Appendix F-3
McNeilan Harbor & Nearshore Ground Conditions Report

McNeilan

converting challenges
into opportunities

& Associates

Harbor & Nearshore Ground Conditions

Icebreaker Wind Demonstration Project

Lake Erie

Submitted to:

Lake Erie Energy Development Corporation

Cleveland, Ohio

McN&A Project No. 16-02

August 2017

McNeilan & Associates, LLC

Norfolk, Virginia

This page intentionally blank

TABLE OF CONTENTS

FIGURES

INTRODUCTION

PROJECT BACKGROUND

The Icebreaker Wind Demonstration Project is proposed by the Lake Erie Energy Development Corporation (LEEDCo) as the first offshore wind demonstration project in the freshwater Great Lakes. The project (Figure 1) will include six, 3.45 MW wind turbine generators, located approximately 13.1 to 17.8 km offshore from Cleveland, Ohio.

Energy generated from the turbine generators will be transmitted through an export cable from the offshore project area to the project substation located at the former Cleveland Public Power (CPP) generating facility on North Marginal Road (Figures 1 and 2).

The portion of the export cable passing beneath the Cleveland Harbor (Figure 2) will be installed within a horizontally directional drilled (HDD) casing. The HDD entry/exits will be located: a) to the northwest of the harbor breakwater and b) at the project substation to be constructed in the former CPP facility (Figure 2).

PURPOSE OF REPORT

This report describes the physical ground conditions on and below the harbor and nearshore portion of the project development area, where the export cable will be installed within a HDD casing. The report is intended to be used as a reference document for various project permitting and environmental evaluation activities. The description, herein, is based on geologic conditions, relevant historical references, and project-specific design studies. The summary description has, to a large degree, been extracted from the project-specific site characterization and design studies.

EXPORT CABLE – HDD UNDERCROSSING OF HARBOR

The envelope of the potential HDD casing and export cable route beneath Cleveland Harbor is shown on Figure 2. The HDD alignment will extend about 1 kilometer from the former CCP generating station, on the south, to the northwest of the Cleveland Harbor Breakwater. On the west, the area is bounded by the existing Confined (dredge) Disposal Facility (CDF) 12. Water depth in the harbor generally is between about 5.5 and 7.5 meters (18 and 24 feet), although the water depth immediately adjacent to the CPP facility increases from about 4 to 5.5 meters (13 to 18 feet).

The export cable route from the turbine area will extend to the east-southeast from turbine position ICE1 towards the harbor breakwater (Figure 1). The cable route is planned to extend on a straight line for about 12.5 kilometers from ICE1. Landward of 12.5 kilometers, the route may continue to the east-southeast or bend to a more southerly direction. Such a southerly bend is required to approach a lakeside HDD entry/exit that is located farther to the west-southwest. The conceptual route landward of kilometer 12.5, as shown on Figures 1 and 2 is anticipated to provide: 1) a desirable route that optimizes cable length, 2) an acceptable bend towards the lakeside HDD entry/exit, and 3) minimize the curve(s) in the HDD bore and casing.

As shown on Figure 2, the potential HDD casing and cable crossing beneath the harbor is anticipated to extend: a) from near the north corner of the former CPP storage yard (where the project substation will be constructed), b) beneath the shoreline that defines the northwestern and northeastern perimeters of the CPP facility, c) pass beneath the harbor and breakwater and d) extend to a lakeside location that is about 150 to 200 meters to the northwest of the breakwater.

The potential HDD alignment (Figure 2) may extend from the landside entry/exit location in the CPP (Figure 3) to the: a) north and then bend to the northwest to parallel the northeastern border of CDF12, b) northeastward from the CPP, or c) follow an intermediate orientation between those two extremes (Figure 2). The potential lakeside entry/exit area and a more narrowly defined probable location are shown on Figure 2.

Figure 4 reproduces the conceptual HDD profile, as shown in the Project's USACE 404 Permit Application (EDR, 2017). As defined by that document, the highest acceptable elevation for the top of the HDD bore beneath the harbor is 11.3 meters below chart datum (equivalent to elevation 162.2 meters re: IGLD). However, where it passes beneath the breakwater, the top of the HDD bore can be no higher than 13.7 meters below chart datum (equivalent to elevation 159.8 meters re: IGLD). We consider it probable that technical considerations (such as frack-out prevention) may require that the HDD bore be deeper than those permitted highest elevations.

AUTHORIZATION

This report was completed as part of the scope of work authorized by LEEDCo's signed acceptance of McNeilan & Associates' Professional Service Agreement for McNeilan & Associates' Proposal Number 16-02 r3, dated February 29, 2016.

PROJECT DATUM

The project datum for the marine components of the project are:

- Horizontal – WGS84, UTM Zone 17N, meters, and
- Vertical – Lake Erie Chart Datum, which is 173.5 meters above the International Great Lakes Datum (IGLD) 1985, low water datum (LWD) – this datum is subsequently referred to as *chart datum*.

In contrast, the project datum for the project substation at the former CPP facility are:

- Horizontal – Ohio State Plane, North Zone NAD83 (2011) Grid North, and
- Vertical – NAVD 1988, feet.

In general, and except as noted otherwise, the project datum used in this report corresponds to those established for the turbine and export cable. However, because the landside substation project datum adopts English units, and uses different horizontal and vertical datum, some information extracted from studies for that facility use its project datum.

HISTORICAL GEOPHYSICAL AND GEOTECHNICAL EXPLORATION PROGRAMS

Six references contain geotechnical and geophysical data that are relevant to the routing, design and construction of the HDD casing. Each is briefly described below. The area for which the data in those references were obtained are shown on Figure 5. In addition to the individual data references, McNeilan & Associates (2017) integrates the data from those references to provide an overview of the site and subsurface conditions; much of the description, contained herein is extracted from that reference.

2016 Land Geotechnical Investigation for Substation Design.

The 2016 Hull Associates report is based on thirteen (13) borings drilled at the CPP facility. Eight of the borings (Figure 6) were in the corner of the facility where the project substation will be constructed and the landside HDD entry/exit located.

The Hull geotechnical program also included:

- Two borings drilled along the northeastern margin of CDF12 (Figure 5), which were advanced through the CDF to penetrate and sample native sediments that underlie the CDF.
- A land geophysical survey in the CPP storage yard that included electro-magnetic and ground penetrating radar data collection. That survey was conducted by Grumman Exploration (2016) and its results are included as Appendix E of the Hull (2016) report.

Exploratory HDD Bores from the CPP Facility

In addition to the conventional geotechnical investigation activities in the CPP facility, nine exploratory HDD bores were advanced toward the northwestern and northeastern shorelines from a location in the northeast portion of the CPP facility (Figure 6). Those bores were advanced, using a Vermeer 24X40, Series II horizontal boring rig, to help evaluate the potential presence of obstructions and oversized inclusions within the reclaimed land in that portion of the CPP facility.

Only one of the nine exploratory HDD bores was successful advanced under and about 13 meters beyond the northwestern CPP perimeter shoreline. The alignment and drilling data for the exploratory bores are provided in DRS Enterprises (2016).

While it is recognized that a larger and more powerful HDD boring machine should penetrate through obstruction that could not be penetrated by the exploratory HDD bores, the refusal of 8 the 9 exploratory HDD bores prior to the bore being advanced under the CPP shoreline reflects the abundance of oversize material and rubble within the fill, and the uncertainty with respect to the subsurface conditions that are to be penetrated by the HDD bore from the landside HDD entry/exit.

2016 Cable Route and Supplemental Marine Geophysical & Geotechnical Program

The marine geophysical survey and geotechnical exploration (G&G program) for cable route design and permitting was conducted in August to October 2016. This program included the geophysical survey and geotechnical exploration for both the inner array and export cable routes.

The area of geophysical survey data collection and marine geotechnical exploration within the harbor and the adjacent nearshore area, to the north of the breakwater, are shown on Figure 5. The results of the geophysical survey data collection and interpretation are provided in Canadian Seabed Research (2016), while the geotechnical exploration results are provided in TDI-Brooks (2017).

The geophysical survey included seafloor mapping and sub-bottom geophysical systems. The area surveyed offshore the breakwater and the survey track-lines within the harbor are shown on Figure 5.

The geotechnical exploration conducted, during the 2016 cable route G&G program, within Cleveland Harbor and the nearshore area (from the breakwater out to about 1.75 kilometers to the northwest of the breakwater) included: 1) five, 10-centimeter-diameter piston coring and 2) fourteen gravity cone penetration test (CPT) soundings. Those exploration were advanced to between 1.6 to 7.4 meters below harbor- or lake-bottom.

1970s US Army Corps of Engineers

In the 1970s, the US Army Corps of Engineers (USACE) was responsible for the design and construction of the new CDF12 and the major reconstruction of the Cleveland Breakwater. The design drawings for those projects include logs of borings drilled in the 1970s. The data for the CDF12 borings are included in USACE (1973) and the data for the breakwater reconstruction are included in USACE (1979). The locations of those borings are shown on Figure 5.

GEOLOGY AND GEOLOGIC CONDITIONS

Today's subsurface stratigraphy beneath Lake Erie has been affected by regional geologic evolution during the Precambrian era and Paleozoic era, and due to glaciation and deglaciation during the Quaternary period (Bolsenga and Herdendorf, 2005).

The HDD alignment, including both the landside and lakeside entry/exit locations, are within the former southern margin of Lake Erie. The area is underlain by a limited thickness of post-glacial deposits overlying Quaternary-age glacial deposits that include a thick glacio-lacustrine sequence underlain by glacial till and drift. The glacial and post-glacial deposits are underlain by the Devonian-age Ohio Shale bedrock.

During the Quaternary period (last 1.6 million years), geologic processes shaped the surficial landscape and deposited unconsolidated sediments that overlie bedrock (. Repeated episodes of glacial advance and retreat covered the Great Lakes region at least six times during the Quaternary (Kindle and Taylor, 1913). Four glacial lobes (Forsythe, 1971; Holcombe, et al, 2005) extended to Lake Erie and produced end moraine deposits. As the glaciers advanced they eroded the landforms, and re-worked and re-deposited the sediments. As the glaciers receded, their meltwaters re-deposited sediments from within the glaciers. The present-day lakebed and subsurface topography is the result of these repeated episodes of erosion of unconsolidated sediment deposits and bedrock, as well as re-deposition of the sediment during and after glaciation.

The glacio-lacustrine sediments were deposited in proglacial lakes during the four stages of glacial retreat of the Laurentide ice sheet. These fine-grained deposits were deposited from melting icebergs and sediments in surface runoff into the lake (CRS, 2016). While the sediments are primarily fine-grained, they frequently include occasional to abundant quantities of oversize inclusions that were either encapsulated in the icebergs or carried into the water by the runoff.

The surficial geology compiled by Brockman and Schumacher (2005), conclude that the Burke Lakefront airport land reclamation, which is several kilometers to the west of the HDD alignment, is underlain by about:

- 3 meters of discontinuous sand and harbor-bottom sediments,
- 30 meters of silt and clay (the glacio-lacustrine sequence),
- 25 meters of glacial till, and
- 3 meters of glacial-age outwash sand, overlying
- Ohio Shale (Devonian age)

The Icebreaker project-specific exploration and geophysical data are consistent with the stratigraphic sequence beneath the Burke Lakefront airport.

The post-glacial deposits along the southern margin of Lake Erie are generally of limited thickness, and most post-date the construction of the Cleveland Breakwater. Within the harbor, a modest thickness of very soft clay and silt overlies the post-glacial deposits that predate the breakwater. To the northwest of the breakwater, a northwesterly-thinning wedge of geologically Recent sediments has been deposited subsequent to the construction of the breakwater.

The landside HDD entry/exit is located on reclaimed land along the pre-industrial Lake Erie shoreline. Borings (Hull, 2016) suggest that about 9.5 (+/-1) meters of fill and coal by-products underlie the anticipated landside HDD entry/exit location. The fill extends from about 3.5 meters above low water Lake level (Chart Datum) to about 6 meters below harbor water level.

SITE AND SUBSURFACE CHARACTERISTICS

Our discussion of the site and subsurface conditions in the areas of interest is divided and presented as follows:

- Soils and materials underlying the CPP entry/exit location,
- Sediments within the anticipated HDD Bore interval beneath Cleveland Harbor, and
- Sediments underlying the Lake Erie entry/exit location to the northwest of the breakwater.

LANDSIDE ENTRY/EXIT AREA

SITE CHARACTERISTICS

The proposed Icebreaker substation is to be located in the storage yard behind (to the north of) the former CPP Lake Road Generating Station, on North Marginal Road (Figure 3). The CPP storage yard is bounded by Cleveland Harbor on its northwestern and northeastern borders.

The area is relative flat with a slight downward slope to the perimeter fence (Figure 6) that bounds the northwestern and northeastern limits of the storage yard.

The CPP facility was initially constructed in about 1912. The approximately 3-acre, storage yard behind the former generating plant consists of "made land." Although the dates and details of the "made land" are not well defined, historical drawings suggest that the northwestern stone breakwater was placed at or near the time of the initial site development and that the area was filled after the early 1960s.

The ground surface elevation in the northern corner of the storage yard and proposed substation area is about El. 170 to 170.5 meters (581 to 582 feet) relative to Chart Datum (KS Associates, 2016). Inside the fence line, the storage yard has a crushed gravel working surface and is generally devoid of vegetation. The shoreline outside of the fence is vegetated with trees and brush, and is covered with various types and quantity of rock and construction debris that appears to have been placed to provide shoreline protection and resist erosion.

The character, cross-section, base elevation, and construction of the shoreline walls that enclose the CPP site is undocumented. The northwestern shoreline appears to be formed by a stacked, cut-block, stone wall. The wall forming the northwestern shoreline, may have been constructed as a breakwater to provide protection for the CPP plant, constructed in the 1920s. The height and foundation underlying the wall are undocumented, although antidotal comments suggest that the wall was probably placed directly on the lakebed. Substantial quantities of debris and rubble are present in front of this portion of the wall (and the corner of the perimeter).

No documentation has been discovered relative to the construction or cross-section of the northeastern shoreline or any underlying, perimeter structure. A 1964 CPP drawing does not show or include reference to such a structure. From the water, the shoreline is highly variable. Rubble is predominant. Various quantities, sizes, and composition of debris appears to form the northern point of the site and much of the northeastern shoreline. The origin of the debris, which appears to provide shoreline protection, is undocumented.

SUBSURFACE CONDITIONS

Subsurface exploration indicates that the project substation site (and landside HDD entry/exit location) is underlain, in descending sequence by:

- About 9.5 meters of fill that is inferred to include both land reclamation fill and industrial by-products,
- One to a few meters of geologically-Recent, lake-bottom sediments, and
- An 18+-meter-thick sequence of silty clay of glacio-lacustrine origin that extends down to more than 26 meters below Chart Datum, or about elevation 147 meters (re IGLD).

The fill consists of varying proportions of sand, gravel, silt, clay, and other materials. In general, the fill is more granular than cohesive in character, although layers of silty and sandy clay are locally present. The fill also includes abundant inclusions of gravel-, cobble-, bolder-, and rock-sized materials that include stone and rock; coal and coal-byproducts; and debris, such as concrete and brick. Sampler blow counts suggest that the fill is loose to dense in situ.

The size and abundance of oversized inclusions appears to be random and unpredictable. Two of eight sample borings and four of six auger borings in the northern corner of the CPP storage yard were terminated (presumably on obstructions) above 8 meters depth (Figure 6). In addition, eight of nine horizontal exploration bores met refusal prior to passing beneath the storage yard fence line.

The fill is underlain (in descending sequence) by a relatively thin and variable layer of Recent sediments of mixed composition overlying a thick layer of cohesive, glacio-lacustrine sediments. The glacio-lacustrine sediments include silty clay, sandy clay, silt, and/or clayey silt (Figure 7). The grain size (Figure 7) of the recovered samples typically include less than 10% particle larger than a #200 sieve opening (i.e., sand and coarser particles), include 30 to 60% (by weight) of particles that are finer than 5 microns (0.005 millimeters), and have a mean grain size of less than 0.01 millimeters. While the recovered samples did not include significant coarse particles, the geologic deposition of the deposit is prone to include sand, gravel, and larger inclusions.

Groundwater in the soil borings was measured to be at about 10 feet below ground surface after completion of drilling.

HDD BORE ALIGNMENT

The potential range of HDD bore alignments is shown on Figures 2 and 5. A conceptual export cable alignment that requires a relatively minimal curve of the HDD bore and casing also is shown on Figures 2 and 5.

The HDD bore beneath the harbor is anticipated to be advanced within the depth interval between 13.5 and 30 meters (re: Chart Datum), or Elevation 143.5 to 160 meters, re: IGLD. This depth interval is anticipated to pass through the thick, cohesive glacio-lacustrine sediments.

AVAILABLE SUBSURFACE DATA

The available subsurface information and data that have been used to anticipate the geological and geotechnical conditions along the potential HDD bore routes and profiles are provided in various documents as discussed previously and as shown on Figure 5.

The geologically-Recent bottom sediments within the harbor are gassy (likely due to the decomposition of abundant organics within the historical and geologically-Recent sediments), and the imaging of the sub-bottom sediment layering was masked by the gassy conditions. Although gassy conditions also are present in some areas outside of the breakwater, the imaging of the sub-bottom stratigraphy was resolved in many areas in both the Chirp sub-bottom and “boomer” seismic reflection data.

Two seismic sections from outside the breakwater are presented on Figures 8 and 9. The records presented on Figure 8 are from survey lines that parallel and are about 200 meters northwest of the breakwater, while the records presented on Figure 9 are from lines that are perpendicular to the breakwater.

The available subsurface data are located: 1) in the landside entry/exit, 2) along the northwestern perimeter of the potential alignment corridor across the harbor, 3) along the breakwater alignment, and 4) in the nearshore portion of Lake Erie. No site-specific data are available for much of the potential alignment corridor across the harbor.

Subsurface profiles based on the geotechnical exploration are shown on Figures 10 and 11. Figure 10 provides the stratigraphy shown on the 1970s-vintage borings drilled along the breakwater alignment, and Figure 11 is drawn perpendicular to the breakwater and includes: 1) 1970s-vintage USACE data along a) the breakwater and b) beneath CDF12 and 2) 2016 borings by Hull (2016) drilled through: a) the future substation at the CPP site and b) CDF12. The soil profiles (Figures 10 and 11) also show the highest HDD bore interval allowed per the project's 404 permit application (EDF, 2017).

SUBSURFACE STRATIGRAHY

The subsurface stratigraphy beneath the HDD alignment is anticipated to be composed of primarily cohesive sediments. Previous 1970s-vintage borings drilled for the USACE's design of CDF12 and the major reconstruction of the harbor breakwater, r and the 2016 Hull borings at the CPP and CDF12 suggest that the stratigraphy, beneath the harbor-bottom will generally be composed of:

- Lake-bottom mud: 0.5- to 3.5-meter-thick,
- A discontinuous sequence of layered silts, sands, and clay: 1- to 7-meter-thick, and
- Normally consolidated to slightly overconsolidated clay: greater than 18-meters-thick.

The data further suggest that the combined thickness of the lake-bottom mud and discontinuous sequence of layered sediments to be about 5.5- to 7.5 meters. The data suggest that the top of the 18+-meter-thick glacio-lacustrine sediments is present at about elevation 162 to 165 meters re: IGLD, and that the top of this sequence may slope downward from south to north.

CSR (2016) has interpreted reflector B1 as the possible bottom of the glacio-lacustrine deposit. As shown on Figures 8 and 9, that reflector (where imaged) is about 24 to 30 meters below the lake-bottom to the northwest of the breakwater. That depth below lake-bottom is equivalent to between about elevation 144 and 149 meters re: IGLD. CSR's (2016) interpretation suggests that the elevation of the stratigraphic boundary may deepen to the north and west.

In comparison, the historical USACE (1973 and 1979) borings generally extend down to only elevation 148 to 152 meters (re: IGLD), and the deepest of the borings (78-1, the farthest west boring) extends down to about elevation 142 meters (re: IGLD). The recent Hull (2016) borings from CDF12 extend down to about elevation 139 meters (re: IGLD), and the deep boring in the CPP extends down to about elevation 147 meters (re: IGLD).

With two possible exceptions, the historical and recent borings appear to have been terminated within the glacio-lacustrine deposit. The bottom 1.5 meters of USACE boring 78-1 (the deepest of the borings, located at the west, southwest limit of the explored breakwater alignment) is labeled as silt on the USACE boring log (USACE, 1979); whether that layer is part of the glacio-lacustrine deposit or the top of an underlying deposit is unknown. The other exception to the generalization is USACE boring 78-3, located near the western corner of the offshore geophysical survey area (Figure 18). That boring encountered a thick sand layer at about 8 meters depth below lake-bottom.

The sand encountered in boring 78-3 could reflect the presence of a sand-filled channel eroded into the thick glacio-lacustrine deposit. This is not an unusual condition for the geologic history of the sediment deposition and conditions present in the project area.

GLACIO-LACUSTRINE SEDIMENTS

The various historical and recent borings typically describe the glacio-lacustrine sediments as silty clay, sandy clay, silt, and/or clayey silt. The consistency of the Lake Erie glacio-lacustrine sediments is typically described as being firm or firm to stiff. Additional description of these sediments, as encountered below the CPP facility and CDF12 was discussed previously.

LAKE ERIE ENTRY/EXIT LOCATION

The HDD bore entry/exit location is assumed to be located about 150 to 200 meters to the northwest of the Cleveland Harbor Breakwater. The location along the potential export cable alignment shown on Figures 2 and 5 is at about kilometer post (EKP) 13.5.

LAKE-BOTTOM CONDITIONS

The water depth and lake-bottom elevation at the entry/exit location into the Lake are anticipated to be about 10 (+/- 0.2) meters, or approximately elevation 163.5 (+/- 0.2) meters (re IGLD).

The multi-beam bathymetry and side scan sonar data indicate complex late-bottom conditions to the northwest of the breakwater. Recent sediments onlap the wedge of sand and toe of the breakwater.

In the anticipated lakeside entry/exit area, CSR (2016) interpreted the lake-bottom to be generally composed of silt and sand, as shown on the side scan sonar mosaic presented on Figure 12. As shown on Figure 12, sand and gravel are mapped on the lake-bottom farther to the northwest. Such sediments also are present within localized portions of and adjacent to much of the anticipated entry/exit area. At the southwestern limit of the potential entry/exit zone, the lake-bottom includes sand waves surrounded by areas of lake-bottom mud.

SUBSURFACE CONDITIONS

Gravity CPTs (TDI-Brooks, 2017) are located near the northeastern and southwestern ends of the potential entry/exit area. Both gCPTs penetrated a sequence of sand and clay with silt layers to about 6 meters depth, below lake-bottom. Individual layers vary from less than 0.2

meters to more than 2 meters thickness. The gCPT resistances suggest that the sand layers are of variable density, while the clay layers appear to be firm in consistency.

The Chirp sub-bottom data suggest that those lake-bottom sediments extend down to the top of the thick glacio-lacustrine clay deposit. Two of the layer boundaries in the gCPTs appear to correlate with intermittent geophysical reflectors mapped from the Chirp data. These reflectors, which were noted to be discontinuous, are shown on the Chirp records provided in Figures 8 and 9. Detailed examination of the data further substantiates the discontinuous nature of the near-surface stratigraphy in the potential lakeside HDD entry/exit area.

REFERENCES

Bolsenga, A.J. and Harendra, C.E. editors (1993), "*Lake Erie and Lake St. Clair Handbook – Chapter 2 Lithosphere – The Solid Earth*," Wayne State University Press.

Brockman, C. S. and Schumacher, G.A. (2005), *Surficial Geology of the Cleveland North 30 X 60-minute quadrangle*, Ohio Division of Geological Survey Map SG-2 Cleveland North, scale 1: 100,000.

Canadian Seabed Research, Ltd. (2016), "2016 Marine Geophysical Survey Results, Icebreaker Offshore Wind Demonstration Project," Report to LEEDCo, Project Number 1604, dated November 25, 2016.

D.R.S. Enterprises, Inc. (2016), "Exploratory HDDs for Project Icebreaker on CPP Property," prepared for LEEDCo, October 18, 2016.

EDR (2017), "USACE 404 Permit Application, Icebreaker Wind Demonstration Project, Lake Erie," Prepared for LEEDCo.

Forsyth, J.L. (1971), "*Geology of Lake Erie Islands and adjacent Shores*," Michigan basin Geological Society, Annual Field Excursion, pp1-4.

Grumman Exploration, Inc. (2016), "Report of Geophysical Survey at the LEEDCo/C Icebreaker Wind Demonstration Project, 2551 N. Marginal Road, Cleveland Ohio," Report to Hull Associates, GEI Project No. 01-36087, dated October 28, 2016; Note – report included as Appendix E of Hull Associates (2016).

Holcombe T.L., Taylor L.A., Reid D.F., Warren J.S., Vincent P.A., and Herdendorf C.E. (2005), "*Revised Lake Erie postglacial lake level history based on new detailed bathymetry*," Journal of Great Lakes Research 29: pages 681-704.

Kindle, E.M. and Taylor, F.B. (1913). "Geological Atlas of the United States, Niagara Folio," *United States Geological Survey Folio*, 190.

KS Associates, Inc. (2016), "Topographic Survey," Prepared for LEEDCo, Drawing No. 16231 BASE01, dated August 31, 2016.

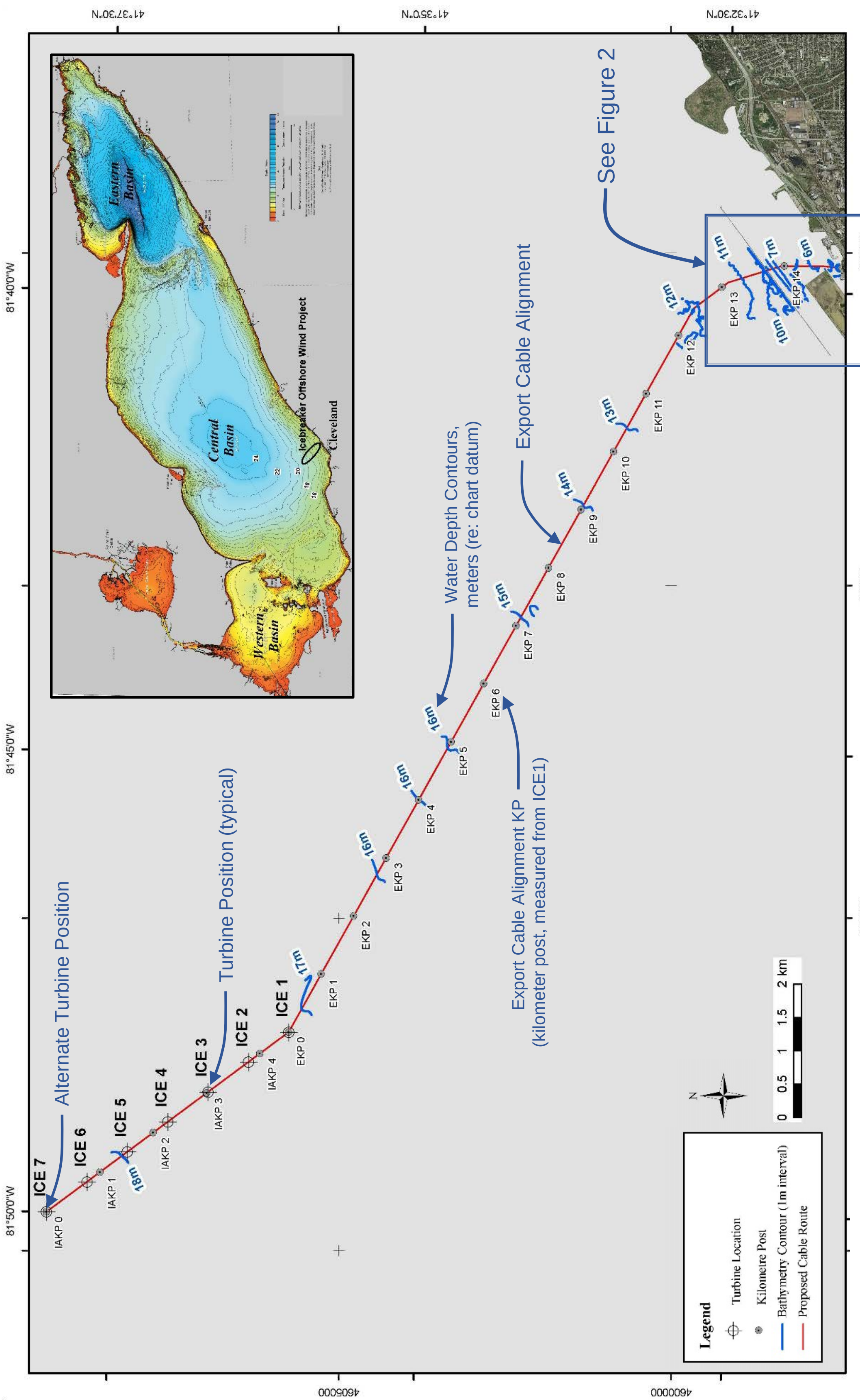
McNeilan & Associates, LLC. (2017). "Export Cable HDD Alignment Ground Conditions Report, Icebreaker Wind Demonstration Project, Lake Erie," Report to LEEDCo, Project No. 16-02, March 30, 2017.

TDI-Brooks International (2017), “Geotechnical Data Report, Cable Route Alignments, Icebreaker Wind Demonstration Project, Lake Erie, Report to LEEDCo, Technical report 16-3613, 28 February 2017.

USACE (1973), “Confined Disposal Area 12 and Repairs to Existing Disposal Areas, Cleveland Harbor, Ohio,” Drawing Number 22-PCL-4, Sheets 1 to 10, dated 4 April 1973.

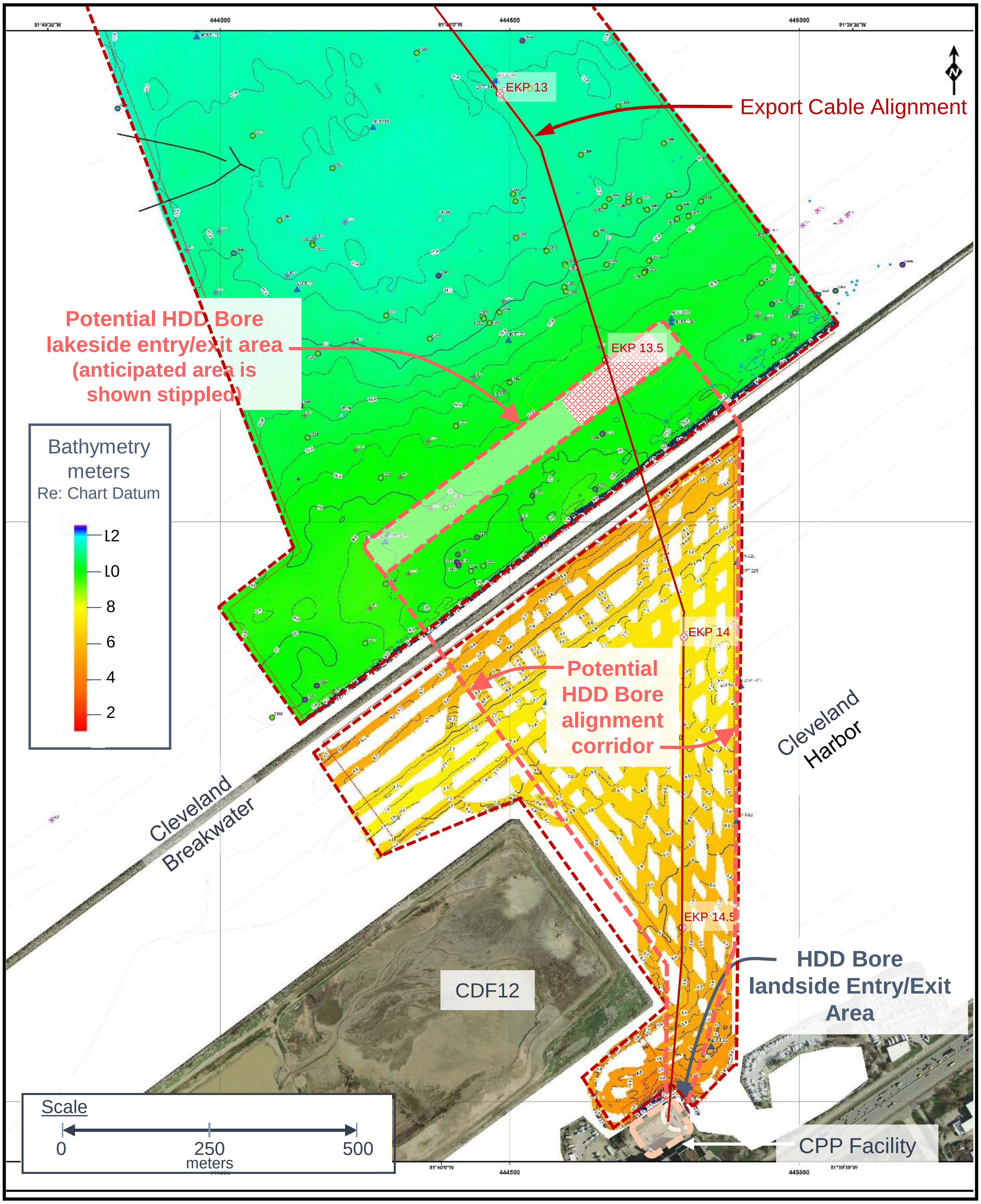
USACE (1979), “East Breakwater Major Rehabilitation, Cleveland Harbor, Ohio,” Drawing Number 79-CEB-1, Sheets 1 to 28, dated 1 March 1979.

This page intentionally blank



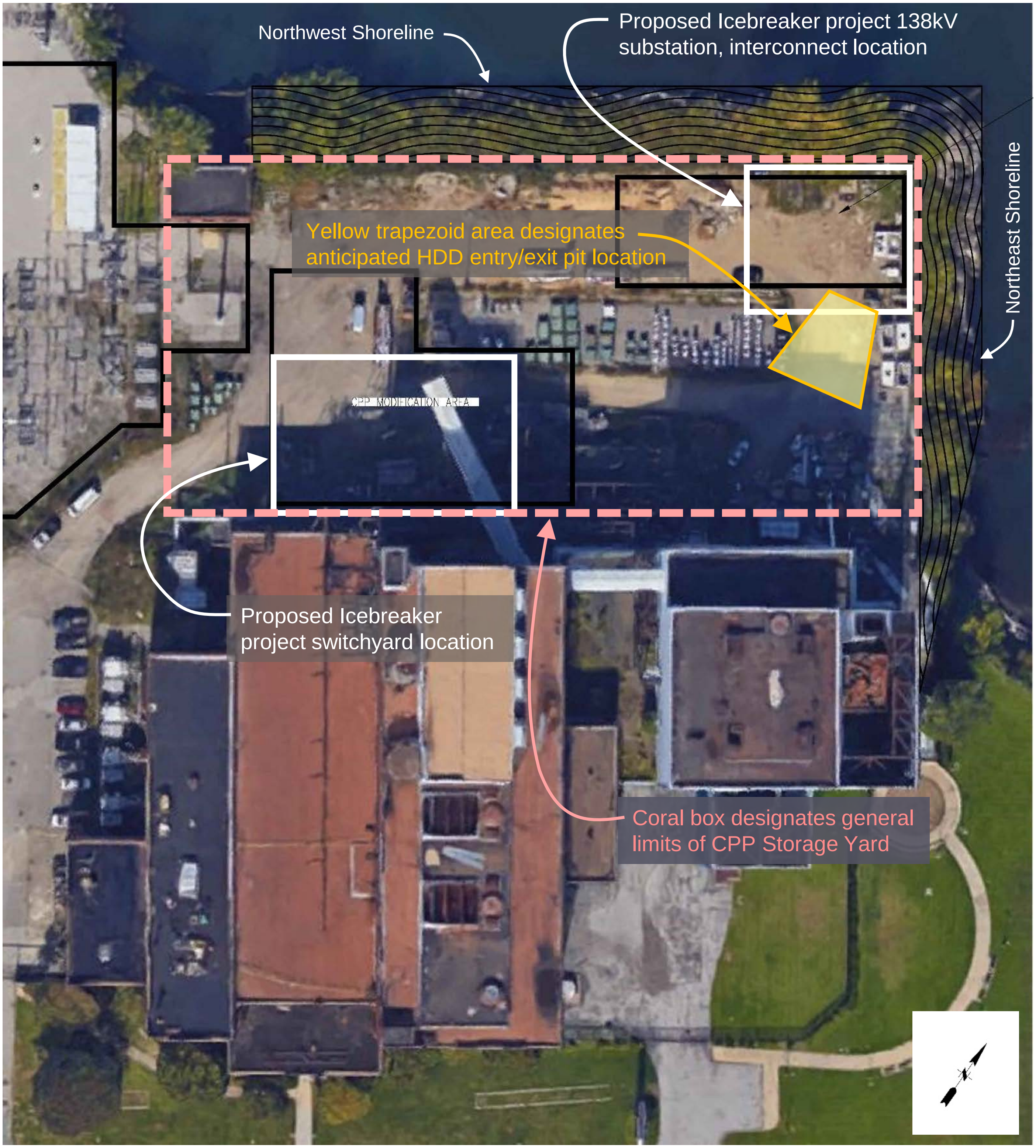
Reference: modified from McNeilan & Associates, 2017 and CSR, 2016. Inset map modified from Holcombe, et. al. (2005)

PROJECT LOCATION
Icebreaker Wind Demonstration Project



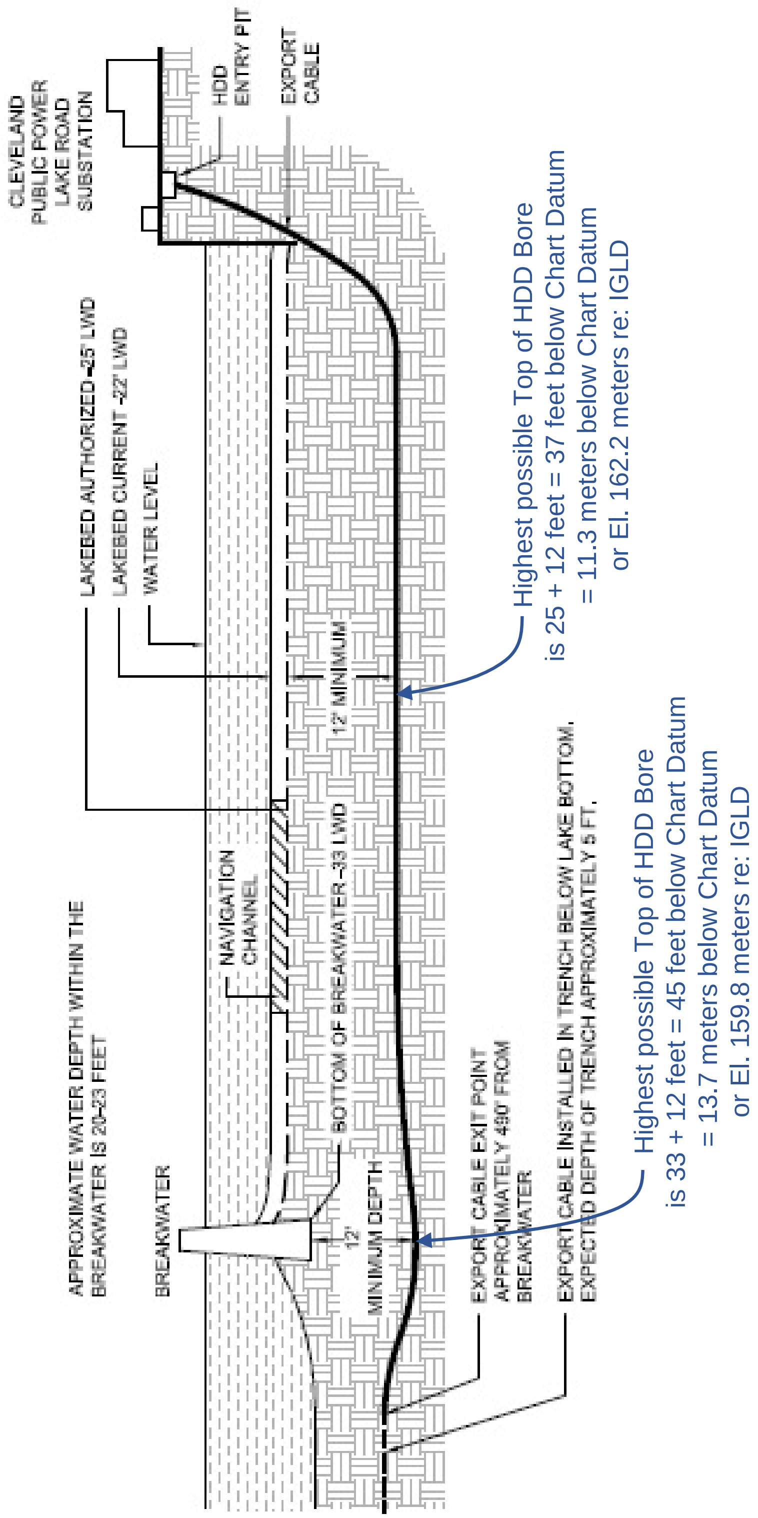
Reference: modified from McNeilan & Associates (2017); bathymetry from Canadian Seabed Research (2016)

CLEVELAND HARBOR AND NEARSHORE BATHYMETRY
Icebreaker Wind Demonstration Project, Lake Erie



Reference: modified from McNeilan & Associates (2017)

CPP FACILITY AND PROJECT SUBSTATION LOCATION
for Icebreaker Wind Demonstration Project

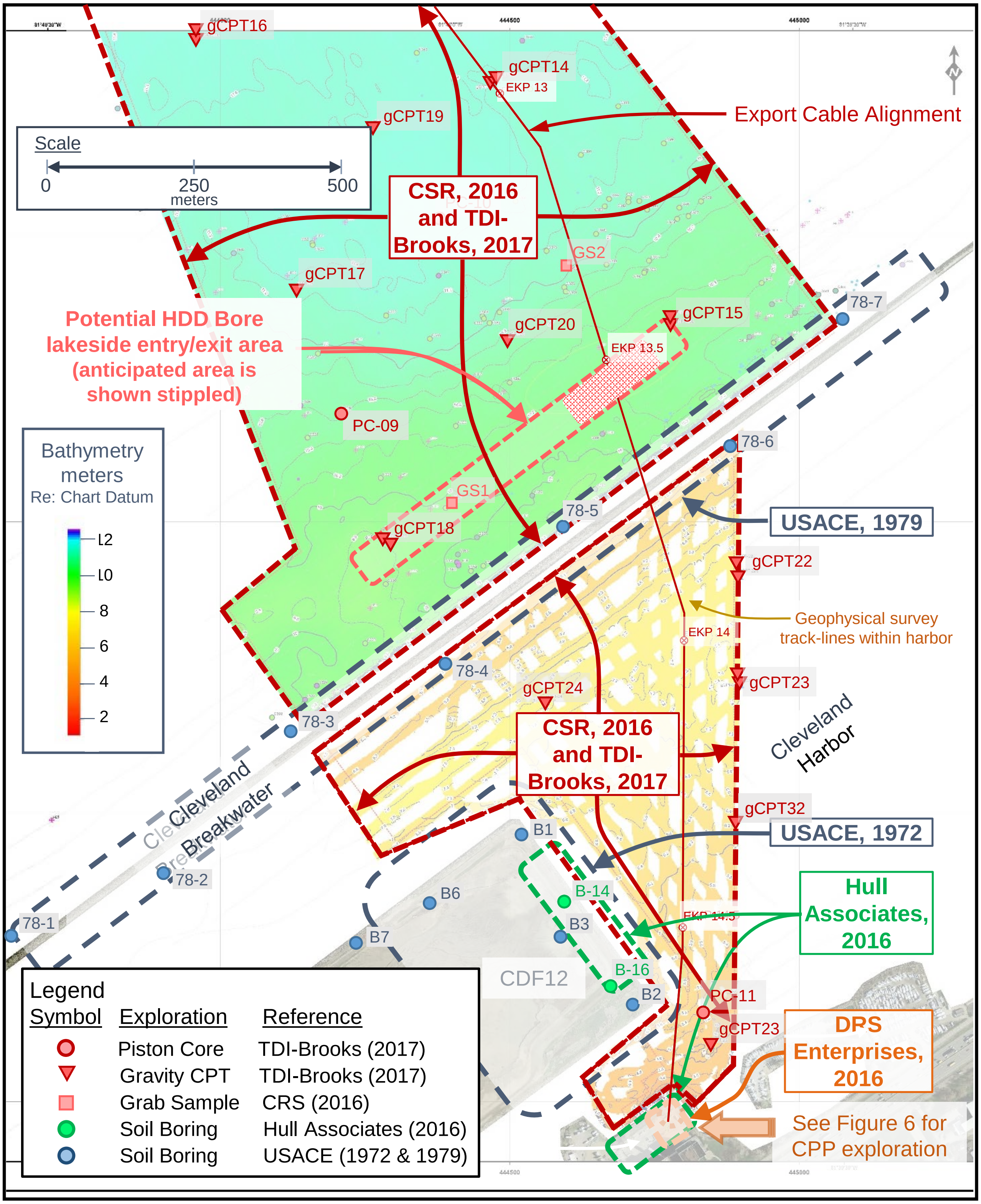


Lake Erie Chart Datum, is the charted low water lake surface elevation; i.e. low water (or chart) datum (LWD).
That datum is 173.5 meters above the International Great Lakes Datum (IGLD) 1985 datum.

Reference: modified from McNeilan & Associates, 2017 based on EDR, 2017 USACE 404 Permit Application

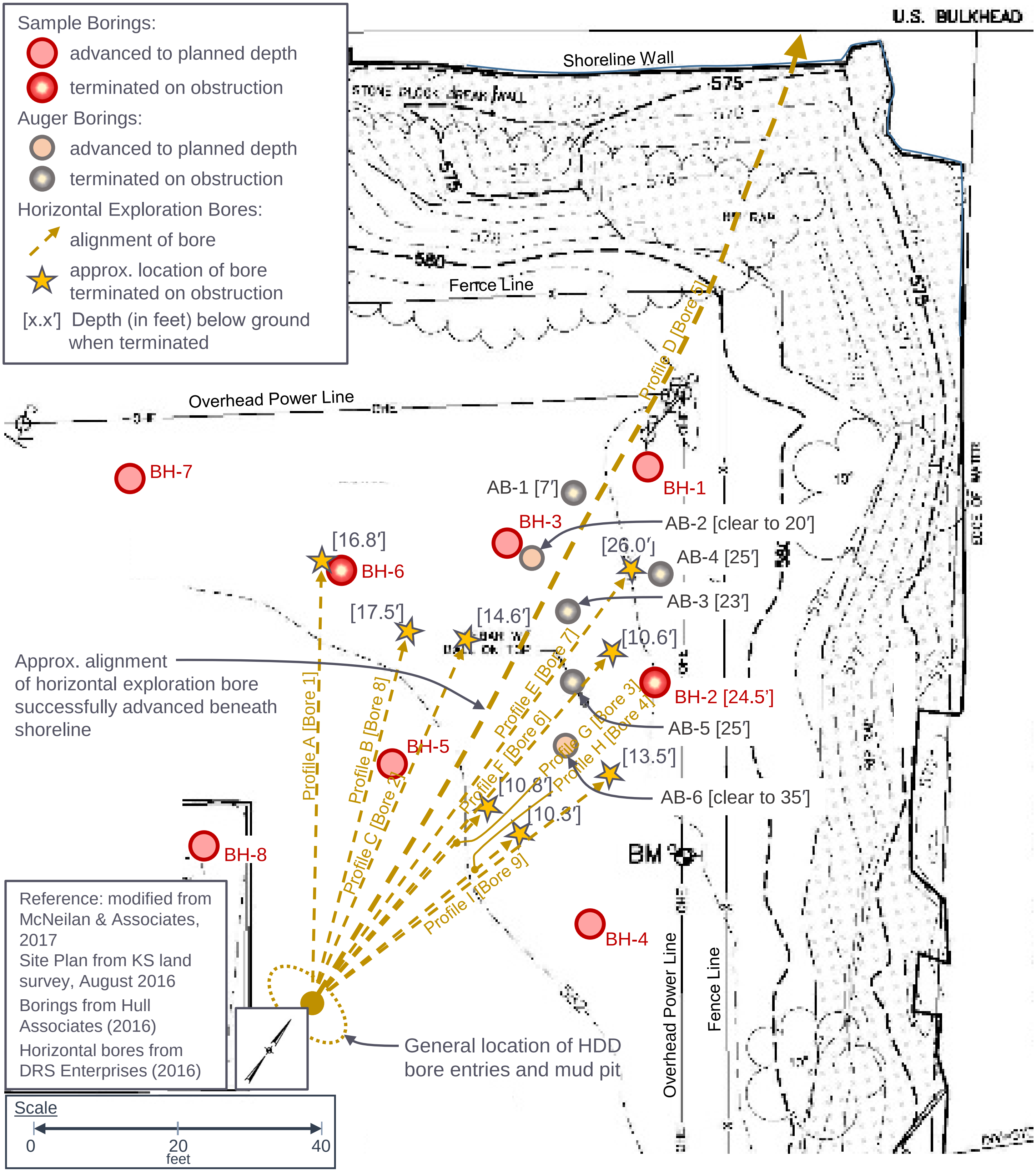
CONCEPTUAL HDD BORE PROFILE
Icebreaker Wind Demonstration Project

McNeilan & Associates

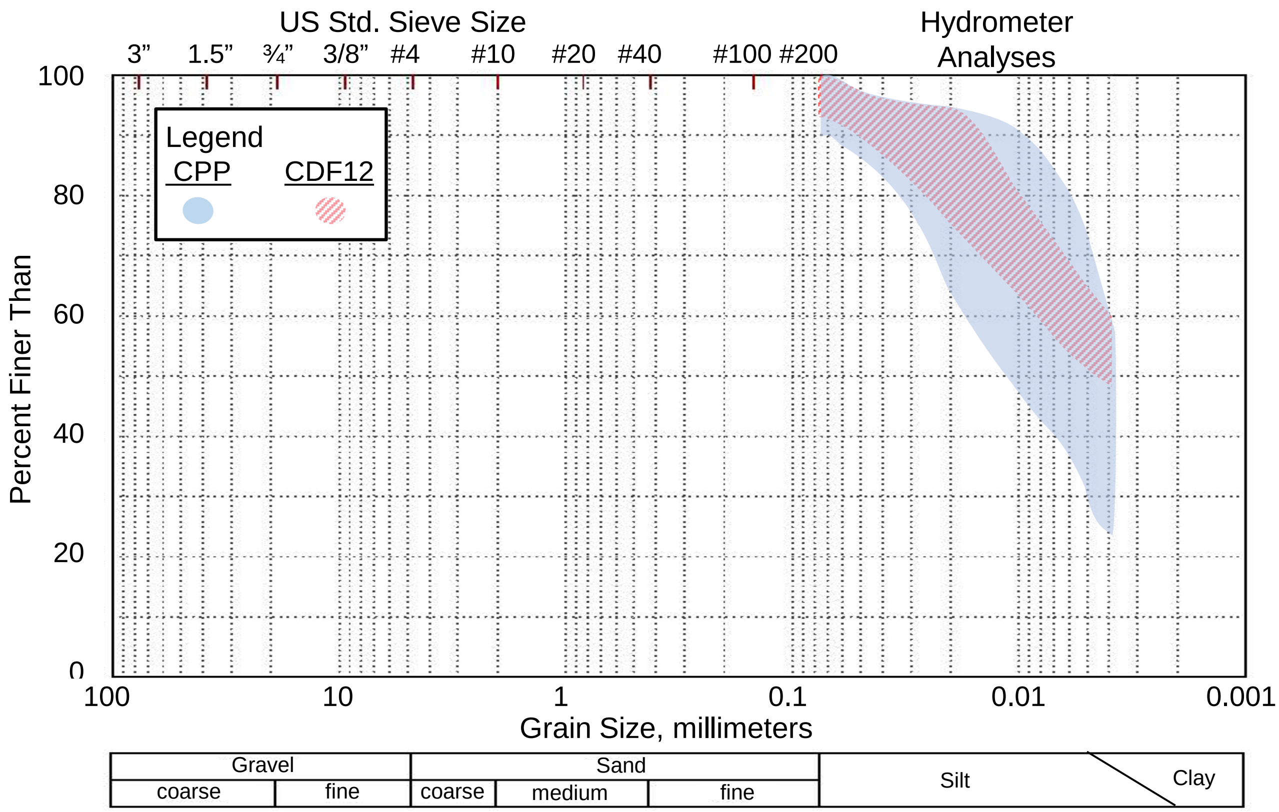


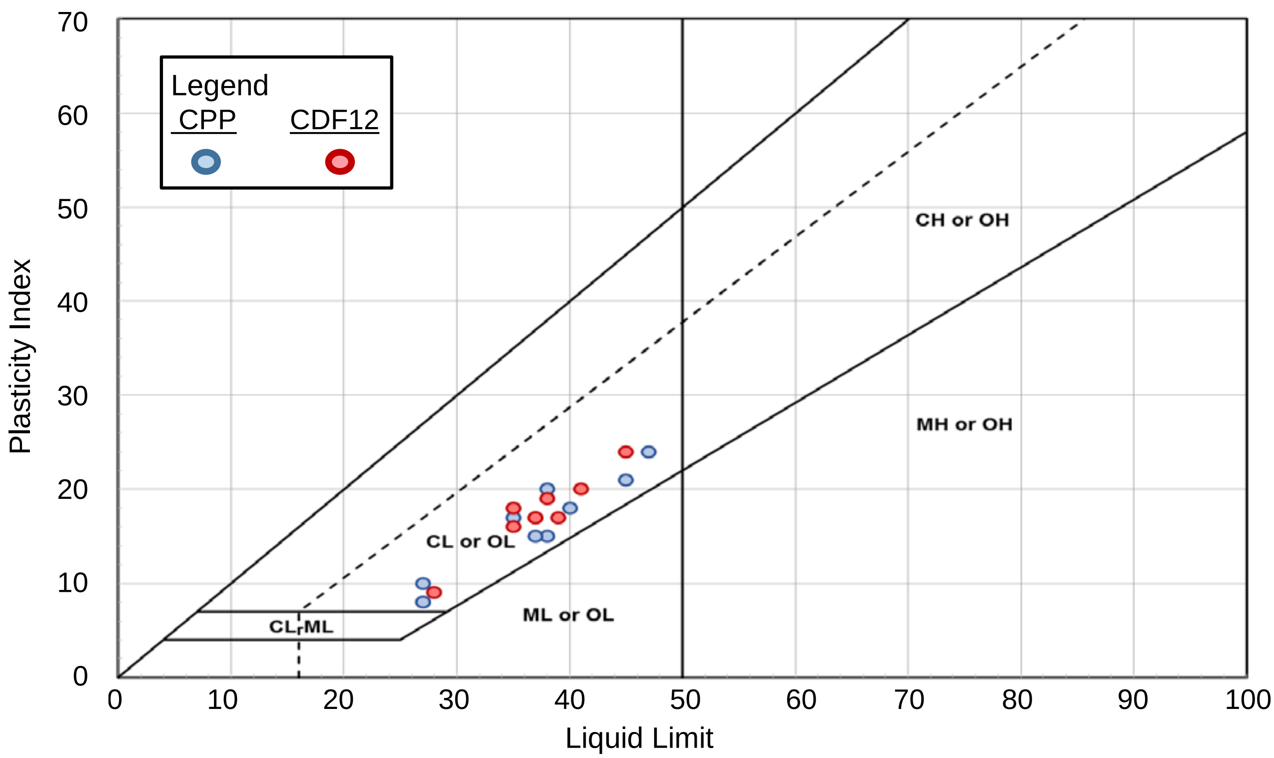
Reference: modified from McNeilan & Associates (2017); bathymetry from Canadian Seabed Research, (2016)

GEOTECHNICAL AND GEOPHYSICAL DATA SOURCES
Harbor and Nearshore Areas, Lake Erie



ONSHORE EXPLORATION PLAN (WITH REFUSAL INFORMATION)
Icebreaker Substation, CPP Storage Yard



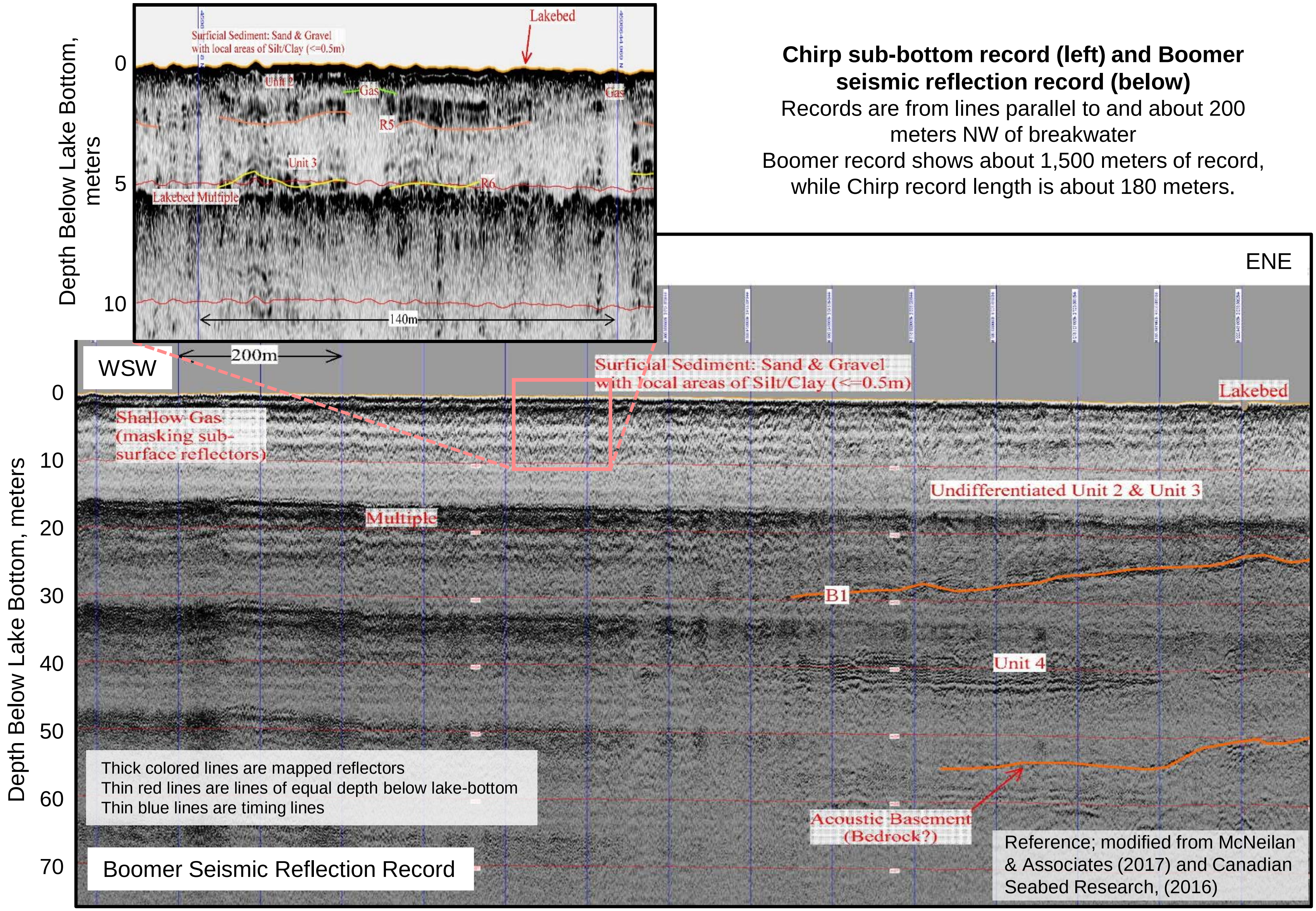


GRAIN SIZE AND PLASTICITY
of Glacio-Lacustrine Sediments, CPP Sub-station and CDF12

Chirp sub-bottom record (left) and Boomer seismic reflection record (below)

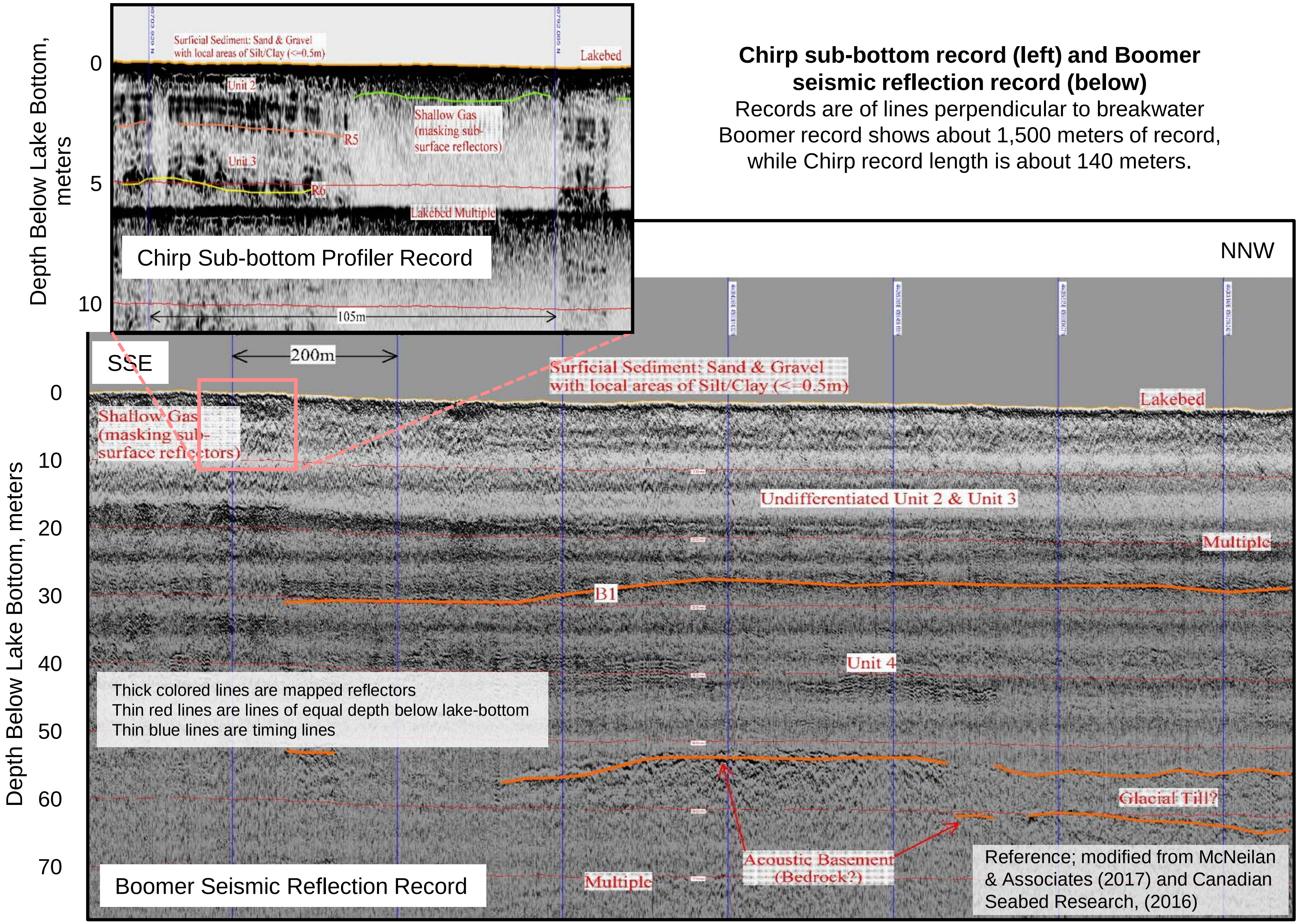
Records are from lines parallel to and about 200 meters NW of breakwater

Boomer record shows about 1,500 meters of record, while Chirp record length is about 180 meters.

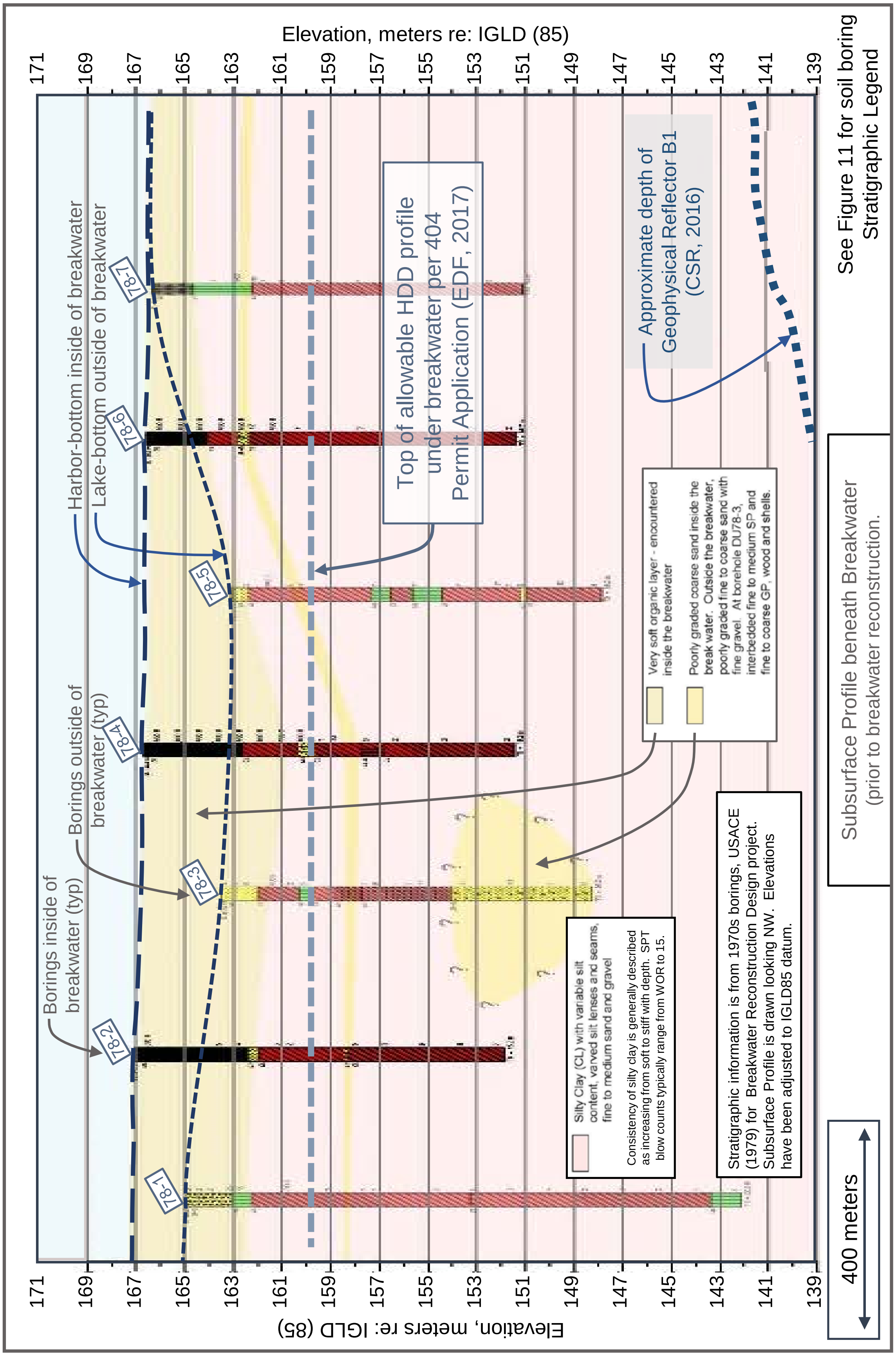


SUBSURFACE GEOPHYSICAL RECORDS
Icebreaker Wind Demonstration Project

Chirp sub-bottom record (left) and Boomer seismic reflection record (below)
Records are of lines perpendicular to breakwater
Boomer record shows about 1,500 meters of record,
while Chirp record length is about 140 meters.

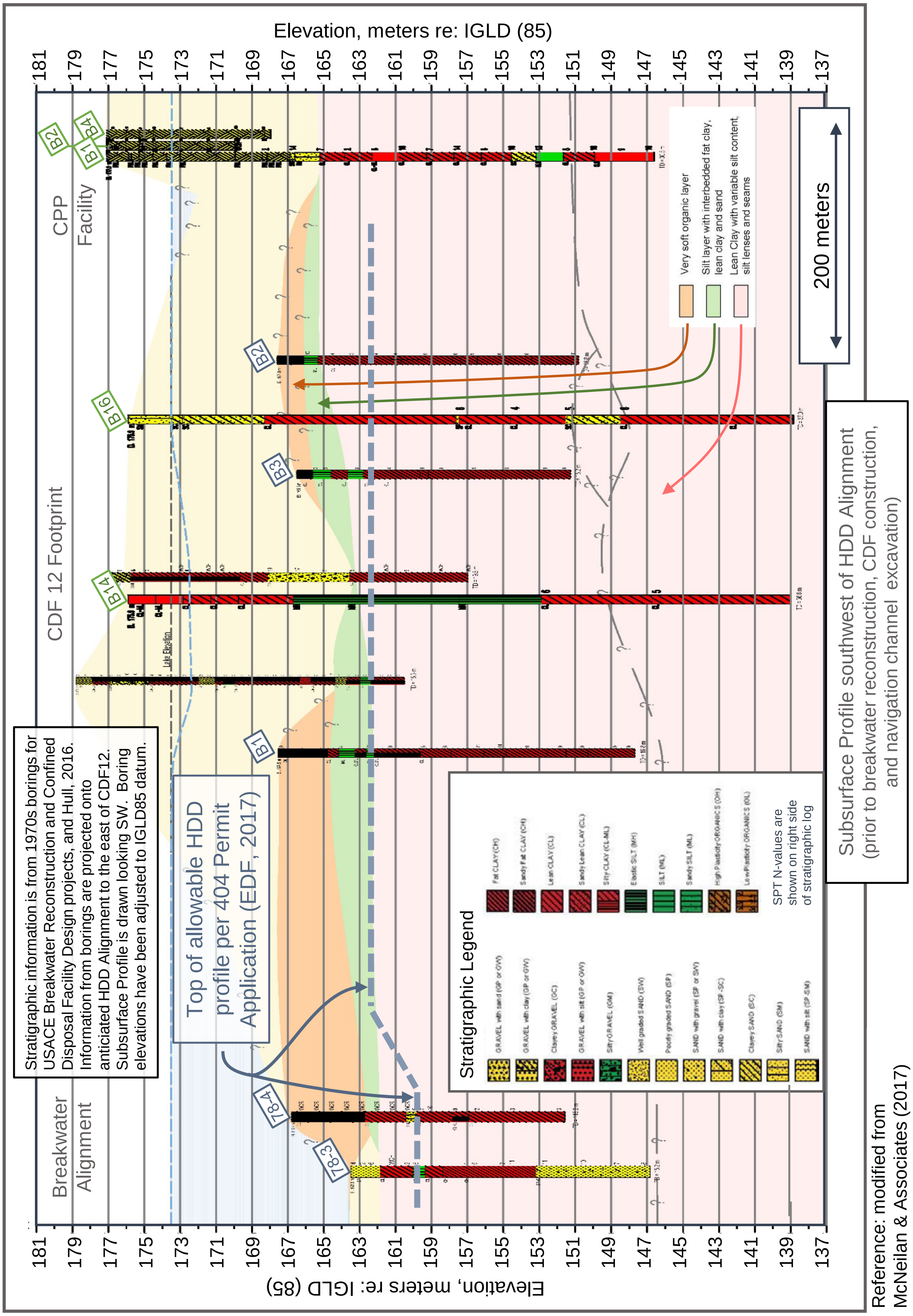


SUBSURFACE GEOPHYSICAL RECORDS
Icebreaker Wind Demonstration Project



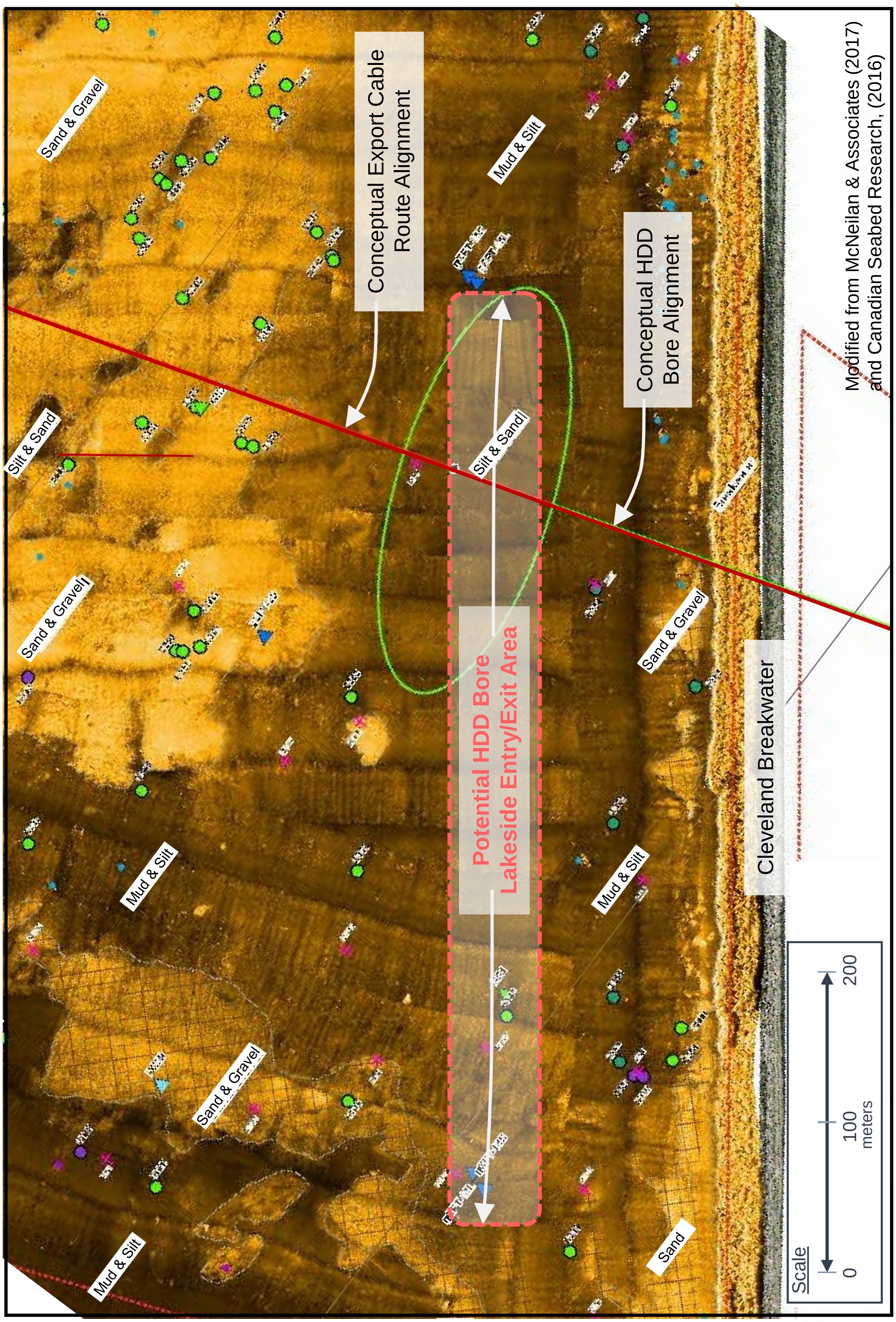
Reference: modified from McNeilan & Associates (2017)

SUBSURFACE STRATIGRAPHY – BENEATH BREAKWATER
Icebreaker Wind Demonstration Project



Reference: modified from McNeilan & Associates (2017)

SUBSURFACE STRATIGRAPHY – BENEATH BREAKWATER - CDF12 - CPP FACILITY
Icebreaker Wind Demonstration Project



SIDE SCAN SONAR MOSAIC, LAKESIDE HDD ENTRY/EXIT
Icebreaker Wind Demonstration Project