Appendix B
Levelton TMEP “Enhanced FEED Study” Geotechnical Foreshore Investigation - Findings Report
Wестridge Loading Facility, Burnaby, BC, April 7, 2015
April 07, 2015

Levelton File # R713-1879-00

CH2M Hill
Metrotower II, Suite 2100
4720 Kingsway Avenue
Burnaby, BC V5H 4N2

Attention: Mr. Mark Clarke, P.Eng.

Project: Trans Mountain Expansion Project (TMEP) – “Enhanced FEED Study”
Subject: Geotechnical Foreshore Investigation – Findings Report
Westridge Loading Facility, Burnaby, BC

1.0 INTRODUCTION & PROJECT DESCRIPTION

This letter is the Levelton Consultants Ltd. (Levelton) findings report that contains the results of the recent geotechnical investigation undertaken in the foreshore area at the Kinder Morgan Westridge facility as part of the TMEP Enhanced FEED study.

The TMEP development at Westridge will involve the construction of new infrastructure to expand the shiploading capabilities of the facility. The design for the facility expansion is not finalized, but will include new ship berthing facilities and loading infrastructure on the “marine-side”, and new piping, manifolds, processing equipment, and some small new storage tanks on the “land-side” of the project. Levelton has recently completed a preliminary geotechnical subsurface investigation programme for the land-side portion of the project based on a proposed filling-type option for the expansion and improvement of the foreshore, which was the proposed development option being considered at the time of the investigation. A summary of the preliminary geotechnical investigation is presented in this findings report, which includes the detailed soil logs and test results from the investigation. Engineering review and assessment will be presented in a future report under a separate cover.

The geotechnical subsurface investigation programme included two types of geotechnical test holes: sonic drill holes completed to obtain information regarding soil stratigraphy and also to allow for the collection of soil samples, and seismic cone penetration tests (SCPTs) to obtain information (where possible) in potentially liquefiable soil deposits. The majority of the sonic drill holes were completed at various locations along the
foreshore, with a few holes completed on the nearby slopes, while the SCPTs were completed at some of the sonic drill hole locations along the foreshore only. Table 1 below summarizes the type, numbers, and general distribution of the test holes completed during the geotechnical investigation.

Table 1: Summary of Completed Test Holes

<table>
<thead>
<tr>
<th>Type of Geotechnical Test Hole</th>
<th>Foreshore Locations</th>
<th>Hillside Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonic Drill Hole</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Seismic Cone Penetration Test</td>
<td>10</td>
<td>---</td>
</tr>
</tbody>
</table>

The sonic drill holes were completed using a track-mounted sonic drill rig (owned and operated by Mud Bay Drilling Company Ltd.) that advanced the approximately 200 mm diameter holes to depths of between 11.7 and 21.0 m below ground surface, depending on location and conditions encountered. Soil samples were collected from the continuous return of the drill, and as well, some discrete samples obtained from a split-spoon sampler during Standard Penetration Testing (SPT), which involved advancing the sampler into the ground at select depths using a trip-hammer attached to the drill rig. The seismic electronic cone penetration tests (SCPTs) were completed using equipment supplied and operated by ConeTec (and mounted on the Mud Bay drill rig). Cone penetration tests were completed at locations and depths where the soils were judged to be of appropriate type and density to allow advancement of the cone, in order to assess the liquefaction potential of those soils. Where such soils were found to be overlain by very dense or obstructive materials (e.g. cobbles, dense overlying fills, etc.), drillout with the Mud Bay sonic rig was completed prior to advancement of the electronic cone. At some locations, it was possible to complete sonic drilling at depths corresponding to the SCPT test depths, in order to allow for the collection of soil samples at those locations and provide a continuous soil profile on the sonic log. However, this was not possible in all cases, and where this occurred, sections of the sonic soil logs do not show any soils information and are marked as “no recovery” (although there is information from the electronic cone penetration tests at the corresponding depths).

Following completion of the sonic drilling and cone penetration testing, the holes were sealed in accordance with provincial Groundwater Regulations, and the collected samples were returned to the Levelton soils and materials laboratory for further classification and testing.

The locations of the sonic drill holes and the SCPTs are as shown on Drawing W1.

2.0 RESULTS OF GEOTECHNICAL SUBSURFACE INVESTIGATION (FEBRUARY, 2015)

The information for the sonic drill holes and the SCPTs should be read together (where applicable), as the information obtained from one method complements the other at any given location. In general, the SCPTs were completed where soil nature and density permitted; however, at most locations, drill-out with the sonic drill at various depths was required. Therefore, gaps appear in both the sonic and SCPT logs, where the other method was utilized. Together, the sonic and SCPT logs combined provide a complete profile to the depth investigated at each location.
2.1. **SONIC DRILLING**

The results of the sonic drill holes completed during this current phase of the project are shown on the attached test hole logs S-01 through S-14. Note that some gaps are shown on the logs (indicated as “no recovery”); in these zones, SCPT testing was completed without sonic drilling at the corresponding depth.

2.2. **ELECTRONIC CONE PENETRATION TESTS**

The results of the SCPTs are shown on the attached cone plots and pore pressure dissipation test summary. Note that the electronic cone tests capture a wide variety of information, and therefore, several plots are required for each test location/depth, in order to present all of the findings. An overview description of the plots for this investigation is as follows:

- For each test location and depth, ConeTec provided three plots:
  - A “standard” CPT plot that includes: corrected tip resistance ($q_t$), sleeve friction ($f_s$), friction ratio ($R_f$), and pore pressure ($u$);
  - An “advanced” plot that includes an interpreted value for undrained shear strength ($S_u$), based on published correlations; and
  - A “seismic” plot that includes values for shear wave velocity ($V_s$) through the soils at various depths.
- Pore pressure dissipation tests were also completed at select locations and depths. The results of the tests are provided on the attached dissipation curves.

3.0 **CLOSURE**

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Yours truly,

**Levelton Consultants Ltd.**

[Original signed by: ]

[Original signed by: ]

Per: Carl M. Kelman, P.Eng.


CMK/DMW/mg

Attachment(s): Terms of Reference

Drawing W1

Sonic Test Hole Logs

Electronic Cone Penetration Test Results (Plots and Dissipation Curves)
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<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>C</th>
<th>N</th>
<th>Type</th>
<th>Water Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>FILL - br. Sand, Gravel and Boulders (greater than 2 ft. dia.), some cobbles, some metal</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>FILL - gr. sandy Silt, some gravel</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>FILL - soft gr. Silt, some sand</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>FILL - gr. gravelly silty Sand (Till Fill)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>FILL - soft gr. sandy Silt, some gravel, some wood at 23 ft. metal wire at 27 ft.</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>FILL - gr. silty Sand, metal wire at 30 ft.</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Compact to dense gr. SAND, some gravel, some cobbles, some shells</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td></td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Very stiff gr. sandy SILT (Glaciated)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Very stiff gr. SILT, some fine sand (Glaciated)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Hard gr. SILT, some clay (Glaciated)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td></td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>Bottom of hole at 59.0 feet.</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C: Condition of Sample
- Good
- Disturbed
- No Recovery

Type: Type of Sampler
- SPT: 2 in. standard
- WH: Weight of Hammer
- WR: Weight of Rod

N: Number of Blows

Moisture Content %
Plastic Limit %
Liquid Limit %
Ground Water Level
Shear strength in kPa (Torvane or Penetrometer)
Shear strength in kPa (Unconfined)
Shear strength in kPa (field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 23/02/2015
By: ABC
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>C</th>
<th>N</th>
<th>Type</th>
<th>Water Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>FILL - br. silty sandy Gravel</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>FILL - gr. sandy Silt, some gravel, some boulders</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>FILL - hard gr. Silt, some sand</td>
<td>G</td>
<td></td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>FILL - firm gr. sandy Silt, some gravel, clayey below 16 ft.</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>FILL - gr. silty Sand</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Compact gr. silty SAND, some shells</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Gr. layered sandy SILT and SAND mixed with shells</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Very stiff to hard gr. SILT, some fine sand (Glaciated)</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Dense gr. sandy SILT, some gravel (Glacial Till)</td>
<td>G</td>
<td></td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Hard gr. SILT, some clay, trace fine sand (Glaciated)</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Dense grey sandy SILT, some gravel, some clay (Glacial Till)</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Hard grey clayey SILT (Glaciated)</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
</tbody>
</table>

Bottom of hole at 59.0 feet.

**C: Condition of Sample**
- Good
- Disturbed
- No Recovery

**Type: Type of Sampler**
- SPT: 2 in. standard
- ST: Shelby
- FP: Fixed piston
- G: Grab
- CORE

**N: Number of Blows**
- WH: Weight of Hammer
- WR: Weight of Rod
- Standard Penetration Test: ASTM D1586

**Hammer Type:**
- Moisture Content %
- Plastic Limit %
- Liquid Limit %
- Ground Water Level
- Shear strength in kPa (Torvane or Penetrometer)
- Shear strength in kPa (Unconfined)
- Shear strength in kPa (field vane)
- Remolded strength in kPa
- Percent Passing # 200 sieve

**Drill Method:** Sonic

**Date Drilled:** 24/02/2015

**By:** ABC
FILL - br. clayey Silt, some gravel, some sand
FILL - br. sandy Silt, some clay, some gravel, some wood
FILL - gr. Silt, some clay
FILL - gr. clayey Silt, some fine sand, some gravel
FILL - gr. silty Sand and Gravel
FILL - gr. Silt, some clay
Gr. SAND mixed with shells, some gravel, some silt
Very stiff gr. SILT (Glaciated)
Hard gr. SILT (Glaciated)
Dense gr. sandy SILT, some gravel (Glacial Till)
Hard gr. SILT (Glaciated)
Very dense gr. fine SAND and SILT (Glaciated)
Hard grey SILT, some fine sand (Glaciated)

Bottom of hole at 50.5 feet.
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>C</th>
<th>N</th>
<th>Type</th>
<th>Water Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>FILL - gr. sandy gravelly Silt and Boulders, some cobbles</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>FILL - gr. sandy Silt, some gravel</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>No Recovery</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>FILL - grey silty Sand and Gravel, trace shells</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>FILL - gr. sandy Silt, trace organics</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Gr. silty SAND, some shells</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Gr. coarse SAND mixed with shells, some silt, some cobbles</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Gr. silty coarse SAND</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Hard grey clayey SILT (Glaciated)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Dense grey coarse SAND, some gravel (Glaciated)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>Dense gr. sandy SILT, some gravel, some cobbles (Glacial Till)</td>
<td>G</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Bottom of hole at 59.0 feet.
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>C</th>
<th>N</th>
<th>Type</th>
<th>Water Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FILL - br. gravelly Sand, some silt</td>
<td>G</td>
<td></td>
<td>SPT</td>
<td>10 30 60 90</td>
</tr>
<tr>
<td></td>
<td>FILL - gr. sandy Silt, trace gravel, log at 4'</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FILL - dense gr. silty Sand, some gravel</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FILL - dense gr. Sand and Gravel, some silt, some cobbles, trace shells</td>
<td>G</td>
<td>48</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FILL - compact silty Sand, some gravel, some shells (Till Fill)</td>
<td>G</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gr. silty gravelly SAND, some shells</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very stiff gr. SILT (Glaciated)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard gr. clayey SILT (Glaciated)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard gr. sandy clayey SILT (Glaciated)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bottom of hole at 39.0 feet.
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>FILL - gr. sandy Silt, some gravel</td>
</tr>
<tr>
<td>2</td>
<td>FILL - gr. Silt, some sand to sandy</td>
</tr>
<tr>
<td>10</td>
<td>FILL - gr. Silt, some clay, some wood</td>
</tr>
<tr>
<td>10</td>
<td>No Recovery</td>
</tr>
<tr>
<td>6</td>
<td>FILL - gr. gravelly sandy Silt, some cobbles</td>
</tr>
<tr>
<td>8</td>
<td>Compact gr. silty SAND / sandy SILT, some shells, some wood</td>
</tr>
<tr>
<td>10</td>
<td>Gr. silty SAND and GRAVEL</td>
</tr>
<tr>
<td>10</td>
<td>Dense gr. sandy SILT, some gravel (Glacial Till)</td>
</tr>
<tr>
<td>12</td>
<td>Hard grey SILT, some clay to clayey (Glaciated)</td>
</tr>
<tr>
<td></td>
<td>Bottom of hole at 50.5 feet.</td>
</tr>
</tbody>
</table>

**Description**
- **C**: Condition of Sample
  - Good
  - Disturbed
  - No Recovery
- **N**: Number of Blows
- **Type**: Type of Sampler
  - SPT: 2 in. standard
  - ST: Shelby
  - FP: Fixed Piston
  - G: Grab
- **Water Level**
- **Sonic**: Shear strength in kPa (Torvane or Penetrometer)
- **Hammer Type**: ASTM D1586
- **Date Drilled**: 23/02/2015

This log is for geotechnical purposes only. This log is the sole property of LEVELTON CONSULTANTS LTD and cannot be used or duplicated in any way without express written permission.
<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
<th>C</th>
<th>N</th>
<th>Type</th>
<th>Water Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>5</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FILL - loose to compact br. Sand and Gravel</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FILL - firm to stiff gr. Silt</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FILL - br. Sand and Gravel, some cobbles, some silt</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compact gr. silty SAND and GRAVEL, trace shells</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dense gr. sandy SILT, some gravel (Glacial Till)</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard gr. SILT, some clay (Glaciated)</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard gr. clayey SILT (Glaciated)</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bottom of hole at 39.0 feet.</td>
<td></td>
<td></td>
<td>G</td>
<td></td>
</tr>
</tbody>
</table>

**C: Condition of Sample**
- Good
- Disturbed
- No Recovery

**Type: Type of Sampler**
- SPT: 2 in. standard
- ST: Shelby
- FP: Fixed Piston
- G: Grab
- CORE

**N: Number of Blows**
- WH: Weight of Hammer
- WR: Weight of Rod
- Standard Penetration Test: ASTM D1586

**Hammer Type:**
- Moisture Content %
- Plastic Limit %
- Liquid Limit %
- Ground Water Level
- Shear strength in kPa (Torvane or Penetrometer)
- Shear strength in kPa (Unconfined)
- Shear strength in kPa (field vane)
- Remolded strength in kPa
- Percent Passing # 200 sieve

**Drill Method:**
- Sonic

**Date Drilled:** 19/02/2015

**By:** ABC
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 2</td>
<td>FILL - br. Sand and Gravel</td>
</tr>
<tr>
<td>2 - 10</td>
<td>FILL - gr. silty Sand, some gravel (Till Fill)</td>
</tr>
<tr>
<td>10 - 15</td>
<td>FILL - loose gr. sandy Silt, some gravel</td>
</tr>
<tr>
<td>15 - 20</td>
<td>No Recovery</td>
</tr>
<tr>
<td>20 - 30</td>
<td>Loose gr. coarse SAND, some gravel, some silt, trace shells</td>
</tr>
<tr>
<td>30 - 35</td>
<td>Compact gr. silty SAND and GRAVEL, trace shells</td>
</tr>
<tr>
<td>35 - 40</td>
<td>Hard gr. SILT, some fine sand (Glaciated)</td>
</tr>
<tr>
<td>40 - 45</td>
<td>Hard gr. SILT, some clay (Glaciated)</td>
</tr>
<tr>
<td>45 - 50</td>
<td>Hard gr. clayey SILT (Glaciated)</td>
</tr>
</tbody>
</table>

**C: Condition of Sample**
- Good |
- Disturbed |
- No Recovery |

**Type: Type of Sampler**
- SPT: 2 in. standard |
- ST: Shelby |
- FP: Fixed Piston |
- G: Grab |
- CORE |

**N: Number of Blows**

**Sonic**

**Drill Method:** Sonic

**Date Drilled:** 17/02/2015

**By:** ABC
Hard gr. clayey SILT (Glaciated) (continued)

Bottom of hole at 69.0 feet.
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>C</th>
<th>N</th>
<th>Type</th>
<th>Water Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FILL - br. coarse Sand and Gravel</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FILL - gr. sandy Silt, some gravel (Till Fill)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compact br. coarse SAND and GRAVEL, trace silt, trace shells</td>
<td>G</td>
<td>21</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard with depth sandy SILT, some clay</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very dense gr. silty SAND (Glaciated)</td>
<td>G</td>
<td>55</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard gr. clayey SILT, some fine sand (Glaciated)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bottom of hole at 50.0 feet.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C: Condition of Sample
- Good
- Disturbed
- No Recovery

Type: Type of Sampler
- SPT: 2 in. standard
- ST: Shelby
- FP: Fixed Piston
- G: Grab

N: Number of Blows

Water Level

Drill Method: Sonic
Date Drilled: 19/02/2015
Description

FILL - br. gravelly coarse Sand
FILL - br. silty Sand and Gravel
FILL - gr. clayey Silt, some sand
FILL - gr. sandy Silt, some clay
FILL - loose gr. silty Sand and Gravel
FILL - gr. gravelly sandy Silt, some clay

No Recovery

Dense gr. sandy SILT, some gravel (Glaciated), with some glacial Till layers

Bottom of hole at 49.0 feet.
## Description

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>C</th>
<th>N</th>
<th>Type</th>
<th>Water Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>FILL - br. Sand and Gravel, some silt</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>FILL - firm gr. br. clayey sandy Silt, some wood</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>15.0</td>
<td>FILL - gr. silty Sand and Gravel</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>15.0</td>
<td>FILL - loose gr. gravelly silty Sand (Till Fill)</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.0</td>
<td>Very loose gr. silty SAND</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>20.0</td>
<td>Firm gr. SILT, some clay</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>25.0</td>
<td>Loose gr. silty SAND, trace shells</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>30.0</td>
<td>Loose to compact with depth gr. silty SAND and GRAVEL mixed with shells,</td>
<td></td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>some cobbles from 35 ft. to 40ft.</td>
<td>G</td>
<td></td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>40.0</td>
<td>Hard grey SILT, some clay, some gravel (Glaciated)</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>45.0</td>
<td>Dense gr. sandy SILT, some gravel, some cobbles (Glacial Till)</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>49.0</td>
<td>Bottom of hole at 49.0 feet.</td>
<td>G</td>
<td></td>
<td>G</td>
<td></td>
</tr>
</tbody>
</table>

### SPT

- **Moisture Content %**
- **Plastic Limit %**
- **Liquid Limit %**
- **Ground Water Level**
- **Shear strength in kPa (Torvane or Penetrometer)**
- **Shear strength in kPa (Unconfined)**
- **Shear strength in kPa (field vane)**
- **Remolded strength in kPa**
- **Percent Passing # 200 sieve**

### Drilling Details

- **Hammer Type:** ASTM D1586 Standard Penetration Test
- **Hammer Type:**
- **Date Drilled:** 18/02/2015
- **Drill Method:** Sonic

---

**Note:** This log is for geotechnical purposes only. It is the sole property of Levelton Consultants Ltd. and cannot be used or duplicated in any way without express written permission.
### Depth (m) Description C N Type Water Level

- **FILL - loose br. sandy Gravel and Cobbles**
- **FILL - loose gr. sandy Silt, some gravel, some cobbles (Till Fill)**
- **FILL - compact br. coarse Sand and Gravel, some cobbles**
- **FILL - gr. sandy Silt, some gravel**
  - Very stiff grey clayey SILT, some sand
- **Dense to very dense gr. sandy SILT, some gravel (Glacial Till)**

**Bottom of hole at 46.0 feet.**

---

### Table

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>C</th>
<th>N</th>
<th>Type</th>
<th>Water Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>FILL - loose br. sandy Gravel and Cobbles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0</td>
<td>FILL - loose gr. sandy Silt, some gravel, some cobbles (Till Fill)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.0</td>
<td>FILL - compact br. coarse Sand and Gravel, some cobbles</td>
<td>24</td>
<td></td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>20.0</td>
<td>FILL - gr. sandy Silt, some gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>Very stiff grey clayey SILT, some sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.0</td>
<td>Dense to very dense gr. sandy SILT, some gravel (Glacial Till)</td>
<td></td>
<td></td>
<td></td>
<td>52/8.5%</td>
</tr>
</tbody>
</table>

---

### Notes

- **C:** Condition of Sample
  - Good
  - Disturbed
  - No Recovery
- **Type:** Type of Sampler
  - SPT : 2 in. standard
  - ST : Shelby
  - FP : Fixed Piston
  - G : Grab
- **N:** Number of Blows
  - WH : Weight of Hammer
  - WR : Weight of Rod
  - Standard Penetration Test : ASTM D1586
  - Hammer Type:
    - Moisture Content %
    - Plastic Limit %
    - Liquid Limit %
    - Ground Water Level
    - Shear strength in kPa (Torravane or Penetrometer)
    - Shear strength in kPa (Unconfined)
    - Shear strength in kPa (field vane)
    - Remolded strength in kPa
    - Percent Passing # 200 sieve

### General Information

- **Drill Method:** Sonic
- **Date Drilled:** 18/02/2015
- **By:** ABC

---

### Project Details
- **Project No:** R713-1879-00
- **Kinder Morgan Westridge Terminal Burnaby, BC**
- **TMEP Enhanced FEED Study**

---

**Legend:**

- G: Grab
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Bottom of hole at 38.5 feet.</td>
</tr>
<tr>
<td>1</td>
<td>FILL - firm br. gr. gravelly sandy Silt, some cobbles.</td>
</tr>
<tr>
<td>2</td>
<td>FILL - stiff gr. sandy Silt, some gravel, trace wood at 8.5 ft.</td>
</tr>
<tr>
<td>5</td>
<td>FILL - loose to compact layered br. gr. gravelly silty Sand / sandy Silt, some wood at 25 ft.</td>
</tr>
<tr>
<td>8</td>
<td>Dense gr. silty SAND and GRAVEL (Glaciated)</td>
</tr>
<tr>
<td>10</td>
<td>Very dense gr. silty SAND, some gravel (Glacial Till).</td>
</tr>
<tr>
<td>12</td>
<td>Note: 38 ft. deep SPT was bouncing on a cobble</td>
</tr>
</tbody>
</table>

### Standard Penetration Test (SPT) Results

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>C</th>
<th>N</th>
<th>Type</th>
<th>Water Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>15</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>15</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>9</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>30/2.5</td>
<td>SPT</td>
<td></td>
</tr>
</tbody>
</table>

### SPT Details

- **Type**: 2 in. standard, Shelby, Fixed Piston, Grab
- **Weight of Hammer (WH)**
- **Weight of Rod (WR)**
- **Liquid Limit %**
- **Plastic Limit %**
- **Ground Water Level**
- **Moisture Content %**
- **Shear strength in kPa (Torvane or Penetrometer)**
- **Shear strength in kPa (Unconfined)**
- **Shear strength in kPa (field vane)**
- **Remolded strength in kPa**
- **Percent Passing # 200 sieve**

**Drill Method**: Sonic

**Date Drilled**: 20/02/2015
### Description

<table>
<thead>
<tr>
<th>Depth (m) (ft)</th>
<th>Description</th>
<th>C</th>
<th>N</th>
<th>Type</th>
<th>Water Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>FILL - loose br. sandy Silt, some gravel, trace clay</td>
<td>G</td>
<td>10</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>FILL - loose br. gravelly silty Sand, some cobbles</td>
<td>G</td>
<td>20</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>FILL - firm br. gr. sandy Silt, some gravel (Till Fill)</td>
<td>G</td>
<td>30</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>FILL - loose br. gravelly silty Sand, some wood</td>
<td>G</td>
<td>40</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>No Recovery</td>
<td>G</td>
<td>50</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Very dense gravelly silty SAND, some cobbles (Glacial Till)</td>
<td>G</td>
<td>60</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Dense gr. gravelly SAND, some silt (Glaciated)</td>
<td>G</td>
<td>70</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Very dense silty SAND (Glaciated)</td>
<td>G</td>
<td>80</td>
<td>SPT</td>
<td></td>
</tr>
<tr>
<td>40.5</td>
<td>Bottom of hole at 40.5 feet.</td>
<td>G</td>
<td>90</td>
<td>SPT</td>
<td></td>
</tr>
</tbody>
</table>

### Notes
- Moisture Content %
- Plastic Limit %
- Liquid Limit %
- Ground Water Level
- Shear strength in kPa (Torvane or Penetrometer)
- Shear strength in kPa (Unconfined)
- Shear strength in kPa (field vane)
- Remolded strength in kPa
- Percent Passing # 200 sieve

### Drilling Details
- **Date Drilled:** 20/02/2015
- **Drill Method:** Sonic
- **By:** ABC

---

**Kinder Morgan Westridge Terminal**  
**Burnaby, BC**  
**TMEP Enhanced FEED Study**

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**Levelton Consultants Ltd.**  
#100 - 12791 Clarke Place  
Richmond, B.C., V6V 2H9  
Tel: 604-278-1411  
Fax: 604-278-1042  
www.levelton.com

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**Sonic Holes FEB 2015**

**Core: 1 LOG PER PAGE  R713-1879-00  - WESTRIDGE SONIC HOLES FEB 2015.GPJ  LEVELTON.GDT  31/3/15**  

**Project No: R713-1879-00**  
**#150 - 12791 Clarke Place**  
**Richmond, B.C., V6V 2H9**  
**Tel: 604-278-1411**  
**Fax: 604-278-1042**  
**www.levelton.com**
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.
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The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.
Job No: 15-02014  
Date: 02:17:15 09:24  
Site: Kinder Morgan Westridge, Burnaby

Max Depth: 11.150 m / 36.58 ft  
Depth Inc: 0.050 m / 0.164 ft  
Avg Int: 0.200 m

Overplot Item:  
Ueq  
Hydrostatic Line

The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.
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The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Max Depth: 9.500 m / 31.17 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.
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Job No: 15-02014  Sounding: SCPT15-S02
Date: 02:24:15 09:15  Cone: 407:T1500F15U500
Site: Kinder Morgan Westridge, Burnaby

DRILLED OUT
Refusal

Max Depth: 11.100 m / 36.42 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

Overplot Item: Ueq
Hydrostatic Line

File: 15-02014_SPS02.COR
Unit Wt: SBT Chart Soil Zones
SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10N: N: 5459609m E: 503241m
Page No: 1 of 1
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Job No: 15-02014  
Sounding: SCPT15-S03  
Date: 02:24:15  13:19  
Site: Kinder Morgan Westridge, Burnaby

Max Depth: 10.000 m / 32.81 ft  
Depth Inc: 0.050 m / 0.164 ft  
Avg Int: 0.200 m

File: 15-02014_SPS03.COR  
Unit Wt: SBT Chart Soil Zones  
SBT: Lunne, Robertson and Powell, 1997

Coords: UTM 10N: 5459595m E: 503242m

Overplot Item: Ueq  Hydrostatic Line

Refusal

DRILLED OUT

Levelton
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.
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Max Depth: 9.900 m / 32.48 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

Overplot Item: Ueq
Hydrostatic Line

File: 15-02014_SPS08.COR
Unit Wt: SBT Chart Soil Zones

SBT: Lunne, Robertson and Powell. 1997
Coords: UTM 10N: N: 5459661m E: 503359m
Page No: 1 of 1
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.
The reported coordinates were acquired from hand-held GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.
Job No: 15-02014  
Date: 02/23/2015 13:57  
Site: Kinder Morgan Westridge, Burnaby  
Sounding: SCPT15-S01  
Cone: 407:T1500F15U500  
Cone Area: 15 sq cm  

Trace Summary:  
Filename: 15-02014_SPS01.PPF  
Depth: 8.950 m / 29.363 ft  
Duration: 400.0 s  
U Min: -3.7 m  
U Max: 4.6 m  
WT: 4.498 m / 14.757 ft  
Ueq: 4.5 m
Levelton

Job No: 15-02014
Date: 02/23/2015 13:57
Site: Kinder Morgan Westridge, Burnaby

Sounding: SCPT15-S01
Cone: 407:T1500F15U500
Cone Area: 15 sq cm

Pore Pressure (m) vs. Time (s)

Trace Summary:
- Filename: 15-02014_SPS01.PPF
- Depth: 11.000 m / 36.089 ft
- Duration: 200.0 s
- U Min: 4.0 m
- U Max: 6.9 m
- WT: 4.484 m / 14.711 ft
- Ueq: 6.5 m
Job No: 15-02014
Date: 02/24/2015 09:15
Site: Kinder Morgan Westridge, Burnaby
Sounding: SCPT15-S02
Cone: 407:T1500F15U500
Cone Area: 15 sq cm

Filename: 15-02014_SPS02.PPF
Depth: 8.350 m / 27.395 ft
Duration: 295.0 s

U Min: 4.8 m
U Max: 8.5 m
WT: 3.253 m / 10.672 ft
Ueq: 5.1 m
Job No: 15-02014  
Date: 02/24/2015 09:15  
Site: Kinder Morgan Westridge, Burnaby  

Sounding: SCPT15-S02  
Cone: 407:T1500F15U500  
Cone Area: 15 sq cm

Trace Summary:  
Filename: 15-02014_SPS02.PPF  
Depth: 11.100 m / 36.417 ft  
Duration: 400.0 s  

U Min: 12.8 m  
U Max: 96.3 m  
WT: 3.300 m / 10.827 ft  
T(50): 33.5 s  
Ir: 100  
Ch: 21.0 sq cm/min
Job No: 15-02014  
Date: 02/16/2015 11:40  
Site: Kinder Morgan Westridge, Burnaby  
Sounding: SCPT15-S05  
Cone: 375:T1500F15U500  
Cone Area: 15 sq cm

Trace Summary:
Filename: 15-02014_SPS05.PPF  
Depth: 4.300 m / 14.107 ft  
Duration: 260.0 s  
U Min: -0.2 m  
U Max: 0.2 m  
WT: 4.235 m / 13.894 ft  
Ueq: 0.1 m
Job No: 15-02014
Date: 02/23/2015 09:50
Site: Kinder Morgan Westridge, Burnaby
Sounding: SCPT15-S06
Cone: 329:T1500F15U500
Cone Area: 15 sq cm

Filename: 15-02014_SPS06.PPF
Depth: 5.050 m / 16.568 ft
Duration: 405.0 s

Time (s)

Pore Pressure (m)

U Min: -1.9 m
U Max: 1.9 m
WT: 3.760 m / 12.336 ft
Ueq: 1.3 m
Job No: 15-02014
Date: 02/17/2015 13:54
Site: Kinder Morgan Westridge, Burnaby

Sounding: SCPT15-S08
Cone: 329:T1500F15U500
Cone Area: 15 sq cm

Trace Summary:
Filename: 15-02014_SPS08.PPF
Depth: 7.350 m / 24.114 ft
Duration: 150.0 s
U Min: 3.1 m
U Max: 3.4 m
WT: 4.060 m / 13.320 ft
Ueq: 3.3 m
Trace Summary:
Filename: 15-02014_SPS08.PPF
Depth: 7.600 m / 24.934 ft
Duration: 300.0 s

U Min: 3.4 m
U Max: 3.8 m
WT: 4.052 m / 13.294 ft
Ueq: 3.5 m
Levelton

Job No: 15-02014
Date: 02/19/2015 11:48
Site: Kinder Morgan Westridge, Burnaby

Sounding: SCPT15-S09
Cone: 329:T1500F15U500
Cone Area: 15 sq cm

Trace Summary:
Filename: 15-02014_SPS09.PPF
Depth: 2.550 m / 8.366 ft
Duration: 135.0 s

Time (s)
Pore Pressure (m)

Filename: 15-02014_SPS09.PPF
Depth: 2.550 m / 8.366 ft
Duration: 135.0 s

U Min: -0.3 m
U Max: 0.1 m
WT: 2.615 m / 8.579 ft
Ueq: -0.1 m
Levelton

Job No: 15-02014
Date: 02/17/2015 09:24
Site: Kinder Morgan Westridge, Burnaby
Sounding: SCPT15-S10
Cone: 329:T1500F15U500
Cone Area: 15 sq cm

Trace Summary:
Filename: 15-02014_SPS10.PPF
Depth: 8.300 m / 27.231 ft
Duration: 585.0 s
U Min: -3.2 m
U Max: 4.0 m
WT: 4.365 m / 14.321 ft
Ueq: 3.9 m
Levelton

Job No: 15-02014
Date: 02/17/2015 09:24
Site: Kinder Morgan Westridge, Burnaby

Sounding: SCPT15-S10
Cone: 329:T1500F15U500
Cone Area: 15 sq cm

Trace Summary:
Filename: 15-02014_SPS10.PPF
Depth: 11.150 m / 36.581 ft
Duration: 265.0 s

U Min: 6.7 m
U Max: 6.9 m
WT: 4.376 m / 14.357 ft
Ueq: 6.8 m
Levelton

Job No: 15-02014
Date: 02/19/2015 08:51
Site: Kinder Morgan Westridge, Burnaby
Sounding: SCPT15-S12
Cone: 329:T1500F15U500
Cone Area: 15 sq cm

Trace Summary:
Filename: 15-02014_SPS12.PPF
Depth: 11.350 m / 37.237 ft
Duration: 1200.0 s
U Min: 7.1 m
U Max: 17.5 m