APPENDIX S

Floodplain Statement of Findings

FLOODPLAIN STATEMENT OF FINDINGS

for the

Champlain Hudson Power Express Transmission Line Project

U.S. DEPARTMENT OF ENERGY
OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY
WASHINGTON, DC

May 2014

ACRONYMS AND ABBREVIATIONS

AC	alternating current
BFE	base flood elevation
BMP	best management practice
CFR	Code of Federal Regulations
CHPE	Champlain Hudson Power Express
CP	Canadian Pacific
CSX	CSX Corporation
DC	direct current
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
EO	Executive Order
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
HDD	horizontal directional drilling
HVDC	high-voltage direct current
MP	milepost
MSL	mean sea level
MW	megawatt
NEPA	National Environmental Policy Act
NYSPSC	New York State Public Service Commission
ROI	region of influence
ROW	right-of-way

FLOODPLAIN STATEMENT OF FINDINGS

FOR THE

CHAMPLAIN HUDSON POWER EXPRESS

TRANSMISSION LINE PROJECT

U.S. Department of Energy

OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY

MAY 2014

Summary

This Floodplain Statement of Findings has been prepared by the U.S. Department of Energy (DOE) in support of a potential issuance of a Presidential permit for the proposed Champlain Hudson Power Express (CHPE) Transmission Line Project. The proposed CHPE Project would involve construction of a buried electric power transmission system that would extend from the international border between the United States and Canada at Champlain, New York and run south to New York City metropolitan area electrical market. The transmission line would be constructed with significant portions of the route beneath Lake Champlain and the Hudson, Harlem, and East rivers. This Statement of Findings has been prepared in accordance with 10 Code of Federal Regulations Part 1022. DOE is reviewing the Presidential permit application that, if issued, would authorize the construction, operation, and maintenance of the United States portion of the project. The proposed electric power transmission system route would encounter floodplains designated by the Federal Emergency Management Agency. The Applicant has assessed the potential for adverse effects from the proposed CHPE Project on floodplains and has developed mitigation plans to avoid and minimize adverse effects on human life, property, and natural resources. DOE has determined that the proposed CHPE Project would avoid floodplains to the maximum extent practicable, that appropriate measures to minimize adverse effects on human health and safety and the functions and values provided by floodplains would be taken, and that the project would comply with applicable floodplain protection standards.

THIS PAGE INTENTIONALLY LEFT BLANK

FLOODPLAIN STATEMENT OF FINDINGS
FOR THE
CHAMPLAIN HUDSON POWER EXPRESS TRANSMISSION LINE PROJECT

TABLE OF CONTENTS

FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

1. Introduction

This Floodplain Statement of Findings addresses the proposed Champlain Hudson Power Express (CHPE) Transmission Line Project route that would cross the international border between the United States and Canada and would be buried underground and would run south through Lake Champlain, roadway and railroad rights-of-way (ROWs), and beneath the Hudson, Harlem, and East rivers in New York State to its terminus in the New York City metropolitan area. The U.S. Department of Energy (DOE) has prepared the *Champlain Hudson Power Express Transmission Line Project Environmental Impact Statement* concurrently with this Statement of Findings. Described in this Statement of Findings are (1) a description of the Proposed Action; (2) justification for locating the Proposed Action in a floodplain; (3) description of the project alternatives evaluated in the Environmental Impact Statement (EIS); (4) determination of conformance with applicable floodplain protection standards; and (5) mitigations that would be implemented to avoid, minimize, and offset potential for those adverse effects. An assessment of effects on floodplains was also incorporated into Chapters 3 and 5 of the EIS. Detailed maps depicting the route for the transmission line installation and the construction of associated structures along each segment of the proposed CHPE Project are included in Appendix A of the EIS.

2. Purpose of the Proposed Action

DOE's action is the review of the Applicant's Presidential permit application that may authorize the construction, operation, and maintenance of the United States portion of the proposed CHPE project.

This Statement of Findings has been prepared in accordance with 10 Code of Federal Regulations (CFR) Part 1022, *Compliance with Floodplain and Wetland Environmental Review*, to address those portions of the proposed CHPE Project that would cross Federal Emergency Management Agency (FEMA)-designated floodplains. In accordance with Executive Order (EO) 11988, *Floodplain Management*, this Statement of Findings addresses the action alternatives considered to avoid adverse effects and incompatible developments in floodplains. The DOE requirements for compliance with EO 11988 are set forth in 10 CFR Part 1022. EO 11988 directs Federal agencies to implement floodplain management requirements through existing procedures and guidelines such as those established to implement the National Environmental Policy Act (NEPA), or those developed by individual states, to the maximum extent practicable. Per EO 11988, an agency may locate a facility in a floodplain if the head of the agency finds there is no practicable alternative. If it is found that there is no practicable alternative, the agency must minimize potential harm to the floodplain, and circulate a notice explaining why the action is to be located in the floodplain prior to taking action. Finally, new construction in a floodplain must apply accepted flood proofing and flood protection, which would include elevating structures above the base flood level rather than filling in land.

3. Description of Proposed CHPE Project

The portion of the proposed CHPE Project transmission line to occur within the United States would be owned and operated by the project Applicant, Champlain Hudson Power Express, Inc. The proposed transmission system would be buried underground and would cross the international border from Canada into the United States underwater near the town of Champlain, New York. Plans would involve the construction, operation, and maintenance of a 1,000-megawatt (MW), high-voltage direct current (HVDC), electric-power transmission line along the following four segments as described in Chapter 3 of the EIS: Lake Champlain, Overland, Hudson River, and New York City Metropolitan Area. Both buried aquatic (underwater) and sub-terrestrial (underground) installation of the transmission line would occur along these segments. Construction of a converter station in Astoria, Queens, and approximately 16 cooling stations to service portions of the line installed using horizontal directional drilling (HDD) techniques would be required. The transmission line would extend 336 miles (541 kilometers [km]) south beneath Lake Champlain; run along the CSX Corporation (CSX) and Canadian Pacific (CP) railroad ROWs; along roadway ROWs; and continue beneath the Hudson, Harlem, and East rivers to a proposed new converter station and substation addition (with an approximate footprint of 1.4 acres [0.6 hectares]) to be constructed in Astoria, Queens, where a 3-mile (5-km)-long underground alternating current (AC) cable would extend through city streets to the Rainey Substation, also in Queens.

The 16 cooling equipment stations would be constructed at different locations along the transmission line route. Each cooling station would consist of a 64-square-foot aboveground structure that would house a chiller unit and a pumping system. Each pumping system would circulate chilled water through a closed-loop system alongside the underground HVDC cable to prevent heat accumulation and potential damage. The entire proposed CHPE Project route is shown in **Figure 1**. Detailed maps depicting locations where the proposed transmission line would encounter FEMA-designated floodplains and coastal flood zones can be found in Appendix A of the EIS.

The proposed Luyster Creek HVDC Converter Station in Astoria would convert the electrical power from direct current (DC) to AC and then transmit that power through a buried HVAC cable circuit to the Astoria and Rainey electrical substations and beyond into New York State's electrical grid.

FEMA defines flood zones by geographic areas according to varying levels of flood risk. A 100-year floodplain is determined based on the area with approximately 1 percent or greater probability of flooding per year and corresponds to either FEMA Zone A (has no established base flood elevation [BFE]) or Zone AE (has an established BFE). The aquatic transmission line would be routed through Lake Champlain and the Hudson, Harlem, and East rivers. With respect to floodplains, these water bodies are classified as a 100-year floodplain by FEMA (Zone AE, also defined as a "High-Risk Area") (FEMA 2012). Additional information on flood risks and potential for effects on floodplains in the vicinity of the proposed CHPE Project route is provided in Chapter 5 of the EIS.

Based on a review of FEMA Flood Insurance Rate Maps (FIRMs), approximately 11.6 acres (4.7 hectares) of 100-year floodplains associated with rivers, streams, and unnamed tributaries are within the proposed CHPE Project's region of influence (ROI) (100 feet [30 meters] along either side of the transmission route) for water resources in the Overland Segment of the proposed CHPE Project route between Dresden and Catskill, New York. These floodplains include FEMA Zones A and AE (FEMA 2012).

In the Hudson River Segment between mileposts (MPs) 295 and 303, where the transmission line route exits the Hudson River in Stony Point, New York, the ROI for the terrestrial portion of the route would cross approximately 2.6 acres (1.1 hectares) of FEMA-mapped floodplains associated with rivers, streams, and unnamed tributaries in Stony Point, Haverstraw, and Clarkstown, New York. These floodplains are classified as Zone A (FEMA 2014).

Where the transmission line leaves the Harlem River at MP 330 to traverse 1 mile over land before entering into the East River, it would be in a flood hazard area associated with Bronx Kill. Flood hazard areas include BFEs that identify the flood risk for coastal communities in the New York City metropolitan area affected by Hurricane Sandy in 2012. The BFE for a 1 percent chance of inundation in any given year (flood hazard Zone AE) (i.e., 100-year flood event) is at an elevation of 11 feet (3 meters) above mean sea level (MSL) on the north side of Bronx Kill, with higher values closer to the shoreline (FEMA 2013).

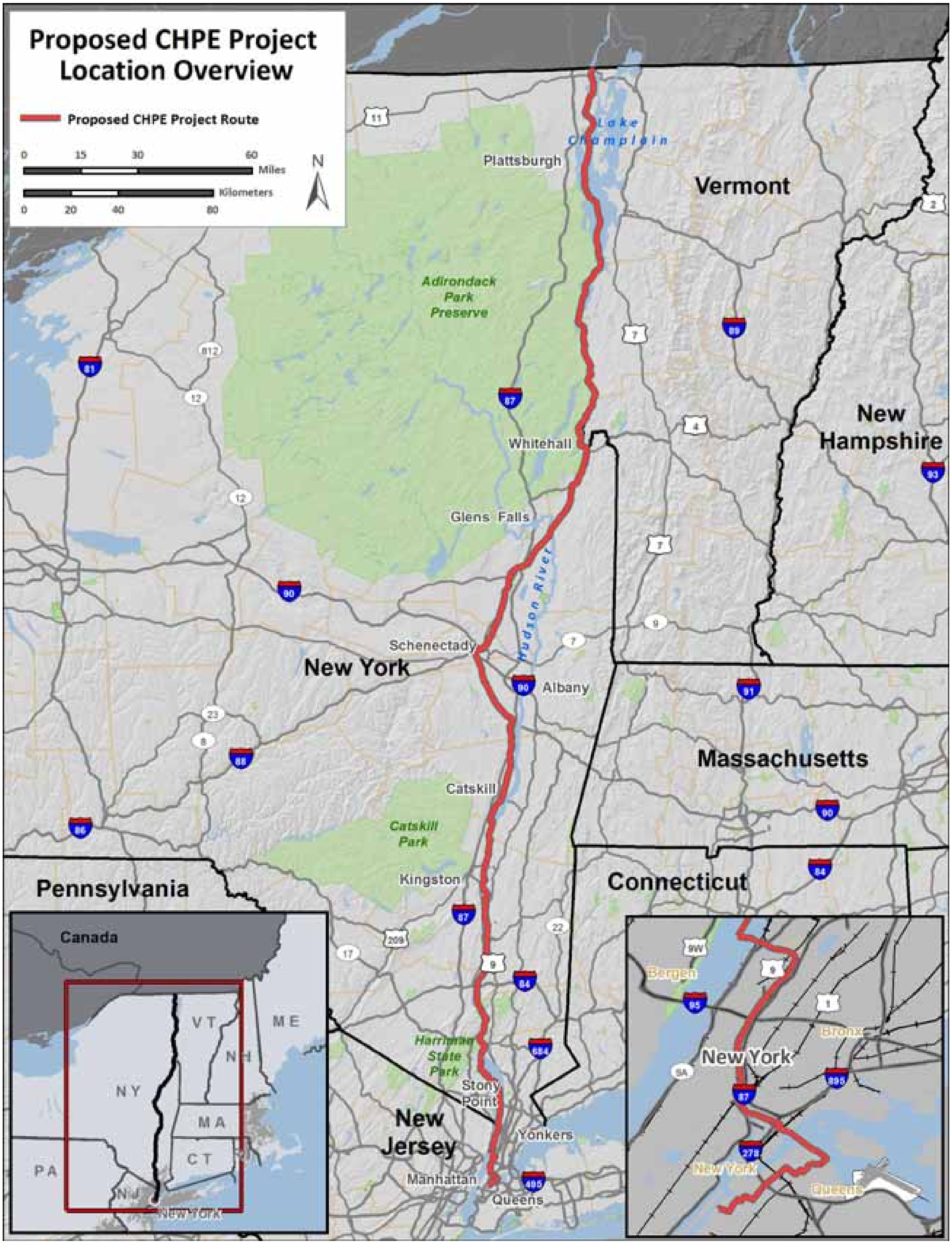


Figure 1. Proposed CHPE Project Route

The transmission line would be routed beneath the East River from the Bronx Borough to Queens, crossing a FEMA Zone VE-designated floodplain before making landfall north of the Luyster Creek HVDC Converter Station. Zone VE is considered a high-risk coastal area, which has a 1 percent or greater chance of flooding and an additional hazard associated with storm waves. The post-Hurricane Sandy BFE for this VE zone is between 16 and 21 feet (5 and 6 meters) above MSL. A portion of the area proposed for the Luyster Creek HVDC Converter Station, which is adjacent to a waterway also referred to as Steinway Creek, is at the confluence of the East River and Long Island Sound. The upland area near the shore, including the converter station site, is designated as Zone AE with a 1 percent flood hazard elevation of 13 feet (4 meters) above MSL. In addition, the Astoria to Rainey interconnection would also cross FEMA Zone AE floodplains prior to the terminus of the transmission line (FEMA 2013).

Of the 16 cooling stations proposed for the CHPE Project, 15 are currently proposed to be sited outside of the 100-year floodplain, and 1 (located at MP 330.6 in the Bronx) could be sited within the 100-year floodplain. This cooling station would be located in flood hazard area FEMA Zone AE (FEMA 2013).

4. Justification for Locating the Project in a Floodplain

The 336-mile transmission line would be installed underground in its entirety. Thus, it is necessary and unavoidable for it to cross floodplains along its route. Approximately 70 percent of the proposed CHPE transmission system would occur beneath major water bodies including Lake Champlain and the Hudson River.

5. Descriptions of the Alternatives Considered

Alternatives considered for the proposed CHPE Project included construction of an overhead transmission route along existing or new transmission system ROWs, or locating the transmission system in other underground ROWs including railroad, highway, and existing transmission line ROWs.

Construction of a new overhead transmission route would offer an opportunity to avoid or minimize impacts on floodplains as it would be possible to span floodplains. Two alternative aboveground transmission routes were considered; however, these alternatives were dismissed from further consideration as being unreasonable because of the difficulty involved with acquiring the new overhead electrical transmission ROWs. Additionally, alternative routes using highway ROWs, existing electric transmission cable ROWs, and constructing the transmission line entirely within railroad ROWs were evaluated but were dismissed as being unreasonable. If determined to be reasonable, these alternative underground routes would also have been located in floodplains similar to those described for the proposed CHPE Project route. Detailed descriptions of CHPE Project alternatives considered but dismissed as unreasonable can be found in Chapter 2 of the EIS.

6. Conformance with Floodplain Protection

As proposed, the CHPE project would conform to applicable state and local floodplain protection standards as described in the *Certificate of Environmental Compatibility and Public Need* issued by the New York State Public Service Commission (NYSPSC) for the proposed CHPE Project (NYSPSC 2013). All structures and facilities would be designed to be consistent with the intent of the standards and criteria of the National Flood Insurance Program (44 CFR Part 60, *Criteria for Land Management and Use*).

No impacts on floodplains, human life, or property would occur from construction, operation, maintenance, inspection, or emergency repair of the aquatic portions of the proposed CHPE Project. The underground installation and burial of the transmission line within the sediments of aquatic portions of the route would not impact flood flows, flood storage, or cause a flooding hazard. Burial of the proposed transmission line under water bodies would have no impacts on current use, property management, and future plans for development. Therefore, no impacts on floodplains would be anticipated from construction or operation of the proposed CHPE Project transmission line in Lake Champlain, the Hudson River, the Harlem River, or the East River.

The terrestrial portions of the proposed CHPE Project would result in temporary impacts on floodplains from construction activities related to burying the cables. Vegetation clearing, ground disturbance, trenching and soil stockpiling, and related construction activity would occur within the floodplains crossed by the proposed CHPE Project. Best management practices (BMPs) that the Applicant has committed to implementing during construction, including use of erosion and sedimentation controls, prohibitions on storing construction equipment or conducting refueling in floodplains, and restoring pre-existing ground contours, would minimize any impacts on flood flows, flood storage, or flood hazards during the construction period. In addition, a number of floodplain crossings would be made using HDD methods that would avoid any direct disturbance within floodplain areas by drilling entirely underground. The complete listing of Applicant-proposed BMPs is provided in Appendix G of the EIS.

No permanent aboveground alterations or new impervious surfaces that could impact flood storage, infiltration, or flooding hazard would result from construction or operation of the underground terrestrial transmission line. Therefore, no impacts from operation and maintenance of the terrestrial portion of the transmission line would be expected.

Aboveground cooling stations would be constructed at 16 locations along the terrestrial portion of the underground transmission line route. Of these, one cooling station with a footprint area of 64 square feet (6 square meters), located at MP 331 in the Bronx Borough, could be located within a designated Zone AE floodplain area where the 1 percent BFE has been established at an elevation of 11 feet above MSL. This cooling station would be associated with a portion of the transmission line that would be installed beneath the Harlem River Rail Yard by HDD. The Harlem River Rail Yard is located within a Zone AE flood area. Supplemental cooling of this specific underground transmission line section would be required to ensure that the cables operate within design parameters. There is no alternative location for the cooling station that would be outside of the designated floodplain. In accordance with the conditions established in the *Certificate of Environmental Compatibility and Public Need* for the proposed CHPE Project (NYSPSC 2013), the cooling station would be constructed such that the ground floor elevation is at or above the 100-year flood elevation level. Therefore, negligible impacts on flood flows, flood storage, or flood hazards would be anticipated.

The Luyster Creek HVDC Converter Station would be constructed and operated within the 100-year floodplain of the East River (see Maps 68 and 69 in Appendix A of the EIS). Based on the Preliminary Work Maps prepared by FEMA as part of an evaluation of flood hazards following Hurricane Sandy (FEMA 2013), the converter station site has a 100-year BFE of 13 feet (4 meters) above MSL. A 500-year (i.e., 0.2 percent) flood event has a BFE of 15 feet at this location. Alternative locations for siting the converter station were considered and are discussed in detail in Chapter 2 of the EIS. Much of the Charles Poletti Power Plant complex is within flood Zone AE, and the proposed Luyster Creek HVDC Converter Station site is currently undeveloped with open space and some vegetation. Use of this area for the proposed converter station site would not interfere with current site operations or plans for future development. Vegetation clearing, grading, and construction activity would occur within this floodplain area. Applicant-proposed measures, including use of erosion and sedimentation controls, restrictions on storing construction equipment, and restoring pre-existing ground contours would minimize any impacts on flood flows, flood storage, or flood hazards during the construction period. A complete listing of Applicant-proposed measures is provided in Appendix G of the EIS.

The 1.4 acres (0.6 hectares) of buildings composing the permanent aboveground converter station and appurtenant facilities would be designed to avoid flood hazard damage and to reduce impacts by grading and raising the first floor above the base flood elevation. In addressing the post-Hurricane Sandy flood elevation recommendations (FEMA 2013), the Applicant has identified that the Luyster Creek HVDC Converter Station first floor would be raised to an elevation greater than the 500-year storm surge impacts plus 2 feet (0.6 meters); or 19 feet (5.8 meters) above MSL. Although this area is subject to tidal influences, it is not a designated floodway. Therefore, no negligible impacts would be expected as a result of constructing and operating the converter station in the floodplain at this location. Additional discussions of impacts on floodplains are provided in Chapter 5 of the EIS.

7. Mitigation Plans

In accordance with 10 CFR Part 1022.12(a)(3), measures to minimize the adverse impacts of actions in floodplains, including minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically sensitive areas, must be considered. Impacts on floodplains (including flood storage and flow) would be avoided by installing the transmission line below ground along nearly its entire length. Sub-terrestrial cable installation would be placed at least 3 feet below the ground. Where installed in Lake Champlain, the transmission cables would be placed at least 3 feet beneath the lake bed. Cable installation beneath the Hudson, Harlem, and East rivers would be at least 6 feet below the riverbed. Exceptions to this depth would occur where the transmission line would cross an existing utility infrastructure line at a shallower depth or be placed on the surface and covered with concrete mats when crossing existing infrastructure or exposed bedrock. To avoid increases in erosion and sedimentation into surface waters from land disturbance during construction along the terrestrial portions of the route, the proposed CHPE Project would use temporary and permanent erosion-control measures along the construction corridor, as needed, and would manage construction storm water in accordance with approved Storm Water Pollution Prevention Plans. Following installation of the terrestrial transmission line, the ground surface would be restored to its pre-existing grade and would be revegetated, as appropriate. The one cooling station that would be sited within coastal floodplains in the Bronx would be designed to avoid flood hazard damage by elevating the structure above the established 100-year floodplain (i.e., 1 percent) elevation. In addressing post-Hurricane Sandy flood elevation concerns, the Applicant has identified that the Luyster Creek HVDC Converter Station first floor would be raised to an elevation greater than the 500-year storm surge impacts.

Applicant-proposed measures for storm water management and floodplains are discussed in detail in Appendix G of the EIS.

8. References

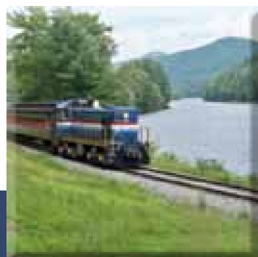
FEMA 2012 — Federal Emergency Management Agency (FEMA). 2012. "FEMA Floodplain Map Service Center." Available online: <*http://www.msc.fema.gov/webapp/wcs/stores/servlet/CategoryDisplay?catalogId=10001&storeId=10001&categoryId=12001&langId=-1&userType=G&type=1&future=false*>. Accessed 28 October 2012.

FEMA 2013 — FEMA. 2013. "Preliminary Work Map Flood Hazard Data." Available online: <*http://fema.maps.arcgis.com/home/webmap/viewer.html?webmap=2f0a884bfb434d76af8c15c26541a545*>. Accessed 30 December 2013.

FEMA 2014 — FEMA 2014. "Advisory Base Flood Elevation." Available online: <*https://geopower.jws.com/rockland/ApplicationsPage.jsp#*>. Accessed 3 January 2014.

NYSPSC 2013 — New York State Public Service Commission (NYSPSC). 2013. "Champlain Hudson Power Express, Inc., Order Granting Certificate of Environmental Compatibility and Public Need." Available online: <*http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7bA7142 3C8-B489-4996-9C5A-016C9F334FFC%7d*>. Accessed 18 April 2013.





APPENDIX T

Programmatic Agreement


PROGRAMMATIC AGREEMENT
AMONG
THE U.S. DEPARTMENT OF ENERGY,
AND
THE NEW YORK STATE HISTORIC PRESERVATION OFFICER
FOR
MANAGING HISTORIC PROPERTIES THAT MAY BE AFFECTED
BY
AUTHORIZING THE CONSTRUCTION, OPERATION, CONNECTION AND MAINTENANCE OF THE
CHAMPLAIN HUDSON POWER EXPRESS HVDC TRANSMISSION LINE PROJECT

WHEREAS, pursuant to the authority delegated by the President of the United States under Executive Order 10485, as amended by Executive Order 12038, the U.S. Department of Energy ("DOE") receives and considers applications for permits for the construction, operation, maintenance, and connection of facilities for the transmission of electric energy at the borders of the United States ("Presidential Permit"); and

WHEREAS, Champlain Hudson Power Express, Inc. and CHPE Properties, Inc (collectively "CHPE") have applied to the DOE's Office of Electricity Delivery and Energy Reliability for a Presidential Permit for the Champlain Hudson Power Express HVDC Transmission Line Project ("Project") in accordance with the DOE's applicable administrative procedures at 10 CFR § 205.320 *et. seq.*; and

WHEREAS, the proposed Project would consist of a 1,000-megawatt high-voltage direct current ("HVDC") transmission system extending approximately 333 miles from the United States' border with Canada to a converter station to be constructed in Astoria, Queens, New York; a 3-mile long high-voltage alternating current transmission system extending from the proposed converter station to an existing substation in Astoria; and ancillary facilities (such as temporary work areas, contractor yards, laydown areas, and access roads); and

WHEREAS, construction of the Project will entail installation of buried transmission cables along waterways and within the rights-of-way of existing transportation infrastructure, including railroads and roadways located within the State of New York; and

WHEREAS, Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470f) ("Section 106"), directs federal agencies to take into account the effects of their undertakings on historic properties listed in or eligible for inclusion in the National Register of Historic Places ("National Register") and to afford the Advisory Council on Historic Preservation ("ACHP") a reasonable opportunity to comment; and

WHEREAS, the procedures set forth in 36 CFR Part 800 - Protection of Historic Properties define how federal agencies meet their statutory responsibilities pursuant to Section 106; and

WHEREAS, the DOE has determined that the issuance of a Presidential Permit for the Project is an undertaking, as defined in 36 CFR § 800.16(y), requiring compliance with Section 106 and its implementing regulations; and

WHEREAS, construction of portions of the Project will also require authorization by the U.S. Army Corps of Engineers ("USACE") pursuant to Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. § 403) and Section 404 of the Clean Water Act (33 U.S.C. § 1344), and the USACE and the DOE have agreed that the DOE is the lead federal agency for purposes of compliance with Section 106, in accordance with 36 CFR § 800.2(a)(2); and

WHEREAS, consistent with 36 CFR § § 800.4(a) and 800.16(d), the area of potential effects ("APE") for this undertaking has been defined to include all areas that could be directly or indirectly affected by construction and/or operation of the Project, including ground-disturbing activities associated with installation of the transmission line, construction of the converter station, and ancillary facilities (such as temporary work areas, contractor yards, laydown areas, and access roads); and

WHEREAS, the Project's APE generally includes the geographic area defined in the attached maps and may be further refined through additional engineering assessments; and

WHEREAS, the Project is located within the identified area of interest of four federally recognized Indian tribes, and the DOE has consulted with the Delaware Indian Nation, the St. Regis Mohawk Tribe, the Shinnecock Indian Nation, and the Stockbridge-Munsee Community Band of Mohican Indians on a government-to-government basis in accordance with 36 CFR § 800.2(c)(ii); and

WHEREAS, the DOE has determined that its undertaking associated with the Project has the potential to adversely affect historic properties listed in or eligible for the National Register and have consulted with the ACHP, the USACE, the New York State Historic Preservation Officer (NYSHPO), and federally recognized Indian tribes pursuant to 36 CFR § 800.14 of the regulations implementing Section 106; and

WHEREAS, pursuant to 36 CFR § 800.14(b), the DOE has elected to execute this Programmatic Agreement ("PA"); and

WHEREAS, pursuant to 30 CFR §§ 800.2(c)(2), 800.6(c)(3), and 800.2(c)(4), the Delaware Indian Nation, the St. Regis Mohawk Tribe, the Shinnecock Indian Nation, the Stockbridge-Munsee Community Band of Mohican Indians, CHPE, and USACE (collectively, the "Concurring Parties") have been invited to concur in this PA.

NOW, THEREFORE, the DOE and the NYSHPO (the "Signatory Parties") agree that the Project shall be administered and implemented in accordance with the following stipulations to satisfy the responsibilities of the DOE under Section 106 for all aspects of the Project.

STIPULATIONS

I. APPLICABILITY

DOE, CHPE, and the SHPO shall ensure that the following stipulations are carried out:

A. DOE, CHPE and SHPO will review Undertakings in accordance with the terms of this agreement.

B. This Programmatic Agreement will be in effect for a period of five years from the date of its execution.

C. DOE will send a copy of this Programmatic Agreement to the ACHP upon execution.

II. CULTURAL RESOURCES MANAGEMENT PLAN

A. Within one year following the issuance of the Presidential Permit for the Project, CHPE shall develop a Cultural Resources Management Plan ("CRMP") specifying how historic properties within the Project's APE will be considered and managed and submit the CRMP to the Signatory and Concurring parties.

B. The CRMP will be prepared by or under the supervision of an individual who meets, or individuals who meet, at minimum, the professional qualification standards for archaeology defined in the *Secretary of the Interior's Professional Qualification Standards* (48 FR 44738–44739, September 19, 1983).

C. The CRMP will be prepared with reference to:

1. The ACHP's guidance on conducting archaeology under Section 106 (2009);

2. The ACHP's February 23, 2007 *Policy Statement Regarding the Treatment of Burial Sites, Human Remains, and Funerary Objects*;

3. The NYSHPO's *Human Remains Discovery Protocol* (NYSHPO 2005);

4. The New York Archaeological Council's (NYAC) *Standards for Cultural Resource Investigations and the Curation of Archaeological Collections in New York State* (1994), as adopted by the NYSHPO in 1995;

5. *The Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation* (48 FR 44716-44742, September 29, 1983), as amended and revised;

6. The DOE's *American Indian and Alaska Native Tribal Government Policy* (DOE 2006); and

7. DOE Policy 141.1: *Management of Cultural Resources.*

D. The CRMP will, at minimum, include the following:

1. An introduction explaining the scope and purpose of the CRMP, the regulatory context and basis under which the CRMP is developed, and the organization of the CRMP.

2. A description of the Project, including the Project's setting, principal Project facilities, and proposed methods of construction.

3. A description of the APE for this undertaking, including potential causes and types of Project effects.

4. Maps of the Project's APE.

5. An overview synthesizing and summarizing data on the history and prehistory of the Project area to provide information regarding the nature and character of historic properties within or potentially within the Project's APE and to provide a context in which to evaluate and consider alternative treatment strategies for historic properties.

6. A summary of cultural resources investigations previously conducted within the APE, including those conducted to identify historic properties that may be affected by the Project.

7. An inventory of known or recorded historic and archaeological resources within the APE, including the following information:

   a) Location and description of known or reported resources based on available information, including the nature and type of resource (i.e., historic, prehistoric, or multi-component archaeological site, district, historic building, structure, or object);

   b) Whether cultural resources investigations conducted to identify and/or evaluate historic properties that may be affected by the Project have confirmed the presence or absence of a previously reported archaeological or historic resource; and

   c) Whether a known or reported historic or archaeological resource is listed in or has been previously determined eligible for inclusion in the National Register.

8. The procedures for completing the identification and, if necessary, the evaluation of historic properties (including properties of traditional religious or cultural significance) within the Project's APE that may be affected (directly and/or indirectly) by the Project.

9. The procedures for assessing the Project's effects (if any) on identified historic properties.

10. Procedures and specific management and/or control measures for resolving any adverse effects on identified archaeological sites and/or historic resources within the APE through the consideration of prudent and feasible Project alternatives, modifications, or treatment measures that would avoid, minimize, reduce, or mitigate adverse effects on historic properties listed in or eligible for inclusion in the National Register.

11. The process for identifying, developing, and implementing additional management and treatment measures for historic properties within the APE, as necessary.

12. Procedures for the unanticipated discovery of archaeological resources.

13. Procedures for the unanticipated discovery of human remains, taking into account applicable state and local laws, and

    a) The NYSHPO's *Human Remains Discovery Protocol* (NYSHPO 2005);

    b) The Native American Graves Protection and Repatriation Act of 1990 (25 USC 3001 *et seq.*) (NAGPRA) and its implementing regulations at 43 CFR Part 10;[1] and

    c) The ACHP's 2007 *Policy Statement Regarding the Treatment of Burial Sites, Human Remains, and Funerary Objects.*

14. Measures for the curation and/or repatriation of artifacts and collections removed from state lands consistent with Title 1, Article 5, Section 233 of the New York State Education Law, as applicable.

15. Procedures for training CHPE staff, contractors, and other appropriate personnel in the requirements of the CRMP and their responsibility to protect historic properties.

16. Measures to prevent looting and vandalism of historic properties within the APE during Project construction.

17. Requirements for any post-construction management or monitoring of identified historic properties.

18. Measures for public interpretation of historic properties and cultural values, to the extent prudent and reasonable.

19. Procedures for implementing the CRMP, including the following:

---

[1] Pursuant to 43 CFR Part 10, NAGPRA applies to human remains, sacred objects, and items of cultural patrimony (described as "cultural items" in the statute) located on federal or tribal lands or in the possession and control of federal agencies or certain museums. The Project will not occupy federal or tribal lands. Notwithstanding the limits of NAGPRA's applicability, the principles described in NAGPRA and its implementing regulations will serve as guidance for CHPE's actions should remains or associated artifacts be identified as Native American, and to the extent such principles and procedures are consistent with any other applicable requirements.

a) The specific individuals responsible for coordinating activities conducted under the CRMP, including coordinating consultation and maintenance of relevant records;

b) A dispute resolution process that is consistent with the process described in Section V of this PA;

c) The use of qualified cultural resources professionals to conduct certain activities under the CRMP (see Stipulation II.B, above);

d) Appropriate standards for cultural resources investigations and reporting;

e) A consultation protocol to coordinate with the Signatory and Concurring parties during implementation of the CRMP, including provisions for periodic reporting, and meetings; and

f) Procedures for review of and amendment to the CRMP.

III. CRMP REVIEW AND APPROVAL

A. CHPE will provide a draft CRMP to the following parties (collectively, the "Consulting Parties"):

1. The Signatory Parties;

2. The Concurring Parties;

3. The National Park Service; and

4. The New York State Department of Public Service.

B. The Consulting Parties will be afforded a 30-day review period to provide comments on the draft CRMP.

C. At the conclusion of the 30 day review period, CHPE will provide the DOE with a revised draft CRMP that includes:

1. Documentation of the views of the Consulting Parties;

2. Revisions adopted by CHPE;

3. An explanation of any revisions proposed by the Consulting Parties not adopted by CHPE.

D. Within 30 days of receipt of the revised draft CRMP described in Stipulation III.C of this CRMP, the DOE shall direct CHPE to make any necessary or appropriate revisions to finalize the CRMP.

E. Following DOE's acceptance of the final CRMP, CHPE shall submit the final CRMP along with documentation of the views of the Consulting Parties to the Signatory and Concurring parties.

F. If any of the Signatory or Concurring parties object to the final CRMP, the objecting party will notify the DOE in writing within 30 days of their receipt of the final CRMP. The DOE will consult with the objecting party, CHPE, and with other Signatory and/or Concurring parties, as appropriate, to seek agreement on the CRMP. If consensus is not reached within 30 days, the DOE will notify the ACHP of the objection, provide all pertinent information and request that the ACHP provide its advisory comments within 30 days of receipt of notification in accordance with Stipulation V of this Programmatic Agreement.

IV. INTERIM MEASURES FOR COMPLIANCE

A. Until the CRMP is accepted by the DOE, the DOE will continue to apply 36 CFR §§ 800.4 through 800.6 for all actions taken with regard to the Project.

B. Upon acceptance of the final CRMP, the DOE shall notify the Signatory and Concurring parties to this agreement of its acceptance, and CHPE shall implement the CRMP in lieu the procedures set forth in 36 CFR §§ 800.4 through 800.6.

V. DISPUTE RESOLUTION

A. Except as provided for in Section III.F of this PA, if at any time during implementation of this PA, the Signatory or Concurring parties object to any action or any failure to act pursuant to this PA, they may file written objections with the DOE.

1. The DOE will consult with the objecting party, and with other Signatory and/or Concurring parties as appropriate, to resolve the objection. The DOE may initiate on its own such consultation to resolve any of the DOE's objections to actions taken or products produced by any party pursuant to this agreement.

2. If the DOE determines that the objection cannot be resolved through consultation alone, the DOE will forward all documentation relevant to the dispute to the ACHP and request that the ACHP comment. After receiving all pertinent documentation, the ACHP will either:

    a) Provide the DOE with recommendations, which the DOE will take into account in reaching a final decision regarding the dispute; or

    b) Notify the DOE that it will comment pursuant to 36 CFR §§ 800.7(c)(1) through (c)(3) and Section 110(l) of the National Historic Preservation Act of 1966, as amended, and proceed to comment.

3. The DOE will take into account any ACHP comments provided in response to such a request, with reference to the subject of the dispute, and will issue a decision on the

matter. The DOE's responsibility to carry out all actions under this PA and the CRMP that are not the subject of dispute will remain unaffected.

VI. DURATION, AMENDMENT, AND TERMINATION OF THIS PROGRAMMATIC AGREEMENT

A. This PA shall take effect on the date it has been fully executed by the Signatory Parties and will remain in effect until terminated pursuant to Stipulation VI.C of this agreement. Any amendments to this PA shall take effect on the dates they are fully executed by the Signatory Parties, or such other self-executing dates as may be described in those documents.

B. Any Signatory Party to this PA may request in writing to the other Signatory Parties that this PA be amended. The Signatory Parties will consult in accordance with 36 CFR § 800.14(b) to consider such amendment.

C. Any Signatory Party to this PA may terminate this agreement by providing 30 days written notice to the other Signatory Parties, provided that the Signatory and Concurring parties are consulted during the 30-day notice period in order to seek agreement on amendments or other actions that would avoid termination. In the event of termination, the DOE will comply with 36 CFR Part 800 with regard to individual actions covered by this PA.

EXECUTION of this PA by the Signatory Parties and implementation of the stipulations provided herein evidences that the DOE and USACE have taken into account the effects of this Project on historic properties and afforded the ACHP an opportunity to comment on those effects.

SIGNATORY PARTIES

NEW YORK STATE HISTORIC PRESERVATION OFFICER

BY: Ruth A Pierpont DATE: 6/17/14

Name Ruth Pierpont
Title Deputy Commissioner OPRHP/Deputy SHPO

U.S. DEPARTMENT OF ENERGY

BY: Matthew A Rosenbaum DATE: 5/16/2014

Name MATTHEW A. ROSENBAUM
Title ACTING DIRECTOR NEDD

CONCURRING PARTIES

DELAWARE NATION

BY: DATE:
Name
Title

ST. REGIS MOHAWK TRIBE

BY: DATE:
Name
Title

SHINNECOCK INDIAN NATION

BY: DATE:
Name
Title

STOCKBRIDGE-MUNSEE COMMUNITY
BAND OF MOHICAN INDIANS

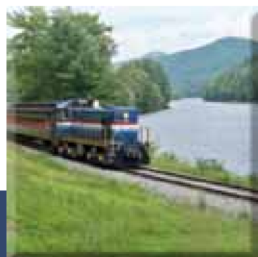
BY: DATE:
Name
Title

CHAMPLAIN HUDSON POWER EXPRESS, INC.

BY: William S. Helmer DATE: June 13, 2014
Name William S. Helmer
Title Executive Vice President and General Counsel

U.S. ARMY CORPS OF ENGINEERS

BY: DATE: 16 JUNE 2014
Name THOMAS M. CREAMER
Title CHIEF OF OPERATIONS, READINESS, AND REGULATORY FUNCTIONS DIVISION



APPENDIX U

Navigation Risk Assessment

Intertek

TRANSMISSION DEVELOPERS INC

CHAMPLAIN HUDSON POWER EXPRESS

NAVIGATION RISK ASSESSMENT

Report Reference. P1488_R3472_Rev 0

Issued 11 April 2014

Metoc Limited
Exchange House
Liphook
Hants GU30 7DW
United Kingdom

Tel: +44 (0) 1428 727800
Fax: +44 (0) 1428 727122

E-mail: info@metoc.co.uk
Web Site: www.metoc.co.uk

DOCUMENT RELEASE FORM

Title:	CHAMPLAIN HUDSON POWER EXPRESS NAVIGATION RISK ASSESSMENT
Client:	TRANSMISSION DEVELOPERS INC
Report Reference:	P1488_R3472_REV 0
Date of Issue:	11 April 2014

		Hard Copy	***Digital***
Distribution:	TRANSMISSION DEVELOPERS INC	No:	
	Intertek Energy & Water consultancy services	No:	
Prepared By:	Saijie Sim		

Project Manager:	Authoriser:
Saijie Sim	Chris Marchant

Rev No	***Date***	***Reason***	***Author***	***Checker***	***Authoriser***
Rev 0	11/04/14	Original	SS	SS	CM

COPY NUMBER: (applies to hard copies only)

Intertek Energy & Water consultancy services is the trading name of Metoc Ltd, a member of the Intertek group of companies

CONTENTS

TABLES

FIGURES

GLOSSARY

AIS	Automatic Identification System
CHPE	Champlain Hudson Power Express
EIA	Environmental Impact Assessment
GIS	Geographical Information System
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
MW	Mega Watt
O&M	Operations & Maintenance
SOW	Scope of Work
TDI	Transmission Developers Inc.
USACE	US Army Corps of Engineers
USCG	US Coast Guard

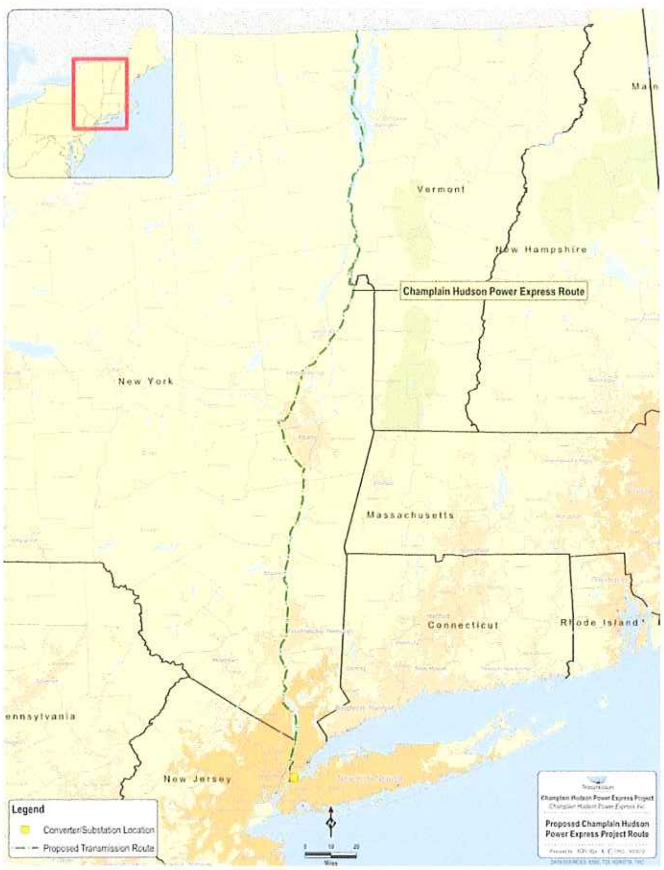
1 INTRODUCTION

1.1 PROJECT BACKGROUND

Transmission Developers Incorporated (TDI) is developing the Champlain Hudson Power Express (CHPE) Project, a high voltage direct current (HVDC) interconnector capable of transferring 1,000 Megawatts (MW) of power between Canada and the USA. The route runs from the US-Canadian border to a new converter station in Astoria, Queens, New York City. The project comprises of two cables and routeing is both terrestrial and marine. The distance totals approximately 336 miles. Approximately 60% of the route (197 miles) will involve underwater (submarine) cables across lake and river sections.

An overview of the route is shown in Figure 1-1.

Figure 1-1 Overview of CHPE route



Source: www.chpexpress.com

Intertek Energy & Water Consultancy Services have been contracted by TDI to conduct a navigation risk assessment for the marine sections of the cable route.

1.2 Scope of Work

This preliminary report focuses on the navigational risk assessment element of the works for Lake Champlain, Hudson and Harlem River sections of the route.

2 NAVIGATIONAL HAZARD ASSESSMENT

The hazard from ship's anchors is accentuated by proximity to a port or anchorage area where, for navigational reasons such as the traffic density, proximity of obstructions, shallow waters and other vessels, anchors are more likely to be readied for deployment.

It is useful to understand how anchors function and how they are used in practice and therefore explanatory notes are included in **Appendix A** of this report.

The following sections detail the findings of the navigation hazard assessment.

2.1 SHIP TRAFFIC ASSESSMENT (EXCLUDING FERRIES)

Shipping traffic intensity ranged from heavy (Hudson, Harlem & East River) to light (Lake Champlain) as identified from the site visit and the US Coast Guard Pilot book (NOAA, 2012a). This is explored further in the following sections.

2.1.1 Lake Champlain

Most of the region around Lake Champlain is sparsely populated and there is little in the way of heavy industries. Lake Champlain is about 97 miles long from Whitehall to the Canadian border and up to 10 miles wide at its widest part. It has vessel traffic between the ports along its shores and, apart from the ferries, these are mainly small vessels involved in recreational activities.

The controlling depth is approximately 12 feet at low lake level through the main channel to the Canadian border and to the principal ports. Vessel height and, ultimately vessel size, is restricted by the fixed bridge at Crown Point, approximately 32 miles north of Whitehall. This has the least overhead clearance of 75 feet (DOT, 2012).

With the exception of the SPIRIT OF ETHAN ALLEN III, the commercial vessels in Lake Champlain are relatively small in size and few in number. Most of the vessels in Lake Champlain have been observed during the site visit to be private recreational boats such as the ones shown in Figure 2-1.

Figure 2-1 Typical vessels in Lake Champlain

At 140 feet long, the SPIRIT OF ETHAN ALLEN III may have anchors of sufficient weight and size to penetrate the riverbed. However that risk is considered low due to it being a regular vessel in Lake Champlain and the vessel operator's familiarity and knowledge of the area.

All the other vessels carry anchors that are small in size and with short chains. They are unlikely to pose a threat to a buried cable system or one that is installed in sufficiently deep waters. Hence the shipping activity in Lake Champlain is considered a minimal hazard to the CHPE cable system.

2.1.2 Hudson River

The CHPE marine cable route lands just North of Dresden to avoid the PCB contamination area. The marine cable route then re-enters the water again just to the North of Cementon in the Catskill region.

A site visit was conducted to Albany Port to observe the vessels present. This provided a good indication of the vessel types to be encountered in the Upper Hudson River, where the cable system re-enters the river. Table 2-1 details the vessel types observed.

Table 2-1 Vessel types at Albany Port

Vessel type	Number
General Cargo	1
Tug	2
Tender	1
Other (work barge)	3

From the above, it can be seen that there is a higher concentration of commercial vessels in the Hudson River compared to Lake Champlain. Large commercial vessels (barges) were observed using the Hudson River during the site visit. There is an industrial area at Rondout Creek at approximately MP245 where commercial vessel traffic is expected. Barges in the region of 200 to 300 feet in length were observed, with tugs, near Tappan Zee and Yonkers. Vessels up to 600 feet in length were observed in the Lower Hudson River, as shown in Figure 2-3.

Figure 2-2 One of the larger vessels observed in the Hudson River

Vessel sizes in the Hudson River are limited by the bridges and the depths of the navigational channels (obtained from www.hudsonriverpilots.com and Sandy Hook Pilots 2014 Tide Tables).

As the CHPE cable system has been carefully routed to avoid the defined anchorages in the Hudson River, the threat to the cable system will most likely come from emergency anchoring. A probability assessment of the CHPE cable system in the Hudson River has been carried out to determine the likelihood of such an event occurring (see Section 2.4).

2.1.3 Harlem River

The Harlem River is a federally maintained shipping channel. Despite this, vessel size is restricted by the combination of shallow water depths and low bridges. Several of the bridges are swing bridges and can be opened to accommodate larger vessels. However vessels are still restricted by the fixed bridges and any vessel requiring more than 25 feet bridge clearance (NYCDOT, 2004) will not be able to fully navigate along the Harlem River.

Any boat requiring more than 5 feet of clearance will require the Spuyten Duyvil Bridge to swing open. All other movable bridges on the Harlem River provide at least 24 feet of clearance while closed, so boats and ships requiring between 5 and 24 feet of clearance need only have one bridge swing open.

The Harlem River joins the East River in Hell Gate between Wards Island and Manhattan Island, extending northward about 7 miles and connects with the Hudson River through Spuyten Duyvil Creek. The channel through Harlem River is narrow and tortuous. The velocity of the current in the Harlem River is 2 knots or more in the narrower parts of the channel.

Traffic is expected to consist of light commercial and recreational vessels due to the restrictions mentioned above. A rowing club house was observed near Spuyten Duyvil, as shown in Figure 2-3. Barges guided by tugboats also occasionally traverse along the Harlem River.

Figure 2-3 Rowing club house at Spuyten Duyvil, Harlem River

Anchors expected to be carried by such vessels are not envisaged to be particularly large or heavy. However due to the shallow water depths present, a probability assessment to determine the likelihood of an emergency anchoring has been prepared (see Section 2.4).

2.2 FERRY TRAFFIC ASSESSMENT

2.2.1 Lake Champlain

There are 11 ferry boats operated by Lake Champlain Transportation (LCT) at the time of writing and these vessels vary in length between 115 feet and 216 feet. Figure 2-4 and 2-5 show examples of these ferries operated by LCT.

Figure 2-4 LCT Ferry - Raymond C Pecor

Source: www.ferries.com

Figure 2-5 LCT Ferry - Northern Lights

Source: www.ferries.com

The Fort Ticonderoga Cable Ferry crosses the CHPE route with two underwater control cables. When the cable ferry operates, a trench is mechanically cut out of the lake bed by the action of the cables running along the bottom and scour by the prop wash from the assist hip tug's thrusters.

All the other vessel ferries in Lake Champlain are perceived as low risk to the cable system due to the ferry operators' familiarity and knowledge of the area. Hence they are not considered further in this report.

2.2.2 Hudson River

Cross Hudson traffic is mainly by various road and rail bridges along the cable route. However there are commercial ferry operations in the Hudson. One operator is NY Waterway. NY Waterway ferries mostly operate in Manhattan but have ferries operating nearby the CHPE cable route.

The ferry vessels for NY Waterway vary in length between 160 feet and 216 feet. An example of a NY Waterway ferry vessel is shown in Figure 2-6.

Figure 2-6 Example of a NY Waterway ferry vessel

Most of the ferries are also available for private charter on an ad-hoc basis with routes determined by their clients, which could result in the vessels travelling close to the CHPE cable route.

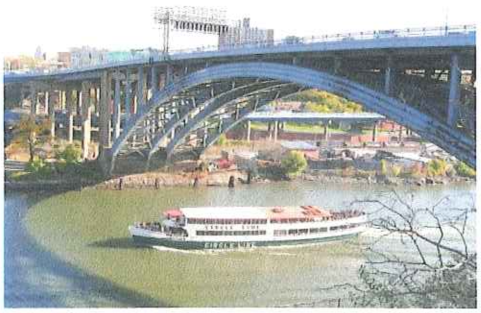
Although the perceived risk from vessel ferries are generally low given the ferry operators enhanced knowledge of the local area, a probability assessment has been carried out for the Hudson River due to the large vessels observed (see Section 2.4). The ferry traffic is captured in the AIS (Automatic Identification System) data used in the probability assessment.

2.2.3 Harlem River

The Harlem River is a narrow waterway with a high concentration of crossing bridges with relatively low clearances. The narrowness and low clearances have made the route unpopular with commercial ferries, although some private ferry services do operate along the Harlem River.

Circle Line Cruises operates sightseeing tours in the Harlem River. Most of the vessels used by them are relatively small with low air draft and require opening of a minimal number of movable bridges on the Harlem River. An example of one of their vessels along the Harlem River is shown in Figure 2-7.

Figure 2-7 Example of Circle Line vessel touring the Harlem River



Although the perceived risk from these vessels are generally low given the vessel operators enhanced knowledge of the local area, a probability assessment has been carried out for the Harlem River due to the shallow waters (see Section 2.4). The vessel traffic is captured in the AIS data used in the probability assessment.

2.3 ANCHORAGES ASSESSMENT

There are various anchorage areas along the CHPE cable route. Some are designated as general and others as special anchorages.

Although the CHPE cable route has been aligned to avoid the designated anchorages, the cable route skirts relatively close to some of the anchorages due to the constrained nature of the rivers. Hence this does not preclude the event of an anchor dragging incident occurring.

Under normal weather conditions, when first deployed, most anchors tend to drag less than 200 feet before engaging (DONG Energy, 2012). However, this is considered conservative for this project as this distance is based on the open seas, where the currents, waves and winds are much stronger. It is anticipated that should an anchor dragging event occur, it would be well below 200 feet.

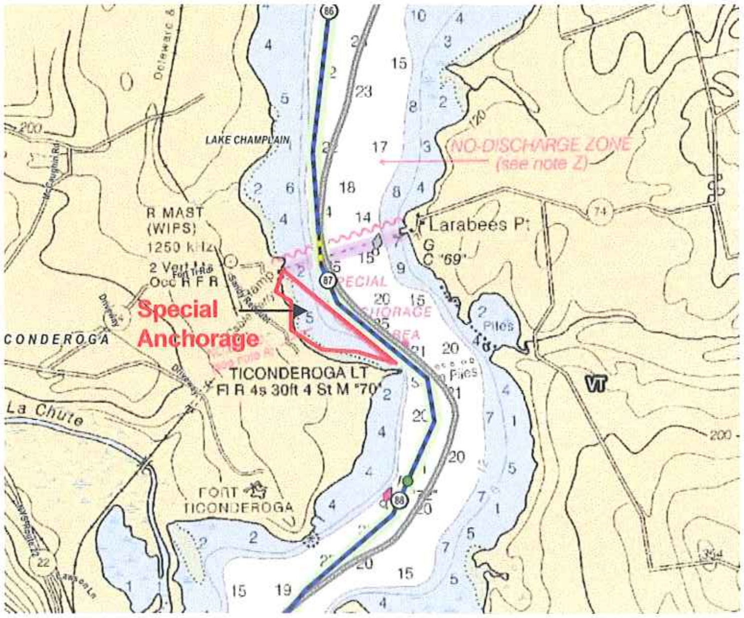
A cautious approach is used in the following sections where anchorages within 200 feet of the CHPE cable route are identified for further analysis.

2.3.1 Lake Champlain

The special anchorage near the Ticonderoga cable ferry has been identified as approximately 200 feet from the CHPE cable route (see red markup in Figure 2-8). This corresponds to approximately MP87 for the CHPE cable route.

Based on the vessel characteristics in Section 2.1.1 where commercial vessels in Lake Champlain are relatively small and few in number and most of the vessels in Lake Champlain are private recreational boats with light anchors and short chains, it is expected that anchor dragging events are rare. If they do occur, they are unlikely to occur for 200 feet. Hence this special anchorage is considered low risk to the cable system.

Figure 2-8 Special anchorage at Ticonderoga (MP87)



2.3.2 Hudson River

The following anchorages have been identified as within 200 feet of the CHPE cable route.

Figure 2-9 Special anchorage at MP253 – 254

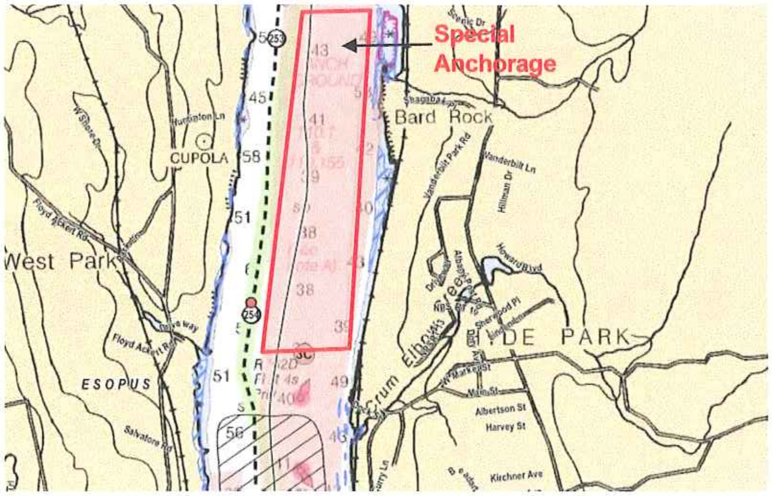


Figure 2-10 Special anchorage at MP316 – 317

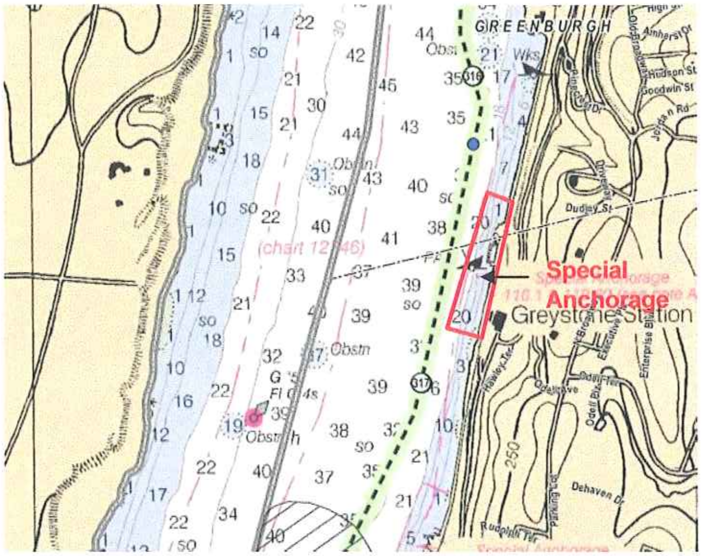


Figure 2-11 Special anchorage at MP318

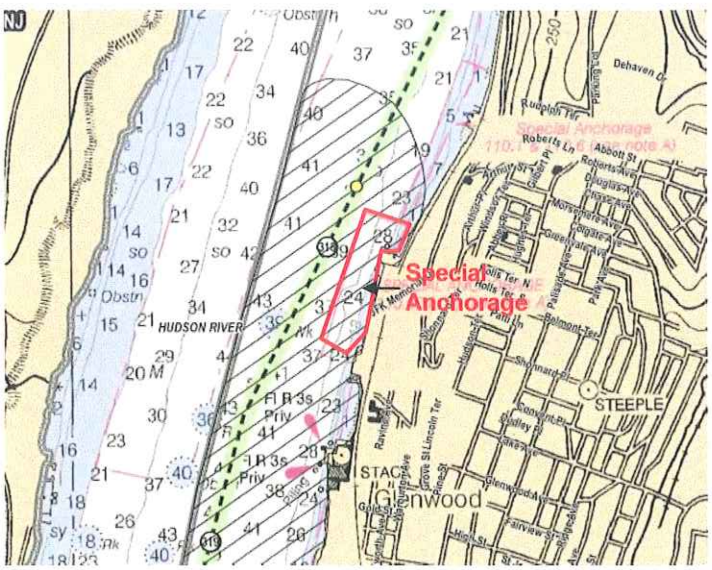
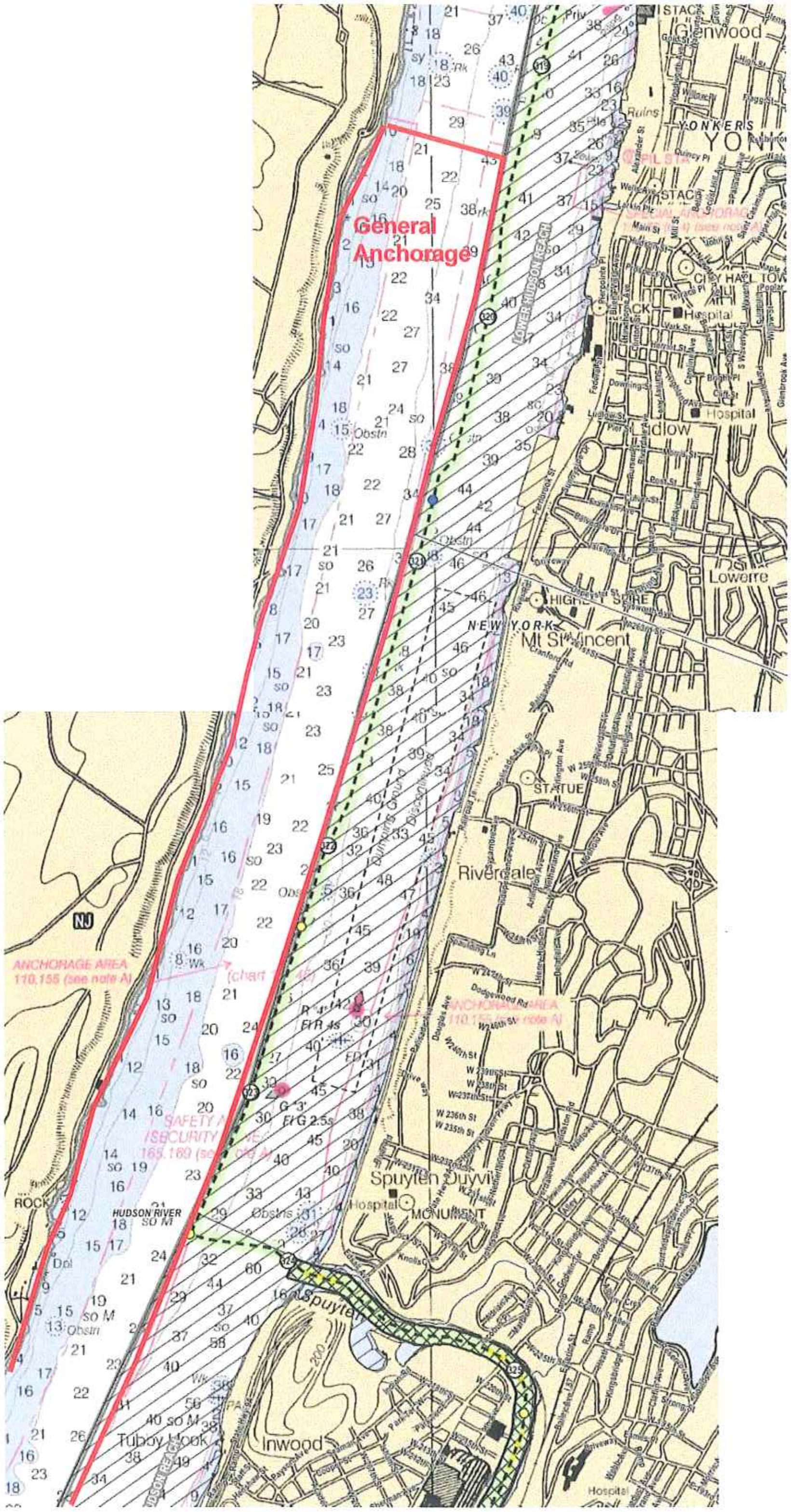


Figure 2-12 General anchorage from MP319.4 - MP323.7



These anchorages present a hazard to the CHPE cable system in terms of an anchor drag.

The anchoring risk has been taken into account in the probability assessment for the Hudson River (see Section 2.4). The vessels in these anchorages have been captured in the AIS data used in the probability assessment.

2.3.3 Harlem River

There are no anchorage areas along the CHPE cable route to the best of Intertek's knowledge.

2.4 EMERGENCY ANCHORING PROBABILITY ASSESSMENT

This section describes the methodology and results used to assess the emergency shipping risk / anchoring risk to the CHPE cable system.

The assessment of the risk to the cable is often best achieved by reference to the fault histories of cable systems in the same area. Fault histories can provide quantitative information on the likelihood of failure per line kilometre per year per hazard. Since the degree of protection afforded to cables has increased over time a fault history can usefully be related to levels of protection, i.e. burial depth. However, this information is hard to come by and is not readily available.

In the absence of cable fault data, Intertek has used a probabilistic technique, described in the Section 2.4.2, to assess the risk of failure.

All relevant factors are assessed for a cable route on a section by section basis and the probabilities generated reflect the risk levels and consequences of interaction with the anchoring hazard.

As the CHPE cable system has been routed to avoid all known anchorages, it was surmised that the anchoring risk to the cable is most likely to originate from emergency anchoring and dragging events.

2.4.1 Use of AIS Data & Vessel Groupings

AIS (Automatic Identification System) is an automatic tracking system used on ships for identifying and locating vessels by electronically exchanging data with other nearby ships and AIS base stations and satellites. It was first developed in the 1990s for collision avoidance among large vessels at sea and became mandatory for most vessels over 300 gross tonnes on international voyages in 2002.

Current US regulations (46 USC § 70114) require the following to be equipped with AIS while operating on the navigable waters of the United States:

- A self-propelled commercial vessel of at least 65 feet overall length
- A vessel carrying more than a number of passengers for hire determined by the Secretary
- A towing vessel of more than 26 feet overall in length and 600 horsepower
- Any other vessel for which the Secretary decides that an automatic identification system is necessary for the safe navigation of the vessel

Many other private vessels in the rivers such will still have AIS fitted for navigational safety reasons. This would cover almost all commercial vessels and the majority of private vessels that would be of risk to the cable.

Information provided by the AIS equipment usually consists of unique identification number for each vessel, vessel name, vessel type, vessel position, course and speed. Other attributes like vessel deadweight tonnage and draught may be filled in by the AIS supplier.

Hence by obtaining AIS data, the vessel traffic intensity along the river can be analysed to determine the concentration of vessel hours. This forms an input into the probability assessment for emergency anchoring.

Historical AIS data along the CHPE cable route for the period of July 2011 was procured from the United States Coast Guard (USCG). This was used to capture the vessel movements during the busiest time of the year so as to provide a worst case scenario in terms of vessel traffic. However due to FOIA Exemptions (b)(7)(E), information such as unique identification numbers and vessel names were removed from the AIS data by USCG to protect the statute and regulations of authorised law enforcement missions.

Furthermore, only AIS data for the Hudson, Harlem and East Rivers were provided. AIS data for Lake Champlain was not provided due to the USCG not having any receivers for Lake Champlain, with coverage described as 'spotty'. Also after reviewing the data, USCG only noted two vessel transmissions in or near Lake Champlain. This reinforces the view in Section 2.1.1 that commercial traffic in Lake Champlain is minimal.

To facilitate easier analysis of the vessel traffic and to avoid becoming inundated with the various vessel classifications, the vessels were grouped into deadweight tonnage bands of 0 – 3 500 tons, 3 500 – 15,000 tons, 15 000 – 40 000 tons, 40 000 tons plus. This allowed a set range of anchor sizes to be used to characterise those carried by shipping fleets in the aforementioned tonnage bands. This is shown below in Table 2-2.

Table 2-2 Typical vessel and anchor weights

Vessel size (deadweight tons)	0 – 3,500	3,500 – 15,000	15,000 – 40,000	40k - plus
Anchor mass (upper end of ship size range)	3,000 kg	5,000 kg	9,000 kg	25,000 kg

Following the processing of the AIS data, the results were produced visually in the form of vessel density heat maps. This allowed areas of heavy vessel traffic near / on the CHPE cable route to be identified. These areas usually denote a higher risk of emergency anchoring events occurring.

2.4.2 Probabilistic Assessment

Intertek have used a probabilistic technique to assess the probability of cable failure from the primary hazard of ship anchoring. This is possible because of the shipping activity and traffic intensities derived from the historical AIS data. The probabilities obtained are of a shipping incident involving emergency anchoring (dragging or dropping) occurring in the vicinity of the CHPE cables. The probabilities will decrease with increase in cable burial depth.

The probabilistic assessment provides perspective, indicating the relative frequency of an event over a period of time. Predictions with regard to mean time before failure are not made and the chance of an incident occurring is the same at any point in the calculated period, i.e. a 1 in 500 year incident could equally occur in year 1 as in year 500.

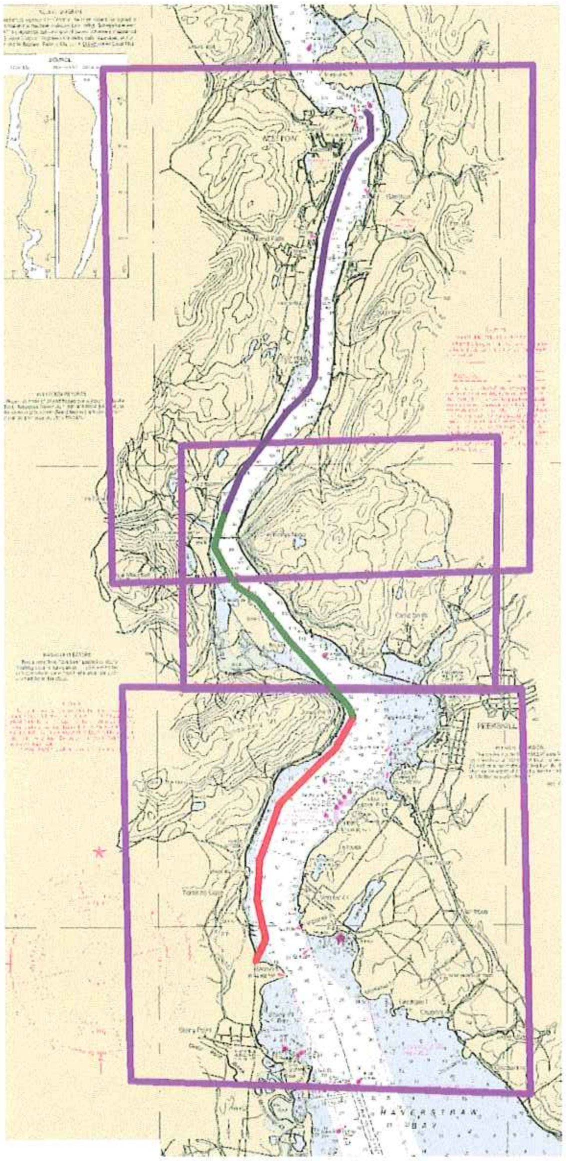
18 sections of the CHPE cable route were assessed based upon the topography of the Hudson, Harlem and East Rivers. Lake Champlain was not assessed due to the lack of AIS data from the USCG and minimal commercial traffic. The 18 sections are listed by their MPs below:

1) East River Section 1 (MP332.5– 331.5)
2) Harlem River Section 2 (MP330.3 – 329.8)
3) Harlem River Section 3 (MP329.8 – 325.0)
4) Harlem River Section 4 (MP325.0 – 324.0)
5) Hudson River Section 5 (MP324.0 – 310.0)
6) Hudson River Section 6 (MP310.0 – 302.9)
7) Hudson River Section 7 (MP295.3 – 292.3)
8) Hudson River Section 8 (MP292.3 – 289.0)
9) Hudson River Section 9 (MP289.0 – 283.5)
10) Hudson River Section 10 (MP283.5 – 280.0)
11) Hudson River Section 11 (MP280.0 – 274.0)
12) Hudson River Section 12 (MP274.0 – 269.0)
13) Hudson River Section 13 (MP269.0 – 260.0)
14) Hudson River Section 14 (MP260.0 – 256.5)
15) Hudson River Section 15 (MP256.5 – 248.5)
16) Hudson River Section 16 (MP248.5 – 245.5)
17) Hudson River Section 17 (MP245.5 – 234.0)
18) Hudson River Section 18 (MP234.0 – 228.5)

These sections enable parts of the cable to be assessed separately according to the vessel traffic intensity in the vicinity of that section. Vessel traffic for each section is unlikely to affect cable parts in other sections during an emergency event due to the shape and topography of the river.

For example, Figure 2-13 shows Hudson River Sections 9, 8 and 7 together with their associated zones of interest. Vessels in the zone of interest for Hudson River Section 9 are unlikely to affect Hudson River Sections 8 and 7 during an emergency event as they are unlikely to be able to navigate around the river bends. The same logic applies for the other river sections.

Figure 2-13 Hudson River Sections 9, 8 and 7 and associated zones of interest



The probabilities are calculated for a range of vessel and anchor sizes. The anchor size for the upper end of the vessel tonnage band is used, as indicated in Table 2-2. The probability of failure of the cable as a consequence of an event caused by emergency anchoring is calculated using the following equation:

$$P_{anchor\ event} = K \times P_{loss} \times P_{recovery} \times P_{human} \times P_{fa}$$

Where:

$P_{anchor\ event}$ = probability of anchor event on the cable (-/year)

K = total number of ship hours in sample box (hr/year)

P_{loss} = probability of engine failure (-/engine hour)

$P_{recovery}$ = probability of failing to recover from a situation within a certain period (-)

P_{human} = probability of anchor operation (-)

P_{fa} = protection factor (-)

- Total number of ship hours in sample box: K

This can be obtained by splitting each zone of interest up into several smaller sample boxes and then interrogating the historical AIS data in each sample box. An example of this is shown in Figure 2-14 below.

The AIS data had readings every 5 mins. Hence by the summation of each reading in the sample box, the total number of ship hours could be determined.

Figure 2-14 Example of zone of interest being divided into sample boxes

The size of the sample box is determined by the anchor dragging distance. In Intertek's experience, under normal weather conditions, when first deployed, most anchors tend to drag less than 200 feet before engaging (DONG Energy, 2012). Hence the size of a sample box is 200 feet.

A vessel does not immediately drop an anchor when it encounters engine problems. It drifts for a period while trying to recover from the engine problem. If unrecoverable, it slows down to approximately 1 knot before dropping an anchor. Anchoring at speeds above 1 knot will most likely lead to vessel structural damage. The period spent drifting will form the zone of interest. This also implies that the CHPE cables will not just be affected by vessels that are directly above it. Vessels in its vicinity must be considered due to the events just described. For a constrained navigational channel like the Hudson River area, the zone of interest will encompass the entire width of the channel. The length of the zone of interest will depend on the areas of the CHPE cables that are being assessed. Each section of the route will have its own zone of interest.

Each zone of interest is split into several sample boxes. Keeping in line with the conservative approach, the sample box which captures the highest density of vessels hours within the zone of interest will be applied to the formula.

As the AIS data procured from the USCG only covered one month in summer (July 2011), the vessel hours were multiplied by 6 to simulate half a year of summer months, which was then added to the same set of vessel hours multiplied by 6 and a factor of 0.8 to simulate half a year of winter months. This provided the results for one annual period.

The factor of 0.8 was to take into account the reduced traffic in the winter months. This was derived from the 2010 freight traffic information obtained from the USACE for the Hudson River (Spuyten Duyvil to Waterford). The volume of freight traffic in terms of tonnage along the river in the winter months were compared with freight traffic in the summer months. On average, the winter months had 20% less freight traffic than the summer months.

This corresponded with Intertek's findings from communications with the Port of Albany Harbour Authority, Hudson River Pilots Association and also with John Vargo, Editor of the magazine "Boating on the Hudson". The commercial traffic on the Hudson River does not vary much season to season. In the summer months, traffic consist of cargo vessels, recreational vessels, fuel transport vessels, ferries and vessels involved in the tourist trade. In the winter months, the ferries and vessels involved in the tourist trade decrease by a considerable amount due to the poor weather and drop in tourist numbers. Cargo vessels also decrease by a certain amount. However, there is a large increase in fuel transport vessel numbers to service the various power plants along the Hudson River due to the increased demand for heating.

Hence this "rebalancing" of the vessel traffic during the winter months by the increase in fuel transport vessels has led to a minimal change in vessel traffic numbers.

Icing up of the Hudson River in the winter has minimal impact on the vessel traffic as the USCG makes daily transits of the river with their icebreakers.

- Probability of engine failure: P_{loss}

This is taken from a report compiled by DNV (Det Norske Veritas) for the Marine & Coastguard Agency (DNV, 2005) for tidal rivers and estuaries around the UK. The value used in the calculations is 0.00015. Due to the lack of suitable data for rivers in the US, this has been applied to the cable route.

- Probability of failing to recover from a situation within a certain period: $P_{recovery}$

Data gathered from various trials in the UK suggest that the probability of failing to take recovery measures in 2 hours is 0.1 for bad weather conditions (Pillay and Vollen, 2004). For analysis purposes, this is applied to the cable route.

- Probability of anchor operation: P_{human}

The anchor will not be dropped in every emergency situation. This depends on the local area, geography and the vessel master's knowledge. The value used in the calculations is 0.3 from DNV (Christensen, 2006).

- Protection factor: P_{fa}

This takes into account the protection offered by soil cover on top of the CHPE cables as well as anchor penetration in soils. The worst case scenario of an unburied cable is 1.

Research previously carried out by Intertek on anchor penetration depths by two of the most common anchor types when fully engaged in different soils have shown that penetration of standard commercial anchors, e.g. Hall or USN stockless anchors into sands will be equivalent to the fluke length multiplied by the sine of the fixed fluke opening angle. In mud, anchor penetration under the same engagement loading could be three times or more than in sand (NCEL, 1983).

For the purpose of this assessment, based on core samples obtained in the previous surveys, very soft high plasticity clay / silt was sampled along the majority of the route.

The range of probabilities of an event from emergency anchoring is shown in Table 2-3 for 7 feet burial in the Hudson River and 8 feet burial in the Harlem River, both in soft sediments.

Table 2-3 Probability of emergency anchor event for CHPE cable sections

Summary event probabilities for emergency anchoring				
Vessel size range (Te DWT)	0 - 3.5k	3.5k-15k	15k - 40k	40k plus
Anchor mass	3,000 kg	5,000 kg	9,000 kg	25,000 kg
Cable Route Section				
P: East River Section 1 (MP332.5 - 331.5)	HDD	HDD	HDD	HDD
Average 1 event per X years, per section	HDD	HDD	HDD	HDD
P: Harlem River Section 2 (MP330.3 - 329.8)	4.21E-05	NA	NA	NA
Average 1 event per X years, per section	23742	NA	NA	NA
P: Harlem River Section 3 (MP329.8 – 325.0)	3.50E-04	NA	NA	NA
Average 1 event per X years, per section	2858	NA	NA	NA
P: Harlem River Section 4 (MP325.0 – 324.0)	6.64E-05	NA	NA	NA
Average 1 event per X years, per section	15056	NA	NA	NA
P: Hudson River Section 5 (MP324.0 – 310.0)	1.65E-03	8.18E-04	3.76E-03	5.67E-07
Average 1 event per X years, per section	608	1222	266	1763668
P: Hudson River Section 6 (MP310.0 – 302.9)	5.52E-04	1.82E-05	2.92E-05	NA
Average 1 event per X years, per section	1810	54870	34294	NA
P: Hudson River Section 7 (MP295.3 – 292.3)	6.33E-03	1.01E-05	1.46E-05	5.67E-07
Average 1 event per X years, per section	158	98765	68587	1763668
P: Hudson River Section 8 (MP292.3 – 289.0)	2.27E-05	8.10E-06	7.29E-06	NA
Average 1 event per X years, per section	44092	123457	137174	NA
P: Hudson River Section 9 (MP289.0 – 283.5)	1.20E-04	6.08E-06	7.29E-06	NA
Average 1 event per X years, per section	8342	164609	137174	NA
P: Hudson River Section 10 (MP283.5 – 280.0)	1.78E-05	6.08E-06	4.86E-06	NA
Average 1 event per X years, per section	56117	164609	205761	NA
P: Hudson River Section 11 (MP280.0 – 274.0)	8.63E-04	2.23E-05	8.75E-05	NA
Average 1 event per X years, per section	1158	44893	11431	NA
P: Hudson River Section 12 (MP274.0 – 269.0)	2.75E-05	1.01E-05	9.72E-06	NA
Average 1 event per X years, per section	36311	98765	102881	NA
P: Hudson River Section 13 (MP269.0 – 260.0)	3.89E-05	8.10E-06	1.46E-05	NA
Average 1 event per X years, per section	25720	123457	68587	NA
P: Hudson River Section 14 (MP260.0 – 256.5)	2.59E-05	1.01E-05	1.22E-05	NA
Average 1 event per X years, per section	38580	98765	82305	NA
P: Hudson River Section 15 (MP256.5 – 248.5)	1.00E-04	8.30E-05	5.10E-05	NA
Average 1 event per X years, per section	9956	12045	19596	NA
P: Hudson River Section 16 (MP248.5 – 245.5)	5.99E-05	1.01E-05	6.08E-04	NA
Average 1 event per X years, per section	16683	98765	1646	NA
P: Hudson River Section 17 (MP245.5 – 234.0)	2.71E-04	6.48E-05	6.08E-04	NA
Average 1 event per X years, per section	3696	15432	1646	NA
P: Hudson River Section 18 (MP234.0 – 228.5)	4.11E-04	3.04E-05	6.08E-04	NA
Average 1 event per X years, per section	2430	32922	1646	NA

The probability figures shown in Table 2-3 are presented in terms of emergency anchor event in a number of years (e.g.1 event in 100 years). N/A appears where vessels of certain tonnage bands are not present along the relevant sections of the route.

3 REMEDIAL PROTECTION METHODS

The principal method of protection for most modern cable systems is burial into the seabed. Burial means that hazardous activities need to penetrate the seabed in order to damage the cable. However, there are instances such as utility crossings or extremely hard soil conditions where burial will not be achievable or is reduced.

In such instances, there are three primary means of remedial protection, as detailed in the following sections. In addition to the remedial protection, periodic surveys should be carried out to check that the cable and remedial protection remain secure.

3.1 CONCRETE MATTRESSES

Concrete mattresses are flexible mats that are made up of numerous concrete blocks bound together with high strength polypropylene rope or steel wire. The flexible nature of concrete mattresses allows them to be laid over a cable and provide stabilisation as well as a physical barrier against dropped objects and dragged anchors.

Figure 3-1 Examples of standard concrete mattresses

Source: www.sps.gb.com

Concrete mattresses are typically deployed in shallow waters, individually or in multiples on a frame and can be guided into position and released by a diver.

Beyond diving limits, they are usually deployed in multiples by a crane on a frame with a remote activated release mechanism and the positioning is monitored by an ROV.

Mattresses are deployed at cable and pipeline crossings, where burial has to be interrupted, to provide stability, separation and protection

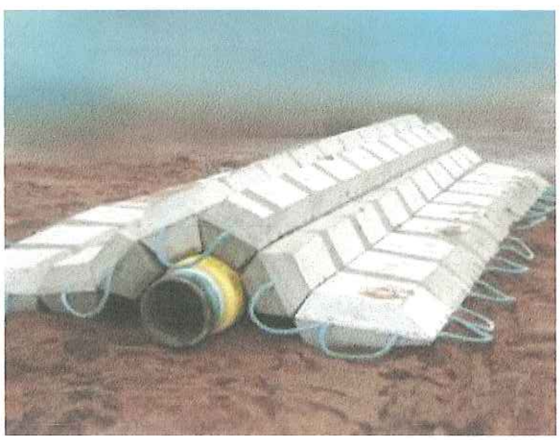
In addition to cable protection, mattresses are routinely used in the oil and gas industry to protect pipelines and umbilicals.

Figure 3-2 Multi mattress deployment

However, standard concrete mattresses are not permanent fixtures and they may be hooked and dragged out of position by trawl / anchor gear, exposing the cable. They act as 'sacrificial' protection in this case. The edges of the standard concrete mattresses may also induce localised scouring of the seafloor in strong current conditions.

Several variations of the concrete mattress exist to deal with specific conditions. For example, tapered edge concrete mattresses have been introduced to improve stability by reducing scouring and also improve over-trawlability, as shown in Figure 3-3.

Figure 3-3 Tapered edge concrete mattress



Source: www.sps.gb.com

Another variation is a concrete shell, shown in Figure 3-4. This design shape allows the concrete shell to be used in trawled areas, as the trawled gear will ride over the shell due to its shape. The shape also reduces scouring of the seafloor around the edges. The curved shape also helps dissipate forces from a dropped / dragged anchor better that the standard mattress.

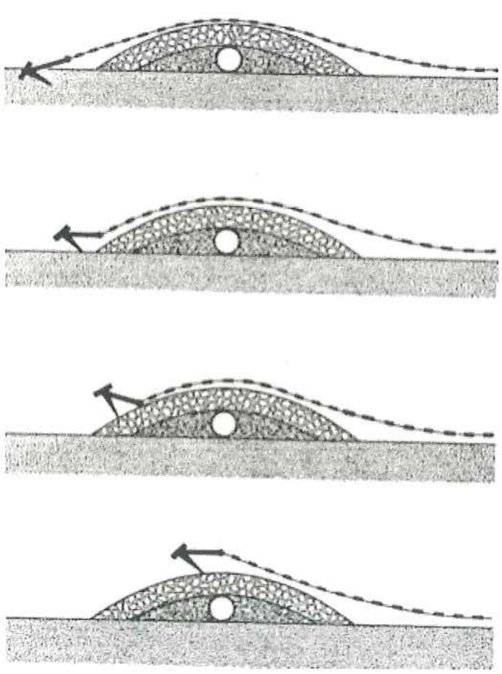
Figure 3-4 Concrete shell

Source: www.armato.se

3.2 ROCK PLACEMENT

Rock placement is another method of cable protection against dropped and dragged anchors, trawling and scouring. The protective cover on top of the cable enables the anchors or fishing gear to slide on top of it without damaging the cable lying beneath. In the worst case scenario it will cut into the rock berm, but the cable will still remain protected. Various model and prototype tests described in the Rock Manual (CIRIA, 2007) confirm that a rock berm initiates an outbalancing force on an anchor and anchor chain, causing a breakout of the anchor to leave the seabed and travel across the rock berm. This is illustrated below in Figure 3-5.

Figure 3-5 Action of anchor on a rock berm

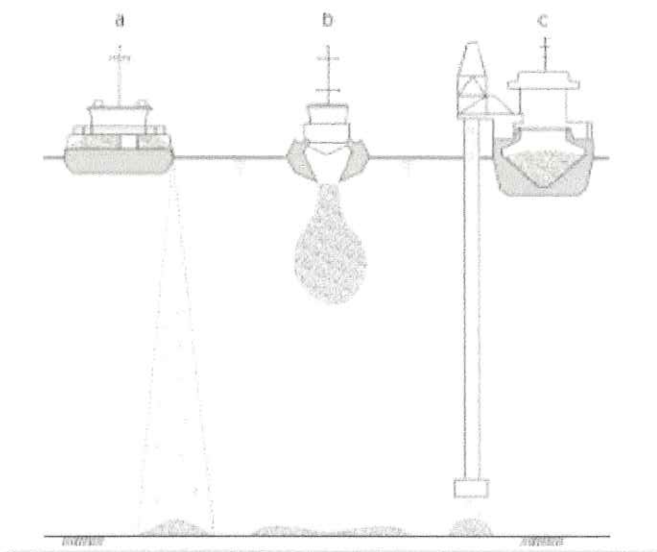


Source: Kuik, 1986

The rock berm also stabilises the cable by preventing any free spanning and protecting the cable from current displacement and scouring.

There are three different rock placement methods which are carried out by different types of vessels. These vessels are shown in Figure 3-6.

Figure 3-6 Different rock placement methods



Source: Kuik, 1986

The type of vessel used will mostly depend on water depth and also the strength of the current. For water depths of 50 m and more, fall pipe vessels (c in Figure 3-6) are recommended due to their ability to place rock with greater precision at those depths.

A variation to rock placement is the use of rock filter bags, as shown in Figure 3-7. The principle is similar to rock placement but instead of dumping rock onto the cable, the rocks are placed into a filter bag and loaded onto a transport vessel. The vessel then places the bag onto the cable to protect and stabilise it. This offers a more targeted placement of rock and reduces the amount of rock required. Some permitting authorities also see rock filter bags as less environmentally intrusive compared to rock placement.

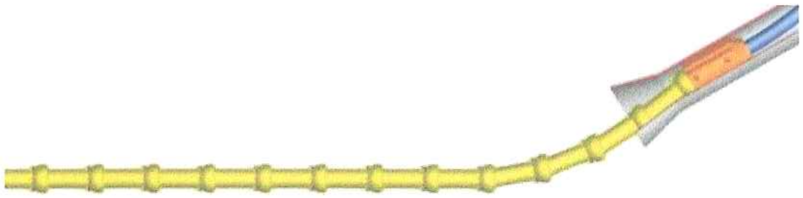
Figure 3-7 Rock filter bags

Source: www.sps.gb.com

3.3 ARTICULATED SHELLS

These are articulated casings which clamp over the cable to provide a protective barrier. They protect the cable from abrasion and dropped objects as well as over bending. They can be manufactured from ductile iron or from polyurethane and are attached to the cable before laying on the seabed. Figures 3-8 and 3-9 show some examples of articulated ducting.

Figure 3-8 Articulated ductile iron shells



Source: www.blueoceanprojects.com

Figure 3-9 Articulated polyurethane shells

Source: www.trelleborg.com

Application of articulated ducting is an industry standard cable protection measure in shallow waters where burial is not possible due to physical or environmental constraints.

4 IMPLICATIONS TO VESSELS

The CHPE cables will be buried for the large majority of the route. However there will be some areas where burial will not be applicable (e.g. crossings with existing cables / pipelines, etc). These areas are localised and will be protected by concrete mattresses, with the exception of the Lake Champlain area where the cables will be surface laid in water depths of 150 feet and greater.

Vessels that drop their anchors either through normal operations or emergency events may have the potential to snag the cables or the protective concrete mattresses in the areas listed above. It may also still be possible to snag a cable that has already been buried should the anchor penetration be greater than the burial depth. This scenario will have the same outcome as that of snagging a surface laid cable.

Commercial fishing vessels also have the potential to snag the cables with their fishing gear (e.g. trawl boards, etc). However only recreational fishing vessels operate in Lake Champlain (no interaction with the river bed) and there is little in the way of commercial fishing in the Hudson River due to high levels of PCB (polychlorinated biphenyl) pollutants in the river. No commercial fishing takes place in the Harlem River. Hence implications to fishing vessels are not considered in this assessment.

The following scenarios cover the safety implications to vessels should an anchor snag occur.

4.1 ANCHOR INTERACTION WITH CONCRETE MATTRESSES

Concrete mattress placed over a cable acts as a protective cover to deflect impact forces and also to stabilise the cable. Most anchors falling onto a concrete mattress will be stopped from penetrating into the river bed and its kinetic energy dissipated / absorbed by the mattress.

For a dragging anchor, it is possible for the anchor to snag onto the edge of the concrete mattress, dragging the mattress away from its location and exposing the cable underneath. As the mattress adds mass to the anchor, the vessel will experience a decrease in dragged movement and may even come to a stop. The protective cover over the cable will need to be replaced to ensure the cable continues to be protected.

In both cases, there are minimal safety implications to the vessel.

4.2 ANCHOR INTERACTION WITH SURFACE LAID AABLE

For a surface laid cable, the chances of an anchor directly hitting the cable is extremely low.

The accident of hitting or cutting a cable does not represent a navigational hazard. Should the cable be cut / exposed, the resulting electrical short can lead to an equipment overload and the tripping of the switchgears, leading to a shutdown of the converter or transformer stations on land. The protection system would de-energize the circuit in a very short time (less than 0.001 second). The vessel involved will suffer no electrical shock due to the high electrical conductivity of water, resulting in a complete earthing of the damaged cable (Sharples, 2011).

The chances of a dragging anchor snagging a cable are significantly higher than a dropped anchor. Should this happen, it is advised by various marine agencies (e.g. International Cable Protection Committee, Maritime and Coastguard Agency in the UK, etc) that for any vessel fouling a cable, the anchor and gear should be slipped and abandoned without attempting to get it clear.

Figure 4-1 Vessel's anchor fouled a power cable

Source: www.maib.gov.uk

Unfortunately there have been instances where this advice was not heeded either due to lack of education or lack of awareness that the anchor has snagged a cable. In the majority of these cases, interaction of ship anchors with cables have led to damaged cables but minimal effects to the ship, for example, a damaged / lost anchor or damaged anchor handling equipment (e.g. windlass motor, brake, etc) (MAIB, 2007) (ICPC, 2009).

There have been no reported incidents where personnel have been injured or a vessel has capsized due to an anchor snagging a cable. However there have been cases where fishing vessels have capsized while attempting to retrieve their fishing gear entangled with cables (MAIB, 1991). As commercial fishing has been discounted for the project area, such instances will not occur.

4.3 OTHER MITIGATION MEASURES

The risks can be further reduced by carrying out an information campaign to inform people of the presence of the cable. This may involve the following:

- Beach / shore warning signposts should be erected where applicable
- Information on the cable position must be given to the issuers of sea charts, e.g. national marine agencies, fishing authorities, etc. It is important to ensure that the submarine power cable is recorded on any chart and registry.

- Existing pipeline and cable operators, harbour authorities, meteorological and hydrographical agencies, military authorities should also be informed of the cable route.
- Carry out dialogue with relevant local stakeholders (e.g. pilots association, marine union workers and their organisations, recreational fishing and yachting clubs, etc). It is important to educate these people on the dangers of trying to recover entangled gear or anchor from a cable by force and the cable owners would prefer to compensate for the lost gear rather than to repair a damaged cable. It can be valuable to provide local stakeholders with free and easy to understand charts showing the position of the cable.
- Regular marine surveys along the cable route should also be carried out to ensure the cable protection is still in place to prevent an anchor snagging event.

5 REFERENCES

1) Christensen, C.F. (2006), Cable Risk Assessment, DNV presentation, 22 March 2006. Available online: http://www.industrie-energieeffizienz.de/page/fileadmin/offshore/documents/StAOWind_Workshops/Seekabe_in_BwStr/Seekabel_in_BWStr_Vortrag_christensen.pdf

2) CIRIA (2007), The Rock Manual – The Use of Rock in Hydraulic Engineering 2nd Edition, CIRIA 683, London, UK. Available online: http://www.ciria.org/service/AM/ContentManagerNet/Default.aspx?template=/TaggedPage/TaggedPageDisplay.cfm&TPLID=66&ContentID=16011&TPPID=5891&AspNetFlag=1&Section=knowledgebase&ThisPage=2

3) DONG Energy (2012), Walney Offshore Wind Farm 2 Offshore Export Cable Post Burial Risk Assessment and Remedial Works, DONG Energy, Ref: 1161828 Rev B

4) DOT (2012), Lake Champlain Bridge Project, Department of Transport. Available online: https://www.dot.ny.gov/lakechamplainbridge/construction

5) DNV (2005), Cost Benefit Analysis of Coastal Waters – Risk Model, Maritime and Coastguard Agency, UK.

6) DNV (2010), Recommended Practice DNV-RP-F107: Risk Assessment of Pipeline Protection, Det Norske Veritas, Norway.

7) ICPC (2009), Loss Prevention Bulletin Damage to Submarine Cables Caused by Anchors, International Cable Protection Committee, UK. Available online: http://www.iscpc.org/publications/Loss_Prevention_Bulletin_Anchor_Damage.pdf

8) Kuik, L.J. (1986), Design and construction of stabilization and protection of subsea pipelines and cables up to 1000m depths, Offshore Technology Conference, 5-8 May 1986, Houston, Texas. Available online: http://www.onepetro.org/mslib/servlet/onepetropreview?id=OTC-5219-MS&soc=OTC

9) MAIB (1991), Report of the Investigation into the Sinking of Fishing Vessel Gray Flamingo with the Loss of Life of Two Crew Members, Marine Accident Investigation Branch, London, UK. Available online: http://www.maib.gov.uk/cms_resources.cfm?file=/grey_%20flamingo_pub_1991.pdf

10) MAIB (2007), Merchant Vessel Nordsee Snagging Power Cable, Marine Accident Investigation Branch, London, UK. Available online: http://www.maib.gov.uk/publications/completed_preliminary_examinations/completed_preliminary_examinations_2007/nordsee.cfm

11) NCEL (1983), Multiple Stockless Anchors for Navy Fleet Moorings, Naval Civil Engineering Laboratory, Techdata Sheet 83-05.

12) NOAA (2012a), United States Coast Pilot 2 Atlantic Coast: Cape Cod, MA to Sandy Hook, NJ, NOAA. Available online: http://www.nauticalcharts.noaa.gov/nsd/coastpilot/files/cp2/CPB2_E41_20111031_1537_WEB.pdf

13) NOAA (2012b), United States Coast Pilot 6 Great Lakes: Lakes Ontario, Erie, Huron, Michigan and Superior and St. Lawrence River, NOAA, Available online: http://www.nauticalcharts.noaa.gov/nsd/coastpilot/files/cp6/CPB6_E42_20120215_1816_WEB.pdf

14) NYCDOT (2004), Reconstruction of the Third Avenue Bridge over the Harlem River in New York City, Heavy Movable Structures Tenth Biennial Symposium, 24 – 28 Oct 2004, Orlando, USA. Available online: http://www.heavymovablestructures.org/assets/technical_papers/Ten14.pdf

15) Pillay, A. and Vollen, F. (2004), "Impact Risk to Pipelines from Shipping Traffic", in: SEM X International Congress & Exposition on Experimental & Applied Mechanics, 7-10 June 2004, Costa Mesa, California. Available online: http://www.sem.org/Proceedings/ConferencePapers-Paper.cfm?ConfPapersPaperID=24657

16) Sandy Hook Pilots Association (2014), 2014 Tide Tables. Available online: http://www.sandyhookpilots.com/files/Informational_Pages_14.pdf

17) Sharples, M. (2011), Offshore Electrical Cable Burial for Wind Farms: State of the Art, Standards and Guidance & Acceptable Burial Depths, Separation Distances and Sand Wave Effect, Bureau of Ocean Energy Management, Regulation & Enforcement, Department of the Interior, USA. Available online: http://www.bsee.gov/uploadedFiles/BSEE/Research_and_Training/Technology_Assessment_and_Research/671AA-Final%20Report%20Offshore%20Electrical%20Cable%20Burial%20for%20Wind%20Farms.pdf

18) Worzyk, T. (2009), Submarine Power Cables – Design, Installation, Repair, Environmental Aspects, Springer – Verlag Berlin Heidelberg, Germany.

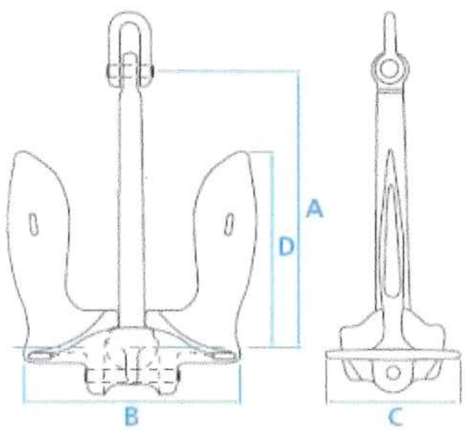
Appendix A Anchor Function & Practice

A.1 Anchor Function & Practice

The bow anchors carried by normal commercial shipping are specified for temporary mooring of a vessel within a harbour or sheltered area when it is awaiting a berth, the tide, etc. The anchors are not designed or specified to hold a ship off a fully exposed coast in rough weather or stop a ship that is moving or drifting. [1] They are specifically designed not to penetrate deeply into stiff soils, which would make them difficult to recover.

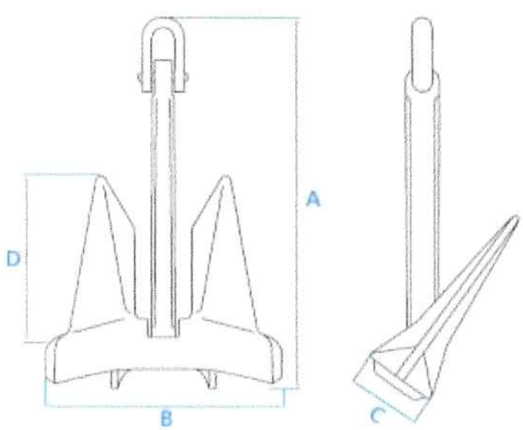
The most common type of anchor on commercial vessels is the stockless anchor, such as the Admiralty pattern or the US Navy pattern which is shown in Figure A1.

Figure A 1 Typical stockless anchor – US Navy pattern



More sophisticated designs, called High Holding Power (HHP) anchors, are increasingly being carried by modern vessels, as shown in Figure A2.

Figure A 2 Typical High Holder Power anchor - AC14 pattern



Both types of anchor contribute to the mooring of a vessel by virtue of their mass and by engaging the seabed. The USN pattern relies more on mass and

[1] International Association of Classification Societies website – Mooring, Anchoring and Towing Requirements 2005

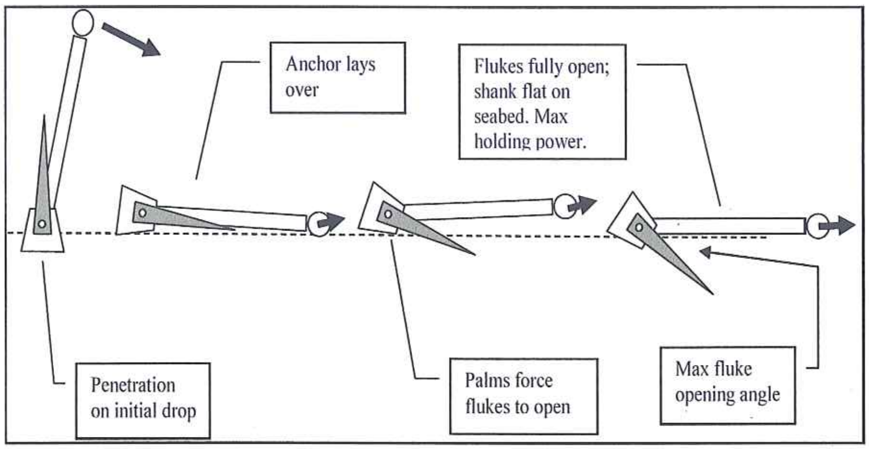
the HHP type penetrates and engages the seabed more efficiently. For the same size vessel an HHP anchor will only be 75% of the mass of the equivalent USN anchor.

The anchor size carried by different vessels is difficult to assess from any single vessel size parameter. Anchors are specified using a combination of vessel's mass, draught, air draft (surface are above the water line), etc, which contribute to the Equipment Number (EN) for the vessel. Calculation of the EN for a range of vessels is impractical within the context of this report.

The operation of an anchor on the seabed during a 'normal' anchoring operation is shown in Figure A3. Although an anchor is said to be 'dropped' anchoring is normally a controlled operation and in fact the anchor may often be lowered slowly to the sea bed using the windlass.

Dropping an anchor risks the anchor crown penetrating too deeply or the chain piling up on the seabed resulting in poor holding power and difficulties in recovery.

Figure A 3 Normal anchor operation



During anchor deployment the vessel will be stopped or stemming the prevailing conditions, falling back on the tide or with the wind as the anchor chain scope (amount of chain paid out) is laid out onto the seabed. The scope will be a fixed amount determined by the depth of water and the prevailing conditions. The vessel will normally be brought up by the weight of the catenary before the full scope is paid out. Usually only one bower (bow) anchor is deployed except in anticipation of very severe weather conditions.

In an emergency situation all necessary means will be used to prevent the vessel grounding or colliding with another object or vessel and this will include deploying one or both anchors. Deploying an anchor whilst a vessel is moving at anything more than a knot (0.5 m/sec) would likely result in failure of the anchor, chain or windlass. To mitigate damage it is generally recommended that an anchor be lowered slowly onto the sea bed, gradually providing drag without putting the equipment (or its operator) at risk. In this situation the anchor and chain could be dragging across the seabed for some distance. If sea room is limited, for example close to a lee shore or channel side, then this degree of finesse may not be possible and the anchor will be allowed to free-fall.

In a dragging situation the normal response is to payout more cable, thereby increasing the mass of the mooring equipment.

Anchors on normal commercial vessels are not designed to engage the seabed deeply. In normal circumstances the anchor flukes will probably not penetrate to their full depth before the mass of chain brings the vessel up. However, in the risk assessment the conservative assumption is made that the anchor flukes will always penetrate to the fullest extent possible in all circumstances.

The maximum penetration depth of an anchor, in 'normal' soils, where the shank and chain do not penetrate below the surface, can be determined by multiplying the fluke length by the sine of the maximum opening angle. Normal soils can be classified as medium to firm sands. Most ships have anchors set up to engage in normal soils for which the maximum opening angles are 45° and 36° for USN and HHP anchors respectively. If softer soils were being encountered regularly the fluke angles would be set to a greater angle to force the anchor to travel deeper.

Anchors are generally of welded or cast construction and, for a particular patented design, have fixed dimensions relative to the mass. The fluke length can be obtained if the mass is known.

A.2 Anchor Penetrations

The depth an anchor will penetrate to will vary.

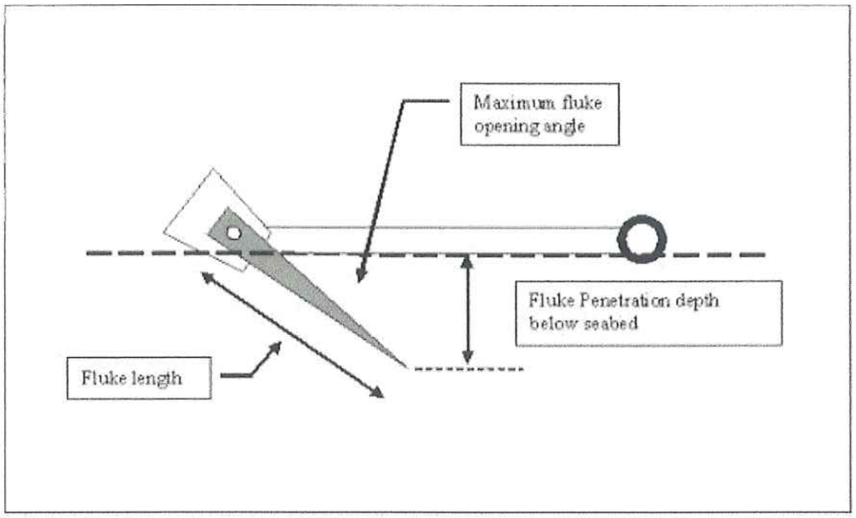
Many permutations are possible and a 'model' anchor size is used to determine a typical embedment depth. The model anchor is normally selected to represent the range of vessel sizes affecting the study area. The selection is subjective to the extent that traffic patterns are only predictable up to a point; vessels outside the normal range may visit randomly and changes in trade can rapidly alter the prevalence of one type of vessel or another.

The "Hall" pattern anchor is used here as a model as this is typical of standard Admiralty or US Navy standard stockless anchors in common use, especially on older vessels. This type of anchor has a relatively long fluke length for its unit mass and a large opening angle, which equates more penetration for a given fluke length.

In determining penetration depth it is assumed that the anchor will always penetrate to its design depth in typical "good holding ground", but no further as per Figure A4. Designated anchorages are normally selected on the basis that they provide 'good holding ground', which generally means a sand bottom.

The maximum anchor penetration depth can be calculated for an anchor using the standard opening angle of the anchor, which for a Hall design anchor is 45°.

Figure A 4 Maximum anchor penetration depth



The penetration depths for two sizes of Hall anchor are shown in Table A1. The penetration of a smaller AC14 High Holding Power (HHP) anchor, which has long flukes but a smaller opening angle is shown for comparison. HHP anchors are more efficient at engaging the seabed and therefore under ship classification rules a smaller HHP anchor can be used in place of a larger standard stockless anchor.

Table A 1 Typical anchor penetration depths in sand

Anchor type	Anchor mass (tons)	Fluke length (mm)	Opening angle (°)	Max penetration (m)
Halls	1.590	900	45	0.636
AC14	1.0	1014	35	0.582
Halls	6.0	1525	45	1.078

The penetrations are based on a 'normal' anchoring operation where the anchor is laid over and gradually pulled into the soil. In emergency deployments (involving a moving vessel) and in dragging situations the anchor is failing to engage the seabed efficiently and will inherently not penetrate to the depths normally achieved.

The penetration of the anchors upon initial deployment is not calculated as there is insufficient data available. However, communications with vessel operators suggest that penetration of an anchor freefalling in water though 10 m (during which distance it will reach terminal velocity) will not exceed the depth of the anchor fluke tip at full penetration in the same substrate i.e. sand.

Anchor drag may appear to be the greatest risk to a cable but it should be noted that an anchor that is dragging, in good holding ground at least, is inherently failing to engage the seabed. Penetration into the seabed is therefore likely to be less than the maximum possible for the particular anchor. The risk increases as the drag speed diminishes and an anchor begins to engage 'normally'; dragging may therefore only be a risk to cable that is not buried or poorly buried.