PART 1 General

1.1 MEASUREMENT FOR PAYMENT

.1 Measurement for payment under this section, shall be as per Section 01 29 00 - Measurement for Payment.

1.2 RELATED WORK

.1 Section 01 33 00 - Submittal Procedures.

.2 Section 01 35 29.06 - Health and Safety Requirements.

.3 Section 01 35 43 - Environmental Procedures.

.4 Section 01 35 44 - Environmental Protection Plan.

.5 Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

1.3 DESCRIPTION OF WORK

.1 The work of this Section comprises the furnishing of all labour, materials and equipment necessary for all excavation, trenching, backfilling, compaction including saw cutting of existing asphalt paving and concrete surface, required to complete the work of this Contract, as specified in this Section and as shown on the Drawings.

.2 The requirements of the following Prince Edward Island, Department of Transportation and Infrastructure (DTI) Specifications are to be followed for all work relating to the material specifications for fill materials and bedding sand.

1.4 REFERENCES

.1 ASTM C117-13, Standard Test Method for Material Finer Than: 0.075mm Sieve in Mineral Aggregates by Washing.

.2 ASTM C136M-14, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

.3 ASTM D698-12e2, Test Method for Laboratory Compaction Characteristics of Soil using Standard Effort.

.4 ASTM D1557-12, Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort.

.5 CAN/ULC -S701-11, Thermal Insulation, Polystyrene, Boards and Pipe Covering.

1.5 DEFINITIONS

.1 Rock excavation: excavation of material from solid masses of igneous, sedimentary or metamorphic rock which, prior to its removal, was integral with its parent mass and was unable to be removed by a Caterpillar 235 Excavator, or equivalent, machine.

.2 Common excavation: excavation of materials of whatever nature, which are not included under the definition of rock excavation, including dense tills, hardpan, frozen materials and partially cemented materials which can be ripped and excavated with heavy construction equipment.

.3 Top Soil: Material capable of supporting good vegetative growth and suitable for use in top dressing, landscaping and seeding.

.4 Cohesionless soil: For compaction purposes, cohesionless soil is:

  .1 Materials having less than 20% passing 75 micrometres sieve, regardless of plasticity of fines.

.5 Cohesive soil: For compaction purposes, cohesive soil is soil not having properties to be classified as cohesionless.

1.6 <u>PROTECTION OF EXISTING FEATURES</u>

.1 Existing buried utilities and structures:

  .1 Size, depth and location of existing utilities and structures as indicated are for guidance only; completeness and accuracy are not guaranteed.

  .2 Prior to commencing any excavation work, notify applicable Departmental Representative or authorities, establish location and state of use of buried utilities and structures. Clearly mark such locations to prevent disturbance during work.

  .3 Confirm locations of buried utilities by careful test excavation.

  .4 Maintain and protect from damage, water, sewer, gas, electric or other utilities encountered. Obtain direction of Departmental Representative before moving or otherwise disturbing utilities or structures.

  .5 Where indicated re-route existing lines in area of excavation. Pay costs for such work.

  .6 Remove abandoned utility lines to distance of 1.5m from foundations. Cap or otherwise seal lines at cut-off points.

  .7 Record locations of maintained, re-routed and abandoned underground lines on "As-Built" drawings.

  .8 Make good and pay for damage to any lines resulting from work.

.2 Existing surface features:

  .1 Protect existing surface features which may be affected by work from damage while work is in progress and repair damage resulting from work.

  .2 Where excavation necessitates root or branch cutting do so only under direct control of Departmental Representative.

.3 Provide adequate protection around bench markers, layout markers, survey markers, geodetic monuments and signage.

1.7 SHORING, BRACING AND UNDERPINNING

.1 Comply with Section 01 35 29.06 - Health and Safety Requirements and applicable local regulations and to protect existing features.

.2 Whenever shoring, sheeting, timbering and bracing of excavations or underpinning is required engage services of a Professional Engineer registered in Canada, to design and assume responsibility for adequacy of shoring, bracing and underpinning.

.3 Design and supporting data submitted to bear the stamp and signature of qualified Professional Engineer registered in Canada.

1.8 COMPACTION DENSITIES

.1 Compaction densities indicated are Standard Proctor Maximum Dry Densities.

1.9 SITE CONDITIONS

.1 The Contractor is responsible to visit the site, assess the setting and become familiar with the existing site conditions.

.2 Before visiting the site the BIDDERS MUST APPLY FOR AND RECEIVE PERMISSION TO VISIT THE SITE from the Project Officer at Departmental Representative office.

.3 No extra payment will be made to the Contractor, above the Contract Price, for costs resultant from failure to determine the conditions that affect the work.

PART 2 Products

2.1 MATERIALS

.1 Crushed rock composed of hard sound, durable uncoated, cubical fragments of consistent quality produced from non-sedimentary bedrock or non-sedimentary boulders, to comply with the PEI Dept of TI&E Specification 401 - Aggregate, for Class "A" material graded within the following limits:

ASTM Sieve Size	Percent Passing
31.5mm0mm	100
25.0mm	95-100
12.5mm	50-83

4.75mm	30-60
1.18mm	15-40
600um	10-32
300um	5-22
75um	3-9

.2 Natural sand or crushed rock screening, free from clay, shale or organic matter, to comply with PEI Dept of TI&E Specification 402 - Bedding Sand, graded with the following limits.

ASTM Sieve Size	Percent Passing
9.5mm	100
4.75mm	87-98
2.36mm	55-95
1.18mm	30-90
600um	10-70
300um	0-35
150um	0-15
75um	0-8

.3 Select Borrow: to requirements of PEI Dept of TIE Specification #206.02.02 - Select Borrow as follows: Borrow shall be non-plastic and composed of clean, uncoated particles free from lumps of clay or other deleterious material with a maximum particle size of 100mm, and a maximum of 30% of the material passing the 4.75 sieve shall pass the 0.075 mm sieve.

.4 Crushed rock, composed of hard, sound, durable, uncoated, cubical fragments of consistent quality produced from non-sedimentary bedrock or non-sedimentary boulders, graded within the following limits, to comply with the PEI Dept of TI&E Specification 401 - Aggregate for Class "D" Material.

ASTM Sieve Size	Percent Passing
50.0mm	100
38.0mm	60-100
31.5mm	50-100
25.0mm	35-70
19.0mm	20-50
12.5mm	10-35
9.5mm	5-25
4.75mm	0-10

.5 Geotextile filter fabric: Refer to Section 31 32 21 - Geotextiles.

PART 3 Execution

3.1 SITE PREPARATION

.1 Remove obstructions, ice and snow, from surfaces to be excavated within limits indicated.
.2 Where applicable, strip topsoil from within limits of excavation and stockpile as directed by Departmental Representative, for re-spreading.
.3 Sawcut pavement or concrete neatly along limits of proposed excavation in order that surface may break evenly and cleanly.

3.2 STOCKPILING
.1 Stockpile fill materials in areas designated by Departmental Representative. Stockpile granular materials in manner to prevent segregation.
.2 Protect fill materials from contamination and freezing.

3.3 DEWATERING OF EXCAVATIONS
.1 Keep excavations free of water while work is in progress.
.2 Protect open excavations, trenches and completed installations against damage due to rainwater, surface run-off, spring water, groundwater, backing up of drains, sewers, flooding from watermains and all other water. Provide pumps, equipment and enclosures required for such protection.
.3 Dispose of water in a manner not detrimental to public and private property, or any portion of work completed or under construction, and in accordance with the requirements of the Environmental Protection Plan.
.4 All new and existing work damaged by failure to provide protection shall be removed and replaced with new work at the expense of the Contractor.

3.4 SAW CUTTING
.1 Existing pavement to be saw cut to produce neat, straight vertical cuts at interface between existing asphalt roadway and new pavement, where excavation meets with asphalt driveways, and at limits of Contract, or as directed by Departmental Representative.

3.5 EXCAVATION
.1 Excavate to lines, grades, elevations and dimensions indicated or required to construct roadways and to install site services.
.2 Remove demolished foundations, rubble and other obstructions encountered during excavation.
.3 Excavations must not interfere with normal 45° splay of bearing from bottom of any footing.
.4 Do not obstruct flow of surface drainage or natural watercourses.

.5 Earth bottoms of excavations to be dry undisturbed soil, level, free from loose or organic matter.

.6 Notify Departmental Representative when soil at bottom of excavation appears unsuitable and proceed as directed by Departmental Representative.

.7 Obtain Departmental Representative's approval of completed excavation.

.8 Remove unsuitable material from bottom of excavation to extent and depth directed by Departmental Representative.

.9 Where required due to unauthorized over-excavation, correct as follows:

  .1 Fill under other areas with Type 2 compacted to 98% density.

.10 Hand trim, make firm and remove loose material and debris from excavations. Where material at bottom of excavation is disturbed compact foundation soil to density at least equal to undisturbed soil.

.11 Rock excavation: For the purpose of bidding it is to be assumed that solid sandstone bedrock, as defined under Par. 1.4 above, will not be encountered during the work of this Section.

3.6 FILL TYPES AND COMPACTION

.1 Dimensions specified in following paragraphs are minimum dimensions of fill after compaction.

.2 Paved areas:

  .1 Use fill types and thickness as indicated on drawings. Compact sandstone (select borrow) sub-base and granular base to 100% SPMD.

.3 Slab-on-Grade:

  .1 Use Class 'A' gravel to underside of concrete areas compacted to 100% SPMD.

  .2 Use select borrow to minimum thickness of 300mm or as indicated on Drawings, or as required to achieve design grades. Compact to 100% SPMD.

3.7 BACKFILLING

.1 Do not proceed with backfilling operations until Departmental Representative has inspected and approved installations.

.2 Areas to be backfilled to be free from debris, snow, ice, water or frozen ground.

.3 Do not use backfill material which is frozen or contains ice, snow, or debris.

.4 Backfilling around site installations.

  .1 Place bedding and surround material as specified and indicated in applicable Section for service or utility to be installed.

.2 Do not backfill around or over cast-in-place concrete within 24 hours after placing.

.3 Place layers simultaneously on both sides of installed work to equalize loading.

.4 Where temporary unbalanced earth pressures are liable to develop on walls or other structures:

.1 Permit concrete to cure for minimum of 14 days or until it has sufficient strength to withstand earth and compaction pressure and approval has been obtained from Departmental Representative or;

.2 If approved by Departmental Representative erect bracing or shoring to counteract unbalance, and leave in place until removal is approved by Departmental Representative.

.5 Place material by hand under, around and over installations until 600mm of cover is provided, except where specifically permitted otherwise. Dumping material directly on installations will not be permitted.

.5 Place backfill material in uniform layers up to grades indicated. Compact each layer before placing succeeding layer. Use methods to prevent damage to installations.

3.8 RESTORATION

.1 Upon completion of work, remove surplus materials and debris, trim slopes and correct defects noted by Departmental Representative.

.2 Clean and reinstate areas affected by work to satisfaction of Departmental Representative.

3.9 SURPLUS MATERIAL

.1 Remove all surplus material from site, and pay all fees as may be charged at disposal site.

.2 Remove all soil contaminated with oil, gasoline, calcium chloride or other toxic or dangerous materials and dispose of in manner to minimize danger at site and in a manner and to a location off site approved by Provincial Authority governing such disposal.

END OF SECTION

PART 1 General

1.1 MEASUREMENT FOR PAYMENT

.1 Geotextile filter fabric will be measured in square metres of material incorporated in this work.

.2 Supply and installation of accessories and other attachments will not be measured but considered incidental to work.

1.2 RELATED WORK

.1 Section 31 23 10 - Excavating, Trenching and Backfilling.

1.3 REFERENCES

.1 CAN/CGSB-4.2-2004 (2013), Textile Test Methods.

.2 CAN/CGSB-148.1-92, Methods of Testing Geotextiles and Geomembranes.

.3 ASTM D4595-11, Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method.

.4 ASTM D4751-99a, Test Method for Determining the Apparent Opening Size of a Geotextile.

1.4 DELIVERY AND STORAGE

.1 During delivery and storage, protect geotextiles from direct sunlight, ultraviolet rays, excessive heat, mud, dirt, dust, debris and rodents.

PART 2 Products

2.1 MATERIALS

.1 Geotextile: non-woven synthetic fibre fabric, supplied in rolls of minimum 3.5 meters width and in one length.

.2 Synthetic fibre to be rot proof, unaffected by action of oil or salt water and not subject to attack of insects or rodents.

.3 Seams or joints to be constructed in accordance with manufacturer's recommendations.

.4 Thread for sewn seams: equal or better resistance to chemical and biological degradation than geotextile.

.5 Physical properties:

- .1 Thickness: minimum 2.54 mm.
- .2 Mass per unit area: minimum 600 g/m^2.
- .3 Tensile strength and elongation (in any principal direction):
  - .1 Tensile strength: minimum 1000 N, wet condition.
  - .2 Elongation at break: 50%.
  - .3 Mullen burst strength: minimum 3600 kPa.

.4 Apparent opening size (AOS): 50 to 250 micrometres.

.6 Securing pins and washers: to CAN/CSA-G40.21, Grade 300W, hot-dipped galvanized with minimum zinc coating of 600 g/m^2 to CSA G164.

PART 3 Execution

3.1 INSTALLATION

.1 Place geotextile material by unrolling onto graded surface and against panels in orientation, manner and locations indicated and retain in position with weights.

.2 Place geotextile material smooth and free of tension stress, folds, wrinkles and creases.

.3 Place geotextile material on sloping surfaces in one continuous length from toe of slope to upper extent of geotextile.

.4 Place geotextile material behind concrete panel surfaces in one continuous length from bottom of harbour to upper extent of panels as indicated.

.5 Overlap each successive strip of geotextile 600 mm over previously laid strip.

.6 Protect installed geotextile material from displacement, damage or deterioration before, during and after placement of material layers.

.7 Replace damaged or deteriorated geotextile to approval of Departmental Representative.

3.2 PROTECTION

.1 Do not permit passage of any vehicle directly on geotextile at any time.

END OF SECTION

PART 1 General

1.1 MEASUREMENT PROCEDURES

.1 No separate measurement for payment will be made under this section. Include costs in piling items.

1.2 RELATED SECTIONS

.1 Section 31 23 10 - Excavating, Trenching and Backfilling.

.2 Section 31 62 16.13 - Steel Sheet Piles

1.3 DELIVERY, STORAGE AND HANDLING

.1 Deliver and handle steel sheet piling in accordance with Section 31 62 16.13.

.2 Protect piles from damage due to excessive bending stresses, impact, abrasion or other causes during delivery, storage and handling.

.3 Replace damaged piles to satisfaction of Departmental Representative.

.4 Load transport and deliver piles.

.5 Supply piles as required to complete work.

1.4 PROTECTION

.1 Protect public and construction personnel, adjacent structure, services and work of other sections from hazards due to pile driving operations.

1.5 EXISTING CONDITIONS

.1 Sub-surface investigation reports are included in the Specification following Division 31.

.2 Notify Departmental Representative in writing if subsurface conditions at site differ from those indicated and await further instructions from Departmental Representative.

1.6 SCHEDULING OF WORK

.1 Submit schedule of planned sequence of driving to Departmental Representative and Departmental Representative for review, not less than 2 weeks prior to commencement of pile driving.

1.7 SUBMITTALS

.1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.

PART 2 Products

2.1 MATERIALS

.1 Material requirements for piles are specified in Section

31 62 16.13.

.2 Supply full length piles and provide equipment of sufficient capacity to handle full length piles without cutting and splicing.

.3 Piles to be driven to bedrock and as required by Geotechnical investigation and indicated on drawings.

.4 Do not splice piles without written permission of Departmental Representative.

PART 3 Execution

3.1 EQUIPMENT

.1 Prior to commencement of pile installation, submit to Departmental Representative for approval, details of equipment for installation of piles.

.2 Hammer: Use hammers capable of developing a blow at operating speed with sufficient energy to drive tip of piles to required penetration. For Impact Hammer, provide manufacturer's name, type, rated energy per blow at normal working rate, mass of striking parts of hammer and mass of driving cap. For non-impact methods of installation such as auguring, jacking, vibratory hammers or other means, give full details of characteristics necessary to evaluate performance.

.3 Leads: Construct pile driver leads to provide free movement of hammer. Hold leads in position at top and bottom, with guys, stiff braces, or other means approved means, to ensure support to pile while being driven.

3.2 PREPARATION

.1 Prior to commencement of pile installation inspect the harbour bottom for obstructions, and clear obstructions found on the pile installation alignment.

.2 Ensure that ground conditions at pile locations are adequate to support pile driving operation. Make provision for access and support of piling equipment during performance of work.

.3 Protect adjacent structures, services and sites.

3.3 FIELD MEASUREMENT

.1 Maintain accurate records of driving for each pile, including:

- .1 Type and make of hammer, stroke or related energy.
- .2 Other driving equipment including water jet, driving cap, cushion.
- .3 Pile size, length and location.
- .4 Sequence of driving piles in group.

.5 Number of blows per metre for entire length of pile and number of blows per 100mm for last 1000mm.
.6 Final tip and cut-off elevations.
.7 Other pertinent information such as interruption of continuous driving, pile damage.
.8 Record elevation taken on adjacent piles during driving of each pile.
.9 Provide Departmental Representative with three copies of records.

3.4 DRIVING

.1 All piles must be driven to established resistance in one continuous operation to avoid freeze.
.2 Use driving caps and cushions to protect piles. Reinforce pile heads if necessary. Piles with damaged heads will be rejected by Departmental Representative.
.3 Hold piles securely and accurately in position while driving.
.4 Deliver hammer blows along axis of pile.
.5 Do not drive piles within 8m of concrete which has been in place less than 3 days.
.6 Ensure no contact between pile and structure takes place when driving batter piles adjacent to existing structures.
.7 Redrive piles lifted during driving of adjacent piles.
.8 Remove loose and displaced material from around piles after completion of driving, and leave clean, solid surfaces to receive foundation concrete.
.9 Use of water jet not permitted.
.10 Cut off piles neatly and squarely at elevations as indicated. Provide sufficient length above cut-off elevation so that part damaged during driving is cut off.
.11 Remove cut-off lengths from site on completion of work.

3.5 CAPACITY AND PENETRATION

.1 Required pile penetration depth to refusal and as indicated.
.2 Installation of each pile will be subject to approval of Departmental Representative. Departmental Representative will be sole judge of acceptability of each pile with respect to final driving resistance, depth of penetration or other criteria used to determine capacity and penetration depth.
.3 Drive each pile to bedrock and to pile tip elevation as indicated. Do not overdrive to cause damage to piles in bedrock. Departmental Representative will determine refusal criteria for piles driven to rock based on type

of piles and driving equipment.

.4 Virtual refusal is defined as ten (10) blows per 25mm with an approved pile hammer by the Departmental Representative.

.5 Refer to geotechnical investigation following Division 31 for soil conditions and recommendations.

3.6 TEST PILES

.1 With a view to determining the required lengths of the piling requirements the contractor may, at his discretion, carry out test driving of piles. The location and number of test piles is left to the discretion of the contractor.

3.7 DRIVING TOLERANCES

.1 Install piles to the following tolerances: pile heads to be within 50mm of locations shown on drawing and where required to permit installation of concrete pile caps.

.2 Top of piles to be aligned to approval of Departmental Representative. Take measure to correct alignment as required.

3.8 DAMAGED OR DEFECTIVE PILES

.1 Departmental Representative will reject any pile that is driving out of position, twisted or is damaged during driving or handling.

.2 Remove rejected pile and replace with a new, and if necessary, a longer pile.

.3 No extra compensation will be made for removing and replacing or other work made necessary through rejection of defective piles.

END OF SECTION

PART 1 General

1.1 MEASUREMENT PROCEDURES

- .1 Refer to Section 01 29 00 - Measurement for Payment.

1.2 RELATED SECTIONS

- .1 Section 31 61 13 - Pile Foundations, General.

1.3 REFERENCES

- .1 ASTM International
  - .1 ASTM A6/A6M-17, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
  - .2 ASTM A325, Standard Specification for Structural Bolts, 120 KSI Tensile.
  - .3 ASTM A1011/A1011M-10, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, and Ultra High Strength.
  - .4 ASTM A328/A328M-13a (2018), Standard Specification for Steel Sheet Piling.
  - .5 ASTM A857/A857M-07 (2013), Standard Specification for Steel Sheet Piling, Cold Formed, Light Gage.
- .2 CSA International
  - .1 CSA G40.20/G40.21-13 (R2018), General Requirements for Rolled or Welded Structural Quality Steel/ Structural Quality Steel.
  - .2 CSA W47.1-09 (R2014), Certification of Companies for Fusion Welding of Steel Structures.

1.4 ACTION AND INFORMATIONAL SUBMITTALS

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
  - .1 Submit manufacturer's instructions, printed product literature and data sheets for piles and include product characteristics, performance criteria, physical size, finish and limitations.
- .2 Submit shop drawings for the following items:
  - .1 A plan layout of sheet piling sections indicating all dimensions.
  - .2 Details of the sheet piling sections.
  - .3 Layout and details of the waler indicating location of splices, splice details, tie bolt details and sheet washer plate details.
  - .4 Details of steel tie rods, steel plate washers, nuts, lock nuts and couplers.

.3 Certificates:
 .1 Submit 2 weeks prior to fabrication, 2 copies of steel producer certificates in accordance with ASTM A1011/A1011M, and mill test reports in accordance with CSA G40.20/G40.21.
 .2 Submit copy of certification for fusion welding in accordance with CSA W47.1.

1.5 QUALITY ASSURANCE
.1 Inspection and testing of steel sheet piling material will be carried out by testing laboratory designated by Departmental Representative at any time during course of Work.
.2 Materials inspected or tested by Departmental Representative which fail to meet contract requirements will be rejected.
.3 Where tests or inspections by designated testing laboratory reveal Work not in accordance with contract requirements, Contractor to pay costs for additional tests and/or inspections.

1.6 DELIVERY, STORAGE AND HANDLING
.1 Deliver, store and handle materials in accordance with manufacturer's written instructions.
.2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
.3 Storage and Handling Requirements:
 .1 Store materials in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area. Store and protect sheet piles from nicks, scratches, and blemishes.
 .2 Replace defective or damaged materials with new.
.4 Use slings for lifting piling, and ensure mass is evenly distributed such that piling is not subjected to excessive bending stresses.
.5 Protect piles from damage due to excessive bending stresses, impact, abrasion or other causes during delivery, storage and handling.
.6 Replace or repair damaged piles with steel to CSA G40.20/ G40.21.
.7 Store sheet piling on level ground or provide supports so that sheet piling is level when stored.
 .1 Provide blocking at spacing not exceeding 5 m so that there is no excessive sagging in piling.
 .2 Overhang at ends not to exceed 0.5 m.
 .3 Block between lifts directly above blocking in lower

lift.

.8 If material is stock-piled on structure, ensure structure is not overloaded.

PART 2 Products

2.1 MATERIALS

.1 Steel sheet piles: to CSA G40.2, Grade 350W, and following:

.2 Continuous interlocking Z section:
- .1 Minimum effective section modulus: 2,601 cm3/wall m.
- .2 Minimum sheet thickness: 12.2 mm.
- .3 Minimum section area = 131.0 cm2
- .4 Interlocks: to be such that section of interlock bar of 1 m minimum length will pass along full length of pile without binding.
- .5 Mark each piece of sheet piling legibly by stenciling or die-and-stamping with information as follows:
  - .1 Heat number.
  - .2 Manufacturer's name.
  - .3 Length and section number. Do not precut lifting or slinging holes in sheet piles.

.3 Structural steel for wales, bearing plates, wales splices, steel pipes, capping channels, support angles and miscellaneous steel: to CSA G40.21, Grade 350 W.

.4 Tie rods, sleeve nuts and turnbuckles:
- .1 Tie rods: diameter as indicated on Drawings, to ASTM A615, Grade 520.
- .2 Tie rods: to continuously threaded bar with double corrosion protection.
- .3 Sleeve nuts, to have load capacity in excess of capacity of tie rod.
- .4 Preassemble, mark and test tie rod assemblies in shop. Align threaded connection to following tolerances at sleeve nut or connector sleeve: 1/80 of normal rod diameter, deviation of centreline, 1 in 160.

.5 Nuts and bolts: hexagon nuts, bolts, and washers: to ASTM F3125 Grade 325.

.6 Backfill material: to Section 31 23 10 - Excavating, Trenching and Backfilling.

2.2 SOURCE QUALITY CONTROL: HOT ROLLED SHEET STEEL PILING

.1 Provide results of tests of sheet piling material to be used on project as follows:

.1 One tension test and 1 bend test from each heat for quantities of finished material less than 50 tonnes.
.2 Two tension tests and 2 bend tests from each heat for quantities of finished material exceeding 50 tonnes.

.2 Tension tests in accordance with CSA G40.20/G40.21. Bend tests: to ASTM A6/A6M.

PART 3 Execution

3.1 EXAMINATION

.1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for steel sheet piles installation in accordance with manufacturer's written instructions.
.1 Visually inspect substrate in presence of Departmental Representative.
.2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
.3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Departmental Representative.

3.2 INSTALLATION

.1 Do pile installation Work in accordance with Section 31 61 13 - Pile Foundations, General except where otherwise specified.
.2 Do welding in accordance with CSA W59.
.3 Do not begin pile installation until required quality control tests have been completed and test results approved by Departmental Representative.
.4 Submit full details of method and sequence of installation of piling to Departmental Representative for approval prior to start of pile installation work. Details must include templates, bracing, setting and driving sequence and number of piles in panels for driving.
.5 When installation is complete, face of wall at top of sheet piles to be within 75 mm of location as indicated and deviation from vertical not to exceed 1 in 100.
.6 Maintain piles in specified alignment and position until connection to permanent tie rod anchorage system is made.

3.3 OBSTRUCTIONS

.1 If obstruction encountered during driving, leave obstructed pile and proceed to drive remaining piles. Return and attempt to complete driving of obstructed pile later.

.2 Advise Departmental Representative immediately if impossible to drive pile to full penetration, and obtain direction from Departmental Representative on further steps required to complete Work.

3.4 CUTTING

.1 When flame cutting tops of piles, and flame cutting holes in piles approved by Departmental Representative, use following procedure:

- .1 When air temperature is above 0 degrees C, no pre-heat is necessary.
- .2 When air temperature is below 0 degrees C, pre-heat until steel 25 mm on each side of line of cut has reached a temperature very warm to hand (approximately 35 degrees C). Temperature indicating crayon marks may be used to measure temperature.
- .3 Use torch guiding device to ensure smooth round holes or straight edges.
- .4 Make cut smooth and free from notches throughout thickness. If grinding is employed to remove notch or crack, finished radius to be minimum 5 mm.

3.5 TIE ROD ANCHORAGE SYSTEM

.1 Support tie rods at intervals along their length.

.2 Fit and adjust tie rod systems so that connections at both waling ends of tie rods are tight before backfilling.

.3 Brace steel sheet pile with waling strips in accordance with shop drawings. Make wales one length between corners and bolt to piles.

3.6 WHARF CLOSURE

.1 Install wharf closure to details indicated on drawings.

.2 Fill top walers with concrete to the details shown on drawings.

3.7 BACKFILLING

.1 Backfill in accordance with Section 31 23 10 - Excavating, Trenching and Backfilling and as indicated.

.2 Protect piling tie rods anchorage system from damage or displacement during backfilling operations.

3.8 WORK ON VICINITY OF STRUCTURES

.1 Care must be taken when carrying out construction operations adjacent to existing dockwalls and structures to avoid any damage or undercutting. Repair and make good any damage at no cost to Departmental Representative.

3.9 COOPERATION AND ASSISTANCE

.1 Furnish use of such boats, equipment, labour and materials as may be reasonably necessary to allow Departmental Representative to inspect, monitor and supervise work. Equip boats with approved life jackets, navigation lights and all other safety devices required.

.2 Cooperate with Departmental Representative on inspection and monitoring work, and provide assistance as requested.

3.10 MONITORING OF WORK

.1 Contractor is responsible to monitor effectiveness and productivity of his own work on an ongoing basis.

.2 Contractor to identify and demonstrate effectiveness of proposed monitoring methods prior to commencement of work.

END OF SECTION

GEOTECHNICAL REVIEW
PROPOSED BREAKWATER RECONSTRUCTION (STRUCTURE 305)
GRAHAM'S POND SMALL CRAFT HARBOUR, KINGS COUNTY, PEI

JOOSE ENVIRONMENTAL PROJECT NO. JE0160-A

JOOSE ENVIRONMENTAL

Joose Environmental Consulting Inc.
P.O. Box 19
North Wiltshire PE C0A 1Y0

March 29, 2016

Joose Environmental Project No. JE0160-A

Ms. Brenda Victor, P. Eng., Project Manager
Public Works and Government Services Canada
3 Queen Street (Cambridge Building)
PO Box 1268
Charlottetown PE C1A 8R4

Dear Ms. Victor:

Reference: Geotechnical Review - Proposed Breakwater Reconstruction (Structure 305)
Graham's Pond Small Craft Harbour, Kings County, Prince Edward Island

Introduction

This report presents the results of the geotechnical review carried out for the above-noted project, in accordance with your request. The purpose of the review was to assess all available geotechnical information for the specified area of the subject site and to compile all of the pertinent data into this summary report.

For the purposes of our review, we have assumed that that the existing geotechnical information serves as a good representation of the present conditions, and we have provided our comments and preliminary recommendations accordingly.

Methodology

The available information reviewed for this project consisted of:

- Jacques Whitford Report No. 2636, issued December 1982;
- WS Langley Report No. L580, issued December 1983;
- Jacques Whitford Report No. 71595, issued September 2002; and
- Jacques Whitford Report No. 71647, issued June 2003.

Five (5) of the boreholes, BH 1, BH 17, BH 21, BH 22, and BH 103 that were drilled in close proximity to Structure 305 during the above noted investigations, were used for this report .

The Jacques Whitford boreholes, BH 22, BH 1 and BH 103, were drilled at the site in 1982, 2002, and 2003, respectively. The WS Langley boreholes (BH 17 and BH 21) were drilled at the site in 1983. All five (5) boreholes were undertaken using a drill rig mounted on a floating barge platform. The boreholes were advanced to depths ranging from 8.5 to 15.1 m below harbour bottom. The borehole locations are shown in relation to Structure 305 on the appended Drawing No. 1.

Samples of the overburden soils encountered were taken at regular intervals by means of a conventional split spoon sampler during the performance of Standard Penetration Tests (SPT). Bedrock was proven at each borehole location, with the exception of BH 22, by rotary core drilling in BX-size (42 mm core diameter) or NQ-size (48 mm core diameter)

The original Borehole Records for BH 1, BH 103, are BH 22, showing the subsurface conditions encountered at the site and the sampling/testing carried out, are included in the Appendix. Although Borehole Records for BH 17 and BH 21 were not available, the conditions encountered at these two locations were obtained from a drawing excerpt (Public Works Canada, Harbour Reconstruction Graham's Pond, Reconstruction of North Breakwater, Drawing No. 1 of 8, dated January 13, 1984).

The elevations for BH 22 (Jacques Whitford Report No. 2636) are referenced to LWOST (low water of ordinary spring tides). LWOST datum is essentially synonymous to Low Normal Tide (LNT) Datum and Chart Datum. The elevations for BH 1 (Jacques Whitford Report No.71595) were initially determined with respect to an Assumed Datum but this has been adjusted to LNT Datum for ease of reference. LNT/Chart Datum are more commonly used today, and are therefore used within this report.

Subsurface Conditions

The subsurface conditions encountered at the boreholes are described below and are shown in detail on the appended Borehole Records, with a summary provided on Table 1 (also appended). The subsurface conditions encountered at the site are also depicted on the Stratigraphic Section included on Drawing No. 1 in the Appendix.

For the purposes of this report, the compact gravelly sand layer (BH 22) and the compact silty sand layer (BH 17 and BH 21) have been designated as till.

<u>Marine Deposit</u>

Marine deposited soils, ranging in composition from sand to organic silt were encountered at the surface (i.e., harbour bottom) at each borehole location. The total thickness of the marine deposit was found to range from 1.7 m at BH 17 to 8.4 m at BH 1.

Standard Penetration Test N-values within the marine deposit were found to range from 0 (i.e., sampler sunk under weight of rods) to 29 indicating highly variable, very loose/very soft to compact, conditions.

Following is a summary of the various marine soil layers encountered at the boreholes with the corresponding N-values and the relative density/consistency (the borehole information is presented from west to east across the site):

Borehole No.	Depth/Marine Soil Description	N-value(s)	Relative Density/Consistency
BH 22	0.0 to 2.0 m - grey brown silty sand, organics, shells	1	Very Loose
BH 17	0.0 to 1.5 m - silty sand, some organics	-	Very Loose (inferred)
	1.5 to 1.7 m - grey organic silt	-	Very Soft (inferred)

Borehole No.	Depth/Marine Soil Description	N-value(s)	Relative Density/Consistency
BH 21	0.0 to 5.5 m - grey organic silt, trace sand	2/2	Very Soft
BH 103	0.0 to 2.9 m - greyish brown sand, trace to some silt, gravel, sandstone cobbles, trace shell fragments	29/13/13/3	Compact to Very Loose
	2.9 to 5.9 m - olive grey sandy clayey silt, trace shell fragments, organic matter	2/0	Soft to Firm
	5.9 to 7.8 m - reddish brown sand, trace to some silt, gravel	15/13/14	Compact
BH 1	0.0 to 2.3 m - brown to dark grey sand, some silt, trace shell fragments	7/8	Loose
	2.3 to 4.4 m - olive grey sandy clayey silt, trace shell fragments, organic matter	1/1	Very Soft
	4.4 to 8.4 m - reddish brown sand, trace to some silt, gravel	27/16	Compact

A grain size analysis carried out on a sample of the clayey silt recovered from BH 1 shows this material to contain 1 percent gravel, 27 percent sand, and 72 percent fines (silt and clay sizes). An Atterberg Limit determination performed on the same sample shows the clayey silt to contain fines of high plasticity based on liquid and plastic limits of 94 percent and 50 percent, respectively. The natural moisture content of selected samples of the clayey silt recovered from BH 1 and BH 103 was found to range from 59 to 85 percent with an average of 73 percent.

To assess the undrained shear strength of the clayey silt, field vane tests and laboratory penetrometer tests were carried out on samples recovered from BH 103. The results of the field vane tests are shown on the appended Borehole Record and show the insitu shear strength (undrained) to range from 24 to 96 kPa with an average of 60 kPa. The results of the laboratory penetrometer tests show the undrained shear strength to range from 22 to 31 kPa with an average of 26 kPa.

The following parameters may be assigned to the clayey silt/organic silt:

Total Unit Weight	17 kN/m^3
Submerged Unit Weight	7 kN/m^3
Effective Friction Angle	28 degrees
Undrained Shear Strength	25 kPa

A grain size analysis carried out on a sample of the compact reddish brown sand recovered from BH 1 shows it to contain 15 percent gravel, 70 percent sand, and 15 percent fines. The sand sample was found to have a natural moisture content of 14 percent.

The following parameters may be assigned to the very loose to loose sand/silty sand and the compact sand/silty sand layers:

	Very Loose to Loose Sand/Silty Sand	Compact Sand/Silty Sand
Total Unit Weight	18 kN/m^3	21 kN/m^3
Submerged Unit Weight	8 kN/m^3	11 kN/m^3
Effective Friction Angle	28 degrees	32 degrees

Glacial Till

A glacial till stratum, generally comprised of reddish brown silty sand, was encountered below the marine soils at each borehole location. The till contains varying amounts of gravel, sandstone cobbles/layers and occasional clay partings. The thickness of the till stratum was found to range from 1.2 m at BH 1 to in excess of 6.5 m at BH 22. The elevation of the till surface was found to range from a low of el. -10.16 m at BH 1 to a high of el. -2.72 m at BH 17. The till surface profile is depicted on the appended stratigraphic section.

The N-values obtained within the till were found to range from 10 to in excess of 50 with an overall average of 23 (excluding the >50 values) indicating a variable, but predominantly compact, relative density. The greater than 50 N-values may be attributed to the presence of gravel, and sandstone cobbles/layers within the till.

Grain size analyses performed on split spoon samples of the till recovered from other boreholes located in the general vicinity of Structure 305 show it to contain an average of 18 percent gravel, 55 percent sand, and 27 percent fines. Selected till samples were found to have an average natural moisture content of 12 percent.

The following parameters may be assigned to the till stratum for design purposes:

Total Unit Weight	22 kN/m^3
Submerged Unit Weight	12 kN/m^3
Effective Friction Angle	32 degrees

Bedrock

Sandstone bedrock was encountered directly below the till stratum at each borehole location with the exception of BH 22 which was terminated within the till. The depth below the harbour bottom to the bedrock surface was found to range from 7.6 m at BH 21 to 9.7 m at BH 103. The elevation of the bedrock surface was found to range from a high of el. -8.58 m at BH 21 to a low of el. -11.33 m at BH 1. The bedrock surface profile is depicted on the appended stratigraphic section.

The rock core recovered consisted predominantly of sandstone with occasional mudstone partings/seams/ layers. The bedrock is horizontally bedded with extremely close (< 20 mm) to close (60 to 200 mm) joints which predominantly occur along the bedding planes. An average RQD (Rock Quality Designation) value of 14 indicates very poor quality, very severely fractured bedrock.

The following parameters may be assigned to the bedrock for design purposes:

Total Unit Weight	23 kN/m^3
Submerged Unit Weight	13 kN/m^3
Effective Friction Angle	35 degrees

Discussion and Recommendations

It is understood that the original breakwater consisted of a timber pile wharf which was replaced primarily with a double walled steel sheet pile (SSP) structure in 1984; a tied back SSP was utilized for the west end of the structure. It is assumed that the proposed reconstruction will likely involve a similar sheet pile or steel pile-supported structure.

The presence of compressible marine soils along the full length of Structure 305 would pose a problem if any new fills (e.g., armour protection) are to be placed near the wharf. If left in place, the compression of this soil under the weight of new fills will subject the wharf structure to high lateral loads that must be accounted for in the wharf design. Furthermore, since none of the existing boreholes were drilled through the existing wharf and fill, the presence/condition of the marine soil within the wharf footprint is not known. Depending on the design details for the new wharf, it may be prudent to drill some boreholes through the existing wharf fill to obtain design parameters for the marine soil.

In the event that new fills are to be placed at the site, the removal of the compressible marine soils, to the depth of more competent soil, would be recommended. Other concerns associated with leaving this soil in place could include:

- settlement of the new infill/wharf deck;
- over-stressing of the tie-rods; and
- downdrag loads on the piles.

Preliminary recommendations are provided below for the design and construction of SSP and pile-supported wharf structures based on the available subsurface information. More specific geotechnical design input can be provided, if requested, during the design stage for this project.

Steel Sheet Piling

The penetration of steel sheet piling into the sandstone bedrock is difficult to predict and would likely be variable. A review of the Department's construction records for the existing wharf may be beneficial to estimate the expected SSP penetration into bedrock. It is recommended that steel sheet piling be installed using a pile driving hammer with a rated energy of 450 joules per cm^2 of pile cross-sectional area.

As noted above, the presence of potentially compressible soils within the wharf footprint could represent a lateral loading and settlement concern. Although such soils located within the present wharf footprint should have compressed and gained some strength under the weight of the existing fills, their present condition is unknown. The potential lateral loading and settlement concerns associated with the marine soil would be minimized if existing grades are maintained (i.e., no new fill loads applied).

Geotechnical parameters for preliminary bulkhead design are provided in the following section.

Design Parameters

The following geotechnical design parameters may be assigned to the various strata encountered for preliminary bulkhead design. These parameters would also be applicable in the case of a pile supported wharf that is subjected to a lateral fill loading.

Parameter/Soil Type	Marine (clayey silt/organic silt)	Marine (very loose/loose sand/silty sand)	Marine (compact sand/silty sand)	Glacial Till	Bedrock (Sandstone)
Total Unit Weight, kN/m^3	17	18	21	22	23
Submerged Unit Weight, kN/m^3	7	8	11	12	13
Effective Friction Angle, degrees	28	28	32	32	35[2]
Undrained Shear Strength, kPa	25	-	-	-	-
Active Earth Pressure Coefficient, Ka	0.36	0.36	0.31	0.31	0.27
Passive Earth Pressure Coefficient, Kp[1]	2.77	2.77	3.25	3.25	3.70

Notes:
[1] neglecting the effects of wall friction
[2] based on bedrock zone fragmented by pile penetration
Ka and Kp values provided are based on a vertical wall and horizontal backfill

Pile-Supported Structure

For the conditions encountered, steel piles (H or pipe) could be considered for use at the site. It is expected that piles would be driven to/into the underlying sandstone bedrock to develop the required capacity. Timber piles could also be considered but would likely be a less appropriate alternative in view of the various obstructions associated with the previous site structure. Such obstruction (e.g., timber members) could also result in some difficult driving areas for steel piles.

Steel piles should be driven using a hammer with a rated energy of at least 350 J/cm^2 of net steel cross sectional area. Previous experience has shown that an actual delivered energy in the order of 200 J/cm^2 is required to attain the allowable contact stress/bearing pressures given below. Refusal may be taken as 10 blows for the last 25 mm of pile penetration.

Actual penetration depths of steel piles into the sandstone bedrock will depend on the driving energy delivered and the bedrock condition/strength at the pile locations. Previous experience has shown that penetration depths can vary significantly from site to site or within the same site, depending on the rock quality and strength, and can range from less than 1 m to 2 m or more.

The vertical capacity of steel piles driven to refusal, as defined above, may be determined using an allowable contact stress of 50 MPa (based on net steel area) for steel H and open end pipe piles. An allowable bearing pressure of 7 MPa may be used for design of closed end pipe piles (based on gross end area).

Re-tapping of some piles (e.g., 20 percent) within a 48-hour period is recommended to assess relaxation effects, and the requirement to re-tap additional piles.

The settlement of piles installed as outlined above and proportioned for the expected loads would be negligible. For the analysis of lateral resistance, an effective pile width of two times the pile diameter may be used.

For driven piles, some uplift resistance will be obtained through shaft friction (typically 50 percent of the shaft friction available in compression is assumed for uplift). The actual magnitude of the uplift resistance would depend on the type/size of the pile selected for use and the depth driven. Additional uplift resistance, if required, could be obtained through the use of socketed piles and/or rock anchors.

Closing Comments

It is important to note that, although the available information was obtained by reputable geotechnical firms, two of the previous investigations were undertaken over 30 years ago. It is possible that some conditions may have changed at the site as a result of natural processes such as sedimentation or scour, or human activities such as infilling or dredging. It is recommended that the Department's records be reviewed to determine if any such activities may have occurred, or are suspected to have occurred. Furthermore, as discussed previously, none of the existing boreholes were drilled through the wharf to permit an assessment of the presence/condition of potentially compressible marine soils below the fill.

Some additional boreholes may be necessary at this site depending on the design details for the new structure and on the review of the Department's records as noted above. It is important to note that since the available geotechnical information was obtained by others, we cannot attest to the correctness or present day relevance of this information.

We trust this letter contains all of the information required at this time, and we are available at your convenience should you have any questions. We would be pleased to provide further geotechnical input for this project on an as required, as requested basis.

Sincerely,

JOOSE ENVIRONMENTAL CONSULTING INC.

George W. Zafiris, P. Eng.
Geotechnical Engineer
georgez@bellaliant.net

GWZ/g

APPENDIX

The following information is intended to assist in the interpretation of terms and symbols used on the borehole logs, test pit logs and reports.

Soils Description

Terminology describing common soil genesis:

Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Modified Unified Soil Classification System (MUSCS) and in accordance with the Canadian Foundation Engineering Manual Fourth Edition (Canadian Geotechnical Society, 2006). The classification excludes particles larger than 75 mm (3 inches). The MUSCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

The list on the following table provides an explanation of terms and symbols used on the geotechnical borehole, test pit and penetrometer logs.

Test Results				Test Symbols	
PI	Plasticity Index	c'	Effective Cohesion	DCP	Dynamic Cone Penetrometer
LL	Liquid Limit	c_u	Undrained Cohesion	SPT	Standard Penetration Test
LI	Liquidity Index	c'_R	Residual Cohesion	CPTu	Cone Penetrometer (Piezocone) Test
DD	Dry Density	φ'	Effective Angle of Internal Friction	PANDA	Variable Energy DCP
WD	Wet Density	φ_u	Undrained Angle of Internal Friction	PP	Pocket Penetrometer Test
LS	Linear Shrinkage	φ'_R	Residual Angle of Internal Friction	U50	Undisturbed Sample 50 mm (nominal diameter)
MC	Moisture Content	c_v	Coefficient of Consolidation	U100	Undisturbed Sample 100mm (nominal diameter)
OC	Organic Content	m_v	Coefficient of Volume Compressibility	UCS	Uniaxial Compressive Strength
WPI	Weighted Plasticity Index	$C_{\alpha\varepsilon}$	Coefficient of Secondary Compression	Pm	Pressuremeter

Test Results				Test Symbols	
WLS	Weighted Linear Shrinkage	e	Voids Ratio	FSV	Field Shear Vane
DoS	Degree of Saturation	φ'_{cv}	Constant Volume Friction Angle	DST	Direct Shear Test
APD	Apparent Particle Density	q_t / q_c	Piezocone Tip Resistance (corrected / uncorrected)	PR	Penetration Rate
s_u	Undrained Shear Strength	q_d	PANDA Cone Resistance	A	Point Load Test (axial)
q_u	Unconfined Compressive Strength	$I_{s(50)}$	Point Load Strength Index	D	Point Load Test (diametral)
R	Total Core Recovery	*RQD*	Rock Quality Designation	L	Point Load Test (irregular lump)

Sample Type

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameters tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ,NQ, BQ, etc	Rock core samples obtained with the use of standard size diamond coring bits.

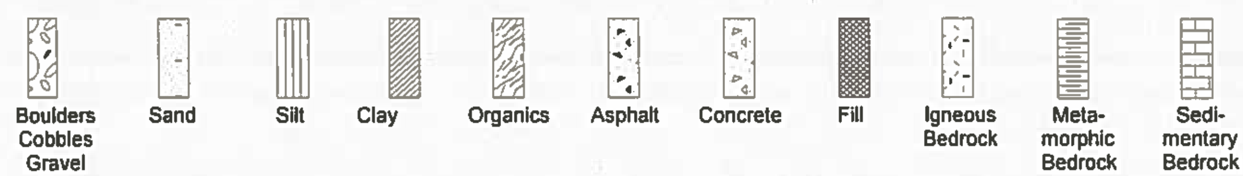
Water Level Measurement

▼ Measurement in standpipe, piezometer, or well

▽ Inferred

Strata Plot

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



BOREHOLE RECORD

BOREHOLE No. 22

CLIENT Public Works Canada

LOCATION Graham's Pond, Prince Edward Island

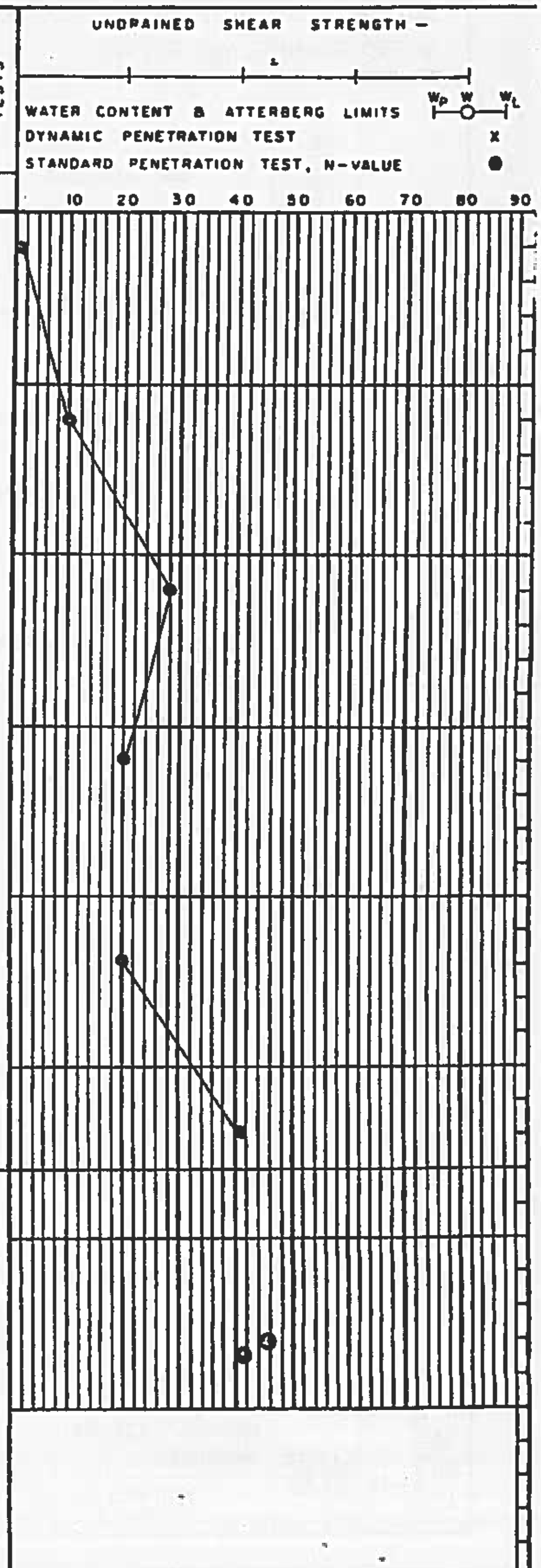
DATES: BORING December 1, 1982 WATER LEVEL

PROJECT No. 2636

CASING SIZE B

DATUM LWOST

DEPTH (FT.)	DEPTH (M)	ELEVATION m	SOIL DESCRIPTION	SAMPLES TYPE	NUMBER	RECOVERY mm	N-VALUE OR RQD %	OTHER TESTS
0	0	-0.76	Very loose, grey brown, SILTY SAND, organics, shells	SS	1	280	1	
5	1							
	2	-2.77	Medium dense GRAVELLY SAND, trace of silt, sandstone fragments interspersed throughout	SS	2	610	10	
10	3			SS	3	610	28	
15	4							
	5			SS	4	150	20	
20	6							
	7			SS	5	430	20	
25	8	-9.30		SS	6	406	41	
30	9		End of borehole					



BOREHOLE RECORD

BOREHOLE No.: 1

PROJECT No.: 71595

CLIENT: Public Works and Government Services Canada

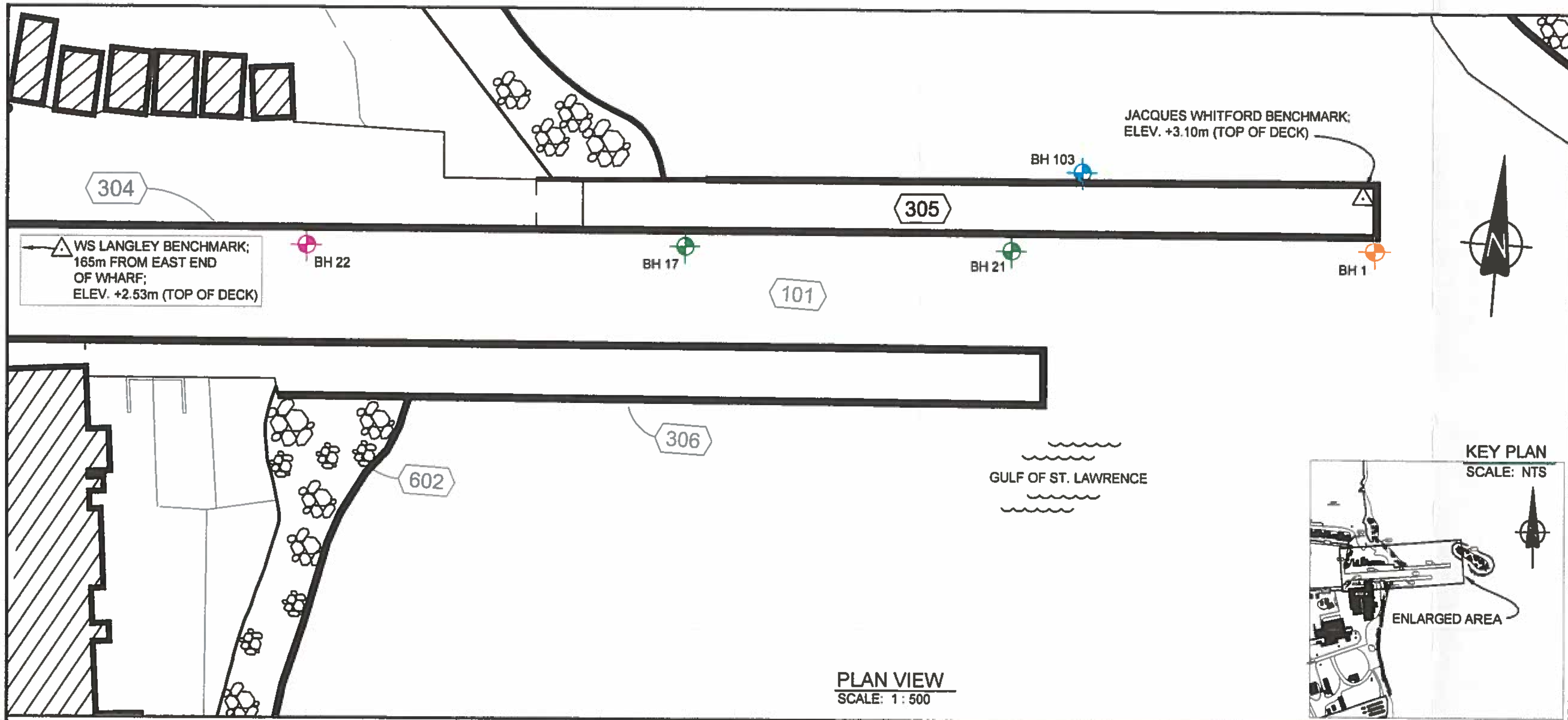
LOCATION: Graham Pond, Kings County, PEI

DATES: BORING: July 31, 2002 **WATER LEVEL:** Tidal **DATUM:** Assumed

Elevation (m) / Depth (m)	Soil Description	Sample Type	Sample No.	Recovery (mm)	SPT N-Value	RQD (%)	Average Joint Spacing, mm	Moisture (%)	Other Tests
95.12	Harbour Bottom								
0.00	Loose brown to dark grey sand, some silt, trace shell fragments: **Marine Deposit**	SS	1	600	7				
		SS	2	600	8				
92.83 / 2.29	Very soft olive grey sandy clayey silt, trace shell fragments, organic matter: **Marine Deposit**	SS	3	600	1			66	S/A
		SS	4	375	1				
90.70 / 4.42	Compact reddish brown sand, trace to some silt, gravel: **Marine Deposit**	SS	5	600	27			14	S
		SS	6	300	16				
86.74 / 8.38	Compact reddish brown silty sand, some gravel, sandstone cobbles/layers: **Till**	SS	7	200	17				

Depth scale: 0–30 ft / 0–9 m

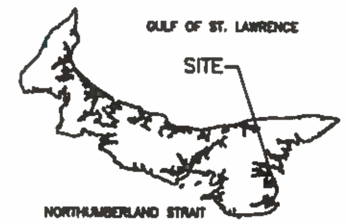
SPT N-Value: 10, 30, 50, 70, 90



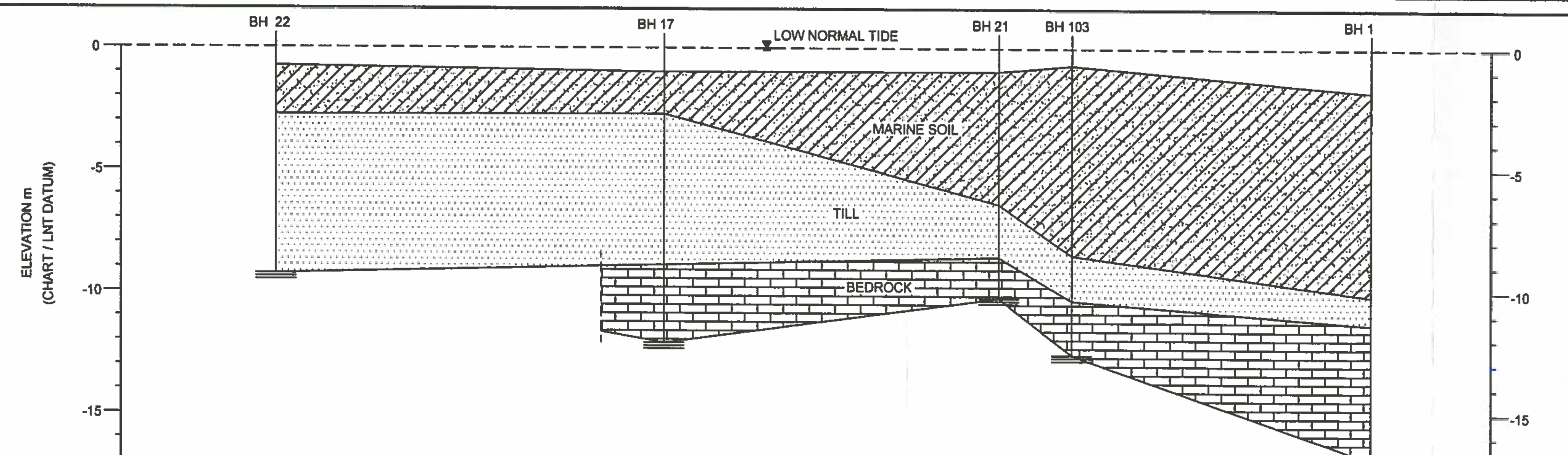
PLAN VIEW
SCALE: 1 : 500

LEGEND

- BOREHOLE LOCATION; JACQUES WHITFORD REPORT NO. 2636, ISSUED DECEMBER, 1982
- BOREHOLE LOCATION; WS LANGLEY REPORT NO. L580, ISSUED DECEMBER, 1983
- BOREHOLE LOCATION; JACQUES WHITFORD REPORT NO. 71595, ISSUED SEPTEMBER, 2002
- BOREHOLE LOCATION; JACQUES WHITFORD REPORT NO. 71647, ISSUED JUNE, 2003
- BENCHMARKS: CHART (LOW NORMAL TIDE) DATUM, AS NOTED



JOOSE ENVIRONMENTAL



STRATIGRAPHIC SECTION
SCALE: 1 : 500 (HORIZONTAL)
1 : 200 (VERTICAL)

BOREHOLE LOCATION PLAN AND STRATIGRAPHIC SECTION

STRUCTURE 305

GRAHAM'S POND SMALL CRAFT HARBOUR, KINGS COUNTY, PEI

CLIENT: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

SCALE: AS SHOWN

DWN BY:	APPD BY:
MLJ	GWZ
JOB NO.: JE0160A	**DWG NO.:** 1
DATE: 2016/03/24	

Geotechnical Investigation

Geotechnical Study - Graham's Pond Breakwater, Graham's Pond Harbour, Gaspereaux, PE

Project No. 121621050

June 25, 2018

Prepared for:

Small Craft Harbours
Fisheries and Oceans Canada
343 University Avenue
Moncton NB E1C 9B6

Prepared by:

Stantec Consulting Ltd.
165 Maple Hills Avenue
Charlottetown PE C1C 1N9

Stantec Consulting Ltd.
165 Maple Hills Avenue, Charlottetown, PE C1C 1N9

June 25, 2018
File: 121621050

Attention: Mr. Patrick Mazerolle, P.Eng.
Small Craft Harbours
Fisheries and Oceans Canada
343 University Avenue
Moncton, NB E1C 9B6

Dear Mr. Mazerolle,

Reference: Geotechnical Study - Graham's Pond Breakwater, Graham's Pond Harbour, Gaspereaux, PE

1. INTRODUCTION

We are pleased to provide the results of our geotechnical investigation performed at the above-referenced site. The purpose of the geotechnical investigation was to obtain subsurface soil, bedrock and groundwater information for input into design and construction of the proposed structure. Our services were completed in general accordance with our proposal dated April 26, 2018.

2. SITE AND PROJECT DESCRIPTION

The project site is located at the existing Graham's Pond Harbour in Gaspereaux, Prince Edward Island. The project involves replacement of the existing South Breakwater. The current structure consists of driven steel sheet piles (SSP), infilled with imported fill and a cast-in-place slab on grade. The current structure is exhibiting signs of failure, including openings in the SSP and large voids below the cast-in-place slab on grade. The current structure is approximately 6 meters in width and extends approximately 75 meters off shore. Details regarding the proposed replacement structure are not known at this time.

3. SUBSURFACE INVESTIGATION PROGRAM

Three boreholes, identified as BH-01 to BH-03 were advanced at the site on April 26, May 8 and May 9, 2018 by Logan Drilling Group of Moncton, New Brunswick. BH-01 was a land-based borehole and was advanced using a track-mounted drilling rig. Due to risks associated with the structural integrity of the existing breakwater structure, BH-02 and BH-03 were not drilled with the track-mounted drilling rig. Their locations were revised and completed with a barge-mounted drilling rig. The boreholes were advanced to depths ranging from approximately 11.51 to 17.12 meters below existing grade (BH-1) or harbour bottom (BH-2 and BH-3) at the approximate locations shown on the attached Drawing No. 1 – Borehole Location Plan.

Borehole locations were established in the field by Stantec Consulting Ltd. (Stantec) personnel located by tape referencing from existing site features. Ground surface elevations were surveyed with a level following completion of the drilling program. The borehole elevations were referenced to the top of the SSP adjacent to BH-02. The elevation of the top of the SSP is taken to be 3.20 meters Chart Datum and is based on an as-built drawing titled "Plan, North and South Elevations", Drawing No. 5 of 9, and dated October 1, 1987. The ground surface elevations are included in Table 1 and presented on the attached Borehole Records.

Reference: Geotechnical Study - Graham's Pond Breakwater, Graham's Pond Harbour, Gaspereaux, PE

Personnel from our Charlottetown office supervised the drilling activities and logged the subsurface conditions encountered at the borehole locations. The overburden soils at the borehole locations were generally sampled at standard intervals using Standard Penetration Test (SPT) techniques with a 50-millimeter, outside-diameter split-barrel sampler in general accordance with the standard test method American Society for Testing and Materials (ASTM) D1586 (*Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*). SPT N-values were recorded for each split-barrel sample obtained. The determination of soils density and consistency as indicated on the Borehole Records, are based on the results of the SPT. Soil samples were stored in moisture-tight containers and returned to our laboratory for further classification and testing. Bedrock samples were retrieved from each borehole in accordance with ASTM D2113 (*Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration*).

3.1. SOIL AND BEDROCK CONDITIONS

The soil and bedrock strata encountered at the site during the subsurface investigation program are described in detail on the attached Borehole Records and are summarized herein. The attached Symbols and Terms used on Borehole and Test Pit Records provide a brief explanation of the terminology and graphics used by Stantec.

Soil classification was based on the procedures described in ASTM D2487 *(Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System))* and ASTM D2488 *(Standard Practice for Description and Identification of Soils, Visual-Manual Procedure)*. A summary of the subsurface conditions encountered are provided in Table 1 and discussed in the following subsections.

Table 1: Subsurface Conditions Summary

Borehole ID	Ground Surface Elevation (m)	Concrete Thickness (mm)	FILL Thickness (m)	MARINE Thickness (m)	TILL Thickness (m)	TILL Elevation (m)	Depth to Bedrock (m)	Bedrock Elevation (m)
BH-01	3.62	180	3.78	2.03	7.83	-2.37	13.82	-10.20
BH-02	-2.03	NE	NE	2.16	5.54	-4.19	7.70	-9.73
BH-03	-1.16	NE	NE	4.93	4.67	-6.09	9.60	-10.76

NE – Not Encountered

Subsurface soil and bedrock conditions encountered generally include:

- CONCRETE
- FILL
- MARINE
- TILL
- SANDSTONE

3.1.1. CONCRETE

Surficial concrete was observed at BH-01 and was approximately 180 millimeters thick. Reinforcing steel was not encountered at the borehole location but was observed at other locations within the concrete slab.

3.1.2. FILL

A fill layer approximately 3.96 meters thick was observed below the concrete at BH-01. The composition of the fill ranged from grey well-graded gravel with silt and sand (crushed rock) at the surface to reddish brown silty sand with gravel (Class B) below. N-values from SPT performed within the fill layer ranged from 9 to 21, with an average of 14, indicating a predominantly compact compactness ranging from loose to compact.

One sample was submitted for gradation testing and the results are presented in Table 2 and appended. The moisture content of the samples averaged 16 percent, ranged from approximately 14 to 19 percent, and are presented on the Borehole Records.

Table 2: FILL - Laboratory Testing Summary

Borehole ID, Sample ID	Moisture Content (%)	Gravel (%)	Sand (%)	Silt / Clay (%)
BH-01, SS3	13.7	29.2	54.2	16.6

3.1.3. MARINE: Silty SAND (SM)

A layer of native marine soil classified as silty SAND (SM) was observed below the fill at BH-01 and at the ground surface of BH-02 and BH-03. The deposit ranged in color from reddish brown to brown to dark brown to grey to greyish green. The thickness of the deposit ranged from approximately 0.74 to 2.03 meters, with an average of 1.55 meters. Trace organics were noted within the deposit. N-values from SPT performed within the layer ranged from 1 to 18, with an average of 6, indicating a predominantly loose compactness ranging from very loose to compact.

One sample was submitted for gradation testing and the results are presented in Table 3 and appended. The moisture content of the samples averaged 32 percent, ranged from approximately 27 to 38 percent, and are presented on the Borehole Records.

Reference: Geotechnical Study - Graham's Pond Breakwater, Graham's Pond Harbour, Gaspereaux, PE

Table 3: MARINE - Laboratory Testing Summary

Borehole ID, Sample ID	Moisture Content (%)	Gravel (%)	Sand (%)	Silt / Clay (%)
BH-02, SS6	26.7	2.5	81.5	16.0

3.1.4. MARINE: Fat CLAY (CH) with sand

A layer of native marine soil classified as greenish grey fat CLAY (CH) with sand was observed below the marine deposited sand at BH-02 and BH-03. The thickness of the deposit ranged from approximately 1.42 to 3.05 meters, with an average of 2.24 meters. Trace organics were noted within the deposit. N-values from SPT performed within the layer ranged from 3 to 5, with an average of 4, indicating a predominantly soft consistency ranging from soft to firm. Very soft zones were also noted within the deposit where the split-spoon sampler was advanced into the deposit under the weight of the hammer.

One sample was submitted for gradation testing and the determination of Atterberg limits and the results are presented in Table 4 and appended. The moisture content of the samples averaged 66 percent, ranged from approximately 64 to 67 percent, and are presented on the Borehole Records.

Table 4: MARINE - Laboratory Testing Summary

Borehole ID, Sample ID	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Gravel (%)	Sand (%)	Silt / Clay (%)
BH-03, SS5	66.8	81.0	34.8	46.2	0.0	16.9	83.1

3.1.5. TILL

A layer of reddish brown silty, clayey sand (SC-SM) to silty, clayey sand (SC-SM) with gravel, geologically classified as glacial till, was observed below the marine deposit at each borehole. Trace cobbles were notes within the deposit. Please note, till can be a heterogenous mixture of soil sizes ranging from clay to silt to sand to gravel to cobbles and boulders. The portions of the various soil sizes can vary widely in the deposit. The thickness of the till ranged from 4.67 to 7.83 meters, with an average of 6.01meters. The till surface was observed at elevations ranging from -2.37 to -6.09 meters. N-values from SPT performed within the till ranged from 6 to 37, with an average of 19, indicating a predominantly compact compactness, ranging from loose to dense.

Three samples were submitted for gradation testing and one for the determination of Atterberg limits. The results are presented in Table 5 and appended. The moisture content of the samples averaged 12 percent, ranged from approximately 11 to 14 percent, and are presented on the Borehole Records.

Reference: Geotechnical Study - Graham's Pond Breakwater, Graham's Pond Harbour, Gaspereaux, PE

Table 5: TILL - Laboratory Testing Summary

Borehole ID, Sample ID	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Gravel (%)	Sand (%)	Silt / Clay (%)
BH-01, SS13	13.6	-	-	-	9.2	55.1	35.7
BH-02, SS7	11.3	16.1	10.9	5.2	14.8	51.7	33.5
BH-03, SS9	11.3	-	-	-	20.3	48.0	31.7

3.1.6. SANDSTONE BEDROCK

SANDSTONE bedrock was encountered at each borehole at depths ranging from approximately 7.70 to 13.82 meters below existing grades. The bedrock elevation ranged from approximately -9.73 to -10.76 meters, chart datum. Bedrock was confirmed by rock coring at each borehole. Photos of the bedrock core are shown on the appended rock core photo log.

Rock core samples indicate the bedrock consists of sandstone. The RQD (Rock Quality Designation) of the bedrock averaged 32 percent and ranged from 0 to 50, indicating a very poor to poor quality. The rock mass was predominantly reddish brown with some whitish red, fine to coarse grained, slightly weathered, with very weak to strong strength. Discontinuities were spaced very close to moderately and were predominantly horizonal and parallel to bedding.

The results of point load tests carried out on selected bedrock core samples are presented on Table 6, appended. The point load index (Is) was determined from both diametral and axial tests. The unconfined compressive strength (Qu) was estimated from the point load data using the relationship Qu = 24 x Is (axial). The point load test data indicate that the sandstone core samples tested fall within the weak (5 to 25 MPa) to strong (50 to 100 MPa) strength classifications. It should be noted that the weakest rock is often not recovered during coring operations and that intact core samples are required for testing. Consequently, a very weak to strong classification would be more representative of the overall rock mass at the site and is used on the Borehole Records.

Reference: Geotechnical Study - Graham's Pond Breakwater, Graham's Pond Harbour, Gaspereaux, PE

4. DESIGN PARAMETERS

As previously discussed, details regarding the proposed replacement structure are not known at this time. We would be pleased to provide additional input and recommendations regarding design and construction of the proposed structure when details are available. The following parameters may be assigned to the various strata encountered for design purposes:

Parameter/Soil Type	MARINE: Silty SAND	MARINE: Fat CLAY	TILL	SANDSTONE (bedrock)	Select Borrow (imported)
Total Unit Weight, kN/m^3	18.0	16.0	20.0	22.0	21.0
Submerged Unit Weight, kN/m^3	8.2	6.2	10.2	12.2	11.2
Effective Friction Angle, degrees	28	24	30	32	32
Undrained Shear Strength, kPa	0	0	0	0	0
Active Earth Pressure Coefficient, K_a	0.36	0.42	0.33	0.31	0.31
Passive Earth Pressure Coefficient, K_p[1]	2.77	2.37	3.00	3.25	3.25

Notes: 1. Neglecting the effects of wall friction

5. CLOSING COMMENTS

Use of this report is subject to the Statement of General Conditions provided in the Appendix. It is the responsibility of Small Craft

Harbours, identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec should any of these not be satisfied. The Statement of General Conditions addresses the following:

- Use of the report
- Basis of the report
- Standard of care
- Interpretation of site conditions
- Varying or unexpected site conditions
- Planning, design or construction

Reference: Geotechnical Study - Graham's Pond Breakwater, Graham's Pond Harbour, Gaspereaux, PE

We trust the information contained in this report meets your current needs. Should you have questions about the contents of this report, or if we can be of further assistance, please contact the undersigned.

Regards,

STANTEC CONSULTING LTD.

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June 25, 2018
Mr. Patrick Mazerolle, P. Eng.

Reference: Geotechnical Study - Graham's Pond Breakwater, Graham's Pond Harbour, Gaspereaux, PE

APPENDIX

STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Consulting Ltd. and the Client. Any use which a third party makes of this report is the responsibility of such third party.

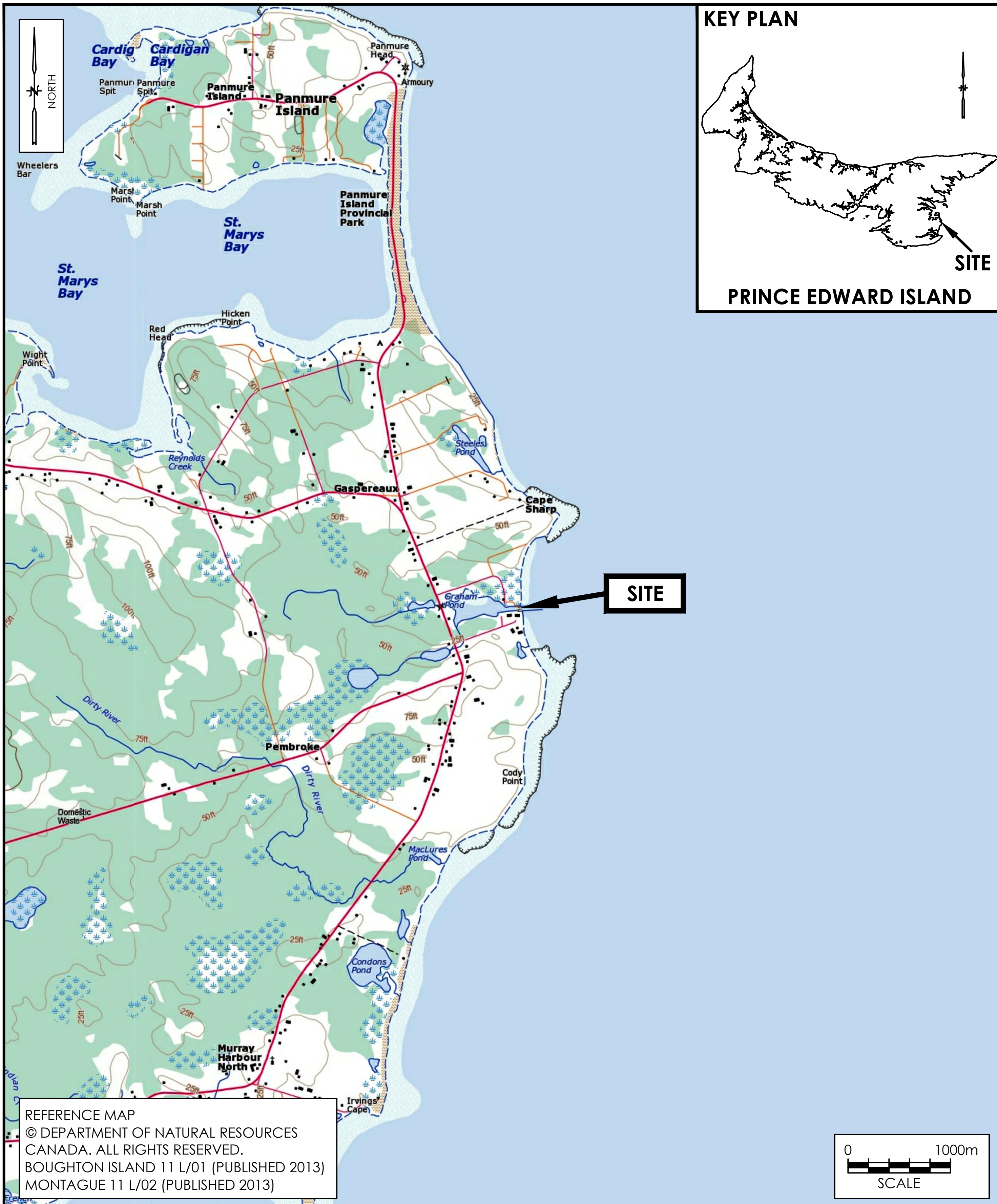
BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec Consulting Ltd.'s present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Consulting Ltd. is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Ltd. at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Consulting Ltd. must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Consulting Ltd. will not be responsible to any party for damages incurred as a result of failing to notify Stantec Consulting Ltd. that differing site or sub-surface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec Consulting Ltd. , sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc.), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Consulting Ltd. cannot be responsible for site work carried out without being present.



THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

SITE LOCATION PLAN

GRAHAM'S POND BREAKWATER
GRAHAM'S POND, GASPEREAUX, PE

Client: SMALL CRAFT HARBOURS

Job No.:	121621050
Scale:	1 : 50 000
Date:	25-JUN-2018
Dwn. By:	MDC
App'd By:	CM
Dwg. No.:	1

Stantec

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THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

EXPLORATION LOCATION PLAN (BH-01-BH-03) GRAHAM'S POND BREAKWATER GRAHAM'S POND, GASPEREAUX, PE	**Job No.:**	121621050	**Dwg. No.:** 2
	Scale:	1 : 1000	
	Date:	25-JUN-2018	Stantec
	Dwn. By:	MDC	
Client: SMALL CRAFT HARBOURS	**App'd By:**	CM	

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25 - 0.5	12.5 - 25	2-4
Firm	0.5 - 1.0	25 - 50	4-8
Stiff	1.0 - 2.0	50 – 100	8-15
Very Stiff	2.0 - 4.0	100 - 200	15-30
Hard	>4.0	>200	>30

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor Quality*
25-50	*Poor Quality*
50-75	*Fair Quality*
75-90	*Good Quality*
90-100	*Excellent Quality*

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	*Crushed*
Severely Fractured	*Shattered or Very Blocky*
Fractured	*Blocky*
Moderately Jointed	*Sound*
Intact	*Very Sound*

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.

Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Igneous Bedrock	Meta-morphic Bedrock	Sedi-mentary Bedrock

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT

▼ measured in standpipe, piezometer, or well

▽ inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_U	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

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BOREHOLE RECORD

BH-01

CLIENT: Small Craft Harbours
LOCATION: Graham's Pond Harbour, Gaspereaux, PE
DATES: BORING 2018/04/26 WATER LEVEL
PROJECT No. 121621050
BOREHOLE No. BH-01
DATUM Chart

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
0	3.62					
	3.44	Concrete				
	3.37	FILL: grey well-graded gavel with silt and sand (crushed rock)	SS	1	405	15
		FILL: reddish brown silty sand with gravel (class B)	SS	2	380	16
			SS	3	380	21
			SS	4	250	15
			SS	5	305	10
			SS	6	150	9
4	-0.34	MARINE: very loose to loose grey silty sand (SM)	SS	7	430	7
			SS	8	125	1
			SS	9	610	4
6	-2.37	Loose to dense reddish brown silty, clayey sand (SC-SM) to silty, clayey sand (SC-SM) with gravel: TILL -with trace cobbles	SS	10	550	20
			SS	11	455	16
			SS	12	405	6
			SS	13	330	8
			SS	14	430	23
9						

Undrained Shear Strength - kPa: 20, 40, 60, 80

Water Content & Atterberg Limits (W_P, W, W_L)

Dynamic Penetration Test, blows/0.3m ★

Standard Penetration Test, blows/0.3m ●

10 20 30 40 50 60 70 80 90

△ Unconfined Compression Test
□ Field Vane Test ■ Remoulded
✖ Torvane

Continued Next Page

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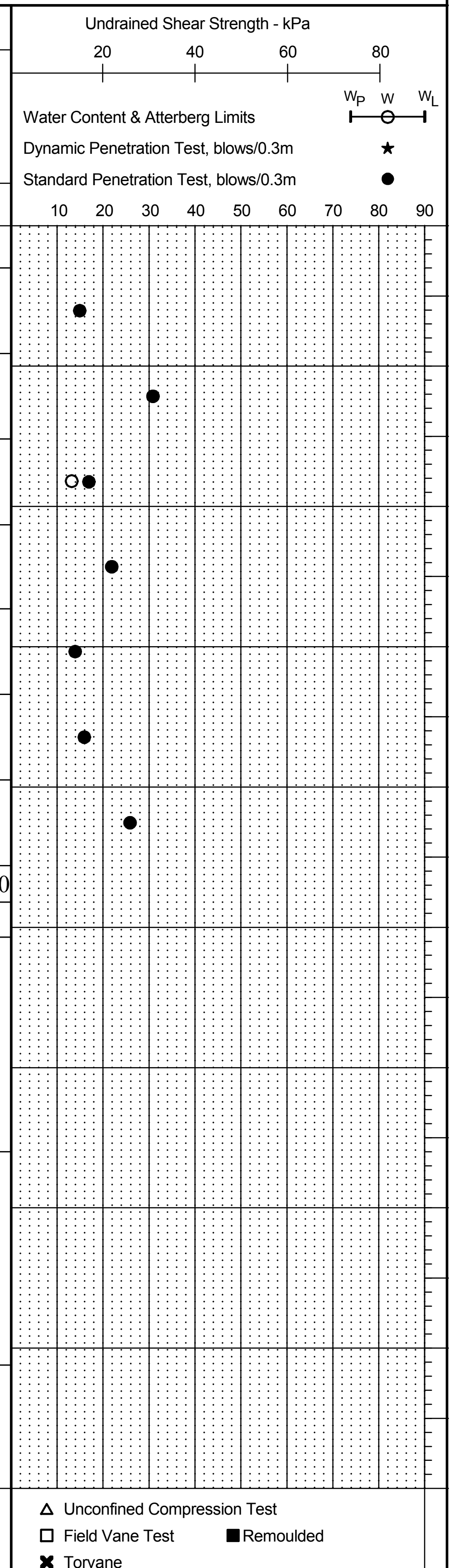
BOREHOLE RECORD

BH-01

CLIENT: Small Craft Harbours
LOCATION: Graham's Pond Harbour, Gaspereaux, PE
DATES: BORING 2018/04/26 WATER LEVEL
PROJECT No. 121621050
BOREHOLE No. BH-01
DATUM Chart

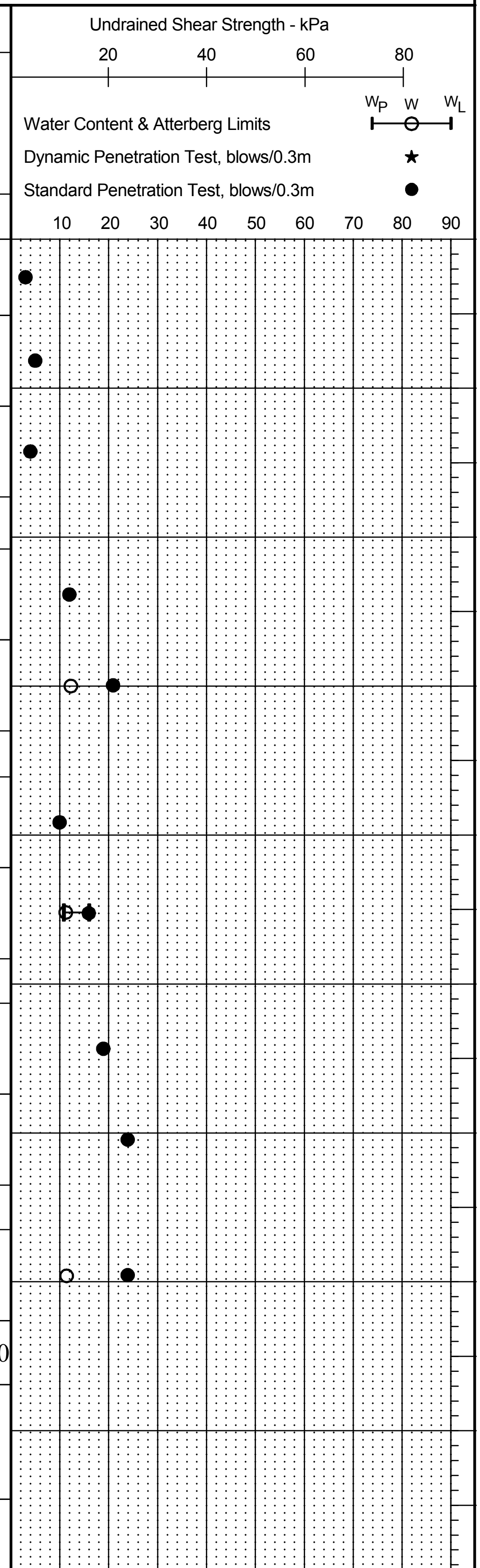
DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
9		Cont'd: loose to dense reddish brown silty, clayey sand (SC-SM) to silty, clayey sand (SC-SM) with gravel: TILL -with trace cobbles			SS	15	405	24
					SS	16	380	15
10					SS	17	305	31
					SS	18	315	17
11					SS	19	205	22
12					SS	20	330	14
					SS	21	175	16
13					SS	22	125	26
	-10.20				SS	23	250	62/250
14		Very poor to poor quality, reddish brown, fine to medium grained SANDSTONE, slightly weathered, very weak to strong strength, discontinuities are predominantly horizontal and spaced very close to moderate. -discontinuities are infilled with mudstone at 14.6, 14.8, 15.8, 16.0 and 16.3 meters. -whitish red to reddish brown color below 15.3 meters.			RC	24	330	0
15					RC	25	1500	33
16					RC	26	1475	40
17	-13.50	End of borehole at 17.12 meters						
18								



Stantec BOREHOLE RECORD BH-02

CLIENT: Small Craft Harbours
PROJECT No.: 121621050
LOCATION: Graham's Pond Harbour, Gaspereaux, PE
BOREHOLE No.: BH-02
DATES: BORING 2018/05/08
WATER LEVEL:
DATUM: Chart

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
0	-2.03	MARINE: very loose to loose brown to dark brown silty sand (SM)	SS	1	250	3
			SS	2	305	5
0.74	-2.77	MARINE: soft to firm greenish grey fat clay (CH) with sand	SS	3	175	4
2.16	-4.19	Loose to compact reddish brown silty, clayey sand (SC-SM) to silty, clayey sand (SC-SM) with gravel: TILL -with trace cobbles	SS	4	330	12
			SS	5	330	21
			SS	6	355	10
			SS	7	305	16
			SS	8	355	19
			SS	9	405	24
			SS	10	380	24
			SS	11	280	99/430
7.70	-9.73	Very poor to poor quality, reddish brown, fine to medium grained SANDSTONE, slightly weathered, very weak to medium strong strength, discontinuities are predominantly horizontal and spaced extremely close to moderate.	RC	12	510	0



△ Unconfined Compression Test
□ Field Vane Test
■ Remoulded
✖ Torvane

Continued Next Page

BOREHOLE RECORD

BH-02

CLIENT: **Small Craft Harbours**
LOCATION: **Graham's Pond Harbour, Gaspereaux, PE**
DATES: BORING **2018/05/08**
WATER LEVEL:

PROJECT No. **121621050**
BOREHOLE No. **BH-02**
DATUM **Chart**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
9		-discontinuities are infilled with mudstone at 9.0, 9.2 and 9.8 meters. -whitish red color from 9.2 to 9.5 meters.			RC	13	1525	50
10					RC	14	810	27
11	-13.54							
		End of borehole at 11.51 meters						
12								
13								
14								
15								
16								
17								
18								

Undrained Shear Strength - kPa: 20, 40, 60, 80

Water Content & Atterberg Limits: W_P W W_L
Dynamic Penetration Test, blows/0.3m ★
Standard Penetration Test, blows/0.3m ●

10 20 30 40 50 60 70 80 90

△ Unconfined Compression Test
□ Field Vane Test ■ Remoulded
✖ Torvane

BOREHOLE RECORD

BH-03

Stantec

CLIENT **Small Craft Harbours**

PROJECT No. **121621050**

LOCATION **Graham's Pond Harbour, Gaspereaux, PE**

BOREHOLE No. **BH-03**

DATES: BORING **2018/05/09**

WATER LEVEL

DATUM **Chart**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
0	-1.16	MARINE: compact reddish brown silty sand (SM)	SS	1	405	18
	-1.47	MARINE: loose to compact greyish green silty sand (SM)	SS	2	330	5
			SS	3	380	8
	-3.04	MARINE: soft greenish grey fat clay (CH) with sand	SS	4	155	3
			SS	5	510	4
			SS	6	230	3
			SS	7	610	3
	-6.09	Compact to dense reddish brown silty, clayey sand (SC-SM) to silty, clayey sand (SC-SM) with gravel: TILL -with trace cobbles	SS	8	430	37
			SS	9	280	22
			SS	10	230	16
			SS	11	100	16
			SS	12	50	13

Undrained Shear Strength - kPa: 20, 40, 60, 80

Water Content & Atterberg Limits: W_P W W_L

Dynamic Penetration Test, blows/0.3m ★

Standard Penetration Test, blows/0.3m ●

10 20 30 40 50 60 70 80 90

△ Unconfined Compression Test

☐ Field Vane Test ■ Remoulded

✖ Torvane

Continued Next Page

BOREHOLE RECORD

BH-03

Stantec

CLIENT **Small Craft Harbours** PROJECT No. **121621050**

LOCATION **Graham's Pond Harbour, Gaspereaux, PE** BOREHOLE No. **BH-03**

DATES: BORING **2018/05/09** WATER LEVEL DATUM **Chart**

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
9		Cont'd: compact to dense reddish brown silty, clayey sand (SC-SM) to silty, clayey sand (SC-SM) with gravel: TILL -with trace cobbles	SS	13	405	17
	-10.76		~~SS~~	~~14~~	~~25~~	~~50/25~~
		Very poor to poor quality, reddish brown, fine to medium grained SANDSTONE, slightly weathered, very weak to medium strong strength, discontinuities are predominantly horizontal and spaced very close to moderate. -discontinuities are infilled with mudstone at 10.7 and 10.8 meters.	RC	15	125	0
10			RC	16	1370	34
11	-12.29	Very poor to poor quality, reddish brown to whitish red, medium to coarse grained SANDSTONE, slightly weathered, very weak to strong strength, discontinuities are predominantly horizontal and spaced very close to moderate. -discontinuities are infilled with mudstone at 11.7 meters.				
12			RC	17	1270	38
13	-14.01	End of borehole at 12.85 meters				

Columns: STRATA PLOT, WATER LEVEL

Undrained Shear Strength - kPa: 20 40 60 80

Water Content & Atterberg Limits W_P W W_L

Dynamic Penetration Test, blows/0.3m ★

Standard Penetration Test, blows/0.3m ●

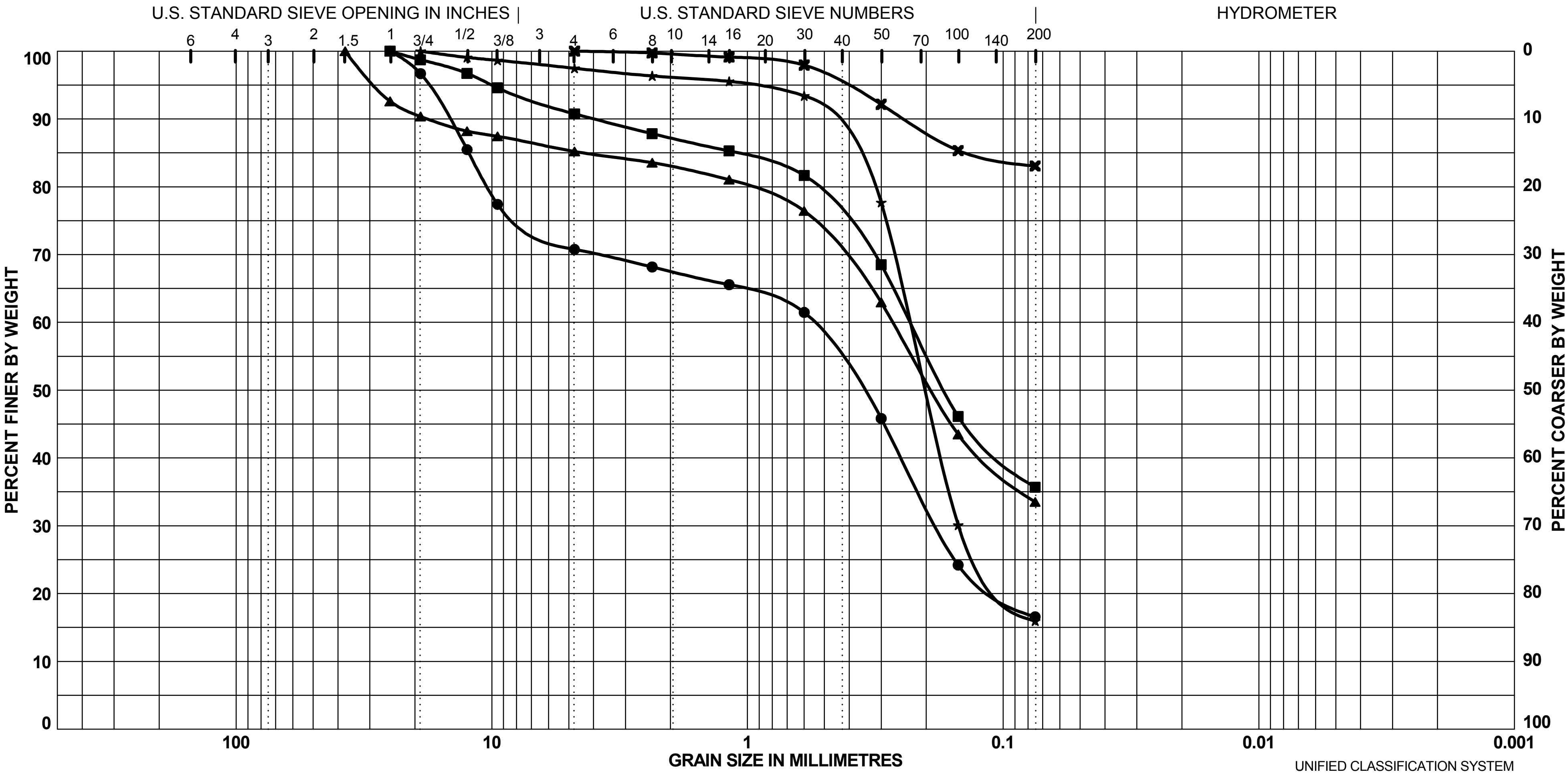
10 20 30 40 50 60 70 80 90

Depth scale: 9 10 11 12 13 14 15 16 17 18

△ Unconfined Compression Test

□ Field Vane Test ■ Remoulded

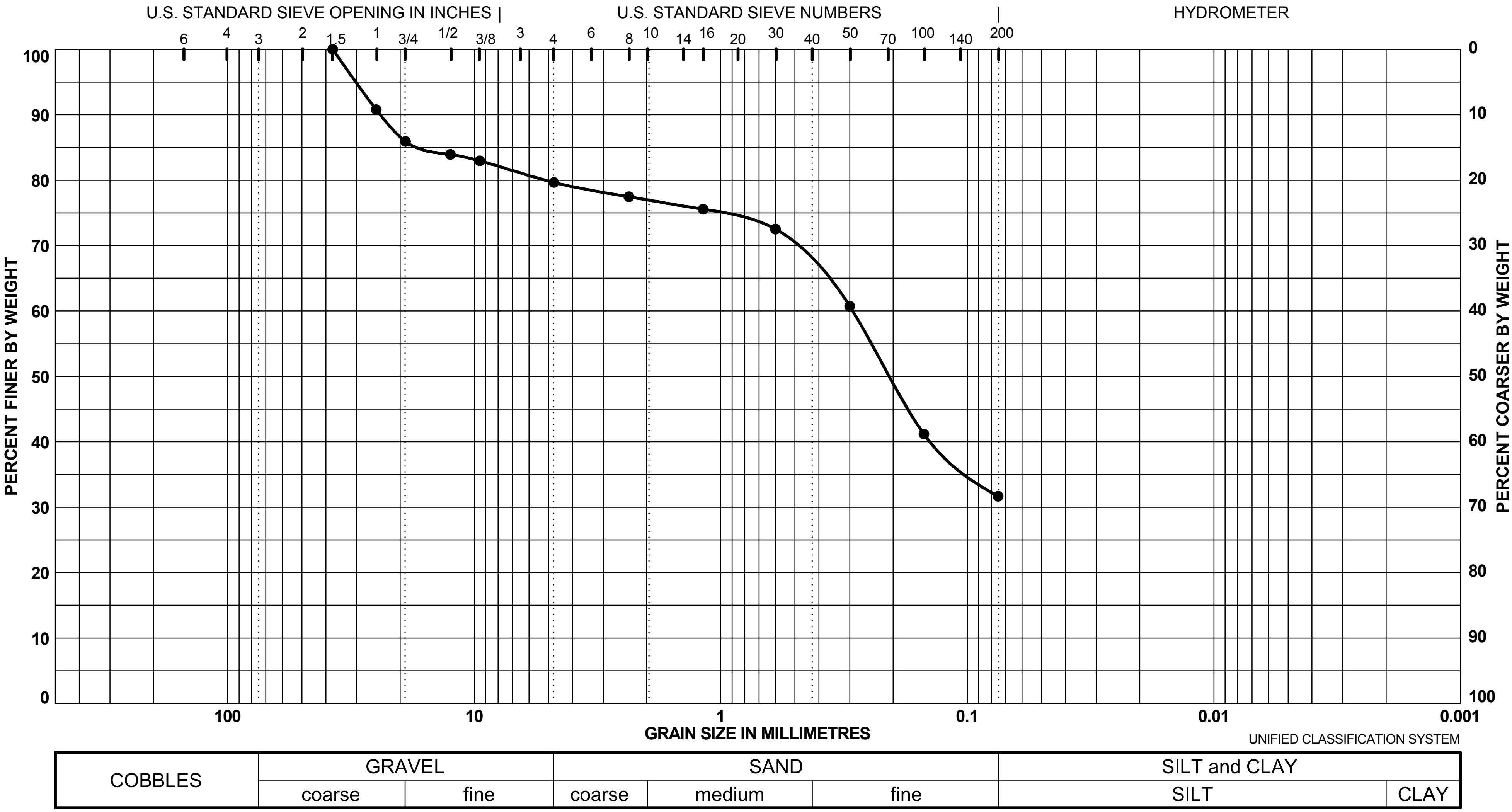
✖ Torvane



COBBLES	GRAVEL		SAND			SILT and CLAY	
	coarse	fine	coarse	medium	fine	SILT	CLAY

	Source	Depth	Description	W%	W_L	W_P	I_P	%Gravel	%Sand	%Silt	%Clay
●	BH-01	1.5	FILL: silty sand with gravel	13.7				29.2	54.2	16.6	
■	BH-01	7.5	Silty, clayey sand (SC-SM): TILL	13.6				9.2	55.1	35.7	
▲	BH-02	4.5	Silty, clayey sand (SC-SM): TILL	11.3	16.1	10.9	5.2	14.8	51.7	33.5	
★	BH-03	0.9	MARINE: Silty SAND (SM)	26.7				2.5	81.5	16.0	
✖	BH-03	2.7	MARINE: Fat CLAY (CH) with sand	66.8	81.0	34.8	46.2	0.0	16.9	83.1	

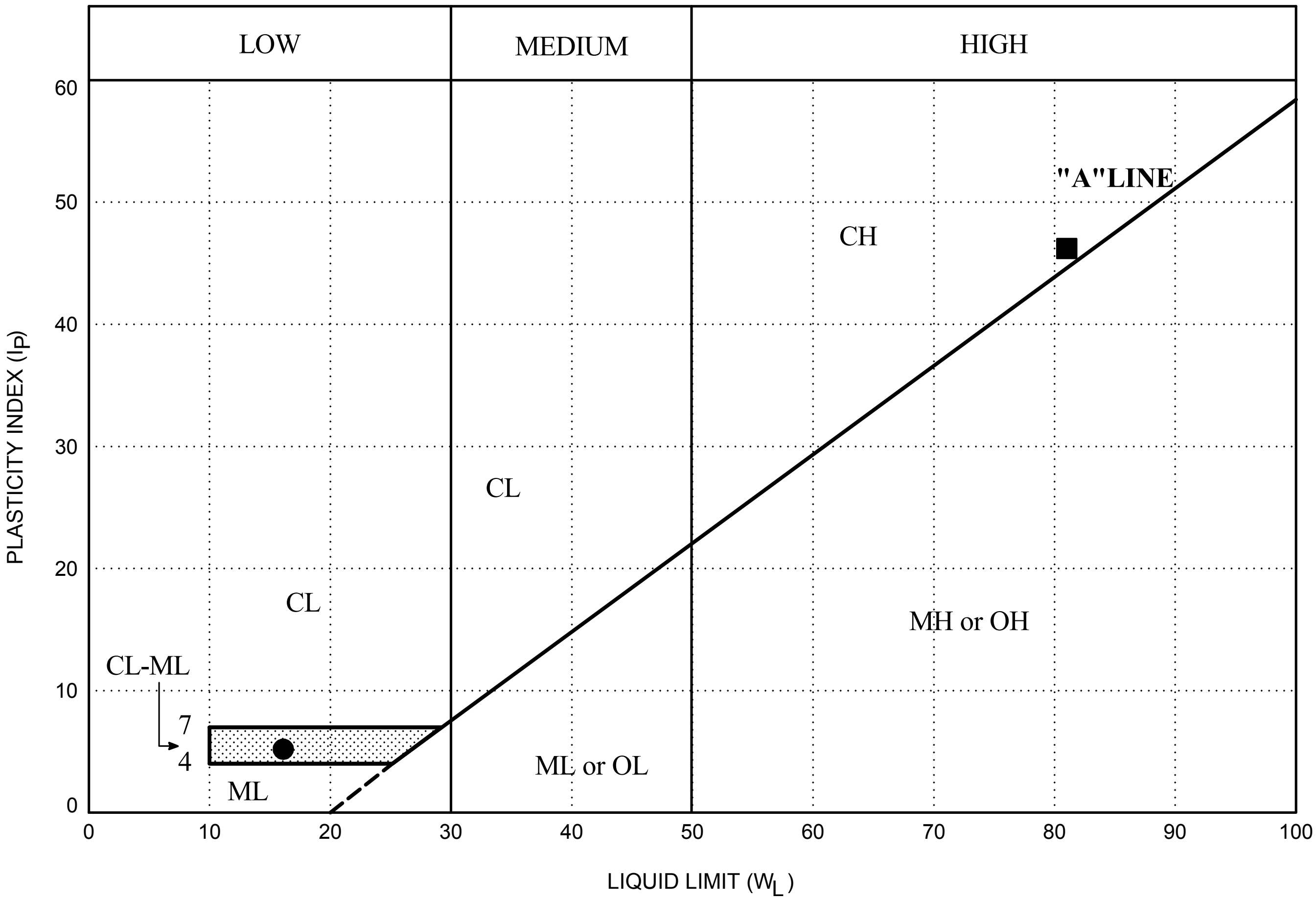
Stantec	Project: **Graham's Pond Harbour,**	Location: **Gaspereaux, PE**
	Job No.: **121621050**	Notes:
	Date: **May 17, 2018**	**GRADATION CURVES**



Source	Depth	Description	W%	W_L	W_P	I_P	%Gravel	%Sand	%Silt	%Clay
● BH-03	6.0	Silty, clayey sand (SC-SM) with gravel: TILL	11.3				20.3	48.0	31.7	

Stantec	Project: **Graham's Pond Harbour,**	Location: **Gaspereaux, PE**	
	Job No.: **121621050**	Notes:	
	Date: **May 17, 2018**	**GRADATION CURVES**	

PLASTICITY CHART



SYM.	SOURCE	DEPTH (m)	LL	PL	PI	W%	DESCRIPTION
●	BH-02	4.5	16.1	10.9	5.2	11.3	Silty, clayey sand (SC-SM): TILL
■	BH-03	2.8	81.0	34.8	46.2	66.8	MARINE: Fat CLAY (CH) with sand

Stantec	Project: **Graham's Pond Harbour**	Location: **Gaspereaux, PE**
	Job No.: **121621050**	Notes:
	Date: **June 25, 2018**	**SOIL PLASTICITY**

Stantec

Table 6 - Point Load Test Summary, Graham's Pond Harbour, Gaspereaux, PE

Borehole Number	Sample Depth, m	Test Type	Is(50), MPa	UCS (Qu), MPa	Rock Type
BH-01	14.2	A	0.6	14	MGSS
	15.1	D	0.8		MGSS
	15.1	A	0.9	21	MGSS
	15.5	D	1.0		MGSS
	15.5	A	2.2	54	MGSS
	16.2	D	0.6		MGSS
	16.2	A	1.2	28	MGSS
	17.1	D	1.5		MGSS
	17.1	A	1.9	46	MGSS
BH-02	8.7	D	0.9		MGSS
	8.7	A	1.1	26	MGSS
	9.3	D	1.2		MGSS
	9.3	A	1.6	38	MGSS
	10.2	D	0.4		MGSS
	10.2	A	0.7	16	MGSS
	10.4	D	0.4		MGSS
	10.4	A	0.9	22	MGSS
BH-03	9.9	D	0.3		MGSS
	9.9	A	0.7	16	MGSS
	10.2	D	0.7		MGSS
	10.2	A	1.2	29	MGSS
	12.2	D	1.9		CGSS
	12.2	A	2.9	69	CGSS
	12.6	D	0.9		MGSS
	12.6	A	2.1	50	MGSS

Legend:
A- axial test
D- diametral test
UCS- unconfined compressive strength
FGSS- fine grained sandstone
MGSS- medium grained sandstone
MS- Mudstone

Note: USC is estimated based on relationship Qu = 24 x Is50 (axial)

Photo 1: BH-01, RC24 – RC26 (13.82 to 17.12 m)

Photo 2: BH-02, RC12 – RC14 (7.69 to 11.51 m)

Photo 3: BH-03, RC15 – RC17 (9.63 to 12.85 m)

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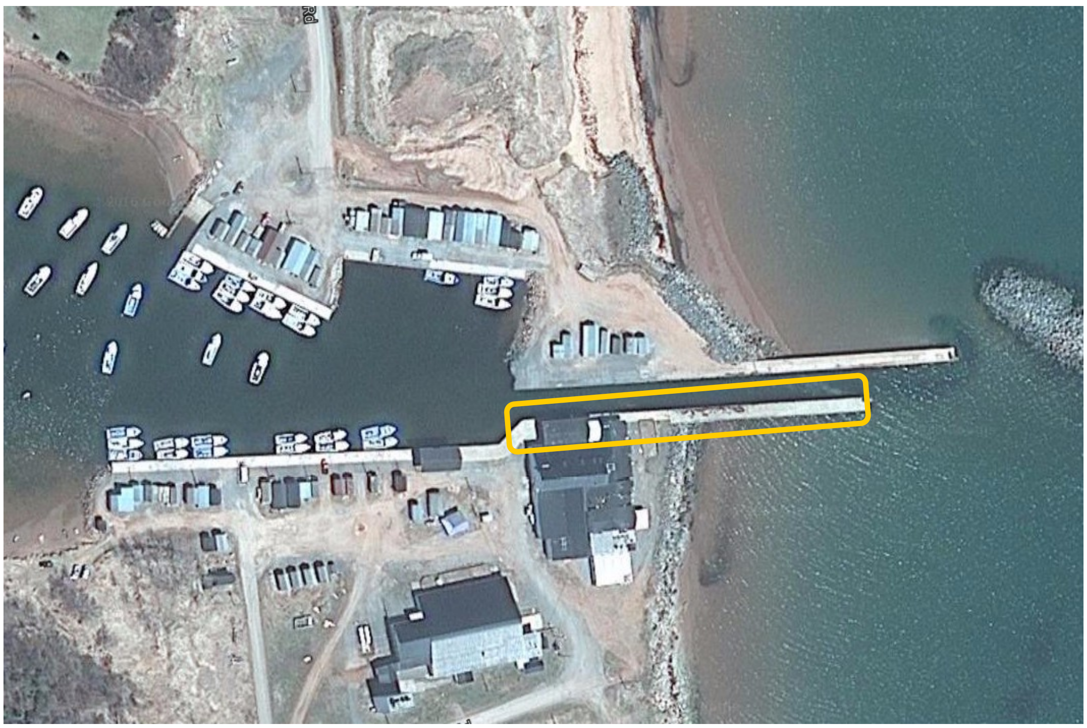
June 21, 2018

SECTION 412/306 INSPECTION
GRAHAMS POND



Introduction

On June 21th, 2018 Diversified Divers Inc. (DDI) was on site at Graham's Pond, PEI completing an underwater inspection of Section 412 and 306.

During this inspection, all information was documented and will be discussed in the report below.

Please call/fax or e-mail me at the contact information listed above to discuss any concerns or ask any additional questions. I would like to thank you for the opportunity of performing this structure inspection.

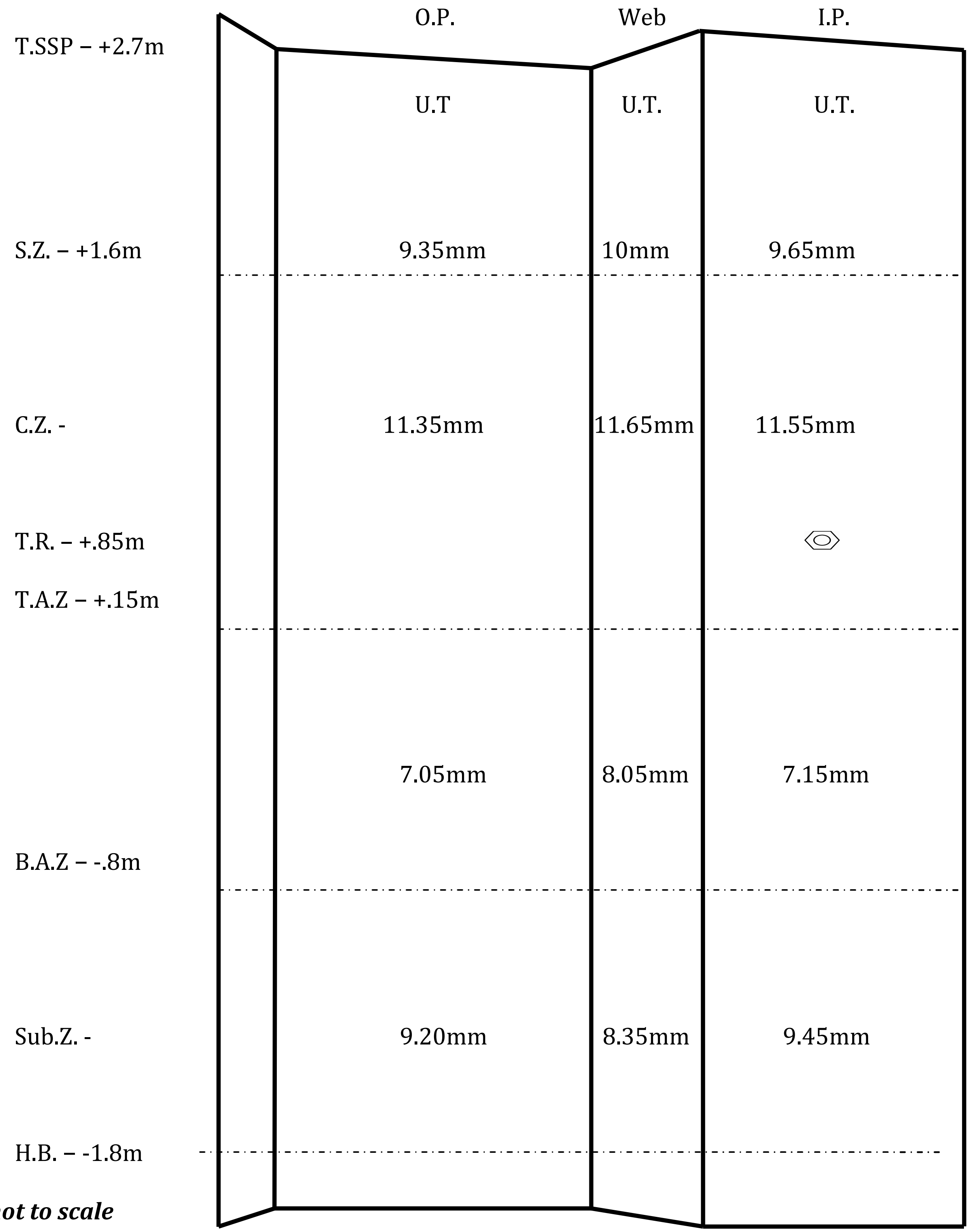
Visual Inspection Notes:

- Full structure 140m long
- 37m elevation change at top of SSP
- 40m end of building(old factory)
- UT taken at 10m,35m, and 95m
- 48m North wall 125mmx125mm hole(web)
- 140m North corner flange separated to bottom(multiple holes in splash zone)
- 80m South wall to rocks holes found on webs and in pans from corner to rocks(75% gone)
- East end 4.4m top SSP to HB
- Distribution bolts missing along 306 at various locations

* Field notes attached.

Location #10m

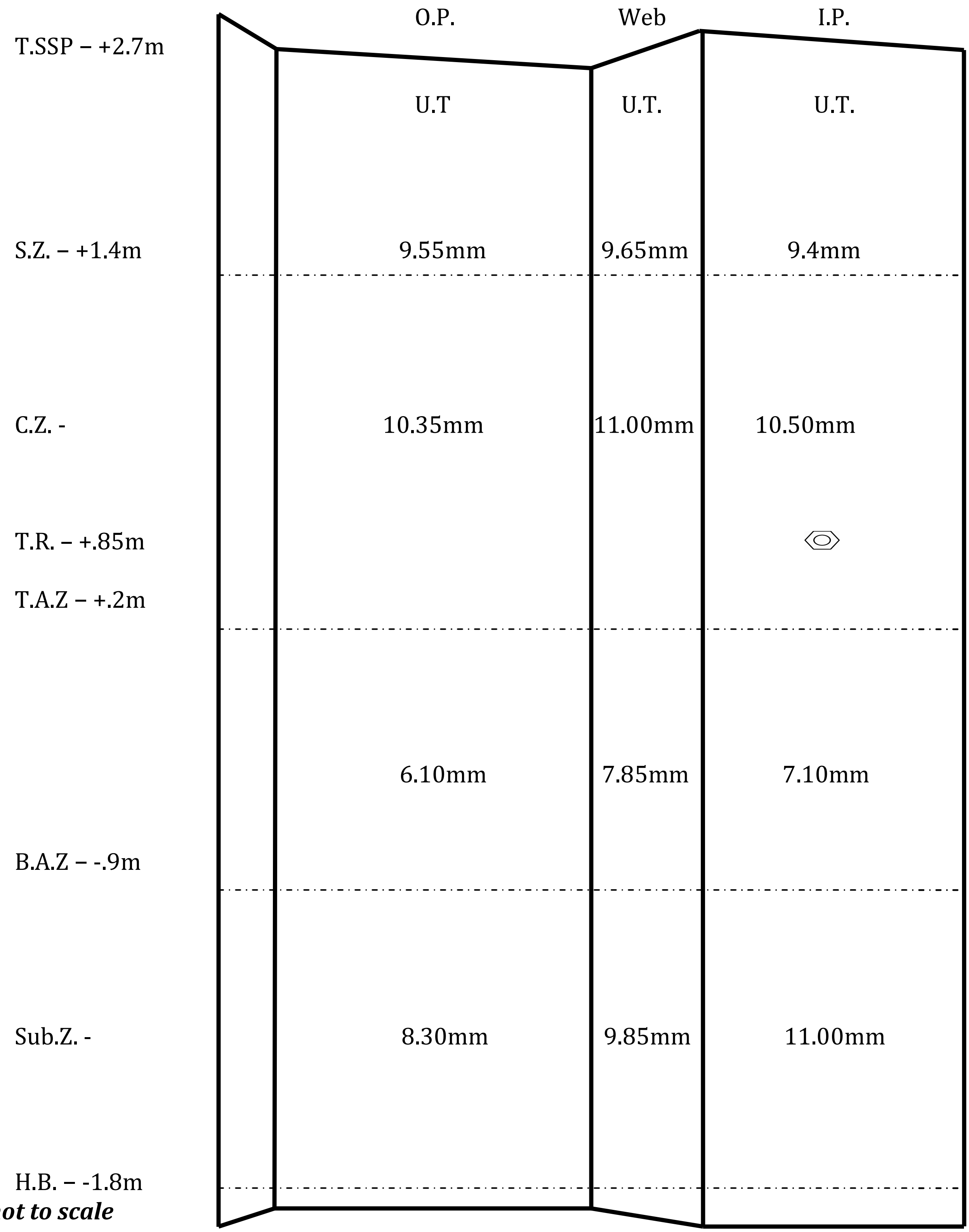
Elevations



***not to scale**

Location #35m

Elevations



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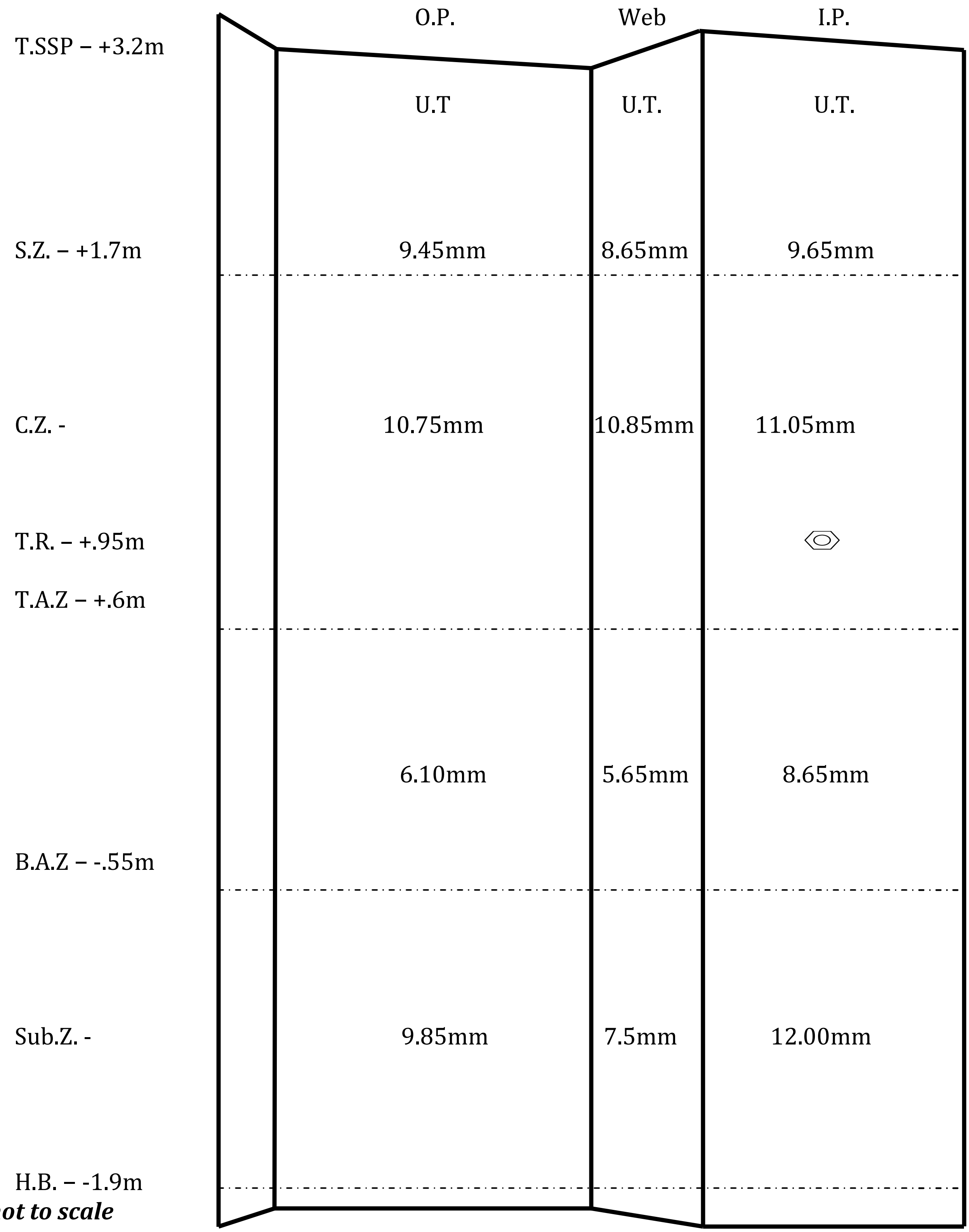
Location #95m

Elevations



not to scale

Legend:

O.P. – Out pan
I.P. – In pan
U.T. – Ultrasonic thickness
T.SSP – Top of Steel Sheet Pile
S.Z. – Splash Zone
C.Z. – Cathodic Zone
T.R. – Tie Rod elevation
T.A.Z – Top of Anodic Zone
B.A.Z – Bottom of Anodic Zone
H.B. – Harbor Bottom
Sub.Z. – Submerged zone (Suction dredge used to achieve lowest achievable elevation)
– Tie Rod

*** Inspection starts at West end of 412.**
* **Top of SSP measurements are noted Section 412@+2.7m/Section 306@+3.2m**

Conclusion:

Section 306
After review we would recommend excavation and extraction of section 306 by means of vibratory hammer and diver assistance for burning and rigging.

Section 412
After review we would recommend a full plate repair from top of SSP to -1m with reinforced concrete in fill.

Thank you for the opportunity to work with you on this project and should you have any questions or comments in regard to this proposal please do not hesitate to contact me at any time.

Respectfully submitted,

James Landrigan
General Manager

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