

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
LITTLE GRAVEL RIVER BRIDGE REHABILITATION  
HIGHWAY 17  
DISTRICT OF THUNDER BAY, ONTARIO**

**G.W.P. 6067-09-00, Site No. 48C-17**

**Geocres Number: 42D-31**

**Report to**

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted at the location of the bridge carrying Highway 17 over Little Gravel River located approximately 45 km west of Schreiber, in the District of Thunder Bay, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin, under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0011.

In the preparation of this report and in addition to the boreholes drilled under the current assignment, reference has been made to information on subsurface conditions contained in a previous report. The title of the previous report is listed as follows:

- Department of Highways of Ontario, Foundation Investigation, Little Gravel River Crossing, T.C.H. No. 17, District No. 19. Project: J267, Geocres No. 58-F-269C, Prepared by Trow, Soderman and Associates, dated November 20, 1958. (Reference 1).

**2 SITE DESCRIPTION**

The Little Gravel River bridge is located on Highway 17 approximately 45 km west of Schreiber in the District of Thunder Bay, Ontario. The site is approximately 460 m west of the Community of Gravel River and 1.1 km west of Mountain Bay Drive.

At present, the highway crosses Little Gravel River on a single-span structure. The bridge span is 15.2 m and the width is 10.5 m. At the site, Little Gravel River flows southerly towards Lake Superior, which is located approximately 200 m south of the bridge. At the bridge location, the river is shallow and slow flowing. The depth of water in the river is reported to vary from 0.6 m to 0.9 m.

The lands surrounding the bridge site consist of some forested areas. A railway runs parallel to Highway 17, crossing Little Gravel River on a bridge approximately 35 m to the south. A commercial building and an accommodation facility are located approximately 150 m east of the bridge.

Photographs in Appendix D show the general nature of the site.

The site lies within the Canadian Shield, characterized by low, rounded hills of Pre-Cambrian bedrock mantled by varying thicknesses of native soils. During the present investigation, bedrock was not contacted within the depth of exploration. The native soils encountered consist of extensive deposits of silty clay and clayey silt.

### **3 SITE INVESTIGATION AND FIELD TESTING**

The site investigation and field testing for this project were carried out during the period of November 6 to 11, 2011 and consisted of drilling and sampling four boreholes (numbered LGR-01 to LGR-04) through the highway embankment in the area of the existing west and east abutments and approaches. Boreholes LGR-02 and LGR-03 were drilled near the abutments and Boreholes LGR-01 and LGR-04 were drilled through the approach embankments. The four boreholes were terminated at 27.4 m depth (elevations 160.0 to 160.1).

The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix F.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling.

The drilling was carried out using a CME 75 truck-mounted drill rig. Wash boring methods with NW-casing were used to advance the boreholes. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In situ vane shear testing was carried out to assess the undrained shear strength of soft to firm cohesive deposits.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Two standpipe piezometers consisting of 19 mm PVC pipe with slotted screen and enclosed in filter sand were installed at this site to permit longer term groundwater level monitoring. The piezometers were subsequently decommissioned in general accordance with MOE Regulation 903.

Boreholes without piezometers were backfilled in general accordance with Regulation 903. The installation and completion details of the boreholes and piezometers are summarized in Table 3.1.

**Table 3.1 – Borehole and Piezometer Completion Details**

| Location                      | Borehole | Piezometer<br>Tip Depth/<br>Elevation (m) | Completion Details  |
|-------------------------------|----------|---|---|
| West<br>Abutment/<br>Approach | LGR-01   | None installed                            | Borehole backfilled with bentonite grout mixture to 1.8 m, concrete to 0.8 m, sand to 0.15 m, then asphalt to surface.                              |
|                               | LGR-02   | 27.4/160.1                                | Sand from 27.4 m to 25.3 m, bentonite grout from 25.3 m to 1.7 m, sand from 1.7 m to 0.15 m, then concrete to surface.                              |
| East<br>Abutment/<br>Approach | LGR-03   | 27.4/160.1                                | Sand from 27.4 m to 25.1 m, bentonite grout from 25.1 m to 2.0 m, concrete from 2.0 m to 0.8 m, sand from 0.8 m to 0.15 m, then asphalt to surface. |
|                               | LGR-04   | None installed                            | Borehole backfilled with bentonite grout to 1.8 m, auger cuttings to 0.15 m, then asphalt to surface.   |

#### 4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing where appropriate. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B.

#### 5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing in Appendix F. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

In general terms, the stratigraphy encountered at this site consists of pavement structure overlying sand fill and native soils. The native soils contacted below the fill consist of an upper layer of silt overlying a thick deposit of very soft silty clay, underlain by loose to compact silt with clay layers.

More detailed descriptions of the individual strata are presented below.

## 5.1 Asphalt and Concrete

All boreholes were drilled through the pavement structure on Highway 17.

In Boreholes LGR-01 and LGR-04, a 115 mm thick layer of asphalt was encountered. In Boreholes LGR-02 and LGR-03, drilled through the approach slab, a 100 mm thick layer of asphalt was encountered over 330 mm and 225 mm of concrete. Granular fill was encountered below the asphalt and concrete.

## 5.2 Sand Fill

A layer of brown sand to gravelly sand fill containing trace to some silt and clay was contacted below the asphalt and concrete in all the boreholes. Wood fragments, possibly comprising remnants of a former timber crib abutment, were observed within the sand fill layer at 5.5 m depth (elevation 182.0) in Borehole LGR-02, drilled at the west abutment. Cobbles were encountered in the lower part of the fill in Borehole LGR-01. Cobbles and boulders may be present elsewhere in the fill.

The thickness of the sand fill was 3.7 m and 2.9 m in Boreholes LGR-01 and LGR-04 drilled at the approaches and 5.9 m and 6.1 m in Boreholes LGR-02 and LGR-03 drilled near the abutments. The depth to the base of the sand fill ranged from 3.0 m to 6.4 m (elevations 181.1 to 184.4).

SPT N-values recorded in the sand fill generally ranged from 11 to 41 blows per 0.3 m of penetration, indicating a compact to dense relative density. A very dense relative density was encountered in the upper 1.4 m to 2.0 m of sand fill in Boreholes LGR-01 and LGR-04, where the SPT-N values were 60 and 67 blows per 0.3 m of penetration. Locally in Borehole LGR-03, a SPT N-value of 4 blows per 0.3 m of penetration was measured near elevation 183.3, indicating a very loose to loose relative density.

The moisture content of samples of the sand fill generally ranged from 7% to 16%, with values of 21% and 29% measured in two samples from below the groundwater level.

Grain size distribution curves for sand fill samples are presented on the Record of Borehole sheets and on Figure B1 of Appendix B. The results of the laboratory tests are summarized as follows:

| Soil Particles | Sand Fill (%) |
|----------------|---------------|
| Gravel         | 7 to 22       |
| Sand           | 72 to 82      |
| Silt and Clay  | 6 to 11       |

### 5.3 Upper Silt

An upper layer of native silt was contacted below the fill in Boreholes LGR-01 and LGR-04, drilled at the approaches. The silt contained some clay and trace to some sand. In Borehole LGR-04, organics and wood fragments were observed in the silt immediately below the fill, and clay seams were encountered in the lower part of this unit.

The thickness of the upper silt layer was 1.2 m and 3.6 m in Boreholes LGR-01 and LGR-04, respectively. The depths to the base of the silt were 5.0 m and 6.6 m (Elev. 182.4 and 180.8).

SPT N-values recorded in the upper silt ranged from 0 to 5 blows per 0.3 m of penetration, indicating a loose to very loose condition.

The moisture content of samples of the upper silt ranged from 29% to 46%.

Grain size distribution curves for two samples of the upper silt are presented on the Record of Borehole sheets and on Figure B2 of Appendix B. The results of the laboratory tests are summarized as follows:

| Soil Particles | Silt (%) |
|----------------|----------|
| Gravel         | 0        |
| Sand           | 4 to 19  |
| Silt           | 71 to 79 |
| Clay           | 10 to 17 |

### 5.4 Silty Clay

Native grey silty clay was encountered below the fill in Boreholes LGR-02 and LGR-03 and below the silt layer in Boreholes LGR-01 and LGR-04 at depths of 5.0 to 6.6 m (Elev. 182.4 to 180.8). The silty clay contains silt seams, particularly near the upper and lower boundaries with the overlying and underlying silt deposits.

The thickness of the silty clay ranged from 10.5 m to 11.6 m. The depth to the base of the silty clay ranged from 16.6 m to 17.2 m (Elev. 170.3 to 170.8).

SPT N-values recorded in the silty clay ranged from 0 to 1 blows for 0.3 m of penetration, indicating a very soft consistency. A higher N-value of 6 blows for 0.3 m was obtained near the base of this deposit where silt layers were encountered within the clay. In-situ vane shear tests performed during drilling indicated undrained shear strengths ranging from 10 kPa to 28 kPa.

The moisture content of samples collected from the silty clay layer varies between 22% and 90%, typically between 47% and 65%.

Grain size distribution curves for selected samples of the silty clay are presented in Appendix B, Figures B3 and B4. Atterberg Limits test results are presented on Figures B6

and B7 of Appendix B. The results are also summarized on the Record of Borehole sheets included in Appendix A. The results shown on Figures B4 and B7 are for samples recovered near the boundaries of the clay unit and are believed to reflect the presence of silt seams/layers within the clay. The results of the laboratory tests are summarized as follows:

| Soil Particles | Silty Clay (%) | Silty Clay with Silt Layers (%) |
|----------------|----------------|---------------------------------|
| Gravel         | 0              | 0                               |
| Sand           | 0              | 0                               |
| Silt           | 17 to 41       | 53 to 74                        |
| Clay           | 59 to 83       | 26 to 47                        |

| Index Property |          |          |
|----------------|----------|----------|
| Liquid Limit   | 53 to 61 | 28 to 35 |
| Plastic Limit  | 22 to 24 | 16 to 18 |

The above results show that the silty clay is generally of high plasticity with a group symbol of CH. Locally near the upper boundary of the clay unit in Borehole LGR-01 and the lower boundary in Boreholes LGR-01, LGR-02 and LGR-04 where silt layers are present, low plasticity (CL) is indicated.

### 5.5 Lower Silt

A lower layer of grey silt containing seams and layers of silty clay was contacted below the silty clay at depths ranging from 16.6 m to 17.2 m (Elev. 170.3 to 170.8). All the boreholes were terminated within the lower silt layer at 27.4 m depth (Elev. 160.0 to 160.1).

SPT N-values recorded in the lower silt layer ranged from 5 to 20 blows per 0.3 m of penetration, indicating a loose to compact relative density. The moisture content ranged from 19% to 31%.

Grain size distribution curves for selected samples of the lower silt layer are presented on the Record of Borehole sheets and on Figure B5 of Appendix B. The curves for some samples are believed to reflect the presence of clay seams within the silt. The results of the laboratory tests are summarized as follows:

| Soil Particles | Silt (%) |
|----------------|----------|
| Gravel         | 0        |
| Sand           | 0        |
| Silt           | 69 to 88 |
| Clay           | 12 to 31 |

Atterberg Limits test results for one sample exhibiting plasticity are presented in Figure B8 of Appendix B. The results were as follows:

| Index Property | (%) |
|----------------|-----|
| Liquid Limit   | 24  |
| Plastic Limit  | 19  |

The above results show that zones of the lower silt exhibit slight plasticity with a group symbol of CL-ML.

## 5.6 Water Levels

Wash boring methods were used to advance the boreholes and therefore natural groundwater levels could not be monitored during drilling. Standpipe piezometers were installed in Boreholes LGR-02 and LGR-03 to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.1.

**Table 5.1 – Water Level Measurements**

| Foundation Unit | Borehole | Date              | Water Level (m) |           | Comments      |
|-----------------|----------|-------------------|-----------------|-----------|---------------|
|                 |          |                   | Depth           | Elevation |               |
| West abutment   | LGR-02   | November 9, 2011  | 3.0             | 184.5     | In piezometer |
|                 |          | November 30, 2011 | 2.2             | 185.3     |               |
|                 |          | May 29, 2012      | 2.2             | 185.3     |               |
| East abutment   | LGR-03   | November 12, 2011 | 3.3             | 184.2     | In piezometer |
|                 |          | November 30, 2011 | 2.7             | 184.8     |               |
|                 |          | May 29, 2012      | 2.6             | 184.9     |               |

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

The groundwater levels will also be affected by the water level in the river. The preliminary GA drawing dated April 2013 indicates that the water level in the Little Gravel River was near Elevation 182.5 in October 2012.

## 5.7 Data from previous investigation, 1958 (Reference 1)

A foundation investigation was conducted at this site in 1958 for construction of the currently existing bridge (Reference 1). The borehole logs, borehole location plan and soil profiles prepared for the previous investigation are reproduced in Appendix C. The approximate locations of the previous boreholes (Boreholes 1 to 4) are included on the drawing in Appendix F.



In general, the subsurface conditions documented during the 1958 investigation are consistent with the conditions encountered during the current investigation, comprising the following:

- A surficial layer of loose sand and gravel fill. The fill was brown in colour and approximately 1.5 m to 2.0 m thick.
- Immediately underlying the fill, a native deposit of grey silt and silty sand was contacted in the four boreholes. The thickness of the native silt/silty sand varies from 2.6 m to 3.0 m, with the lower 1.5 m grading to clayey silt at one location. The silt and silty sand was in a loose state.
- A deposit of varved silty clay was found in all the boreholes below the native silt and silty sand. The thickness of the silty clay was approximately 10.7 m. The in-situ field vane tests conducted in the silty clay, indicated undrained shear strengths ranging from 14 kPa to 28 kPa, indicating a typically soft consistency.
- Light grey silt was contacted below the silty clay, extending to depths of 49.0 m to 50.3 m in two boreholes. The silt was in a compact to dense state. Thin layers of fine sand and clay were found within the silt layer, and a 7.6 m thick layer of silty clay was encountered near the base of this deposit in one borehole.
- A layer of dense gravel and boulders was encountered approximately 50.0 m below the ground surface in Boreholes 1 and 4.
- Water was encountered in the boreholes at depths ranging from 0.9 m to 1.5 m below ground surface, near elevations 183.9 to 185.1.

## 6 MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. MMM Group Limited surveyed the borehole locations and provided the co-ordinates and the ground surface elevations.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied a truck mounted CME 75 drill rig and conducted the drilling, sampling and in-situ testing operations.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Stephane Loranger, C.E.T. of Thurber Engineering Ltd.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

Overall planning and supervision of the field program was conducted by Mr. Mark Farrant, P.Eng.

Interpretation of the data and preparation of the report was carried out by Ms. R. Palomeque Reyna, P.Eng. and Mr. Murray Anderson, P. Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**7 GENERAL**

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical recommendations for the proposed rehabilitation of the existing Little Gravel River bridge on Highway 17, located 45 km west of Schreiber in the District of Thunder Bay, Ontario. The site is approximately 460 m west of the Community of Gravel River and 1.1 km west of Mountain Bay Drive.

At present, Highway 17 crosses Little Gravel River on a single-span concrete rigid frame bridge with a span of 15.2 m and a width of 10.5 m. Design drawings from 1959 indicate that each abutment of the existing bridge is supported on 57 Class B timber piles driven to a design tip elevation of 167.6. The pile cut-off elevation was 181.3, leaving a design pile length of 13.7 m. The design load per pile was 135 kN (15 tons, working stress design).

Retaining walls extend laterally from the abutments for a distance of 9.1 m from the northwest and southeast corners and 7.0 m from the northeast and southwest corners of the bridge. The retaining walls are also supported on timber piles, with 21 piles at the northwest and southeast retaining walls and 16 piles at the northeast and southwest retaining walls.

The embankment height at both approaches is approximately 5.5 m.

The discussion and recommendations presented in this report are based on the information provided by McCormick Rankin and on the factual data obtained in the course of the investigation.

**8 ASSESSMENT OF EXISTING ABUTMENT FOUNDATIONS**

Based on the preliminary GA drawing dated April 2013, rehabilitation of the bridge will consist of replacement of the existing reinforced concrete deck with a new precast deck on steel girders. The

rehabilitation will include modification of the tops of the abutments and wingwalls, and replacement of the approach slabs.

We understand from McCormick Rankin that replacement of the deck will reduce the unfactored dead load by 18%. The live load will not change. The total load on the foundations will therefore be reduced.

The archive drawings indicate that the existing bridge abutments are supported on timber piles with a design tip elevation of 167.6. Based on the borehole information, the timber piles were driven through the upper loose to very loose silt layer, very soft silty clay stratum, and approximately 3.0 m into the underlying loose to compact silt encountered at elevations 170.3 to 170.8. The design load per pile (working stress design) was 135 kN (15 tons).

As the dead load and total load on the abutment foundations will be reduced by deck replacement, the performance of the timber piles extended to the lower silt stratum is not expected to be impacted by the proposed bridge rehabilitation.

Differential movement appears to have occurred in the past between the abutments and retaining walls. Photographs 3 and 4 in Appendix D show the apparent differential movement at the abutments. The abutment appears to have settled relative to the retaining walls, and the retaining walls are now forward of the abutment face. It is not known whether this is an as-constructed condition, if/when the movement occurred, or if the retaining walls have moved outward from the original position.

The apparent differential settlement likely occurred due to higher foundation loads imposed by the abutments than the retaining walls, as well differential consolidation of the clay layers under the weight of the approach fill. It is unlikely that the stream erosion has played a role in settlement of the timber pile foundations. As the bridge was constructed over 50 years ago, any long-term foundation settlement due to consolidation should be complete and no additional settlement is anticipated.

It is imperative that erosion protection be maintained to prevent undermining of the pile caps and retaining walls, and in particular to avoid any further outward movement of the retaining walls due to consequent reduction in lateral resistance of the supporting timber piles.

## **9 APPROACH EMBANKMENTS**

The existing approach embankments are approximately 5.5 m high. We understand that bridge rehabilitation will require that the grade on Highway 17 be raised 130 mm at the centreline of the road, resulting in placement of 500 mm of new granular fill along the tops of slopes at the approaches near the bridge where the concrete curb and gutter will be placed.

The embankment foundation soils generally consist of native deposits of loose to very loose silt, very soft silty clay, and underlying loose to compact silt.

It is expected that the proposed 130 mm grade raise and 500 mm of new granular fill placed along the tops of the approach slopes will not impact the stability of the embankment slopes.

Placement of approximately 130 mm of granular fill at the road centreline to raise the existing highway grade and 500 mm at the approach slopes will induce immediate (elastic) settlement in the existing non-cohesive fill and silt layers as well as time dependent (consolidation) settlement in the underlying silty clay deposit. Based on elastic analysis, the immediate settlement may be considered to be negligible. The anticipated long-term consolidation settlement computed using one-dimensional consolidation theory is in the order of 5 mm to 10 mm at the road centreline and 15 mm to 20 mm at the approach slopes. It is estimated that 70% of the consolidation settlement will occur in one year.

The roadway surface at the approaches should be periodically inspected for settlement at the approaches and padding of the asphalt should be provided as necessary to re-establish grades after construction.

As the abutment loads will be reduced and the existing abutments are supported on timber piles extending to the silt underlying the compressible clay stratum, the grade raise is not expected to impact the abutments.

## 10 ABUTMENT BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the modified abutments and wing walls should consist of Granular A or Granular B Type II or Type III material meeting the requirements of Special Provision 110S13 "Amendment to OPSS 1010, April 2004". The backfill must be in accordance with OPSS 902, and placed to the extents shown in OPSS 3101.150.

All new embankment fill should be placed in regular lifts and be compacted in accordance with OPSS 501. Also, compaction equipment to be used adjacent to retaining structures must be restricted in accordance OPSS 501.

Lateral earth pressures acting on the abutments/wing walls may be assumed to be distributed triangularly and to be governed by the characteristics of the wall backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p_h = K (\gamma h + q)$$

Where:

$p_h$  = horizontal pressure on the wall at depth  $h$  (kPa)

$K$  = earth pressure coefficient (see Table 10.1)

$\gamma$  = unit weight of retained soil (see Table 10.1)

$h$  = depth below top of fill where pressure is computed (m)

$q$  = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill and the existing material adjacent to the wall. Typical values are given in Table 10.1.

**Table 10.1 – Earth Pressure Coefficients (K)**

| Condition                     | Earth Pressure Coefficient (K)  |                             |  |                             |
|-------------------------------|---|-----------------------------|--|-----------------------------|
|                               | OPSS Granular A or<br>Granular B Type II<br>$\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$ |                             | OPSS Granular B Type I, Type III<br>or Existing Granular Fill<br>$\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$ |                             |
|                               | Horizontal<br>Surface Behind<br>Wall  | Sloping Backfill<br>(2H:1V) | Horizontal<br>Surface Behind<br>Wall   | Sloping Backfill<br>(2H:1V) |
| Active<br>(Unrestrained Wall) | 0.27  | 0.40*                       | 0.31   | 0.48*                       |
| At Rest<br>(Restrained Wall)  | 0.43  | -                           | 0.47   | -                           |
| Passive                       | 3.7   | -                           | 3.3  | -                           |

\* For wing walls.

The use of a material with a high friction angle and low active pressure coefficient (Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

The factors in Table 10.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.16 in the Commentary to the Canadian Highway Bridge Design Code.

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or at a depth of 1.7 m for Granular A or Granular B Type II.

## 11 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone                      0
- Zonal Velocity Ratio                                      0.0
- Acceleration Related Seismic Zone                0
- Zonal Acceleration Ratio                              0.0
- Peak Horizontal Acceleration                        0.02

The soil profile type at this site has been classified as Type IV. Therefore, according to Clause 4.4.6.1, Table 4.4 of the CHBDC, a Site Coefficient “S” (ground motion amplification factor) of 2.0 should be used in seismic design.

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active ( $K_{AE}$ ) and passive ( $K_{PE}$ ) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 11.1 may be used:

**Table 11.1 – Earth Pressure Coefficients for Earthquake Loading**

| Condition              | Earth Pressure Coefficient (K)   |  |
|------------------------|--|--|
|                        | OPSS Granular A or<br>OPSS Granular B Type II<br>$\phi = 35^\circ$<br>$\gamma = 22.8 \text{ kN/m}^3$ | OPSS Granular B Type I, Type III<br>or Existing Granular Fill<br>$\phi = 32^\circ$ ,<br>$\gamma = 21.2 \text{ kN/m}^3$ |
| Active ( $K_{AE}$ )*   | 0.28   | 0.32   |
| Passive ( $K_{PE}$ )   | 3.7  | 3.2  |
| At Rest ( $K_{OE}$ )** | 0.45   | 0.50   |

\* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

\*\* After Woods

The potential for liquefaction of the foundations soils was assessed using the Bray et al. (2004) criteria, based on Figure 6.15 of the Canadian Foundation Engineering Manual (CFEM, 2006) for fine-grained soils. Using these methods, it is estimated that under the existing conditions the foundation soils at the abutments are moderately susceptible to liquefaction. Some toe failure may occur but it is expected to be of limited nature and readily repairable.

## 12 SCOUR AND EROSION CONTROL

Erosion protection should be provided along any slopes that may be in contact with the river flow.

The scour depth at this site should be evaluated to confirm that the existing pile caps are placed below the scour depth and there is no potential for undermining of the pile caps.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS 804.

## 13 EXCAVATION AND GROUNDWATER CONTROL

Excavation for modification of the abutments is expected to be limited to the existing sand to gravelly sand backfill adjacent to the structure. Cobbles were encountered locally while drilling within the existing embankment fill.

The excavation and backfilling for foundations must be carried out in accordance with OPSS 902.

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the sand fill above the water level is classified as a Type 3 soil.

Based on the preliminary GA for the bridge structure, it is not expected that work at the abutments will require excavation below the river/groundwater level. If excavation extends below the water level, the cohesionless fill and native silt are classified as Type 4 soils. Excavation below the groundwater level/river level without prior dewatering is not recommended since the inflow of groundwater will make it difficult to maintain a dry, sound base on which to work.

The bridge rehabilitation will be done in stages in order to keep at least one highway lane operational. Roadway protection should be provided in accordance with OPSS 539 and designed for Performance Level 2.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. The selection and design of the roadway protection system is also the responsibility of the Contractor. All shoring systems must be designed by a Professional Engineer experienced in such designs.

The Contractor should be prepared to pump from sumps to remove any seepage water or surface water collecting in an excavation.

#### **14 CONSTRUCTION CONCERNS**

Potential construction concerns include, but are not necessarily limited to:

- Cobbles and boulders may be encountered in the existing approach fill during excavation or installation of roadway protection.
- The existing approach embankments are underlain by very soft silty clay. The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing embankments to support the proposed construction equipment, and the effects of any proposed excavation or additional fill placement (i.e, as a pad for crane support) on the stability of the embankment.



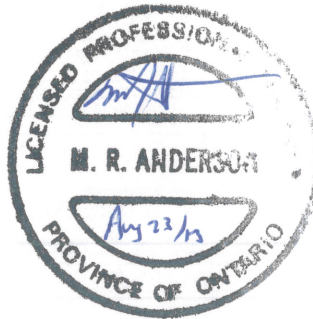
## 15 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Ms. R. Palomeque Reyna and Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

### Thurber Engineering Ltd.

Rocío Palomeque Reyna, P.Eng., M.Eng.  
Geotechnical Engineer

Murray R. Anderson, P.Eng., M.Eng.  
Senior Foundations Engineer



Report reviewed by:  
P.K. Chatterji, P.Eng., Ph.D.  
Review Principal



## **Appendix A**

### **Record of Borehole Sheets**

## EXPLANATION OF ROCK LOGGING TERMS

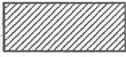
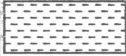



### ROCK WEATHERING CLASSIFICATION

|                                  |   |
|----------------------------------|---|
| <b>Fresh (FR)</b>                | No visible signs of weathering.   |
| <b>Fresh Jointed (FJ)</b>        | Weathering limited to the surface of major discontinuities.   |
| <b>Slightly Weathered (SW)</b>   | Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material. |
| <b>Moderately Weathered (MW)</b> | Weathering extends throughout the rock mass, but the rock material is not friable.                            |
| <b>Highly Weathered (HW)</b>     | Weathering extends throughout the rock mass and the rock is partly friable.                                   |
| <b>Completely Weathered (CW)</b> | Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.       |

### DISCONTINUITY SPACING

| Bedding             | Bedding Plane Spacing |
|---------------------|-----------------------|
| Very thickly bedded | Greater than 2m       |
| Thickly bedded      | 0.6 to 2m             |
| Medium bedded       | 0.2 to 0.6m           |
| Thinly bedded       | 60mm to 0.2m          |
| Very thinly bedded  | 20 to 60mm            |
| Laminated           | 6 to 20mm             |
| Thinly Laminated    | Less than 6mm         |

### SYMBOLS

|  |           |
|--|-----------|
|   | CLAYSTONE |
|   | SILTSTONE |
|   | SANDSTONE |
|   | COAL      |
|  | BEDROCK   |

### STRENGTH CLASSIFICATION

| Rock Strength         | Approximate Uniaxial Compressive Strength |                     | Field Estimation of Hardness*  |
|-----------------------|---|---------------------|--|
|                       | (MPa)                                     | (psi)               |  |
| Extremely Strong      | Greater than 250                          | Greater than 36,000 | Specimen can only be chipped with a geological hammer                          |
| Very Strong           | 100-250                                   | 15,000 to 36,000    | Requires many blows of geological hammer to break                              |
| Strong                | 50-100                                    | 7,500 to 15,000     | Requires more than one blow of geological hammer to break                      |
| Medium Strong         | 25.0 to 50.0                              | 3,500 to 7,500      | Breaks under single blow of geological hammer.                                 |
| Weak                  | 5.0 to 25.0                               | 750 to 3,500        | Can be peeled by a pocket knife with difficulty                                |
| Very Weak             | 1.0 to 5.0                                | 150 to 750          | Can be peeled by a pocket knife, crumbles under firm blows of geological pick. |
| Extremely Weak (Rock) | 0.25 to 1.0                               | 35 to 150           | Indented by thumbnail  |

### TERMS

|                                     |   |
|-------------------------------------|---|
| Total Core Recovery: (TCR)          | Core recovered as a percentage of total core run length   |
| Solid Core Recovery: (SCR)          | Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run |
| Rock Quality Designation: (RQD)     | Total length of sound core recovered in pieces 0.1m in length or larger as a % of total core run length.                |
| Uniaxial Compressive Strength (UCS) | Axial stress required to break the specimen   |
| Fracture Index: (FI)                | Frequency of natural fractures per 0.3m of core run.  |

# UNIFIED SOILS CLASSIFICATION

| MAJOR DIVISIONS      |                                 | GROUP SYMBOL | TYPICAL DESCRIPTION   |
|----------------------|---------------------------------|--------------|---|
| COARSE GRAINED SOILS | GRAVEL AND GRAVELLY SOILS       | GW           | Well-graded gravels or gravel-sand mixtures, little or no fines.  |
|                      |                                 | GP           | Poorly-graded gravels or gravel-sand mixtures, little or no fines.  |
|                      |                                 | GM           | Silty gravels, gravel-sand-silt mixtures.   |
|                      |                                 | GC           | Clayey gravels, gravel-sand-clay mixtures.  |
|                      | SAND AND SANDY SOILS            | SW           | Well-graded sands or gravelly sands, little or no fines.  |
|                      |                                 | SP           | Poorly-graded sands or gravelly sands, little or no fines.  |
|                      |                                 | SM           | Silty sands, sand-silt mixtures.  |
|                      |                                 | SC           | Clayey sands, sand-clay mixtures.   |
| FINE GRAINED SOILS   | SILTS AND CLAYS<br>$W_L < 50\%$ | ML           | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.     |
|                      |                                 | CL           | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.<br>( $W_L < 30\%$ ). |
|                      |                                 | CI           | Inorganic clays of medium plasticity, silty clays.<br>( $30\% < W_L < 50\%$ ).  |
|                      |                                 | OL           | Organic silts and organic silty-clays of low plasticity.  |
|                      | SILTS AND CLAYS<br>$W_L > 50\%$ | MH           | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.                                    |
|                      |                                 | CH           | Inorganic clays of high plasticity, fat clays.  |
|                      |                                 | OH           | Organic clays of medium to high plasticity, organic silts.  |
| HIGHLY ORGANIC SOILS |                                 | Pt           | Peat and other highly organic soils.  |
| CLAY SHALE           |                                 |              |   |
| SANDSTONE            |                                 |              |   |
| SILTSTONE            |                                 |              |   |
| CLAYSTONE            |                                 |              |   |
| COAL                 |                                 |              |   |

## SYMBOLS AND TERMS USED ON TEST HOLE LOGS

### TEXTURAL CLASSIFICATION OF SOILS

| CLASSIFICATION | PARTICLE SIZE      | VISUAL IDENTIFICATION                               |
|----------------|--------------------|---|
| Boulders       | Greater than 200mm | same  |
| Cobbles        | 75 to 200mm        | same  |
| Gravel         | 4.75 to 75mm       | 5 to 75mm   |
| Sand           | 0.075 to 4.75mm    | Not visible particles to 5mm                        |
| Silt           | 0.002 to 0.075mm   | Non-plastic particles, not visible to the naked eye |
| Clay           | Less than 0.002mm  | Plastic particles, not visible to naked eye         |

### COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

| TERMINOLOGY                     | PROPORTION |
|---------------------------------|------------|
| Trace or Occasional             | < 10%      |
| Some                            | 10 to 20%  |
| Adjective (e.g. silty or sandy) | 20 to 35%  |
| And (e.g. sand and gravel)      | 35 to 50%  |

### TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

| DESCRIPTIVE TERM | UNDRAINED SHEAR STRENGTH (kPa) | APPROX. SPT <sup>(1)</sup> "N" VALUE |
|------------------|--------------------------------|--------------------------------------|
| Very Soft        | < 10                           | < 2                                  |
| Soft             | 10 to 25                       | 2 to 4                               |
| Firm             | 25 to 50                       | 4 to 8                               |
| Stiff            | 50 to 100                      | 8 to 15                              |
| Very Stiff       | 100 to 200                     | 15 to 30                             |
| Hard             | > 200                          | > 30                                 |

(1) Standard Penetration Test – the number of blows from a 63.5kg hammer falling through 0.76m to advance a 60 degree truncated cone 0.3m

### TERMS DESCRIBING DENSITY (COHESIONLESS SOILS)

| DESCRIPTIVE TERM | SPT "N" VALUE |
|------------------|---------------|
| Very Loose       | < 4           |
| Loose            | 4 to 10       |
| Compact          | 10 to 30      |
| Dense            | 30 to 50      |
| Very Dense       | > 50          |


### HIERARCHY OF SOIL STRENGTH PREDICTION

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT Value
- 5) Pocket Penetrometer

### LEGEND FOR TEST HOLE LOGS

 Shelby Tube   
 A – Casing   
  SPT   
  Grab/Auger sample   
  Core   
  No Recovery

- MC – Moisture Content (% by Weight) as determined by sample

 Water Level  
 C<sub>vane</sub> Shear Strength Determination by Field Insitu Vane  
 C<sub>pen</sub> Shear Strength Determination by Pocket Penetrometer  
 C<sub>lab</sub> Shear Strength Determination using a Laboratory Vane Apparatus  
 C<sub>U</sub> Undrained Shear Strength determined by Unconfined Compression Test  
 AS/GS/BS Auger Sample/Grab Sample/ Block Sample  
 SS Split-spoon  
 SC Soil core  
 AED Oedometer test  
 TXL Triaxial test

## METRIC

| SOIL PROFILE        |  |            | SAMPLES |      |            | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT                                       | PLASTIC LIMIT<br>w <sub>p</sub> | NATURAL MOISTURE CONTENT<br>w | LQUID LIMIT<br>w <sub>L</sub> | UNIT WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------------|--|------------|---------|------|------------|-------------------------|-----------------|--|---------------------------------|-------------------------------|-------------------------------|---|---------------------------------------|
| ELEV<br>DEPTH       | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                         |                 | SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |                                 | WATER CONTENT (%)             | GR                            |   |                                       |
| 187.4<br>0.0<br>0.1 | <b>ASPHALT:</b> (115mm)<br><br>Gravelly <b>SAND</b> , trace silt and clay<br>Very Dense to Compact<br>Brown<br>Moist<br>(FILL) | [Pattern]  | 1       | SS   | 60         |                         |                 |  |                                 |                               |                               |   |                                       |
|                     |  |            | 2       | SS   | 41         |                         |                 |  |                                 |                               |                               |   | 22 72 6<br>(SI+CL)                    |
|                     |  |            | 3       | SS   | 41         |                         |                 |  |                                 |                               |                               |   |                                       |
|                     |  |            | 4       | SS   | 26         |                         |                 |  |                                 |                               |                               |   |                                       |
| 183.6<br>3.8        | <b>SILT</b> , some clay, trace sand<br>Very Loose<br>Grey  | [Pattern]  | 5       | SS   | 1          |                         |                 |  |                                 |                               |                               |   |                                       |
| 182.4<br>5.0        | Silty <b>CLAY</b> , with silt layers<br>Very Soft<br>Grey  | [Pattern]  | 6       | SS   | 0          |                         |                 |  |                                 |                               |                               |   | 0 0 74 26                             |
|                     |  |            | 7       | SS   | 0          |                         |                 |  |                                 |                               |                               |   |                                       |
|                     | Without silt layers  | [Pattern]  | 8       | SS   | 0          |                         |                 |  |                                 |                               |                               |   |                                       |

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No LGR-01

2 OF 3

METRIC

W.P. 6067-09-00 LOCATION Little Gravel River Bridge N 5 420 759.7 E 248 060.6 ORIGINATED BY SLL  
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN  
DATUM Geodetic DATE 2011.11.08 - 2011.11.09 CHECKED BY RPR

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                 | PLASTIC<br>LIMIT<br>W <sub>P</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|-----------------|------------------------------------|-------------------------------------|-----------------------------------|--|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | 20 40 60 80 100                             | 20 40 60 80 100 |                                    |                                     |                                   |  |   |
|               | Continued From Previous Page   |            |         |      |            |                            |                 |   |                 |                                    |                                     |                                   |  |   |
|               | Silty CLAY<br>Very Soft<br>Grey  |            | 9       | SS   | 0          |                            | 177             |   |                 |                                    |                                     |                                   |  | 0 0 18 82   |
|               |  |            |         |      |            |                            | 176             |   |                 |                                    |                                     |                                   |  |   |
|               |  |            | 10      | SS   | 0          |                            |                 |   |                 |                                    |                                     |                                   |  |   |
|               |  |            |         |      |            |                            | 175             | 20  |                 |                                    |                                     |                                   |  |   |
|               |  |            | 11      | SS   | 0          |                            | 174             |   |                 |                                    |                                     |                                   |  |   |
|               |  |            |         |      |            |                            | 173             |   |                 |                                    |                                     |                                   |  |   |
|               |  |            | 12      | SS   | 0          |                            | 172             | 40  |                 |                                    |                                     |                                   |  |   |
|               | With silt layers   |            |         |      |            |                            | 171             |   |                 |                                    |                                     |                                   |  |   |
| 170.8         |  |            | 13      | SS   | 1          |                            |                 |   |                 |                                    |                                     |                                   |  |   |
| 16.6          | SILT, some clay, with clay<br>seams/layers<br>Compact to Loose/Firm<br>Grey<br>Wet |            |         |      |            |                            | 170             |   |                 |                                    |                                     |                                   |  |   |
|               |  |            | 14      | SS   | 12         |                            | 169             |   |                 |                                    |                                     |                                   |  | 0 0 88 12   |
|               |  |            |         |      |            |                            | 168             |   |                 |                                    |                                     |                                   |  |   |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
20  
15 10 5 (%) STRAIN AT FAILURE

## METRIC

[illegible]



## METRIC

[illegible]

ONTMT4S 1197.GPJ 2012TEMPLATE(MTO).GDT 6/14/13

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

RECORD OF BOREHOLE No LGR-02

2 OF 3

METRIC

W.P. 6067-09-00 LOCATION Little Gravel River Bridge N 5 420 759.3 E 248 069.5 ORIGINATED BY SLL  
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN  
DATUM Geodetic DATE 2011.11.07 - 2011.11.08 CHECKED BY RPR

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  | PLASTIC<br>LIMIT<br>W <sub>P</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |                                    |                                     |                                   |  |  |
|               | Continued From Previous Page                                 |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |  |
|               | Silty CLAY<br>Very Soft<br>Grey                              |            | 9       | SS   | 0          |                            | 177             |   |  |                                    |                                     |                                   |  |  |
|               |  |            | 10      | SS   | 0          |                            | 176             |   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |            |                            | 175             | 4.0   |  |                                    |                                     |                                   |  |  |
|               | With thin silt seams (varved)                                |            | 11      | SS   | 0          |                            | 174             |   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |            |                            | 173             |   |  |                                    |                                     |                                   |  |  |
|               |  |            | 12      | SS   | 0          |                            | 172             | 5.0   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |            |                            | 171             |   |  |                                    |                                     |                                   |  |  |
|               |  |            | 13      | SS   | 0          |                            |                 |   |  |                                    |                                     |                                   |  |  |
| 170.3         |  |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |  |
| 17.2          | SILT, some clay, with clay seams<br>Compact to Loose<br>Grey |            | 14      | SS   | 18         |                            | 170             |   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |            |                            | 169             |   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |            |                            | 168             |   |  |                                    |                                     |                                   |  |  |

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity  
20  
15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No LGR-02

3 OF 3

METRIC

W.P. 6067-09-00 LOCATION Little Gravel River Bridge N 5 420 759.3 E 248 069.5 ORIGINATED BY SLL  
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN  
DATUM Geodetic DATE 2011.11.07 - 2011.11.08 CHECKED BY RPR

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  | PLASTIC<br>LIMIT<br>W <sub>P</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |                                    |                                     |                                   |  |  |
|               | Continued From Previous Page   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |  |
|               | SILT, some clay<br>Loose to Compact<br>Grey  |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |  |
|               |  |            | 15      | SS   | 6          |                            |                 |   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |  |
|               |  |            | 16      | SS   | 10         |                            |                 |   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |  |
|               |  |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |  |
|               |  |            | 17      | SS   | 10         |                            |                 |   |  |                                    |                                     |                                   |  | 0 0 69 31  |
| 160.1<br>27.4 | END OF BOREHOLE AT 27.4m.<br>Piezometer installation consists of<br>25mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>Nov.09/11 3.0 184.5<br>Nov.30/11 2.2 185.3<br>May 29/12 2.2 185.3 |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |  |

+ 3, × 3: Numbers refer to  
Sensitivity 20  
15 5  
10 (%) STRAIN AT FAILURE

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

RECORD OF BOREHOLE No LGR-03

2 OF 3

METRIC

W.P. 6067-09-00 LOCATION Little Gravel River Bridge N 5 420 738.0 E 248 085.5 ORIGINATED BY SLL  
HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN  
DATUM Geodetic DATE 2011.11.09 - 2011.11.11 CHECKED BY RPR

| SOIL PROFILE                 |   | SAMPLES    |        |      | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                    | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|------------------------------|---|------------|--------|------|----------------------------|-----------------|---|--------------------|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV<br>DEPTH                | DESCRIPTION   | STRAT PLOT | NUMBER | TYPE |                            |                 | "N" VALUES                                  | SHEAR STRENGTH kPa |                                    |                                     |                                   |  |  |
| Continued From Previous Page |   |            |        |      |                            |                 |   |                    |                                    |                                     |                                   |  |  |
|                              | Silty <b>CLAY</b><br>Very Soft<br>Grey                      |            | 9      | SS   | 0                          |                 |   |                    |                                    |                                     |                                   |  |  |
|                              |   |            |        |      |                            | 177             |   |                    |                                    |                                     |                                   |  |  |
|                              |   |            | 10     | SS   | 0                          |                 |   |                    |                                    |                                     |                                   |  |  |
|                              |   |            |        |      |                            | 176             |   |                    |                                    |                                     |                                   |  |  |
|                              |   |            |        |      |                            | 175             | 3.0   |                    |                                    |                                     |                                   |  |  |
|                              |   |            | 11     | SS   | 0                          |                 |   |                    |                                    |                                     |                                   |  |  |
|                              |   |            |        |      |                            | 174             |   |                    |                                    |                                     |                                   |  | 0 0 19 81  |
|                              |   |            |        |      |                            | 173             |   |                    |                                    |                                     |                                   |  |  |
|                              |   |            | 12     | SS   | 0                          |                 |   |                    |                                    |                                     |                                   |  |  |
|                              |   |            |        |      |                            | 172             | 3.0   |                    |                                    |                                     |                                   |  |  |
|                              |   |            |        |      |                            | 171             |   |                    |                                    |                                     |                                   |  |  |
|                              |   |            | 13     | SS   | 0                          |                 |   |                    |                                    |                                     |                                   |  |  |
| 170.3                        |   |            |        |      |                            |                 |   |                    |                                    |                                     |                                   |  |  |
| 17.2                         | <b>SILT</b> , some clay, with clay seams<br>Compact<br>Grey |            |        |      |                            | 170             |   |                    |                                    |                                     |                                   |  |  |
|                              |   |            | 14     | SS   | 20                         |                 |   |                    |                                    |                                     |                                   |  |  |
|                              |   |            |        |      |                            | 169             |   |                    |                                    |                                     |                                   |  |  |
|                              |   |            |        |      |                            | 168             |   |                    |                                    |                                     |                                   |  |  |

Continued Next Page

+ <sup>3</sup> , × <sup>3</sup> : Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

## METRIC

| SOIL PROFILE  |                                    |  |            |                                       |                         | DYNAMIC CONE PENETRATION RESISTANCE PLOT |  |     |  |  |  |  |  | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |                   |             | UNIT WEIGHT |    | REMARKS & GRAIN SIZE DISTRIBUTION (%) |    |  |  |  |  |  |
|---|------------------------------------|--|------------|---------------------------------------|-------------------------|--|--|-----|--|--|--|--|--|---|-------------------|-------------|-------------|----|---------------------------------------|----|--|--|--|--|--|
| ELEV<br>DEPTH   | DESCRIPTION                        |  | STRAT PLOT | SAMPLES<br><br>NUMBER TYPE "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE                          |  |     |  |  |  |  |  |   | $\gamma$          |             |             |    |                                       |    |  |  |  |  |  |
|   | Continued From Previous Page       |  |            |                                       |                         |  | SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |     |  |  |  | WATER CONTENT (%)<br>w <sub>P</sub> w w <sub>L</sub> |  |   | kN/m <sup>3</sup> | GR SA SI CL |             |    |                                       |    |  |  |  |  |  |
| 160.1   | SILT, some clay<br>Compact<br>Grey |  |            | 15                                    | SS                      | 11                                       |  | 167 |  |  |  |  |  |   | H <sub>C</sub>    |             | 0           | 0  | 77                                    | 23 |  |  |  |  |  |
|   |                                    |  |            |                                       |                         |  |  |     |  |  |  |  |  |   |                   |             |             |    |                                       |    |  |  |  |  |  |
|   |                                    |  |            |                                       |                         |  |  |     |  |  |  |  |  |   |                   |             |             |    |                                       |    |  |  |  |  |  |
|   |                                    |  |            |                                       |                         |  |  |     |  |  |  |  |  |   |                   |             |             |    |                                       |    |  |  |  |  |  |
|   |                                    |  |            |                                       |                         |  |  |     |  |  |  |  |  |   |                   |             |             |    |                                       |    |  |  |  |  |  |
| 160.1   |                                    |  |            | 16                                    | SS                      | 13                                       |  | 164 |  |  |  |  |  | ○   |                   | 0           | 0           | 79 | 21                                    |    |  |  |  |  |  |
| 27.4  |                                    |  |            | 17                                    | SS                      | 13                                       |  | 161 |  |  |  |  |  | ○   |                   |             |             |    |                                       |    |  |  |  |  |  |
| END OF BOREHOLE AT 27.4m.<br>Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.                                |                                    |  |            |                                       |                         |  |  |     |  |  |  |  |  |   |                   |             |             |    |                                       |    |  |  |  |  |  |
| WATER LEVEL READINGS:<br>DATE      DEPTH (m)    ELEV. (m)<br>Nov.12/11    3.3         184.2<br>Nov.30/11    2.7         184.8<br>May 29/12    2.6         184.9 |                                    |  |            |                                       |                         |  |  |     |  |  |  |  |  |   |                   |             |             |    |                                       |    |  |  |  |  |  |

+ 3, × 3: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No LGR-04

1 OF 3

METRIC

W.P. 6067-09-00 LOCATION Little Gravel River Bridge N 5 420 735.8 E 248 096.8 ORIGINATED BY SLL  
 HWY 17 BOREHOLE TYPE NW Casing COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.06 - 2011.11.07 CHECKED BY RPR

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|---|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | 20  | 40 | 60 | 80 | 100 |   |   |
| 187.4         |  |            |         |      |            |                            |                 |   |    |    |    |     |   |   |
| 0.0           | ASPHALT: (115mm)   |            |         |      |            |                            |                 |   |    |    |    |     |   |   |
| 0.1           | SAND, trace to some gravel, trace silt<br>Very Dense<br>Brown<br>Moist<br>(FILL)                                 |            | 1       | SS   | 67         |                            | 187             |   |    |    |    |     |   |   |
|               |  |            |         |      |            |                            | 186             |   |    |    |    |     |   |   |
|               |  |            | 2       | SS   | 60         |                            |                 |   |    |    |    |     |   |   |
|               |  |            |         |      |            |                            | 185             |   |    |    |    |     |   |   |
|               | Compact<br>Wet   |            | 3       | SS   | 19         |                            |                 |   |    |    |    |     |   |   |
| 184.4         |  |            |         |      |            |                            |                 |   |    |    |    |     |   |   |
| 3.0           | SILT, some clay, trace to some sand,<br>occasional organics and wood<br>fragments<br>Loose to Very Loose<br>Grey |            | 4       | SS   | 5          |                            | 184             |   |    |    |    |     |   | 0 19 71 10  |
|               |  |            |         |      |            |                            |                 |   |    |    |    |     |   |   |
|               |  |            | 5       | SS   | 3          |                            | 183             |   |    |    |    |     |   |   |
|               |  |            |         |      |            |                            |                 |   |    |    |    |     |   |   |
|               | With silt seams  |            |         |      |            |                            | 182             |   |    |    |    |     |   |   |
|               |  |            | 6       | SS   | 0          |                            |                 |   |    |    |    |     |   | 0 4 79 17   |
|               |  |            |         |      |            |                            | 181             |   |    |    |    |     |   |   |
| 180.8         |  |            |         |      |            |                            |                 |   |    |    |    |     |   |   |
| 6.6           | Silty CLAY, with thin silt seams<br>Very Soft<br>Grey  |            | 7       | SS   | 0          |                            | 180             |   |    |    |    |     |   |   |
|               |  |            |         |      |            |                            |                 |   |    |    |    |     |   |   |
|               |  |            |         |      |            |                            | 179             |   |    |    |    |     |   |   |
|               |  |            | 8       | SS   | 0          |                            |                 |   |    |    |    |     |   |   |
|               |  |            |         |      |            |                            |                 |   |    |    |    |     |   |   |
|               |  |            |         |      |            |                            | 178             |   |    |    |    |     |   |   |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

## METRIC

| SOIL PROFILE |   |            | SAMPLES |      |            | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT |                                 | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |          | UNIT WEIGHT | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|---|------------|---------|------|------------|-------------------------|-----------------|--|---------------------------------|---|----------|-------------|---------------------------------------|
| ELEV DEPTH   | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                         |                 | 20 40 60 80 100                          | W <sub>p</sub> W W <sub>L</sub> | WATER CONTENT (%)                                   | 20 40 60 |             |                                       |
|              | Continued From Previous Page  |            |         |      |            |                         |                 |  |                                 |   |          |             |                                       |
|              | Silty <b>CLAY</b> , trace sand<br>Very Soft<br>Grey                         |            | 9       | SS   | 0          |                         | 177             |  |                                 |   |          |             | 0 0 17 83                             |
|              |   |            |         |      |            |                         |                 |  |                                 |   |          |             |                                       |
|              |   |            | 10      | SS   | 0          |                         | 176             |  |                                 |   |          |             |                                       |
|              |   |            |         |      |            |                         |                 |  |                                 |   |          |             |                                       |
|              |   |            | 11      | SS   | 0          |                         | 175             | 2.0                                      |                                 |   |          |             |                                       |
|              |   |            |         |      |            |                         |                 |  |                                 |   |          |             |                                       |
|              |   |            | 12      | SS   | 0          |                         | 174             |  |                                 |   |          |             |                                       |
|              |   |            |         |      |            |                         |                 |  |                                 |   |          |             |                                       |
|              |   |            | 13      | SS   | 6          |                         | 173             |  |                                 |   |          |             |                                       |
|              |   |            |         |      |            |                         |                 |  |                                 |   |          |             |                                       |
|              |   |            | 14      | SS   | 11         |                         | 172             | 3.0                                      |                                 |   |          |             |                                       |
|              |   |            |         |      |            |                         |                 |  |                                 |   |          |             |                                       |
|              | With silt layers  |            |         |      |            |                         | 171             |  |                                 |   |          |             | 0 0 54 46                             |
| 170.3        |   |            |         |      |            |                         |                 |  |                                 |   |          |             |                                       |
| 17.1         | <b>SILT</b> , some clay, with clay seams/layers<br>Compact to Loose<br>Grey |            |         |      |            |                         | 170             |  |                                 |   |          |             |                                       |
|              |   |            |         |      |            |                         |                 |  |                                 |   |          |             |                                       |
|              |   |            |         |      |            |                         | 169             |  |                                 |   |          |             |                                       |
|              |   |            |         |      |            |                         | 168             |  |                                 |   |          |             |                                       |

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity



## METRIC

[illegible]

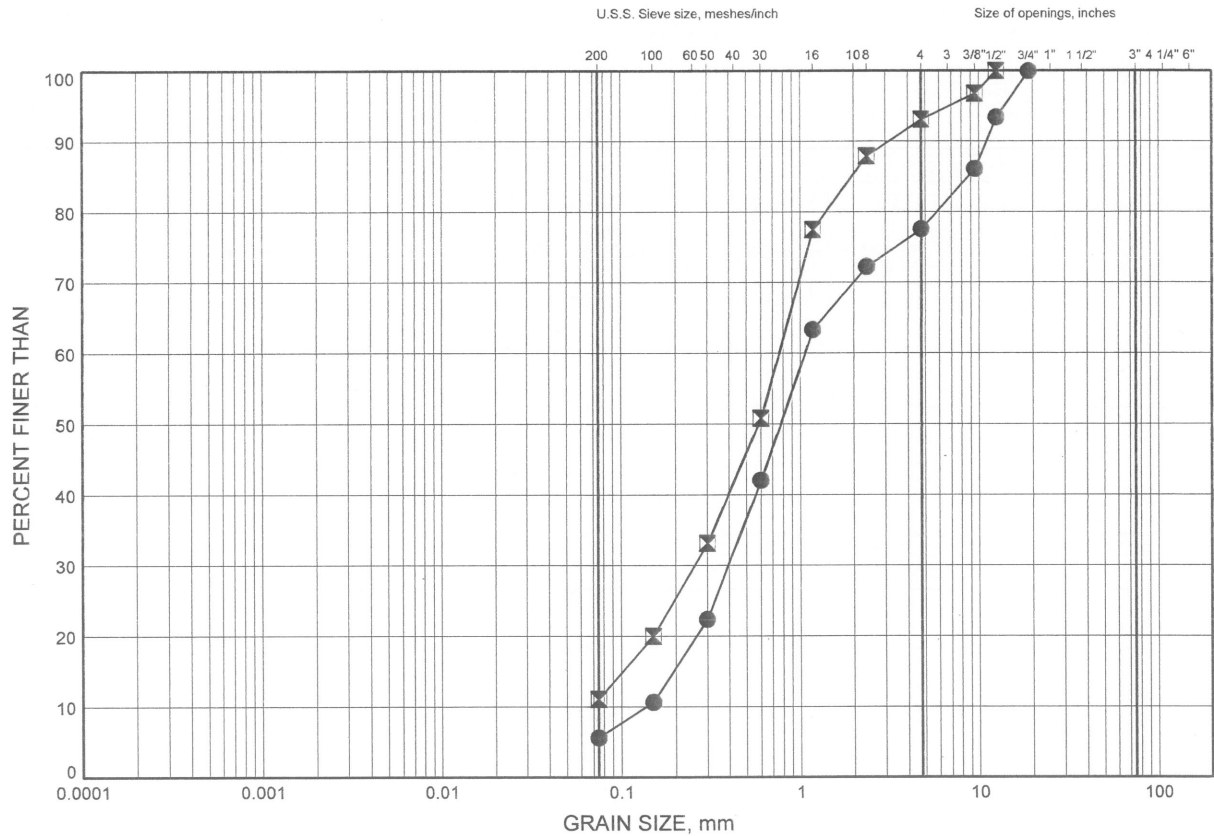
## **Appendix B**

### **Laboratory Test Results**

NWR 32 Rehabs  
GRAIN SIZE DISTRIBUTION

FIGURE B1

GRAVELLY SAND FILL & SAND FILL



|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LGR-01   | 1.83      | 185.57    |
| ⊠      | LGR-02   | 2.59      | 184.91    |

Date April 2013  
W.P. 6067-09-00

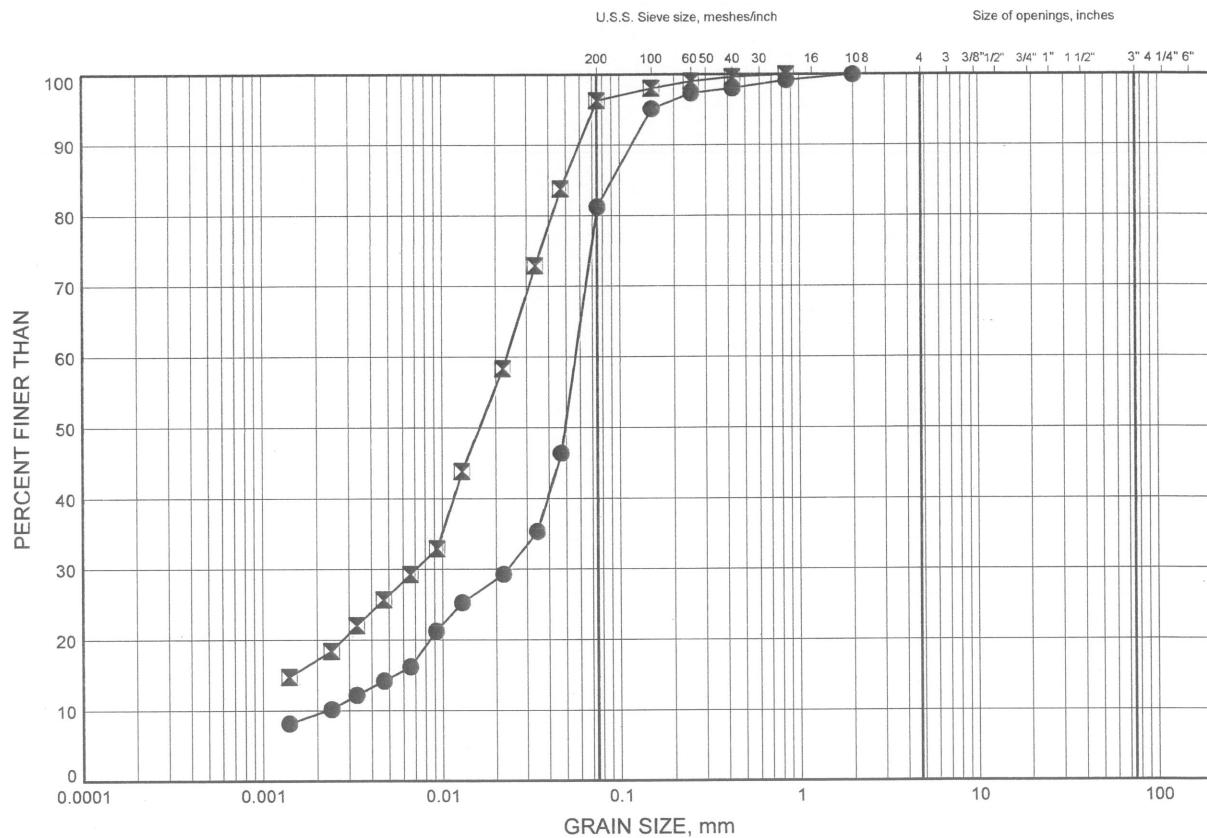


Prep'd AN  
Chkd. RPR

# NWR 32 Rehabs GRAIN SIZE DISTRIBUTION

FIGURE B2

## UPPER SILT



|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LGR-04   | 3.35      | 184.04    |
| ⊠      | LGR-04   | 5.79      | 181.61    |

Date June 2013  
W.P. 6067-09-00

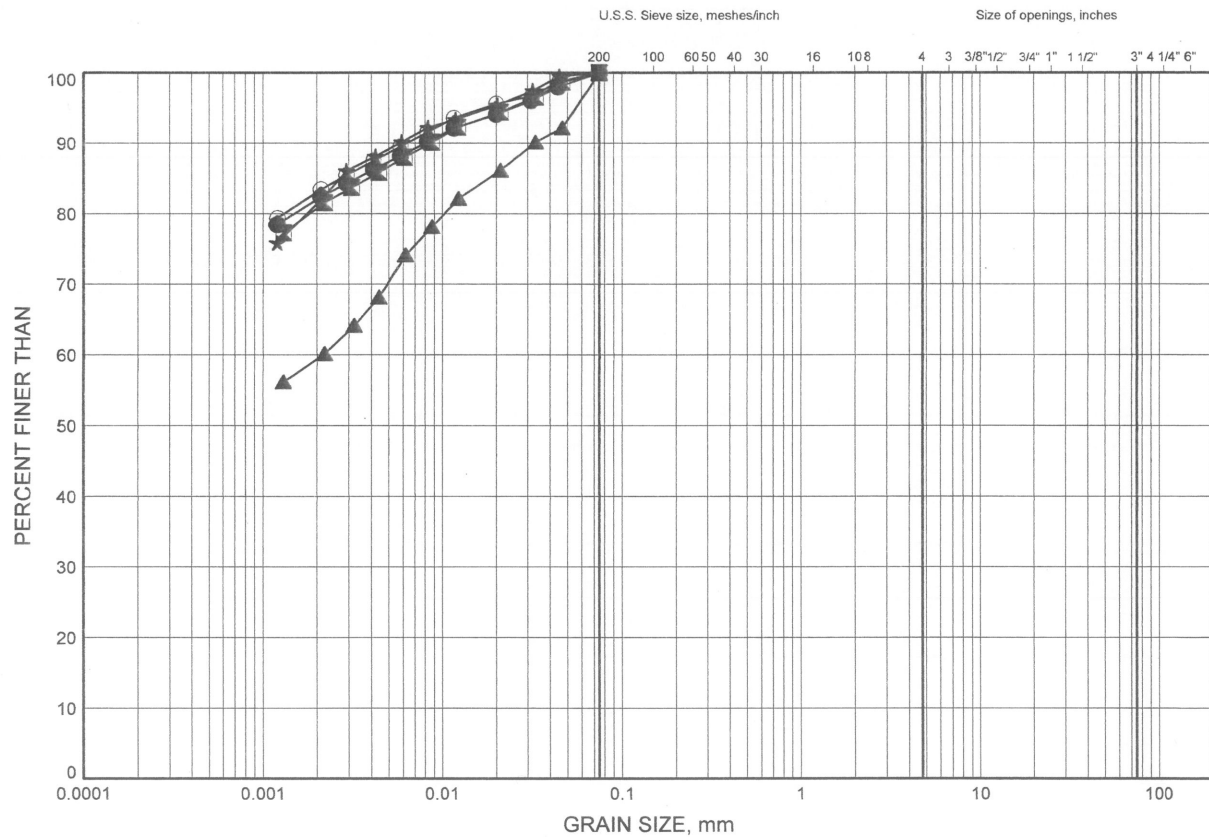


Prep'd AN  
Chkd. RPR

# NWR 32 Rehabs GRAIN SIZE DISTRIBUTION

FIGURE B3

## SILTY CLAY



|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LGR-01   | 10.36     | 177.03    |
| ⊠      | LGR-02   | 8.84      | 178.66    |
| ▲      | LGR-03   | 7.32      | 180.18    |
| ★      | LGR-03   | 13.41     | 174.09    |
| ⊙      | LGR-04   | 10.36     | 177.03    |

Date August 2013

W.P. 6067-09-00



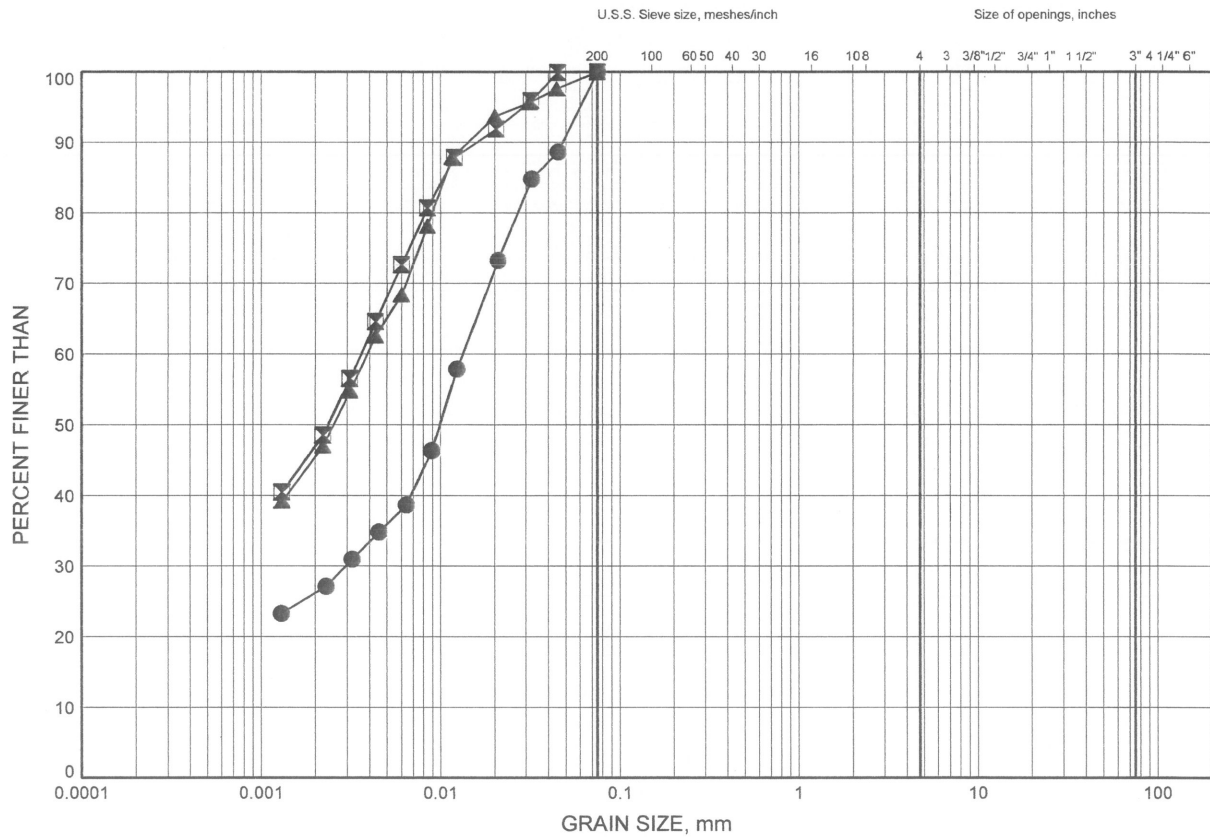
Prep'd AN

Chkd. RPR

# NWR 32 Rehabs GRAIN SIZE DISTRIBUTION

FIGURE B4

## SILTY CLAY WITH SILT SEAMS/LAYERS



|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LGR-01   | 5.79      | 181.61    |
| ⊠      | LGR-02   | 16.76     | 170.73    |
| ▲      | LGR-04   | 16.46     | 170.94    |

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 8/15/13

Date August 2013  
W.P. 6067-09-00

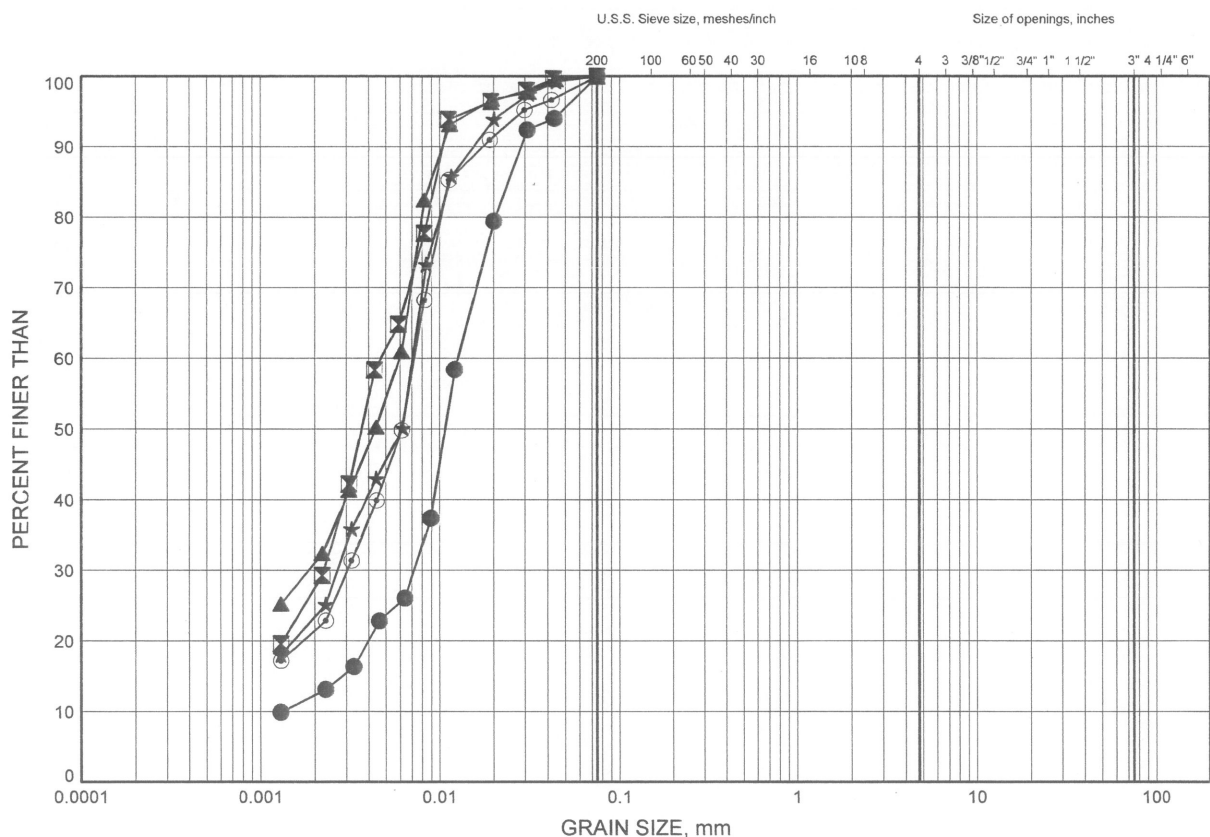


Prep'd AN  
Chkd. RPR

# NWR 32 Rehabs GRAIN SIZE DISTRIBUTION

FIGURE B5

## LOWER SILT WITH CLAY SEAMS



|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LGR-01   | 17.98     | 169.41    |
| ⊠      | LGR-01   | 24.08     | 163.32    |
| ▲      | LGR-02   | 27.13     | 160.37    |
| ★      | LGR-03   | 21.03     | 166.47    |
| ⊙      | LGR-03   | 24.08     | 163.42    |

Date June 2013  
W.P. 6067-09-00

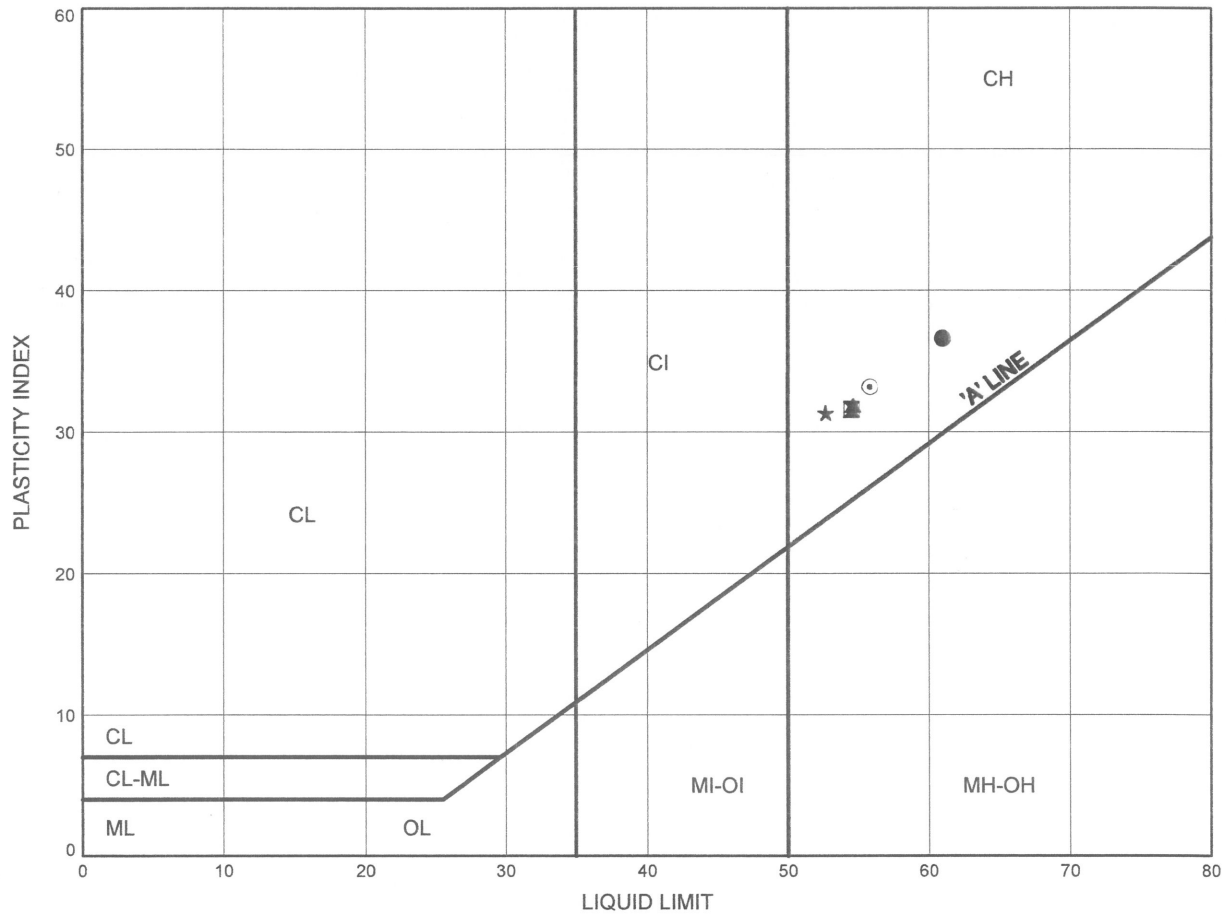


Prep'd AN  
Chkd. RPR

NWR 32 Rehabs  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B6

**SILTY CLAY**



**LEGEND**

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LGR-01   | 10.36     | 177.03    |
| ⊠      | LGR-02   | 8.84      | 178.66    |
| ▲      | LGR-03   | 7.32      | 180.18    |
| ★      | LGR-03   | 13.41     | 174.09    |
| ⊙      | LGR-04   | 10.36     | 177.03    |

Date August 2013  
 W.P. 6067-09-00



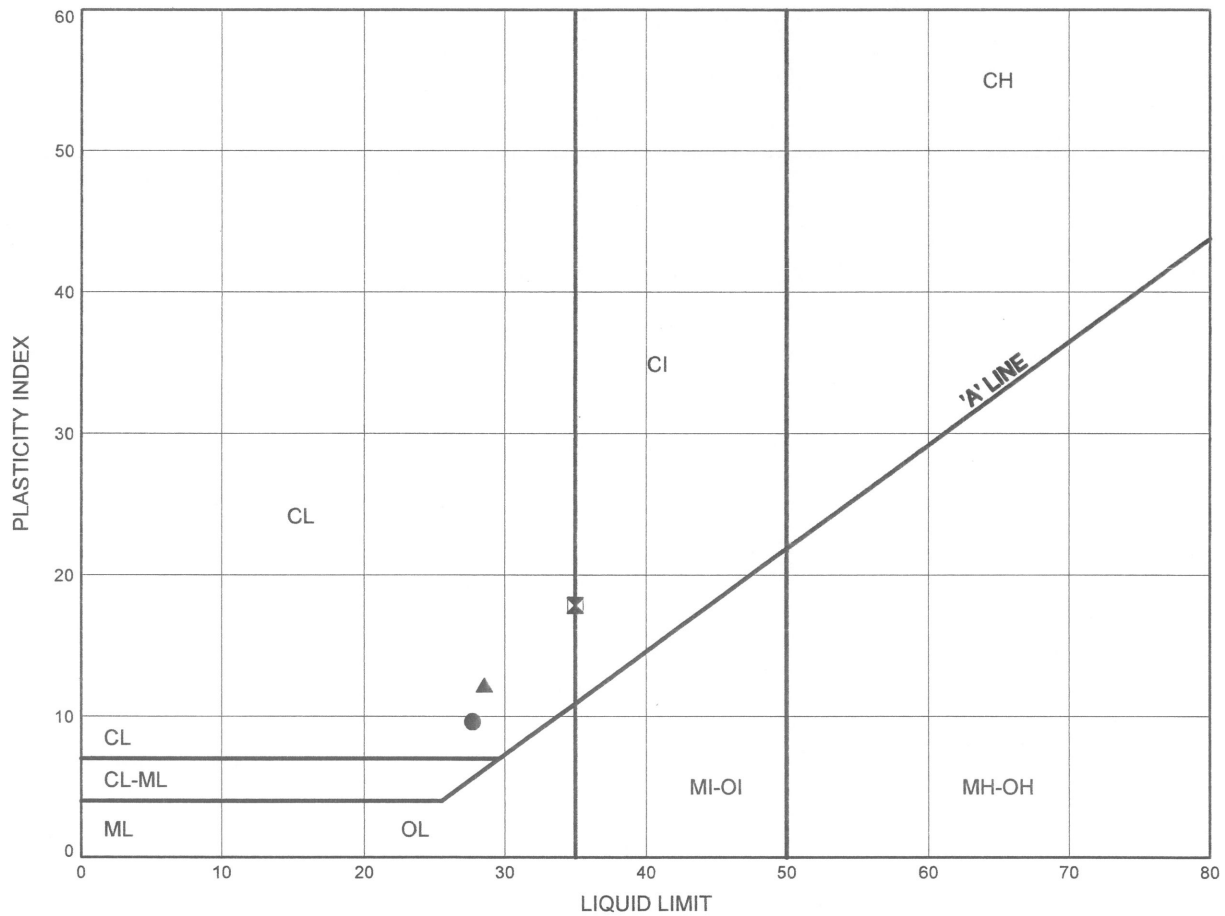
Prep'd AN  
 Chkd. RPR



NWR 32 Rehabs  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B7

**SILTY CLAY WITH SILT SEAMS/LAYERS**



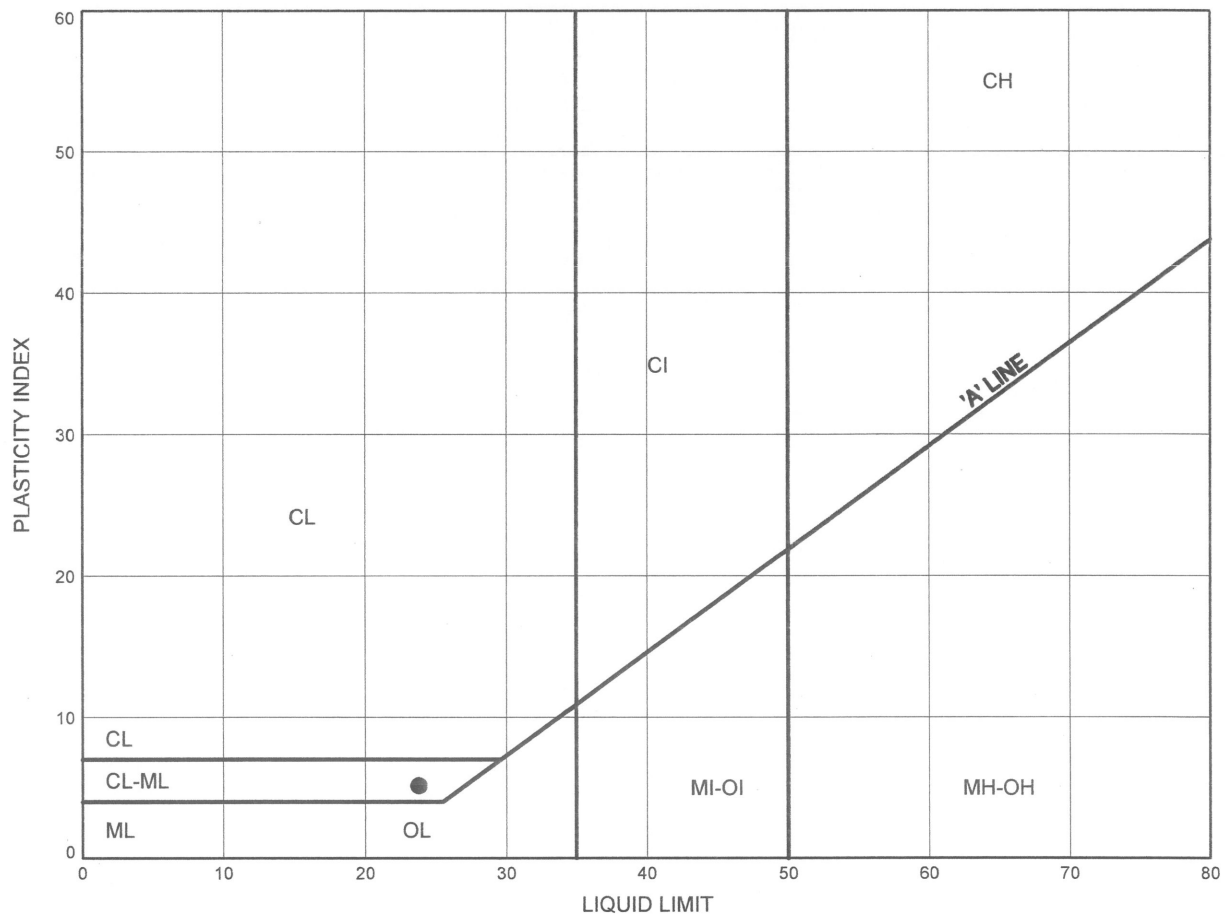
**LEGEND**

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LGR-01   | 5.79      | 181.61    |
| ⊠      | LGR-02   | 16.76     | 170.73    |
| ▲      | LGR-04   | 16.46     | 170.94    |

NWR 32 Rehabs  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B8

**LOWER SILT**



**LEGEND**

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LGR-03   | 21.03     | 166.47    |

Date June 2013  
W.P. 6067-09-00

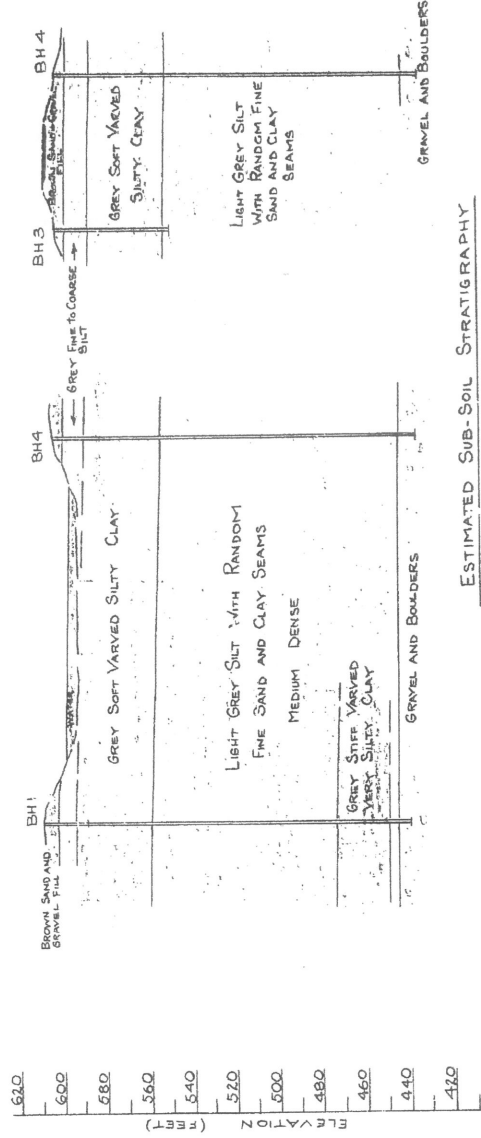
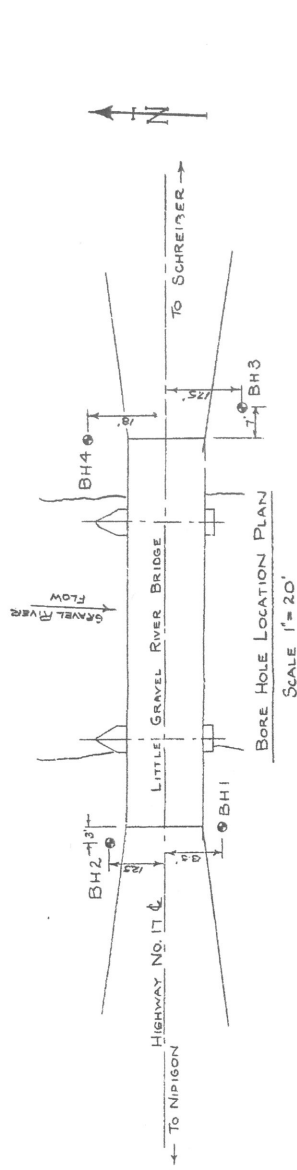


Prep'd AN  
Chkd. RPR

## **Appendix C**

### **Record of Borehole Sheets, Borehole Locations and Soil Profile From Previous Investigation**

DRAWING No. 1  
JOB No. C108/J267



# LITTLE GRAVEL RIVER

BORE HOLE LOCATION

AND

SUB-SOIL STRATIGRAPHY

SCALE: AS SHOWN

DWN BY: K.P.

CHKD. BY: L.G.S.

Nov. 1958

## TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT Little Gravel River Bridge

LOCATION Highway No. 17

HOLE LOCATION

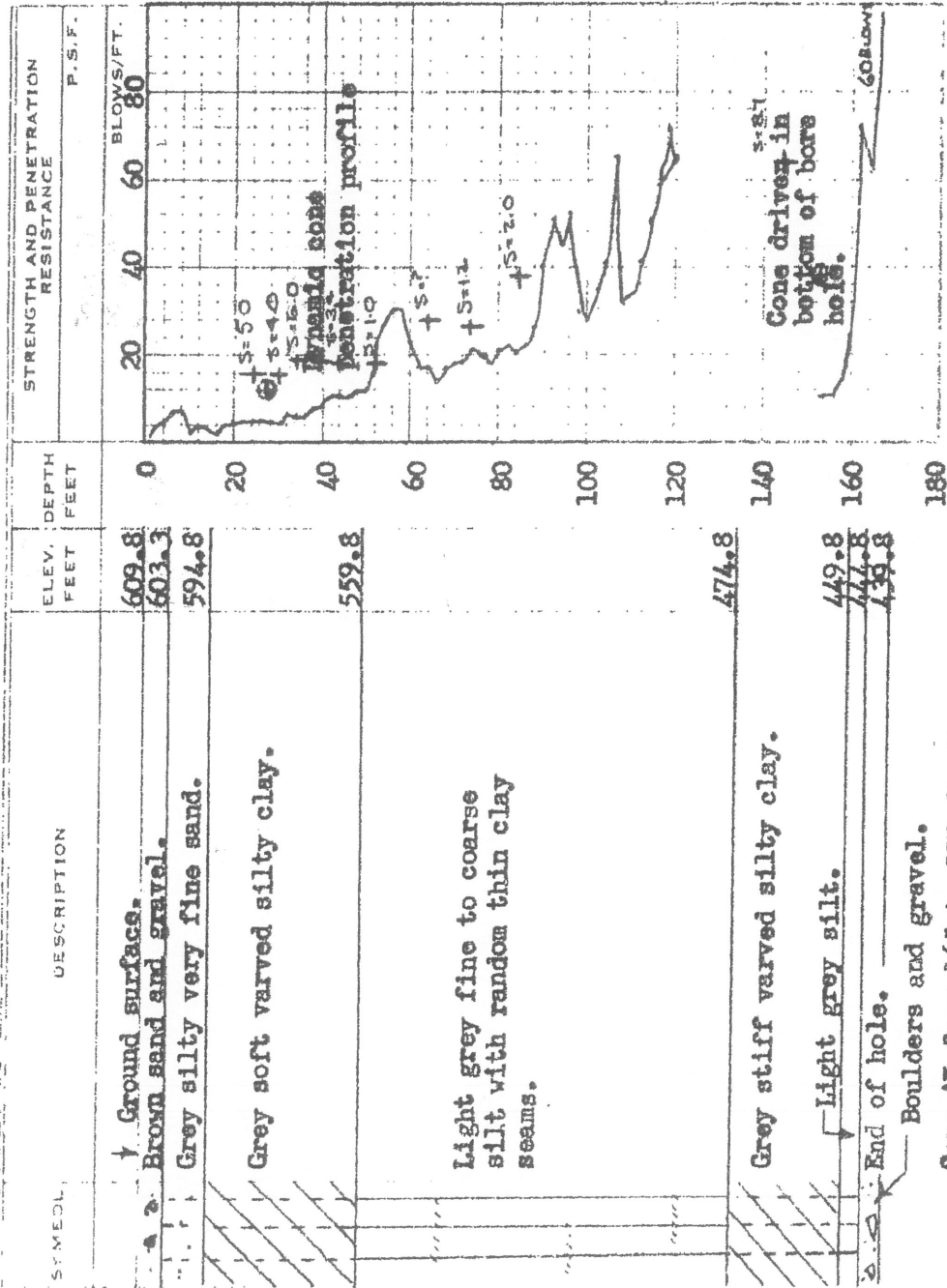
WOLF ELEVATION AND DATUM 609.8

BOREHOLE NO. 1

FIELD SUPERVISOR K.P.

H. H. DRILLER

PREP. I.P.



Ground water level = 0.5 ft in caved hole.

| CONSISTENCY | MOIST. CONTENT - % DRY WT. | SAMPLE | NATURAL UNIT WT.<br>P.C.F. |
|-------------|----------------------------|--------|----------------------------|
|             |                            |        | SS1                        |
|             |                            |        | SS2                        |
|             |                            |        | SS3                        |
|             |                            |        | SS4                        |
|             |                            |        | SS5                        |
|             |                            |        | SS6                        |
|             |                            |        | SS7                        |
|             |                            |        | SS8                        |
|             |                            |        | SS9                        |
|             |                            |        | SS10                       |
|             |                            |        | SS11                       |
|             |                            |        | SS12                       |
|             |                            |        | SS13                       |
|             |                            |        | SS14                       |
|             |                            |        | SS15                       |
|             |                            |        | SS16                       |
|             |                            |        | SS17                       |
|             |                            |        | SS18                       |
|             |                            |        | SS19                       |
|             |                            |        | SS20                       |

PROJECT NO. C108/J267

# TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT Little Gravel River Bridge

LOCATION Highway No. 17

HOLE LOCATION See plan

HOLE ELEVATION AND DATUM 610.3

BOREHOLE NO. 2

FIELD SUPERVISOR K.P.

DRILLER H.U.

PREP. K.P.

DRAWING NO.

## LEGEND

2" DIA. SPLIT TUBE

2" SHELBY TUBE

2" SPLIT TUBE

2" DIA. CONE

CASING

2" SHELBY

1/2 UNCONFINED COMPRESSION (Qu)

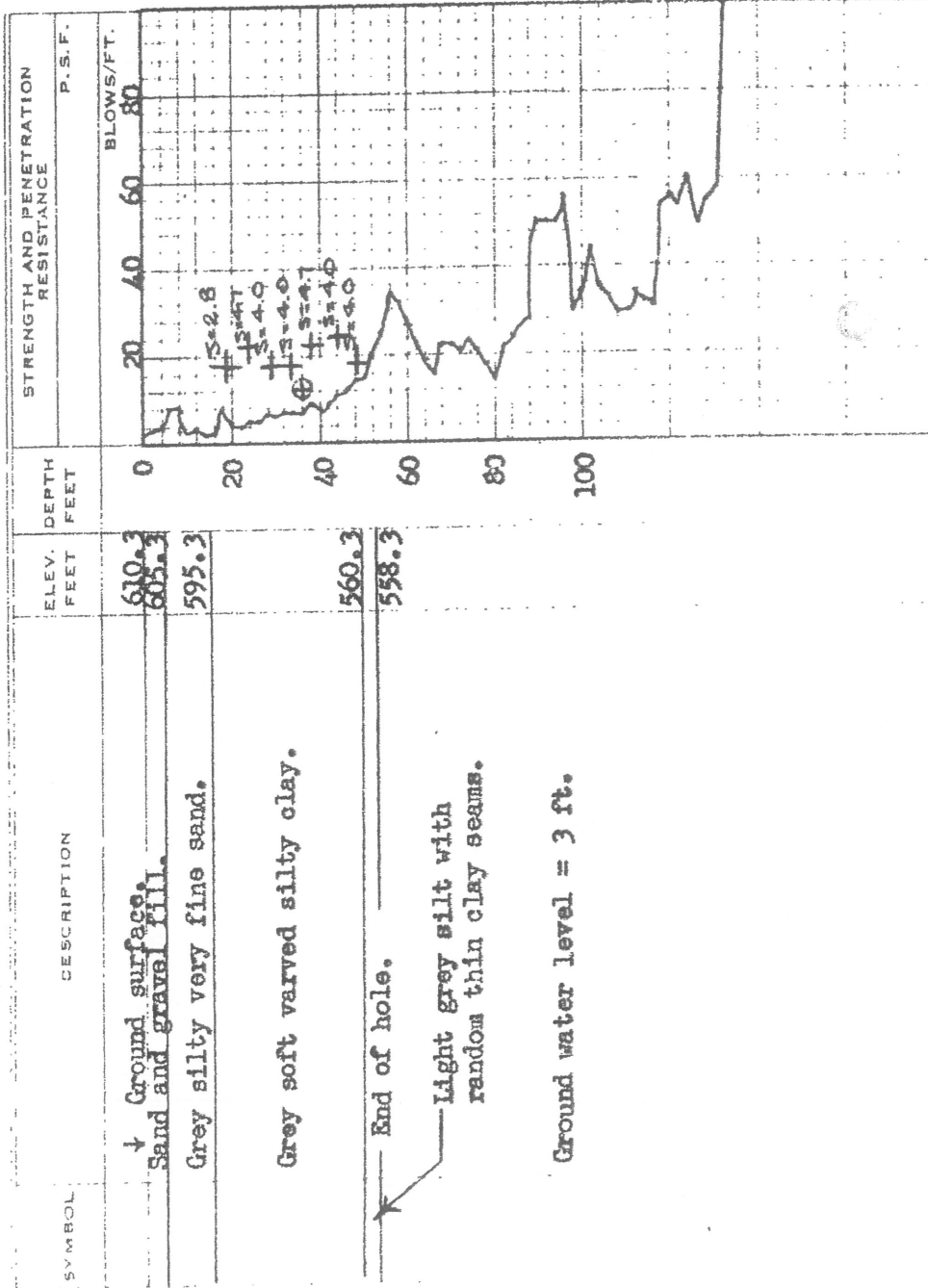
VANE TEST (C) AND SENSITIVITY (S)

NATURAL MOISTURE AND

LIQUIDITY INDEX

LIQUID LIMIT

PLASTIC LIMIT



| CONSISTENCY                | SAMPLE | NATURAL UNIT WT. P.C.F. |
|----------------------------|--------|-------------------------|
| MOIST. CONTENT - % DRY WT. |        |                         |
|                            | 2581   |                         |
|                            | 2582   |                         |
|                            | 2583   |                         |
|                            | 2584   |                         |
|                            | 2585   |                         |
|                            | 2586   |                         |
|                            | 2587   |                         |
|                            | 2588   |                         |
|                            | 2589   |                         |
|                            | 2590   |                         |

# TROW SODERMAN AND ASSOCIATES

ITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

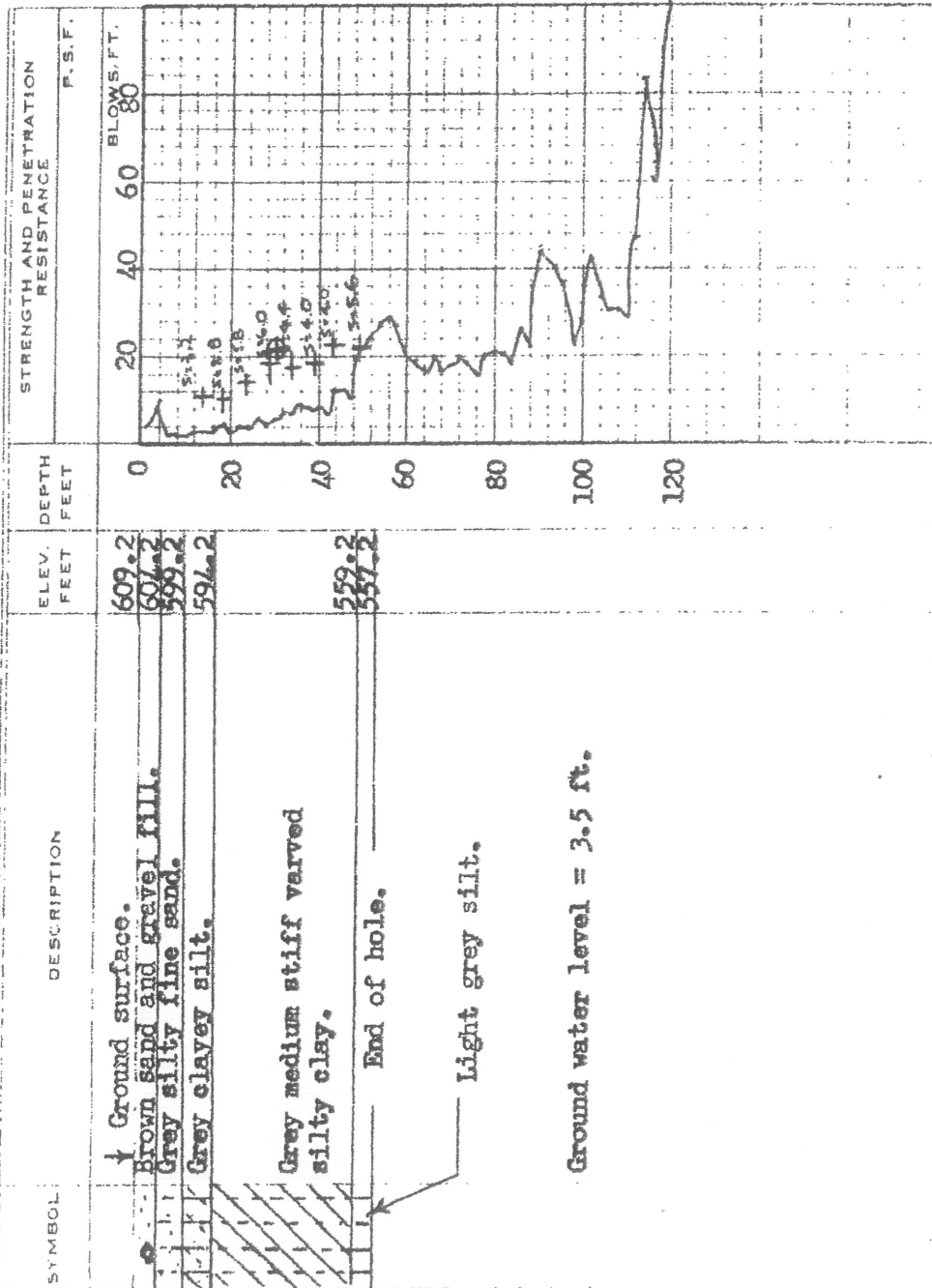
PROJECT Little Gravel River  
 LOCATION Highway No. 17  
 HOLE LOCATION See plan  
 HOLE ELEVATION AND DATUM 609.2

BOREHOLE NO. 3  
 FIELD SUPERVISOR K.P.  
 DRILLER E.S.  
 PREP. K.P.

DRAWING NO. 4

## LEGEND

- 2" DIA. SPLIT TUBE
- 2" SHELBY TUBE
- 2" SPLIT TUBE
- 2" DIA. CONE
- CASING
- 2" SHELBY
- 1/2 UNCONFINED COMPRESSION (QU)
- VANE TEST (C) AND SENSITIVITY (S)
- NATURAL MOISTURE AND LIQUIDITY INDEX
- LIQUID LIMIT
- PLASTIC LIMIT



| CONSISTENCY                | SAMPLE | NATURAL UNIT WT. P.C.F. |
|----------------------------|--------|-------------------------|
| MOIST. CONTENT - % DRY WT. |        |                         |
|                            | 551    |                         |
|                            | 552    |                         |
|                            | 553    |                         |
|                            | 554    |                         |
|                            | 555    |                         |
|                            | 556    |                         |
|                            | 557    |                         |
|                            | 558    |                         |
|                            | 559    |                         |
|                            | 560    |                         |

PROJECT NO. C108/J267

TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT Little Gravel River  
LOCATION Highway No. 17  
HOLE LOCATION See plan  
HOLE ELEVATION AND DATUM. 608.4

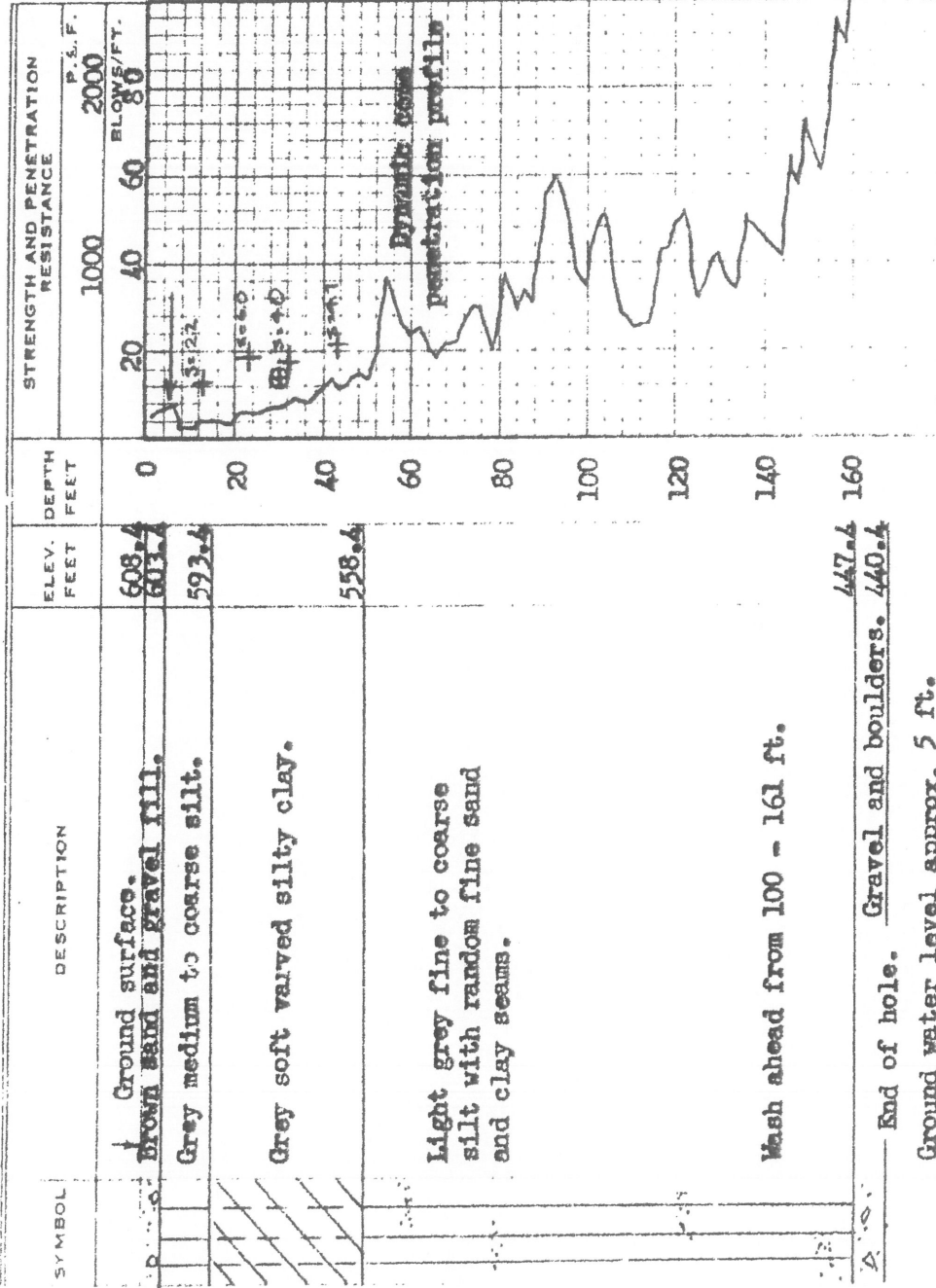
BOREHOLE NO. 4 K.P.  
FIELD SUPERVISOR K.S.  
DRILLER K.P.  
PREP.

DRAWING NO. 5

LEGEND

- 2" DIA. SPLIT TUBE
- 2" SHELBY TUBE
- 2" SPLIT TUBE
- 2" DIA. CONE
- CASING
- 2" SHELBY

1/2 UNCONFINED COMPRESSION (QU)  
VANE TEST (C) AND SENSITIVITY (S)  
NATURAL MOISTURE AND  
LIQUIDITY INDEX  
LIQUID LIMIT  
PLASTIC LIMIT



| CONSISTENCY                | SAMPLE | NATURAL UNIT WT. P.C.F. |
|----------------------------|--------|-------------------------|
| MOIST. CONTENT - % DRY WT. | SS1    |                         |
|                            | SS2    |                         |
|                            | TW3    |                         |
|                            | SS4    |                         |
|                            | SS5    |                         |
|                            | SS6    |                         |
|                            | SS7    |                         |
|                            | SS8    |                         |
|                            | SS9    |                         |
|                            | SS10   |                         |



## **Appendix D**

### **Site Photographs**



**Photograph 1** – Little Gravel River Bridge, north side looking west



**Photograph 2** – Little Gravel River Bridge, north side looking east





**Photograph 3** – Little Gravel River Bridge, west abutment



**Photograph 4** – Under Little Gravel River Bridge, looking south to railway bridge

## **Appendix E**

### **List of SPs and OPSS, and Suggested Text for Selected NSSPs**

**1.- List of Special Provisions and OPSS Documents Referenced in this Report**

- OPSS 501
- OPSS 539
- OPSS 804
- OPSS 902
- OPSS 1010
- OPSD 3101.150
- Special Provision 110S13 "Amendment to OPSS 1010, April 2004".

## **Appendix F**

**Drawing titled "Borehole Locations and Soil Strata"**



METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

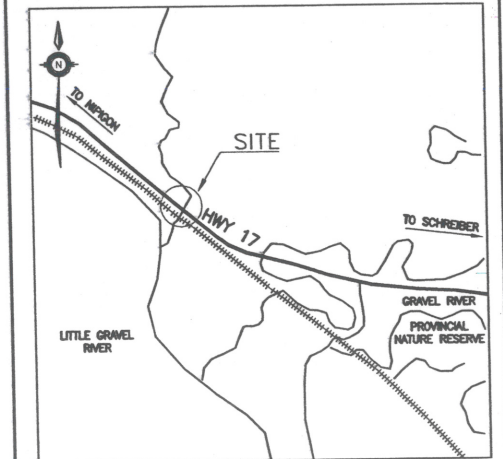
CONT No  
WP No 6067-09-01

HIGHWAY 17  
LITTLE GRAVEL RIVER BRIDGE  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET  
S02



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- ◆ Borehole (Current Investigation)
- ◊ Borehole (Previous Investigation)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- ▽ Water Level During Drilling
- ↑ Water Level In Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

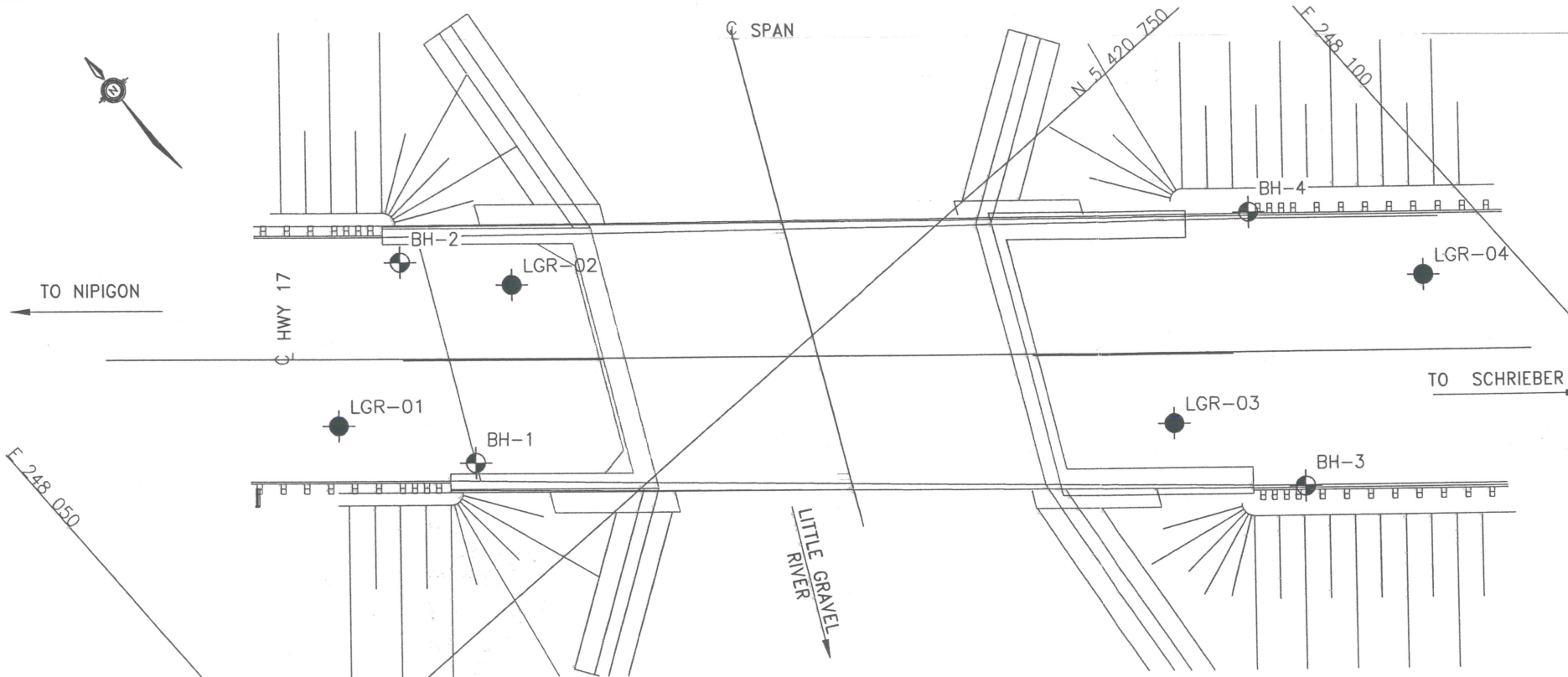
| NO     | ELEVATION | NORTHING    | EASTING   |
|--------|-----------|-------------|-----------|
| LGR-01 | 187.4     | 5 420 759.7 | 248 060.6 |
| LGR-02 | 187.5     | 5 420 759.3 | 248 069.5 |
| LGR-03 | 187.5     | 5 420 738.0 | 248 085.5 |
| LGR-04 | 187.4     | 5 420 735.8 | 248 096.8 |
| BH-1   | 185.9     | 5 420 755.0 | 248 063.7 |
| BH-2   | 186.0     | 5 420 762.9 | 248 066.7 |
| BH-3   | 185.7     | 5 420 732.7 | 248 087.7 |
| BH-4   | 185.4     | 5 420 742.2 | 248 093.2 |

-NOTES-

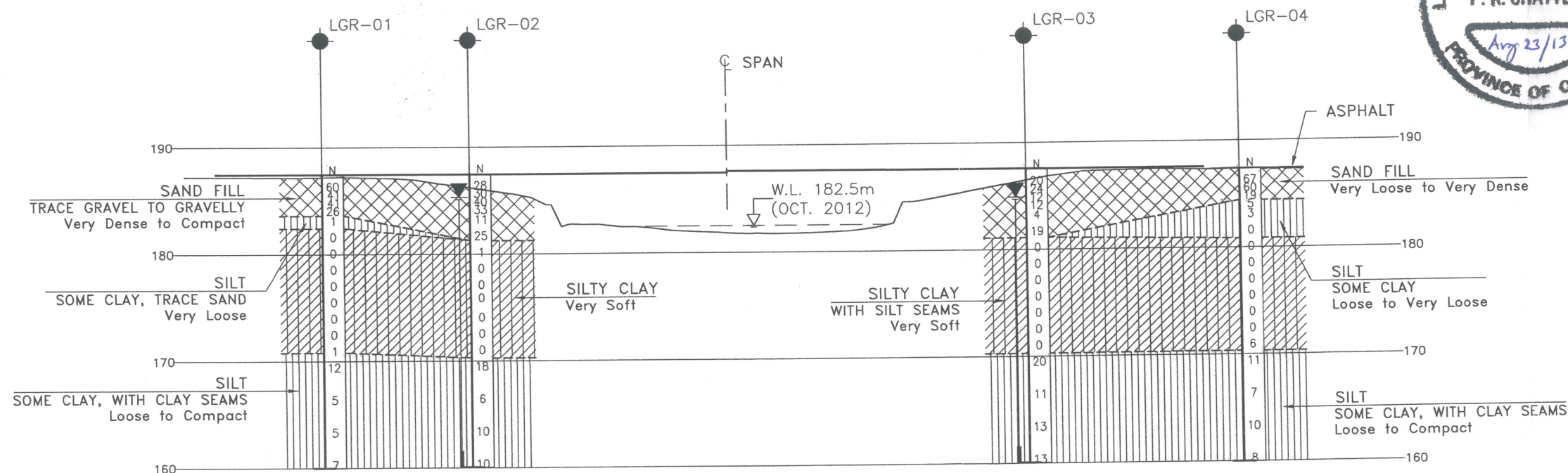
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 42D-31

| DATE   | BY   | DESCRIPTION |
|--------|------|-------------|
| DESIGN | RPR  | CHK RPR     |
| DRAWN  | AN   | CHK         |
| LOAD   | SITE | 48C-17      |
| STRUCT | DWG  | 2           |
| DATE   | MAY  | 2013        |



PLAN  
SCALE 1:250



PROFILE ALONG C HWY 17

SCALE 1:250  
H 1:250  
V 1:500