

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
RETAINING WALL DISTRESS  
HIGHWAY 401 / CORNWALL CENTRE ROAD  
CORNWALL, ONTARIO**

**SITE NO. 31-209**

**Geocres Number: 31G - 232**

**Report to**

**MTO Eastern Region**

Thurber Engineering Ltd.  
2010 Winston Park Drive, Suite 103  
Oakville, Ontario  
L6H 5R7  
Phone: (905) 829 8666  
Fax: (905) 829 1166

June 15, 2009

File: 15-6-19

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted for the observed west median retaining wall distress of the Highway 401 and Cornwall Centre Road overpass structure located in Cornwall, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, borehole logs, stratigraphic profile and a written description of the subsurface conditions. A model of the subsurface conditions was developed to describe the geotechnical conditions that may have contributed to the retaining wall distress and for assessing the short and longer term remedial measures required to address the observed distress of the retaining wall.

The west retaining wall is visibly distressed, as described later, and it has been reported that the maximum forward movement of the top of the wall is in the order of 400 mm. It is understood that concerns have been expressed regarding the wall since at least 2005 and that the movement of the wall has been regularly monitored since 2007.

Based on concerns raised and on examination of the wall distress, City of Cornwall decided to close the Cornwall Centre Road to traffic and MTO initiated this foundation investigation to assess if any geotechnical/foundation factors have led to the wall distress. Concurrently, it is understood that MTO has also initiated a structural assessment of the distress to ascertain if the wall distress is partly or wholly due to structural reasons and to assess safety of the 401 bridges at the Cornwall Centre Road.

Thurber's scope of work involved an initial site inspection to assess the condition of the retaining wall and to provide a set of recommendations for a subsurface investigation to help narrow down the possible cause(s) of the observed distress. Following the initial visual inspection of the distress, it was proposed to drill a series of boreholes to variable depths throughout the site and advancing a series of test pits along the length of the east and west retaining walls to observe the condition of the footings and founding soils (if possible).



## **2 SITE DESCRIPTION**

The Cornwall Centre Road Overpass is located in the City of Cornwall on Highway 401 just west of Highway 138/Brookdale Avenue interchange. Twin, single span, 19 m long, overpass structures carry the eastbound and westbound lanes of Highway 401 over Cornwall Centre Road. The structures are on a tangent section and are skewed at an angle of approximately 51° with respect to Highway 401 centreline and they are separated by a 15.0 m wide median.

The surrounding land is essentially flat and the highway is constructed on an embankment that is approximately 7 m high.

The bridges are simply supported on closed abutments and the median fill is supported by a concrete retaining wall. Available design drawings indicate that the total height of the west retaining wall is 8.5 m from the top of wall to underside of footing. Drawing TWP#31-209-1-A, the General Arrangement, suggests that the footings should be placed on dense sandy till. Drawing TWP#31-209-2-A, however, includes a note that all footings must be founded on firm clay. Additional retaining walls extend beyond the abutments in all four quadrants. The original design drawings are attached as Appendix G.

Photographs of the west retaining wall and the observed distress are provided in Appendix E.

The general site area is located within the physiographic region referred to as the Lancaster Flats, a relatively level, poorly drained till plain that was flooded and subsequently overlain by fine grained lake sediments. Drumlins and stony crests protrude through the lake sediments in some areas throughout the region. Drainage is generally poor but tends to flow south towards the St. Lawrence River.

Grey calcareous limestone bedrock of the Bobcaygeon Formation underlies the site. Bedrock maps indicate that the surface of the bedrock outcrops approximately 3 km west of the site and slopes in a southerly direction towards the St. Lawrence River.

## **3 WALL MOVEMENT MONITORING DATA**

As part of the Ministry's ongoing maintenance program, the geomatics section of the Eastern Region office has initiated a monitoring program of six points located on the top of the west retaining wall between the east and west bound lanes. The program was designed to monitor the movement of the wall at these points throughout the year and has been reportedly been in place since 2005 when the distress was initially observed.

Monitoring data from the spring of 2007 to the present has been provided for review and is attached in Appendix D.

In general, an increase in retaining wall movement measured along the top of the wall has been observed in all monitoring points from October to April since 2007 with very little movement observed during the summer and autumn months. The retaining wall movements are progressively increasing each year and recently, the retaining wall movement has increased

significantly along the top of the wall when compared to readings taken in October of 2008. From October 2008 to March 2009, the displacements have increased from a minimum of 4.2 mm to a maximum of 10.7 mm. The largest displacements have been observed along the southern portion of the west wall where the retaining structure is in contact with the 401 overpass structure.

In March of 2009 a series of twelve points were established beneath the eastbound lane of the Highway 401 on the face of the west abutment wall to monitor the wall movement.

The monitoring points established on the abutment wall indicate that the displacements range from 0.4 to 3.5 mm over the course of approximately 75 days.

The displacements observed at the top of the retaining wall at the EBL west abutment range from 0.4 to 1.2 mm with the most displacement occurring at the two ends (north and south) of the structure since the start of the monitoring program along the face of the wall.

The least displacements that have been observed along the retaining wall are in the points established just above Cornwall Centre Road. These points have only shown displacements in the order of 0.5 to 1.1 mm of total displacement since the start of monitoring.

## **4 SITE INVESTIGATION AND FIELD TESTING**

### **4.1 General**

An initial site visit was carried out by Thurber and the MTO on April 30, 2009 in order to visually assess the distress of the west retaining wall and to develop a potential scope of geotechnical investigation. Based on the site visit observations, the field investigation consisted of a series of test pits numbered 09-01 through 09-07 that were excavated on May 5, 2009 along the length of the west retaining wall and at the southern wing of the eastern retaining wall. The investigation included drilling and sampling of ten boreholes and the excavation of an additional four test pits with a vacuum excavator from between May 11 to 20, 2009. A subsequent site inspection was carried out on May 26, 2009, following the completion of the subsurface investigation.

#### **4.1.1 Site Examination**

During the two site inspections, the observations indicated the following:

- The west side median retaining wall is clearly leaning towards Cornwall Centre Road, and appears to bulge outwards around the centre of median. Visually, the inclination of the wall appears to increase towards the top;
- Observations of the east side median wall indicate that it may have moved a small amount but does not exhibit the obvious signs of distress evident in the west wall;

- The west wall had originally been keyed into the abutments and these keys have been sheared off by the forces driving the wall movement (certainly near the top of the wall) and damage has resulted to the abutment walls;
- The skewed structure arrangement has resulted in more severe damage where the retaining wall meets the west abutment of the EBL structure. Here, the wall is in hard contact with, and is wedged under the bridge soffit which has resulted in spalling of concrete pieces from the top of the wall and damage to the bridge;
- The face of the west wall exhibits a number of vertical or near vertical cracks, the worst of which is near the middle of the wall which have opened significantly;
- The presence of a number of areas of calcite deposition on the face of the wall, suggest long term seepage through the wall. There are a number of weep holes through the wall at approximately 1 m height above Cornwall Centre Road grade. These holes are open to distances of approximately 82 cm behind the face of the wall. The lack of calcite deposition or staining below the holes and the fact that the holes have been cored suggest that they were installed some time after the wall was constructed;
- Observations of the site topography reveal that for a distance of approximately 20 m behind the west wall, the highway median drains to the area just behind the wall and this area may collect surface water after precipitation or snow melt;
- Wet conditions at a 150 mm CSP that daylight north of the WBL abutment suggests that the designed weeper behind the abutment is functioning as intended.

#### **4.1.2 Geotechnical Investigation**

Thurber positioned the boreholes and test pits in the field relative to local site features. The coordinates and ground surface elevations at the boreholes and test pits were subsequently established by the MTO Eastern Region Geomatics Section.

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

A member of Thurber's engineering staff supervised the test pitting, drilling and sampling operations on a full time basis. The inspector logged the soil and groundwater conditions encountered in the boreholes and test pits and collected, labelled and arranged for transport of the samples to Thurber's laboratory.

#### **4.2 Test Pits**

The purpose of the test pits was to allow the following:

- Examination of the subsurface conditions with emphasis on the condition of the retaining wall stem/footing contact and any signs of distress, below grade;

- Evidence of bearing capacity failure of the wall footings and rotation or translation of the wall and footings;
- Evidence of global instability of the wall;
- Evidence of softening of the soils in front of the wall as well as the drainage and groundwater conditions.

Six test pits were dug using a conventional rubber tired backhoe along the base of the west retaining and abutment walls (TP09-01, 02, 03, 04, 05 and 06) and their locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix F. TP09-13 was advanced along the west retaining wall between Borehole 09-04 and the retaining structure using a vacuum excavator. The test pits dug along the west wall were advanced to the top of the footing which was encountered at depths ranging between 1.57 and 1.75 m.

Test pits planned along the base of the east retaining wall had to be advanced using a vacuum excavator due to the close proximity of a gas line. Four test pits (TP09-8, 09-9, 09-10 and 09-11) were excavated using this method. TP09-07 was excavated to 1.93 m depth using a backhoe. The location of these test pits are also shown on the attached Borehole Locations and Soil Strata Drawing in Appendix F.

The vacuum excavated pits along the east wall could not be excavated deeper than 1.1 m due to sloughing of the sides of the pits and significant accumulation of water in the excavation making subsurface observations difficult.

### **4.3 Boreholes**

The borehole program consisted of drilling 10 boreholes at the following locations:

- Boreholes 09-03, 09-06 and 09-09 were drilled approximately 2 to 3 m behind the top of west retaining wall to assess the quality of the wall backfill. Borehole 09-03 was advanced to a depth of 12.1 m (El. 57.3 m) while Boreholes 09-06 and 09-09 were respectively advanced to depths of 7.9 and 8.1 m (El. 61.2 and 61.4 m).
- Borehole 09-02 was drilled about 10 m west of the west retaining wall to a depth of 12.2 m (El. 57.2 m) to assess fill quality in the median.
- Borehole 09-04 was drilled in front of the west retaining wall to a depth of 10.1 m (El. 53.3 m) to assess founding soils below the footing.
- Boreholes 09-01, 09-07, 09-08 and 09-10 were drilled about 2 to 10 m behind the east retaining wall to assess the quality of the wall backfill and median fill. Borehole 09-01 was also close to the SE corner of Hwy 401 WBL east abutment. The east retaining wall boreholes were drilled to a depth of 16.7 m (El. 52.2 m) in Borehole 09-01 and from 6.7 to 8.2 m (El. 60.8 to 62.2 m) in Boreholes 09-07, 09-08 and 09-10.

- Borehole 09-05 was drilled adjacent to Hwy 401 EBL west abutment to a depth of 16.9 m below the ground surface (El. 53.2 m).
- Core samples of the underlying bedrock formation were recovered from Boreholes 09-01, 09-04 and 09-05.

A number of these boreholes were drilled to refusal or into the underlying bedrock. Selected holes behind the retaining walls were drilled to 8 m depth so as not to damage the subdrains behind the structures.

Boreholes 09-04 and 09-05 were advanced using a truck mounted drill rig through the paved surfaces, while the remaining boreholes were advanced using a track mounted drill rig. Hollow stem augers were used to advance the boreholes in the overburden materials while NQ2 diamond coring equipment was used to advance borehole in the bedrock at select locations. Samples were obtained using a split spoon sampler in conjunction with Standard Penetration Tests (SPT). All samples were brought back to our laboratory for visual identification and moisture content determination. Gradation tests were conducted on a number of soil samples paying particular attention to the backfill behind the median retaining walls and the abutments. The results are shown on the Record of Borehole sheets in Appendix A and on the charts in Appendix B. The gradation test results for the retaining wall backfill were compared to OPSS Granular 'A' and Granular 'B' specifications.

Standpipe piezometers were installed in five boreholes to monitor groundwater levels. The completion details of the piezometers are presented in Table 4.1. The boreholes without piezometers were backfilled with a mixture of bentonite holeplug and cuttings upon completion of drilling.

**Table 4.1 – Piezometer Details**

Borehole Number	Tip Position (m)		Completion Details
	Depth	Elev.	
09-01	13.4	55.6	Bentonite Holeplug from 16.7 to 13.4 m, sand filter and screen from 13.4 to 11.7 m, bentonite holeplug from 11.7 to 2.8 m, cuttings from 2.8 m to ground surface.
09-02	12.2	57.2	Sand filter and screen from 12.2 to 10.7 m, sand filter from 10.7 to 10.2 m, bentonite holeplug from 10.2 to 3.1m, cuttings from 3.1 m to ground surface.
09-03	12.1	57.3	Sand filter and screen from 12.1 to 10.6 m, sand filter from 10.6 to 9.2 m, bentonite holeplug from 9.2 to 2.6 m, cuttings from 2.6 m to ground surface.
09-04	10.1	53.3	Sand filter and screen from 10.1 to 8.6 m, sand filter from 8.6 to 6.0 m, bentonite holeplug from 6.0 to 0.2 m, concrete and flush mount casing from 0.2 m to ground surface.
09-05			No Piezometer Installed
09-06			No Piezometer Installed
09-07			No Piezometer Installed
09-08	6.7	62.2	Sand filter and screen from 6.7 to 5.2 m, sand filter from 5.2 to 4.9 m, bentonite holeplug from 4.9 m to ground surface.
09-09			No Piezometer Installed
09-10			No Piezometer Installed

## 5 DESCRIPTION OF SUBSURFACE CONDITIONS

### 5.1 General

Reference is made to the Record of Borehole sheets in Appendix A and to the Borehole Locations and Soil Strata Drawings in Appendix F. An overall description of the stratigraphy based on the conditions encountered in the boreholes is given in the following paragraphs. However, the factual data presented in the borehole logs takes precedence over this general description and interpretation of the site conditions.

The soil stratigraphy encountered at this site generally consists of surficial pavement, topsoil and fill layers of varying composition overlying a native silty clay, underlain by a deposit of silty sand till to sand and silt till. The overburden materials are underlain by a calcareous limestone bedrock of the Bobcaygeon Formation.

More detailed descriptions of the individual strata are presented below.

### 5.2 West Median Retaining Wall

#### 5.2.1 Test Pits

In general, the test pits along the west side of Cornwall Centre Road encountered a surficial layer of topsoil in TP09-01 and asphalt in TP09-02 to 09-06. The topsoil was measured to be 75 mm in thickness and the asphalt was measured to be 50 mm in thickness. The asphalt was

in turn underlain by a layer of grey sand and gravel. The sand and gravel was found to range in thickness from 125 to 200 mm.

The surficial fill layers were underlain by a moist, dark brown silty clay fill similar in appearance to a reworked cohesive soil typical to the region. A single pocket penetrometer reading indicated an undrained shear strength in the clay fill of 150 kPa indicating a very stiff consistency. The silty clay fill was encountered at depths ranging from 75 to 250 mm below the ground surface in TP09-02 to 09-06 and TP09-13. In TP09-01 the silty clay fill extended to the top of the footing (1.63 m).

Immediately beneath the cohesive fill in all test pits except TP09-01, a layer of sand fill was encountered. The sand fill consisted of a brown sand with some gravel and trace of cobbles. Perched groundwater was observed to seep into the test pits from this layer. The surface of the sand fill was contacted at depths ranging from 0.45 to 0.55 m below the ground surface (El. 63.0 to 63.1 m). The base of the sand fill was encountered at depths ranging from 0.9 to 1.2 m (El. 62.3 to 62.7 m).

A second layer of silty clay fill was encountered in TP09-02 to 09-06 and TP09-13 immediately below the sand fill layer. The silty clay fill is brown to grey and contains some sand and trace gravel with occasional cobbles. Pocket penetrometer readings in the cohesive fill indicated undrained shear strengths ranging from 50 to 75 kPa indicating a stiff consistency. The silty clay fill was initially encountered at depths ranging from 0.9 to 1.2 m below the ground surface (El. 62.3 to 62.7 m). The silty clay fill extends to the top of the footing in all of the test pits where it was encountered. All test pits were terminated at the top of the retaining wall footings at depths varying from 1.6 to 1.75 m (El. 61.8 to 61.9 m).

### **5.2.2 Boreholes**

The soils encountered immediately behind the west retaining wall were observed in Boreholes 09-3, 09-6 and 09-9. Borehole 09-02 was drilled to determine the nature of the soils some distance from the retaining wall within the centre median. Borehole 09-04 was drilled on the east side of the west retaining wall (Cornwall Centre Road).

In all of the boreholes drilled near the west retaining wall with the exception of 09-04, a thin layer of topsoil ranging in thickness from 75 to 100 mm was encountered. Beneath the topsoil in Borehole 09-03, a 1.3 m thick layer of clayey silt fill with some sand and trace gravel was encountered. The clayey silt fill was observed to extend to approximately 1.4 m below the ground surface (El. 67.9 m). SPT N- values in the clayey silt fill ranged from 1 to 10 blows for 0.3 m of penetration indicating a very soft to stiff consistency. Moisture contents of the clayey silt fill ranged from 10 to 22%.

At the surface of Borehole 09-04, a 100 mm thick layer of asphalt was encountered which was in turn underlain by a 0.6 m layer of gravelly sand fill (granular roadbase). The moisture content of the roadbase was measured as 4%. The results of a grain size analysis carried out

on the single sample of granular roadbase indicated that the material was composed of 45% gravel, 39% sand and 16% fines (silt and clay).

Beneath the topsoil in Boreholes 09-02, 09-06 and 09-09, the clayey silt fill in Borehole 09-03 and underlying the granular roadbase in Borehole 09-04, a silty sand fill, similar in composition to a reworked glacial till common to the area was encountered. The surface of the silty sand fill was encountered at depths ranging from 0.1 to 1.4 m below the ground surface (El. 67.9 to 69.3 m) in the boreholes drilled through the highway median and at a depth of 0.7 m (El. 62.7 m) in Borehole 09-04. The base of the cohesionless fill layer was contacted at depths ranging from 3.7 to 5.3 m (El. 64.1 to 65.4 m) in the four boreholes drilled behind the retaining wall and at 2.6 m (El. 60.8 m) in Borehole 09-04.

SPT N-values of the silty sand fill were observed to range from 3 to 40 blows for 0.3 m of penetration indicating a very loose to dense relative density. A single N-value of 100 blows for 0.1 m of penetration was recorded in Borehole 09-03, though the high blow count may represent the presence of cobbles. Moisture contents ranged from 4 to 21% though are typically around 10%. The results of grain size distribution analyses carried out on fourteen samples of the fill are presented in Figures B1 to B4 of Appendix B.

The results of laboratory tests carried out on the fourteen samples were as follows:

Gravel %	1 to 58
Sand %	31 to 63
Silt %	26 to 39 (where hydrometer conducted)
Clay %	7 to 14 (where hydrometer conducted)
Silt and Clay%	11 to 32 (sieve only)

Beneath the silty sand fill, a layer of a moist, brown sand and gravel fill was encountered in Boreholes 09-03 09-06 and 09-09. The granular fill was similar in appearance to a Granular A or Granular B Type 1 material. The fill was contacted at depths below the ground surface ranging from 3.7 to 5.3 m (El. 64.1 to 65.4 m). The bottom of the fill layer was encountered at depths below the ground surface ranging from 6.8 to 7.5 m (El. 62.0 to 62.6 m).

SPT N-values in the sand and gravel backfill ranged from 6 to 40 blows for 0.3 m of penetration indicating a loose to dense relative density. Moisture contents of the backfill ranged from 4 to 11%. The results of grain size distribution analyses carried out on five samples of the fill are presented in Figures B1 to B4 of Appendix B.



The results of laboratory tests carried out on the five samples were as follows:

Gravel %	41 to 53
Sand %	38 to 45
Silt and Clay%	10 to 16

Immediately below the fill layers, a layer of native silty clay was encountered in all of the boreholes drilled through the west Highway 401 centre median. The silty clay is brown and contains trace to some sand and trace gravel and trace organics. The surface of the silty clay was contacted at depths of 4.7 to 7.5 m below the ground surface (El. 62.0 to 64.7 m). The base of the silty clay was encountered at depths ranging from 6.3 to 8.1 m (El. 61.3 to 63.1 m). Boreholes 09-06 and 09-09 were terminated in the silty clay layer at depths of 7.9 and 8.1 m (El. 61.2 and 61.4 m) respectively.

SPT N-values in the silty clay were recorded to range from 4 to 22 blows for 0.3 m of penetration indicating a firm to very stiff consistency. Three N-values recorded in Boreholes 09-06 and 09-09 were as high as 50 blows for 0.125 m of penetration indicating a hard consistency. Moisture contents range from 7 to 37% though is typically around 30%. The results of grain size distribution analyses tests carried out on three samples of the silty clay are presented in Figure B9 and the results of a single Atterberg Limits test is presented on Figure B13 of Appendix B, respectively.

The results of laboratory tests carried out on the three samples were as follows:

Gravel %	1 to 5
Sand %	25 to 37
Silt %	34 to 42
Clay %	21 to 32
Liquid Limit	52
Plastic Limit	26

The results of these tests indicate that the silty clay is a CH soil (high plasticity).

Beneath the silty clay in Boreholes 09-02 and 09-03 and beneath the silty sand fill in Borehole 09-04, a grey silty sand till to sand and silt till was encountered. The sand and silt till contains some clay and trace of gravel. The surface of the cohesionless till was encountered below the ground surface at a depth of 6.3 and 8.1 m (El. 63.1 and 61.3 m) in Boreholes 09-02 and 09-03 respectively and at 2.6 m (El. 60.8 m) in Borehole 09-04. The base of the glacial till layer was contacted in Borehole 09-2 at a depth of 12.1 m (El. 57.2 m) while Borehole 09-03 was terminated in the cohesionless till layer on the probable surface of the bedrock at a depth of 12.1 m below the ground surface (El. 57.3 m). The base of the glacial till layer was encountered on the surface of the bedrock in Borehole 09-04 at a depth of 6.9 m (El. 56.5 m).

SPT N-values in the cohesionless till layer ranged from 15 to 100 blows for 0.3 m of penetration indicating a compact to very dense relative density. Four N-values were recorded to be greater than 100 blows for 0.025 m of penetration indicating a very dense relative density. Moisture contents of the cohesionless glacial till layer range from 5 to 11%. The results of grain size distribution analyses tests carried out on six samples of the silty sand till to sand and silt till are presented in Figure B11 and the results of a single Atterberg Limits test is presented on Figure B13 of Appendix B, respectively.

The results of laboratory tests carried out on the six samples were as follows:

Gravel %	2 to 9
Sand %	44 to 51
Silt %	31 to 42
Clay %	10 to 13
Liquid Limit	19
Plastic Limit	12

The results of these tests indicate that the sand and silt is a CL-ML soil (non-plastic).

Beneath the cohesionless till layer in Boreholes 09-02 and 09-03, calcareous limestone bedrock was encountered at a depth of 12.1 m below the ground surface (El. 57.2 to 57.3 m). The surface of the bedrock was inferred based on bouncing of the split spoon sampler and fragments of the limestone in the tip of the sample upon recovery. The bedrock was not confirmed by coring in any of the boreholes drilled behind the west retaining wall within the Highway 401 median.

Core samples of the limestone bedrock were recovered in Borehole 09-04, drilled on the east side of the west retaining wall (Cornwall Centre Road). The surface of the bedrock was encountered at a depth of 6.9 m below the road surface (El. 56.5 m). Core samples recovered from the bedrock indicate that the bedrock is fresh and grey with occasional sub-vertical joints. The Total Core Recovery (TCR) of the bedrock was measured to range from 97 to 100% while the Rock Quality Designation (RQD) ranges from 97 to 100% indicating an excellent quality and generally improves with depth.

The initial and final groundwater depths and elevations measured in the boreholes and piezometers are shown in Table 5.1.

**Table 5.1 – Groundwater Depths and Elevations**

Borehole Number	Piezometer Tip Depth (m)	Date	Water Level (m)		Condition
			Depth	Elevation	
09-02	12.2	May 11/09	10.5	58.9	Open Borehole
		May 13/09	5.3	64.1	In Piezometer
		May 15/09	5.7	63.7	
		May 19/09	5.8	63.6	
		May 20/09	5.9	63.5	
09-03	12.1	May 11/09	9.9	59.5	Open Borehole
		May 13/09	6.0	63.4	In Piezometer
		May 15/09	6.3	63.1	
		May 19/09	6.4	63.0	
		May 20/09	6.4	63.0	
		May 26/09	6.3	63.1	
09-04	10.1	May 19/09	0.3	63.1	In Piezometer
		May 20/09	0.3	63.1	
		May 26/09	1.0	62.4	
09-06	N/A	May 19/06	6.4	62.8	Open Borehole
09-09	N/A	May 19/06	6.5	63.0	Open Borehole

The above water levels reflect the unstabilized conditions in the boreholes upon completion of drilling or the piezometric head at the level of the piezometer tips at the time of the readings. The measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected. The results indicate a groundwater level at about El. 62.4 to 63.5 m which is near the surface of Cornwall Centre Road.

### 5.3 East Median Retaining Wall

#### 5.3.1 Test Pits

A total of four test pits (TP09-07, 09-08, 09-09 and 09-11) were advanced adjacent to the west side of the east retaining wall. Three of the tests pits were advanced using a vacuum excavator due to the proximity to existing utilities, and the fourth test pit, dug along the south wing wall was advanced using a conventional rubber tire backhoe to the top of the footing. In general, the soils that were encountered in the test pits along the eastern retaining wall along Cornwall Centre Road were comprised of a surficial layer of asphalt underlain by a sand fill. The asphalt was measured to be 50 mm in thickness and was underlain by approximately 150 mm of sand fill. The single test pit dug along the southern wing wall (TP09-07) encountered a 150 mm thick surficial layer of topsoil.

Beneath the sand fill and topsoil, a layer of silty clay fill was encountered in test pits TP09-07 and 09-08. The cohesive fill is dark brown to brown and contains some sand, gravel, occasional cobbles and construction debris. The surface of the clay was encountered at depths ranging from 0.15 to 0.2 m (El. 63.3 to 63.5 m). The silty clay fill was found to extend to the top of the footing in TP09-07, where the test pit was terminated at a depth of 1.93 m (El. 61.7 m). In TP09-08, the base of the silty clay fill was encountered at a depth of 0.85 m (El. 62.7 m). Beneath the cohesive fill and immediately below the sand fill in TP09-09 and 09-11, a second layer of sand fill was encountered. This layer of sand fill is wet and is comprised of some gravel and occasional cobbles. The surface of the sand fill was encountered at depths ranging from 0.2 to 0.85 m (El. 62.0 to 63.3 m). The three test pits advanced adjacent to the retaining wall structures were all terminated at depths of 1.0 to 1.1 m (61.2 to 62.5 m) in the sand fill layer due to the rapid discharge of perched groundwater into the excavation and sloughing of the test pit sidewalls.

### **5.3.2 Boreholes**

At the surface of the four boreholes drilled through the centre median on the east side of the eastern retaining wall (Boreholes 09-01, 09-07, 09-08 and 09-10) a thin layer of topsoil was encountered. The topsoil was found to range in thickness from 50 to 100 mm. Beneath the topsoil in Borehole 09-01, a 0.7 m thick layer of clayey silt fill was encountered. The single SPT N-value recorded in the clayey silt fill was 9 blows for 0.3 m of penetration indicating a stiff consistency. The moisture content of the cohesive fill was measured to be around 21%.

Beneath the topsoil in Boreholes 09-07, 09-08 and 09-10, and beneath the clayey silt fill in Borehole 09-01, a layer of brown silty sand fill with some clay and trace gravel was encountered. The surface of the silty sand fill was contacted at depths ranging from 0.1 to 0.7 m (El. 68.3 to 69.3 m). The bottom of the cohesionless fill was encountered at depths ranging from 3.0 to 6.1 m (El. 63.0 to 66.0 m). In Borehole 09-08, a second layer of silty sand fill was encountered at a depth of 3.7 m below the ground surface (El. 65.2 m). The bottom of the second cohesionless fill deposit was encountered at a depth of 6.1 m (El. 62.8 m).

SPT N-values in the silty sand fill varied widely ranging from 3 to 48 blows for 0.3 m of penetration indicating a very loose to dense relative density. One N-value in the cohesionless fill layer was recorded as 50 blows for 0.075 m of penetration indicating a very dense relative density. It should be noted that the high N-value may have been due to the presence of gravel or cobbles as indicated by the split spoon bouncing upon impact. Moisture contents of the silty sand fill range from 3 to 12%. The results of grain size distribution analyses carried out on fourteen samples of the fill are presented in Figures B5 to B8 of Appendix B.

The results of laboratory tests carried out on the fourteen samples were as follows:

Gravel %	2 to 9
Sand %	47 to 55
Silt %	28 to 38
Clay %	8 to 15

In all of the boreholes, a sand and gravel fill material similar in nature to a Granular B Type 1 was encountered beneath the upper silty sand fill. The upper surface of the granular fill was contacted at depths ranging from 3.0 to 6.1 m (El. 63.0 to 66.0 m). Where penetrated, the sand and gravel was observed to vary in thickness from 0.6 to 0.7 m. Borehole 09-10 was terminated in the granular fill at a depth of 7.7 m below the ground surface (El. 61.7 m).

SPT N-values recorded in the granular fill ranged widely from 16 to 80 blows for 0.3 m of penetration indicating a compact to very dense relative density. Two N-values were greater than 50 blows for 0.075 m of penetration, though the lack of split spoon advancement may have been as a result of the presence of cobbles. Moisture contents measured in the granular fill ranged from 3 to 17% though were typically less than 10%. The results of grain size distribution analyses carried out on five samples of the fill are presented in Figures B5 to B8 of Appendix B.

The results of laboratory tests carried out on the five samples were as follows:

Gravel %	29 to 72
Sand %	22 to 44
Silt and Clay%	6 to 29 (sieve only)

In Boreholes 09-07 and 09-08, a native silty clay was encountered immediately below the sand and gravel fill. The surface of the cohesive material was contacted at depths of 6.7 and 6.1 m (El. 62.4 and 62.8 m) in Boreholes 09-07 and 09-08 respectively. Boreholes 09-07 and 09-08 were respectively terminated within the silty clay layer at depths of 8.2 and 6.7 m (El. 60.8 and 62.2 m).

SPT N-values recorded in the native cohesive layer ranged from 6 to 8 blows for 0.3 m of penetration, indicating a firm to stiff consistency. Moisture contents of the silty clay were measured to range from 40 to 44%. The results of grain size distribution analyses tests carried out on two samples of the silty clay are presented in Figure B10 and the results of a single Atterberg Limits test is presented on Figure B13 of Appendix B, respectively.

The results of laboratory tests carried out on the two samples were as follows:

Gravel %	0 to 2
Sand %	12 to 18
Silt %	31 to 32
Clay %	51 to 54
Liquid Limit	71
Plastic Limit	28

The results of these tests indicate that the silty clay is a CH soil (high plasticity).

In Borehole 09-01, the granular fill was underlain by a native silty sand till to sand and silt till. The till is grey and contains some clay, trace gravel and is interbedded with a slightly coarser sand layer. The surface of the till layer was encountered at a depth of 6.7 m below the ground surface (El. 62.3 m) and the bottom of the till layer was found to be at a depth of 13.3 m below the ground surface (El. 55.7 m). At a depth of 8.5 m (El. 60.5 m) a 1.7 m thick layer of sand with some silt was encountered.

SPT N-values in the glacial till and sand interbeds ranged from 25 to 32 blows for 0.3 m of penetration to greater than 100 blows for 0.025 m of penetration indicating a compact to very dense relative density. Moisture contents of the cohesionless till ranged from 11 to 21%. The results of a grain size distribution analysis carried out on one sample of the sand and silt till is presented in Figure B12 of Appendix B.

The results of laboratory tests carried out on the single cohesionless till sample is as follows:

Gravel %	2
Sand %	43
Silt %	48
Clay %	7

Beneath the cohesionless till layer in Borehole 09-01, limestone bedrock was encountered at a depth of 13.3 m (El. 55.7 m). Samples of the bedrock were recovered using diamond coring equipment to a depth of 16.7 m (El. 52.2 m). Core samples recovered from the bedrock indicate that the bedrock is fresh and grey with occasional rubble zones and clay till infilling. Several vertical joints were also noted. The Total Core Recovery (TCR) of the bedrock was measured to be 100% in both runs while the Rock Quality Designation (RQD) ranges from 89 to 100% and improves with depth indicating a good to excellent quality.

Point load testing carried out on the bedrock recovered from the borehole indicate that the equivalent Unconfined Compressive Strength (UCS) of the limestone ranges from 27 to 133 MPa indicating a moderately strong to very strong bedrock.

The initial and final groundwater depths and elevations measured in the boreholes and piezometers are shown in Table 5.2.

**Table 5.2 – Groundwater Depths and Elevations**

Borehole Number	Piezometer Tip Depth (m)	Date	Water Level (m)		Condition
			Depth	Elevation	
09-01	13.4	May 13/09	6.7	62.3	In Piezometer
		May 15/09	6.4	62.6	
		May 19/09	6.6	62.4	
		May 20/09	6.7	62.3	
09-07	N/A	May 20/09	6.7	62.4	Open Borehole
09-08	6.7	May 20/09	Dry	N/A	Open Borehole
09-10	N/A	May 20/06	7.3	62.1	Open Borehole

The above water levels reflect the unstabilized conditions in the boreholes upon completion of drilling or the piezometric head at the level of the piezometer tips at the time of the readings. The measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected. The water level is observed to be at approximately El. 62.3 m or at the surface of Cornwall Centre Road.

#### 5.4 Highway 401 Bridge Abutments

The subsurface materials encountered through the Highway 401 embankments are shown in Borehole 09-05. At the ground surface a 175 mm thick layer of asphalt overlying a 325 mm thick layer of concrete was encountered. The pavement material was then underlain by a coarse grained sand and gravel fill similar in nature to a Granular B Type 1. The sand and gravel was consistent in texture with depth and was observed to be moist and brown and contain trace to some silt. The layer was first contacted at a depth of 0.5 m below the roadway (El. 69.7 m). The base of the granular fill was encountered at a depth of 6.8 m (El. 63.4 m).

SPT N-values of the granular fill layer varied widely ranging from 70 to 6 blows for 0.3 m of penetration indicating a very dense to loose relative density. Typically the blow counts were in the order of 25 to 30 blows for 0.3 m of penetration. Moisture contents of the granular fill recovered from beneath Highway 401 ranged from 3 to 7%. The results of grain size distribution analyses carried out on four samples of the granular fill are presented in Figures 2 and 3 of Appendix B.

The results of laboratory tests carried out on four samples were as follows:

Gravel %	37 to 44
Sand %	42 to 48
Silt and Clay%	13 to 19

The granular fill was underlain by a native silty clay deposit. The cohesive layer was moist and brown and contained some sand and trace of gravel. The silty clay was first contacted at a depth of 6.8 m (El. 63.4 m) and the bottom of the layer was contacted at a depth of 7.7 m (El. 62.5 m). A single SPT N-value in the silty clay layer indicated a blow count of 6 blows for 0.3 m of penetration indicating a firm consistency. The moisture content of the single sample recovered from the silty clay was measured to be 19%. The results of grain size distribution analyses tests carried out on the single sample of the silty clay is presented in Figures 2 and 3 and the results of a single Atterberg Limits test is presented on Figure B9 of Appendix B, respectively.

The results of laboratory tests carried out on the four samples were as follows:

Gravel %	2
Sand %	36
Silt %	42
Clay %	20
Liquid Limit	26
Plastic Limit	14

The results of these tests indicate that the silty clay is a CL soil (low plasticity).

The cohesive layer was underlain by a sand and silt till layer at a depth of 7.7 m (El. 62.5 m). The sand and silt till was fully penetrated and the bottom of the strata was encountered at a depth of 13.3 m (El. 56.8 m). SPT N-values in the cohesionless till layer ranged from 18 blows for 0.3 m of penetration to greater than 100 blows for 0.05 m of penetration indicating a compact to very dense relative density. Moisture contents of the till layer ranged from 4 to 22%. The results of grain size distribution analyses carried out on two samples of the sand and silt till are presented in Figures 2 and 3 of Appendix B.

The results of laboratory tests carried out on the two samples were as follows:

Gravel %	7 to 15
Sand %	42 to 45
Silt %	39 (Where hydrometer conducted)
Clay %	9 (Where hydrometer conducted)
Silt and Clay%	42 (Sieve only)

The glacial till layer was in turn underlain by the calcareous limestone bedrock of the Bobcaygeon Formation. The surface of the bedrock was encountered at a depth of 13.3 m below



the ground surface (El. 56.8 m). The borehole was terminated in the bedrock formation at a depth of 16.9 m (El. 53.2 m). Core samples recovered from the bedrock in Borehole 09-05 indicated that the bedrock is generally fresh and grey with occasional sub-vertical joints. The Total Core Recovery (TCR) of the bedrock ranges from 94 to 100% while the Rock Quality Designation (RQD) ranges from 94 to 100% and improves with depth.

Point load testing carried out on the bedrock recovered from the borehole indicate that the equivalent Unconfined Compressive Strength (UCS) of the limestone ranges from 10 to 125 MPa indicating a weak to very strong bedrock.

The groundwater level was not measured following completion of drilling operations due to the use of drilling fluid during coring operations.

## **6 MISCELLANEOUS**

Thurber marked the borehole locations in the field and obtained utility clearances prior to drilling. MTO Eastern Region Geomatics Section surveyed the as-drilled borehole and test pit locations and recorded the coordinates and ground surface elevations at each location.

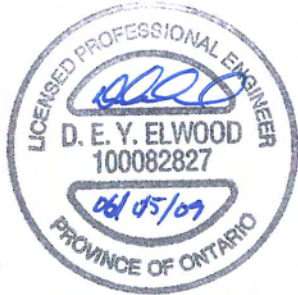
George Downing Estate Drilling Inc. of Grenville-Sur-la-Rouge, Quebec supplied and operated a truck-mounted CME-75 and a track-mounted CME-75 drill rig to conduct the drilling, sampling operations in the paved and median areas respectively.

The initial site inspection was carried out by Dr. Paulo J. Branco, P.Eng. and the subsequent site inspections were carried out by Mr. Alastair E. Gorman, P.Eng. The test pitting, drilling and sampling operations were supervised in the field on a full time basis by Mr. Stephane Loranger and Mr. George Azzopardi of Thurber.

Laboratory testing was carried out by Thurber Engineering Ltd. in its MTO-approved Oakville laboratory.

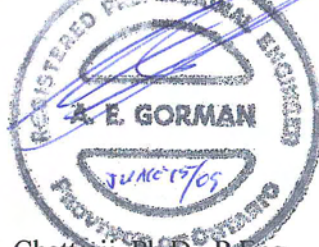
Overall supervision of the field program was performed by Mr. Alastair Gorman, P. Eng. The report was reviewed by Dr. P.K. Chatterji, P. Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



David Elwood, M.Sc., P.Eng.  
Geotechnical Engineer

Alastair E. Gorman, M.Sc., P.Eng.  
Senior Foundations Engineer



P.K. Chatterji, Ph.D., P.Eng.  
Principal, Designated MTO Contact



**FOUNDATION INVESTIGATION AND DESIGN REPORT  
RETAINING WALL DISTRESS  
HIGHWAY 401 / CORNWALL CENTRE ROAD  
CORNWALL, ONTARIO**

**SITE NO. 31-209**

**Geocres Number: 31G - 232**

**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**7 GENERAL**

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist selection and design of short term remedial measures for the existing Highway 401/Cornwall Centre Road west retaining wall. Conceptual schemes for longer term remedial measures are also presented in the report. Additional investigation and design efforts will be required to design the longer term measures.

Twin, single span, 19 m long, overpass structures carry the eastbound and westbound lanes of Highway 401 over Cornwall Centre Road. The structures are on a tangent section and are skewed at an angle of approximately 51° with respect to Highway 401 centreline and they are separated by a 25 m wide median. An approximately 8.0 m high cantilever type retaining wall supports the median on the east and west sides of Cornwall Centre Road.

The existing Highway 401/Cornwall Centre Road west median retaining wall, which previously had been observed to exhibit signs of distress, has recently shown increased signs of movement and distress. The structure is variable in height, decreasing in height from the EBL to the WBL abutments. Grades along the west retaining wall are respectively near El. 70.2 and 69.4 m at the EBL of the Highway 401 and centre median and El. 63.5 m at the Cornwall Centre Road level.

The original G.A. DWG TWP # 31-209-1-A, indicate that the retaining wall was designed to be supported on 4.3 m wide spread footings founded on dense sandy till at El. 59.4 m. However DWG TWP # 31-209-2-A has a note that the footing must be founded on firm clay. The results of the test pits indicate that the founding elevations are somewhere around 61.2 m. A simple conversion of the imperial elevations on the drawing suggests that the footings were to be founded at El. 59.4 m (metric). However, the same conversion shows that the top of the wall adjacent to the WBL should be at El. 67.9 m, as opposed to the surveyed El. 69.3 m. This suggests a change in datum and that the present day surveyed elevations do not correspond to the design elevations.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of the investigation.

## **8 OBSERVATIONS FROM TEST PITTING AND BOREHOLES**

### **8.1 Test Pits**

While the visual examination of the exposed west retaining wall indicates outward bulging of the upper part of the wall and noticeable vertical cracking, none of the test pits revealed any obvious cracking or crushing of concrete at the footing/wall interface. No obvious signs of footing/wall translation or bearing capacity failure were noted in any of the test pits.

TP09-03 indicated a wall rotation of 12 mm over 1.2 m length into the test pit and the footing toe was 35 mm higher than at the wall/footing interface. However no cracking was visible at the wall/footing interface, suggesting that the footing may have been formed in this manner.

The test pits revealed that the top of the wall footings are at 1.6 to 1.9 m depth below the road level and the footing width in front of the wall, where it could be measured, is 1.0 to 1.5 m.

### **8.2 Boreholes**

Based on boreholes drilled behind the wall, the wall appears to be founded on compact to very dense sand and silt till, though it is possible that they are partially founded on hard clay. Both of these founding conditions agree with what the designers envisioned for founding strata.

Borehole 09-04 drilled in front of the wall indicates that based on the design footing founding level of 61.2 m, the retaining wall footing is founded close to the contact between fill and the underlying compact to very dense silty sand till, which is underlain by limestone bedrock at El. 56.5 m.

The backfill behind both the west and east walls extends to 6.7 to 7.7 m depth. The upper 4 to 6 m of wall backfill consists of silty sand with a fines content of 33% to 48% and the backfill appears to resemble a reworked glacial till. This upper backfill does not meet the specification for either Granular 'A' or Granular 'B' Type I materials. The lower 1 to 3 m of the wall backfill above the weeper is a cleaner sand and gravel. The water level noted during the investigation throughout the site is at approximately the base of the backfill.

The backfill adjacent to Highway 401 bridge abutment is a sand and gravel fill which has less fines content ranging from 13 to 19%. This backfill meets the Granular 'B' Type I specification except for the fines content.

### **8.3 Monitoring Data**

The west wall monitoring data provided by the MTO indicates that the displacement of the wall has increased from when the data starts in April 2007 to May 2009. The greatest increase in displacement, 12.4 mm, has occurred adjacent to the EBL where the wall is in hard contact with the bridge soffit.

The data shows a maximum of 5.8 mm of movement from October 2007 to April 2008 and a maximum increase in displacement of 7.7 mm from October 2008 to May 2009. Between these increases, the displacement readings are constant or reduce slightly, indicating seasonal effects possibly linked to higher water levels and/or forces due to freezing of the backfill. The displacements monitored in the spring of 2009 indicate an increase in displacement with time.

The limited number of annual cycles available indicates that the rate of displacement may be accelerating.

## **9 GEOTECHNICAL ASSESSMENT**

- The distress at the site appears, for all practical purposes, to be limited to the west median retaining wall. The foundation investigation and site inspection did not reveal any evidence to suggest that there are geotechnical issues requiring investigation at the other retaining walls or the abutments. It is understood that a structural assessment is concurrently underway to establish if there are structural issues that have contributed to the observed distress at the west retaining wall;
- The test pits and boreholes confirm that the wall appears to be founded on a compact to very dense sand and silt till as envisioned in the original design;
- No evidence was found to indicate failure or movement of the wall foundation either in sliding, rotation or bearing. There was no evidence of cracking or spalling of the wall stem at any of the exposed footing locations;
- The upper 4 to 6 m of wall backfill consists of silty sand with a fines content of 33% to 48% and the backfill appears to resemble a reworked glacial till. The lower 1 to 3 m of the wall backfill above the weeper is a cleaner sand and gravel. The water level noted during the investigation throughout the site is at approximately the base of the backfill. The backfill adjacent to Hwy 401 bridge abutment has less fines content ranging from 13 to 19%;
- The median behind the west retaining wall appears to collect surface drainage from at least 20 m of the median. During wet periods this collection of surface water is likely to saturate the upper, silty backfill which will not drain as quickly as the lower cleaner granular backfill. This will result in transient increase in the earth pressure loading on the wall. This situation may occur every year and may be contributing to the continuing movement of the wall. Frost action in the fine grained soils followed by the spring thaw may also have a role in the wall movement from October to April each year;
- A cursory review of the retaining wall design drawings also indicates the possibility that the width of the wall footing (14 ft or 4.3 m) may not be adequate for an 8 m high wall. Since this is not a geotechnical issue, the structural consultant should review this aspect. The structural review may indicate other structural reasons for the wall distress or a

combination of structural reasons and the above geotechnical assessment of additional seasonal lateral pressure on the wall may better explain the noted distress.

## **10 GEOTECHNICAL CONCLUSIONS**

While it is evident that the wall is suffering distress and that displacement is continuing, no evidence of problems related to geotechnical resistance was uncovered, i.e. no signs of bearing capacity failure, sliding or rotation.

There is evidence however that the upper portion of the backfill behind the west wall is of lower quality than would be considered acceptable, and probably lower than assumed by the designers. The quality of the fill results in earth pressures on the wall that are probably higher than assumed in design. The poor quality backfill material may not be free draining, allowing an accumulation of groundwater during wet seasons increasing the pressure acting on the face of the wall. This results in a geotechnical driving force that may be higher than that contemplated in the original design. The accumulation of water in the moderately frost susceptible soils would also increase the likelihood of frost action. Combinations of these factors may be contributing to the wall movement each year

## **11 CONCEPTUAL REMEDIAL OPTIONS**

Considering the extent and the apparent nature of the west retaining wall distress, remedial action is recommended for stabilizing the west wall prior to opening Cornwall Centre Road. The remedial work has been divided into short term and longer term measures. The short term measures are designed to slow the current movement of the west wall which in turn would allow for Cornwall Centre Road to be opened to traffic until such time that the longer term measures are implemented. It is understood that any short term measures may need to be in place for four years or more. The design must consider the effects of several cycles of winter and spring conditions and freeze/thaw conditions. In design of the remedial measures, care must be taken to minimize the potential for damage to Highway 401.

### **11.1 Short Term Measures**

#### **11.1.1 Unloading Behind the Wall**

In order to reduce the driving forces acting on the west retaining wall, it is recommended that a minimum depth of 1.2 m of backfill be removed from behind the wall. The excavation to achieve this unloading should extend horizontally for a distance of 4 m behind the retaining wall and then be graded up at a slope not exceeding 2H:1V to meet the existing ground surface.

Immediately behind the retaining wall, the soil removal can be contained between the median-side wing walls of each structure, provided that structural analysis shows that the wing walls can safely support the highway fill after the median fill has been excavated. If the wing walls cannot support the loads from the highway fill, then the zone of unloading should be sloped at 2H:1V

against the wing walls. Similarly where the zone of unloading extends beyond the wing walls, the side slopes from the edge of shoulder should not exceed 2H:1V.

The resulting excavation must be reviewed by traffic engineering staff in the context of roadside safety and the necessary guiderails, barriers, etc. must be incorporated in the design.

The recommended excavation will tend to attract local highway and median drainage and it is recommended that consideration be given to providing suitable drainage to remove this water.

It is recommended that no equipment approach closer than 4 m from the back of the wall. No stockpiling of material should be permitted within 8 m of the back of the wall.

### **11.1.2 Deadman Anchors**

Based on discussions with the Structural Consultant, AECOM, it is understood that unloading behind the wall alone may not increase the safety of the west wall sufficiently and additional stabilization measures involving the installation of tiebacks attached to a deadman anchorage system is being considered. The deadman anchor system will be designed by AECOM. Soil parameters to be used for the design of the anchor system are provided in a subsequent section.

The deadman anchor block should be set back from the wall a suitable distance to avoid the overlap of the passive earth pressure zone with the zone of the active earth pressure behind the wall. Based on a 1.2 m depth of unloading, a minimum set back distance of 8 to 10 m is suggested between the anchor block and the back of the wall.

The anchor blocks must be cast in intimate contact with the surrounding fill or, if shoring or formwork is used to cast the anchor blocks, the space between the silty sand fill and the concrete anchor block must be grouted or backfilled with granular fill and compacted to a minimum of 98% of the Standard Proctor Maximum Dry Density (SPMDD).

Where excavations for the deadman anchor blocks are located in close proximity to live traffic lanes, temporary shoring may be required to retain the embankment fill and native soils during installation. Temporary shoring in the form of trench boxes or steel H-Piles with timber lagging may be considered. Temporary shoring should be designed by a licensed Professional Engineer experienced in design of shoring with special consideration of traffic loads and any sloping retaining surfaces. If shoring is required during construction to retain excavations adjacent to Highway 401, an item titled "Roadway Protection" as per SP539S01 should be included in the contract documents. Performance Level 2 is recommended as per Clause 539.04.02.01. Design parameters for the design of temporary highway protection are provided below in Tables 12.1 and 12.2.

In order to minimize any destabilizing effect of an anchor block excavation on the existing Highway 401 embankments, consideration may be given to casting a single anchor block in the central part of the median and connecting all anchors to the same block.

All excavations and temporary shoring design (if required) for installing the deadman system must be carried out in accordance with the requirements of the Ontario Health and Safety Act (OHSA). The temporary excavations must not destabilize the existing Highway 401 embankments. The silty sand fill is classed as a Type 3 soil for the purpose of OHSA. No stockpiling of excavated soil or new fill should be done within 8.0 m of the west retaining wall.

### **11.1.3 Wall Monitoring Program**

It is recommended that monitoring of the west wall movements continue on a weekly basis until it is clear that the short term remedial measures have arrested the movement. The monitoring should extend at least until May of 2010, which will document the movements of the wall through at least another freeze-thaw cycle.

Visual inspection of the site should also be carried out on a weekly basis until at least May, 2010.

### **11.2 Longer Term Measures**

The longer term measures could include either partial or complete removal of the west retaining wall, or reconstruction of the wall.

If partial or complete removal of the wall is considered, it can be assumed that the median fill can be safely graded at an inclination of 2H:1V. This option would require the installation of permanent roadway protection to support the highway and could have significant implications for roadside safety. Design parameters have been provided for highway protection below in Tables 12.1 and 12.2.

If it is decided to reconstruct the wall, the soil conditions encountered on site are considered to be suitable for the support of either a cantilevered concrete wall or a RSS wall.

All long term solutions must:

- Take full account of the geotechnical conditions encountered at the site
- Be designed in collaboration with the structural engineer
- Take account of the service life, i.e. date of future structure rehabilitation

## **12 GEOTECHNICAL PARAMETERS FOR DESIGN OF REMEDIAL MEASURES**

The geotechnical design parameters required for the design of temporary (short term) and longer term remedial measures of the retaining wall have been assessed based on the results of the subsurface investigation carried out on both sides of the structure. The active side of the wall (behind the structure) were assessed from the observations of Borehole 09-03 and the passive wall parameters were assessed based on the results of the borehole drilled through Cornwall Centre Road (Borehole 09-04).

For each deposit encountered in the respective boreholes, the Bulk Unit Weight ( $\gamma$ ), Friction Angle ( $\phi^\circ$ ), Active Coefficient of Lateral Earth Pressure ( $K_a$ ), Passive Coefficient of Lateral Earth Pressure ( $K_p$ ) and the At Rest Coefficient of Lateral Earth Pressure ( $K_o$ ) have been provided



below in Table 12.1 and 12.2. The parameters assumes horizontal backfill surface for both the active and passive sides.

**Table 12.1 Geotechnical Parameters (Active Side)**

Depth (m)	Material	Bulk Unit Wt. (kN/m <sup>3</sup> )	Friction Angle (°)	Active Coefficient (K <sub>a</sub> )	Passive Coefficient (K <sub>p</sub> )	Coefficient At Rest (K <sub>o</sub> )
0 - 1.4	Clayey Silt Fill	20	28	0.36	2.8	0.53
1.4 - 5.3	Silty Sand Fill	22	29	0.35	2.85	0.52
5.3 - 6.8	Sand & Gravel Fill	23	32	0.31	3.3	0.47
6.8 - 8.1	Silty Clay	19	28	0.36	2.8	0.53
8.1 - 12.1	Sand & Silt Till	23	32	0.31	3.3	0.47

**Table 12.2 Geotechnical Parameters (Passive Side)**

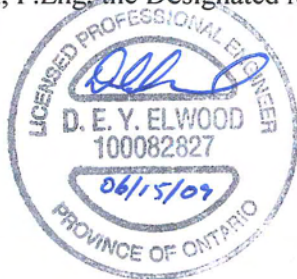
Depth (m)	Material	Bulk Unit Wt. (kN/m <sup>3</sup> )	Friction Angle (°)	Active Coefficient (K <sub>a</sub> )	Passive Coefficient (K <sub>p</sub> )	Coefficient At Rest (K <sub>o</sub> )
0 - 0.7	Gravelly Sand Fill	23	30	0.33	3.0	0.5
0.7 - 2.6	Silty Sand Fill	22	29	0.35	2.85	0.52
2.6 - 6.9	Sand & Silt Till	23	32	0.31	3.3	0.47

The borehole logs provide the elevations of the various stratigraphic units and the water levels observed in the boreholes. Submerged unit weights should be used for soils below the groundwater table.

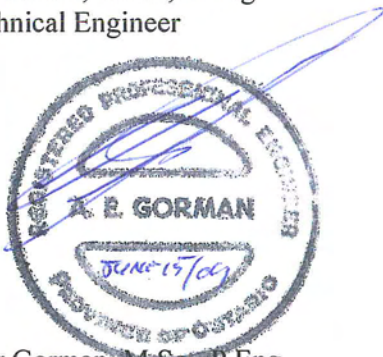
The footing for the wall appears to be founded on the compact to dense sand and silt till. The bearing resistance for the sand and silt till is 375 kPa for a factored ULS and 250 kPa for the SLS.

### 13 CLOSURE

Engineering analysis and preparation of this foundation design report was carried out by Mr. David Elwood, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng and Dr. P.K. Chatterji, P.Eng, the Designated MTO Contact.



David Elwood, M.Sc., P.Eng.  
Geotechnical Engineer



Alastair Gorman, M.Sc., P.Eng.  
Associate, Senior Foundations Engineer



P.K. Chatterji, Ph.D., P.Eng.  
Principal, Designated MTO Contact

**APPENDIX A**

**RECORD OF BOREHOLE SHEETS**

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT <sup>(1)</sup> 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

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



### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

### 5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$






 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT              Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

# UNIFIED SOILS CLASSIFICATION

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

## EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION		SYMBOLS	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.

TERMS					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Uniaxial Compressive Strength (UCS)	Axial Stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.				

# RECORD OF BOREHOLE No 09-01

1 OF 2

METRIC

G.W.P. 15-64-19 LOCATION 4 991 153.6 N 203 386.3 E ORIGINATED BY SLL  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Rods COMPILED BY SLL  
 DATUM Geodetic DATE 2009-12-05 - 2009-12-05 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 09-01

2 OF 2

METRIC

G.W.P. 15-64-19 LOCATION 4 991 153.6 N 203 386.3 E ORIGINATED BY SLL  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Rods COMPILED BY SLL  
 DATUM Geodetic DATE 2009-12-05 - 2009-12-05 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
	Continued From Previous Page							20 40 60 80 100 40 80 120 160 200					
58.8	<b>SAND</b> , some gravel, trace silt Dense Grey Wet  <b>SAND &amp; SILT</b> , some clay, trace gravel Compact to Very Dense Grey Moist (TILL)												
10.2			13	SS	25								
			1.5	SS	100/ .125								
55.7	<b>LIMESTONE BEDROCK</b> , fresh, grey, with some rubble zones from 13.7 to 13.8m. Vertical joints from 13.5 to 13.7m and 14.0 to 14.2m. Cohesive till layer at 15.2m for 25mm.												
13.3			1	RUN									
			2	RUN									
52.2													
16.7	END OF BOREHOLE AT 16.7m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) May 13, 09 6.7 62.3 May 15, 09 6.4 62.6 May 19, 09 6.6 62.4 May 20, 09 6.7 62.3												

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

20  
15  
10

(%) STRAIN AT FAILURE

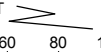


# RECORD OF BOREHOLE No 09-02

1 OF 2

METRIC

G.W.P. 15-64-19 LOCATION 4 991 153.46 N 203 341.9 E ORIGINATED BY SLL  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL  
 DATUM Geodetic DATE 2009-11-05 - 2009-11-05 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
69.4														
0.0								○ UNCONFINED + FIELD VANE						
0.1	<b>SOD:</b> (75mm)							● QUICK TRIAXIAL × LAB VANE						
	Silty <b>SAND</b> , some clay, trace gravel Dense to Compact Brown Moist (FILL)		1	SS	40		69							
			2	SS	23		68							2 50 39 10
			3	SS	21									
	Loose		4	SS	4		67							
			5	SS	7		66							
	Compact		6	SS	13		65							5 48 37 10
64.7			7	SS	22		64							
4.7	Silty <b>CLAY</b> , some sand, trace gravel, trace organic material Very Stiff to Stiff Brown Moist		8	SS	12									1 25 42 32
63.1			9	SS	17		63							
6.3	<b>SAND &amp; SILT</b> , some clay, trace gravel Compact Brown to Grey Moist (TILL)		10	SS	16		62							2 46 39 13
			11	SS	57		61							
	Very Dense		12	SS	100/ 275		60							
			13	SS	58									4 44 42 11

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 09-02

2 OF 2

METRIC

G.W.P. 15-64-19 LOCATION 4 991 153.46 N 203 341.9 E ORIGINATED BY SLL  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL  
 DATUM Geodetic DATE 2009-11-05 - 2009-11-05 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL												
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									WATER CONTENT (%)											
	Continued From Previous Page																											
	<b>SAND &amp; SILT</b> , some clay, trace gravel Very Dense Grey Moist (TILL)		14	SS	100/ .125		59																					
57.2							58																					
57.2	<b>LIMESTONE BEDROCK</b> , weathered		16	SS	100/ .025																							
12.2	END OF BOREHOLE AT 12.2m. PROBABLE BEDROCK SURFACE. BOREHOLE OPEN AND WATER LEVEL AT 10.5m ON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH (m)</th> <th>ELEV. (m)</th> </tr> </thead> <tbody> <tr> <td>May 13, 09</td> <td>5.3</td> <td>64.1</td> </tr> <tr> <td>May 15, 09</td> <td>5.7</td> <td>63.7</td> </tr> <tr> <td>May 19, 09</td> <td>5.8</td> <td>63.6</td> </tr> <tr> <td>May 20, 09</td> <td>5.9</td> <td>63.5</td> </tr> </tbody> </table>	DATE	DEPTH (m)	ELEV. (m)	May 13, 09	5.3	64.1	May 15, 09	5.7	63.7	May 19, 09	5.8	63.6	May 20, 09	5.9	63.5												
DATE	DEPTH (m)	ELEV. (m)																										
May 13, 09	5.3	64.1																										
May 15, 09	5.7	63.7																										
May 19, 09	5.8	63.6																										
May 20, 09	5.9	63.5																										

# RECORD OF BOREHOLE No 09-03

1 OF 2

METRIC

G.W.P. 15-64-19 LOCATION 4 991 153.0 N 203 353.3 E ORIGINATED BY SLL  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL  
 DATUM Geodetic DATE 2009-11-05 - 2009-11-05 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE							WATER CONTENT (%)		
69.4								20	40	60	80	100					
0.9 0.1	<b>SOD: (75mm)</b>  Clayey <b>SILT</b> , some sand, trace gravel, organic stained Very Soft to Stiff Brown Moist (FILL)		1	SS	1		69							○			Grinding Auger
			2	SS	10									○			
67.9			3	SS	100/ .100		68							○			
1.4	Silty <b>SAND</b> , some clay, trace gravel Very Dense to Dense Brown Moist to Wet (FILL)		4	SS	38		67							○			
			5	SS	33		66							○			
			6	SS	22		65							○			
	Compact		7	SS	13									○			
64.1							64							○			
5.3	<b>SAND &amp; GRAVEL</b> , trace to some silt Compact Brown Moist (FILL)		8	SS	22									○			
	Loose		9	SS	9		63										
62.6																	
6.8	Silty <b>CLAY</b> , some sand, trace gravel Firm to Soft Grey Moist		10	SS	4		62							○			
			1	ST										○			
61.3							61							○			
8.1	<b>SAND &amp; SILT</b> , some clay, trace gravel Compact Grey Moist (TILL)		11	SS	19									○			
			12	SS	17		60										

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 09-03

2 OF 2

METRIC

G.W.P. 15-64-19 LOCATION 4 991 153.0 N 203 353.3 E ORIGINATED BY SLL  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SLL  
 DATUM Geodetic DATE 2009-11-05 - 2009-11-05 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL															
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100																				
	Continued From Previous Page																															
57.3	SAND & SILT, some clay, trace gravel Compact Grey Moist (TILL) Very Dense		13	SS	18											3 50 38 10																
			14	SS	100																											
58																																
12.1	END OF BOREHOLE AT 12.1m. PROBABLE BEDROCK SURFACE. BOREHOLE OPEN AND WATER LEVEL AT 9.9m ON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH (m)</th> <th>ELEV. (m)</th> </tr> </thead> <tbody> <tr> <td>May 13, 09</td> <td>6.0</td> <td>63.4</td> </tr> <tr> <td>May 15, 09</td> <td>6.3</td> <td>63.1</td> </tr> <tr> <td>May 19, 09</td> <td>6.4</td> <td>63.0</td> </tr> <tr> <td>May 20, 09</td> <td>6.4</td> <td>63.0</td> </tr> <tr> <td>May 26, 09</td> <td>6.3</td> <td>63.1</td> </tr> </tbody> </table>	DATE	DEPTH (m)	ELEV. (m)	May 13, 09	6.0	63.4	May 15, 09	6.3	63.1	May 19, 09	6.4	63.0	May 20, 09	6.4	63.0	May 26, 09	6.3	63.1													
DATE	DEPTH (m)	ELEV. (m)																														
May 13, 09	6.0	63.4																														
May 15, 09	6.3	63.1																														
May 19, 09	6.4	63.0																														
May 20, 09	6.4	63.0																														
May 26, 09	6.3	63.1																														

# RECORD OF BOREHOLE No 09-04

1 OF 2

METRIC

G.W.P. 15-64-19 LOCATION 4 991 151.7 N 203 362.6 E ORIGINATED BY SLL  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Rods COMPILED BY SLL  
 DATUM Geodetic DATE 2009-05-15 - 2009-05-15 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
63.4								20 40 60 80 100					
0.0	ASPHALT: (100mm)		1	AS				40 80 120 160 200					GR SA SI CL
0.1	Gravelly <b>SAND</b> , some silt Brown Moist (FILL)												45 39 16 (SI+CL)
62.7			2	SS	12								
0.7	Silty <b>SAND</b> , some clay to clayey, trace gravel, trace rootlets Compact Brown Moist (FILL)		3	SS	12								2 46 38 14
			4	SS	18								
60.8			5	SS	15								
2.6	Silty <b>SAND</b> , some clay, trace gravel Compact Brown to Grey Moist (TILL)		6	SS	18								9 51 31 10
			7	SS	22								
			8	SS	100/ 275								
	Very Dense		9	SS	87								7 46 36 10
56.5													
6.9	<b>LIMESTONE BEDROCK</b> , fresh, grey, sub-vertical joints from 9.0 to 9.1m.		1	RUN								FI	RUN 1# TCR=100%, SCR=75%, RQD=100%, UCS=MPa
			2	RUN								0	RUN 2# TCR=97%, SCR=93%, RQD=97%, UCS=MPa
			3	RUN								0	RUN 3# TCR=100%, SCR=100%, RQD=100%,

Continued Next Page

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

20  
15 5  
10  
(%) STRAIN AT FAILURE

## METRIC

[illegible]

# RECORD OF BOREHOLE No 09-05

1 OF 2

METRIC

G.W.P. 15-64-19 LOCATION 4 991 142.6 N 203 323.9 E ORIGINATED BY SLL  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Rods COMPILED BY SLL  
 DATUM Geodetic DATE 2009-05-13 - 2009-05-14 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
70.2								20	40	60	80	100		
0.0	ASPHALT: (175mm)						70							
0.2	CONCRETE: (325 mm)													
69.7														
0.5	SAND & GRAVEL, trace to some silt Very Dense to Compact Brown Moist (FILL)		1	SS	70		69							37 45 18 (SI+CL)
			2	SS	24		68							
			3	SS	25									
	Dense		4	SS	31		67							44 42 13 (SI+CL)
			5	SS	26		66							38 42 19 (SI+CL)
			6	SS	16		65							
	Loose		7	SS	6									37 48 15 (SI+CL)
			8	SS	14		64							
63.4														
6.8	Silty CLAY, some sand, trace gravel, Loose Brown Moist		9	SS	6		63							2 36 42 20
62.5														
7.7	SAND & SILT, some clay, trace to some gravel Compact to Very Dense Grey Moist (TILL)		10	SS	18		62							7 45 39 9
			11	SS	100/ 275									
			12	SS	100/ 200		61							15 42 42 (SI+CL)

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

## METRIC

[illegible]

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

























# RECORD OF BOREHOLE No 09-06

1 OF 1

METRIC

G.W.P. 15-64-19 LOCATION 4 991 157.8 N 203 361.9 E ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2009-05-19 - 2009-05-19 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR  SA  SI  CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20    40    60    80    100						
69.2														
0.0	<b>SOD:</b> 100 mm													
0.2	Silty <b>SAND</b> , some gravel, trace clay, occasional limestone fragments Brown Loose Moist to Wet (FILL)		1	SS	4		69							
														
			2	SS	3		68							6  47  37  9
														
	Compact		3	SS	23		67							10  52  31  7
														
			4	SS	20		66							
														
			5	SS	26		65							16  51  26  7
65.4														
3.7	<b>SAND &amp; GRAVEL</b> , trace silt Dense to Compact Brown Moist (FILL)		6	SS	30		64							
														
			7	SS	34		63							43  41    16 (SI+CL)
														
	Organic Staining		8	SS	28		62							41  43    16 (SI+CL)
														
	Loose Grey Wet		9	SS	6		61							
62.3														
6.9	Silty <b>CLAY</b> , some sand, trace gravel Hard Grey Moist		10	SS	50/ .150		60							2  37  34  28
														
61.2			11	SS	50/ .150		59							
7.9	END OF BOREHOLE AT 7.9m Open borehole groundwater level at 6.4m depth upon completion. Borehole backfilled with holeplug to ground surface.						58							

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 09-07

1 OF 1

METRIC

G.W.P. 15-64-19 LOCATION 4 991 149.0 N 203 380.0 E ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2009-05-20 - 2009-05-20 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								20 40 60 80 100 40 80 120 160 200								
69.1								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w <sub>p</sub> w w <sub>L</sub> WATER CONTENT (%)			
0.0	SOD: 100 mm						69								GR SA SI CL	
0.2	Silty <b>SAND</b> , trace to some clay, trace gravel Loose Brown Moist (FILL)		1	SS	7		69									
			2	SS	6		68									3 49 36 11
			3	SS	50/ .075		67									Split Spoon Bouncing
			4	SS	26		66									6 50 36 8
			5	SS	45		65									3 49 38 10
			6	SS	24		64									8 49 34 9
			7	SS	21		63									
			8	SS	5		62									
63.0																
6.1	<b>SAND &amp; GRAVEL</b> Compact Brown Wet (FILL)		9	SS	25		63								40 44 16 (SI+CL)	
62.4																
6.7	Silty <b>CLAY</b> , some sand Firm Grey Moist		10	SS	6		62									
			11	SS	6		61								0 18 31 51	
60.8																
8.2	END OF BOREHOLE AT 8.2m Open borehole groundwater level at 6.7m depth upon completion. Borehole backfilled with holeplug to ground surface.															

ONTMT4S 6419.GPJ 28/5/09

# RECORD OF BOREHOLE No 09-08

1 OF 1

METRIC

G.W.P. 15-64-19 LOCATION 4 991 147.2 N 203 386.5 E ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2009-05-20 - 2009-05-20 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
68.9								20 40 60 80 100							
0.0	<b>SOD: 75 mm</b>							40 80 120 160 200							
0.1	Silty <b>SAND</b> , some clay, trace gravel Brown Compact Moist (FILL)		1	SS	19		68								6 47 36 12
			2	SS	25										
	Dense		3	SS	33										9 47 35 9
			4	SS	27										
66.0							66								
3.0	<b>SAND &amp; GRAVEL</b> , some silt Very Dense Brown Moist (FILL)		5	SS	80										29 42 29 (SI+CL)
65.2															
3.7	Silty <b>SAND</b> , some clay, trace gravel Dense to Compact Brown Moist (FILL)		6	SS	48		65								4 51 34 11
			7	SS	28		64								
			8	SS	31										4 49 34 13
62.8							63								
6.1	Silty <b>CLAY</b> , some sand, trace gravel, trace organics Firm Mottled Brown/Grey Moist		9	SS	8										2 12 32 54
62.2															
6.7	END OF BOREHOLE AT 6.7m Borehole open and dry upon completion. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE        DEPTH (m)        ELEV. (m)														

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 09-09

1 OF 1

METRIC

G.W.P. 15-64-19 LOCATION 4 991 148.6 N 203 347.7 E ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2009-05-19 - 2009-05-19 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
69.5								20	40	60	80	100		
0.0	SOD: 75 mm							40	80	120	160	200		
0.2	SAND & GRAVEL, trace to some silt Compact Brown Moist (FILL)		1	SS	12		69						○	23 63 14 (SI+CL)
			2	SS	14		68						○	
	Loose		3	SS	7		67						○	26 43 32 (SI+CL)
	Dense		4	SS	32		66						○	58 31 11 (SI+CL)
			5	SS	22		65						○	
	Compact		6	SS	31		64						○	23 47 30 (SI+CL)
			7	SS	22		63						○	
	Dense		8	SS	40		62						○	43 45 12 (SI+CL)
	Loose		9	SS	10								○	
	Compact		10	SS	16								○	53 38 10 (SI+CL)
62.0														
7.5	Silty CLAY, some sand, trace gravel Hard Grey Moist		11	SS	50/ 125								○	5 37 37 21
61.4														
8.1	END OF BOREHOLE AT 8.1m Open borehole groundwater level at 6.5m depth upon completion. Borehole backfilled with holeplug to ground surface.													

ONTMT4S 6419.GPJ 28/5/09

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 09-10

1 OF 1

METRIC

G.W.P. 15-64-19 LOCATION 4 991 145.1 N 203 372.7 E ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2009-05-20 - 2009-05-20 CHECKED BY DEE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100 40 80 120 160 200						
69.4														
0.0	<b>SOD: 75 mm</b>													
0.1	Silty <b>SAND</b> , trace to some clay, trace gravel Brown Loose Moist (FILL) Compact		1	SS	7		69						○	
			2	SS	10		68						○	2 50 37 10
			3	SS	17		67						○	
			4	SS	13		66						○	3 50 33 15
	Loose		5	SS	4		65						○	
			6	SS	4		64						○	
	Very Loose		7	SS	3		63						○	6 52 33 10
	Loose		8	SS	4		62						○	
63.3														
6.1	<b>SAND &amp; GRAVEL</b> , trace silt Compact Brown Moist (FILL)		9	SS	16		63						○	47 38 15 (SI+CL)
			10	SS	50/ .150		62						○	72 22 6 (SI+CL)
61.7			11	SS	50/								○	
7.7	END OF BOREHOLE AT 7.7m Open borehole groundwater level at 7.3m depth upon completion. Borehole backfilled with holeplug to ground surface.				.075									

ONTMT4S 6419.GPJ 28/5/09

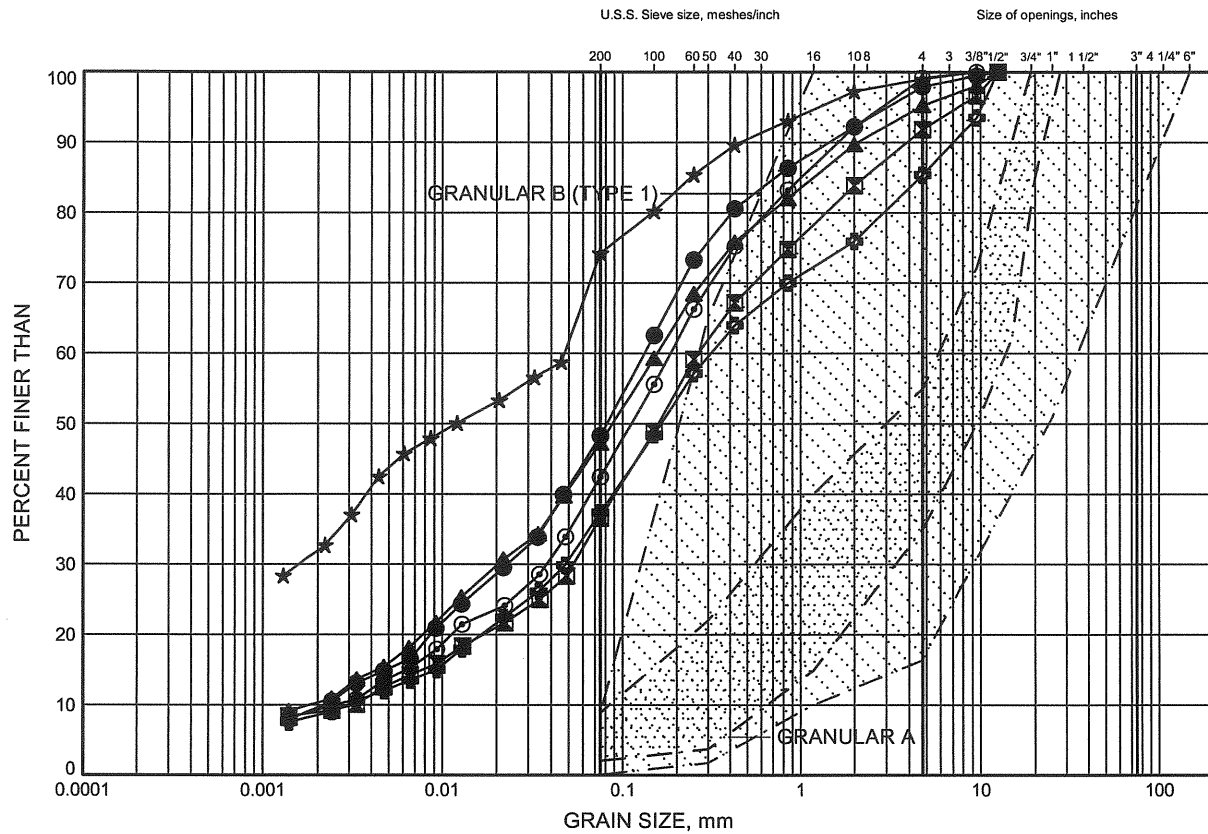
## **APPENDIX B**

### **GEOTECHNICAL LABORATORY TEST RESULTS**

# Cornwall Centre Road GRAIN SIZE DISTRIBUTION

FIGURE B1

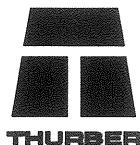
## WEST RETAINING WALL BACKFILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-02	1.07	68.32
⊠	09-02	2.59	66.79
▲	09-02	4.11	65.27
★	09-02	5.64	63.74
⊙	09-03	2.59	66.80
⊕	09-03	3.35	66.04

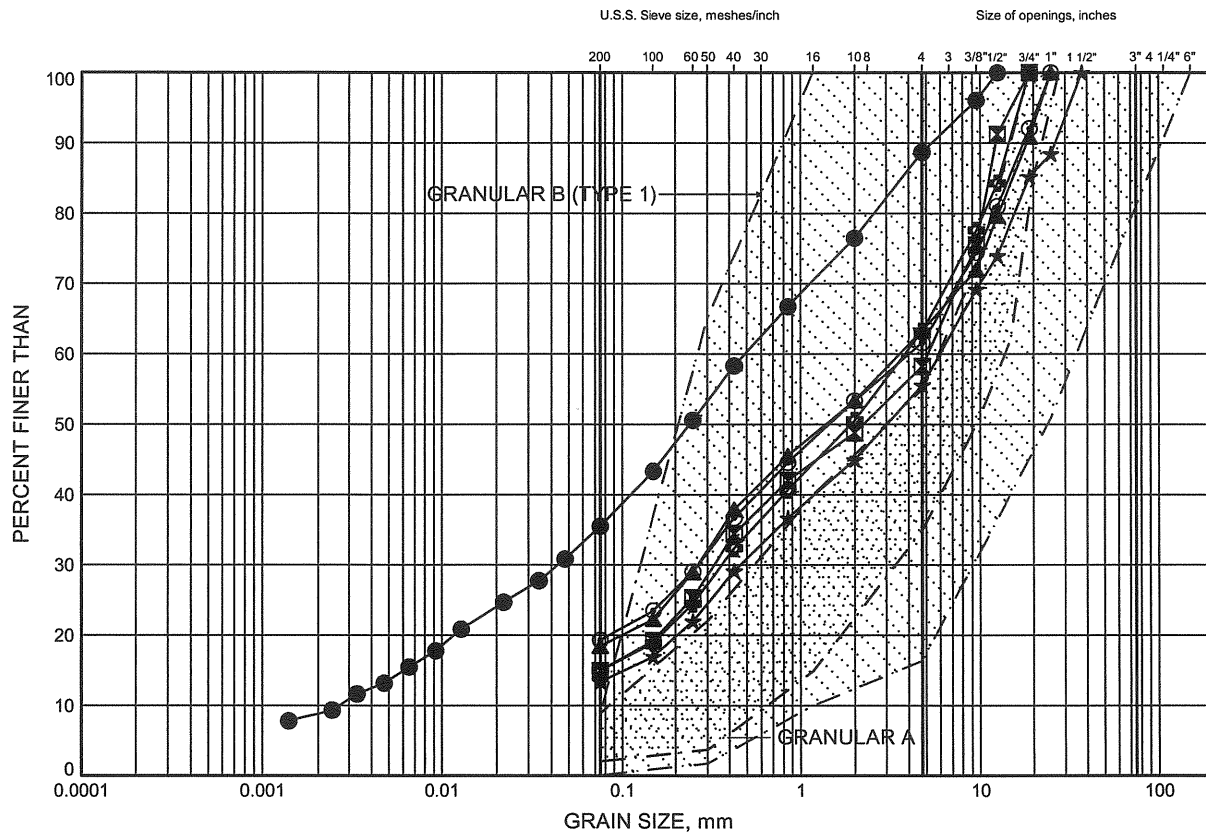


W.P.# ..15-64-19.....  
Prepared By .MFA.....  
Checked By .DEE.....

# Cornwall Centre Road GRAIN SIZE DISTRIBUTION

FIGURE B2

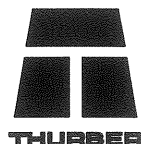
## WEST RETAINING WALL BACKFILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-03	4.88	64.52
⊠	09-03	5.64	63.75
▲	09-05	1.07	69.10
★	09-05	3.35	66.82
⊙	09-05	4.11	66.06
⊕	09-05	5.64	64.53



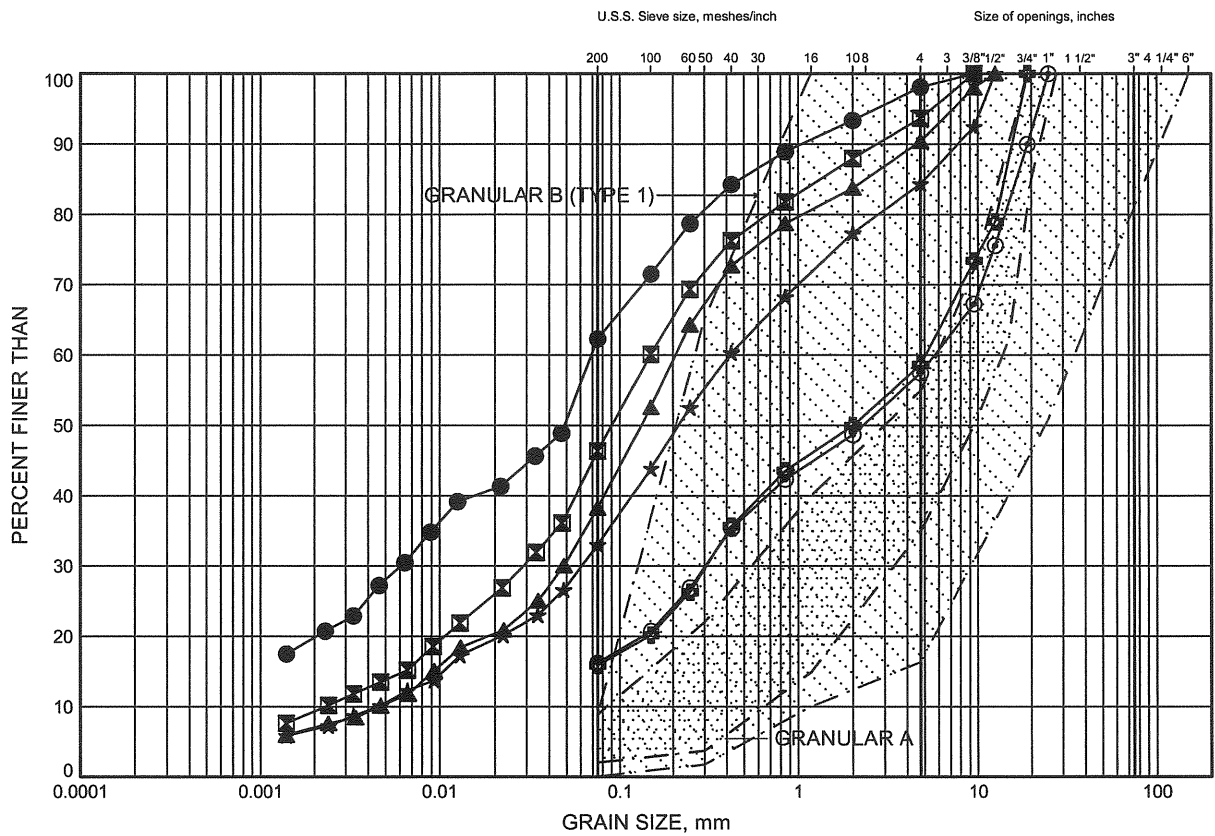
W.P.# 15-64-19  
Prepared By MFA  
Checked By DEE



Cornwall Centre Road  
GRAIN SIZE DISTRIBUTION

FIGURE B3

WEST RETAINING WALL BACKFILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-05	7.16	63.01
⊠	09-06	1.07	68.10
▲	09-06	1.83	67.33
★	09-06	3.35	65.81
⊙	09-06	4.88	64.29
⊕	09-06	5.64	63.52

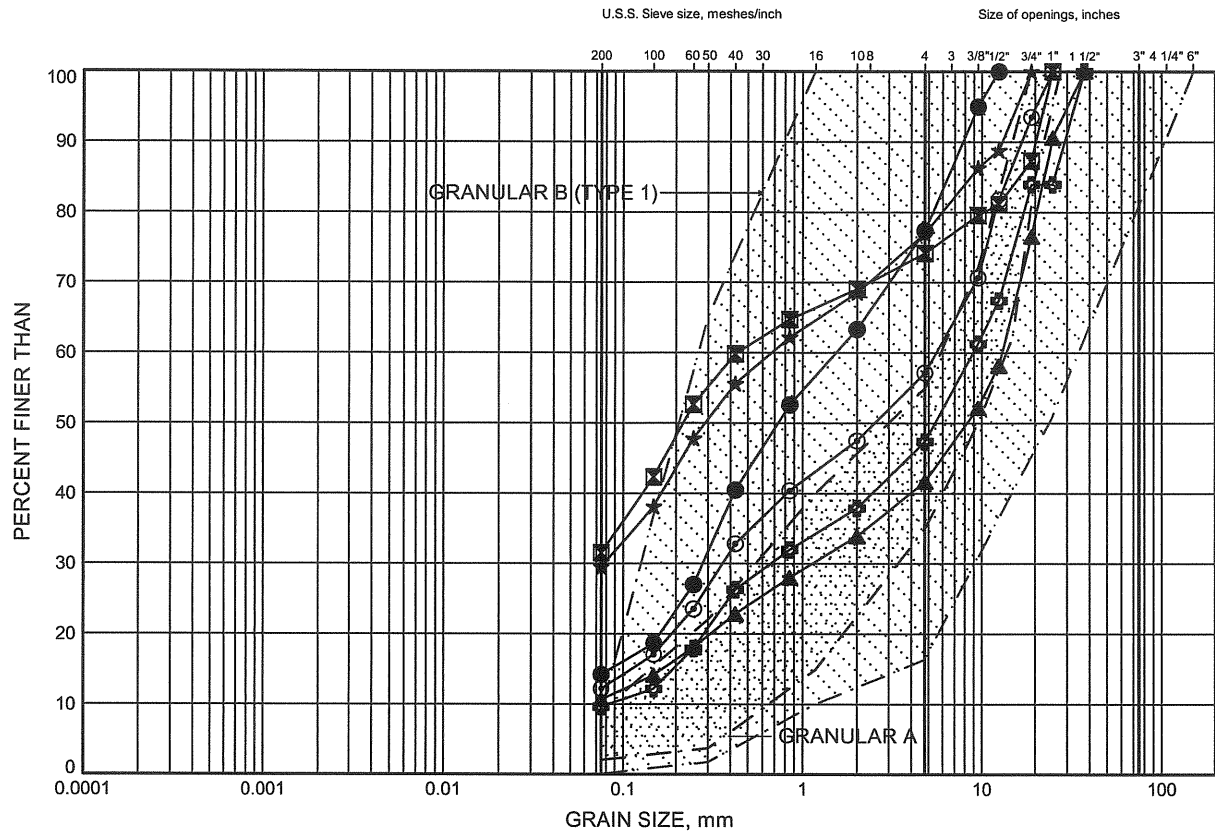


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Checked By .DEE.....

# Cornwall Centre Road GRAIN SIZE DISTRIBUTION

FIGURE B4

## WEST RETAINING WALL BACKFILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-09	0.30	69.18
⊠	09-09	1.83	67.65
▲	09-09	2.59	66.89
★	09-09	4.11	65.37
⊙	09-09	5.64	63.84
⊕	09-09	7.16	62.32

GRAIN SIZE DISTRIBUTION - THURBER 6419.GPJ 15/6/09

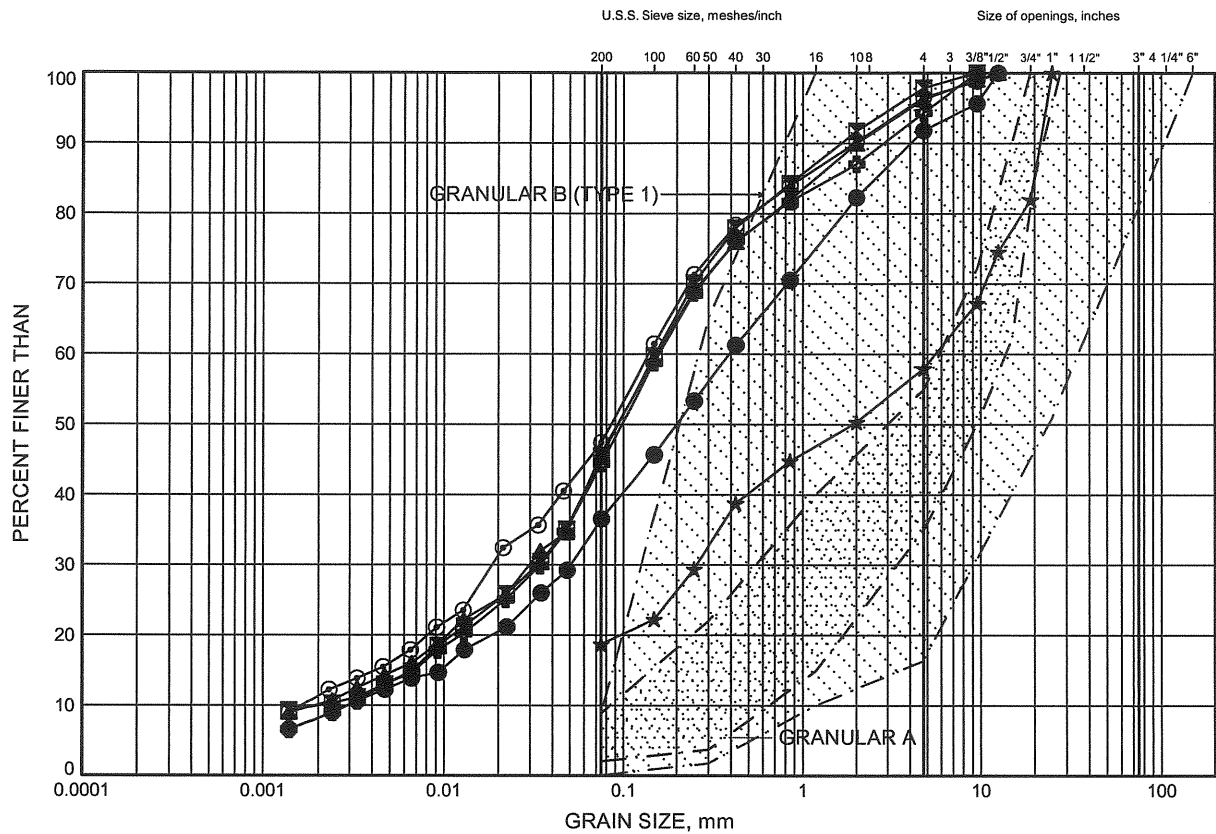
W.P.# 15-64-19  
Prepared By MFA  
Checked By DEE



# Cornwall Centre Road GRAIN SIZE DISTRIBUTION

FIGURE B5

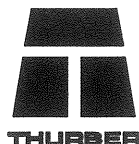
## EAST RETAINING WALL BACKFILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-01	1.07	67.92
⊠	09-01	2.59	66.39
▲	09-01	4.88	64.11
★	09-01	6.40	62.58
⊙	09-07	1.07	68.00
⊕	09-07	2.59	66.48

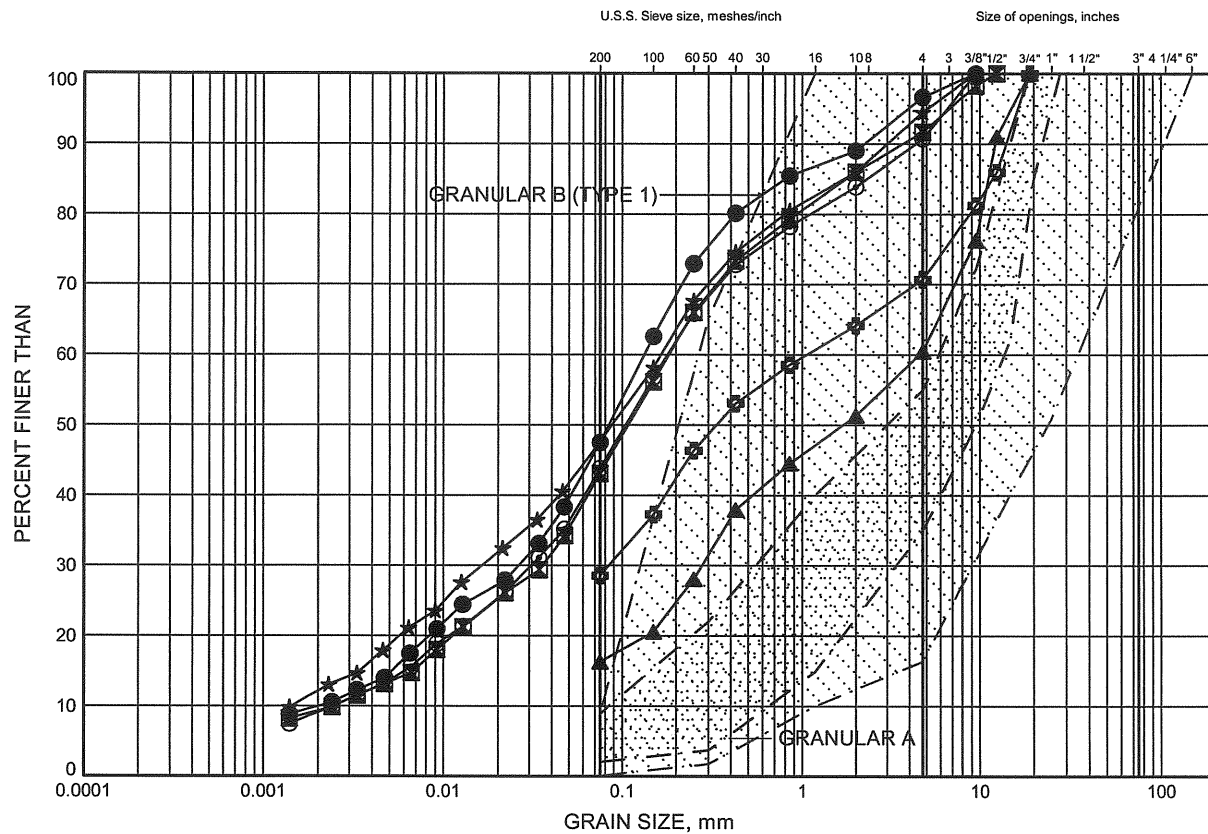


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Prepared By MFA  
Checked By DEE

# Cornwall Centre Road GRAIN SIZE DISTRIBUTION

FIGURE B6

## EAST RETAINING WALL BACKFILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-07	3.35	65.72
⊠	09-07	4.88	64.19
▲	09-07	6.40	62.67
★	09-08	0.30	68.64
⊙	09-08	1.83	67.11
⊕	09-08	3.35	65.59



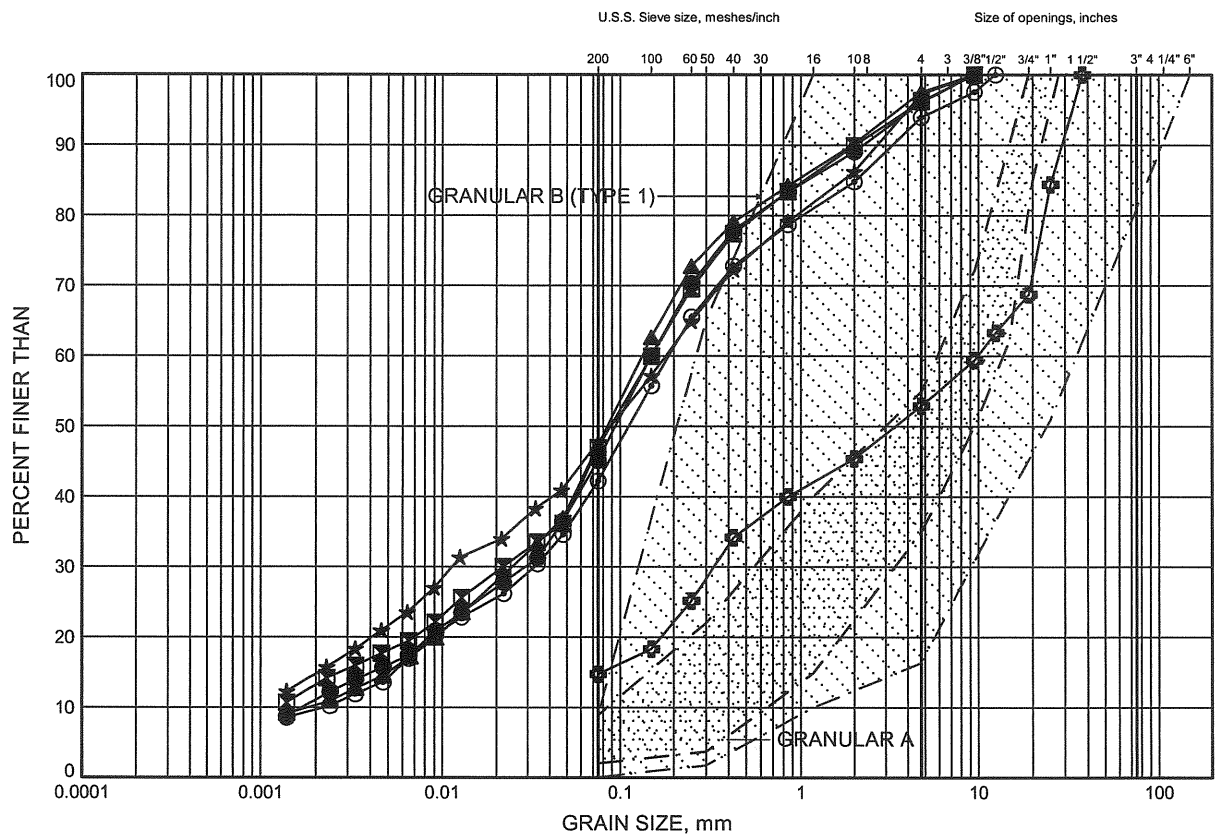
W.P.# ..15-64-19.....  
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Checked By .DEE.....

# Cornwall Centre Road

## GRAIN SIZE DISTRIBUTION

FIGURE B7

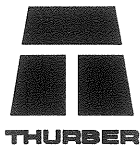
### EAST RETAINING WALL BACKFILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-08	4.11	64.83
⊠	09-08	5.64	63.30
▲	09-10	1.07	68.29
★	09-10	2.59	66.77
⊙	09-10	4.88	64.48
⊕	09-10	6.40	62.96

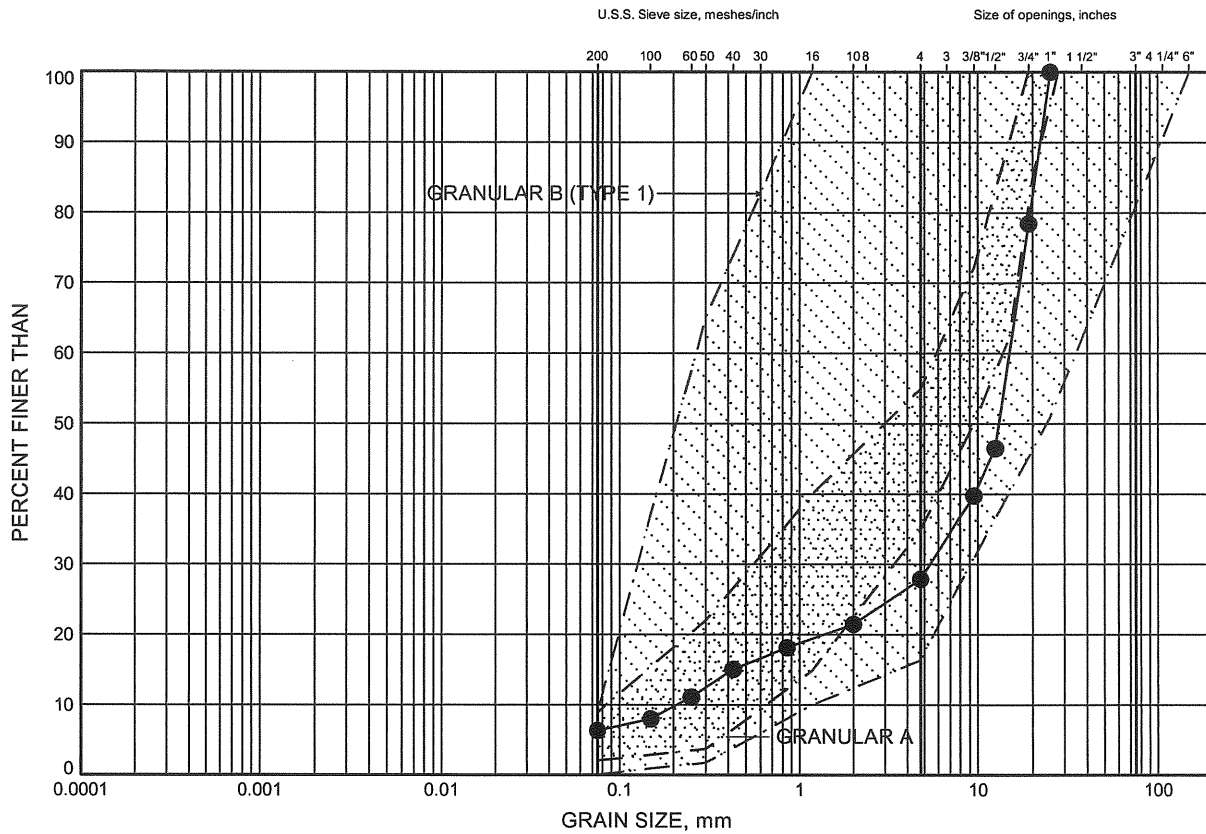


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 Prepared By .MFA.....  
 Checked By .DEE.....

Cornwall Centre Road  
GRAIN SIZE DISTRIBUTION

FIGURE B8

EAST RETAINING WALL BACKFILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-10	7.16	62.20

GRAIN SIZE DISTRIBUTION - THURBER 6419.GPJ 15/6/09

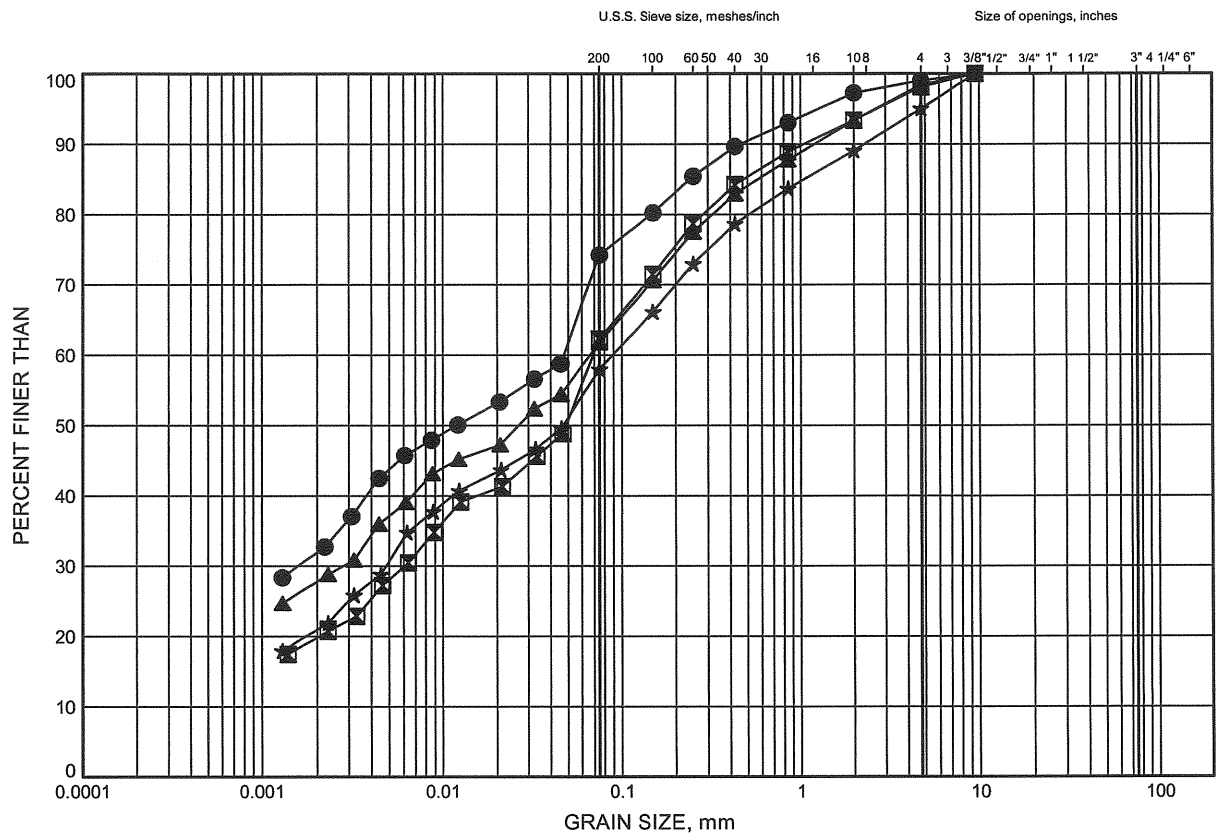
W.P.# 15-64-19.....  
Prepared By MFA.....  
Checked By DEE.....



# Cornwall Centre Road GRAIN SIZE DISTRIBUTION

FIGURE B9

## WEST RETAINING WALL SILT CLAY



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-02	5.64	63.74
⊠	09-05	7.16	63.01
▲	09-06	7.16	62.00
★	09-09	7.92	61.56

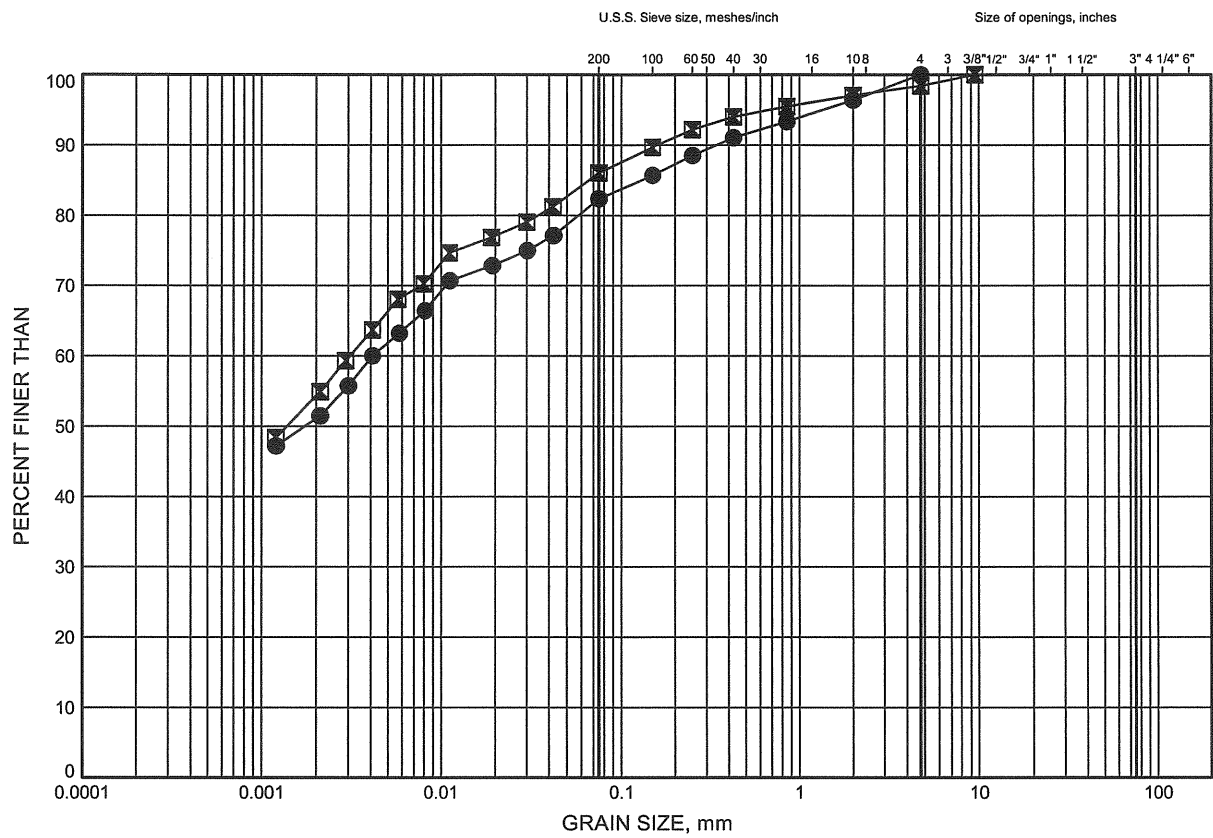


W.P.# 15-64-19.....  
Prepared By MFA.....  
Checked By DEE.....

Cornwall Centre Road  
GRAIN SIZE DISTRIBUTION

FIGURE B10

EAST RETAINING WALL SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-07	7.92	61.15
◻	09-08	6.40	62.54



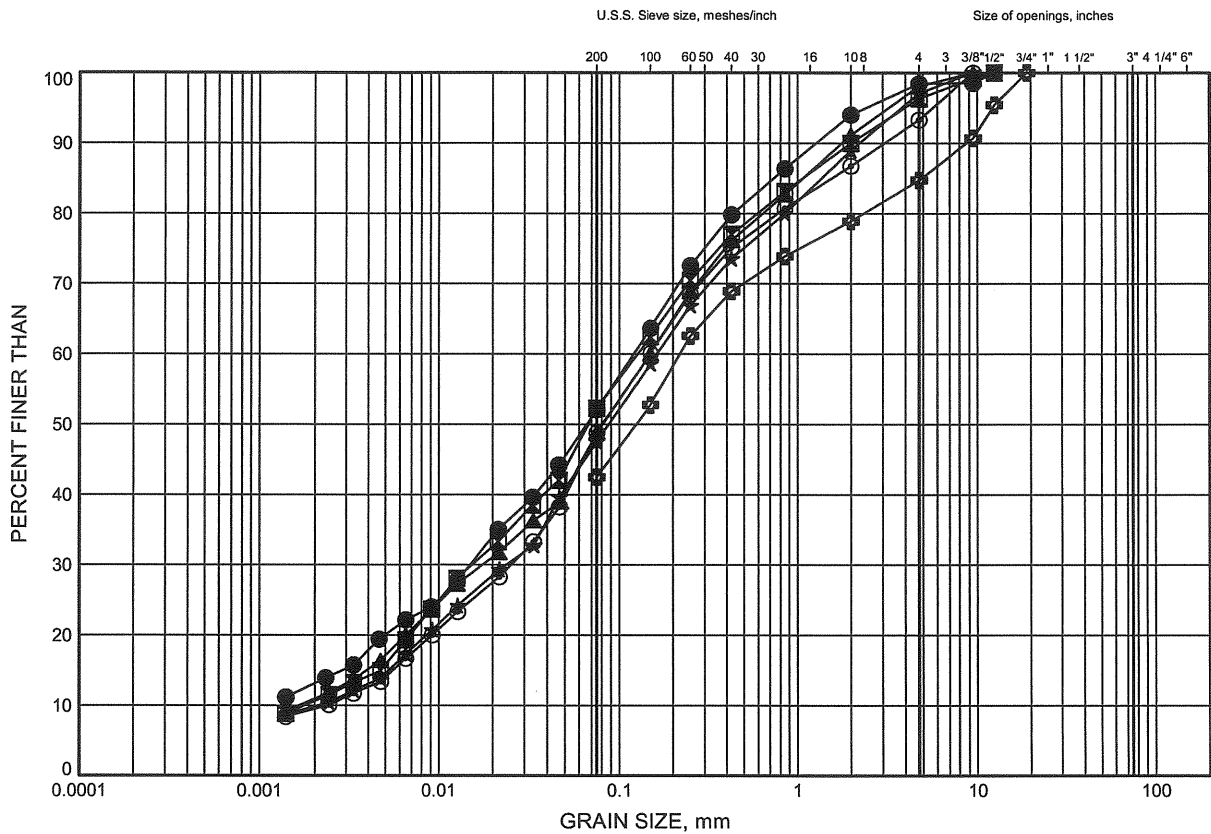
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Checked By .DEE.....



Cornwall Centre Road  
GRAIN SIZE DISTRIBUTION

FIGURE B11

WEST RETAINING WALL SAND & SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-02	7.16	62.22
⊠	09-02	9.45	59.93
▲	09-03	8.69	60.71
★	09-03	10.21	59.18
⊙	09-05	7.92	62.25
⊕	09-05	9.45	60.72

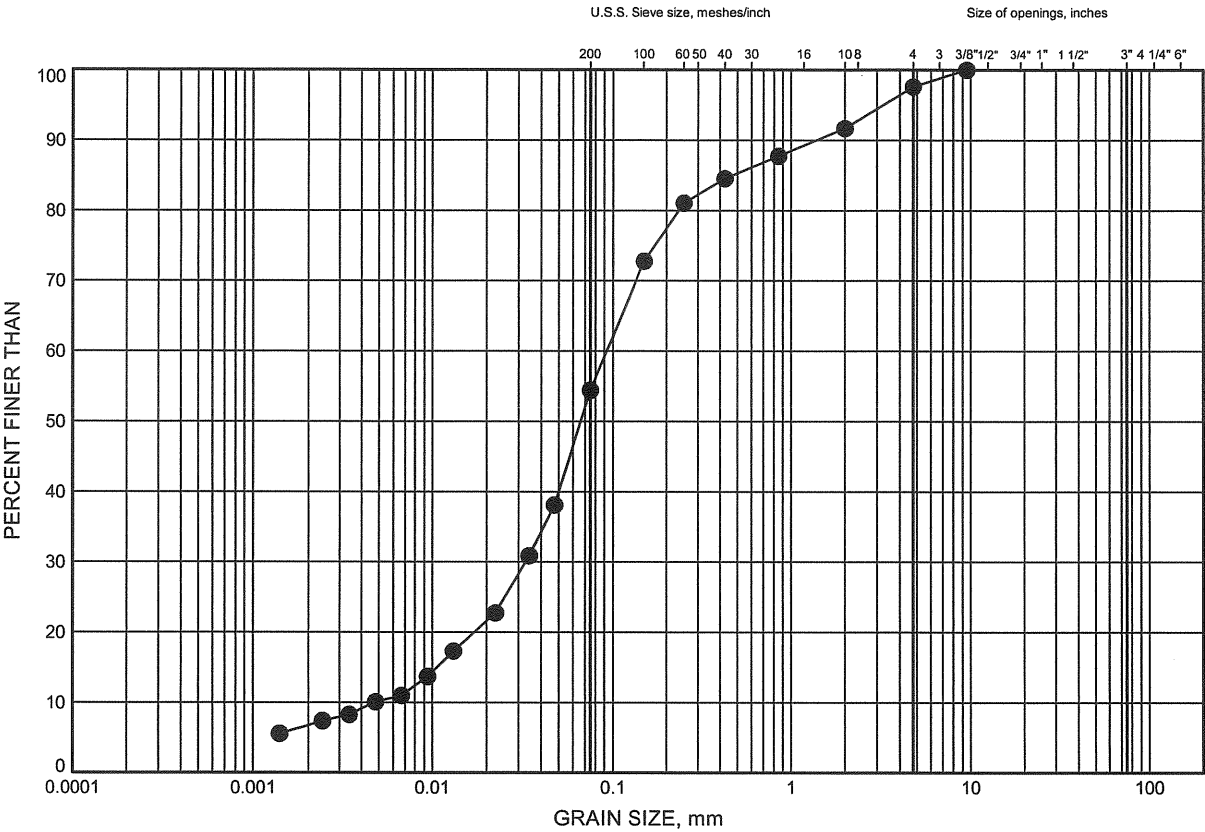


W.P.# ..15-64-19.....  
Prepared By .MFA.....  
Checked By .DEE.....

Cornwall Centre Road  
GRAIN SIZE DISTRIBUTION

FIGURE B12

EAST RETAINING WALL SILT & SAND TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-01	12.34	56.64

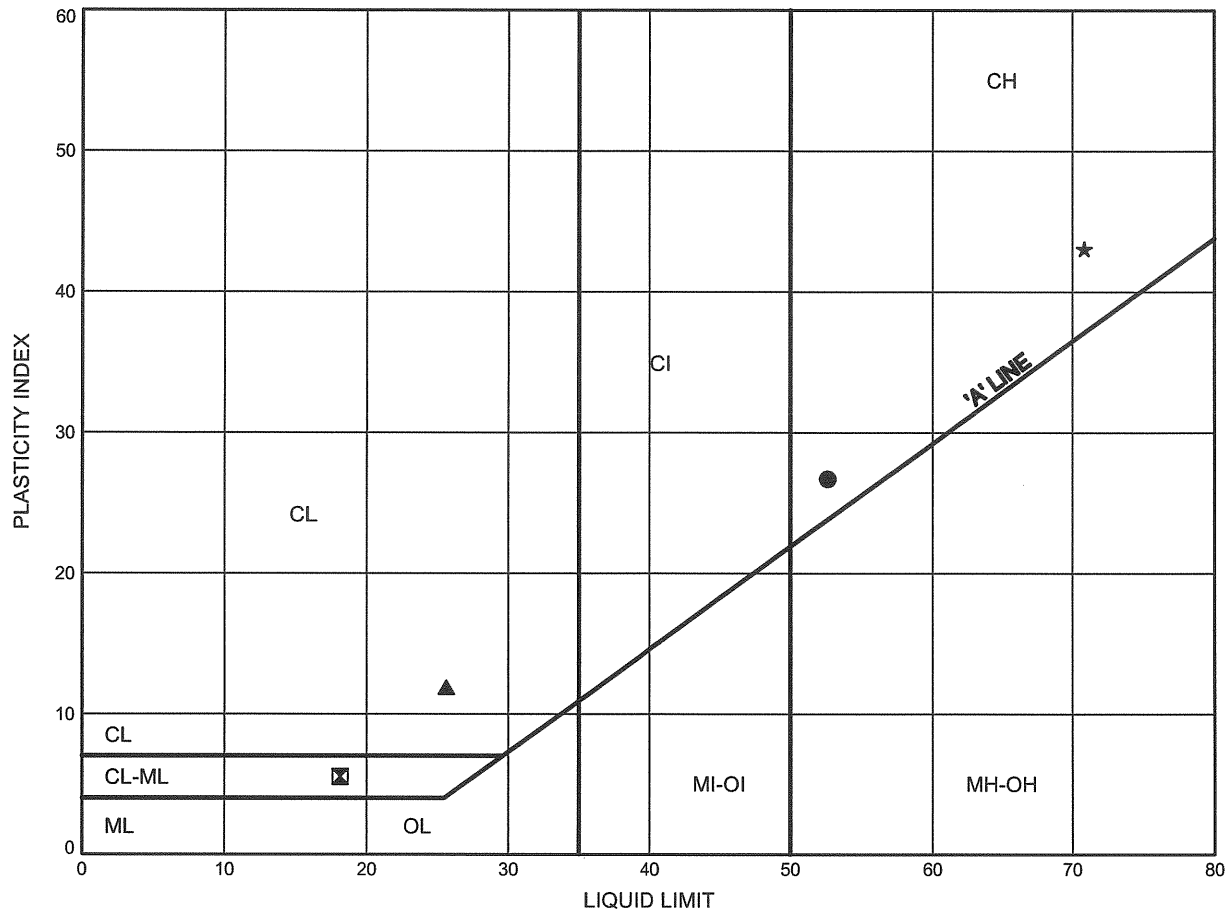
GRAIN SIZE DISTRIBUTION - THURBER 6419.GPJ 15/6/09

W.P.# 15-64-19  
Prepared By MFA  
Checked By DEE



Cornwall Centre Road  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B13



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	09-02	5.64	63.74
☒	09-02	7.16	62.22
▲	09-05	7.16	63.01
★	09-07	7.92	61.15

Date June 2009

Project 15-64-19




Prep'd MFA

Chkd. DEE

## **APPENDIX C**

### **RECORD OF TEST PITS**

STRATIGRAPHY						
DEPTH	ELEV.	Sample Depth (m)	Soils Class.	C <sub>pen</sub> (kPa)	Water Content (%)	Photo
- 0	ORGANICS, trace roots and rootlets: (75mm) 63.33					
-	CLAY, silty, with sand layer from pipe backfill, firm, brown to grey, moist (FILL)					
- 0.4						
-						
- 0.6						
-						
- 0.8						
-						
- 1.0	62.33					
-						
- 1.2						
-						
- 1.4						
-	TOP OF CONCRETE FOOTING – 1.0m in width					
- 1.6	END OF TEST PIT AT 1.63m (Elev. 61.7 m)					
-						
- 1.8	No obvious cracks observed at footing/wall interface.					
-						
2.0	61.33					

# **THURBER ENGINEERING LTD.**

Location: Cornwall Centre Road, Cornwall, Ontario

Date: May 5, 2009

Excavation Co: Bob Buiting Co. Ltd

Client: MTO

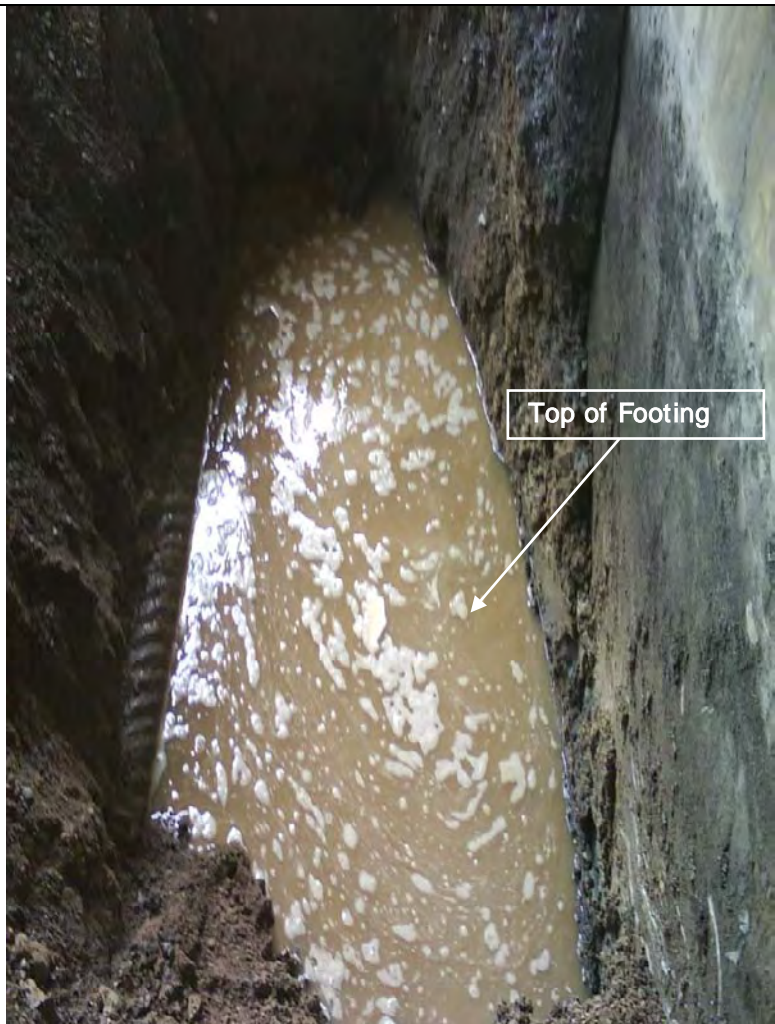
Weather: Cloudy

Inspector: SLL

Project: 15-64-19

Method: Backhoe

**LOG OF TEST PIT: NO. TP 09-1**  
**JOB NO.: 15-64-19**

STRATIGRAPHY						
DEPTH	ELEV.	Sample Depth (m)	Soils Class.	C <sub>pen</sub> (kPa)	Water Content (%)	Photo
- 0	ASPHALT: (50mm) 63.43					
-	SAND, some gravel, grey, moist, (200mm): (FILL)					
-	CLAY, silty, topsoil stained, dark brown, moist: (FILL)					
-						
- 0.4						
-	SAND, some gravel with occasional cobbles, brown, wet (FILL)					
- 0.6						
-						
- 0.8						
-						
- 1.0	CLAY, silty, with occasional cobbles, brown to grey, moist to wet (FILL) 62.43					
- 1.2						
-						
- 1.4						
-	TOP OF CONCRETE FOOTING – 1.5 m in width					
- 1.6	END OF TEST PIT AT 1.57m (Elev. 61.86 m).					
-						
- 1.8	A 150mm dia. CSP was located approx. 1.3m from retaining wall and 0.7m below top of concrete curb.					
-						
-	Water seepage was noted from the 150mm dia. CSP backfill.					
- 2.0	61.43					
	No obvious cracks observed at footing/wall interface.					

# **THURBER ENGINEERING LTD.**

Location: Cornwall Centre Road, Cornwall, Ontario

Date: May 5, 2009

Excavation Co: Bob Buitting Co. Ltd

Client: MTO

Weather: Cloudy


Inspector: SLL

Project: 15-64-19

Method: Backhoe

**LOG OF TEST PIT: NO. TP 09-2**  
**JOB NO.: 15-64-19**



STRATIGRAPHY						
DEPTH	ELEV.	Sample Depth (m)	Soils Class.	C <sub>pen</sub> (kPa)	Water Content (%)	Photo
- 0	ASPHALT: (50mm) 63.48					
-	SAND, some gravel, grey, moist, (125mm): (FILL)					
-	CLAY, silty, topsoil stained, dark brown, moist (FILL)					
- 0.4						
-	SAND, some gravel with occasional cobbles, brown, moist (FILL)					
- 0.6						
-						
- 0.8						
-	CLAY, silty, with occasional cobbles, brown to grey, moist (FILL) 62.48					
- 1.0						
-						
- 1.2						
-						
- 1.4						
-						
- 1.6	TOP OF CONCRETE FOOTING – 1.5 m wide					
-	END OF TEST PIT AT 1.63m (Elev. 61.85 m).					
- 1.8	A 150mm dia. CSP was located approx. 1.5m from retaining wall and 1.2m below top of concrete curb.					
-	Some minor water seepage coming from SAND/CLAY interface at 0.9m below ground surface.					
- 2.0	61.48					
<p>The retaining wall rotated into excavation approx. 12mm as measured with a 1.2m long level.</p> <p>Footing toe approx. 35mm higher than at wall interface as measured with a 1.2m long level.</p> <p>No obvious cracks observed at footing/wall interface.</p>						

# **THURBER ENGINEERING LTD.**

Location: Cornwall Centre Road, Cornwall, Ontario

Date: May 5, 2009

Excavation Co: Bob Buiting Co. Ltd

Client: MTO


Weather: Cloudy

Inspector: SLL

Project: 15-64-19

Method: Backhoe

**LOG OF TEST PIT: NO. TP 09-3**  
**JOB NO.: 15-64-19**

STRATIGRAPHY						
DEPTH	ELEV.	Sample Depth (m)	Soils Class.	C <sub>pen</sub> (kPa)	Water Content (%)	Photo
- 0 ASPHALT: (50mm)	63.52					
- SAND, some gravel, grey, moist, (125mm): (FILL)						
- CLAY, silty, organic stained, dark brown, moist (FILL)						
- 0.4						
- SAND, some gravel with occasional cobbles, brown, moist (FILL)						
- 0.6						
-						
- 0.8						
-						
- CLAY, silty, with occasional cobbles and construction debris, brown to grey, wet (FILL)	62.52					
- 1.0						
- 1.2						
- 1.4						
- 1.6 TOP OF CONCRETE FOOTING						
- END OF TEST PIT AT 1.68m (Elev. 61.84 m).						
- 1.8 A 150mm dia. CSP was located approx. 1m from retaining wall and 0.8m below top of concrete curb and gutter.						
- No obvious cracks observed at footing/wall interface.						
- 2.0	61.52					

# **THURBER ENGINEERING LTD.**

Location: Cornwall Centre Road, Cornwall, Ontario

Date: May 5, 2009

Excavation Co: Bob Buiting Co. Ltd

Client: MTO

Weather: Cloudy


Inspector: SLL

Project: 15-64-19

Method: Backhoe

**LOG OF TEST PIT: NO. TP 09-4  
JOB NO.: 15-64-19**



STRATIGRAPHY						
DEPTH	ELEV.	Sample Depth (m)	Soils Class.	C <sub>pen</sub> (kPa)	Water Content (%)	Photo
- 0 ASPHALT: (50mm)	63.53					
- SAND, some gravel, grey, moist, (19mm CRL): (FILL)						
- CLAY, silty, topsoil stained, dark brown, moist (FILL)						
- 0.4						
-						
-						
- 0.6 SAND, some gravel with occasional cobbles, brown, wet (FILL)						
-						
- 0.8						
-						
- 1.0	62.53					
-						
- 1.2 CLAY, silty, with occasional cobbles, brown to grey, moist to wet (FILL)						
- 1.4						
-						
- TOP OF CONCRETE FOOTING						
- 1.6 END OF TEST PIT AT 1.68m (Elev. 61.85 m).						
-						
- 1.8 There was no inclination noted on the 1.2m level along the retaining wall.						
- Asphalt debris encountered at footing level.						
- 2.0 No obvious cracks observed at footing/wall interface.	61.53					

**THURBER ENGINEERING LTD.**

Location: Cornwall Centre Road, Cornwall, Ontario

Date: May 5, 2009

Excavation Co: Bob Buitting Co. Ltd

Client: MTO


Weather: Cloudy

Inspector: SLL

Project: 15-64-19

Method: Backhoe

**LOG OF TEST PIT: NO. TP 09-5**  
**JOB NO.: 15-64-19**

STRATIGRAPHY						
DEPTH	ELEV.	Sample Depth (m)	Soils Class.	C <sub>pen</sub> (kPa)	Water Content (%)	Photo
- 0 ASPHALT: (50mm)	63.58					
- SAND, some gravel, grey, moist, (19mm CRL): (FILL)						
- CLAY, silty, topsoil stained, dark brown, moist (FILL)						
- 0.4				150 kPa		
-						
- 0.6 SAND, some gravel with occasional cobbles, brown, wet (FILL)						
-						
- 0.8						
-						
- 1.0	62.58					
-						
- 1.2 CLAY, silty, with occasional cobbles, brown to grey, moist to wet (FILL)				50 - 75 kPa		
- 1.4						
-						
- 1.6						
- TOP OF CONCRETE FOOTING						
- 1.8						
- END OF TEST PIT AT 1.75m (Elev. 61.83 m).						
- No obvious cracks observed at footing/wall interface.						
- 2.0	61.58					

**THURBER ENGINEERING LTD.**

Location: Cornwall Centre Road, Cornwall, Ontario

Date: May 5, 2009

Excavation Co: Bob Buiting Co. Ltd

Client: MTO


Weather: Cloudy

Inspector: SLL

Project: 15-64-19

Method: Backhoe

**LOG OF TEST PIT: NO. TP 09-6**  
**JOB NO.: 15-64-19**

STRATIGRAPHY						
DEPTH	ELEV.	Sample Depth (m)	Soils Class.	Cpen (kPa)	Water Content (%)	Photo
- 0 ORGANICS, trace roots and rootlets: (150mm)	63.59					
- CLAY, silty, with occasional cobbles and construction debris (re-bar), dark brown to brown, moist (FILL)				50 kPa		
- 0.4						
- 0.6						
- 0.8						
- 1.0	62.59					
- 1.2				75 kPa		
- 1.4						
- 1.6						
- 1.8						
- TOP OF CONCRETE FOOTING – 1.0 m width						
- 2.0 END OF TEST PIT AT 1.93m (Elev. 61.66 m).	61.59					
- No obvious cracks observed at footing/wall interface.						
.						

**THURBER ENGINEERING LTD.**

Location: Cornwall Centre Road, Cornwall, Ontario

Date: May 5, 2009

Excavation Co: Bob Buiting Co. Ltd

Client: MTO

Weather: Cloudy


Inspector: SLL

Project: 15-64-19

Method: Backhoe

**LOG OF TEST PIT: NO. TP 09-7  
JOB NO.: 15-64-19**



STRATIGRAPHY						
DEPTH	ELEV.	Sample Depth (m)	Soils Class.	C <sub>pen</sub> (kPa)	Water Content (%)	Photo
- 0	ASPHALT: (50mm) 63.55					
-	SAND, some gravel, grey, moist: (FILL)					
-	CLAY, silty, topsoil stained, dark brown, moist: (FILL)					
- 0.4						
-						
- 0.6						
-						
- 0.8						
-	SAND, some gravel with occasional cobbles, brown, wet: (FILL)					
- 1.0	62.55					
-	END OF TEST PIT AT 1.1m (Elev. 62.45 m)					
-						
-	A 114mm dia. Gas Pipe was located approx. 0.3m from retaining wall and 0.8m below top of concrete curb.					
-						
-	A 150mm CSP was found approx. 0.9m from the retaining wall and 1.0m below top of concrete curb.					
-						
-	No obvious cracks observed at footing/wall interface					

# **THURBER ENGINEERING LTD.**

Location: Cornwall Centre Road, Cornwall, Ontario

Date: May 14, 2009

Excavation Co: DBC Environmental

Client: MTO


Weather: Cloudy, Rain

Inspector: SLL

Project: 15-64-19

Method: Daylighting

**LOG OF TEST PIT: NO. TP 09-8**  
**JOB NO.: 15-64-19**

STRATIGRAPHY						
DEPTH	ELEV.	Sample Depth (m)	Soils Class.	C <sub>pen</sub> (kPa)	Water Content (%)	Photo
- 0	ASPHALT: (50mm) 63.45					
-	SAND, some gravel, grey, moist: (FILL)					
-	SAND, trace gravel and silt, brown, moist to wet (FILL)					
- 0.4						
-						
- 0.6						
-						
- 0.8						
-						
- 1.0	62.45					
-	END OF TEST PIT AT 1.1m (Elev. 62.35 m)					
- 1.2						
-	A 114mm dia. Gas Line located approx. 0.3m from retaining wall and 0.8m below top of concrete curb.					
-	A 150mm CSP was encountered approx. 0.9m from the retaining wall and 1.0m below top of concrete curb.					
-	No obvious cracks observed at footing/wall interface					

# **THURBER ENGINEERING LTD.**

Location: Cornwall Centre Road, Cornwall, Ontario

Date: May 14, 2009

Excavation Co: DBC Environmental

Client: MTO

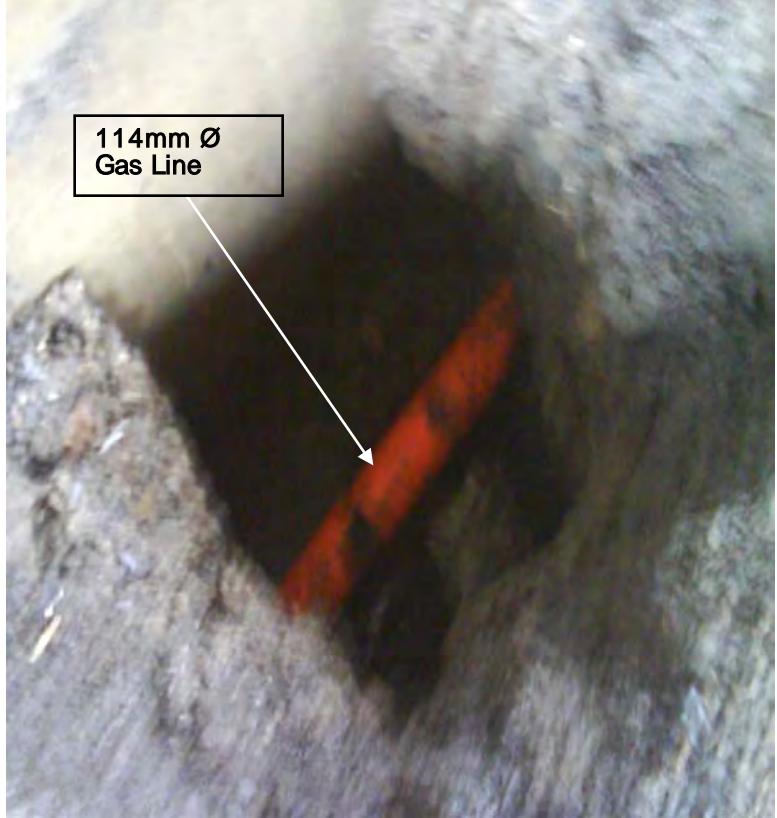
Weather: Cloudy, Rain

Inspector: SLL

Project: 15-64-19

Method: Daylighting

**LOG OF TEST PIT: NO. TP 09-9**  
**JOB NO.: 15-64-19**

STRATIGRAPHY						
DEPTH	ELEV.	Sample Depth (m)	Soils Class.	C <sub>pen</sub> (kPa)	Water Content (%)	Photo
- 0 ASPHALT: (50mm)	62.22					
- SAND, some gravel, grey, moist: (FILL)						
- SAND, trace gravel and silt, brown, moist to wet (FILL)						
- 0.4						
-						
- 0.6						
-						
- 0.8						
-						
- 1.0 END OF TEST PIT AT 1.0m (Elev. 61.22 m)	61.22					
-						
- A 114mm dia. Gas Line was located approx. 0.3m from retaining wall and 0.8m below top of concrete curb.						
- Tracer wire for the gas line was sheared in two by vacuum. Contacted Union Gas, they came and stated that the wire is not a tracer wire.						
- No obvious cracks observed at footing/wall interface						
-						

# **THURBER ENGINEERING LTD.**

Location: Cornwall Centre Road, Cornwall, Ontario

Date: May 14, 2009

Excavation Co: DBC Environmental

Client: MTO


Weather: Cloudy, Rain

Inspector: SLL

Project: 15-64-19

Method: Daylighting

**LOG OF TEST PIT: NO. TP 09-11**  
**JOB NO.: 15-64-19**

STRATIGRAPHY						
DEPTH	ELEV.	Sample Depth (m)	Soils Class.	C <sub>pen</sub> (kPa)	Water Content (%)	Photo
- 0	ASPHALT: (50mm) 63.57					
-	SAND, some gravel, grey, moist, (19mm CRL): (FILL)					
-	CLAY, silty, topsoil stained, dark brown, moist (FILL)					
- 0.4						
-	SAND, some gravel with occasional cobbles, brown, wet (FILL)					
- 0.6						
-						
- 0.8						
-						
-	CLAY, silty, with occasional cobbles and construction debris, brown to grey, wet (FILL) 62.57					
- 1.0						
-						
- 1.2						
-						
- 1.4						
-						
- 1.6	TOP OF CONCRETE FOOTING					
-	END OF TEST PIT AT 1.68m (Elev. 61.89 m)					
-	No obvious cracks observed at footing/wall interface.					
-	No inclination was noted along ret. wall face.					

# **THURBER ENGINEERING LTD.**

Location: Cornwall Centre Road, Cornwall, Ontario

Date: May 14, 2009

Excavation Co: DBC Environmental Services

Client: MTO

Weather: Cloudy

Inspector: SLL

Project: 15-64-19

Method: Daylighting

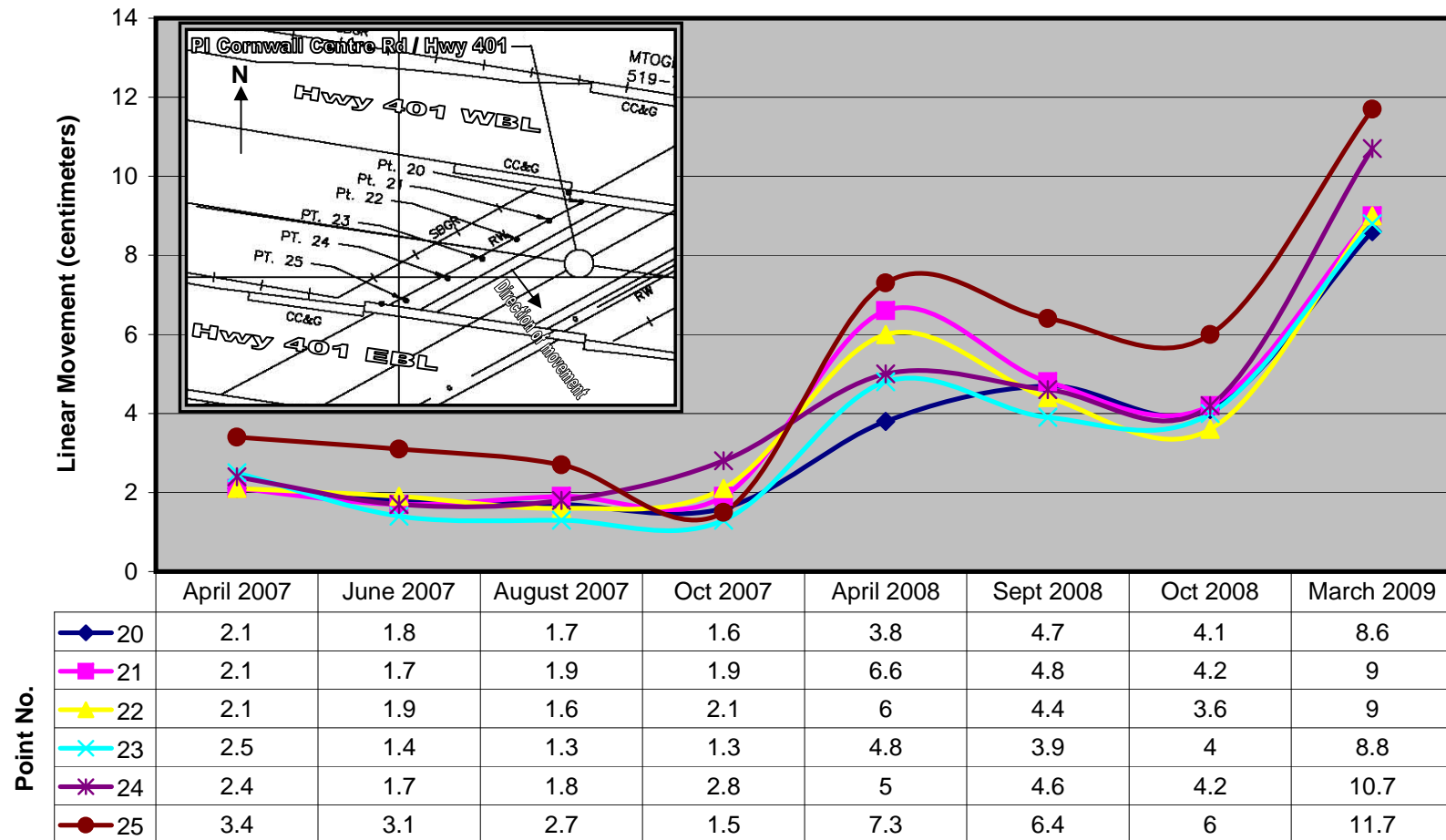
**LOG OF TEST PIT: NO. TP 09-13**  
**JOB NO.: 15-64-19**

## **APPENDIX D**

### **MTO GEOMATICS WESTERN RETAINING WALL MONITORING DATA**



## Hwy 401 - Cornwall Centre Rd. - West Retaining Wall Movement

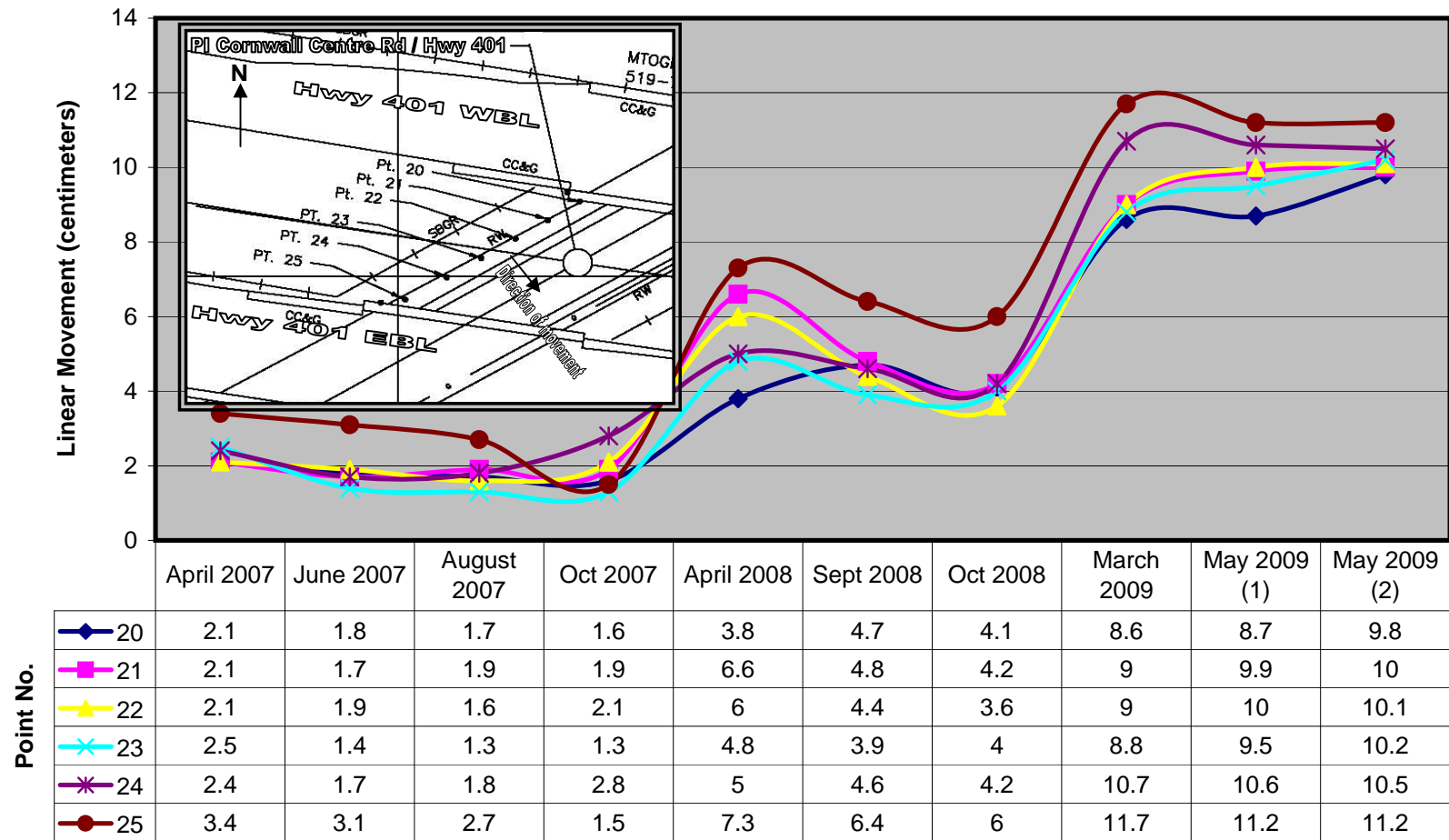


# Bridge Site Monitoring Data - Site No. 31-2091

May 19, 2009

Point Description	Delta Northing	Delta Easting	Linear Movement (m)	Direction of Movement (Azimuth)	Elevation Change (m)
<b>East Retaining Wall</b>					
11	-0.001	0.005	0.005	101.310	-0.004
12	0.006	0.008	0.010	53.130	-0.002
13	0.018	0.016	0.024	41.634	-0.001
14	0.013	0.006	0.014	24.775	-0.002
15	0.011	0.018	0.021	58.570	-0.002
16	0.010	0.016	0.019	57.995	-0.003
<b>West Retaining Wall</b>					
25	-0.099	0.052	0.112	152.289	-0.008
24	-0.090	0.055	0.105	148.570	-0.008
23	-0.092	0.045	0.102	153.935	-0.008
22	-0.085	0.054	0.101	147.572	-0.005
21	-0.088	0.048	0.100	151.390	-0.005
20	-0.083	0.052	0.098	147.933	-0.003
<b>Benchmark Data for above points observed in February 2007</b>					
<b>West Abutment Wall (EBL)</b>					
101	-0.100	0.016	0.101	170.910	0.023
102	-0.075	0.056	0.094	143.253	0.018
103	-0.102	0.009	0.102	174.958	0.016
104	-0.031	-0.007	0.032	192.724	0.021
105	-0.037	-0.009	0.038	193.671	0.023
106	-0.033	-0.011	0.035	198.435	0.016
107	0.021	-0.032	0.038	303.275	0.019
108	0.010	-0.023	0.025	293.499	0.016
109	0.017	-0.027	0.032	302.196	0.023
110	0.013	-0.036	0.038	289.855	0.020
111	0.025	-0.031	0.040	308.884	0.021
112	0.031	-0.033	0.045	313.210	0.015
<b>Benchmark Data for above points observed in May 2009</b>					

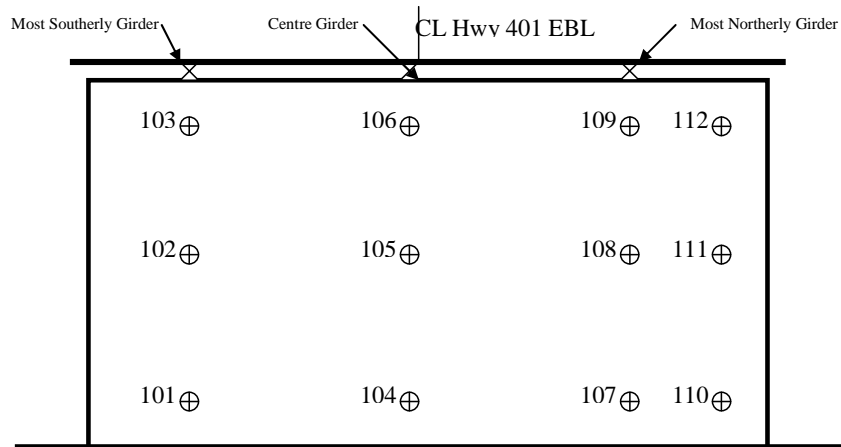
## Hwy 401 - Cornwall Centre Rd. - West Retaining Wall Movement



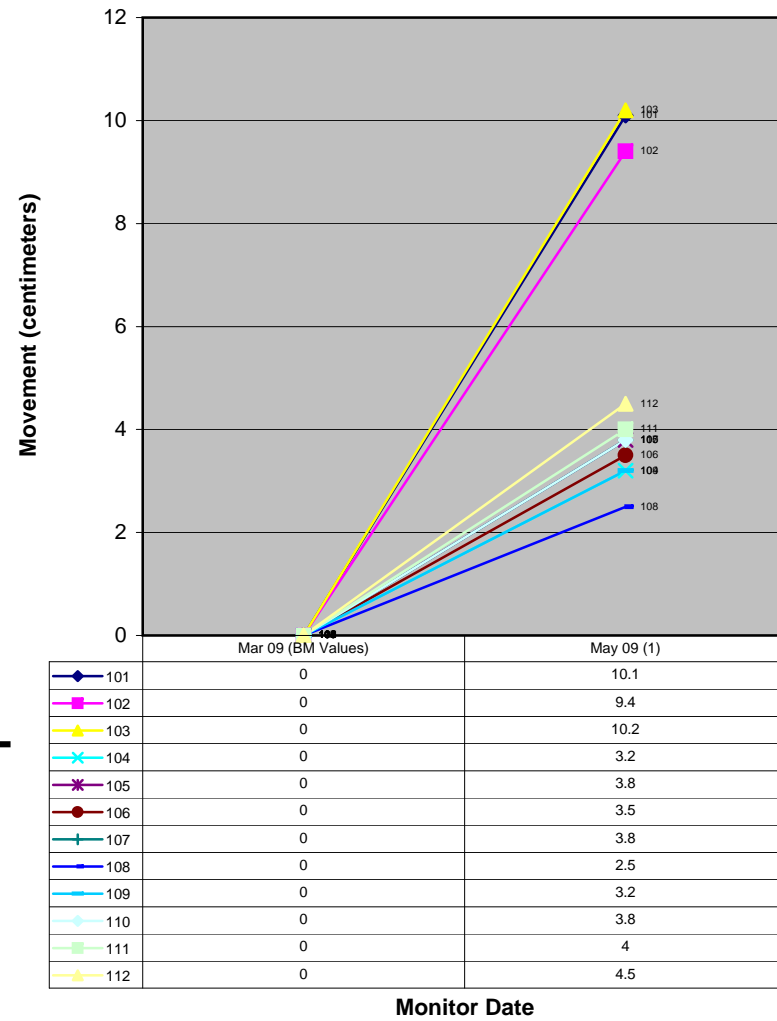
Movement Since February 2007

## West Abutment Wall Movement

**West Abutment Wall Monitor Points**



**Elevation View of West Abutment Wall**



Observation Date	West Retaining Wall Monitor Point Movement Summary					
	20	21	22	23	24	25
April 2007	2.1	2.1	2.1	2.5	2.4	3.4
June 2007	1.8	1.7	1.9	1.4	1.7	3.1
August 2007	1.7	1.9	1.6	1.3	1.8	2.7
Oct 2007	1.6	1.9	2.1	1.3	2.8	1.5
April 2008	3.8	6.6	6	4.8	5	7.3
Sept 2008	4.7	4.8	4.4	3.9	4.6	6.4
Oct 2008	4.1	4.2	3.6	4	4.2	6
March 2009	8.6	9	9	8.8	10.7	11.7
May 2009 (1)	8.7	9.9	10	9.5	10.6	11.2
May 2009 (2)	9.8	10	10.1	10.2	10.5	11.2

Observation Date	West Abutment Wall (EBL) Monitor Point Movement Summary											
	101	102	103	104	105	106	107	107	109	110	111	112
Mar 09 (BM Values)	0	0	0	0	0	0	0	0	0	0	0	0
May 09 (1)	10.1	9.4	10.2	3.2	3.8	3.5	3.8	2.5	3.2	3.8	4	4.5

## **APPENDIX E**

### **SITE PHOTOS**



Plate 1 – Cornwall Centre Road Overpass (facing north)



Plate 2 – Western retaining wall distress (EBL and median)





Plate 3 – Retaining wall contact with EBL and associated damage



Plate 4 – Median retaining wall distress (facing south)





Plate 5 – Vertical cracks in median retaining wall



Plate 6 – Distress at EBL abutment and median retaining wall

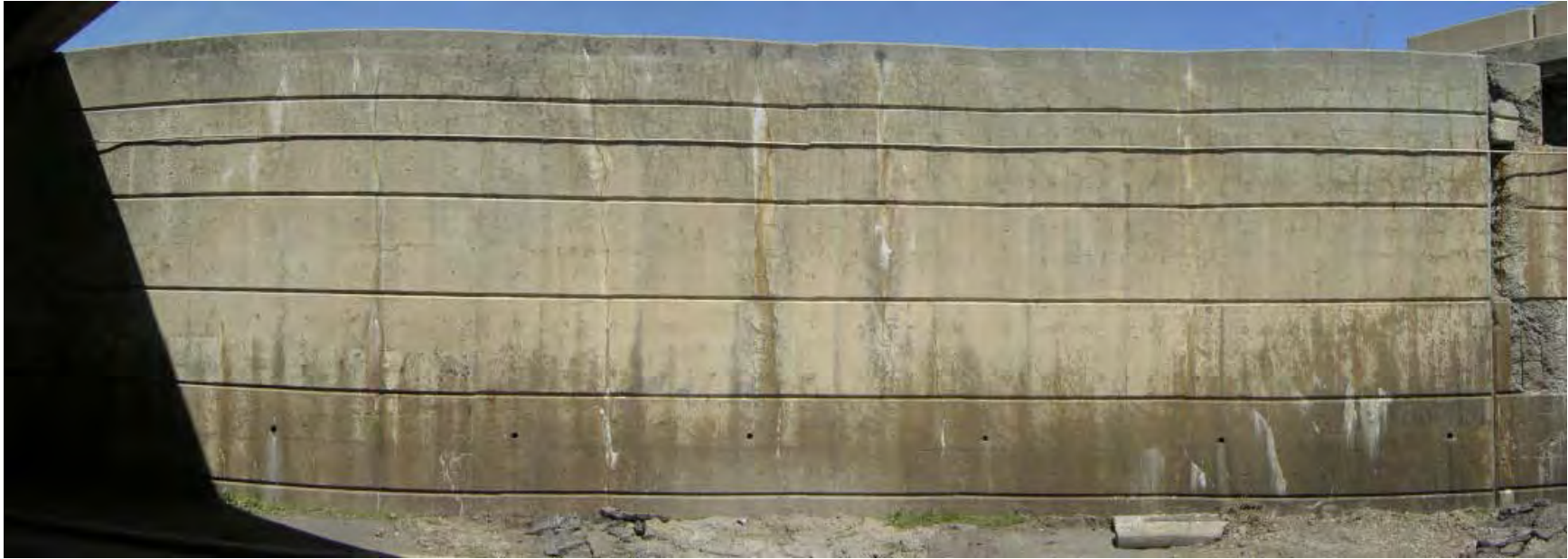


Plate 7 – Panoramic view of centre median retaining wall

## **APPENDIX F**

### **BOREHOLE LOCATIONS AND SOIL STRATA DRAWING**



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

CONT No
GWP No

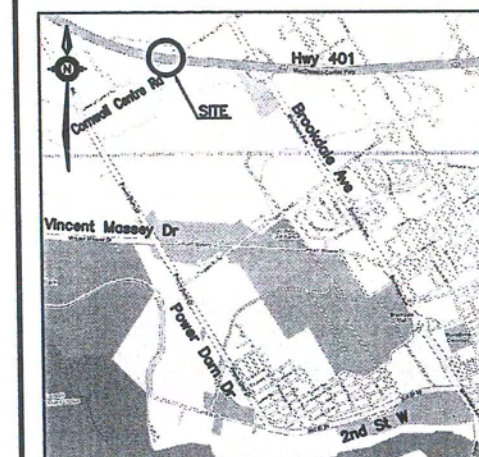
HIGHWAY 401  
CORNWALL CENTRE ROAD OVERPASS  
RETAINING WALL  
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET








**THURBER ENGINEERING LTD.**  
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



## KEYPLAN

### LEGEND

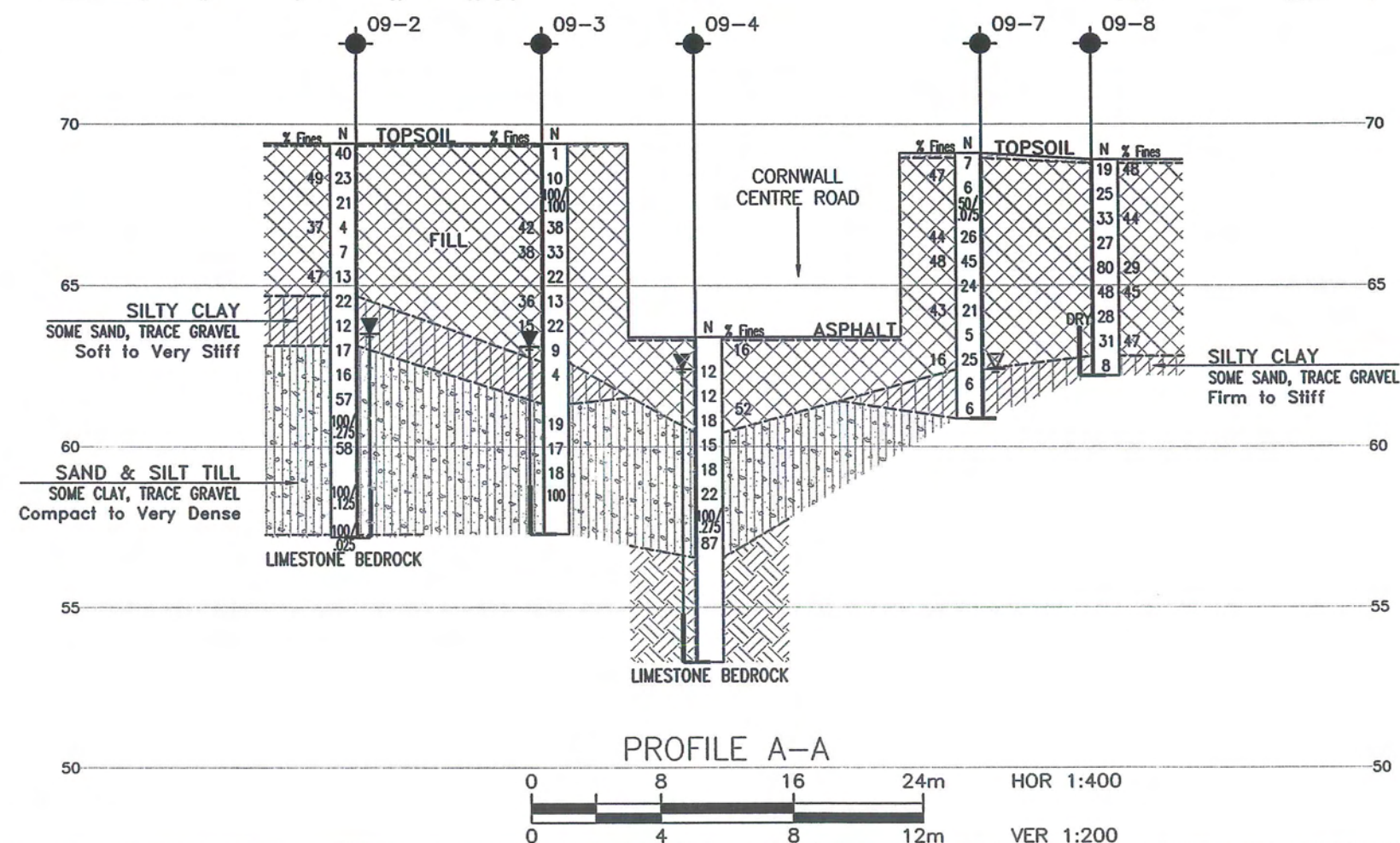
- |   |                                       |
|---|---------------------------------------|
|  | Borehole                              |
|  | Borehole and Cone                     |
| N   | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE  | Blows /0.3m (60° Cone, 475J/blow)     |
| PH  | Pressure, Hydraulic                   |
|  | Water Level                           |
|  | Head Artesian Water                   |
|  | Piezometer                            |
| 90%   | Rock Quality Designation (RQD)        |
| A/R   | Auger Refusal                         |

NO	ELEVATION	NORTHING	EASTING
09-1	69.0	4 991 153.0	203 386.3
09-2	69.4	4 991 153.4	203 341.9
09-3	69.4	4 991 153.0	203 353.3
09-4	63.4	4 991 151.7	203 362.6
09-5	70.2	4 991 142.6	203 323.9
09-6	69.2	4 991 157.8	203 361.9
09-7	69.1	4 991 149.0	203 380.0
09-8	68.9	4 991 147.2	203 386.6
09-9	69.5	4 991 148.6	203 347.7
09-10	69.4	4 991 145.1	203 372.7

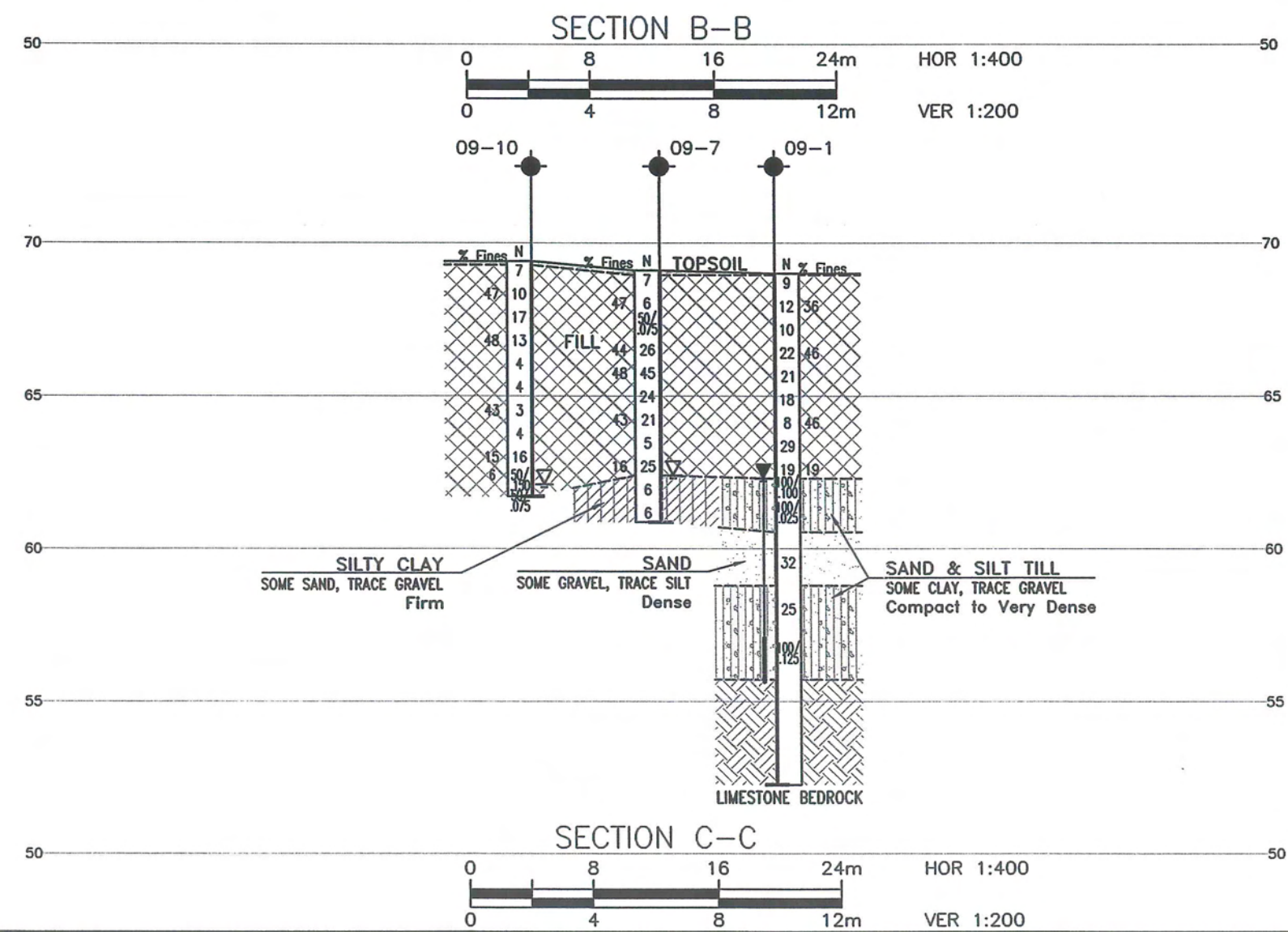
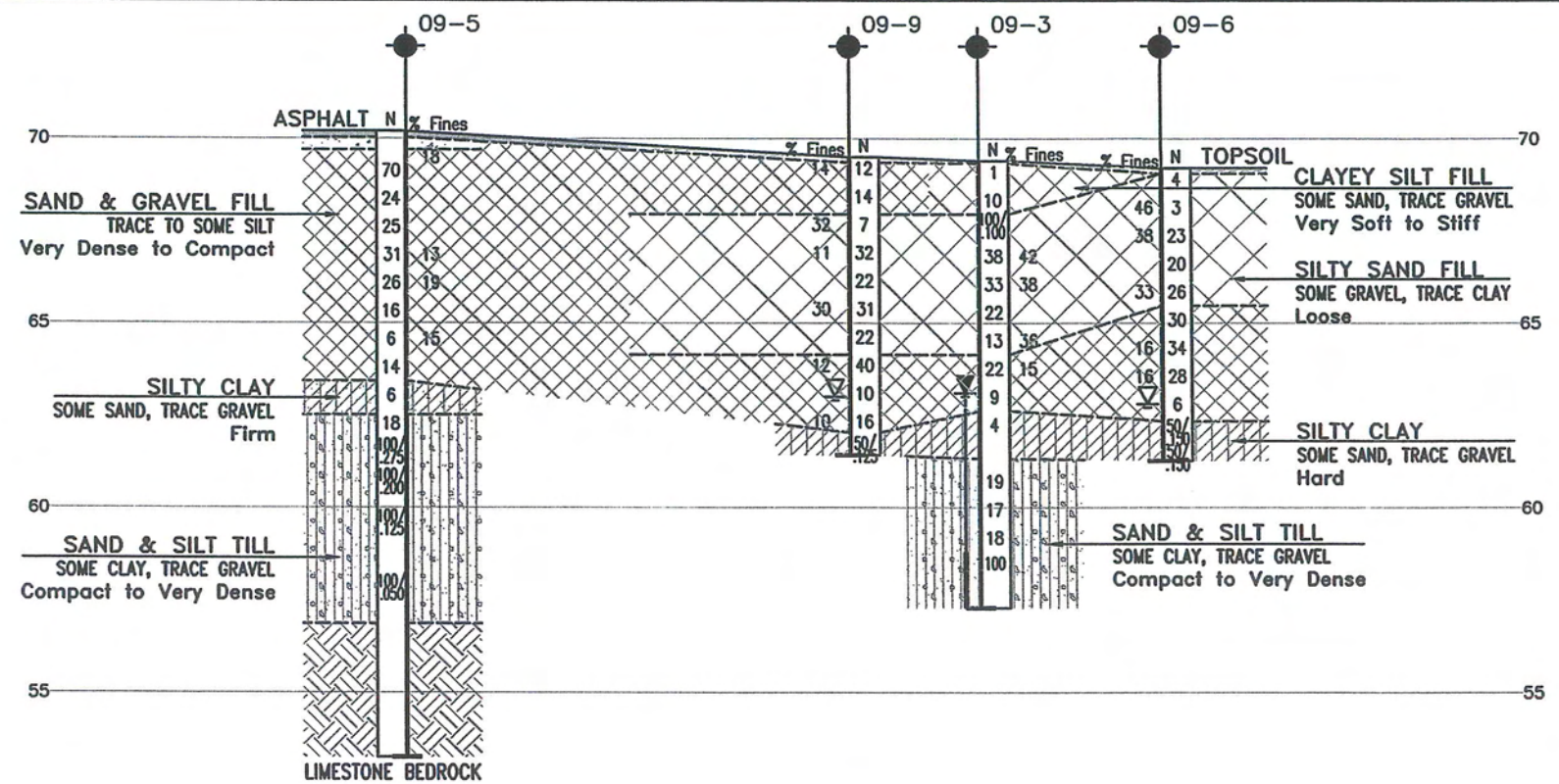
-NOTES-

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

GEOCRES No. 31G-232

[illegible]





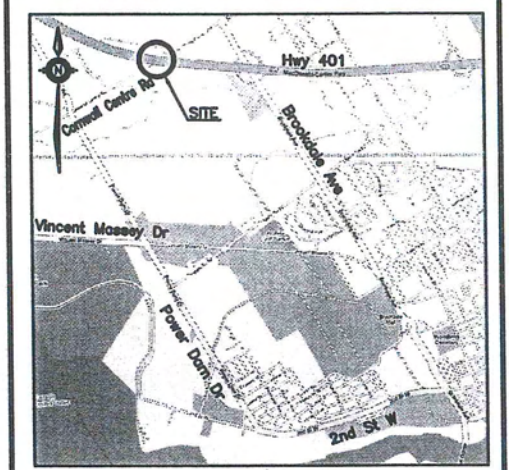
**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No

HIGHWAY 401  
CORNWALL CENTRE ROAD OVERPASS  
RETAINING WALL  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

**THURBER ENGINEERING LTD.**  
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



**LEGEND**

- Borehole
- Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
09-1	69.0	4 991 153.0	203 386.3
09-2	69.4	4 991 153.4	203 341.9
09-3	69.4	4 991 153.0	203 353.3
09-4	63.4	4 991 151.7	203 362.6
09-5	70.2	4 991 142.6	203 323.9
09-6	69.2	4 991 157.8	203 361.9
09-7	69.1	4 991 149.0	203 380.0
09-8	68.9	4 991 147.2	203 386.5
09-9	69.5	4 991 148.6	203 347.7
09-10	69.4	4 991 145.1	203 372.7

**-NOTES-**

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

2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

**GEOCRE No. 31G-232**



**REVISIONS**

DATE	BY	DESCRIPTION
DESIGN	DEE	CHK AEG
DRAWN	MFA	CHK PKC

LOAD DATE JUN. 2009  
STRUCT DWG 2

**APPENDIX G**

**ORIGINAL SITE PLAN AND  
RETAINING WALL DESIGN DRAWING  
(1960)**



SHEET No	TOTAL S



PROVINCE OF ONTARIO

DEPARTMENT OF HIGHWAYS

PLANNING AND DESIGN BRANCH

DESIGN DIVISION

KEY PLAN

W.P. No. \_\_\_\_\_ Contract No. \_\_\_\_\_

Name of Structure \_\_\_\_\_

Highway No. \_\_\_\_\_ Dist. No. \_\_\_\_\_

Location \_\_\_\_\_

\_\_\_\_\_

in The Township of \_\_\_\_\_

in The County of \_\_\_\_\_

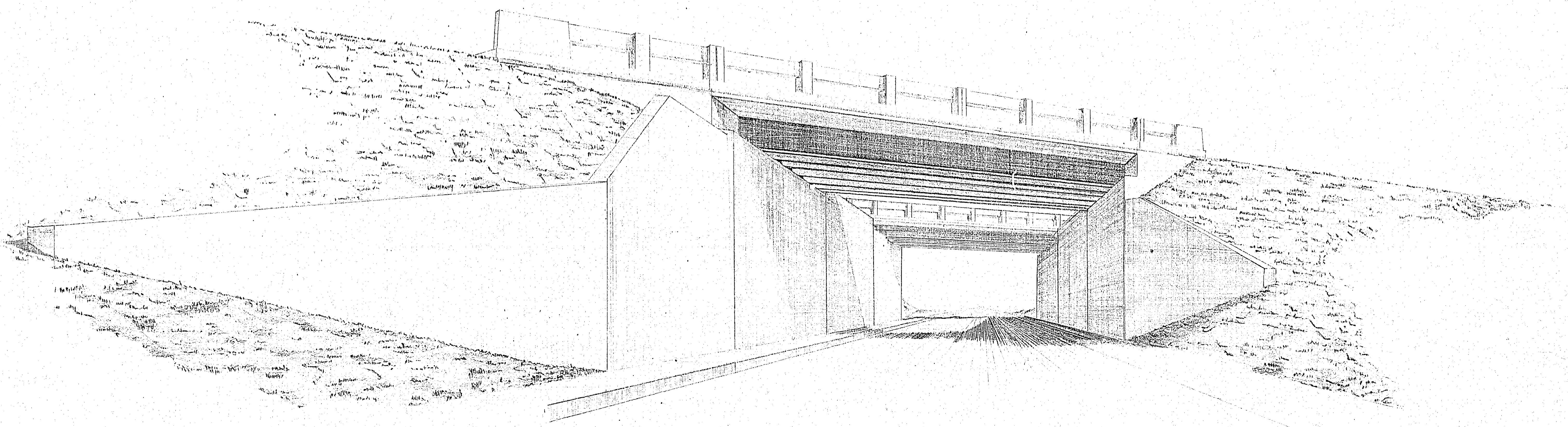
Station \_\_\_\_\_ to Station \_\_\_\_\_

Length Miles \_\_\_\_\_

Survey Plan Nos. \_\_\_\_\_

Survey Profile Nos. \_\_\_\_\_

Soil Profile Nos. \_\_\_\_\_



CORNWALL TOWNSHIP

BRIDGE NO. 9

C-9 WP 79-59

APPROVED FOR CONTRACT

JULY 29, 1960

Date

*Am L*

Bridge Engineer

BRIDGE OFFICE D. No.

D-4517

\_\_\_\_\_ Date \_\_\_\_\_

\_\_\_\_\_ Project Design Engineer \_\_\_\_\_

\_\_\_\_\_ Date \_\_\_\_\_

\_\_\_\_\_ Road Design Engineer \_\_\_\_\_

\_\_\_\_\_ Date \_\_\_\_\_

\_\_\_\_\_ Senior Project Design Engineer \_\_\_\_\_

PLANNING & DESIGN Dwg. No.

TwP 31-209

Stage 1: Not Revised as Constructed for Reasons

DATE	REV. No

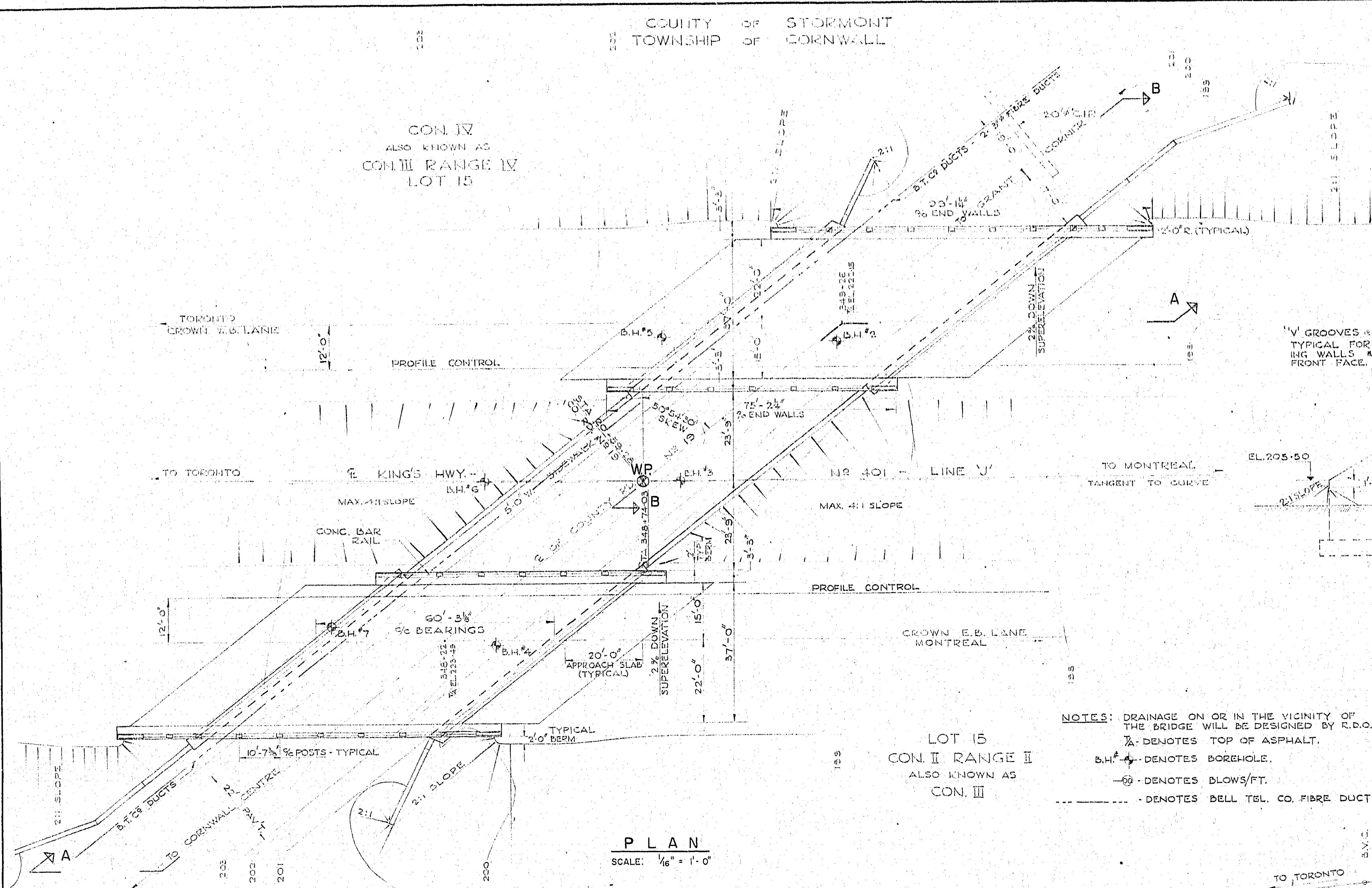
DATE	REV. No

BD-1-L



COUNTY OF STORMONT  
TOWNSHIP OF CORNWALL

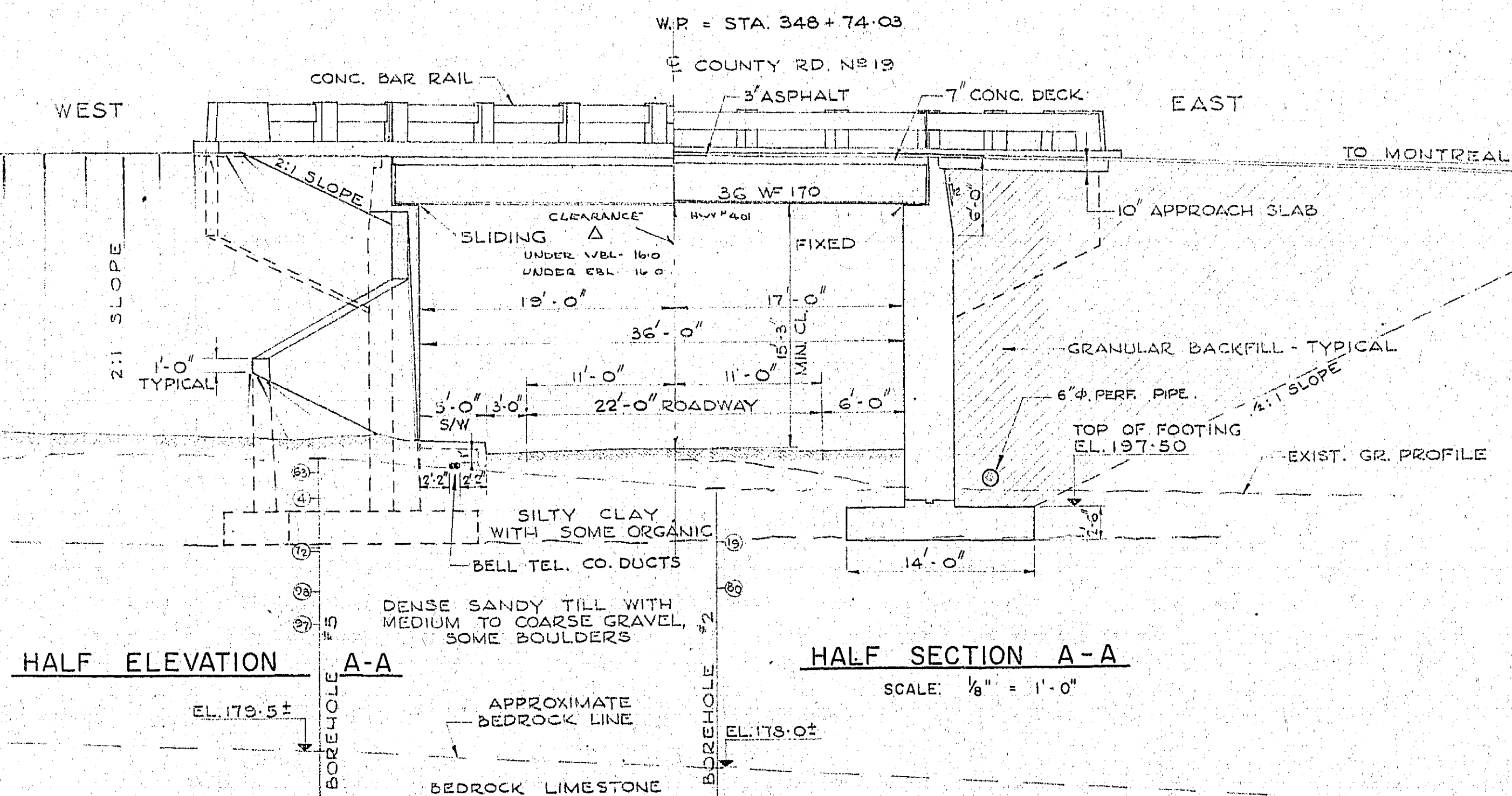
CON. IV  
ALSO KNOWN AS  
CON. III RANGE IV  
LOT 15



PLAN  
SCALE: 1/16" = 1'-0"

NOTES: DRAINAGE ON OR IN THE VICINITY OF  
THE BRIDGE WILL BE DESIGNED BY E.D.O.  
X DENOTES TOP OF ASPHALT.  
B.H. # DENOTES BOREHOLE.  
B DENOTES BLOWS/FT.  
--- DENOTES BELL TEL. CO. FIBRE DUCTS (2).

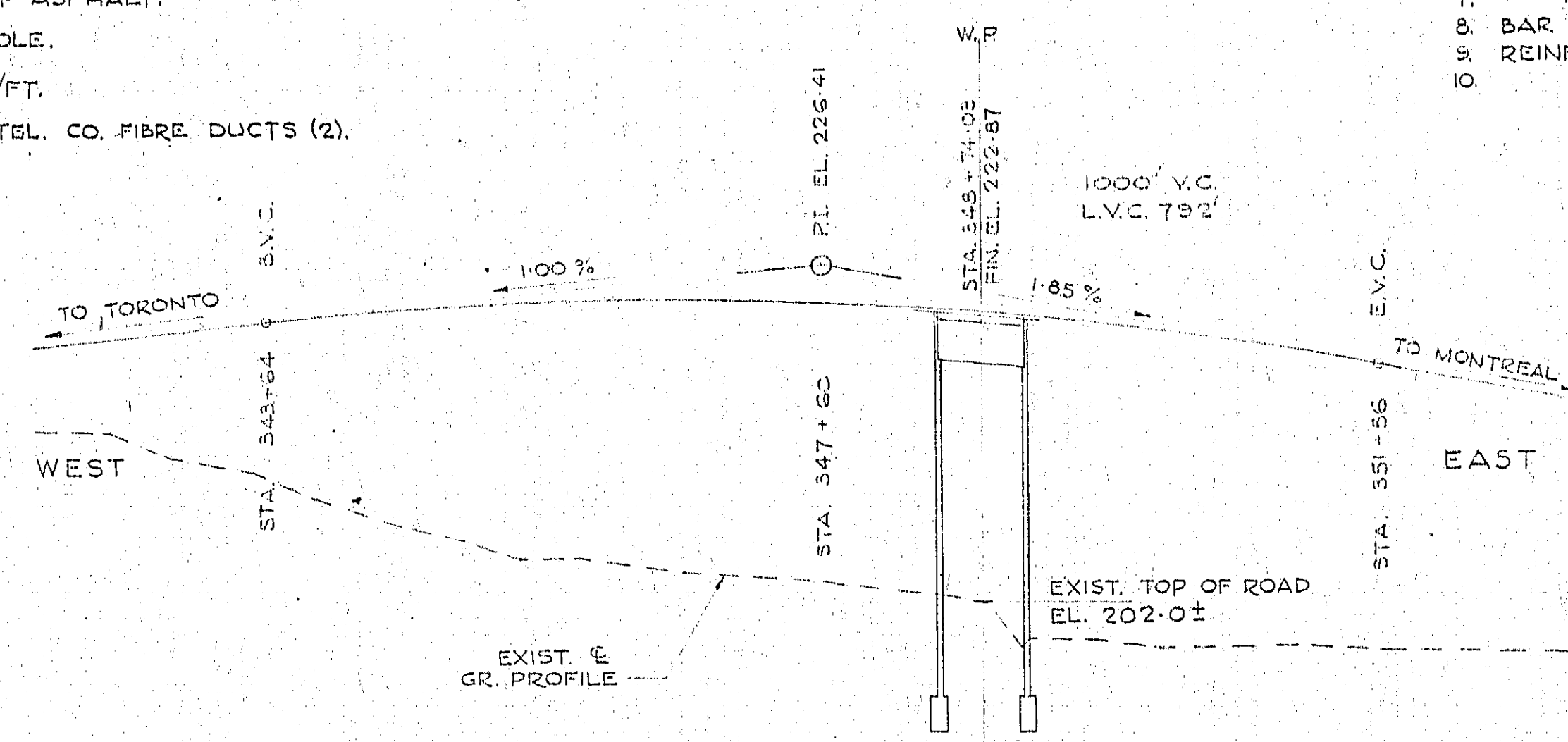
LOT 15  
CON. II RANGE II  
ALSO KNOWN AS  
CON. III



HALF ELEVATION A-A

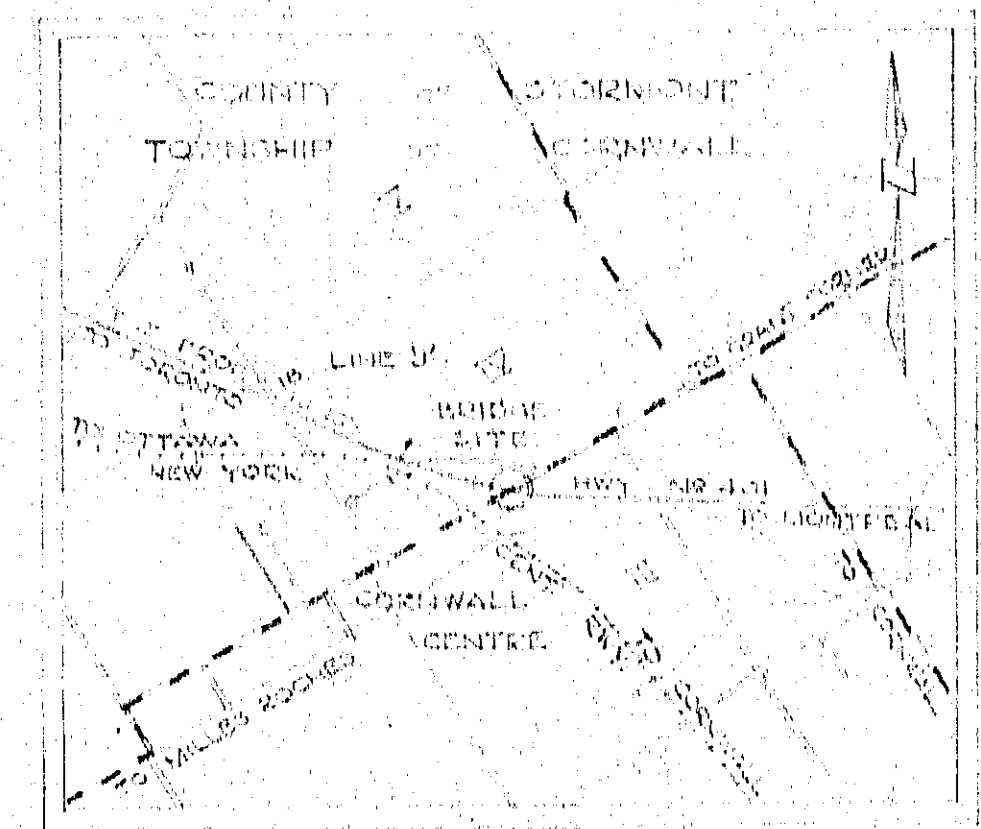
HALF SECTION A-A

SCALE: 1/8" = 1'-0"



PROFILE AT PROFILE CONTROL ON FINISHED PAVEMENT

SCALE: HORIZ. 1" = 100'  
VERT. 1" = 10'



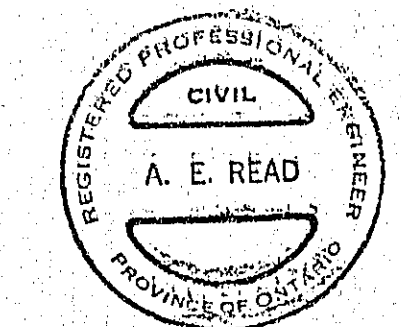
KEY PLAN  
SCALE: 1" = 1 MI

- GENERAL NOTES:
1. CONCRETE WORK ON THIS STRUCTURE SHALL NOT BE COMMENCED UNTIL MONUMENTS TO FIX CONTROL POINTS HAVE BEEN ERECTED & CHECKED BY THE DISTRICT ENGINEER.
  2. STRUCTURE TO BE BUILT IN ACCORDANCE WITH FORM 3 & THE SPECIAL PROVISIONS, EXTRA COPIES OF WHICH MAY BE OBTAINED FROM THE DISTRICT ENGINEER.
  3. ALL CONCRETE SHALL BE 3000 P.S.I. AT 28 DAYS, MAXIMUM SIZE AGGREGATE 1" AN ADJUSTMENT IS TO BE MADE TO THE CONCRETE AS SPECIFIED BY THE MATERIALS & RESEARCH SECTION OF THE D.H.O.
  4. SLUMP SHALL BE DETERMINED BY THE ENGINEER.
  5. ALL EXPOSED CORNERS TO HAVE 1" CHAMFERED.
  6. CONSTRUCTION JOINTS ADDITIONAL TO THOSE INDICATED ON THE DRAWINGS TO BE APPROVED BY THE ENGINEER.
  7. COVER TO REINFORCEMENT SHALL BE: 3" TO WALLS & FOOTINGS IN CONTACT WITH SOIL & WATER, 2" OTHER WALLS, 1" ELSEWHERE UNLESS OTHERWISE NOTED.
  8. THE COMPLETE SOIL INVESTIGATION REPORT DA-1006 MAY BE EXAMINED AT THE BRIDGE OFFICE, DEPT. OF HWYS. OR INT. THE DEPT. DOES NOT GUARANTEE THE ACCURACY OF THE REPORT, NOR THE ABRIDGED VERSION SHOWN ON THESE PLANS.
  9. THE GENERAL CONTRACTOR SHALL BE RESPONSIBLE FOR FINISHING BEARING SEATS FOR STRUCTURAL STEEL TO SPECIFIED ELEVATIONS DEAD LEVEL WITH A TOLERANCE OF 1/4" IF EAST TOO HIGH THE CONCRETE SHALL BE RUSH HAMMERED DOWN TO THE CORRECT ELEVATION, IF FINISHED TOO LOW FULL BEARING PLATE SHALL BE USED TO BRING THE BEARING TO CORRECT ELEVATION, SUCH WORK SHALL BE AT THE EXPENSE OF THE GENERAL CONTRACTOR. THE USE OF GROUT IS PROHIBITED.
  10. NO CONCRETE IS TO BE PLACED ABOVE BRIDGE SEAT ELEVATIONS UNTIL STRUCTURAL STEEL IS ERECTED.
  11. WELDING SHALL CONFORM TO C.S.A. SPECIFICATION W59-1946 FOR WELDING OF BRIDGES & SHALL BE DONE BY A WELDER QUALIFIED UNDER THE PROVISIONS OF C.S.A. SPECIFICATION W47-1947. THE ELECTRODE USED SHALL BE CLASSIFIED E6015 OR E6010 AS OUTLINED IN THE C.S.A. SPECIFICATION FOR MILD STEEL ARC WELDING ELECTRODES W48-1, 1952.
  12. STRUCTURAL STEEL CONTRACTOR:
    - 1. THE DESIGN, FABRICATION & ERECTION OF THE STRUCTURAL STEEL SHALL BE IN ACCORDANCE WITH THE LATEST ISSUE OF C.S.A. SPECIFICATION S6 FOR STEEL HIGHWAY BRIDGES.
    - 2. ALL STEEL TO BE 25000 PSI MEDIUM GRADE STRUCTURAL STEEL TO C.S.A. SPECIFICATION S40-4, EXCEPT THE SPALL TO WHICH SHALL BE STRUCTURAL STEEL F.O.R. IN ACCORDANCE WITH THE LATEST ISSUE OF ASTM SPECIFICATION A373.
    - 3. ALL SHOP CONNECTIONS TO BE RIVETED USING 7/8" RIVETS.
    - 4. WELDING SHALL CONFORM TO THE LATEST ISSUE OF C.S.A. SPECIFICATION W57.
- FOR FURTHER STEEL NOTES SEE DWG. N4 D-4 S17-4.

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT.
2. SETTING OUT DETAILS.
3. ABUTMENT DETAILS.
4. STEELWORK DETAILS.
5. DECK SLAB.
6. RETAINING WALLS - I.
7. " " " " - II.
8. BAR RAIL & WING WALLS.
9. REINFORCING STEEL SCHEDULE - I.
10. " " " " - II.

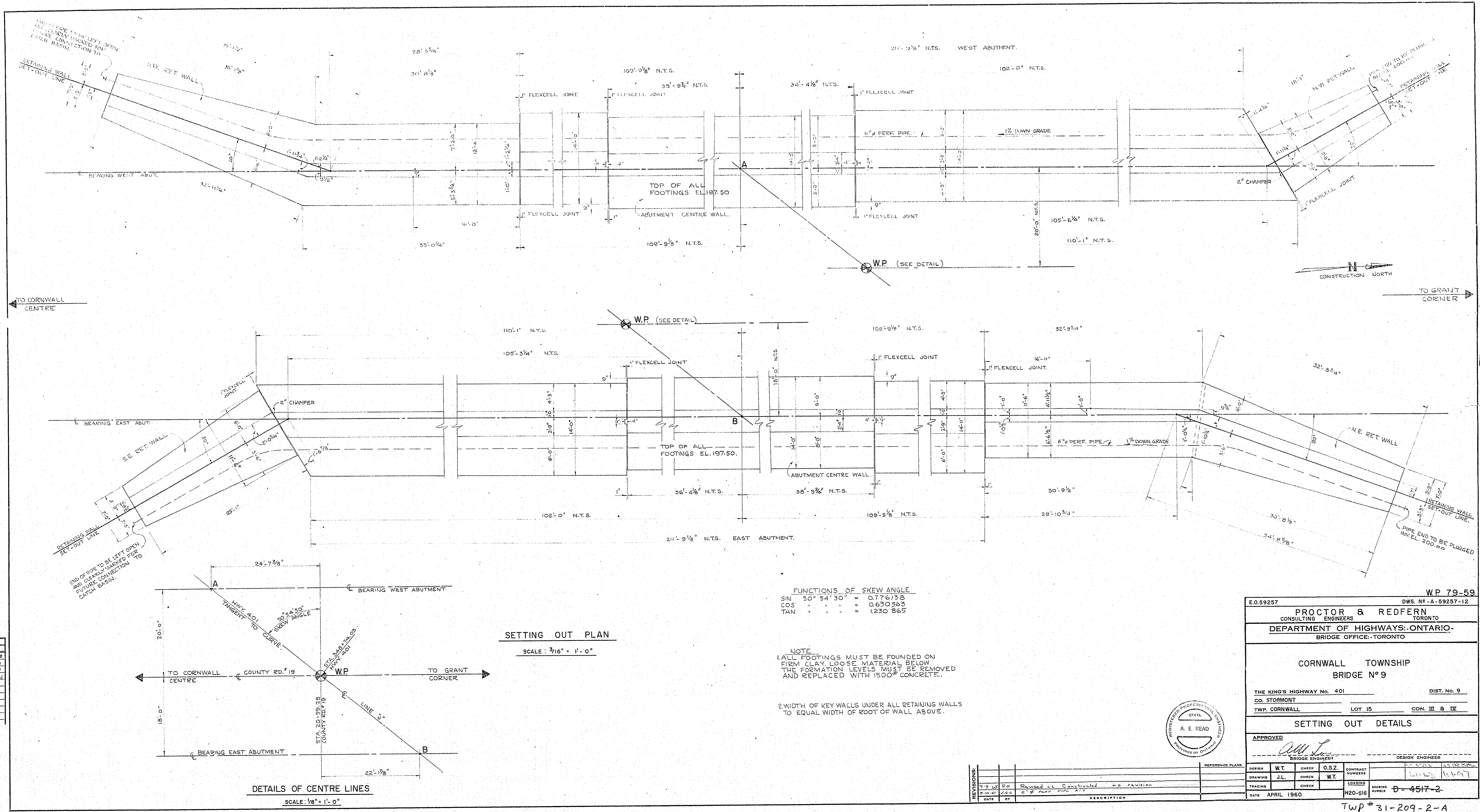
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10	CL. 5	10.12.60



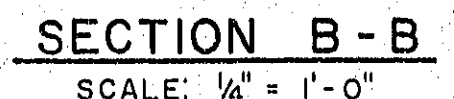
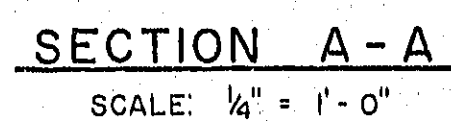
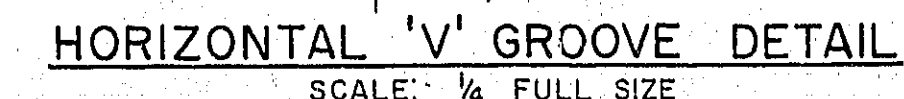
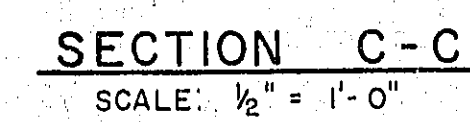
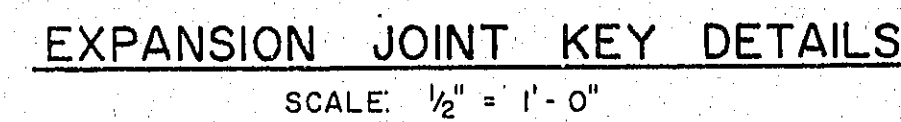
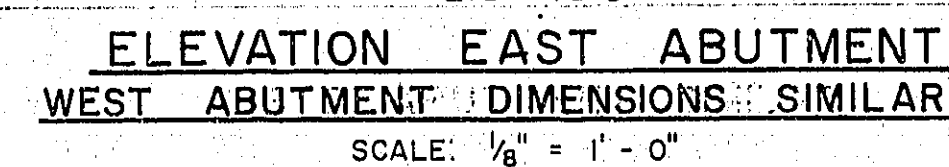
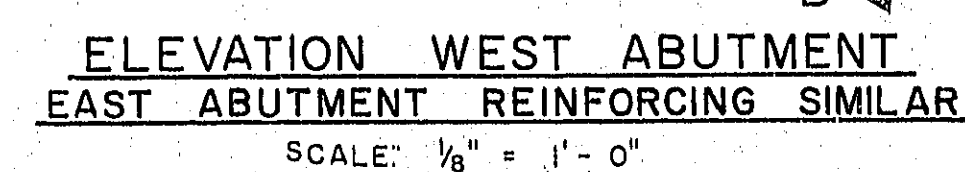
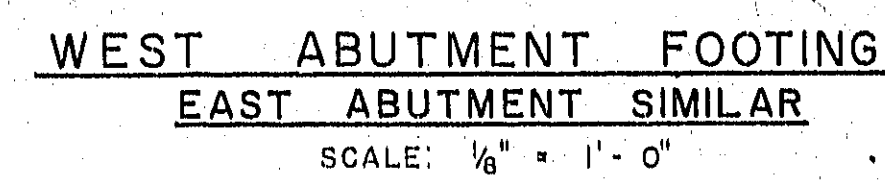
E.O. 59257		W.P. 79-59			
CONSULTING ENGINEERS		TORONTO			
DEPARTMENT OF HIGHWAYS-ONTARIO					
BRIDGE OFFICE-TORONTO					
CORNWALL TOWNSHIP					
BRIDGE NO. 9					
THE KING'S HIGHWAY No. 401		DIST. No. 9			
CO. STORMONT					
TWP. CORNWALL		LOT 15			
		CON. III & IV			
GENERAL ARRANGEMENT					
APPROVED					
A. E. READ		DESIGN ENGINEER			
BRIDGE ENGINEER					
REVISIONS:		REFERENCE PLANS:			
NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION
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3	7/15/60	REVISED GENERAL NOTES	3	7/15/60	REVISED GENERAL NOTES
4	7/15/60	REVISED GENERAL NOTES	4	7/15/60	REVISED GENERAL NOTES
5	7/15/60	REVISED GENERAL NOTES	5	7/15/60	REVISED GENERAL NOTES
6	7/15/60	REVISED GENERAL NOTES	6	7/15/60	REVISED GENERAL NOTES
7	7/15/60	REVISED GENERAL NOTES	7	7/15/60	REVISED GENERAL NOTES
8	7/15/60	REVISED GENERAL NOTES	8	7/15/60	REVISED GENERAL NOTES
9	7/15/60	REVISED GENERAL NOTES	9	7/15/60	REVISED GENERAL NOTES
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TWP# 31-209-1-A



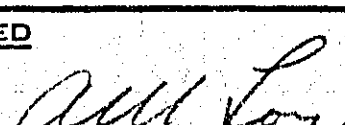




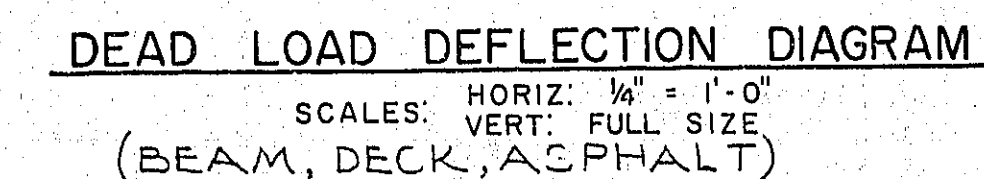
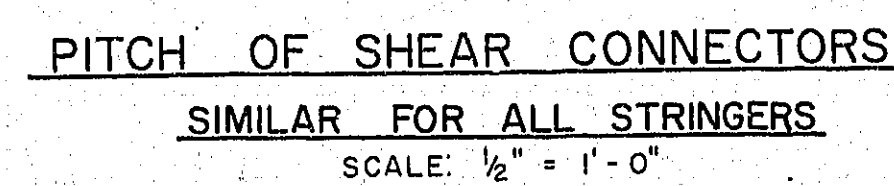
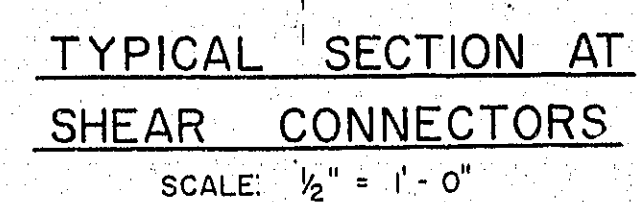
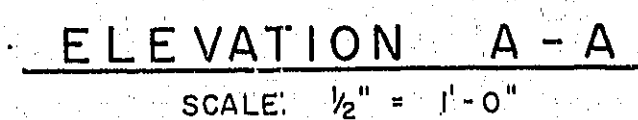
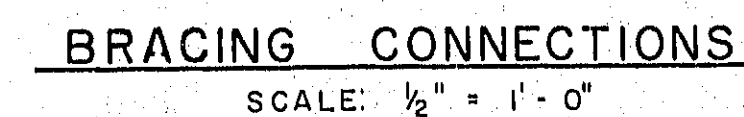
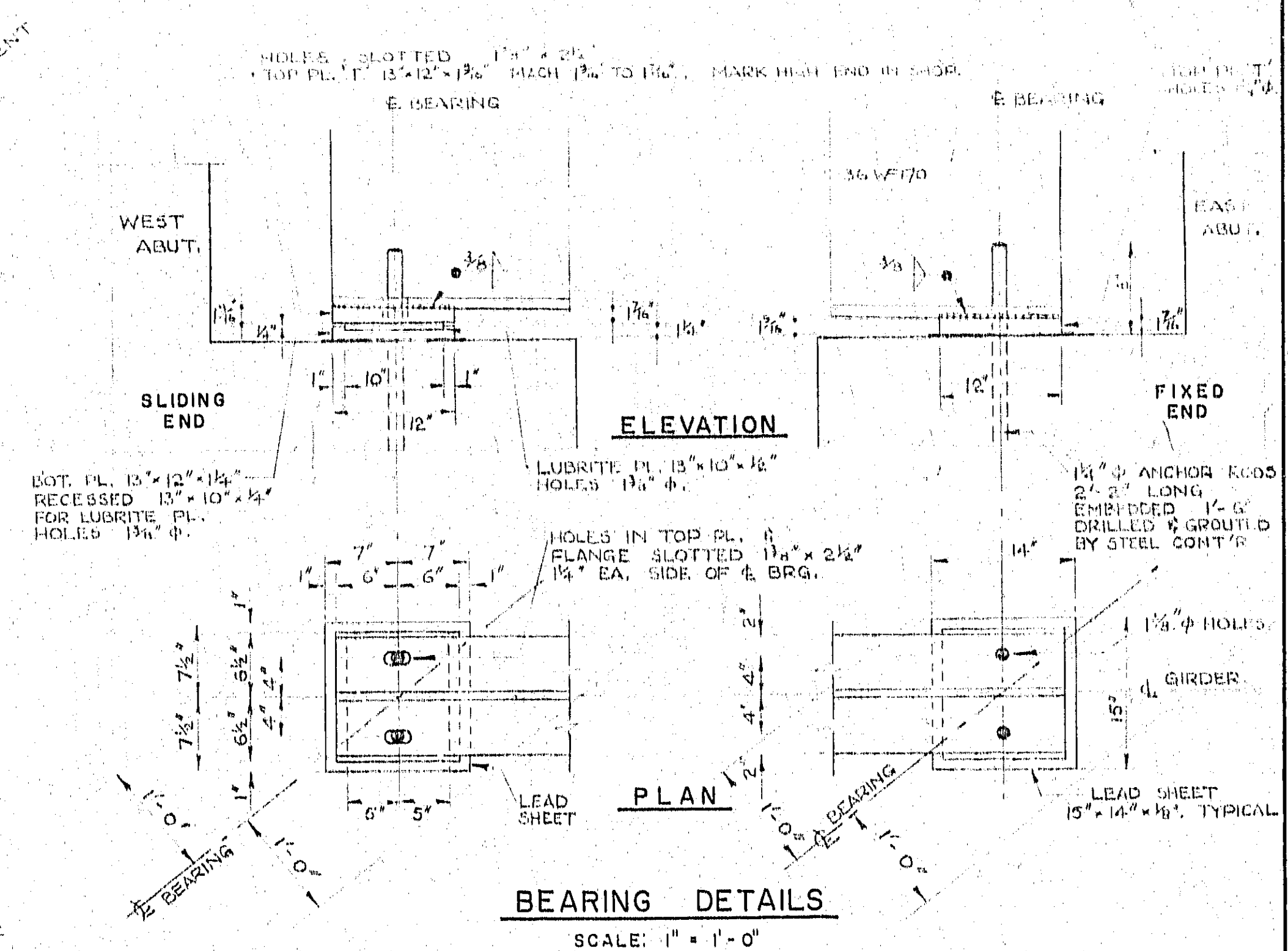



<u>NOTE</u>		
(N)	DENOTES	NEAR FACE.
(F)	"	FAR "
(E,F)	"	EACH "
(T)	"	TOP "
(B)	"	BOTTOM "
ALT.	"	ALTERNATE.
C.J.	"	CONSTRUCTION JOINT.

W.P. 79-59

E.O. 59257	DWG. N° A-59257-13						
<b>PROCTOR &amp; REDFERN</b> CONSULTING ENGINEERS TORONTO							
<b><u>DEPARTMENT OF HIGHWAYS-ONTARIO-</u></b> BRIDGE OFFICE-TORONTO							
<b>CORNWALL TOWNSHIP</b> <b>BRIDGE N° 9</b>							
THE KING'S HIGHWAY No. 401	DIST. No. 9						
CO. STORMONT							
TWP. CORNWALL	LOT 15	CON. III & IV					
<b>ABUTMENT DETAILS</b>							
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<b>DESIGN</b>	<b>W.T.</b>	<b>CHECK</b>	<b>O.S.Z.</b>	<b>CONTRACT NUMBER</b>	<div style="border: 1px solid black; padding: 2px;">61-4242</div>	<b>WORKING DRAWING</b>	<div style="border: 1px solid black; padding: 2px;">61-4242</div>
<b>DRAWING</b>	<b>J.N.G.</b>	<b>CHECK</b>	<b>W.T.</b>	<b>LOADING NUMBER</b>			
<b>TRACING</b>		<b>CHECK</b>					
<b>DATE</b>	<b>APRIL, 1960</b>			<b>H20-S16</b>	<div style="border: 1px solid black; padding: 2px;">D-4517-3</div>		

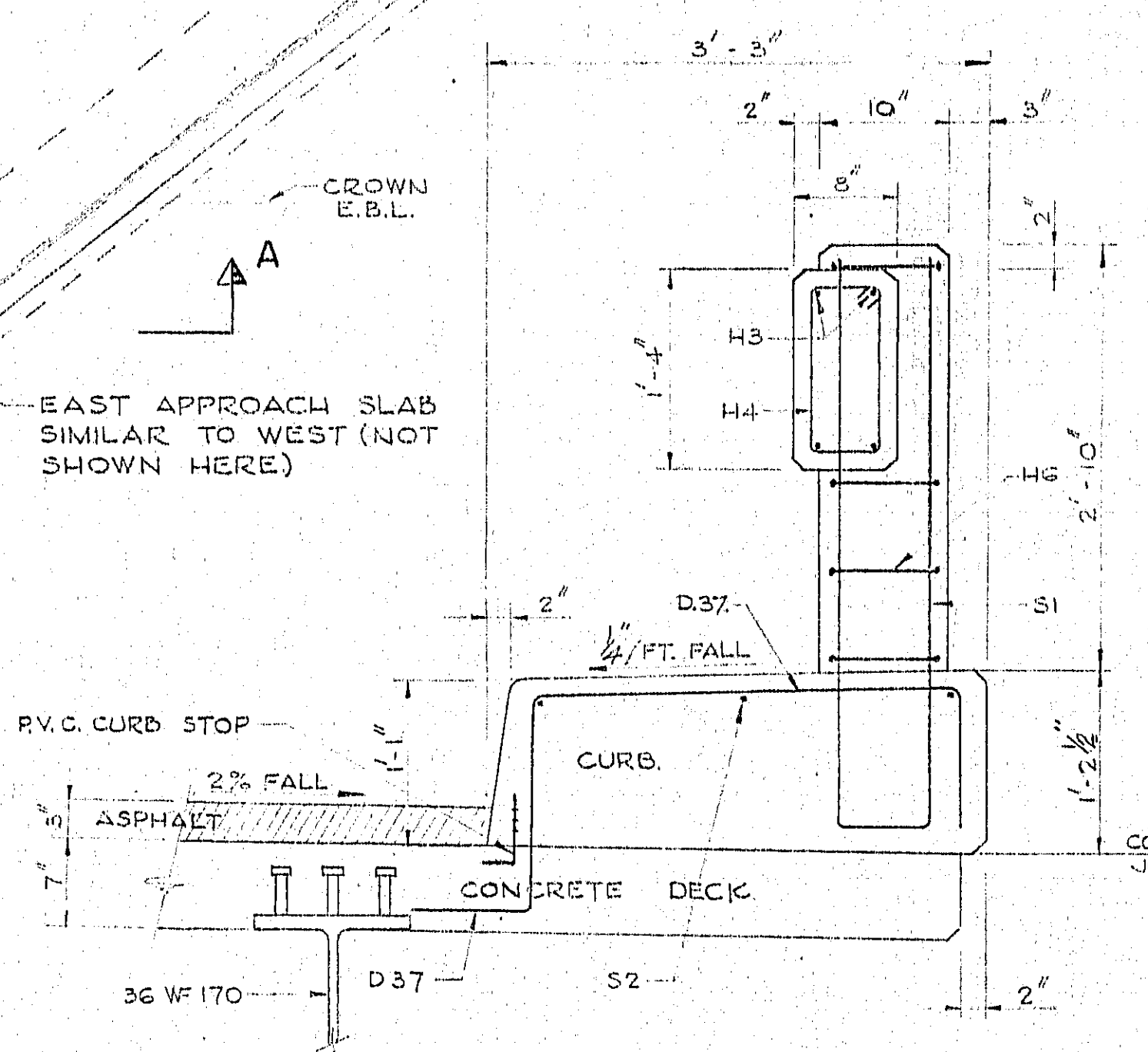
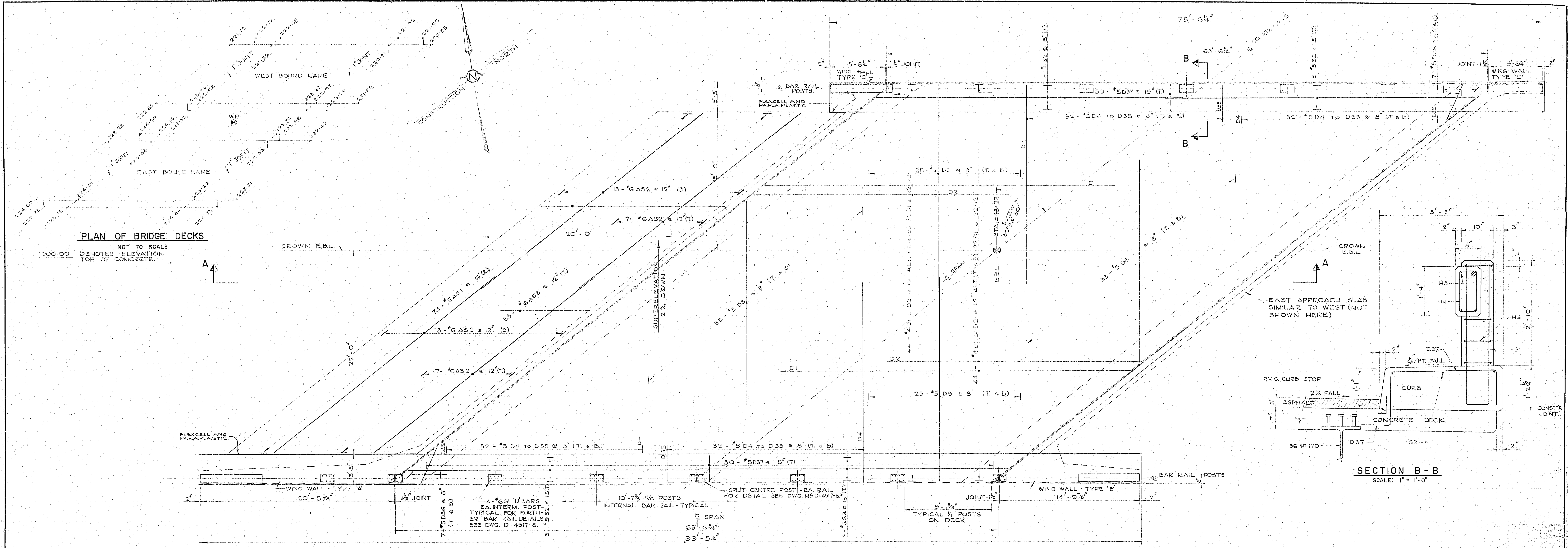




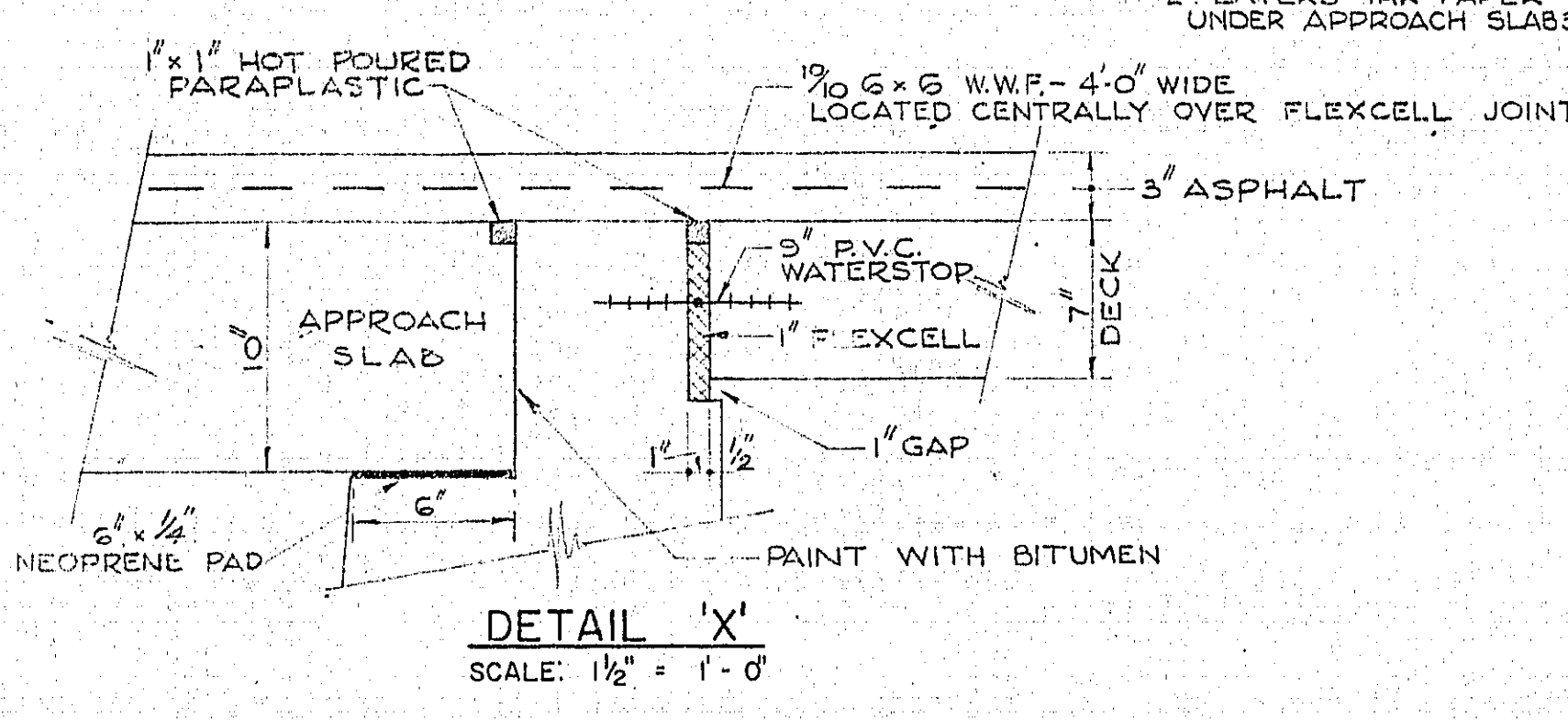
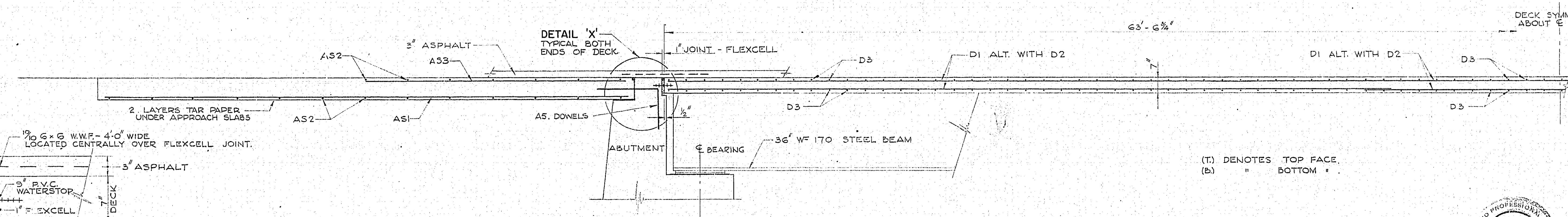
REGISTERED PROFESSIONAL ENGINEER  
CIVIL  
A. E. READ  
PROVINCE OF ONTARIO  
REFERENCE PLAN

TWP# 31-209-4-A





PLAN OF EAST BOUND DECK  
REINFORCEMENT IN WEST BOUND DECK SIMILAR  
SCALE: 1/4" = 1'-0"



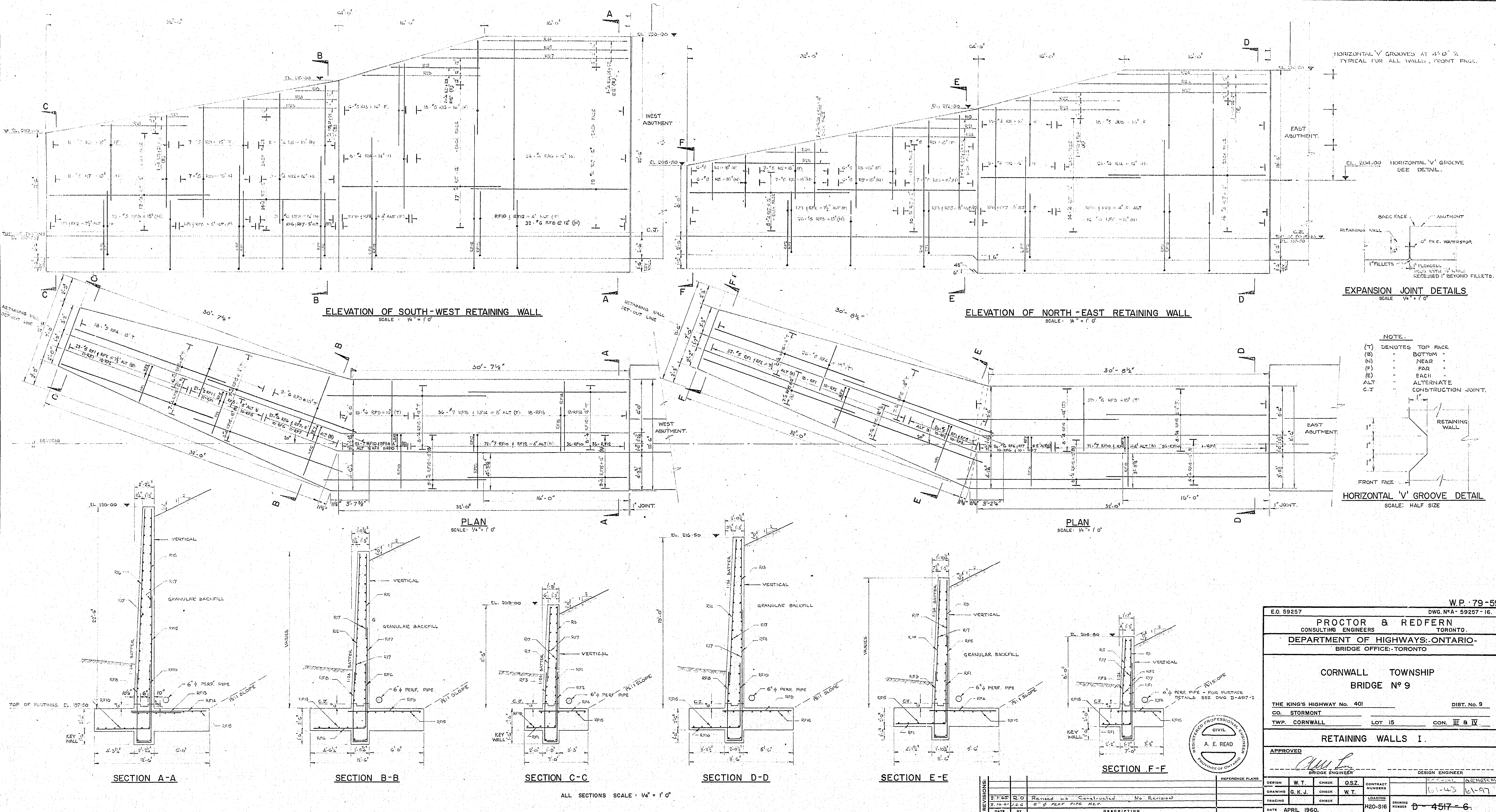
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7	CH. 7	1960
8	CH. 8	1960
9	CH. 9	1960
10	CH. 10	1960

E.O. 59257		W.P. 79-59	
CONSULTING ENGINEERS			
DEPARTMENT OF HIGHWAYS-ONTARIO			
BRIDGE OFFICE-TORONTO			
CORNWALL TOWNSHIP			
BRIDGE No. 9			
THE KING'S HIGHWAY No. 401		DIST. No. 9	
CO. STORMONT		CON. III & IV	
TWP. CORNWALL		LOT 15	
DECK SLAB			
APPROVED		DESIGN ENGINEER	
BRIDGE ENGINEER		DESIGNER	
DESIGN	W.T.	CHECK	O.S.Z.
DRAWING	J.N.G.	CHECK	W.T.
TRACING		CHECK	
DATE	MARCH, 1960	LOADING	H20-S16
DRAWING NUMBER		D-4517-5	

TWP # 31-209-5-A



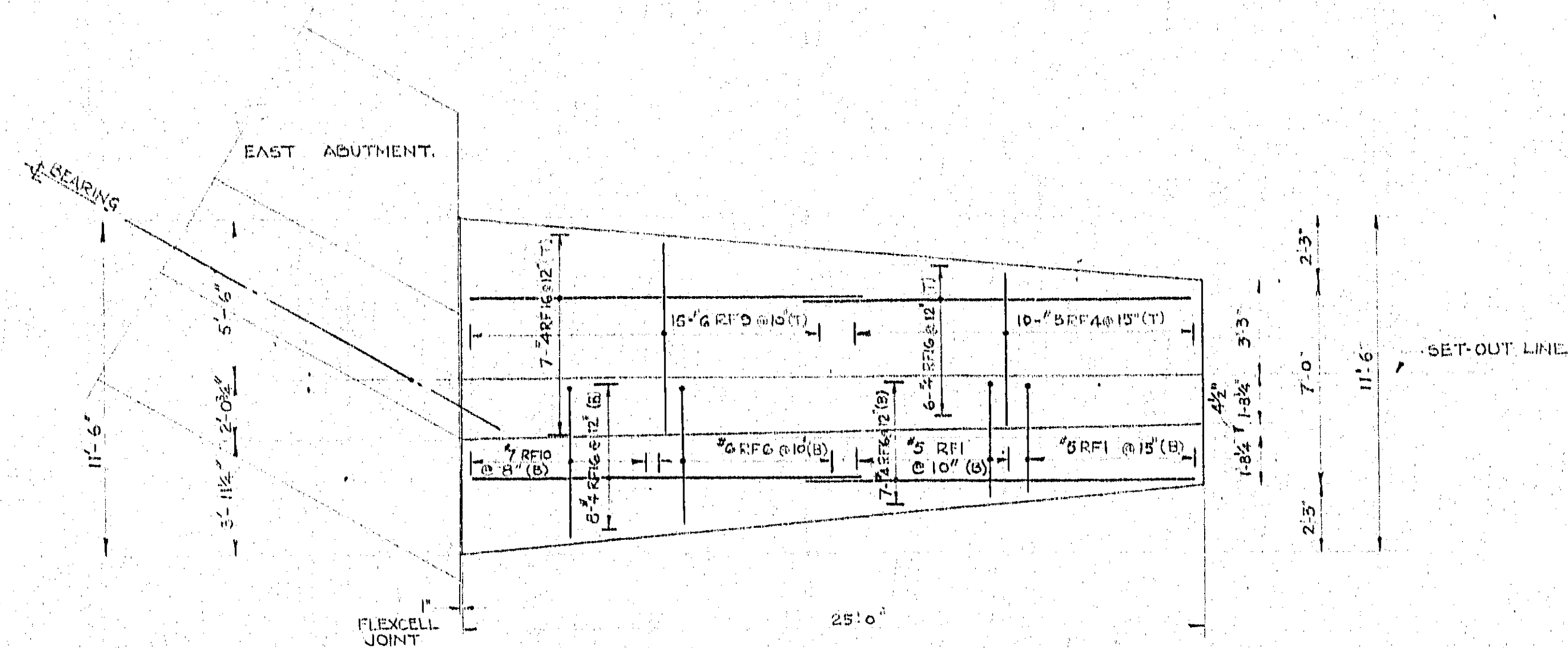
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10	FOR	1960



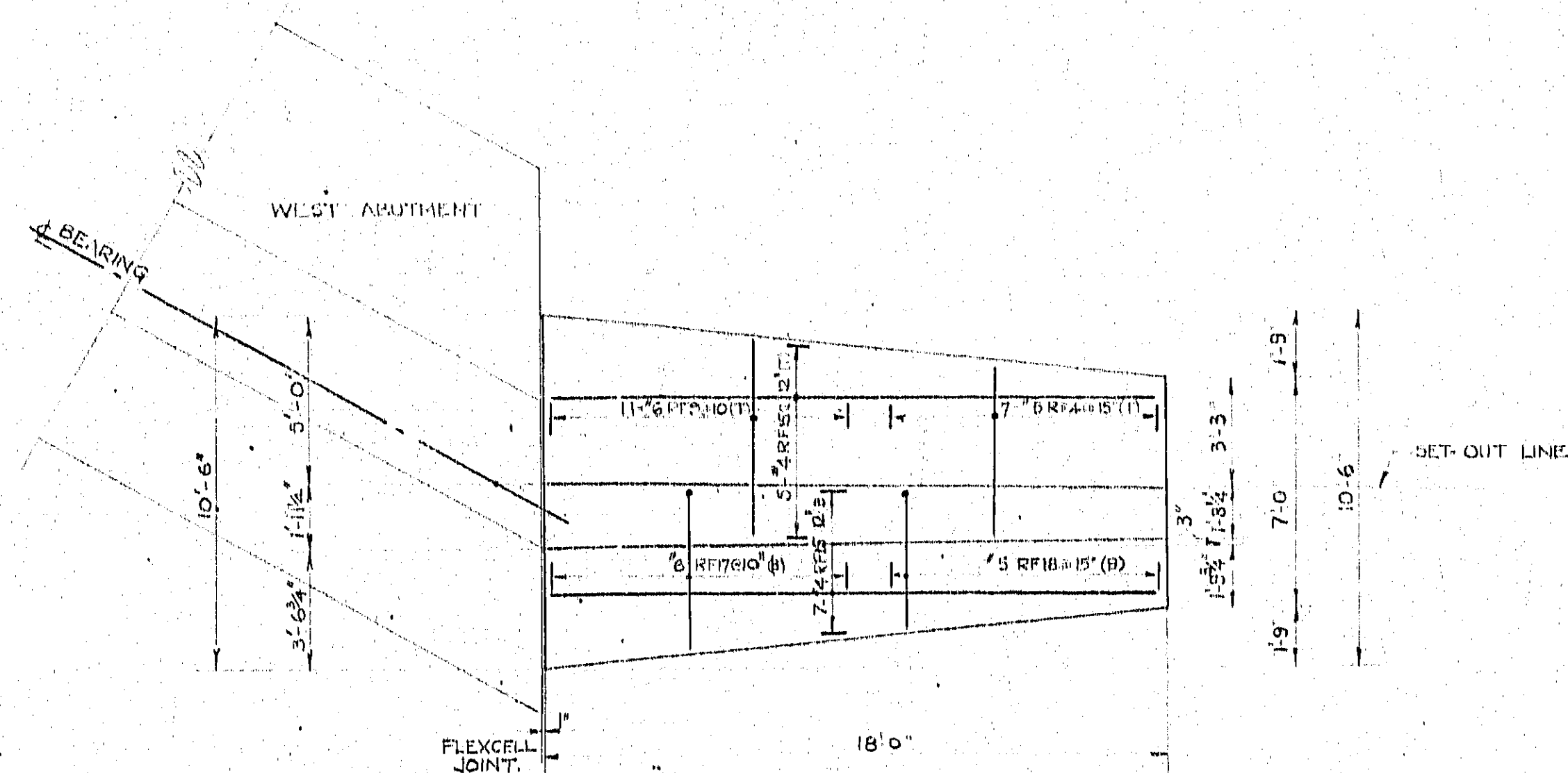
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<b>PROCTOR &amp; REDFERN</b> CONSULTING ENGINEERS TORONTO.			
DEPARTMENT OF HIGHWAYS-ONTARIO BRIDGE OFFICE-TORONTO			
CORNWALL TOWNSHIP		BRIDGE N° 9	
THE KING'S HIGHWAY No. 401		DIST. No. 9	
CO. STORMONT		CON. III & IV	
TWP. CORNWALL		LOT 15	
RETAINING WALLS I.			
APPROVED		DESIGN ENGINEER	
BRIDGE ENGINEER		CONTRACT NUMBER	
DESIGN	W.T. CHECK	O.S.Z.	CONTRACT NUMBER
DRAWING	G.K.J. CHECK	W.T.	CONTRACT NUMBER
TRACING	CHECK		CONTRACT NUMBER
DATE APRIL 1960.		DRAWING NUMBER H20-916	

Twp# 31-209-6-A

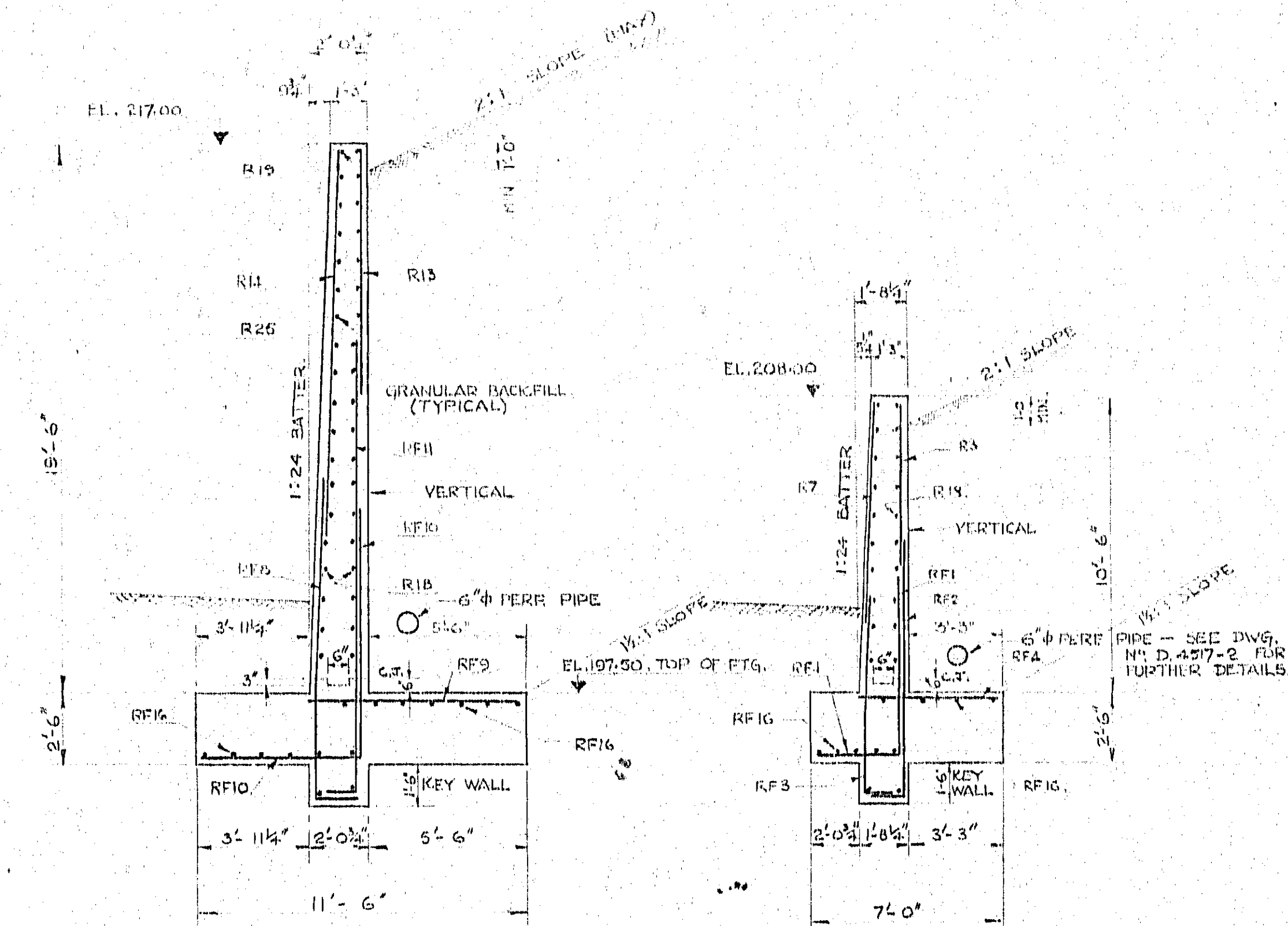




PLAN  
SOUTH-EAST RETAINING WALL

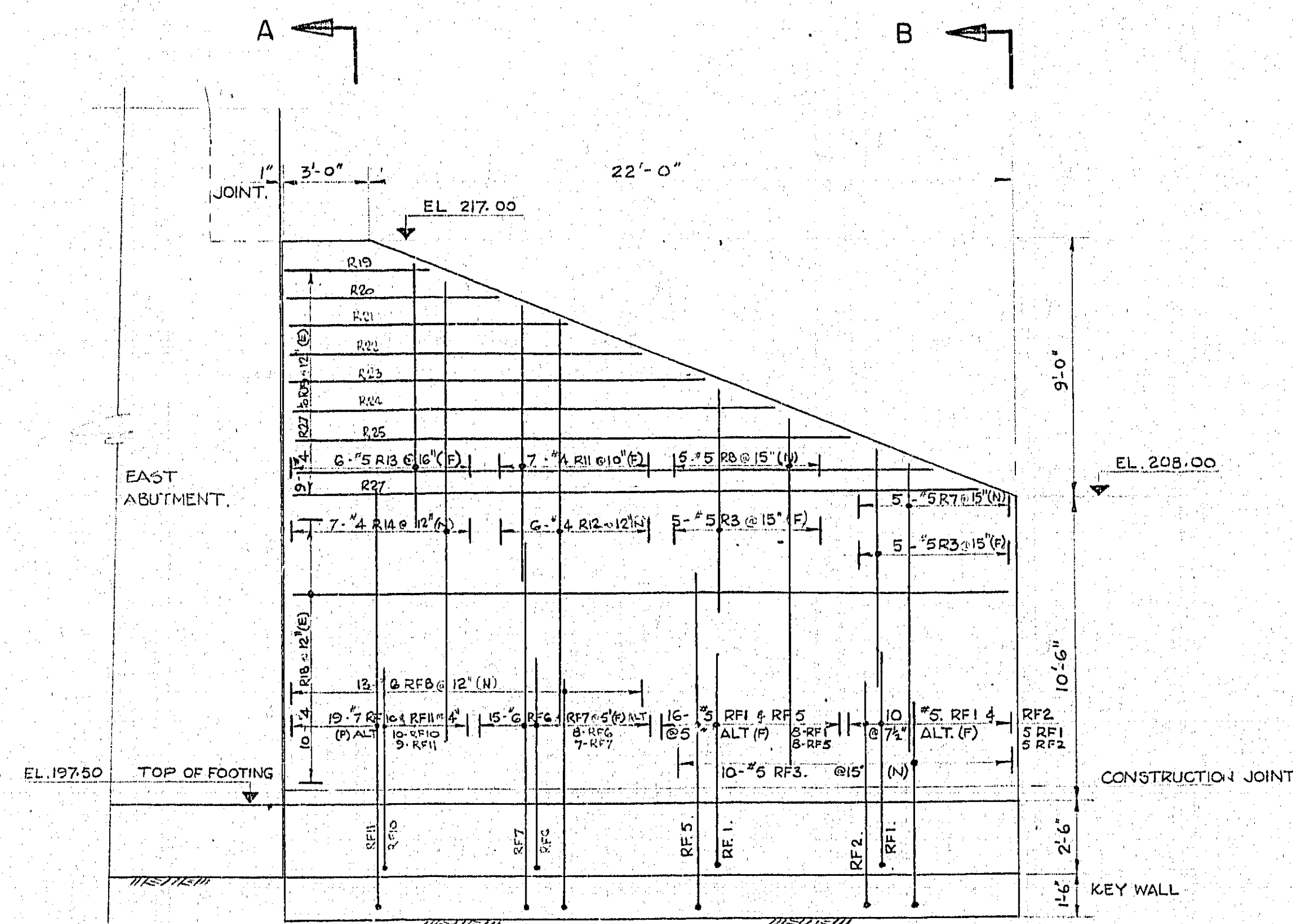


PLAN  
NORTH-WEST RETAINING WALL



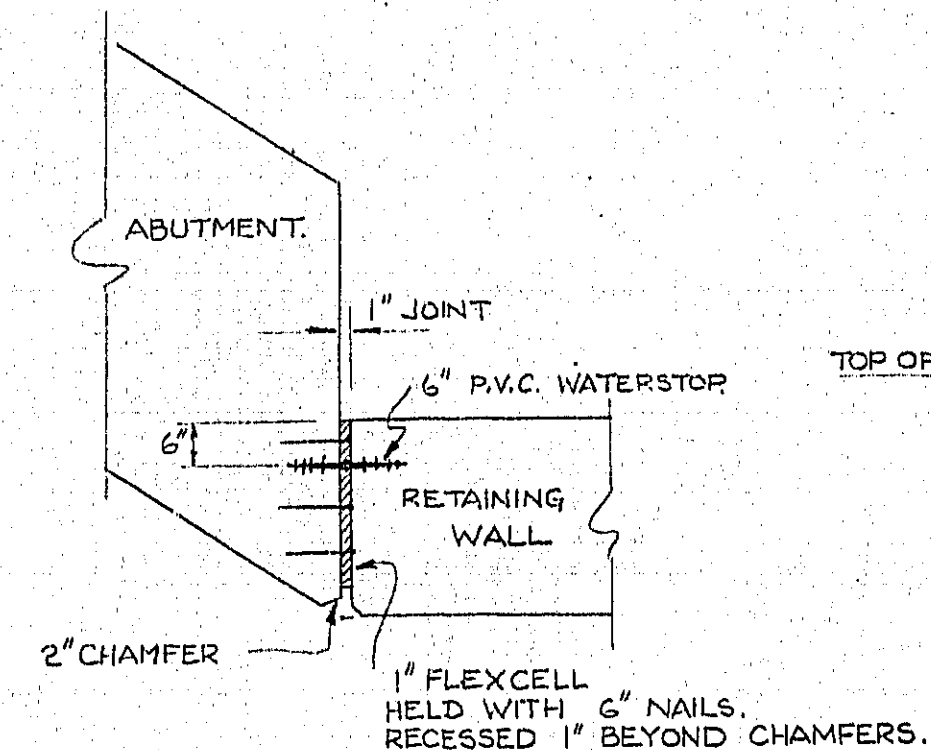
SECTION A-A

SECTION B-B

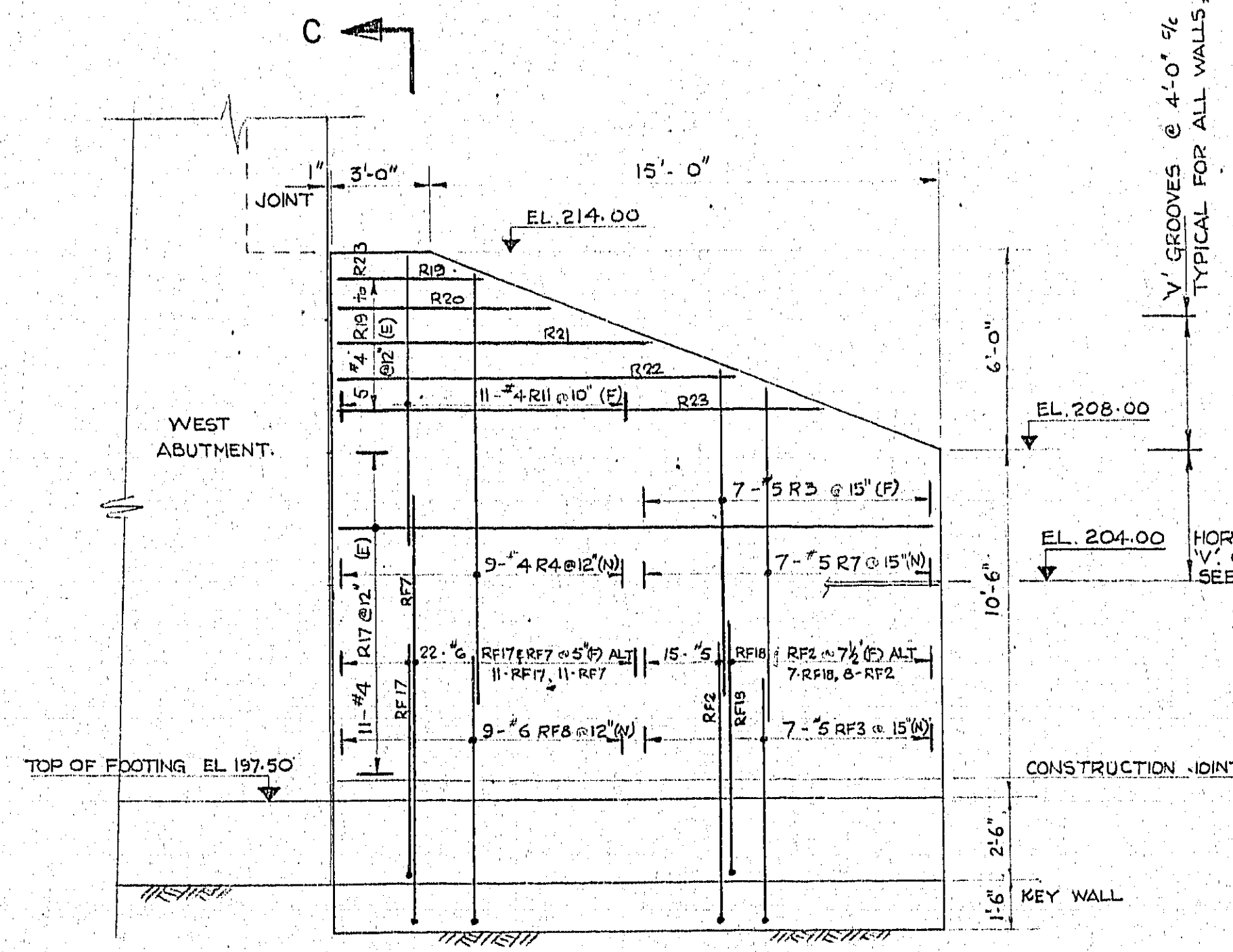


ELEVATION  
SOUTH-EAST RETAINING WALL

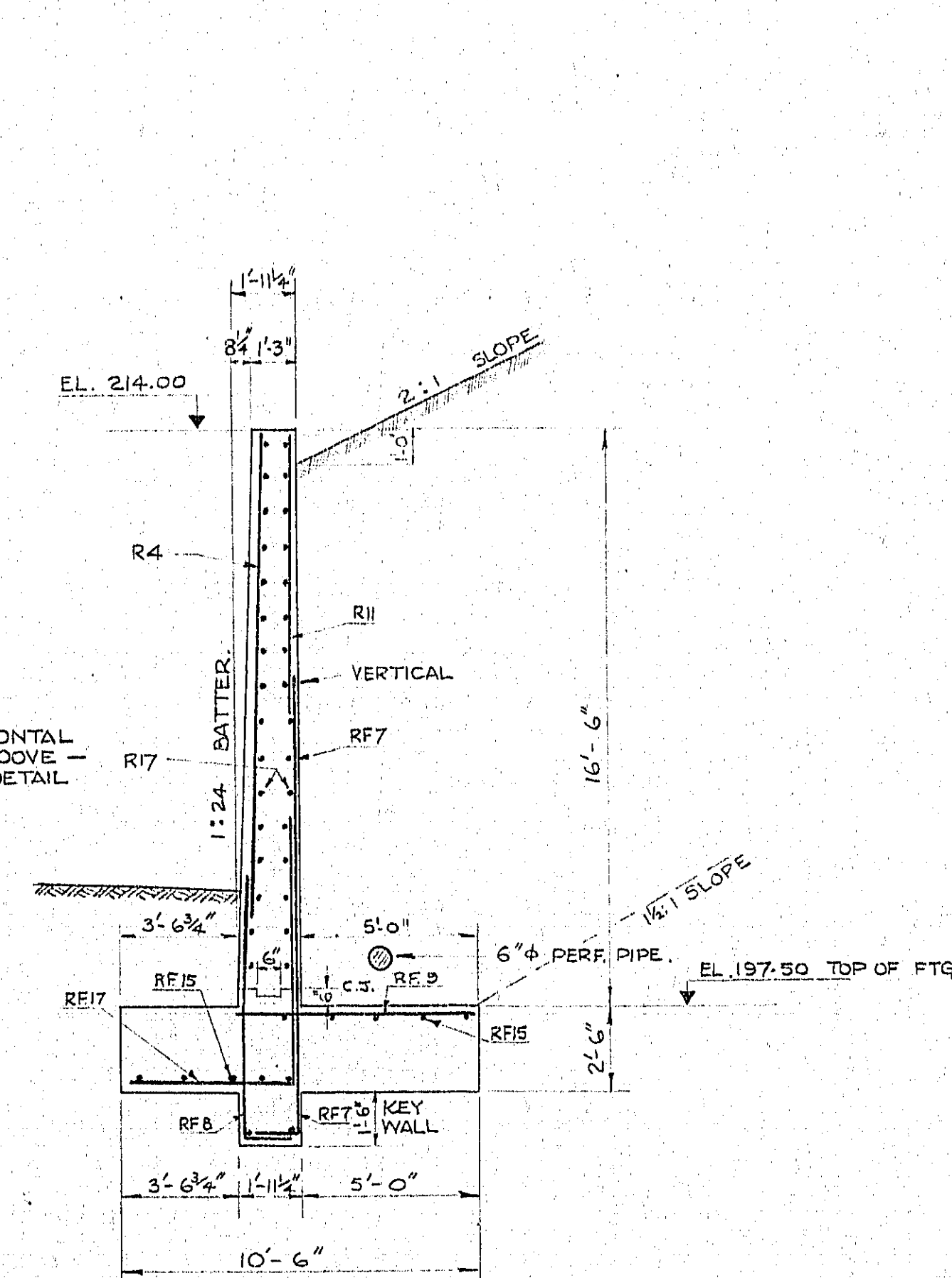
(N) DENOTES NEAR FACE.  
(F) FAR  
(E) EACH  
(T) TOP  
(B) BOTTOM  
(ALT.) ALTERNATING  
(C.J.) CONSTRUCTION JOINT.  
ALL SCALES 1/4" = 1'-0"  
UNLESS OTHERWISE NOTED.



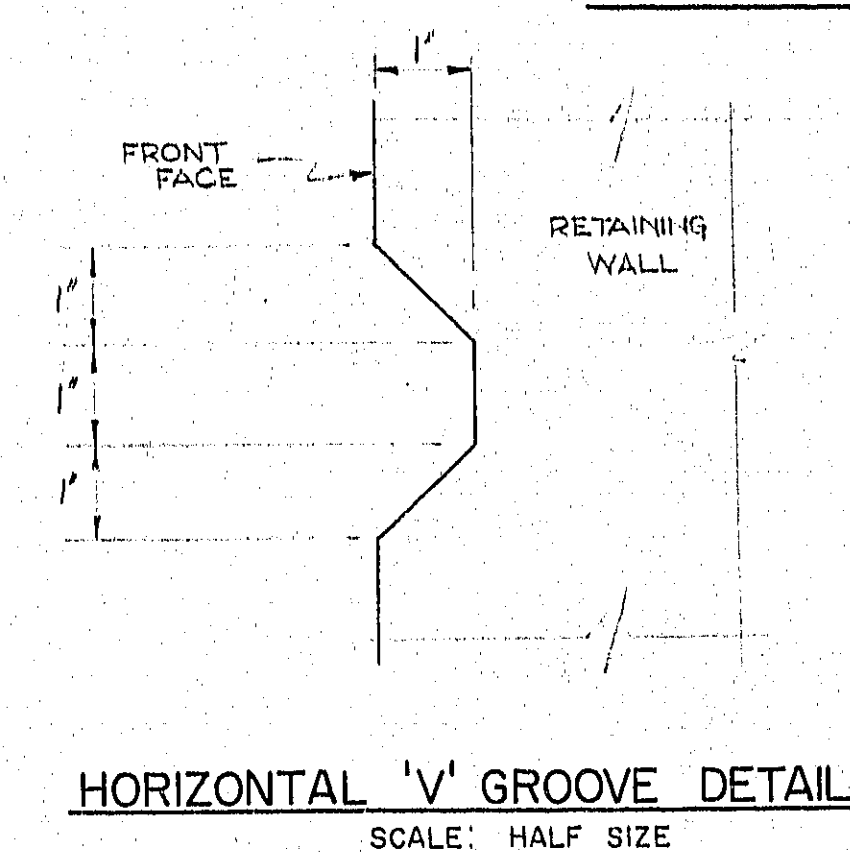
EXPANSION JOINT  
SCALE: 1/2" = 1'-0"



ELEVATION  
NORTH-WEST RETAINING WALL



SECTION C-C



HORIZONTAL 'V' GROOVE DETAIL  
SCALE: 1/2" = 1'-0"

NO.	FOR	DATE
1	FOR	1960
2	FOR	1960
3	FOR	1960
4	FOR	1960
5	FOR	1960
6	FOR	1960
7	FOR	1960
8	FOR	1960
9	FOR	1960
10	FOR	1960

E.O. 59257		DWG. N° A-59257-17							
PROCTOR & REDFERN CONSULTING ENGINEERS TORONTO									
DEPARTMENT OF HIGHWAYS-ONTARIO BRIDGE OFFICE-TORONTO									
CORNWALL TOWNSHIP BRIDGE N° 9									
THE KING'S HIGHWAY No. 401		DIST. No. 9							
CO. STORMONT		CON. III & II							
TWP. CORNWALL		LOT 15							
RETAINING WALLS. II.									
APPROVED		DESIGN ENGINEER							
A. E. READ		B. E. READ							
BRIDGE ENGINEER		DESIGN ENGINEER							
DESIGN	W.T.	CHECK	O.S.Z.						
DRAWING	J.L.	CHECK	W.T.						
TRACING	CHECK	CHECK	W.T.						
DATE	APRIL 1960	LOADING	H20-S16						
REVISIONS	<table border="1"> <tr> <th>NO.</th> <th>DESCRIPTION</th> </tr> <tr> <td>1</td> <td>Revised as Constructed</td> </tr> <tr> <td>2</td> <td>6" PERF. PIPE REV.</td> </tr> </table>			NO.	DESCRIPTION	1	Revised as Constructed	2	6" PERF. PIPE REV.
NO.	DESCRIPTION								
1	Revised as Constructed								
2	6" PERF. PIPE REV.								

TWP #31-209-7-A

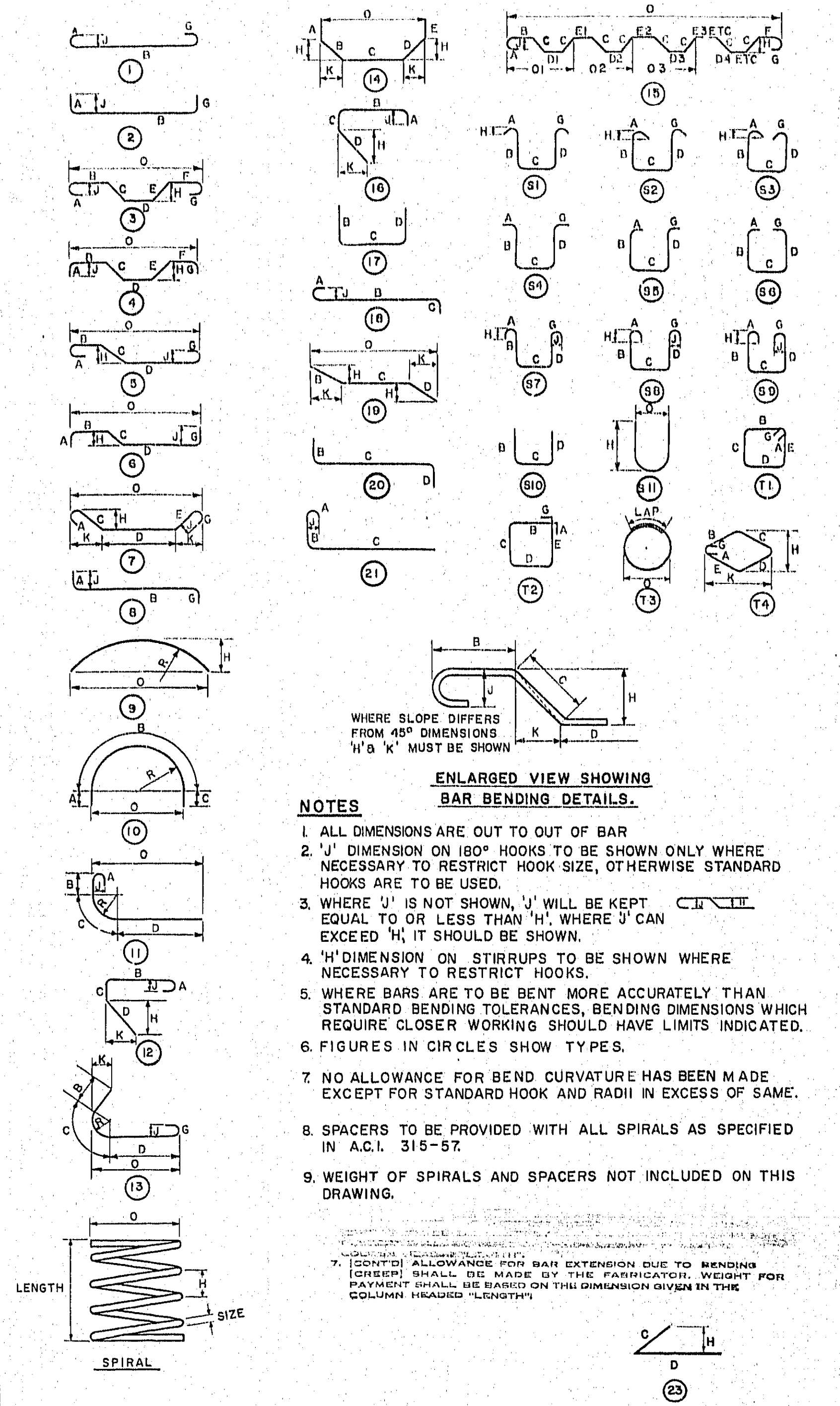




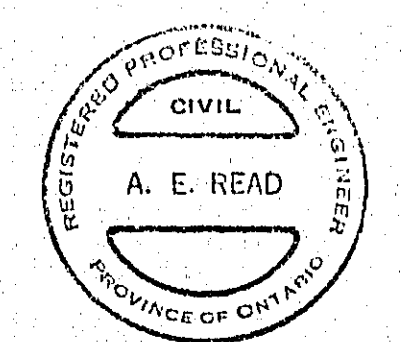


MARK	NO. BARS	SIZE	LENGTH	TYPE	A	B	C	D	E	F	G	H	J	K	L	M	O	R	SHAPE	LOCATION
RETAINING WALL FOOTINGS																				
RF1	53	5	11'-0"	2	7'-6"	3'-6"														
RF2	44	5	9'-0"	2	8'-0"	1'-0"														
RF3	61	5	8'-0"	16		1'-0"	3'-6"	3'-6"						2"						
RF4	61	5	5'-9"																STR.	
RF5	28	5	12'-9"	2	11'-9"	1'-0"														
RF6	28	5	11'-6"	2	7'-0"	4'-6"														
RF7	30	5	13'-9"	2	12'-9"	1'-0"														
RF8	35	5	8'-0"	16		1'-0"	3'-6"	4'-6"						2 1/2"						
RF9	86	5	7'-0"																STR.	
RF10	33	7	12'-0"	2	7'-0"	5'-0"														
RF11	58	7	15'-6"	2	14'-6"	1'-0"														
RF12	36	7	17'-0"	2	16'-0"	1'-0"														
RF13	18	7	2'-9"																STR.	
RF14	18	7	7'-9"																STR.	
RF15	133	4	17'-6"																STR.	
RF16	28	4	13'-0"																STR.	
RF17	11	6	11'-0"	2	7'-3"	4'-0"														
RF18	7	5	10'-6"	2	7'-6"	3'-0"														
RETAINING WALLS																				
R1	6	5	5'-3"																STR.	
R2	7	5	8'-9"																STR.	
R3	34	5	8'-6"																STR.	
R4	9	5	13'-0"																STR.	
R5	6	5	6'-3"																STR.	
R6	7	5	7'-9"																STR.	
R7	29	5	10'-0"																STR.	
R8	5	5	12'-3"																STR.	
R9	14	5	8'-0"																STR.	
R10	14	5	11'-9"																STR.	
R11	39	4	9'-0"																STR.	
R12	24	4	13'-9"																STR.	
R13	30	5	9'-3"																STR.	
R14	38	5	16'-0"																STR.	
R15	18	5	10'-6"																STR.	
R16	24	4	19'-0"																STR.	
R17	242	4	17'-6"																STR.	
R18	20	4	24'-6"																STR.	
R19	10	4	4'-9"																STR.	
R20	6	4	7'-1"																STR.	
R21	12	4	9'-5"																STR.	
R22	6	4	11'-9"																STR.	
R23	12	4	14'-1"																STR.	
R24	8	4	16'-5"																STR.	
R25	4	4	18'-9"																STR.	
R26	4	4	21'-1"																STR.	
R27	6	4	23'-5"																STR.	

MARK	NO. BARS	SIZE	LENGTH	TYPE	A	B	C	D	E	F	G	H	J	K	L	M	O	R	SHAPE	LOCATION
ABUTMENT FOOTINGS																				
AF1	284	7	18'-3"	2	12'-9"	5'-6"														
AF2	280	7	15'-6"	2	9'-0"	7'-6"														
AF3	284	4	5'-3"	2	4'-3"	1'-0"														
AF4	634	6	7'-0"																STR.	
AF5	638	6	9'-0"																STR.	
AF6	68	4	36'-0"																STR.	
AF7	102	4	25'-0"																STR.	
AF8	68	4	38'-0"																STR.	
AF9	358	7	12'-0"	16		2'-0"	3'-6"	6'-6"												
AF10	120	5	9'-6"	2	7'-6"	2'-0"														
ABUTMENT WALL																				
A1	284	4	13'-0"																STR.	
A2	284	4	10'-0"																STR.	
A3	284	4	15'-9"	2	13'-0"	2'-9"														
A4	552	4	4'-6"																STR.	
A5	236	7	4'-6"	2	2'-6"	2'-0"														DOWELS INTO APPROACH SLAB
A6	120	5	23'-6"																STR.	
A7	452	4	36'-0"																STR.	
A8	200	4	38'-0"																STR.	
A9	180	7	9'-0"																STR.	
A10	120	5	13'-0"																STR.	
A11	12	5	10'-0"	23			4'-0"	6'-0"												2'-6 1/4"
A12	12	5	8'-0"	6			3'-3"	4'-9"												2'-0 3/8"
A13	16	4	5'-10"	20			2'-0"	2'-10"	1'-0"											
A14	84	6	6'-9"	34	9"		2'-0"	1'-3"	2'-0"											9"
A15	22	5	8'-0"	23			3'-0"	5'-0"												1'-10 3/4"
A16	6	5	6'-0"	6			3'-0"	3'-0"												1'-10 3/4"
A17	18	5	9'-0"	6			3'-0"	6'-0"												1'-10 3/4"



- NOTES**
- ALL DIMENSIONS ARE OUT TO OUT OF BAR
  - "J" DIMENSION ON 180° HOOKS TO BE SHOWN ONLY WHERE NECESSARY TO RESTRICT HOOK SIZE, OTHERWISE STANDARD HOOKS ARE TO BE USED.
  - WHERE "J" IS NOT SHOWN, "J" WILL BE KEPT EQUAL TO OR LESS THAN "H", WHERE "J" CAN EXCEED "H", IT SHOULD BE SHOWN.
  - "H" DIMENSION ON STIRRUPS TO BE SHOWN WHERE NECESSARY TO RESTRICT HOOKS.
  - WHERE BARS ARE TO BE BENT MORE ACCURATELY THAN STANDARD BENDING TOLERANCES, BENDING DIMENSIONS WHICH REQUIRE CLOSER WORKING SHOULD HAVE LIMITS INDICATED.
  - FIGURES IN CIRCLES SHOW TYPES.
  - NO ALLOWANCE FOR BEND CURVATURE HAS BEEN MADE EXCEPT FOR STANDARD HOOK AND RADII IN EXCESS OF SAME.
  - SPACERS TO BE PROVIDED WITH ALL SPIRALS AS SPECIFIED IN A.C.I. 315-57.
  - WEIGHT OF SPIRALS AND SPACERS NOT INCLUDED ON THIS DRAWING.



ALL BARS TO BE DETAILED AS PER A.C.I. SPECIFICATIONS.  
ALL STEEL TO BE HARD GRADE & HIGH BOND EXCEPT AS NOTED.

PRINT RECORD		DEPARTMENT OF HIGHWAYS - ONTARIO			
NO.	FOR	DATE	NO.	FOR	DATE
1	FOR	11.6.61			
2	FOR	11.6.61			
3	FOR	11.6.61			
4	FOR	11.6.61			
5	FOR	11.6.61			
REVISIONS					
DATE BY					
3.9.63 R.O. Revised as Contained in Revision					
DATE BY					
TWP# 31-209-9-A					
BRIDGE OFFICE TORONTO					
CORNWALL TOWNSHIP					
BRIDGE No. 9					
THE KING'S HWY. NO. 401 DIST. NO. 9					
CO. STORMONT					
TWP. CORNWALL LOT 15 CON. VII B.I.V.					
REINFORCING STEEL SCHEDULE I.					
WEIGHT OF STEEL SEE DWG D-1517-10 CONTRACT					
REQUISITION A 59670 NUMBER					
DRAWING J.L. CHECK W.T. DRAWING					
DATE APRIL 1960 NUMBER					
PROCTOR & REDFERN					
CONSULTING ENGINEERS TORONTO					



[illegible]