# Foundation Investigation and Design Report

# Pearl Lake Realignment
# Alternative 2

**GWP 414-01-00**

## Highway 11/17
## 14 km east of Highway 587

**Geocres No.: 52A-132**

**Prepared for**
**Ministry of Transportation, Northwestern Region**


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# Part A - **FOUNDATION INVESTIGATION REPORT**

## 1 Introduction

TBT Engineering has been retained by the Ministry of Transportation to provide Total Project Management (TPM) services for the design of the highway improvements. As an addendum to the assignment, foundation investigation and design services were required to assess a potential realignment at Pear Lake. Specifically, this report addresses proposed realignment Alternative No. 2 which considers a realignment of the highway to the south between the existing highway and Pearl Lake.

The site is located on Highway 11/17, approximately 5.4 km East of Hwy 587, Easterly 8.9 km, Station 23+450 to 23+675 $^{+}$/-.

A foundation investigation was carried out to investigate subsurface conditions at the site. This investigation consisted of a number of boreholes drilled in the vicinity of the proposed new alignment, laboratory testing and geotechnical analysis of the data. In addition, two boreholes were put down along the existing adjacent highway. This report provides a summary of that work and of the conditions encountered. This report discusses the foundation aspects of the proposed new alignment and reviews potential impacts of the alignment on the existing highway. Subsequent to the completion of the field work, and based in part on predictions of foundation performance the proposed re-alignment (No. 2) was deleted from the project.

The foundation section has assigned GEOCRES No. 52A-132 to this site.

# 2 Site Description

The site is located on Highway 11/17, approximately 5.4 km East of Hwy 587, Easterly 8.9 km. At this location Highway 11/17 runs generally in a north-south direction. The proposed revised alignment was to be located to the east side of the existing highway (up to 25 m east) between the existing highway and Pear Lake. The existing rock fill highway embankment is approximately 4 m high.

## 2.1 Surficial Geology

Based on review of Northern Ontario Engineering Geology Terrain Study 58, Ontario Geological Survey, Ministry of Natural Resources, 1981, the area surrounding the site consists of a gravel and sand outwash plain. However, this is not consistent with the findings of this investigation. The area being investigated skirts the southern limit of a Archean – Keweenan bedrock contact, transitioning from bedrock knob dominated to bedrock plain terrain, resulting in a topographical divide. This is interpreted to be a controlling landform feature providing conditions (marine) for the deposition of fine grained lacustrine soils along the low-lands adjacent to the topographical divide. Subsurface geotechnical investigations along the western edge of Pearl Lake confirm this approach with the presence of fine grained lacustrine soils.

## 2.2 Bedrock Geology

The bedrock geology at and surrounding Pearl Lake is mapped to consist of Late Precambrian (Keweenan) Sibley Group red sandstone and limey sandstone (forming the bedrock plain deposit) abutting the underlying Early Precambrain (Archean) felsic igneous basement rocks. The topographical features of this contact are visually evident at surface with granitic bedrock knobs present northwest of Highway 11/17 forming irregular topology with complex bedrock slopes of varying steepness in comparison to the adjacent lands southeasterly which are predominantly low lying with organic rich pockets.

General Area of Proposed Alignment – Looking South

## 3 Investigation Procedures

A site investigation was undertaken between February 20 and March 22, 2007. A total of 11 boreholes and 5 dynamic cone penetration test probes were carried out along the proposed alignment. In addition, two boreholes were carried out through the existing highway embankment.

The investigation was carried out using a track mounted Star Drill 100 rig, a CME 45 drill rig and a water well rig. The Star rig and CME 45 drill rigs are equipped for geotechnical testing and sampling and were utilized for the majority of the drilling operations. Both hollow stem auger and casing methods were utilized. The well rig (equipped with a down hole hammer) was utilized to advance 200 mm diameter casing through the rock fill of the existing highway embankment at two locations. Once the casing was installed,

the CME 45 drill rig was utilized to completed geotechnical testing and sampling below the rock fill.

At the boreholes, soil samples were obtained at the boreholes with a split spoon sampler as a part of the Standard Penetration Testing (SPT). The SPT involves driving a thick walled sampler into the soils under a standardized energy (63.5 kg, falling 760 mm). The number of blows required to drive the sampler 0.3 m, known as the SPT blow count (N), was recorded. In addition, relatively undisturbed thin wall tube samples were obtained at selected depths.

Field vane testing (MTO field vane) was carried out at selected depths both within the peat and clay soils. Some of the MTO field vane test results have not been reported at location where it was suspected that the test was carried out across sand seams and do not represent the true condition of the clay. In addition, small diameter lab vanes were carried out within selected thin walled tube samples.

The dynamic cone penetrometer test (DCPT) is a continuous test, driving a 51 mm diameter cone with the energy of a 63.5 kg weight falling through 760 mm. The number of blows required to drive the cone 0.3 m is recorded which provides an indication of the condition of the soil.

Borehole and DCPT probe locations were referenced in the field and ground surface elevations were surveyed and referenced to data provided by MTO and the following datum:

Horizontal Datum: North American Datum 1983 (NAD83) 3 Degree Modified Transverse Mercator (MTM) Grid Coordinates MTM Zone 15

Vertical Datum: Canadian Geodetic Vertical Datum 1928 Adjustment, Geodetic Elevations

Benchmark: BM 232-228 T/O nut S.E. corner Hydro Tower
Station 23+403.511 o/s/ 22.120 LT
Elev. 232.228 Geodetic

A summary of the borehole location data is provided on the enclosed Borehole Location Plan and Strata Drawings.

The borehole characteristics and drill techniques utilized are summarized in Tables 1.

**Table 1. Drill Summary**

| Location | Surface Elevation (metres) | Refusal (Elevation/Depth) (metres) | Comments |
|---|---|---|---|
| BH 1 | 229.9 | NA | Hollow Stem Augers, Swamp |
| BH 2 | 229.8 | 209.6 / 20.2 | Hollow Stem Augers, DCPT, Swamp |
| BH 3 | 233.4 | NA | Through Highway, Well Rig |
| BH 4 | 229.8 | 211.1 / 18.7 | Hollow Stem Augers, Swamp |
| BH 5 | 233.4 | NA | Through Highway, Well Rig |
| BH 6 | 229.9 | 210.4 / 19.5 | Hollow Stem Augers, Cored Through Cobbles, Swamp |
| BH 7 | 229.9 | 209.9 / 20.0 | Hollow Stem Augers, DCPT, Swamp |
| BH 8 | 229.9 | 211.0 / 18.9 | Hollow Stem Augers, DCPT, Swamp |
| BH 9 | 231.5 | 230.9 / 0.6 | Hollow Stem Augers, Boulders noted at surface |
| BH 10 | 229.7 | 223.3 / 6.4 | Hollow Stem Augers, Swamp |
| BH 11 | 231.3 | 229.4 / 1.9 | Hollow Stem Augers, Boulders noted at surface |
| BH 12 | 232.5 | 231.6 / 0.9 | Hollow Stem Augers |
| BH 13 | 229.6 | 226.7 / 2.9 | Hollow Stem Augers, Swamp |
| DCPT 101 | 227.2 | 205.9 / 21.3 | DCPT, Swamp |
| DCPT 102 | 226.6 | 240.6 / 22.0 | DCPT, Swamp |
| DCPT 103 | 229.9 | 209.4 / 20.5 | DCPT, Swamp |
| DCPT 104 | 229.9 | NA | DCPT, Swamp |
| DCPT 105 | 232.7 | 232.3 / 0.4 | DCPT |

The boreholes were backfilled at the completion of the investigations using a bentonite backfill mixture to ensure the environmental integrity of the site.

Soil samples were transported to TBT Engineering's laboratory in Thunder Bay for testing. Routine testing included moisture content and grain size analysis. The results of this testing are shown on the Borehole Logs (Appendix A) and on the laboratory data reports (Appendix B).

# 4 Sub-Surface Conditions

Details of the subsurface conditions are provided on the Borehole Logs and on the Section Plans, Drawings Appendix A. In general, the subsurface conditions along the majority of the proposed alignment (360 m) consists of a significant deposit of peat and marl overlying a deep deposit of very soft to firm clay and clayey silt which extends to a depths of about 20 m. A thin discontinuous sand layer was identified below the peat at several locations. Below the clay and clayey silt, a stratum of silty sand to sandy silt with cobbles and/or boulders exists.

At Boreholes 9, 11, and 12 and at DCPT 105, no significant peat deposit was identified. These test holes are generally located along the proposed alignment centre line and left of centre for the most northern 100+ m of the proposed alignment. At these locations, the subsurface stratigraphy consists of silty sands and gravels with cobbles and boulders. Auger refusal was met within 3 m.

Boreholes 3 and 5 were carried out through the existing highway embankment. At these locations, the subsurface stratigraphy consist of asphalt overlying sand and gravel fill and rock fill. Below the rock fill, peat with rock fill and peat was which is underlain by a thin discontinuous sand layer and clay.

### 4.1.1 Asphalt

Asphalt was present at the surface of Borehole 3 and 5 which were located along the east side of the existing highway embankment.

### 4.1.2 Sand and Gravel Fill

Below the asphalt of along the existing embankment, a sand and gravel fill was identified to estimated depths of 1.2 to 2.2 m at Boreholes 3 and 5. The material type and depths were estimated based on cuttings blown to the top of casing during drilling with the well rig.

### 4.1.3 Rock Fill

Rock fill was encountered along the existing highway embankment below the sand and gravel fill and extended to depths of 4.8 to 5.7 m as observed during drilling operations with a well rig and down hole hammer. Rock fill and peat were observed to depth of 5.1 to 7.9 m. Rock fill was found to extend to elevations of 228.5 to 225.5 m. Based on visual observations of the embankment slopes, the rock fill is expected to have rock sizes of up to one metre diameter.

### 4.1.4 Peat

Peat was found to exist below the rock fill along the existing embankment and at surface for most of the proposed alignment.

Below the existing embankment (Boreholes 3 and 5) peat was found to extend to depths of 5.9 to 7.9 m (elevations 225.5 to 227.5 m). The peat below the embankment has a moisture content of 100 % (dry weight basis).

Along the proposed alignment, peat was found at surface of all of the boreholes except at Boreholes 9 and 12 which are located along the centre line and left sides of the proposed alignment between Station (23 + 605 and 23 + 760). For the most part, the depth of peat was in the order of 2 to 5 m and extended to elevations of 228 to 225 m. The water is near the surface of this deposit. Moisture contents in the peat along the proposed alignment are between 250 and 700% (dry weight basis). The estimated undrained shear strength of the peat based on field and lab vane testing varied from 15 to 40 kPa and decreased with depth.

A consolidation test on a sample of peat from Borehole 4 at a depth of 3.1 m was carried out. The test was carried out to estimate both primary and secondary consolidation properties and was limited to the expected design normal stress range of 5 to 100 kPa. Under primary consolidation, the peat has a measured constrained modulus of 0.3 MPa and a coefficient of consolidation ($C_V$) in the range of 1.2 to 2.2 $mm^2$/min. The secondary compression index ($C_\alpha$) has been measured at 0.15 over a normal effective

stress range of 10 to 100 kPa. The modified secondary compression index ($C_{\alpha\epsilon}$) has been measured at 3% over the same stress range.

Drained direct shear testing was also carried out on a selected sample of peat. The peat was initially allowed to consolidate (primary consolidation) under a given normal effective stress and then sheared under drained conditions. The results of this testing indicate the peat has a drained angle of internal friction of 14° at a horizontal strain of 4% and 28° at a horizontal strain of 20%.

### 4.1.5 Marl

A discontinuous layer of marl (up to 2 m thick) exists below the peat as identified at Boreholes 1, 2 and 7 and extends to depths of 3.6 to 5.3 m (elevations 226.5 to 224.5 m). The marl contains organics and shells and has moisture contents between 110 and 220 %. The estimated undrained shear strength of the marl based on lab vane testing varied from 5 to 10 kPa. An Atterberg limit test carried out on a sample of marl from Borehole 1 at a depth of 3.0 m indicates the marl is non-plastic.

### 4.1.6 Sand

A discontinuous sand layer (up to 2.6 m thick) exists below the peat as identified at Boreholes 4, 5 and 6. The sand layer has trace amounts of silts and organics and is in a very loose condition as indicated by SPT (N) values of 0 blows/0.3 m.

### 4.1.7 Silty Clay

A deep silty clay deposit was identified over the majority of the proposed alignment and below the existing highway embankment between stations 23+450 to 23+575. The clay was not encountered at Boreholes 9 to 13. The surface of the clay stratum generally starts at depths of 3.5 to 6 m between elevations 224 to 226 m and extends to elevations of 218 to 217 m. The thickness of the clay stratum was found to vary from about 7 to 10 m. Atterberg limits carried out on selected samples indicate the clay generally of medium plasticity with the natural moisture content exceeding the liquid limit.

The clay stratum was found to contain occasional silty sand seams generally less than 50 mm in thickness. However, layer of very loose silty sand estimated to be about 1.5 m thick was identified at Borehole 6. Grainsize analyses carried out on selected silts sand seams indicates the sand content varies from 76 to 78 and the silt content varies from 22 to 24 %.

Below the proposed alignment, the clay has a very soft to firm consistency as indicated by estimated undrained shear strengths of 6 to 45 kPa (based on field and lab vane testing). A consolidated undrained direct shear test carried out on a sample from Borehole 7 at a depth of 6.4 m was carried out. The sample was initially consolidated to the estimated existing effective overburden pressure ($P'_o$). The results of this test indicate an undrained shear strength of 9 kPa at 3% strain.

Below the existing embankment, the clay has a firm to stiff consistency as indicated by field vanes of 40 to 90 kPa taken at Borehole 5. A consolidated undrained direct shear test carried out on a sample from Borehole 7 at a depth of 6.4 m was carried out at an effective overburden pressure of 100 kPa to model the estimated overburden pressure below the embankment. The results of this test indicate an undrained shear strength of 29 kPa at 3% strain.

A consolidated drained direct shear test was also carried out on the clay. The results of this test indicate the clay has a drained angle of internal friction (ø') of 20°with a cohesion intercept (c') of 0 kPa.

Consolidation testing carried out on a clay sample from Borehole 7 at a depth of 6.4 m indicates the clay is normally consolidated with an estimated over consolidation ratio (OCR) of 1.25. Within the anticipated design stress range, the volume compressibility ($m_v$) varies from $1.25 \times 10^{-3}$ $m^2$/kN ($1/m_v$ = 0.8 MPa) and the coefficient of consolidation varies from 0.3 to 2.1 $mm^2$/min. The hydraulic conductivity with the design stress range as interpreted from the consolidation testing varies from $10^{-9}$ to $10^{-8}$ cm/sec.

### 4.1.8 Clayey Silt

A stratum of clayey silt exists below the above noted silty clay stratum as identified at Boreholes 2, 4, 6, 7 and 8 and starts at depths of 11.5 to 14.5 m. This stratum generally exists between elevations 218.5 and 210.5 m. Clayey silt was also identified at Borehole 10 between elevations 223 and 226 m. As with the silty clay stratum, occasional silty sand seams were identified. Atterberg limits carried out on selected samples indicate the soil is classified as CL-ML with the natural moisture content exceeding the liquid limit.

Below the proposed alignment, the clay has a very soft to stiff consistency as indicated by SPT (N) values of 0 to 9 blows/0.3 m and a field vane test of 75 kPa.

Consolidation testing carried out on a clay sample from Borehole 2 at a depth of 14.3 m indicates the clayey silt is normally consolidated with an estimated over consolidation ratio (OCR) of 1.2. Within the anticipated design stress range, the volume compressibility ($m_v$) varies from $2.4x10^{-4}$ $m^2/kN$ ($1/m_v$ = 4.7 MPa) and the coefficient of consolidation varies from 0.7 to 2.1 $mm^2/min$. The hydraulic conductivity with the design stress range as interpreted from the consolidation testing varies from $10^{-9}$ to $10^{-8}$ cm/sec.

### 4.1.9 Silt

A discontinuous stratum of silt was identified below the above noted clayey silt at Boreholes 2 and 8 and exists between elevations 215.5 and 211.5 m. As indicated by Atterberg limits, the silt is non-plastic. Based on grain size analysis, the silt contains a trace of sand and clay with over 95 silt sized particles. The silt is very loose to loose with SPT (N) values of 0 to 8 blows/0.3 m.

A thin (0.2 m thick) silt layer was also noted at Borehole 13 at a depth of 1.6 m (below the peat).

### 4.1.10 Lower Sands

At Boreholes 2, 4, 7 and 8 a layer of sand and/or silty sand with occasional cobbles was identified below the above note silts and/or clayey silt. The sand starts at depths of 16.5

to 18.2 m and extend to the limit of the boreholes at depths of 18.7 to 20.2 m. This stratum rises to the north. At Boreholes 9, 11, 12 and 13, this stratum was identified at surface to depths 1.8 m and extends to depths of up to 2.9 m (auger refusal). This stratum is in a very loose to very dense condition with SPT (N) values of 0 to 92 blows/0.3 m. Grain size analyses carried out on selected samples indicates the sand content varies from 50 to 92%, the silt content varies from 8 to 35 % and the gravel content varies from 0 to 23 %.

### 4.1.11 Refusal

Auger refusal was met at Boreholes 2, 4, 6 to 13 and at DCPT's 101 to 103 and 105. Refusal depths carried out within the swamp generally varied from 18 to 22 m. At boreholes 9 to 13, auger refusal was met at depths of 0.6 to 6.4 m. Auger refusal may be on bedrock or cobble and boulders. Auger refusal material was cored utilizing diamond corning techniques for a depth of 3 m at Borehole 6 and was identified as cobbles and boulders.

### 4.1.12 Ground Water

The ground water level was at or above the peat surface during the field investigations.

## 5 Miscellaneous

The field drilling services for this project were provided by TBT Engineering and Fraser (1994) Ltd. Laboratory testing was carried out at the TBT Engineering laboratory in Thunder Bay. The field operations were supervised by D. Vale, B.Eng. and Adam Rose, B.Eng. This report was prepared by G. Maki, P.Eng. and W. Hurley, P.Eng.

# Part B FOUNDATION DESIGN RECOMMENDATIONS

## 6 Discussions and Engineering Recommendations

### 6.1 Introduction

The proposed re-alignment is located on a curve section of Highway 11/17. Specifically, this report addresses proposed realignment Alternative No. 2 which considers a realignment of the highway to the south between the existing highway and Pearl Lake. The existing embankment is 4 to 5 m high and is located on the west side of Pearl Lake. The revised section is to be of a similar vertical alignment, with a horizontal revision, east of the existing alignment, to the west and north of Pearl Lake.

During the geotechnical investigation for the project, very soft soils were encountered in probes south of the toe of existing slope. The probes were extended to more than 7 m below the toe of slope, terminating in soft clay deposits.

During earlier investigations for the potential 4 laning along this route (WP 372-90-00), a preliminary investigation was carried out within Pearl Lake. The investigation encountered organic deposits over very soft to soft clays. The investigations terminated 7 to 9 m below the water in the soft deposits. The alignment investigated at that time was south of the current alignment, in deeper water of Pearl Lake.

Much of the topography along the proposed alignment route consists of saturated swamp along the edge of the lake and saturated cedar swamps to the north. The water surface is at or above the surface of the organics.

This section of Highway 11/17 is remote and there are few if any detour options around the site should the road be closed for construction or in the case of an embankment failure.

The foundation investigation as described in Part A, was carried out to investigate subsurface conditions at the site. This investigation consisted of a number of boreholes and probes advanced in the vicinity of the realignment, laboratory testing and

geotechnical analysis of the data. The data and analyses contained within this report were discussed in detail during the design phases of the project. At that time it was decided not to further pursue this Option for the curve realignment. The purpose of this section of the report (Part B) is to document the options investigated and the geotechnical analyses undertaken. These are based on the conditions encountered at the test locations and our interpretation of the subsurface conditions at the site.

### 6.2 Stability Analyses

Stability analyses for various embankment sections were carried out to investigate various design alternatives. Stability analyses were carried out using SlopeW software and limit equilibrium analyses. Slopes were analyzed using the Morgenstern-Price method and a target minimum factor of safety of 1.3.

The soil parameters used for the analyses were as shown on Table 4.

**Table 5 Stability Analyses Soil Properties**

| Soil | Internal Friction ,φ (degrees) | Cohesion, Cu (kPa) | Unit Weight γ ($kN/m^3$) |
|---|---|---|---|
| Rock Fill | 45 | 0 | 18 |
| Sand & Gravel | 35 | 0 | 20 |
| Peat (undrained) | 0 | 15 | 11 |
| Peat | 14 (@4%), 28(@20%) | 0 | 11 |
| Clay | 20 | 0 | 18 |
| Clay (undrained) | 0 | 9-55 | 18 |

The results of the stability analyses are discussed for the various embankment alternative sections are discussed below.

Option 1: Excavation of Peat Subgrade without Roadway Protection:
The first option reviewed involved complete removal of the peat below the new embankment (to a depth of up to 6 m) with partial removal of the existing embankment to improve stability. Traffic was to be routed along the west bound lane and west side shoulder. The excavation length was limited to take advantage of 3D effects. However, as illustrated on the attached stability analyses report (Figure 1, Appendix C)

the calculated factors of safety are less than acceptable. (FoS< 1.2). Furthermore, large deformations within the existing embankment would be anticipated for this configuration. Further lowering the grade of the temporary traffic lanes would increase the stability of the excavation; however, this is not considered practical given grading restrictions.

Long term settlements of the new embankment due to consolidation of the deep clay layers may be in the order of one metre. These will occur over a time period in excess of 10 years at a decreasing rate.

Option 2: Excavation of Peat Subgrade with Sheet Piling:
This option is similar to Option 1 with the east bound lane removed to improve stability of the excavation and to limit loads on the proposed sheet pile wall. A preliminary assessment of sheet pile requirements indicates that even with a heavy section, a cantilevered system will not stabilize the 6+ m deep excavation and hold back the existing roadway fills (given the extent of soft clays). As such, a tieback system would be required. However, given the depth of rock fill below the existing embankment a tie back system is not considered feasible/practical.

Option 3: Floating Roadway Embankment Over Peat:
This option appeared to be the most feasible/practical solution. However, accommodation of staged construction (over several years) and settlement issues would be required. Future maintenance requirements would be significant to address ongoing embankment settlements.

A preliminary assessment of stability indicated that flanking berms will be required (likely in the order of 1 to 1.5 m thick extending 20 + m beyond the toe of the embankment). The embankment will need to be constructed in stages to allow for consolidation and subsequent strength gain to be achieved between stages. It is estimated that 1 to 2 m thick lifts will be the maximum permissible with about a 1 month delay between stages. Examples of stability analyses reports are provided in Appendix C, Figures 2 and 3.

Primary consolidation settlements of the embankment will be in the order of 2.3 m (0.9 m within clay and 1.4 m within peat). It is anticipated that an additional 0.5 to 1 m of

settlement may occur within the peat layer over the long term due to secondary consolidation (at an ever decreasing rate).

Preloading may be considered to reduce secondary consolidation. Detailed preload design should include an assessment of acceptable settlement performance, preload duration (potentially measured in years) and preload thickness.

The use of a geogrid will likely be required to reduce risk of shear failure through peat.

Rock fill was anticipated as the initial fill material, with granular fill required for the upper lifts of the embankment. Ideally, at the end of fill placement, the grade would be set to allow for all remaining primary consolidation with additional preload thickness considered to offset some long term consolidation. After a set period of time (in the order of 2 to 5 years depending on settlement performance requirements), the embankment would be cut to final grade with pavement structure completed at that time.

Settlements along the exiting embankment would be induced which will require maintenance especially during the fill placement phase of construction. Settlements along the existing embankment occurring after the fill placement phase are expected to be manageable, but must be confirmed. A preliminary finite element assessment of the proposed floated embankment illustrating primary consolidation of the peat and clays (secondary consolidation would be in addition) is attached.(Figure 4, Appendix C). Calculated induced settlements of the existing embankment are in the order of 0.3 m.

## 6.3 Red Flag Issues

It should be noted, that even where the excavation of the peat is considered (as in Options 1 and 2, above), long term settlement issues would still need to be addressed. These are due to very significant consolidation of the underlying clays, potentially over one metre). Staged construction would be required during fill placement to avoid failure through the weak clays. While staging and settlement performance is more critical with Option 3 (leaving the peat in place), the risks and costs associated with a deep (6 m) excavation are avoided.

## 7 Limitations

Conclusions and recommendations presented in this report are based on the information determined at the test hole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

The design recommendations provided in this report are preliminary in nature and are based on the conceptual project described in the text.

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Benchmarks and elevations referred to in this report are used primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

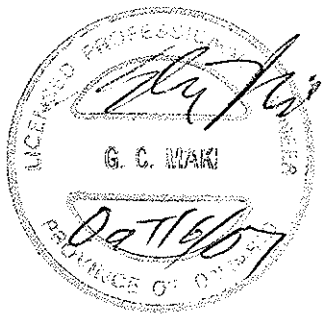
Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of dewatering procedures which may be considered cannot readily be determined from boreholes. These include local and seasonal fluctuations of the groundwater level, changes in soil conditions between test locations, thin and/or discontinuous layers of highly permeable soils, etc.

The information contained within this report in no way reflects any environmental aspect of the site or soil.

## 8 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate the contact us at your convenience.

Yours truly,
For TBT ENGINEERING

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# APPENDIX A

# BOREHOLE LOGS

## EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ($c_u$) AS FOLLOWS:

| $c_u$ (kPa) | 0 - 12 | 12 - 25 | 25 - 50 | 50 - 100 | 100 - 200 | >200 |
|---|---|---|---|---|---|---|
| | VERY SOFT | SOFT | FIRM | STIFF | VERY STIFF | HARD |

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

| N (BLOWS/0.3m) | 0 - 5 | 5 - 10 | 10 - 30 | 30 - 50 | >50 |
|---|---|---|---|---|---|
| | VERY LOOSE | LOOSE | COMPACT | DENSE | VERY DENSE |

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

| RQD (%) | 0 - 25 | 25 - 50 | 50 - 75 | 75 - 90 | 90 - 100 |
|---|---|---|---|---|---|
| | VERY POOR | POOR | FAIR | GOOD | EXCELLENT |

JOINTING AND BEDDING:

| SPACING | 50mm | 50 - 300mm | 0.3m - 1m | 1m - 3m | >3m |
|---|---|---|---|---|---|
| JOINTING | VERY CLOSE | CLOSE | MOD. CLOSE | WIDE | VERY WIDE |
| BEDDING | VERY THIN | THIN | MEDIUM | THICK | VERY THICK |

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

| | | | |
|---|---|---|---|
| S S | SPLIT SPOON | T P | THINWALL PISTON |
| W S | WASH SAMPLE | O S | OSTERBERG SAMPLE |
| S T | SLOTTED TUBE SAMPLE | R C | ROCK CORE |
| B S | BLOCK SAMPLE | P H | T W ADVANCED HYDRAULICALLY |
| C S | CHUNK SAMPLE | P M | T W ADVANCED MANUALLY |
| T W | THINWALL OPEN | F S | FOIL SAMPLE |

### STRESS AND STRAIN

| | | |
|---|---|---|
| $u_w$ | kPa | PORE WATER PRESSURE |
| $r_u$ | 1 | PORE PRESSURE RATIO |
| $\sigma$ | kPa | TOTAL NORMAL STRESS |
| $\sigma'$ | kPa | EFFECTIVE NORMAL STRESS |
| $\tau$ | kPa | SHEAR STRESS |
| $\sigma_1, \sigma_2, \sigma_3$ | kPa | PRINCIPAL STRESSES |
| $\epsilon$ | % | LINEAR STRAIN |
| $\epsilon_1, \epsilon_2, \epsilon_3$ | % | PRINCIPAL STRAINS |
| E | kPa | MODULUS OF LINEAR DEFORMATION |
| G | kPa | MODULUS OF SHEAR DEFORMATION |
| $\mu$ | 1 | COEFFICIENT OF FRICTION |

### MECHANICAL PROPERTIES OF SOIL

| | | |
|---|---|---|
| $m_v$ | $kPa^{-1}$ | COEFFICIENT OF VOLUME CHANGE |
| $C_c$ | 1 | COMPRESSION INDEX |
| $C_s$ | 1 | SWELLING INDEX |
| $C_\alpha$ | 1 | RATE OF SECONDARY CONSOLIDATION |
| $c_v$ | $m^2/s$ | COEFFICIENT OF CONSOLIDATION |
| H | m | DRAINAGE PATH |
| $T_v$ | 1 | TIME FACTOR |
| U | % | DEGREE OF CONSOLIDATION |
| $\sigma'_{vo}$ | kPa | EFFECTIVE OVERBURDEN PRESSURE |
| $\sigma'_p$ | kPa | PRECONSOLIDATION PRESSURE |
| $\tau_f$ | kPa | SHEAR STRENGTH |
| $c'$ | kPa | EFFECTIVE COHESION INTERCEPT |
| $\phi'$ | -° | EFFECTIVE ANGLE OF INTERNAL FRICTION |
| $c_u$ | kPa | APPARENT COHESION INTERCEPT |
| $\phi_u$ | -° | APPARENT ANGLE OF INTERNAL FRICTION |
| $\tau_R$ | kPa | RESIDUAL SHEAR STRENGTH |
| $\tau_r$ | kPa | REMOULDED SHEAR STRENGTH |
| $S_t$ | 1 | SENSITIVITY = $\frac{c_u}{\tau_r}$ |

### PHYSICAL PROPERTIES OF SOIL

| | | |
|---|---|---|
| $\rho_s$ | $kg/m^3$ | DENSITY OF SOLID PARTICLES |
| $\gamma_s$ | $kN/m^3$ | UNIT WEIGHT OF SOLID PARTICLES |
| $\rho_w$ | $kg/m^3$ | DENSITY OF WATER |
| $\gamma_w$ | $kN/m^3$ | UNIT WEIGHT OF WATER |
| $\rho$ | $kg/m^3$ | DENSITY OF SOIL |
| $\gamma$ | $kN/m^3$ | UNIT WEIGHT OF SOIL |
| $\rho_d$ | $kg/m^3$ | DENSITY OF DRY SOIL |
| $\gamma_d$ | $kN/m^3$ | UNIT WEIGHT OF DRY SOIL |
| $\rho_{sat}$ | $kg/m^3$ | DENSITY OF SATURATED SOIL |
| $\gamma_{sat}$ | $kN/m^3$ | UNIT WEIGHT OF SATURATED SOIL |
| $\rho'$ | $kg/m^3$ | DENSITY OF SUBMERGED SOIL |
| $\gamma'$ | $kN/m^3$ | UNIT WEIGHT OF SUBMERGED SOIL |

| | | |
|---|---|---|
| e | 1, % | VOID RATIO |
| n | 1, % | POROSITY |
| w | 1, % | WATER CONTENT |
| $S_r$ | % | DEGREE OF SATURATION |
| $w_L$ | % | LIQUID LIMIT |
| $w_P$ | % | PLASTIC LIMIT |
| $w_S$ | % | SHRINKAGE LIMIT |
| $I_P$ | % | PLASTICITY INDEX = $w_L - w_P$ |
| $I_L$ | 1 | LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$ |
| $I_C$ | 1 | CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$ |
| $e_{max}$ | 1, % | VOID RATIO IN LOOSEST STATE |
| $e_{min}$ | 1, % | VOID RATIO IN DENSEST STATE |
| $I_D$ | 1 | DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$ |
| D | mm | GRAIN DIAMETER |
| $D_n$ | mm | n PERCENT - DIAMETER |
| $C_U$ | 1 | UNIFORMITY COEFFICIENT |
| h | m | HYDRAULIC HEAD OR POTENTIAL |
| q | $m^3/s$ | RATE OF DISCHARGE |
| v | m/s | DISCHARGE VELOCITY |
| i | 1 | HYDRAULIC GRADIENT |
| k | m/s | HYDRAULIC CONDUCTIVITY |
| j | $kN/m^3$ | SEEPAGE FORCE |

TBT Engineering

# RECORD OF Borehole No 1

1 OF 1 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+450 o/s 15.0 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 8, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 229.9 | | | | | | | | 20 40 60 80 100 | 20 40 60 | | |
| 0.0 | PEAT - black | | | | | | 229 | | | | Frost to 1.0 m. |
| 228.0 | | | 1 | SS | 1 | | 228 | ★ | 584 | | |
| 1.9 | MARL - trace organics, trace shells, grey, soft | | 2 | GS | | | | | | | |
| 226.3 | | | 3 | TW | | | 227 | | 113 | | |
| 3.6 | CLAY - Silty, occasional silty sand seam, grey, very soft to firm | | | | | | 226 | × | 194 | | |
| | | | 4 | SS | 0 | | 225 | | | | |
| | | | 5 | TW | | | 224 | | | | |
| | | | 6 | GS | | | 223 | ★ | | | |
| | - 200 mm silty sand layer | | 7 | SS | 0 | | 222 | | | | |
| | - 50 mm silty sand layer | | 8 | TW | | | 221 | | | | |
| | | | | | | | 220 | | | | |
| | | | 9 | TW | | | 219 | ★ | | | |
| 218.3 | | | | | | | | × | | | |
| 11.6 | End of Borehole @ 11.6 m. | | | | | | | | | | |

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 B 05-097.GPJ ON_MOT.GDT 10/17/07

TBT Engineering

# RECORD OF Borehole No 2

1 OF 2 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+490 o/s 3 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 10, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 229.8 | | | | | | | | 20 40 60 80 100 | 20 40 60 | | |
| 0.0 | PEAT - black | | | | | | 229 | | | | Frost to 1.0 m. |
| | | | 1 | TW | | | 228 | | 554 | | |
| 226.8 | | | | | | | 227 | | 212 | | |
| 3.0 | MARL - trace organics, trace shells, grey, very soft | | 2 | TW | | | | | | | |
| 226.2 | | | | | | | 226 | | | | |
| 3.6 | CLAY - Silty, occasional silty sand seam, grey, very soft to firm | | 3 | TW | | | 225 | | | | |
| | | | 4 | TW | | | 224 | | | | |
| | | | | | | | 223 | | | | |
| | | | 5 | GS | | | 222 | | | | |
| | | | 6 | SS | 0 | | 221 | | | | |
| | | | 8 | TW | | | 220 | | | | |
| | | | | | | | 219 | | | | |
| 217.6 | | | | | | | 218 | | | | |
| 12.2 | SILT - Clayey, occasional sand seam, grey, soft | | 9 | SS | 0 | | 217 | | | | |
| | | | 10 | TW | | | 216 | | | | |
| | | | | | | | 215 | | | | |

Continued Next Page

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

# RECORD OF Borehole No 2

2 OF 2 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+490 o/s 3 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 10, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 213.6 | | | 11 | SS | 2 | | 214 | | | | |
| 16.2 | SILT - red, compact | | 12 | SS | 17 | | 213 | | | | |
| 211.6 | | | | | | | 212 | | | | |
| 18.2 | SAND - trace silt, red, loose to compact | | 13 | SS | 8 | | 211 | | | | 0 92 (8) |
| 209.6 | | | | | | | 210 | | | | |
| 20.2 | End of Borehole @ 20.2 m. Refusal to DCPT. | | | | | | | | | | |

20 40 60 80 100 (SHEAR STRENGTH kPa)

20 40 60 (WATER CONTENT %)

× 3, ★ 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 B 05-097.GPJ ON_MOT.GDT 10/17/07

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# RECORD OF Borehole No 3

1 OF 1

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+488 o/s 8.1 m LT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 21, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 233.4 | | | | | | | | 20 40 60 80 100 | 20 40 60 | | |
| 233.4 / 0.0 | ASPHALT | | | | | | 233 | | | | Well rig with down hole hammer. Grab sample obtained from cuttings blown to top of casing. 200 mm diameter casing. |
| 232.2 / 1.2 | FILL - SAND & GRAVEL - brown | | | | | | | | | | |
| | FILL - ROCKFILL | | 1 | GS | | | 232 | | ● | | |
| | | | | | | | 231 | | | | |
| | | | 2 | GS | | | 230 | | ● | | |
| 227.7 / 5.7 | PEAT - with rockfill (inferred from cuttings) | | | | | | 229 | | | | |
| | | | | | | | 228 | | | | |
| | | | | | | | 227 | | | | |
| 225.5 / 7.9 | End of Borehole @ 7.9 m. Casing could not be advanced due to shifting rockfill. | | | | | | 226 | | | | |

×³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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# RECORD OF Borehole No 4

1 OF 2

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+525 o/s 3.5 m LT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **February 25, 2007** BOREHOLE TYPE **#45** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 229.8 | | | | | | | | | | | |
| 0.0 | PEAT - black | | | | | | | | | | Frost to 1.1 m. |
| | | | 2 | TW | | | 229 | | 484 | | |
| | | | | | | | 228 | | | | |
| | | | 1 | TW | | | 227 | | 571 | | |
| | | | | | | | | | | | |
| | | | 3 | TW | | | 226 | | | | |
| 225.3 | | | | | | | | | | | |
| 4.5 | SAND - trace silt, red, very loose | | 4 | SS | 0 | | 225 | | | | 0 96 (3) |
| | - clay seam | | 5 | SS | 0 | | | | | | |
| 223.7 | | | | | | | 224 | | | | |
| 6.1 | CLAY - Silty, occasional silty sand seam (5 - 50 mm thickness), grey, very soft to soft | | 6 | SS | 0 | | | | | | |
| | | | 7 | TW | | | 223 | | | | |
| | | | | | | | 222 | | | | |
| | | | 8 | SS | 1 | | 221 | | | | 0 76 (24) (sand seam) |
| | | | | | | | 220 | | | | |
| | | | 9 | SS | 2 | | 219 | | | | |
| | | | | | | | 218 | | | | |
| | | | 10 | SS | 1 | | | | | | |
| 216.8 | | | | | | | 217 | | | | |
| 13.0 | SILT - Clayey, occasional silty sand seam (5 - 50 mm thickness), grey, stiff | | | | | | | | | | |
| | | | 11 | SS | 9 | | 216 | | | | |
| | | | | | | | 215 | | | | |

Continued Next Page

× 3, ★ 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

# RECORD OF Borehole No 4

2 OF 2 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+525 o/s 3.5 m LT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **February 25, 2007** BOREHOLE TYPE **#45** DATUM **Geodetic** CHECKED BY **WH**

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT | UNIT WEIGHT | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | ○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE | $w_P$ $w$ $w_L$ WATER CONTENT (%) | $\gamma$ kN/m³ | GR SA SI CL |
| | | | 12 | SS | 9 | | 214 | | | | |
| | | | | | | | | | | | |
| | - - - - -<br>- occasional cobble | | 13 | SS | 23 | | 213 | | | | |
| 212.4<br>17.4 | SAND - Silty, cobbles, red | | | | | | 212 | | | | |
| 211.1 | | | 14 | SS | >99 | | | | | | |
| 18.7 | End of Borehole @ 18.7 m.<br>Auger Refusal. | | | | | | | | | | |

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 B 05-097.GPJ ON_MOT.GDT 10/17/07

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# RECORD OF Borehole No 5

1 OF 2

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+550 o/s 18.6 m LT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 22, 2007** BOREHOLE TYPE **Schramm Rotadrill** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS |
|---|---|---|---|---|---|---|
| 233.4 | | | | | | |
| 233.4 / 0.0 | ASPHALT - 50 mm | | | | | |
| 233.1 / 0.3 | FILL - SAND & GRAVEL | | 1 | GS | | |
| 231.2 | | | | | | |
| 2.2 | FILL - ROCKFILL | | | | | |
| 228.6 | | | | | | |
| 4.8 / 228.3 | PEAT - with rockfill | | | | | |
| 5.1 | PEAT - black | | 2 | GS | | |
| 227.5 | | | | | | |
| 5.9 | SAND - some silt to Silty, brown | | 3 | TW | | |
| | | | 4 | TW | | |
| | - - - - - | | | | | |
| 224.9 | - grey/brown | | | | | |
| 8.5 | CLAY - Silty, occasional silty sand seam, grey, firm to stiff | | 5 | TW | | |

ELEVATION SCALE: 233, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED × FIELD VANE
■ SPT (N) ★ LAB VANE
20 40 60 80 100

PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$

WATER CONTENT (%): 20 40 60

UNIT WEIGHT $\gamma$ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Well rig (down hdp hammer) utilized to advance 200 mm casing through rockfill. Grab sample obtained from cuttings blown to top of casing.

100

Continued Next Page

×³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

# RECORD OF Borehole No 5

2 OF 2 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+550 o/s 18.6 m LT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 22, 2007** BOREHOLE TYPE **Schramm Rotadrill** DATUM **Geodetic** CHECKED BY **WH**

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | GR SA SI CL |
| 217.9 | | | | | | | 218 | | | | |
| 15.5 | End of Borehole @ 15.5 m. | | | | | | | | | | |

×³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

# RECORD OF Borehole No 6

1 OF 2

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+550 o/s 3.0 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 15, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 229.9 | | | | | | | | 20 40 60 80 100 | 20 40 60 | | |
| 0.0 | PEAT - black | | | | | | 229 | | | | Frost to 0.6 m. |
| | | | 1 | SS | 1 | | | | | | |
| | | | | | | | 228 | × | | | |
| | | | 2 | TW | | | 227 | | | | |
| 225.7 | | | | | | | 226 | | 96 | | |
| 4.2 / 225.4 | SAND - Silty, some organics, brown | | 3 | SS | 1 | | | | | | |
| 4.5 | CLAY - Silty, occasional silty sand seams, grey, very soft to soft | | | | | | 225 | × | | | |
| | | | 4 | TW | | | 224 | ★ | | | |
| 222.9 | | | | | | | 223 | | | | |
| 7.0 | SAND - trace silt, brown, very loose | | 5 | SS | 1 | | | | | | 0 78 (22) |
| 221.4 | | | | | | | 222 | | | | |
| 8.5 | CLAY - Silty, occasional silty sand seams, grey, very soft to firm | | 6 | TW | | | 221 | ★ | | | |
| | | | 7 | SS | 2 | | 220 | | | | |
| | - - - - - - trace organics | | 8 | TW | | | 219 | | | | |
| | | | | | | | 218 | ★ | | | |
| | | | 9 | SS | 1 | | 217 | × | | | |
| 215.3 | | | | | | | 216 | | | | |
| 14.6 | SILT - Clayey, brown/grey | | | | | | 215 | | | | |

Continued Next Page

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

# RECORD OF Borehole No 6

2 OF 2 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+550 o/s 3.0 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 15, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 10 | TW | | | | | | | |
| | - - - - -<br>- frequent cobbles/boulders | | | | | | 214 | | | | Cored through cobbles/boulders |
| | | | C1 | RC | | | 213 | | | | RC # 1<br>REC = 7%<br>RQD = 0% |
| | | | C2 | RC | | | 212 | | | | RC # 2<br>REC = 50%<br>RQD = 10% |
| 210.4 | | | | | | | 211 | | | | |
| 19.5 | End of Borehole @ 19.5 m. | | | | | | | | | | |

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED × FIELD VANE ■ SPT (N) ★ LAB VANE; 20 40 60 80 100

PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT; WATER CONTENT (%): 20 40 60

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 B 05-097.GPJ ON_MOT.GDT 10/17/07

TBT Engineering

# RECORD OF Borehole No 7

1 OF 2

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+550 o/s 15 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **February 21, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 229.9 | | | | | | | | |
| 0.0 | PEAT - black | | | | | | | Frost to 0.8 m. |
| | | | 1 | AS | | | | |
| | | | 2 | SS | 1 | | | |
| | | | 3 | SS | 0 | | | |
| 225.7 | | | | | | | | |
| 4.2 | MARL - trace organics, trace shells, grey, very soft | | 4 | SS | 0 | | | |
| 224.6 | | | | | | | | |
| 5.3 | CLAY - Silty, occasional silty sand seam (5 - 50 mm thickness), grey, very soft | | 5 | TW | | | | Cu = 9.5 kPa based on Undrained Direct Shear test @ 6.4 m. |
| | | | 6 | SS | 0 | | | |
| | | | 7 | SS | 0 | | | |
| | | | 8 | SS | 1 | | | |
| 218.1 | | | | | | | | |
| 11.8 | SILT - Clayey, occasional silty sand seam, grey, very soft to firm | | 9 | SS | 0 | | | |
| | | | 10 | SS | 0 | | | |

ELEVATION SCALE: 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 215

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE; 20 40 60 80 100

PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$

WATER CONTENT (%): 20 40 60

530

128

Continued Next Page

×³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 B 05-097.GPJ ON_MOT.GDT 10/17/07

TBT Engineering

# RECORD OF Borehole No 7

2 OF 2 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+550 o/s 15 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **February 21, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 11 | SS | 6 | | 214 | | | | |
| | | | 12 | TW | | | 213 | | | | |
| 211.9 | | | | | | | 212 | | | | |
| 18.0 | SAND - Silty, occasional cobbles, red, compact to very dense | | 13 | SS | 12 | | | | | | 0 65 (35) |
| | - - - - - | | 14 | SS | 92 | | 211 | | | | |
| 209.9 | - trace gravel | | | | | | 210 | | | | |
| 20.0 | End of Borehole @ 20.0 m. | | | | | | | | | | |

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: 20 40 60 80 100

WATER CONTENT (%): 20 40 60

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

# RECORD OF Borehole No 8

1 OF 2

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+575 o/s 7 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **February 20, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 229.9 | | | | | | | | | | | |
| 0.0 | PEAT - some wood, black | | | | | | | | | | Frost to 0.8 m. |
| | | | 1 | SS | 1 | | | | | | |
| | | | 2 | SS | 4 | | | | | | |
| | | | 3 | SS | 1 | | | | | | |
| 225.0 | | | 4 | SS | 2 | | | | | | |
| 4.9 | CLAY - Silty, occasional silty sand seam (5 - 50 mm thickness), grey, very soft | | | | | | | | | | |
| | | | 5 | SS | 0 | | | | | | |
| | | | 6 | SS | 0 | | | | | | |
| | | | 7 | SS | 0 | | | | | | |
| | | | 8 | SS | 0 | | | | | | |
| 218.3 | | | | | | | | | | | |
| 11.6 | SILT - Clayey, occasional silty sand seam (5 - 50 mm thickness), grey, very soft to soft | | | | | | | | | | |
| | | | 9 | SS | 3 | | | | | | |
| | | | 10 | SS | 0 | | | | | | |
| 215.0 | | | | | | | | | | | |

Continued Next Page

× 3, ★ 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

# RECORD OF Borehole No 8

2 OF 2 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+575 o/s 7 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **February 20, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14.9 | SILT - red, very loose | | 11 | SS | 0 | | 214 | | | | 0 1 96 3 |
| 213.4 | | | | | | | | | | | |
| 16.5 | INFERRED SAND - no recovery, continued with DCPT | | 12 | SS | 0 | | 213 | | | | 3.9 m of sand blow-up @ 16.5 m. |
| 211.0 | | | | | | | 212 | | | | |
| 18.9 | End of Borehole @ 18.9 m. | | | | | | 211 | | | | |

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED × FIELD VANE ■ SPT (N) ★ LAB VANE; 20 40 60 80 100

WATER CONTENT (%): 20 40 60

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 B 05-097.GPJ ON_MOT.GDT 10/17/07

TBT Engineering

# RECORD OF Borehole No 9

1 OF 1

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+605 o/s 14 m LT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 14, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | GR SA SI CL |
| 231.5 | | | | | | | | | | | |
| 0.0 / 230.9 | SAND - some gravel, rock fragments | | 1 | SS | >99 | | 231 | | ● | | Note: Boulders noted @ surface near borehole location. |
| 0.6 | End of Borehole @ 0.6 m. Auger Refusal. | | | | | | | | | | |

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 B 05-097.GPJ ON_MOT.GDT 10/17/07

TBT Engineering

# RECORD OF Borehole No 10

1 OF 1 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+600 CL** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 12, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS |
|---|---|---|---|---|---|---|
| 229.7 | | | | | | |
| 0.0 | PEAT - black | | | | | |
| | | | 1 | SS | 3 | |
| | | | 2 | SS | 2 | |
| 225.7 | | | | | | |
| 4.0 | SILT - Clayey, grey, very soft | | | | | |
| | | | 3 | SS | 0 | |
| 223.7 | | | | | | |
| 6.0 | SAND & GRAVEL - trace silt, | | | | | |
| 223.3 | cobbles/boulders, brown | | 4 | TW | | |
| 6.4 | End of Borehole @ 6.4 m. Auger Refusal. | | | | | |

ELEVATION SCALE: 229, 228, 227, 226, 225, 224

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE
20 40 60 80 100

PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$

WATER CONTENT (%)
20 40 60

UNIT WEIGHT $\gamma$ kN/m³

408
134

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Frost to 0.8 m.

GR SA SI CL
39 53 (9)

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 B 05-097.GPJ ON_MOT.GDT 10/17/07

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# RECORD OF Borehole No 11

1 OF 1

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+630 CL** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 13, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 231.3 | | | | | | | | 20 40 60 80 100 | 20 40 60 | | |
| 231.2 / 0.0 | PEAT - 150 mm | | | | | | | | | | |
| 0.2 | FILL - SAND - some gravel, trace silt, brown, compact | | 1 | SS | 20 | | 231 | | | | Note: Boulder noted at surface near broehole location. |
| 230.2 | | | | | | | | | 131.1 | | 20 70 (10) |
| 1.2 | SAND - some gravel, trace silt, peat layer | | 2 | SS | 19 | | 230 | | | | |
| 229.4 | | | 3 | SS | 101 | | | >> | | | |
| 1.9 | End of Borehole @ 1.9 m. Auger Refusal. | | | | | | | | | | Four attempts to advance borehole deeper. |

×³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 B 05-097.GPJ ON_MOT.GDT 10/17/07

TBT Engineering

# RECORD OF Borehole No 12

1 OF 1 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+670 o/s 3 m LT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 14, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 232.5 | | | | | | | | 20 40 60 80 100 | 20 40 60 | | |
| 0.0 | SAND - Gravelly, Silty, brown | | | | | | 232 | | | | |
| 231.6 | | | SS | 1 | >99 | | | | ● | | 22 49 (29) |
| 0.9 | End of Borehole @ 0.9 m. Auger Refusal. | | | | | | | | | | Two attempts to advance borehole deeper. |

×³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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# RECORD OF Borehole No 13

1 OF 1 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+630 o/s 15 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 3, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), × FIELD VANE, ★ LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 229.6 | | | | | | | | 20 40 60 80 100 | 20 40 60 | | |
| 0.0 | PEAT - black | | | | | | 229 | | | | Frost to 0.8 m. |
| 228.0 | | | | | | | | | | | |
| 227.8 | SILT - grey | | 1 | SS | 12 | | 228 | | | | |
| 1.8 | SAND - Silty, Gravelly, cobbles, brown, dense | | 2 | SS | 47 | | | | | | 23 50 (27) |
| 226.7 | | | 3 | SS | >99 | | 227 | | | | |
| 2.9 | End of Borehole @ 2.9 m. Auger Refusal. | | | | | | | | | | |

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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# RECORD OF DCPT No 101

1 OF 2

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+450 o/s 29.2 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 7, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT | UNIT WEIGHT | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| 227.2 | | | | | | | | 20 40 60 80 100 | | $\gamma$ kN/m$^3$ | GR SA SI CL |
| 0.0 | NO SAMPLING - Dynamic Cone Penetration Test Only | | | | | | 227 | ○ UNCONFINED ✕ FIELD VANE ■ SPT (N) ★ LAB VANE | $w_P$ $w$ $w_L$ WATER CONTENT (%) 20 40 60 | | |
| | | | | | | | 226 | | | | |
| | | | | | | | 225 | | | | |
| | | | | | | | 224 | | | | |
| | | | | | | | 223 | | | | |
| | | | | | | | 222 | | | | |
| | | | | | | | 221 | | | | |
| | | | | | | | 220 | | | | |
| | | | | | | | 219 | | | | |
| | | | | | | | 218 | | | | |
| | | | | | | | 217 | | | | |
| | | | | | | | 216 | | | | |
| | | | | | | | 215 | | | | |
| | | | | | | | 214 | | | | |
| | | | | | | | 213 | | | | |

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✕$^3$, ★$^3$: Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

TBT Engineering

# RECORD OF DCPT No 101

2 OF 2 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+450 o/s 29.2 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 7, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT<br>SHEAR STRENGTH kPa<br>○ UNCONFINED ✕ FIELD VANE<br>■ SPT (N) ★ LAB VANE | PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT<br>WATER CONTENT (%) | UNIT WEIGHT | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| | | | | | | | | 20 40 60 80 100 | 20 40 60 | | GR SA SI CL |
| | | | | | | | 212 | | | | |
| | | | | | | | 211 | | | | |
| | | | | | | | 210 | | | | |
| | | | | | | | 209 | | | | |
| | | | | | | | 208 | | | | |
| | | | | | | | 207 | | | | |
| 205.9 | | | | | | | 206 | | | | |
| 21.3 | End of DCPT @ 21.3 m. | | | | | | | | | | |

✕[3], ★[3]: Numbers refer to Sensitivity ○[3%] STRAIN AT FAILURE

TBT Engineering

# RECORD OF DCPT No 102

1 OF 2

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+500 o/s 43.649 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 7, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | 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 | $w_P$ $w$ $w_L$ | $\gamma$ | GR SA SI CL |
| 226.6 | | | | | | | | ○ UNCONFINED ✕ FIELD VANE ■ SPT (N) ★ LAB VANE | WATER CONTENT (%) 20 40 60 | kN/m³ | |
| 0.0 | NO SAMPLING - Dynamic Cone Penetration Test Only | | | | | | 226 225 224 223 222 221 220 219 218 217 216 215 214 213 212 | | | | |

Continued Next Page

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

# RECORD OF DCPT No 102

2 OF 2 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+500 o/s 43.649 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 7, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| 204.6 / 22.0 | End of DCPT @ 22.0 m. Refusal to DCPT. | | | | | | 211, 210, 209, 208, 207, 206, 205 | | | | |

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

# RECORD OF DCPT No 103

1 OF 2

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+500 o/s 14.611 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 8, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT | UNIT WEIGHT | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| 229.9 | | | | | | | | 20 40 60 80 100 | | $\gamma$ kN/m$^3$ | GR SA SI CL |
| 0.0 | NO SAMPLING - Dynamic Cone Penetration Test Only | | | | | | 229 | ○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE | $w_P$ $w$ $w_L$ WATER CONTENT (%) 20 40 60 | | |
| | | | | | | | 228 | | | | |
| | | | | | | | 227 | | | | |
| | | | | | | | 226 | | | | |
| | | | | | | | 225 | | | | |
| | | | | | | | 224 | | | | |
| | | | | | | | 223 | | | | |
| | | | | | | | 222 | | | | |
| | | | | | | | 221 | | | | |
| | | | | | | | 220 | | | | |
| | | | | | | | 219 | | | | |
| | | | | | | | 218 | | | | |
| | | | | | | | 217 | | | | |
| | | | | | | | 216 | | | | |
| | | | | | | | 215 | | | | |

Continued Next Page

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

# RECORD OF DCPT No 103

2 OF 2 **METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+500 o/s 14.611 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 8, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | 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 | $w_P$ $w$ $w_L$ | $\gamma$ kN/m³ | GR SA SI CL |
| | | | | | | | | ○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE | WATER CONTENT (%) 20 40 60 | | |
| | | | | | | | 214 | | | | |
| | | | | | | | 213 | | | | |
| | | | | | | | 212 | | | | |
| | | | | | | | 211 | | | | |
| | | | | | | | 210 | | | | |
| 209.4 | | | | | | | | | | | |
| 20.5 | End of DCPT Testing @ 20.5 m. Refusal to DCPT. | | | | | | | | | | |

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

# RECORD OF DCPT No 104

1 OF 1

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+600 o/s 15.0 m RT** TBTE JOB# **05-097** COMPILED BY **TB**

DATE **March 12, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT | UNIT WEIGHT | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | ○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE | $w_P$ w $w_L$ WATER CONTENT (%) | $\gamma$ kN/m³ | GR SA SI CL |
| 229.9 | | | | | | | | 20 40 60 80 100 | 20 40 60 | | |
| 0.0 | NO SAMPLING - Dynamic Cone Penetration Test Only | | | | | | 229 | | | | |
| | | | | | | | 228 | | | | |
| | | | | | | | 227 | | | | |
| | | | | | | | 226 | | | | |
| | | | | | | | 225 | | | | |
| | | | | | | | 224 | | | | |
| | | | | | | | 223 | | | | |
| | | | | | | | 222 | | | | |
| | | | | | | | 221 | | | | |
| | | | | | | | 220 | | | | |
| | | | | | | | 219 | | | | |
| | | | | | | | 218 | | | | |
| | | | | | | | 217 | | | | |
| 216.5 | | | | | | | | | | | |
| 13.4 | End of DCPT @ 13.4 m. | | | | | | | | | | |

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MOT_DCPT 05-097.GPJ ON_MOT.GDT 10/17/07

TBT Engineering

# RECORD OF DCPT No 105

1 OF 1

**METRIC**

W.P. **414-01-00** PROJECT **Pearl Alignment Revision** SITE NO. ORIGINATED BY **DV**

DIST **61** HWY **11/17** LOCATION **23+630 o/s 14 m LT** TBTE JOB# **05-097** COMPILED BY **TB**

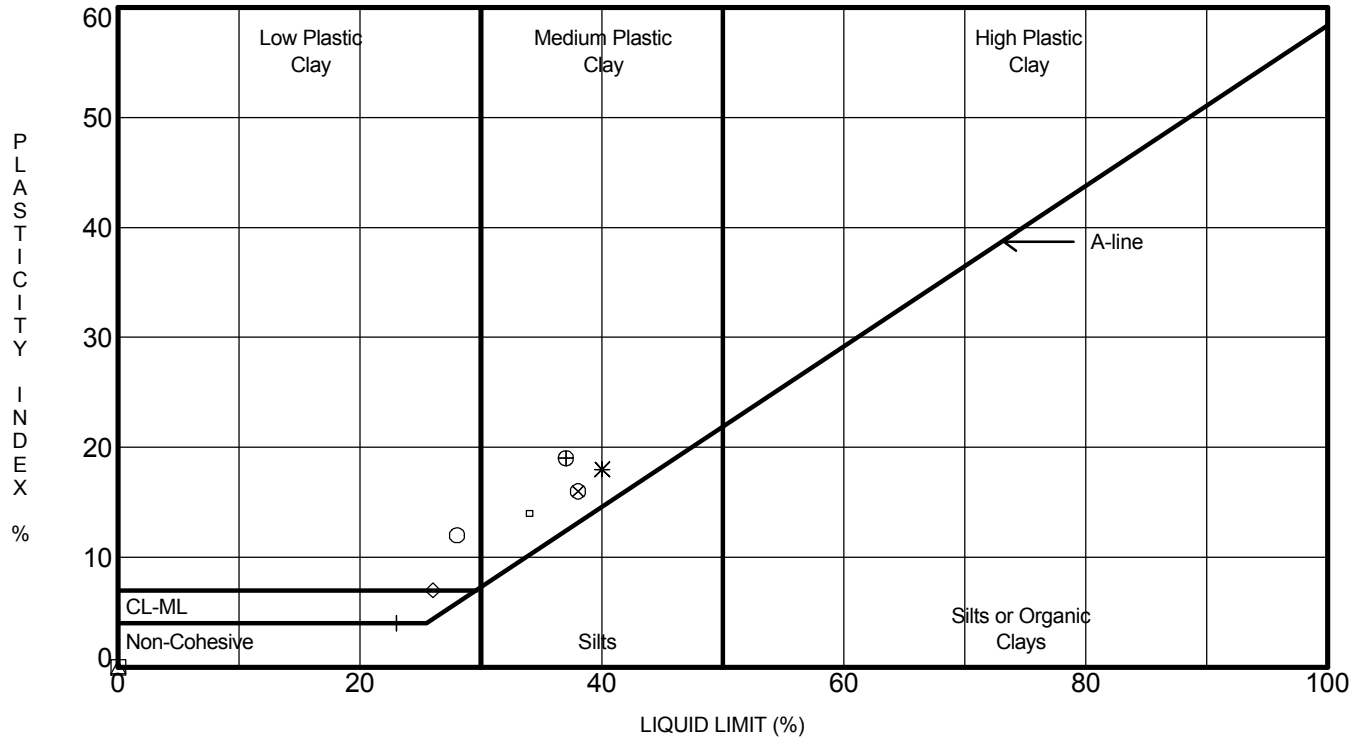
DATE **March 14, 2007** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **WH**

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ■ SPT (N) × FIELD VANE ★ LAB VANE) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | GR SA SI CL |
| 232.7 | | | | | | | | | | | |
| 0.0 / 232.3 | NO SAMPLING - Dynamic Cone Penetration Test Only | | | | | | | | | | |
| 0.4 | End of DCPT @ 0.4 m. Refusal to DCPT. | | | | | | 232 | | | | |

$\times^3$, $\star^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# APPENDIX B

# Laboratory Test Data




| | Borehole No. | Sample No. | Depth (m) | LL% | PL% | PI% | M/C% |
|---|---|---|---|---|---|---|---|
| □ | **1** | | **3.00** | **NP** | **NP** | **NP** | **113** |
| ✳ | **1** | | **7.00** | **40** | **22** | **18** | **67** |
| × | **2** | | **6.70** | **40** | **22** | **18** | **58** |
| + | **2** | | **13.70** | **23** | **19** | **4** | **41** |
| ◇ | **2** | | **15.20** | **26** | **19** | **7** | **35** |
| △ | **2** | | **16.80** | **NP** | **NP** | **NP** | **23** |
| ○ | **4** | | **9.40** | **28** | **16** | **12** | **38** |
| ▫ | **6** | | **6.40** | **34** | **20** | **14** | **53** |
| ⊗ | **6** | | **13.40** | **38** | **22** | **16** | **32** |
| ⊕ | **7** | | **6.40** | **37** | **18** | **19** | **54** |

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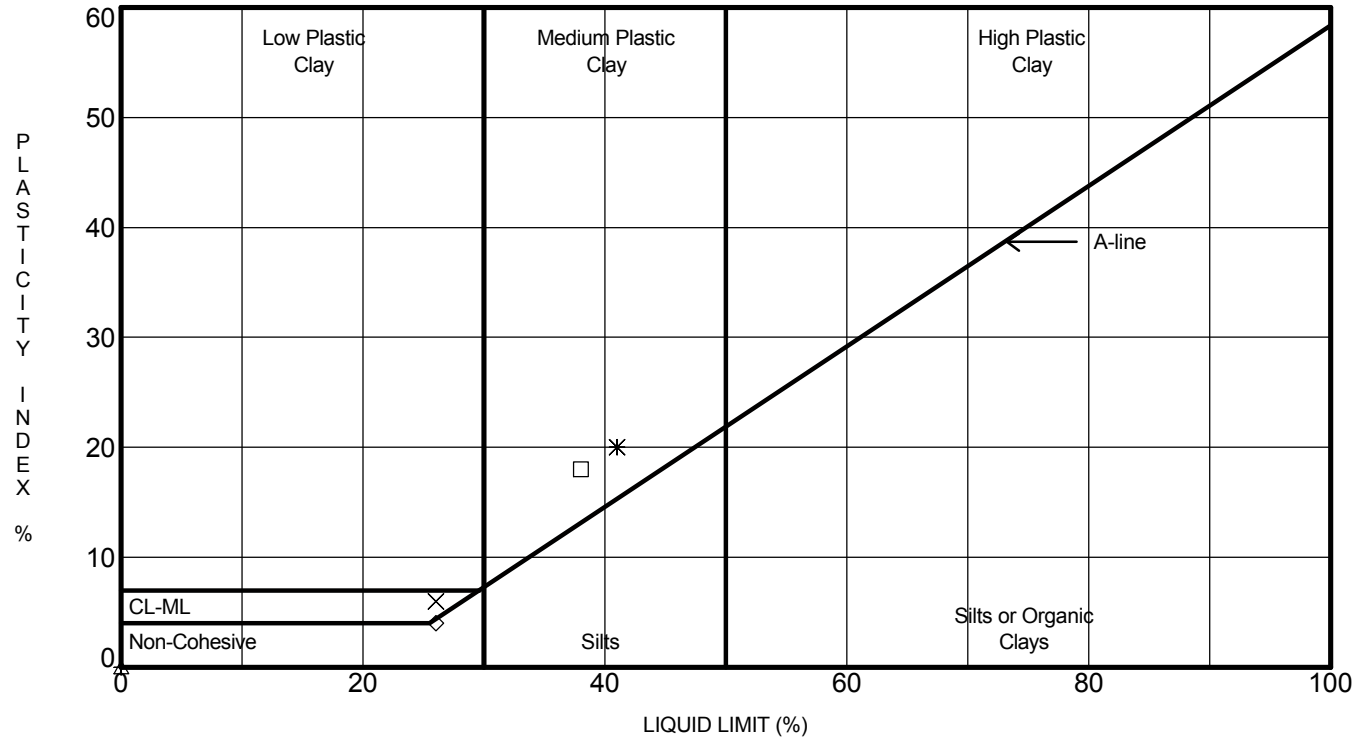
Thunder Bay, Ontario P7C 3V4
Telephone: 807-624-5160
Fax: 807-624-5161

# ATTERBERG LIMIT RESULTS

W P: 414-01-00

District: 61

Highway: 11/17




| | Borehole No. | Sample No. | Depth (m) | LL% | PL% | PI% | M/C% |
|---|---|---|---|---|---|---|---|
| □ | **8** | | **6.10** | **38** | **20** | **18** | **44** |
| ✳ | **8** | | **9.10** | **41** | **21** | **20** | **48** |
| × | **8** | | **12.20** | **26** | **20** | **6** | **35** |
| + | **8** | | **15.20** | **NP** | **NP** | **NP** | **26** |
| ◇ | **10** | | **4.60** | **26** | **22** | **4** | **60** |
| △ | **13** | | **1.60** | **NP** | **NP** | **NP** | **58** |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

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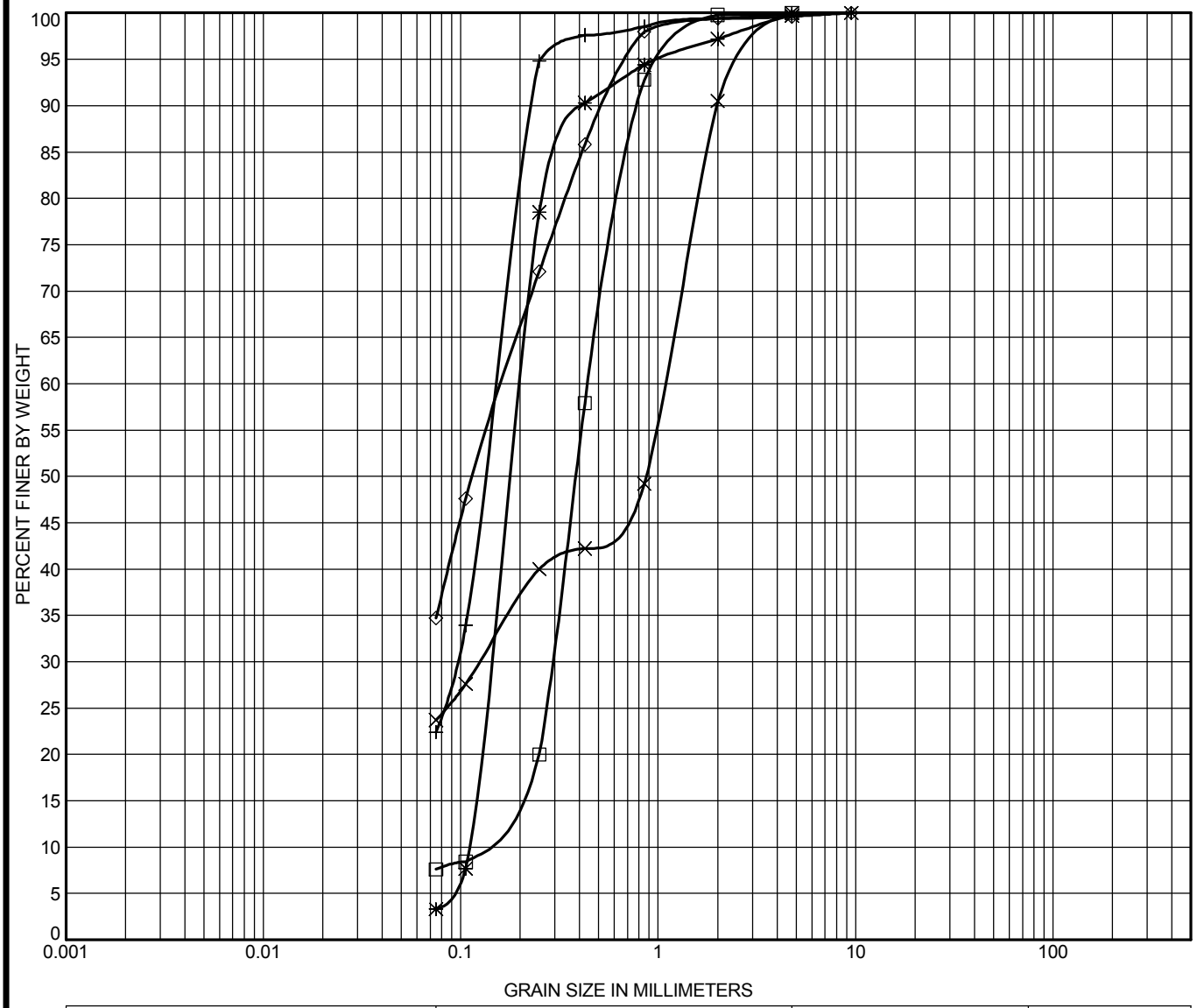
Fax: 807-624-5161

# ATTERBERG LIMIT RESULTS

W P: 414-01-00

District: 61

Highway: 11/17




| SILT OR CLAY | SAND | | | GRAVEL | | COBBLES |
|---|---|---|---|---|---|---|
| | fine | medium | coarse | fine | coarse | |

Remarks:

| | Test Hole | Depth | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| □ | **2** | **18.30** | **4.75** | **0.443** | **0.288** | **0.119** | **0.0** | **92.4** | **7.6** | |
| ✳ | **4** | **4.60** | **9.5** | **0.2** | **0.139** | **0.109** | **0.3** | **96.4** | **3.3** | |
| × | **4** | **9.10** | **4.75** | **1.063** | **0.125** | | **0.0** | **76.3** | **23.7** | |
| + | **6** | **7.30** | **4.75** | **0.153** | **0.094** | | **0.0** | **77.6** | **22.4** | |
| ◇ | **7** | **18.30** | **9.5** | **0.164** | | | **0.4** | **64.9** | **34.7** | |

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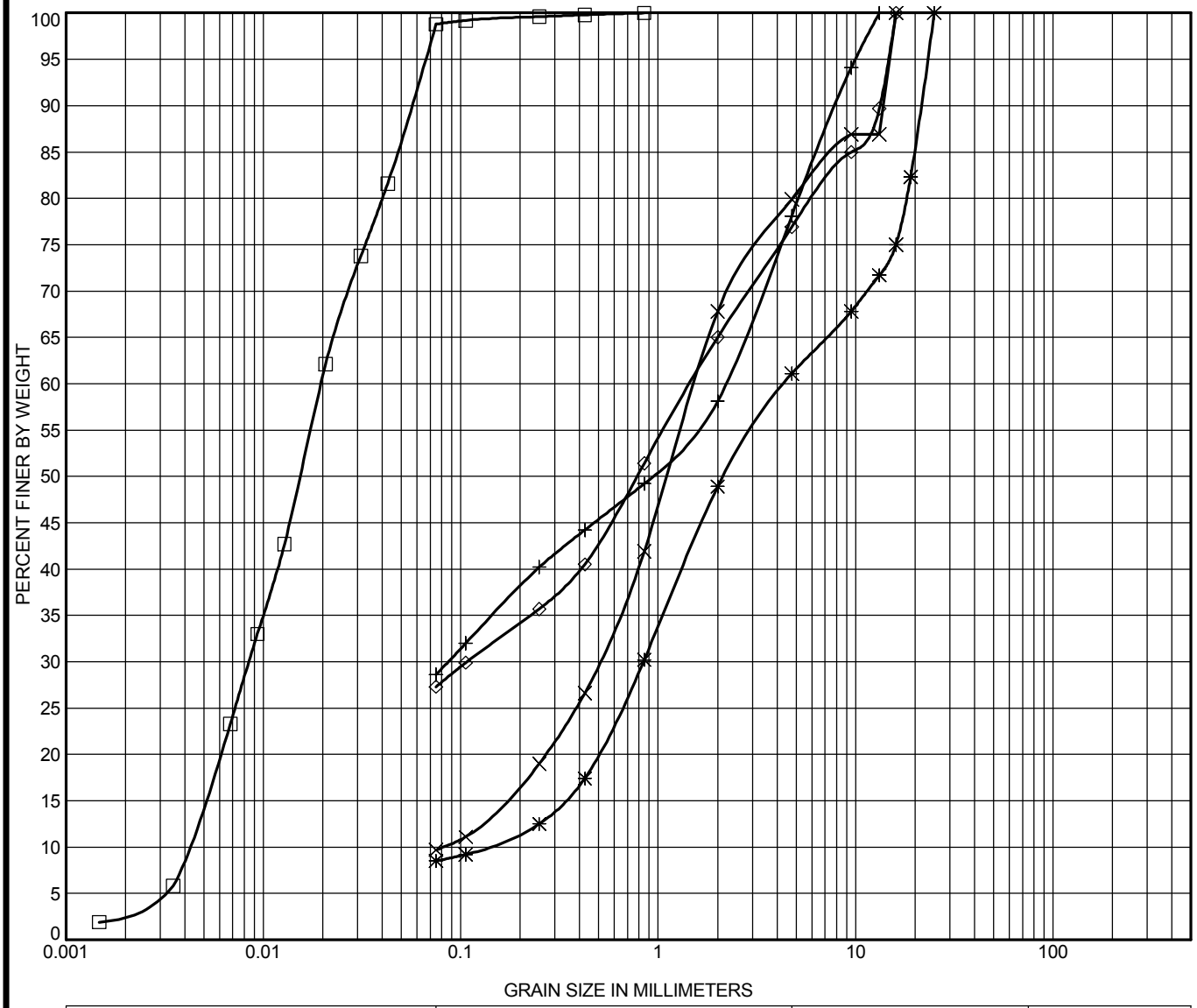
## GRAIN SIZE DISTRIBUTION

Project: Pearl Alignment Revision

W P: 414-01-00

DIST: 61 HWY: 11/17




| SILT OR CLAY | SAND | | | GRAVEL | | COBBLES |
|---|---|---|---|---|---|---|
| | fine | medium | coarse | fine | coarse | |

Remarks:

| | Test Hole | Depth | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| □ | **8** | **15.20** | **0.85** | **0.02** | **0.008** | **0.004** | **0.0** | **1.2** | **98.8** | |
| ✳ | **10** | **6.10** | **25** | **4.394** | **0.841** | **0.131** | **38.9** | **52.6** | **8.5** | |
| × | **11** | **0.90** | **16** | **1.546** | **0.496** | **0.081** | **20.1** | **70.2** | **9.7** | |
| + | **12** | **0.75** | **13.2** | **2.171** | **0.086** | | **21.9** | **49.5** | **28.6** | |
| ◇ | **13** | **2.40** | **16** | **1.46** | **0.108** | | **23.1** | **49.6** | **27.3** | |

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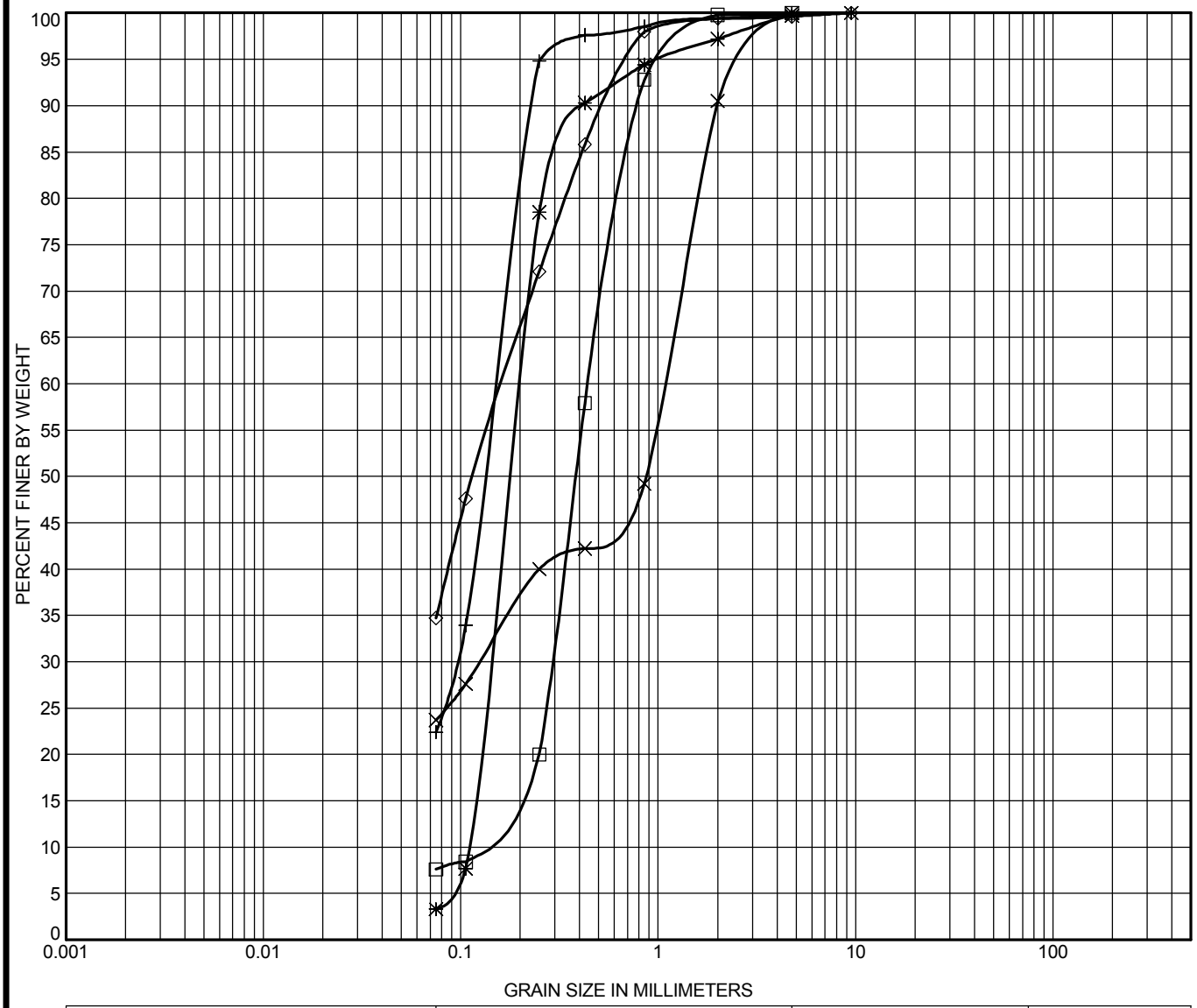
# GRAIN SIZE DISTRIBUTION

Project: Pearl Alignment Revision

W P: 414-01-00

DIST: 61 HWY: 11/17




| SILT OR CLAY | SAND | | | GRAVEL | | COBBLES |
|---|---|---|---|---|---|---|
| | fine | medium | coarse | fine | coarse | |

Remarks:

| | Test Hole | Depth | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| □ | **2** | **18.30** | **4.75** | **0.443** | **0.288** | **0.119** | **0.0** | **92.4** | **7.6** | |
| ✳ | **4** | **4.60** | **9.5** | **0.2** | **0.139** | **0.109** | **0.3** | **96.4** | **3.3** | |
| × | **4** | **9.10** | **4.75** | **1.063** | **0.125** | | **0.0** | **76.3** | **23.7** | |
| + | **6** | **7.30** | **4.75** | **0.153** | **0.094** | | **0.0** | **77.6** | **22.4** | |
| ◇ | **7** | **18.30** | **9.5** | **0.164** | | | **0.4** | **64.9** | **34.7** | |

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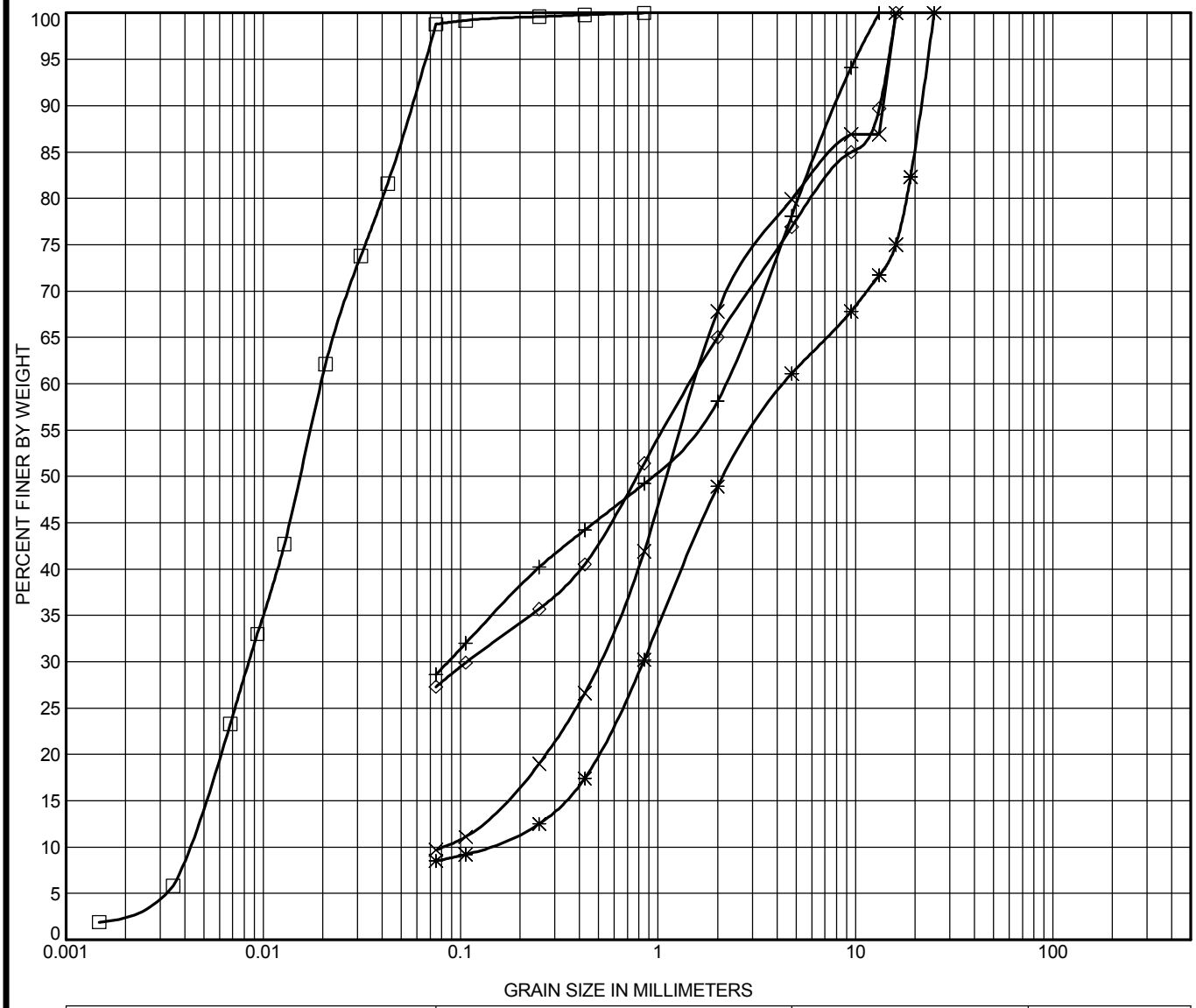
## GRAIN SIZE DISTRIBUTION

Project: Pearl Alignment Revision

W P: 414-01-00

DIST: 61 HWY: 11/17




| SILT OR CLAY | SAND | | | GRAVEL | | COBBLES |
|---|---|---|---|---|---|---|
| | fine | medium | coarse | fine | coarse | |

Remarks:

| | Test Hole | Depth | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| □ | **8** | **15.20** | **0.85** | **0.02** | **0.008** | **0.004** | **0.0** | **1.2** | **98.8** | |
| ✳ | **10** | **6.10** | **25** | **4.394** | **0.841** | **0.131** | **38.9** | **52.6** | **8.5** | |
| × | **11** | **0.90** | **16** | **1.546** | **0.496** | **0.081** | **20.1** | **70.2** | **9.7** | |
| + | **12** | **0.75** | **13.2** | **2.171** | **0.086** | | **21.9** | **49.5** | **28.6** | |
| ◇ | **13** | **2.40** | **16** | **1.46** | **0.108** | | **23.1** | **49.6** | **27.3** | |

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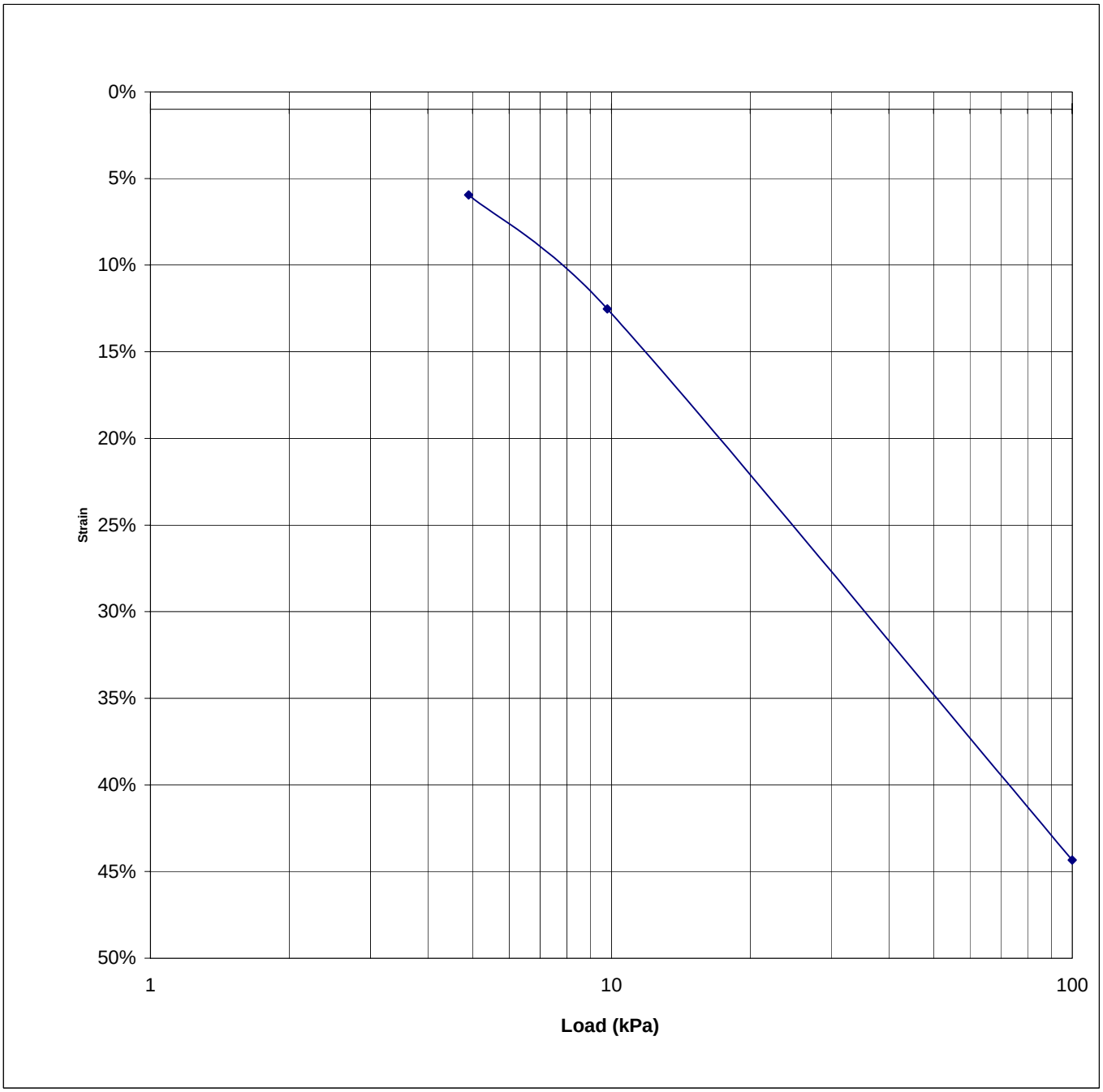
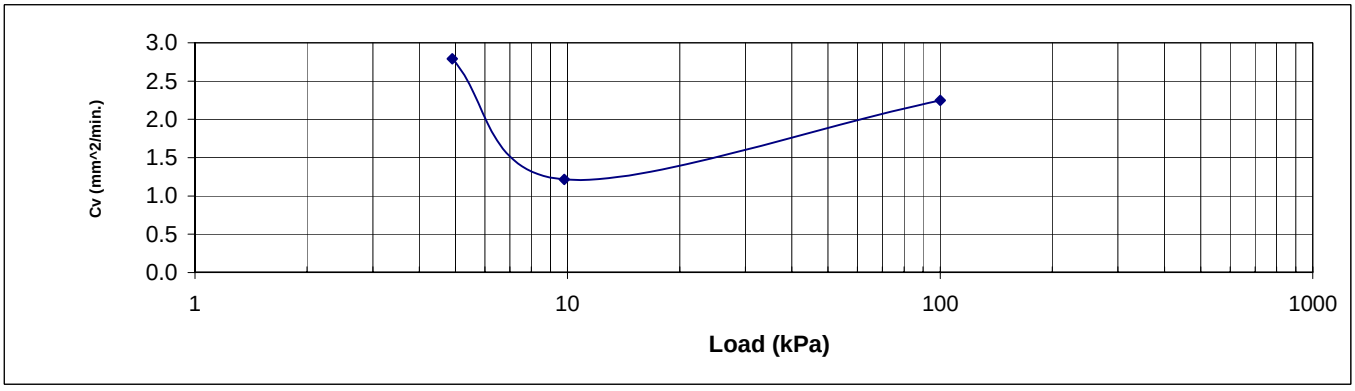
# GRAIN SIZE DISTRIBUTION

Project: Pearl Alignment Revision

W P: 414-01-00

DIST: 61 HWY: 11/17



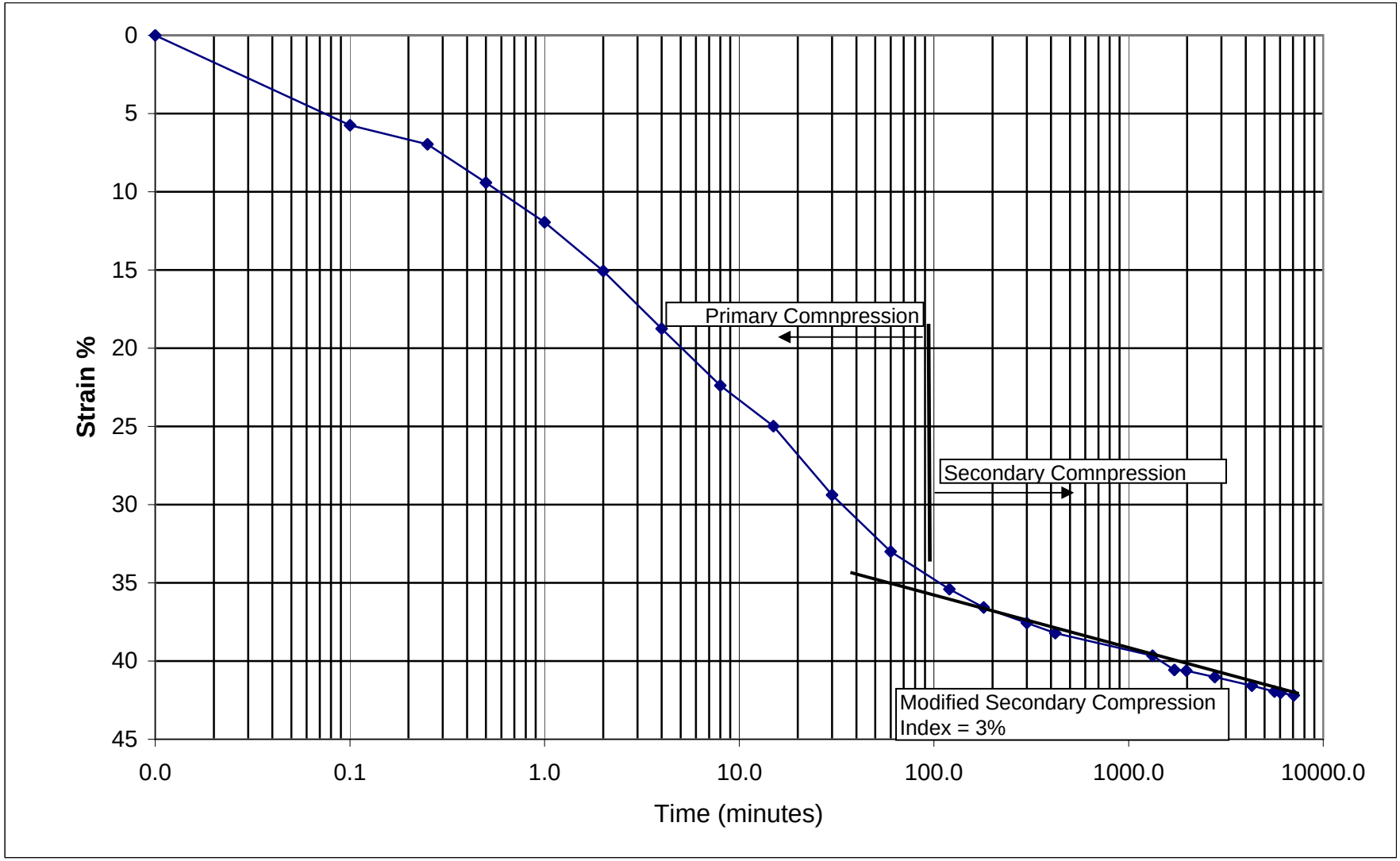




**CONSOLIDATION TEST**
**PEAT SAMPLE**

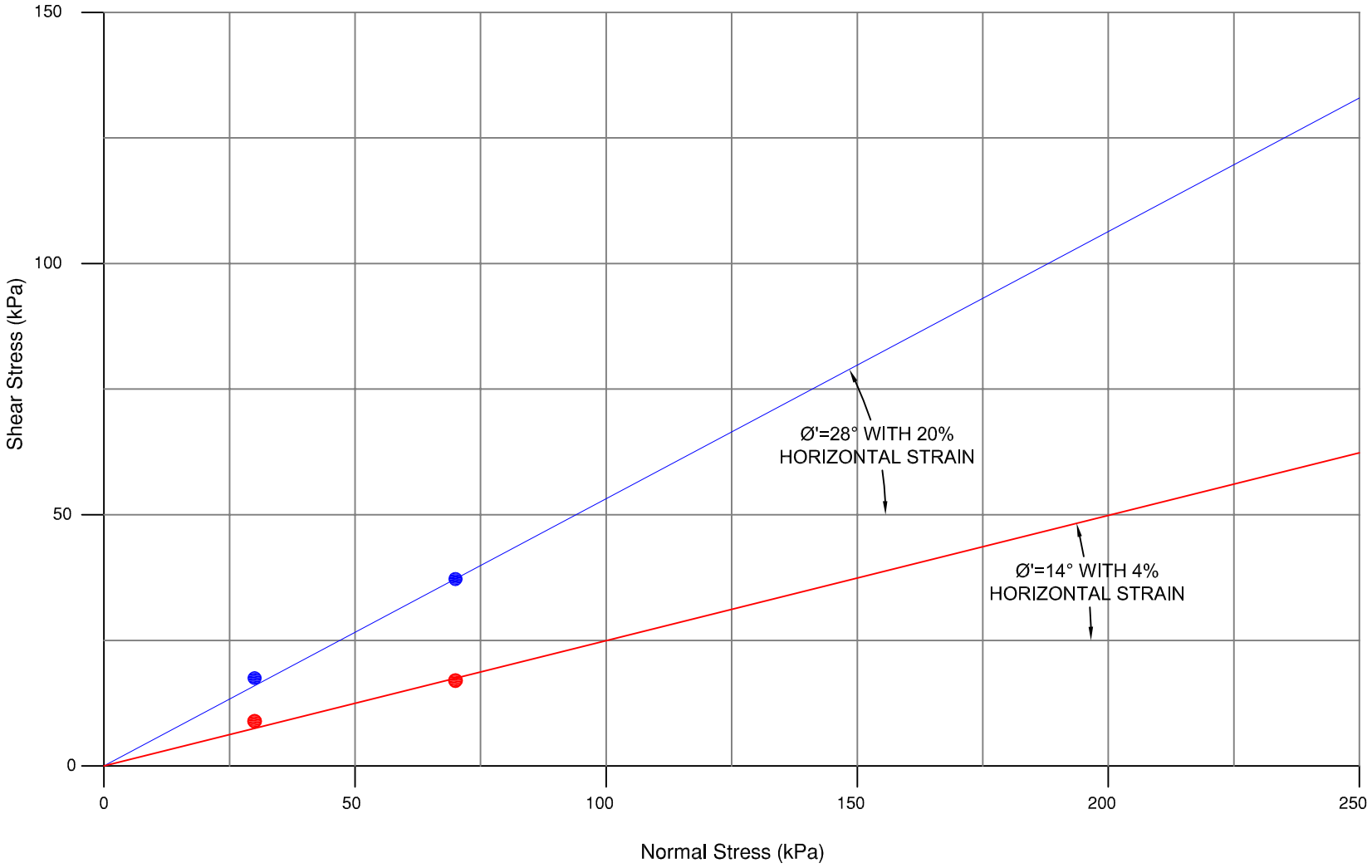
Project No.: 05-097

Borehole 4 Depth: 3.1 m Lab No.: 07-231

**Single Stage Consolidation Test - PEAT**
**Borehole 4, Depth 3.1 m**
**Stress Increment from 10 kPa to 100 kPa.**



# CONSOLIDATED/DRAINED
# DIRECT SHEAR TESTING

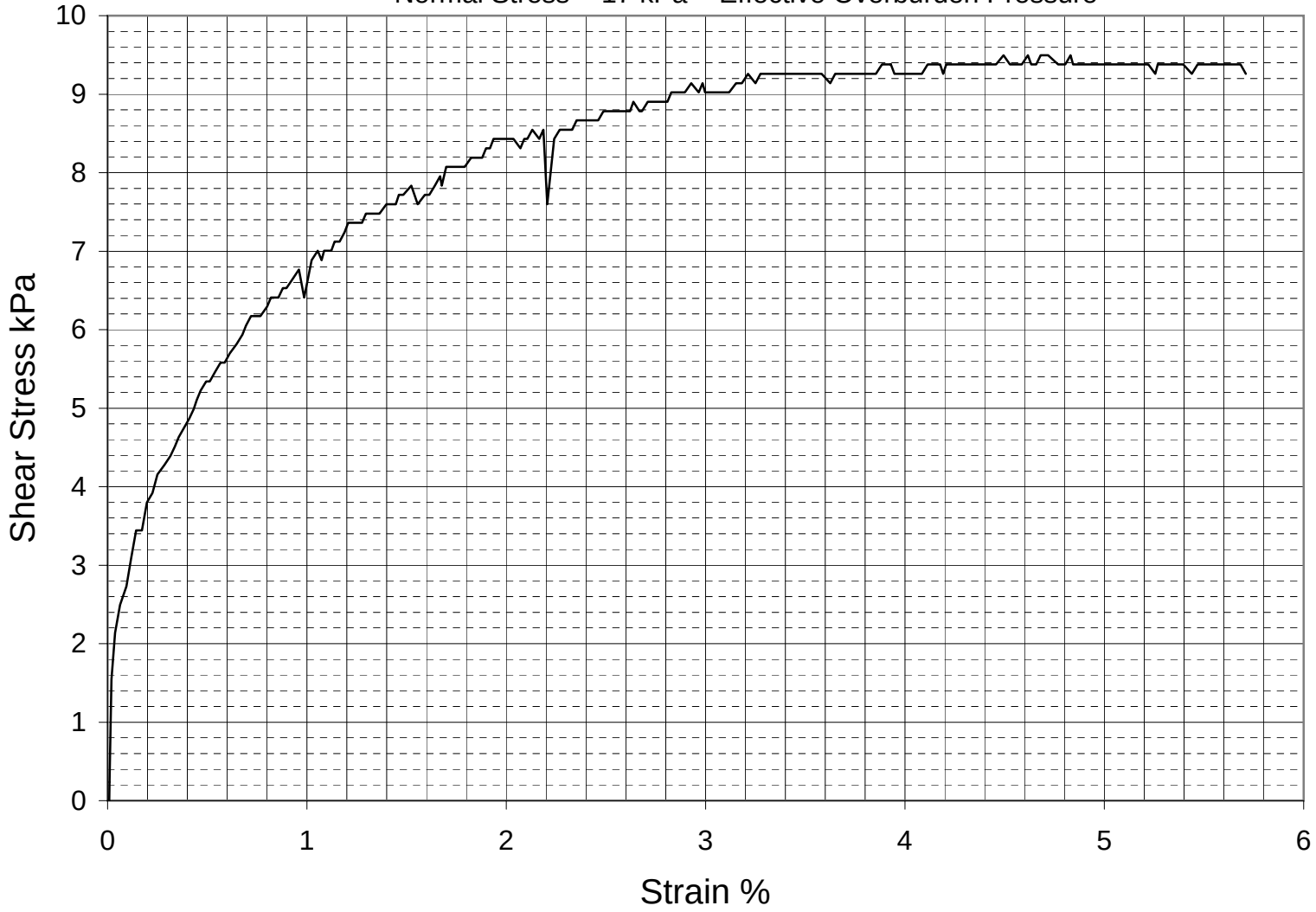



BH 4 @ 3.1 m - PEAT

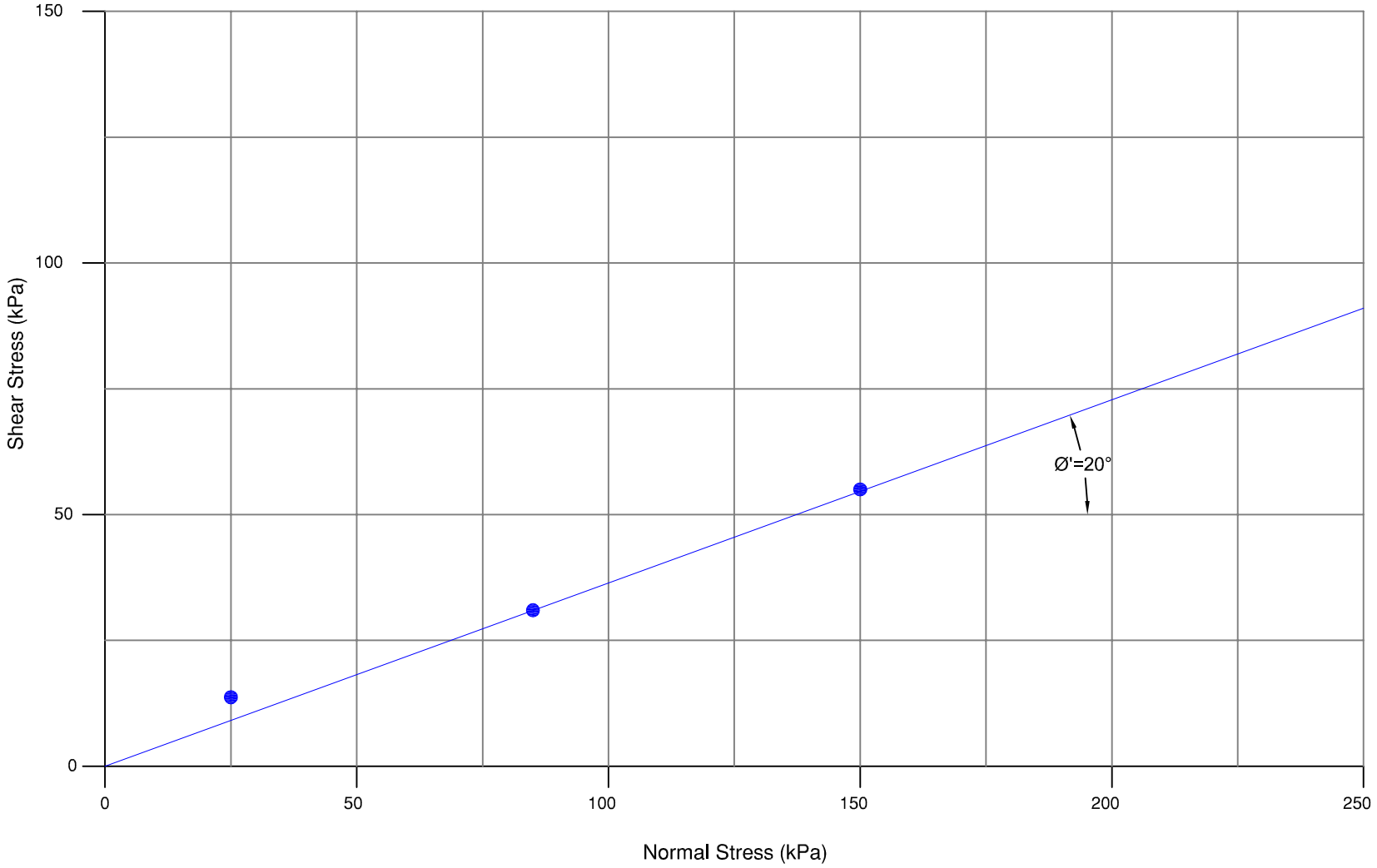
TBT ENGINEERING

PEARL LAKE
ALIGNMENT No. 2
REFERENCE No: 05-097

CONSOLIDATED UNDRAINED DIRECT SHEAR TEST
BH 7 AT 6.4 m - CLAY
Normal Stress = 17 kPa = Effective Overburden Pressure



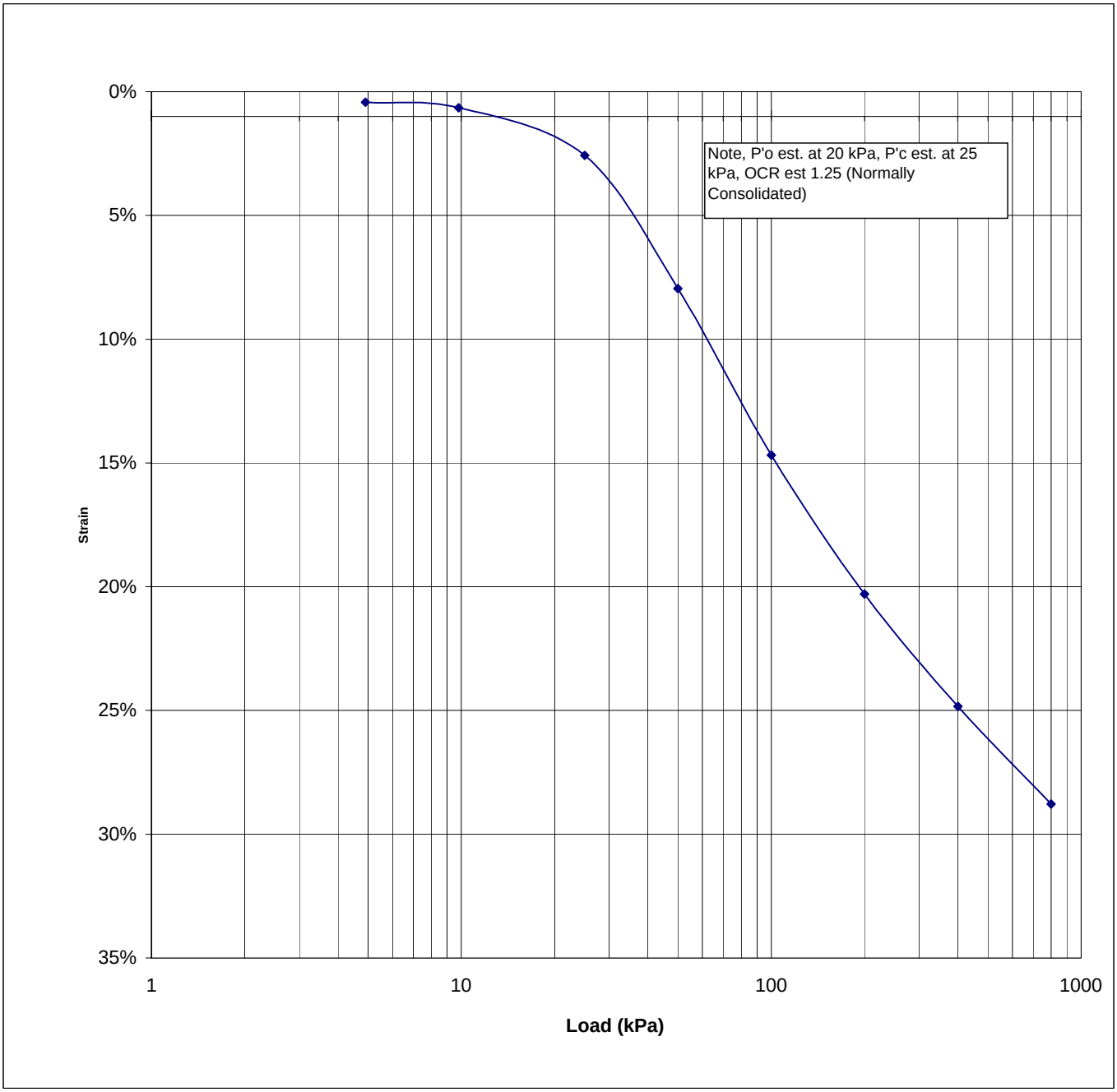
# CONSOLIDATED/DRAINED
# DIRECT SHEAR TESTING

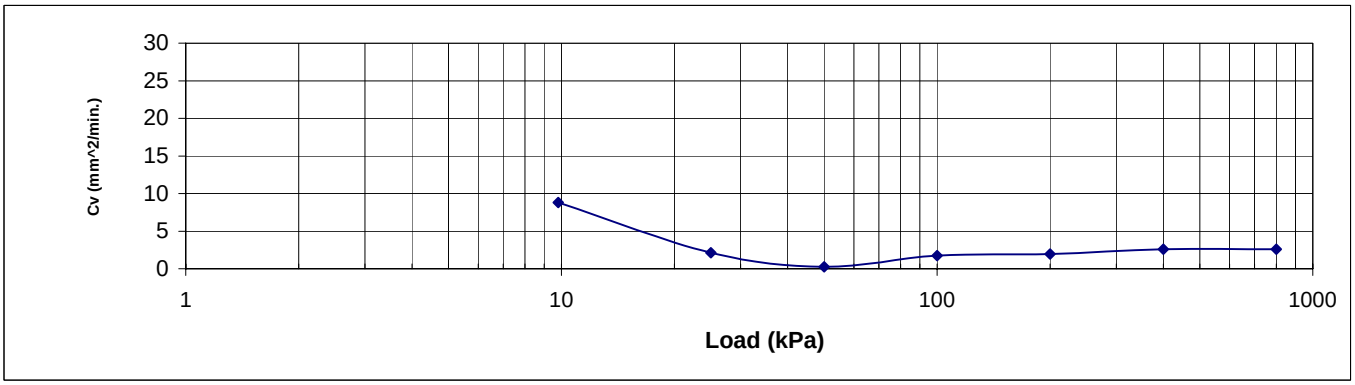



BH 7 @ 6.4 m CLAY

**TBT ENGINEERING**

PEARL LAKE
**ALIGNMENT No. 2**
**REFERENCE No: 05-097**




**CONSOLIDATION TEST**
**Pearl - Clay**

Borehole 7 Depth: 6.4 m Lab No.: 07-110

Project No.: 05-097

# APPENDIX C

Stability Analyses
Finite Element Analyses

# OPTION 1

Title: Cut from toe at 4:1 and remove peat
Comments: Drained Analysis
Name: Excavation DN Removal of Lane.gsz
Analysis Kind: SLOPE
Method: Morgenstern-Price

Material #: 1
Description: Rock Fill
Model: MohrCoulomb
Wt: 18
Cohesion: 0
Phi: 45
Piezometric Line: 1

Material #: 2
Description: Sand and Gravel
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 35
Piezometric Line: 0

Material #: 3
Description: Peat
Model: MohrCoulomb
Wt: 11
Cohesion: 0
Phi: 28
Piezometric Line: 1

Material #: 4
Description: Clay
Model: MohrCoulomb
Wt: 18
Cohesion: 0
Phi: 20
Piezometric Line: 1

Material #: 5
Description: Water
Model: NoStrength
Wt: 9.807
Piezometric Line: 0

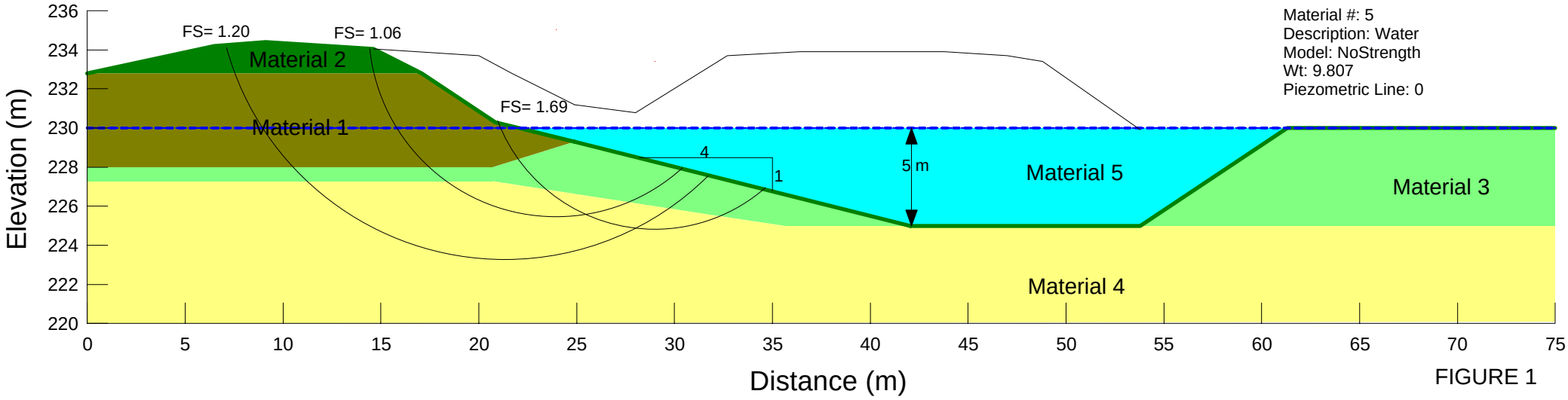
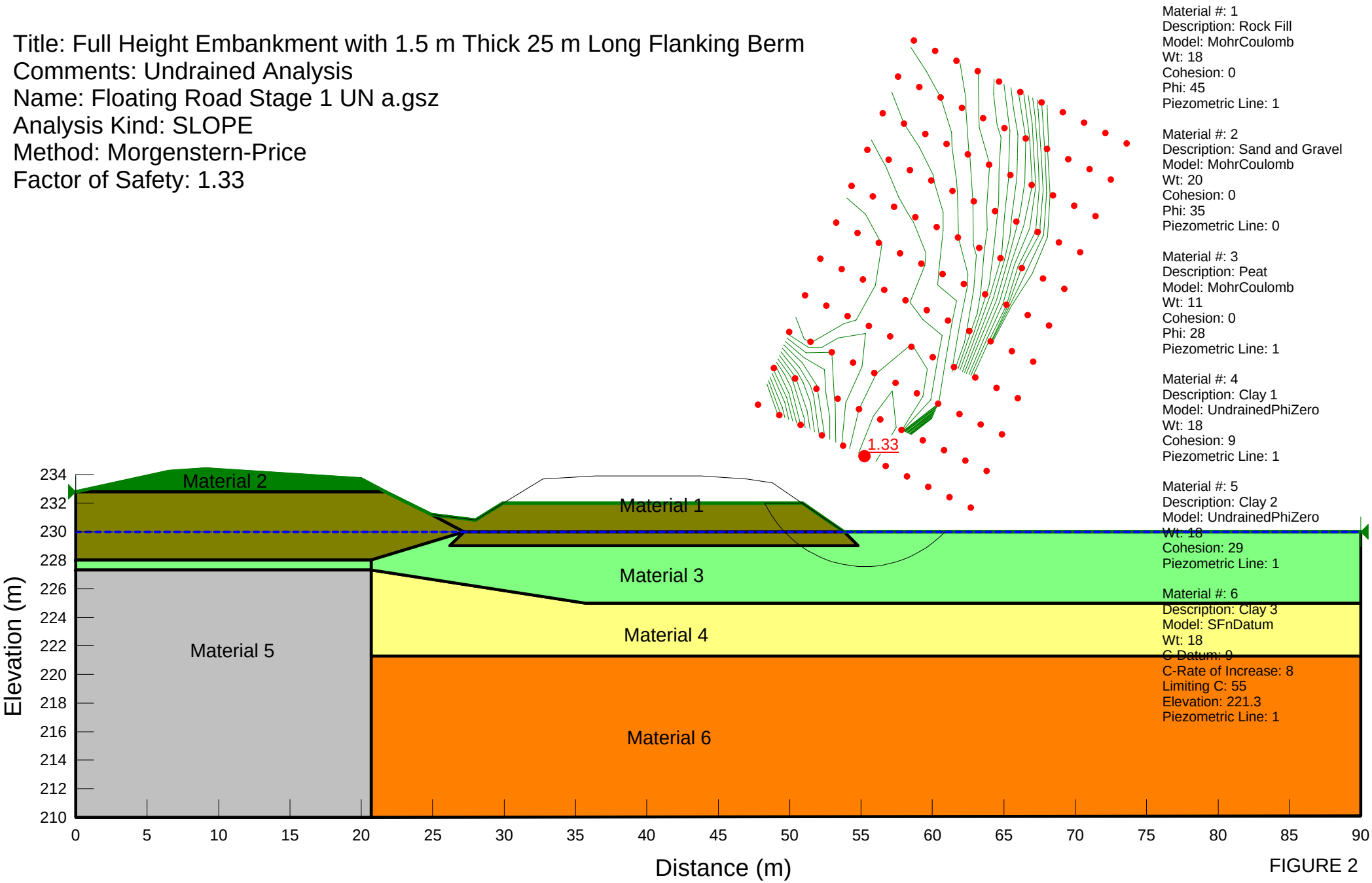



FIGURE 1

# OPTION 3

Title: Full Height Embankment with 1.5 m Thick 25 m Long Flanking Berm
Comments: Undrained Analysis
Name: Floating Road Stage 1 UN a.gsz
Analysis Kind: SLOPE
Method: Morgenstern-Price
Factor of Safety: 1.33




Material #: 1
Description: Rock Fill
Model: MohrCoulomb
Wt: 18
Cohesion: 0
Phi: 45
Piezometric Line: 1

Material #: 2
Description: Sand and Gravel
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 35
Piezometric Line: 0

Material #: 3
Description: Peat
Model: MohrCoulomb
Wt: 11
Cohesion: 0
Phi: 28
Piezometric Line: 1

Material #: 4
Description: Clay 1
Model: UndrainedPhiZero
Wt: 18
Cohesion: 9
Piezometric Line: 1

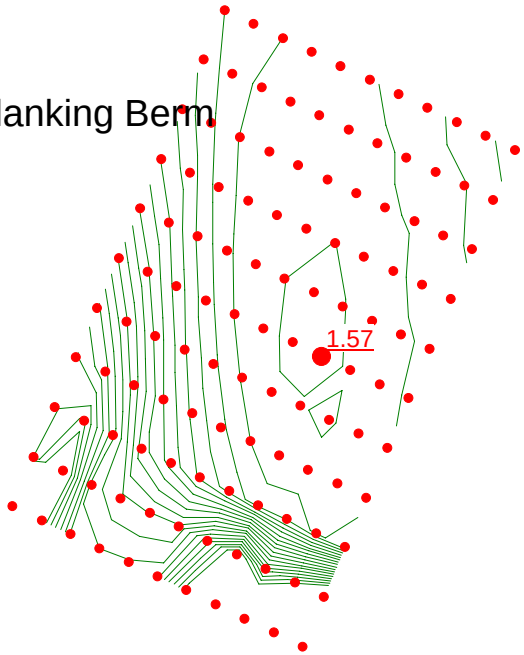
Material #: 5
Description: Clay 2
Model: UndrainedPhiZero
Wt: 18
Cohesion: 29
Piezometric Line: 1

Material #: 6
Description: Clay 3
Model: SFnDatum
Wt: 18
C-Datum: 9
C-Rate of Increase: 8
Limiting C: 55
Elevation: 221.3
Piezometric Line: 1

FIGURE 2

# OPTION 3

Title: Full Height Embankment with 1.5 m Thick 25 m Long Flanking Berm
Comments: Undrained Analysis
Name: Floating Road Stage 2 UN a.gsz
Analysis Kind: SLOPE
Method: Morgenstern-Price
Factor of Safety: 1.57




Material #: 1
Description: Rock Fill
Model: MohrCoulomb
Wt: 18
Cohesion: 0
Phi: 45
Piezometric Line: 1

Material #: 2
Description: Sand and Gravel
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 35
Piezometric Line: 0

Material #: 3
Description: Peat
Model: MohrCoulomb
Wt: 11
Cohesion: 0
Phi: 28
Piezometric Line: 1

Material #: 4
Description: Clay 1
Model: UndrainedPhiZero
Wt: 18
Cohesion: 9
Piezometric Line: 1

Material #: 5
Description: Clay 2
Model: UndrainedPhiZero
Wt: 18
Cohesion: 29
Piezometric Line: 1

Material #: 6
Description: Clay 3
Model: SFnDatum
Wt: 18
C-Datum: 9
C-Rate of Increase: 8
Limiting C: 55
Elevation: 221.3
Piezometric Line: 1

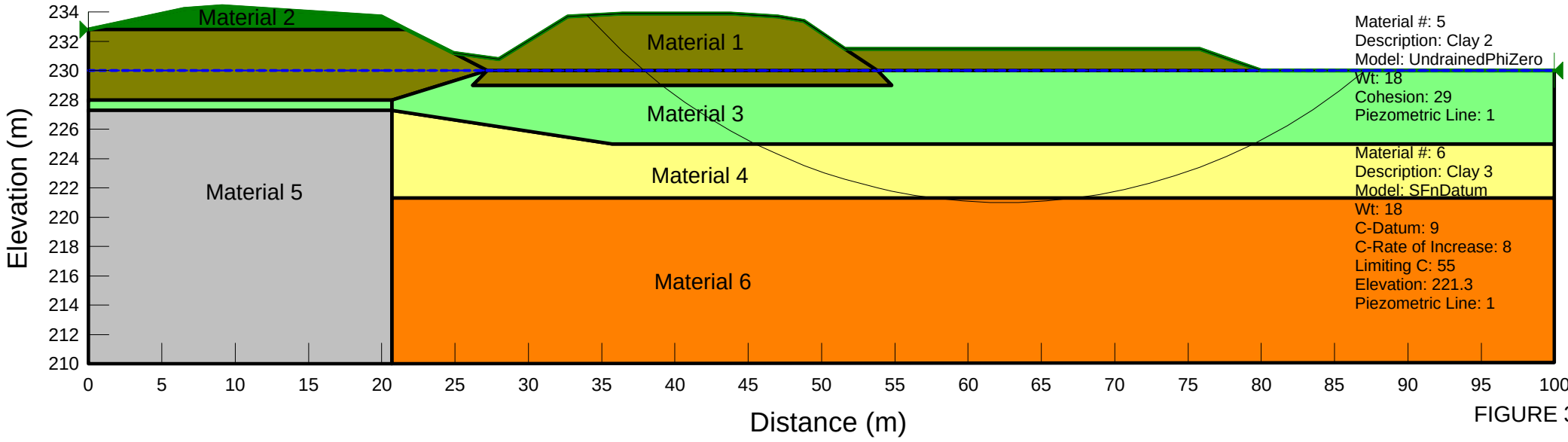



FIGURE 3

# OPTION 3

ASSESSMENT OF PRIMARY CONSOLIDATION
- does not include effects of secondary consolidation
- grade of proposed embankment has been maintained

Comments: Drained Analysis
Adjust Fill: true

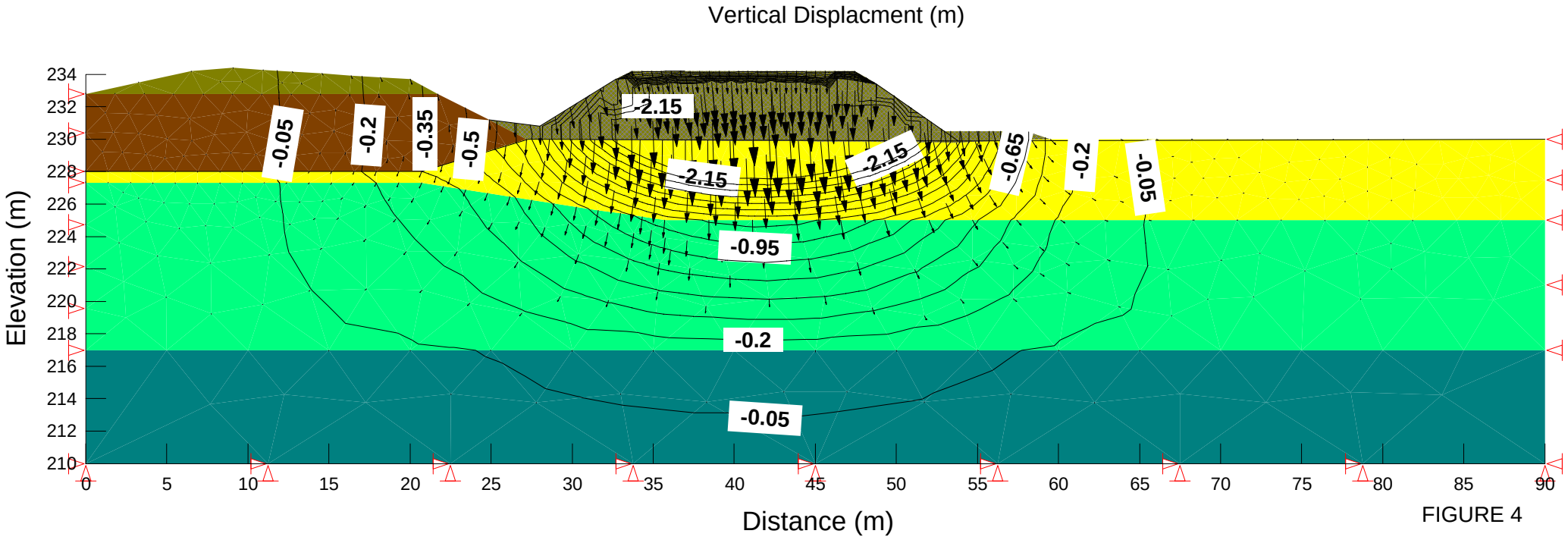
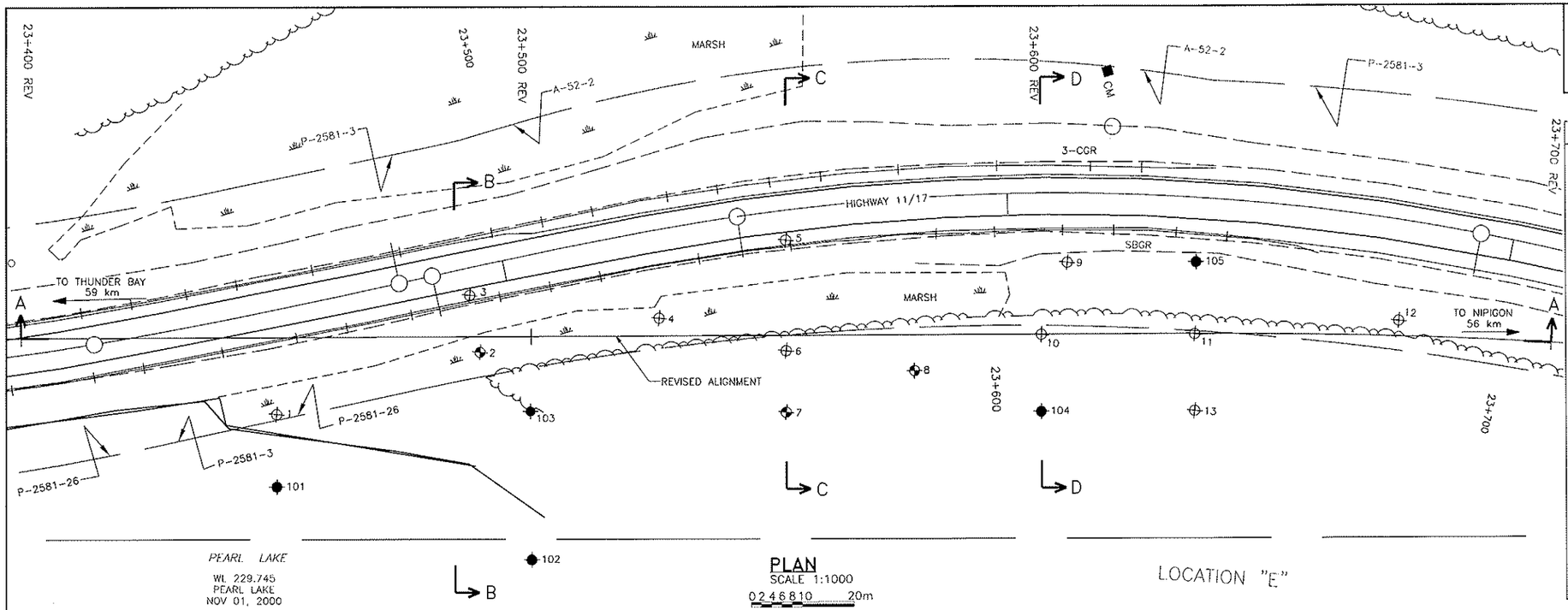



FIGURE 4

# APPENDIX D

## BOREHOLE LOCATIONS AND SOIL STRATA DRAWINGS




PLAN
SCALE 1:1000
0 2 4 6 8 10 20m

SOIL STRATA SYMBOLS

- PEAT
- MARL
- SILT
- SAND
- SAND & GRAVEL
- GRAVEL
- CLAY
- BEDROCK

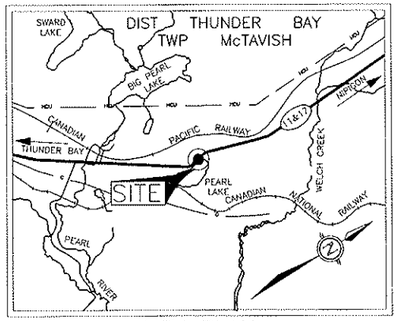
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP NO 414-01-00

PEARL LAKE
TOWNSHIP OF McTAVISH
BOREHOLE LOCATIONS AND SOIL STRATA

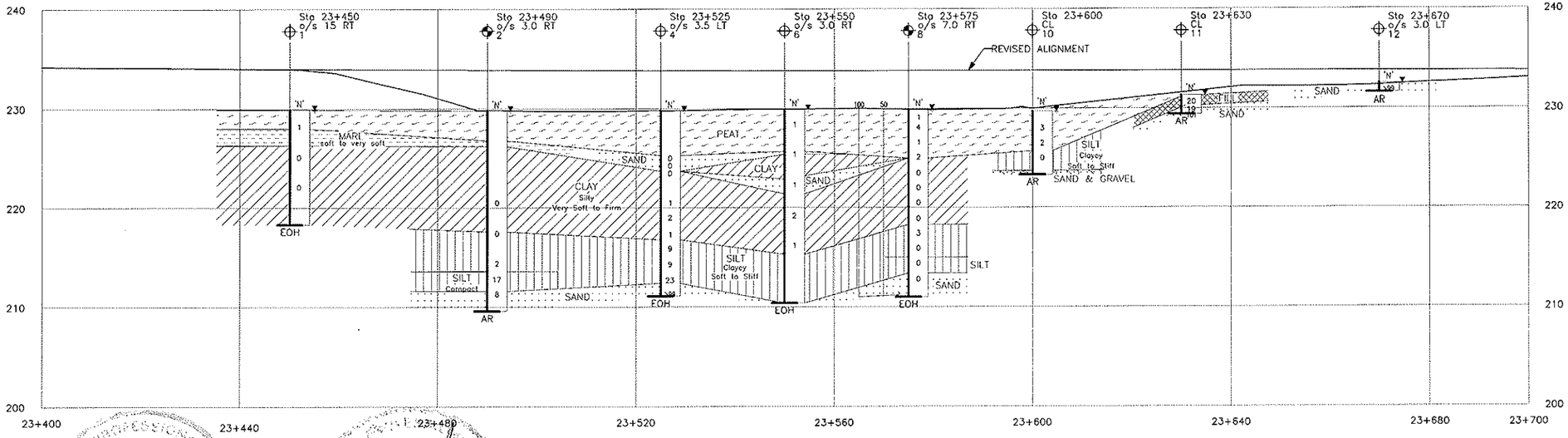
SHEET

TBT ENGINEERING




KEY PLAN
1.0 km 0 1.0 km
SCALE 1:100,000

| No | ELEVATION | EASTING | NORTHING |
|---|---|---|---|
| 1 | 229.9 | 404799.9 | 5393852.0 |
| 2 | 229.8 | 404799.9 | 5393893.7 |
| 3 | 233.4 | 404788.6 | 5393895.0 |
| 4 | 229.8 | 404803.6 | 5393929.1 |
| 5 | 233.4 | 404796.3 | 5393957.4 |
| 6 | 229.9 | 404817.0 | 5393951.2 |
| 7 | 229.9 | 404828.5 | 5393947.8 |
| 8 | 229.9 | 404828.0 | 5393974.1 |
| 9 | 231.5 | 404816.4 | 5394008.9 |
| 10 | 229.7 | 404828.4 | 5394000.0 |
| 11 | 231.3 | 404837.0 | 5394028.8 |
| 12 | 232.5 | 404846.2 | 5394067.9 |
| 101 | 227.2 | 404813.5 | 5393847.9 |
| 102 | 226.6 | 404841.7 | 5393891.7 |
| 103 | 229.9 | 404813.8 | 5393899.8 |
| 104 | 229.9 | 404842.8 | 5393995.7 |
| 105 | 232.7 | 404823.7 | 5394033.1 |




LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- 'N' Std Pen Test (Blows/0.3m)
- WL at time of investigation

NOTE
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence

℄ REVISED ALIGNMENT PROFILE A–A
SCALE 1:1000
SCALE 1:500
HOR 0 2 4 6 8 10 20m
VERT 0 2 4 6 8 10m

HORIZONTAL DATUM
North American Datum 1983 (NAD83)
3 Degree Modified Transverse Mercator (MTM) Grid Coordinates MTM Zone 15

VERTICAL DATUM
Canadian Geodetic Vertical Datum 1928 Adjustment, Geodetic Elevations

Borehole Elevations referenced from
BM 232.228
3/0 NOR S.E. CORNER HYDRO TOWER
Sta 23+403.511 o/s 22.120 LT
Elev 232.228 Geodetic

PLAN & PROFILE REFERENCED FROM DRAWING FILE
B&C-370-11&17-13.dwg AND
B&C-370-11&17-14.dwg MAY 2006

G. C. MAKI
PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

| REVISIONS | DATE | BY | REVISION |
|---|---|---|---|
| | 17/10/2007 | TB | FINAL |
| | 24/08/2007 | TB | FOR DRAFT REVIEW |

| | | | | | |
|---|---|---|---|---|---|
| HWY 11/17 PEARL LAKE | | | | DIST | THUNDER BAY |
| SUBM'D | WH | CHECKED | DATE AUGUST 2007 | SITE | |
| DRAWN | TB | CHECKED | CZ APPROVED | DWG | 1 |

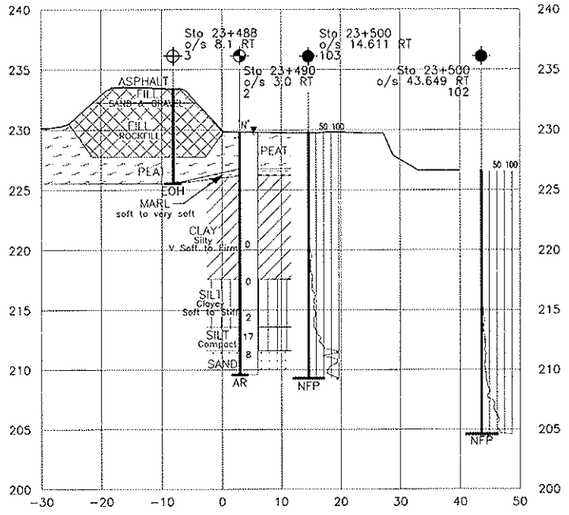
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP NO 414-01-00

PEARL LAKE
TOWNSHIP OF McTAVISH
BOREHOLE LOCATIONS AND SOIL STRATA

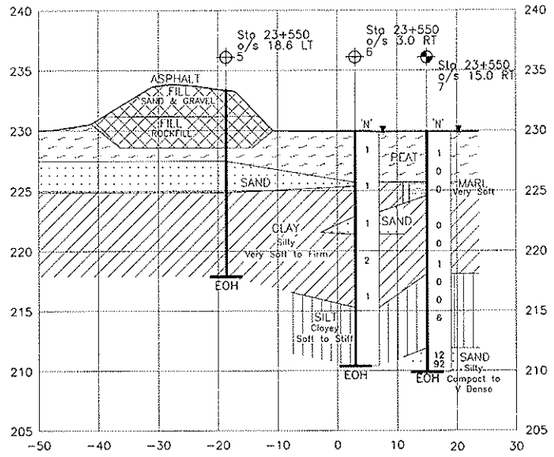
SHEET

**TBT ENGINEERING**




SECTION B–B
SCALE 1:1000
SCALE 1:500

HOR 0 2 4 6 8 10 20m
VERT 0 2 4 6 8 10m

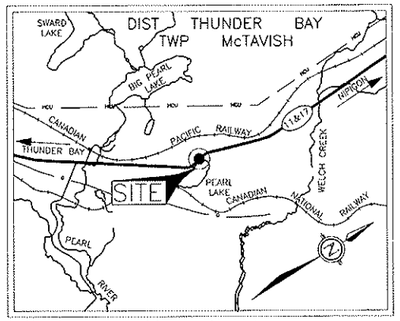



SECTION C–C
SCALE 1:1000
SCALE 1:500

HOR 0 2 4 6 8 10 20m
VERT 0 2 4 6 8 10m

SOIL STRATA SYMBOLS

- PEAT
- MARL
- SILT
- SAND
- SAND & GRAVEL
- GRAVEL
- CLAY
- BEDROCK




KEY PLAN
1.0 km 0 1.0 km
SCALE 1:100,000

| No | ELEVATION | EASTING | NORTHING |
|---|---|---|---|
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| 5 | 233.4 | 404796.3 | 5393957.4 |
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| 8 | 229.9 | 404828.0 | 5393974.1 |
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| 102 | 226.6 | 404841.7 | 5393891.7 |
| 103 | 229.9 | 404813.8 | 5393899.8 |
| 104 | 229.9 | 404842.8 | 5393995.7 |
| 105 | 232.7 | 404823.7 | 5394033.1 |

LEGEND

- Borehole
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- WL at time of investigation

NOTE
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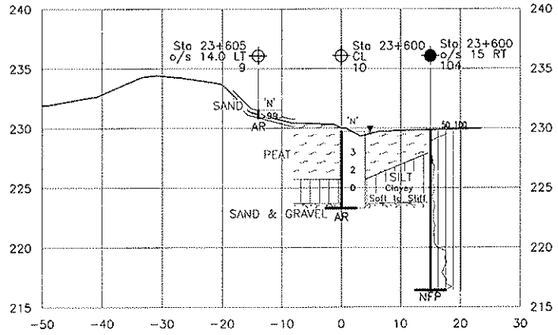


SECTION D–D
SCALE 1:1000
SCALE 1:500

HOR 0 2 4 6 8 10 20m
VERT 0 2 4 6 8 10m


HORIZONTAL DATUM
North American Datum 1983 (NAD83)
3 Degree Modified Transverse Mercator
(MTM) Grid Coordinates MTM Zone 15

VERTICAL DATUM
Canadian Geodetic Vertical Datum
1928 Adjustment, Geodetic Elevations

Borehole Elevations referenced from

BM 232.228
T/O NUT S.E. CORNER HYDRO TOWER
Sta. 23+403.511 o/s 22.120 LT
Elev. 232.228 Geodetic

PLAN & PROFILE REFERENCED FROM DRAWING FILE
B&C-370-11&17-13.dwg AND
B&C-370-11&17-14.dwg MAY 2006

| REVISIONS | | | |
|---|---|---|---|
| | | | |
| | 17/10/2007 | TB | FINAL |
| | 24/08/2007 | TB | FOR DRAFT REVIEW |
| | DATE | BY | REVISION |

| | | | | | |
|---|---|---|---|---|---|
| HWY 11/17 PEARL LAKE | | | | DIST | THUNDER BAY |
| SUBM'D | WH | CHECKED | DATE AUGUST 2007 | SITE | |
| DRAWN | TB | CHECKED CZ | APPROVED | DWG | 2 |