# STATE OF VERMONT
# PUBLIC SERVICE BOARD

Petition of Champlain VT, LLC d/b/a TDI New England )
for a Certificate of Public Good, pursuant to 30 V.S.A. §248, )
authorizing the installation and operation of a high voltage )
direct current (HVDC) underwater and underground electric ) Docket No. _____
transmission line with a capacity of 1,000 MW, a converter )
station, and other associated facilities, to be located in Lake )
Champlain and in the Counties of Grand Isle, Chittenden, )
Addison, Rutland, and Windsor, Vermont, and to be known )
as the New England Clean Power Link Project ("NECPL") )

## PREFILED DIRECT TESTIMONY OF ANDREW THUMAN

## ON BEHALF OF CHAMPLAIN VT, LLC

December 8, 2014

Summary:

Mr. Thuman provides testimony regarding 30 V.S.A. § 248(b)(5), the Natural Environment, specifically regarding water purity and water pollution as they relate to Lake Champlain.

## List of Exhibits

| Exhibit Number | Name of Exhibit |
|---|---|
| TDI-AT-1 | Resume |
| TDI-AT-2 | Lake Water Quality Modeling Report (HDR) |
| TDI-AT-3 | 2014 Vermont Water Quality Standards |

**Q1. Please state your name and position relative to this Project.**

A1. Response: My name is Andrew Thuman. On this Project, I am leading the water quality modeling effort to assess the potential water quality impacts associated with the New England Clean Power Link ("NECPL") cable installation in Lake Champlain ("Project").

**Q2. Please describe your qualifications and expertise.**

A2. Response: I received my Bachelor's Degree in Civil Engineering and Master's Degree in Environmental Engineering from Manhattan College; and hold a Professional Engineer license in the State of New Jersey. I am a Vice President at HDR and their national water quality practice leader. My business address is One Riverfront Plaza, 1037 Raymond Blvd., Suite 1400, Newark, NJ 07102-5418. I have 24 years of professional experience conducting water quality modeling studies in rivers, lakes, estuaries and their associated watersheds. The majority of these projects were completed to assess water quality impacts associated with both point and nonpoint source inputs to natural water systems. The water quality modeling frameworks used on these projects ranged from systems involving pathogen fate and transport; biochemical oxygen demand ("BOD") oxidation, nitrification and diurnal algal impacts on steady-state dissolved oxygen ("DO") concentrations; to state-of-the-art, time-variable coupled hydrodynamic and water quality models to investigate the fate and transport of many constituents (total suspended solids ("TSS"), metals, nutrients, BOD, pathogens) and nutrient related eutrophication issues.

My resume is attached as ***Exhibit (Exh.) TDI-AT-1***.

**Q3. On whose behalf are you offering this testimony?**

A3. Response: I am offering this testimony on behalf of Champlain VT, LLC, d/b/a TDI New England ("TDI-NE").

**Q4. Have you previously testified before the Public Service Board or in other judicial or administrative proceedings?**

A4. Response: No, I have not.

**Q5. What is the purpose of your testimony?**

A5. Response: The purpose of my testimony is to introduce and describe the extensive water quality modeling our firm conducted to analyze the Project's potential impacts on water quality in Lake Champlain during cable installation. My testimony relates to criteria 30 V.S.A. § 248(b)(5), specifically regarding water purity and water pollution.

**Q6. Have you relied on the work of any other experts concerning this Project?**

A6. Response: Yes, I have relied on the water quality modeling support from engineers and scientists at my firm that report directly to me on this Project and also from other firms involved in this Project, including TRC Environmental Corporation, Drs. Thomas and Patricia Manley of Middlebury College and Marine Research Corp., and TDI-NE, who have provided data and other information needed to support the water quality modeling.

**Q7. Have you provided project information to other experts in support of their section 248 testimony and if so, what?**

A7. Response: No, I have not, other than my final Lake Champlain Water Quality Modeling Report, *Exh. TDI-AT-2*.

## 30 V.S.A. § 248(b)(5) – Natural Environment and 10 V.S.A. § 6086(a)(1) – Water Purity and Water Pollution

**Q8. Can you please briefly summarize the work you have performed to evaluate the potential water quality impacts associated with installation of the NECPL?**

A8. Response: I have completed water quality modeling to assess the potential impacts of sediments resuspended during cable installation on Lake Champlain water quality. As part of cable installation, a trench is temporarily created in the sediment for placing the cable three to four feet below the sediment surface using either a jet-plow or shear-plow method. Both methods involve pulling the plow through the sediment to create the trench with the jet-plow using water jets to fluidize the sediment in the trench and the shear-plow using physical force to move the sediments for cable installation. During this cable installation process, the sediments in the trench can be resuspended into the water column above the trench. The water quality modeling calculated the time-varying and spatial distribution of various water quality parameters along the cable route. The calculated increases in the modeled parameters due to the resuspension of lake sediments during cable installation were compared to applicable Vermont Water Quality Standards ("VWQS"). The water quality constituents considered in the model included: total suspended solids ("TSS"); total phosphorus ("TP"); dissolved phosphorus ("DP"); arsenic; cadmium; copper; lead; nickel; zinc; silver; and mercury.

The results of our modeling are discussed in detail in our Lake Champlain Water Quality Modeling Report, which is attached as ***Exh. TDI-AT-2.*** For reference, the 2014 Vermont Water Quality Standards are attached as ***Exh. TDI-AT-3.***

**Q9. Let's start with basic modeling methodology. Can you please describe the model you used for your analysis?**

A9. Response: I used the Danish Hydraulic Institute ("DHI") three-dimensional hydrodynamic and water quality model called MIKE3 Flow Module ("FM"). The hydrodynamic model component calculates the movement of water as a function of river flow inputs, meteorology (e.g., wind speed/direction, heat exchange) and density as constrained by the shoreline and bathymetric (water depth) features of Lake Champlain. The water quality model component calculates water column concentrations for various constituents as a function of the water circulation calculated with the hydrodynamic model, external source loads, constituent reactions (e.g., decay or die-off) and settling for particulate forms of modeled constituents. The model calculations are completed in model segments that divide the lake into a discrete horizontal and vertical model mesh of non-overlapping elements.

**Q10. Is the MIKE3 model a commonly used modeling tool in your profession?**

A10. Response: Yes, the MIKE3 model is used regularly for modeling studies that analyze water circulation or water movement issues (e.g., flooding, hydraulic structures) as well as water quality issues associated with point and nonpoint sources (e.g., nutrients, temperature). The MIKE3 model has a wide user community and is an accepted model for completing water quality assessments in regulatory settings. In addition, the model has the capability to provide fine model segment resolution in areas of interest. This capability was used in the Project to provide more detailed information at representative locations along the cable route.

**Q11. What general environmental inputs are necessary to run the model, and how did you obtain the necessary inputs?**

A11. <u>Response</u>: There are a number of basic model inputs necessary for both the hydrodynamic and water quality modeling components of MIKE3. The model inputs can be grouped into physical features (e.g., lake shoreline and bathymetry), external inputs (e.g., meteorological conditions, river flows and assigned cable resuspension source) and model coefficients (e.g., settling rates). In this case, the model inputs were developed from recent Lake Champlain-specific information available. These sources included: 2010 data on lake sediment characteristics (e.g., porosity, median particle diameter, sorbed metals concentrations); 1994 and 1999 data reports on sediment sorbed silver, mercury and phosphorus concentrations; and Vermont Department of Environmental Conservation ("VTDEC") in-lake long term monitoring project data (secchi depth, TSS, TP and temperature). Additional details on the data sources and how they were used in the water quality modeling can be found in the Lake Champlain Water Quality Modeling Report. In addition, vertical temperature profiles from the VTDEC long term monitoring program and Richelieu River outflows were used to calibrate the hydrodynamic model.

**Q12. What project specific inputs are necessary for the model, and how did you obtain those inputs?**

A12. <u>Response</u>: The project-specific inputs used in the modeling included the: cable installation speed; cable trench dimensions for both the jet-plow and shear-plow installation methods; trench sediment resuspension release fraction; particulate constituent settling rate; and sediment specific characteristics along the cable route. The cable installation speed and trench dimensions were obtained from TDI-NE based on the installation method in the different sections of the lake. North of Crown Point, New York/Chimney Point, Vermont, the jet-plow installation method is proposed in water depths less than 150 feet and south of Crown Point the shear-plow installation method is proposed. At water depths greater than 150 feet, the cable is proposed to be placed on the bottom of the lake. The sediment resuspension release fraction was determined from a number of different references that included estimates based on observation of underwater video of cable installation, calculations based on fluidization of trench sediments, and past modeling studies of cable installation that have received regulatory approval. Settling rates were calculated using Stokes Law, median sediment particle diameter and sediment specific gravity data along with setting a minimum settling rate based on the flocculation effect of cohesive sediments present along the cable route. Sediment properties were obtained from data provided by Drs. Thomas and Patricia Manley in 2014 including ***Exh. TDI-SM-3***, while constituent concentrations for Lake

Champlain that were collected in 2010 were used to determine the resuspension source assigned in the water quality model. Additional detail on these model inputs and data sources can be found in the Lake Champlain Water Quality Modeling Report.

**Q13. You mentioned that the model is calibrated. Can you please describe that calibration process further, and explain what purpose the calibration serves.**

A13. Response: The calibration process involves defining external model inputs with observed data (i.e., lake shoreline and bathymetry, meteorology, river inflows) for a given time period and then comparing the model output to observed data within the lake. The comparison of model output to observed data is an important step in model development in that it tests how well the model represents observed conditions in the lake. The Lake Champlain hydrodynamic model was calibrated to observed vertical temperature profiles in the lake and Richelieu River outflows. During the proposed cable installation months the model reproduces the observed river outflow well and also reasonably reproduces the observed temperatures and vertical temperature structure at most stations. This includes reproducing observed temperatures ranging from 5 to 22°C and completely mixed to vertically stratified temperature conditions, depending on the relevant season and location. In addition, the model calculated bottom velocities are similar to those reported by Dr. Thomas Manley based on available data in the lake. Given the successful calibration of the model to observed river outflow, temperature and bottom velocities, the model-calculated water circulation is also considered to reasonably represent actual circulation patterns in the lake and is considered capable of appropriately representing water circulation in the lake for the subsequent water quality modeling and assessments.

**Q14. Generally speaking, how does the MIKE3 model report out its results?**

A14. Response: The MIKE3 model completes calculations for water circulation and water quality concentrations in a water body by dividing the water body up into a "mesh" of small geographic segments, and then calculating relevant constituents (e.g., water velocity, temperature, concentrations) in each individual segment of the model mesh. The model mesh is made up of horizontal elements that can be either triangular or rectangular and can be refined to provide resolution in areas of interest (e.g., at representative locations along the cable route). In the vertical dimension, the model mesh uses a sigma layer segmentation that provides an equal number of elements in the vertical water column regardless of water depth. A finer model mesh resolution can be used at locations of interest to provide a refined analysis of the potential water quality impacts in certain geographic locations. An example of the fine model mesh used for the Lake Champlain model is presented in Figure 2 of the Water Quality Modeling Report (***Exh. TDI-AT-2***). In addition, the MIKE3 model is run on a time-varying basis such that continuous model output is available to analyze the cable installation as it progresses along the cable route. This provides a more accurate analysis of short term water quality impacts, such as those associated with the cable installation here.

**Q15. Turning to the specific project here, can you describe how the model was set up in this case?**

A15. Response: Yes. As shown in Figure 2 of the Water Quality Modeling Report (***Exh. TDI-AT-2***), the entire lake was divided into representative mesh segments in the model. This mesh was then further refined around five selected representative locations along the proposed cable installation route in order to provide a detailed analysis of the water quality impacts that are expected to occur in the vicinity of the cable installation. An example of the fine-resolution mesh is provided in Figure 2 of the Water Quality Modeling Report. The five detailed modeling locations were selected to provide a representative range of the differences in installation types (shear-plow vs. jet-plow), different geographic areas in which the installation will occur (north, main-lake, and south lake) and different water depths (shallow water vs. deep water). These specific areas included:

- Milepoint (MP) 6: this milepoint is located in the northern lake and is representative of jet-plow installation in shallower water depths;
- MP20, MP50 and MP68 – these locations are in the main lake at deeper depths where the majority of the cable installation will occur and are representative of where jet-plow installation (MP20 and MP68) and laying on the lake bottom (MP 50) will occur; and
- MP83 – this location represents a shallow more riverine section of the lake, where the shear-plow installation will be used.

A map of these representative locations is provided in Figure 1 of the Water Quality Modeling Report. It should be noted that TDI-NE proposes to place the cable on the bottom in locations deeper than 150 feet, without using any plows. However, in our modeling simulations, we assumed the use of a jet-plow in these locations in order to provide a more conservative analysis of the potential water quality impacts of the Project. As a result of this assumption, in deep water locations (similar to the representative MP50 location), our model assumes the use of a jet-plow installation for about 44 miles more than TDI-NE proposes to use this installation method. In these locations the cable will be placed on the bottom and allowed to self-bury into sediment, with less temporary disturbance of bottom sediments.

**Q16. Did you consult with the Agency of Natural Resources in the design of the modeling methodology used for this Project?**

A16. <u>Response:</u> Yes. TDI-NE consulted with the Agency several times in the development of the modeling methodology. A proposed water quality study plan was shared with the Agency on June 24, 2014, and Agency staff feedback was incorporated into the final design and helped inform and refine the modeling methodology. On September 11, 2014, HDR provided the Agency with the proposed sediment property and constituent inputs (e.g., metals and phosphorus) to the model and TDI-NE accepted the Agency's recommendation for modifying these values.

**Q17. Let's turn to the results of your analysis. Can you please describe the outcome of your modeling work for the NECPL?**

A17. <u>Response:</u> Yes. The detailed results of the water quality modeling are presented in the Lake Champlain Water Quality Modeling Report (***Exh. TDI-AT-2***), and I will summarize them here. As noted above, five representative locations along the cable route were used to complete the water quality assessment that included: shallow northern and southern lake locations (approximately 20 feet deep); and three deeper mid-lake locations (depths ranging from approximately 60-300 feet). These five representative locations are indicative of the water quality changes expected along the entire cable route due to the similar sediment characteristics and bottom lake currents.

Overall, the modeling results at each of the five locations demonstrate that the water quality impacts associated with cable installation are short-term and geographically limited to areas adjacent to the cable installation location. By way of example, Figures 5, 10, 14, 19, 24 and 29-31 from the Water Quality Modeling Report show the calculated water quality concentration increases expected at MP6, which is a shallow water location where the jet-plow installation method will be used. As noted above, we analyzed the expected increase in a range of constituents at each representative location, including TSS, TP, DP, and a range of metals (arsenic; cadmium; copper; lead; nickel; zinc; silver; and mercury). The model output for each constituent is displayed in two primary ways. First, using TSS at MP6 as an example in Figure 5, we show both an "overhead plan" view and a "vertical-slice" view that shows a snap-shot of a particular point in time in the model calculation, which corresponds with the jet-plow installation passing by MP6. We then also provide the expected water quality model output on a time-scale for each location, which for the TSS example, is shown in Figure 10.

**Q18. Using Figure 5 (TSS at MP6) as an example, can you please describe in more detail what the overhead plan and vertical-slice view figure shows?**

A18. Response: Yes. In Figure 5 on the left hand side, you see the overhead plan view of the lake in the area around MP6. The model results show the expected dispersion of TSS horizontally in the lake at the point when the jet-plow installation reaches MP6 (which includes the effect of previous installation activities up-lake from that installation point). The extent of the TSS dispersion plume shown in Figure 5 is largely a factor of five attributes: (1) cable installation speed (how fast the installation activity is moving); (2) rate of sediment (TSS) resuspension associated with the jet-plow activity; (3) specific sediment characteristics in this particular location in the lake; (4) the TSS settling rate (i.e., how quickly the TSS settles out of the water column back to the lake bed); and (5) the modeled water flow and currents in this area of the lake. For relative scale, we have included a corridor on each of the plan view maps that is 200 feet on either side of the installation point (400 feet wide). As is evident in this view, the extent of dispersion is limited to this area around the point of installation.

On the right-hand side of Figure 5 you see the vertical slice view. This shows the model output approximately at the point of the installation activity at MP6. The location selected is just behind the installation activity to provide a better view of the lateral and vertical dispersion of TSS (or other modeled constituents) immediately after the plow passes the installation point, as the resuspended sediment generally tends to spread out slightly in the water column following installation. In each vertical-slice view, the exact location of this slice is represented by the thin east-west line on the corresponding overhead plan view that is perpendicular to the north-south direction of the installation.

The vertical-slice view also shows the bathymetry of the lake bottom in that particular location, and shows how the water column is divided into lateral and vertical cells to create the small "mesh" modeling cells for that location. Each cell in Figure 5 displays the calculated constituent concentration. This view allows the reader to better understand the spatial extent to which the calculated constituent disperses both laterally and vertically in the water column. As can be seen in this figure, at a location just behind the installation at MP6, elevated TSS levels are quite limited geographically, dispersing to just a few cells adjacent to and above the point of installation, with the water current generally drifting the plume to the west (left) of the point of installation. At all representative locations, the calculated TSS increases are less than 3 mg/L above background levels within 200 feet laterally from the installation point and within 3-10 feet up from the bottom of the lake. Similar figures are presented for TSS, TP and DP at the other four representative locations in the Water Quality Modeling Report. Modeled concentrations for the metal constituents are not displayed in the overhead plan view and vertical-slice view and only on a time-scale because the existing sediment dissolved metals concentrations are less than the applicable acute and chronic VWQS values.

**Q19. Let's turn to the time-scale figures. Again using TSS at MP6 as an example (Figure 10), can you please describe in more detail what the time-scale figure shows?**

A19. Response: Yes. As shown in Figure 10, the time-scale figures show how the calculated concentration for each constituent decreases over time after cable installation at each representative location (in this figure, TSS at MP6). These figures represent the concentration for one individual model cell, which is indicated on the corresponding vertical-slice in Figure 5 with a small circle that represents the model cell with the highest instantaneous maximum concentration for representative purposes. So, for example, the concentration time-scale for TSS at MP6 shown in Figure 10 corresponds to the middle-bottom cell in the vertical-slice view shown on Figure 5. As is evident in this figure, the TSS concentration temporarily increases just after the point of installation, and then decreases rapidly after installation as resuspended sediment settles back to the sediments. In fact, the TSS concentrations at MP 6 are less than 3 mg/L above background levels within one to three hours after installation. Similar figures are included in the Water Quality Modeling Report for TSS, TP, and DP at the five representative modeling locations, which all show similar short term increases in the constituent concentrations. TSS are less than 3 mg/L above background levels and TP and DP are less than 0.01 mg/L above background levels within one to four hours after cable installation. We have also included time-scale figures for the dissolved metals concentrations in the Water Quality Modeling Report. These figures show that all of the model calculated dissolved metals concentrations (arsenic, cadmium, copper, lead, nickel, zinc, silver and mercury) are much less than applicable acute and chronic VWQS criteria as are the existing sediment dissolved metals concentrations. All of the available collected sediment PCB data were reported as non-detect or less than the method detection limit (MDL) and are not expected to impact lake water quality as a result of the cable installation.

**Q20. Based on the results of your modeling what general conclusions can you draw regarding the Project's potential impact on water quality.**

A20. <u>Response:</u> The results from the water quality modeling have shown that water quality impacts associated with the cable installation in Lake Champlain are expected to be minimal. The calculated increases in TSS and TP are a one-time event of short duration (on the order of a few hours) and of limited spatial and vertical extent. Within 200 feet from the point of installation, and within 3-10 feet from the lake bottom, TSS, TP and DP concentrations temporarily increase along the lake bottom but return to less than 3 mg/L TSS above background levels and less than 0.01 mg/L TP or DP above background levels in one to four hours after cable installation. All of the constituent concentrations from project related activities are less than the relevant VWQS criteria at all times, including the calculated dissolved metals concentrations and existing sediment dissolved concentrations, which are less than the applicable acute and chronic VWQS criteria. As a result, based on the model results, we expect the water quality impacts associated with the cable installation to be quite limited, with no adverse impact on designated or existing uses.

**Q21. In your professional opinion, will the Project comply with applicable water quality standards in Lake Champlain?**

A21. <u>Response:</u> Yes. The applicable state (VTANR) water quality standards in Lake Champlain are for the eight metals analyzed (arsenic, cadmium, copper, lead, nickel, zinc, silver and mercury) and for TP. All of the calculated metals concentrations are less than the applicable acute and chronic VWQS and, therefore, the Project will be in compliance with the VWQS for metals. For TP, the VWQS criteria vary in the lake along the cable installation route from 0.010-0.025 mg/L and are applied as an annual mean in the euphotic zone. Because the calculated TP increases are of short duration (on the order of hours), it is not expected that the one-time, short term TP increases will meaningfully contribute to the annual mean TP concentrations in the lake. Therefore, the Project will not significantly contribute to existing exceedances of the VWQS for TP in Lake Champlain. There is no specific VWQS for TSS but calculated TSS concentration increases are less than 3 mg/L above background levels at 200 feet from the point of installation and within one to four hours from the time of cable installation.

**Q22. Lake Champlain is listed as an impaired water way on the State's 303d list under the Clean Water Act for phosphorous. Can you please speak in a little more detail regarding the Project's potential impacts on phosphorous in Lake Champlain?**

A22. Response: As discussed previously, the calculated TP increases from the one-time installation activities are of short duration (on the order of hours), are not expected to meaningfully change the annual mean TP lake concentrations and are not expected to significantly contribute to existing exceedances of the VWQS for TP in Lake Champlain. In addition, we also analyzed the Project's potential phosphorus impacts in the lake by comparing the expected one-time phosphorous resuspension associated with cable installation activities to the total estimated annual external phosphorus sources to Lake Champlain, and also calculated the potential increase in the euphotic zone and mixed layer depth DP concentrations in the lake. These additional assessments are discussed below and, to be more conservative, include the assumed jet-plow resuspension source for 44 miles of the cable route where the cable will actually be placed on the bottom of the lake with minimal sediment disturbance.

- The one-time DP mass re-introduced to the lake due to the cable installation represents 0.01% of the total annual external phosphorus input based on external loading data to Lake Champlain from 1991-2008. DP was used for this calculation because the resuspended particulate phosphorus fraction settles quickly back to the sediment and does not contribute significantly to the one-time phosphorus source from the cable installation. It should be noted that the cable installation does not represent a new source of phosphorous contribution to the lake but rather represents a one-time re-introduction of phosphorus associated with existing lake sediments into the water column on a short term basis (one to four hours).
- The total potential one-time DP increase in both the euphotic zone and surface mixed layer is less than 0.009 μg/L (or less than 0.1% of existing DP levels in the lake). This analysis could be considered conservative because it assumes that the DP mass re-introduced from the sediments into the bottom of the lake as a result of the Project can completely transfer into the surface layer of the lake. In reality, the thermocline within the lake represents a barrier to vertical mass transport in the lake, and would therefore significantly limit this transport during periods of temperature stratification (i.e., approximately May through October). Only the DP fraction of TP was considered for this assessment because the particulate phosphorus fraction that is resuspended near the bottom of the lake

will settle quickly back to the sediments and will not materially affect concentrations in the water column.

Overall, the majority of the one-time, short term duration phosphorus increases near the bottom of the lake due to the cable installation will be confined to water depths deeper than the euphotic zone and the mixed layer depth and, therefore, it is not expected that phosphorus and algal levels in the surface layer of the lake will be impacted due to the Project.

**Q23. In your professional opinion, will the Project's installation have an undue adverse impact on water quality in Lake Champlain?**

A23. Response: No. Based on the water quality modeling completed and my understanding of the cable installation methods, it is my professional opinion that the Project will not adversely impact water quality in Lake Champlain. My professional opinion is based on the short term duration and the limited spatial extent of the calculated water quality increases for TSS, TP and metals associated with the cable installation. In addition, the Project will be in compliance with the applicable VWQS for metals and not meaningfully contribute to existing exceedances of the VWQS for TP in Lake Champlain.

**Q24. Does this conclude your testimony at this time?**

A24. Response: Yes.