\$818,003	289,047	\$187,090	228,158	\$306,911	204,607
August	\$852,540	301,251	\$191,332	233,332	\$316,692	211,128
September	\$917,693	324,273	\$206,568	251,912	\$346,232	230,821
October	\$939,900	332,120	\$212,978	259,729	\$357,918	238,612
November	\$951,234	336,125	\$199,532	243,332	\$338,510	225,673
December	\$1,117,779	394,975	\$200,910	245,012	\$353,583	235,722
	<b>\$5,597,149</b>	<b>1,977,791</b>	<b>\$1,198,410</b>	<b>1,461,475</b>	<b>\$2,019,845</b>	<b>1,346,563</b>

<b>2005</b>	650 Network		651 Line Connection		652 Transformation Conn.	
	Charge	Demand	Charge	Demand	Charge	Demand
January	\$1,124,798	397,455	\$203,853	248,601	\$353,688	235,792
February	\$1,008,720	356,438	\$197,556	240,922	\$342,735	228,490
March	\$1,023,772	361,757	\$202,303	246,711	\$349,539	233,026
April	\$946,179	334,339	\$211,607	258,057	\$355,296	236,864
May	\$865,572	305,856	\$201,028	245,156	\$334,359	222,906
June	\$884,505	312,546	\$197,374	240,700	\$326,477	217,651
July	\$877,385	310,030	\$193,965	236,543	\$325,194	216,796
August	\$854,233	301,849	\$200,701	244,757	\$337,056	224,704
September	\$900,738	318,282	\$204,940	249,927	\$339,521	226,347
October	\$877,093	309,927	\$200,442	244,442	\$335,390	223,593
November	\$1,064,476	376,140	\$201,541	245,672	\$342,948	228,632
December	\$1,052,508	371,911	\$203,025	247,592	\$352,658	235,105
	<b>\$11,479,980</b>	<b>4,056,530</b>	<b>\$2,418,336</b>	<b>2,949,080</b>	<b>\$4,094,859</b>	<b>2,729,906</b>

<b>2006</b>	650 Network		651 Line Connection		652 Transformation Conn.	
	Charge	Demand	Charge	Demand	Charge	Demand
January	\$1,066,511	376,859	\$216,327	263,814	\$369,752	246,501
February	\$1,042,201	368,269	\$204,803	249,760	\$351,546	234,364
March	\$1,016,720	359,265	\$214,971	262,160	\$363,810	242,540
April	\$983,281	347,449	\$207,179	252,657	\$344,999	229,999
May	\$863,226	305,027	\$193,619	236,121	\$322,283	214,855
June	\$880,130	311,000	\$210,629	256,865	\$349,640	233,093
July	\$924,929	326,830	\$205,984	251,200	\$343,223	228,815

August	\$954,384	337,238	\$204,833	249,796	\$341,489	227,659
September	\$823,213	290,888	\$194,793	237,552	\$323,294	215,529
October	\$910,635	321,779	\$198,656	242,264	\$333,032	222,021
November	\$909,421	321,350	\$185,001	225,611	\$308,648	205,765
December	\$1,025,088	362,222	\$205,315	250,384	\$143,445	95,630
	<b>\$11,399,738</b>	<b>4,028,176</b>	<b>\$2,442,111</b>	<b>2,978,184</b>	<b>\$3,895,157</b>	<b>2,596,771</b>

<b>2007</b>	650 Network		651 Line Connection		652 Transformation Conn.	
	Charge	Demand	Charge	Demand	Charge	Demand
January	\$1,056,241	373,230	\$203,700	248,415	\$148,925	99,283
February	\$1,072,932	379,128	\$208,345	254,079	\$148,476	98,984
March	\$1,039,745	367,401	\$200,394	244,383	\$147,039	98,026
April	\$918,094	324,415	\$196,028	239,058	\$126,311	84,207
May	\$771,268	272,533	\$165,090	201,329	\$67,596	45,064
June	\$871,999	308,127	\$191,450	233,476	\$109,551	73,034
July	\$857,201	302,898	\$186,985	228,031	\$123,180	82,120
August	\$834,442	294,856	\$184,362	224,832	\$133,236	88,824
September	\$882,669	311,897	\$207,096	252,556	\$125,250	83,500
October	\$904,114	319,475	\$224,313	273,552	\$140,802	93,868
November	\$878,121	380,139	\$162,255	275,008	\$156,696	97,327
December	\$869,509	376,411	\$154,575	261,991	\$153,826	95,544
	<b>\$10,956,337</b>	<b>4,010,510</b>	<b>\$2,284,592</b>	<b>2,936,710</b>	<b>\$1,580,887</b>	<b>1,039,781</b>

<b>2008</b>	650 Network		651 Line Connection		652 Transformation Conn.	
	Charge	Demand	Charge	Demand	Charge	Demand
January	\$905,153	391,841	\$157,467	266,893	\$157,514	97,835
February	\$892,810	386,498	\$149,605	253,568	\$148,207	92,054
March	\$827,629	358,281	\$152,620	258,678	\$172,152	106,927
April	\$781,496	338,310	\$147,688	250,319	\$145,713	90,505
May	\$696,220	301,394	\$142,694	241,855	\$131,999	81,987
June	\$728,334	315,296	\$145,118	245,936	\$126,826	78,774
July	\$697,879	302,112	\$142,788	242,014	\$125,034	77,661
August	\$709,061	306,953	\$141,041	239,052	\$120,418	74,794
September	\$678,715	293,816	\$141,278	239,454	\$130,780	81,230
October	\$765,975	331,591	\$148,276	251,316	\$140,984	87,568
November	\$766,617	331,869	\$133,427	226,148	\$135,464	84,139
December	\$833,751	360,931	\$148,174	251,142	\$162,921	101,193
	<b>\$9,283,641</b>	<b>4,018,892</b>	<b>\$1,750,177</b>	<b>2,966,375</b>	<b>\$1,698,014</b>	<b>1,054,667</b>

<b>2009</b>	650 Network		651 Line Connection		652 Transformation Conn.	
	Charge	Demand	Charge	Demand	Charge	Demand
January	\$996,728	387,832	\$175,069	250,099	\$150,219	92,728
February	\$959,535	373,360	\$164,602	235,146	\$147,226	90,880
March	\$951,915	370,395	\$171,501	245,002	\$154,115	95,133
April	\$805,495	313,422	\$159,942	228,488	\$144,327	89,091
May	\$684,705	266,422	\$153,708	219,583	\$116,778	72,085
June	\$759,834	295,655	\$158,887	226,981	\$128,698	79,443
July	\$731,787	275,108	\$163,135	233,050	\$108,923	69,378
August	\$808,965	304,122	\$176,094	251,563	\$121,598	77,451
September	\$785,772	295,403	\$184,653	263,790	\$135,020	86,000
October	\$833,341	313,286	\$175,518	250,740	\$140,190	89,293
November	\$889,225	334,295	\$182,652	260,931	\$129,577	82,533
December	\$919,972	345,854	\$179,816	256,880	\$139,491	88,848
	<b>\$10,127,272</b>	<b>3,875,154</b>	<b>\$2,045,577</b>	<b>2,922,253</b>	<b>\$1,616,163</b>	<b>1,012,863</b>

	kW	kW	kW
<b>2004 (Jul-Dec)</b>	1,977,791	1,461,475	1,346,563
<b>2005</b>	4,056,530	2,949,080	2,729,906
<b>2006</b>	4,028,176	2,978,184	2,596,771
<b>2007</b>	4,010,510	2,936,710	1,039,781
<b>2008</b>	4,018,892	2,966,375	1,054,667
<b>2009</b>	3,875,154	2,922,253	1,012,863
<b>Averages (5 yr / 5 yr / 2 yr):</b>	<b>4,019,797</b>	<b>2,939,425</b>	<b>1,057,605</b>
<b>Proposed:</b>	<b>4,019,797</b>	<b>2,939,425</b>	<b>1,057,605</b>
Current:	4,150,498	2,847,032	2,777,933
Variance:	(130,701)	92,393	(1,720,328)
	-3.15%	3.25%	-61.93%