APPENDIX Q
CABLE AMPACITY AND THERMAL CALCULATIONS
(CC 162C)
CASE 10-T-0139

CHPE LLC

UNDERGROUND DC CABLES

Potential Thermal Effects of Underground DC Cables on Co-Located Infrastructure

70082351-TN-005
MAY 2022

CHPE LLC

Potential Thermal Effects of Underground DC Cables on Co-Located Infrastructure

Note: While this analysis was performed specifically for the assets noted in design packages 1A and 1B, the results in this report are applicable for other design packages, segments and utilities.

PROJECT NO. 70082351

OUR REF. NO. 70082351-TN-005

DATE: MAY 2022

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QUALITY CONTROL

Issue/revision	First Issue	Second Issue	Third Issue
Remarks	First Issue	Second Issue	Third Issue
Date	31/05/2022	10/06/2022	28/06/2022
Prepared by	**Lee Martin**	**Lee Martin**	**Lee Martin**
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Signature			
Project number	70082351	70082351	70082351
Report number	70082351-TN-005	70082351-TN-005	70082351-TN-005
File reference	70082351-TN-005	70082351-TN-005	70082351-TN-005
Note: Text charges to clarify document covers entire CHPE project made 18/11/2022.			

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1 INTRODUCTION AND EXECUTIVE SUMMARY

1.1 INTRODUCTION

The Champlain Hudson Power Express (CHPE) project will deliver 1250MW of renewable power from Hydro-Quebec TransEnergie's Hertel substation near La Prairie Quebec to NYPA's Astoria Annex 345kV substation located in the Astoria neighborhood in the New York City borough of Queens.

The HVDC transmission system comprises two symmetrical monopole HVDC voltage source converter stations at either end of the link and a HVDC cable circuit, comprising two, +/-400kV DC cables.

The HVDC cable route within the United States will comprise of approximately 193 miles of submarine cable route and approximately 147 miles of land cable route.

The HVDC underground cable system will be installed within existing town and state roadway and railroad rights of way (ROW). The two cables will be installed side by side in ducts buried in a trench or by horizontal directional drill (HDD).

Along the route there are multiple utility services and infrastructure co-located in the same ROW.

The objective of this report is to assess the thermal interaction of the HVDC cable system on this co-located infrastructure (CI).

1.2 EXECUTIVE SUMMARY

The only co-located utility that will possibility be affected by the heat generated by the HVDC cable system will be any underground power distribution or transmission electricity cables, which in turn may affect the HVDC cable system due to the heat they generate, potentially resulting in a de-rating of the service, or the HVDC cable, unless the effect is mitigated.

A review of the information available for the route shows that in the majority of cases any electrical utilities are overhead and therefore can be discounted.

The temperature profile of the ground surrounding the HVDC cable system will not have any detrimental effect on any co-located infrastructure such as - storm drainpipes/culverts, water mains, gas or oil pipelines, and telecoms services (fiber or copper).

Electrical power cables will be affected by the HVDC cable system, and if parallel or crossing services of this nature are identified along the route to ascertain whether there are any issues with the mutual interaction between the service and the HVDC cable system.

A review of the available information with regard to CI shows that the vast majority are either storm/drainage pipes or culverts with any electrical services being mainly overhead. Underground Telecommunication services appear to be mainly fiber optic cables.

The study findings are currently applicable for the entire project. It may be determined in the future that exceptional circumstances for a particular or newly discovered CI warrant a further targeted study which can be evaluated at that time.

2 REFERENCED DOCUMENTS

Document Number	Document Title
Drawing No. G-000 Rev A	CHPE Package 1A – Putnam to Dresden Cover Sheet
Drawing No. G-002 Rev A	CHPE Package 1A – Putnam to Dresden Survey Notes and Legend
Drawing No. C-101 Rev A	CHPE Package 1A – Putnam to Dresden STA. 10000+00 to STA. 10015+00
Drawing No. C-621 Rev A	CHPE Package 1A – Putnam to Dresden Trenching Details
Drawing No. C-901 Rev A	CHPE Package 1A – Putnam to Dresden Utility Typical Separation Details
Document 1AA0518810 Rev A.	CHPE A1 – Technical Proposal Land Cable
Document 1709319.EXO – (4-26-22 FINAL)	Thermal Analysis

3 POTENTIAL THERMAL EFFECTS OF UNDERGROUND DC CABLES ON CO-LOCATED INFRASTRUCTURES

3.1 Thermal modelling of the HVDC Cable System

The HVDC cable system will generate heat as a result of the losses – primarily I^2R losses in the conductor – which causes the cable to heat up and this heat is dissipated through the various media that surrounds the cable. In practice this results in a temperature gradient from the cable core outwards with the highest temperature being at the cable conductor reducing to background ambient temperature at a distance determined by the thermal characteristics of the surrounding materials.

This process is fundamental to the design of the cable system and therefore a process that is well understood by the cable supplier with various computerized models available to evaluate the situation.

Referring to NKT Document 1AA0518810 Rev A - CHPE A1 – Technical Proposal Land Cable Section 7 – Cable Ampacity Analysis, which provides the basis for the current rating assessment for the cable being provided, it is possible to see the temperature gradient, represented as contours in Figure 1 below, relevant to the condition with the cables buried in an open trench – not under asphalt.

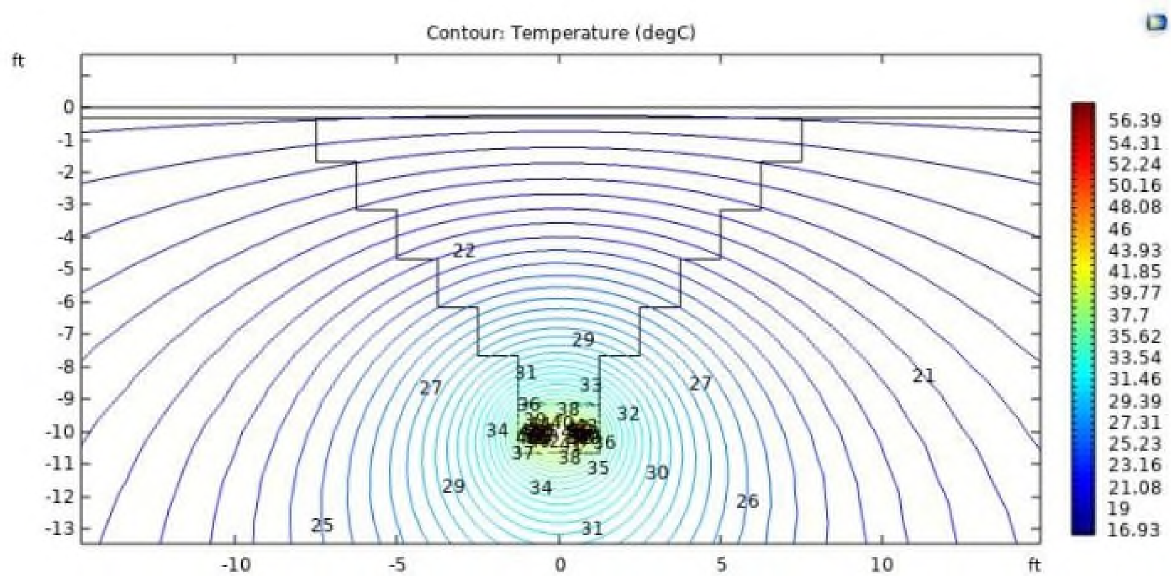

Figure 1 – Temperature profile

An external study was commissioned by TDI, reference Exponent Document 1709319.EXO – Thermal Analysis (4-26-22 FINAL) which considers a number of installed conditions and configurations to anticipate the temperature changes as a result of the HVDC cable.

The configuration considered most appropriate to the conditions modelled by NKT is configuration 2 the output of which can be seen in Figure 2 below.

Configuration #	$TR_{flow\ fill}$ $\left(\frac{K \cdot m}{W}\right)$	$TR_{concrete}$ $\left(\frac{K \cdot m}{W}\right)$	TR_{soil} $\left(\frac{K \cdot m}{W}\right)$	$T_{ambient}$ $(°C)$	h $\left(\frac{W}{m^2 \cdot K}\right)$	d $(in.)$	Maximum $T(°C)$	$T_{2\ ft\ above\ cable}$ $(°C)$
2	1.00	1.00	1.00	22	100	60	48.7	35.9

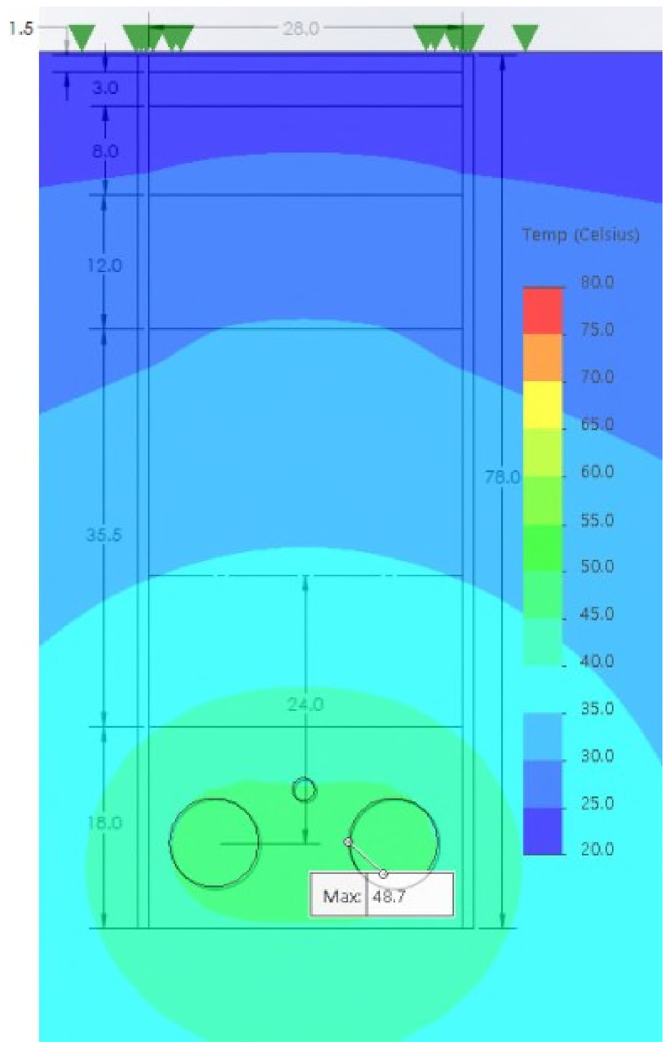

Figure 2

In both models, as shown in Figures 1 & 2 above, it is possible to see that the predicted temperature for the soil 2' away from the cable system is approximately 35°C with the temperature at a distance of 5' being approximately 25°C.

A consequence of this is that any co-located infrastructure will be subject to some element of heating depending upon its location with respect to the HVDC cable system.

For the purposes of this report, it is assumed that any underground co-located infrastructure will be located a minimum of 2' vertically and 5' horizontally from the HVDC cable system. These being the minimum separation distances as defined in Kiewit drawing C-901 Rev A – "Utility Typical Separation Details"

Any overhead services are obviously not affected.

3.2 Co-Located Infrastructure Package 1A - Temperature

The report has limited the detailed assessment to Package 1A – Putnam to Dresden. There are 14 identified co-located services in this section as shown in Appendix A, Table 1.

Of these seven are overhead services and therefore can be discounted from further consideration.

Of the remainder four are fiber optic cables installed in ducts and three are storm drains/culverts.

All the storm drains/culverts cross the HVDC cable system and, with the assumed separation of 2', this means that the surrounding ground temperature directly above the cable system as they cross will be at approximately 35°C.

Two of the telecommunication services cross the HVDC cable system and, with the assumed separation of 2', this means that the surrounding ground temperature directly above the cable system as they cross will be at approximately 35°C.

The other two run in parallel at different separation distances, 15' and 10'. The temperature of the surrounding ground 10' from the cable system is assessed as approximately 22°C with the temperature at 15' being assessed as approximately 20°C.

All electrical, civil and structural infrastructure is required to operate over a wide range of ambient conditions, typically -5°C to 40°C, or higher. Temperatures of the levels predicted in this study are well within this range and will have no effect on these services.

3.3 Co-Located Infrastructure – General

The only co-located utility that will possibility be affected by the heat generated by the HVDC cable system will be any underground power distribution or transmission electricity cables, which in turn may affect the HVDC cable system due to the heat they, in turn, will generate, potentially resulting in a de-rating of the service, or the HVDC cable, unless the effect is mitigated.

A review of the information available for the route shows that the majority, and maybe all, of cases any electrical utilities are overhead and therefore can be discounted.

In summary the temperature profile of the ground surrounding the HVDC cable system will not have any detrimental effect on any co-located infrastructure such as storm drainpipes/culverts, water mains, gas or oil pipelines, and telecoms services (fiber or copper). Electrical power cables will be affected by the HVDC cable system and if parallel or crossing services of this nature are identified along the route, they will need to be investigated on an individual basis to ascertain whether there are any issues with the mutual interaction between the service and the HVDC cable system.

APPENDIX A – UTILITIES INTERACTION

Table 1 – Utilities Interaction

Utility owner and Location	Utility	Length Parallel (ft)	Parallel /Crossing (°)	Description	Comments/Temperature
Level 3	Fiber Cable in HDPE Duct		C	Fiber Located in RR ROW - East Side	Utility not found, assumed 90°crossing, 2' separation 35°C
AT&T	Fiber Cable in HDPE Duct		C	Fiber Located in RR ROW - West Side	Utility not found, assumed 90° crossing, 2' separation 35°C
Washington County 10000+90	Storm Drainage Pipe/Culvert	50	C ≈ 90°	HDP - Route 3	Crossing is at 90°, Assumed 2' separation. 35°C
National Grid 10004+90	Utility (Electric)	175	C ≈ 60°	Overhead Service Connection - Route 3	Discounted
National Grid 10006+05	Utility (Electric)	110	C ≈ 45°	Overhead Service Connection - Route 3	Discounted
National Grid 10006+10-10008	Utility (Electric)	200	P	Overhead Lines - Route 3	Discounted
National Grid 10007+90	Utility (Electric)	500	C ≈ 25°	Overhead Service Connection - Route 3	Discounted
Verizon 10007+90-10009+40	Overhead Telecomm	150	P	Short Aerial Route	Discounted
Washington County 10009 – 10000+90	Storm Drainage Pipe/Culvert	63	C ≈ 50°	HDP - Route 3	Assumed 2' separation 35°C
Verizon 10009+40-10222+65	Fiber Cable in HDPE Duct	1325	P	Approx. 15' off West edge of pavement - Route 3	Assumed 15' separation 20°C

National Grid 10007+85	Utility (Electric)	500	C	Overhead Service Connection - Route 3	Discounted
Washington County 10014+90	Storm Drainage Pipe/Culvert	50	C ≈ 80°	HDP - Route 3	Assumed 2' separation 35°C
Verizon 10009+75	Fiber Cable in HDPE Duct	1325	P	Approx. 10' off West edge of pavement - Route 3	Assumed 10' separation 22°C
Verizon 10014+90 – 10038+10	Overhead Telecomm	2320	P	Approx. 10' off West edge of pavement - Route 3	Discounted