BEFORE THE
PUBLIC SERVICE COMMISSION
STATE OF NEW YORK

Application of Champlain Hudson Power Express, Inc. for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII of the PSL for the Construction, Operation and Maintenance of a High Voltage Direct Current Circuit from the Canadian Border to New York City.	Case No. 10-T-0139

APPLICATION OF CHPE LLC AND CHPE PROPERTIES, INC. FOR AN AMENDMENT TO CERTIFICATE OF ENVIRONMENTAL COMPATIBILITY AND PUBLIC NEED

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Dated: January 29, 2021

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I. INTRODUCTION

CHPE LLC and CHPE Properties, Inc. (collectively, the "Applicants"), by submitting this Application ("Application") to the New York State Public Service Commission (the "Commission"), seek to amend the Certificate of Environmental Compatibility and Public Need issued in this proceeding on April 18, 2013 (the "Certificate").[1] The Certificate authorizes the Applicants to build, maintain, and operate the Champlain Hudson Power Express Project (the "Project"), an approximately 330 mile High Voltage, Direct Current ("HVDC") transmission cable with the capacity to transmit 1,000 megawatts ("MW") into the New York City ("NYC") load pocket.

[1] On July 16, 2020, the Commission approved the transfer of the Certificate from Champlain Hudson Power Express, Inc. ("CHPEI") to CHPE LLC. For the purposes of this filing, "Applicants" represents both past and current Certificate Holders. In August, 2020, Champlain Hudson Power Express, Inc. converted from a corporation (CHPEI) to a limited liability company (CHPE LLC) and transferred its CECPN from CHPEI to CHPE LLC. *See* Case 20-E-0145: *Petition of Champlain Hudson Power Express, Inc., CHPE Properties, Inc., and CHPE LLC for a Declaratory Ruling that a Series of Intra-Corporate Transactions are Not Transfers Subject to Review Under the Public Service Law or, in the Alternative, for Certain Approvals Pursuant to Sections 70 and 121 of the Public Service Law,* Order Approving Transfers (July 17, 2020).

Since the Certificate was issued, the Applicants have worked diligently, in parallel efforts, to obtain the additional governmental permits and approvals necessary to fully and finally authorize construction and operation of the Project, as well its construction program, with a view towards further minimization of Project impacts and consideration of such changed circumstances. With the recent approval of a certain route modification,[2] the Applicants have the necessary State approvals to proceed to the Project construction phase for a 1,000 MW transmission line.

Although the Project as currently configured and approved will provide a substantial contribution to the State's renewable policy goals, during the normal course of discussions with potential HVDC vendors the Applicants have been made aware of advances in the design of HVDC transmission systems that would allow for an increase in the throughput capacity from 1,000 MW to 1,250 MW with no significant changes in the impacts associated with the construction, operation, or maintenance of the facility. Given that there is widespread agreement that the state's 70% renewables by 2030 mandate requires displacement of a substantial portion of the fossil fuel-fired generation that New York City ("NYC") currently relies upon, the Applicants filed an uprate request with the New York Independent System Operator ("NYISO"). On December 10, 2020, the NYISO Operating Committee confirmed that an additional 250 MW could be reliably added to the grid. The Applicants have worked diligently since receiving notice from the NYISO to prepare this Application in the intervening period.

Accordingly, by this Application, the Applicants propose a revision to the Certificate to reflect a change in transmission cable allowing an increase in the anticipated Project nameplate capacity rating from 1,000 MW to 1,250 MW. This proposed modification represents a unique opportunity for increased transmission of renewable energy into NYC with no significant changes to the Project as currently approved. Notice of this application has been provided as required by § 122(2) of the Public Service Law (the "PSL") and the Commission's rules. *See* 16 NYCRR § 85-2.10.[3]

In support of their request for an amendment, the Applicants state as follows:

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[2] Case 10-T-0139 - *Application of Champlain Hudson Power Express, Inc. for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII of the PSL for the Construction, Operation and Maintenance of a High Voltage Direct Current Circuit from the Canadian Border to New York City*, Order Granting Amendment of Certificate of Environmental Compatibility and Public Need Subject to Conditions (January 26, 2021).

[3] Affidavits of Service and Affidavits of Publication are being filed under separate cover.

1. On March 30, 2010, the Applicants submitted the original Certificate application (the "Original Application"), which led to a three-year process that culminated in the issuance of the Order granting the Certificate (the "CECPN Order").[4] The Applicants carried their burden of demonstrating that the Project would serve the public interest, convenience, and necessity, and the Commission made all the findings that, by statute, must accompany issuance of a certificate pursuant to Article VII of the PSL (PSL §126). Furthermore, during the process leading up to the eventual CECPN Order, the Applicants successfully built a coalition of affected parties, and that coalition produced the joint proposal of settlement (the "Joint Proposal") that formed the basis of the Commission's favorable decision.

2. In making its finding that the Project will serve the public interest, convenience, and necessity, the Commission took note of the Project's "unique and substantial benefits" and concluded that it would "advance major energy and policy goals" of both New York State (the "State") and NYC.[5] The Commission also concluded that the Project would provide a "significant amount of additional capacity that would enhance energy security" in NYC and, through the import of "renewable energy," would increase supply diversity and enhance system reliability.[6] In addition, the Commission noted that the Project would serve to facilitate proper functioning of the energy markets in the State and would afford "price stability benefits."[7] At the heart of the Commission's determination to grant the Certificate was the conclusion that "the Facility's expected emission reductions are a substantial environmental benefit, a benefit that is expected to be enduring."[8]

3. Since the Certificate was issued, the Applicants have worked diligently, in parallel efforts, to obtain the additional governmental permits and approvals necessary in order to fully and finally authorize construction and operation of the Project, to conduct outreach and

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[4] Case 10-T-0139: *Application of Champlain Hudson Power Express, Inc. for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII of the PSL*, Order Granting Certificate of Environmental Compatibility and Public Need (April 18, 2013), at 100.

[5] CECPN Order, at 100.

[6] CECPN Order, at 97.

[7] CECPN Order, at 98.

[8] CECPN Order, at 52.

coordination efforts directed at interested stakeholders, to finalize the commercial arrangements that will allow for Project financing, and to refine the Project construction program with a view towards further minimization of Project impacts.[9]

4. While working with HVDC equipment manufacturers to finalize the design of the Project, the Applicants were made aware of continuing advances in the design of HVDC transmission systems that allow for increased transmission capacity with no significant change in cable or converter station sizes or properties.[10] The key relevant advance is the development and marketing of a 1,250 MW HVDC system ("Preferred Transmission System") that utilizes cables essentially identical to those that employed by the 1,000 MW HVDC system. What this means for the Project is that the nameplate capacity rating and energy delivered would increase by 25% with no significant increases in the impacts associated with the construction, operation, and maintenance of the facility.

5. In order to understand the feasibility of interconnecting the Project to the bulk power grid at the 1,250 MW capacity, the Applicants filed a 250 MW uprate request in the Interconnection Queue maintained by NYISO at Queue Position #887. On December 10, 2020, the NYISO Operating Committee approved the System Reliability Interconnection Study for the proposed 250 MW uprate confirming that an additional 250 MW could be reliably added to the grid.

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[9] *See* Case 10-T-0139: *Application of Champlain Hudson Power Express, Inc. for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII of the PSL*, Order Granting, in Part, Amendment of Certificate of Environmental Compatibility and Public Need Subject to Condition (March 10, 2020), (Errata issued August 24, 2020) ("Amendment 1"); Case 10-T-0139: *Application of Champlain Hudson Power Express, Inc. for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII of the PSL*, Order Granting, in Part, Amendment of Certificate of Environmental Compatibility and Public Need Subject to Conditions (August 13, 2020); Case 10-T-0139: *Application of Champlain Hudson Power Express, Inc. for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII of the PSL*, Order Granting Amendment of Certificate of Environmental Compatibility and Public Need Subject to Conditions (September 21, 2020) ("Amendment 2"); Case 10-T-0139: *Application of Champlain Hudson Power Express, Inc. for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII of the PSL*, Order Granting Amendment of Certificate of Environmental Compatibility and Public Need Subject to Conditions (January 26, 2020) ("Amendment 3").

[10] The Transmission System is comprised of the HVDC cables extending from the Canadian border to Astoria, Queens, the Converter Station located in Astoria and HVAC cables which are required for the grid interconnection in New York City.

Modification to Transmission Capacity

6. The Applicants request approval of a revision to the CECPN Order that approves the Preferred Transmission System, which will result in an increase in the anticipated Project nameplate capacity rating from 1,000 MW to 1,250 MW, as well as associated modifications to the Project's transmission components.

7. The Preferred Transmission System would involve very minor changes to the Project's HVDC cables profile, Converter Station, and High Voltage, Alternating Current ("HVAC") cables as approved by the Commission ("Certified Transmission System"). These changes would not materially increase environmental impacts or result in any change in location of the Project. In a case involving delivery of electricity into Zone K (Long Island), the Commission determined that the substitution of a different cable design for the originally proposed HVDC cable system would not "result in any material increase in any environmental impact of the authorized facility or a substantial change in the location of all or a portion of such facility other than as provided in the application for a certificate."[11]

8. In addition, the associated construction and operation activities for the Preferred Transmission System are completely consistent with those provided for the Certified Transmission System as described in the administrative record in this proceeding (the "Project Documentation"). Additional details on these changes are described more fully in Section 2 of this Application.

9. In the Clean Energy Standard proceeding, the Commission recently re-emphasized the need for increased deliveries of renewable energy to NYC. According to the Commission, "without displacing a substantial portion of the fossil fuel-fired generation that New York City currently relies upon, the statewide 70 by 30 Target would be difficult to achieve."[12] Furthermore, the Commission noted that "[a]bsent new transmission capacity, the addition of new upstate renewable developments will fail on its own to increase the penetration of

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[11] Case 02-T-0036: *Application of Neptune Regional Transmission System LLC for a Certificate of Environmental Compatibility and Public Need*, Order Granting Amendment of Certificate of Environmental Compatibility and Public Need (October 28, 2004), at 12.

[12] Case 15-E-0302: *Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and Clean Energy Standard*, Order Adopting Modifications to the Clean Energy Standard (October 15, 2020), at 78.

renewable energy consumed in New York City to a level that enables statewide compliance with the 70 by 30 Target."[13]

10. The Preferred Transmission System offers a unique opportunity to increase deliveries of renewable power into NYISO's Zone J (NYC) with no significant additional impacts.

Conclusion

11. In summary, the case for the Project meeting all of the legal standards set forth by section 126 of the Public Service Law was persuasive in 2013; in view of the actions taken by the State and NYC since that event, both with respect to the Project and generally with respect to fossil fuel emissions and need for an increase in renewable energy, the case has only become stronger. Furthermore, capitalizing on the opportunity to increase the amount of renewable energy delivered directly into NYC by 25%, an opportunity presented by recent improvements in HVDC cable and converter technology, is manifestly in the public interest. For all the reasons set forth herein, the Applicants respectfully urge the Commission to conduct an expeditious review of the Application and conclude that review with an order approving the proposed modification. The proposed changes to the Certified Transmission System present neither a material increase in any environmental impact nor a substantial change to the location of the Project facilities. Therefore, The Commission retains the discretion to act on this Application without scheduling a hearing (PSL §123[2]).

[13] *Id*.

II. DESCRIPTION OF PROPOSED PROJECT MODIFICATION

12. The Applicants are seeking approval of the Preferred Transmission System, which is capable of transmitting 1,250 MW of energy.

13. The design of the upland and submarine cables that are part of the Preferred Transmission System is consistent with the Certified Transmission System cables as provided in the Project Documentation.[14] The conductor design, which consists of copper wires surrounded by a conductor shield, insulation, metallic shield / sheath, moisture barrier, and jacket / outer sheath, is unchanged. The submarine cables (like the Certified Transmission System cables for submarine service) will continue to have armoring for additional protection.

14. The mechanical properties of the Preferred Transmission System HVDC cables are also similar to those of the Certified Transmission System cables. As shown in the table below, the diameter of the Preferred Transmission System HVDC cables is such that there will not need to be any modifications to the previously approved overland or in-water installation, including the width of trenches as described in the Project Documentation.

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[14] *See, e.g.,* Exhibit 10 of the Joint Proposal of Settlement. On-line at: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={80DB6900-6B02-4FFC-A7F7-37A221582A44}

	Certified Transmission System HVDC Cables	**Preferred Transmission System HVDC Cables**	**Delta**
Capacity (MW)	1,000	1,250	25%
Rated Continuous Voltage (kV)	320	400	25%
Rated Continuous Current Under Installation Conditions (Amps)	1638	1638	0
Overland Cables			
Diameter	4.72 in (119.96 mm)	4.86 in (123.53 mm)	3.0%
Weight in Air	20.7 lbs/ft (30.7 kg/m)	21.1 lbs/ft (31.4 kg/m)	2.1%
Submarine Cables			
Diameter	5.24 in (133 mm)	5.36 in (137.3 mm)	3.2%
Weight in Air	34.9 lbs/ft (51.9 kg/m)	35.9 lbs/ft (53.4 kg/m)	2.9%
Weight in Water	26.9 lbs/ft (40 kg/m)	26.4 lbs/ft (39.3 kg/m)	-1.8%

15. Due to the similarities of the Preferred Transmission System HVDC cables to those approved by the Commission, there will be no changes in the construction and operation of the Project as described in the Project Documentation.

16. For the terrestrial portions of the Project route, the underground HVDC cables will still be buried via excavated trenches or Horizontal Directional Drilling ("HDD") methods. HVDC cables will be installed in the conduits as approved by the Commission on March 20, 2020 and these cable lengths will be attached together in splice vaults as described in the Project Documentation. There also will be no changes to the initial clearing, trench excavation, backfilling, and restoration / revegetation activities as described in the Project Documentation.

17. For underwater cable installation, the primary methods utilized for installation will be jet-plowing and shear plowing, with shoreline transitions completed by HDD. The HVDC submarine cables will continue to be bundled together when installed within the water

bodies either by jet-plow or shear-plow techniques. The installation vessels used for in-water construction will remain the same as those described in Project Documentation.

18. In the Project Documentation, the converter station is described as a "compact type" with a total footprint (*i.e.*, building and associated footprint) of approximately 4.5 acres. The converter station for the Preferred Transmission System would occupy a total footprint of approximately 5.5 acres, a minor increase in the necessary area given the Allowable Deviation Zone and available land in the Astoria complex.

19. In the Project Documentation, HVAC cables are shown extending from the Astoria East substation to the Rainey substation. These cables will be installed via techniques that remain unchanged from those described in the Project Documentation. To accommodate the 250 MW uprate, the design of this HVAC system has been altered such that there are now two conductors per phase proposed instead of one conductor per phase. The two conductors per phase system uses smaller diameter cables, which results in a narrower, but deeper configuration compared to the one cable per phase system. A typical diagram showing the new HVAC configurations is included as Exhibit A.

20. The environmental impact analysis contained in Section III of this Application documents that the similarity of the specifications of the Preferred Transmission System to those of the Certified Transmission System in terms of dimensions, thermal emissions, magnetic fields, etc. result in impacts associated with the Preferred Transmission System that are similar or less than those associated with the Certified Transmission System. The environmental impact analysis contained in Section III and the lack of change in routing support a finding by the Commission that there are no material increases in environmental impacts or a substantial change in location associated with making the requested change other than an approximately one acre increase in the size of the area occupied by the converter station.

III. DESCRIPTION OF ENVIRONMENTAL IMPACTS

21. The environmental impacts associated with the Project were thoroughly reviewed by the Commission in connection with its review and approval of the Original Application, as supplemented and amended. The requested modification does not propose any alterations to approved construction methodologies, operational protocols and practices, or upland or submerged routing of the Project.

22. Key elements of the Original Application are Exhibit 4 – Environmental Impacts ("Exhibit 4"), which provides an assessment of the Certified Route, Exhibit 5 – Design Drawings, which included Project design drawings including cross-sections of the proposed facilities ("Exhibit 5"), and Exhibit E-1 – Description of Proposed Transmission Lines, which includes Project drawings of the proposed transmission cables ("Exhibit E-1"). On February 7, 2012, the Applicants updated Exhibit 4 with Exhibit 121: Environmental Impacts Associated with Routing Proposed in Joint Proposal ("Exhibit 121"), which was soon followed by the filing of the Joint Proposal. Appendix E to the Joint Proposal provided guidelines for developing the EM&CP ("EM&CP Guidelines"). Appendix F to the Joint Proposal presented Best Management Practices ("BMPs") to guide Project construction and maintenance activities (e.g., erosion and sediment control; vegetative clearing, general clearing and restoration). The analysis that follows below presents each of the resource areas provided in Exhibit 4 and Exhibit 121.[15]

23. The construction methods and operational procedures for the Project are described in Exhibit 4 of the Original Application (see §4.1), Exhibit 121 (see §4.1). A cross section of the conduit installation was approved on March 20, 2020 by the Commission. There will be no changes to the construction and operation as described in the Project Documentation should the Commission approve the use of the Preferred Transmission System.

24. The Preferred Transmission System HVDC and the HVAC cables will be installed in the same location and in the same manner as the Certified Transmission System cables, so that the disturbance will be of the same magnitude and type. As such, the expected impacts

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[15] Amendment 2 Petition and Amendment 3 Petition also included an assessment of the environmental impacts associated with the proposed route modifications. This analysis also adhered to the resource areas provided in Exhibit 4 and Exhibit 121.

associated with the Preferred Transmission System HVDC and HVAC cables will be essentially identical to those presented in the Project Documentation for Land Use (§4.2[16]), Geology, Topography, and Soils (§4.3), Vegetation and Natural Communities (§4.4), Wetlands and Water Resources (§4.5), Physical and Chemical Characteristics of Major Aquatic Systems (§4.6), Fisheries (§4.7), Wildlife (§4.8), and Historic and Archeological Resources (§4.10).[17]

25. Exhibits 4 and Exhibit 121 (§4.9) provide an analysis of potential impacts to state or federal threatened or endangered ("TE") species, candidate TE species, and special concern species that might be found in the vicinity of the Certified Transmission System route. The Applicants, in collaboration with the New York State Department of Environmental Conservation ("NYSDEC") and the other settlement parties, have identified and developed several measures, to be implemented where necessary, to avoid or minimize potential impacts to TE wildlife species listed at 6 N.Y.C.R.R. Part 182 and their occupied habitats. These measures are described in Conditions 51 and 52 of the Certificate Conditions, the BMPs, and EM&CP Guidelines.

26. For terrestrial TE species, the Preferred Transmission System HVDC cables will be located in the same habitats as those considered in the Project Documentation and there should be no significant difference in impacts. The Applicants would employ the previously referenced avoidance and minimization measures, including BMPs, which were developed in consultation with the U.S. Fish and Wildlife Service. These measures include, but are not limited to, conducting tree clearing during winter months to avoid Indiana bats and northern long-eared bats, employing HDD technology to install cables under sensitive Karner blue butterfly lupine habitat, and marking all known locations of protected and sensitive species on construction drawings and in the field. As the Preferred Transmission System HVDC and HVAC cables will be installed in the same location and in the same

[16] Sections reference both Exhibit 4 of Original application and Exhibit 121.

[17] For the Preferred Alternatives presented in Amendment 2, see the analyses presented in petition Appendices G and H; for the Harlem River Yard Alternative and route augmentation for splice vaults in Rockland County, see the analysis contained in Section 3 of the Amendment 3 petition.

manner as the Certified Transmission System cables, it is expected that the impacts to terrestrial TE species will be the same or less.

27. For aquatic TE species, the primary species of concern are the shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchu*) which are found in the Hudson River from the Federal Dam at Troy downriver to the southern tip of Manhattan, New York. The Preferred Transmission System HVDC cables will be installed in trenches at the same depth as those associated with the Certified Transmission System cables. The Applicants commissioned Exponent, Inc. ("Exponent") to assess the expected thermal and magnetic fields associated with the submarine portion of the Preferred Transmission System. A copy of this report is provided as Exhibit B. The expected thermal losses from the Preferred Transmission System HVDC cables are expected to be 7.6 watts per foot (W/ft) (24.9 watts per meter (W/m), which is significantly less than the expected loss of 13.1 W/ft (43.1 W/m) from the Certified Transmission System cables. In terms of the anticipated change in the magnetic field generated by the submarine HVDC cables, Exponent calculated direct current (DC) magnetic field values at the river and lake bottom for multiple configurations and distances. The results showed that the expected magnetic fields associated with the modification are similar to those values associated with the Project as permitted. As previously described, the thermal loss associated with the Preferred Transmission System HVDC cables is anticipated to be less than that associated with the Certified Transmission System cables. Based on this analysis, it is not expected that there would be any additional adverse impacts to aquatic TE species.

28. Because the Preferred Transmission System HVDC and HVAC cables will be installed in the same locations and manner as the Certified Transmission System cables, the impact to visual and aesthetic resources in terms of the transmission system installation will be identical to those presented in the Project Documentation (See Exhibit 4 and Exhibit 121, §4.11).

29. The converter station for the Preferred Transmission System will occupy a slightly larger footprint but will be comparable in terms of height to the converter station approved in the CECPN Order so that the visual impacts should be comparable. In addition, the Commission's approval of the relocation of the converter station as presented in the Amendment 2 Petition is further from residential areas and therefore is expected to result

in a reduction of the visual impacts to potential viewers from those contemplated at the time of the issuance of the CECPN Order.

30. The noise impacts associated with the installation of the Preferred Transmission System will be the same magnitude and type as those presented in the Project Documentation (See Exhibit 4 and Exhibit 121, §4.11). Construction noise will be temporary in nature and the impact will vary depending upon the construction equipment in use and existing background or ambient noise at given times and locations. Because the Preferred Transmission System will be installed in the same location and manner as the Certified Transmission System, there will be no change in the expected disturbance associated with noise. There will be no permanent noise impacts associated with the Preferred Transmission System. It is anticipated that there will be no material increase in the audible noise emission from the converter station associated with the Preferred Transmission System as compared to the anticipated noise levels described in the Project Documentation. As discussed in the Amendment 2 Petition, the previously completed Noise Assessment (Exhibit 107 of the Joint Proposal) demonstrates that this level of expected noise would be in compliance with the New York City Zoning Resolution for industrial and residential property lines, the New York City Noise Code, and the NYSDEC Noise Policy.

31. The public health impacts associated with the Preferred Transmission System, including those related to the electric and magnetic fields associated with the operation of the HVDC and HVAC transmission cables, are anticipated to be consistent with those of the Certified Transmission System as described in the Project Documentation (See Exhibit 4 and Exhibit 121, §4.13). As discussed in the Revised Electric and Magnetic Field Report (Exhibit 39 of the Joint Proposal), the burial of the HVDC and HVAC cables reduces the electric field levels to inconsequential levels. Reports completed by Exponent concluded that the magnetic field associated with the Preferred Transmission System overland HVDC and HVAC cables would be consistent with the "New York Public Service Commission's Interim Policy Statement on Magnetic Fields," as issued on September 11, 1990. Copies of these reports are attached hereto and identified as Exhibits C and D.

32. The Preferred Transmission System would require a converter station that would occupy a slightly larger footprint than that associated with the Certified Transmission System. The environmental setting for the proposed location of the converter station is fully described

in Amendment 2 Petition, which concluded that any environmental impacts would be comparable to those considered in the CECPN Order. Given the long history of industrial use in this location, the increase of approximately one (1) acre of disturbance is unlikely to adversely affect any environmental resource. Previously agreed upon measures to limit exposure to contamination to the extent it is present by workers, the community, and the environment would be implemented, as would other BMPs to avoid and minimize impacts to the environment and surrounding land uses.

33. Based on the analysis summarized above, the use of the Preferred Transmission System does not create a material increase in any environmental impacts over those associated with the Certified Transmission System. The Preferred Transmission System represents the minimum adverse environmental impact attainable, taking into account the state of available technology, environmental and engineering constraints, and other pertinent considerations. The Preferred Transmission System offers an opportunity to increase the efficiency of the Project and provide 25% more renewable energy to NYC, an area dominated by fossil fuel generation.

IV. CONCLUSION

For the reasons set forth herein, CHPE LLC and CHPE Properties, Inc. respectfully request that the Certificate be amended as specified above.

DATED: January 29, 2021

Respectfully submitted,

/s/ ***Steven D. Wilson***

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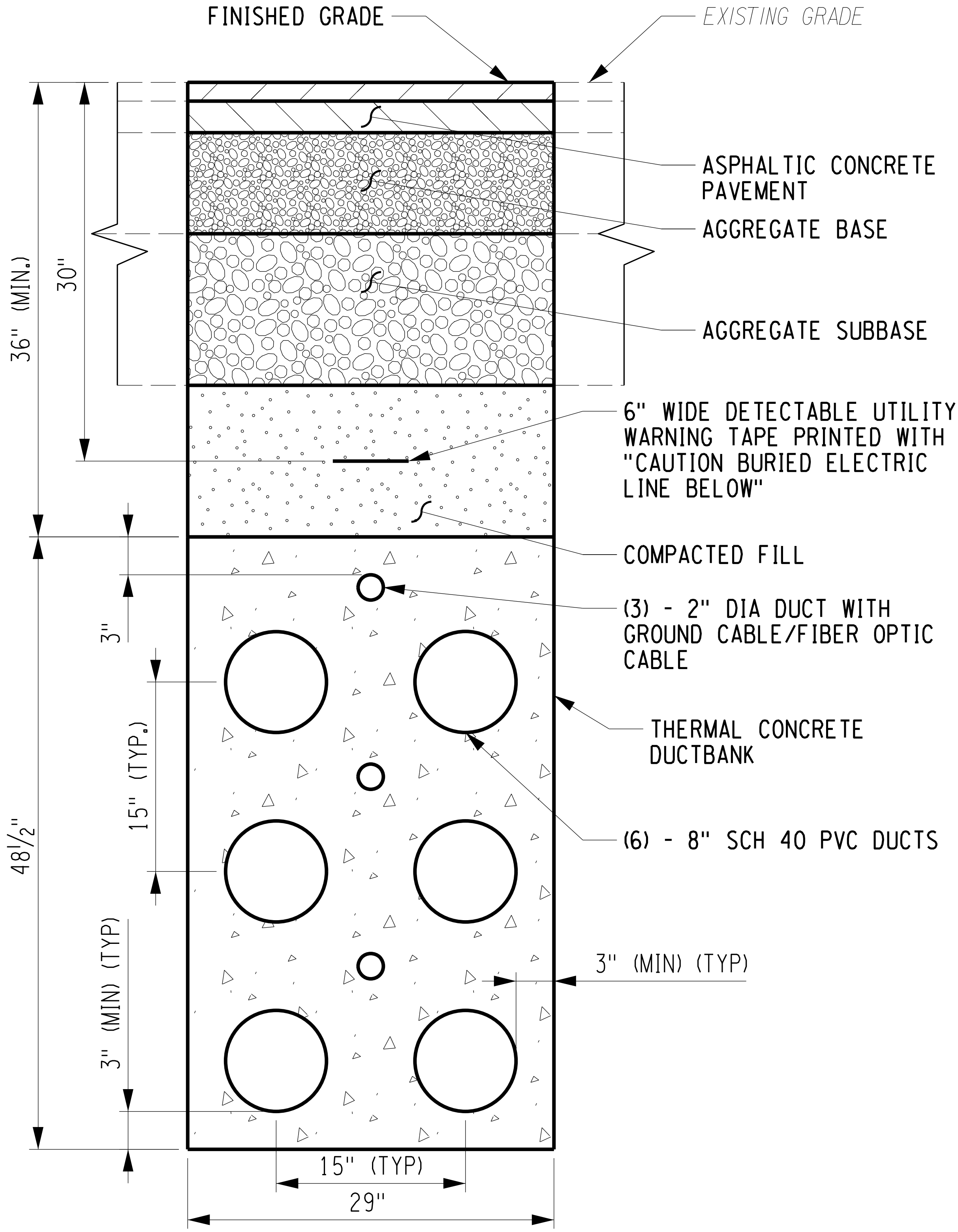
Transmission
Developers Inc.
A Blackstone Portfolio Company

Exhibit A

REVISED TYPICAL TRENCH DETAIL FOR HVAC CONFIGURATION



TYPICAL ELECTRIC DUCTBANK TRENCH CROSS SECTION

NOT TO SCALE

PROJECT TITLE: CHAMPLAIN HUDSON POWER EXPRESS TRANSMISSION DEVELOPERS, INC.	LOCATIONS	
AECOM	DRAWING TITLE: ASTORIA–RAINEY HVAC CABLE	DATE: 02/21/2020 DRAWING NUMBER: FIG 01

DESIGN SUPERVISOR:
DESIGNED BY:
CHECKED BY:
DRAFTED BY:
CHECKED BY:

Transmission Developers Inc.

A Blackstone Portfolio Company

Exhibit B

MAGNETIC FIELD CALCULATIONS FOR CHAMPLAIN HUDSON POWER EXPRESS TRANSMISSION PROJECT: COMPARISONS OF 1,000 MW AND 1,250 MW DC CABLE CONFIGURATIONS IN WATER BODIES

Exponent®

M E M O R A N D U M

TO:	Josh Bagnato Transmission Developers, Inc.
FROM:	Benjamin Cotts, Ph.D., P.E. William H. Bailey, Ph.D.
DATE:	January 14, 2021
PROJECT:	1709319.EX0
SUBJECT:	Magnetic Field Calculations for Champlain Hudson Power Express Transmission Project: 1,000 MW and 1,250 MW DC Cable Configurations in Water Bodies

Executive Summary

Transmission Developers, Inc. (TDI) is proposing to operate the direct current (DC) cables to be installed under Lake Champlain and New York rivers as part of the Champlain Hudson Power Express (CHPE) Transmission Project at 400 kilovolts (kV), which will raise the maximum power capacity of the cables to 1,250 megawatts (MW). Exponent calculated the DC magnetic fields during operation at 1,250 MW for comparison to the DC magnetic fields previously calculated for operation at 1,000 MW, the power transfer capacity permitted for this project by the New York Public Service Commission (NYPSC). The current plan to install the DC transmission cables strapped together in all water bodies will result in very low magnetic-field levels at the surface of water bodies, which will be far less than 200 mG.[1]

Consistent with the permitted analysis at 1,000 MW the magnetic-field levels were calculated for heights of 1 and 10 feet above the lake or river bottom, the calculated magnetic-field values are slightly higher for operation at 1,250 MW than at 1,000 MW. At distances of 10 ft to either side of the cable centerline the differences in magnetic-field levels are just a few mG or less.

The calculated compass deviations at 1 and 10 feet above the bottom are very similar for operation at 1,000 and 1,250 MW. The differences in compass deviations between these power transfer levels at these depths is less than2.5 degrees. At the surface of water bodies, the greater distances from the cables means that compass deviations will be even less.

[1] New York Public Service Commission (NYPSC). Opinion No. 78-13. Cases 26529 and 26559, Issued June 19, 1978 and New York Public Service Commission (NYPSC). Statement of Interim Policy on Magnetic Fields of Major Electric Transmission Facilities. Cases 26529 and 26559 Proceeding on Motion of the Commission. Issued and Effective: September 11, 1990.

As for heat losses, the cables now proposed to accommodate the 1,250 MW load are specified to have a heat loss of 25 Watts per meter (W/m), which is significantly less than the previously assumed 43.1 W/m for the operation of previous cables at 1,000 MW. Thus, the heat loss at the higher power transfer now proposed will be less than was evaluated in previous state and federal reviews of the Project.

In summary, power transfers at 1,250 MW will not cause DC magnetic field levels, compass deviations, or power losses due to heating to change because of current flow on the cables. The small differences between prior calculations and those for proposed operation at 1,250 MW are due to small changes in cable diameter and burial depth.

Introduction

The purpose of this memorandum is to provide calculations of DC magnetic fields, compass deviations, and thermal cable losses from DC submarine cable configurations in lakes and rivers at 1,250 MW in anticipation of the TDI proposal to operate these permitted transmission facilities at 400 kV and increase the total power from 1,000 MW to 1,250 MW. The 1,000 MW cable loading was approved by the NYPSC Certificate of Environmental Compatibility and Public Need in case 10-T-0139 on April 18, 2013.

The configurations that Champlain Hudson Power Express (CHPE) proposed to be installed in water bodies remain relatively unchanged between the permitted 1,000 MW cables and the proposed 1,250 MW cables, (with the primary differences being slightly larger cables and somewhat different burial depths) and are summarized below:

Proposed Cable Configurations in Water Bodies

Three cable configurations to be installed in water bodies were evaluated:

1. In ***Lake Champlain***, cables are strapped together and buried 4 feet (ft) below the lake bottom;

2. In the ***Hudson River***, cables are strapped together and buried a minimum of 7 ft below the river bottom in areas outside the Federal navigation channel;[2]

3. In the ***Harlem River***, cables are strapped together and buried a minimum of 6 ft below the river bottom except in areas with rock, where the burial depth is 15 ft; [3]

The proposed cables are slightly larger in diameter compared to the previously-modeled cables which increases the separation by .05 feet. As with the permitted cables, the proposed

[2] For areas within the Federal navigation channel, the design burial depth is 9 ft below the riverbed. The calculated deviations to the geomagnetic field at these locations are less than for a 7-ft burial depth case and are not included in figures and tables below.

[3] For other areas in the Harlem River, the design burial depth is 8 ft below the riverbed. The calculated deviations to the geomagnetic field at these locations are less than the 6-ft burial depth case and are not included in figures and tables below.

will be strapped together in all configurations. Calculations of magnetic field levels and compass deviations were performed for each of the three above configurations with the cables modeled side-by-side (the horizontal arrangement) and with one cable on top of the other (the vertical arrangement), consistent with the permitting record.

Previous Cable Configurations in Water Bodies

Previous assessments submitted by TDI to the NYPSC included DC magnetic-field calculations at the surface of water bodies from underwater cables. In addition, Exponent had provided calculations of DC magnetic fields and compass deviations at 1 ft, 10 ft, and 19 ft above the lakebed or riverbed for various burial depths requested by the NYPSC. These previous calculations performed for a 1,000 MW operating condition are compared in this report to the proposed operation at 1,250 MW.

A. DC Magnetic Fields

Input Data for Magnetic Field Calculations

The input data used for the calculations of the DC magnetic fields, compass deviations, and thermal losses for the three configurations in water bodies are provided in Table 1.

Table 1. Summary of inputs to DC magnetic field and heat loss calculations for permitted and proposed designs for cable installations in water bodies

Location	Input Parameter	Prior Modeling Design†,‡,§	Proposed Modeling Design
	Nominal Line Voltage (kV)	±300	±400
	Nominal Power Transfer (MW)	1,000	1,250
	Current Flow (Amperes) at Winter Conductor Rating	1,670	1,638
	Heat Loss (W/m per cable)	43.1	25
Lake Champlain	Horizontal Cable Separation center to center (ft)	0.40	0.45
	Burial Depth, to cable center (ft)	4, 6	4
	Water Depth (ft)	400	400
Harlem River	Horizontal Cable Separation, center to center (ft)	0.40	0.45
	Burial Depth, to cable center (ft)	6	6
	Water Depth (ft)	15	15
Hudson River, Outside Channel	Horizontal Cable Separation, center to center (ft)	0.40	0.45
	Burial Depth, to cable center (ft)	3	7*
	Water Depth (ft)	32	32

† Attachment M, Revised Electric and Magnetic Fields Report, 7/13/2010. Also cited in Case Record as Exhibit 39 to Joint Proposal, filed 2/24/12.

‡ Exhibit 92, 02-18-11 HDR response letter to DOS. Attachment A. Exponent Inc Report on Heat and EMF, 2-8-2011.

§ Exhibit 100, 03-18-11- HDR Letter to DOS. Attachment A. Exponent Inc Report on Heat and EMF, 3-11-2011

* Depth in Hudson River outside the Maintained Federal Navigation Channel was increased from six feet to seven feet in the permit issued by the U.S. Army Corps of Engineers. This burial depth was approved in the Commission's amendment order issued on March 19,2020.

Calculated Magnetic Field Levels at 1,000 and 1,250 MW

Table 2 to Table 4 summarize the DC magnetic-field levels from the cables reported for the permitted configurations of DC cables evaluated at a height of 3.3 ft above the surface of the water bodies traversed by the Project's DC cables. These calculations were previously reported without incorporation of earth's geomagnetic field and so results here are also presented only in terms of the magnetic field from the cable (consistent with cited comparisons in the record). Calculated values for other cases and a 19-ft distance above the cables are contained in Appendix A.

Additional calculations of DC magnetic field values for below the water surface, close to the lake or river bottom, are summarized in Table 5 and Table 6. These calculations include the additive effect of earth's geomagnetic field (consistent with cited comparisons in the record).

Water Surface

The calculated values at the water surface were previously submitted into the record with a spacing between cables of 6 to more than 11 feet.[4] These installation configurations result in higher magnetic field levels at the surface of the water than a configuration where the two cables are strapped together. Comparisons of DC magnetic fields for the prior configurations and power transfer of 1,000 MW in the record and the new proposed configuration with closer cable spacing and 1,250 MW are shown below in Table 2 to Table 4. DC magnetic fields calculated at the surface of water bodies during operation at 1,250 MW are far lower than the prior values calculated at 1,000 MW.

Table 2. Calculated magnetic-field levels (mG) at 3.3 ft above water surface in Lake Champlain for buried cables in water depth of 400 ft

	Calculated Magnetic-Field Levels (mG) at Horizontal Distances from the Center of the Cables				
Cable Configuration	**−50 ft**	**-25 ft**	**Max**	**+25 ft**	**+50 ft**
Prior 6-ft separation (3-ft burial depth; 1,000 MW)*	0.4	0.4	0.4	0.4	0.4
Proposed 0.45-ft separation (4-ft burial depth; 1,250 MW)	<0.1	<0.1	<0.1	<0.1	<0.1

[4] Article VII Petition, Volume 3 – Appendix H: - EMF report. Electric and Magnetic Fields Report. TRC, March 2010. Also cited in Case Record as Exhibit 22 to Joint Proposal, filed 2/24/12.

Attachment M, Revised Electric and Magnetic Fields Report, 7/13/2010. Also cited in Case Record as Exhibit 39 to Joint Proposal, filed 2/24/12.

* Attachment M, Revised Electric and Magnetic Fields Report, 7/13/2010. Also cited in Case Record as Exhibit 39 to Joint Proposal, filed 2/24/12.. Note: the values of 0.4 mG in the table were calculated for a cable separation of 6 feet. At a later date the horizontal separation between the cables was reduced to 0.4 feet and so for that separation, the computed magnetic field values would be even lower, < 0.1 mG, at all distances from the centerline.

Table 3. Calculated magnetic-field levels (mG) at 3.3 ft above water surface in the Harlem River for buried cables in water depth of 18 ft

Cable Configuration	Calculated Magnetic-Field Levels (mG) at Distances from the Center of the Cables				
	−50 ft	-25 ft	Max	+25 ft	+50 ft
Prior (1,000 MW)*	-	-	-	-	-
Proposed 0.45-ft separation (6-ft burial; 1,250 MW)	1.5	3.5	6.5	3.5	1.5

* No previous calculations of DC magnetic-fields at the surface of the water in the Harlem River.

Table 4. Calculated magnetic-field levels (mG) at 3.3 ft above water surface in the Hudson River for buried cables in water depth of 32 ft

Cable Configuration	Calculated Magnetic-Field Levels (mG) at Distances from the Center of the Cables				
	−50 ft	-25 ft	Max	+25 ft	+50 ft
Prior 11.6-ft separation (3-ft burial 1,000 MW)*	16.6	31.4	44.6	31.4	16.6
Proposed 0.45-ft separation (7-ft burial; 1,250 MW)	1.1	2.0	2.7	2.0	1.1

* Article VII Petition, Volume 3 – Appendix H: - EMF report. Electric and Magnetic Fields Report. TRC, March 2010. Also cited in Case Record as Exhibit 22 to Joint Proposal, filed 2/24/12. Note: the values in the table had previously been calculated for a cable separation of 11.6 feet. At a later date the horizontal separation between the cables was reduced to 0.4 feet and so for that separation, the computed magnetic field values would be lower, and more similar to that calculated for the 1,250 MW case with 0.45-ft separation, presented above.

Subsurface

Exponent calculated DC magnetic field values below the water surface close to the lake or river bottom for multiple configurations and distances. The direction of current flow on the cables, geographic alignment of the cables, and cable arrangement were assessed including the effect of earth's geomagnetic field and so are presented as deviations from earth's geomagnetic field (consistent with cited comparisons in the record). In Table 5 and Table 6 below only the cases with the largest absolute maximum value above the cables are shown. These values would apply to installations of the cables in any water body.

Table 5. Calculated magnetic-field deviation (mG) at 1 ft above the bottom for the north-south alignment of touching cables and southward current in the easternmost cable (H) or southward current top (V)

Location/ Burial Depth	Configuration	Magnetic-field Deviation (mG) at Distances from Center of Cables		
		-10 ft	**0 ft or max**	**+10 ft**
Lake Champlain 4 ft	Prior (1,000 MW) – H‡	-21.1	164.8	-16.0
	Proposed (1,250 MW) – H	-23.1	181.8	-17.4
	Prior (1,000 MW) – V	-	-	-
	Proposed (1,250 MW) – V	27.1	129.4	-29.9
Hudson / Harlem River 6 ft	Prior (1,000 MW) – H§	-11.0	83.5	-6.1
	Proposed (1,250 MW) – H	-12.0	92.0	-6.5
	Prior (1,000 MW) – V§	24.8	15.3	-26.2
	Proposed (1,250 MW) – V	27.3	64.3	-28.7
Hudson River 7 ft	Prior (1,000 MW) – H	-	-	-
	Proposed (1, 250 MW) – H	-7.7	70.2	-2.5
	Prior (1,000 MW) – V	-	-	-
	Proposed (1,250 MW) – V	26.0	48.9	-26.8
Hudson River 8 ft	Prior (1,000 MW) – H‡	-3.9	50.3	0.3
	Proposed (1,250 MW) – H	-	-	-

H = horizontal arrangement; V = vertical arrangement.

‡ Exhibit 92, 02-18-11 HDR response letter to DOS. Attachment A. Exponent Inc Report on Heat and EMF, 2-8-2011.

§ Exhibit 100, 03-18-11- HDR Letter to DOS. Attachment A. Exponent Inc Report on Heat and EMF, 3-11-2011.

Table 6. Calculated magnetic-field levels (mG) at 10-ft above the bottom for the north-south alignment of touching cables and southward current in the easternmost cable (H) or southward current top (V)

Location/ Burial Depth	Configuration	Magnetic-field Deviation (mG) at Distances from Center of Cables		
		-10 ft	0 ft or max	+10 ft
Lake Champlain 4 ft	Prior (1,000 MW) – H‡	3.4	20.7	5.8
	Proposed (1,250 MW) – H	3.7	22.8	6.5
	Prior (1,000 MW) – V	-	-	-
	Proposed (1,250 MW) – V	14.7	15.7	-13.6
Hudson / Harlem River 6 ft	Prior (1,000 MW) – H§	4.1	15.8	6.1
	Proposed (1,250 MW) – H	4.5	17.4	6.7
	Prior (1,000 MW) – V§	10.7	1.8*	-9.7
	Proposed (1,250 MW) – V	11.8	12.0	-10.6
Hudson River 7 ft	Prior (1,000 MW) – H	-	-	-
	Proposed (1, 250 MW) – H	4.7	15.4	6.6
	Prior (1,000 MW) – V	-	-	-
	Proposed (1,250 MW) – V	10.6	10.6	-9.4
Hudson River 8 ft	Prior (1,000 MW) - H‡	4.3	12.5	5.9
	Proposed (1,250 MW) – H	-	-	-

H = horizontal arrangement; V = vertical arrangement.

‡ Exhibit 92, 02-18-11 HDR response letter to DOS. Attachment A. Exponent Inc Report on Heat and EMF, 2-8-2011.

§ Exhibit 100, 03-18-11- HDR Letter to DOS. Attachment A. Exponent Inc Report on Heat and EMF, 3-11-2011.

* In the vertical configuration the maximum value is offset from the center of the cables. The results presented in Exhibit 100 reported values at 0 feet horizontally from the cable (see Exhibit 100, Table 1 while the maximum deviation occurs at a few feet from the centerline (see Exhibit 100, Figure 2).

The calculated subsurface magnetic fields in these tables at 1 and 10 feet above the bottom for cables buried to varying depths are very similar for operation at 1,000 and 1,250 MW. Compared at the same burial depths, the largest difference between the DC magnetic fields calculated at these two power transfer levels in Table 5 at 1 foot above bottom is 17 mG, just 3.3% of the background geomagnetic field (515.6 mG). At 10 feet to either side of the cables the maximum difference is even less, 2.5 mG or 0.48%. Small differences of similar magnitudes also are evident at a distance of 10 feet above bottom in Table 5.

B. Compass Deflections

Comparisons of compass deflections produced by changes to the magnetic field calculated for operation at 1,000 MW and 1,250 MW are summarized in Table 7 at 1 foot and 10 feet above the bottom for cables in a side-by side horizontal arrangement and in Table 8 in a vertical arrangement.

Table 7. Calculated deflection (degrees) from magnetic north declination at 1 ft and 10 ft above the bottom for cables, in a north-south orientation, buried 4 ft below bottom (in a side-by side horizontal arrangement, southward current in the easternmost cable)

Cable Configuration	Evaluation Height Above Bottom	Deflection from Magnetic North (degrees) at Distances from Center of Cables				
		−25 ft	-10 ft	max	+10 ft	+25 ft
Prior (1,000 MW) ‡	1 ft	-0.7	-7.9	-32.1	7.4	0.7
	10 ft	-1.3	-3.9	-4.1	3.8	1.2
Proposed (1,250 MW)	1 ft	-0.8	-8.6	-34.4	8.1	0.8
	10 ft	-1.4	-4.2	-4.4	4.1	1.4

‡ Exhibit 92, 02-18-11 HDR response letter to DOS. Attachment A. Exponent Inc Report on Heat and EMF, 2-8-2011, Table 8

Table 8. Calculated deflection (degrees) from magnetic north declination at 1 ft and 10 ft above the bottom for cables in a north-south orientation buried 6 ft below bottom (in a vertical arrangement, southward current top).

Cable Configuration	Evaluation Height Above Bottom	Deflection from Magnetic North (degrees) at Distances from Center of Cables				
		−25 ft	-10 ft	max	+10 ft	+25 ft
Prior (1,000 MW)§	1 ft	-1.5	-2.8	21.3	-2.8	-1.5
	10 ft	-0.6	1.5	4.6	1.5	-0.6
Proposed (1,250 MW)	1 ft	-1.7	-3.0	22.9	-3.0	-1.7
	10 ft	-0.6	1.6	5.0	1.6	-0.6

§ Exhibit 100, 03-18-11- HDR Letter to DOS. Attachment A. Exponent Inc Report on Heat and EMF, 3-11-2011. Table 3

The calculated compass deviations in these tables at 1 and 10 feet above the bottom for cables in a horizontal arrangement and buried 4 feet or in a vertical arrangement and buried 6 feet are very similar for operation at 1,000 and 1,250 MW. The differences in compass deviations between these power transfer levels are all less than 2.5 degrees. In addition, the expected maximum deflection at 19 feet above the bottom for the 1,000 MW project was 1.9 degrees, very similar to the maximum compass deviation of 2.1 degrees calculated at the same 19-ft height above the Hudson and Harlem riverbeds.

Calculation Methods

Exponent calculated the DC magnetic fields for the 1,250 MW cable configurations of the CHPE DC transmission line of the CHPE DC transmission line and loading provided by TDI by the application of the Biot-Savart law which is derived from fundamental laws of physics. Application of the Biot-Savart Law is particularly appropriate for long straight conductors such as those in the present case. Modeling was performed for the submarine cable system installed in Lake Champlain, the Hudson River, and the Harlem River. For comparisons to calculated values reported by TRC in reports filed by TDI with the NYPSC and summarized above in Table 2 to Table 4, Exponent calculated the magnetic field produced by the just the DC cables as did TRC in previous filings.

For other calculations of the magnetic field and compass deviations by Exponent that were submitted by TDI to the NYPSC and summarized above in Table 5 to Table 8, both the contribution of the DC cables and the geomagnetic field of the earth were considered, and the results expressed as the magnetic field deviation or compass deflection. In this report, the figures prepared by Exponent in the Appendix present the deviation from ambient magnetic field along transects perpendicular to the cables and compass deviations calculated from these results.

The magnetic field vectors from the cables along north, east, and vertical axes were combined with the parallel vectors of the earth’s geomagnetic field as determined by the latest International Geomagnetic Reference Field Model (IGRF13) for specified latitude and longitude coordinates (NGDC, 2019) to obtain the total resultant magnetic field. The geomagnetic field at 40.932272 N latitude and 73.914373 W latitude was used in all calculations, corresponding to the geomagnetic components:

Northern component	201.54 mG
Eastern component	-45.96 mG
Downward component	472.40 mG
Total Magnetic Field	**515.6 mG**

Along the project route, the geomagnetic field does not vary sufficiently to affect the reported magnetic-field values and compass deflections by more than 0.5%.

Appendix A

Supplementary Calculations for Proposed Operation at 1,250 MW

In addition to Exponent's calculations for proposed operation of the CHPE DC submarine cables at 1,250 MW summarized in the body of this memorandum, Exponent prepared graphical profiles of calculated magnetic fields and compass deviations and tabulated values for selected aquatic route segments as in Table A-1. These calculations reflect variations in burial depth, horizontal and vertical distances from the cables, and orientation of the cables in north-south and east-west directions.

Table A-1. Tables and Figures in Appendix A

	DC Magnetic Field		Compass Deviation	
Water Body	**Figures**	**Tables**	**Figures**	**Tables**
Lake Champlain	A-1	A-2, A-4, A-6, A-8	A-4	A-10, A-12, A-14, A-16
Hudson River	A-2	A-2, A-4, A-6, A-8	A-5	A-10, A-12, A-14, A-16
Harlem River	A-3	A-3, A-5, A-7, A-9	A-6	A-11, A-13, A-15, A-17

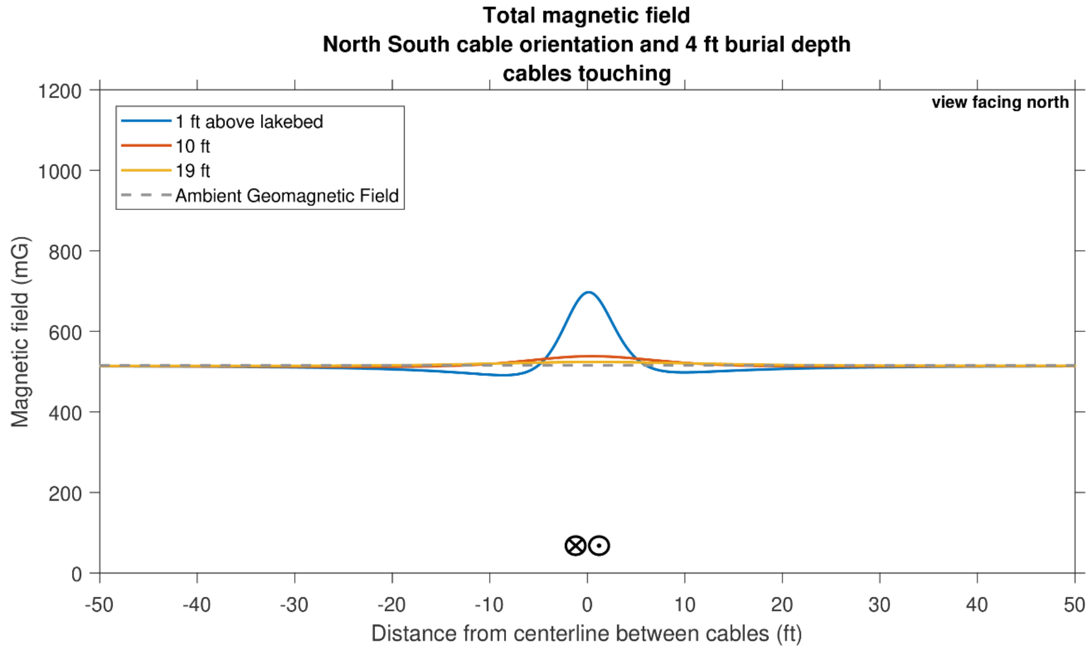


Figure A-1. Magnetic field profile (mG) above north-south-oriented cables buried 4 ft below the bottom of Lake Champlain, with cables touching and a southward current in the eastern cable.

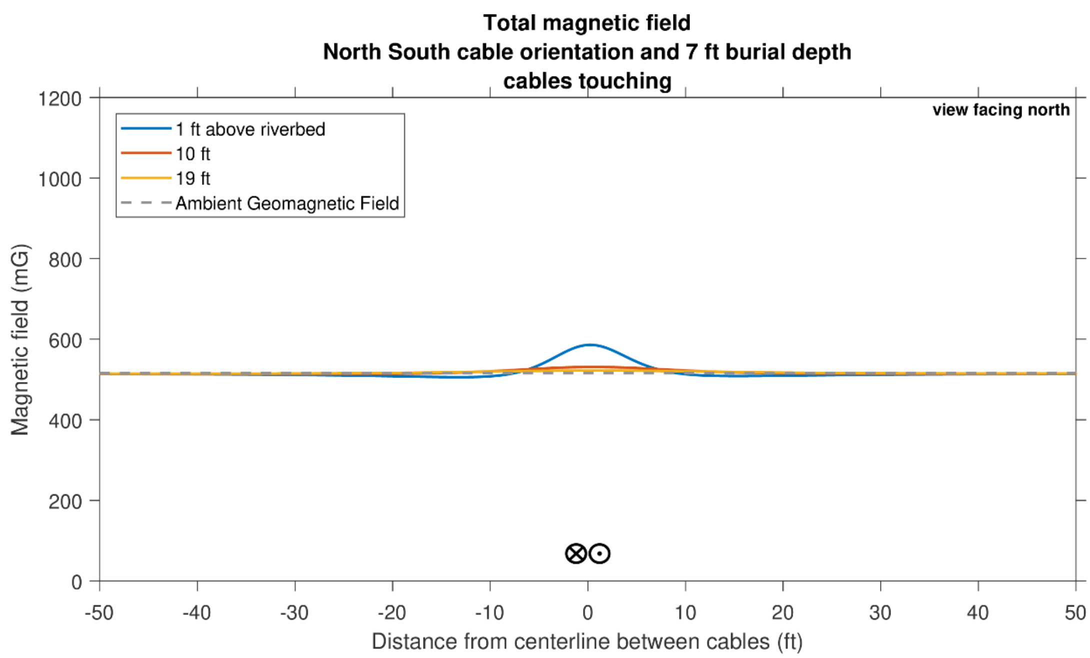


Figure A-2. Magnetic field profile (mG) above north-south-oriented cables buried 7 ft below the bottom of the Hudson River, with the cables touching and a southward current in the eastern cable.

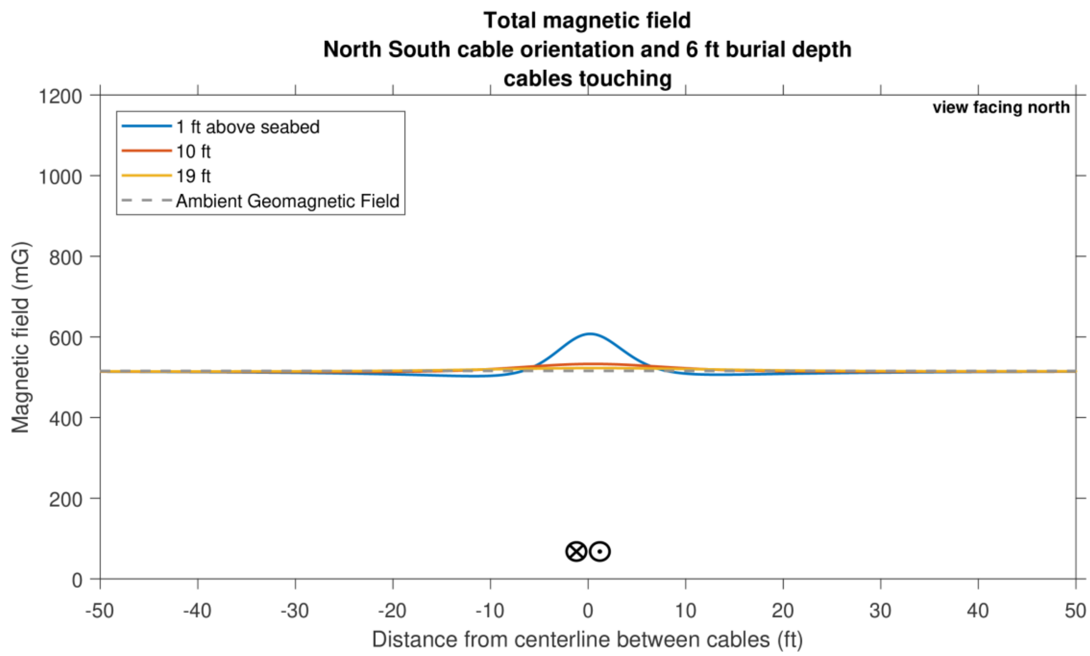


Figure A-3. Magnetic field profile (mG) above north-south-oriented cables buried 6 ft below the bottom of the Harlem River, with cables touching and a southward current in the eastern cable.

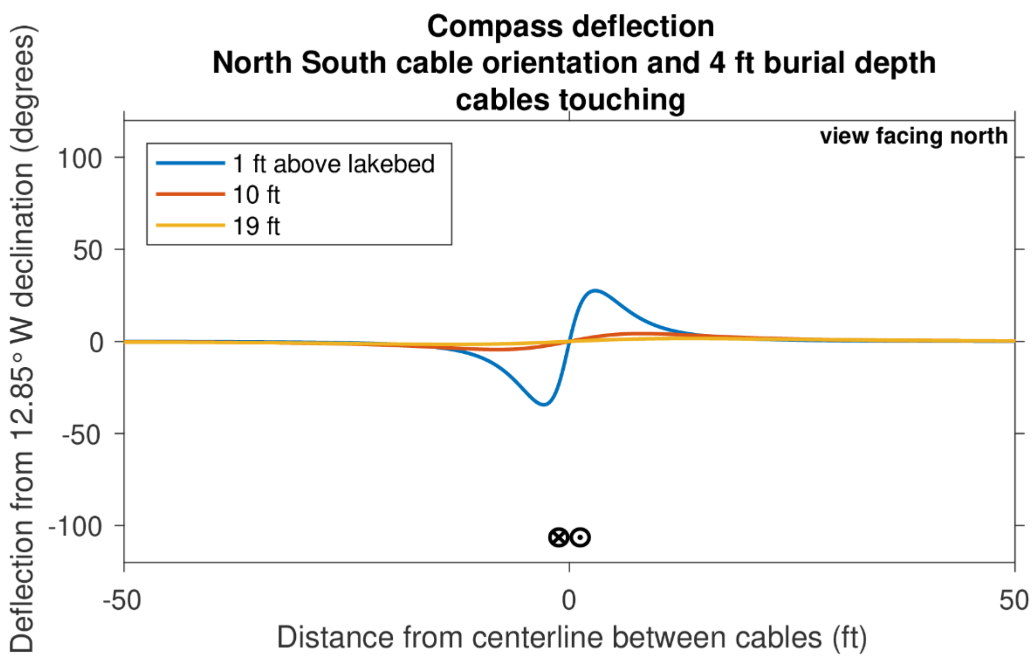


Figure A-4. Compass deflection (degrees) from 12.85° W declination above the north-south-oriented cables buried 4 ft below the bottom of Lake Champlain, with cables touching and a southward current in the eastern cable.

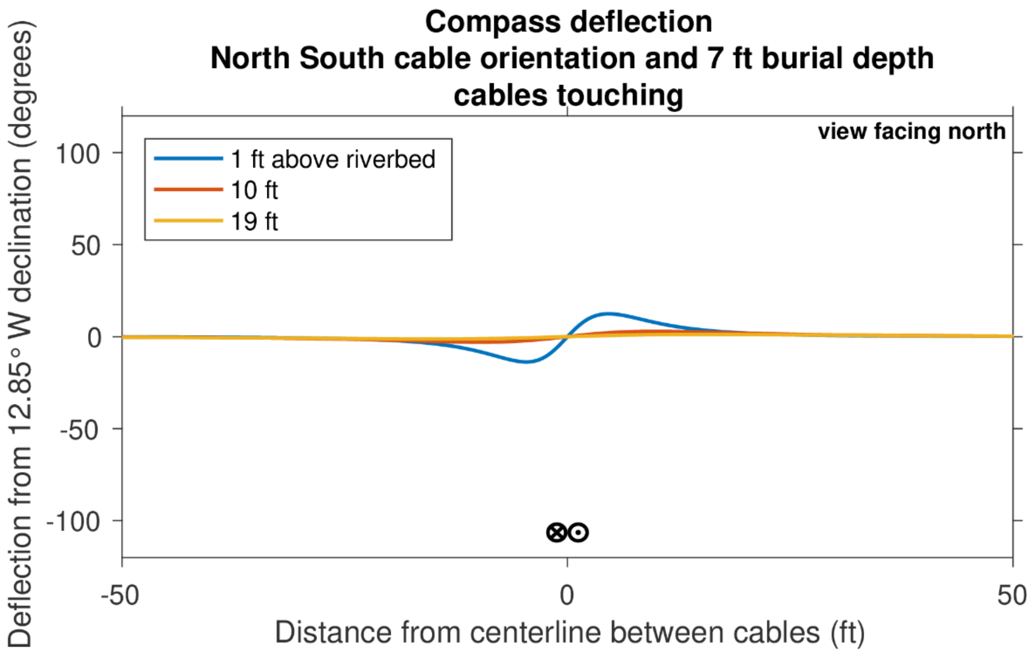


Figure A-5. Compass deflection (degrees) from 12.85° W declination above the north-south-oriented cables buried 7 ft below the bottom of the Hudson River, with cables touching and a southward current in the eastern cable.

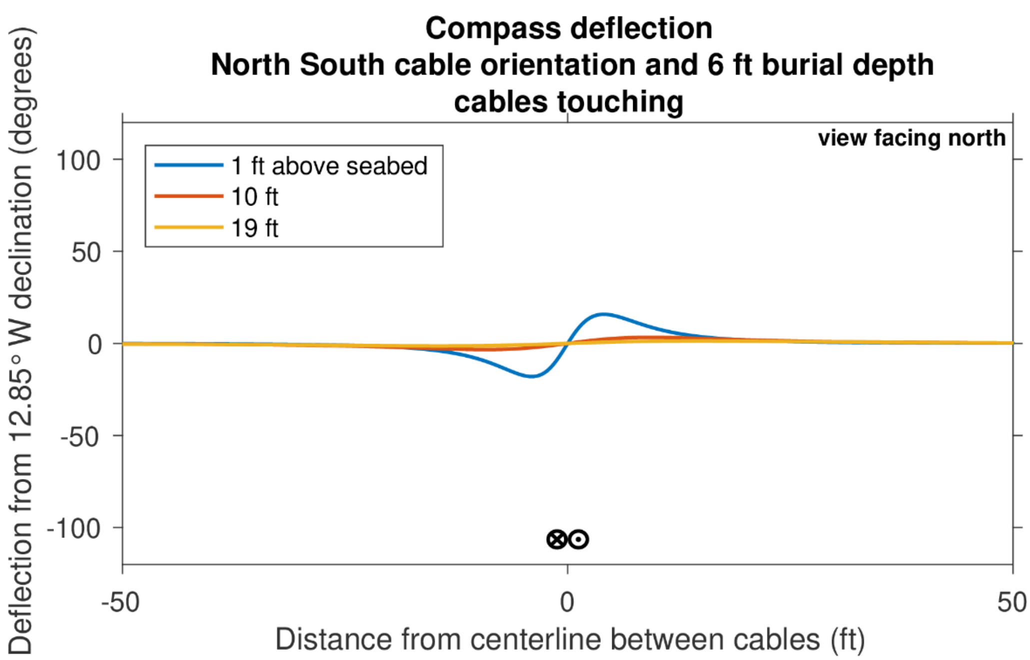


Figure A-6. Compass deflection (degrees) from 12.85° W declination above the north-south-oriented cables buried 6 ft below the bottom of the Harlem River, with cables touching and a southward current in the eastern cable

Table A-2. Magnetic-field deviation (mG) from the 515.6 mG geomagnetic field, above the lakebed or riverbed and offset from the centerline of the bipolar DC circuit (horizontal arrangement) with north-south orientation of cables in Lake Champlain and the Hudson River

Location	Cable burial depth (phasing)	Height above the lakebed or riverbed (ft)	Magnetic-field deviation at distances from the circuit centerline							
			-50 ft	-25 ft	-10 ft	max + deviation	max - deviation	+10 ft	+25 ft	+50 ft
Lake Champlain	4 ft (southward current west)	1	1.8	6.6	24.9	28.6	-169.3	19.6	6.1	1.7
		10	1.5	3.3	-3.2	3.4	-22.6	-6.0	2.4	1.3
		19	1.1	0.7	-4.3	1.2	-8.4	-5.3	<0.1	0.8
	4 ft (southward current east)	1	-1.8	-6.5	-23.1	181.8	-24.2	-17.4	-6.0	-1.7
		10	-1.5	-3.2	3.7	22.8	-3.3	6.5	-2.3	-1.3
		19	-1.1	-0.7	4.4	8.4	-1.2	5.3	0.1	-0.8
Hudson River	7 ft (southward current west)	1	1.7	5.6	9.3	10.6	-68.5	4.2	4.9	1.6
		10	1.4	2.2	-4.4	2.3	-15.4	-6.4	1.4	1.2
		19	0.9	0.2	-3.8	1.0	-6.6	-4.6	-0.4	0.7
	7 ft (southward current east)	1	-1.7	-5.6	-7.7	70.2	-9.9	-2.5	-4.9	-1.6
		10	-1.4	-2.2	4.7	15.4	-2.2	6.6	-1.3	-1.2
		19	-0.9	-0.2	3.9	6.6	-1.0	4.6	0.5	-0.7

Table A-3. Magnetic-field deviation (mG) from the 515.6 mG geomagnetic field, above the riverbed and offset from the centerline of the bipolar DC circuit (horizontal arrangement) with a north-south orientation of cables in the Harlem River and at the Crossing Location

Location	Cable burial depth (phasing)	Height above the riverbed	Magnetic-field deviation at distances from the circuit centerline -50 ft	-25 ft	-10 ft	max + deviation	max - deviation	+10 ft	+25 ft	+50 ft
Harlem River	6 ft (southward current west)	1	1.7	6.0	13.8	14.0	-89.0	8.4	5.3	1.6
		10	1.4	2.6	-4.2	2.6	-17.3	-6.4	1.7	1.2
		19	1.0	0.4	-4.0	1.1	-7.1	-4.8	-0.3	0.7
	6 ft (southward current east)	1	-1.7	-5.9	-12.0	92.0	-12.8	-6.5	-5.3	-1.6
		10	-1.4	-2.5	4.5	17.4	-2.5	6.7	-1.6	-1.2
		19	-1.0	-0.3	4.1	7.1	-1.0	4.9	0.4	-0.7

Table A-4. Magnetic-field deviation (mG) from the 515.6 mG geomagnetic field, above the lakebed or riverbed and offset from the centerline of the bipolar DC circuit (horizontal arrangement) with an east-west orientation of cables in Lake Champlain and the Hudson River

Location	Cable burial depth (phasing)	Height above the lakebed or riverbed (ft)	Magnetic-field deviation at distances from the circuit centerline							
			-50 ft	-25 ft	-10 ft	max + deviation	max - deviation	+10 ft	+25 ft	+50 ft
Lake Champlain	4 ft (westward current north)	1	1.9	7.4	33.8	47.5	-186.3	10.5	5.2	1.6
		10	1.8	4.8	1.4	5.7	-23.9	-10.8	0.9	1
		19	1.4	2	-2.6	2.1	-8.9	-7	-1.3	0.5
	4 ft (westward current south)	1	-1.9	-7.4	-33	188.2	-41.1	-7.8	-5.2	-1.6
		10	-1.8	-4.8	-0.9	24	-5.6	11.1	-0.8	-1
		19	-1.4	-1.9	2.7	8.9	-2.1	7	1.3	-0.5
Hudson River	7 ft (westward current north)	1	1.9	6.8	17.7	17.7	-73.1	-4.5	3.7	1.4
		10	1.7	3.7	-1.1	3.8	-16.2	-9.7	-0.1	0.9
		19	1.3	1.3	-2.6	1.6	-6.9	-5.9	-1.6	0.3
	7 ft (westward current south)	1	-1.9	-6.8	-16.6	73.4	-16.8	6.1	-3.6	-1.4
		10	-1.7	-3.7	1.4	16.3	-3.8	9.9	0.2	-0.8
		19	-1.3	-1.3	2.6	6.9	-1.6	5.9	1.6	-0.3

Table A-5. Magnetic-field magnitude (mG) from the 515.6 mG geomagnetic field, above the riverbed and offset from the centerline of the bipolar DC circuit (horizontal arrangement) with an east-west orientation of cables in the Harlem River and at the Crossing location

Location	Cable burial depth (phasing)	Height above riverbed	Magnetic-field deviation at distances from the circuit centerline							
			-50 ft	-25 ft	-10 ft	max + deviation	max - deviation	+10 ft	+25 ft	+50 ft
Harlem River	6 ft (westward current north)	1	1.9	7.1	22.7	23.4	-95.5	-0.7	4.2	1.5
		10	1.7	4.1	-0.5	4.3	-18.3	-10.2	0.2	0.9
		19	1.3	1.5	-2.6	1.8	-7.5	-6.2	-1.5	0.4
	6 ft (westward current south)	1	-1.9	-7.1	-21.6	95.9	-21.7	2.8	-4.1	-1.5
		10	-1.7	-4	0.9	18.3	-4.3	10.3	-0.1	-0.9
		19	-1.3	-1.5	2.7	7.5	-1.8	6.2	1.5	-0.4

Table A-6. Magnetic-field deviation (mG) from the 515.6 mG geomagnetic field, above the lakebed or riverbed and offset from the centerline of the bipolar DC circuit (vertical arrangement) with a north-south orientation of cables in Lake Champlain and the Hudson River

Location	Cable burial depth (phasing)	Height above the lakebed or riverbed (ft)	Magnetic-field deviation at distances from the circuit centerline							
			-50 ft	-25 ft	-10 ft	max + deviation	max - deviation	+10 ft	+25 ft	+50 ft
Lake Champlain	4 ft (southward current top)	1	0.2	2.1	27.1	129.4	-101.7	-29.9	-3.2	-0.5
		10	0.7	4.4	14.7	15.7	-13.8	-13.6	-4.9	-1.0
		19	1.0	3.8	5.7	5.8	-5.1	-4.7	-3.9	-1.2
	4 ft (southward current bottom)	1	-0.2	-2.0	-25.5	116.5	-114.2	31	3.3	0.5
		10	-0.7	-4.3	-14.6	14.1	-15.5	13.8	4.9	1
		19	-1.0	-3.8	-5.6	5.2	-5.8	4.7	3.9	1.2
Hudson River	7 ft (southward current top)	1	0.4	3.3	26.0	48.9	-41.6	-26.8	-4.2	-0.7
		10	0.9	4.4	10.6	10.6	-9.4	-9.4	-4.7	-1.1
		19	1.1	3.4	4.3	4.5	-4.0	-3.4	-3.4	-1.2
	7 ft (southward current bottom)	1	-0.4	-3.2	-25.6	43.8	-46.6	27.1	4.3	0.7
		10	-0.8	-4.3	-10.5	9.5	-10.5	9.5	4.7	1.1
		19	-1.1	-3.4	-4.2	4.1	-4.5	3.4	3.4	1.2

Table A-7. Magnetic-field deviation (mG) from the 515.6 mG geomagnetic field, above the riverbed and offset from the centerline of the bipolar DC circuit (vertical arrangement) with a north-south orientation of cables in the Harlem River

		Magnetic-field deviation at distances from the circuit centerline							
Cable burial depth (phasing)	**Height above the riverbed (ft)**	**-50 ft**	**-25 ft**	**-10 ft**	**max + deviation**	**max - deviation**	**+10 ft**	**+25 ft**	**+50 ft**
6 ft (southward current top)	1	0.3	2.9	27.3	64.3	-53.8	-28.7	-3.9	-0.6
	10	0.8	4.4	11.8	12.0	-10.6	-10.6	-4.8	-1.1
	19	1.1	3.6	4.7	4.9	-4.4	-3.8	-3.5	-1.2
6 ft (southward current bottom)	1	-0.3	-2.8	-26.6	57.7	-60.4	29.2	4.0	0.6
	10	-0.8	-4.4	-11.7	10.7	-11.9	10.7	4.8	1.1
	19	-1.0	-3.5	-4.6	4.4	-4.9	3.8	3.6	1.2

Table A-8. Magnetic-field deviation (mG) from the 515.6 mG geomagnetic field, above the lakebed or riverbed and offset from the centerline of the bipolar DC circuit (vertical arrangement) with an east-west orientation of cables in Lake Champlain and the Hudson River

Location	Cable burial depth (phasing)	Height above the lakebed or riverbed (ft)	Magnetic-field deviation at distances from the circuit centerline							
			-50 ft	-25 ft	-10 ft	max + deviation	max - deviation	+10 ft	+25 ft	+50 ft
Lake Champlain	4 ft (westward current top)	1	-0.4	<0.1	20.4	156.9	-90.3	-37.4	-5.3	-1.1
		10	0.3	3.4	16.3	19.6	-12.1	-12.0	-5.8	-1.5
		19	0.7	3.7	7.2	7.2	-4.5	-3.1	-4.0	-1.5
	4 ft (westward current bottom)	1	0.4	0.1	-18.2	101.2	-148.7	37.6	5.3	1.1
		10	-0.2	-3.4	-16.3	12.3	-19.4	12.2	5.8	1.5
		19	-0.7	-3.7	-7.2	4.5	-7.2	3.2	4.0	1.5
Hudson River	7 ft (westward current top)	1	-0.2	1.5	24.1	60.3	-36.5	-28.9	-6.0	-1.2
		10	0.4	3.8	12.3	13.3	-8.2	-7.5	-5.3	-1.5
		19	0.8	3.5	5.7	5.7	-3.5	-2.0	-3.3	-1.5
	7 ft (westward current bottom)	1	0.2	-1.5	-23.5	38.2	-59.1	29	6.0	1.2
		10	-0.4	-3.7	-12.3	8.3	-13.2	7.7	5.3	1.5
		19	-0.8	-3.5	-5.6	3.5	-5.6	2.1	3.4	1.5

Table A-9. Magnetic-field deviation (mG) from the 515.6 mG geomagnetic field, above the riverbed and offset from the centerline of the bipolar DC circuit (vertical arrangement) with an east-west orientation of cables in the Harlem River

Cable burial depth (phasing)	Height above riverbed (ft)	Magnetic-field deviation at distances from the circuit centerline							
		-50 ft	-25 ft	-10 ft	max + deviation	max - deviation	+10 ft	+25 ft	+50 ft
6 ft (westward current top)	1	-0.2	1.1	24.1	79.1	-47.4	-32.3	-5.8	-1.2
	10	0.4	3.7	13.5	15.0	-9.3	-8.8	-5.5	-1.5
	19	0.8	3.6	6.1	6.1	-3.8	-2.3	-3.5	-1.5
6 ft (westward current bottom)	1	0.2	-1.0	-23.1	50.2	-77.0	32.3	5.8	1.2
	10	-0.4	-3.7	-13.5	9.4	-14.9	9.0	5.5	1.5
	19	-0.8	-3.5	-6.1	3.8	-6.1	2.4	3.6	1.5

Table A-10. Compass deflection (degrees) from 12.85° W declination, above the lakebed or riverbed and offset from the centerline of the bipolar DC circuit (horizontal arrangement) with a north-south orientation of cables in Lake Champlain and the Hudson River

Location	Cable burial depth and phasing	Height above lakebed or riverbed (ft)	Compass deflection at distances from the circuit centerline							
			-50 ft	-25 ft	-10 ft	max + deflection	max - deflection	+10 ft	+25 ft	+50 ft
Lake Champlain	4 ft (southward current west)	1	0.1	0.8	8.1	27.6	-34.4	-8.6	-0.8	-0.1
		10	0.3	1.4	4.1	4.3	-4.4	-4.2	-1.4	-0.3
		19	0.3	1.1	1.5	1.6	-1.6	-1.5	-1.1	-0.3
	4 ft (southward current east)	1	-0.1	-0.8	-8.6	27.6	-34.4	8.1	0.8	0.1
		10	-0.3	-1.4	-4.2	4.3	-4.4	4.1	1.4	0.3
		19	-0.3	-1.1	-1.5	1.6	-1.6	1.5	1.1	0.3
Hudson River	7 ft (southward current west)	1	0.2	1.1	7.5	12.4	-13.7	-8.0	-1.1	-0.2
		10	0.3	1.3	2.9	2.9	-3.0	-3.0	-1.3	-0.3
		19	0.3	1.0	1.1	1.3	-1.3	-1.1	-1.0	-0.3
	7 ft (southward current east)	1	-0.2	-1.1	-8.0	12.4	-13.7	7.5	1.1	0.2
		10	-0.3	-1.3	-3.0	2.9	-3.0	2.9	1.3	0.3
		19	-0.3	-1.0	-1.1	1.3	-1.3	1.1	1.0	0.3

Table A-11. Compass deflection (degrees) from 12.85° W declination, above the riverbed or concrete blanket and offset from the centerline of the bipolar DC circuit (horizontal arrangement) with a north-south orientation of cables for the Harlem River and Crossing locations

Location	Cable burial depth (phasing)	Height above riverbed	Compass deflection at distances from the circuit centerline							
			-50 ft	-25 ft	-10 ft	max + deflection	max - deflection	+10 ft	+25 ft	+50 ft
Harlem River	6 ft (southward current west)	1	0.1	1.0	7.9	15.8	-18.0	-8.5	-1.0	-0.1
		10	0.3	1.3	3.3	3.3	-3.4	-3.3	-1.4	-0.3
		19	0.3	1.0	1.2	1.4	-1.4	-1.3	-1.1	-0.3
	6 ft (southward current east)	1	-0.1	-1.0	-8.5	15.8	-18.0	7.9	1.0	0.1
		10	-0.3	-1.4	-3.3	3.3	-3.4	3.3	1.3	0.3
		19	-0.3	-1.1	-1.3	1.4	-1.4	1.2	1.0	0.3

Table A-12. Compass deflection (degrees) from 12.85° W declination, above the lakebed or riverbed and offset from the centerline of the bipolar DC circuit (horizontal arrangement) with an east-west orientation of cables for Lake Champlain and the Hudson River

Location	Cable burial depth (phasing)	Height above lake/riverbed (ft)	Compass deflection at distances from the circuit centerline							
			-50 ft	-25 ft	-10 ft	max + deflection	max - deflection	+10 ft	+25 ft	+50 ft
Lake Champlain	4 ft (westward current north)	1	<0.1	-0.2	-1.7	18.4	-4.9	2.2	0.2	<0.1
		10	-0.1	-0.3	-0.9	1.1	-0.9	1.0	0.3	0.1
		19	-0.1	-0.3	-0.3	0.4	-0.4	0.4	0.3	0.1
	4 ft (westward current south)	1	<0.1	0.2	2.2	18.4	-4.9	-1.7	-0.2	<0.1
		10	0.1	0.3	1.0	1.1	-0.9	-0.9	-0.3	-0.1
		19	0.1	0.3	0.4	0.4	-0.4	-0.3	-0.3	-0.1
Hudson River	7 ft (westward current north)	1	<0.1	-0.2	-1.6	3.9	-2.5	2.1	0.3	<0.1
		10	-0.1	-0.3	-0.6	0.7	-0.6	0.7	0.3	0.1
		19	-0.1	-0.2	-0.3	0.3	-0.3	0.3	0.2	0.1
	7 ft (westward current south)	1	<0.1	0.3	2.1	3.9	-2.5	-1.6	-0.2	<0.1
		10	0.1	0.3	0.7	0.7	-0.6	-0.6	-0.3	-0.1
		19	0.1	0.2	0.3	0.3	-0.3	-0.3	-0.2	-0.1

Table A-13. Compass deflection (degrees) from 12.85° W declination, above the riverbed or the concrete blanket and offset from the centerline of the bipolar DC circuit (horizontal arrangement) with an east-west orientation of cables

Location	Cable burial depth (phasing)	Height above riverbed	Compass deflection at distances from the circuit centerline							
			-50 ft	-25 ft	-10 ft	max + deflection	max - deflection	+10 ft	+25 ft	+50 ft
Harlem River	6 ft (westward current north)	1	<0.1	-0.2	-1.6	5.7	-3.0	2.2	0.2	<0.1
		10	-0.1	-0.3	-0.7	0.8	-0.7	0.8	0.3	0.1
		19	-0.1	-0.2	-0.3	0.3	-0.3	0.3	0.2	0.1
	6 ft (westward current south)	1	<0.1	0.2	2.2	5.7	-3.0	-1.6	-0.2	<0.1
		10	0.1	0.3	0.8	0.8	-0.7	-0.7	-0.3	-0.1
		19	0.1	0.2	0.3	0.3	-0.3	-0.3	-0.2	-0.1

Table A-14. Compass deflection (degrees) from 12.85° W declination, above the lakebed or riverbed and offset from the centerline of the bipolar DC circuit (vertical arrangement) with a north-south orientation of cables

Location	Cable burial depth and phasing	Height above lakebed or riverbed (ft)	Compass deflection at distances from the circuit centerline							
			-50 ft	-25 ft	-10 ft	max + deflection	max - deflection	+10 ft	+25 ft	+50 ft
Lake Champlain	4 ft (southward current top)	1	-0.5	-1.9	-6.4	37.1	-6.7	-6.4	-1.9	-0.5
		10	-0.4	-0.8	1.4	6.5	-0.8	1.4	-0.8	-0.4
		19	-0.3	-0.1	1.4	2.4	-0.3	1.4	-0.1	-0.3
	4 ft (southward current bottom)	1	0.5	1.8	6.1	6.4	-49.2	6.1	1.8	0.5
		10	0.4	0.8	-1.4	0.8	-6.8	-1.4	0.8	0.4
		19	0.3	0.1	-1.4	0.3	-2.5	-1.4	0.1	0.3
Hudson River	7 ft (southward current top)	1	-0.5	-1.6	-1.8	18.3	-2.6	-1.8	-1.6	-0.5
		10	-0.4	-0.5	1.6	4.4	-0.6	1.6	-0.5	-0.4
		19	-0.2	<0.1	1.2	1.9	-0.2	1.2	<0.1	-0.2
	7 ft (southward current bottom)	1	0.5	1.5	1.7	2.5	-21.3	1.7	1.5	0.5
		10	0.4	0.5	-1.6	0.6	-4.6	-1.6	0.5	0.4
		19	0.2	<0.1	-1.3	0.2	-2.0	-1.3	<0.1	0.2

Table A-15. Compass deflection (degrees) from 12.85° W declination, above the riverbed and offset from the centerline of the bipolar DC circuit (vertical arrangement) with a north-south orientation of cables in the Harlem River

		Compass deflection at distances from the circuit centerline							
Cable burial depth (phasing)	**Height above lake/riverbed (ft)**	**-50 ft**	**-25 ft**	**-10 ft**	**-50 ft**	**max - deflection**	**+10 ft**	**-50 ft**	**+50 ft**
6 ft (southward current top)	1	-0.5	-1.7	-3.0	22.9	-3.4	-3.0	-1.7	-0.5
	10	-0.4	-0.6	1.6	5.0	-0.6	1.6	-0.6	-0.4
	19	-0.3	<0.1	1.3	2.1	-0.3	1.3	<0.1	-0.3
6 ft (southward current bottom)	1	0.5	1.6	3.0	3.3	-27.6	3.0	1.6	0.5
	10	0.4	0.6	-1.6	0.6	-5.2	-1.6	0.6	0.4
	19	0.3	<0.1	-1.3	0.3	-2.1	-1.3	<0.1	0.3

Table A-16. Compass deflection (degrees) from 12.85° W declination, above the lakebed or riverbed and offset from the centerline of the bipolar DC circuit (vertical arrangement) with an east-west orientation of cables for Lake Champlain and the Hudson River

Location	Cable burial depth (phasing)	Height above lake/riverbed (ft)	Compass deflection at distances from the circuit centerline							
			-50 ft	-25 ft	-10 ft	max + deflection	max - deflection	+10 ft	+25 ft	+50 ft
Lake Champlain	4 ft (westward current top)	1	0.1	0.4	1.6	1.7	-6.2	1.6	0.4	0.1
		10	0.1	0.2	-0.3	0.2	-1.4	-0.3	0.2	0.1
		19	0.1	<0.1	-0.3	0.1	-0.5	-0.3	<0.1	0.1
	4 ft (westward current bottom)	1	-0.1	-0.4	-1.3	68.0	-1.3	-1.3	-0.4	-0.1
		10	-0.1	-0.2	0.3	1.7	-0.2	0.3	-0.2	-0.1
		19	-0.1	0	0.3	0.6	-0.1	0.3	<0.1	-0.1
Hudson River	7 ft (westward current top)	1	0.1	0.4	0.4	0.6	-3.4	0.4	0.4	0.1
		10	0.1	0.1	-0.4	0.1	-1	-0.4	0.1	0.1
		19	0.1	<0.1	-0.3	0.1	-0.4	-0.3	<0.1	0.1
	7 ft (westward current bottom)	1	-0.1	-0.3	-0.4	7.2	-0.6	-0.4	-0.3	-0.1
		10	-0.1	-0.1	0.4	1.1	-0.1	0.4	-0.1	-0.1
		19	-0.1	<0.1	0.3	0.5	-0.1	0.3	<0.1	-0.1

Table A-17. Compass deflection (degrees) from 12.85° W declination, above the riverbed and offset from the centerline of the bipolar DC circuit (vertical arrangement) with an east-west orientation of cables for the Harlem River

Cable burial depth (phasing)	Height above riverbed (ft)	Compass deflection at distances from the circuit centerline							
		-50 ft	-25 ft	-10 ft	max + deflection	max - deflection	+10 ft	+25 ft	+50 ft
6 ft (westward current top)	1	0.1	0.4	0.7	0.8	-4.2	0.7	0.4	0.1
	10	0.1	0.1	-0.4	0.1	-1.1	-0.4	0.1	0.1
	19	0.1	<0.1	-0.3	0.1	-0.5	-0.3	<0.1	0.1
6 ft (westward current bottom)	1	-0.1	-0.4	-0.7	11.3	-0.7	-0.7	-0.4	-0.1
	10	-0.1	-0.1	0.4	1.3	-0.1	0.4	-0.1	-0.1
	19	-0.1	<0.1	0.3	0.5	-0.1	0.3	<0.1	-0.1

Transmission Developers Inc.

A Blackstone Portfolio Company

Exhibit C

MAGNETIC FIELD CALCULATIONS FOR CHAMPLAIN HUDSON POWER EXPRESS TRANSMISSION PROJECT: COMPARISONS OF 1,000 MW AND 1,250 MW DC CABLE CONFIGURATIONS ON LAND

Exponent®

MEMORANDUM

TO:	Josh Bagnato Transmission Developers, Inc.
FROM:	Benjamin Cotts, Ph.D., P.E.
DATE:	January 14, 2021
PROJECT:	1709319.EX0
SUBJECT:	Magnetic Field Calculations for Champlain Hudson Power Express Transmission Project: 1,000 MW and 1,250 MW DC Cable Configurations on Land

Executive Summary

Transmission Developers, Inc. is proposing to operate the direct current (DC) cables to be installed on land as part of the Champlain Hudson Power Express (CHPE) Transmission Project at 400 kilovolts(kV), which will raise the maximum power capacity of the cables to 1,250 megawatts (MW). Exponent compared the calculated DC magnetic fields at 1,000 MW for the design permitted in the New York Public Service Commission (NYPSC) Certificate of Environmental Compatibility and Public Need in case 10-T-0139 on April 18, 2013 to the DC magnetic fields calculated at 1,250 MW for the newly proposed project capacity. This comparison shows that the new design specifications for cable operation will result in DC magnetic fields less than 200 milligauss (mG) within six feet of the centerline of the cables. Differences between previous and proposed magnetic field values result from small differences in the separation and burial depth of the cables, not current flow which is the source of the magnetic field.

Introduction

The purpose of this memorandum is to compare the calculated DC magnetic fields from the DC cable configurations on land for the Champlain Hudson Power Express Transmission project at the 1,000 MW cable loadings previously submitted by TDI to the NYPSC in case 10-T-0139, and permitted by the NYPSC, to new values in anticipation of the TDI proposal to operate these permitted transmission facilities at 400 kV and 1,250 MW. These comparisons are provided for two burial depths of the DC transmission line. With the exception of a one-mile segment proposed on Randall's Island, which involves a six-foot burial depth (or greater), the on-land portion of the project has assumed an approximately three-foot burial depth.[1] Although the new

[1] The assumed 3.2-ft burial depth used for modeling is the minimum depth of the cable burial on land. The cables could be buried deeper in certain segments of the route.

proposed operating conditions for permitted DC transmission facilities on land would increase the line voltage, they would not increase the maximum current carried by the cables so the magnetic fields will not be changed based solely on line currents or the increase in capacity from 1,000 MW to 1,250 MW;[2] any changes in magnetic field levels will be small and result from differences between the previous and proposed configurations and burial depths of the DC cables.

Input Data for Magnetic Field Calculations

The input data used for the calculations of the DC magnetic fields and related parameters for the new design proposed, are compared in Table 1 below to those used for the prior calculations that were used to describe the permitted design.

Table 1. Summary of Inputs to DC Magnetic Field Calculations for Previous and Proposed Designs for Underground Cable Installations on Land

Input Parameter	Previous Modeling Design*	Proposed Modeling Design
Nominal Line Voltage (kilovolts)	±300	±400
Nominal Power (MW)	1,000	1,250
Current Flow (amperes) at Winter Conductor Rating	1670	1638
On Land Configuration		
Horizontal Cable Separation (feet)†	1.00	1.33
Burial Depth, to cable center (feet)	3.25	3.2
Randall's Island Configuration		
Horizontal Cable Separation, center to center (feet)	Not Evaluated	1.33
Burial Depth to center of cable (feet)	Not Evaluated	6.2

* Exhibit 116 to Joint Proposal, filed 2/24/12.
† Representative results for prior design configurations included other separation distances including 0.34 feet (cables touching). It is Exponent's understanding that this cable separation and a cable separation of 3-ft were not carried forward in the design.

[2] Magnetic-field levels depend on the current flowing on the cables of the transmission line. Current is proportional to the power and inversely proportional to the voltage so at a higher voltage (±400 kV) more power can be transferred with the same current. The original calculations assumed a voltage of ±300 kV and 1670 Amperes. The prior modeled load current is slightly higher than the more recent load current for the 1,000 MW cable which is 1643 A. The maximum current on the ±400-kV, 1,250-MW cables will be the same 1643 A.

Summary of Magnetic Field Calculations

Table 2 summarizes the DC magnetic-field levels reported for the permitted design of the DC cables on land for the previous 1,000 MW cable design operating at ±300/±320 kV and the new proposed 1,250 MW cables designed to operate at ±400 kV.

Table 2. Calculated magnetic-field levels (mG) at 1 m above ground for On Land Cables

Cable Configuration	Burial depth (ft)	Cable Spacing (ft)	Horizontal Distance from Center of Cables						
			−20 ft	−10 ft	−6 ft	0 ft	+6 ft	+10 ft	+20 ft
Prior on Land* (1,000 MW)	3.25	1.00	24.8	76.9	<161.8†	255.5	<161.8†	76.9	24.8
Proposed on Land (1,250 MW)	3.2	1.33	32.4	101	183.6	337.5	183.6	101	32.4
Proposed Randall Island (1,250 MW)§	6.2	1.33	29.3	75.5	113.6	158.6	113.6	75.5	29.3

* Results presented along a transect perpendicular to the transmission centerline. The calculations do not reflect any contribution from the static magnetic field of the earth.

† Exhibit 116 from which prior calculations were extracted reported values in 5-foot increments and thus did not present calculations at ± 6 feet (the minimum ROW width).

§ The calculated DC magnetic field values listed in the table above in the column for 6 feet distance from the center of cables was calculated by Exponent in a previous analysis for TDI.

The DC magnetic field for proposed operation at 400 kV at a distance of six feet from the centerline of the cables and one meter above the ground is 183.6 mG. This distance is within the right-of-way allowed adjacent to lands owned or controlled by a railroad company or a public highway (six feet from outer edge of cables) and all other areas (eight feet from outer edge of cables) as specified in modified Certificate Condition 140.[3]

The NYPSC's Interim Policy on magnetic fields states that magnetic fields from new Article VII transmission lines cannot exceed 200 mG at the edge of the right of way (ROW).[4] As shown in Table 2, above, the calculated DC magnetic-field levels at six feet to either side of the cables at a height of one meter above ground is below 200 mG for both the previous 1,000 MW and Proposed 1,250 MW underground DC configurations are below 200 mG at specified boundaries. For additional context, the International Commission on Non-Ionizing Radiation

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3 Order Granting, In Part, Amendment of Certificate of Environmental Compatibility and Public Need Subject To Conditions (Issued and Effective March 20, 2020).

Note: distances in Order refer to distances from the outer surface of the cable. Distances in Tables are referenced to the centerline of the circuit so equivalent distances to the effective edge of the specified right-of-way in the Order from the centerline are 6.9 feet and 8.9 feet.

4 New York Public Service Commission (NYPSC). Opinion No. 78-13. Cases 26529 and 26559, Issued June 19, 1978 and New York Public Service Commission (NYPSC). Statement of Interim Policy on Magnetic Fields of Major Electric Transmission Facilities. Cases 26529 and 26559 Proceeding on Motion of the Commission. Issued and Effective: September 11, 1990.

Protection (ICNIRP) has established a DC magnetic field exposure limit of 4,000,000 mG as a general public health standard.[5]

Calculation Methods

For comparisons to DC magnetic field values calculated in previous submissions, Exponent calculated DC magnetic fields by the application of the Biot-Savart Law, which is derived from fundamental laws of physics. Application of the Biot-Savart Law is particularly appropriate for long straight conductors such as those in the present case. The calculations assumed that all conductors are parallel to one another, infinite in length, and that there is no attenuation of magnetic-field levels by any surrounding medium. Magnetic fields were calculated along a transect perpendicular to the transmission line centerlines and reported at a height of one meter above ground, as recommended by Institute of Electrical and Electronics Engineers (IEEE) Standards—C95.3.1-2010 and 0644-2019.[6]

For the proposed configuration of the cables on Randall's Island, Exponent calculated magnetic fields from the DC cables by Finite Element Analysis (FEA) using COMSOL Multiphysics software.

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[5] International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines on limits of exposure to static magnetic fields. Health Phys. 96:504-14, 2009.

[6] Institute of Electrical and Electronics Engineers (IEEE). IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic fields with respect to Human Exposure to Such Fields, 0 Hz to 100 kHz. New York: IEEE. IEEE Std. C95.3.1-2010 and Institute of Electrical and Electronics Engineers (IEEE). Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines (ANSI/IEEE Std. 644-2019). New York: IEEE, 2019.

Exhibit D

MAGNETIC FIELD CALCULATIONS FOR CHAMPLAIN HUDSON POWER EXPRESS TRANSMISSION PROJECT: COMPARISONS OF 1,000 MVA AND 1,250 MVA AC DUCT BANK CONFIGURATIONS

Exponent®

MEMORANDUM

TO:	Josh Bagnato Transmission Developers, Inc.
FROM:	Benjamin Cotts, Ph.D., P.E.
DATE:	December 16, 2020
PROJECT:	1709319.EX0
SUBJECT:	Magnetic Field Calculations for Champlain Hudson Power Express Transmission Project: Comparisons of 1,000 MVA and 1,250 MVA AC Duct Bank Configurations

Introduction

The purpose of this memorandum is to compare the calculated alternating current (AC) magnetic fields submitted by Transmission Developers, Inc. (TDI) to the New York Public Service Commission (NYPSC) in case 10-T-0139 for a single-circuit, 345-kV XLPE underground line with 1 conductor per phase[1] to a new configuration of the single-circuit, 345-kV XLPE underground line with 2 conductors per phase now proposed by TDI to support operation at 1250 mega-volt amperes (MVA).

Input Data for Magnetic Field Calculations

The input data used for the calculations of the magnetic fields for the two configurations of the single-circuit duct banks are summarized in Table 1 below. Additional detail is provided in Appendix A.

1 Exhibit 119 Revised EMF Report for HVAC Cable. Thomas J. F. Ordon. Electric and Magnetic Fields Report. Project # 169201. Report Supplement. The Champlain Hudson Power Express Project. TRC, December 28, 2011.

Table 1. Summary of Inputs to AC Magnetic Field Calculations for Permitted and Proposed XLPE Cable Designs on Land

Input Parameter	Permitted Design* § (1 conductor per phase)	Proposed Design (2 conductors per phase)
Nominal Line Voltage (kilovolts)	345	345
Nominal Power (mega-volt-amperes)	1,000	1,250
Current Flow (amperes) at Winter Conductor Rating	1673	1,049
NYPA GIS Substation to Con Edison Rainey Substation		
Horizontal Cable Separation (feet)	0.75	1.25
Burial Depth, Conductor Centers (feet)	4.23, 4.98, 4.98	4.05, 5.30, 6.55

* Sources: Exhibit 39: Attachment M, 7/13/2010.
§ Exhibit 119 Revised EMF Report for HVAC Cable Dec 28, 2011.

Summary of Magnetic Field Calculations

Table 2 summarizes the magnetic-field levels reported for the previous 1-conductor per phase configuration and the magnetic field levels calculated by Exponent for the new proposed configuration of the duct bank with 2-conductors per phase.

Table 2. Calculated magnetic-field levels (mG) at 1 m above ground

Duct Bank Configuration	Distance from Center of Duct Bank				
	−50 feet	-20 feet	0 feet	+20 feet	+50 feet
Previous (1-conductor/phase)	4.6	25	182	25	4.6
Proposed (2-conductor/phase)*	0.3	3.6	61	3.6	0.3

* At each location along a transect perpendicular to the transmission centerline, magnetic-field levels are presented as the rms flux density of the maximum field ellipse as specified by NYPSC EMF policy (NYPSC, 1990).

The magnetic field of the previous duct bank configuration was calculated to be 182 mG directly above the duct bank, measured at 1 m above ground. At ± 20 feet and ± 50 feet from the centerline the magnetic field level diminished to 25 mG and 4.6 mG, respectively. At these same locations, the magnetic fields from the proposed 2-conductors per phase duct bank configuration were calculated to be about 3 to 15-fold lower than the previously permitted 1-conductor per phase design. The lower magnetic fields of the 2-conductors per phase design above ground result from the lower currents on each conductor, optimal phasing of the split-phases, and the placement of two phase conductor at a deeper burial depth of 6.55 feet (Table 1).

The NYPSC's Interim Policy on magnetic fields states that magnetic fields created by new Article VII transmission lines cannot exceed 200 mG at the edge of the right of way (ROW).[2] Thus, both the previous design of the 345-kV duct bank and the proposed design of the 345-kV duct bank comply with the NPSPSC standard both above the duct bank and for distances away from the centerline of the duct bank.

Calculation Methods

Exponent calculated the AC magnetic fields as the rms flux density of the maximum field ellipse as specified by NYPSC Interim Policy using algorithms developed by the Bonneville Power Administration (BPA), an agency of the U.S. Department of Energy, for modeling AC transmission lines.[3] BPA's algorithms apply simplifying assumptions about the conductors that have shown to yield accurate magnetic-field levels from AC transmission lines. The calculations assumed that all conductors are parallel to one another and infinite in length, there is no attenuation of magnetic-field levels by any surrounding medium, the load on phase conductors is balanced and there are no unbalanced currents flowing on the outer sheaths of

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2 New York Public Service Commission (NYPSC). Opinion No. 78-13. Cases 26529 and 26559, Issued June 19, 1978 and New York Public Service Commission (NYPSC). Statement of Interim Policy on Magnetic Fields of Major Electric Transmission Facilities. Cases 26529 and 26559 Proceeding on Motion of the Commission. Issued and Effective: September 11, 1990

3 Bonneville Power Administration (BPA). Corona and Field Effects Computer Program. Bonneville Power Administration, 1991.

XLPE cables. The proposed cables were modeled at an assumed winter normal conductor (WNC) rating of 1,049 amperes (A) at 60 Hertz. The proposed duct bank was designed with an optimal phase configuration for the two sets of conductors in the duct bank. This means that the conductors on the left and right sides of the duct bank are designed with phases of ABC and CBA, top-to-bottom, respectively (Figure 1) which reduces magnetic-field levels substantially compared to other phasing alternatives.

Magnetic fields were calculated along a transect perpendicular to the transmission line centerlines and reported at a height of 1 m above ground, as recommended by Institute of Electrical and Electronics Engineers (IEEE) Standards—C95.3.1-2010 and 0644-2019.[4]

[4] Institute of Electrical and Electronics Engineers (IEEE). IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic fields with respect to Human Exposure to Such Fields, 0 Hz to 100 kHz. New York: IEEE. IEEE Std. C95.3.1-2010 and Institute of Electrical and Electronics Engineers (IEEE). Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines (ANSI/IEEE Std. 644-2019). New York: IEEE, 2019.

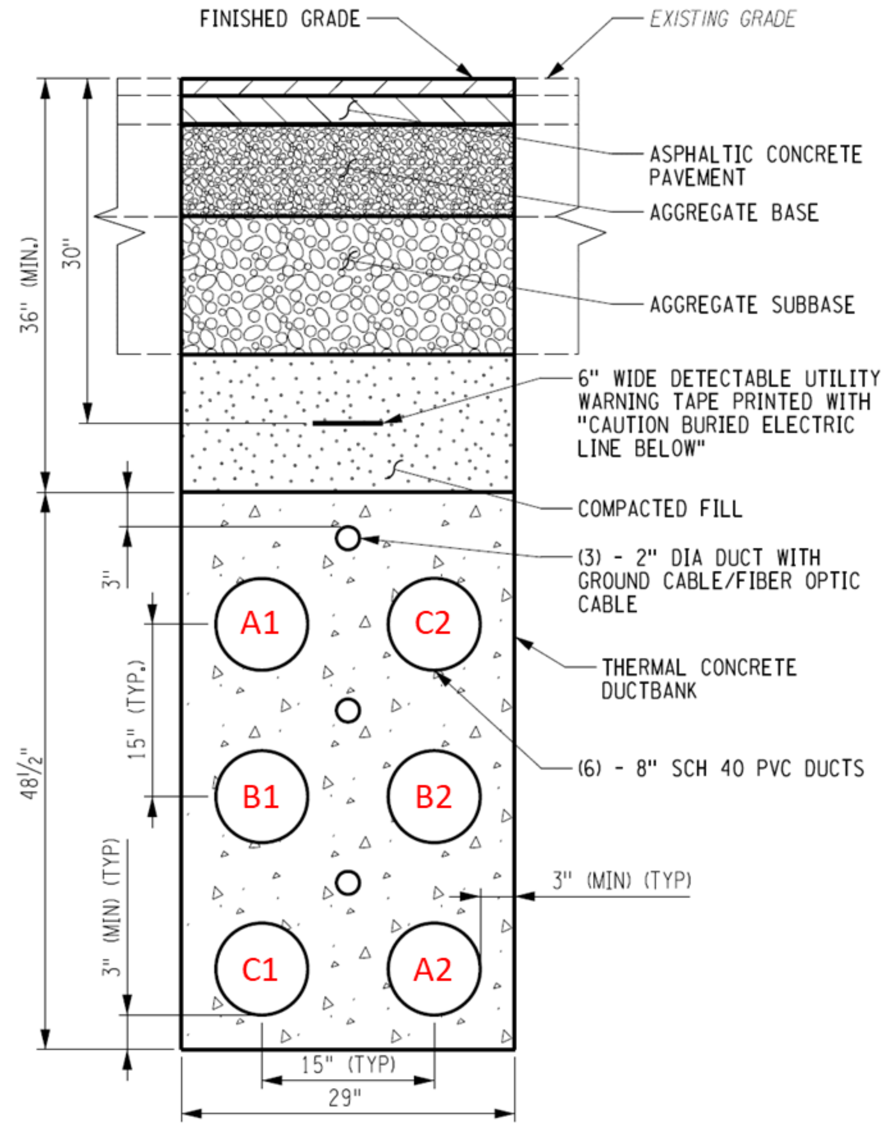

Figure 1. Representative cross-section of the proposed duct bank configuration with 2-conductors per phase.

Calculated Magnetic Field Profile

Figure 2 illustrates the graphic profile of the calculated magnetic-field levels for the proposed 2-conductors per phase duct bank over a wider range of distances than presented in Table 2. A table of the calculated magnetic-field levels for the 2-conductors per phase configuration of the duct bank at 1-ft increments to ±150 ft from the duct-bank centerline is provided in Appendix B.

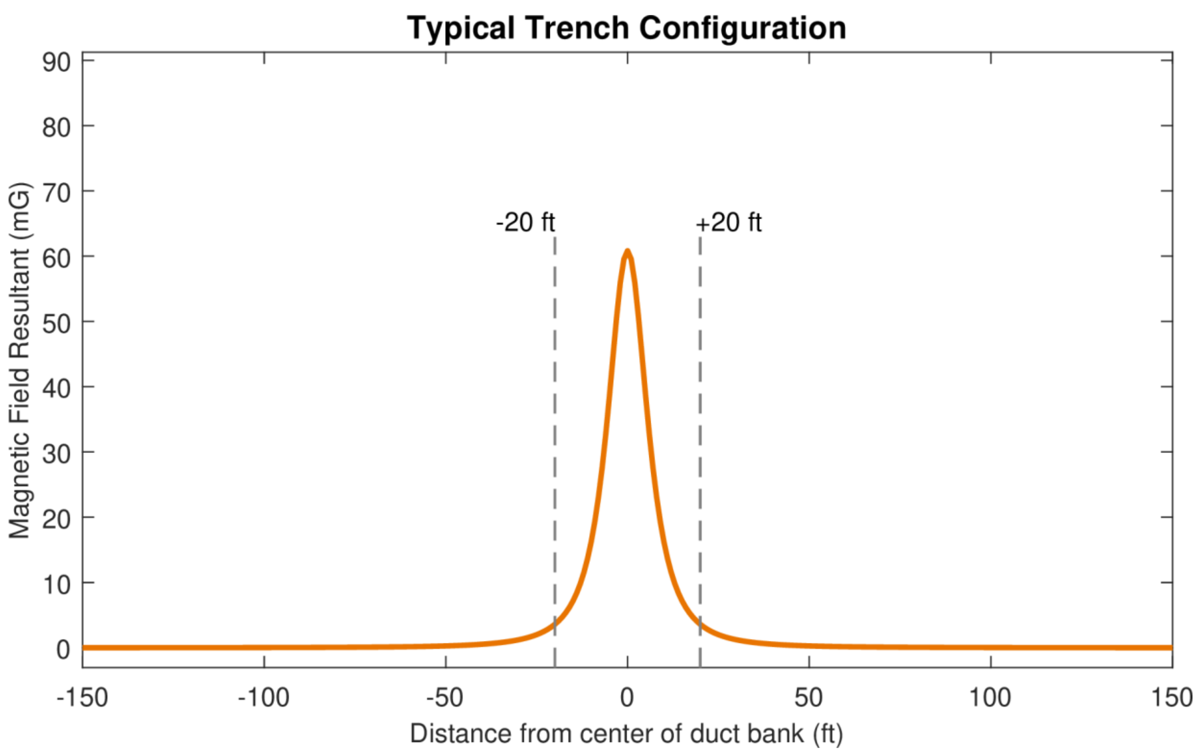

Figure 2. Magnetic-field levels at 3.3 ft (1.0 m) above ground from the proposed 2-conductors per phase at WNC conductor rating.

Appendix A

The Champlain Hudson Power Express

Input Data for Transmission Line AC Magnetic Field Calculations

Table A-1. Input data for AC magnetic field calculations (2 conductors/phase)

Bundle	x-feet	y-feet	n cond	cond dia (inches)	Spacing (inches)	l-n voltage (kV)	V Phasing	Current (A)	Ph-Ph Voltage	I Phasing
1	-0.63	-4.05	1	5.760	0	199.186	0	1049	345	0
2	-0.63	-5.30	1	5.760	0	199.186	240	1049	345	240
3	-0.63	-6.55	1	5.760	0	199.186	120	1049	345	120
4	0.63	-6.55	1	5.760	0	199.186	0	1049	345	0
5	0.63	-5.30	1	5.760	0	199.186	240	1049	345	240
6	0.63	-4.05	1	5.760	0	199.186	120	1049	345	120

Appendix B

The Champlain Hudson Power Express

Calculated AC Magnetic Field Levels

Table B-1. Calculated AC magnetic fields (2 conductors/phase)

Dist (feet)	Magnetic Field Maximum (mG)
-150	<0.1
-149	<0.1
-148	<0.1
-147	<0.1
-146	<0.1
-145	<0.1
-144	<0.1
-143	<0.1
-142	<0.1
-141	<0.1
-140	<0.1
-139	<0.1
-138	<0.1
-137	<0.1
-136	<0.1
-135	<0.1
-134	<0.1
-133	<0.1
-132	<0.1
-131	<0.1
-130	<0.1
-129	<0.1
-128	<0.1
-127	<0.1
-126	<0.1
-125	<0.1
-124	<0.1
-123	<0.1
-122	<0.1
-121	<0.1
-120	<0.1
-119	<0.1
-118	<0.1
-117	<0.1
-116	<0.1
-115	<0.1
-114	<0.1
-113	<0.1
-112	<0.1
-111	<0.1
-110	<0.1
-109	<0.1
-108	<0.1
-107	<0.1

Continued on next page

Table B-1 – Continued from previous page

Dist (feet)	Magnetic Field Maximum (mG)
-106	<0.1
-105	<0.1
-104	<0.1
-103	<0.1
-102	<0.1
-101	<0.1
-100	<0.1
-99	<0.1
-98	<0.1
-97	<0.1
-96	<0.1
-95	<0.1
-94	<0.1
-93	<0.1
-92	<0.1
-91	<0.1
-90	<0.1
-89	<0.1
-88	<0.1
-87	<0.1
-86	<0.1
-85	<0.1
-84	<0.1
-83	<0.1
-82	<0.1
-81	<0.1
-80	<0.1
-79	<0.1
-78	<0.1
-77	<0.1
-76	<0.1
-75	<0.1
-74	<0.1
-73	<0.1
-72	<0.1
-71	0.1
-70	0.1
-69	0.1
-68	0.1
-67	0.1
-66	0.1
-65	0.1
-64	0.1
-63	0.1

Continued on next page

Table B-1 – Continued from previous page

Dist (feet)	Magnetic Field Maximum (mG)
-62	0.2
-61	0.2
-60	0.2
-59	0.2
-58	0.2
-57	0.2
-56	0.2
-55	0.2
-54	0.2
-53	0.2
-52	0.3
-51	0.3
-50	0.3
-49	0.3
-48	0.3
-47	0.3
-46	0.4
-45	0.4
-44	0.4
-43	0.4
-42	0.5
-41	0.5
-40	0.5
-39	0.6
-38	0.6
-37	0.7
-36	0.7
-35	0.8
-34	0.9
-33	0.9
-32	1.0
-31	1.1
-30	1.2
-29	1.3
-28	1.5
-27	1.6
-26	1.8
-25	2.0
-24	2.2
-23	2.5
-22	2.8
-21	3.2
-20	3.6
-19	4.1

Continued on next page

Table B-1 – Continued from previous page

Dist (feet)	Magnetic Field Maximum (mG)
-18	4.7
-17	5.4
-16	6.2
-15	7.2
-14	8.4
-13	9.8
-12	11.6
-11	13.7
-10	16.2
-9	19.4
-8	23.1
-7	27.5
-6	32.7
-5	38.5
-4	44.6
-3	50.7
-2	55.9
-1	59.5
0	60.8
1	59.5
2	55.9
3	50.7
4	44.6
5	38.5
6	32.7
7	27.5
8	23.1
9	19.4
10	16.2
11	13.7
12	11.6
13	9.8
14	8.4
15	7.2
16	6.2
17	5.4
18	4.7
19	4.1
20	3.6
21	3.2
22	2.8
23	2.5
24	2.2
25	2.0

Continued on next page

Table B-1 – Continued from previous page

Dist (feet)	Magnetic Field Maximum (mG)
26	1.8
27	1.6
28	1.5
29	1.3
30	1.2
31	1.1
32	1.0
33	0.9
34	0.9
35	0.8
36	0.7
37	0.7
38	0.6
39	0.6
40	0.5
41	0.5
42	0.5
43	0.4
44	0.4
45	0.4
46	0.4
47	0.3
48	0.3
49	0.3
50	0.3
51	0.3
52	0.3
53	0.2
54	0.2
55	0.2
56	0.2
57	0.2
58	0.2
59	0.2
60	0.2
61	0.2
62	0.2
63	0.1
64	0.1
65	0.1
66	0.1
67	0.1
68	0.1
69	0.1

Continued on next page

Table B-1 – Continued from previous page

Dist (feet)	Magnetic Field Maximum (mG)
70	0.1
71	0.1
72	<0.1
73	<0.1
74	<0.1
75	<0.1
76	<0.1
77	<0.1
78	<0.1
79	<0.1
80	<0.1
81	<0.1
82	<0.1
83	<0.1
84	<0.1
85	<0.1
86	<0.1
87	<0.1
88	<0.1
89	<0.1
90	<0.1
91	<0.1
92	<0.1
93	<0.1
94	<0.1
95	<0.1
96	<0.1
97	<0.1
98	<0.1
99	<0.1
100	<0.1
101	<0.1
102	<0.1
103	<0.1
104	<0.1
105	<0.1
106	<0.1
107	<0.1
108	<0.1
109	<0.1
110	<0.1
111	<0.1
112	<0.1
113	<0.1

Continued on next page

Table B-1 – Continued from previous page

Dist (feet)	Magnetic Field Maximum (mG)
114	<0.1
115	<0.1
116	<0.1
117	<0.1
118	<0.1
119	<0.1
120	<0.1
121	<0.1
122	<0.1
123	<0.1
124	<0.1
125	<0.1
126	<0.1
127	<0.1
128	<0.1
129	<0.1
130	<0.1
131	<0.1
132	<0.1
133	<0.1
134	<0.1
135	<0.1
136	<0.1
137	<0.1
138	<0.1
139	<0.1
140	<0.1
141	<0.1
142	<0.1
143	<0.1
144	<0.1
145	<0.1
146	<0.1
147	<0.1
148	<0.1
149	<0.1
150	<0.1