ATTACHMENT K

Burial Depth Report

Confidential Document for Settlement Discussions pursuant to Commission's Settlement Guidelines
Champlain Hudson Power Express
Case 10-T-0139
October 26, 2011

At recent settlement conferences, settlement parties discussed the placement and burial of high voltage direct current ("HVDC") transmission cables within Lake Champlain as proposed by the Champlain Hudson Power Express project ("CHPE" or "Project"). Staff of the NYS Department of Public Service ("DPS") have requested that previous reports to the parties relating to such placement and burial be consolidated and reissued, and this is the format employed here. This final document has also benefitted from review and comment by settlement parties.

Non-Burial and Installation in Deep Water within Lake Champlain

Three areas of inquiry have been raised with regard to the Applicants' proposal to not bury the cables within the deeper waters of Lake Champlain: (i) generally accepted engineering approaches to cable installation and protection in such areas (including applicable standards and standard practices), as well as potential specific techniques that may be used; (ii) underwriting standards and practices in this situation; and (iii) safety issues associated with unburied cables in deep water areas, including operational response of the line if a fault occurs. These three areas are addressed below.

Cable Installation Standards and Practices

A major HVDC submarine cable system represents a very significant financial commitment. For such a project to be viable, the owner must be able to demonstrate a clear financial return over the project's operating life, and the project's financial backers and insurers must be convinced of the integrity of the Project, including the level of protection against external mechanical damage.

The two most common methods of protection of a submarine cable against external mechanical damage are armoring or armoring and burial. The primary reason for burying a submarine cable in the bottom sediments is to increase the protection that is provided by the cable armoring against physical damage caused by anchors, fishing equipment, ice scouring, etc. Therefore, burial of submarine cables is most common in two circumstances: (a) in water bodies that are plied by larger, typically commercial or commercial-sized vessels with long anchor chains and (b) in relatively shallow waters, where even small vessels and ice scour may make non-burial problematic. In areas where the water depth makes it highly unlikely that ice scouring or accidental dragging of anchors, fishing equipment or other types of marine equipment could occur, it is common practice to surface-lay the submarine cable on the bottom with touch down monitoring using a remotely operated vehicle ("ROV").

Settlement parties have proposed that, for water depths of greater than one hundred and fifty (150) feet, the cables may be laid on the lake bed via ROV-monitored surface laying, provided a report prepared by a recognized authoritative technical consultant concludes that public health and safety can be appropriately protected without burial in such locations The Applicants believe that this proposal is reasonable as the risks associated with non-burial at the suggested

depth represent a negligible risk based on existing conditions and in fact may remove certain technical complications associated with cable installation in deeper waters.

Existing Conditions

In order to characterize the maritime traffic presently found on Lake Champlain and to assess the possibilities of changes to such traffic in the future, the Applicants contacted Professor James Lindgren of the State University of New York at Plattsburgh. Professor Lindgren referred the Applicants to Arthur B. Cohen, Executive Director of the Lake Champlain Maritime Museum. Mr. Cohen advised the Applicants that no commercial fishing operations remain on Lake Champlain and that vessels plying Lake Champlain are therefore predominately privately-owned pleasure craft. He did note that a few commercial site-seeing vessels and some waterfront maintenance or construction vessels also operate on the Lake. These vessels either restrict their operations to shallow water or, when in deep water, are cruising and not anchored. On occasion, specialized craft do traverse the lake along defined corridors for limited periods of time to complete discrete, specific tasks. An example of this type of craft would be the Project's cable-laying vessels and support barges. Another example cited by Mr. Cohen is the planned use of a tug and barge to investigate a sunken vessel that is suspected of leaking oil. All of these types of uses involve planning and checking of navigation charts and databases to determine where submerged infrastructure may be located and how such infrastructure may be avoided. Mr. Cohen doubted that significant changes in the maritime use of Lake Champlain in the foreseeable future were likely.

The vessels operating on Lake Champlain, with very few exceptions, will not carry sufficient anchor line or chain to anchor in water exceeding one hundred and fifty (150) feet in depth. Anchoring will require an anchor scope, the ratio of anchor line length to depth of water, of 5 to 1 under normal conditions and 7 to 1, or more, during heavy weather.[1] With an anchor scope of 5 to 1, the vessel would have to carry at least 750 feet of anchor line to allow for securing itself in one hundred and fifty (150) feet of water. Some referenced authorities suggest carrying anchor lines of at least 10 times the maximum depth of water anticipated.[2]

The Applicants also spoke with staff from NYPA and VELCO to obtain information on their experience with the PV-20 high voltage submarine cables which were surface-laid on the bottom of Lake Champlain between New York State and Vermont. There are a total of seven (7) 120-kV-rated cables submerged in the lake. Each of these cables is armored with steel spiraled around the cable core. Four 500-MCM low-pressure cables were installed in 1958 and three 1,000-MCM cables were installed in 1971. In the middle of the Lake, the cables are under approximately two hundred (200) feet of water. At others areas along their route, the cables are laid on the surface of the Lake bottom in shallower waters. Neither NYPA nor VELCO staff was aware of any operational problems arising out of external physical damage to the cables lying on the bottom of Lake Champlain.

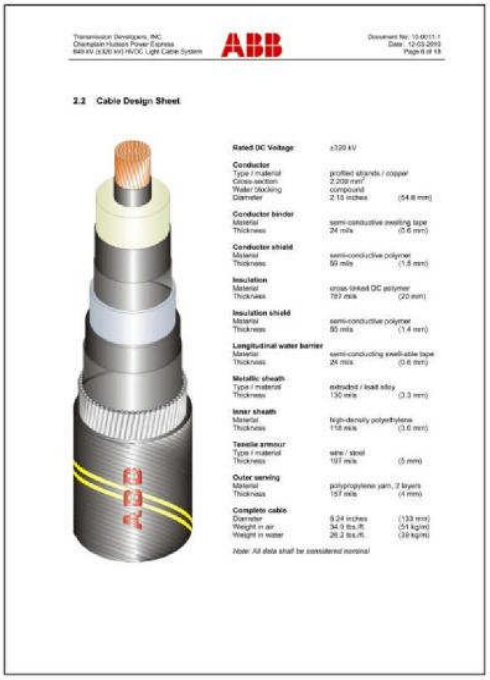
The submarine cable proposed in connection with the Project is to be armored with steel wire

[1] Anchor Buddy, http://www.anchorbuddy.co.nz/anchoring.html

[2] UK Sailing, Sail Cruising and Yachting Guide, http://www.bluemoment.com/anchorrodes.html

cladding just under the outer jacket (Figure 1). This armor layer covers the entire perimeter of the sheath. If a vessel anchor snagged on the cable, damage could be caused by the shear force applied by the anchor to the cable jacket and armor coat. A calculation of the shear force that would have to be applied by the anchor to penetrate the cable armor is presented in Attachment A.

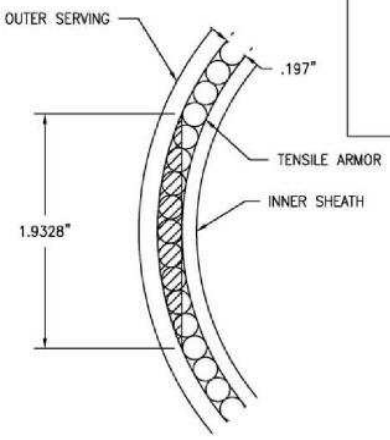
The calculations in Attachment A show that it is improbable that a pleasure boat typical of those found on Lake Champlain could produce the thrust necessary to tension an anchor line to the force necessary to cut into the armored cable. Specialty commercial vessels might have the strength necessary to damage the cable, but they would not routinely operate on the lake in the vicinity of where the cable is laid. The Applicants note that the analysis suggests that non-burial may also be safely achieved at depths as shallow as 100 feet, but have agreed for purposes of settlement to a minimum depth for non-burial of 150 feet.



2.2 Cable Design Sheet

Rated DC Voltage	±320 kV	
Conductor		
Type / material	profiled strands / copper	
Cross-section	2,209 mm²	
Water blocking	compound	
Diameter	2.15 inches	(54.6 mm)
Conductor binder		
Material	semi-conductive swelling tape	
Thickness	24 mils	(0.6 mm)
Conductor shield		
Material	semi-conductive polymer	
Thickness	60 mils	(1.5 mm)
Insulation		
Material	cross-linked DC polymer	
Thickness	787 mils	(20 mm)
Insulation shield		
Material	semi-conductive polymer	
Thickness	55 mils	(1.4 mm)
Longitudinal water barrier		
Material	semi-conducting swell-able tape	
Thickness	24 mils	(0.6 mm)
Metallic sheath		
Type / material	extruded / lead alloy	
Thickness	130 mils	(3.3 mm)
Inner sheath		
Material	high-density polyethylene	
Thickness	118 mils	(3.0 mm)
Tensile armour		
Type / material	wire / steel	
Thickness	197 mils	(5 mm)
Outer serving		
Material	polypropylene yarn, 2 layers	
Thickness	157 mils	(4 mm)
Complete cable		
Diameter	5.24 inches	(133 mm)
Weight in air	34.9 lbs./ft.	(51 kg/m)
Weight in water	26.2 lbs./ft.	(39 kg/m)

Note: All data shall be considered nominal



Deep Water Installation

In deeper waters, simultaneous lay and burial operations become increasingly complex and difficult since an increase in water depth necessitates an increase in the layback (horizontal distance between the plow and installation vessel). As the layback increases, the amount of cable that must be maintained in a catenary, from the stern of the installation vessel through the water column to the bell mouth of the plow, increases proportionally. To maintain the cables in a catenary that leads to the bell mouth of the plow, the cables will need to be held very tight from the stern of the installation vessel. If the catenary is held too loose, then the cables could touchdown on the lake bed ahead of the plow, thereby placing the cables at risk of being run over by the plow. On the other hand, tightly held cables will begin to influence the stability of the plow.

Based on these concerns, the installation firm consulted by the Applicants does not believe that simultaneous lay and plowing is a viable method for cable burial in Lake Champlain at water depths greater than one hundred (100) feet. Instead, at these depths any burial activities would have to be performed by an ROV that would bury the cables using water jetting after the initial surface laying of the cables by the lay vessel. If there were any sort of complication during post-lay water jetting, it would be difficult at these depths for divers to support and maintain the ROV. Non-burial in deeper waters alleviates these types of concerns.

Cable Installation Standards and Practices

With respect to cable installation practices, the Applicants contacted two different marine engineering services, the US Coast Guard ("USCG"), the Naval Facilities Engineering Command ("NAVFAC") and the International Cable Protection Committee ("ISCPC") to identify potential standards with regards to burial of submarine cables. Generally speaking, the consensus was that the decision to bury or surface-lay a cable is a combination of engineering judgment and owner criteria. A representative of NAVFAC stated that her process is to compile data of vessel traffic and utility failures for similar water bodies in order to extrapolate the appropriate level of protection for the specific water body in which the new cables would be installed. The ISCPC does not have any standards for burial depth during cable installation and topics included in their "Recommendations" publications did not include any discussion of burial depths.

In the absence of established standards, the Applicants have relied on consultation with established firms with wide-ranging experience in submarine cable installation. In addition to consulting with USCG, NAVFAC, and ISCPC, firms that have provided information used in the development of the Project and responses to Information Requests include Nexans, ABB, and Caldwell Marine. Given the complexity of the Project, the Applicants would expect that "level of experience" would weigh heavily in the criteria employed during the selection process for the contractor retained to install the cables.

Underwriting Standards

The Applicants provided this report to their insurance advisor, Marsh USA, Inc. The responses provided by senior executives at this major company regarding the insurability of this Project are provided in Attachment B.

Safety and Reliability

For the reasons previously discussed, it is expected that there will be no significant difference in reliability and safety performance between a buried and surface-laid submarine cable circuit at depths greater than one hundred and fifty (150) feet. In the unlikely event that there is an electrical failure in a cable core, the fault current path will be from the cable's conductor to its metallic sheath and armor. That is, the fault current, which will discharge the cable's inherent capacitance to ground, will be predominantly internal to the cable. Also, because of the symmetric monopole connection of the voltage source converter stations at both ends of the transmission line, there will be no significant fault current contribution from the transmission grid at the sending or receiving end of the Project cable circuit. Finally, the computer-based protection installed at the converter stations at each end of the Project cable circuit will detect the fault and will reduce the current flowing in the cables to zero within a fraction of a second.

Burial Depth in Lake Champlain

The Applicants have also requested that the target burial depth in Lake Champlain be set at a minimum of three (3) feet where cables are required to be buried. Settlement parties have requested additional information as to the rationale for this preference.

Southern Lake Champlain – Shear Plow

Settlement parties have agreed that a shear plow should be utilized in the southern portion of Lake Champlain. The supporting analysis that was provided to parties assumed a burial depth of approximately one (1) meter below the surface. In general, each increase in the target depth complicates installation, requiring additional time, effort, and cost to achieve the required burial depth goal. The Applicants have been informed by a respected installation firm that three (3) feet is a threshold point for shear plowing and that deeper burial depth requires a higher tow force to advance the plow. A higher tow force, in turn, requires a larger vessel to accommodate the additional machinery needed to achieve the necessary force. Given the size restrictions for vessels entering Lake Champlain, a burial target of greater than three (3) feet necessitates more time and greater costs as the laying vessel has to be transported in sections and assembled within Lake Champlain.

Northern Lake Champlain

As for shear plow burial, each increase in the target depth in northern Lake Champlain complicates installation, requiring additional time, more power, and further cost to achieve the required burial depth goal. There is also a commensurate increase in the degree of disturbance from the installation activities if the target burial for the water jetting is four (4) feet instead of three (3) feet.

In addition, as discussed above, simultaneous lay and burial operations in deeper waters become increasingly complex and difficult since an increase in water depth necessitates an increase in the layback and therefore poses more risks of cable damage. In waters where the cables must be buried by an ROV, the depth of the waters will make it more difficult for divers to support and maintain the ROV. Installation at a depth of three feet as compared to four feet would lessen the potential for complications.

Existing Burial Depth Standards

The Applicants are unaware of any existing burial depth standard for waters of the United States. The Applicants are aware that the New York District of the U.S. Army Corps of Engineers ("USACE") has cited a burial requirement of four (4) feet. However, it is the Applicants' understanding that this burial depth is from the District's Nationwide General Permit 12 - Utility Line Activities requirements and, as they will be applying for an individual permit. The parameters established in the nationwide permit program do not bind the USACE in its review of any individual permit.

The Applicants believe a reasonable case can be made for three (3) feet burial as part of the USACE permitting process. First, other districts have adopted this standard or in some cases been silent on the issue. For example, the Norfolk District has stated that cables should be buried "at least 3 feet below the bottom depth[3]" and for the Wilmington District burial outside the federal navigation channel is a minimum of two (2) feet below the substrate when the utility lines "might interfere with navigation[4]." In developing their regional standards for Nationwide Permit 12, the Detroit District (which includes the Great Lakes and St. Lawrence Seaway[5]) specifically rejected a suggestion that submarine cables be buried to a depth of three (3) feet when transitioning from land to a lake. The District notes that "to date we are unaware of any justification" that would require such a restriction and that, barring other factors, "the District believes that the decision to bury a cable is an economic one best decided by the applicant[6]." The District's Nationwide Permit only requires burial of at least six (6) feet below the authorized Federal channel depth.

The Applicants would also point to the Juan de Fuca transmission project, which recently received a USACE permit[7]. The Applicants were unable to locate the USACE permit, but would note that the U.S. Department of Energy's record of decision for the project states that the cables

[3] http://www.nao.usace.army.mil/technical%20services/Regulatory%20branch/NWP2007/NW-12.pdf
[4] http://www.saw.usace.army.mil/wetlands/NWP2007/PDF-SAW-NWP2007/NWP12_6-07.pdf
[5] http://www.lre.usace.army.mil/what/detroitresources/
[6] http://www.lre.usace.army.mil/functions/rf/html/2007_NWP_MI_SUPS/NWP_12.pdf
[7] http://www.jdfcable.com/downloads/08-10-03-SBX-NR-jdf-ArmyCorpsPermit.pdf

will be installed in a trench that will "typically be 3 to 5 feet (1 to 1.5 meter[m]) deep[8]." The developer's materials state that the target burial depth is three (3) to six (6) feet[9].

Certificate Condition Language

Settlement parties have proposed that for water depths of less than one hundred and fifty (150) feet in Lake Champlain, the cables would be buried with a jet plow in the northern portions of the lake and with a shear plow south of Crown Point. Where water depths are greater than one hundred (100) feet, but less than one hundred and fifty (150) feet, the Applicants anticipate post-lay burial via water jetting using a remotely operated vehicle and water ("ROV"). And in water greater than one hundred and fifty (150) feet, the cables may be laid on the lake bed via ROV-monitored surface laying, provided that a report prepared by a recognized authoritative technical consultant concludes that public health and safety can be appropriately protected without such burial, and such conclusion is ratified by Commission approval of the EM&CP or an appropriate Project Segment EM&CP.

Throughout settlement discussions, Applicants have shown a willingness to accept deeper burial requirements where required for environmental reasons. Based on available information, the Applicants believe that a case has been made for a target depth of three (3) feet in Lake Champlain when burial is required. The Applicants are suggesting a range of target burial depths (i.e. three (3) to four (4) feet) in Lake Champlain to allow for the possibility that the USACE may require deeper burial without requiring an amendment to the Certificate Conditions.
The Applicants have provided draft language for cable installation in Lake Champlain in Attachment C.

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[8] http://efw.bpa.gov/environmental_services/Document_Library/PortAngeles/PAROD.pdf

[9] http://www.jdfcable.com/faq.shtml

ATTACHMENT A

The submarine cable proposed in connection with the Project is to be armored with steel wire cladding just under the outer jacket (Figure 1). This armor layer covers the entire perimeter of the outer sheath. Using typical mechanical properties for steel, the armor layer will have a tensile strength of at least 58,000 psi[10] and a shear strength of 43,500 psi[11]. If a vessel anchor snagged on the cable, damage would be caused by the shear force applied by the anchor to the cable jacket and armor coat. Ignoring any shear strength provided by the outer jacket and using the configuration of the cable only, the shear force that would have to be applied by the anchor to penetrate the cable armor can be calculated.

The shear force of 43,500 psi would be applied over a triangular area approximately 2 inches long by the armor's diameter of 0.197 inches (197 mils) equaling 0.381 square inches. The shear force required to cut into the cable would be:

43,500 psi

x 0.381 square inches

16,563 pounds

Due to the anchor line scope, only a portion of the applied line tension is transferred to the anchor.

Based on the ABB cable data (typical for submarine cables of this type), the cable will have a submerged weight of 26.2 pounds per foot. Assuming the vessel in question has enough power to apply a force approaching that which would be necessary to cut into the cable, the anchor would, more likely, bring the cable to the surface. Applying 16,500 pounds of force could lift almost 600 feet of submerged cable before it cut through the armor and one can reasonably assume that the vessel operator would recognize the situation before this time.

To apply enough shear force to the cut into the cable, the anchor, anchor clevis, anchor line and cleat on the vessel would all have to be rated at more than 16,500 pounds. Commercially available, high-end, double-braid nylon and polyester anchor lines in the 1/2 to 5/8 inch diameter range have rated breaking strengths of 8,500 and 15,200 pounds respectively.[12] Even these high-end lines would not be sufficient to apply the calculated force to the cable. In addition, the force would have to be applied exactly orthogonal (perpendicular) to the cable surface. Any angle other than ninety (90) degrees would reduce the shear force applied to the cable (or require higher tension to produce the equivalent shear). Finally, the above scenarios also assume the boat operator has the seven hundred and fifty (750) feet of line necessary to reach the cable that is surface-laid at water depths of one hundred and fifty (150) feet, which seems unlikely in the case of most vessels likely to be found on Lake Champlain.

It is therefore improbable that a pleasure boat typical of those found on Lake Champlain could produce the thrust necessary to tension an anchor line to the force necessary to cut into the armored cable. Specialty commercial vessels might have the strength necessary to damage the cable, but would not routinely operate on the lake in the vicinity of where the cable is laid.

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[10] ASTM A 36

[11] http://www.roymech.co.uk/Useful_Tables/Matter/shear_tensile.htm

[12] Reference bucrop.com

ATTACHMENT B

From: Cobleigh, David A [mailto:David.A.Cobleigh@marsh.com]
Sent: Monday, August 15, 2011 3:04 PM
To: Bill Helmer; Donald Jessome
Cc: Sherman, Sarah M
Subject: Fw: burial report

Sarah - I think this hits it on the head. Bill - feel free to contact us if you need anything else.
Thanks all and look forward to next steps,
Dave

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www.marsh.com <http://www.marsh.com> | Marsh USA Inc.

From: Sherman, Sarah M
To: Cobleigh, David A
Sent: Mon Aug 15 13:58:23 2011
Subject: RE: burial report

We understand that the primary contractor/bidder has put forth a cable lay plan that includes sections of unburied cable in the deep waters of Lake Champlain. Underwriters will accept this lay plan with the support of an independent third party engineering analysis, which verifies the primary contractor's conclusions regarding the cable lay strategy, and thus, the project will be insurable from a Builders Risk and Operating insurance program standpoint.

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ATTACHMENT C

Certificate Condition 90

a. [Hudson, Harlem, and East Rivers]

b. Cable installation in Lake Champlain shall be designed and installed to meet the following criteria:

(i) in locations where the water depth is less than one hundred fifty (150) feet, the target burial depth is three (3) to four (4) feet below the sediment surface, except where the cables crosses other utility lines or other infrastructure or where geologic or bathymetric features prevent burial at such depth, and adequate measures for cable and infrastructure protection are provided;

(ii) in locations where water depth is one hundred fifty feet (150) or greater, the target burial depth is three to four feet below the sediment surface, however the cables may be buried at shallower depths or laid on the lake bed where Certificate Holders provide a report prepared by a recognized authoritative technical consultant demonstrating and concluding that public health and safety can be appropriately protected without such burial, and the proposed installation method is approved by the Commission in the Project Segment EM&CP.

c. Where the cables will be located in the portion of Lake Champlain south of Crown Point (Route Mile 73), the Certificate Holders will rely on the shear plow installation method or, when reliance on such method is infeasible, an alternative method that avoids environmental impacts to a substantially equivalent degree. Where cables will be located in the portion of Lake Champlain north of Crown Point, the Certificate Holders will rely on a jet-plow or, in deeper waters, a self-propelled remotely operated vehicle (ROV) that will bury the cables using water jetting after the initial surface lay of the cables from the lay vessel.

d. Utility and other infrastructure crossings shall be executed consistent with site-specific design measures for each such crossing as specified in the approved EM&CP.